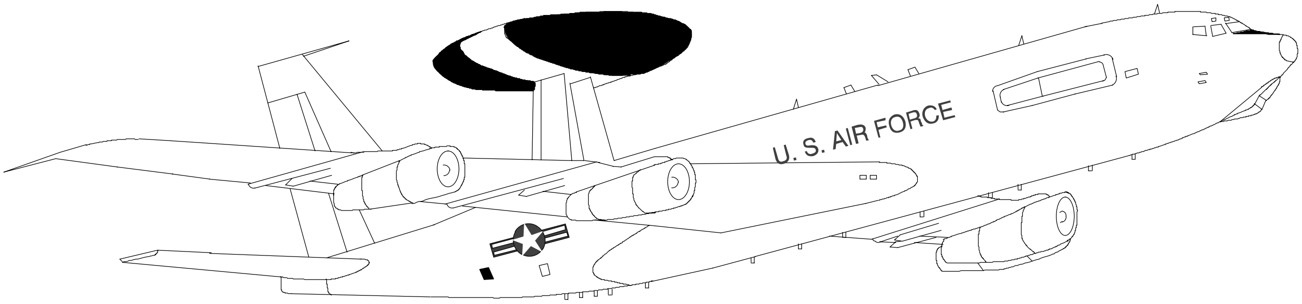
T.O. 1E-3A-1

FLIGHT MANUAL

USAF SERIES
E-3B & E-3C
AIRCRAFT



THE BOEING COMPANY
F34601-96-C-0720

PREPARED BY OC-ALC 557 ACSS/GFEAT

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31 JULY 1999 **CHANGE 18 – 14 JUL 2006**

LIST OF EFFECTIVE PAGES

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NOTE: The portion of the text and illustrations affected by the changes is indicated by a vertical line in the outer margins of the page. Changes to illustrations are indicated by miniature pointing hands.

Dates of issue for original and changed pages are:

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Change	2	1 Aug 2000
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1-15 Added	15
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1-17	3
1-18 Blank	3
1-19 – 1-22	15
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1-26 – 1-29	3
1-30	10
1-31	3
1-32	0
1-33 – 1-34	3
1-35 – 1-36 Deleted	3
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1-39 – 1-40	15
1-41 – 1-43	0
1-44 Blank	0
1-45 – 1-46	0
1-47 – 1-48	7
1-49 – 1-55	0
1-56	3
1-57	6
1-58	0
1-59 – 1-60	13
1-61	7
1-62	0
1-63	1
1-64	0
1-65	9
1-66 – 1-69	0
1-70	7
1-71	3
1-72 – 1-80	0
1-81 – 1-82	7
1-83 – 1-85	0
1-86 – 1-87	16
1-88 – 1-89	7
1-90 – 1-101	0
1-102 – 1-103	10
1-104 – 1-107	0
1-108 – 1-110	13
1-111	6
1-112 – 1-115	0
1-116	13
1-117 – 1-118	14
1-119 – 1-120	0
1-121	7
1-122 – 1-125	0
1-126	3
1-127 – 1-128	0
1-129 – 1-130	3
1-131 – 1-133	14
1-134 Blank	3
1-135 – 1-136 Deleted	3
1-137	15
1-138 – 1-139	3
1-140	0
1-141 – 1-142	7
1-143 – 1-144	0
1-145	16
1-146 – 1-147	7
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1-179	16
1-180	15
1-181	0
1-182	3
1-183 – 1-184	15
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1-188 – 1-189	0
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1-207	0
1-208	3
1-209	0
1-210 – 1-211	3
1-212 – 1-214	0
1-215	3
1-216 – 1-217	0
1-218	3
1-218A – 1-218B Deleted	10
1-219	0
1-220 – 1-221	15
1-222	3
1-223 – 1-224	10
1-225 – 1-228	0
1-229	3
1-230 – 1-234	0
1-235	3
1-236 – 1-238	15
1-239 – 1-240	0
1-241 – 1-242	7
1-243 – 1-246	15
1-247 – 1-248	0
1-249 – 1-250	13
1-251	7
1-252 – 1-253	0
1-254	17
1-255 – 1-261	0
1-262	1
1-263 – 1-264	2
1-265 – 1-275	0
1-276	15
1-277 – 1-279	0
1-280	3
1-280A – 1-280C Added	3
1-280D Blank Added	3
1-281	7
1-282 – 1-293	0
1-294 Blank	0
1-295 – 1-296	0
1-297	11
1-298	14
1-298A Added	7
1-298B Blank Added	7
1-299 – 1-304	0
1-305	3
1-306 – 1-312	0
1-313	17
1-314	0
1-315	17
1-316 – 1-318	0
1-319 – 1-320	17
1-321 – 1-324	0
1-325 – 1-326	15
1-327 – 1-328A	17
1-328B Blank Added	15
1-329 – 1-332	16
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1-338T – 1-338AD	17
1-338AE – 1-338AF Added	17
1-339 – 1-340	15
1-341 – 1-342	0
1-343 – 1-344	15
1-345 – 1-346	0
1-347 – 1-349	3
1-350	15
1-351	3
1-352 – 1-355	15
1-356 – 1-359	3
1-360 – 1-364	15
1-365 – 1-372 Deleted	3
1-373 – 1-374	3
1-375	15
1-376 – 1-382	3
1-383 – 1-384	0
1-385	3
1-386	16
1-387 – 1-390	3
1-391 – 1-392 Deleted	3
1-393	3
1-394	16
1-395 – 1-399	3
1-400 Blank	3
1-401	3
1-402 – 1-404	0
1-405 – 1-408	15
1-409 – 1-412 Deleted	3
1-413	3
1-414	0
1-415 – 1-416	3
1-417 – 1-421	0
1-422 – 1-423	3
1-424 – 1-431	0
1-432 – 1-433	3
1-434 – 1-435	0
1-436	3
1-437 – 1-440	15
1-441	3
1-442	0
1-443	3
1-444	0
1-445	3
1-446 – 1-462	0
1–463 – 1-464	15
1-465	0
1-466	15
1-467 – 1-468	0
1-469	15
1-470	0
1-471 – 1-476	15
1-477 – 1-482 Added	15
1-483 – 1-485	17
1-486 – 1-489 Added	15
1-490 Blank Added	15

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1-493 – 1-556 Deleted	15
1-557 – 1-572	15
1-573 – 1-582 Deleted	15
1-583	15
1-584	9
1-585	0
1-586	9
1-587 – 1-588	12
1-589	0
1-590 – 1-592	3
1-593	13
1-594 – 1-595	15
1-596 – 1-596A	16
1-596B Added	7
1-597	8
1-598 – 1-600	9
1-601 – 1-602	12
1-603 – 1-604	9
1-604A Added	9
1-604B Blank Added	9
1-605	9
1-606	0
1-607	3
1-608 – 1-609	0
1-610	15
1-611 – 1-612	0
1-613	2
1-614 Blank	2
1-614A	3
1-614B Added	2
1-615	8
1-616	15
1-617	0
1-618 – 1-619	15
1-620	14
1-621	0
1-622	12
1-623 – 1-624	0
1-624A Added	15
1-624B Blank Added	15
1-625 – 1-626	0
1-627 – 1-628	15
1-629	0
1-630	12
1-631 – 1-686	0
1-687 – 1-688	12
1-689	7
1-690 – 1-692	12
1-693 – 1-696	0
1-697	12
1-698 – 1-699	0
1-700 – 1-702	15
1-703 – 1-705	0
1-706 – 1-709	12
1-710 – 1-714	0
1-715	12
1-716 – 1-718	0
1-719	9
1-720 – 1-723	12
1-724 – 1-725	0
1-726 – 1-727	15
1-728 – 1-738	0
1-739 – 1-740	12
1-741 – 1-746	0
1-747	10
1-748 – 1-811	0
1-812 – 1-816	12
1-816A – 1-816F Added	12
1-817 – 1-820	12
1-820A – 1-820B Added	12
1-821	15
1-822 – 1-826	0
1-827 – 1-828	13
1-829	15
1-830	0
1-831 – 1-832	12
1-833	0
1-834	15
1-834A Added	15
1-834B Added	15
1-835	15
1-836 – 1-836A	12
1-836B – 1-836D	15
1-836E	12
1-836F	15
1-836G Added	12
1-836H Blank Added	12
1-837 – 1-838	15
1-838A – 1-838H	15
1-839	12
1-840	17
1-840A – 1-840G Added	12
1-840H Blank Added	12
1-841 – 1-842	12
1-842A – 1-842B Added	12
1-842C	16
1-842D – 1-842G	12
1-842H Blank Added	12
1-843 – 1-844	12
1-844A – 1-844G Added	12
1-844H Blank Added	12
1-845 – 1-846	12
1-846A – 1-846G Added	12
1-846H Blank Added	12
1-847 – 1-848	12
1-848A – 1-848B Added	12
1-849 – 1-851	12
1-852 Blank	12
1-853 – 1-854	7
1-855	6
1-856 – 1-860	15
1-860A – 1-860B Added	15
1-860C	16
1-860D Added	15
1-860E	16
1-860F – 1-860H Added	15
1-861	15
1-862	7
1-863 – 1-864	3
1-865 – 1-866 Deleted	3
1-867 – 1-869	0
1-870	15
1-871 – 1-872 Deleted	3
1-873	15
1-874	3
1-875 – 1-878	15
1-878A Added	15
1-878B Blank Added	15
1-879	15
1-880	3
1-881 – 1-884 Deleted	3
1-885	3
1-886	16
1-887	15
1-888 – 1-890	0
1-891	16
1-892	0
1-893	6
1-894	0
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1-896	3
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1-905 – 1-906	3
1-907 – 1-908 Deleted	3
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1-911	0
1-912	3
1-913	0
1-914 – 1-916	3
1-917	15
1-918 Blank	0
1-919 – 1-926	0
1-927	9
1-928	10
1-929 – 1-937	0
1-938 – 1-940	17
1-941 – 1-959	0
1-960 Blank	0
1-961	3
1-962	0
1-963	7
1-964 – 1-966	0
1-967 – 1-968	17
1-969	10
1-970 – 1-972	7
1-973	0
1-974	6
1-975 – 1-978	10
1-979 – 1-980 Deleted	3
1-981 – 1-985	3
1-986 – 1-988	0
1-989	15
1-990	0
1-991 – 1-994	3
1-995 – 1-997	0
1-998	3
1-999	0
1-1000	6
1-1001	3
1-1002 – 1-1006	0
1-1007 – 1-1008	3
1-1009	0
1-1010	3
1-1011 – 1-1016	0
1-1017 – 1-1018	7
1-1019	6
1-1020 Blank	0
1-1021 – 1-1022	0
1-1023 – 1-1024	3
1-1025 – 1-1031	0
1-1032 – 1-1033	3
1-1034 – 1-1038	7
1-1039	0
1-1040	7
1-1041 – 1-1044	0
1-1045	4
1-1046 – 1-1048	0
1-1049	7
1-1050 – 1-1061	0
1-1062 Blank	0
1-1063 – 1-1077	0
1-1078	3
1-1079 – 1-1082	0
1-1083	3
1-1084 – 1-1087	0
1-1088	14
1-1089 – 1-1091	0
1-1092 Blank	0
1-1093 – 1-1094	7
1-1095 – 1-1105	0
1-1106	1
1-1107	0
1-1108 Blank	0
1-1109 – 1-1170 Deleted	3
2-1 – 2-2	0
2-3	15
2-4	17
2-5	18
2-6 – 2-9	17
2-10	16
2-11	15
2-12 – 2-13	17
2-14 – 2-19	15
2-20	3
2-21	16
2-22 – 2-24	15
2-25	16
2-26	0
2-27	16
2-28 – 2-29	15
2-30	0
2-31	17
2-32	16
2-33 – 2-37	15
2-38 – 2-39	16
2-40	15
2-41 – 2-43	0
2-44	6
2-45 – 2-46	17
2-47 – 2-49	16
2-50 – 2-51	15
2-52	16
2-53 – 2-55	0
2-56	3
2-57	15
2-58	0
2-59 – 2-60	15
2-61	16
2-62	15
2-63 – 2-64	17
2-65 – 2-70	15
2-71	16
2-72 – 2-73	15
2-74 – 2-75	0
2-76	3
2-77 – 2-84	0
2-85 – 2-86	3
2-87 – 2-89	15
2-90 – 2-91	16
2-92 – 2-95	15
2-96	0
3-1	9
3-2	0
3-3 – 3-4	15
3-5 – 3-7	0
3-8 – 3-9	9
3-10 – 3-10A	15
3-10B Blank Added	9
3-11	0
3-12	6
3-13 – 3-18	0
3-19 – 3-20	7
3-21 – 3-22	0
3-23 – 3-24	15
3-25 – 3-28	0
3-29 – 3-32	17
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3-59	10
3-60 – 3-65	0
3-66	15
3-67 – 3-68	0
3-69	3
3-70	0
3-71	7
3-72	6
3-73 – 3-74	3
3-75 – 3-77	0
3-78	15
3-79 – 3-80	0
3-81	15
3-82	0
3-83	3
3-84 – 3-85	15
3-86	0
3-87 – 3-90	15
3-91	16
3-92 – 3-93	0
3-94	15
3-95 – 3-96	3
3-97	15
3-98 – 3-104	16
3-105	3
3-106	0
3-107 – 3-108	9
3-109	0
3-110	6
3-111 – 3-112	16
3-113	0
3-114	7
3-115	6
3-116	0
3-117	3
3-118	0
3-119 – 3-120	6
3-121 – 3-122	3
3-123	0
3-124	3
3-125	1
3-126	0
3-127 – 3-128	16
4-1 – 4-11	15
4-12	16
4-13	15
4-14	17
4-15 – 4-16 Added	15
5-1	13
5-2 – 5-3	0
5-4	13
5–5	14
5-6	3
5-7	10
5-8 – 5-10	0
5-11	1
5-12	0
5-13 – 5-14	15
5-15 – 5-16	14
5-17 – 5-18	0
5-19 – 5-20	13
5-21	1
5-22 – 5-24	3
5-25	7
5-26	14
5-27 – 5-29	0
5-30	13
5-31	15
5-32	9
5-33 – 5-34	13
6-1	3
6-2	0
6-3 – 6-4	3
6-5 – 6-6 Deleted	3
6-7	0
6-8	3
6-9 – 6-19	0
6-20	3
6-21	0
6-22 – 6-23	3
6-24 Blank	0
7-1 – 7-6	0
7-7	10
7-8	0
7-9 – 7-10	15
7-11 – 7-14	0
7-15	3
7-16	14
7-17	3
7-18 Blank	2
7-19 – 7-28 Deleted	2
7-29	10
7-30	0
7-31	10
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Technical Order/Equipment Configuration Status Record

ECP/TCTO NO.	TITLE	INCORP. DATE
316	Deficient AFSCS Transceiver Performance	25 May 1977
318/516	Rudder Force Output Revision	15 Sep 1977
344/325	GCB/Ground Power Interlock System Revision	1 Aug 1977
362/507	New Adapter for Air Data Computer	15 Sep 1977
371/530	Load Adjuster at Flight Engineer's Station	15 Sep 1977
387/537	Forward Forced Air Cooling System Maintenance Panel	15 Sep 1977
393/540	Replacement of Variable Transformer, Lighting	25 Mar 1978
384/612	New Sensitivity Time Control for Beacon Receiver	25 Mar 1978
478/598	Bus Power Control Unit Modification	20 Mar 1979
579/641	Landing Gear Downlock Stripe Viewing Modification	20 Mar 1979
618/662	Fuel Boost Pump Replacement	20 Mar 1979
591/656	Electrical Bonding of Fuel System Components	20 Jul 1979
641/678	Landing Gear Manual Release Cable Modification	20 Jul 1979
None/713	Removal of Parallel Yaw Damper Rudder Servo	1 Jul 1980
724/717	Reactivation of Parallel Yaw Damper	1 Jul 1980
727/718	Installation of Supplementary Anticollision Lights	1 Nov 1980
None/723	Addition of Safety Wire to Rudder Switch	1 Nov 1980
633/707	Installation of AN/ARN-118 TACAN	25 Jul 1981
627/Unk	Conversion of Block 05 Airplanes to US Standard	25 Jul 1981
775/Unk	Revision of Switchlight Wiring, Flight Engineer's Panel	25 Jul 1981
771/Unk	Modification of NCS Computer Program	25 Sep 1982
None/762	Revision of Guard, Rudder Override Switch	25 Sep 1982
None/758	Conversion of E-3A (Core) Airplane to E-3B	20 Dec 1983
None/759	Conversion of US Standard Airplanes to E-3C	20 Dec 1983
703/715	Installation of Group B ERV	20 Dec 1983
877/769	Installation of AN/APS-133(V) Weather Radar	25 Apr 1984
None/5N10-3-2-511	Sextant Electronic Averager	20 Dec 1984
837/534	Installation of Smoke/Fume Detector	25 Aug 1985
None/1E-3A-593	Modification 20 to NCS Computer Program	25 Aug 1985
None/1E-3-535	Replacement of CPI/FDR	20 Dec 1986
None/1E-3-549	Standby Attitude Indicator	20 Dec 1986
1E-3A-555	UHF Satellite Communications System on E-3B and E-3C Aircraft	17 Nov 1990
None/1E-3-560	Forced Air Monitor Alarm and Circuit Breaker Modification to E-3 Aircraft	11 Nov 1994

Technical Order/Equipment Configuration Status Record (Continued)

ECP/TCTO NO.	TITLE	INCORP. DATE
None/1E-3-581	Forced Air Control Circuitry and Ram Air Check Valve Modification to E-3 Aircraft	11 Nov 1994
1E-3-586	Modification 21 to NCS Computer Program	25 Jan 1988
None/1E-3-562	IDG Instrumentation and Servicing Modification	25 Oct 1988
887/1E-3-547	Installation of AN/ARC-204 A(V)2 UHF Radio System E-3	1 Mar 1995
None/1E-3-677	Removal of Nose Wheel Speaker	1 Dec 1994
None/1E-3-697	Disables Smoke and Fume Detection System	31 Jul 1996
1E-3-704	Modification 24 to NCS Computer Program	TBD
None/1E-3-712	Removal of Frequency Division Multiplex (FDM Equipment)	24 Oct 1996
None/1E-3-720	Replacement of CADC with SCADC	1 Jun 2001
None/1E-3-723	Removes Smoke and Fume Detection System	TBD
1204/1E-3-719	Installation of GINS in E-3	1 Jun 2001
None/1E-3-735	Replacement of ARC-165 HF Radio with ARC-230 HF Radio on ALL E-3B/C Aircraft	1 Nov 2000
1219/1E-3-728	Installation of Air Refueling Amplifier in E-3	1 Jun 2001
None/1E-3-665	Installation of Radar System Improvement	TBD
None/1E-3-753	Replacement of Pilot and Copilot Map Holders With Cloth Pouches	TBD
UNK/12P3-5QRC81 -502	Modification of IRCM Set, PN 4018355G3, and OCU Test Set, PN C66-0078-001, to add ECU Fault Indication Capability	TBD
None/1E-3-755	Incorporation of Broadcast Intelligence Equipment on E-3B/C aircraft	TBD
None/1E-3-756	Installation of Notepad Clipboard on Pilot's and Copilot's Sliding Window, E-3B/C aircraft	TBD
None/1E-3-778	FM Immunity – VOR/ILS Receivers	5 Dec 2000
1258/1E-3-769	GINS Data Transfer	1 Jun 2001
1303/1E-3-719A	GAS-1 Antenna and Controller	1 Jun 2001
1237/None	GINS Strong Signal Anomaly	1 Jun 2001
1335/1E-3-817	Receiver Autonomous Integrity Monitoring (RAIM), Fault Detection and Exclusion	TBD
None/1E-3-819	Replacement of Fuel Boost Pump With Built-In Thermal Protection (SOTA)	TBD
CM5194/1E-3–841	Installation of Integrated DAMA-GATM – (IDG)	TBD
1E-3–844	Replacement of Fuel Override Pump With Built-In Thermal Protection	TBD
None/1E-3-845	ESS System Disabled and Removal of ESS Display P/N EDS 110–0000	TBD

Flight Manual, Safety Supplement, and Operational Supplement Status

This page is published with each Safety and Operational Supplement, and each Flight Manual Change or revision. It provides a comprehensive listing of the current Flight Manuals, Flight Crew Checklists, Safety Supplements, and Operational Supplements. If you are missing any publications listed on this page, see your Publications Distribution Officer and get your copy. Changes in preparation are shown in parentheses ( ).

FLIGHT MANUAL		***Date***	***Change***
T.O. 1E-3A-1	Flight Manual	31 Jul 99	18 – 14 Jul 06
T.O. 1E-3A-1-1	Performance Data	31 Jul 99	7 – 1 Oct 05
T.O. 1E-3A-43-1-1	Mission System Operations	1 Apr 01	13 – 1 Apr 06

FLIGHT CREW CHECKLIST		***Date***	***Change***
T.O. 1E-3A-1CL-1	Pilots and Flight Engineer	31 Jul 99	10 – 1 Jun 06
T.O. 1E-3A-1CL-3	Navigator	31 Jul 99	10 – 1 Apr 06

MISSION CREW CHECKLIST		***Date***	***Change***
T.O. 1E-3A-43-1-1CL-1	Mission Crew Commander's, Senior Director's, Air Surveillance Officer's, and Electronic Combat Officer's	1 Apr 01	3 – 1 Nov 05
T.O. 1E-3A-43-1-1CL-2	Battle Staff's, Weapons Director's Air Surveillance Technician's	1 Apr 01	
T.O. 1E-3A-43-1-1CL-4	Airborne Radar Technician's	1 Apr 01	4 – 1 May 04
T.O. 1E-3A-43-1-1CL-5	Airborne Computer Display Maintenance Technician's	1 Apr 01	6 – 1 Sep 05
T.O. 1E-3A-43-1-1CL-6	Airborne Communications System Operator's	1 Apr 01	6 – 1 Apr 06
T.O. 1E-3A-43-1-1CL-7	Airborne Avionics Communications Technician's	1 Apr 01	7 – 1 Apr 06

Flight Manual, Safety Supplement, and Operational Supplement Status (Continued)

CURRENT SUPPLEMENTS

Number	*Date*	*Short Title*	*Flight Manual Pages Affected*

REPLACED/RESCINDED SUPPLEMENTS

Number	*Date*	*Disposition*

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I–R ELECTRONICS COOLING SYSTEMS

I–S ICE AND RAIN PROTECTION SYSTEMS

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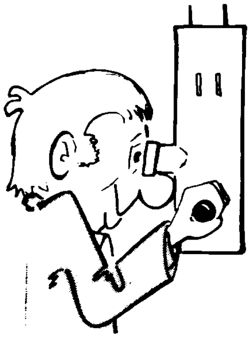
IIIA SYSTEM EMERGENCY PROCEDURES

V OPERATING LIMITATIONS

VI FLIGHT CHARACTERISTICS

VII ADVERSE WEATHER OPERATIONS

IMPORTANT! Read these pages carefully



SCOPE.

This manual must be used in conjunction with T.O.s 1E-3A-1-1 and 1E-3A-43-1-1 to obtain all the information necessary for operation of the airplane. T.O. 1E-3A-1-1 is a separate volume containing the performance data. T.O. 1E-3A-43-1-1 is a special supplemental manual covering the mission equipment installed in the airplane. The information in the manuals provides you with a general knowledge of the airplane, its characteristics, and specific normal and emergency operating procedures. Your flying experience is recognized; therefore, basic flight principles are avoided. These manuals provide the best possible operating instructions under most circumstances, but are a poor substitute for sound judgement. Multiple emergencies, adverse weather, terrain, or extenuating circumstances may require modification of the procedure(s) presented in this manual.

FLIGHT MANUAL BINDERS.

Looseleaf binders and sectionalized tabs are available for use with your manual. They are obtained through local purchase procedures and are listed in the Federal Supply Schedule (FSC Group 75, Office Supplies, Part 1). Check with your supply personnel for assistance in procuring these items. Due to the size of section I, it is suggested that dividers be used at the beginning of each subsection.

PERMISSIBLE OPERATIONS.

The Flight Manual takes a positive approach and normally states only what you can do. Usually, operations or configurations which exceed the limitations as specified in this manual are prohibited, except in actual emergencies, unless authorized by your major command.

HOW TO BE ASSURED OF HAVING LATEST DATA.

You must remain constantly aware of the latest manual, checklists and status of supplements. The Technical Order Catalog provides a listing of the current Flight Manuals, Safety Supplements, Operational Supplements and Checklists.

ARRANGEMENT.

This manual is divided into 7 interdependent sections to simplify reading it straight through or using it as a reference manual. For convenience, section I has been divided into 22 subsections, describing major systems or groups of related systems. You must be familiar with the system operating instructions in section I, the limitations in section V and the flight characteristics in section VI, to perform the procedures in sections II, III, and IV. In adverse weather conditions, the procedures in sections II and III shall be modified as shown in section VII.

CHECKLISTS.

The Flight Manual contains the amplified checklists. Abbreviated checklists have been issued as separate technical orders. See the latest supplement status page for current applicable checklists. Line items in the Flight Manual and checklists are arranged in the same order. If authorized by an interim Safety or Operational Supplement that affects a checklist, write in the applicable change on the affected checklist page. If a printed supplement contains a replacement checklist page, file the page in front of the existing checklist page, but do not discard the old page (in case the supplement is cancelled).

HOW TO GET PERSONAL COPIES.

Each flight crew member is entitled to personal copies of the Flight Manual, Safety Supplements, Operational Supplements, and Checklists. The required quantities should be ordered before you need them to assure their prompt receipt. Check with your Flight Manuals personnel – it is their job to fulfill your Technical Order requests. Basically, you must order the required quantities on the publication Requirements Table (see Technical Order Catalog). Technical Order 00-5-1 gives detailed information for ordering these publications. Make sure a system is established at your base to deliver these publications to the flight crews immediately upon receipt.

SAFETY AND OPERATIONAL SUPPLEMENTS.

Safety supplements are a rapid means of transmitting information about hazardous conditions or safety problems. These supplements contain operating instructions, or restrictions that affect safety or safety modifications. Operational supplements are a rapid means of transmitting information not involving safety. Supplements are issued by teletype (interim) or as printed (formal) supplements. Interim supplements are either replaced by a formal printed supplement (with a new number) or by a quick change to the manual. Formal supplements are identified by red letters SS or by black letters OS around the borders of the pages.

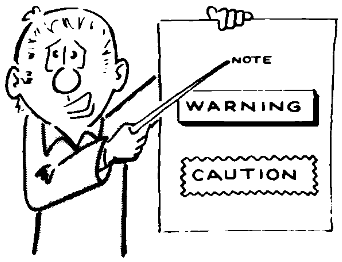
All supplements are numbered in sequence. A safety supplement has the letters SS in the number, An operational supplement has the letter S in the number. All current supplements must be complied with. A safety and operational supplement status page is in each printed supplement and each change to this manual (pages i and ii) to show the current status of supplements and checklists. These pages are only current when prepared. To be sure of the latest information check the Technical Order Catalog. The title page of this manual and the title block of each supplement show the effect of each change on supplements. File each supplement in front of the manual, with the latest on top, regardless of whether it is an operational supplement or safety supplement.

CHANGE SYMBOL.

The change symbol, as illustrated by the black line in the margin of this paragraph, indicates text changes made to the current revision. Changes to illustrations are indicated with a miniature hand.

WARNINGS, CAUTIONS, AND NOTES.

The following definitions apply to Warnings, Cautions, and Notes found through the manual.



WARNING

Operating procedures, techniques, etc., which can result in personal injury or loss of life if not carefully followed.

CAUTION

Operating procedures, techniques, etc., which can result in damage to equipment if not carefully followed.

NOTE

An operating procedure, technique, etc., which is considered essential to emphasize.

The following definitions apply to the words shall, will, should, and may:

SHALL or WILL

Used to express that the requirements are binding and mandatory.

SHOULD

Used to express a non-mandatory desire or preferred method of accomplishment and shall be construed as a non-mandatory provision.

MAY

Used to express an acceptable or suggested means of accomplishment and shall be construed as a non-mandatory provision. Not used to express possibility (might).

YOUR RESPONSIBILITY — TO LET US KNOW.

Every effort is made to keep the Flight Manual current. Review conferences with operating personnel and a constant review of accident and flight reports assure inclusion of the latest data in the manual. However, we cannot correct an error unless we know of its existence. Comments, corrections and questions regarding this manual or any phase of the Flight Manual program are welcomed. These should be forwarded through your major command (HQ ACC/DOYA, 205 Dodd Blvd, Ste 101, Langley AFB, VA 23665-2789, ATTN: E-3 Functional) on AF Form 847 to the Commander, OC-ALC 557 ACSS/GFSYRT, 3001 Staff Dr, STE 2AH1-100A, Tinker AFB, Oklahoma 73145-3022.

Nomenclature Table

Equipment common names as designated on the various control panels are used throughout this manual. Following is a list of the common names with the corresponding official nomenclature.

COMMON/PANEL	OFFICIAL
Rotodome	Antenna Pedestal
Surveillance Radar System	B Radar Set AN/APY-1 ◀ C Radar Set AN/APY-2 ◀
Radar High Voltage Power Supply	High Voltage Power Supply Transformer and Rectifier Assembly
Data Processing System	Data Analysis – Programming Group AN/AYQ-6
Control Power Supply (Interface Adapter Unit)	Control-Power Supply C-9614/A
TACAN	Navigation Set, TACAN, AN/ARN-118
Control Panel	Control Panel C-96031 A
Receiver-Transmitter	R/T, TACAN, RT-1159/ARN-118 (V) Receiver/Transmitter
	Adapter MX-9577/A Mounting Base MT-4915/A
Signal Data Converter	Converter, Signal Data CV-3188/A
Antenna	Antenna, TACAN TOP
	Antenna, TACAN BOT
VHF Navigation Receiver	Receiver Radio RNA-34A
VHF NAV Control Panel	Control, Frequency Selector 313N-4B
VOR/LOC Antenna	Antenna, VOR/LOC
Glide Slope (GS) Antenna	Antenna Assembly, Glide Slope 37P-5
Marker Beacon Receiver	Receiver, Marker Beacon MKA-28D
Control Panel	Module
Indicator Lights	Lights, Marker Beacon
Outer	Outer
Middle	Middle
Airways	Airways
Antenna	Antenna, Marker, Beacon DMN27-1A
Radio Altimeter Indicator	Indicator, Radio Altimeter 339H-1
Receiver-Transmitter	Altimeter, Radio Set 860F-1
Antenna, Transmitting	Antenna, Radio Altimeter 437X-1, XMT
Antenna, Receiving	Antenna, Radio Altimeter 437X-1, RCV
ADF Control Panel	Control, Direction Finder 614L-8
Receiver	Receiver, Direction Finder 51Y4
Loop Antenna	Antenna, Loop, ADF LPA-73A-1
Error Corrector	Quadrantal Error Corrector OCA-738-1 -30U6P
Sense Antenna	Antenna, Sense, ADF
Blade Antenna (Upper)	Antenna AIMS, Upper
Blade Antenna (Lower)	Antenna AIMS, Lower
DFDR/CVR/CPL	Digital Flight Data Recorder/Cockpit Voice Recorder/Crash Position Locator

COMMON/PANEL	OFFICIAL
Attitude Heading Reference System	AHRS
Attitude/Directional Gyro	Displacement Gyro 2171AB
Compass Adapter	Compass Adapter 6501V
Remote Compass Transmitter (Flux Valve)	Magnetic Azimuth Detector DT309/AJN
Rate Gyro	Rate Gyro XMTR TRU-2A/A
Compass Controller	Compass Controller No. 1 3804C1 Compass Controller No. 2 3804C1
Flight Loads Recorder	Flight Loads Recorder
Signal Data Recorder	Recorder, Signal Data MXU 553/A
Flight Director System	Flight Director System
Steering Computer	Flight Director Computer 562A-5F4
Control Panel	Flight Director Control 614E-10D
Weather Radar	AN/APS-133(V)
Receiver Transmitter	Receiver/Transmitter RTA-1FB
Antenna	Antenna ANT 1TB
Radar Indicator	Radar Indicator PP1-1TB
Control Panel	Radar Control Panel CON-1SB
Rendezvous Radar Beacon	Radar Transponder RT-871/APX-78
Control Panel	Control XPDR - Radar AN/APX-78
Antenna	Antenna Radar XPDR
Situation Display (Multipurpose) Console	Console, Situation Display OJ-320/A
Auxiliary Display Unit	Indicator, Digital Display IP-1169/A
Electronic Typewriter Keyboard	Keyboard – Transmitter, Teletypewriter TT–676/A
UHF Equipment	Communications System AN/ARC-169
UHF Communications Radio Control	Control–Indicator C-9639/A
UHF Control Panel (Flight Deck)	Control–Indicator C-9640/A
FDM BITE Monitor	Indicator, Fault Locating ID-1987/A
UHF Radio Set	Radio Set AN/ARC-168
UHF Transceiver	Receiver–Transmitter, OR-148/A
UHF ADF Equipment	Direction Finder Group AN/ARA-50
UHF ADF Loop	Antenna AS-909A/ARA-48
UHF Radio Set	Radio Set AN/ARC-204 A(V)2
UHF Transceiver	Receiver–Transmitter, RT-1500 A/A
Transceiver Power Supply	Power Supply, PP-8090 A/A
HYBRID Multicoupler	Antenna Coupler, CU-2423 A/A
Radio Frequency Oscillator	Crystal Controlled Oscillator, OS-286 A/A
Control–Indicator	Control–Indicator, C-11641 A/A
BITE Indicator	Fault Locating Indicator, ID-1988 D/A
UHF Antennas	
High Power Transmit	Antenna AS-3040/A
Low Power Transmit	Antenna AS-3041/A
Receive	Antenna AS-3039/A
VHF–AM Equipment	Radio Set AN/ARC-166
VHF–AM Transceiver	Receiver–Transmitter Radio RT-1163/A

Nomenclature Table (Continued)

COMMON/PANEL	OFFICIAL
VHF–AM Antennas	Antenna AS-3064/A
VHF–FM Radio Control	Radio Set AN/ARC-114
VHF–FM Blade Antenna	Antenna AS-3081/A
HF Antenna–Probe Fin	Antenna
HF Antenna–Probe Wing (2)	Antenna
HF Radio Subsystem	Radio Set Group AN/ARC-229
Radio Set Control	Control, Radio Set, C-12544/ARC-230
Radio Set Control	Control, Radio Set, C-12543/ARC-229
Radio Set	Radio Set, AN/ARC-230
Radio Receiver–Transmitter	Receiver–Transmitter, Radio, RT-1786/ARC-230
Electrical Equipment Mounting Base	Mounting Base, Electrical Equipment, MT-7115/ARC-230
Amplifier–Power Supply	Amplifier, Power Supply, AM-7551/ARC-230
Electrical Equipment Mounting Base	Mounting Base, Electrical Equipment, MT-7114/ARC-230
Antenna Coupler Group	Antenna Coupler Group, OE-548/ARC-229
Antenna Coupler	Coupler, Antenna, CU-2575/ARC-229
Coupler–Power Supply	Coupler–Power Supply, CV–4330/ARC–229
Flight Deck Interface Unit	Control, Radio Set, C–12548/A
Data Set Control Panel (TADIL–A/LINK 11)	Control–Indicator C–9529/A
WBSV Delay Control	Switch Assembly SA–2041/A
KGX-40/TSEC TADIL-A Crypto Control Panel	Remote Control Unit KGX-40/TSEC
WBSV Zeroize Control	Switch Assembly SA-2042/A
Lamp Test Panel	Indicator, Light ID-2008/A
HF/VHF Baseband Distribution Panel	Panel, Signal Distribution, Radio SB-3786/A
UHF Baseband Distribution Panel	Panel, Signal Distribution, Radio SB-3787/A
Audio Distribution System (ADS)	Intercommunications Set AN/A1C-28(V)
ADS Panel, Flight Crew (Flight Deck)	Control, Intercommunications Set, C-9658/A
Maintenance Intercom Panel (Mission)	Control, Intercommunications Set, C-9659/A
Maintenance Intercom Panel (Airplane)	Control, Intercommunications Set, C-9660/A
Keyer	Dial, Telephone TA-934/A
Public Address System (PA)	Amplifier, Audio Frequency AM-6716/A
Footswitch	Switch, Microphone M-8805/55-001
Cooling Air Monitor Panel	Panel, Air Sensor Alarm, ID-2007/A
Avionics Power Disconnect Panel (APD)	Avionics Power Disconnect Panel
FAC Unpress & Override Panel	FAC Unpress & Override Panel
COMM Disconnect Panel (CDP)	COMM Disconnect Panel
GPS Antenna	CRPA-2 Antenna AS-3821/ARN GAS–1 CRPA AS-3821A/ARN
Antenna Electronics (AE)	Antenna Electronics AE-1 AS-3820/AR
Antenna Control Unit (ACU)	Antenna Control Unit AS–3820C/AR
Mission Data Loader (MDL), including receptacle and portable cartridge	Mission Data Loader MU-1089/A
Mission Data Loader, Data Receptacle	Data Receptacle, Rockwell DR-902B

COMMON/PANEL	OFFICIAL
Portable Data Cartridge for MDL	Data Cartridge, Rockwell DC-903
Mission Data Loader (MDL), receptacle only	Data Receptacle, Rockwell DR-200
Memory Card (PCMCIA) for MDI	Personal Computer Memory Card International Association (PCMCIA)
Data Receptacle	Rockwell 200
Data Cartridge	Rockwell Flash Memory Card (PCMCIA)
LESS IDG IFF System	AIMS Transponder Set AN/APX–101(V)
IFF Mode 4 computer	KIT–1C TSEC
IFF Antenna Selector Switch	AIMS Switch Panel
IFF Caution Light	LIGHT – IFF AIMS ◀
WITH IDG IFF Transponder	Transponder Set, Digital AN/APX–119
IFF Mode 4 Applique	KIV–119 Mode 4 Cryptographic Applique
IFF Mode S Transponder Power Switch (P5)	(Replaces antenna selector switch, no assigned nomenclature)
IFF Caution Light	(No assigned nomenclature) ◀
LESS IDG VHF Mission Radio Control	Control Radio Set C–9620/A
VHF Radio Control (Flight Deck)	Control Radio Set C–9621/A ◀
WITH IDG VHF–AM Radio Equipment	Radio Set AN/ARC 210
VHF–AM Transceiver	Receiver–Transmitter Radio RT–1794(C)/ARC–210
VHF 1 and 2 Control	Radio Set Control C–12561/A
VHF Access Control Panel (P73)	Control, Radio Set C–12700/A
VHF Flight Deck Control Head	Remote Control Unit (RCU) 379F–20
FM Immunity Filter	FM Immunity Filter ◀
LESS IDG SATCOM Control Panel	Control, Antenna C–11982/ARC–171(V)
Satellite Interface Module	Modem, Communications MD–1238/ARC–171(V) ◀
WITH IDG DAMA SATCOM	Radio Set AN/ARC–234(C)(V)1
SATCOM Control Panel (P73)	Control–Indicator C–12699/A ◀
LESS IDG UHF BITE Indicator	Indicator, Fault Indicating ID–1988/A ◀
WITH IDG UHF BITE Indicator	Indicator, Fault Indicating ID–1988F/A ◀
WITH IDG RVSM Altitude Alerters	(No assigned nomenclature) ◀

NOTE

For a complete listing of mission equipment nomenclature, refer to T.O. 1E-3A-43-1-1.

Coding and Serialization

▶	Means *through* or *and later airplanes*.
◀	Used where required to indicate the end of coded information.
*	Indicates special test configuration, subject to change.
B	Information applies only to E-3B airplanes.
C	Information applies only to E-3C airplanes.

B

		6	75-0558	11	76-1605	16	77-0353	22	78-0578
1	71-1407	7	75-0559	12	76-1606	18	77-0355	23	79-0001
3	75-0556	8	75-0560	13	76-1607	19	77-0356	24	79-0002
4	73-1675	9	71-1408	14	77-0351	20	78-0576	25	79-0003
5	75-0557	10	76-1604	15	77-0352	21	78-0577		

C

2	*73-1674	30	81-0005
26	80-0137	31	82-0006
27	80-0138	32	82-0007
28	80-0139	33	83-0008
29	81-0004	34	83-0009

ENGINEERING CHANGE PROPOSALS (ECP) AND TIME COMPLIANCE TECHNICAL ORDERS (TCTO)

ECPs and PRRs are contractor generated changes to airplanes or equipment. If an ECP/PRR is incorporated in airplanes before delivery to the Air Force (in line); the change is recorded by ECP/PRR number and there is no TCTO. Changes to delivered airplanes (retrofit) are made by TCTO.

TCTOs authorize and give instructions for inspection and modification of equipment. When a TCTO, ECP, or PRR is issued, applicable information is added to the manual and identified by reference to the TCTO, or ECP, or PRR. After all equipment has been modified, the obsolete information and all reference to the TCTO or ECP will usually be removed from the manual.

ECPs and TCTOs listed in this change with their incorporation effectivities are:

NOTE

(None) means no ECP issued.

(Unk) means number unknown at publication date.

RSIP None/TCTO 1E-3-665 Installation of Radar System Improvement.

U TCTO 12P3-5QRC81-502 Modification of IRCM Set, PN 4018355G3, and OCU Test Set, PN C66-0078-001, to add ECU Fault Indication Capability.

AP TCTO-1E-3-755, Installation of Broadcast Intelligence

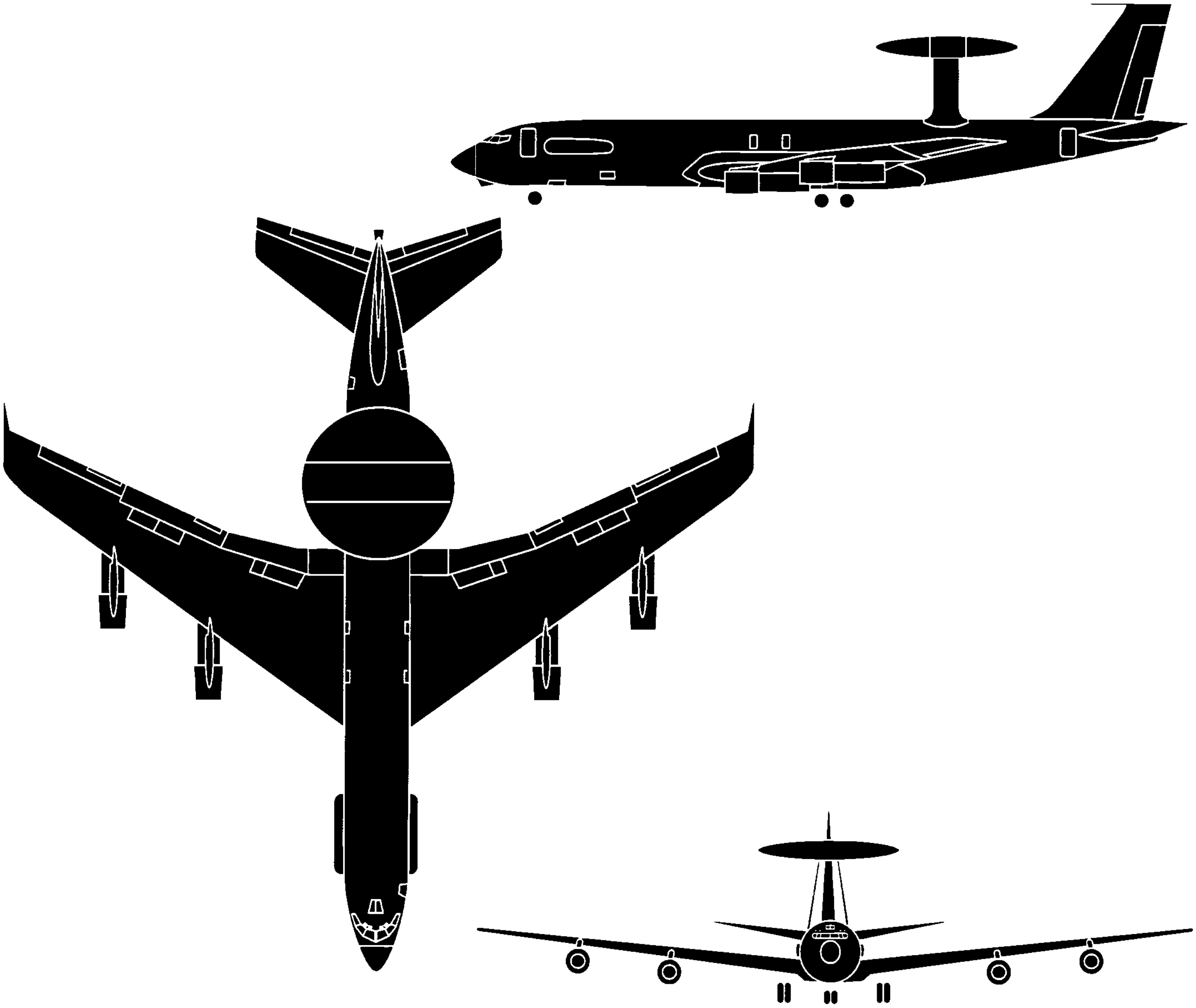
697 Disables Smoke and Fume Detection

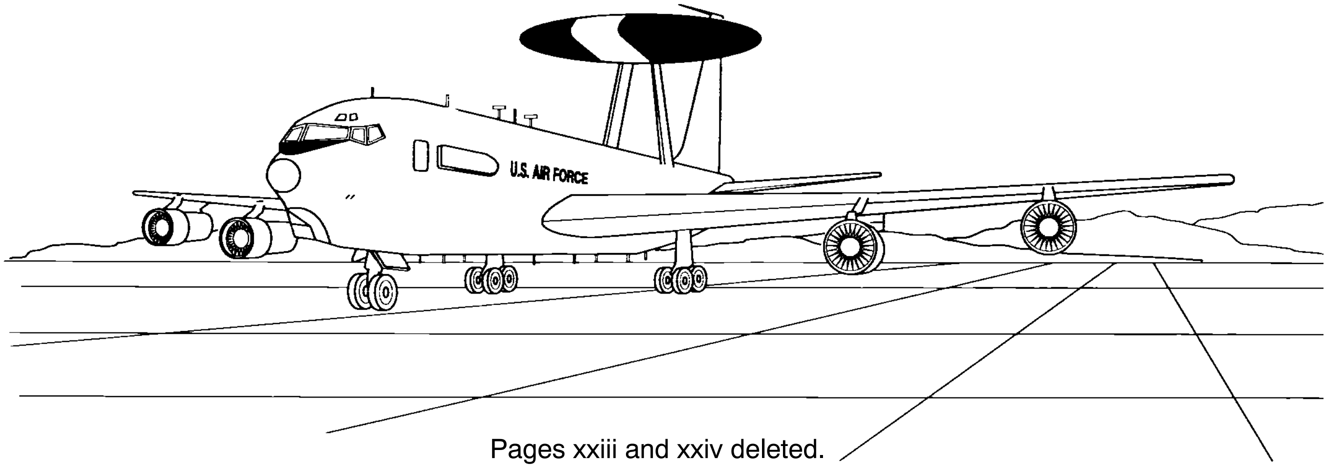
RAIM TCTO 1E-3-817, Receiver Autonomous Integrity Monitoring (RAIM), Fault Detection, and Exclusion

SOTA TCTO 1E-3-819, Replacement of Fuel Boost Pump With Built-In Thermal Protection

GA GINS Anomalies Group 1 Software Change.

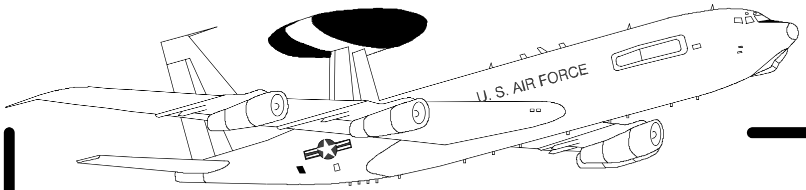
THE AIRPLANE





Pages xxiii and xxiv deleted.

Section I



DESCRIPTION AND OPERATION

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SUBSECTION I-A
AIRPLANE

Table of Contents

Title ***Page***

SUMMARY

The airplane is a four engine, long range jet transport, modified for its operational mission of airborne early warning and control by the addition of special mission systems. The mission systems are: surveillance radar, identification system, data processing system, data display and control system, and communications system. The surveillance radar and identification system antennas are mounted in a 30–foot diameter rotating antenna housing (rotodome) mounted on struts above the aft fuselage. Airplane maximum gross weight for inflight operations is 344,000 pounds. Airplane maximum gross weight for all ground operations is 325,000 pounds. Airplane general arrangements and dimensions are shown in *figure 1-1*. All antenna locations are shown in *figure 1-2*.

The airplane has a gas turbine auxiliary power unit (APU) to provide engine starting air, electric power and air conditioning on the ground. Conventional flight controls are assisted by hydraulically operated spoilers for roll control and by hydraulic rudder boost. The spoilers may be raised simultaneously for use as speed brakes.

AIRPLANE INTERIOR ARRANGEMENT

The interior of the airplane (*figure 1-3*) is divided into four pressurized compartments on two decks. The flight deck and mission crew compartments, on the main deck, contain all crew stations. A crew rest area is provided at the rear of the mission crew compartment. Two electronic equipment compartments on the lower deck are accessible in flight from the main deck by access hatches and on the ground through doors on the right side of the airplane.

WARNING

- All personnel entering lower compartment in flight shall wear ear protection. At least one person per lower compartment shall maintain intercom communication with flight crew or mission crew. Flight engineer will select BOTH with maintenance interphone switch to improve crew communications. High noise levels in lower compartments during flight could prevent hearing emergency signals and could cause personnel hearing damage.

- Some mission radar equipment in aft lower compartment is pressurized with sulfur hexafluoride (SF_6) gas. SF_6 is colorless, odorless, and heavier than air. To prevent being overcome by leakage of SF_6, crewmembers will ensure flight engineer is venting aft lower compartment (by opening the aft outflow valve) before entering compartment.

- Crewmembers will don oxygen masks before entering aft lower compartment if an SF_6 leak is suspected; or a malfunction exists or to perform maintenance in a mission radar component pressurized with SF_6. Flight engineer will vent aft lower compartment per SULFUR HEXAFLUORIDE (SF_6) LEAK, section III.

- During ground operations personnel gaining access to closed compartments such as cabin, aft lower compartment or rotodome should be aware of unusual or pungent odor or, nose or throat irritation. If encountered the aircraft/area should be vacated until it is properly ventilated.

- Oxygen is required for personnel entering the aft lower compartment when pressurization is in manual operations.

- Do not remain in aft lower compartment for more than 15 minutes per hour while mission radar is transmitting.

There are two entrances on the left side of the mission crew compartments. An additional door is on the right side, near the crew rest area, for servicing and for ground emergency exit.

FLIGHT CREW

The normal flight crew for this airplane consists of two pilots, a flight engineer, and a navigator. The flight deck also contains a seat for an observer. Flight crew stations are located as shown in *figure 1-3*. Arrangement of flight crew instrument panels is shown in *figures 1-4* through *1-15*. General arrangement, and rack equipment locations, are shown in *figure 1-16*.

MISSION EQUIPMENT AND MISSION CREW

Special mission equipment is located in the mission crew compartment, in the two lower compartments, and in the rotodome. Mission crew stations are located in the mission crew compartments. Mission equipment and mission crew duties are described in T.O. 1E–3A–43–1–1.

RADIATION HAZARDS

WARNING

- In flight, do not transmit on mission radar within 1,300 feet horizontally or 650 feet vertically from another aircraft.

- Because of the high power of the mission radar, and the resulting large safety distances, operation of the mission radar on the ground is prohibited, except for radar maintenance operations, performed by radar maintenance personnel, in accordance with radar maintenance technical orders.

- If the mission radar is operating on the ground, observe the following safety distance limits from the rotodome:

  1,300 feet for personnel not inside airplane and for refueling and defueling operations. 3,000 feet for unshielded electro–explosive devices.

- If weather radar is operating on the ground, all personnel not inside the airplane must be kept outside a 240° arc with a 60–foot radius centered on the nose radome. To prevent possible ignition of fuel vapors, maintain a 100–foot clearance from nose radome to any equipment being refueled or defueled and from ungrounded electro–explosive devices.

- Do not transmit on HF radio on the ground if ground personnel can touch the exterior of the airplane or are using headsets connected to the airplane. Transmission causes electrical voltages on exterior of airplane which are not dangerous, but could shock personnel causing sudden movement, thus causing injury.

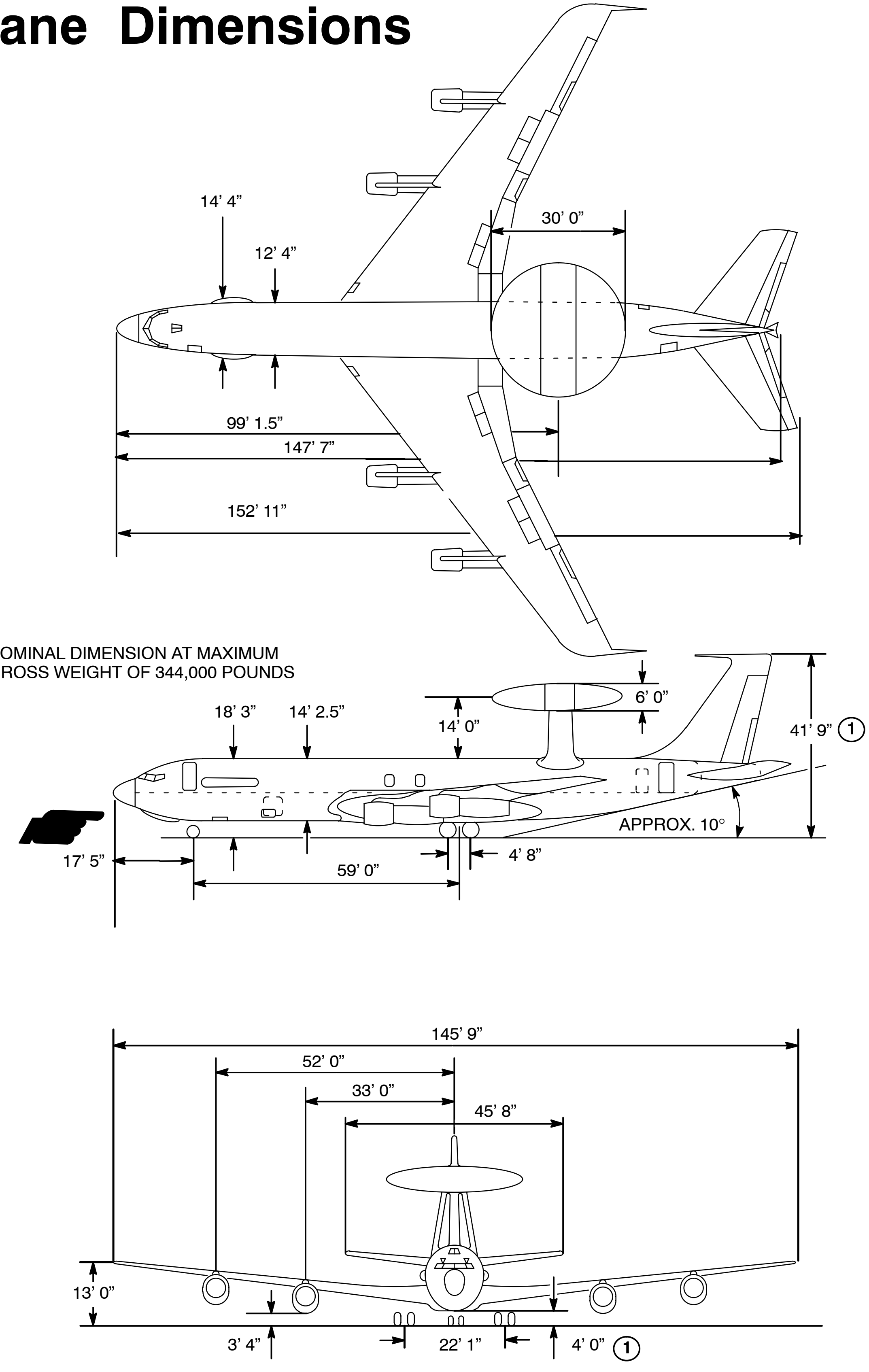
- During ground operation, to prevent possible ignition of fuel vapor, do not transmit on HF, ERCS, or UHF high power radio within 200 feet of equipment being refueled or defueled.

- Follow procedures in T.O. 1E–3A–43–1–1 for TADIL–A/LINK 11 operation during air refueling.

- Do not transmit on HF radio on the ground unless personnel are a minimum of ten feet from radiating antenna.

- WITH IDG On the ground the IFF transponder transmits if selected to NORM. It must be selected to NORM to run any of the mode initiated built in tests (IBITs). During transmission the minimum personnel safety distance is 10 feet from either antenna. Minimum electro-explosive device distance is 25 feet. ◀
- WITH IDG Do not transmit on VHF–AM radio on ground unless personnel are a minimum of ten feet from radiating antennas.◀
- If UHF is operating on ground, observe following safety distance limits from respective antenna:
  Ten feet – UHF directional
  Five feet – UHF high–power
  One foot – UHF low power.
- Do not transmit on LESS IDG VHF–AM.◀ or VHF–FM radio on ground unless personnel are at least one foot from radiating antennas.
- WITH IDG Do not transmit on SATCOM on ground unless personnel are a minimum of 20 feet from radiating antennas. During ground operation to prevent possible ignition of fuel vapor, do not transmit on SATCOM within 200 feet of equipment being refueled or defueled. Do not transmit within 45 feet of unshielded electro–explosive devices.◀

Airplane Dimensions



① NOMINAL DIMENSION AT MAXIMUM GROSS WEIGHT OF 344,000 POUNDS

D57 003 I

Figure 1-1

Antenna Locations

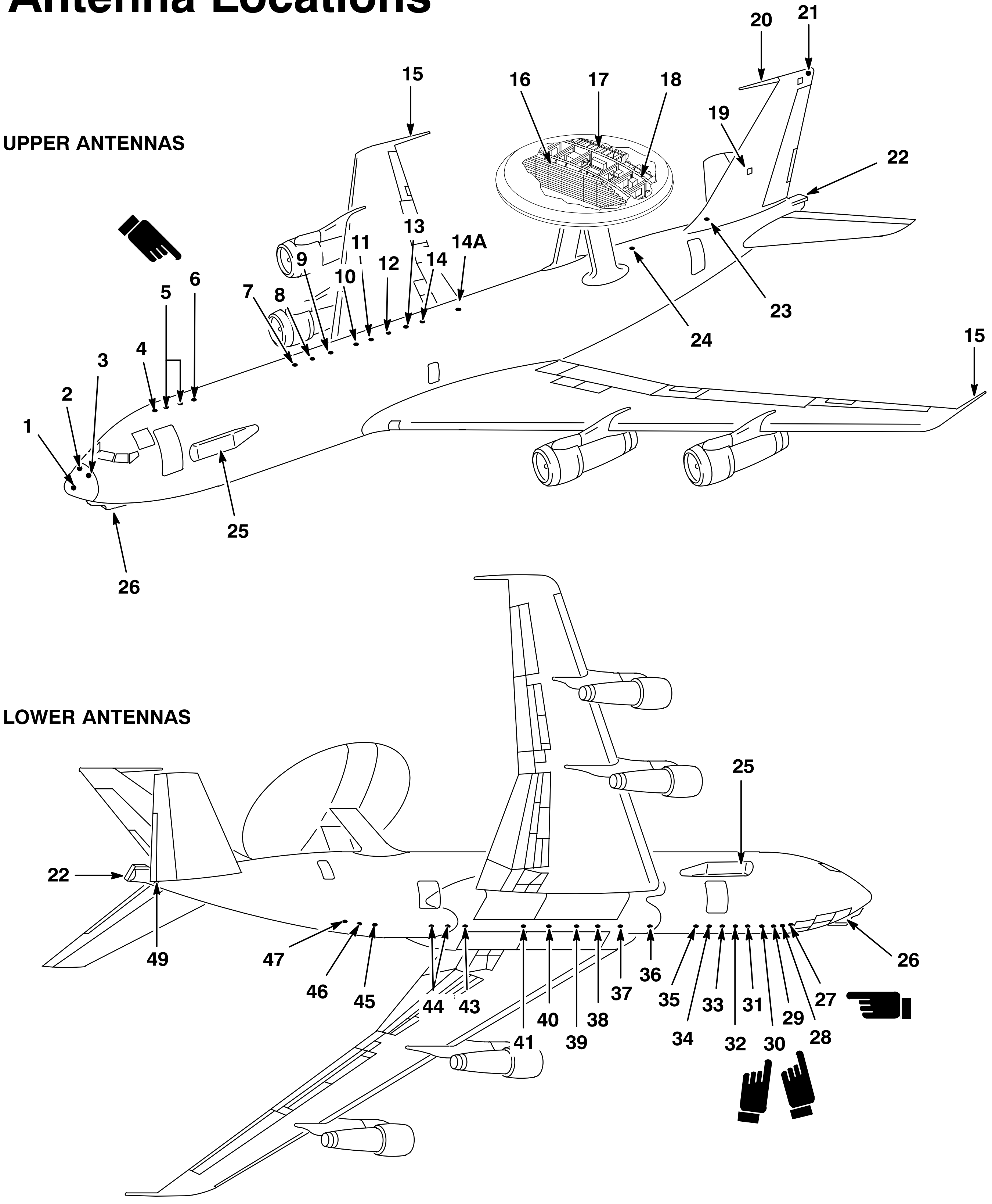


Figure 1-2 (Sheet 1 of 3)

Antenna Locations (Continued)

NO.	ITEM	STATION NO. LOCATION	TYPE
1	WEATHER RADAR ANTENNA	NOSE	PARABOLIC
2	JTIDS ANTENNA	NOSE	RECTANGULAR HORN
3	GLIDESLOPE ANTENNA	178	FOLDED DIPOLE
4	UHF HIGH POWER TRANSMIT ANTENNA	350	BLADE
5	GINS ANTENNAS	410 & 430	PHASED ARRAY
6	WITH IDG TCAS UPPER	468	PLANAR ARRAY ◀
7	TACAN NO. 1	510	BLADE
8	UHF LOW POWER TRANSMIT ANTENNA	550	BLADE
9	IFF	590	BLADE
10	TACAN NO. 2	600F+10	BLADE
11	UHF SATCOM/LOS TRANSMIT/RECEIVE ANTENNA	600H+10	SATCOM/LOS
12	FLIGHT CREW VHF AM TRANSMIT/RECEIVE ANTENNA	600L+10	BLADE
13	UHF SATCOM/LOS TRANSMIT/RECEIVE ANTENNA	670	SATCOM/LOS
14	UHF RECEIVE ANTENNA	750	BLADE
14A	WITH AP BI RECEIVE ANTENNA	790	SATCOM ◀
15	HF TRANSMIT ANTENNA	BOTH WING TIPS	PROBE
16	SURVEILLANCE RADAR	ROTODOME	PHASED ARRAY
17	MISSION IFF ANTENNA	ROTODOME	PHASED ARRAY
18	UHF TRANSMIT TADIL-C/LINK 4	ROTODOME	LOG PERIODIC
19	VOR/LOCALIZER	FIN	DUAL PLATE
20	FLIGHT CREW HF TRANSMIT ANTENNA	FIN	PROBE
21	FLIGHT CREW HF RECEIVE ANTENNA	FIN CAP	SADDLE
22	ESM ANTENNA	TAILCONE	SPIRAL
23	CRASH POSITION LOCATOR	1230	BLADE
24	CRASH POSITION LOCATOR TRANSMIT ANTENNA	1230	BLADE
25	ESM ANTENNA	360-540 BOTH SIDES	SPIRAL
26	ESM ANTENNA	180	SPIRAL
27	LESS IDG UHF HIGH POWER TRANSMIT ANTENNA WITH IDG TCAS LOWER ◀	408	BLADE ◀ PLANAR ARRAY ◀
28	TACAN NO. 1	430	BLADE
29	LESS IDG UHF LOW POWER TRANSMIT ANTENNA WITH IDG UHF HIGH POWER TRANSMIT ANTENNA ◀	450	BLADE ◀
30	LESS IDG IFF WITH IDG UHF LOW POWER TRANSMIT ANTENNA/IFF ◀	504	BLADE ◀
31	RENDEZVOUS RADAR BEACON	535	BLADE
32	UHF LOW POWER TRANSMIT ANTENNA	570	BLADE
33	TACAN NO 2	604	BLADE
34	MARKER BEACON	600D+8	ENCLOSED WIRE
35	ADF LOOP	600E+10	FIXED LOOP

Figure 1-2 (Sheet 2 of 3)

NO.	ITEM	STATION NO. LOCATION	TYPE
36	FLIGHT CREW UHF GUARD TRANSMIT ANTENNA	600L+10	BLADE
37	VHF-FM TRANSMIT/RECEIVE ANTENNA	670	BLADE
38	ADF SENSE	720	FIXED LOOP
39	VHF-AM TRANSMIT/RECEIVE ANTENNA	850	BLADE
40	UHF ADF ANTENNA	889	LOOP
41	FLIGHT DECK VHF-AM GUARD RECEIVE ANTENNA	930	BLADE
42	DELETED		
43	UHF RECEIVE ANTENNA	981	BLADE
44	LOW RANGE RADIO ALTIMETER	1011 & 1030	FLAT PLATE
45	FLIGHT CREW UHF GUARD RECEIVE ANTENNA ①	1134	BLADE
46	UHF RECEIVE ANTENNA	1116	BLADE
47	UHF RECEIVE ANTENNA	1134	BLADE
48	DELETED		
49	JTIDS ANTENNA	TAIL	RECTANGULAR HORN

① USED FOR R6, R12 (UHF GUARD), R19, AND R20 (HQAN TOD RECEIVER).

Figure 1-2 (Sheet 3 of 3)

Airplane Interior Arrangement and Crew Movement (Typical)

1. COPILOT’S SEAT
2. FLIGHT DECK ①
3. FLIGHT ENGINEER’S STATION
4. COMMUNICATIONS CONSOLE
5. CONVENIENCE (ELECTRIC 400 HZ) OUTLET (4 PLACES)
6. COMPUTER OPERATOR CONSOLE
7. MISSION CREW COMPARTMENT ①
8. SITUATION DISPLAY CONSOLES
9. OVERWING ESCAPE HATCHES (2 PLACES)
10. E33 RACK

10A. RADAR CONSOLE

11. ENTRY TO LOWER DECK (2 PLACES)
12. CREW BAGGABE TIEDOWN
13. CREW REST SEATS
14. BUNKS
15. CREW REST AREA ①
16. COAT CLOSET
17. LAVATORY
18. STORAGE
19. GALLEY
20. LOWER AFT COMPARTMENT ①
21. APU
22. LIQUID OXYGEN CONVERTER
23. DUTY OFFICER’S CONSOLE
24. T.O. STORAGE (G FILE)

24A. E-22 RACK

25. BAILOUT CHUTE
26. LOWER FORWARD COMPARTMENT ①
27. NAVIGATOR STATION
28. OBSERVER’S SEAT
29. PILOT’S SEAT

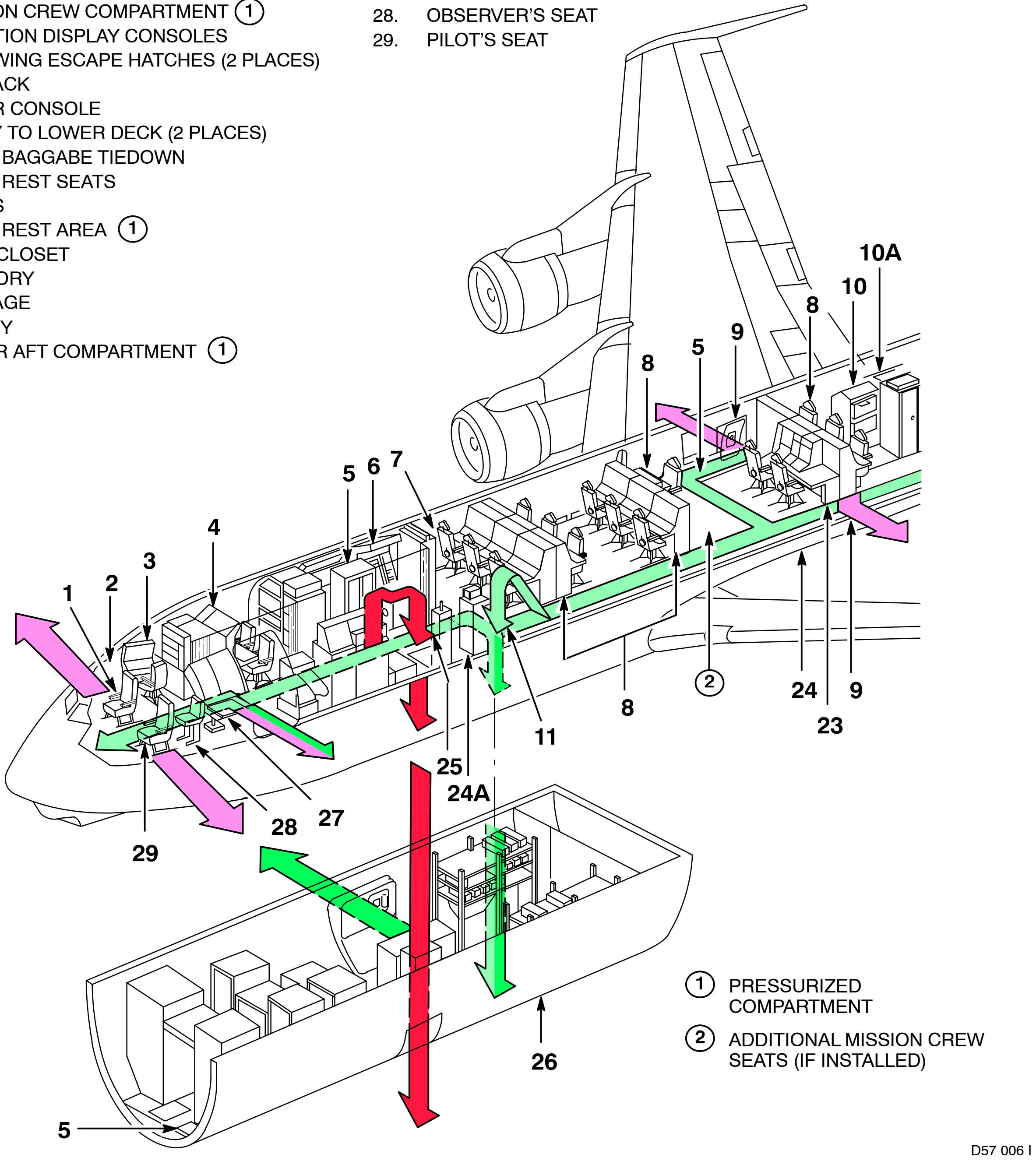


Figure 1-3 (Sheet 1 of 4)

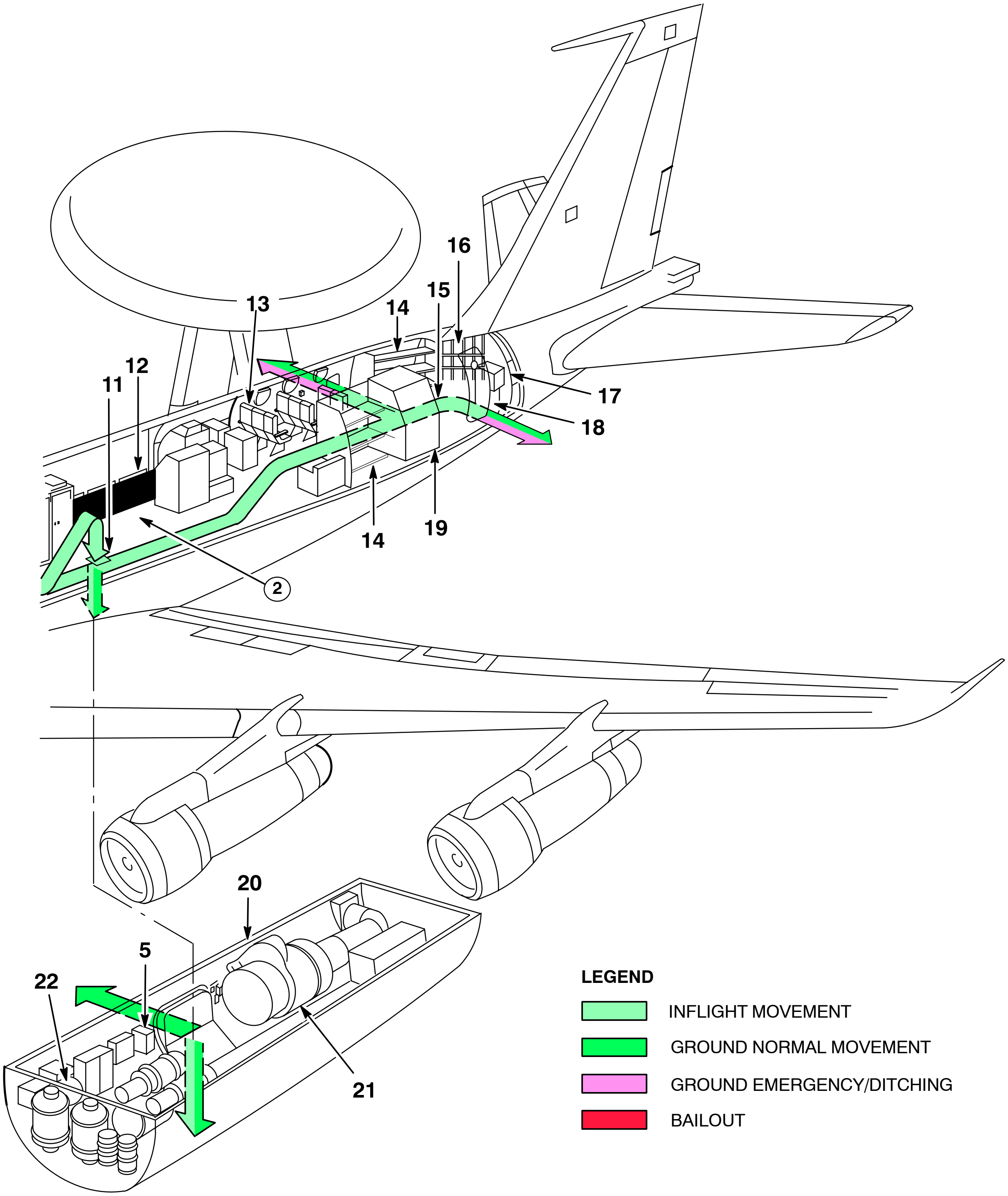


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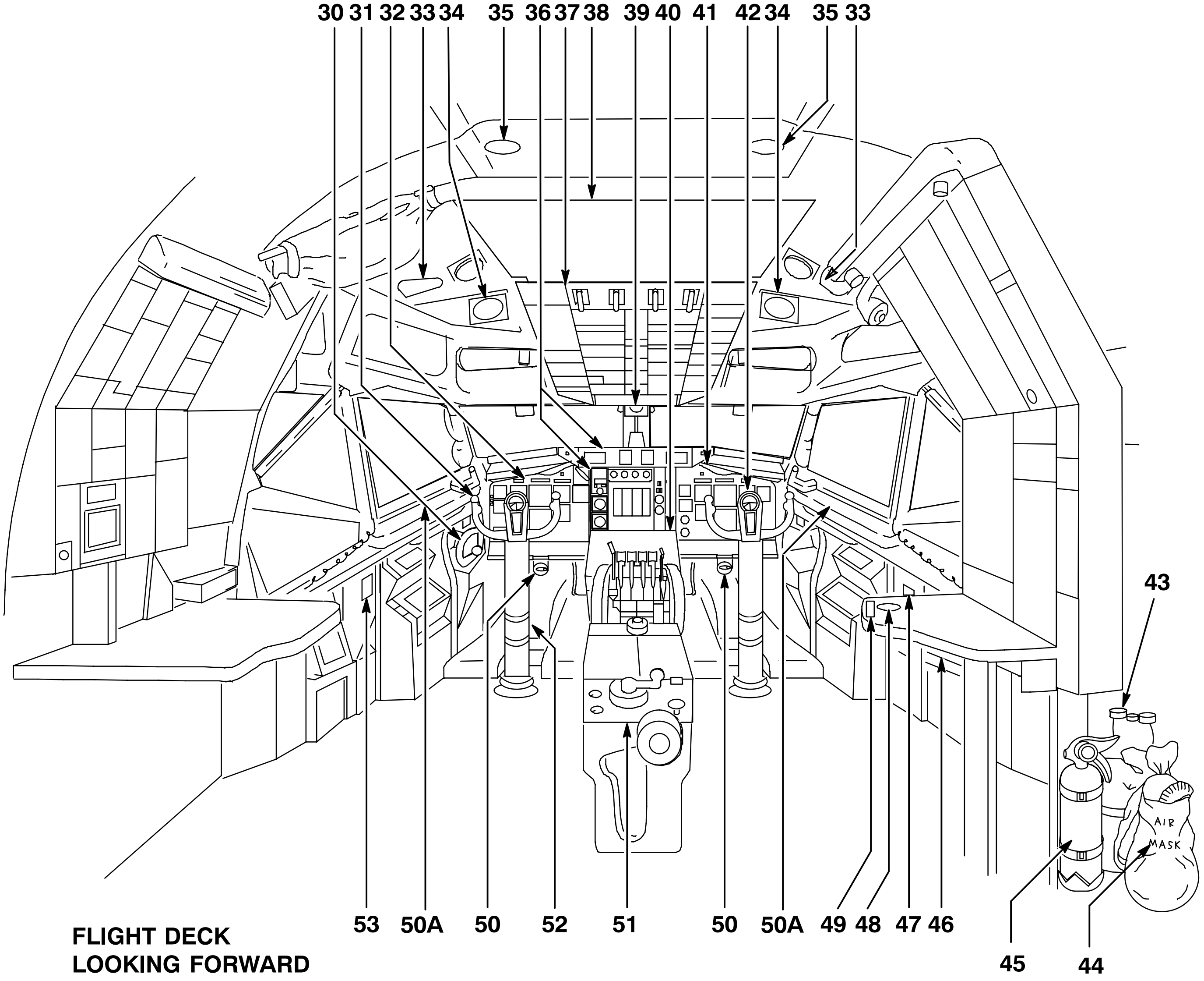
Figure 1-3 (Sheet 2 of 4)

Airplane Interior Arrangement and Crew Movement (Typical) (Continued)

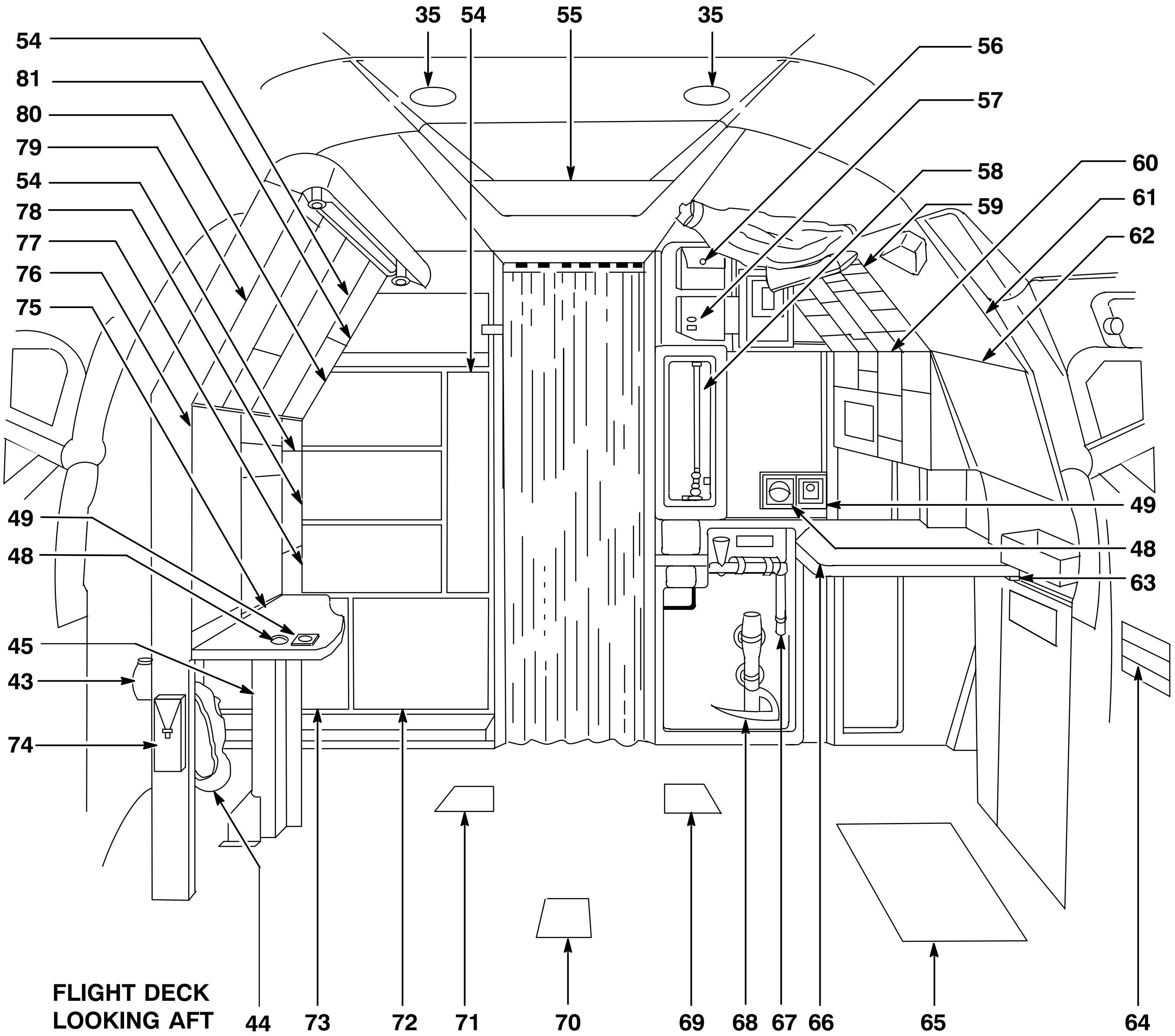


FLIGHT DECK
LOOKING FORWARD

30. NOSE GEAR STEERING WHEEL
31. PILOT'S CONTROL WHEEL
32. PILOT'S INSTRUMENT PANEL
33. ESCAPE STRAP STOWAGE (2 PLACES)
34. FLIGHT DECK SPEAKER (2 PLACES)
35. AIR REFUELING LEAK CHECK VIEW PORTS (2 PLACES)
36. CENTER INSTRUMENT PANEL
37. PILOT'S OVERHEAD PANEL
38. P5 CIRCUIT BREAKER PANEL
39. STANDBY COMPASS
40. FORWARD ELECTRONIC PANEL
41. COPILOT'S INSTRUMENT PANEL
42. COPILOT'S CONTROL WHEEL
43. PORTABLE OXYGEN BOTTLE
44. FIREFIGHTER'S OXYGEN ASSEMBLY (SMOKE MASK)
45. FIRE EXTINGUISHER
46. WARNING HORN, FIRE BELL, MACH WARNING BELL (3 ITEMS UNDER TABLE)
47. COPILOT'S SIDE PANEL
48. CUPHOLDER (2 PLACES)
49. ASHTRAY (2 PLACES)
50. RUDDER PEDAL ADJUSTMENT CRANK (2 PLACES)
50A. NOTEPAD CLIPBOARD (2 PLACES)
51. AFT ELECTRONIC PANEL AND AISLE CONTROL STAND
52. STICK SHAKER
53. PILOT'S SIDE PANEL

D57 008 I

Figure 1-3 (Sheet 3 of 4)



FLIGHT DECK LOOKING AFT

54. FLIGHT ENGINEER'S AUXILIARY PANEL
55. AIR CONDITIONING OUTLET
56. FIRST AID KIT
57. SPARE BULB STOWAGE
58. PORTABLE OXYGEN BOTTLE RECHARGER
59. NAVIGATOR'S UPPER PANEL
60. NAVIGATOR'S LOWER PANEL
61. P7 CIRCUIT BREAKER PANEL
62. P6 CIRCUIT BREAKER PANEL
63. NAVIGATOR'S TABLE LATCH
64. OBSERVER'S PANEL
65. ACCESS TO FORWARD LOWER COMPARTMENT
66. NAVIGATOR'S TABLE
67. LANDING GEAR HANDCRANK
68. CRASH AXE
69. LEFT MAIN LANDING GEAR MANUAL EXTENSION ACCESS
70. NOSE LANDING GEAR MANUAL EXTENSION ACCESS
71. RIGHT MAIN LANDING GEAR MANUAL EXTENSION ACCESS
72. P61-5 CIRCUIT BREAKER PANEL
73. P61-6 CIRCUIT BREAKER PANEL
74. LOAD ADJUSTER STORAGE
75. FLIGHT ENGINEER'S TABLE
76. FLIGHT ENGINEER'S LOWER PANEL
77. P61-4 CIRCUIT BREAKER PANEL
78. P61-3 CIRCUIT BREAKER PANEL
79. FLIGHT ENGINEER'S UPPER PANEL
80. P61-2 CIRCUIT BREAKER PANEL
81. P61-1 CIRCUIT BREAKER PANEL

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Figure 1-3 (Sheet 4 of 4)

Pilot’s Instrument Panel

1. MARKER BEACON LIGHTS
2. ANGLE OF ATTACK INDICATOR
3. MACH/AIRSPEED INDICATOR
4. FLIGHT DIRECTOR ANNUNCIATOR
5. ATTITUDE DIRECTOR INDICATOR (ADI)
6. AUTOPILOT WARNING LIGHT
7. AUTOPILOT ANNUNCIATORS
8. PNEUMATIC BRAKE HANDLE
9. RADIO ALTIMETER
10. ALTIMETER
11. RNAV ANNUNCIATORS PANEL
12. VERTICAL VELOCITY INDICATOR
13. HORIZONTAL SITUATION INDICATOR (HSI)
14. DESIGNATED PILOT SELECTOR PANEL
15. BUS CONTROL PANEL
16. ADC SOURCE SELECT PANEL
17. ADI ATTITUDE SOURCE SELECTOR PANEL
18. RMI SELECTOR SWITCH
19. ACCELEROMETER
20. RADIO MAGNETIC INDICATOR (RMI)
21. CLOCK

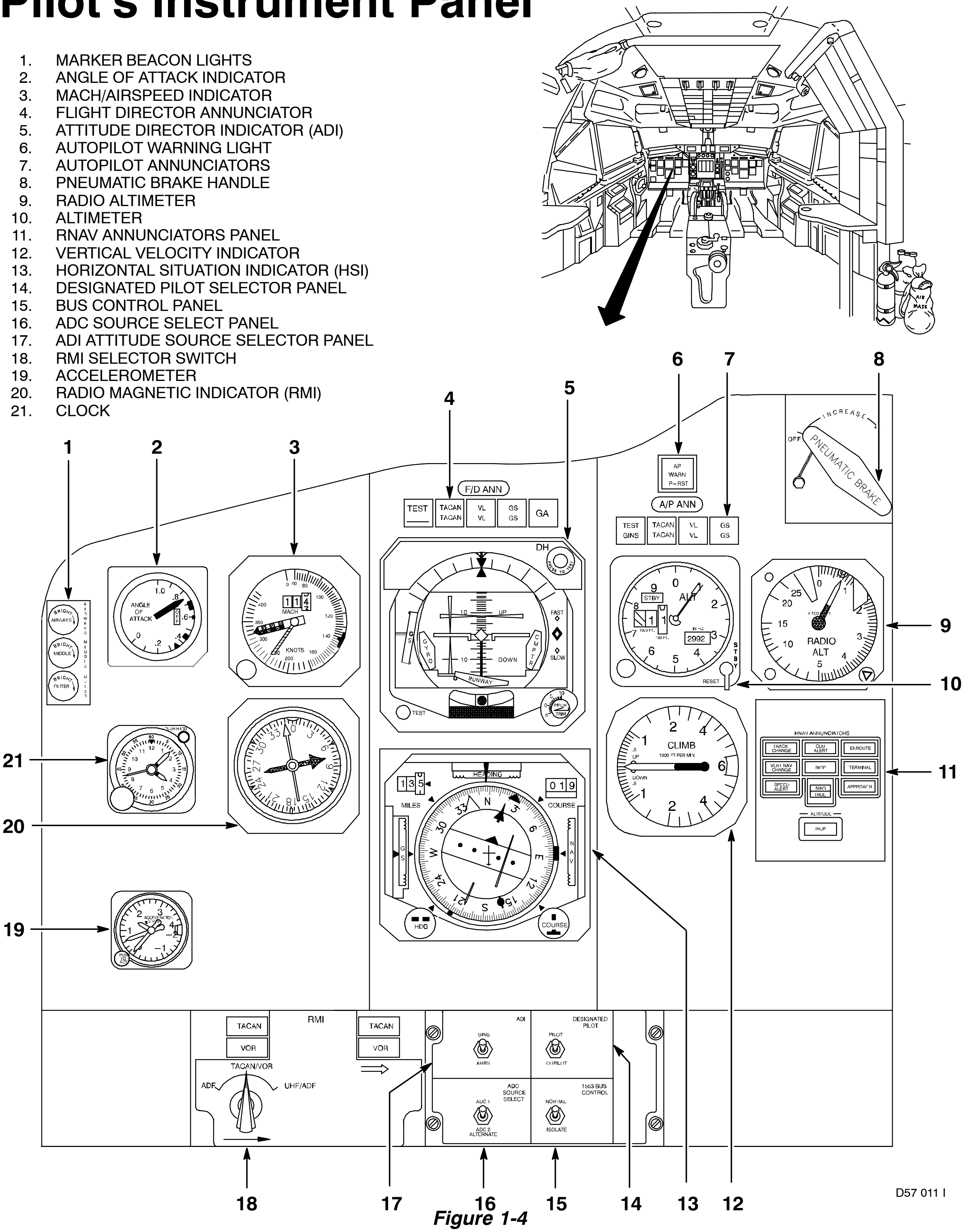


Figure 1-4

Pilot's Instrument Panel

1. MARKER BEACON LIGHTS
2. ANGLE OF ATTACK INDICATOR
3. MACH/AIRSPEED INDICATOR
4. FLIGHT DIRECTOR ANNUNCIATOR
5. ATTITUDE DIRECTOR INDICATOR (ADI)
6. AUTOPILOT WARNING LIGHT
7. AUTOPILOT ANNUNCIATORS
8. PNEUMATIC BRAKE HANDLE
9. RADIO ALTIMETER
10. ALTIMETER
11. RNAV ANNUNCIATORS PANEL
12. **LESS IDG** VERTICAL VELOCITY INDICATOR
12. **WITH IDG** TCAS/VERTICAL SPEED INDICATOR
13. **WITH IDG** ALTITUDE ALERTER PANEL
14. HORIZONTAL SITUATION INDICATOR (HSI)
15. DESIGNATED PILOT SELECTOR PANEL
16. BUS CONTROL PANEL
17. ADC SOURCE SELECT PANEL
18. ADI ATTITUDE SOURCE SELECTOR PANEL
19. RMI SELECTOR SWITCH
20. ACCELEROMETER
21. RADIO MAGNETIC INDICATOR (RMI)
22. CLOCK

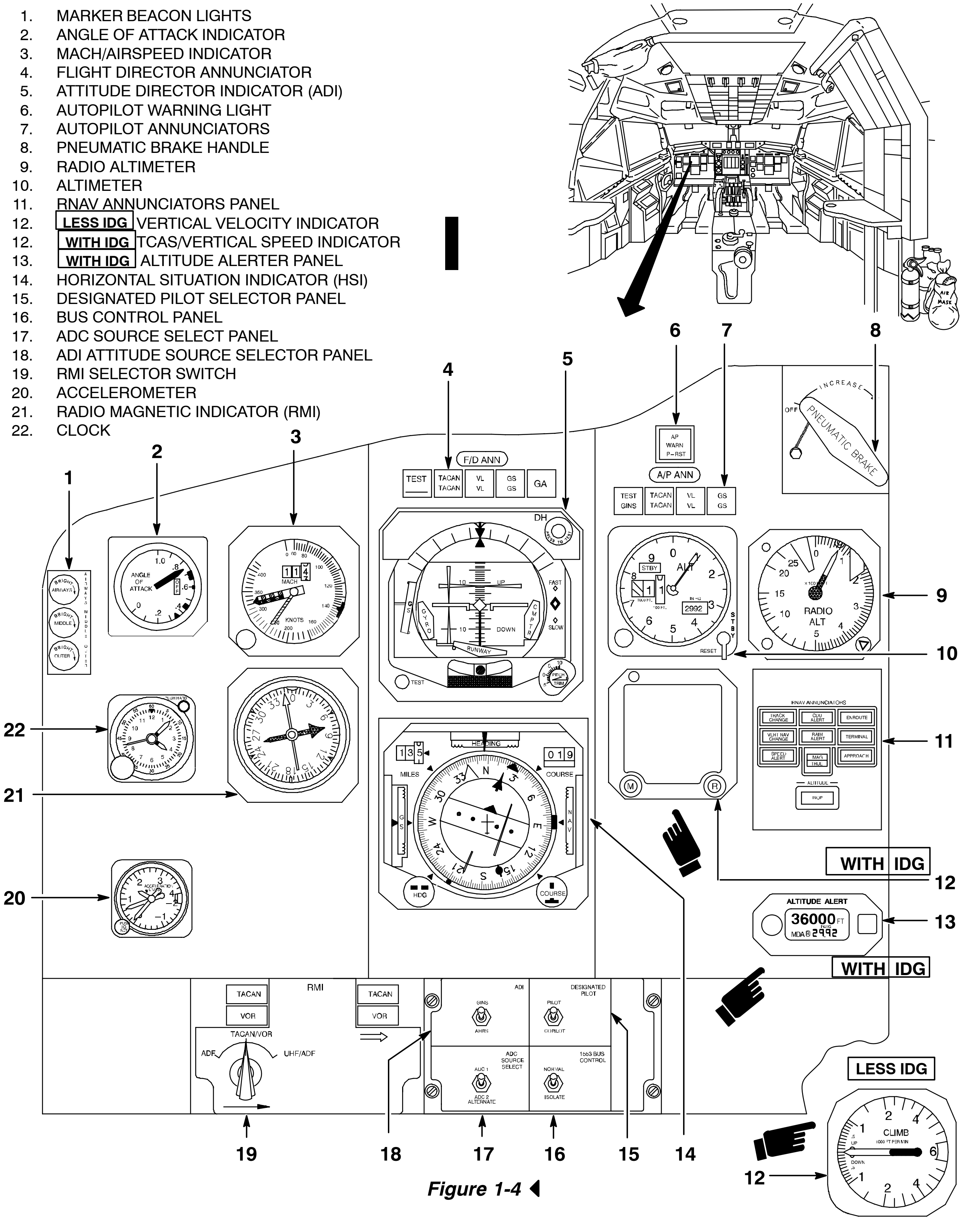
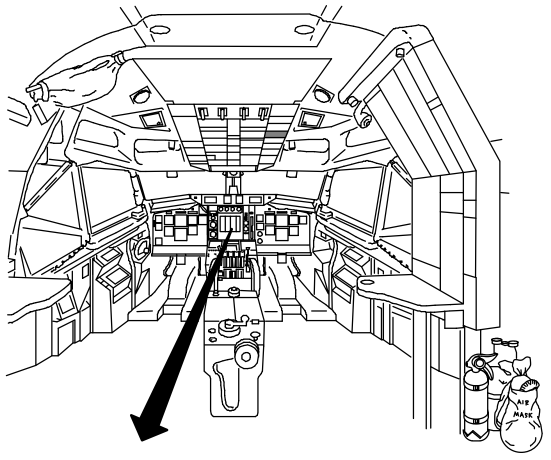


Figure 1-4

W252 007 I

Center Instrument Panel and Glare Shield

1. MASTER FIRE WARNING LIGHT (2 PLACES)
2. FLIGHT DIRECTOR MODE SELECTOR (2 PLACES)
3. NAVIGATION MODE SELECTOR (2 PLACES)
4. VHF NAV CONTROL (2 PLACES)
5. INFLIGHT REFUELING SIGNAL LIGHTS
6. INDICATOR LIGHTS CONTROLS
7. IFF CAUTION LIGHT
8. RUDDER BOOST LIGHT
9. LANDING GEAR DOOR AND LANDING GEAR WARNING LIGHTS
10. LANDING GEAR DOWN LIGHTS
11. TRAILING EDGE FLAP POSITION INDICATORS (2 PLACES)
12. LANDING GEAR LEVER
13. LEADING EDGE FLAP LIGHTS
14. FUEL FLOW INDICATOR (FF)
15. EXHAUST GAS TEMPERATURE INDICATOR (EGT)
16. TACHOMETER (N_1)
17. ENGINE PRESSURE RATIO INDICATOR (EPR)
18. STANDBY ATTITUDE INDICATOR
19. THREE AXIS TRIM INDICATOR
20. PARALLEL YAW DAMPER INDICATOR
21. YAW DAMPER DISENGAGE LIGHT
22. OIL PRESSURE CAUTION LIGHTS (4 PLACES)



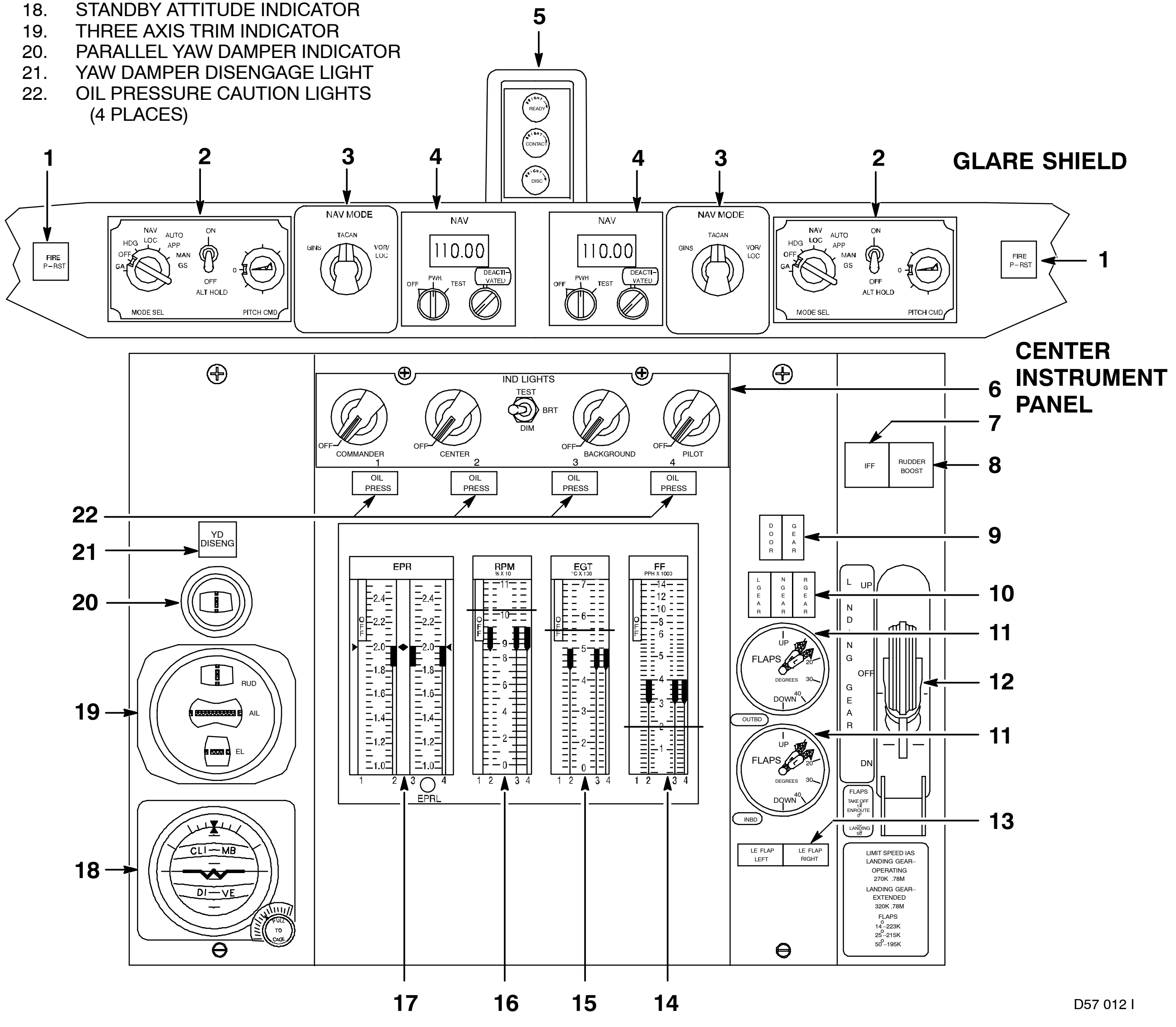
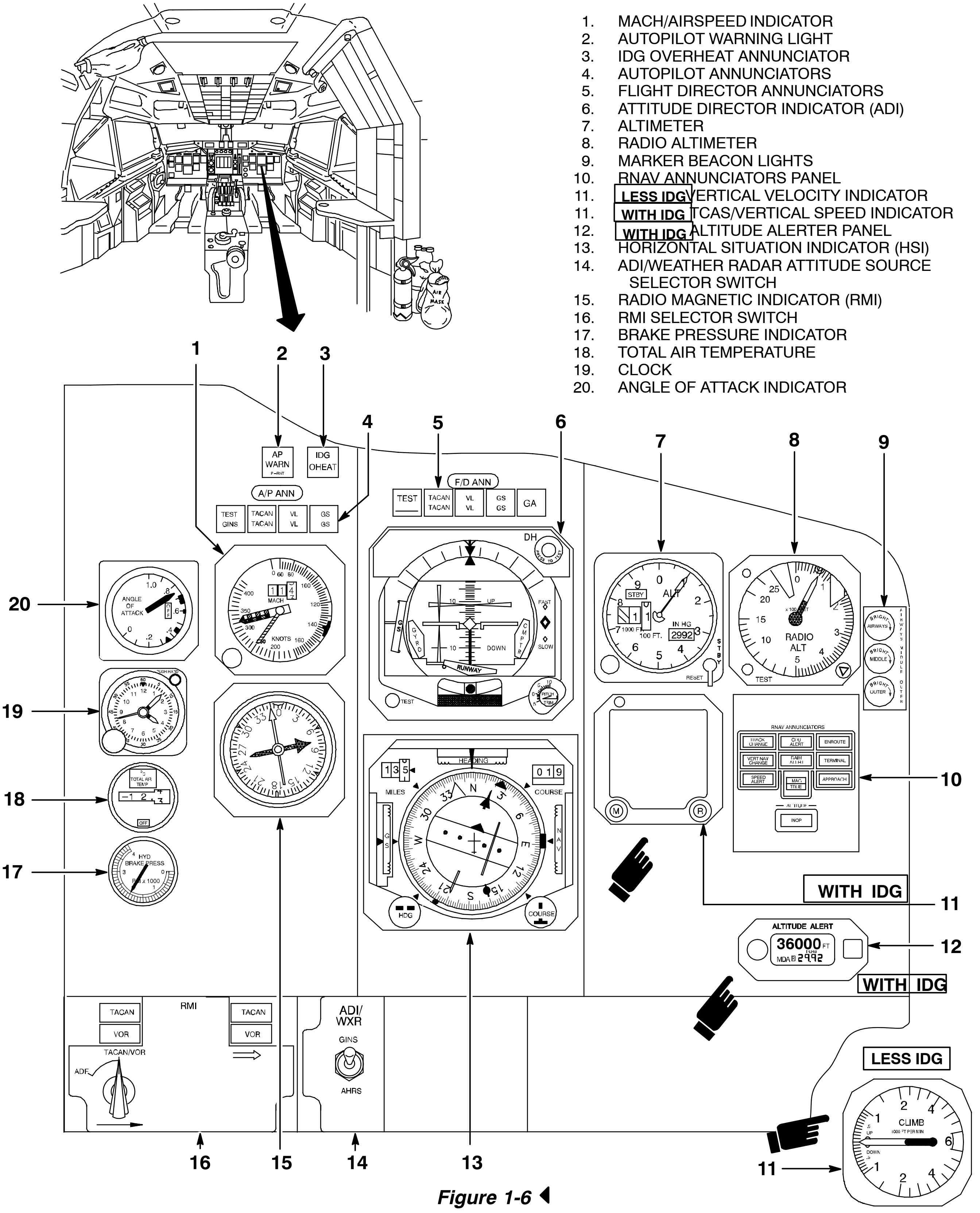


Figure 1-5

Copilot’s Instrument Panel



1. MACH/AIRSPEED INDICATOR
2. AUTOPILOT WARNING LIGHT
3. IDG OVERHEAT ANNUNCIATOR
4. AUTOPILOT ANNUNCIATORS
5. FLIGHT DIRECTOR ANNUNCIATORS
6. ATTITUDE DIRECTOR INDICATOR (ADI)
7. ALTIMETER
8. RADIO ALTIMETER
9. MARKER BEACON LIGHTS
10. RNAV ANNUNCIATORS PANEL
11. LESS IDG VERTICAL VELOCITY INDICATOR
11. WITH IDG TCAS/VERTICAL SPEED INDICATOR
12. WITH IDG ALTITUDE ALERTER PANEL
13. HORIZONTAL SITUATION INDICATOR (HSI)
14. ADI/WEATHER RADAR ATTITUDE SOURCE SELECTOR SWITCH
15. RADIO MAGNETIC INDICATOR (RMI)
16. RMI SELECTOR SWITCH
17. BRAKE PRESSURE INDICATOR
18. TOTAL AIR TEMPERATURE
19. CLOCK
20. ANGLE OF ATTACK INDICATOR

Figure 1-6 ◀

LESS IDG Pilot's Overhead Panel

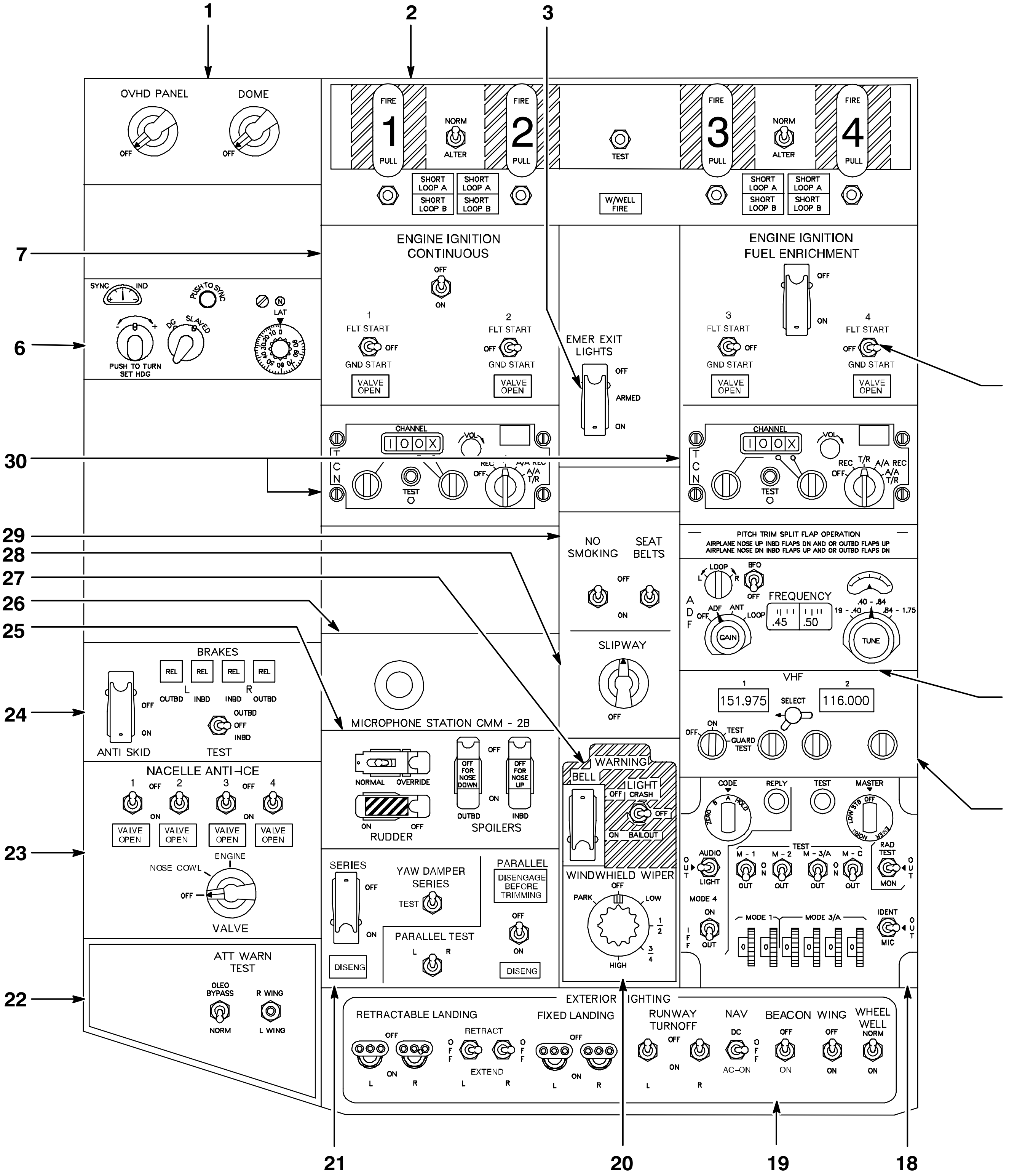


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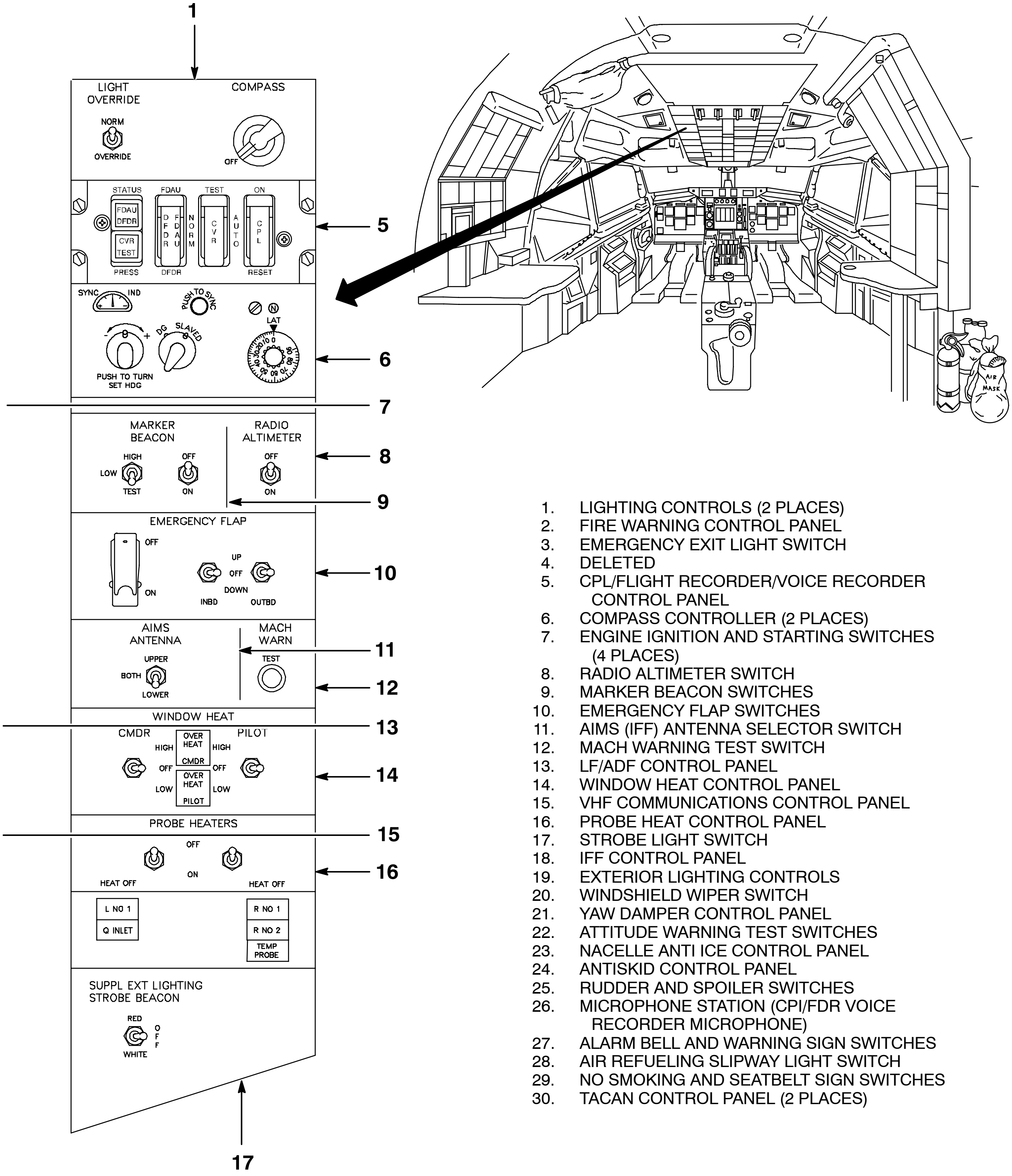
Figure 1-7 (Sheet 1 of 2)



1. LIGHTING CONTROLS (2 PLACES)
2. FIRE WARNING CONTROL PANEL
3. EMERGENCY EXIT LIGHT SWITCH
4. DELETED
5. CPL/FLIGHT RECORDER/VOICE RECORDER CONTROL PANEL
6. COMPASS CONTROLLER (2 PLACES)
7. ENGINE IGNITION AND STARTING SWITCHES (4 PLACES)
8. RADIO ALTIMETER SWITCH
9. MARKER BEACON SWITCHES
10. EMERGENCY FLAP SWITCHES
11. AIMS (IFF) ANTENNA SELECTOR SWITCH
12. MACH WARNING TEST SWITCH
13. LF/ADF CONTROL PANEL
14. WINDOW HEAT CONTROL PANEL
15. VHF COMMUNICATIONS CONTROL PANEL
16. PROBE HEAT CONTROL PANEL
17. STROBE LIGHT SWITCH
18. IFF CONTROL PANEL
19. EXTERIOR LIGHTING CONTROLS
20. WINDSHIELD WIPER SWITCH
21. YAW DAMPER CONTROL PANEL
22. ATTITUDE WARNING TEST SWITCHES
23. NACELLE ANTI ICE CONTROL PANEL
24. ANTISKID CONTROL PANEL
25. RUDDER AND SPOILER SWITCHES
26. MICROPHONE STATION (CPI/FDR VOICE RECORDER MICROPHONE)
27. ALARM BELL AND WARNING SIGN SWITCHES
28. AIR REFUELING SLIPWAY LIGHT SWITCH
29. NO SMOKING AND SEATBELT SIGN SWITCHES
30. TACAN CONTROL PANEL (2 PLACES)

Figure 1-7 (Sheet 2 of 2)◀

WITH IDG Pilots' Overhead Panel

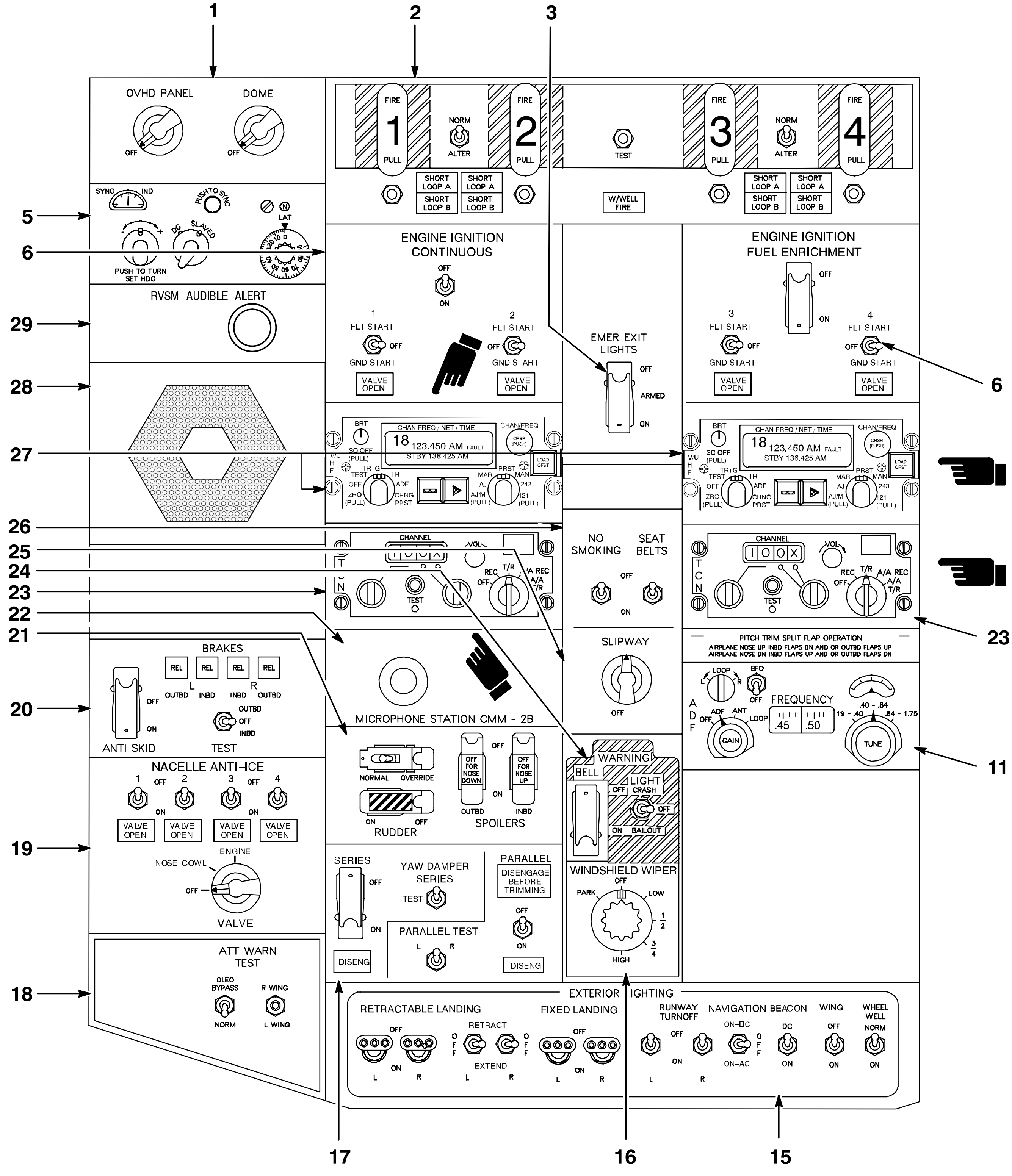
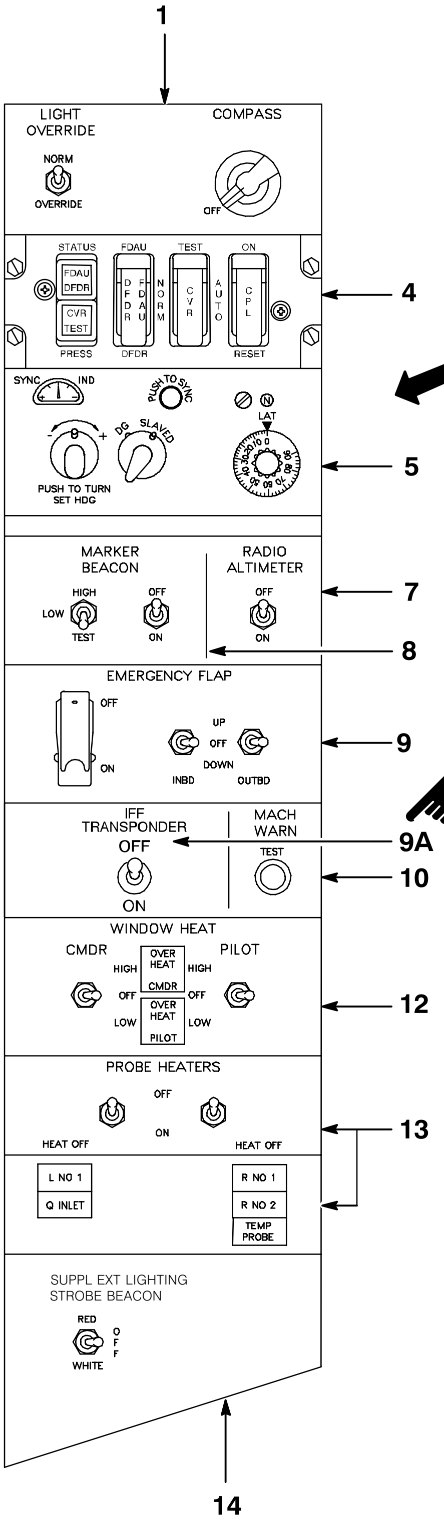
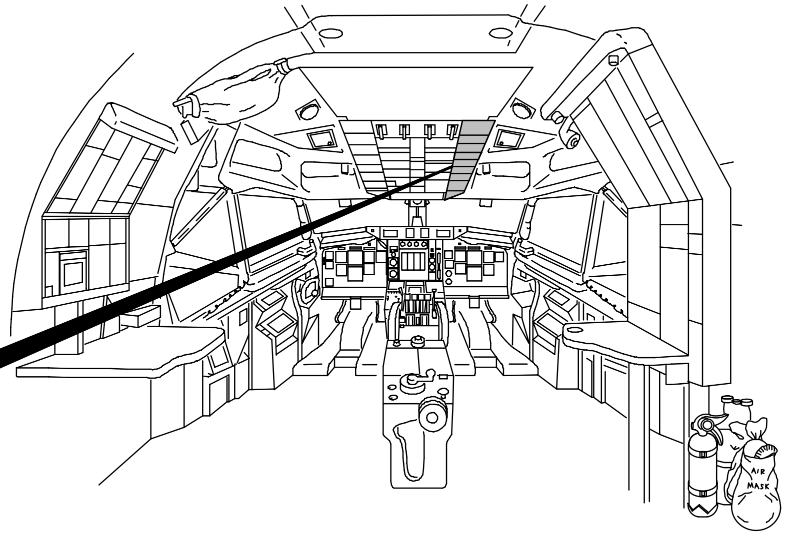


Figure 1-7A (Sheet 1 of 2)





1. LIGHTING CONTROLS (2 PLACES)
2. FIRE WARNING CONTROLS
3. EMERGENCY EXIT LIGHT SWITCH
4. CPL/FLIGHT RECORDER/VOICE RECORDER CONTROL PANEL
5. COMPASS CONTROLLER (2 PLACES)
6. ENGINE IGNITION AND STARTING SWITCHES (4 PLACES)
7. RADIO ALTIMETER SWITCH
8. MARKER BEACON SWITCHES
9. EMERGENCY FLAP SWITCHES
9A. IFF TRANSPONDER POWER SWITCH
10. MACH WARNING TEST SWITCH
11. LF/ADF CONTROLS
12. WINDOW HEAT CONTROL PANEL
13. PROBE HEAT CONTROL PANEL
14. STROBE LIGHT SWITCH
15. EXTERIOR LIGHTING CONTROLS
16. WINDSHIELD WIPER SWITCH
17. YAW DAMPER CONTROL PANEL
18. ATTITUDE WARNING TEST SWITCHES
19. NACELLE ANTI–ICE CONTROLS
20. ANTISKID CONTROL PANEL
21. RUDDER AND SPOILER SWITCHES
22. MICROPHONE STATION (CPI/FDR VOICE RECORDER MICROPHONE)
23. TACAN CONTROLS (2 PLACES)
24. ALARM BELL AND WARNING SIGN SWITCHES
25. AIR REFUELING SLIPWAY LIGHT SWITCH
26. NO SMOKING AND SEATBELT SIGN SWITCHES
27. VHF–AM RADIO CONTROL UNIT (2 PLACES) (COPILOT’S IS NO. 1)
28. TCAS SPEAKER
29. RVSM AUDIBLE ALERT SPEAKER

Figure 1-7A (Sheet 2 of 2) ◀

Forward Electronic Panel

1. UHF FLIGHT DECK DIGITAL RADIO CONTROL PANEL
2. WEATHER RADAR INDICATOR
3. DELETED
4. GINS CONTROL DISPLAY UNIT (2 PLACES)

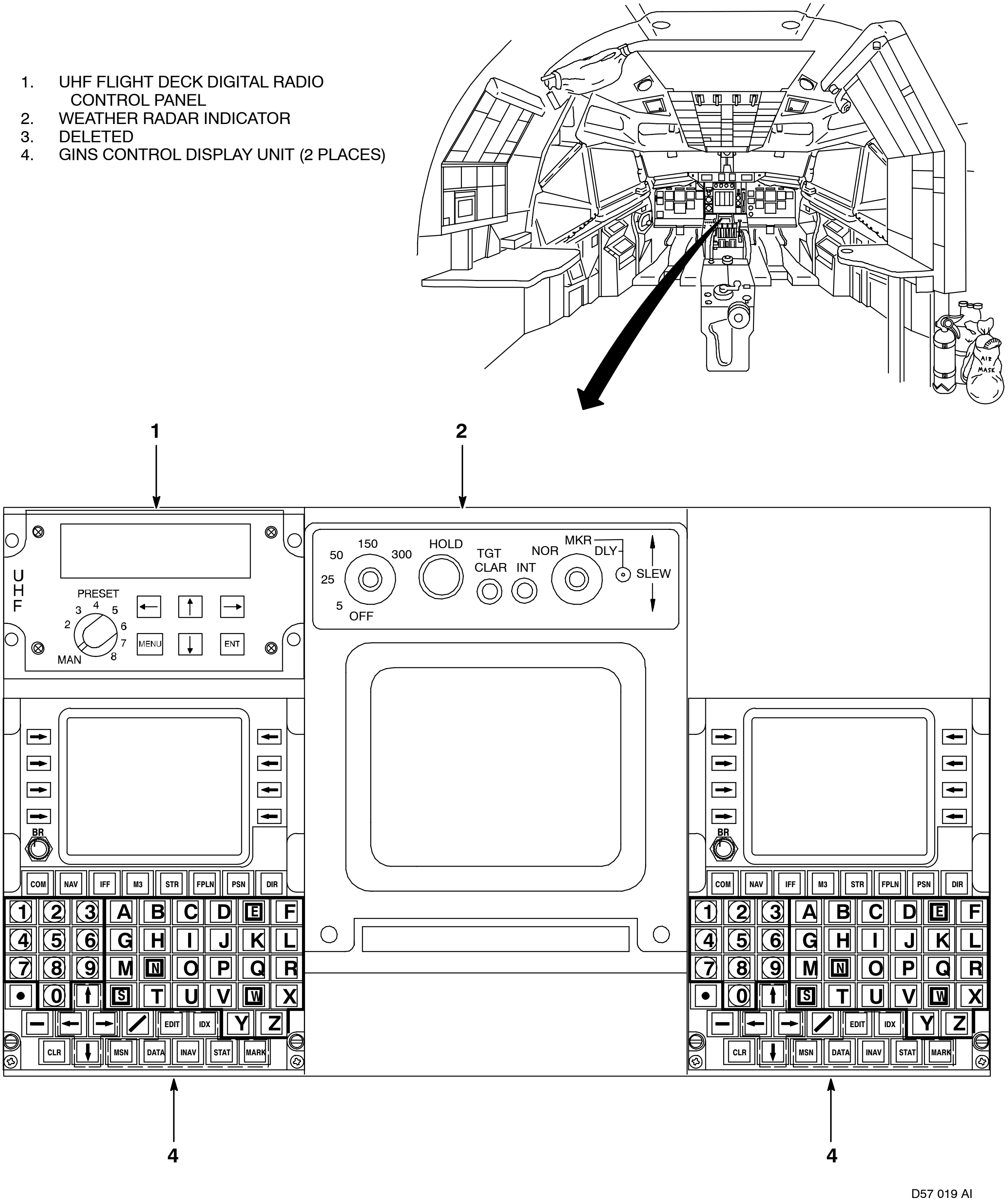


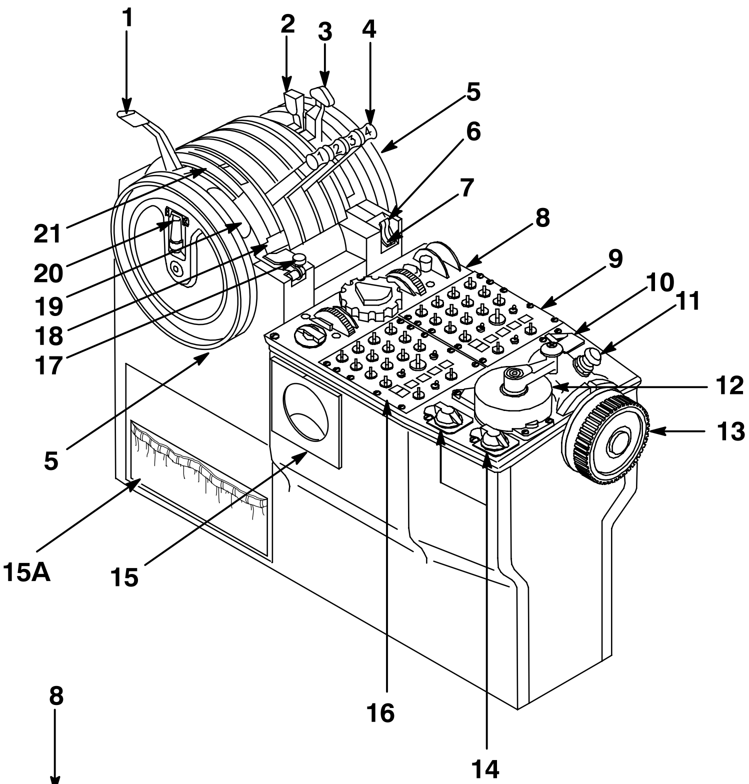
Figure 1-8

Aisle Control Stand and Aft Electronic Panel

1. SPEED BRAKE LEVER
2. THROTTLE FRICTION CONTROL
3. FLAP LEVER
4. THROTTLES
5. STABILIZER TRIM WHEEL (2 PLACES)
6. MAIN ELECTRIC STABILIZER TRIM CUTOUT SWITCH
7. AUTOMATIC STABILIZER TRIM CUTOUT SWITCH
8. AUTOPILOT CONTROL
9. COPILOT'S ADS PANEL
10. WARNING HORN CUTOUT LEVER
11. STABILIZER BRAKE RELEASE
12. RUDDER TRIM HANDLE AND INDICATOR
13. AILERON TRIM WHEEL AND INDICATOR
14. RADIO PANELS LIGHT CONTROLS (2 PLACES)
15. CUP HOLDER

15A. MAP HOLDER (2 PLACES) ☛

16. PILOT'S AND OBSERVER'S ADS PANEL
17. PARKING BRAKE LIGHT
18. PARKING BRAKE LEVER
19. STABILIZER TRIM INDICATOR (2 PLACES)
20. MANUAL STABILIZER TRIM HANDLE (2 PLACES)
21. SPEED BRAKE SCALE



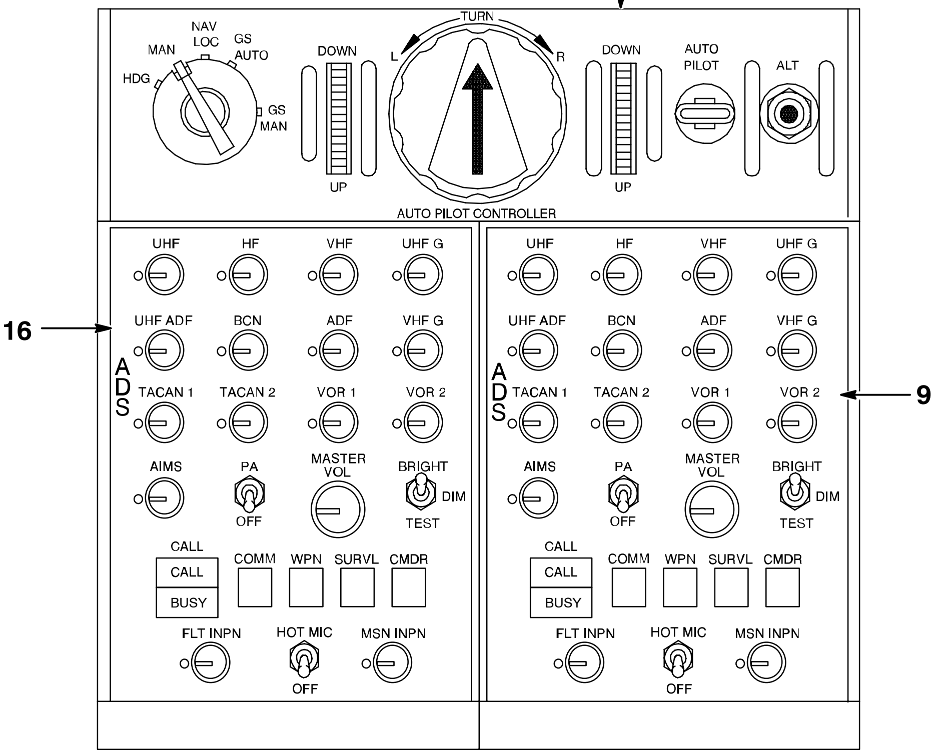


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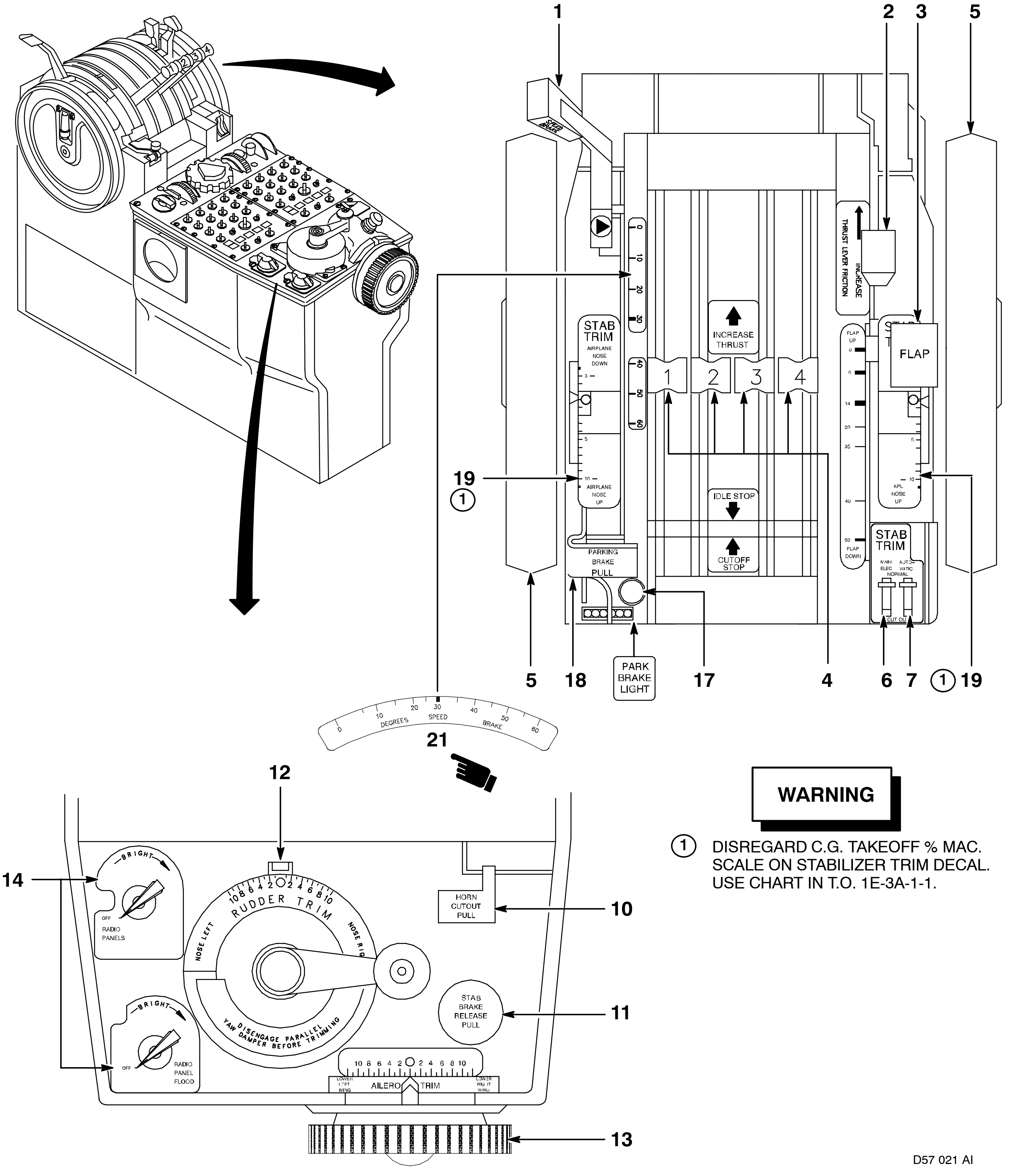
Figure 1-9 (Sheet 1 of 2)



WARNING

① DISREGARD C.G. TAKEOFF % MAC. SCALE ON STABILIZER TRIM DECAL. USE CHART IN T.O. 1E-3A-1-1.

Figure 1-9 (Sheet 2 of 2)

Pilot’s Auxiliary Panels and Observer’s Panel

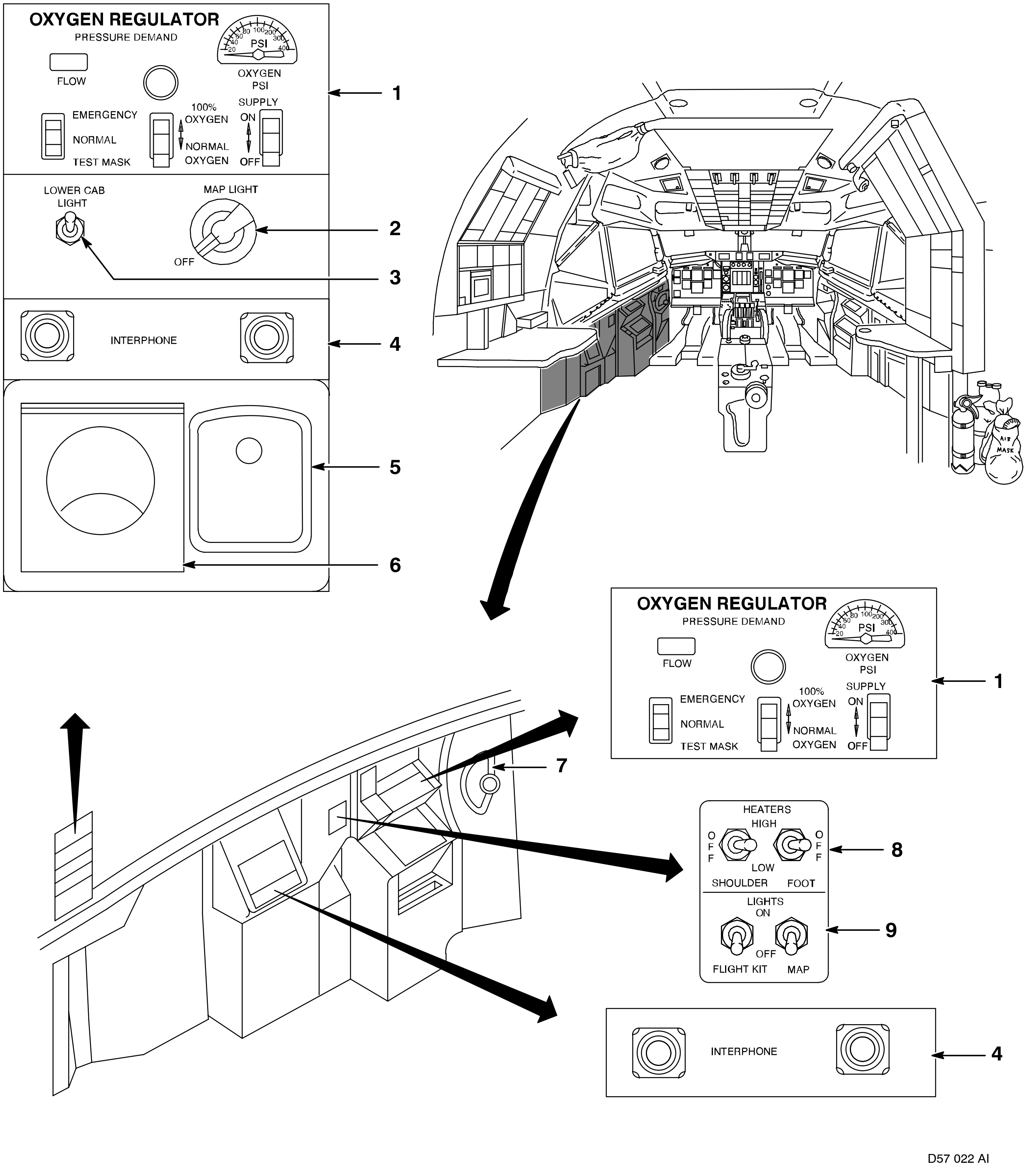
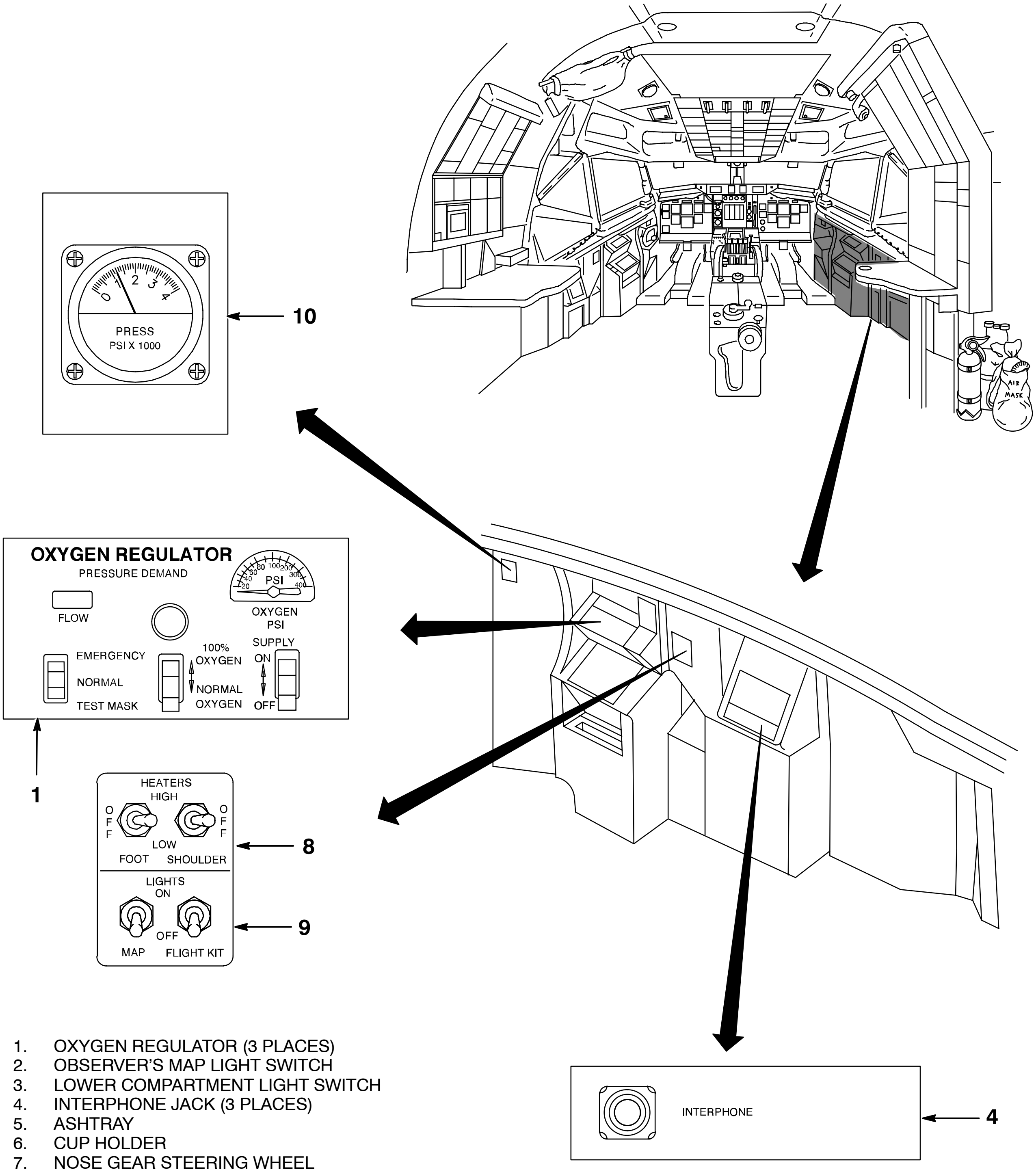


Figure 1-10 (Sheet 1 of 2)



1. OXYGEN REGULATOR (3 PLACES)
2. OBSERVER'S MAP LIGHT SWITCH
3. LOWER COMPARTMENT LIGHT SWITCH
4. INTERPHONE JACK (3 PLACES)
5. ASHTRAY
6. CUP HOLDER
7. NOSE GEAR STEERING WHEEL
8. FOOT AND SHOULDER HEATER SWITCHES (2 PLACES)
9. MAP AND FLIGHT KIT LIGHT SWITCHES (2 PLACES)
10. EMERGENCY BRAKE PRESSURE GAGE

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Figure 1-10 (Sheet 2 of 2)

Flight Engineer’s Upper Panel

1. ELECTRICAL PANEL
2. AIR CONDITIONING AND BLEED AIR PANEL
3. CLOCK
4. PRESSURIZATION CONTROLS AND INDICATORS

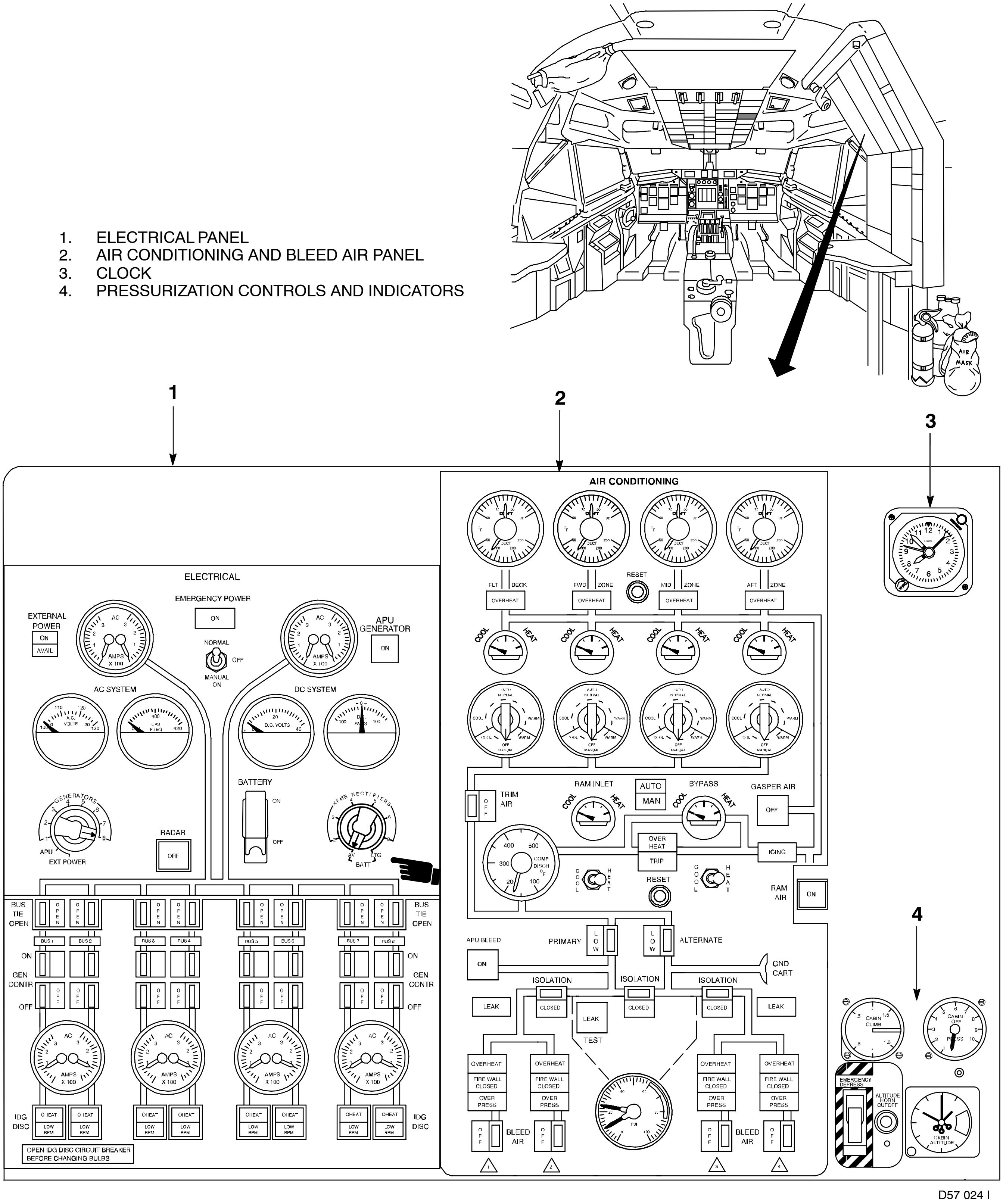
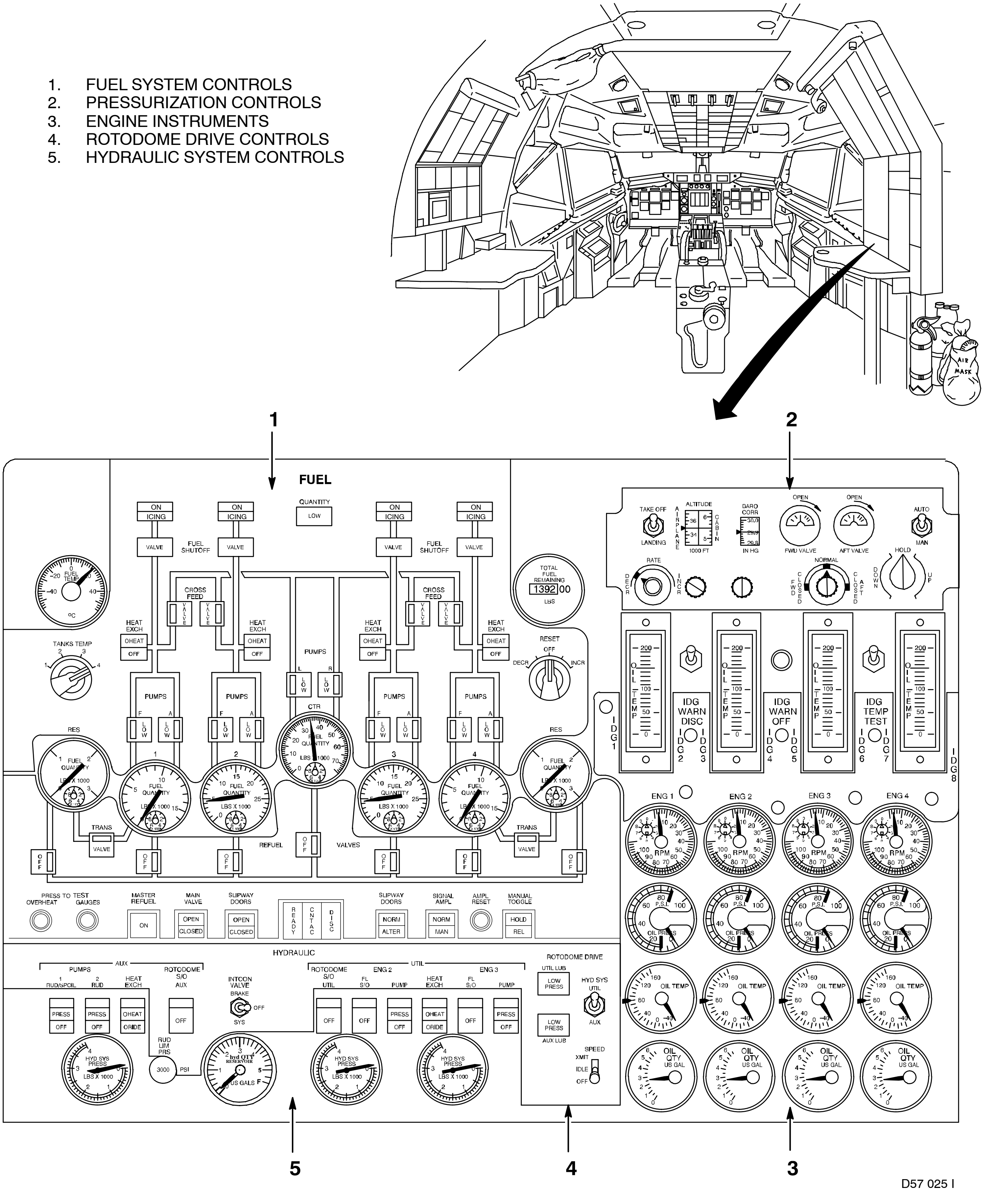


Figure 1-11

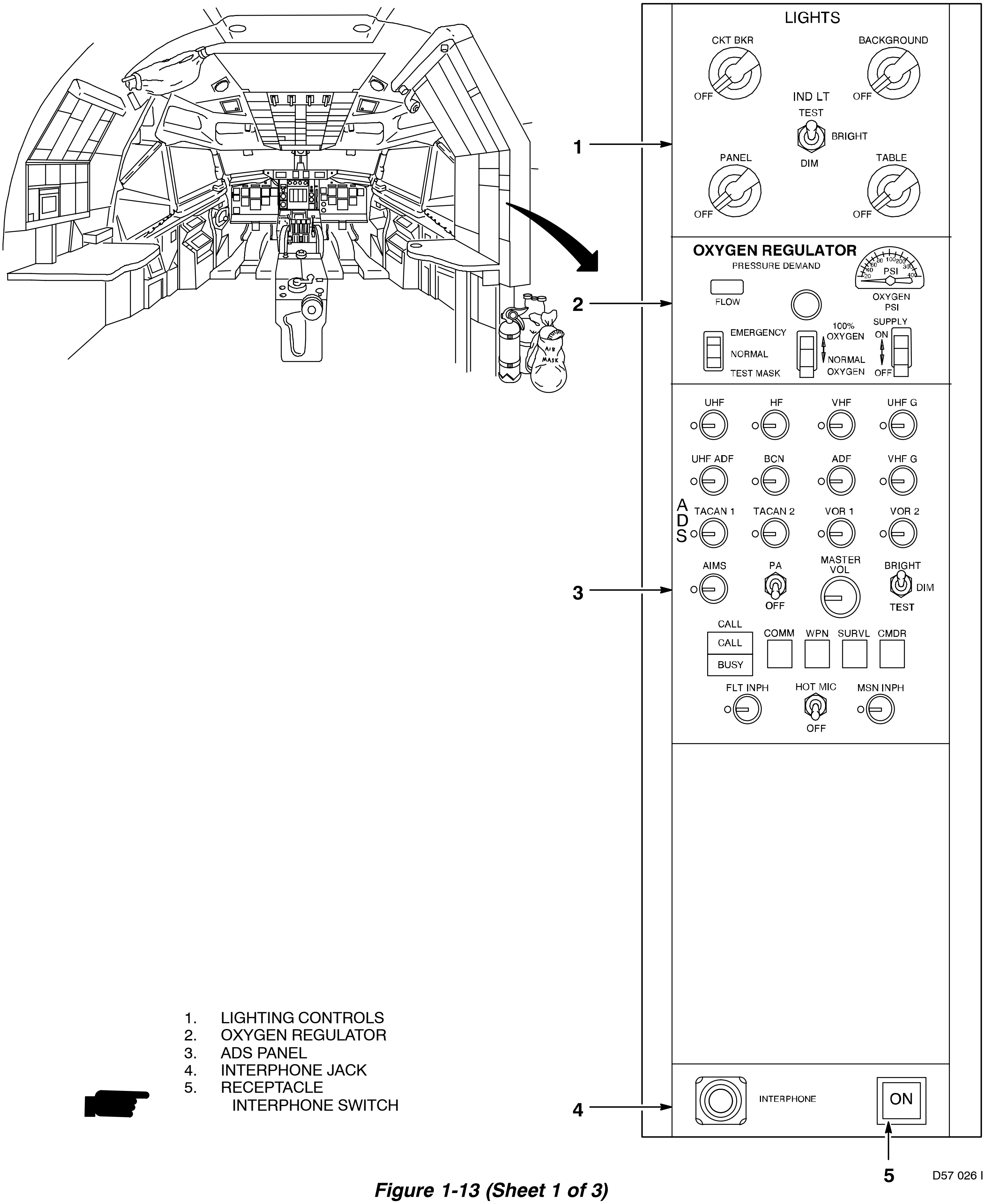
Flight Engineer’s Lower Panel



1. FUEL SYSTEM CONTROLS
2. PRESSURIZATION CONTROLS
3. ENGINE INSTRUMENTS
4. ROTODOME DRIVE CONTROLS
5. HYDRAULIC SYSTEM CONTROLS

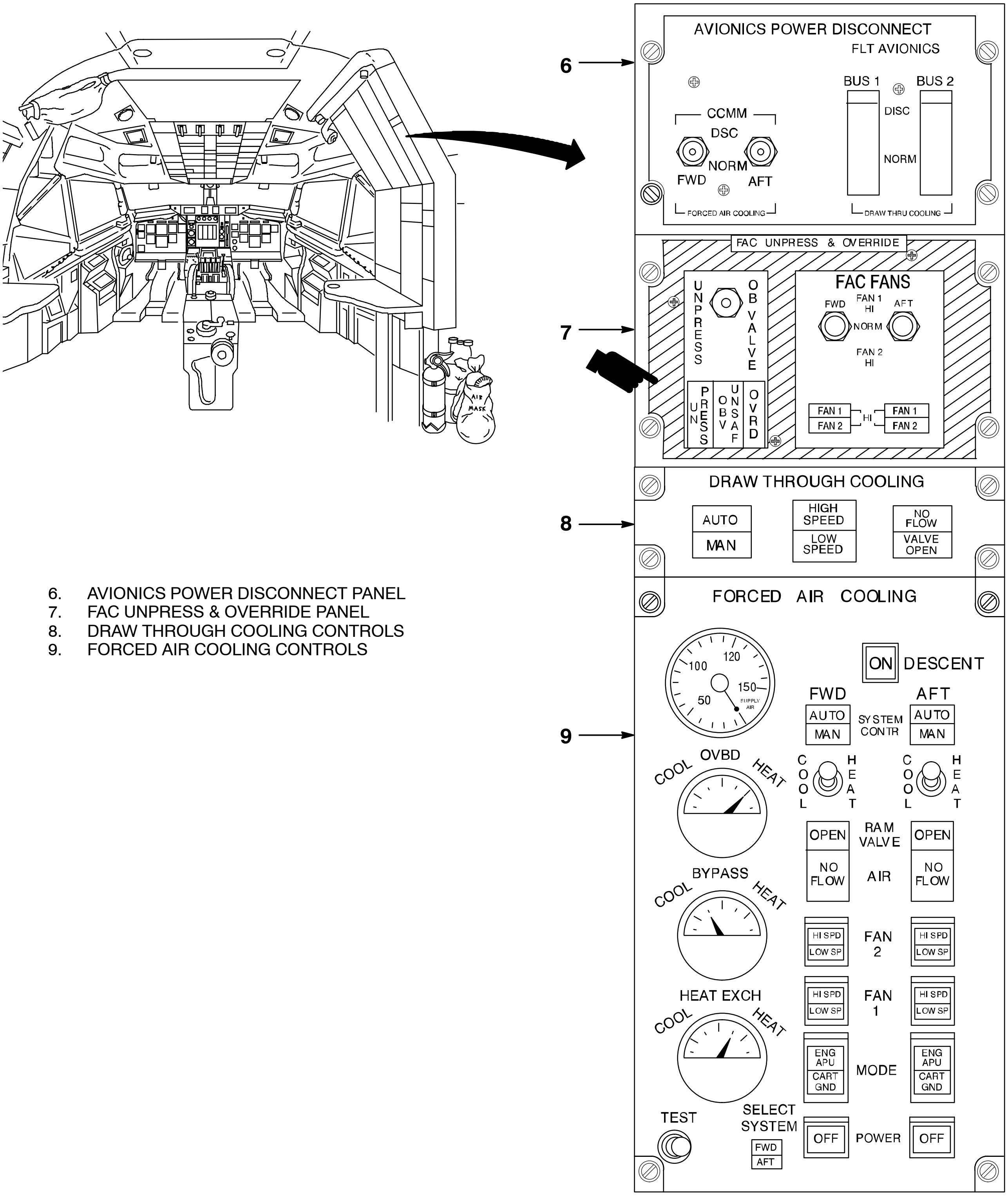
Figure 1-12

Flight Engineer’s Auxiliary Panels



1. LIGHTING CONTROLS
2. OXYGEN REGULATOR
3. ADS PANEL
4. INTERPHONE JACK
5. RECEPTACLE
   INTERPHONE SWITCH

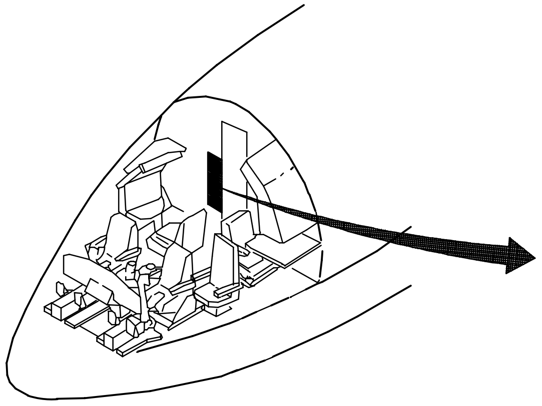
Figure 1-13 (Sheet 1 of 3)



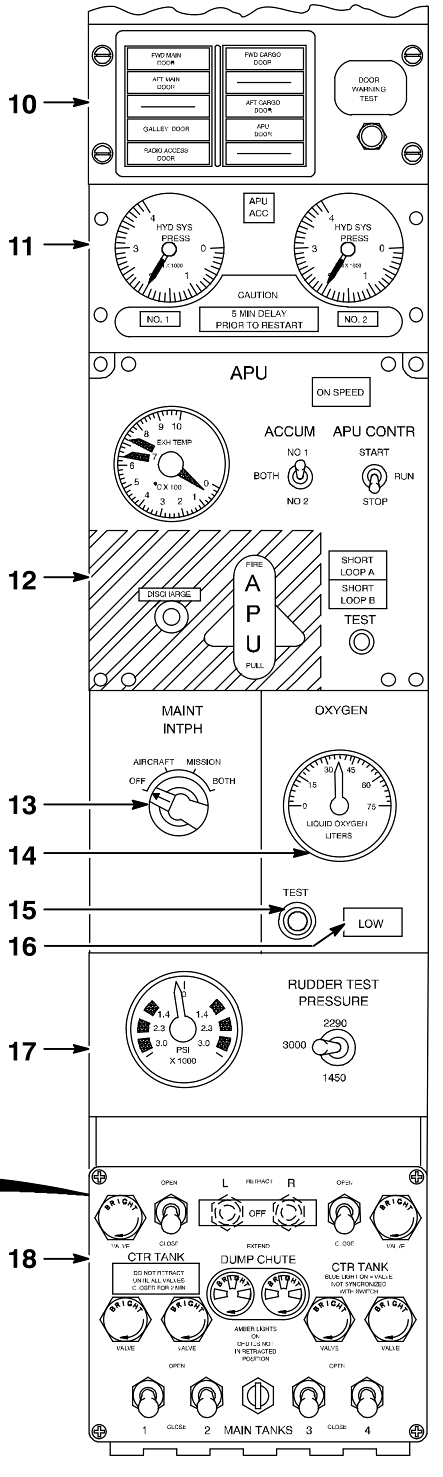
6. AVIONICS POWER DISCONNECT PANEL
7. FAC UNPRESS & OVERRIDE PANEL
8. DRAW THROUGH COOLING CONTROLS
9. FORCED AIR COOLING CONTROLS

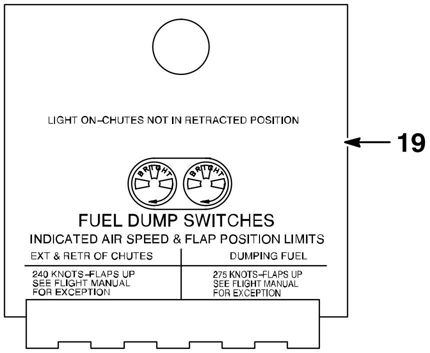
Figure 1-13 (Sheet 2 of 3)

Flight Engineer’s Auxiliary Panels (Continued)



10. DOOR WARNING PANEL
11. APU ACCUMULATOR PRESSURE GAGES
12. APU CONTROL PANEL
13. MAINTENANCE INTERPHONE SELECTOR
14. LIQUID OXYGEN QUANTITY GAGE
15. LIQUID OXYGEN QUANTITY GAGE TEST BUTTON
16. LIQUID OXYGEN LOW LEVEL AND LOW PRESSURE CAUTION LIGHT
17. RUDDER GROUND TEST PANEL
18. FUEL DUMP PANEL
19. FUEL DUMP PANEL COVER

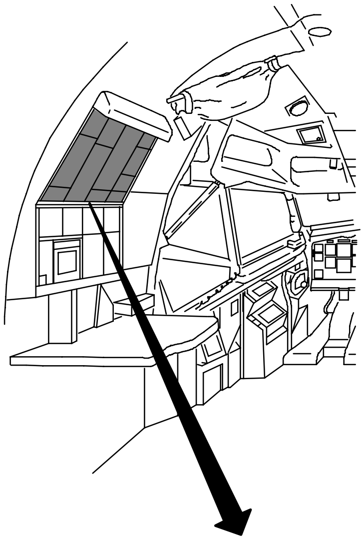




D57 028 I

Figure 1-13 (Sheet 3 of 3)

Navigator’s Upper Panel



1. HF RADIO CONTROL PANEL
2. GASPER AIR
3. LIGHTING CONTROLS
4. OXYGEN REGULATOR
5. ALTIMETER
6. STATIC AIR TEMPERATURE INDICATOR
7. TRUE AIR SPEED INDICATOR
8. DUAL DISTANCE DISPLAY
9. RADIO MAGNETIC INDICATOR (RMI)
10. RMI SELECTOR PANEL
11. AUDIO SELECTOR PANEL
12. RENDEZVOUS RADAR BEACON CONTROL PANEL
13. HAVE SIREN CONTROLS

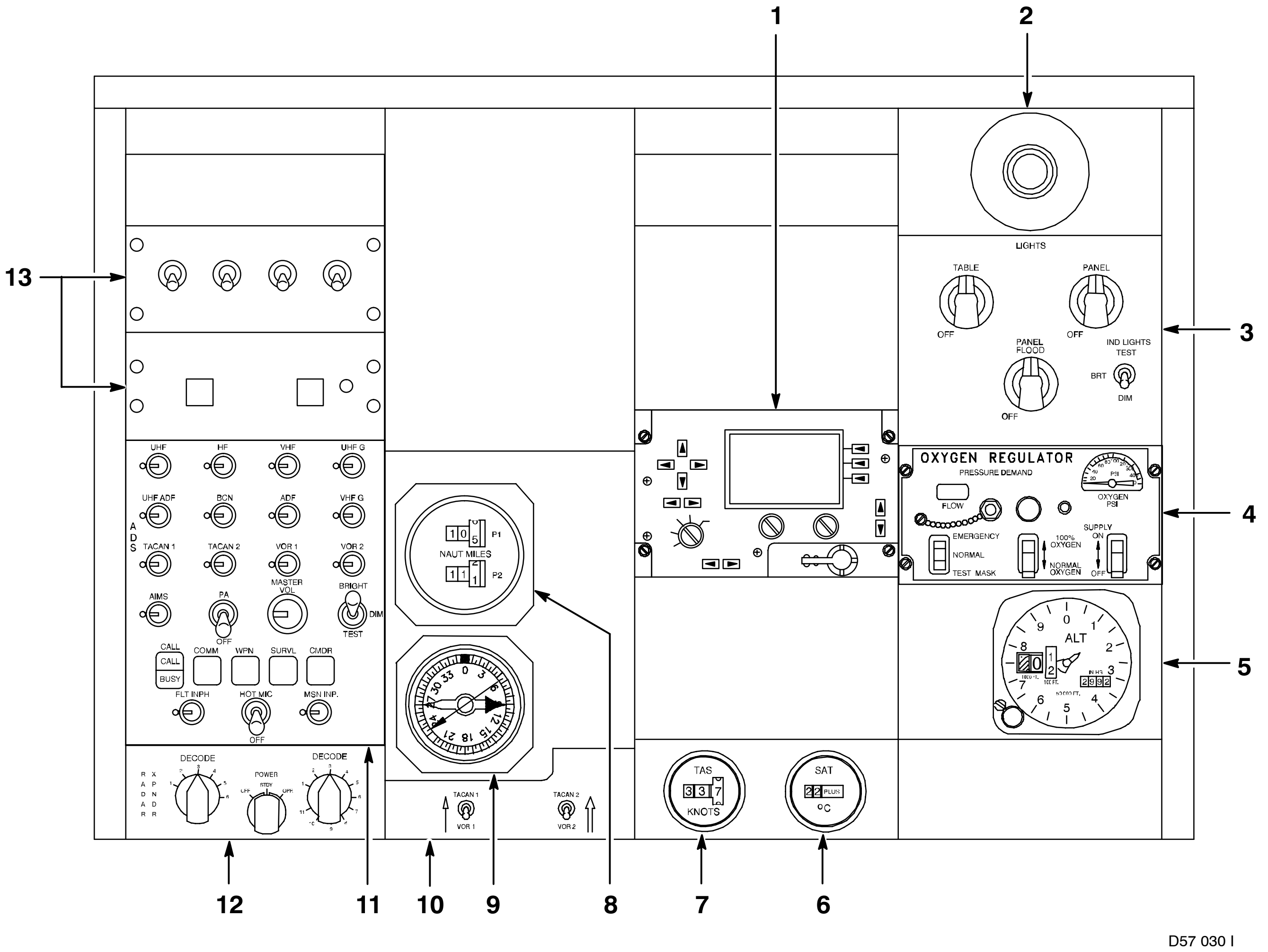


Figure 1-14

Navigator's Lower Panel

1. CLOCK
2. AUTOPILOT GINS SOURCE DISPLAY
3. WEATHER RADAR CONTROL PANEL
4. RNAV ANNUNCIATORS PANEL
5. GINS MISSION DATA LOADER
6. GINS CONTROL DISPLAY UNIT
7. GINS CONTROL PANEL
8. WEATHER RADAR INDICATOR
9. INTERPHONE JACK

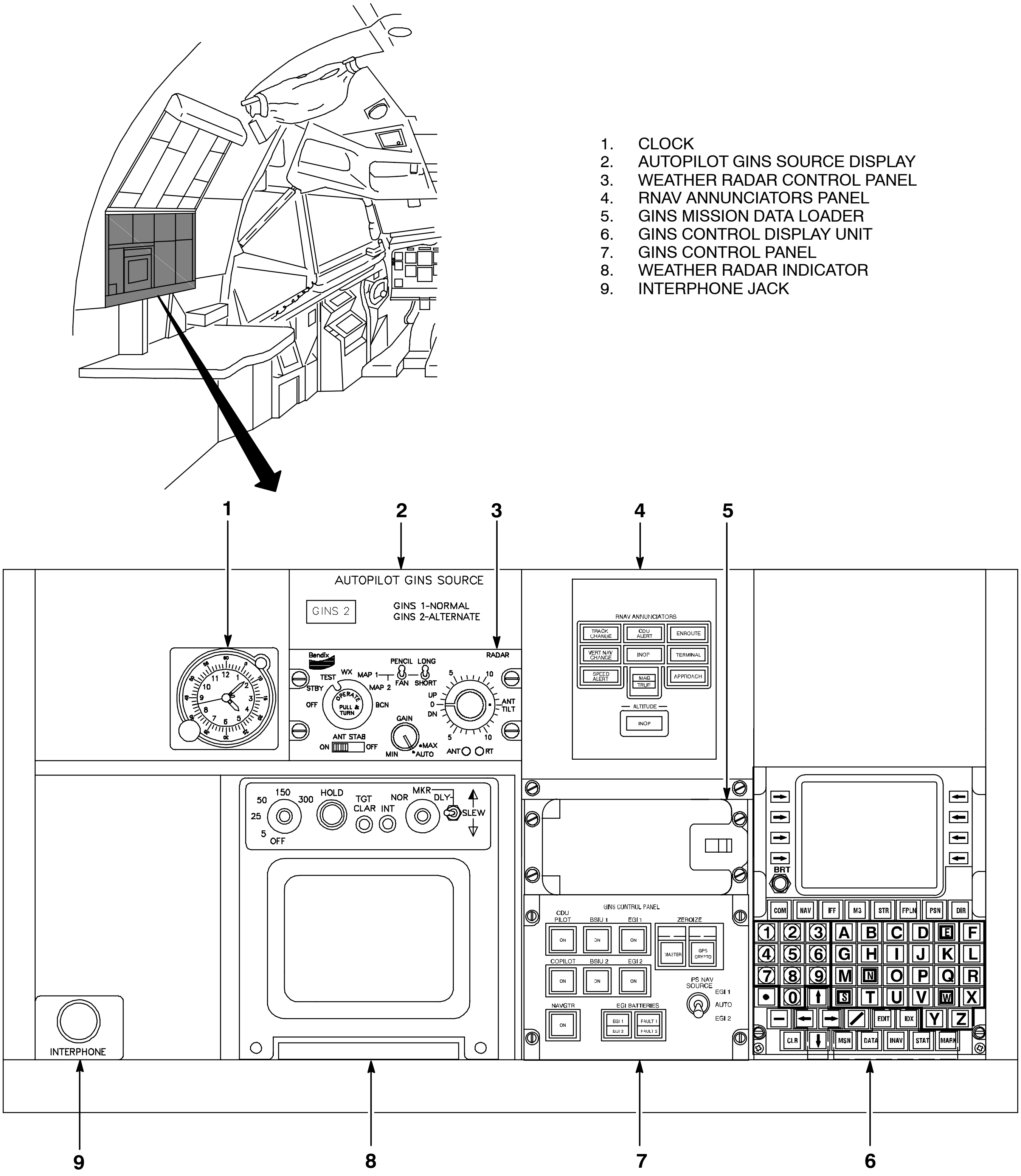


Figure 1-15

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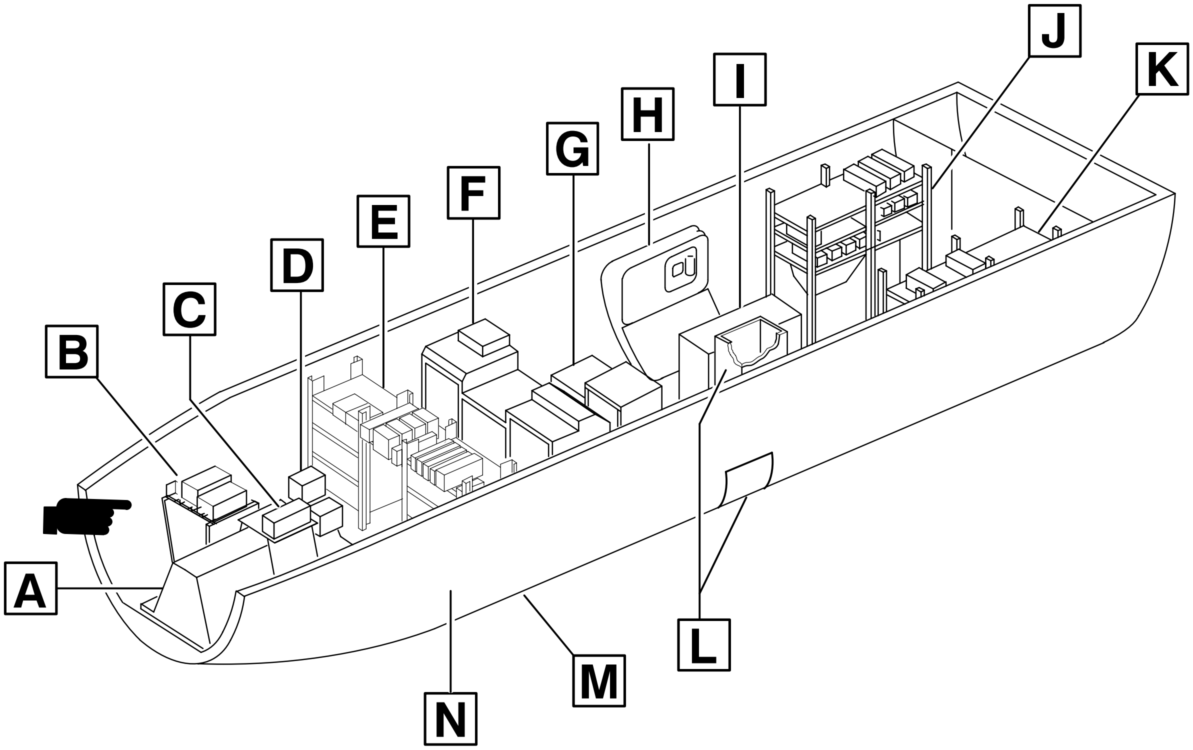
Forward Lower Compartment



A	NOSE WHEEL ENCLOSURE	H	FORWARD CARGO DOOR
B	EQUIPMENT RACK E5	I	EQUIPMENT RACK E4
C	WEATHER RADAR RECEIVER/TRANSMITTER	J	EQUIPMENT RACK E16
D	AIRPLANE BATTERY PAIR	K	EQUIPMENT RACK E15
E	EQUIPMENT RACK E1	L	BAILOUT CHUTE AND AERODYNAMIC SPOILER PANEL
F	EQUIPMENT RACK E2	M	ELECTRONIC ACCESS DOOR (BOTTOM, KEEL; NOT SHOWN)
G	EQUIPMENT RACK E3	N	EMERGENCY LIGHTING BATTERY PAIR (LEFT SIDE OPPOSITE AIRPLANE BATTERY PAIR: NOT SHOWN)

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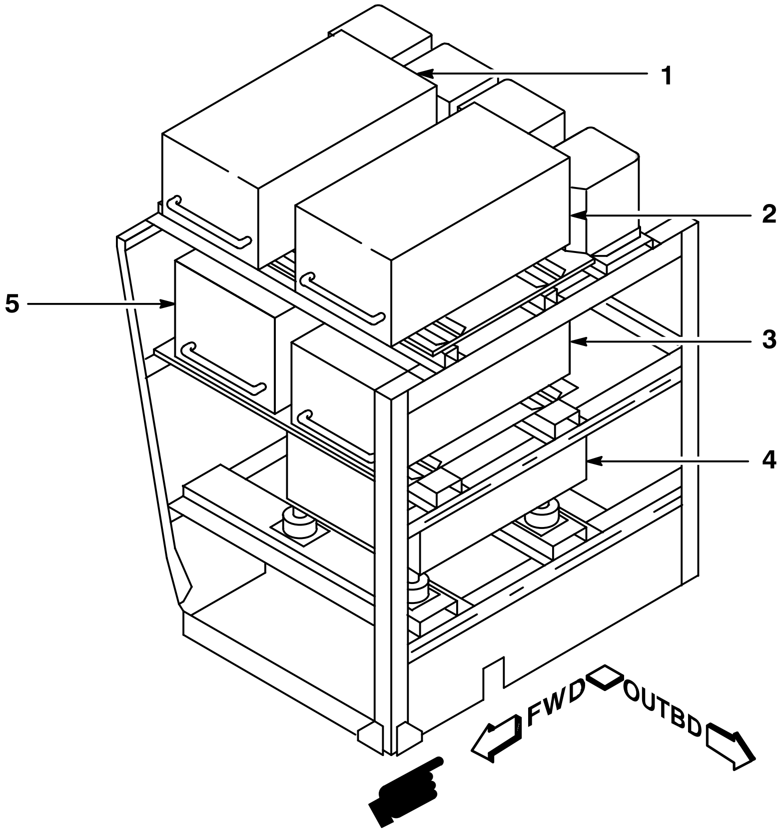
Figure 1-16 (Sheet 1 of 7)

Forward Lower Compartment (Continued)

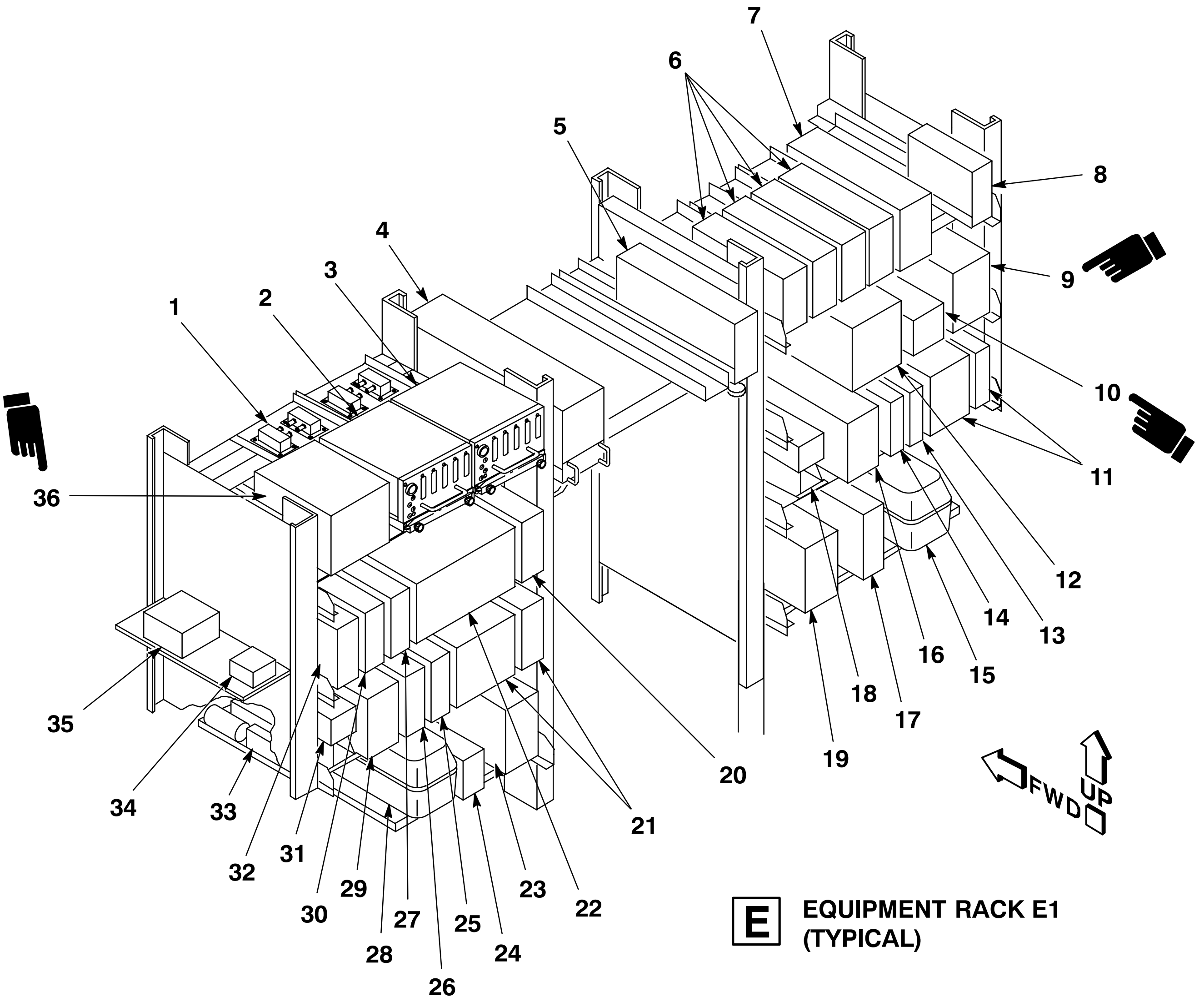


B EQUIPMENT RACK E5

1. T14 (TRU 8)
2. T13 (TRU 4)
3. T12 (TRU 2)
4. AIRPLANE BATTERY CHARGER
5. EMERGENCY POWER INVERTER

D57 620 I

Figure 1-16 (Sheet 2 of 7)



E **EQUIPMENT RACK E1 (TYPICAL)**

1. 1553 BUS COUPLERS
2. BSIU 1
3. BSIU 2
4. DFDR/FDU
5. FUEL FLOWMETER UNIT
6. CABIN ZONE TEMP CONTROLLERS
7. AIR CONDITIONING PACK TEMP CONTROLLER
8. CABIN PRESSURIZATION CONTROLLER
9. LESS IDG MODE 4 TRANSPONDER/COMPUTER ◀
10. LESS IDG IFF MODE 2◀
    WITH IDG IFF MODE S TRANSPONDER ◀
11. TACAN NO. 2
12. FLIGHT LOADS RECORDER (IF INSTALLED)
13. FLIGHT INSTRUMENT ACCESSORY UNIT NO. 2
14. FLIGHT DIRECTOR COMPUTER NO. 2
15. AHRS NO. 2
16. VOR/ILS NO. 2
17. ADF RECEIVER
18. VOR/ILS AMPLIFIER
19. CENTRAL AIR DATA COMPUTER NO. 2
20. PARALLEL YAW DAMPER COMPUTER
21. TACAN NO. 1
22. AUTOPILOT COMPUTER
23. CENTRAL AIR DATA COMPUTER NO. 1
24. MARKER BEACON RECEIVER
25. FLIGHT INSTRUMENT ACCESSORY UNIT NO. 1
26. FLIGHT DIRECTOR COMPUTER NO. 1
27. POWER JUNCTION BOX
28. AHRS NO. 1
29. VOR/ILS NO. 1
30. AFC ACCESSORY UNIT
31. VOR/ILS AMPLIFIER
32. SERIES YAW DAMPER COMPUTER
33. THREE-AXIS RATE TRANSMITTER
34. AUTOPILOT ADAPTER
35. ELEVATOR TORQUE ADAPTER
36. WITH IDG TCAS COMPUTER ◀

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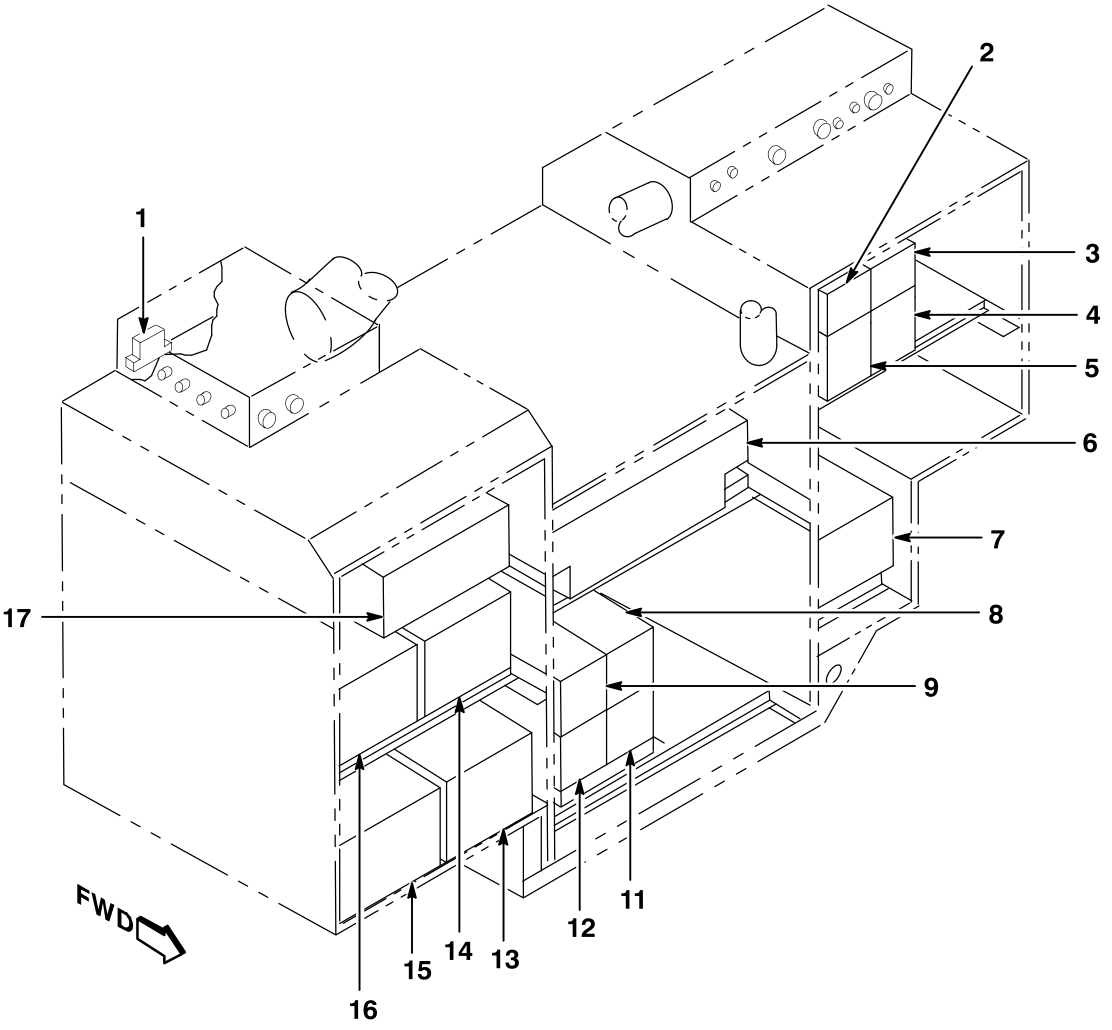
Figure 1–16 (Sheet 3 of 7)

Forward Lower Compartment (Continued)



F **EQUIPMENT RACK E2** ①

1. UHF TRANSMISSION LINE SWITCH (T1)
2. UHF BANDPASS FILTER (R17)
3. UHF BANDPASS FILTER (R18)
4. UHF BANDPASS FILTER (R11)
5. UHF BANDPASS FILTER (R10)
6. UHF HIGH POWER FILTER (T1)
7. UHF TRANSCEIVER (RT11)
8. UHF BANDPASS FILTER (T18)
9. UHF BANDPASS FILTER (T17)
10. DELETED
11. UHF BANDPASS FILTER (T11)
12. UHF BANDPASS FILTER (T10)
13. UHF TRANSCEIVER (RT18)
14. UHF TRANSCEIVER (RT10)
15. UHF TRANSCEIVER (RT17)
16. UHF TRANSCEIVER (T1)
17. UHF HIGH POWER AMPLIFIER (T1)

① COOLED BY FORWARD FORCED AIR SYSTEM

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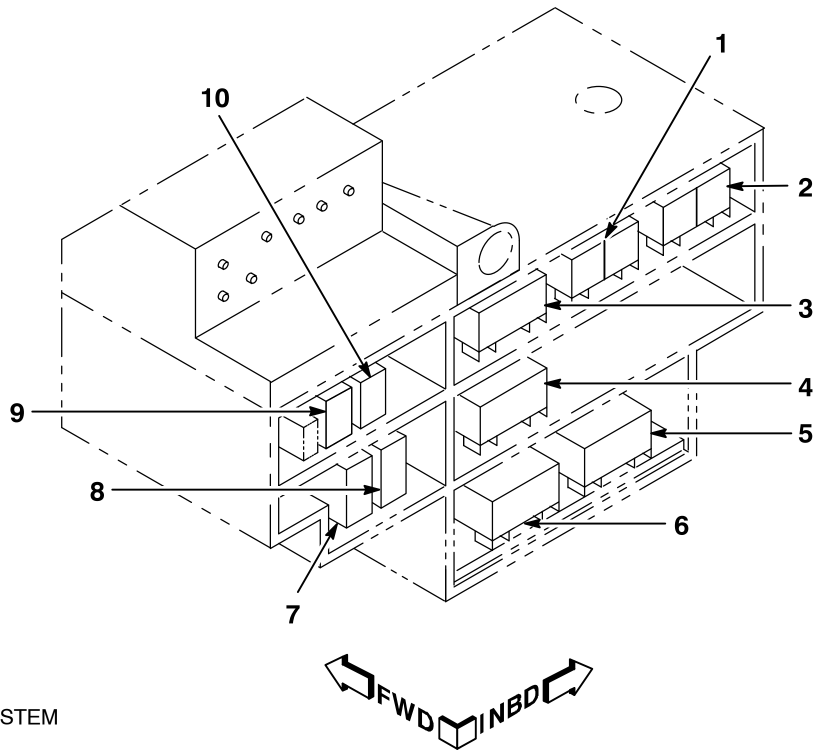
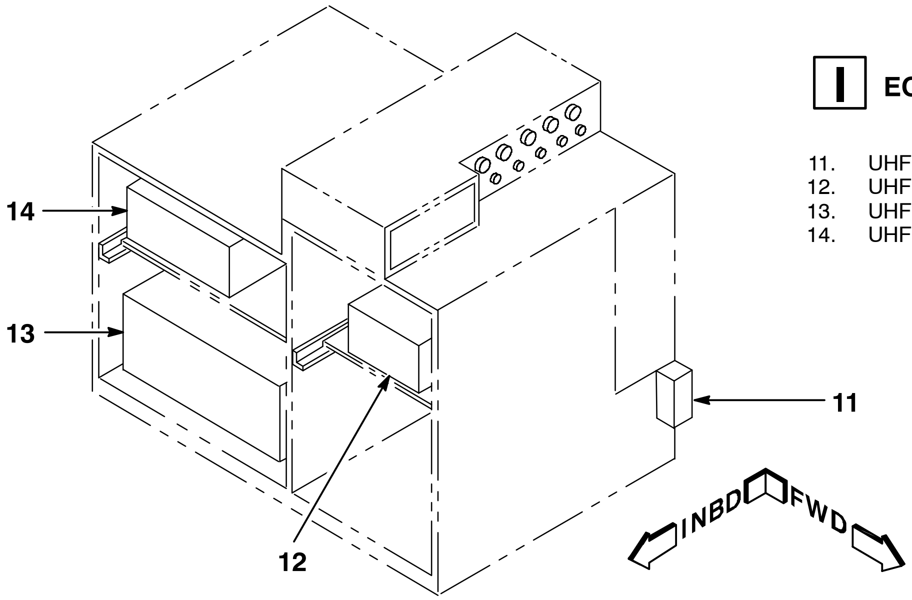
Figure 1-16 (Sheet 4 of 7)

G EQUIPMENT RACK E3 ①

1. UHF MULTICOUPLER (RT 8, 9)
2. UHF MULTICOUPLER (RT 15, 16)
3. UHF TRANSCEIVER (RT 8)
4. UHF TRANSCEIVER (RT 9)
5. UHF TRANSCEIVER (RT 16)
6. UHF TRANSCEIVER (RT 15)
7. UHF TRANSCEIVER POWER SUPPLY (RT 15)
8. UHF TRANSCEIVER POWER SUPPLY (RT 16)
9. UHF TRANSCEIVER POWER SUPPLY (RT 8)
10. UHF TRANSCEIVER POWER SUPPLY (RT 9)

① COOLED BY FORWARD FORCED AIR SYSTEM





I EQUIPMENT RACK E4 ①

11. UHF AN/APX-78 RADAR TRANSPONDER
12. UHF TRANSCEIVER (T3)
13. UHF HIGH POWER FILTER (T3)
14. UHF HIGH POWER AMPLIFIER (T3)

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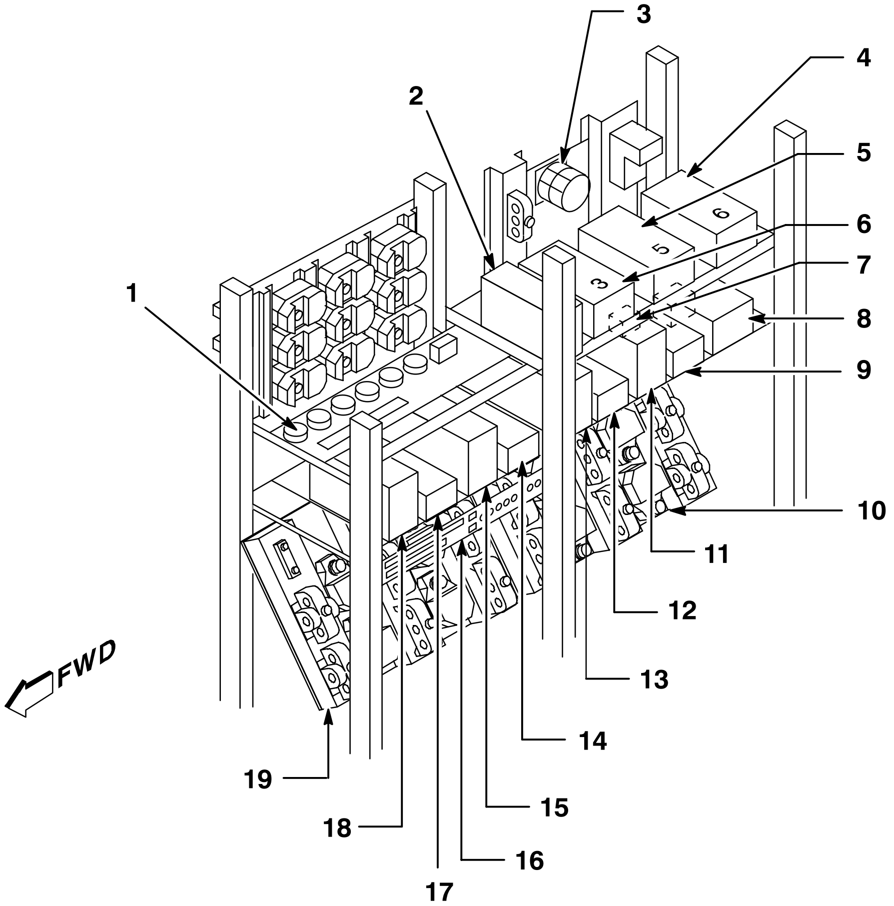
Figure 1-16 (Sheet 5 of 7)

Forward Lower Compartment (Continued)



J **EQUIPMENT RACK E16**

1. AVIONICS POWER DISCONNECT RELAY ASSY (E-16-90)
2. BUS POWER CONTROL UNIT
3. RADAR ELECTRICAL LOAD CONTROL UNIT POWER CONTACTOR
4. TRU 6
5. TRU 5
6. TRU 3
7. AERIAL REFUELING SIGNAL AMPLIFIER
8. APU GENERATOR CONTROL UNIT
9. FREQUENCY AND LOAD CONTROLLER NO. 8
10. P28 PANEL
11. GENERATOR CONTROL UNIT NO. 8
12. FREQUENCY AND LOAD CONTROLLER NO. 7
13. GENERATOR CONTROL UNIT NO. 7
14. FREQUENCY AND LOAD CONTROLLER NO. 6
15. GENERATOR CONTROL UNIT NO. 6
16. P38 PANEL
17. FREQUENCY AND LOAD CONTROLLER NO. 5
18. GENERATOR CONTROL UNIT NO. 5
19. P26 PANEL

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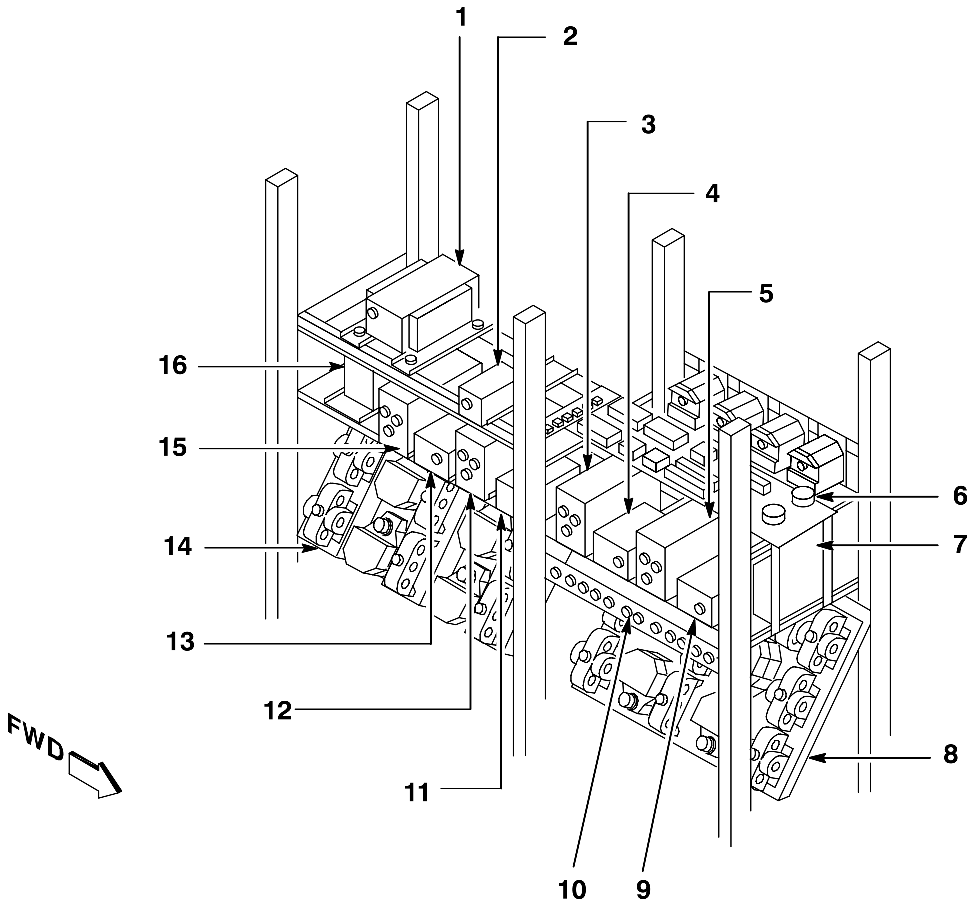
Figure 1-16 (Sheet 6 of 7)



K **EQUIPMENT RACK E15**

1. EMERGENCY LIGHTING BATTERY CHARGER
2. FREQUENCY REFERENCE UNIT
3. GENERATOR CONTROL UNIT NO. 3
4. FREQUENCY AND LOAD CONTROLLER NO. 3
5. GENERATOR CONTROL UNIT NO. 4
6. COMM DISCONNECT RELAY ASSEMBLY (E15-90)
7. MAINTENANCE ANNUNCIATOR
8. P23 PANEL
9. FREQUENCY AND LOAD CONTROLLER NO. 4
10. P37 PANEL
11. FREQUENCY AND LOAD CONTROLLER NO. 2
12. GENERATOR CONTROL UNIT NO. 2
13. FREQUENCY AND LOAD CONTROLLER NO. 1
14. P25 PANEL
15. GENERATOR CONTROL UNIT NO. 1
16. EXTERNAL POWER TRANSFORMER RECTIFIER

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Figure 1-16 (Sheet 7 of 7)

SUBSECTION I-B
ENGINES

Table of Contents

SUMMARY

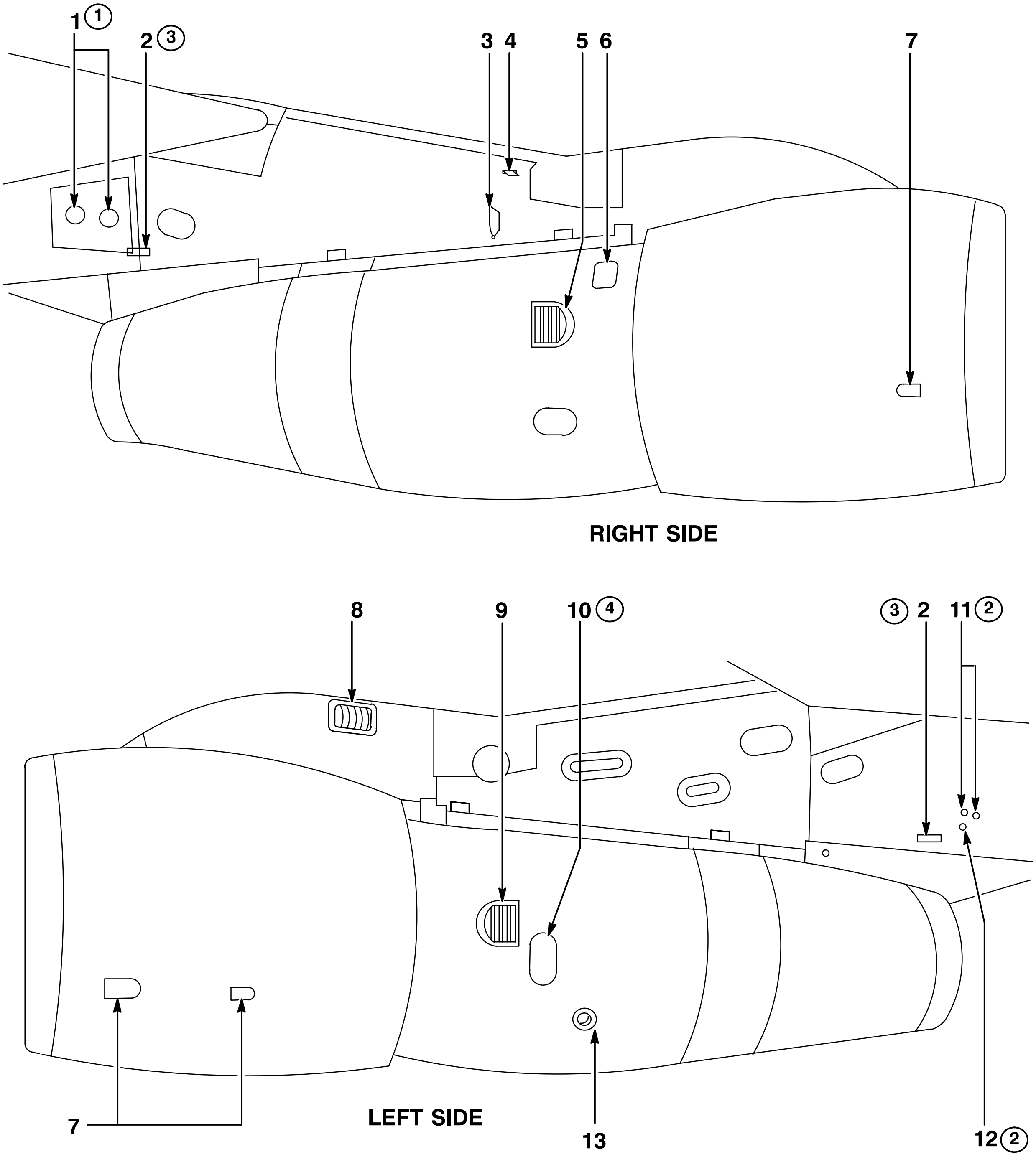
The airplane is powered by four Pratt and Whitney TF-33-PW-100A turbofan engines (*figure 1-17*), supported individually in strut mounted nacelles beneath the wing. Each engine has two tandem mounted compressors on concentric shafts, and with their respective turbines, comprise two rotor systems that are mechanically independent but related by airflow. The low pressure compressor (N_1) consists of two large diameter fan stages, plus seven smaller diameter compression stages, and is driven by three turbine stages. The high pressure compressor (N_2) has seven stages and is driven by a single turbine stage. Inlet air is compressed through the two fan stages and is divided into two flowpaths. The outer layer of air is discharged into two ducts and vented overboard at the aft end of the fan cowl. The inner core airflow continues to be compressed in the compressors and flows through the diffuser case which reduces the air velocity. Fuel is mixed with the compressed air, ignited, and burns in the eight combustion chambers. The resultant expanding gas flows through the reaction turbines which drive the compressors and accessories, and is expelled out the exhaust nozzle. The high pressure (N_2) turbine drives engine accessories through reduction gears.

ENGINE THRUST

The engine is flat rated to provide constant thrust at sea level over a wide range of ambient temperatures. Below 15°C, the installed engine develops approximately 20,500 pounds of static thrust. Above 15°C, thrust decreases linearly with increased temperature, to approximately 19,100 pounds at 35°C.

Engine Nacelle

NO. 2 ENGINE SHOWN



RIGHT SIDE

LEFT SIDE

① OUTBOARD SIDE OF INBOARD STRUTS ONLY

② INBOARD SIDE OF INBOARD STRUTS ONLY

③ BOTH SIDES OF ALL STRUTS

④ LEFT SIDE OF ALL ENGINES

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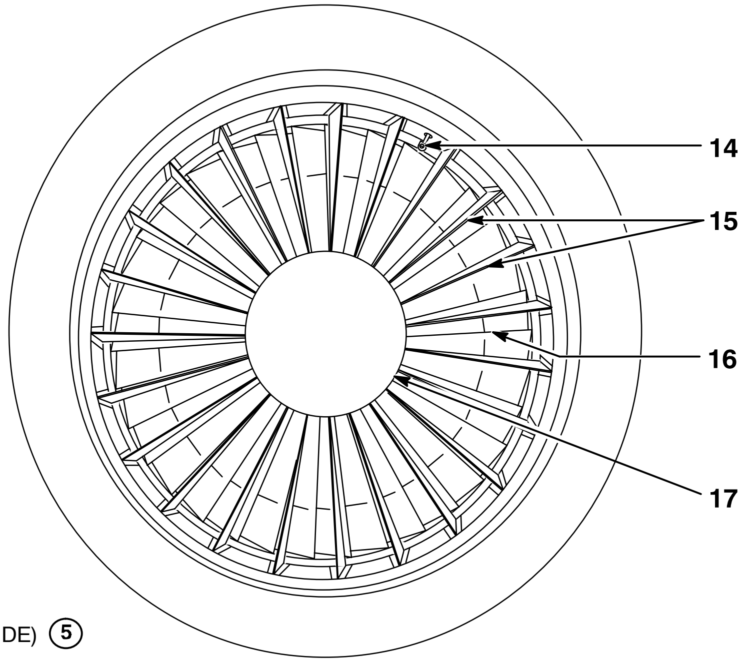
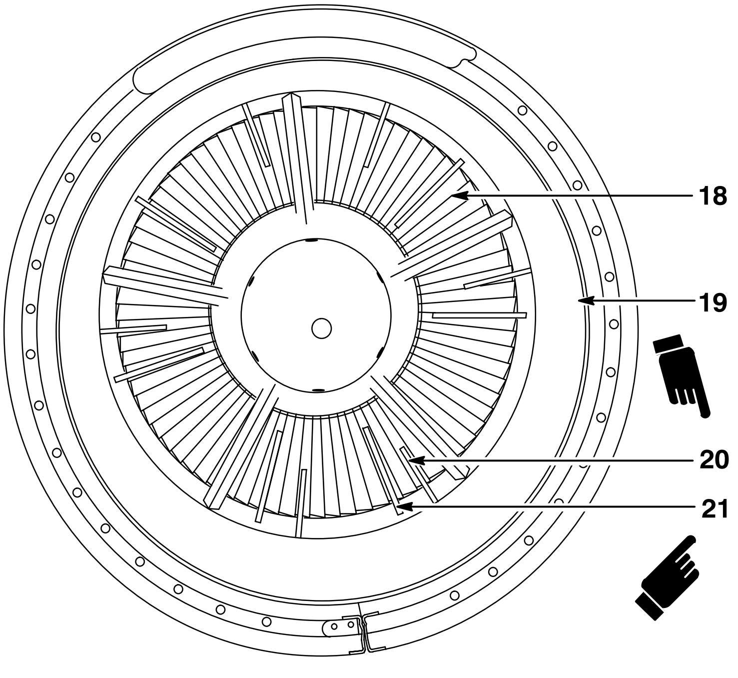
Figure 1-17 (Sheet 1 of 2)



1. FIRE BOTTLE PRESSURE GAGES (2 PLACES)
2. DROOP STRIPE (2 PLACES) ③
3. MANUAL START VALVE RELEASE
4. EPR (P_{t2}) PROBE
5. 6 INCH SURGE BLEED VALVE EXHAUST (RH SIDE) ⑤
6. OIL TANK ACCESS DOOR
7. NOSE COWL ANTI-ICE EXHAUST (3 PLACES)
8. BLEED AIR PRECOOLER EXHAUST
9. 4 3/4 INCH SURGE BLEED VALVE EXHAUST (LH SIDE) ⑥
10. FIRE EXTINGUISHER ACCESS
11. FIRE BOTTLE THERMAL DISCHARGE INDICATORS (RED) (2 PLACES)
12. FIRE BOTTLE DISCHARGE INDICATOR (YELLOW)
13. OIL BREATHER
14. SURGE BLEED VALVE P_{t2} PROBE
15. INLET GUIDE VANES
16. FAN BLADES
17. NOSE DOME
18. TURBINE WHEEL
19. EXHAUST NOZZLE
20. T_{t7} PROBES (6 PLACES)
21. EPR (P_{t7}) PROBES (6 PLACES)



⑤ VALVE NORMALLY OPEN WHEN ENGINE SHUT DOWN

⑥ VALVE NORMALLY CLOSED WHEN ENGINE SHUT DOWN

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Figure 1-17 (Sheet 2 of 2)

ENGINE CONTROLS

Engine controls include the throttles (*figure 1-9*), ignition and start switches, fuel system controls and fire switches. Engine controls are described in *figure 1-18*.

The throttle is the primary thrust control for the engine. The throttle also operates the engine fuel shutoff valve and firewall fuel shutoff valve and turns on the engine ignition for starting if the start selector switch is not OFF. For engine starting, and shutdown, the throttles have two stop positions at the idle end of the normal operating range. These positions are:

IDLE STOP (idle):	Engine fuel shutoff valve and firewall fuel shutoff valve open, ignition initiated, fuel heat armed.
CUTOFF STOP (cutoff):	Engine fuel shutoff valve and firewall fuel shutoff valve closed, ignition and fuel heat disarmed.

The lever must be pulled up to leave cutoff, or to move below idle. For starting, the lever must be forward of cutoff approximately two to seven degrees to operate ignition and the start selector switch must be set to GND START or FLT START.

NOTE

When retarding throttle to idle, press knob toward handle to prevent lifting over stop into cutoff range.

ENGINE INSTRUMENTS

Engine instruments are located on the pilots' center panel (*figure 1-5*) and on the engineer's panel (*figure 1-12*). Engine instruments on the center panel are the vertical scale type. These include engine pressure ratio (EPR), low pressure compressor rpm (N_1) exhaust gas temperature (EGT) fuel flow gages, and caution lights to indicate blocked oil filter or low oil pressure. Instruments on the engineer's panel include high pressure compressor rpm (N_2), oil pressure, oil temperature, oil quantity gages and IDG oil temperature indicators. Air pressure in the bleed air system (used for start engines) is indicated by the duct pressure gage on the engineer's panel. Engine instruments are described in *figure 1-18*.

ENGINE PRESSURE RATIO (EPR) INDICATORS

Engine pressure ratio indicators show the ratio of exhaust total pressure (P_{t7}) to inlet total pressure (P_{t2}), which is a measure of the net thrust developed by the engine. The indicators are driven electrically by a transmitter on the engine, which receives the P_{t2} signal from a pitot tube on the engine strut, and a P_{t7} signal from probes in the exhaust stream. The indicators are powered by 115 vac.

If EPR exceeds 2.5, the OFF flag appears and power to the indicator is removed. If the OFF flag is in view, crosscheck other engine instruments before assuming power to gage has failed.

LOW PRESSURE COMPRESSOR (N_1) TACHOMETERS

The low pressure compressor (N_1) tachometers on the pilot's center panel are operated by 115 vac power to the indicator and by self-contained tachometer generators on the engines. The indicators are graduated in percent rpm with 100% equal to approximately 6,800 rpm. Since the low pressure compressor rpm varies with throttle setting, N_1 can be used as a backup for a damaged or nonfunctioning EPR indicator (with charts in T.O. 1E-3A-1-1), the tolerance is ±2% below 95% N_1 and ±1% above 95% N_1.

If N_1 RPM exceeds 110%, the OFF flag appears and power to the indicator is removed. If the OFF flag is in view, crosscheck other engine instruments before assuming power to gage has failed.

EXHAUST GAS TEMPERATURE INDICATORS

Exhaust gas temperature (EGT) is measured by six thermocouples in the exhaust nozzle of each engine. 115 vac electrical power is required to operate the system. The indicators are graduated in degrees Celsius.

CAUTION

If the exhaust gas temperature exceeds 700°C, the OFF flag appears and power is removed from the gage. If the OFF flag is in view, crosscheck other engine instruments before assuming power to gage has failed.

FUEL FLOW GAGES

Engine fuel flow gages, showing fuel flow in pounds per hour, are located on the center instrument panel. 115 vac power for the gages and fuel flow transmitters is supplied from panel P61-1. A fuel flow transmitter is located near the top of each engine strut. The mark at 2,000 PPH fuel flow indicates approximate upper limit fuel flow corresponding to entry into compressor airflow instability zone. Refer to section V for limits on engine fuel flow limitations Vs gen load.

If fuel flow exceeds 14,000 pph, the OFF flag appears and power to the indicator is removed. If the OFF flag is in view, crosscheck other engine instruments before assuming power to gage has failed.

HIGH PRESSURE COMPRESSOR (N_2) TACHOMETERS

The high pressure compressor (N_2) tachometers, located on the flight engineer's panel (*figures 1-12* and *1-18*) are conventional, round-dial gages, driven by a tachometer generator on each engine. The tachometers operate without outside electrical power. The gages are graduated in percent of rpm with 100 percent equal to approximately 9,650 rpm.

OIL PRESSURE GAGES

Oil pressure at the oil filter outlet is indicated by conventional oil pressure gages, graduated in pounds per square inch. The oil pressure gages are mounted on the flight engineer's panel. The gages are operated electrically by 28 vac power. Allowable tolerance for the oil pressure gage system is ±5 psi. Refer to INSTRUMENT MARKINGS and OIL PRESSURE LIMITATIONS, section V.

OIL TEMPERATURE GAGES

Oil temperature gages, graduated in degrees Celsius, mounted on the flight engineer's panel indicate the temperature of the oil supplied to the bearings. The gages are electrically operated by 28 vac power.

OIL QUANTITY GAGES

Oil quantity gages, mounted on the flight engineer's panel, indicate the quantity of oil in the engine oil tank in gallons. Quantity is measured by a probe in the tank. Minimum measurable quantity is 1/2 gallon. Gage readings can be ±1/4 gallon from actual quantity. Therefore, minimum gage reading can be as low as 1/4 gallon. The gages require 28 vdc power. If power to gage is lost, pointer is moved below zero.

IDG OIL TEMPERATURE INDICATORS

Four dual-channel IDG oil temperature indicators, mounted on the flight engineer's panel, indicate the current temperature of the oil supply circulating through each of the eight integrated drive generator assemblies. Each individual indicator channel independently monitors and displays the oil temperature of its associated IDG and, in the event the oil temperature reaches 163 ± 5°C. will cause the OHEAT segment of the associated IDG DISC switchlight and the copilot's IDG OHEAT warning annunciator to illuminate. Indicator scales are graduated from 0 to 200°C, with a CAUTION band from 155°C to 200°C. The indicators are operated by 28 vdc power supplied from a circuit breaker on the P61-5 panel. Indicator testing is provided by a test circuit module and a spring-loaded control switch, panel-mounted adjacent to the indicators. Activation of the test switch causes all indicator channels to read above 190°C, the OHEAT segment of all eight IDG Disc Switchlights to illuminate, and the Copilot's IDG OHEAT Warning Annunciator to illuminate.

BLEED AIR PRESSURE (DUCT PRESSURE) GAGE

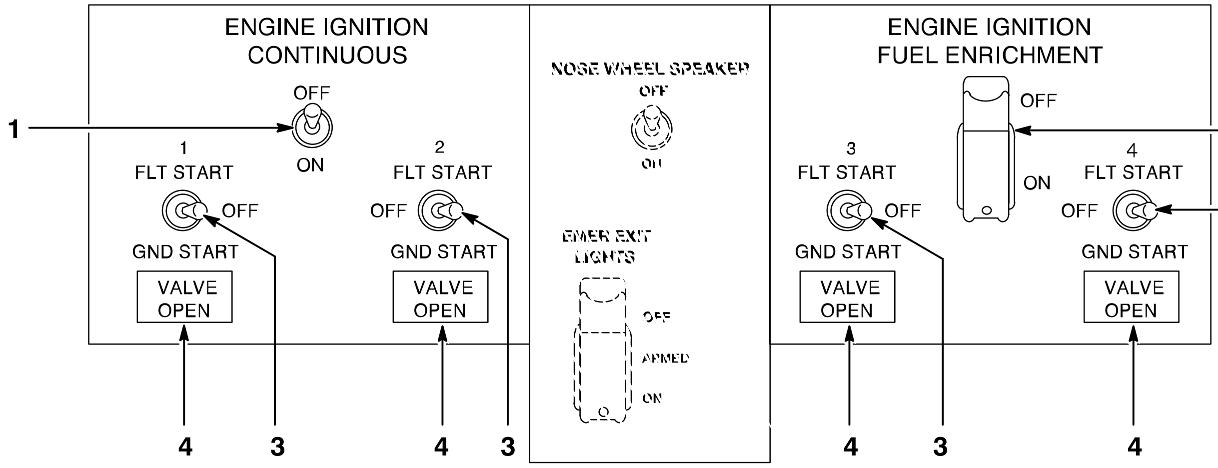
The duct pressure gage, mounted on the flight engineer's panel, indicates the air pressure in the bleed air ducts in pounds Per Square Inch (psi). A separate pointer is provided for the left and right wing ducts.

ENGINE FUEL SYSTEM

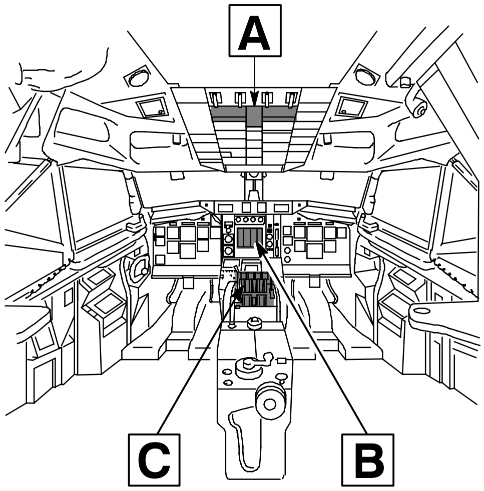
The engine fuel system receives fuel from the fuel tanks, fuel tank boost pumps or crossfeed manifold and delivers it to the fuel control unit. System components are shown in *figure 1-19*.

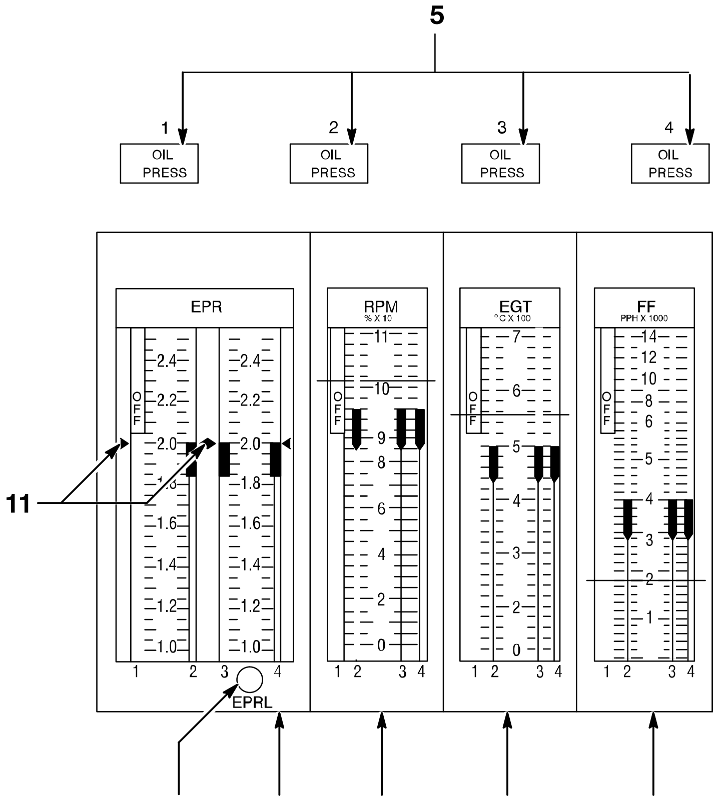
The engine fuel shutoff valve is located in the fuel control unit and is controlled by the throttle lever (*figure 1-18*). The fire wall fuel shutoff valve in the wing dry bay is controlled by the engine fire switch and throttle (*figure 1-18*). Pulling the fire switch closes the valve, regardless of throttle position. Fuel from the tank flows through the shutoff valve, then through the fuel flowmeter transmitter, into the first stage of the engine fuel pump. Fuel leaving the pump passes through the fuel heater and fuel filter, then into the second stage of the pump. Second stage pump discharge passes directly to the fuel control unit. Fuel leaving the fuel control unit passes through the fuel-oil cooler, which heats the fuel slightly, and into the engine fuel manifold.

Engine Controls and Indicators

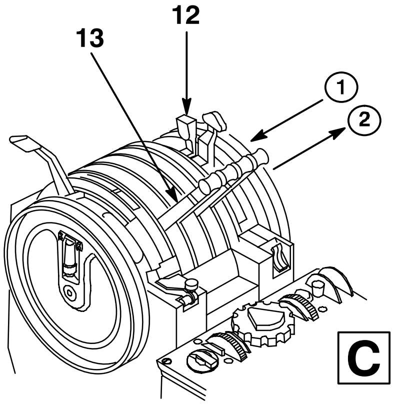


A PILOT'S OVERHEAD PANEL





B CENTER INSTRUMENT PANEL



C AISLE CONTROL STAND

① PRESS IN THIS DIRECTION WHEN RETARDING TO IDLE TO PREVENT JUMPING OVER STOP.

② LIFT IN THIS DIRECTION TO CLEAR IDLE/CUTOFF STOP.

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Figure 1-18 (Sheet 1 of 6)

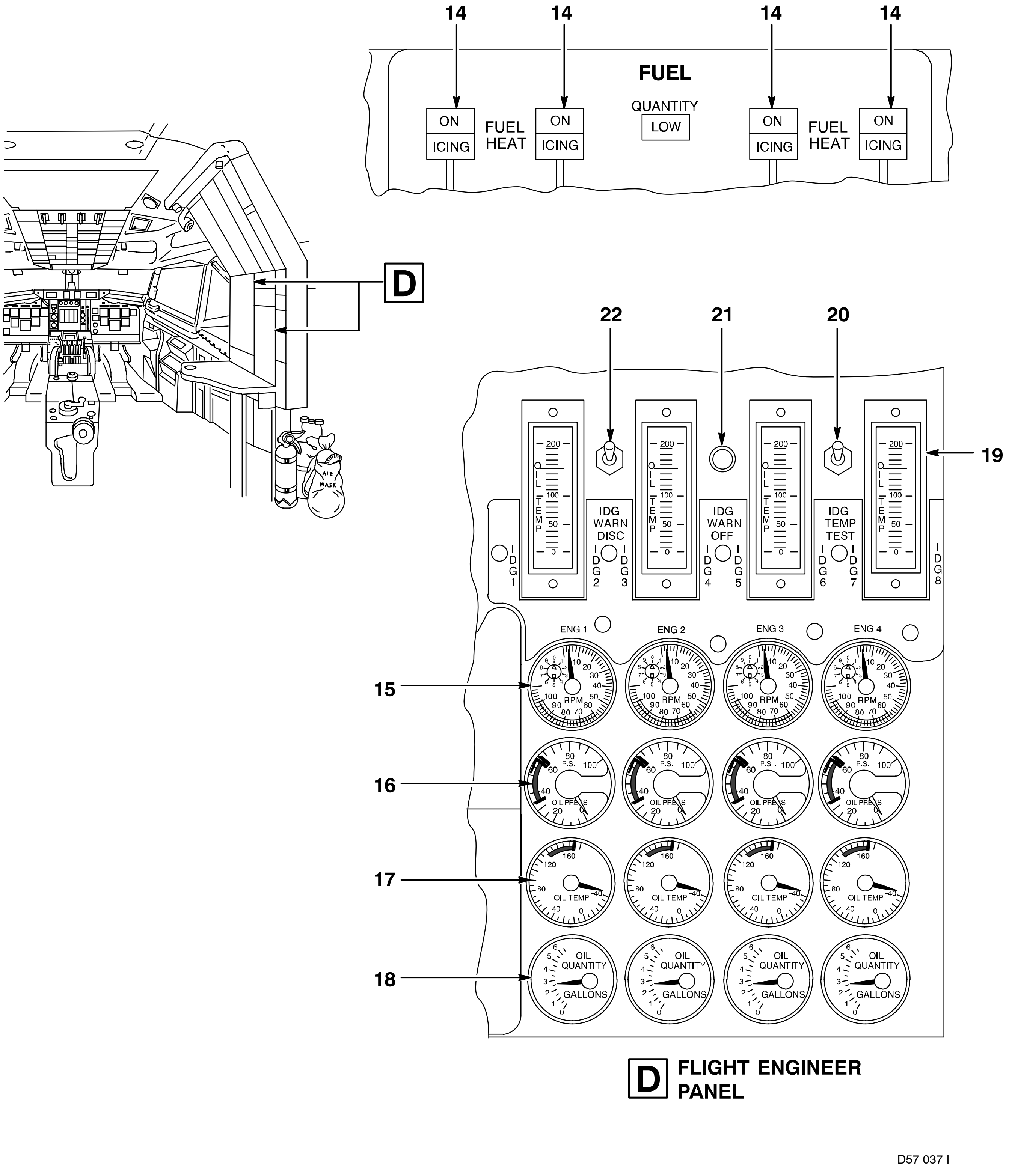


Figure 1-18 (Sheet 2 of 6)

Engine Controls and Indicators (Continued)

NO.	CONTROL/INDICATOR	FUNCTION
		A PILOT'S OVERHEAD PANEL
1	CONTINUOUS Ignition Switch	When set to ON, energizes continuous ignition system for all engines if throttles are forward of cutoff, start switches are OFF, and FIRE switches are in. Provides continuous ignition source to prevent engine flameout in turbulence, precipitation, icing, or in case of suspected EGW leak from liquid cooling system into fuel tank. When set to OFF, de-energizes continuous ignition. Continuous ignition is powered by the emergency AC bus.
2	FUEL ENRICHMENT Switch (Guarded)	When set to ON, opens fuel enrichment valves to allow increased fuel flow for engine starting in cold weather or high altitude with any alternate grade fuel. When set to OFF, fuel enrichment valves are closed. Fuel enrichment is mechanically shut off when fuel flow exceeds 1,500 pph.
3	FLT START–OFF–GND START Switches (Engine Start Selectors) (One per engine)	Three position switches. Mechanically latched in OFF position. Lever must be pulled out to move from OFF. Ignition operates only when throttle is forward of cutoff and fire switch is pushed in.
	OFF	Ignition is de-energized. Start valve is closed. Continuous ignition is armed. Switch is spring loaded to OFF from GND START.
	FLT START (Flight Start)	Switch is mechanically held in FLT START. When set to FLT START, ignition is armed, continuous ignition is de-energized, start valve remains closed.
	GND START	Spring loaded to OFF. When set (and held) to GND START, switch arms ignition, de-energizes continuous ignition, and opens start valve.

CAUTION

Do not use GND START position in flight, or attempt to re-engage starter on a rotating engine. Starter drive can be damaged.

4	VALVE OPEN Indicators (Green) (One per engine)	VALVE OPEN indicator illuminates when engine start duct is pressurized downstream of engine start valve.

Figure 1-18 (Sheet 3 of 6)

NO.	CONTROL/INDICATOR	FUNCTION
		B CENTER INSTRUMENT PANEL
5	OIL PRESS Caution Light (Amber) (One light per engine)	When illuminated, indicates engine oil pressure at filter outlet is below 32 psi or the pressure differential across the oil filter reached 50 psid. Pressure switch normally opens at 36 psig on start causing caution lights to go out.
		NOTE When starting engines, the OIL PRESS caution light may remain illuminated, or illuminate intermittently, for up to four minutes after the oil temperature reaches 40°C at idle rpm. The light shall be out four minutes after the oil temperature reaches 40°C.
6	FF Gage (Fuel Flow) (Single unit with 4 scales, one for each engine)	Moving tape indicates fuel flow to engine in thousands of pounds per hour. Operated by fuel flow transmitter in engine nacelle strut. OFF flag appears if power from transmitter is interrupted or fuel flow exceeds 14,000 PPH. Yellow line at 2,000 PPH indicates approximate upper limit fuel flow corresponding to entry into compressor instability zone. Refer to section V for limits on fuel flow versus generator load.
7	EGT (Exhaust Gas Temperature) Gage (Single unit with 4 scales, one for each engine)	Moving tape indicates exhaust gas temperature for each engine in degrees Celsius. OFF flag appears if power to gage is interrupted or EGT exceeds 700°C. Red line indicates limit of 555°C.
8	N_1 RPM % Gage (Single unit with 4 scales, one for each engine)	Moving tape on vertical scales indicate speed of each low pressure (N_1) compressor in percent RPM. 100% N_1 is approximately 6,800 RPM. Operated by tachometer generator on engine and 115 vac electric power to indicator. Can be used as a backup for EPR gage with charts in T.O. 1E-3A-1-1. OFF flag appears if power is removed from unit or N_1 RPM exceeds 110%. Red line indicates limit of 101.1% N_1. Tolerance is ±2% below 95% N_1, ±1% above 95% N_1.
9	EPR (Engine Pressure Ratio) Gage (Single unit with 4 scales, one for each engine)	Moving tape on scale indicates engine pressure ratio (EPR, P_{t7}/P_{t2}) for each engine. OFF flag appears if power to one unit of gage is interrupted or EPR exceeds 2.5. Tolerance is ±0.01 EPR.
10	EPRL (EPR Limit) Knob	Used to set bugs (11) to desired setting or limit. Push knob in and turn to set outboard bugs. Pull and turn to set inboard bugs.
11	Limit Pointers (Bugs)	Used to indicate limit or desired condition. Set by EPRL knob (10).

Figure 1-18 (Sheet 4 of 6)

Engine Controls and Indicators (Continued)

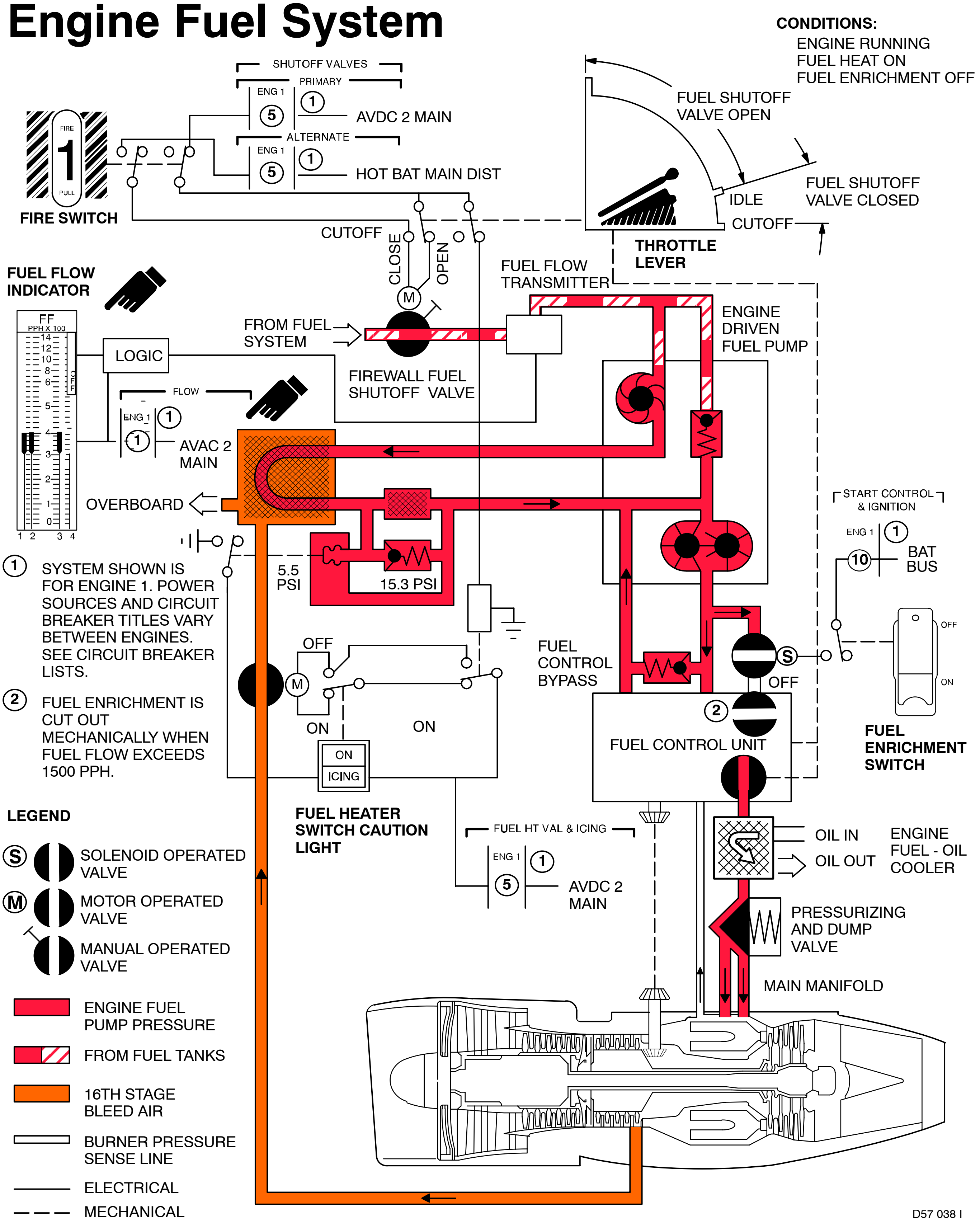
NO.	CONTROL/INDICATOR	FUNCTION
	C AISLE CONTROL STAND	
12	Throttle FRICTION Control (Friction Lever)	Controls setting of throttle friction device. Moving friction lever forward increases friction. Moving friction lever aft decreases friction.
13	Throttles (4)	Operate engine fuel control unit by cables, to control fuel flow to engine. In lower portion of operating range also operate engine fuel shutoff valve and firewall fuel shutoff valve and arm engine ignition. IDLE STOP (idle) position is lower end of normal operating range. Movement forward from idle increases engine thrust. Movement aft toward idle decreases thrust. When throttle is set between idle and CUTOFF STOP (cutoff), engine fuel shutoff valve and firewall fuel shutoff valve operate. Throttle must be pulled up to clear idle. When lever is set to cutoff, engine fuel shutoff valve and firewall fuel shutoff valve close, ignition is disabled, and fuel heat valve closes. Due to individual engine adjustments, throttles do not always align perfectly at same indicated EPR. Maximum allowable misalignment at cruise is 1/2 knob width.
	D FLIGHT ENGINEER PANEL	
14	FUEL HEAT Switch/Caution Lights (Amber/Green) (One per engine)	Amber ICING caution light illuminates when pressure drop across fuel filter closes pressure switch. When depressed (ON), commands motor operated valve to admit 16th stage bleed air to fuel heater and illuminates green ON indicator. In released (OFF) position, ON indicator goes out and valve is commanded closed.
15	N_2% RPM Gages (One per engine)	Pointer indicates speed of high-pressure (N_2) compressor of engine in percent RPM. 100% N_2 is approximately 9,650 RPM. Gages are operated by tachometer generator on engine and will operate without outside electrical power source. If tachometer generator fails, pointer moves to zero.
16	OIL PRESS Gages (One per engine)	Indicate pressure (±5 psi) of oil leaving oil filter in psi. Gages are operated electrically. If power is lost, pointer moves below zero.
17	OIL TEMP Gages (One per engine)	Indicate temperature of oil supplied to engine bearings in degrees Celsius. If power to gage is lost, pointer moves to zero. If temperature probe or wiring is defective, pointer moves to full scale (high) position.

Figure 1-18 (Sheet 5 of 6)

NO.	CONTROL/INDICATOR	FUNCTION
18	OIL QUANTITY Gages (One per engine)	Indicate quantity of oil in engine tank in gallons. Quantity is sensed by a resistance probe in tank. Minimum quantity sensed is 1/2 gallon. Minimum quantity indicated is 1/2 ± 1/4 gallon. Pointer moves below zero if power to gage is lost.
19	IDG Oil Temperature Indicators (One per engine)	Pointer for each indicator channel indicates internal oil temperature of its associated IDG. Each channel contains an overheat warning circuit which causes the associated IDG DISC OHEAT segment and copilot's IDG OHEAT annunciator to illuminate if IDG oil temperature reaches 163°C ±5.
20	IDG TEMP TEST Switch	When placed to down position, causes all IDG Oil Temperature Indicator Channels to drive to above 190°C, all IDG Disc Switchlight OHEAT Segments to illuminate, and Copilot's IDG OHEAT Annunciator to illuminate. Switch is spring-loaded to OFF (UP) position.
21	IDG WARN OFF Indicator Lamp	Illuminates when copilot's IDG OHEAT warning annunciator is disconnected from the IDG oil temperature indicating system via the IDG WARN DISC control switch. Indicator has press-to-test function and variable aperture (dimmable) lens.
22	IDG WARN DISC Control Switch	When placed to down position, disconnects copilot's IDG OHEAT warning annunciator from IDG oil temperature indicating system. This causes the IDG WARN OFF indicator to illuminate and extinguishes the copilot's IDG OHEAT annunciator, if illuminated.

Figure 1-18 (Sheet 6 of 6)

Engine Fuel System



① SYSTEM SHOWN IS FOR ENGINE 1. POWER SOURCES AND CIRCUIT BREAKER TITLES VARY BETWEEN ENGINES. SEE CIRCUIT BREAKER LISTS.

② FUEL ENRICHMENT IS CUT OUT MECHANICALLY WHEN FUEL FLOW EXCEEDS 1500 PPH.

LEGEND

Ⓢ SOLENOID OPERATED VALVE

Ⓜ MOTOR OPERATED VALVE

MANUAL OPERATED VALVE

🟥 ENGINE FUEL PUMP PRESSURE

▨ FROM FUEL TANKS

🟧 16TH STAGE BLEED AIR

▭ BURNER PRESSURE SENSE LINE

—— ELECTRICAL

– – – MECHANICAL

Figure 1-19

ENGINE FUEL CONTROL UNIT

The engine fuel control unit is a hydraulic/mechanical fuel metering unit which is governed by throttle position, high pressure compressor rpm (N_2), and engine burner pressure to control engine speed and thrust.

NOTE

> If the N_2 rpm sensing shaft breaks, engine fuel flow stabilizes between normal rated thrust and takeoff thrust. Throttle movement does not control engine power or rpm. Refer to ENGINE FAILURE OR FIRE, section III.

ENGINE FUEL HEATERS

Each engine is equipped with a fuel heater which is heated by 16th stage bleed air from the engine. The fuel heater is used to heat the fuel entering the fuel filter (*figure 1-19*) to prevent ice crystals in the fuel from blocking ports in the fuel control and clogging the filter. The motor operated fuel heat valves are controlled by the FUEL HEAT switches (*figure 1-18*).

FUEL HEATER GROUND OPERATION

Fuel heat shall be used on all engines for one minute before takeoff when the fuel temperature in any tank is 0°C or below. (If using center tank fuel assume fuel is at outside air temperature.) Fuel heat shall not be used during takeoff. Fuel heat may be used at idle thrust if engines have been at idle for five minutes or more. If engines have not been at idle for at least five minutes, increase fuel flow to 1,500 pph or above while using fuel heat and for two minutes after using fuel heat. This will ensure traces of ice have been cleared from the fuel control unit in the event of a rejected takeoff.

CAUTION

> The fuel control unit uses fuel pressure to regulate operation of some internal components. At idle fuel flow, many of the ports and components are in closed position and cannot be clogged by ice (dislodged from the fuel filter by fuel heat operation). As fuel flow increases, these ports and components gradually move to their open position. When fuel flow increases to 1,500 pounds per hour, all of these components are in their full open position. Also, warm fuel from the fuel heater heats the fuel control so that any water which reaches the fuel control from the fuel heater does not freeze. When fuel flow is reduced to idle, it can take up to five minutes for the internal ports to close in the fuel control. If fuel heat is applied during this five minute period, it could cause blocking of a fuel passage by ice.

FUEL HEATER OPERATION DURING FLIGHT

When ice or contamination in the fuel blocks the fuel filter. the pressure drop across the filter rises and causes the ICING caution light to illuminate (*figure 1-18*).

If the ICING caution light is illuminated or the fuel flow is fluctuating for any unexplained reason, operate fuel heat and continue for 30 seconds after the ICING light goes out, but not over one minute total time.

CAUTION

- If the ICING caution light remains illuminated after one minute of fuel heater operation or illuminates repeatedly, the cause is probably not fuel icing. Continued operation of the engine with ICING caution light illuminated should not be attempted unless required for safety of flight. If fuel temperature in tank feeding engine is above 0°C, fuel icing is not likely.

- Fuel heat will not be used during takeoff run, final landing approach, or go-around.

- Maintain engine fuel flow of at least 1,500 pounds per hour while using fuel heat and for two minutes after using fuel heat.

- It is not necessary to shut down an engine if the fuel heater cannot be turned off. However, maintain fuel flow of at least 1,500 pph and monitor oil temperature.

If the fuel temperature in any main wing tank (TAT if using center tank) drops to 0°C or below and using fuel without icing inhibitor (fuel other than JP-4, JP-5, or JP-8: NATO F-40, F-44, or F-34), turn on the fuel heaters on all engines for one minute at 30-minute intervals.

ENGINE FUEL ENRICHMENT SYSTEM

The fuel enrichment system is used for ground starting of cold soaked engines at low temperatures (when the outside air temperature is at or below zero degrees Celsius) and air starting of engines above 15,000 feet when using JP-5, JP-8, or JET A/Al fuels. This system is not required with JP-4 fuel. When the FUEL ENRICHMENT switch on the pilots' overhead panel (*figure 1-18*) is set to on, the system supplies additional fuel (more than normally supplied through the fuel control) to the engine during starts. The additional fuel is automatically shut off any time fuel flow exceeds 1,500 pph. The fuel enrichment switch should be turned off after engine starting is completed in order to prevent possible damage to the valve solenoid resulting from continuous operation. Power to operate the fuel enrichment valves come from the battery bus through the START CONTROL & IGNITION circuit breakers.

CAUTION

- Do not use fuel enrichment to attempt to increase fuel flow during engine stall recovery. Added fuel flow in this condition can cause engine damage. (Refer to ENGINE STALL RECOVER, section III.)
- If aviation gasoline is used as fuel (refer to section V) do not use fuel enrichment, regardless of outside temperature. Fuel flow is sufficient for starting at any outside temperature without fuel enrichment. Added fuel flow could increase EGT and damage engine.

ENGINE STARTING SYSTEM

Each engine is equipped with an air turbine starter, geared to the N_2 compressor. The starter operates on low pressure (20 to 60 psig) air from the bleed air manifold. Lower pressures are required at high altitudes and high temperatures (high density altitude). Higher pressures are required at low altitude and low temperatures (low density altitude). Air for starting can be provided by the APU, another engine, or a ground starting unit. A connection for ground starting air is provided in the right wing root fairing. Starter controls include starter and ignition selector switches on the overhead panel (*figure 1-7*), the throttles (*figure 1-9*), and the air-conditioning and bleed air controls on the engineer's panel (*figure 1-11*). A schematic of the system is shown in *figure 1-20*.

If the start valve fails to operate electrically, it may be manually opened. Refer to ENGINE OPERATION.

ENGINE IGNITION SYSTEM

There are two, 18 joule ignition systems for each engine (*figure 1-20*). The ground and flight start system operates ignitor plugs in burner cans 4 and 5. The continuous system operates one ignitor plug in burner can 4.

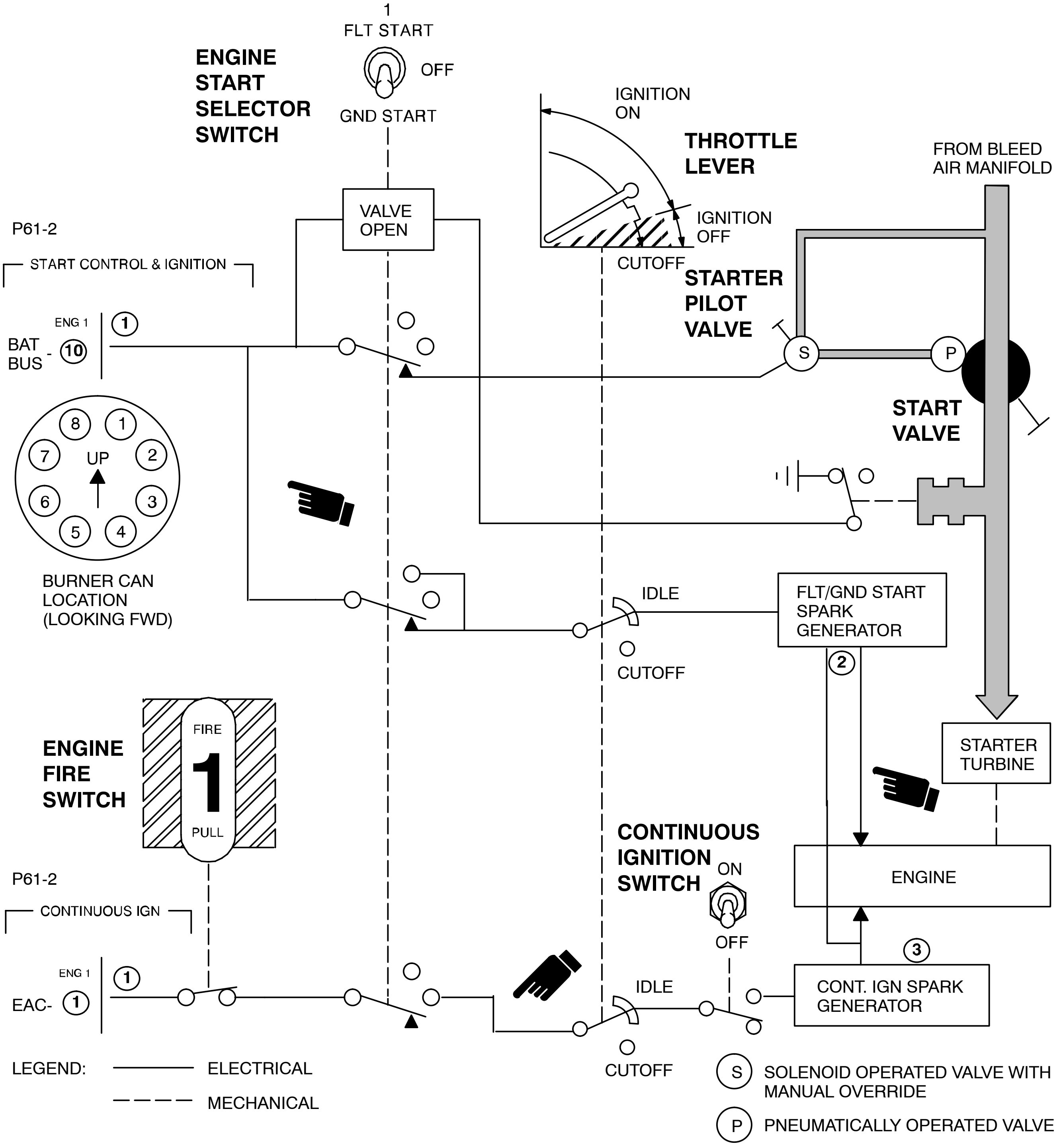
The ground and flight system is used for ground and flight starts. There is a starter-ignition switch for each engine (*figure 1-18*) on the overhead panel. The GND START position opens the start valve and arms the ground and flight start system. Also, power to the associated engine continuous ignition system is interrupted. The FLT START position arms the ground and flight start system and shuts off engine continuous ignition to that engine. The throttle must be out of cutoff to energize the ground and flight start system.

ENGINE SURGE BLEED SYSTEM

Each engine is equipped with a surge bleed system to prevent compressor stalling during certain phases of engine operation. This system is required since the stages of the twin spool compressor assembly are only designed to perform at optimum efficiency at or near normal operating RPM.

In order to prevent compressor stall and surge when operating at low RPM, or during acceleration from standstill to steady RPM (during start), or during deceleration, a surge bleed system is incorporated consisting of a 6-inch diameter bleed valve (5, *figure 1-17*), located on the right side of the compressor case, and a 4-3/4 inch diameter bleed valve (9, *figure 1-17*), located on the left side of the compressor case. These valves are controlled by differential pressure sensed between a probe (14, *figure 1-17*) in the compressor inlet and the ninth stage, and can relieve 12th stage pressure when open. The actuation pressure for the system is obtained from the 16th stage air.

Engine Starting and Ignition System



① SYSTEM SHOWN IS FOR ENGINE NO 1. CIRCUIT BREAKER TITLES VARY BETWEEN ENGINES. REFER TO CIRCUIT BREAKER LISTS.

② FIRES THE IGNITOR PLUGS IN BURNER CANS 4 AND 5.

③ FIRES THE IGNITOR PLUG IN BURNER CAN 4 ONLY.

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Figure 1-20

The control for the surge bleed system is designed so that the 4 3/4-inch valve remains closed during all operating conditions except during rapid deceleration, when it opens to assist the 6-inch valve to relieve the 12th stage pressure. The 6-inch valve is open when the engine is not operating and remains open until N_2 compressor RPM reaches approximately 80% RPM, when it closes. Above 80% N_2 RPM, this valve opens during rapid deceleration and when the engine approaches a compressor stall.

During normal, on-speed operation, both bleed valves remain closed until N_2 RPM is reduced below 80% RPM, when the 6-inch valve again opens. The 12th stage air, when relieved by either or both of the two bleed valves, is vented overboard. The only indication of surge bleed valve opening visible from the flight deck is a slight EPR drop. The 6-inch bleed valve must be open for engine start, or a hung start results. Refer to ENGINE (COMPRESSOR) STALLS AND SURGES, this section.

NOTE

Momentary asymmetric thrust can occur when throttles are retarded. This asymmetric thrust is due to variations in surge bleed valve operation. The condition usually corrects itself within 3 to 5 seconds without further pilot action. Since the action of individual surge bleed valves varies with the rate of throttle movement, the same pattern of asymmetric thrust does not occur each time throttles are retarded.

ENGINE OIL SYSTEM

Each engine has a self contained lubricating oil system which supplies the main engine bearings and accessory drives. The oil tank has a total volume of 6.8 U.S. gallons. A quantity gage on the flight engineer's panel is used to measure the oil tank quantity. The full indication is approximately 6.0 U.S. gallons.

NOTE

- When engine is shut down, oil can flow from the tank into the engine. Oil quantity checks must be made within 30 minutes of engine shut down, for accurate reading. Using the gages after 30 minutes can cause overfilling of the engine oil tank.
- Under some operating conditions, oil scavenging is not complete, so the oil quantity appears to decrease. This is caused by overheated oil foaming in a scavenge pump, blocking the flow. Refer to LOW OR FLUCTUATING OIL QUANTITY, Section III.

Oil flows by gravity to the engine driven oil pump. Oil pressure (measured at the oil filter outlet) is regulated and, if excessive, is returned to the pump inlet. The oil is filtered and directed to the engine bearings and accessory drives for lubrication and cooling. The oil is scavenged from the oil sumps and returned to the oil tank through the fuel-oil cooler located on the top right side of the engine and if oil temperature is high enough, through an air-oil cooler located in the bottom of the fan duct.

Minimum oil quantity for starting as shown on oil quantity gage is 1/4-gallon. Within one minute after start (five minutes at –65°F), check that the oil quantity gage indicates within two gallons of the servicing quantity noted in AFTO Form 781 or the quantity noted after engine shutdown. During start, the only positive indication of sufficient oil for operation is an increase in oil pressure within 30 seconds of start initiation. Oil quantity indication decreases up to two gallons when engine starts due to oil needed to fill engine lines, coolers, and oil passages.

If the oil filter becomes clogged for any reason, a bypass valve opens at a predetermined pressure and allows unfiltered oil to be routed around the oil filter and enter the engine. The oil pressure caution light illuminates (*figure 1-18*) if the system pressure is below 32 psig or if pressure across the oil filter reaches 50 psi differential which indicates the oil filter is being bypassed. Refer to OIL SYSTEM MALFUNCTIONS, Section III, ENGINE OIL PRESSURE LIMITATIONS, Section V, and Section VII for the appropriate procedures.

Heat absorbed from the oil in the fuel-oil cooler is transferred to the fuel which is used as a coolant. The oil flow through the fuel-oil cooler is controlled by a thermostatically controlled valve. This valve regulates the oil flow to maintain the oil temperature at the required value. If the oil temperature increases above a certain value, a separate regulator valve opens, allowing oil to flow through the air-oil cooler to provide additional oil cooling. Both oil coolers incorporate a pressure relief feature which allows oil to bypass the affected cooler if it becomes clogged. A breather system connects the oil tank, individual bearing compartments, and a breather chamber, all of which are vented overboard.

ENGINE OPERATION

Engine operation includes starting, inflight operation, and shutdown. Normal operating procedures are in section II. Emergency procedures are in section III. Limitations are in section V.

EXHAUST GAS TEMPERATURE AND ENGINE LIFE

Exhaust gas temperature (EGT), along with other engine parameters, indicates engine operating conditions. Careful analysis of abnormal indications will determine if the engine has exceeded its normal operating envelope or if the abnormality is in the indicating system. An erroneous temperature reading, an improper thrust setting, or an engine malfunction is indicated whenever the exhaust gas temperature limits are exceeded. Exhaust gas temperature is a good indication of how the engine is doing, but also it is usually one of the first indications of malfunction. Prolonged exposure to higher than normal temperatures will decrease the life of engine hot-section components and should be avoided. Certain inspections must be performed if temperature limits are exceeded. The extent of the inspection required depends upon the maximum temperature attained and the length of time that the temperature was above the allowable limit. When the allowable exhaust gas temperatures (as outlined in section V) are exceeded, the highest temperature reached and the time of operation in the overtemperature range must be noted so that suitable inspections can be performed.

The longer a turbofan engine is operated at any high level of thrust, the shorter is the life of the engine hot-section components, even though the allowable time and temperature limits are not exceeded. Good operating practice, therefore, dictates that high thrust settings, such as during takeoff, be used only as long as required.

Since instrument indications can lag the actual operating temperatures, care must be used. To prevent riding the red line during engine operation, throttle movement during operation with high power should be monitored carefully. Temperature indications can take longer to reflect an impending malfunction than other parameters, so all parameters should be considered carefully.

CAUTION

Prolonged engine operation at the limits of EGT and RPM shortens engine life.

GROUND STARTING

The normal ground starting air pressure source will be APU bleed air. Alternate starting methods are ground air source or cross start from an operating engine. A duct pressure of 20 to 60 psig as shown on the duct pressure gage is required for start. When starting an engine, N_2 rpm is a measure of starter cranking speed and of airflow through the high pressure compressor. N_1 rpm is a secondary measure of airflow and an indication that the low speed compressor is rotating. EGT is the first indication of combustion in the engine.

CAUTION

- A definite indication of N_1 rpm, either visually or on engine instruments, must be observed before moving throttles to idle (from cutoff).
- If ground crew has not called “rotation”, or N_1 RPM is not indicated by 25% N_2, release start switch and investigate cause before attempting another start.

NOTE

- If airplane is fueled with fuel other than JP-4 or AVGAS, fuel enrichment may be used for starting below 32°F (0°C).
- If airplane is fueled with fuel other than JP-4 or AVGAS, fuel enrichment must be used for starting below 0°F (–18°C).

NORMAL GROUND STARTING PROCEDURE

Refer to section II for starting procedure. Normal procedure uses electric operation of the start valve by the engine start selector switches. The starter disengages when the start selector switch is returned to OFF.

CAUTION

- If start valve fails to close when start selector is released (indicated by VALVE OPEN indicator illuminated, or no rise in duct pressure), call “no cutout” and terminate start by setting throttle to CUTOFF, closing wing ISOLATION valve(s), and shut off starter air source to avoid damage to the starter.
- Failure to hold engine start selector in GND START until 35% N_2 RPM is reached can result in a Hot Start. Refer to STARTING MALFUNCTIONS, section II.
- Do not attempt to re-engage starter until N_2 rotation has stopped. Starter drive shaft can shear if starter is engaged while engine is rotating.
- The BATTERY switch must be ON for all engine starts. FLT/GND START ignition, fire detection, and fire extinguisher receive power from the battery. Do not attempt to start engine with continuous ignition.
- Do not attempt engine starts without ac electrical power. All engine instruments, except N_2 tachometers, require ac power for operation.
- When engine rpm and EGT have stabilized after starter cutout, N_2 rpm should be between 54 and 60% and EGT below 340°C. N_1 rpm below 25% at this time is a sign of possible internal engine malfunctions.

ALTERNATE GROUND STARTING PROCEDURES

External Air Start

To start with external air, follow normal checklist procedure for APU start, except substitute external air for APU air. External electric power will be required if APU generator is inoperative.

WARNING

Reduce engine power to idle on operating engines before disconnecting ground air. High-pressure bleed air can cause hose to whip and injure ground crew if check valve fails to close.

Cross Start

After one engine is started, ground air or APU can be disconnected and engine bleed air used for cross-starting other engines. Under some conditions, up to 80 to 90% N_1 rpm on the engine supplying air can be required to obtain required duct pressure.

NOTE

- For normal operations, APU start is preferred to cross-start. Cross-start is noisier, uses more fuel, and is more dangerous to personnel and equipment behind the airplane.
- In order to save time for SCRAMBLE starts, the APU bleed valve can be closed after the first engine is started and the remaining engines cross-started. This allows the APU to begin the cool down period while engines are being started.

Manual Start

If an engine cannot be started because the starter pilot valve does not operate electrically, the starter valve can be operated manually. The manual start tool is stowed on the side of the left-hand flight avionics rack in the forward lower compartment. If interphone communication is available, the starting sequence is the same as a normal start (including use of start switches), except that the engineer must also call for “start valve open” or “start valve closed” on interphone. If interphone is not available, a signal man must be positioned where he can see the pilots and the valve operator. Pilot will brief ground crew on signals to be used.

To open the start valve manually, insert the point of the tool in the start valve release lug (3, *figure 1-17*) from above and push up on the handle. Maintain pressure on the valve until the engineer calls for valve closing. When pressure is released, the start valve should close by air pressure.

WARNING

- When performing a manual start, ground crew should use caution when in vicinity of fan duct exit nozzle. Air blast from operating engine could cause injury to personnel in fan discharge air path and in danger areas shown in section II.
- Leave throttle at idle after manual start until ground crewman is clear of fan discharge air stream.

CAUTION

If start valve does not close when released, notify pilot to shut down engine to prevent starter damage.

ENGINE WARMUP AND GROUND OPERATION

There is no requirement for engine warmup as long as oil pressure remains below 65 psi when the engine is accelerating to takeoff thrust. At temperatures below –18°C (0°F), a short warmup can be required. Refer to ENGINE LIMITATIONS, section V.

NOTE

When maintenance crews trim an engine, the bleed air and electrical loads are removed to give a standard test condition. If the rpm appears low, let the engine idle for 5 minutes, then remove bleed air and electric load from that engine and check N_2 rpm. Under these conditions, N_2 should be 56 to 58%. (With electrical and bleed air loads, rpm is lower.)

INFLIGHT STARTING PROCEDURE

Refer to ENGINE RELIGHT, section III.

THROTTLE KNOB ALIGNMENT

Throttle knobs do not always align perfectly when all engines are set to the same indicated EPR because of variations in individual engine fuel controls, adjustment of throttle linkage, bleed air flow fluctuations, and tolerances in EPR indicators. Throttle alignment is checked at low power during engine maintenance and at cruise (approximately 0.72 Mach) during functional check flights. When all engines are at the same cruise EPR, throttle knobs should align within one half knob width. (See *figure 1-21*.)

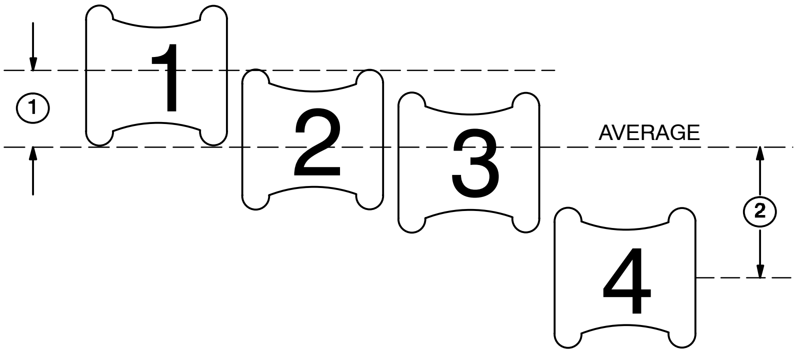
ENGINE FUEL FLOW AND GENERATOR LOAD

The high electrical loads on this airplane require more horsepower from the gearbox than on other airplanes with the same engines. The higher mechanical load changes engine acceleration under load. In some cases, it is possible to slow the N_2 turbine to the point where the engine stalls. To prevent this problem, a minimum fuel flow of 2,000 pounds per hour will be used when mission radar is operating in high power. Refer to ENGINE LIMITATIONS, section V.

ENGINE (COMPRESSOR) STALLS AND SURGES

Certain combinations of airspeed, fuel flow, electrical load, and engine rpm can cause an airflow condition in the engine compressor stages which is similar to the airflow around a stalled wing. This condition is referred to as engine (or compressor) stall or engine (or compressor) surge.

Engine Throttle Alignment Limits



① DIMENSION ① FROM CENTER OF NO. 1 THROTTLE TO AVERAGE (CENTER OF NO. 2 AND NO. 3 THROTTLES) IS 1/2 KNOB WIDTH (ACCEPTACLE).

② DIMENSION ② FROM CENTER OF NO. 4 THROTTLE TO AVERAGE (CENTER OF NO. 2 AND NO. 3 THROTTLES) IS ONE KNOB WIDTH (NOT ACCEPTABLE).

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Figure 1-21

ENGINE STALLS

Engine stalls, which are aerodynamic stalls of one or more compressor blades, are caused by a reduction in the airflow through the compressor. The usual cause of engine stalls is a rapid rise of engine burner air pressure, caused by moving the throttle too rapidly during acceleration. Other causes are moving the throttle too slowly on deceleration below 80% N_2 (in the range where the surge bleed valves should be opening), or an improper adjustment of the engine fuel control.

Engine stalls vary in intensity and duration, depending on the portion of the compressor which is actually stalled, from one stage to a complete high or low speed compressor.

CAUTION

Prolonged engine stalls can lead to high EGT and possible engine damage. Observe the fuel flow vs. generator load limits in section V.

If a stall occurs, as indicated by engine noise, decreasing N_2 rpm, or high EGT, immediately perform the ENGINE STALL RECOVERY procedure in section III.

ENGINE SURGES

Engine surges are momentary engine stalls. Surges usually last only a few seconds without any pilot action to correct the condition.

ENGINE STALL PREVENTION

To prevent (or reduce) engine stalls, follow the instructions below:

1. When increasing thrust, move throttle slowly (take approximately five seconds from idle to TRT). Observe the limitations in section V to avoid compressor stalls and surges.

2. When decreasing thrust, after N_2 RPM is below 80%, move throttle rapidly to desired setting. Observe the limitations in section V to avoid repeated engine surges and compressor stalls.

CAUTION

If continuous thrust setting in the instability range is needed, set the inboard throttles above the instability range and set outboard throttles below the instability range, with approximately the same (4 engine) total fuel flow as the equal EPR condition.

ENGINE FIRE PROTECTION

Each engine has a fire detector and a fire extinguisher.

ENGINE FIRE DETECTORS

A fire detector system is installed on each engine (*figure 1-22*) to give visual and aural warnings of excessive temperatures or fires in the engine strut or engine accessory compartment. A rapid temperature rise or an excessive temperature causes the fire relay to close, sounding the alarm bell and lighting the master fire warning lights and the light in the engine FIRE switch. The alarm bell sounds until the master fire warning light is pressed. The master fire warning light goes out, but the light in the fire switch stays on until the detector has cooled. There are two sets of detector loops (loops A and B) located on the top and bottom of each engine. These loops are mounted parallel to one another. The detector loops located on top of the engine (strut) will activate anytime both loops detect a temperature in excess of 760°F along the total length of the loop, or 955°F on a one-foot section. The detector loops located on the bottom of the engine will activate anytime both loops detect a temperature in excess of 620°F along the total length of the loop or 805°F on a one-foot section. The minimum alarm reset temperature is 700°F for the strut and 550°F for the engine. A short-circuit discriminator circuit is provided for each loop. An indicator on the fire warning panel (*figure 1-23*) lights if a short circuit is detected in a loop. The discriminator unit prevents operation of the alarm circuit if a short circuit is detected in the loop.

A test switch for the engine fire detector loops is located on the overhead panel, between the NO 2 and NO 3 fire switches (*figure 1-23*).

ENGINE FIRE EXTINGUISHER

The engine fire extinguisher systems include the storage bottles for extinguishing agent, discharge lines, discharge valves, and the engine fire shutoff switches. System components are shown in *figures 1-22* and *1-23*.

EXTINGUISHING AGENT BOTTLES

Fire extinguishing agent is stored under pressure in four steel pressure bottles, located two in each inboard engine strut. Each pair of bottles serves two engines only (the inboard engine where mounted and the same-side outboard engine). The transfer switch allows discharging both bottles into the same engine or second bottle into the other engine on the same wing.

Each bottle is equipped with a pressure gage and discharge indicators. A yellow disc (12, *figure 1-17*) on the inside of the strut blows out if either bottle is fired electrically. A red disc (11, *figure 1-17*) on the strut (one per bottle) blows out if the bottle has discharged due to overheat. The pressure gages (1, *figure 1-17*) visible through a window in the strut, should indicate 600 (±60) psi at 59°F (15°C). A chart of maximum and minimum pressures is in *figure 1-22*.

ENGINE FIRE SWITCHES

The engine fire switches contain the individual engine fire warning lights and are marked with the engine number. The fire switches are located on the aft end of the overhead panel. (See *figure 1-23*.)

The primary function of the fire switch is to arm the fire bottle discharge circuit. Also, the switch provides a separate electrical signal for operating valves which are usually closed on engine shutdown.

CAUTION

> Do not pull the fire switch on an operating engine, unless the engine cannot be shutdown with the throttle. (Refer to ENGINE FAILURE OR FIRE, section III.) Pulling the fire switch while the fuel control unit fuel shutoff valve is open can damage engine driven fuel pumps and fuel control unit.

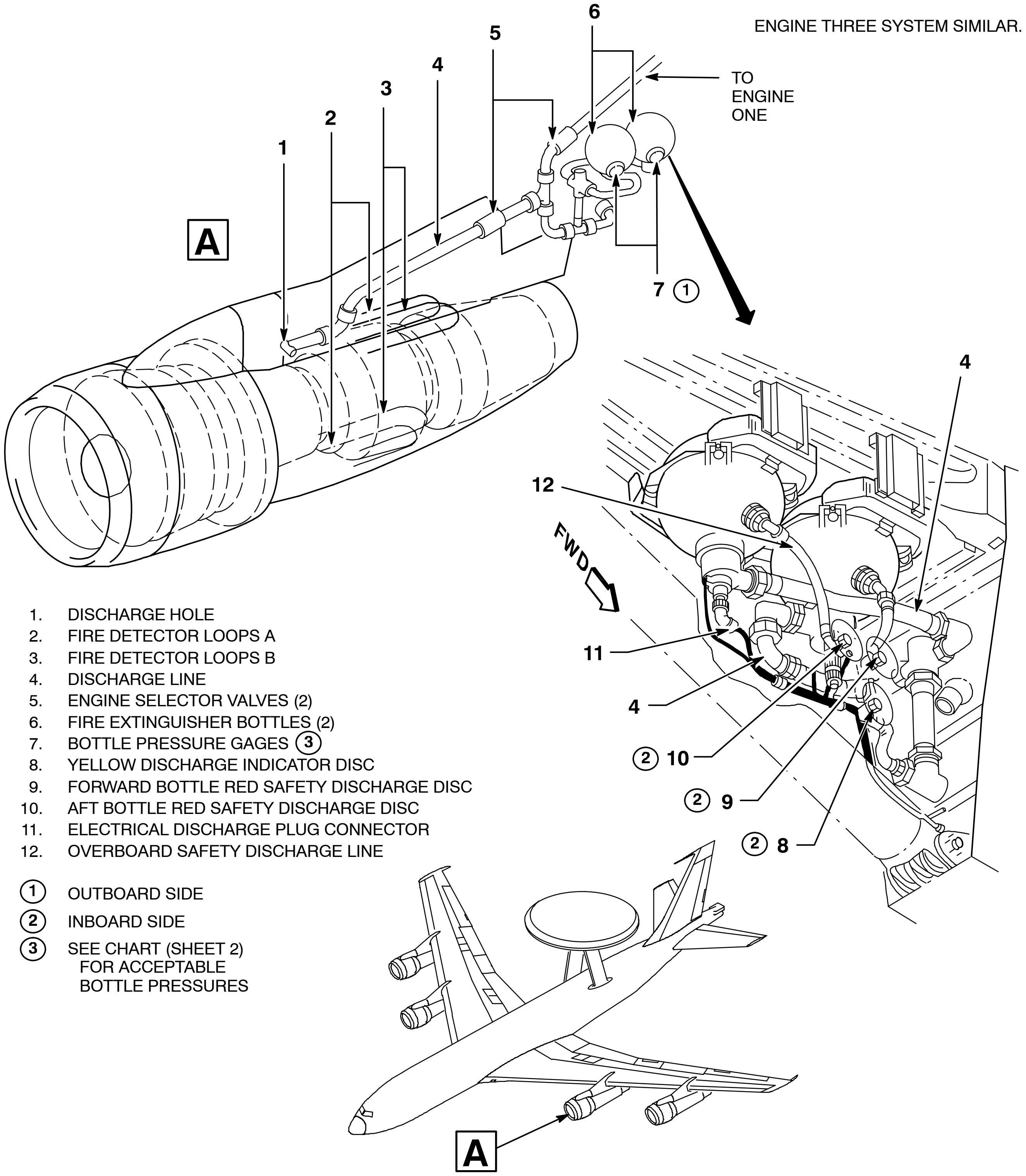
Pulling the fire switch about 1/2-inch (which requires 10 to 12 pounds force) performs these functions:

NOTE

> The functions marked with an asterisk (*) require dc power from a TRU. These functions do not occur when ac electric power is lost.

1. The bottle discharge button for that engine is armed.
2. Firewall fuel shutoff valve closes.
3. Generator breakers open in 3 to 9 seconds.
4. Engine anti-ice valves close. (Inboard engine valves only, if ac power is lost.)
5. Engine bleed air valve closes.*
6. Bleed air firewall shutoff valve closes.*
7. Hydraulic shutoff valve closes (inboards only).
8. Continuous ignition is interrupted.
9. Fuel heat valve is closed.*

Engine Fire Systems



NOTE

ENGINE THREE SYSTEM SIMILAR.

1. DISCHARGE HOLE
2. FIRE DETECTOR LOOPS A
3. FIRE DETECTOR LOOPS B
4. DISCHARGE LINE
5. ENGINE SELECTOR VALVES (2)
6. FIRE EXTINGUISHER BOTTLES (2)
7. BOTTLE PRESSURE GAGES ③
8. YELLOW DISCHARGE INDICATOR DISC
9. FORWARD BOTTLE RED SAFETY DISCHARGE DISC
10. AFT BOTTLE RED SAFETY DISCHARGE DISC
11. ELECTRICAL DISCHARGE PLUG CONNECTOR
12. OVERBOARD SAFETY DISCHARGE LINE

① OUTBOARD SIDE
② INBOARD SIDE
③ SEE CHART (SHEET 2) FOR ACCEPTABLE BOTTLE PRESSURES

Figure 1-22 (Sheet 1 of 2)

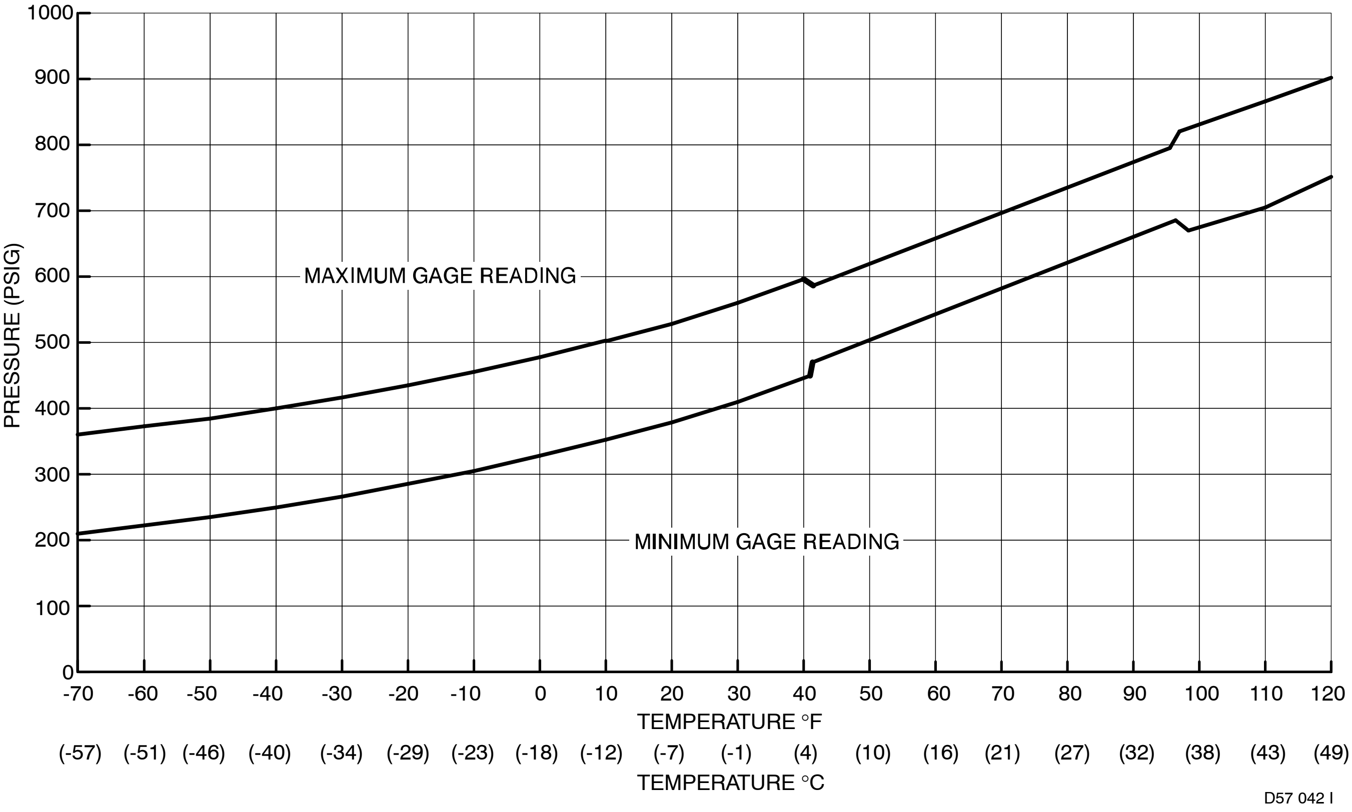


Figure 1-22 (Sheet 2 of 2)

BOTTLE DISCHARGE AND TRANSFER SWITCHES

There is a bottle discharge switch for each engine. The switches are mechanically unlocked by pulling the engine fire switch handles. Pressing the fire bottle discharge button (for one second) fires the explosive squib in the selected extinguishing agent container in the strut, releasing the agent to the selected engine.

To discharge the second extinguisher bottle into the same engine:

1. Set bottle transfer switch to ALTER (or to opposite position).

CAUTION

Since there are only two fire bottles on each side, in flight wait 30 seconds (to see if fire goes out) after discharging first fire bottle before discharging second bottle into the same engine. If both bottles are used on one engine, there is no fire protection for the other engine on that side.

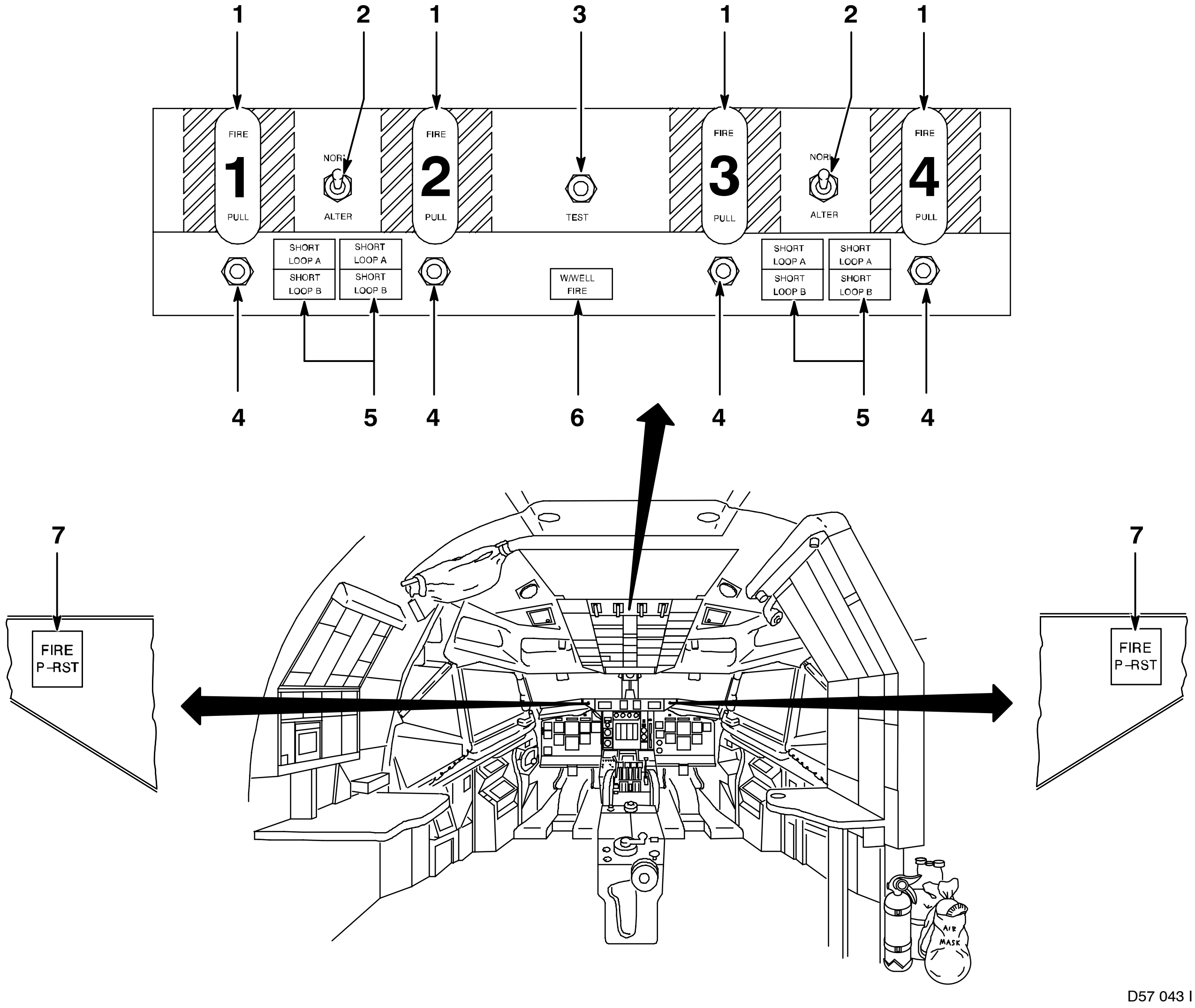
2. Press bottle discharge button.

To discharge the second bottle into the other engine on the same side of the airplane, leave the bottle transfer switch in the same position as used for the first discharge, then press the other bottle discharge button on the same side.

ENGINE ELECTRIC POWER SOURCES

Electric power sources for the engines are listed in *figure 1-24*.

Fire Warning Controls and Indicators



NO.	CONTROL/INDICATOR	FUNCTION
1	Engine 1, 2, 3 and 4 Fire Switches (Contain Engine Fire Warning Lights) (Red)	When red warning light is illuminated in fire switch, indicates a fire in that engine. Fire alarm bell sounds and red master FIRE warning lights illuminate. Warning light in fire switch stays illuminated until fire detector has cooled. When pulled, the fire switch arms the respective fire extinguisher discharge button, and closes the firewall fuel shutoff valve, fuel heat valve, bleed air valves, nose cowl and engine anti-ice valves, and interrupts continuous ignition. Generator breaker opens after a 3 to 9 second delay. Additionally, on NO 2 or 3 engine the hydraulic fluid shutoff valve closes. Full travel of switch is approximately 1/2 inch. Normal operating force is approximately 10 to 12 pounds.

Figure 1-23 (Sheet 1 of 2)

<table>
<tr><th>NO.</th><th>CONTROL/INDICATOR</th><th>FUNCTION</th></tr>
<tr><td colspan="3">CAUTION
Operation of engine driven hydraulic pumps for more than five minutes with fire switch pulled (fluid shutoff valve closed) and engine windmilling can damage pumps.</td></tr>
<tr><td></td><td></td><td>Pressing engine fire bottle discharge button (4) now discharges fire extinguisher.</td></tr>
<tr><td>2</td><td>NORM – ALTER Switches (Bottle Transfer Switches)</td><td>Controls routing of fire extinguishing agent. Allows pilot to discharge second fire bottle on same side of airplane into engine on which a fire warning was received.</td></tr>
<tr><td></td><td>NORM</td><td>Routes agent from a bottle to its respective engine.</td></tr>
<tr><td></td><td>ALTER</td><td>Crossover routing of fire extinguisher agent which allows use of second fire bottle to same engine.</td></tr>
<tr><td>3</td><td>TEST Button</td><td>When pressed, energizes test circuit, shorting out each detector to simulate fire. Fire bell rings, SHORT LOOP A and SHORT LOOP B caution lights illuminate, master FIRE warning lights illuminate, and all engine fire switch warning lights illuminate immediately after TEST is pressed. After a short delay (approximately one second) the W/WELL FIRE warning light illuminates.</td></tr>
<tr><td>4</td><td>Fire Bottle Discharge Buttons (4)</td><td>When engine fire switch is pulled, pressing discharge button for that engine discharges fire extinguishing agent into engine.</td></tr>
<tr><td>5</td><td>SHORT LOOP A, SHORT LOOP B Caution Lights (one set per engine) (Amber)</td><td>When illuminated, indicate a short circuit in that fire detector loop. Illuminates when TEST button or light cover is pressed. Pressing light cover test lights only. If one loop is shorted, fire detection is still available from other loop.</td></tr>
<tr><td>6</td><td>W/WELL FIRE Warning Light (Red)</td><td>When illuminated, indicates a fire has been detected in the wheel well. Illuminates after TEST button has been pressed for at least one second.</td></tr>
<tr><td>7</td><td>FIRE/P–RST Warning Lights (RED) (Master Fire Warning Lights) (2)</td><td>Illuminates when any fire detector loop (engine, APU, or wheel well) senses a fire. When pressed, silences fire bell, resets detector circuit, and light goes out. Does not silence APU fire warning horn in wheel well.</td></tr>
</table>

Figure 1-23 (Sheet 2 of 2)

Engine Electric Power Sources

EQUIPMENT/SYSTEM	TYPE OF POWER	POWER SOURCE	CIRCUIT BREAKER LOCATION/LABEL
ENGINE 1			
EGT and N_1 RPM Gages ①	115V AC	AVAC Bus 2	P61-2, EGT & RPM (N_1) ENG 1
EPR Gage ①	115V AC	AVAC Bus 4	P61-2, ENGINE 1 EPR
Fuel Flow Gage ①	115V AC	AVAC Bus 2	P61-1, FLOW – ENG 1
Oil Pressure Light ②	28V DC	AVDC Bus 2	P61-2, OIL PRESS LIGHTS ENG 1
Oil Quantity Gage ②	28V DC	AVDC Bus 4	P61-2, ENGINE 1 OIL QTY
Oil Pressure and Temperature Gages ①	28V AC	28V AC Bus 2	P61-2, OIL PRESS & TEMP ENG 1
Start Valve and FLT/GND START Ignitor	28V DC	BAT Bus	P61-2, START CONTROL & IGNITION, ENG 1
Continuous Ignition	115V AC	EAC Bus	P61-2, CONTINUOUS IGN ENG 1
Fire Detector	28V DC	BAT Bus	P5, FIRE PROTECTION – FIRE DETECTION – ENG 1
Fire Extinguisher			
Valve	28V DC	BAT Bus	P5, FIRE PROTECTION – FIRE EXTINGUISHER – ENG 1
Squib	28V DC	BAT Bus	P5, FIRE PROTECTION – SQUIB – ENG 1
ENGINE 2			
EGT and N_1 RPM Gages ①	115V AC	AVAC Bus 4	P61-2, ENG 2 EGT & RPM (N_1)
EPR Gage ①	115V AC	AVAC Bus 2	P61-2, ENGINE 2 EPR
Fuel Flow Gage ①	115V AC	AVAC Bus 4	P61-1, FLOW – ENG 2
Oil Pressure Light ②	28V DC	AVDC Bus 4	P61-2, OIL PRESS LIGHTS, ENG 2
Oil Quantity Gage ②	28V DC	AVDC Bus 2	P61-2, ENGINE 2 OIL QTY
Oil Pressure and Temperature Gages ①	28V AC	28V AC Bus 2	P61-2, OIL PRESS & TEMP ENG 2

Figure 1-24 (Sheet 1 of 3)

EQUIPMENT/SYSTEM	TYPE OF POWER	POWER SOURCE	CIRCUIT BREAKER LOCATION/LABEL
Start Valve and FLT/GND START Ignitor	28V DC	BAT BUS	P61-2, START CONTROL & IGNITION, ENG 2
Continuous Ignition	115V AC	EAC Bus	P61-2, CONTINUOUS IGN ENG 2
Fire Detector	28V DC	BAT BUS	P5, FIRE PROTECTION – FIRE DETECTION – ENG 2
Fire Extinguisher			
Valve	28V DC	BAT BUS	P5, FIRE PROTECTION – FIRE EXTINGUISHER – ENG 2
Squib	28V DC	BAT BUS	P5, FIRE PROTECTION – SQUIB – ENG 2
ENGINE 3			
EGT and N_1 RPM Gages ①	115V AC	AVAC Bus 6	P61-2, EGT & RPM (N_1) ENG 3
EPR Gage ①	115V AC	AVAC Bus 8	P61-2, ENGINE 3 EPR
Fuel Flow Gage ①	115V AC	AVAC Bus 6	P61-1, FLOW – ENG 3
Oil Pressure Light ③	28V DC	AVDC Bus 6	P61-2, OIL PRESS LIGHTS ENG 3
Oil Quantity Gage ②	28V DC	AVDC Bus 8	P61-2, ENGINE 3 OIL QTY
Oil Pressure and Temperature Gages ①	28V AC	28V AC Bus 8	P61-2, OIL PRESS & TEMP ENG 3
Start Valve and FLT/GND START Ignitor	28V DC	BAT BUS	P61-2, START CONTROL & IGNITION, ENG 3
Continuous Ignition	115V AC	EAC Bus	P61-2, CONTINUOUS IGN ENG 3
Fire Detector	28V DC	BAT BUS	P5, FIRE PROTECTION – FIRE DETECTION – ENG 3
Fire Extinguisher			
Valve	28V DC	BAT BUS	P5, FIRE PROTECTION – FIRE EXTINGUISHER – ENG 3
Squib	28V DC	BAT BUS	P5, FIRE PROTECTION – SQUIB – ENG 3

Figure 1-24 (Sheet 2 of 3)

Engine Electric Power Sources (Continued)

EQUIPMENT/SYSTEM	TYPE OF POWER	POWER SOURCE	CIRCUIT BREAKER LOCATION/LABEL
ENGINE 4			
EGT and N_1 RPM Gages ①	115V AC	AVAC Bus 8	P61-2, EGT & RPM (N_1) ENG 4
EPR Gage ①	115V AC	AVAC Bus 6	P61-2, ENGINE 4 EPR
Fuel Flow Gage ①	115V AC	AVAC Bus 8	P61-2, FLOW – ENG 4
Oil Pressure Light ②	28V DC	AVDC Bus 8	P61-2, OIL PRESS LIGHTS ENG 4
Oil Quantity Gage ③	28V DC	AVDC Bus 6	P61-2, ENGINE 4 OIL QTY
Oil Pressure and Temperature Gages ①	28V AC	28V AC Bus 8	P61-2, OIL PRESS & TEMP ENG 4
Start Valve and FLT/GND START Ignitor	28V DC	BAT BUS	P61-2, START CONTROL & IGNITION, ENG 4
Continuous Ignition	115V AC	EAC BUS	P61-2, CONTINUOUS IGN ENG 4
Fire Detector	28V DC	BAT BUS	P5, FIRE PROTECTION – FIRE DETECTOR – ENG 4
Fire Extinguisher			
Valve	28V DC	BAT BUS	P5, FIRE PROTECTION – FIRE EXTINGUISHER – ENG 4
Squib	28V DC	BAT BUS	P5, FIRE PROTECTION – SQUIB – ENG 4
ALL ENGINES			
IDG Oil Temperature Indicators	28V DC	28V DC Bus 8	P61-5, INTGR DR GEN TEMP

① Inoperative when AC power is lost.

② Inoperative when AC power is lost to TRU and dc tie bus circuit breakers are open.

③ Inoperative if dc tie bus circuit breakers are open.

Figure 1-24 (Sheet 3 of 3)

SUBSECTION I-C
AUXILIARY POWER UNIT

Table of Contents

SUMMARY

The gas turbine powered Auxiliary Power Unit (APU) provides electrical power, air conditioning and bleed air for ground operation and engine starting. The unit is located in the lower aft compartment (*figure 1-25*).

The APU has a centrifugal compressor. Air from the intake flows to the center of the disc, then moves outward and is compressed. Air leaving the compressor flows to the combustion section, with bleed output to the airplane bleed air system.

Air from the compressor is mixed with fuel to provide a combustible mixture in the combustion section. The mixture is burned and accelerated through the turbine. The turbine is a two stage axial flow type, mounted on the same shaft as the compressor. Exhaust gases from the turbine flow into the exhaust duct and out of the airplane through the exhaust door. Turbine rotation speed is regulated by the governor and fuel control unit.

An accessory drive unit contains reduction gears to drive the generator, oil pump, cooling fan and Permanent Magnet Generator (PMG) for control and ignition. The accessory gearbox also contains the gear train to connect the starter to the turbine shaft.

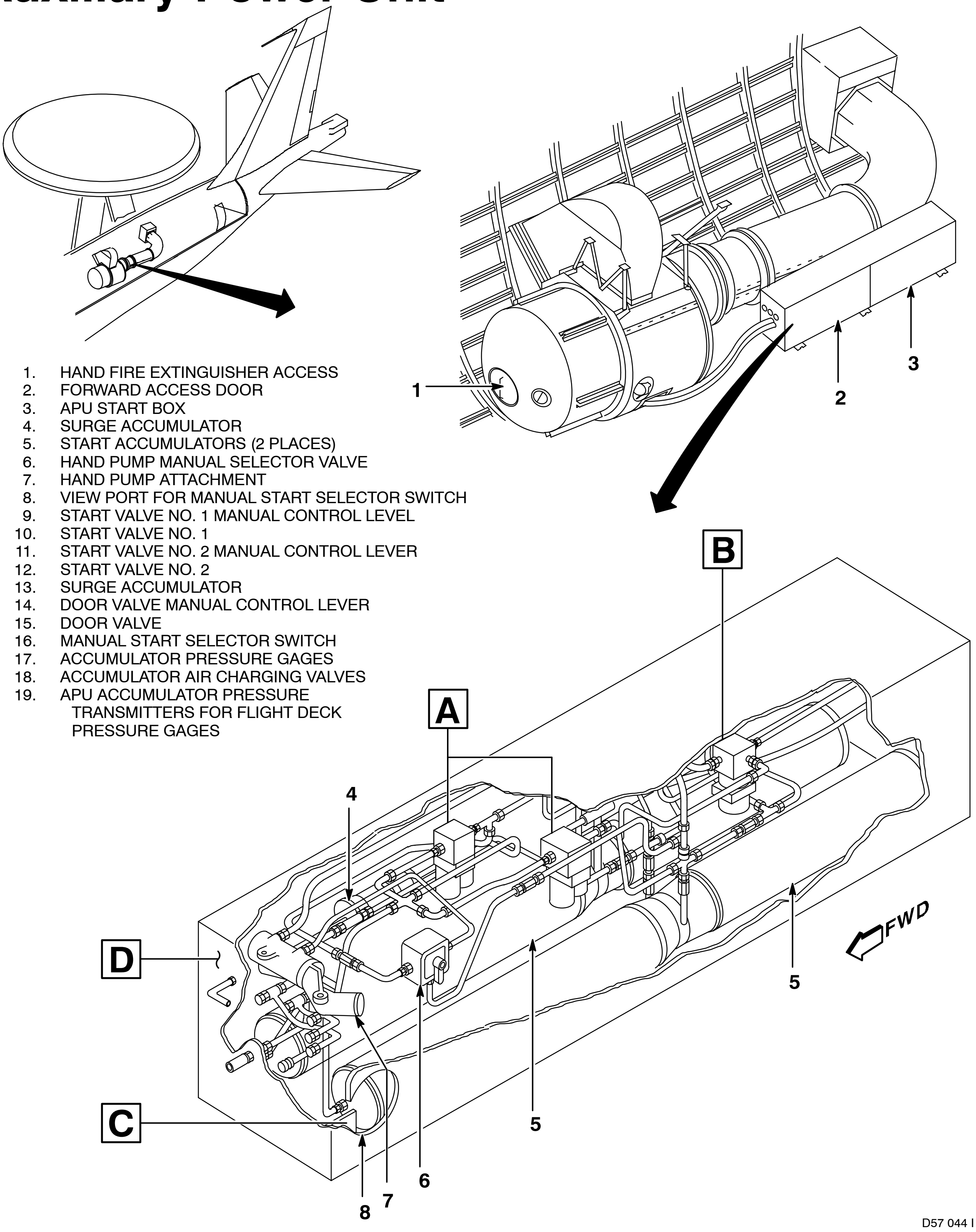
APU STARTING SYSTEM

The APU starter is a hydraulic motor, operated by pressure from two accumulators (*figure 1-26*). The accumulators are charged by the auxiliary hydraulic system (auxiliary pump NO 1). Either accumulator contains enough fluid to start the APU once, when the temperature is above –29°C. Below that temperature, use both accumulators.

Accumulator capacity is approximately 1 1/2 gallons. Recharging takes about 5 minutes when ac power is available to the auxiliary NO 1 hydraulic pump and the auxiliary rotodome shutoff valve is open. A hand pump allows manual recharging of the accumulators. Use of the hand pump to recharge the accumulators can require the efforts of two people. Accumulator pressure gages are at the APU and on the flight engineer's auxiliary panel.

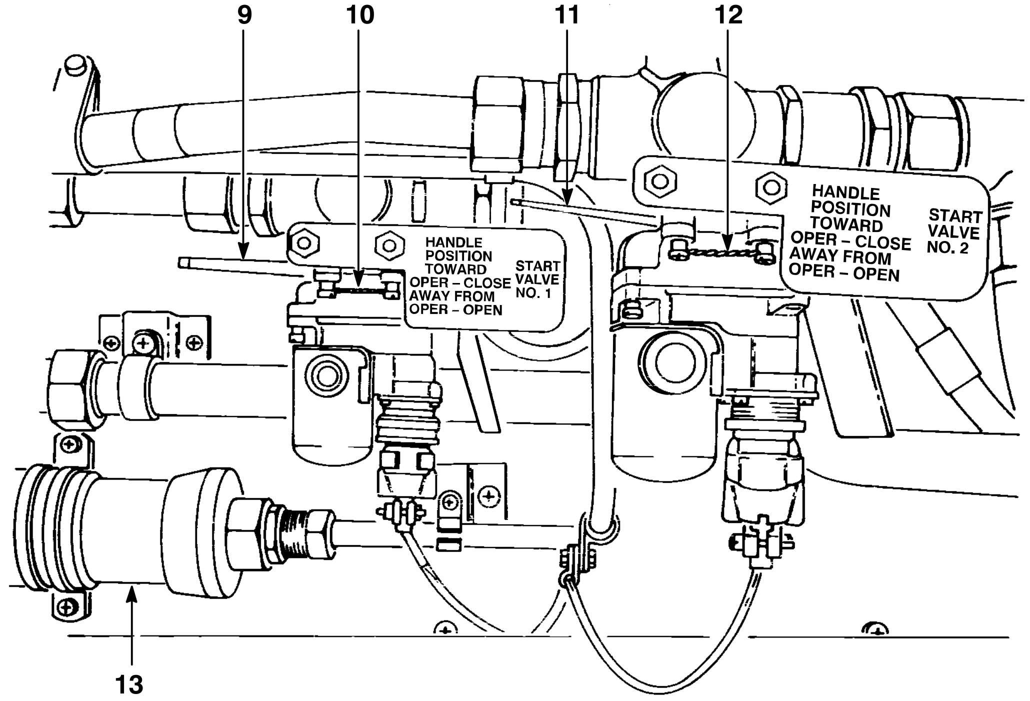
The starter can be controlled electrically, from the flight engineer's station or manually from the hydraulic start box at the APU. The electrically operated sequence is automatic. It is initiated using the APU CONTR switch on the engineer's auxiliary panel (*figure 1-13*).

Auxiliary Power Unit

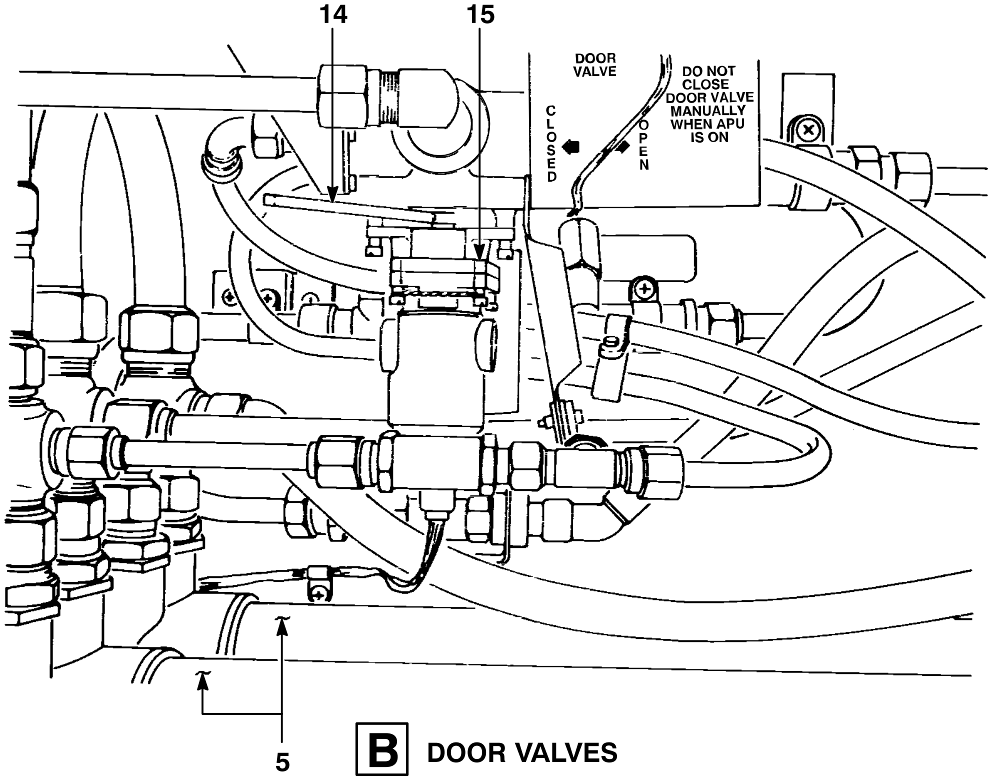


1. HAND FIRE EXTINGUISHER ACCESS
2. FORWARD ACCESS DOOR
3. APU START BOX
4. SURGE ACCUMULATOR
5. START ACCUMULATORS (2 PLACES)
6. HAND PUMP MANUAL SELECTOR VALVE
7. HAND PUMP ATTACHMENT
8. VIEW PORT FOR MANUAL START SELECTOR SWITCH
9. START VALVE NO. 1 MANUAL CONTROL LEVEL
10. START VALVE NO. 1
11. START VALVE NO. 2 MANUAL CONTROL LEVER
12. START VALVE NO. 2
13. SURGE ACCUMULATOR
14. DOOR VALVE MANUAL CONTROL LEVER
15. DOOR VALVE
16. MANUAL START SELECTOR SWITCH
17. ACCUMULATOR PRESSURE GAGES
18. ACCUMULATOR AIR CHARGING VALVES
19. APU ACCUMULATOR PRESSURE TRANSMITTERS FOR FLIGHT DECK PRESSURE GAGES

Figure 1-25 (Sheet 1 of 4)



A START VALVES



B DOOR VALVES

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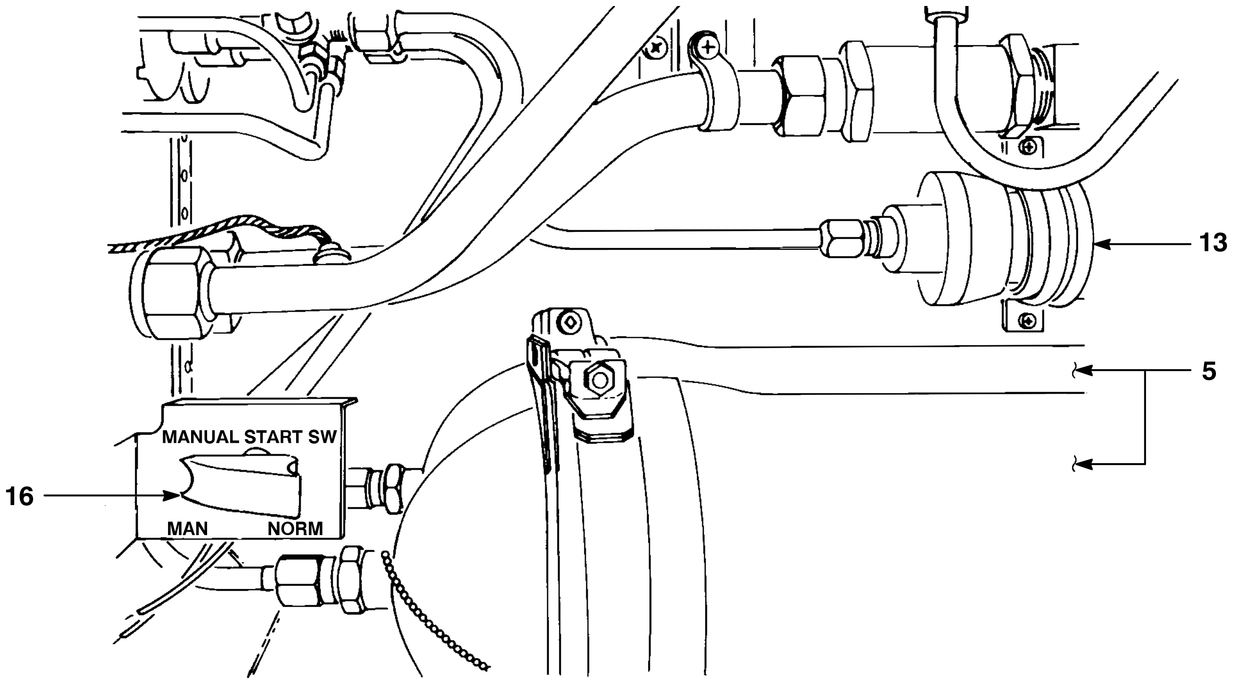
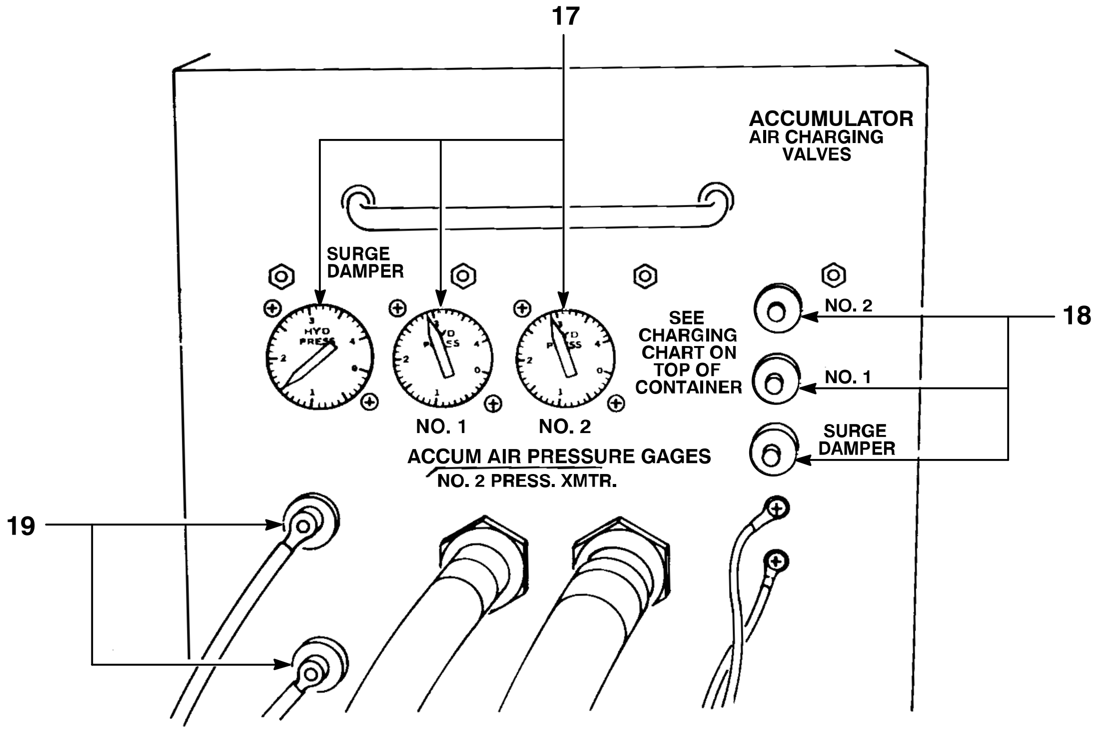
Figure 1-25 (Sheet 2 of 4)

Auxiliary Power Unit (Continued)



C MANUAL START SWITCH



D ACCUMULATOR PRESSURE GAGES

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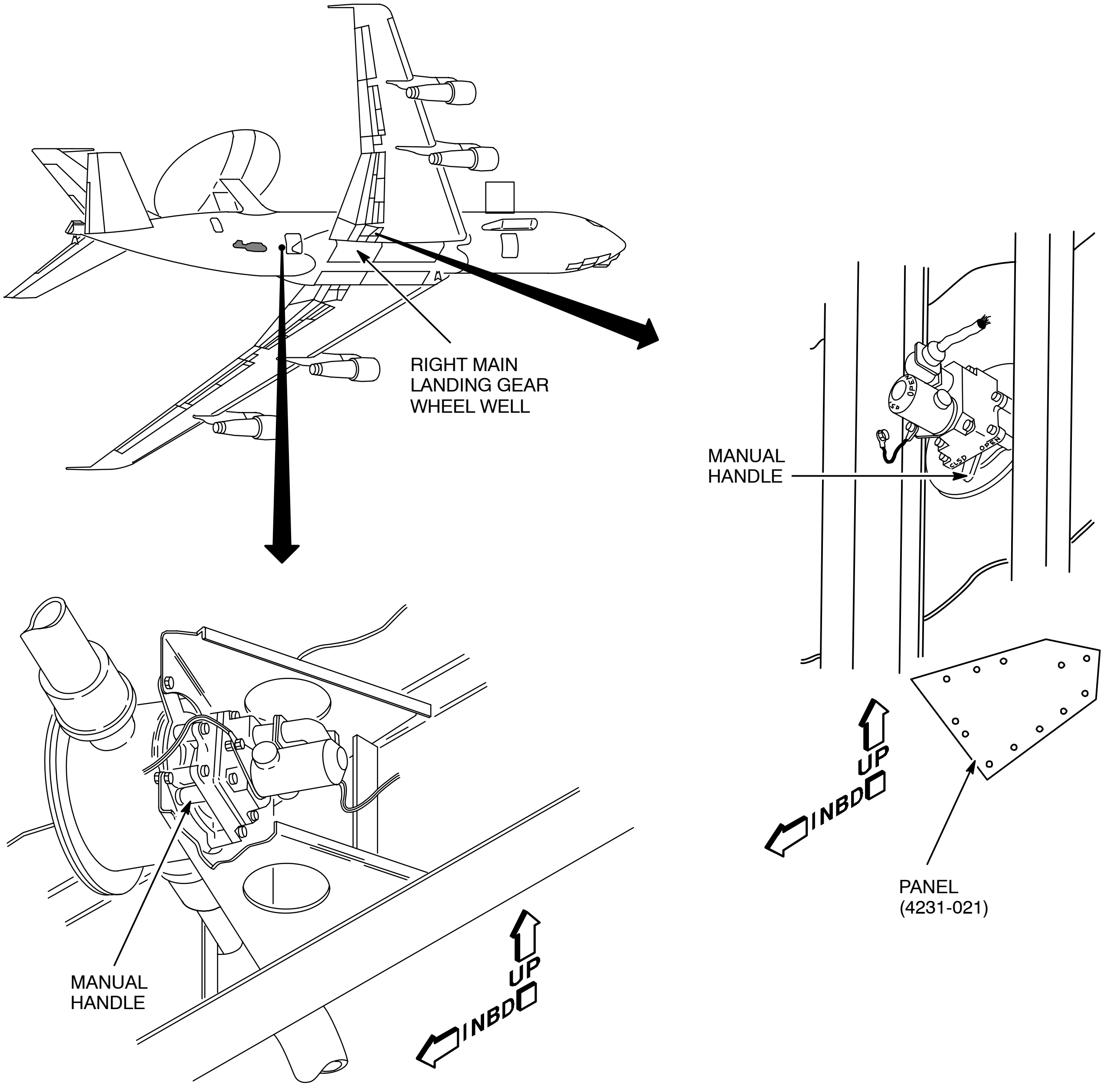
Figure 1-25 (Sheet 3 of 4)



AIRPLANE APU FUEL SHUTOFF VALVES

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Figure 1-25 (Sheet 4 of 4)

APU Start and Control System Schematic

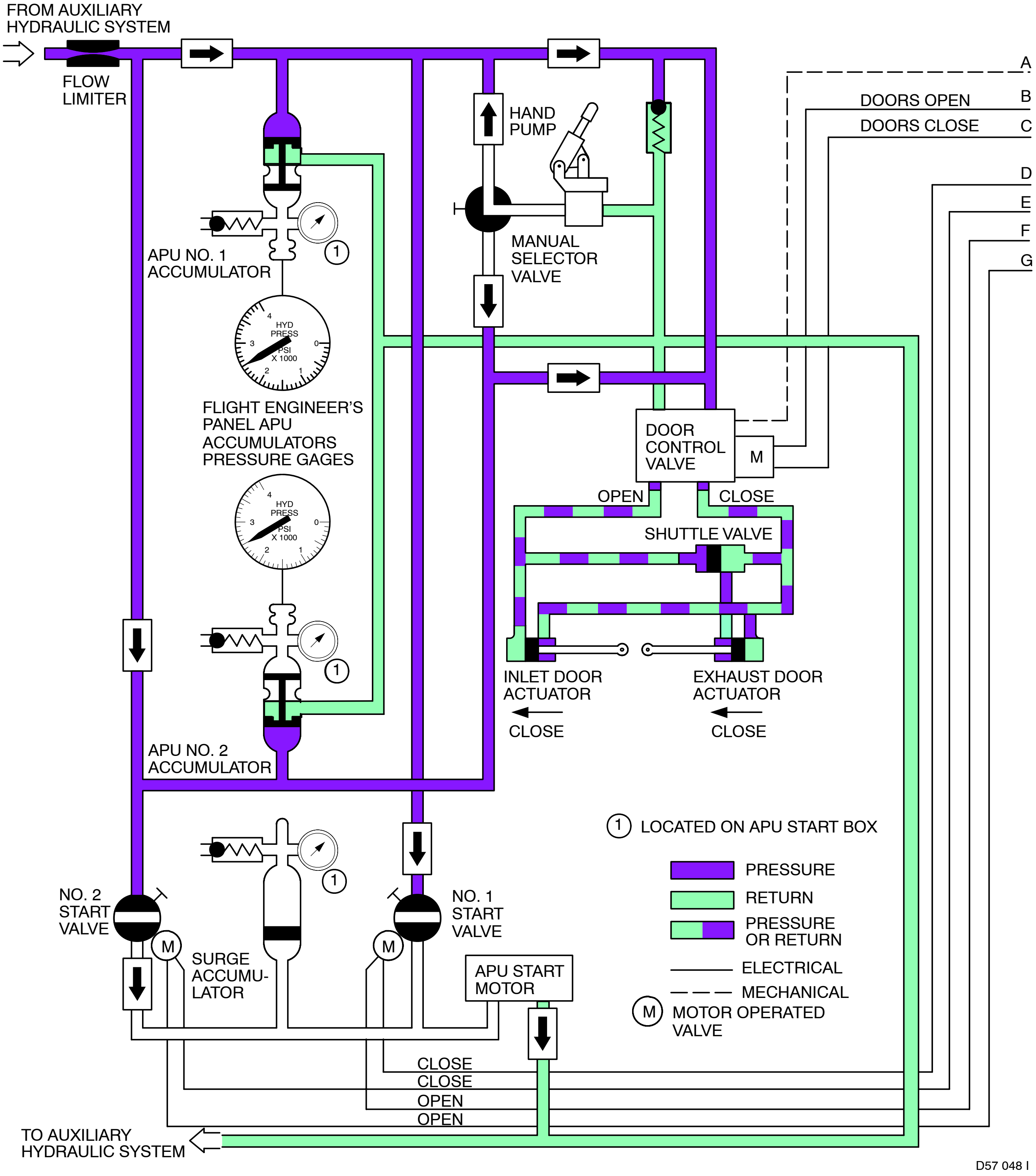
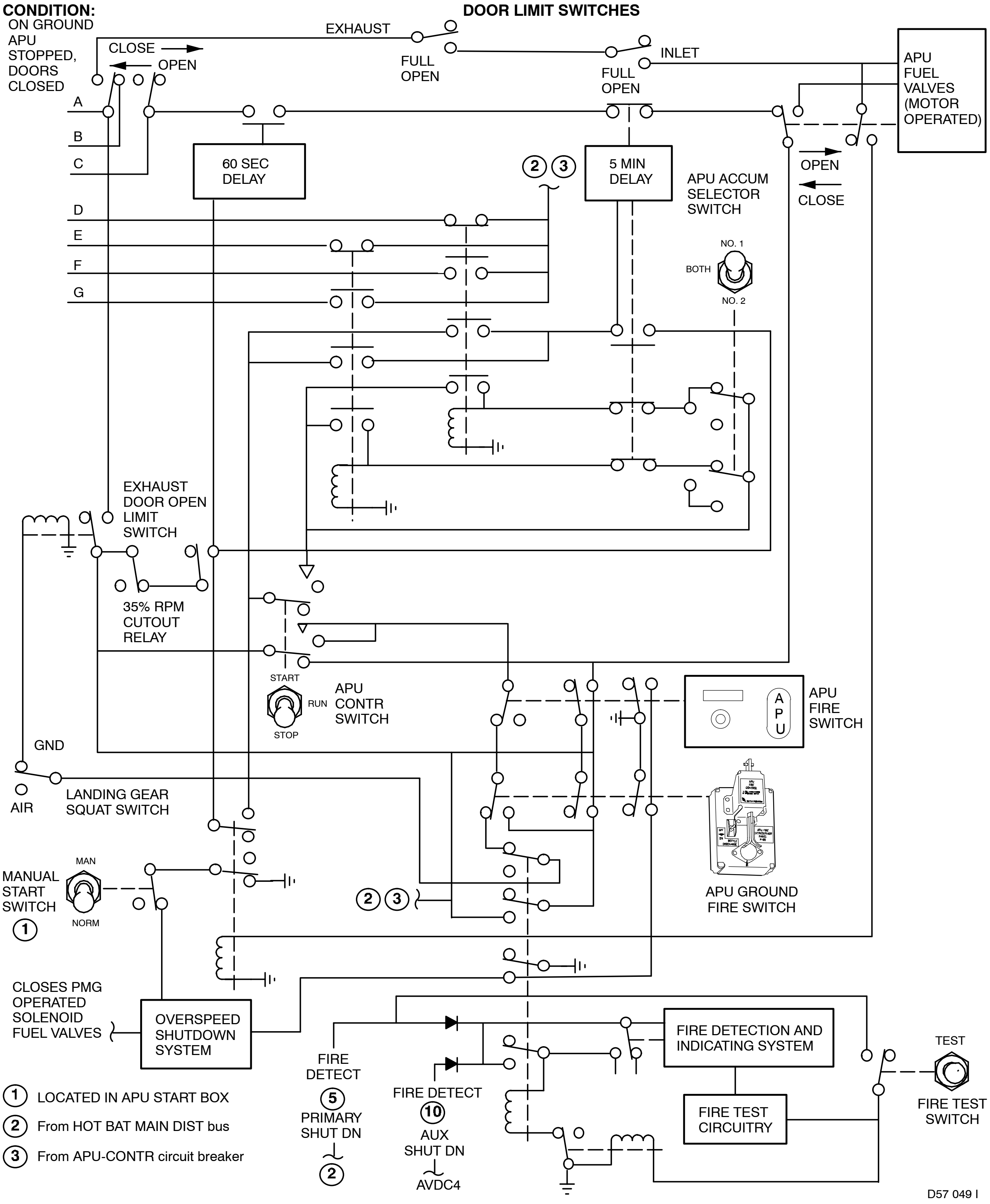


Figure 1-26 (Sheet 1 of 2)



① LOCATED IN APU START BOX

② From HOT BAT MAIN DIST bus

③ From APU-CONTR circuit breaker

Figure 1-26 (Sheet 2 of 2)

Power for the APU starting system is supplied through P61-2, APU CONTR circuit breaker. Power for the rotodome shutoff valve is supplied through P61-4, ROTODOME – AUXILIARY SOV circuit breaker.

NOTE

- A five minute time delay relay in the start control circuit prevents attempting a second start within five minutes if the first attempt failed. This five minute delay allows time for fuel to drain from the APU and also for recharging the accumulators.
- A timer prevents closing the APU doors for 60 seconds after the APU CONTR switch is set to STOP (or APU fire switch is pulled). The APU DOOR caution light remains illuminated until the doors are fully closed, approximately 90 seconds after setting the APU CONTR switch to STOP or pulling fire switch.

FUEL SYSTEM

Fuel is supplied to the APU through a shrouded line which passes through the right outboard end of the center fuel tank. This fuel line is connected to the crossfeed manifold and through a check valve to number three main wing tank. Fuel for starting, when the crossfeed manifold is not pressurized, is supplied by gravity feed from the number three main wing tank. Fuel can also be supplied from any fuel tank by pressurizing the crossfeed manifold. If fuel feed is via the crossfeed manifold, a check valve prevents filling the number three main wing tank through the gravity feed line. The APU fuel feed system has four shutoff valves. Two of the APU fuel shutoff valves (airplane APU fuel valves) are electrically controlled by the APU CONTR switch and APU fire switches (and can also be operated manually). One of the airplane valves is located on the aft side of the right wing spar (in right wheel well). The other airplane valve is located in the aft lower compartment mounted above and to the left of the forward end of the APU. The other two APU fuel valves are located in the APU fuel control and are automatically opened when APU RPM reaches approximately 10% by voltage supplied from the PMG.

LUBRICATION SYSTEM

The APU lubrication system provides oil for the turbine and compressor bearings and for the accessory unit. A sight glass near the oil filler cap is used to check oil quantity. The oil pump provides bearing lubrication under pressure. A low oil pressure sensing system shuts the APU down automatically if the oil pressure drops below 60 to 45 psi.

APU FIRE DETECTOR

The APU is equipped with a fire detector. If a fire is detected, the master FIRE warning lights (7, *figure 1-23*), the red light in the APU fire switch and a red light on the APU ground fire panel illuminate. The flight deck fire bell and the APU ground fire warning horn in the right wheel well sound.

NOTE

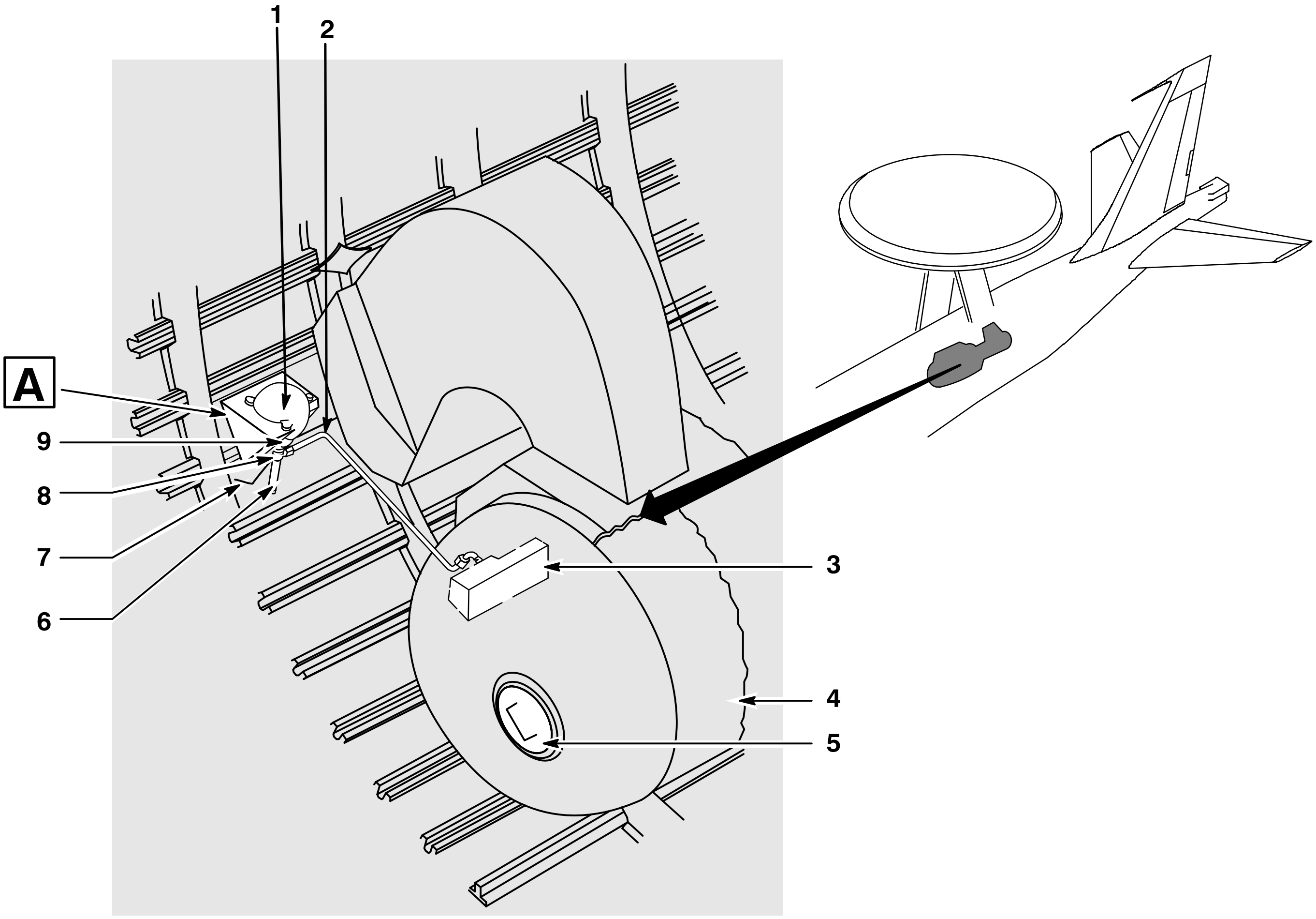
- The battery must be installed to operate the primary APU fire detector.
- The master fire warning light is illuminated when a fire is detected by any of the six fire detector systems (four engines, APU, or wheel well) or when the engine or APU fire detector TEST button is pushed. The master FIRE warning light alone is not a positive indication of an APU fire.
- Pressing the master FIRE warning light resets the light and silences the flight deck fire bell, but does not silence the ground APU fire warning horn.

If a fire is detected, the APU automatically shuts down. Fire detector controls and indicators are shown in *figure 1-23*, *1-27*, and *1-28*.

APU FIRE EXTINGUISHER

The APU is equipped with one fire extinguishing agent container (fire bottle). The fire bottle has a pressure gage which is visible from the aft cargo door area. The bottle pressure should be as shown in *figure 1-27*. A fire extinguisher switch is armed when the APU fire switch on the same panel is pulled approximately 1/2-inch. The agent is discharged electrically by pressing the DISCHARGE button on the APU flight deck control panel or setting the switch on the ground control panel to ON. (See *figures 1-27* and *1-28*.)

APU Fire Extinguishing System



APU FIRE EXTINGUISHER ACCEPTABLE PRESSURE

A

TEMPERATURE DEGREES F.	MINIMUM ALLOWABLE PRESSURE
–60	240
–40	280
–20	330
0	380
20	430
40	480
60	540
80	600
100	670
120	750
140	870

1. FIRE EXTINGUISHING BOTTLE
2. DISCHARGE LINE
3. CONNECTOR MOUNTING PAD
4. APU SHROUD
5. HAND FIRE EXTINGUISHER ACCESS
6. ELECTRICAL LEAD
7. GROUND LEAD
8. GROUND LUG
9. PRESSURE GAGE

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Figure 1-27

APU Controls and Indicators

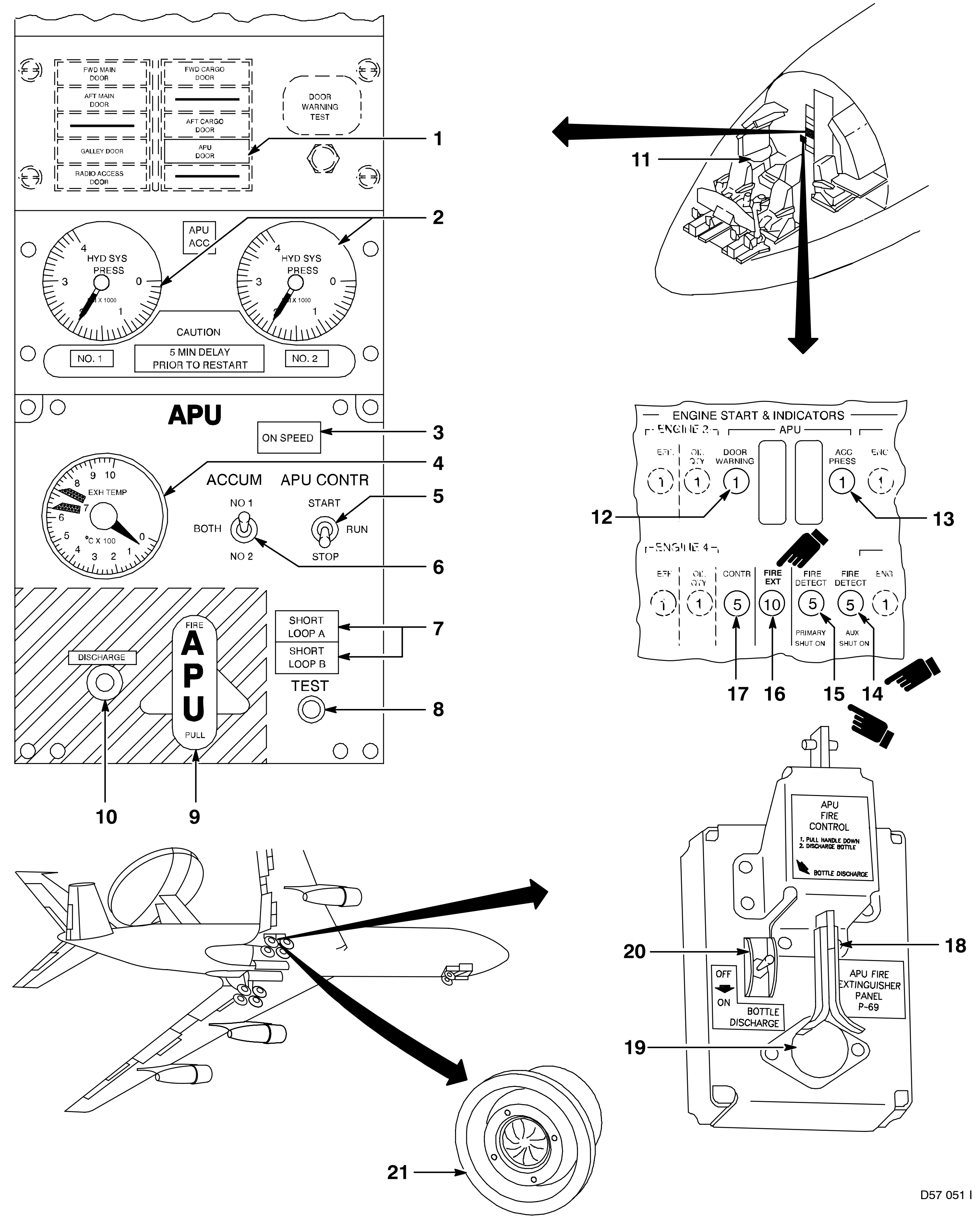

Figure 1-28 (Sheet 1 of 4)

NO.	CONTROL	LOCATION	FUNCTION
1	APU DOOR Caution Light (Amber)	FE AUX Panel	When illuminated, indicates either APU inlet or exhaust door is not fully closed.
2	APU Accumulator Pressure (Gages)	FE AUX Panel	Indicates pressure in APU starting accumulators. Gages are electrically powered from emergency AC bus.
3	ON SPEED Indicator (Green)	FE AUX Panel	When illuminated, indicates turbine is running at normal speed.
4	EXH. TEMP Gage (EGT Gage)	FE AUX Panel	Indicates turbine exhaust temperature in degrees C. Red line at 650°C is running limit. Red line at 720°C is momentary starting limit.
5	APU CONTR Switch (APU Control Switch)	FE AUX Panel	Operates start and shutdown circuits if battery installed in airplane. START position is spring loaded to RUN. When held to START initiates automatic start sequence. When set to STOP causes APU to shut down. The START position of this switch is wired in series with the squat switch to prevent inflight APU operation. Switch can be set to STOP in flight to close APU doors.
6	ACCUM (Accumulator) Switch	FE AUX Panel	Selects either or both accumulators for starting APU.
7	SHORT LOOP A, SHORT LOOP B Caution lights (Amber)	FE AUX Panel	Illuminates to indicate short circuit in detector loops when occurring or when TEST button is pressed.
8	TEST Button	FE AUX Panel	When pressed, conducts electrical tests of fire detector loops. Causes APU FIRE warning light and master FIRE warning light and SHORT LOOP A and B caution lights to illuminate, APU fire warning horn and fire bell to sound. Can be pressed while APU is operating.

CAUTION

Do not pressurize airplane if APU DOOR caution light is illuminated, to avoid damage to APU shroud. Refer to DOOR CAUTION LIGHT ILLUMINATED, section III.

Figure 1-28 (Sheet 2 of 4)

APU Controls and Indicators (Continued)

NO.	CONTROL	LOCATION	FUNCTION
9	APU FIRE Switch (Contains APU Fire Warning Light) (Red)	FE AUX Panel	Warning light in handle indicates APU fire. Pulling handle approximately 1/2 inch (with approximately 10 pounds force) initiates automatic APU shutdown (if fire detection system has not already shut down APU), silences ground warning horn, and arms APU fire extinguisher discharge button (10) on this panel. Warning light remains on until detector has cooled.

WARNING

Primary fire detector, fire extinguisher, DISCHARGE button, and APU FIRE switch are inoperative if battery is removed or inoperative.

10	DISCHARGE Button	FE AUX Panel	Pulling either APU fire switch also arms the APU fire extinguisher discharge button on the same panel. Does not function if battery is removed or not operating or if discharge button is pressed at location where APU fire switch has not been pulled.
11	Flight Deck Fire Bell	P35 (Under FE Table)	Sounds when APU fire detector detects a fire or when APU fire TEST button is pressed. Silenced by pressing master fire warning lights in flight deck.
12	APU DOOR WARNING CB	P61-2	Provides electrical power from hot battery bus to APU door warning system.
13	APU ACC PRESS CB	P61-2	Provides electrical power from emergency AC bus to APU accumulator pressure gages on flight engineer's auxiliary panel.
14	APU FIRE DETECT AUX SHUT DN CB	P61-2	Provides electrical power from AVDC bus 4 to auxiliary APU fire detector and shutdown circuit.
15	APU FIRE DETECT PRIMARY SHUT DN CB	P61-2	Provides electrical power from hot battery bus to primary APU fire detector and shutdown circuit.
16	APU FIRE EXT CB	P61-2	Provides electrical power from hot battery bus to APU fire extinguisher.

Figure 1-28 (Sheet 3 of 4)

NO.	CONTROL	LOCATION	FUNCTION
17	APU CONTR CB	P61-2	Provides electrical power from hot battery bus to APU control circuit.
18	APU FIRE CONTROL Switch (APU Ground Fire Switch)	Right Wheel Well	Pulling APU Ground Fire Switch initiates automatic APU shutdown (if fire detection system failed to shut down APU), arms APU fire extinguisher BOTTLE DISCHARGE switch (20) only, and silences APU ground fire warning horn.

WARNING

Primary fire detector, fire extinguisher, BOTTLE DISCHARGE switch, and APU ground fire switch are inoperative if battery is removed or inoperative.

NO.	CONTROL	LOCATION	FUNCTION
19	APU FIRE Warning Light (Flashing Red)	Right Wheel Well	Flashes when fire detected in APU. Remains on until fire detector has cooled.
20	BOTTLE DISCHARGE Switch	Right Wheel Well	When set to ON, fires squib in APU fire extinguishing agent bottle, releasing agent. Switch is armed when APU FIRE CONTROL switch is pulled. When set to OFF, deenergizes squib circuit. Does not function if battery is removed or not operating.
21	APU Ground Fire Warning Horn	Right Wheel Well	Sounds when fire is detected by detector loop A and B, or when TEST button on APU control panel is pressed. Silenced by pulling APU ground fire switch or APU FIRE switch in flight deck.

Figure 1-28 (Sheet 4 of 4)

GENERATOR

The APU generator is an air cooled, 115 ± 4 volt, 3-phase, 400 ± 10 Hz (as measured at the flight engineer's panel) generator with a capacity of 170 amperes per phase. The generator is driven directly by the APU accessory unit. Frequency is regulated by the APU governor (by controlling the speed of the APU). The generator is controlled through the electric power system. Generator control is automatic, except for placing the generator on the ac power system bus or removing it. (See subsection I-E.) If the generator overspeeds, the APU automatically shuts down. If the APU underspeeds, the APU generator is tripped off the bus by an underfrequency condition. However, the APU governor reacts to the underspeed as it would to a flameout and causes a large increase in fuel flow and the ignition to come on until the APU is running above 95% rpm.

CONTROLS AND INDICATORS

The APU is started and operated from the flight engineer's station. An auxiliary APU fire panel is provided in the right wing near the top of the landing gear strut to allow ground crew personnel to operate the fire extinguisher. APU controls and indicators are shown in *figure 1-28*.

APU NORMAL OPERATION

APU operation is automatic, except for starting, shutdown, placing the generator on the bus or removing it from the bus, operation of the bleed air valve, and fire extinguisher discharge. The APU cannot be operated in flight since the control circuits are wired through the squat switch. If a takeoff is made with the APU operating, the squat switch initiates an automatic APU-shutdown sequence.

When the APU CONTR switch is set and held to START, the following occurs during a normal start. (See *figure 1-26*.) The APU DOOR OPEN caution light illuminates when doors start to open. APU accumulator pressure drops about 100 psi while doors open, which takes about five seconds. When the doors are fully open, the airplane APU fuel shutoff valves open. After the airplane APU fuel valves open, the start valves to the APU (selected by the accumulator switch) open, APU accumulator pressure starts to decrease and is depleted in about 5 to 10 seconds (the start valves close at 35% RPM so accumulator pressure is not always completely depleted). When APU is at about 10% RPM, the APU solenoid operated fuel valves open and ignition occurs; EGT starts to rise about one to two seconds after the hydraulic start valves open. EGT peaks (at about the 95% RPM range) at roughly 500°C, about 10 to 15 seconds after the start valves open. The ON SPEED indicator illuminates at 95% RPM. The APU CONTR switch can be set to RUN. EGT stabilizes below 400°C in about five seconds or less after the ON SPEED indicator illuminates (with no load on the APU).

APU automatic shutdown is caused by any of the following: actuation of APU fire detection system, low oil pressure, overspeed, opening of the landing gear squat switch or if the battery is discharged. Regardless of the cause, the automatic shutdown feature operates through the overspeed logic and shuts down the APU by closing both permanent magnet generator (PMG) solenoid operated fuel valves. In addition, if the shutdown was due to actuation of the APU fire detection system, the APU inlet and exhaust doors close within 90 seconds and the two motor operated airplane APU fuel valves, controlled by the APU CONTR switch, also close.

Emergency shutdown of the APU, initiated by pulling either APU FIRE handle, shuts down the APU in the same manner as an automatic shutdown due to actuation of APU fire detection system. Pulling either APU FIRE handle also arms the APU fire extinguisher discharge switch on the same panel.

NOTE

- The APU gives priority to generation of electrical power. When the APU generator is on-line, the APU limits the supply of bleed air available for air conditioning and engine start in order to meet the electrical load demands. The APU also limits the supply of bleed air to keep the exhaust gas temperature below 650°C. If the EGT rises over 650°C (except for less than 10 seconds during load application), shut down APU.
- The power feeder duct cooling system can trip the APU generator off the line. This occurs if the power feeder duct air temperature exceeds 180 ± 10°F. For a complete description of this system, refer to POWER FEEDER DUCT COOLING.

APU NORMAL START

1. Set BATTERY switch to ON and EMERGENCY POWER switch to NORMAL.

   Battery is required for operation of APU start circuit, intercom, fire detector, fire extinguisher, and door warning lights.

2. Verify that accumulator pressure is at least 2,500 psi if temperature is above –18°C (0°F), 3,000 psi if temperature is between –18°C and –40°C (0°F and –40°F), and 3,500 psi below –40°C (–40°F). Recharge accumulator if required.
3. Verify that APU circuit breakers (*figure 1-28*) are closed.
4. Set ACCUM switch to NO 1 or NO 2 if temperature is above –29°C (–20°F) or BOTH if temperature is below –29°C (–20°F).
5. Set APU BLEED switch off.

6. Set (and hold) APU CONTR switch to START. APU accumulator pressure drops. The EGT rises.

CAUTION

- Monitor EGT. If EGT is above 650°C (except between 650°C and 720°C for no more than 10 seconds during start or load application) or if EGT exceeds 720°C at any time, shut down APU.

- Set APU CONTR switch to STOP if EGT does not start to rise within two seconds of APU accumulator pressure stabilizing after drop for APU starter. Wait five minutes, then switch to other accumulator for second attempt.

NOTE

- An automatic five minute time delay must expire before a second start can be attempted.

- If the airplane is fueled with JP-5 or JP-8 and fuel temperature is below –30°C (–22°F), it can be difficult or impossible to start the APU.

7. When ON SPEED indicator illuminates (30 seconds at 0°F and above, 60 seconds below 0°F measured from time EGT starts to rise), set APU CONTR switch to RUN.

8. Set APU generator and APU BLEED switches as required.

CAUTION

- If APU shuts down during power transfer, or from no apparent cause, have condition of APU accessory drive shaft checked before next start attempt. Also check output from airplane battery.

- If auxiliary hydraulic pump NO 1 and/or aft forced air cooling fan NO 1 are operating during electrical power transfer, the corresponding ELCU can trip, causing system shutdown. If this occurs, restart system(s) immediately to prevent damage to equipment.

9. Accumulator recharges when auxiliary rotodome drive shutoff valve is open, if auxiliary pump NO 1 is operating.

APU NORMAL SHUTDOWN

1. Press APU BLEED switch to close APU bleed valve. ON light goes out. If the primary or alternate flow control valves are not closed before closing the APU bleed air valve, the APU can surge. This can also cause the APU generator to trip off.

2. Press APU GENERATOR switch to remove generator load. ON light goes out.

3. Run APU for 60 seconds with no load. EGT should stabilize below 400°C.

4. Set APU CONTR switch to STOP. APU Door caution light remains illuminated for approximately 90 seconds.

CAUTION

Do not attempt takeoff with either APU door open.

NOTE

- The EGT should decrease immediately after setting the APU CONTR switch to STOP.

- If the APU does not shut down with the APU CONTR switch, pull APU fire switch, EGT should decrease immediately. After APU door caution light goes out, push in APU fire switch to prevent inadvertent discharge of APU fire bottle. Maintenance action is required prior to next start.

APU MANUAL OPERATION

WARNING

- Because the monitoring systems and communication systems are inoperative with the battery removed, any malfunction could develop into a dangerous condition before adequate countermeasures could be taken or personnel be warned. Therefore operation of the APU without battery is prohibited, except in emergencies.
- If battery power is not available, the primary fire detection and fire extinguishing systems are inoperative. The auxiliary fire detection, interphone and lower lobe lights are operative if an external power source is used until the APU generator can be placed on line.

APU MANUAL START

1. Verify the following circuit breakers are closed:

   a. On P61-2 circuit breaker panel:

      APU – ACC PRESS

      APU – CONTR

      APU – DOOR WARNING

      APU – FIRE EXT

      APU – FIRE DETECT PRIMARY SHUT DN

      APU – FIRE DETECT AUX SHUT DN

   b. On P61-4 circuit breaker panel:

      ROTODOME – AUXILIARY–SOV

      HYDRAULIC – AUX PUMPS – CONTR NO 1

      HYDRAULIC – AUX PUMPS – LOW PRESS LIGHTS

   c. On P61-6 circuit breaker panel:

      HOT BATTERY BUS – BUS PWR CONT UNIT PROT

      HOT BATTERY BUS – MAIN BUS DISTR

      BATTERY BUS – BUS PWR CONT UNIT CONT

   d. On P37 circuit breaker panel:

      EXT PWR TR 28 VDC – BPCU

      EXT PWR 1A 115 VAC – BPCU

   e. On P5 circuit breaker panel:

      FIRE DETECTION – MASTER FIRE WARN

2. Set BATTERY switch to ON and EMERGENCY POWER switch to NORMAL.
3. Set APU CONTR switch to RUN.
4. Verify APU start accumulators are charged to at least 2,500 psi if temperature is above –18°C (0°F), 3,000 psi if temperature is between –18°C (0°F) and –40°C (–40°F) or 3,500 psi if temperature is below –40°C (–40°F). Pump manually if required.
5. Manually open APU fuel shutoff valves, one on aft side of right wing spar and other one above and to left of forward end of APU.
6. Open forward and aft compartment access doors on APU hydraulic start box.
7. Set MANUAL START SWITCH to MAN position. Switch is located in forward compartment of hydraulic start box.
8. Manually set the APU door control valve to OPEN. APU inlet and exhaust doors open.
9. Set ACCUM switch to the accumulator selected to start APU.

10. Manually open applicable accumulator start valve. Both, if temperature less than –29°C (–20°F). APU starts to motor.

WARNING

If APU does not start, do not close APU doors or attempt a restart for at least five minutes. This is to allow fuel vapors or excess fuel to clear and prevent a possible explosion on the next start. The automatic five-minute time delay is inoperative under these conditions.

CAUTION

If APU EGT gage does not indicate an increase in temperature within two seconds of APU accumulator pressure stabilizing after drop for APU starter, set MANUAL START switch to NORM. Investigate and correct problem before initiating a new start. This will take two people to monitor APU EGT during manual start. One will monitor EGT from the flight deck and the second person will perform the APU manual start.

NOTE

If the airplane is fueled with JP-5 or JP-8 and fuel temperature is below –30°C (–22°F), it can be difficult or impossible to start the APU.

11. When APU starts, close accumulator start valve.

12. Press APU GENERATOR switch to ON and set ac meter selector switch to APU.

NOTE

If for any reason the battery is removed or inoperative, at least one bus tie breaker, which controls a transformer-rectifier unit (NO 2, 3, 4, 5, 6 or 8), must be closed prior to battery removal (all bus tie breakers may be closed if desired). Once battery power is removed, bus tie breakers cannot be closed. Power to operate the bus tie breakers comes from the battery bus. Unless a bus tie breaker which connects power to a TRU is closed, no power is available to operate the bus tie breakers. The APU can be started or external power connected to the airplane, but no power can be connected to any airplane or mission equipment unless such a bus tie breaker is left closed or the battery is reinstalled.

13. Operate APU BLEED switch as desired.

14. Recharge accumulator, using auxiliary hydraulic pump NO 1. Auxiliary rotodome shutoff valve must be open.

APU MANUAL SHUTDOWN

1. Press APU BLEED switch to close APU bleed valve. ON light goes out. If the primary or alternate flow control valves are not closed before closing the APU bleed air valve, the APU can surge. This can also cause the APU generator to trip off.

2. Press APU GENERATOR switch to remove generator load. All lights go out.

3. Run APU for 60 seconds with no load. EGT should stabilize below 400°C.

4. Set APU CONTR switch to STOP.

5. Set MANUAL START SWITCH to NORM. This shuts down APU. Allow APU to stop before closing inlet and exhaust doors.

6. Manually set the APU door control valve to CLOSE. APU inlet and exhaust doors close.

7. Close forward and aft compartment access doors on APU hydraulic start box.

8. Manually close APU fuel shutoff valves, one on aft side of right wing spar and other one above and to left of forward end of APU.

RECHARGING APU ACCUMULATORS

APU ACCUMULATOR RECHARGING WITH AUXILIARY HYDRAULIC SYSTEM

1. Auxiliary rotodome shutoff switch – ON

CAUTION

If the accumulator recharge is accomplished while any engine is running, the rotodome should be rotated at idle speed using the utility hydraulic system.

2. NO 1 auxiliary pump switch – ON

3. Verify that accumulators are charged to desired pressure.

4. NO 1 auxiliary pump switch – OFF

NOTE

If temperature is below –40°C (–40°F) pump accumulators manually to increase pressure from 3,000 to 3,500 psi.

APU ACCUMULATOR MANUAL RECHARGING

1. Open forward access door of APU.

2. Set MANUAL START SWITCH to NORMAL.

3. Select NO 1 or NO 2 accumulator with manual selector valve on hand pump.

4. Insert pump handle, insert handle retaining pin, pump until accumulator reaches desired pressure.

SUBSECTION I-D
FUEL SYSTEM

Table of Contents

Title ***Page***

SUMMARY

Fuel in the airplane is carried in seven tanks as shown in *figures 1-29* and *1-30*. The airplane is equipped for single-point ground refueling and for inflight refueling from boom type tankers. Fuel dump chutes are provided in each wing. Two boost pumps are installed in each main tank and the center tank, to provide positive pressure to the engine driven fuel pumps. Fuel can be transferred from reserve tanks to outboard main tanks only.

FUEL TANKS

The seven fuel tanks in this airplane are: left and right reserve tanks (or NO 1 and NO 4 reserve); main tank Nos 1, 2, 3, and 4; and the center wing tank. Wing tanks are integral tanks. The center tank is a combination of bladder cells and integral tanks, with integral tanks in the wing roots and bladder sections in the body. Each tank has overwing fuel fillers, sump drains, and dripsticks for measuring fuel quantity. Fuel tank capacities are listed in *figure 1-31*.

Fuel flow into each tank is automatically shut off when fuel level reaches the float switches in the fuel level control pilot valve (primary float switch). The primary float switch closes the tank refueling valve. (See *figure 1-29*.) If the tank continues to fill, a secondary float switch closes the main refueling valve. During air refueling, uncoordinated roll/yaw motion with wing tanks nearly full can cause fuel to reach the secondary float switch. When the main valve closes, the increased pressure in the fuel manifold operates the pressure switch (*figures 1-29* and *1-32*), causing a disconnect. The secondary float switches can be checked on the ground with the FLOAT SWITCH PRECHECK switch on the ground refueling panel (37, *figure 1-33*).

FUEL VENTS

The fuel tank vent system is built into the wing structure. A vent scoop at each wing tip provides positive pressure to the vent system.

CONTROLS AND INDICATORS

Fuel system controls are located on the flight engineer's panel, at the ground refueling panel, and on the flight engineer's auxiliary panel. Fuel system controls are shown in *figure 1-33*.

FUEL QUANTITY GAGES

An individual fuel quantity gage for each tank is installed on the flight engineer's panel (19, *figure 1-33*). Similar gages (33) are installed on the ground refueling panel. The master refuel switch (16 or 38) must be on to use the ground gages. The flight engineer's panel gages are calibrated to read correctly in wings-level flight with two degrees nose up pitch attitude. These gages do not read accurately on the ground because of airplane attitude and the difference in wing bending. The ground refueling panel gages show correct fuel quantity when the airplane is parked with zero pitch and roll. The flight engineer's panel gage readings can be corrected to true fuel quantity by use of tables in T.O. 1E-3A-2-28-1-1. To make sure of a correct reading press the gage test button (17) momentarily before reading gages.

Fuel quantity gages are the primary means of determining the amount of fuel on board the airplane. If a more accurate preflight check is required, use the dripsticks.

Fuel System Schematic

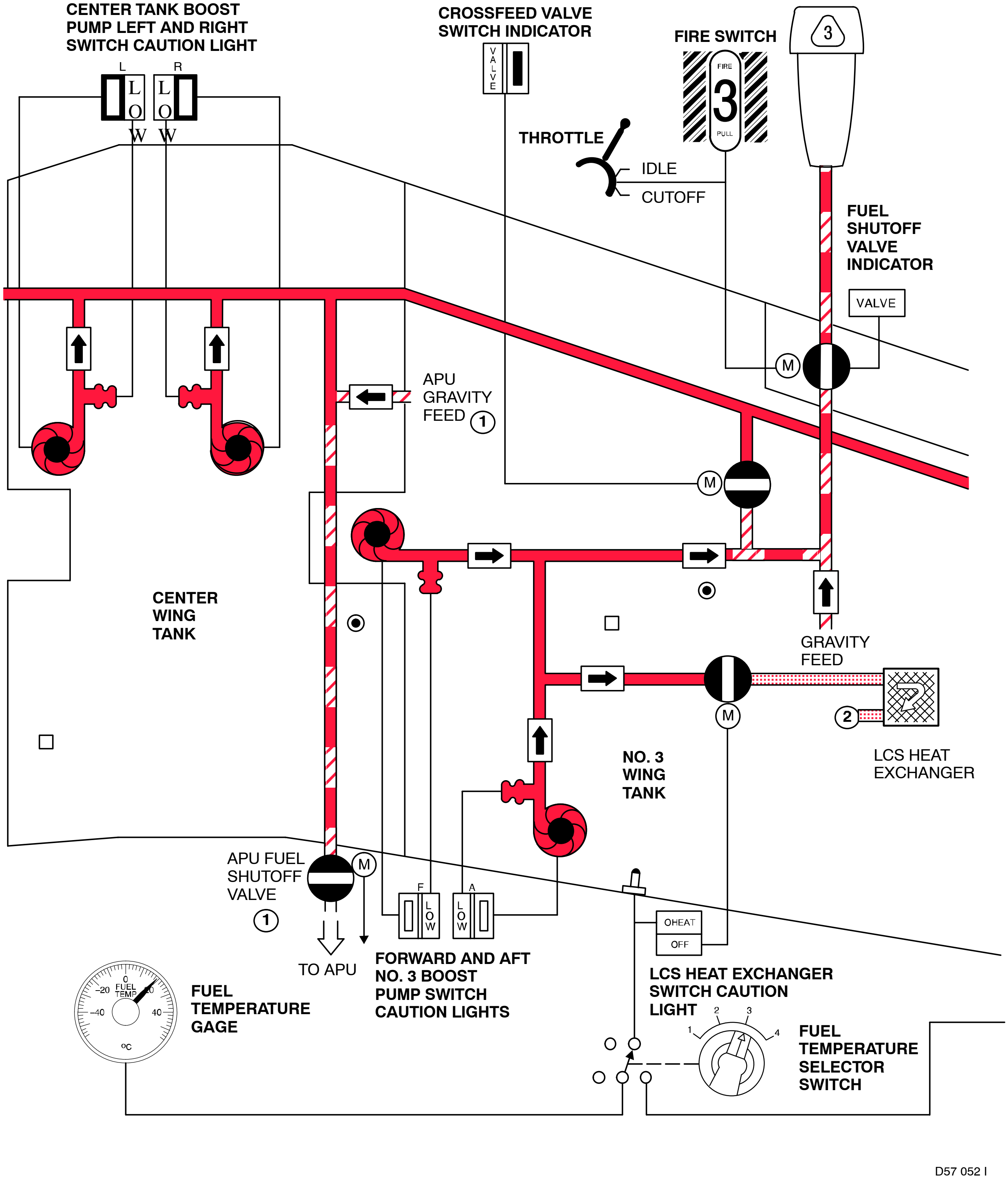

Figure 1-29 (Sheet 1 of 4)

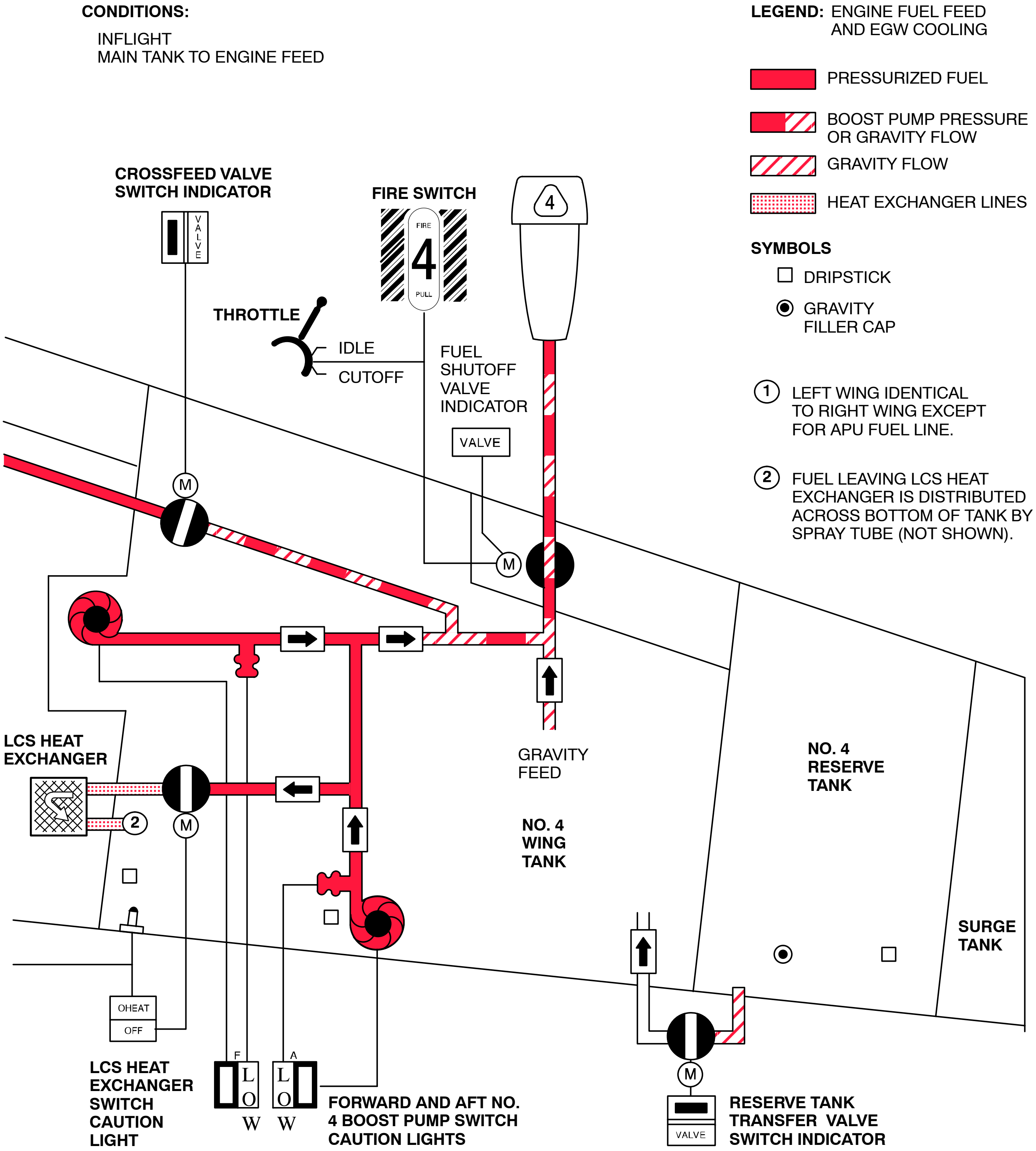

Figure 1-29 (Sheet 2 of 4)

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Fuel System Schematic (Continued)

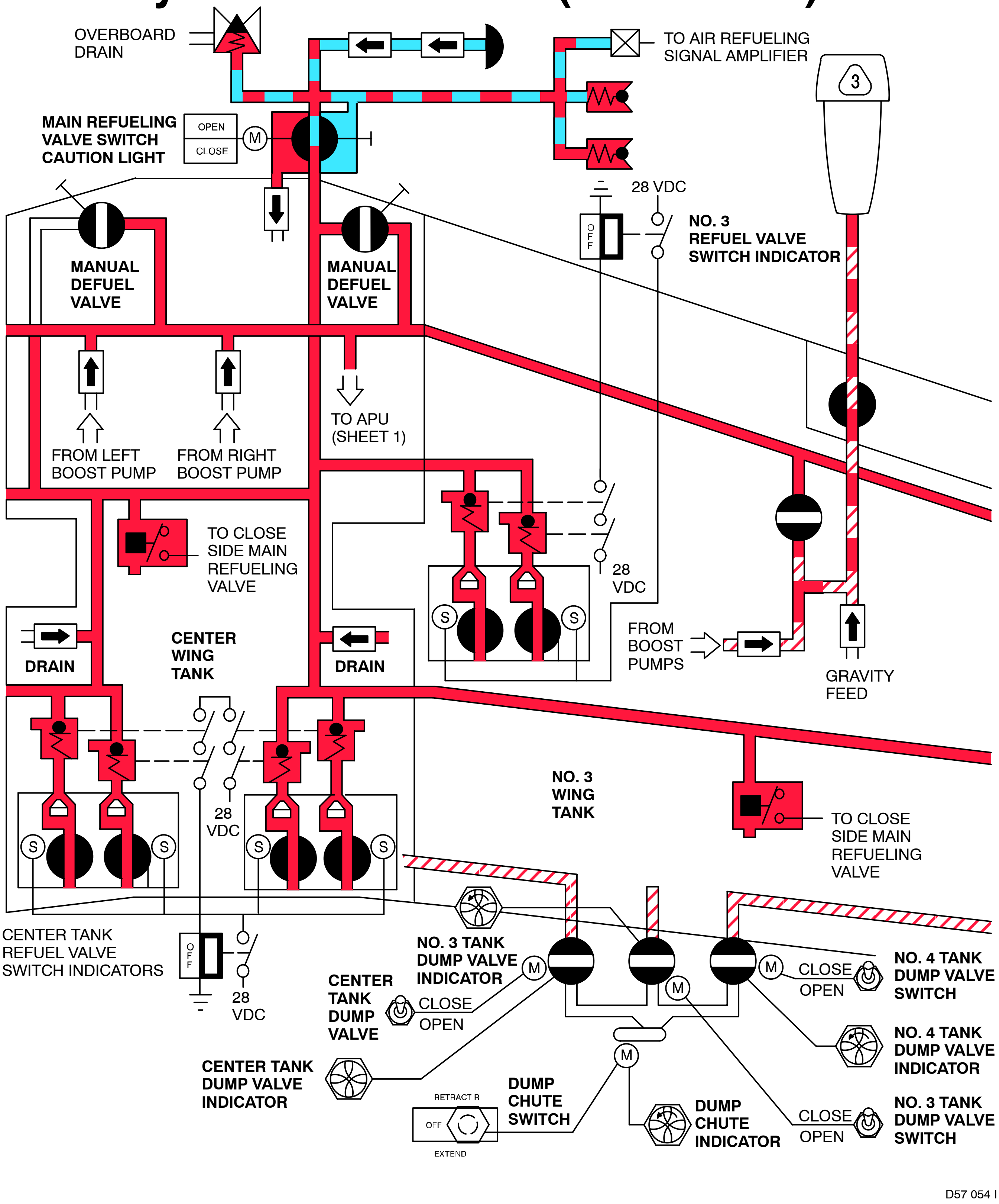


Figure 1-29 (Sheet 3 of 4)

CONDITION:
AIR REFUELING

NOTE

- POWER FOR ALL REFUELING SYSTEM COMPONENTS IS CONTROLLED THROUGH MASTER REFUEL SWITCH
- LEFT WING IS IDENTICAL TO RIGHT WING
- RESERVE TANK TRANSFER VALVE POWERED FROM NO. 4 TANK DUMP VALVE SWITCH

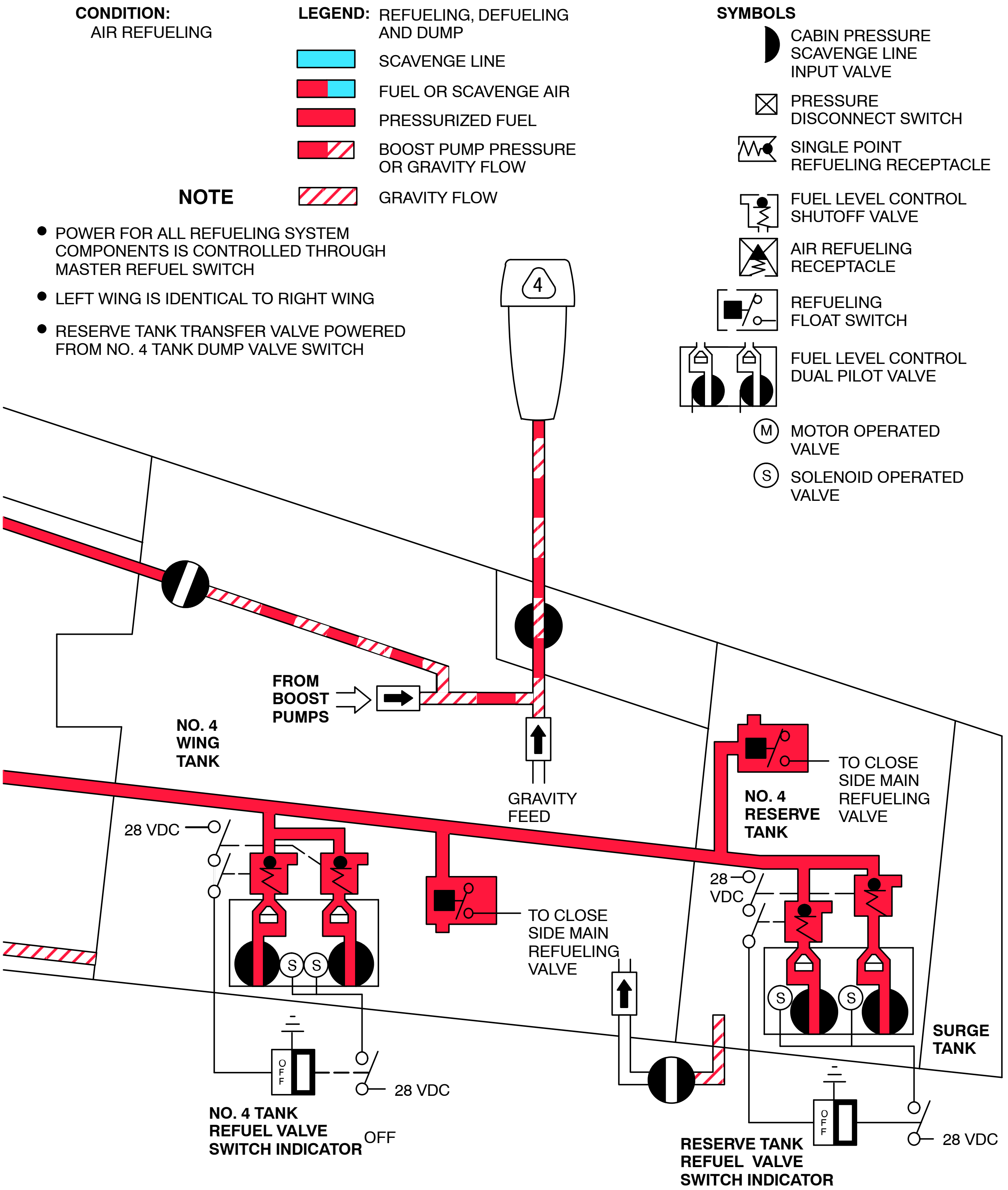
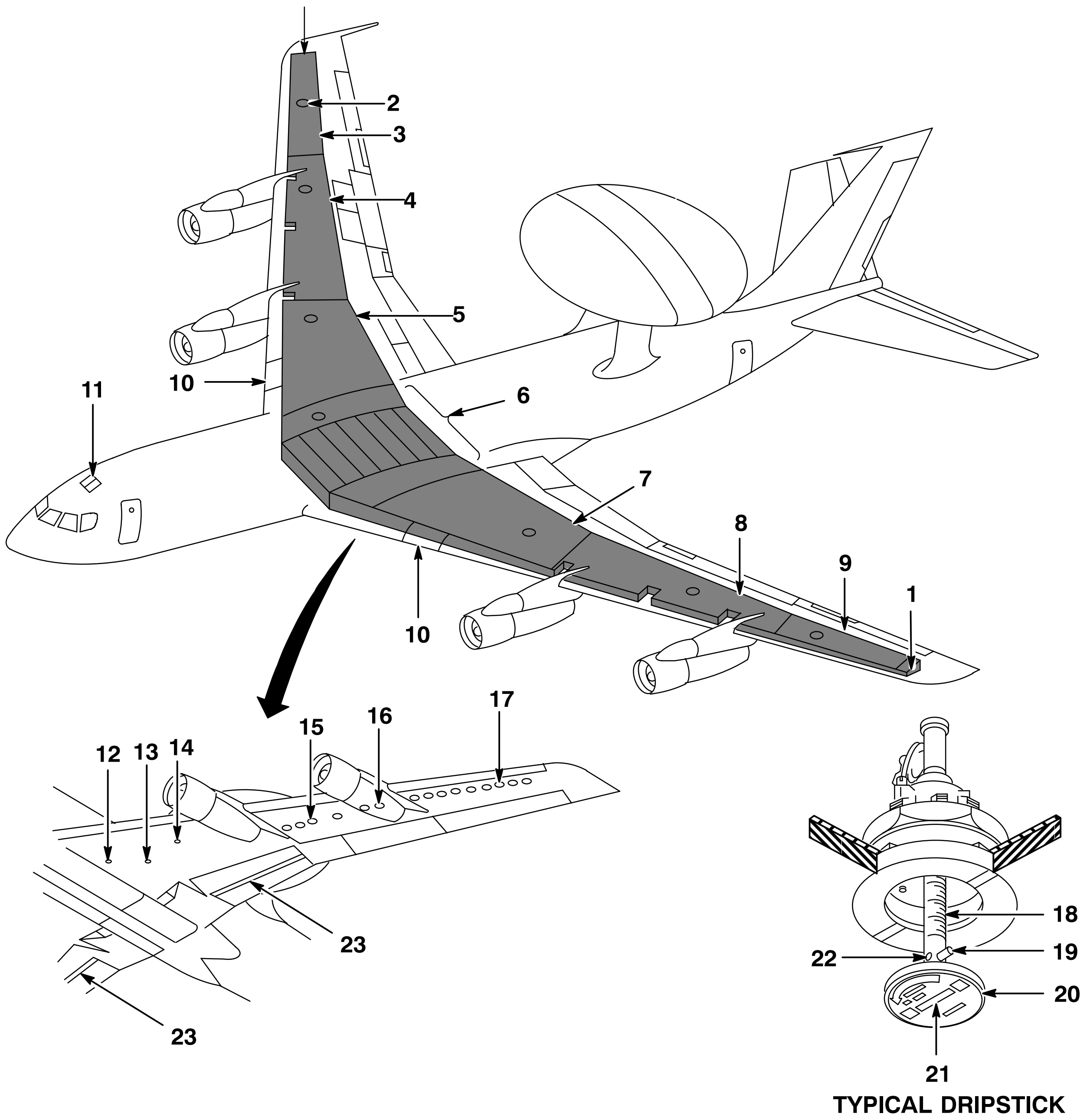


Figure 1-29 (Sheet 4 of 4)

Fuel System Component Locations



1. VENT SURGE TANK (2 PLACES)
2. OVERWING FILLER PORT (7 PLACES) (TYPICAL)
3. RESERVE TANK NO. 4
4. MAIN TANK NO. 4
5. MAIN TANK NO. 3
6. CENTER TANK
7. MAIN TANK NO. 2
8. MAIN TANK NO. 1
9. RESERVE TANK NO. 1
10. DEFUELING STATION (2 PLACES)
11. AIR REFUELING SLIPWAY DOORS
12. CENTER WING TANK DRIP STICK
13. MAIN TANK NO. 2 INBOARD DRIP STICK
14. MAIN TANK NO. 2 OUTBOARD DRIP STICK
15. MAIN TANK NO. 1 INBOARD DRIP STICK
16. MAIN TANK NO. 1 OUTBOARD DRIP STICK
17. RESERVE TANK NO. 1 DRIP STICK
18. CALIBRATED SCALE
19. LOCKING PIN
20. CAP
21. SCREW DRIVER SLOT
22. DRIPHOLE
23. FUEL DUMP CHUTES (2 PLACES)

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Figure 1-30

Fuel Tank Capacities

TANK	USABLE CAPACITY (U.S. GAL) ①		USABLE FUEL – LB GROUND FUEL LOAD		USABLE FUEL – LB AERIAL FUEL LOAD		UNUSABLE FUEL – LB		FUEL REMAINING AFTER DUMP– LB ⑥	
	GROUND ②	AERIAL ③	JP–4	JP–8	JP–4	JP–8	JP–4	JP–8	JP–4	JP–8
NO. 1 Reserve	439	423	2,854	2,941	2,750	2,834	5	5	0	0
NO. 1 Main	2,323	2,185	15,100	15,564	14,203	14,640	77	79	4,100	4,200
NO. 2 Main	4,069	3,846	26,449	27,262	24,999	25,768	60	63	3,700	3,800
Center	10,193	10,193	66,255	68,293	66,255	68,293	203	210	1,600	1,700
NO. 3 Main	4,069	3,846	26,449	27,262	24,999	25,768	60	63	3,700	3,800
NO. 4 Main	2,323	2,185	15,100	15,564	14,203	14,640	77	79	4,100	4,200
NO. 4 Reserve	439	423	2,854	2,941	2,750	2,834	5	5	0	0
Totals	23,855 ②	23,101 ③	155,061 ①⑤	159,827 ①⑤	150,159 ①⑤	154,777 ①⑤	487 ①⑤	504 ①⑤	17,200 ①④⑤	17,700 ①④⑤

① Individual airplanes can vary ±1.5%.
② Capacity shown is approximate reading at automatic shutoff level with airplane on level ground.
③ Capacity shown is for manual shutoff levels set for aerial refueling missions.
④ Approximate capacity in level flight attitude.
⑤ Fuel density of JP–4 = 6.5 lb/gal and JP–8 = 6.7 lb/gal (+20°C).
⑥ Fuel remaining after dumping to standpipes.

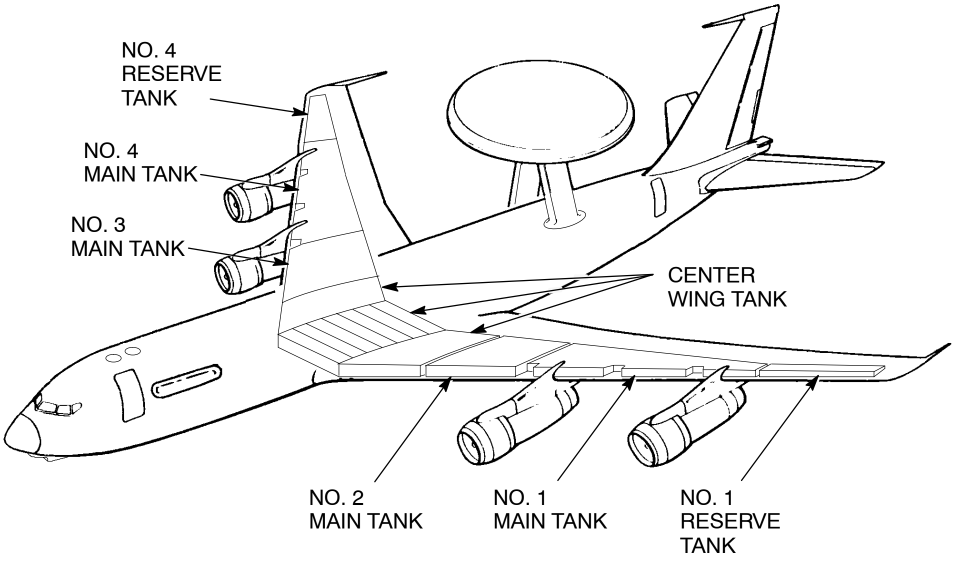


Figure 1-31

Tanker-Receiver Electrical Connection

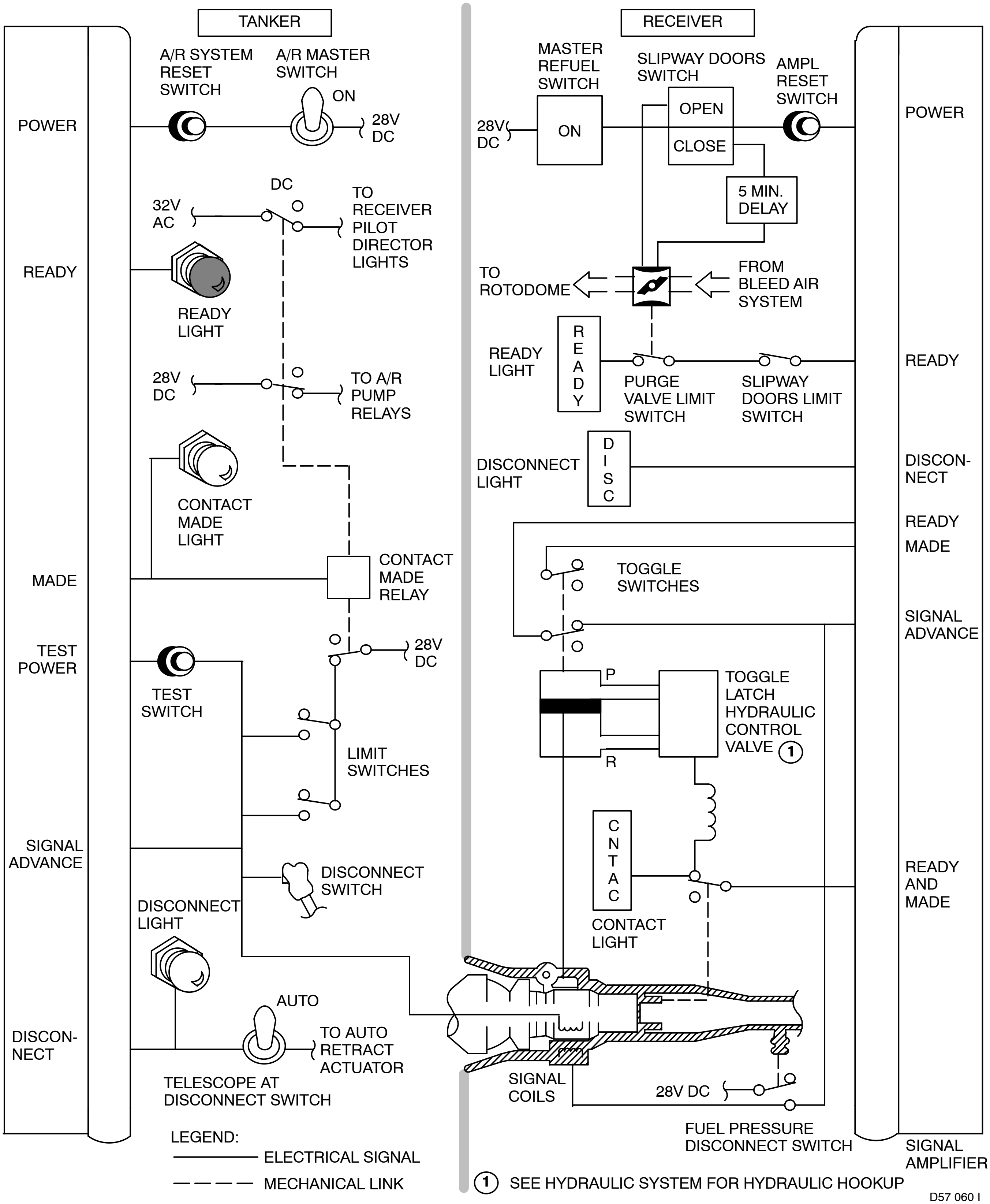


Figure 1-32

Fuel System Controls and Indicators

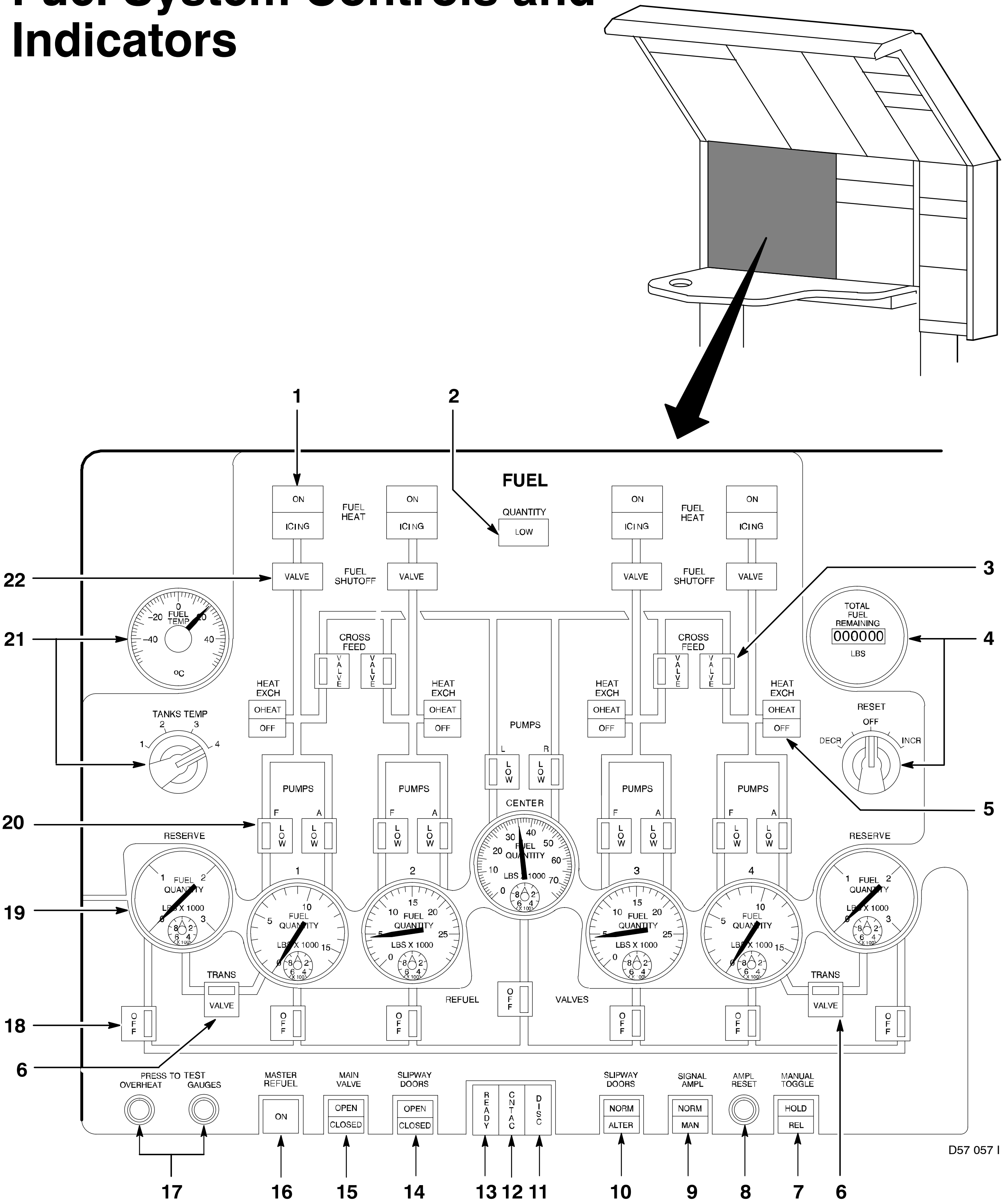
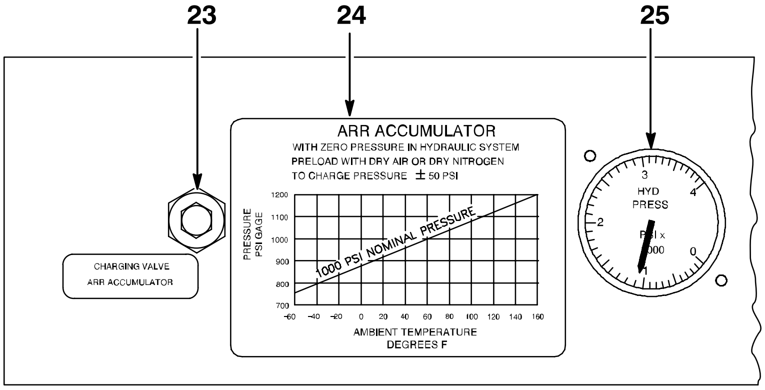
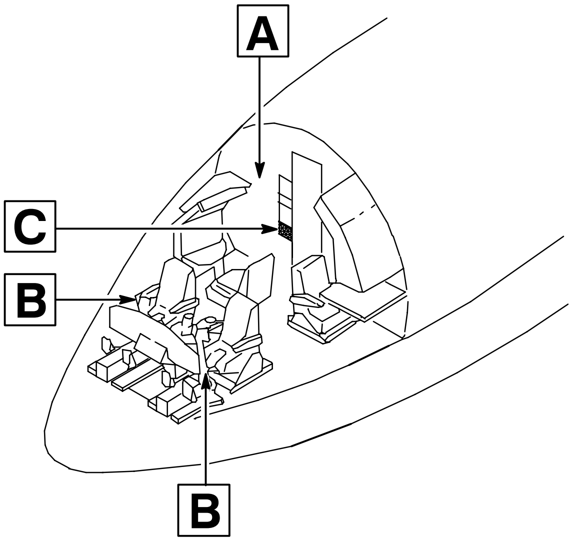


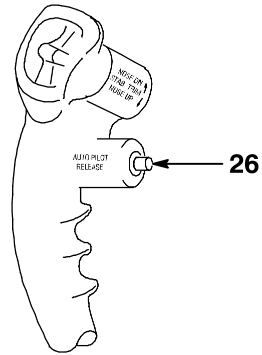
Figure 1-33 (Sheet 1 of 9)

Fuel System Controls and Indicators (Continued)

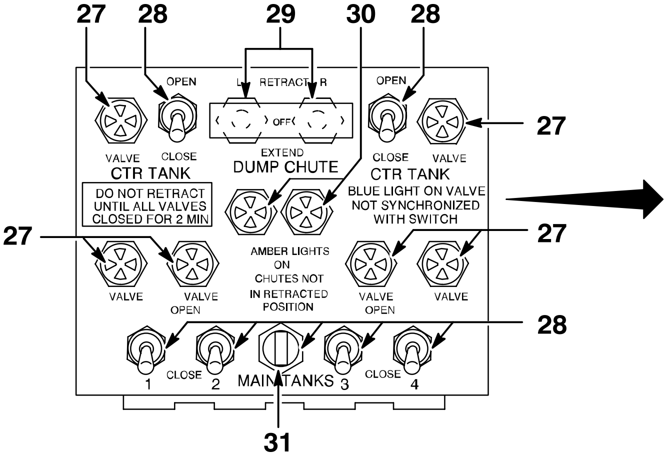


A AIR REFUELING ACCUMULATOR PRESSURE GAGE

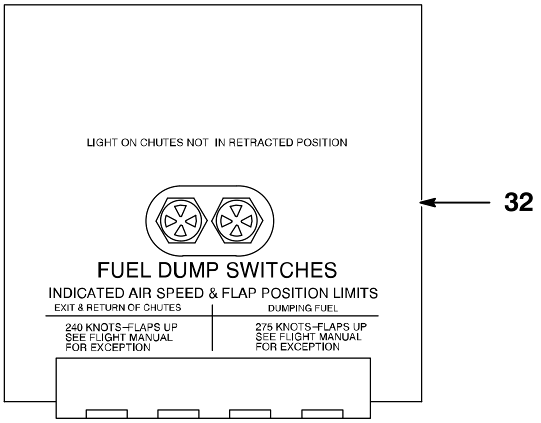




B PILOT'S CONTROL WHEEL



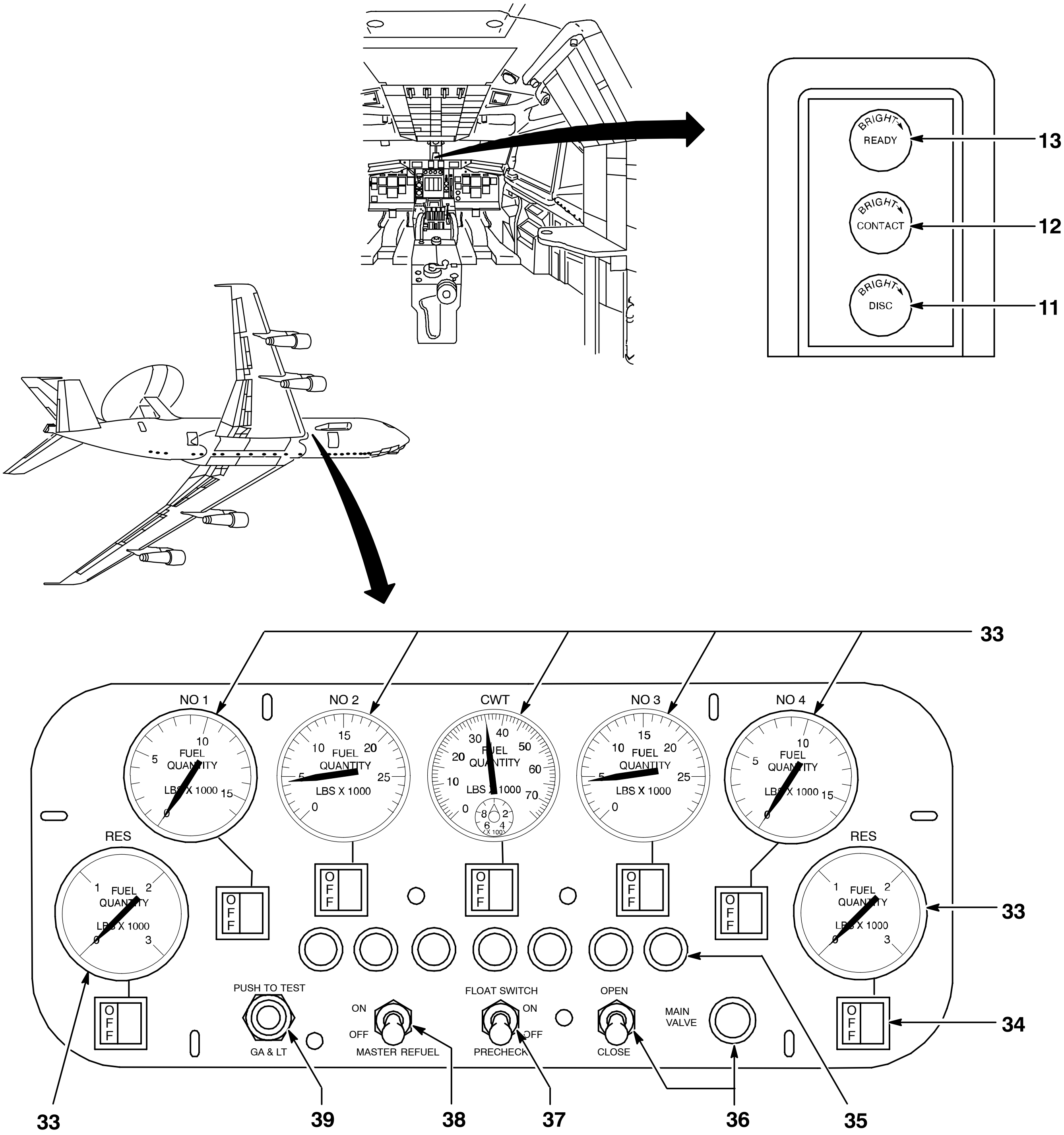
C FUEL DUMP PANEL



FUEL DUMP PANEL COVER

D57 058 I

Figure 1-33 (Sheet 2 of 9)



D GROUND REFUELING PANEL

D57 059 I

Figure 1-33 (Sheet 3 of 9)

Fuel System Controls and Indicators (Continued)

NO.	CONTROL/INDICATOR	FUNCTION
	FLIGHT ENGINEER'S FUEL PANEL (SHEET 1)	
1	FUEL HEAT Switch/Caution Lights (Green, Amber) (One per engine)	Amber ICING caution light illuminates when pressure drop across fuel filter closes pressure switch. When depressed (ON) green ON indicator illuminates and motor operated valve is commanded open, admitting hot 16th stage bleed air to fuel heater. In released (off) position, valve is commanded closed and ON indicator goes out. Throttle must be out of cutoff and FIRE switch closed before fuel heat valve functions.
2	QUANTITY Caution Light (Amber)	LOW caution light is illuminated when total fuel on board is less than 9,000 pounds. Light inoperative if either master refuel switch (16 or 38) is on.
3	CROSS FEED Switch/Indicators (Green) (One per engine)	When depressed (on) line light illuminates and motor operated valve opens. In released (off) position, line light is off, valve closes. VALV indicator is on when valve is not in position selected by switch.
4	TOTAL FUEL REMAINING Digital Meter and RESET Switch (Fuel Remaining Gage)	Switch is spring loaded to OFF. When set to INC causes fast increase in meter number. When set to DECR causes fast decrease in meter number. When set to intermediate mark causes slower change rate. Fuel quantity must be set in gage at start of flight or after refueling. When engines are operating, fuel system flow transmitters cause digital meter to count down as fuel is consumed.

NOTE

- Gage does not automatically reset if fuel is added, defueled, dumped (or used by APU). Digital meter must be reset manually after refueling, fuel dump, or extended APU use.
- For increased accuracy, set gage in level flight at cruise altitude.

NO.	CONTROL/INDICATOR	FUNCTION
5	HEAT EXCH Switch/Caution Lights (Amber) (One per main tank)	In depressed (on) position, opens motor operated shutoff valve to LCS heat exchangers in inboard main fuel tanks 2 and 3. In released (off) position, valve closes and OFF caution light illuminates. OHEAT caution light illuminates when fuel temperature is above preset limit (49°C from sea level to 27,000 ft. decreasing to 23°C at 45,000 ft. as shown in section V). If altitude input from air data computer is lost, OHEAT light illuminates at 49°C.

NOTE

WITH SOTA The HEAT EXCH OHEAT caution lights do not give adequate fuel boiling temperature margin when using JP-4 or Jet B fuel with the thermally protected fuel boost pumps. (See *figure 5-9*) ◀

Figure 1-33 (Sheet 4 of 9)

NO.	CONTROL/INDICATOR	FUNCTION
6	TRANS (Reserve Tank Transfer) Switch/Indicators (Green) (One for each reserve tank)	In depressed (open) position, line light illuminates and motor operated reserve tank transfer valve opens. In released (closed) position, line light goes out and transfer valve closes. VALVE indicator comes on when valve is not in position indicated by switch.
7	MANUAL TOGGLE Switch/ Caution Light (Green/Amber)	Operates only with SIGNAL AMPL switch in MAN. In depressed (HOLD) position, operates manual boom latching. Green HOLD indicator illuminated when switch depressed. In released (REL) position, releases boom latches. Amber REL caution light illuminates when switch released. READY indicator also illuminates (if purge valve is open) when toggles released.
8	AMPL RESET Button	When pressed with slipway doors open, cycles signal amplifier back to ready condition (through contact). If DISC caution light is illuminated, DISC light goes out, CNTAC light flashes and READY light illuminates.
9	SIGNAL AMPL Switch/Caution Light (Amber, Green)	In depressed (NORM) position, sets automatic disconnect mode in fuel receiver system and signal amplified. Green NORM indicator illuminates. In released (MAN) position, sets manual disconnect mode in fuel receiver system and signal amplifier. Amber MAN caution light illuminates. (System is set for manual contact and/or disconnect.)
10	SLIPWAY DOORS NORM–ALTER Switch/Indicator (Green)	In depressed (NORM) position, selects normal (auxiliary hydraulic system) opening system for doors and NORM indicator illuminates. In released (ALTER) position, selects alternate (utility hydraulic system) door opening system and ALTER indicator illuminates.

NOTE

Landing gear handle must be in UP position to pressurize alternate slipway door and toggle latch system. Pressure is supplied from the nose gear up line.

NO.	CONTROL/INDICATOR	FUNCTION
11	DISC Indicator/Caution Light (Amber) ①	When illuminated, tanker or receiver has initiated disconnect. Illuminates when disconnect button is pressed during manual disconnect and when boom contact is broken during automatic disconnect. Goes out when AMPL RESET button is pressed.
12	CONTACT Indicator/Caution Light (Green) ①	When illuminated, boom is in contact and has latched. Indicator goes out when boom leaves receptacle.
13	READY Indicator/Caution Light (Blue) ①	When illuminated, refueling system is ready for contact with slipway doors and purge valve open and toggles released. READY indicator goes out when contact is made.

① Also located on glare shield.

Figure 1-33 (Sheet 5 of 9)

Fuel System Controls and Indicators (Continued)

NO.	CONTROL/INDICATOR	FUNCTION
14	SLIPWAY DOOR OPEN– CLOSE Switch/Caution Light (Green, Amber)	In depressed (OPEN) position, opens slipway doors and rotodome purge valve. Green OPEN indicator is illuminated when slipway doors are full open. In released (CLOSED) position, closes slipway doors and starts five-minute timer to close rotodome purge valve. Amber CLOSE caution light illuminates when slipway doors are closed.
15	MAIN VALVE Switch/Caution Light (Green, Amber)	In depressed (OPEN) position, closes switch to open main refueling valve. Green OPEN indicator illuminates when valve is open. In released (CLOSED) position, closes main refueling valve. Amber CLOSED caution light illuminates when valve is closed.
16	MASTER REFUEL Switch/ Indicator (Green)	In depressed (ON) position, closes switch to apply power to refueling system and ON indicator illuminates. When in released (OFF) position, opens switch to remove power from refueling system and ON indicator goes out.
17	PRESS TO TEST Buttons OVERHEAT GAUGES	When OVERHEAT button is pressed, causes OVERHEAT caution light to illuminate in HEAT EXCH switch/caution lights. When GAUGES button is pressed, causes fuel quantity indications to move toward zero. Indications return to normal when either button is released. The fuel temperature gage on the radar console indicates a rise in fuel temperature when the OVERHEAT Switch is depressed.
18	REFUEL VALVES Switch/ Indicator (Green) (One per tank)	When pressed (on) closes switch (line light illuminates) to allow fuel pressure to open valve from tank to fuel manifold. When pressed again (OFF) closes refueling valve and line light goes out. OFF indicator goes out when valve leaves closed position.

NOTE

If tank is allowed to fill completely, a float switch causes the refueling valve to close. In this case, both the OFF indicator and line light are illuminated. If REFUEL VALVES switch is then pressed (OFF), the line light goes out.

NO.	CONTROL/INDICATOR	FUNCTION
19	FUEL QUANTITY Gages (One per tank)	Indicate fuel quantity in each tank in thousands of pounds. Small pointer indicates hundreds of pounds. Gages are most accurate in flight at 2° nose up attitude. Corrections in T.O. 1E-3A-2-28-1-1 must be applied on the ground. When fuel quantity gages are unpowered, pointers remain in position.

Figure 1-33 (Sheet 6 of 9)

NO.	CONTROL/INDICATOR	FUNCTION
20	PUMPS Switch/Caution Lights (Amber) (Boost Pump Switches) Two per tank (except reserves) F – Forward pump A – Aft pump L – Left pump R – Right pump	In depressed (on) position, turns pump on and line light illuminates. In released (off) position, turns pump off and line light goes out. LOW caution light illuminates when pump pressure is low and PUMPS switch is on.
21	TANKS TEMP Temperature Gage and Selector Switch (four position)	Temperature gage indicates temperature of fuel in main tank selected by TANKS TEMP selector switch.
22	FUEL SHUTOFF Indicators (Green) (One per engine)	VALVE indicator is on when shutoff valve is in transit. Valve is operated by throttle and engine fire switch.
	A FLIGHT ENGINEER'S AUXILIARY PANEL	
23	Air Refueling Accumulator Charging Valve	Provides means to charge the air refueling accumulator.
24	Air Refueling Accumulator Charging Pressure Decal	Relates air refueling accumulator precharge and temperature.
25	Air Refueling Accumulator Pressure Gage	Indicates hydraulic pressure in air refueling system accumulator in thousands of psi when system is pressurized. Indicates precharge when system is depressurized.
	B PILOT'S CONTROL WHEEL (SHEET 2)	
26	Autopilot/Boom Disconnect Buttons (2)	On outboard horn of pilots' control wheels. When pressed, disconnects boom latching toggles (DISC caution light illuminates) and (if engaged) autopilot, and parallel yaw damper also disengage. Hold button depressed until boom tip is clear of receptacle.
	C FUEL PUMP PANEL	
27	Dump VALVE Indicators (Blue) (One per dump valve switch)	Dump VALVE indicator illuminates when dump valve position does not agree with switch position.
28	Dump Valve Switches (6) (One switch for main tanks 1, 2, 3 and 4. Two switches for center tank)	When set to OPEN with chutes extended, dump valves open. When set to CLOSE, dump valves close. Main tank 1 and 4 switches also dump reserve tanks 1 and 4. Reserve tank transfer valves also close when number 1 and 4 dump valves close.

Figure 1-33 (Sheet 7 of 9)

Fuel System Controls and Indicators (Continued)

NO.	CONTROL/INDICATOR	FUNCTION
29	DUMP CHUTE Switches (Two switches, tied together with bar.)	When set to EXTEND, causes dump chutes to extend. When set to OFF, power is removed from dump chute motors. When set to RETRACT, dump valves close and chutes retract and latch. Reserve transfer valves do not close when dump chutes retract if dump valves are not closed. Bar can be removed for individual switch operation.
30	DUMP CHUTE Caution Lights (Amber) (Two Lights)	DUMP CHUTE caution light illuminates when associated dump chute is not retracted and latched. Both caution lights can be observed through hole in dump panel cover when cover is closed.
31	Panel Light Switch	Causes dump panel background lights to illuminate when dump panel cover is opened, if flight engineer auxiliary panel background lights are illuminated.
32	Dump Panel Cover	Protects switches from accidental operation. In closed position, holds DUMP CHUTE switches in OFF position and dump valve switches to CLOSE and panel light switch (31) turns off panel lights.
	D GROUND REFUELING PANEL (SHEET 2)	
33	Fuel Quantity Gages (One for each tank)	Indicate fuel quantity in each tank in thousands of pounds. Small pointer indicates hundreds of pounds. (Operate in parallel with gages on engineer panel.) Gages are most accurate when airplane is level (zero pitch, zero roll). When fuel quantity gages are unpowered, pointers remain in last position. Master refuel switch (38) must be on to read gages.
34	OFF Switch/Caution Lights (Amber) (One per tank)	In depressed (ON) position, open refueling valve from tank to manifold. In released (OFF) position, close refueling valve from tank to manifold. OFF caution light illuminates when valve is completely closed and MASTER REFUEL switch is ON. Line light illuminates when valve is open and MASTER REFUEL switch is ON. (Operates in parallel with REFUEL VALVES switches on engineer panel.)
35	FLOAT SWITCH Caution Lights (7) (Amber)	Indicate fuel level float switch position for each tank. Indicator illuminates when float switch is closed.

Figure 1-33 (Sheet 8 of 9)

NO.	CONTROL/INDICATOR	FUNCTION
36	MAIN VALVE OPEN–CLOSE Switch and Indicator (Blue)	When set to OPEN, opens main refueling valve. MAIN VALVE indicator illuminates when valve is open. When set to CLOSE, closes main refueling valve. MAIN VALVE indicator goes out when valve is closed. (Operates in parallel with MAIN VALVE switch on engineer panel.)
37	FLOAT SWITCH PRECHECK Switch	When set to up position tests operation of float switches and FLOAT SWITCH indicators. Indicators illuminate one at a time when switch is set to on, if fuel manifold is pressurized. If moved during refueling, closes main refuel valve.
38	MASTER REFUEL Switch	When set to ON, connects power to refueling system. (Also transfers fuel quantity signal to ground fuel gages (33) and makes QUANTITY LOW caution light (2) inoperative.) When set to OFF, removes power from refueling system. Must be on to read fuel quantity gages (33).
39	PUSH TO TEST GA & LT Button	When pressed, illuminates all ground refueling panel lights and causes fuel quantity gages needles to rotate counterclockwise toward zero.
	SLIPWAY Light Switch (Not shown)	Located on pilots' overhead panel (*figure 1-7*). Controls on-off and brightness of slipway lights. Causes lights to illuminate and increases brightness when turned clockwise. Full counterclockwise position turns lights off.

Figure 1-33 (Sheet 9 of 9)

UNDERWING FUEL MEASURING STICKS (DRIP STICKS)

The drip sticks (*figure 1-30*) in all tanks allow the crew to check the volume of fuel in each tank. The depth of fuel in a tank can be measured to within ±0.1 inch. The quantity accuracy depends on the size of the tank. (For example, in the reserve tanks, ±0.1 inch at full tank equals ±1.5 gallons. In the center tank ±0.1 inch at full tank equals ±6.5 gallons.)

To obtain a fuel quantity reading, unlock the drip stick, slowly pull it down until a steady drip of fuel appears at the tip of the stick, then note the reading in inches on the stick (at the bottom of the wing). The scale reading in inches must be corrected for pitch and roll attitude and converted to gallons (T.O. 1E-3A-2-28-1-1). The quantity in gallons multiplied by the weight per gallon (density) of the fuel in the tank equals the weight of fuel in pounds. Flight engineers should be familiar with the drip stick procedure.

TOTAL FUEL REMAINING GAGE

The Total Fuel Remaining Gage is provided as a backup for the tank quantity gages and as a quick reference aid in determining inflight gross weight. This gage is not a totalizer. The gage sums the signals from the engine fuel flow transmitters and subtracts that quantity from the total set in by the flight engineer.

NOTE

- The total fuel remaining gage does not correct for fuel added, defueled, dumped, lost through leaks, or used by APU. Reset gage manually after refueling or fuel dump, after fuel leaks are stopped, or after extensive APU use.
- The fuel flow indicating system accuracy is ±1% of the flow rate. When the rate is converted to fuel volume used, the accuracy is ±2% of the quantity which has passed through the flow transmitters since the system was reset. The accuracy of the total fuel remaining gage also depends on the accuracy of the fuel quantity originally set in the gage. The error can be several percent if flight deck fuel gages are used on the ground and especially if the airplane is not level. For greatest accuracy, use the dripsticks or fuel gages and then correct for airplane attitude as shown in T.O. 1E-3A-2-28-1-1.

SINGLE POINT REFUELING

The airplane is equipped with two receptacles for single point ground refueling. Refueling controls are located on the flight engineer's panel and on the ground refueling panel on the right side of the airplane ahead of the wing (*figure 1-33*). Ground panel controls override the flight engineer's controls. The ground refueling system uses the same manifold as the air refueling receiver system.

Refueling requires battery power in the airplane. To refuel the airplane from the ground refueling panel, follow procedures in T.O. 1E-3A-2-7.

AIR REFUELING

The air refueling (receiver) system allows the airplane to be refueled from boom-equipped tankers. The receiver system consists of a receptacle, piping to the refueling manifold, and control valves. Component locations are shown in *figures 1-29* and *1-30*.

SLIPWAY AND RECEPTACLE

The refueling slipway, located on top of the airplane at approximately station 290, has two hydraulically operated doors, lights for night refueling, boom receptacle and latches, and signal coils for the tanker-receiver signal system (*figure 1-32*). The doors are operated by both hydraulic systems through the SLIPWAY DOORS OPEN–CLOSE switch on the flight engineer's panel (*figure 1-33*). The SLIPWAY DOORS NORM–ALTER switch selects either auxiliary (NORM) or utility (ALTER) hydraulic power.

NOTE

The landing gear lever must be set to UP to operate the doors in ALTER.

Lights for night refueling are located in each door and in the boom receptacle. Light intensity is controlled by the SLIPWAY light switch on the pilot's overhead panel (27, *figure 1-7*).

Boom latches, located in the receptacle, are operated by hydraulic power. The latches normally operate automatically as controlled by the signal system. When manual control of boom latching is desired or the automatic function fails, pressing the SIGNAL AMPL switch allows manual control. The MANUAL TOGGLE switch controls manual latching. The latches can also be released by the pilot's autopilot disconnect buttons (26, *figure 1-33*).

CAUTION

- When operating in manual latch mode, make sure latches are released (REL caution light on) before contact is made. Inserting boom with latches in hold position could damage boom and break latches.

- Tanker automatic disconnect system does not function if SIGNAL AMPL switch is in MAN position or if there is a malfunction in either tanker or receiver-signal coil system (*figure 1-32*).
- Do not press AMPL RESET switch until boom is clear of receptacle.

REFUELING RECEIVER PROCEDURES

Refueling procedures for tank filling are similar to single-point refueling procedures. Detailed procedures are contained in T.O. 1-1C-1 and T.O. 1-1C-1-27 (for the receiver crew). When refueling, observe fuel system limitations shown in Section V and fuel loading instructions in this section.

BOOST PUMPS

There are two electrically operated boost pumps in each of the four main tanks and in the center tank. There is a forward (F) and aft (A) pump for main tanks 1, 2, 3, and 4. The two center tank pumps deliver fuel at a higher pressure than the main tank pumps and feed fuel to the engine, regardless of main tank pump settings, if the appropriate crossfeed valves are open. Boost pump controls are on the flight engineer's panel (*figure 1-33*). Boost pump power is from P61-1 panel, BOOST PUMPS circuit breakers TANK 1, 2, 3, and 4 (3 per pump) and CENTER TANK (1 per pump).

CAUTION

If any combination of boost pump circuit breakers trip, set pump switch to OFF and open all circuit breakers for that pump. In flight, unless required for safety of flight, leave circuit breakers open. Do not reset circuit breakers until maintenance personnel inspect the system.

NOTE

The center tank fuel override pumps and main tank boost pumps are thermally protected. A thermal switch on each of the three motor phases removes power when case temperature reaches 375°F. The thermal switches are not resettable.

FUEL TRANSFER

Fuel cannot be transferred between tanks, except from reserve tanks to main tanks 1 and 4. Transfer from the reserve tanks is by gravity flow. Reserve tank fuel must not be transferred when gross weight is above 285,000 pounds.

FUEL DUMP

The fuel dump system (*figures 1-29, 1-30, 1-31,* and *1-33*) consists of dump chutes under each wing, dump valves for main wing tanks and center tank, and controls on the flight engineer's auxiliary panel (*figure 1-13*). Airplane gross weight can be reduced from maximum takeoff weight (325,000 lb) to maximum landing weight (250,000 lb) in about 33 minutes.

The dump rate decreases as fuel level drops. To reduce fuel level to the undumpable level shown in *figure 1-31* requires an additional 40 to 45 minutes after reaching maximum landing weight.

WARNING

Observe the fuel dumping limitations in Section V. Refer to AERODYNAMIC AND STRUCTURAL LIMITATIONS and FUEL DUMPING LIMITATIONS. Damage to airplane or to fuel dump system components could occur if these limits are exceeded.

NOTE

If AVAC bus two loses power, left dump chute does not operate. If AVAC bus eight loses power, right dump chute does not operate.

When the dump chute switches are set to EXTEND, the dump chutes unlatch, illuminating the dump chute caution lights and energizing a relay applying power to close the dump valves for each chute. When the chutes are extended fully, a second relay allows power to open the dump valves. If the chutes are retracted with the valves open, and valve switches set to OPEN, the second relay opens, commanding the dump valves to close. When the chute retracts and latches, power is removed from the closed side of the dump valves and the dump chute caution light goes out.

When dump valves for main tanks 1 and 4 open, the reserve tank transfer valves open automatically. When dump valves for main tanks 1 and 4 close, the reserve tank transfer valves close, if the reserve tank transfer switches are set to closed.

GRAVITY FEED

Fuel may be fed from any main wing tank directly to engine without use of the boost pumps. Full takeoff rated thrust is not always available above approximately 12,000 feet altitude with boost pumps off. Reserve tank fuel may be fed to the outboard engines by transfer to the outboard main tanks. Center tank fuel cannot be used without boost pumps.

FUEL LOADING AND MANAGEMENT

NOTE

> When ground refueling following an operation where any amount of JP-4, JET-B, F-40 or AVGAS has been mixed with fuel in the main or reserve tanks, all transferable fuel will be transferred to the center tank before wing tanks are filled with a fuel for which the fuel pumps are not temperature/altitude limited. The Ground Handling-Service and Airframe Manual T.O. 1E-3A-2-7 contains a procedure for tank-to-tank transfer.

A specific sequence of fuel loading and fuel management must be followed in order to:

1. Control location of airplane cg.
2. Reduce wing and fuselage bending loads.
3. Protect wing structure from overpressure if both automatic shutoff valves fail to operate.
4. Prevent nuisance disconnects from pressure surges or uncoordinated roll during air refueling.
5. Control fuel level in main wing tanks to provide fuel reserves and allow proper operation of liquid cooling system Refer to ELECTRONICS COOLING SYSTEMS.

STANDARD FUEL LOADS

Standard fuel loads for ground and aerial refueling are shown in T.O. 1E-3A-5-2.

NOTE

> In this manual, the term fuel load or total fuel load refers to the usable fuel quantity in the airplane at the end of refueling.

FUEL LOADING PROCEDURES

This fuel loading procedure will be used for all aerial and ground refueling operations. Ground refueling will be performed in accordance with T.O. 1E-3A-2-7.

NOTE

> When the tank is filled to auto–shutoff, it is volumetrically full. The flight engineer's panel gages may not provide the correct reading. The P11 gage may not provide the correct reading when compared to the fuel load tables. The correct quantity of fuel in the full tanks is shown in Fig. 1-31, USABLE FUEL–LB GROUND FUEL LOAD. This value should be used to fill out the Form F and set the TOTAL FUEL REMAINING gage.

It is recommended that the computations indicated in this procedure be performed using the approved computer program. It is not necessary to refer to this procedure when using the computer program because the program leads the user automatically through all of the computation steps. Nevertheless, this procedure is written to describe both the manual and computerized methods. If a computer is not available, manual computations will be performed using this procedure.

1. Determine airplane operating weight and cg.
2. Determine total fuel load. Refer to Standard Fuel Load tables, T.O. 1E-3A-5-2, for fuel distribution.

WARNING

- If fuel to be loaded on the ground has a density less than 6.5 lb/gal, use Aerial Refueling Standard Fuel Load table for 6.5 lb/gal, T.O. 1E-3A-5-2, to determine the fuel distribution, and observe maneuvering restrictions for AERIAL SFL (*figure 5-8*).
- Thermally protected center tank fuel override pumps and main tank fuel boost pumps are not qualified for flight using JP–4, JET–B or F–40 fuel at fuel temperatures exceeding 85°F or at altitudes exceeding 35,000 feet.

NOTE

> The center tank fuel override pumps and main tank boost pumps are thermally protected. A thermal switch on each of the three motor phases removes power when case temperature reaches 375°F. The thermal switches are not resettable.

3. Use the weight and balance computer program to plot fuel burn c.g. track with this fuel distribution. If fuel burn c.g. tracks outside the c.g. envelope or mission requirements dictate a more forward c.g., the fuel distribution is adjusted as described in the procedure below. When fuel distribution is computed proceed to step 4.

   If the computer program is not accessible, the operator will determine by any other approved means whether or not c.g. tracks outside the envelope. If c.g. tracks outside the envelope then steps (a) through (e) below will be performed to adjust the standard fuel load.

WARNING

If a computer plot is not available to confirm that c.g. does not track outside the envelope, safety of flight requires that the operator determine by any other approved means that the standard fuel load does not allow c.g. to track outside the envelope.

   (a) Subtract operating weight from 205,000 lb.

   (b) Subtract result of step (a) from total fuel load.

   (c) Read distribution of fuel load determined in step (b).

   (d) Add the quantity determined in step (a) to the center tank level from step (c).

   (e) This yields the adjusted fuel distribution.

NOTE

See example problems on following pages.

4. Load fuel to distribution determined above, using sequence in *figure 1-34*.

CAUTION

- For air refueling, fuel will be fed from main wing tanks directly to engine. Fuel filling sequence requires this fuel feed arrangement for proper tank filling rates.
- If outside air temperature, fuel tank temperature, or temperature of fuel being loaded is less than –30 °C, close tank refueling valve when tank quantity is as listed below:

  Reserve tanks: 2350 pounds

  Outboard Main Tanks 1 and 4:
  14,150 pounds

  Inboard Main Tanks 2 and 3:
  25,300 pounds

- If a tank refuel valve is known to be inoperative or if a refuel valve does not close as shown by fuel quantity increasing 300 pounds (500 pounds below –30°C) beyond quantity when switch for that tank was pressed and if a tank fuel quantity equals that in step c. of this procedure, discontinue single point or air refueling (disconnect if air refueling). Ground refueling may be continued by overwing fueling. Air refueling may be resumed after normal fuel management procedures have reduced fuel below quantities determined in step c. by an amount that allows refueling. Maintain symmetrical tank loading.
- Do not attempt air refueling with JP–5 or JP–8 fuel if fuel temperature is lower than three degrees C above freezing point of fuel (refer to section V).

5. Reset TOTAL FUEL REMAINING gage.

NOTE

- Airplane fuel quantity gages are the primary means of determining the total fuel quantity. The TOTAL FUEL REMAINING gage is a reliable secondary means, if the proper quantity is set after refueling, dumping, or APU operation.
- Enter the sum of the gage readings into the TOTAL FUEL REMAINING gage.
- If there is any question of fuel gage accuracy when refueling on the ground, have maintenance personnel use dripsticks to check fuel quantity.

6. Resume normal fuel management, *figure 1-35* or *1-36.*

EXAMPLE PROBLEMS

Example Problem 1.

Step 1.	Mission operating weight		197,000 lb
	Mission operating c.g.		31.62% MAC
Step 2.	Total mission fuel load		90,000 lb
	Read fuel distribution	Center	10,931 lb
	(ground load at 6.7 lb/gal)	Mains 2 & 3 (sum)	42,060 lb
		Mains 1 & 4 (sum)	31,128 lb
		Reserves (sum)	5,882 lb

Step 3. Run condition in computer program. Fuel burn c.g. remains within c.g. envelope limit.

Step 4. Load fuel to distribution determined above.

Complete remainder of procedure (through step 6.).

NOTE

Since center tank does not have more than 20,000 lb, manage fuel according to *figure 1-36*.

Example Problem 2.

Step 1.	Mission operating weight		197,000 lb
	Mission operating c.g.		32.46% MAC
Step 2.	Total mission fuel load		90,000 lb
	Read fuel distribution	Center	10,931 lb
	(ground load at 6.7 lb/gal)	Mains 2 & 3 (sum)	42,060 lb
		Mains 1 & 4 (sum)	31,128 lb
		Reserves (sum)	5,882 lb

Step 3. Run condition in computer program. Fuel burn c.g. track exceeds c.g. envelope limit. The distribution must be adjusted. Use the Standard Load Adjust function in the computer program, or use the manual process if computer is not accessible.

Subtract operating weight from 205,000 lb		8,000 lb
Subtract 8,000 lb from 90,000 lb fuel load		82,000 lb
Read fuel distribution	Center	6,931 lb
(ground load at 6.7 lb/gal)	Mains 2 & 3 (sum)	38,060 lb
	Mains 1 & 4 (sum)	31,128 lb
	Reserves (sum)	5,882 lb
Add 8,000 lb to 6,931 lb to determine final center tank quantity.		14,931 lb

Step 4. Load fuel to distribution determined above.

Complete remainder of procedure (through step 6.).

NOTE

Since center tank does not have more than 28,000 lb [20,000 + (205,000 – operating weight)], manage fuel according to *figure 1-36*.

Example Problem 3.

Step 1.	Mission operating weight		197,000 lb
	Mission operating c.g.		32.35% MAC
Step 2.	Total mission fuel load		110,000 lb
	Read fuel distribution	Center	20,000 lb
	(ground load at 6.7 lb/gal)	Mains 2 & 3 (sum)	52,990 lb
		Mains 1 & 4 (sum)	31,128 lb
		Reserves (sum)	5,882 lb

Step 3. Run condition in computer program. Fuel burn c.g. remains within c.g. envelope limit.

Step 4. Load fuel to distribution determined above.

Complete remainder of procedure (through step 6.).

NOTE

Since center tank does not have more than 20,000 lb, manage fuel according to *figure 1-36*.

Example Problem 4.

Step 1.	Mission operating weight		197,000 lb
	Mission operating c.g.		33.86% MAC
Step 2.	Total mission fuel load		110,000 lb
	Read fuel distribution	Center	20,000 lb
	(ground load at 6.7 lb/gal)	Mains 2 & 3 (sum)	52,990 lb
		Mains 1 & 4 (sum)	31,128 lb
		Reserves (sum)	5,882 lb

Step 3. Run condition in computer program. Fuel burn c.g. track exceeds c.g. envelope limit. The distribution must be adjusted. Use the Standard Load Adjust function in the computer program, or use the manual process if computer is not accessible.

Subtract operating weight from 205,000 lb		8,000 lb
Subtract 8,000 lb from 110,000 lb fuel load		102,000 lb
Read fuel distribution	Center	20,000 lb
(ground load at 6.7 lb/gal)	Mains 2 & 3 (sum)	44,990 lb
	Mains 1 & 4 (sum)	31,128 lb
	Reserves (sum)	5,882 lb
Add 8,000 lb to 20,000 lb to determine final center tank quantity.		28,000 lb

Step 4. Load fuel to distribution determined above.

Complete remainder of procedure (through step 6.).

NOTE

Since center tank does not have more than 28,000 lb [20,000 + (205,000 – operating weight)], manage fuel according to *figure 1-36*.

Example Problem 5.

Step 1.	Mission operating weight	197,000 lb
	Mission operating c.g.	31.62% MAC
Step 2.	Total mission fuel load	128,000 lb

Read fuel distribution (ground load at 6.7 lb/gal)	Center	36,466 lb
	Mains 2 & 3 (sum)	54,524 lb
	Mains 1 & 4 (sum)	31,128 lb
	Reserves (sum)	5,882 lb

Step 3. Run condition in computer program. Fuel burn c.g. remains within c.g. envelope limit.

Step 4. Load fuel to distribution determined above.

Complete remainder of procedure (through step 6.).

NOTE

Since center tank has more than 20,000 lb, manage fuel according to *figure 1-35*.

Example Problem 6.

Step 1.	Mission operating weight	197,000 lb
	Mission operating c.g.	33.86% MAC
Step 2.	Total mission fuel load	128,000 lb

Read fuel distribution (ground load at 6.7 lb/gal)	Center	36,466 lb
	Mains 2 & 3 (sum)	54,524 lb
	Mains 1 & 4 (sum)	31,128 lb
	Reserves (sum)	5,882 lb

Step 3. Run condition in computer program. Fuel burn c.g. track exceeds c.g. envelope limit. The distribution must be adjusted. Use the Standard Load Adjust and Center Tank Switch Fuel functions in the computer program, or use the manual process if computer is not accessible.

Subtract operating weight from 205,000 lb	8,000 lb
Subtract 8,000 lb from 128,000 lb fuel load	120,000 lb

Read fuel distribution (ground load at 6.7 lb/gal)	Center	28,466 lb
	Mains 2 & 3 (sum)	54,524 lb
	Mains 1 & 4 (sum)	31,128 lb
	Reserves (sum)	5,882 lb

Add 8,000 lb to 28,466 lb to determine final center tank quantity.	36,466 lb

Step 4. Load fuel to distribution determined above.

Complete remainder of procedure (through step 6.).

NOTE

Since center tank has more than 28,000 lb [20,000 + (205,000 – operating weight)], manage fuel according to *figure 1-35*.

Fuel Loading Sequence

TOTAL FUEL LOAD	RESERVE TANKS 1 AND 4	OUTBOARD MAIN TANKS 1 AND 4	INBOARD MAIN TANKS 2 AND 3	CENTER TANK
Under 40,000 lb ① ② ③	Empty	Load 1/4 of total load in each main tank	Load 1/4 of total load in each main tank	Empty
Between 40,000 and 80,000 lb ① ② ③	Load to standard fuel load level ④	Load to standard fuel load level ④ Load equal amounts in inboard and outboard tanks until outboard mains are full.	Load to standard fuel load level ④	Load to desired level (not to exceed 9,000 lb) ④
Over 80,000 lb ① ② ③	Full	Full	If center tank below 45,000 lb, load to standard fuel load level ④ ⑤ ⑥ ⑦ ⑧	Load to standard fuel load level (not to exceed 45,000 lb if wing tanks are not full) ④ ⑤ ⑥ ⑦ ⑧
			Center tank over 45,000 lb, load to full ④ ⑤ ⑥ ⑦ ⑧	When wing tanks are full/23,000 lb inboards, load to standard fuel load level, then continue loading inboard wing tanks to standard fuel load level ④ ⑤ ⑥

① For air refueling, feed all engines directly from main tanks.
② Load all tanks simultaneously, except as specified.
③ Close tank refuel valves 300 pounds below desired level (500 pounds below –30°C) to allow for valve closing.
④ Final fuel tank distributions will correspond to Standard Fuel Loads as listed in the FUEL LOADING PROCEDURE in this section and Standard Fuel Load Tables in T.O. 1E-3A-5-2. Fuel tank values may be adjusted using the fuel adjustment procedure listed in FUEL LOADING PROCEDURE in this section.
⑤ If air refueling, open center tank refuel valve before closing inboard wing tank valve to prevent pressure disconnect.
⑥ Do not exceed allowable maneuver limit, *figure 5–8*. Fuel for engine/APU and taxi may be added to center tank but do not exceed 344,000 lb gross weight.
⑦ If Operating Weight Empty (O.W.E.) exceeds 181,000 lb, decrease 45,000 limit by (O.W.E. – 181,000).
⑧ Hold inboard tanks at 23,000 lb for air refueling to prevent pressure disconnects while filling center tank. When center tank is filled to desired level, continue filling inboard tanks to standard fuel load level.

Figure 1-34

FUEL MANAGEMENT

WARNING

Fuel boost and override pumps are not qualified for flight using JP-4 or Jet B fuel at fuel temperatures exceeding 85°F. Observe flight limitations given for JP-4/Jet B and manage fuel load such that JP-4/Jet B or JP-8/JP-5 mixed with JP-4/Jet B is burned first. Maintain flight restrictions until all JP-4/Jet B or JP-8/JP-5 mixed with JP-4/Jet B has been burned or drained from the aircraft. Any fuel load consisting of more than 0.1% JP-4/Jet B is to be considered JP-4.

There are two basic fuel management procedures. The amount of fuel in the center tank determines which procedure to use.

If the center tank contains more than 20,000 lb, use the procedure below. This procedure is also shown in *figure 1-35*.

NOTE

If the center tank fuel quantity has been adjusted by the procedure in step 3. of the FUEL LOADING PROCEDURE, this 20,000 lb criterion is increased by the quantity (205,000 lb – Operating Weight).

1. Use center tank to engines 1 and 4 and inboard main tank to engines 2 and 3 for takeoff. Crossfeed valves 1 and 4 must be open. All boost pumps must be on.
2. When climb power is set (and before 3,000 lb burned from each inboard main tank), switch to center tank feeding all engines. All crossfeed valves must be open. Both center tank boost pumps must be on. Use center tank fuel until center tank contains 20,000 lb of fuel.

NOTE

- If the center tank fuel quantity has been adjusted by the procedure in step 3. of the FUEL LOADING PROCEDURE, this 20,000 lb criterion is increased by the quantity (205,000 lb – Operating Weight).
- Crews will monitor cg and limit crew movement aft, as required, as the cg approaches the aft limit. The airplane cg is closest to the aft limit, during cruise, under the following conditions: Operating weight cg greater than 32%. Fuel quantity in the mains and reserves equals 67,800 lb (fuel in tanks 2 and 3 equals fuel in tanks 1 and 4 plus reserves). Center tank equals 15,400 lb.

3. When center tank quantity has reached level determined in step 2., change to main tanks feeding directly to engines. One crossfeed valve will remain open and center tank pumps will remain off until 3,000 lb has been burned from each main tank.
4. After 3,000 lb has been burned from each main tank, switch to feeding outboard engines from center tank and continue feeding inboard engines from inboard tanks until the wing tanks are equalized.
5. When the weight of fuel in inboard main tanks equals the total in outboard main tanks plus reserve tanks, change to main tanks feeding directly to engines. One crossfeed valve will remain open and center tank pumps must be off.
6. Transfer of reserve tank fuel between gross weights of 285,000 lb and 230,000 lb is permissable. Reserve tank transfer is normally not started until airplane weight is 230,000 lb or less for all missions, to reduce wing bending and improve load distribution.

NOTE

- The transfer of reserve tank fuel should be delayed until gross weight is 230,000 lb or less on air refueling missions so that reserve tanks are full before gross weight exceeds 285,000 lb.
- For operation with alternate grade fuels, refer to Section V.
- If outside (total) air temperature is less than 3 °C above freezing point of fuel, and airplane is fueled with JP-5, JP-8 (F-34 or F-35) or commercial equivalent, transfer reserve fuel as soon as possible after reaching 285,000 lb gross weight to prevent freezing of fuel in reserve tank.

- Fuel transfer time is longer with alternate fuels than with JP-4. For operation with alternate grade fuels, refer to Section V.

- If outboard main tanks and reserves are at auto shut–off prior to aerial refueling, they may be reduced to the aerial fuel load levels (2,820 lb in each reserve tank and 14,640 lb in each outboard main tank) immediately prior to aerial refueling by doing the following:

(a) Open transfer valves until reserves are at 2,820 lb in each tank.

(b) Burn mains 1, 2, 3 and 4 until reserves are at desired levels.

(c) Close transfer valves.

(d) Continue burning mains 1, 2, 3 and 4 until 1 and 4 are at desired levels.

(e) Resume normal fuel management.

If only the reserve tanks are at auto shut–off levels, perform the following prior to aerial refueling:

(1) Open transfer valves until reserves are at 2,820 lb in each tank.

(2) Close transfer valves and resume normal fuel management.

7. When the fuel weight for the inboard tanks 2 and 3 is 8,000 lb each and the combined fuel weight of the outboard tanks 1 and 4 plus respective reserves is 8,000 lb each (32,000 lb total), use center tank fuel to all engines until center tank is empty, or until amount needed for ballast remains. (Do not exceed 35% c.g. limit.)

WARNING

Center wing fuel tank pumps must be off unless personnel are available in the flight deck to monitor LOW pressure lights. Each center wing tank fuel pump switch must be positioned to off without delay when the respective center wing tank fuel pump LOW pressure light illuminates.

8. Use main tanks to engine for remaining flight time.

If the center tank contains 20,000 lb of fuel or less, use the procedure below. This procedure is also shown in *figure 1-36*.

NOTE

If the center tank fuel quantity has been adjusted by the procedure in step 3. of the FUEL LOADING PROCEDURE, this 20,000 lb criterion is increased by the quantity (205,000 lb – Operating Weight).

1. Use main tanks to engines for takeoff. All main tank pumps must be on for takeoff. One crossfeed valve will be open. Burn 3,000 lb from each main tank.

NOTE

- If center tank is empty, omit steps 2., 4. and 5. below.

- If weight of fuel in inboard main tanks 2 and 3 equals weight of fuel in outboard main tanks plus reserve tanks, proceed to step 3. below.

2. When 3,000 lb of fuel has been burned from each main tank, change to center tank feeding outboard engines 1 and 4 and inboard mains to inboard engines 2 and 3. Crossfeed valves 1 and 4 must be open. Both center tank boost pumps must be on. Continue until wing tanks are equalized.

3. Transfer of reserve tank fuel between gross weights of 285,000 lb and 230,000 lb is permissable. Reserve tank transfer is normally not started until airplane weight is 230,000 lb or less for all missions; this action improves wing strength and load distribution.

NOTE

- The transfer of reserve tank fuel should be delayed until gross weight is 230,000 lb or less on air refueling missions so that reserve tanks are full before gross weight exceeds 285,000 lb.

- For operation with alternate grade fuels, refer to Section V.

- If outside (total) air temperature is less than 3°C above freezing point of fuel and airplane is fueled with JP-5, JP-8 (F-34 or F-35) or commercial equivalent, transfer reserve fuel as soon as possible after reaching 285,000 lb gross weight to prevent freezing of fuel in reserve tank.

- Fuel transfer time is longer with alternate fuels than with JP-4. For operation with alternate grade fuels, refer to Section V.

- If a reserve tank is at auto shut–off level, perform the following prior to aerial refueling:

(a) Open transfer valves until reserves are at desired levels.

(b) Close transfer valves and resume normal fuel management.

4. When weight of fuel in inboard main tanks equals the weight in outboard tanks plus reserves, change to main tanks feeding directly to engines. One crossfeed valve will remain open and center tank pumps must be off.

5. The main tanks will feed all engines until the fuel weight for the inboard tanks 2 and 3 is 8,000 lb each and the combined fuel weight of outboard tanks 1 and 4 plus respective reserves is 8,000 lb each (32,000 lb total); then use center tank fuel to all engines until center tank is empty or until amount needed for ballast remains. (Do not exceed 35% cg limit.)

WARNING

Center wing fuel tank pumps must be off unless personnel are available in the flight deck to monitor LOW pressure lights. Each center wing tank fuel pump switch must be positioned to off without delay when the respective center wing tank fuel pump LOW pressure light illuminates.

6. Use main tanks to engines for remaining flight time.

When using either of the above sequences and surveillance radar must be operated with less than 5,000 pounds of fuel in main tanks, monitor tank temperature and coordinate with mission crew to monitor LCS coolant temperature per limits in Section V.

Both boost pumps will be on for each tank being used during all takeoffs (or go-arounds), descents and landings. Additionally, both main tank pumps should be on when radar cooling system is operating.

During start and taxi one pump per each tank in use is required.

One crossfeed valve will normally remain open to maintain pressure in the crossfeed manifold during all operations.

Fuel Management - Center Tank More Than 20,000 lb②

STEP	FLIGHT PHASE	TANK	BOOST PUMPS	CROSS FEED	REMARKS
1	Start Taxi, Takeoff, Initial Climb	Reserves	———	———	Transfer valves closed
		Main tanks 1 and 4	One per tank for start and taxi, 2 per tank for takeoff	1 and 4 open	Engines 1 and 4 fed from center tank
		Main tanks 2 and 3		2 and 3 closed	Engines 2 and 3 fed from tanks 2 and 3
		Center	Both on	———	
2	When not over 3,000 lb burned in tank 2 or 3 and until center tank holds 20,000 lb ②	Reserves	———	———	
		Main tanks 1, 2, 3, 4	Both on	1, 2, 3 and 4 open	Center tank feeds all engines
		Center	Both on	———	
3	Cruise (until 3,000 lb has been burned from each main tank)	Reserves	———	———	
		Main tanks 1, 2, 3 and 4		One open	All engines feed directly from main tanks. Monitor fuel temperature if LCS in use
		Center	Off	———	
4	Cruise (until total fuel in tanks 2 and 3 equals fuel in tanks 1 and 4 plus reserves) ①	Reserves	———	———	
		Main tanks 1 and 4	One per tank on (2 if LCS in use)	1 and 4 open	Engines 1 and 4 fed from center tank
		Main tanks 2 and 3		2 and 3 closed	Engines 2 and 3 fed from tanks 2 and 3
		Center	Both on	———	
5	Cruise (until main tanks contain 8,000 lb each) **NOTE** Outboard tanks include quantity in reserves	Reserves	———	———	Transfer at 230,000 lb
		Main tanks 1, 2, 3, 4	One per tank on (2 if LCS in use)	One open	Engines fed from main tanks
6	Cruise (when main tanks 8,000 lb)	Center	Both on	———	Until center tank empty, or c.g. ballast remains

Figure 1-35 (Sheet 1 of 2)

Fuel Management - Center Tank More Than 20,000 lb (Continued)

STEP	FLIGHT PHASE	TANK	BOOST PUMPS	CROSS FEED	REMARKS
		Main Tanks 1, 2, 3, 4	One per tank on (2 if LCS in use)	All open	Until center tank empty, or c.g. ballast remains
7	Descent, landing (center tank contains fuel above c.g. ballast)	Center	Both on	———	Until center tank empty, or c.g. ballast remains
		Main Tanks 1, 2, 3, 4	Both on	All open	
8	Descent, landing (center tank empty, or c.g. ballast remains)	Main Tanks 1, 2, 3, 4	Both on	One open	All engines fed from main tanks for rest of flight

WARNING

Engine flameout can occur if airplane pitch attitude exceeds 8 degrees nose up or 10 degrees nose down when any outboard main tank contains less than 2,500 pounds or any inboard main tank contains less than 6,500 pounds. Refer to MINIMUM FUEL PROCEDURES, section II.

NOTE

① If outboard main tanks and reserves are at auto shut–off prior to aerial refueling, they may be reduced to aerial fuel load levels (2,820 lb in each reserve tank and 14,460 lb in each outboard main tank) immediately prior to aerial refueling by doing the following:

(1) Open transfer valves.
(2) Burn mains 1, 2, 3 and 4 until reserves are at desired levels.
(3) Close transfer valves.
(4) Continue burning mains 1, 2, 3 and 4 until 1 and 4 are at desired level.
(5) Resume normal fuel management.

If only the reserve tanks are at auto shut–off levels, perform the following prior to aerial refueling:

(1) Open transfer valves until reserves are at desired levels.
(2) Close transfer valves and resume normal fuel management.

② This 20,000 lb criterion is increased by the quantity (205,000 – operating weight) when:
The standard fuel load distribution has been modified.
Standard fuel loads are used, and mission requirements dictate a more forward c.g.

Figure 1-35 (Sheet 2 of 2)

Fuel Management - Center Tank 20,000 lb or Less②

STEP	FLIGHT PHASE	TANK	BOOST PUMPS	CROSS FEED	REMARKS
1	Start, Taxi, Takeoff, Initial Climb. Burn 3,000 lb of fuel from each main wing tank ②	Reserves	———	———	Transfer valves closed
		Main tanks 1, 2, 3, 4	One per tank for start and taxi, 2 per tank for takeoff and climb	One open	Engines fed directly from main tank
		Center	Off	———	
2	Cruise (until total fuel in tanks 2 and 3 equals fuel in tanks 1 and 4 plus reserves) ①	Reserves	———	———	Transfer valves closed
		Main tanks 1 and 4	One per tank on	Open	Engines 1 and 4 fed from center tank
		Main tanks 2 and 3	(2 if LCS in use)	Closed	Engines 2 and 3 fed directly from tanks 2 and 3
		Center	Both on	———	
3	Cruise (until main tanks contain 8,000 lb each) **NOTE** Outboard tanks include quantity in reserves	Reserves	———	———	Transfer when gross weight is 230,000 lb
		Main tanks 1, 2, 3, 4	One per tank on (2 if LCS in use)	One open	All engines fed directly from main tanks. Monitor fuel temperature if LCS in use
		Center	Off	———	———
4	Cruise (when main tanks 8,000 lb)	Center	Both on	———	Until center tank empty, or c.g. ballast remains
		Main tanks 1, 2, 3, 4	One per tank on (2 if LCS in use)	All open	
5	Descent, landing (center tank contains fuel above c.g. ballast)	Center	Both on	———	Until center tank empty, or c.g. ballast remains
		Main tanks 1, 2, 3, 4	Both on	All open	

Figure 1-36 (Sheet 1 of 2)

Fuel Management - Center Tank 20,000 lb or Less (Continued)

STEP	FLIGHT PHASE	TANK	BOOST PUMPS	CROSS FEED	REMARKS
6	Descent, landing (center tank empty, or c.g. ballast remains)	Main tanks 1, 2, 3, 4	Both on	One open	All engines fed from main tanks for rest of flight

WARNING

Engine flameout can occur if airplane pitch attitude exceeds 8 degrees nose up or 10 degrees nose down when any outboard main tank contains less than 2,500 pounds or any inboard main tank contains less than 6,500 pounds. Refer to MINIMUM FUEL PROCEDURES, section II.

NOTE

① If outboard main tanks and reserves are at auto shut–off prior to aerial refueling, they may be reduced to aerial fuel load levels (2,820 lb in each reserve tank and 14,460 lb in each outboard main tank) immediately prior to aerial refueling by doing the following:

(1) Open transfer valves.
(2) Burn mains 1, 2, 3 and 4 until reserves are at desired levels.
(3) Close transfer valves.
(4) Continue burning mains 1, 2, 3 and 4 until 1 and 4 are at desired level.
(5) Resume normal fuel management.

If only the reserve tanks are at auto shut–off levels, perform the following prior to aerial refueling:

(1) Open transfer valves until reserves are at desired levels.
(2) Close transfer valves and resume normal fuel management.

② This 20,000 lb criterion is increased by the quantity (205,000 – operating weight) when:
The standard fuel load distribution has been modified.
Standard fuel loads are used, and mission requirements dictate a more forward c.g.

Figure 1-36 (Sheet 2 of 2)

SUBSECTION I-E
ELECTRICAL POWER SYSTEM

Table of Contents

Title ***Page***

SUMMARY

When engines are operating, eight engine-driven generators (two per engine) supply electric power. On the ground the APU generator or external power carts supply power, if engines are not operating. The airplane generators are normally operated in parallel. The APU and external power cannot be operated in parallel with the airplane generators or with each other. The power system supplies 115/200 vac power and 28 vac power and through transformer/ rectifiers 28 vdc power. When all normal sources of ac power are lost, emergency ac power is supplied to an emergency ac bus from a battery powered inverter. The dc power distribution system provides battery power to a hot battery bus, and when needed, to other battery buses, the flight deck UHF radio, emergency dc bus and emergency inverter. An ac powered battery charger charges the battery when ac power is available and certain battery voltage and temperature criteria are met. See *figure 1-37* for locations of major electrical system components.

CONTROLS AND INDICATORS

Operating controls for the electrical system are located on the engineer's panel, circuit breaker panels in the flight deck and mission crew area and in the lower forward electrical compartment. *Figure 1-38* shows the engineer's panel controls with the location and function of each.

ELECTRICAL POWER DISTRIBUTION

The electrical power system is normally operated with all engine driven generators in parallel and all buses powered. See *figures 1-39, 1-40* and *1-41* for schematics of the electrical system operating in the normal configuration. *Figure 1-42* shows a breakdown by bus, of all electrical loads attached to each bus. Power to operate various airplane components is distributed through circuit breaker panels P5, P6, P7 and P61. See *figures 1-43* through *1-46.* Power for selected avionics and comm systems is distributed through power control relays controlled by the AVIONICS POWER DISCONNECT panel. Power for selected mission equipment and systems is distributed through power control relays controlled by the COMM DISCONNECT panel and circuit breaker panels P66 and P67. The panels are shown in *figures 1-38, 1-47* and *1-48*.

Electrical System Component Locations

1. P5 CB PANEL
2. FLIGHT ENGINEER STATION
3. P61 CB PANELS (6)
4. P7 CB PANEL
5. AIRPLANE BATTERIES (2)
6. P66 CB PANELS (3)
7. GENERATORS (2 PER ENGINE)
8. P67 CB PANELS (3)
9. APU (GROUND USE ONLY)
10. EXTERNAL POWER RECEPTACLES (4)
11. P37 CB PANEL
12. E15 EQUIPMENT RACK
13. P38 CB PANEL
14. E16 EQUIPMENT RACK
15. EMERGENCY LIGHTING BATTERIES (2)
16. P6 CB PANEL
17. E5 EQUIPMENT RACK
18. INDICATOR LIGHTS
19. INTERPHONE RECEPTACLE

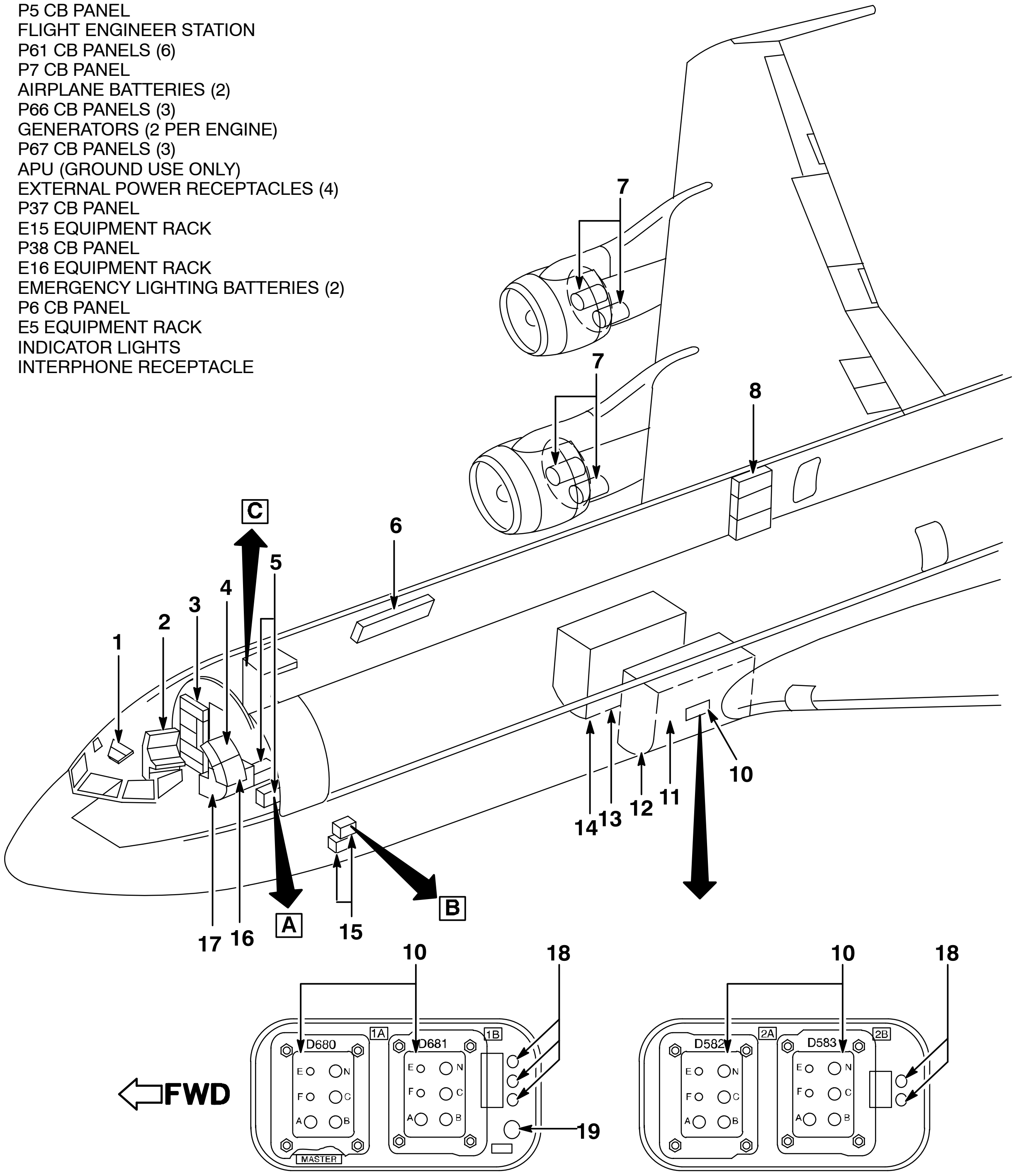


Figure 1-37 (Sheet 1 of 2)

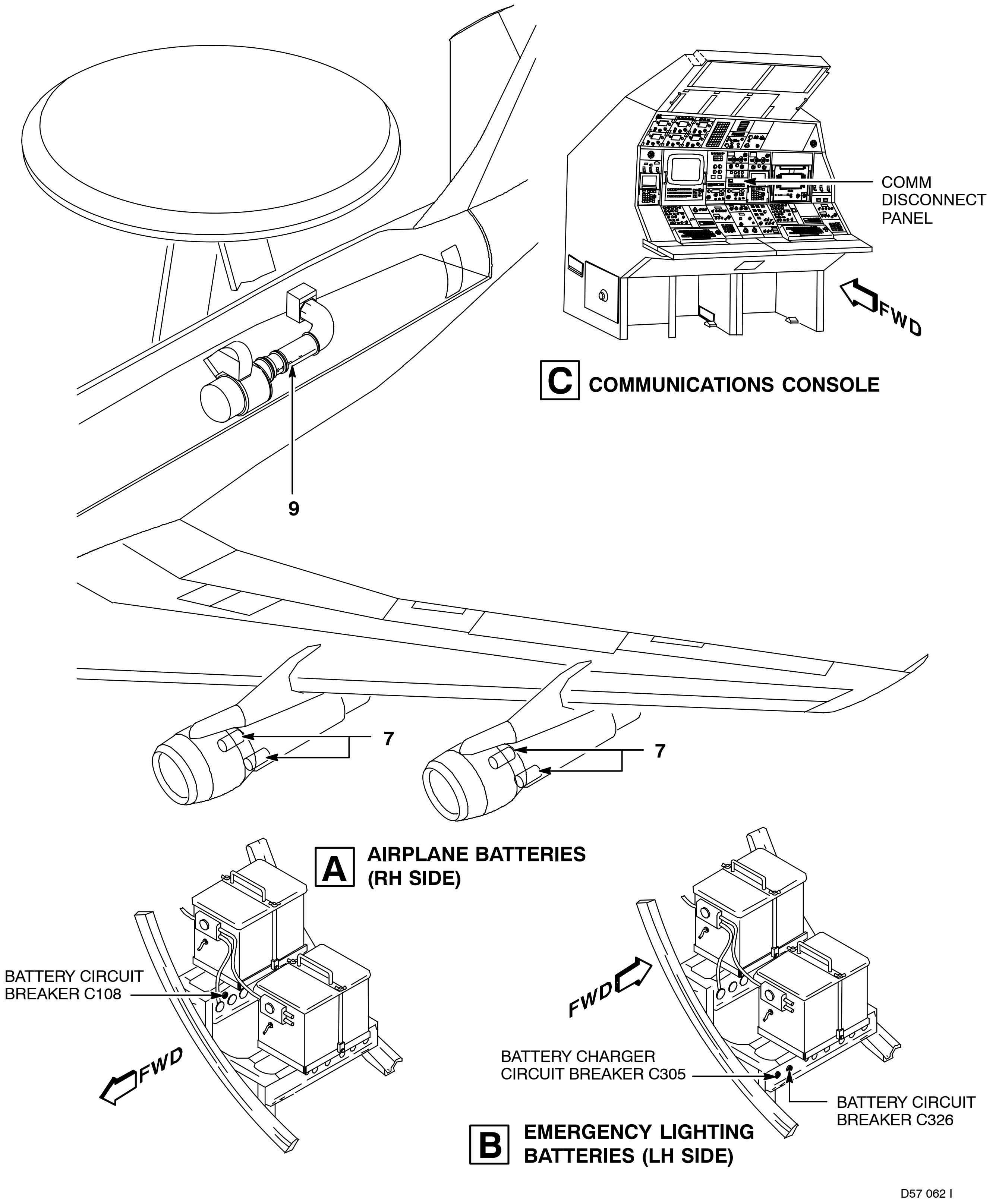


Figure 1-37 (Sheet 2 of 2)

Electrical Systems Controls and Indicators

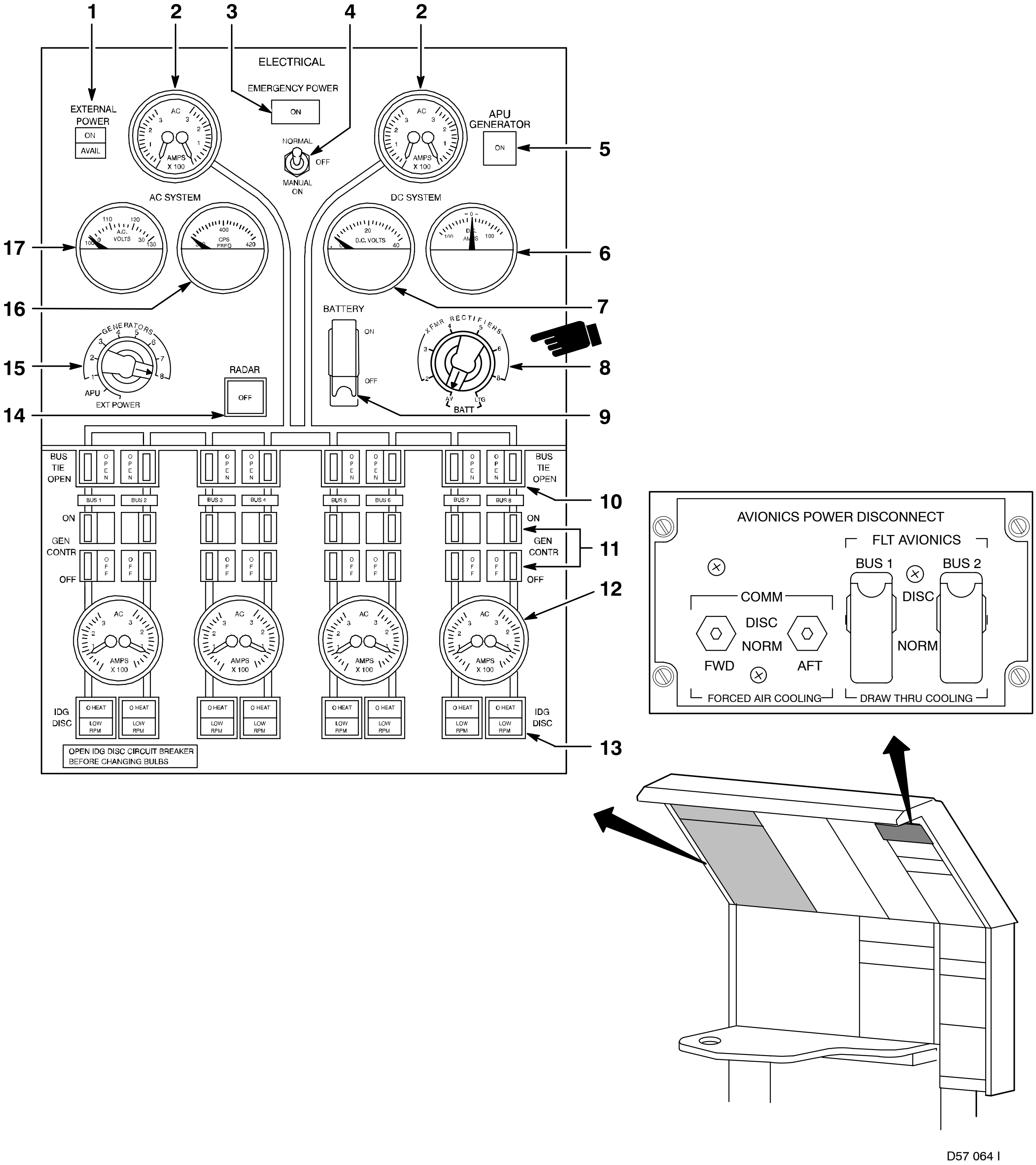


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Figure 1-38 (Sheet 1 of 7)

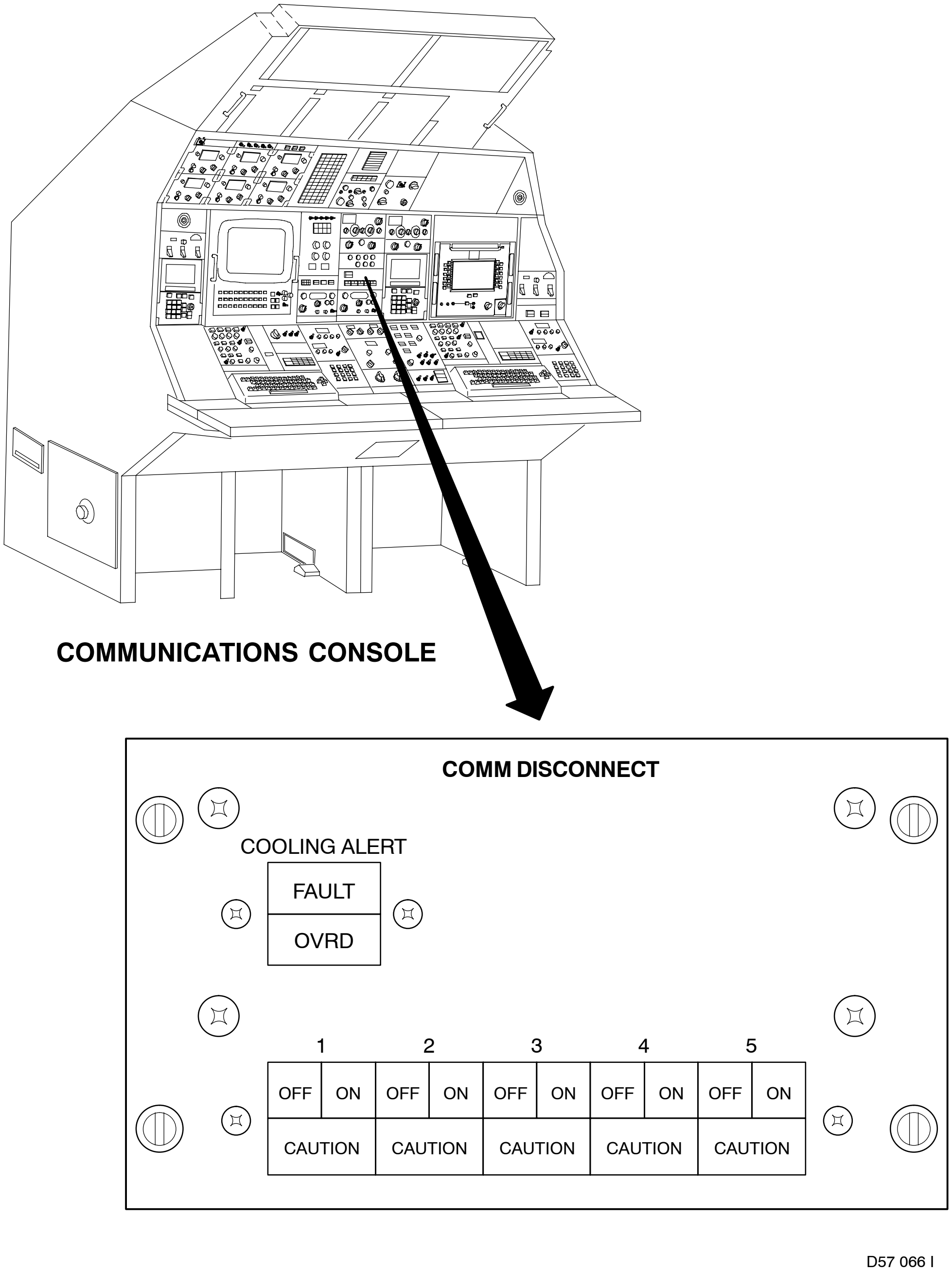


Figure 1-38 (Sheet 2 of 7)

Electrical Systems Controls and Indicators (Continued)

NO.	CONTROL/INDICATOR	FUNCTION
1	EXTERNAL POWER Switch/ Indicator (Green)	AVAIL indicator illuminates when power is available on external power connector 1A, and voltage, frequency, phase sequence, and external power cart connector plug configuration, are correct. When switch is pressed, ON indicator illuminates, the switch is held in magnetically and external power is connected to sync bus. When pressed again, disconnects external power from sync bus, ON indicator goes out, and AVAIL stays illuminated. Light does not dim.

CAUTION

- If ON indicator does not illuminate when switch is pressed, check ammeter. If no current is indicated, one more attempt to close switch is permitted. (Press switch twice.)
- If external power is on the airplane bus and the AVAIL indicator is not illuminated, the EXTERNAL POWER switch must be off (ON indicator out) before connecting APU or airplane generators. When changing from APU or airplane generators to external power and the external power cart(s) are operating but the AVAIL indicator is not illuminated, remove the APU and airplane generator power before applying external power (EXTERNAL POWER switch ON). Closing EXTERNAL POWER switch when the AVAIL light is not illuminated causes damage to the generators or APU accessory drive.

2	External Power and APU Ammeters (Two Double-meters)	When external power connected, pointers indicate load on each external power source. Left hand meter indicates load (in amperes) on external power receptacles 1A and 1B on LH and RH needles. Right hand meter indicates load (in amperes) on external power receptacles 2A and 2B. When APU is on bus, right hand pointer of right hand meter indicates load on APU.
3	EMERGENCY POWER Caution Light (Amber)	ON caution light illuminates when the EMERGENCY POWER switch is set to NORMAL or MANUAL ON, the BATTERY switch is set to ON, and the battery is supplying power to the battery buses, the flight deck UHF radio, the emergency dc bus, and the inverter. When the EMERGENCY POWER switch is set to NORMAL and the emergency ac relay loses power, the ON caution light illuminates, the emergency ac buses are connected to the inverter, and the battery buses are powered by the TRUs or the battery. The ON caution light illuminates when the EMERGENCY POWER switch is set to MANUAL ON and the battery buses are powered by the TRUs or the battery.

NOTE

The Emergency AC relay (EAC) connects the emergency buses to the inverter when the voltage at the EAC (from distribution bus 2) is less than 109 ± 2 volts or greater than 121 ± 2 volts.

Figure 1-38 (Sheet 3 of 7)

NO.	CONTROL/INDICATOR	FUNCTION
4	EMERGENCY POWER Switch	Controls operation of emergency inverter and power to the flight deck UHF radio and the emergency ac and dc buses. When set to NORMAL, allows automatic operation. When set to MANUAL ON, connects inverter to dc power (TRUs or battery) and inverter output to the emergency ac bus. When set to OFF, shuts down inverter, the flight deck UHF radio, and deenergizes emergency ac and dc buses, causing loss of power to CSU1 and CSU2, cutting off all internal and external communication.
5	APU GENERATOR Switch/Indicator (Green)	Momentary switch. When pressed (ON), connects APU generator to bus. ON indicator illuminates when generator is on bus. Interlocked with external power switch and airplane generator control breakers. Airplane generators and external power disconnect automatically if APU is connected to bus. When pressed again (OFF), disconnects APU generator from bus. Light does not dim.

CAUTION

If ON indicator does not illuminate when switch is pressed, check ammeter. If no current is indicated, one more attempt to close switch is permitted. (Press switch twice.)

NO.	CONTROL/INDICATOR	FUNCTION
6	DC Ammeter (DC AMPS)	Indicates load in amperes on source selected on DC meter selector switch.
7	DC Voltmeter (DC VOLTS)	Indicates voltage of source selected on DC meter selector switch.
8	DC Meter Selector Switch	Selects DC source to display on DC voltmeter and ammeter. When set to AV BATT, meters are connected to airplane battery. When set to LTG BATT, meters are connected to emergency light battery. When set to XFMR RECTIFIERS positions 2 through 8, meters are connected to TRUs 2, 3, 4, 5, 6 and 8, respectively.
9	BATTERY Switch (Guarded ON)	When set to ON, connects battery to battery buses when the battery buses are not powered by the TRUs, enables APU generator or external power to be connected, applies power to the tie bus differential protection logic of the bus power control unit. (The bus power control unit receives power from other sources also.) When set to OFF, battery is disconnected from the battery buses (except the hot battery bus) and the APU generator or external power is disconnected.

Figure 1-38 (Sheet 4 of 7)

Electrical Systems Controls and Indicators (Continued)

NO.	CONTROL/INDICATOR	FUNCTION
10	BUS TIE OPEN Switch/Caution Lights (8) (Amber)	Momentary switches. Opens bus-tie breaker for generator of same number as bus. When pressed, opens bus-tie breaker and line light goes out and OPEN caution is illuminated.
11	GEN CONTR Switch/Indicators (16) (Generator Switches)	Momentary switches. When pressed, operates generator (16) control circuit to open or close generator breaker and close bus-tie breaker.

NOTE

If generator 3 is turning, generator breakers 1, 2, 3 and 4 can be closed without battery power. If generator 7 is turning, generator breakers 5, 6, 7 and 8 can be closed without battery power.

	ON Row of Switch/Indicators (8) (White) (Generator ON Switches)	When pressed (ON), closes generator field circuit, closes bus tie breaker, and closes generator breaker after APU or external power trips off. (Opens APU or external power breaker if connected.) Line light illuminates in both rows (ON and OFF) and BUS TIE switch when generator and bus tie breakers close. Switch is overridden by engine fire switch.

CAUTION

When transferring from external power or APU to the airplane generators, close only one generator breaker. When bus tie breaker recloses, the other generator breakers may be closed as rapidly as desired. Attempting to close the first two generator breakers at once on power transfer can damage generator drive.

	OFF Switch/Caution Lights (8) (White, Amber) (Generator OFF Switches)	When depressed (OFF), opens generator field circuit and generator breaker, closes bus-tie breaker (unless differential fault exists on that main bus or the tie bus). Filled in line disappears in both rows (ON and OFF), and amber OFF caution light illuminates when generator breaker opens.
12	Ammeters (AC) 4 Double Meters	Indicate load on generator buses in hundreds of amperes. Meter tolerance is ±5 amperes.

Figure 1-38 (Sheet 5 of 7)

NO.	CONTROL/INDICATOR	FUNCTION
13	IDG DISC Switch/Caution Lights (8) (Amber, Green) (Guarded) (Disconnect Switches)	Guarded momentary switches. When a disconnect switch is pressed, the generator drive is mechanically disconnected. As the generator slows down, the generator breaker trips (underspeed trip) and the bus tie breaker closes.

WARNING

Engine fuel line damage can result from IDG case separation. Possible indications of case separation are generator failure, illumination of LOW RPM light, and abnormally high or low IDG oil temperature indication. If any of these conditions exist, check for abnormally high engine fuel flow before disconnecting IDG. If fuel leak is suspected, do not attempt IDG disconnect. Shut down engine if not needed for safety of flight.

CAUTION

- If the indicated frequency of isolated generator is outside the range of 400 ± 8 Hz, fluctuates more than 4 Hz within the ±8 Hz range, or OHEAT light illuminates or generator breaker does not remain closed, shut generator down and disconnect IDG.
- Generator drives can only be disconnected when the engines are operating at or above idle speed. If the IDG DISC switch is pressed when the engines are not running, or are turning at below idle speed, IDG damage may result at the next engine start.
- When replacing bulbs in the IDG DISC (disconnect) switch, open INTGR DR GEN DISC circuit breaker (P61-5) for that generator before replacing bulb. Leave breaker open until switch cover has been pressed closed following new bulb insertion.

NOTE

- Disconnected generator drive cannot be reconnected in flight.
- The IDG is assumed to be disconnected if the LOW RPM light illuminates after the IDG DISC switch is pressed. LOW RPM light, high IDG temperature and OHEAT light indications after IDG disconnect do not affect continued operation of the engine.

NO.	CONTROL/INDICATOR	FUNCTION
	OHEAT Caution Light (Amber)	Amber OHEAT is illuminated by IDG temperature indicating system when IDG oil temperature exceeds normal operating temperature (163 ± 5°C). Light also is illuminated during test of the IDG temperature indicating system.

Figure 1-38 (Sheet 6 of 7)

Electrical Systems Controls and Indicators (Continued)

NO.	CONTROL/INDICATOR	FUNCTION
	LOW RPM Indicator (Low RPM Light) (Green)	If the LOW RPM light illuminates after the IDG DISC switch has been pressed, the generator drive has disconnected. The light is operated by a speed-sensing circuit on the input shaft of the drive and normally illuminates if engine N_2 rpm is too low for the drive to maintain generator frequency (about 48% N_2) and dc power is available.

CAUTION

If LOW RPM light fails to go out when starting engine and generator breaker will not close, shut down the engine and have maintenance make a visual check for structural integrity and verify the IDG is reconnected before attempting restart. If LOW RPM stays illuminated after restart, disconnect IDG and resume operation with generator inoperative.

NOTE

The IDG is assumed to be disconnected if the LOW RPM light illuminates after the IDG DISC switch is pressed. LOW RPM light, high IDG temperature and OHEAT light indications after IDG disconnect do not affect continued operation of the engine.

NO.	CONTROL/INDICATOR	FUNCTION
14	RADAR Switch/Caution Light (Amber) (Guarded)	When depressed, allows connection of radar bus to sync bus. When released, disconnects radar bus from sync bus. OFF caution light illuminates when switch is released.
15	AC Meter Selector Switch	Selects source to be connected to AC voltmeter (AC VOLTS) and frequency meter (CPS FREQ).
16	AC Frequency Meter	Indicates frequency of bus selected on AC meter selector switch. Airplane generator frequency can be read only when the GEN CONTR line lights are illuminated. (Generator breaker closed.) APU generator frequency can be read only when the APU GENERATOR ON light is illuminated. External power generator frequency can be read when a cart is plugged into external power receptacle 1A. Meter tolerance is approximately ±3 Hz at 402 Hz.
17	AC Voltmeter	Indicates voltage of bus selected on AC meter selector switch. Airplane generator voltage can be read only when GEN CONTR line lights are illuminated. APU generator voltage can be read only when the APU GENERATOR ON light is illuminated. External power generator voltage can be read whenever a cart is plugged into external power receptacle 1A.

Figure 1-38 (Sheet 7 of 7)

AC POWER SOURCES

AC power is provided by the following sources: engine driven generators, APU-driven generator, an external power cart, and an emergency inverter. Normally the eight engine-driven generators are operated in parallel to provide all necessary power. The APU generator is used to supply power prior to engine start, after engines are shut down,or if external power is not available. Normally, one external power cart is sufficient to supply power for airplane loads. However, up to four carts, with each cart providing a single leg of power and connected to a separate external power connector, and all carts operated in parallel, can be used, if required. If two or more carts are required, they must have phase synchronization, or load sharing capability between the carts, and be connected to each other. The Tri–Electron cart may be used as a single power source capable of feeding multiple external power receptacles. The emergency inverter supplies power to certain ac loads when no other source of ac power is available or when selected.

GENERATORS AND DRIVES

Each engine has two 75 KVA (218 ampere), three phase ac generators and integral gear drives. Together, the generator and drive are referred to as an integrated drive generator (IDG). Output of the generators is 115/200 volt, three phase, approximately 400 Hz power. Each generator can be connected to its own bus or paralleled through the bus-tie breakers to the tie bus (or sync bus). Generator controls are located on the flight engineer's panel.

The generator drive is controlled hydraulically to maintain a constant output speed from a variable input. The generator drives can be disconnected from the engines by switches on the flight engineer's panels when the engines are operating at or above idle speed. Each generator drive has its own oil system. Oil from the left generator drive is cooled by an air-oil cooler mounted in the fan duct on the left side of the engine. The oil from the right generator drive is cooled by an air-oil cooler mounted in the fan duct on the right side of the engine. Oil temperature is monitored through four dual-channel temperature indicators located above the other engine instruments on the flight engineer's console. Refer to subsection I-B ENGINES.

CAUTION

- Generator drives can only be disconnected when the engines are operating at or above idle speed. If the IDG DISC switch is pressed when the engines are not running or are turning at below idle speed, IDG damage may result at the next engine start.
- When replacing bulbs in the IDG DISC (disconnect) switch, open INTGR DR GEN DISC circuit breaker (P61-5) for that generator before replacing bulb. Leave breaker open until switch cover has been pressed closed following new bulb insertion.

NOTE

Generator drives cannot be reengaged in flight. Once a generator is disconnected, the drive must be reconnected on the ground. Disconnect is indicated by illumination of the GEN CONTR OFF light (generator breaker tripped) and illumination of the LOW RPM light in the IDG disconnect switch after the disconnect switch is pressed.

APU GENERATOR

The generator is a 60 KVA (170 ampere), 115/200 volt, 400 ± 7 Hz three phase air cooled generator. The APU generator cannot be paralleled with the other generators or with external power. See *figure 1-28* for APU generator controls and indicators. Frequency of the APU generator is controlled within ±2 Hz under constant load by the APU governor which controls the speed of the APU turbine. Refer to AUXILIARY POWER UNIT.

CAUTION

When changing power sources, the electrical load control units (ELCUs) controlling the forced air cooling fans and the NO 1 auxiliary hydraulic pump can trip. Make sure that forced air cooling fans and NO 1 auxiliary hydraulic pump are operating after power transfer. Electronic equipment cooled by forced air system could be damaged if fans stop. Rotodome bearing could be damaged if auxiliary hydraulic pump NO 1 stops while engines are running and auxiliary rotodome drive is in use.

Electrical Power Distribution

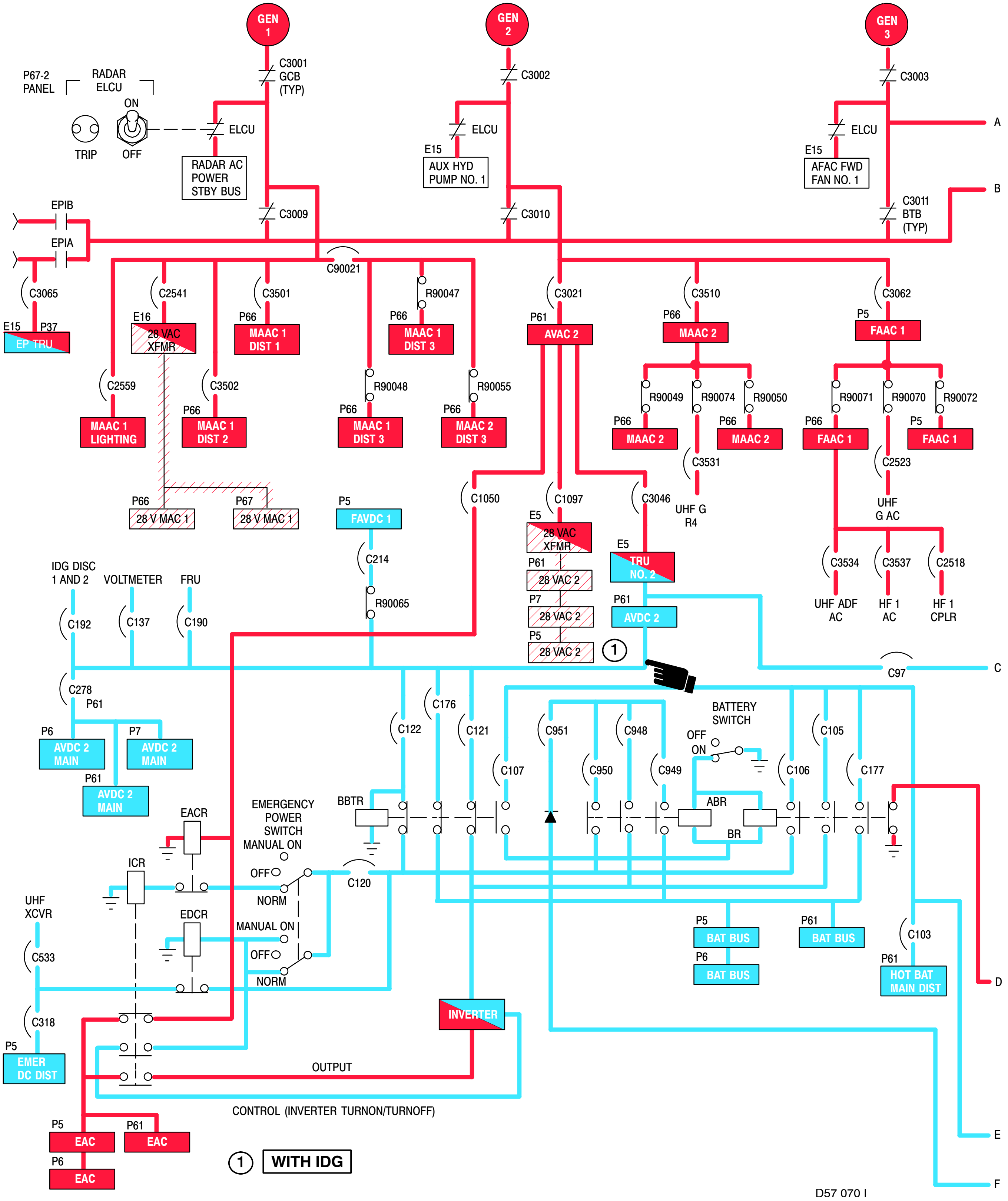


Figure 1-39 (Sheet 1 of 3)

Electrical Power Distribution (Continued)

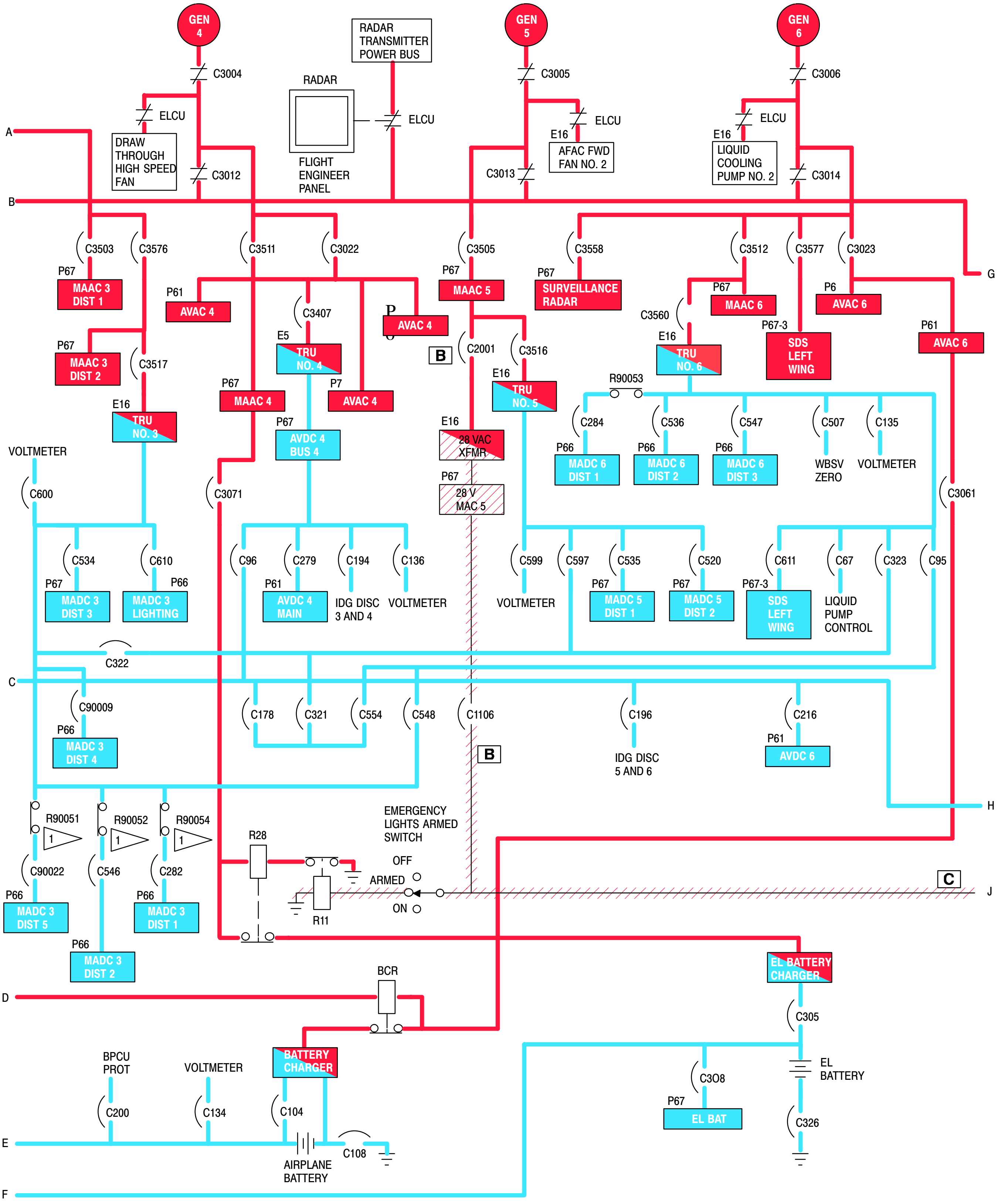
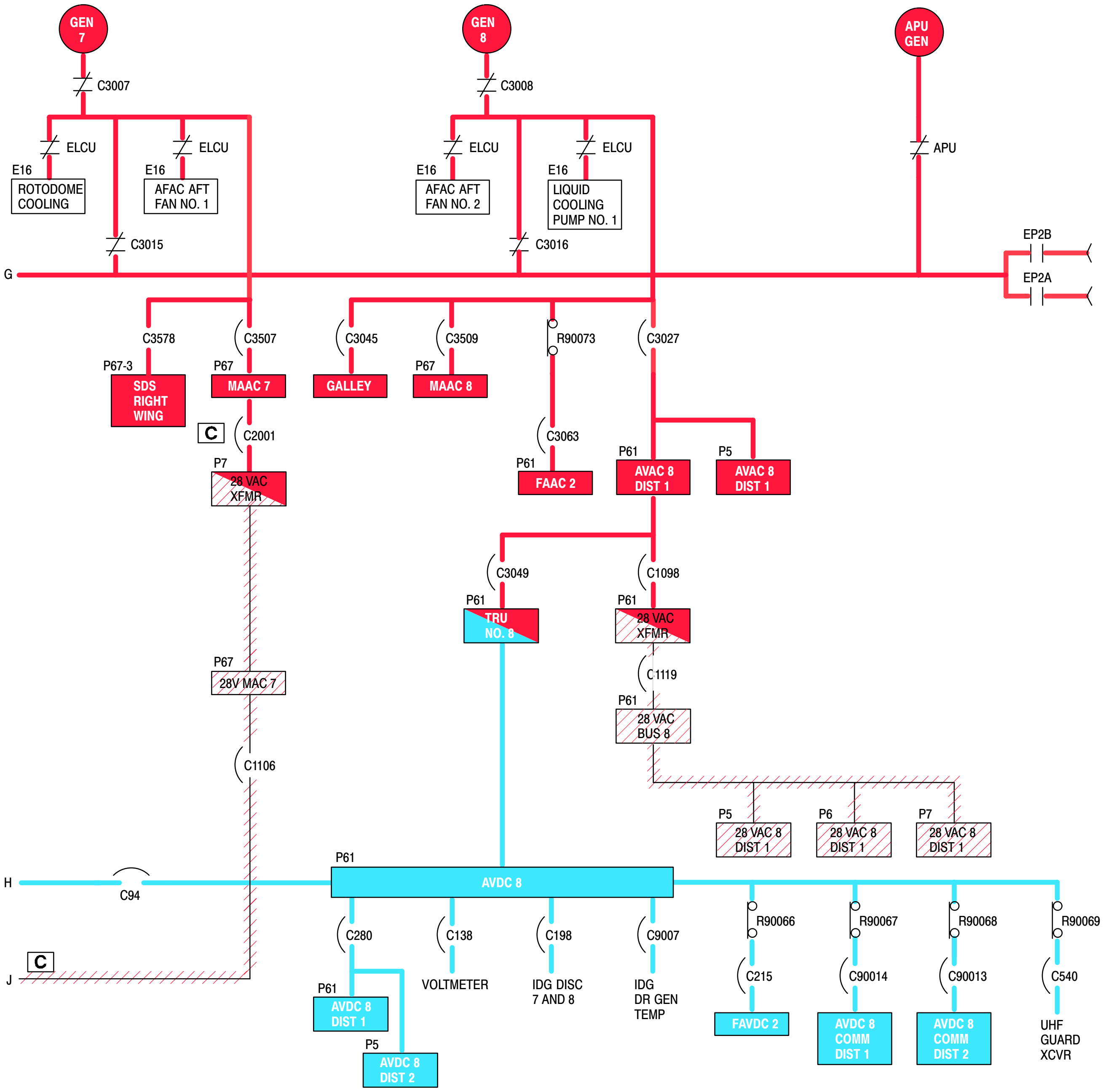


Figure 1-39 (Sheet 2 of 3)



LEGEND

ABR	AUXILIARY BATTERY RELAY
AFAC	AVIONICS FORCED AIR COOLING
APC	AUXILIARY POWER CONTACTOR
AVAC	AIR VEHICLE AC
AVDC	AIR VEHICLE DC
BCR	BATTERY CHARGER RELAY
BR	BATTERY RELAY
BBTR	BATTERY BUS TRANSFER RELAY
EACR	EMERGENCY AC RELAY
EDCR	EMERGENCY DC RELAY
ELCU	ELECTRICAL LOAD CONTROL UNIT
EMER	EMERGENCY
EP	EXTERNAL POWER
FAAC	FLIGHT AVIONICS AC
FADC	FLIGHT AVIONICS DC
GCB	GENERATOR CONTROL BREAKER
ICR	INVERTER CONTROL RELAY
IDG DISC	INTEGRATED DRIVE GENERATOR DISCONNECT
MAAC	MISSION AVIONICS AC
MAC	MISSION AC
MADC	MISSION AVIONICS DC
TRU	TRANSFORMER RECTIFIER UNIT

CONDITIONS: ALL GENERATORS ON
BUS POWER ON.

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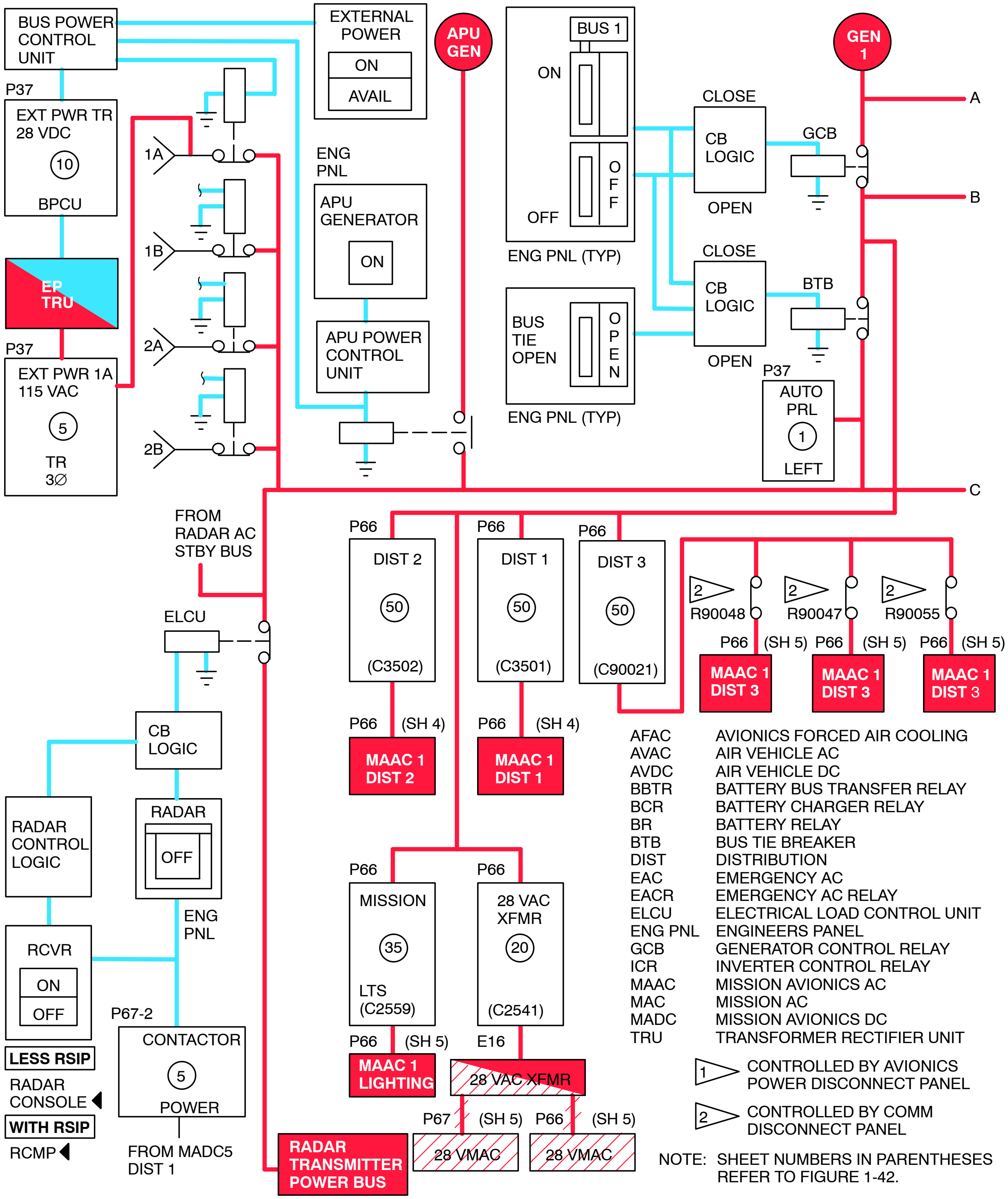
Figure 1-39 (Sheet 3 of 3)

AC Power Distribution Schematic



AFAC	AVIONICS FORCED AIR COOLING
AVAC	AIR VEHICLE AC
AVDC	AIR VEHICLE DC
BBTR	BATTERY BUS TRANSFER RELAY
BCR	BATTERY CHARGER RELAY
BR	BATTERY RELAY
BTB	BUS TIE BREAKER
DIST	DISTRIBUTION
EAC	EMERGENCY AC
EACR	EMERGENCY AC RELAY
ELCU	ELECTRICAL LOAD CONTROL UNIT
ENG PNL	ENGINEERS PANEL
GCB	GENERATOR CONTROL RELAY
ICR	INVERTER CONTROL RELAY
MAAC	MISSION AVIONICS AC
MAC	MISSION AC
MADC	MISSION AVIONICS DC
TRU	TRANSFORMER RECTIFIER UNIT

1	CONTROLLED BY AVIONICS POWER DISCONNECT PANEL
2	CONTROLLED BY COMM DISCONNECT PANEL

NOTE: SHEET NUMBERS IN PARENTHESES REFER TO FIGURE 1-42.

Figure 1-40 (Sheet 1 of 6)

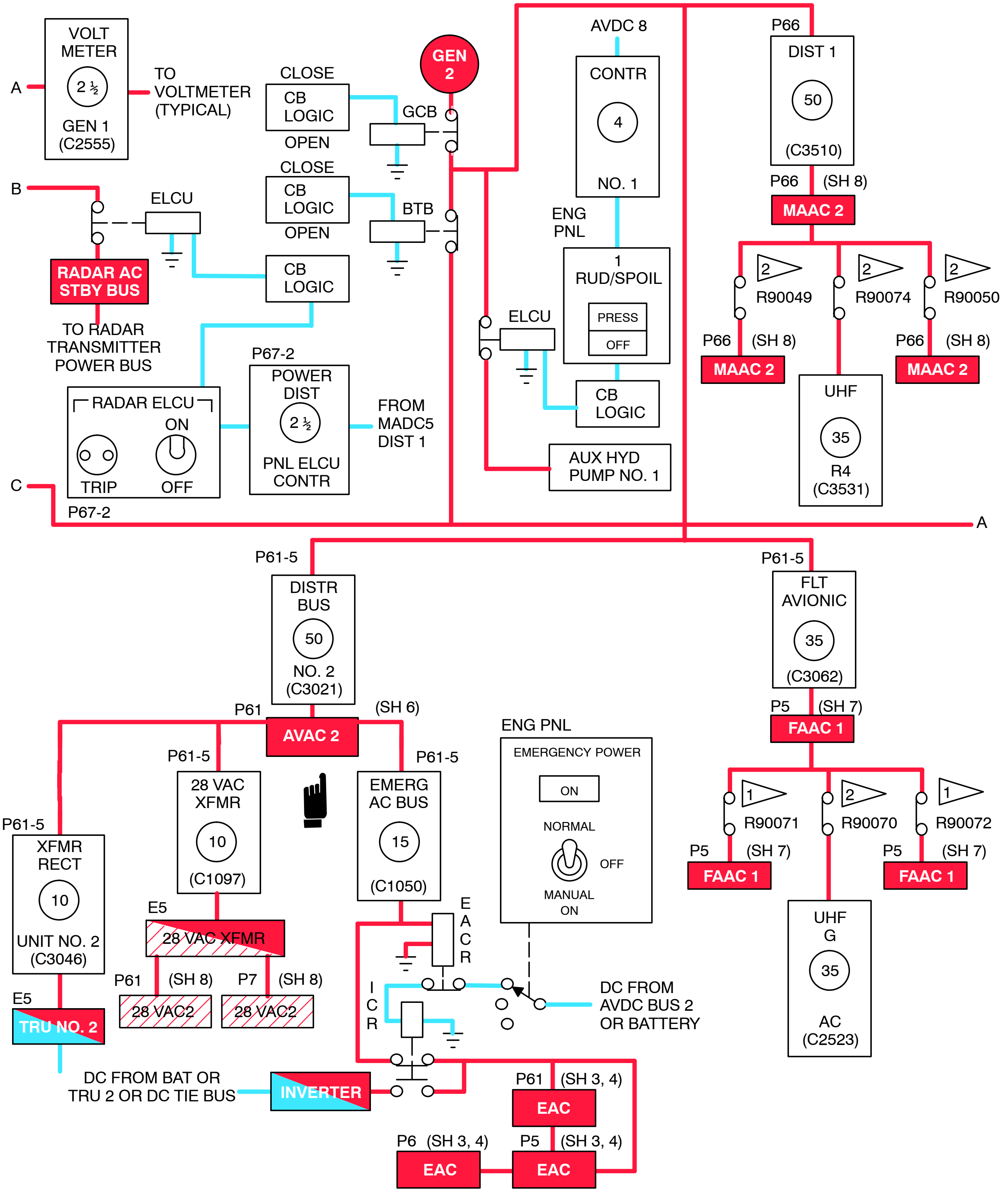


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Figure 1-40 (Sheet 2 of 6)

AC Power Distribution Schematic (Continued)

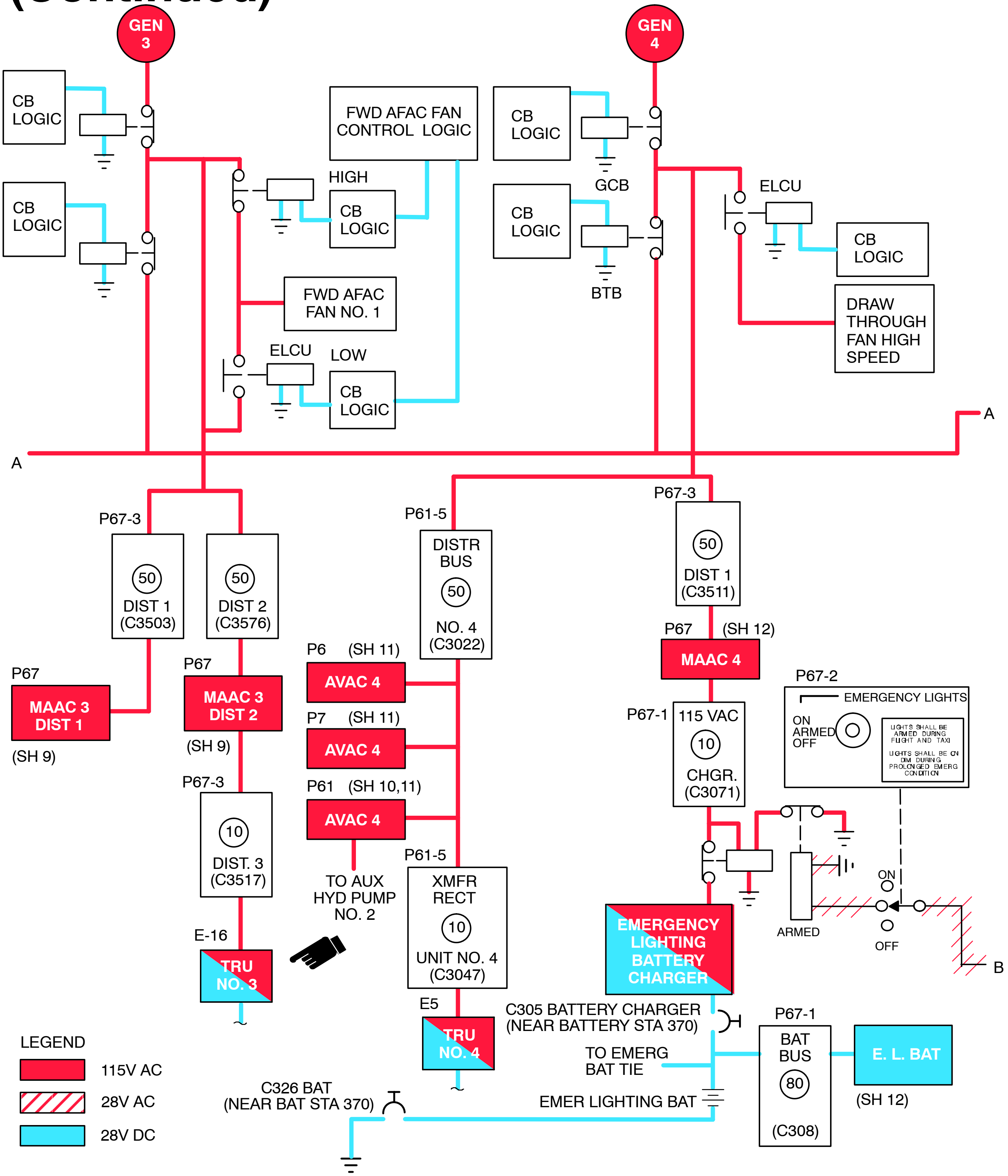

Figure 1-40 (Sheet 3 of 6)

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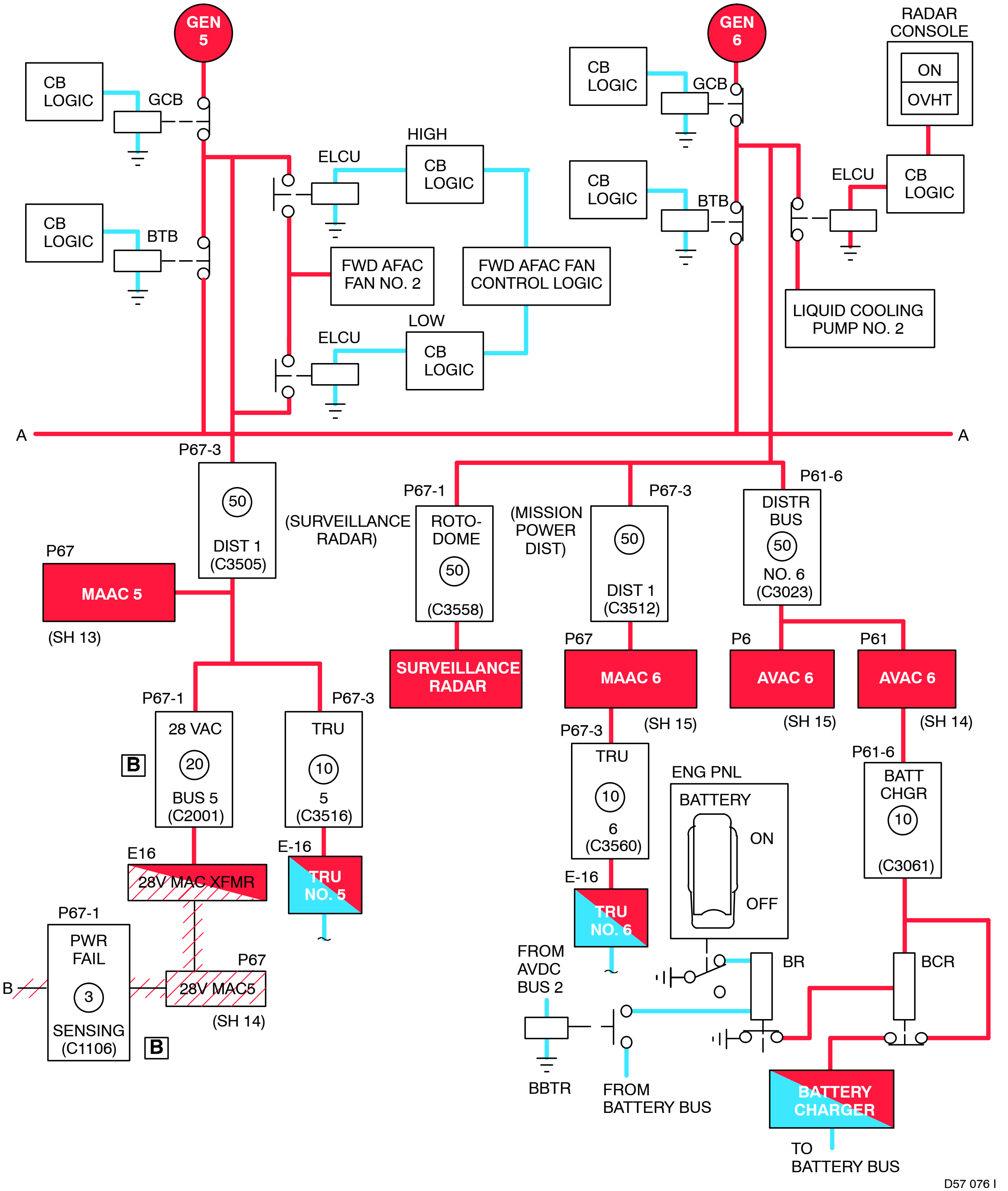

Figure 1-40 (Sheet 4 of 6)

AC Power Distribution Schematic (Continued)

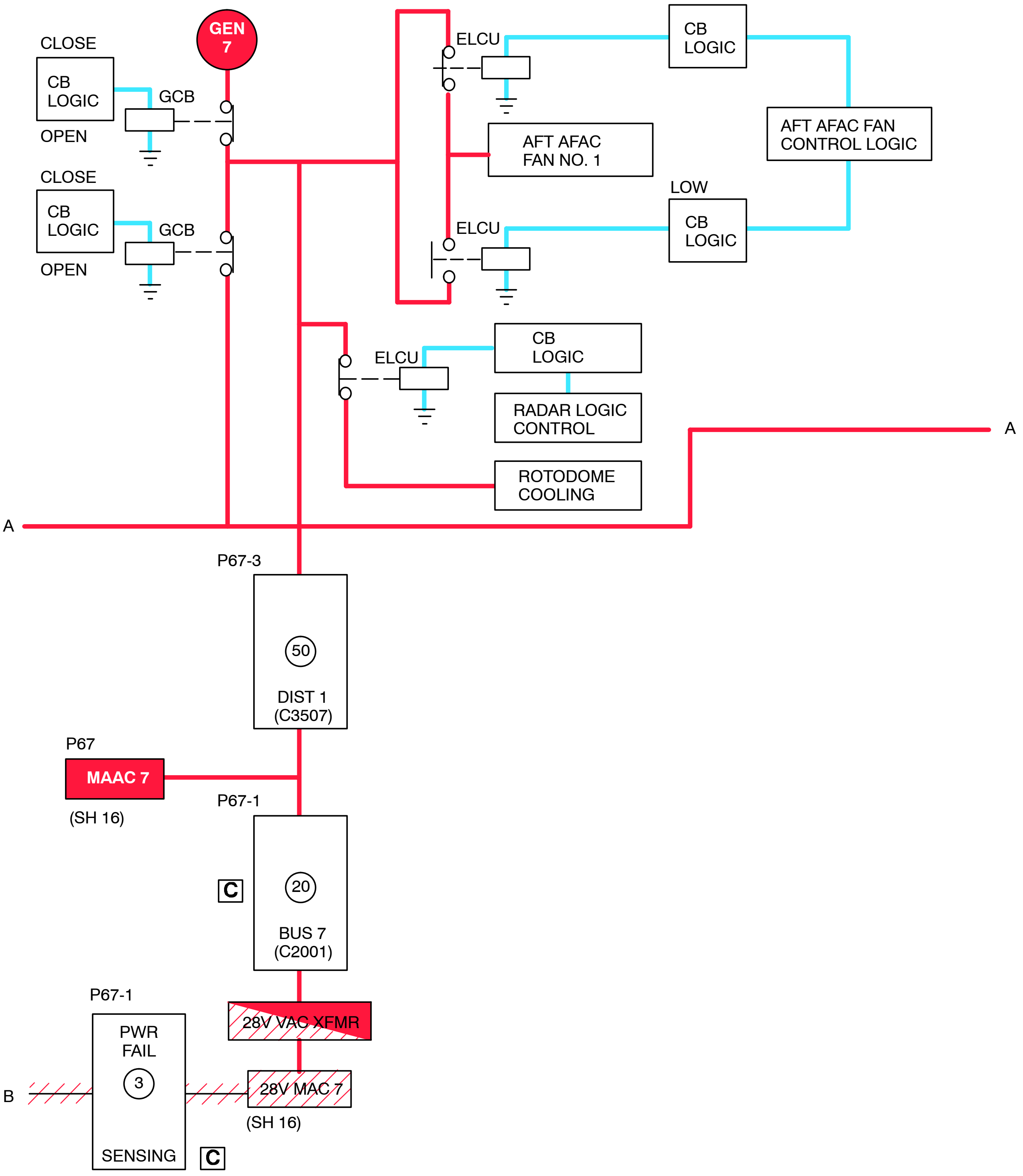

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Figure 1-40 (Sheet 5 of 6)

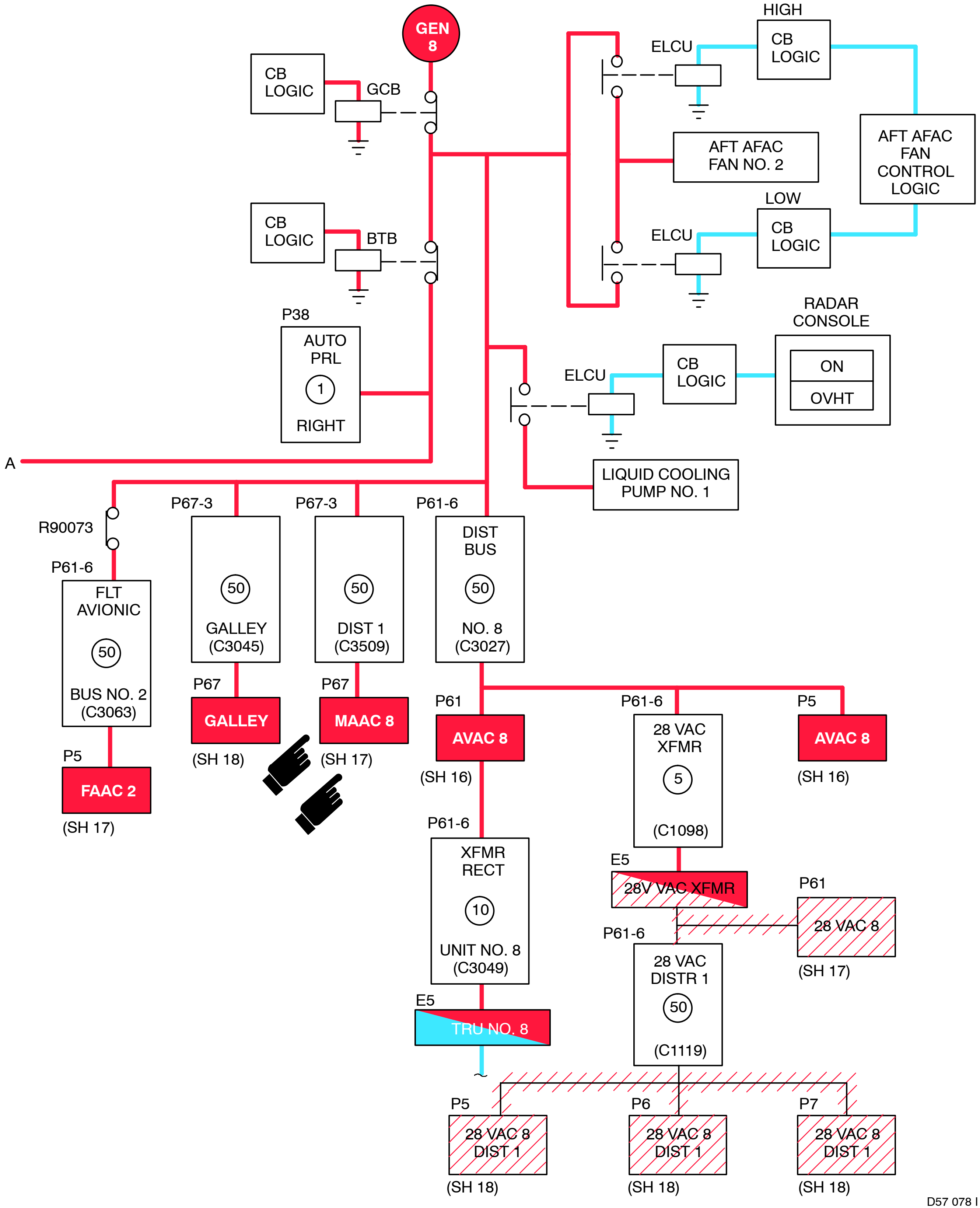


Figure 1-40 (Sheet 6 of 6)

DC Power Distribution Schematic

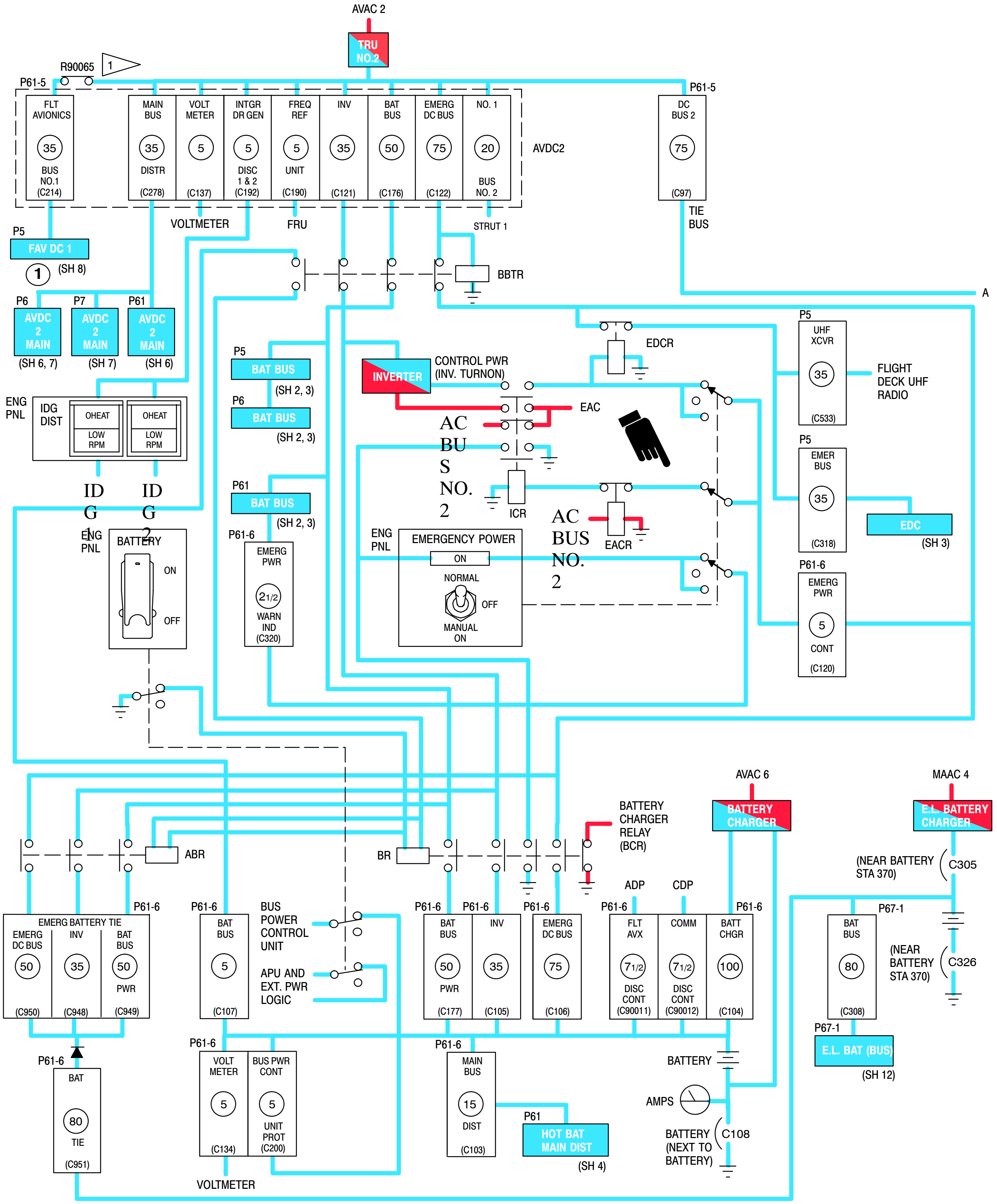
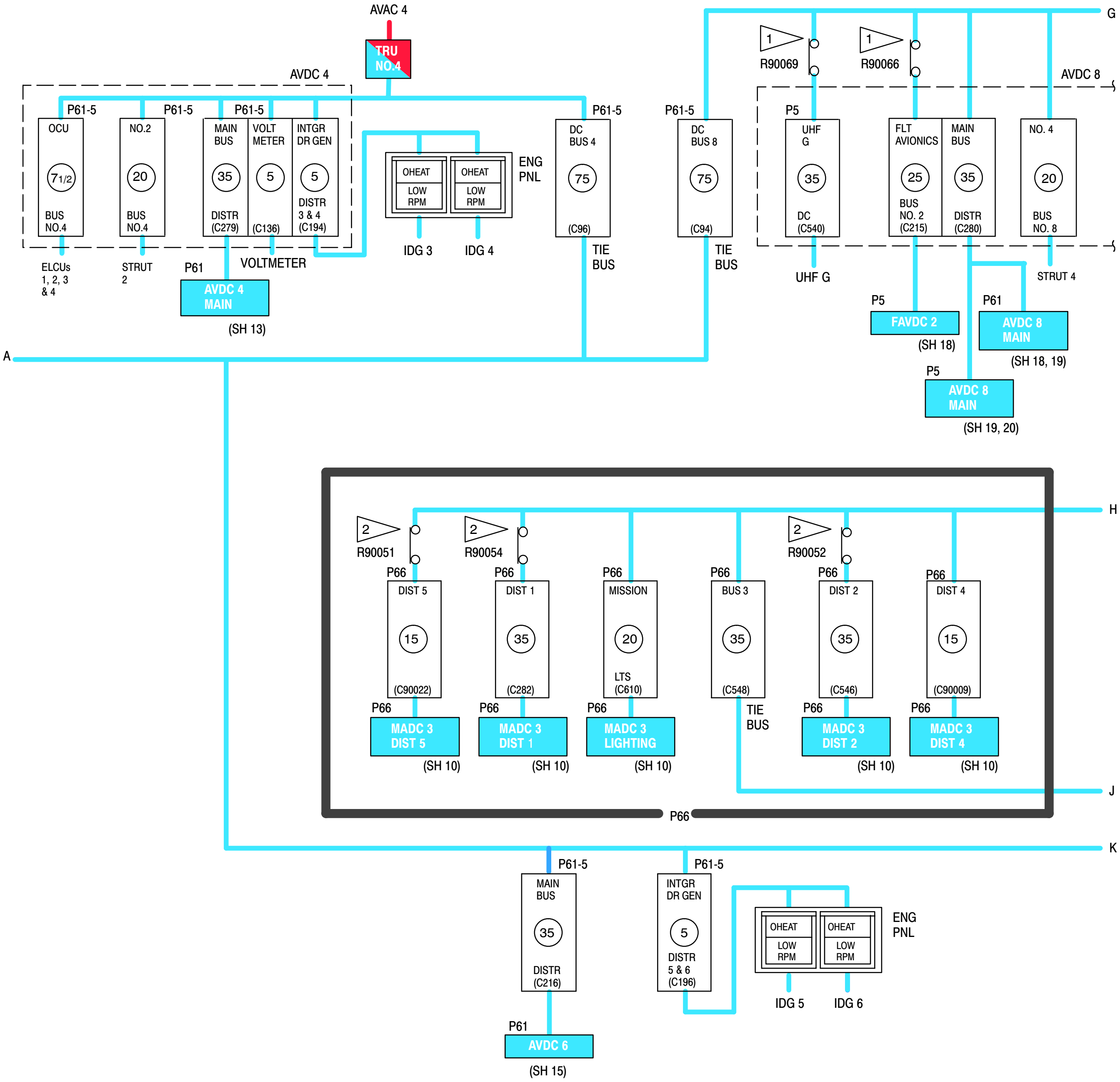


Figure 1-41 (Sheet 1 of 3)



LEGEND

ABR	AUXILIARY BATTERY RELAY	EMER	EMERGENCY
AVAC	AIR VEHICLE AC	ENG PNL	ENGINEERS PANEL
AVDC	AIR VEHICLE DC	FAV DC	FLIGHT AVIONICS DC
BBTR	BATTERY BUS TRANSFER RELAY	ICR	INVERTER CONTROL RELAY
BR	BATTERY RELAY	IDG	INTEGRATED DRIVE GENERATOR
DIST	DISTRIBUTION	MAAC	MISSION AVIONICS AC
EACR	EMERGENCY AC RELAY	MADC	MISSION AVIONICS DC
EDCR	EMERGENCY DC RELAY	WBSV	WIDE BAND SECURE VOICE

1 CONTROLLED BY AVIONICS POWER DISCONNECT PANEL

2 CONTROLLED BY COMM DISCONNECT PANEL

① SHEET NUMBERS IN PARENTHESES REFER TO FIGURE 1-42.

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Figure 1-41 (Sheet 2 of 3)

DC Power Distribution Schematic (Continued)

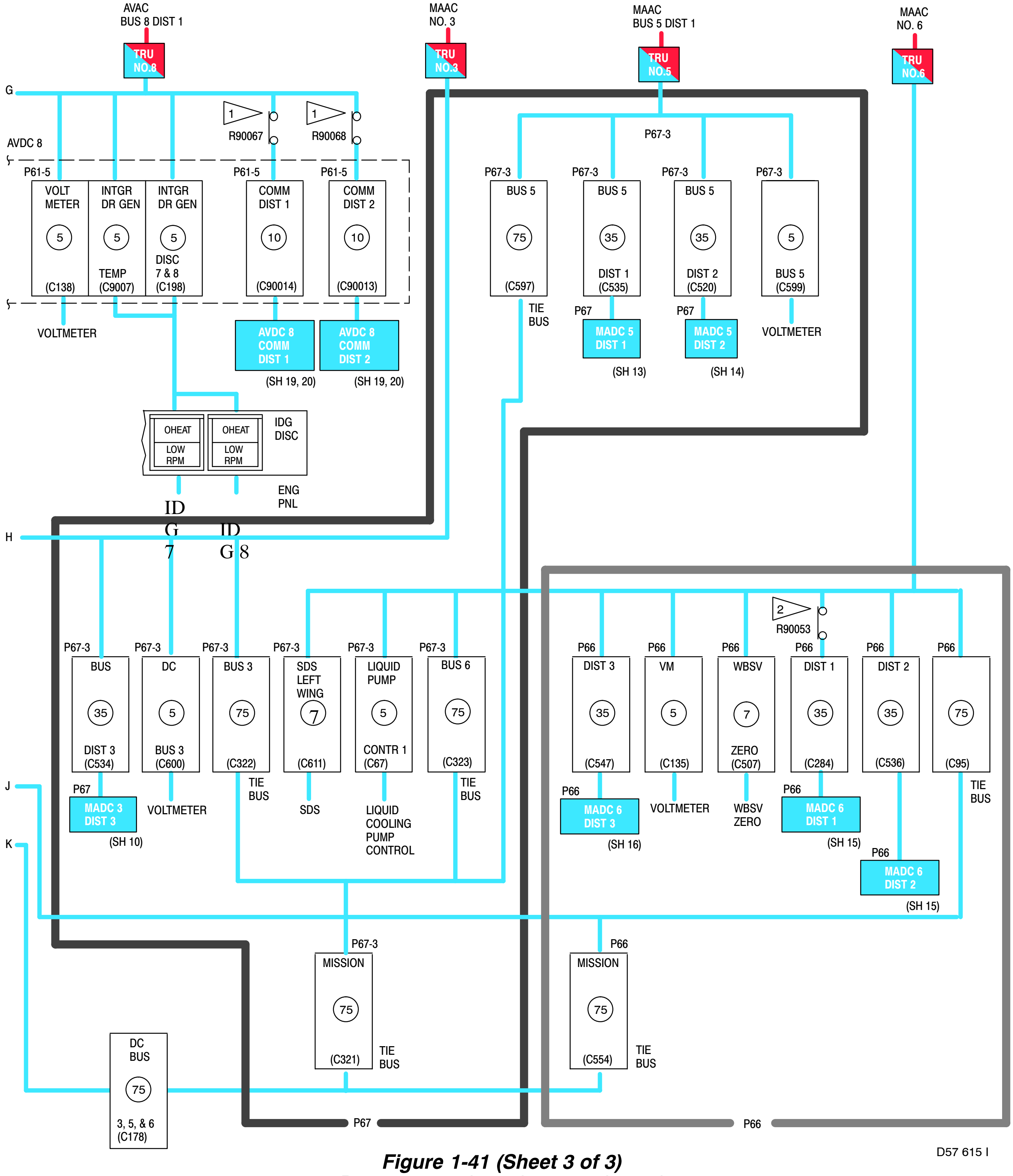


Figure 1-41 (Sheet 3 of 3)

Pages 1–149 through 1–152 deleted

Bus Distribution Diagram

LEGEND

APU – AUXILIARY POWER UNIT

AVAC – AIR VEHICLE AC

AVDC – AIR VEHICLE DC

BAT BUS – BATTERY BUS

EAC – EMERGENCY AC

EDC – EMERGENCY DC

E.L. BAT – EMERGENCY LIGHTING BATTERY BUS

EXT PWR – EXTERNAL POWER

FAAC – FLIGHT AVIONICS AC

FA VDC – FLIGHT AVIONICS DC

GEN – GENERATOR

HOT BAT MAIN DIST – HOT BATTERY MAIN DISTRIBUTION

MAAC – MISSION AVIONICS AC

MADC – MISSION AVIONICS DC

TRU – TRANSFORMER RECTIFIER UNIT

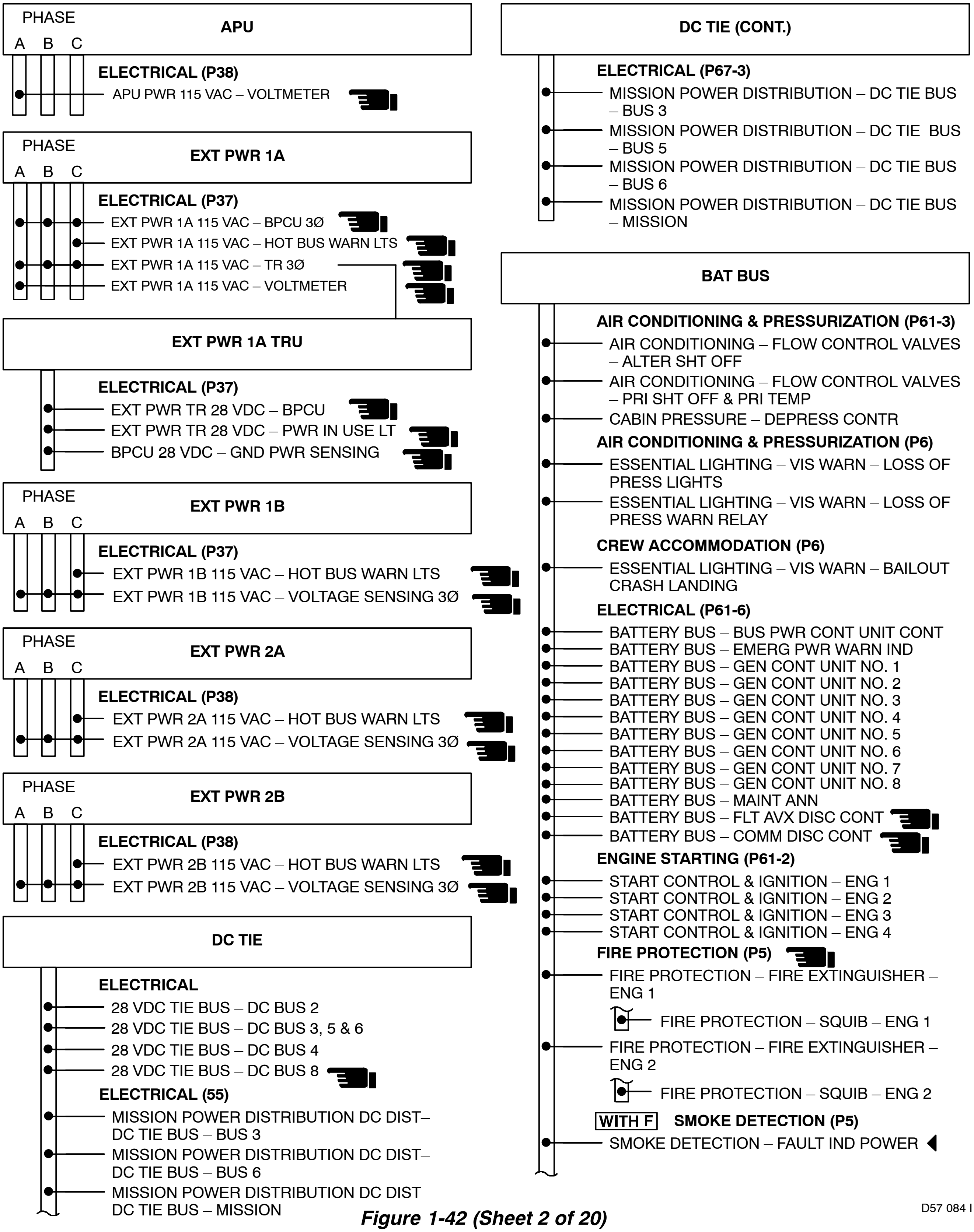
28 VAC – 28 VOLT AIR VEHICLE AC

28 VMAC – 28 VOLT MISSION AC

XFMR – TRANSFORMER

Figure 1-42 (Sheet 1 of 20)

Bus Distribution Diagram (Continued)



APU

PHASE A B C

ELECTRICAL (P38)

- APU PWR 115 VAC – VOLTMETER

EXT PWR 1A

PHASE A B C

ELECTRICAL (P37)

- EXT PWR 1A 115 VAC – BPCU 3Ø
- EXT PWR 1A 115 VAC – HOT BUS WARN LTS
- EXT PWR 1A 115 VAC – TR 3Ø
- EXT PWR 1A 115 VAC – VOLTMETER

EXT PWR 1A TRU

ELECTRICAL (P37)

- EXT PWR TR 28 VDC – BPCU
- EXT PWR TR 28 VDC – PWR IN USE LT
- BPCU 28 VDC – GND PWR SENSING

EXT PWR 1B

PHASE A B C

ELECTRICAL (P37)

- EXT PWR 1B 115 VAC – HOT BUS WARN LTS
- EXT PWR 1B 115 VAC – VOLTAGE SENSING 3Ø

EXT PWR 2A

PHASE A B C

ELECTRICAL (P38)

- EXT PWR 2A 115 VAC – HOT BUS WARN LTS
- EXT PWR 2A 115 VAC – VOLTAGE SENSING 3Ø

EXT PWR 2B

PHASE A B C

ELECTRICAL (P38)

- EXT PWR 2B 115 VAC – HOT BUS WARN LTS
- EXT PWR 2B 115 VAC – VOLTAGE SENSING 3Ø

DC TIE

ELECTRICAL

- 28 VDC TIE BUS – DC BUS 2
- 28 VDC TIE BUS – DC BUS 3, 5 & 6
- 28 VDC TIE BUS – DC BUS 4
- 28 VDC TIE BUS – DC BUS 8

ELECTRICAL (55)

- MISSION POWER DISTRIBUTION DC DIST– DC TIE BUS – BUS 3
- MISSION POWER DISTRIBUTION DC DIST– DC TIE BUS – BUS 6
- MISSION POWER DISTRIBUTION DC DIST DC TIE BUS – MISSION

DC TIE (CONT.)

ELECTRICAL (P67-3)

- MISSION POWER DISTRIBUTION – DC TIE BUS – BUS 3
- MISSION POWER DISTRIBUTION – DC TIE BUS – BUS 5
- MISSION POWER DISTRIBUTION – DC TIE BUS – BUS 6
- MISSION POWER DISTRIBUTION – DC TIE BUS – MISSION

BAT BUS

AIR CONDITIONING & PRESSURIZATION (P61-3)

- AIR CONDITIONING – FLOW CONTROL VALVES – ALTER SHT OFF
- AIR CONDITIONING – FLOW CONTROL VALVES – PRI SHT OFF & PRI TEMP
- CABIN PRESSURE – DEPRESS CONTR

AIR CONDITIONING & PRESSURIZATION (P6)

- ESSENTIAL LIGHTING – VIS WARN – LOSS OF PRESS LIGHTS
- ESSENTIAL LIGHTING – VIS WARN – LOSS OF PRESS WARN RELAY

CREW ACCOMMODATION (P6)

- ESSENTIAL LIGHTING – VIS WARN – BAILOUT CRASH LANDING

ELECTRICAL (P61-6)

- BATTERY BUS – BUS PWR CONT UNIT CONT
- BATTERY BUS – EMERG PWR WARN IND
- BATTERY BUS – GEN CONT UNIT NO. 1
- BATTERY BUS – GEN CONT UNIT NO. 2
- BATTERY BUS – GEN CONT UNIT NO. 3
- BATTERY BUS – GEN CONT UNIT NO. 4
- BATTERY BUS – GEN CONT UNIT NO. 5
- BATTERY BUS – GEN CONT UNIT NO. 6
- BATTERY BUS – GEN CONT UNIT NO. 7
- BATTERY BUS – GEN CONT UNIT NO. 8
- BATTERY BUS – MAINT ANN
- BATTERY BUS – FLT AVX DISC CONT
- BATTERY BUS – COMM DISC CONT

ENGINE STARTING (P61-2)

- START CONTROL & IGNITION – ENG 1
- START CONTROL & IGNITION – ENG 2
- START CONTROL & IGNITION – ENG 3
- START CONTROL & IGNITION – ENG 4

FIRE PROTECTION (P5)

- FIRE PROTECTION – FIRE EXTINGUISHER – ENG 1
  - FIRE PROTECTION – SQUIB – ENG 1
- FIRE PROTECTION – FIRE EXTINGUISHER – ENG 2
  - FIRE PROTECTION – SQUIB – ENG 2

WITH F **SMOKE DETECTION (P5)**

- SMOKE DETECTION – FAULT IND POWER ◀

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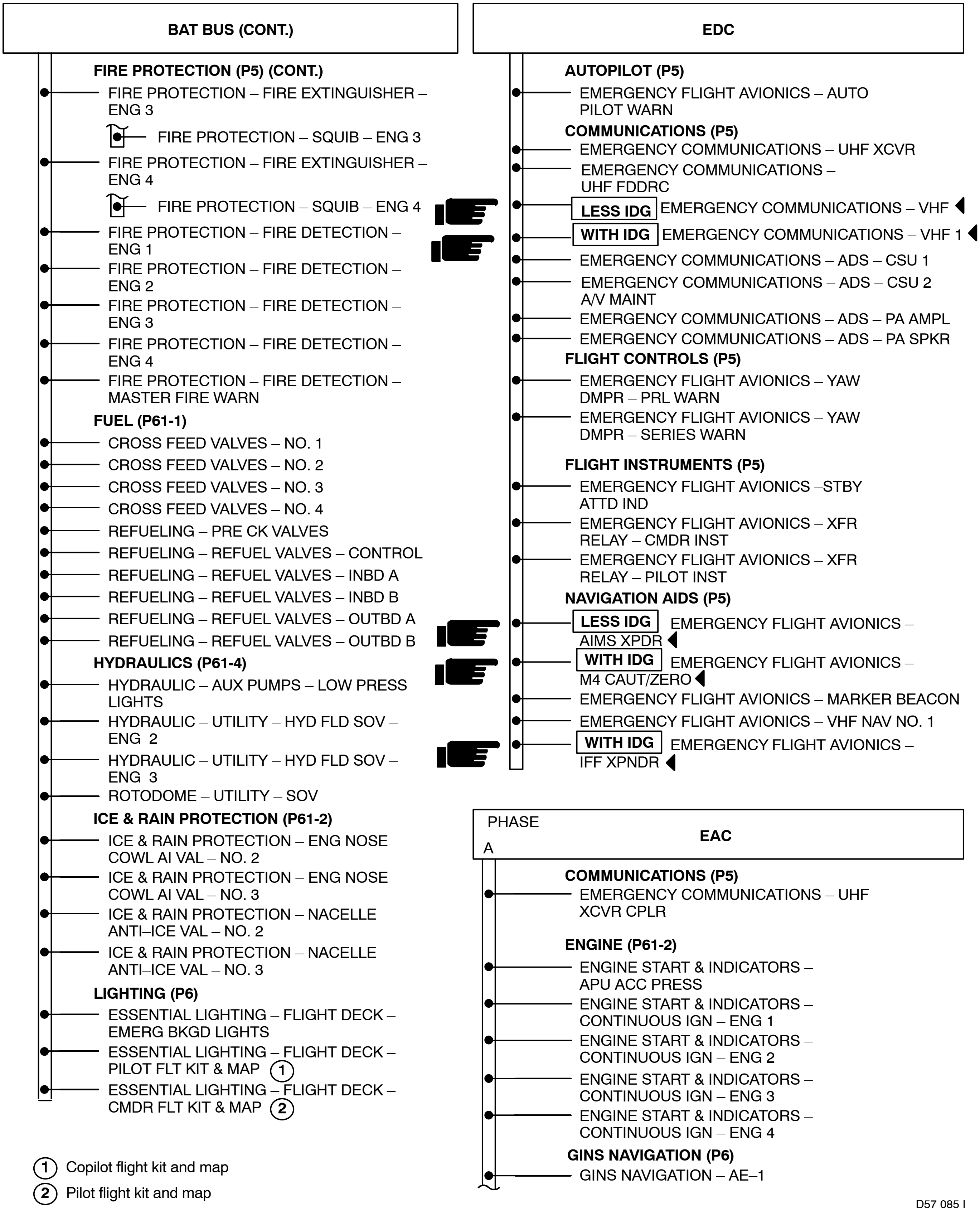
Figure 1-42 (Sheet 2 of 20)



BAT BUS (CONT.)

FIRE PROTECTION (P5) (CONT.)
- FIRE PROTECTION – FIRE EXTINGUISHER – ENG 3
  - FIRE PROTECTION – SQUIB – ENG 3
- FIRE PROTECTION – FIRE EXTINGUISHER – ENG 4
  - FIRE PROTECTION – SQUIB – ENG 4
- FIRE PROTECTION – FIRE DETECTION – ENG 1
- FIRE PROTECTION – FIRE DETECTION – ENG 2
- FIRE PROTECTION – FIRE DETECTION – ENG 3
- FIRE PROTECTION – FIRE DETECTION – ENG 4
- FIRE PROTECTION – FIRE DETECTION – MASTER FIRE WARN

FUEL (P61-1)
- CROSS FEED VALVES – NO. 1
- CROSS FEED VALVES – NO. 2
- CROSS FEED VALVES – NO. 3
- CROSS FEED VALVES – NO. 4
- REFUELING – PRE CK VALVES
- REFUELING – REFUEL VALVES – CONTROL
- REFUELING – REFUEL VALVES – INBD A
- REFUELING – REFUEL VALVES – INBD B
- REFUELING – REFUEL VALVES – OUTBD A
- REFUELING – REFUEL VALVES – OUTBD B

HYDRAULICS (P61-4)
- HYDRAULIC – AUX PUMPS – LOW PRESS LIGHTS
- HYDRAULIC – UTILITY – HYD FLD SOV – ENG 2
- HYDRAULIC – UTILITY – HYD FLD SOV – ENG 3
- ROTODOME – UTILITY – SOV

ICE & RAIN PROTECTION (P61-2)
- ICE & RAIN PROTECTION – ENG NOSE COWL AI VAL – NO. 2
- ICE & RAIN PROTECTION – ENG NOSE COWL AI VAL – NO. 3
- ICE & RAIN PROTECTION – NACELLE ANTI–ICE VAL – NO. 2
- ICE & RAIN PROTECTION – NACELLE ANTI–ICE VAL – NO. 3

LIGHTING (P6)
- ESSENTIAL LIGHTING – FLIGHT DECK – EMERG BKGD LIGHTS
- ESSENTIAL LIGHTING – FLIGHT DECK – PILOT FLT KIT & MAP ①
- ESSENTIAL LIGHTING – FLIGHT DECK – CMDR FLT KIT & MAP ②

① Copilot flight kit and map

② Pilot flight kit and map

EDC

AUTOPILOT (P5)
- EMERGENCY FLIGHT AVIONICS – AUTO PILOT WARN

COMMUNICATIONS (P5)
- EMERGENCY COMMUNICATIONS – UHF XCVR
- EMERGENCY COMMUNICATIONS – UHF FDDRC
- **LESS IDG** EMERGENCY COMMUNICATIONS – VHF ◀
- **WITH IDG** EMERGENCY COMMUNICATIONS – VHF 1 ◀
- EMERGENCY COMMUNICATIONS – ADS – CSU 1
- EMERGENCY COMMUNICATIONS – ADS – CSU 2 A/V MAINT
- EMERGENCY COMMUNICATIONS – ADS – PA AMPL
- EMERGENCY COMMUNICATIONS – ADS – PA SPKR

FLIGHT CONTROLS (P5)
- EMERGENCY FLIGHT AVIONICS – YAW DMPR – PRL WARN
- EMERGENCY FLIGHT AVIONICS – YAW DMPR – SERIES WARN

FLIGHT INSTRUMENTS (P5)
- EMERGENCY FLIGHT AVIONICS –STBY ATTD IND
- EMERGENCY FLIGHT AVIONICS – XFR RELAY – CMDR INST
- EMERGENCY FLIGHT AVIONICS – XFR RELAY – PILOT INST

NAVIGATION AIDS (P5)
- **LESS IDG** EMERGENCY FLIGHT AVIONICS – AIMS XPDR ◀
- **WITH IDG** EMERGENCY FLIGHT AVIONICS – M4 CAUT/ZERO ◀
- EMERGENCY FLIGHT AVIONICS – MARKER BEACON
- EMERGENCY FLIGHT AVIONICS – VHF NAV NO. 1
- **WITH IDG** EMERGENCY FLIGHT AVIONICS – IFF XPNDR ◀

PHASE A **EAC**

COMMUNICATIONS (P5)
- EMERGENCY COMMUNICATIONS – UHF XCVR CPLR

ENGINE (P61-2)
- ENGINE START & INDICATORS – APU ACC PRESS
- ENGINE START & INDICATORS – CONTINUOUS IGN – ENG 1
- ENGINE START & INDICATORS – CONTINUOUS IGN – ENG 2
- ENGINE START & INDICATORS – CONTINUOUS IGN – ENG 3
- ENGINE START & INDICATORS – CONTINUOUS IGN – ENG 4

GINS NAVIGATION (P6)
- GINS NAVIGATION – AE–1

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Figure 1–42 (Sheet 3 of 20)

Bus Distribution Diagram (Continued)

EAC (CONT.)

	PHASE A
FLIGHT INSTRUMENTS (P5)	
EMERGENCY FLIGHT AVIONICS – NO. 1 ATTD XFMR AC ①	●
WITH IDG EMERGENCY FLIGHT AVIONICS – VSI/TA CMDR	●
EMERGENCY FLIGHT AVIONICS – VSI/TA PILOT	●
FUEL (P61-1)	
INDICATORS – QUANTITY – GND REFUEL BATT	●
LIGHTING (P6)	
ESSENTIAL LIGHTING – FLIGHT DECK – MN INST PANEL BKGD & FLOOD	●
ESSENTIAL LIGHTING – FLIGHT DECK – COMPASS	●

HOT BAT

ELECTRICAL (P61-6)

- HOT BATTERY BUS – BATT BUS CONT
- HOT BATTERY BUS – BATT BUS PWR
- HOT BATTERY BUS – BATT CHGR
- HOT BATTERY BUS – BUS PWR CONT UNIT PROT
- HOT BATTERY BUS – EMERG DC BUS
- HOT BATTERY BUS – INV
- HOT BATTERY BUS – VOLTMETER
- HOT BATTERY BUS – MAIN BUS DISTR
  - **GINS NAVIGATION (P6)**
    - GINS NAVIGATION – CDU – NVGTR – BSIU 1 – CTRL PNL & MDL
  - **APU (P61-2)**
    - ENGINE START & INDICATORS – APU – DOOR WARN
    - ENGINE START & INDICATORS – APU – CONTR
    - ENGINE START & INDICATORS – APU – FIRE DETECT PRIMARY SHUT DN
    - ENGINE START & INDICATORS – APU – FIRE EXT
  - **FUEL (P61-1)**
    - REFUELING – ISLN VALVE & SEC FLT SYS ②
    - SHUT OFF VALVES – ALTERNATE – ENG 1
    - SHUT OFF VALVES – ALTERNATE – ENG 2
    - SHUT OFF VALVES – ALTERNATE – ENG 3
    - SHUT OFF VALVES – ALTERNATE – ENG 4

EMERG BATTERY TIE

ELECTRICAL (P61-6)

- BAT TIE
  - BAT BUS PWR
  - EMERG DC BUS
  - INV

GEN 1

	PHASE A	B	C
ELECTRICAL (P25)			
BUS TIE BREAKER 1	●	●	●
GENERATOR BREAKER 1	●	●	●
ELECTRICAL (P66-1)			
MISSION POWER DISTRIBUTION AC DIST			
VOLTMETER GEN 1			●
BUS 1 – DIST 1	●	●	●
BUS 1 – DIST 2	●	●	●
BUS 1 – DIST 3	●	●	●
28 VAC XFMR		●	
MISSION LTS			●
RADAR (E15)			
RADAR XMTR STBY PWR (ELCU)	●	●	●

MAAC 1 DIST 1

	PHASE A	B	C
COMMUNICATIONS (P66-2)			
SPARE	●		
SPARE		●	
SPARE			●
JTIDS – CDU AC	●		
JTIDS – HPAG	●	●	●
JTIDS – DPG – R/T	●	●	●

MAAC 1 DIST 2

	PHASE A	B	C
COMMUNICATIONS (P66)			
TADIL – A1	●		
NBSV – 5, 6	●		
NBSV – 1, 2	●		
NBSV – 3, 4	●		

① Transformer supplies 26 VAC for synchro excitation

② Supplies power to MASTER REFUEL switch

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Figure 1–42 (Sheet 4 of 20)

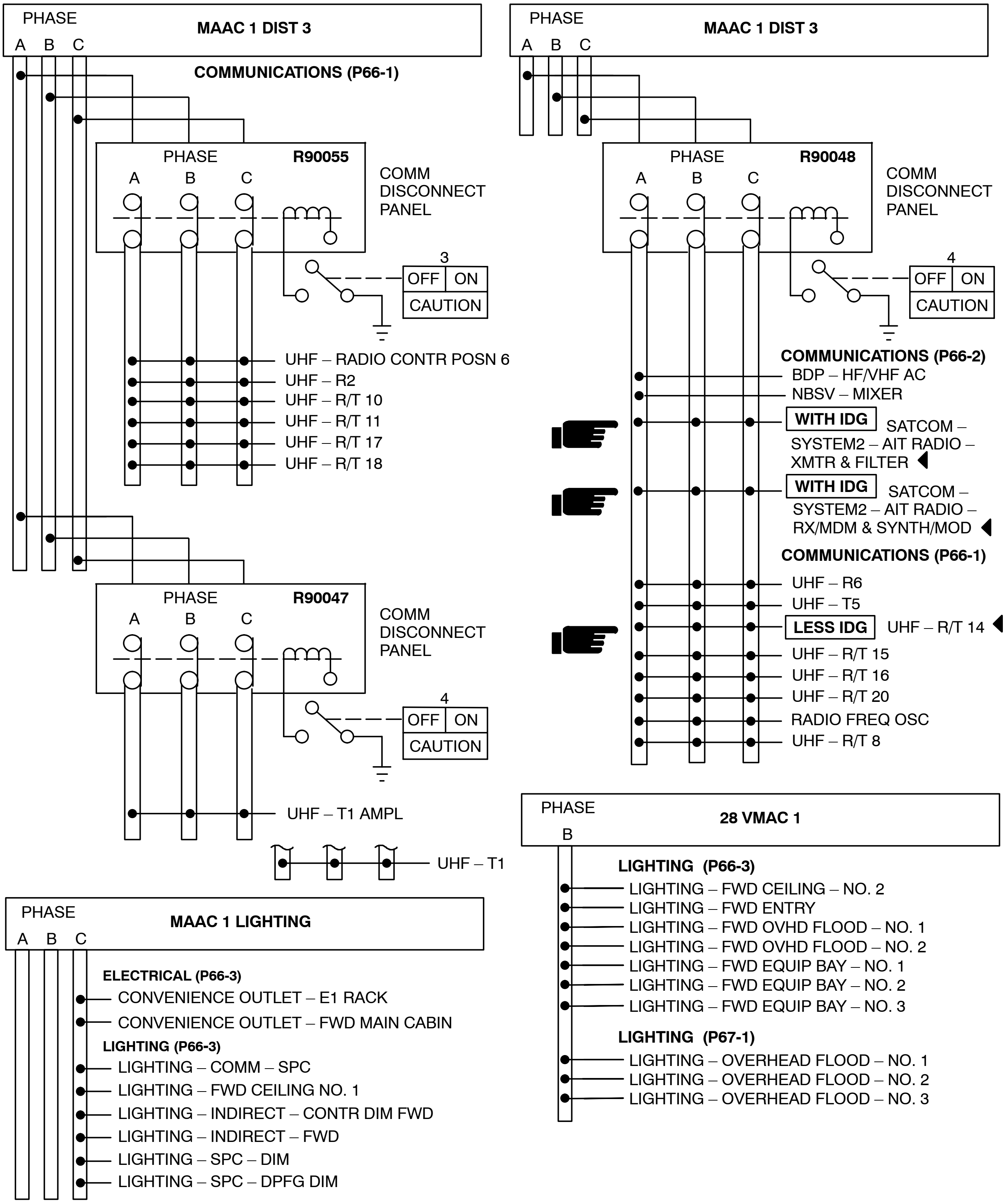
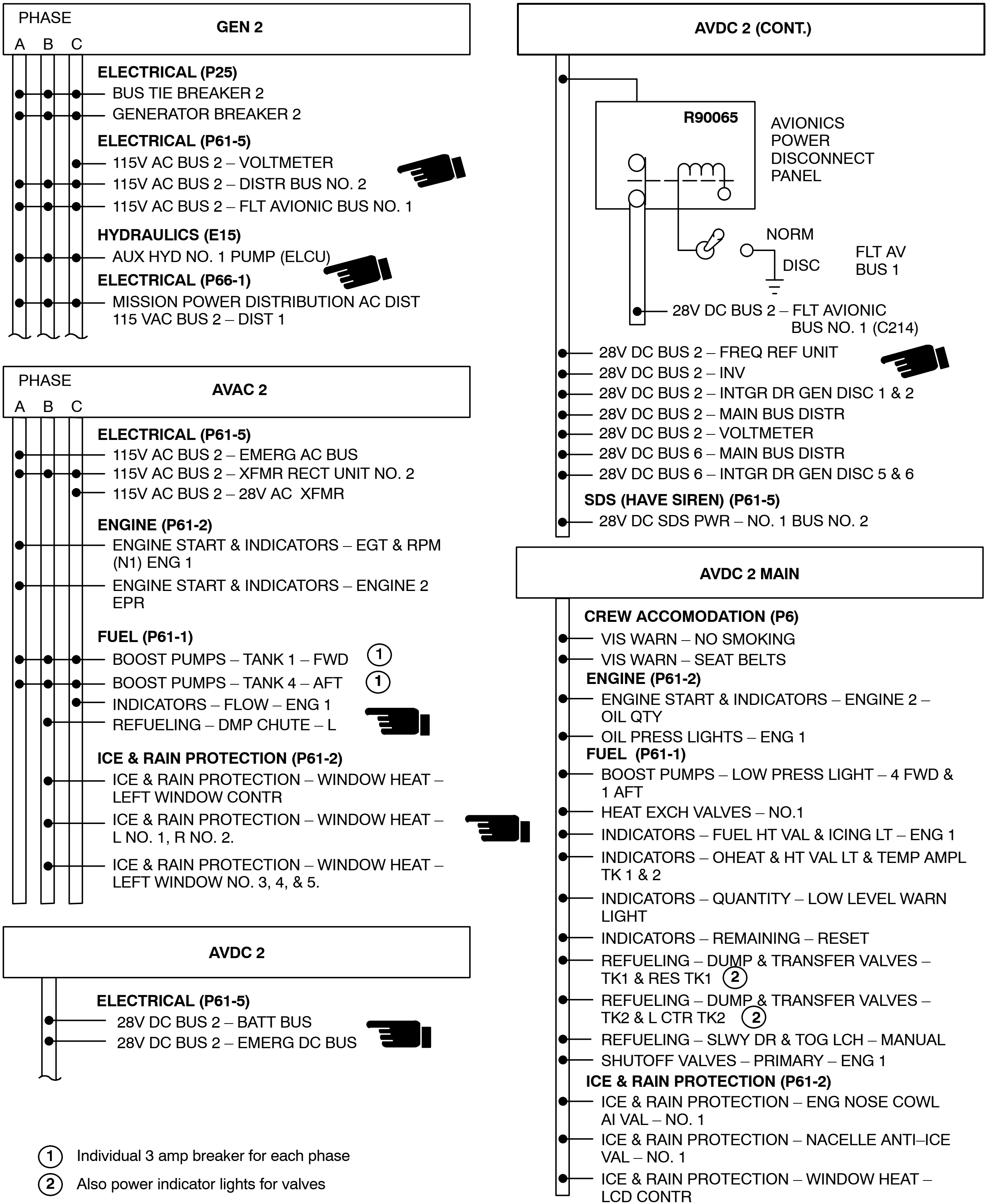


Figure 1–42 (Sheet 5 of 20)

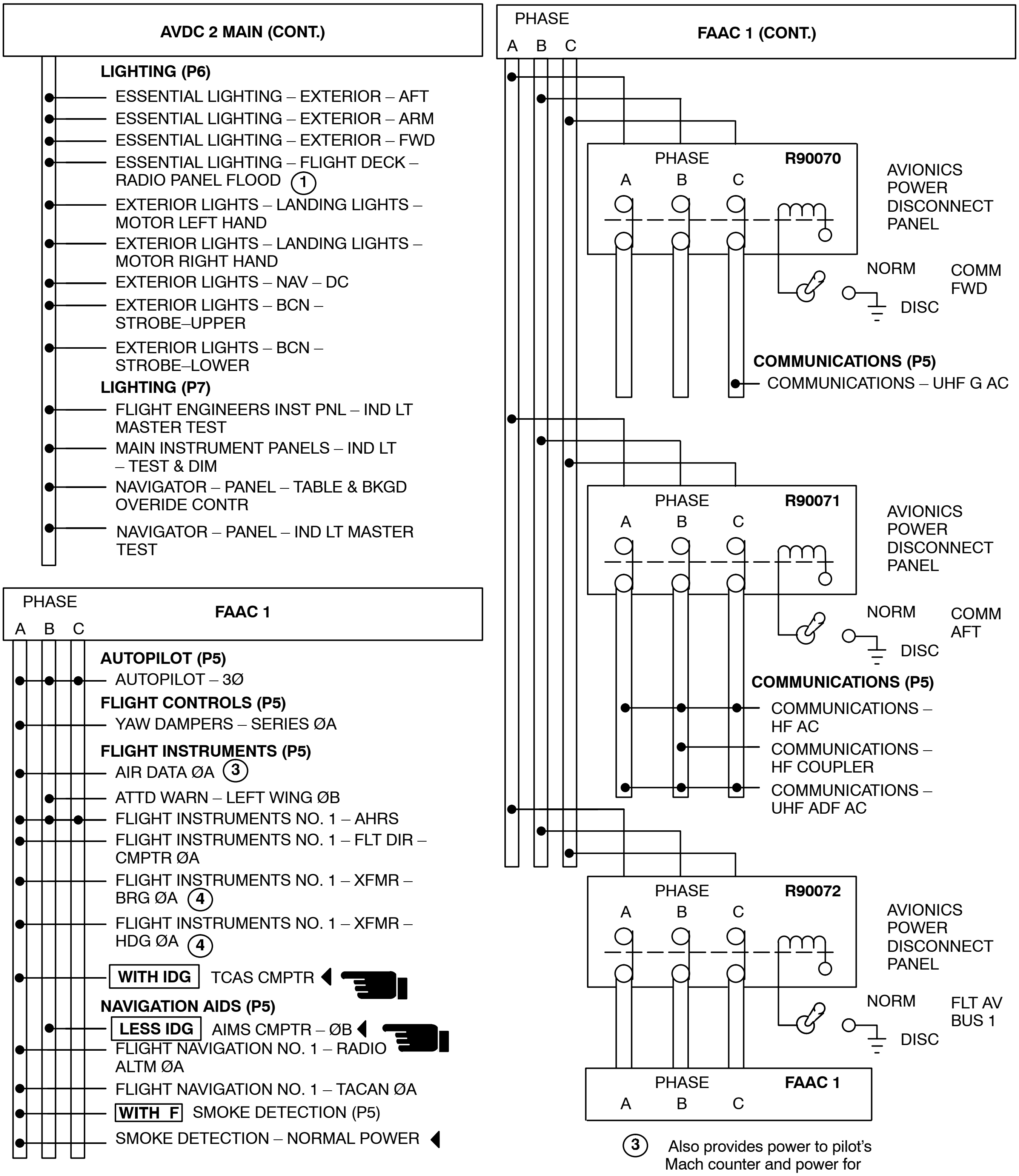
Bus Distribution Diagram (Continued)



① Individual 3 amp breaker for each phase

② Also power indicator lights for valves

Figure 1-42 (Sheet 6 of 20)



① Aisle stand and electronic panels

③ Also provides power to pilot's Mach counter and power for CADC 1 synchro outputs

④ Transformer supplies 26 VAC for instrument synchro excitation

Figure 1–42 (Sheet 7 of 20)

Bus Distribution Diagram (Continued)

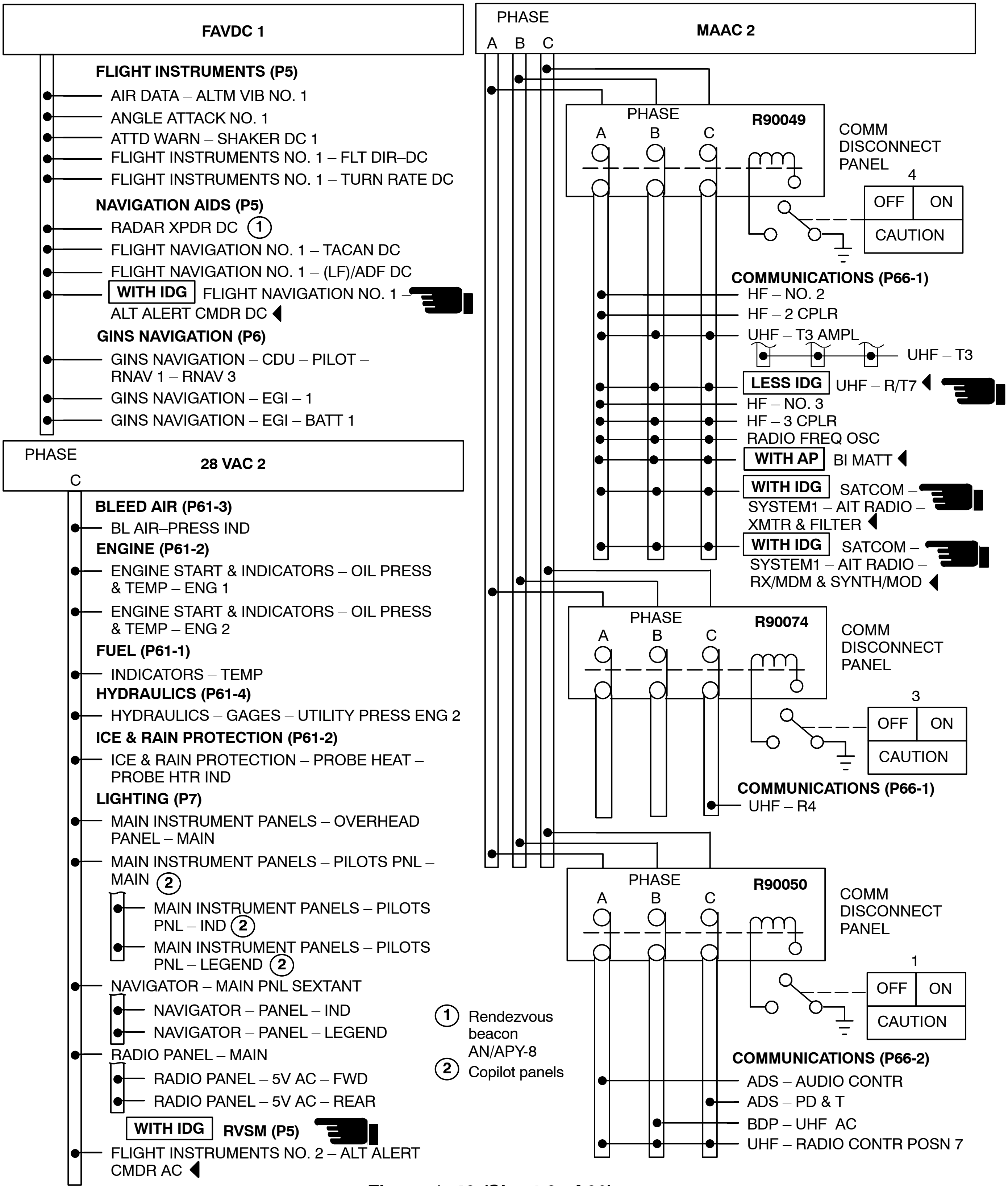


Figure 1–42 (Sheet 8 of 20)

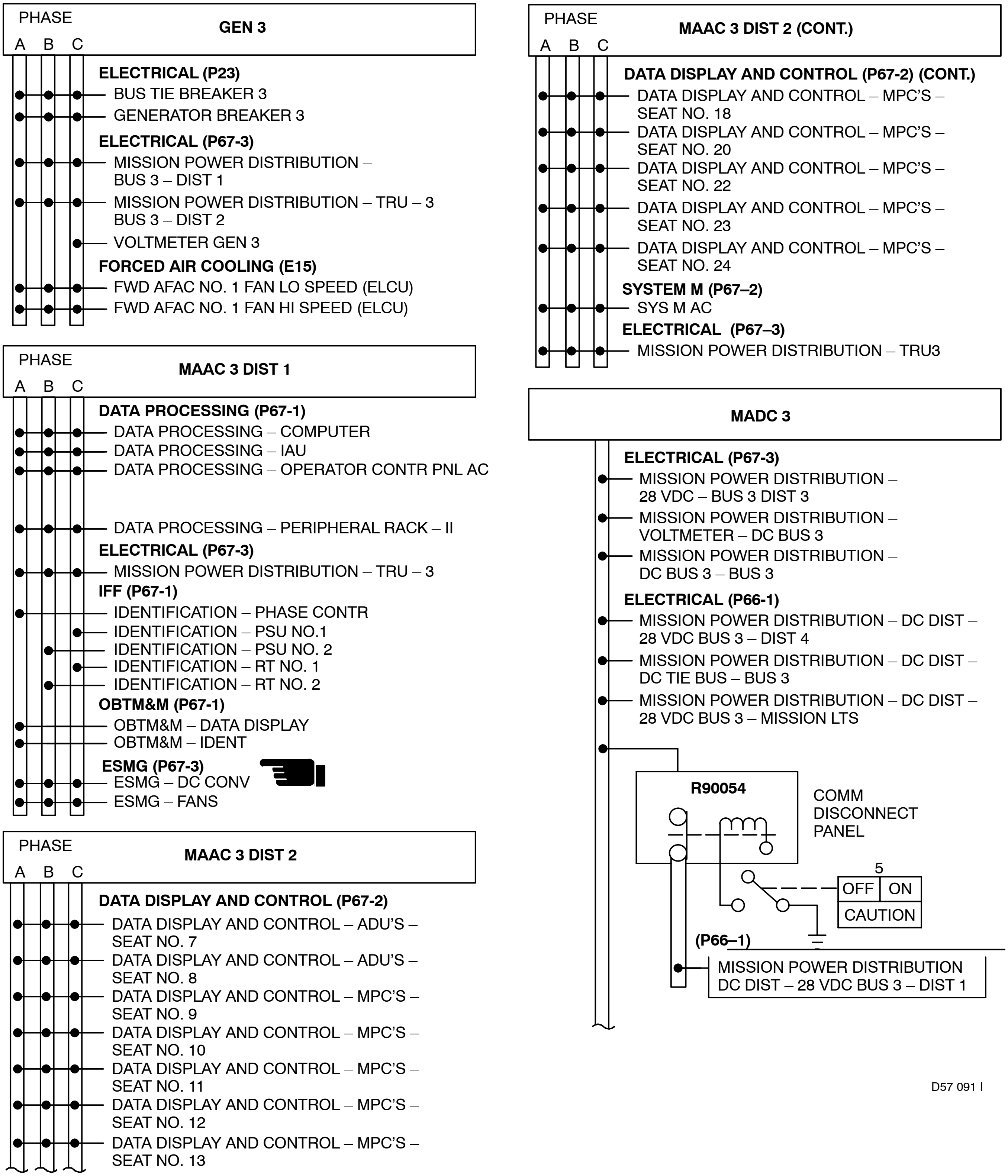
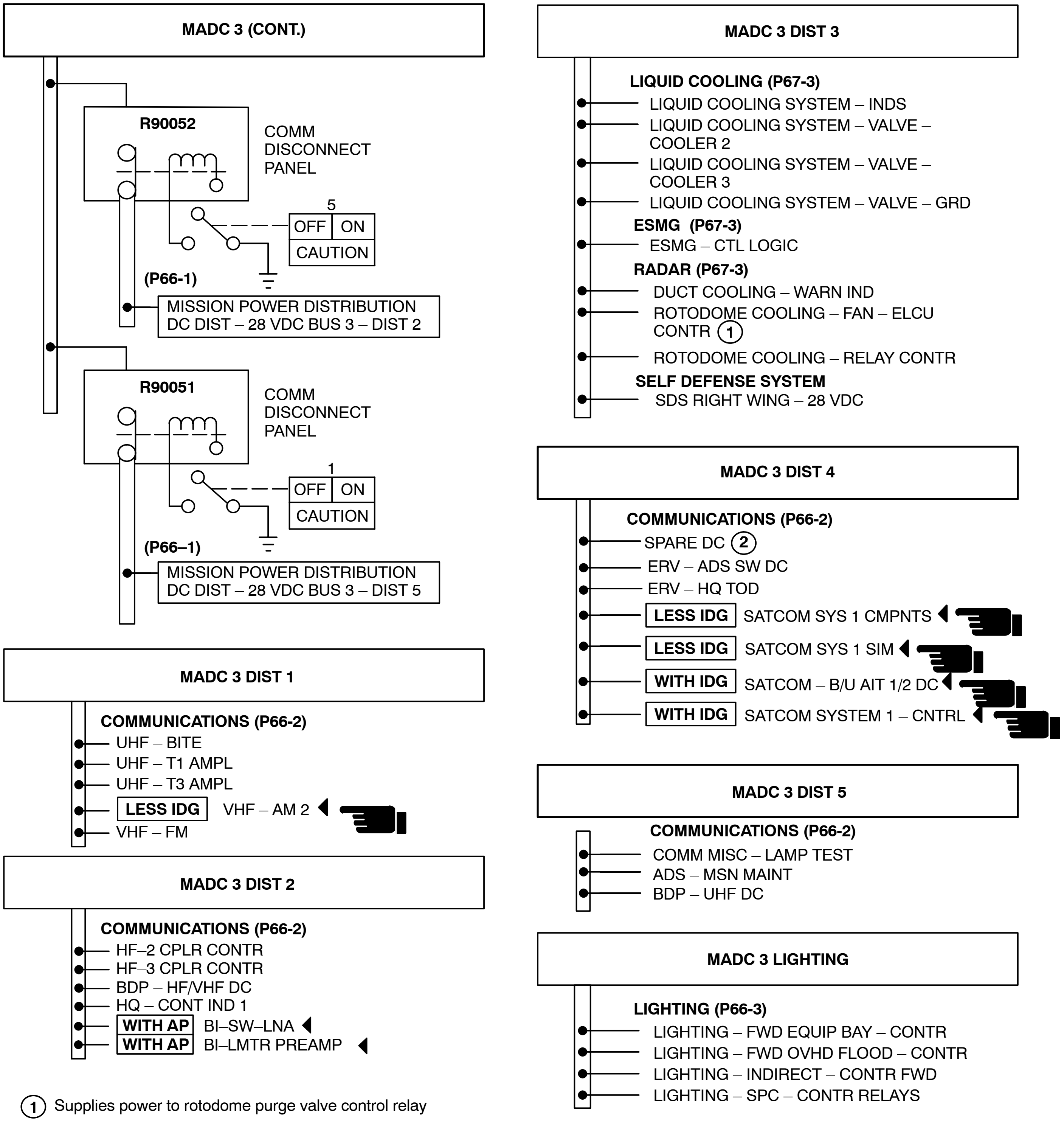


Figure 1-42 (Sheet 9 of 20)

Bus Distribution Diagram (Continued)



① Supplies power to rotodome purge valve control relay

② Banded open

Figure 1–42 (Sheet 10 of 20)

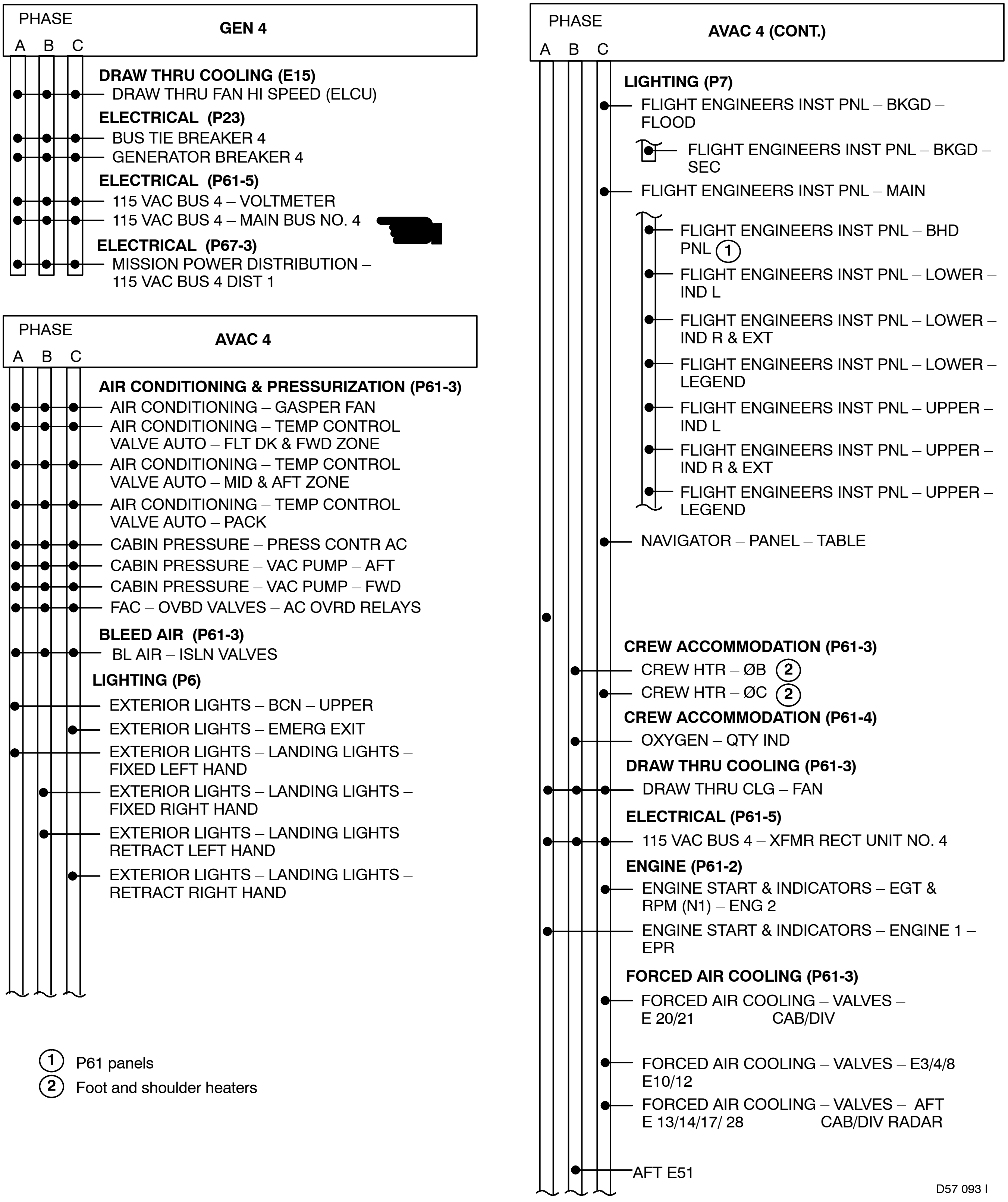


Figure 1-42 (Sheet 11 of 20)

Bus Distribution Diagram (Continued)

AVAC 4 (CONT.)

A	B	C	PHASE
			FORCED AIR COOLING (P61-3) (CONT.)
●			FORCED AIR COOLING – VALVES – AFT TEMP C HE/OB/BYPASS
	●		FORCED AIR COOLING – VALVES – FWD E19/23/41
●			FORCED AIR COOLING – VALVES – FWD E2
●			FORCED AIR COOLING – VALVES – FWD TEMP C HE/OB/BYPASS
			FUEL (P61-1)
●	●	●	BOOST PUMPS – CENTER TANK – L
●	●	●	BOOST PUMPS – TANK 2 – FWD ①
●	●	●	BOOST PUMPS – TANK 3 – AFT ①
		●	INDICATORS – FLOW – ENG 2
●			INDICATORS – QUANTITY – L TANKS & R MANUAL AMPL ②
			HYDRAULICS (P61-4)
●	●	●	HYDRAULIC – AUX PUMPS – NO. 2 POWER
			ICE & RAIN PROTECTION (P61-2)
●			ICE & RAIN PROTECTION – PROBE HEAT – Q SPR HTR
		●	ICE & RAIN PROTECTION – PROBE HEAT – RIGHT PITOT & AUX
	●		ICE & RAIN PROTECTION – PROBE HEAT – RIGHT TAT & ANGLE ATTACK 2 ③
			LIGHTING (P6)
		●	ESSENTIAL LIGHTING – FLIGHT DECK – DOME

MAAC 4

A	B	C	PHASE
			DATA DISPLAY AND CONTROL (P67-2)
●	●	●	DATA DISPLAY AND CONTROL – DATA DISPLAY CONTROLLER – Z5
●	●	●	DATA DISPLAY AND CONTROL – DATA DISPLAY CONTROLLER – Z6
●	●	●	DATA DISPLAY AND CONTROL – MPC'S – SEAT NO. 14
●	●	●	DATA DISPLAY AND CONTROL – MPC'S – SEAT NO. 15
●	●	●	DATA DISPLAY AND CONTROL – MPC'S – SEAT NO. 16
●	●	●	DATA DISPLAY AND CONTROL – MPC'S – SEAT NO. 17

① Individual 3 amp breaker for each phase

② Does not supply fuel remaining gage

③ Also powers TAT gage

MAAC 4 (CONT.)

A	B	C	PHASE
			LIGHTING (P67-1)
●			LIGHTING – AFT CEILING – NO. 1
●			LIGHTING – AFT CEILING – NO. 2
●			LIGHTING – AFT CEILING – NO. 3
●	●	●	LIGHTING – BAT – 115 VAC CHGR
	●		LIGHTING – IND DIM NO. 1
	●		LIGHTING – IND DIM NO. 2
●			LIGHTING – INDIRECT – NO. 1
	●		LIGHTING – INDIRECT – NO. 2
		●	LIGHTING – INDIRECT – NO. 3
		●	LIGHTING – INDIRECT – NO. 4

E.L. BAT

ELECTRICAL (P67-1)

- LIGHTING POWER DISTRIBUTION – BAT BUS

LIGHTING (P67-1)

- LIGHTING – BAT – BUS TIE P66
  - LIGHTING – COMM – COMPT EMER CEILING **(P66-3)**
  - LIGHTING – FWD EMER – ENTRY **(P66-3)**
  - LIGHTING – FWD EMER – EQUIP BAY
- LIGHTING – EMERGENCY – FM M706
- LIGHTING – EMERGENCY – AFT CEILING
- LIGHTING – EMERGENCY – AFT ENTRY
- LIGHTING – EMERGENCY – AFT EQUIP BAY
- LIGHTING – EMERGENCY – AISLE
- LIGHTING – EMERGENCY – AREA
- LIGHTING – EMERGENCY – AREA CONTR
- LIGHTING – EMERGENCY – BAT PWR CONTR RELAY
- LIGHTING – EMERGENCY – OVHD NO. 1
- LIGHTING – EMERGENCY – OVHD NO. 2
- LIGHTING – EMERGENCY – OVHD NO. 3

AVDC 4

ELECTRICAL (P61-5)

- 28 VDC BUS 4 – INTGR DR GEN DISC 3 & 4
- 28 VDC BUS 4 – MAIN BUS DISTR
- 28 VDC BUS 4 – VOLTMETER

SDS (HAVE SIREN) (P61-5)

- 28 VDC SDS PWR OCU BUS 4
- 28 VDC SDS PWR NO. 2 BUS 4

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Figure 1-42 (Sheet 12 of 20)

AVDC 4 MAIN

AIR CONDITIONING & PRESSURIZATION (P61-3)
- AIR CONDITIONING – FLOW CONTROL VALVES – LOW FLOW & ALTER TEMP
- AIR CONDITIONING – GASPER FAN CONTR
- AIR CONDITIONING – INDICATORS – MID & AFT ZONE TEMP

APU (P61-2)
- ENGINE START & INDICATORS – APU – FIRE DETECT AUX SHUT DN

BLEED AIR (P61-3)
- BL AIR – LEAK DETECT IND
- BL AIR VALVES – ENG 2 & 3

CREW PROVISIONS (P61-4)
- OXYGEN & DOOR WARNING IND LT

DRAW THRU COOLING (P61-3)
- DRAW THRU CLG – ALT SWITCH NO. 1

ENGINE (P61-2)
- ENGINE START & INDICATORS – ENGINE 1 OIL QTY
- OIL PRESS LIGHTS – ENG 2

FORCED AIR COOLING (P61-3)
- FORCED AIR COOLING – FAN – NO. 2 AFT
- FORCED AIR COOLING – FAN – NO. 2 FWD
- FORCED AIR COOLING – SYS CONTR – VALVE RELAYS AFT
- FORCED AIR COOLING – SYS CONTR – VALVE RELAYS FWD

FUEL (P61-1)
- BOOST PUMPS – LOW PRESS LIGHT – 3 FWD & 2 AFT R CENTER
- HEAT EXCH VALVES – NO. 2
- INDICATORS – FUEL HT VAL & ICING LT – ENG 2
- SHUT OFF VALVES – PRIMARY – ENG 2

HYDRAULICS (P61-4)
- HYDRAULIC – AUX PUMPS – CONTR NO. 2
- HYDRAULIC – GAGES – BRAKE & SYS INTCON VALVES
- HYDRAULIC – HEAT EXCH – BYPASS VALVE UTILITY
- HYDRAULIC – UTILITY – LOW PRESS – ENG 2
- HYDRAULIC – UTILITY – LOW PRESS – ENG 3
- ROTODOME – UTILITY – DRIVE UNIT
- ROTODOME – UTILITY – LUBE PRESS SW

ICE & RAIN PROTECTION (P61-2)
- ICE & RAIN PROTECTION – WSHLD WPR – LEFT

GEN 5

PHASE
A B C

ELECTRICAL (P26)
- BUS TIE BREAKERS
- GENERATOR BREAKERS

ELECTRICAL (P67-3)
- MISSION POWER DISTRIBUTION – VOLTMETER – GEN 5
- 115 VAC BUS 5 – DIST 1

FORCED AIR COOLING (E16)
- FWD AFAC NO. 2 FAN LOW SPEED (ELCU)
- FWD AFAC NO. 2 FAN HIGH SPEED (ELCU)

MAAC 5

PHASE
A B C

ELECTRICAL (P67-3)
- MISSION POWER DISTRIBUTION – TRU – 5

B **LIGHTING (P67-1)**
- LIGHTING POWER DISTRIBUTION – 28 VAC BUS 5 ØB

RADAR (P67-1)
- SURVEILLANCE RADAR – ANALOG RACK
- SURVEILLANCE RADAR – CM PNL
- SURVEILLANCE RADAR – DIGITAL RACK

MADC 5

ELECTRICAL (P67-3)
- MISSION POWER DISTRIBUTION 28 VDC – BUS 5 DIST 1
- MISSION POWER DISTRIBUTION 28 VDC – BUS 5 DIST 2
- MISSION POWER DISTRIBUTION VOLTMETER – DC BUS 5

MADC 5 DIST 1

DATA PROCESSING (P67-1)
- DATA PROCESSING – OPERATOR CONTR PNL DC

IFF (P67-1)
- IDENTIFICATION – PWR CONTR

LIGHTING (P67-1)
- LIGHTING – AFT EQUIP BAY – CONTR
- LIGHTING – IND CONTR – NO. 1
- LIGHTING – IND CONTR – NO. 2
- LIGHTING – OVERHEAD FLOOD – FWD CONTR

RADAR (P67-2)
- CM PNL DC
- CONTACTOR POWER
- PWR DIST PNL (DC)
- PWR DIST PNL ELCU CONTR

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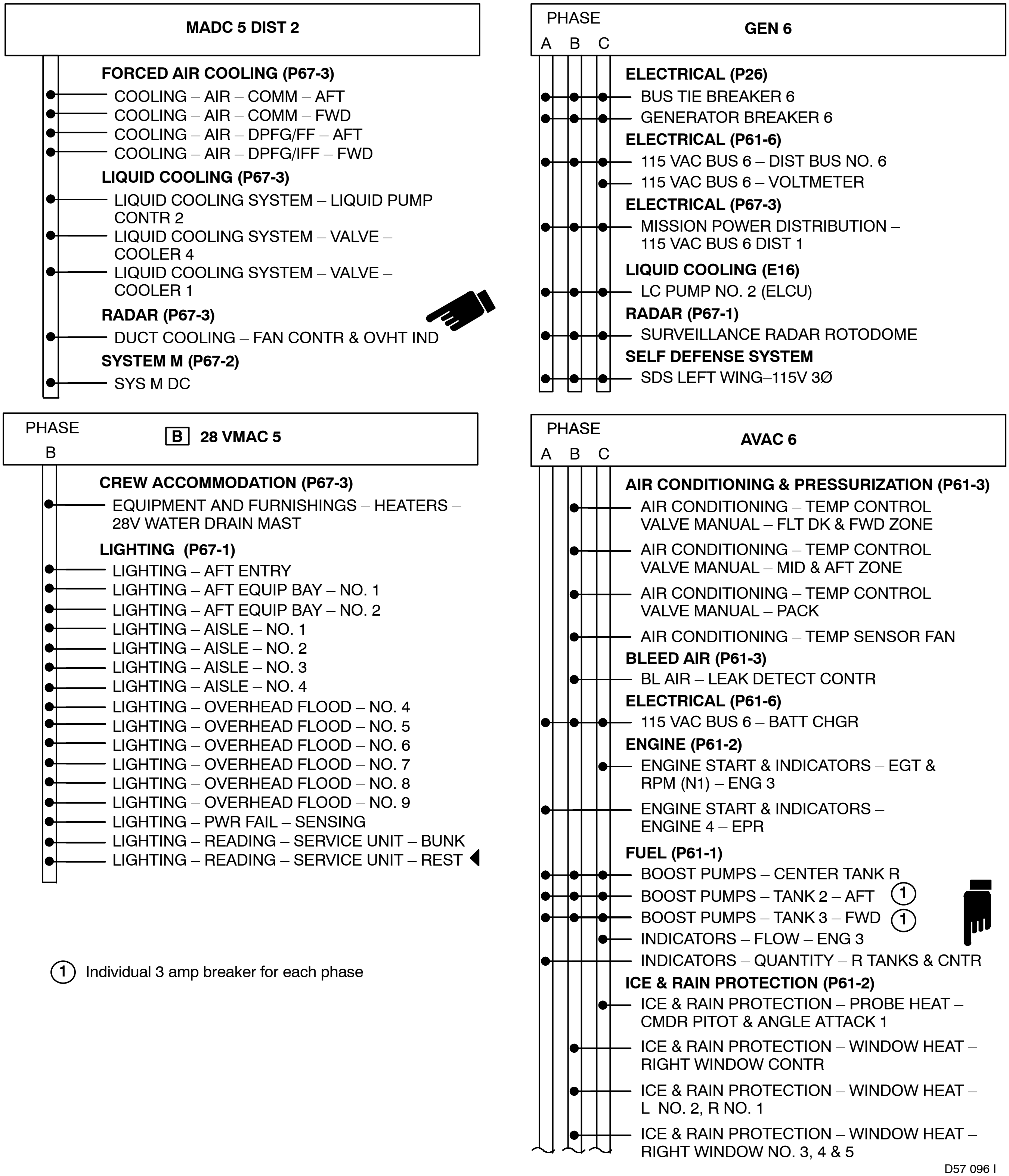
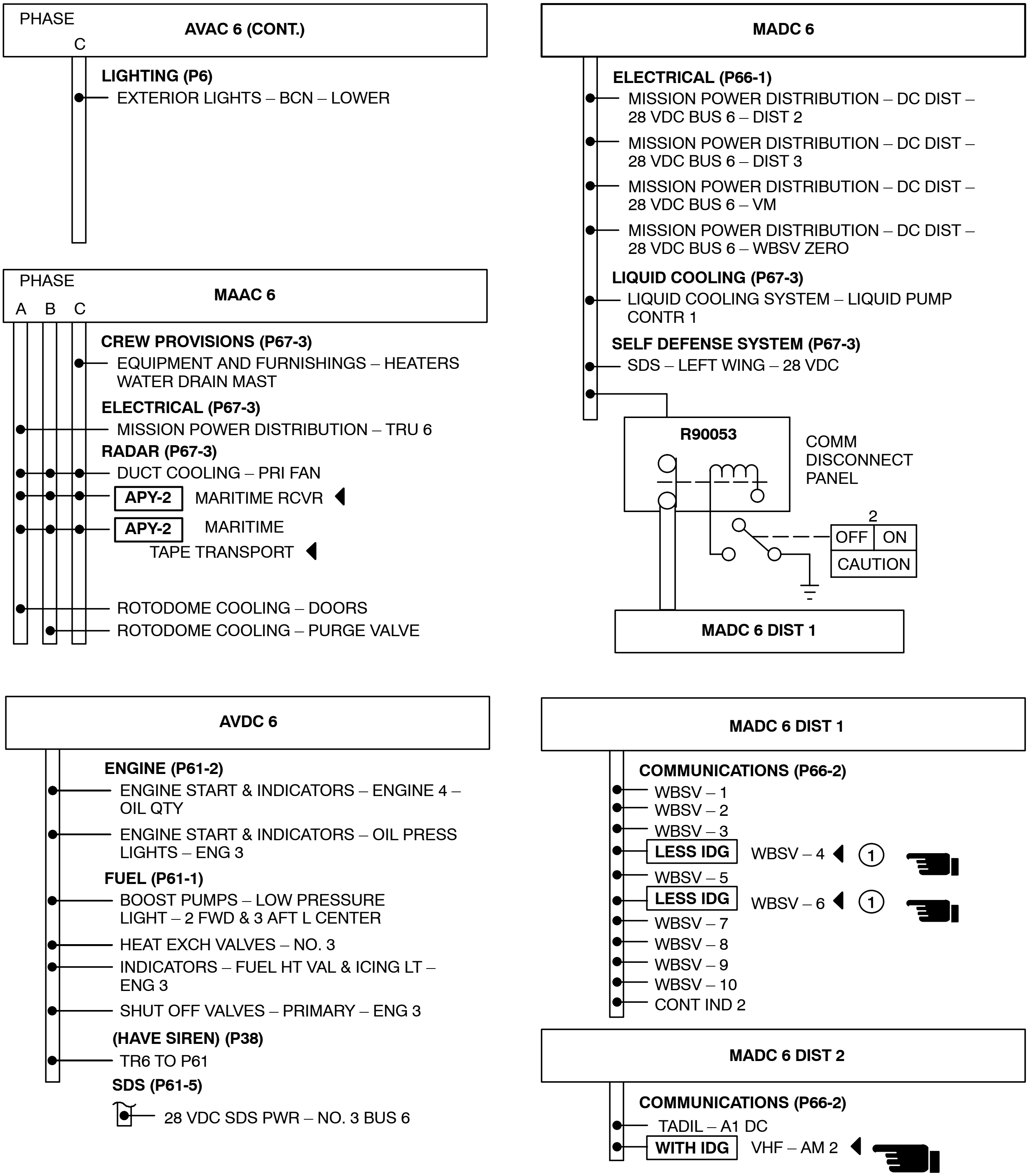
Figure 1-42 (Sheet 13 of 20)

Bus Distribution Diagram (Continued)



① Individual 3 amp breaker for each phase

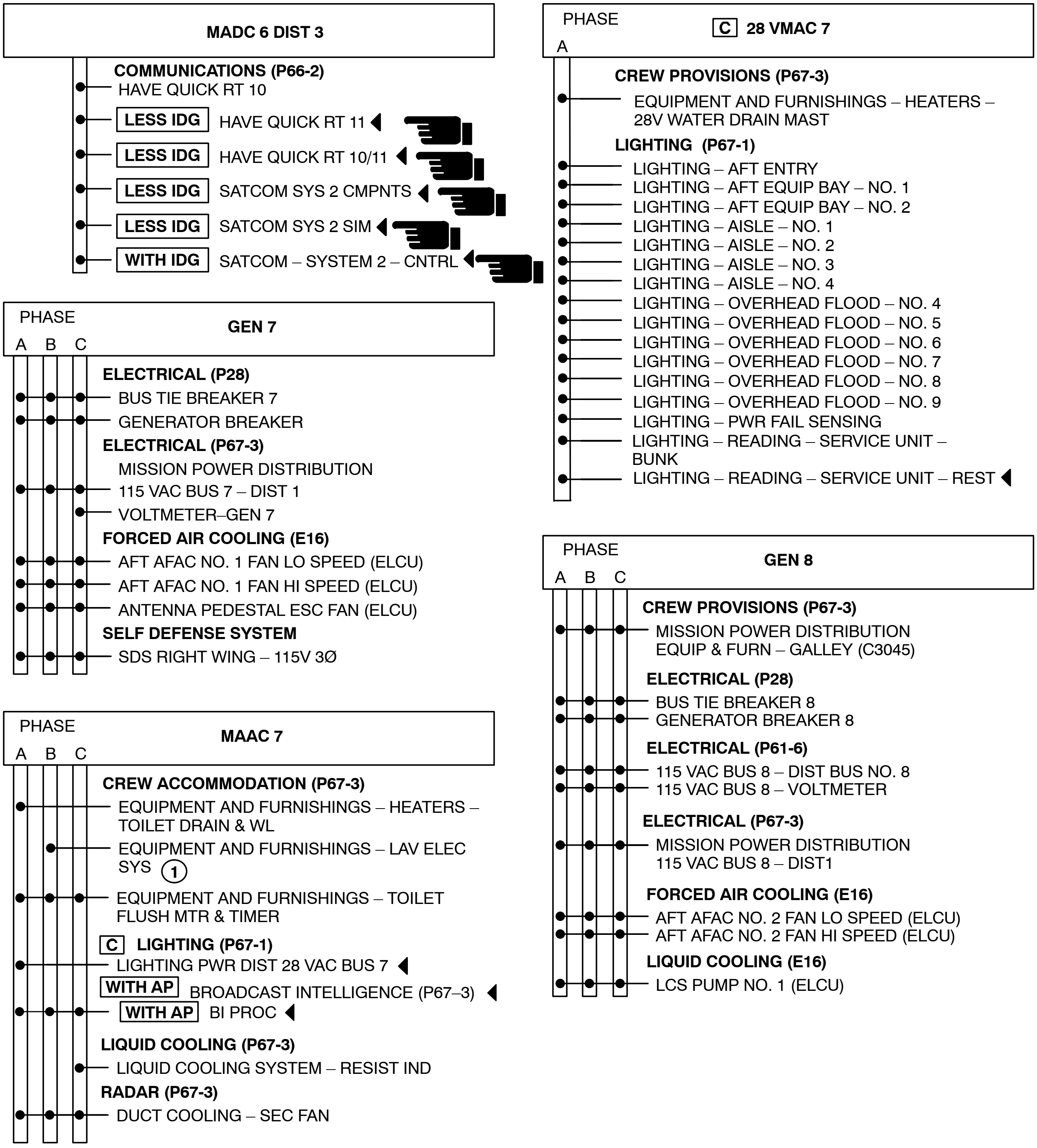
Figure 1-42 (Sheet 14 of 20)



① **WITH IDG** Banded open.

Figure 1–42 (Sheet 15 of 20)

Bus Distribution Diagram (Continued)



MADC 6 DIST 3

COMMUNICATIONS (P66-2)
- HAVE QUICK RT 10
- LESS IDG HAVE QUICK RT 11
- LESS IDG HAVE QUICK RT 10/11
- LESS IDG SATCOM SYS 2 CMPNTS
- LESS IDG SATCOM SYS 2 SIM
- WITH IDG SATCOM – SYSTEM 2 – CNTRL

PHASE A B C — GEN 7

ELECTRICAL (P28)
- BUS TIE BREAKER 7
- GENERATOR BREAKER

ELECTRICAL (P67-3)
- MISSION POWER DISTRIBUTION 115 VAC BUS 7 – DIST 1
- VOLTMETER–GEN 7

FORCED AIR COOLING (E16)
- AFT AFAC NO. 1 FAN LO SPEED (ELCU)
- AFT AFAC NO. 1 FAN HI SPEED (ELCU)
- ANTENNA PEDESTAL ESC FAN (ELCU)

SELF DEFENSE SYSTEM
- SDS RIGHT WING – 115V 3Ø

PHASE A B C — MAAC 7

CREW ACCOMMODATION (P67-3)
- EQUIPMENT AND FURNISHINGS – HEATERS – TOILET DRAIN & WL
- EQUIPMENT AND FURNISHINGS – LAV ELEC SYS ①
- EQUIPMENT AND FURNISHINGS – TOILET FLUSH MTR & TIMER

C LIGHTING (P67-1)
- LIGHTING PWR DIST 28 VAC BUS 7
- WITH AP BROADCAST INTELLIGENCE (P67–3)
- WITH AP BI PROC

LIQUID COOLING (P67-3)
- LIQUID COOLING SYSTEM – RESIST IND

RADAR (P67-3)
- DUCT COOLING – SEC FAN

PHASE A — C 28 VMAC 7

CREW PROVISIONS (P67-3)
- EQUIPMENT AND FURNISHINGS – HEATERS – 28V WATER DRAIN MAST

LIGHTING (P67-1)
- LIGHTING – AFT ENTRY
- LIGHTING – AFT EQUIP BAY – NO. 1
- LIGHTING – AFT EQUIP BAY – NO. 2
- LIGHTING – AISLE – NO. 1
- LIGHTING – AISLE – NO. 2
- LIGHTING – AISLE – NO. 3
- LIGHTING – AISLE – NO. 4
- LIGHTING – OVERHEAD FLOOD – NO. 4
- LIGHTING – OVERHEAD FLOOD – NO. 5
- LIGHTING – OVERHEAD FLOOD – NO. 6
- LIGHTING – OVERHEAD FLOOD – NO. 7
- LIGHTING – OVERHEAD FLOOD – NO. 8
- LIGHTING – OVERHEAD FLOOD – NO. 9
- LIGHTING – PWR FAIL SENSING
- LIGHTING – READING – SERVICE UNIT – BUNK
- LIGHTING – READING – SERVICE UNIT – REST

PHASE A B C — GEN 8

CREW PROVISIONS (P67-3)
- MISSION POWER DISTRIBUTION EQUIP & FURN – GALLEY (C3045)

ELECTRICAL (P28)
- BUS TIE BREAKER 8
- GENERATOR BREAKER 8

ELECTRICAL (P61-6)
- 115 VAC BUS 8 – DIST BUS NO. 8
- 115 VAC BUS 8 – VOLTMETER

ELECTRICAL (P67-3)
- MISSION POWER DISTRIBUTION 115 VAC BUS 8 – DIST1

FORCED AIR COOLING (E16)
- AFT AFAC NO. 2 FAN LO SPEED (ELCU)
- AFT AFAC NO. 2 FAN HI SPEED (ELCU)

LIQUID COOLING (E16)
- LCS PUMP NO. 1 (ELCU)

① Supplies shaver outlet rectifier

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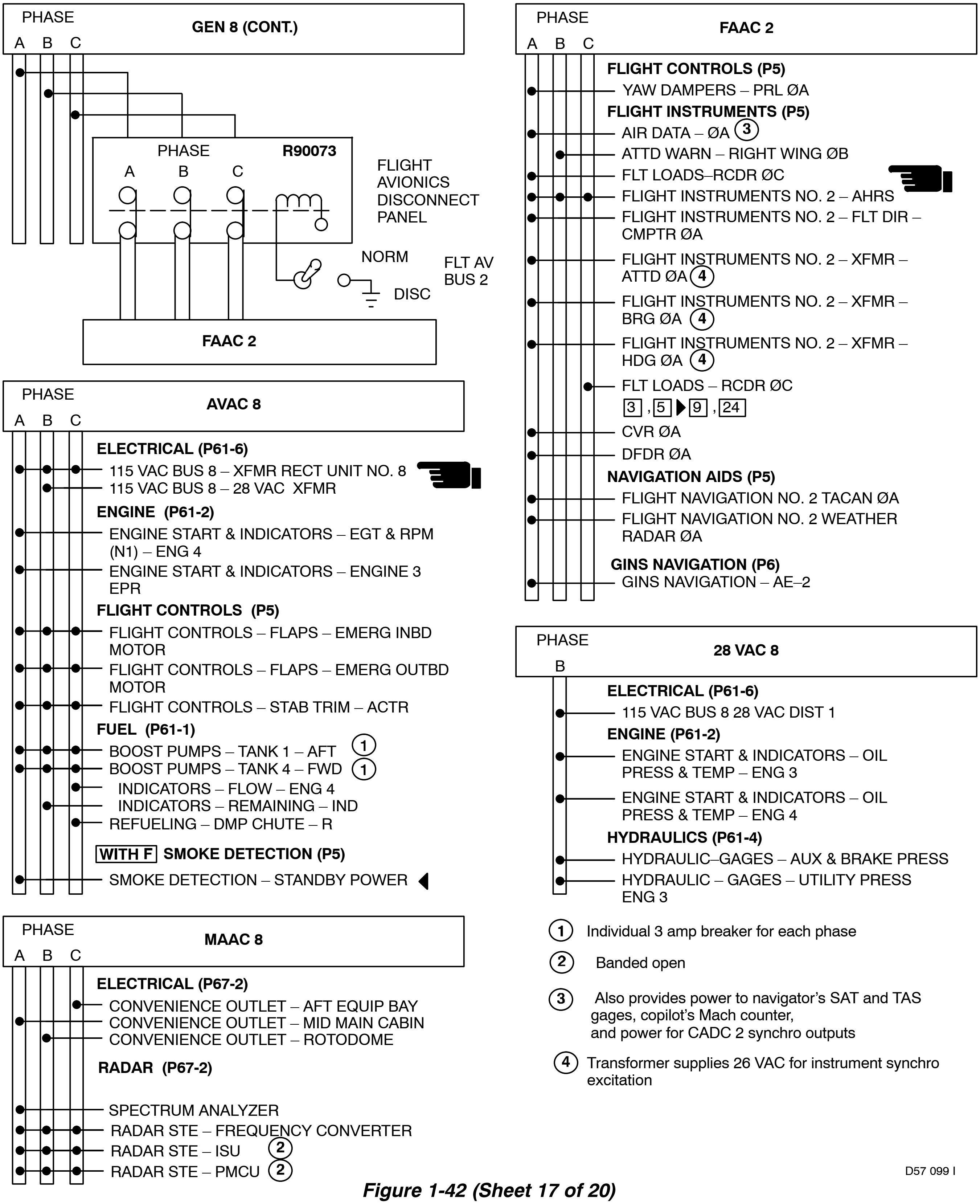
Figure 1–42 (Sheet 16 of 20)



① Individual 3 amp breaker for each phase

② Banded open

③ Also provides power to navigator's SAT and TAS gages, copilot's Mach counter, and power for CADC 2 synchro outputs

④ Transformer supplies 26 VAC for instrument synchro excitation

Figure 1-42 (Sheet 17 of 20)

Bus Distribution Diagram (Continued)

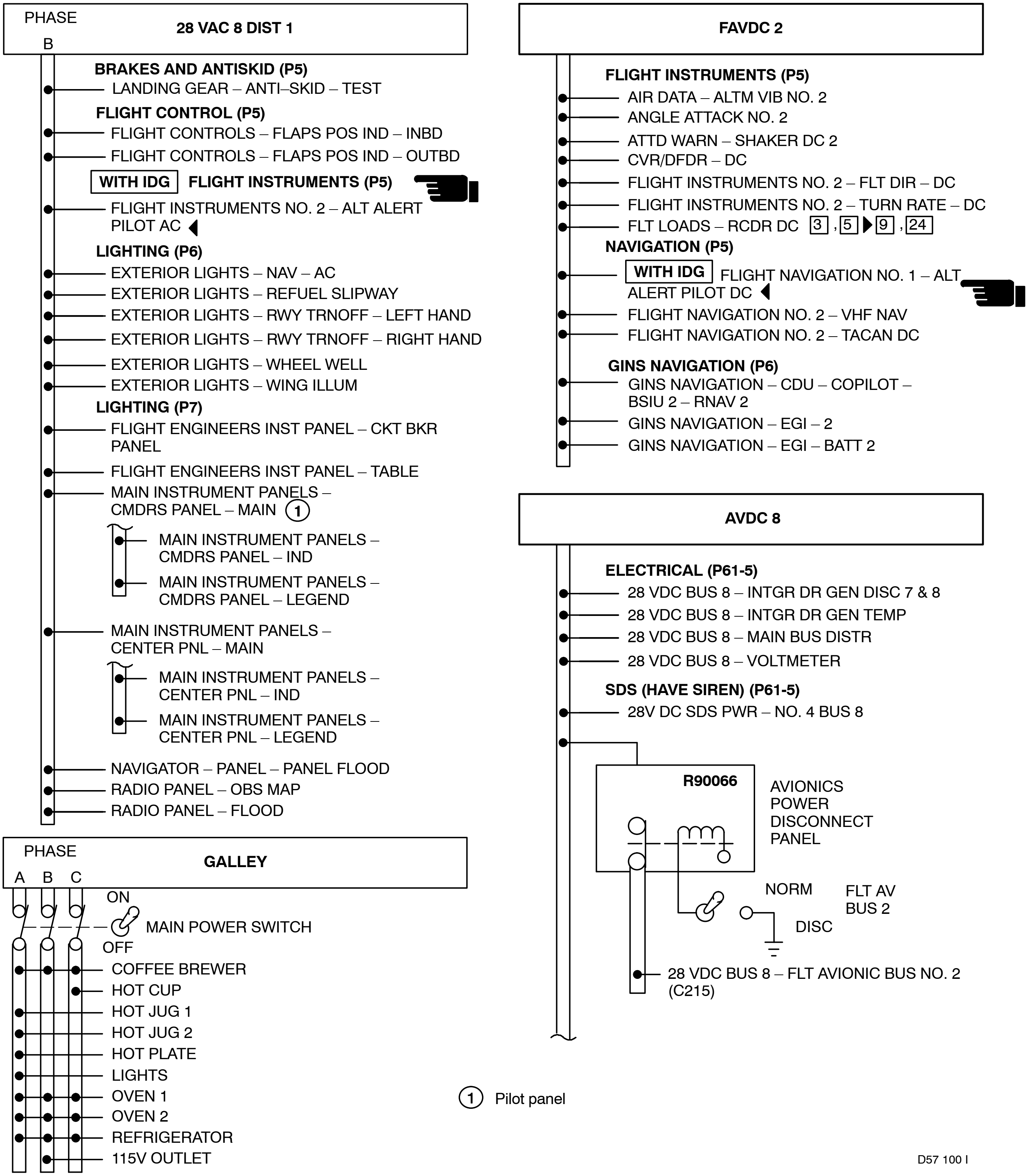


Figure 1–42 (Sheet 18 of 20)

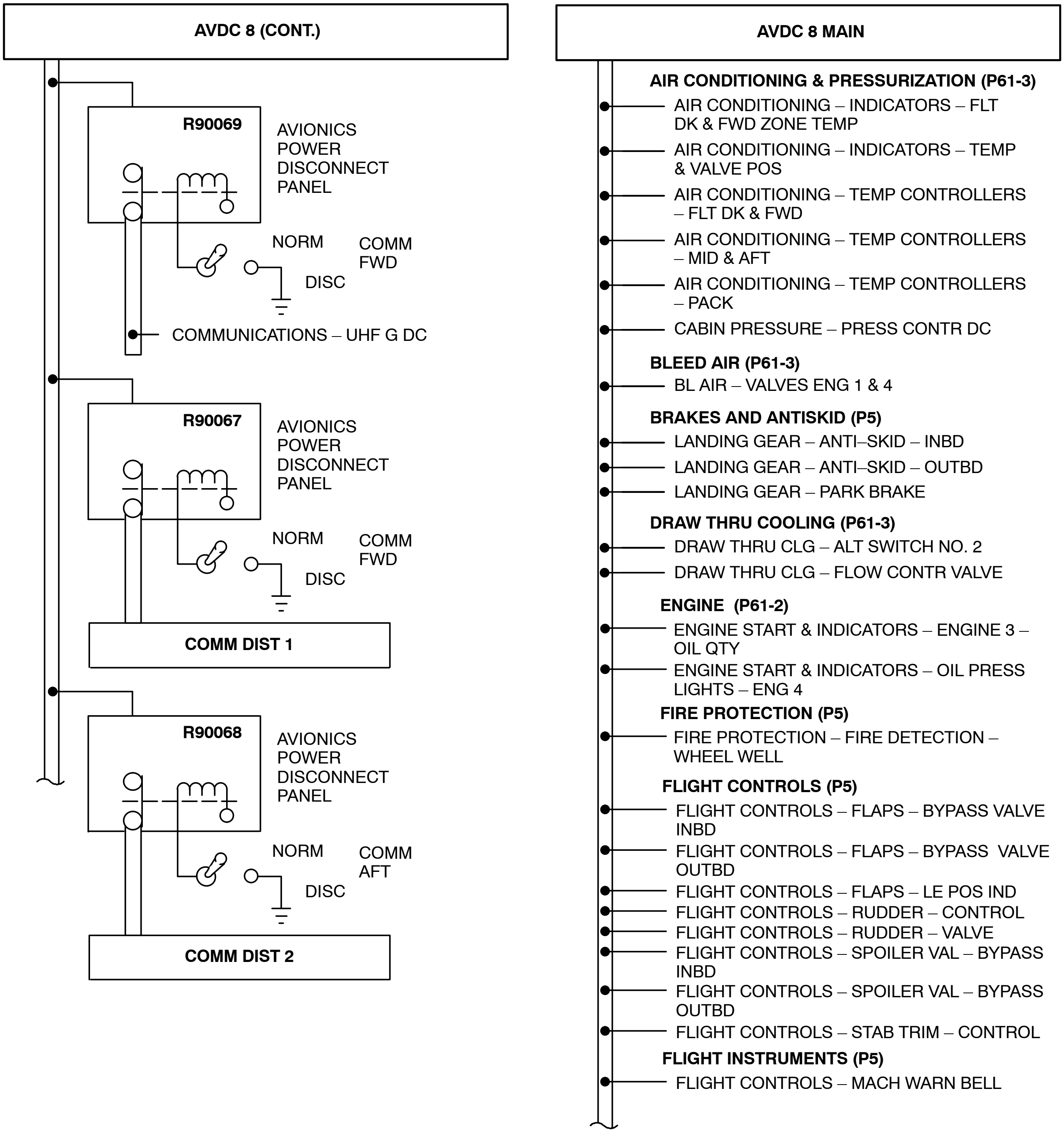


Figure 1-42 (Sheet 19 of 20)

Bus Distribution Diagram (Continued)

AVDC 8 MAIN (CONT.)

FORCED AIR COOLING (P61-3)

- FORCED AIR COOLING – FAN NO. 1 AFT
- FORCED AIR COOLING – FAN NO. 1 FWD
- FORCED AIR COOLING – SYS CONTR – LOGIC AFT
- FORCED AIR COOLING – SYS CONTR – LOGIC FWD

FUEL (P61-1)

- BOOST PUMPS – LOW PRESS LIGHT – 1 FWD & 4 AFT
- HEAT EXCH VALVES – NO. 4
- INDICATORS – FUEL HT VAL & ICING LT – ENG 4
- INDICATORS – OHEAT & HT VAL LT – & TEMP AMPL TANK 3 & 4
- REFUELING – DUMP & TRANSFER VALVES – TK 3 & R CTR TK
- REFUELING – DUMP & TRANSFER VALVES – TK 4 & RES TK 4
- REFUELING – SLWY DR & TOG LCH – NORMAL
- SHUT OFF VALVES – PRIMARY – ENG 4

HYDRAULICS (P61-4)

- HYDRAULIC – AUX PUMPS – CONTR NO. 1
- HYDRAULIC – GAGES – QTY
- HYDRAULIC – HEAT EXCH – BYPASS VALVE AUX
- HYDRAULICS – UTILITY – PUMP DEPRESS 2 & 3
- ROTODOME – AUXILIARY – DRIVE UNIT
- ROTODOME – AUXILIARY – LUBE PRESS SW
- ROTODOME – AUXILIARY – SOV

AVDC 8 MAIN (CONT.)

ICE & RAIN PROTECTION (P61-2)

- ICE & RAIN PROTECTION – ENG NOSE COWL AI VAL – NO. 4
- ICE & RAIN PROTECTION – NACELLE ANTI–ICE VAL – NO. 4
- ICE & RAIN PROTECTION – WINDOW HEAT – RDC CONTR
- ICE & RAIN PROTECTION – WSHLD WPR – RIGHT

LANDING GEAR (P5)

- FLIGHT CONTROLS – WARN HORN CUTOUT RELAY
- LANDING GEAR – POS LIGHTS
- LANDING GEAR – SAFETY – LEFT RLY
- LANDING GEAR – SAFETY – RIGHT RLY & LEVER LATCH
- LANDING GEAR – WARN HORN ①

AVDC 8 COMM DIST 1

COMMUNICATIONS (P5)

- COMMUNICATIONS – HF/VHF INTFC DC
- COMMUNICATIONS – VHF G

AVDC 8 COMM DIST 2

COMMUNICATIONS (P5)

- COMMUNICATIONS – UHF ADF DC
- COMMUNICATIONS – HF DC

① Also power takeoff warning system

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Figure 1-42 (Sheet 20 of 20)

EXTERNAL POWER

The airplane has four external power receptacles on the left side forward of the wing root. External power is connected to the airplane bus by the EXTERNAL POWER switch on the flight engineer's panel (*figure 1-38*).

Ammeters (2, *figure 1-39*) indicate the load on each receptacle. External power cannot be placed in parallel with engine generators or APU. (Closing the external power switch opens the generator breakers and the APU breaker.) The first external power source connected must be on connector 1A (the forward connector). Circuit breakers which control use of external power are located on circuit breaker panels P37 (*figure 1-49*) and P38 (*figure 1-50*). Capacity of each receptacle is 90 KVA (262 amperes).

CAUTION

- If external power is on the airplane bus and the AVAIL indicator is not illuminated, the EXTERNAL POWER switch must be off (ON indicator out) before connecting APU or airplane generators. When changing from APU or airplane generators to external power and the external power cart(s) are operating and properly connected but the AVAIL indicator is not illuminated, remove the APU and airplane generator power before applying external power (EXTERNAL POWER switch ON). Failure to observe this caution when the AVAIL light does not illuminate results in damage to the generators.

- When connecting external power, wait seven seconds after the external power source is connected to the external receptacles or the BATTERY switch is set to ON, whichever occurs last, before pressing EXTERNAL POWER switch to ON. This allows the BPCU to complete its power quality checks. If external power is switched ON sooner, an out of tolerance external power source can be applied to sync bus.

- When changing power source to external power or changing from external power to APU or airplane generators, the ELCUs controlling the forced air cooling fans and the NO 1 auxiliary hydraulic pump can trip. Make sure that forced air cooling fans and NO 1 auxiliary hydraulic pump are operating after power transfer. (Press switch twice to reset ELCU.) Electronic equipment cooled by forced air system could be damaged if fans stop. Rotodome bearing could be damaged if auxiliary hydraulic pump NO 1 stops and auxiliary rotodome drive is in use.

NOTE

Multiple external power receptacles are provided for mission equipment maintenance, including radar operation. Normal airplane preflight operation can be performed using only one external power cart. A list of ground power units is in subsection I-W.

EMERGENCY INVERTER

When all other sources of ac power are lost, the emergency inverter located in E5 rack converts 24 vdc power to single phase 115 ± 5 volt, 400 ± 5 Hz ac power to operate certain essential airplane equipment. The emergency inverter can also be selected through the use of the EMERGENCY POWER switch, even if normal ac power is available.

AC POWER FREQUENCY, VOLTAGE, AND LOAD DIVISION REGULATION

Certain ac power system components provide control of frequency, voltage, and loads, to regulate load division among paralleled generators, and to limit fault currents and power output. The control and regulating devices are: constant speed drives (CSD), frequency and load control (FLC), a frequency reference unit (FRU), generator control units (GCU) and a bus power control unit (BPCU). See *figures 1-49* and *1-50*.

GENERATOR CONSTANT SPEED DRIVES

Each (engine-driven) generator is mechanically driven by a constant speed drive (CSD). The CSD is a mechanical drive with a hydraulically controlled differential which provides a constant rotation speed to the generator whenever the engine speed is above a minimum value. The CSD output speed is controlled by an internal governor. The governor also responds to electrical signals provided by the frequency and load control unit.

FREQUENCY AND LOAD CONTROL UNITS

The frequency and load control (FLC) unit, for each generator, performs two functions: precise control of generator frequency and control of generator load to divide the load equally among the paralleled generators.

Frequency is controlled by comparing the actual frequency of the generator with a reference frequency signal (402 ± 0.1 Hz) provided by the frequency reference unit (FRU). Due to frequency meter tolerance, the indicated frequency can be 402 ± 3 Hz. If a difference occurs, an electrical signal is sent to the CSD governor which then adjusts the generator rotation speed. The frequency control function is performed during parallel or isolated operation. In the absence of FRU input to the FLC, the CSD governors control frequency at a mechanically preset value of 400 ± 5 Hz. Due to frequency meter tolerances, the indicated frequency can be 400 ± 8 Hz. All frequency control is automatic. There are no manual means to control frequency in flight.

Load monitoring circuits compare the individual generator load with the average generator load. If a load division imbalance occurs, the FLC adjusts the CSD governor to change generator speed to balance the load. The FLCs are located in racks E15 (*figure 1-49*) and E16 (*figure 1-50*).

FREQUENCY REFERENCE UNIT

A single frequency reference unit (FRU) provides the reference frequency which is fed to all eight FLCs. System frequency is maintained near 402 Hz. Due to frequency meter tolerance, the indicated frequency can be 402 ± 3 Hz. If the FRU fails or if electrical power is removed from the FRU, the CSD governors maintain generator frequency at 400 ± 5 Hz. Due to frequency meter tolerances, the indicated frequency can be 400 ± 8 Hz. The FRU is located in the E15 rack.

REQUIRED OPERATING RANGE FOR TRUE AND INDICATED GENERATOR FREQUENCIES

CONDITION	TRUE OR ACTUAL– FREQUENCY RANGE	INDICATED* FREQUENCY RANGE
FRU CONTROLLING	402 ± 0.1 Hz 401.9 Hz to 402.1 Hz	402 ± 3 Hz 399 Hz to 405 Hz
CSD GOVERNOR CONTROLLING	400 ± 5 Hz 395 Hz to 405 Hz	400 ± 8 Hz 392 Hz to 408 Hz

* As read at Flight Engineers Station

GENERATOR CONTROL UNITS

There is a generator control unit (GCU) for each generator. Each GCU regulates voltage, limits fault currents and power, provides other fault protection, assists in load division and controls the generator circuit breaker and bus tie breaker for the associated generator. Voltage regulation is automatic. There is no manual procedure to control voltage in flight. The GCUs are located in racks E15 and E16.

BUS POWER CONTROL UNIT

The bus power control unit (BPCU) controls the APU and external power contactors. The BPCU trips all external power contactors when the voltage, frequency and current are not within limits. The BPCU trips the APU contactor when the voltage and frequency are not within limits. The BPCU trips all bus tie breakers and APU or external power contactors when a differential fault occurs on the tie bus. The BPCU prevents closure of the external power contactors if the voltage, phase sequence and frequency are not correct. The BPCU contains an interlock circuit which prevents parallel operation of main generators and APU or external power. Control power for the BPCU is supplied from the battery (HOT BATTERY BUS, BUS PWR CONT UNIT PROT circuit breaker, panel P61-6), battery bus (BATTERY BUS, BUS PWR CONT UNIT CONT circuit breaker, panel P61-6), the APU permanent magnet generator (any time the APU is running, no circuit breaker and no switch) and the external power TRU (EXT PWR TR 28V DC BPCU circuit breaker, panel P37). The BPCU is located in rack E16.

EMERGENCY AC POWER

The emergency ac (EAC) buses normally receive power from the tie bus or, during isolated operation, from generator number 2. If this power is not available or the EMERGENCY POWER switch is set to MANUAL ON, the EAC buses receive power from the inverter. The inverter is supplied dc power from the dc tie bus; or if operating isolated, from TRU number 2; or if TRU power is not available, from the battery. When the EMERGENCY POWER switch (*figure 1-38*) is set to NORMAL, the EAC buses receive power from the inverter only if ac power is not available; and the inverter receives battery power only if TRU power is not available and the BATTERY switch is set to ON. When the EMERGENCY POWER switch is set to OFF, all power is cut off to the EAC buses, inverter, flight deck UHF radio, central switching units (CSU) 1 and 2 and emergency dc (EDC) bus. When the EMERGENCY POWER switch is set to MANUAL ON, the EAC buses receive power from the inverter.

AC POWER DISTRIBUTION

Power from the generators (operating individually or in parallel) or from the APU or external power, is distributed to airplane and mission equipment by 12 main load buses and one radar bus. The airplane generators are connected in parallel through the synchronizing (sync or tie) bus. APU or external power is also distributed through the sync bus. A schematic of the ac distribution system is shown in *figure 1-40*. Five 400 Hz convenience outlets *(figure 1-3)* are located in the mission compartment and lower deck (a sixth is located in the rotodome). Two 60 Hz convenience outlets along with a 60 Hz converter are located aft of the Radar Technician Console. The converter is powered by the RADAR STE FREQUENCY CONVERTER circuit breaker on the P67–2 circuit breaker panel. It supplies up to 1000 watts of 115 vac 60 Hz power to the outlets. These outlets provide power for laptop computers, test equipment, video cameras, and other personal electronics.

The following terms are used in electrical power system operating, abnormal and emergency procedures:

Parallel –	The normal method of generator operation, with all generators synchronized and feeding the synchronizing (sync or tie) bus through the bus-tie breakers.
Isolated –	One or more generators not feeding the sync bus. Generator breaker closed and bus-tie breaker open.
Isolate –	To remove a generator from parallel operation by opening the bus-tie breaker.
Shut Down –	To remove electrical power from the generator by opening the generator breaker. In most cases the bus-tie breaker recloses so that the bus is still powered. Refer to AC POWER SYSTEM FAULT PROTECTION.
Disconnect –	Disengage the mechanical portion of the IDG from the engine.

AIRPLANE AC BUSES

There are four airplane ac load buses, powered by generators 2, 4, 6 and 8. Generator number 2 supplies the EAC bus when operating isolated. The buses are supplied with 115 ± 4 volt, 402 ± 0.1 Hz power. Due to frequency meter tolerances, the frequency observed at the flight engineer's panel is 402 ± 3 Hz if the FRU is operating. If the frequency reference unit is inoperative, the indicated frequency can be 400 ± 8 Hz. Buses 2 and 8 also supply 28-vac power through transformers to 28-vac buses. Large airplane equipment loads are powered directly from the generators (*figures 1-39* and *1-40*). Power to these units is controlled by contactors (ELCUs) in the E15 and E16 electrical racks in the forward lower compartment. Power to individual components is controlled by circuit breakers on panels P5, P6, P7, and P61 in the cockpit and P66 and P67 in the mission compartments. Bus output is distributed through circuit breakers on the P5, P6, P7, and P61 panels and bus control relays controlled by switches on the AVIONICS POWER DISCONNECT panel on the flight deck. Circuit breaker and switch arrangement is shown in *figures 1-38* and *1-43* through *1-48*.

MISSION AC BUSES

There are eight mission ac buses, two special power loads powered from the generators through contactors, and one radar bus. The radar bus is powered only from the tie bus, since the radar transmitter load is greater than the capacity of one generator. Mission bus power distribution is shown in *figures 1-39* and *1-40*. Mission bus NO 1 supplies power to a transformer for a 28-volt mission bus (P66 and P67).

Power to the radar bus is controlled from the flight engineer's panel, the P67 panel, and the radar maintenance console. Mission bus NO 7 supplies a transformer for the 28- volt mission bus (P67).

LESS IDG Circuit Breaker Panel P5

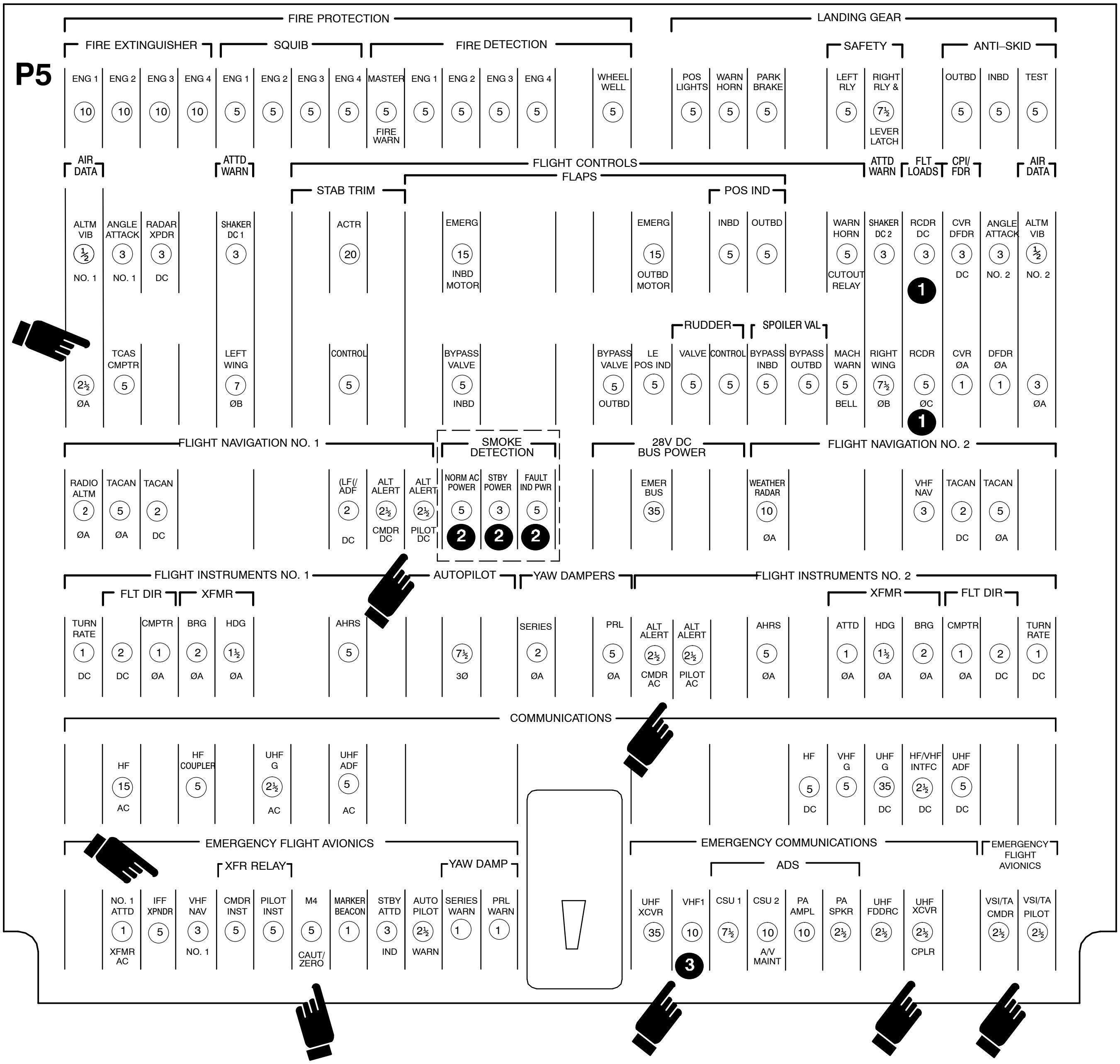
❶ BANDED OPEN EXCEPT **3** , **5** ▶ **9** , **24**

❷ **WITH F**

D57 104 I

Figure 1-43 ◀

WITH IDG Circuit Breaker Panel P5



❶ BANDED OPEN EXCEPT **3** , **5** ▶ **9** , **24**

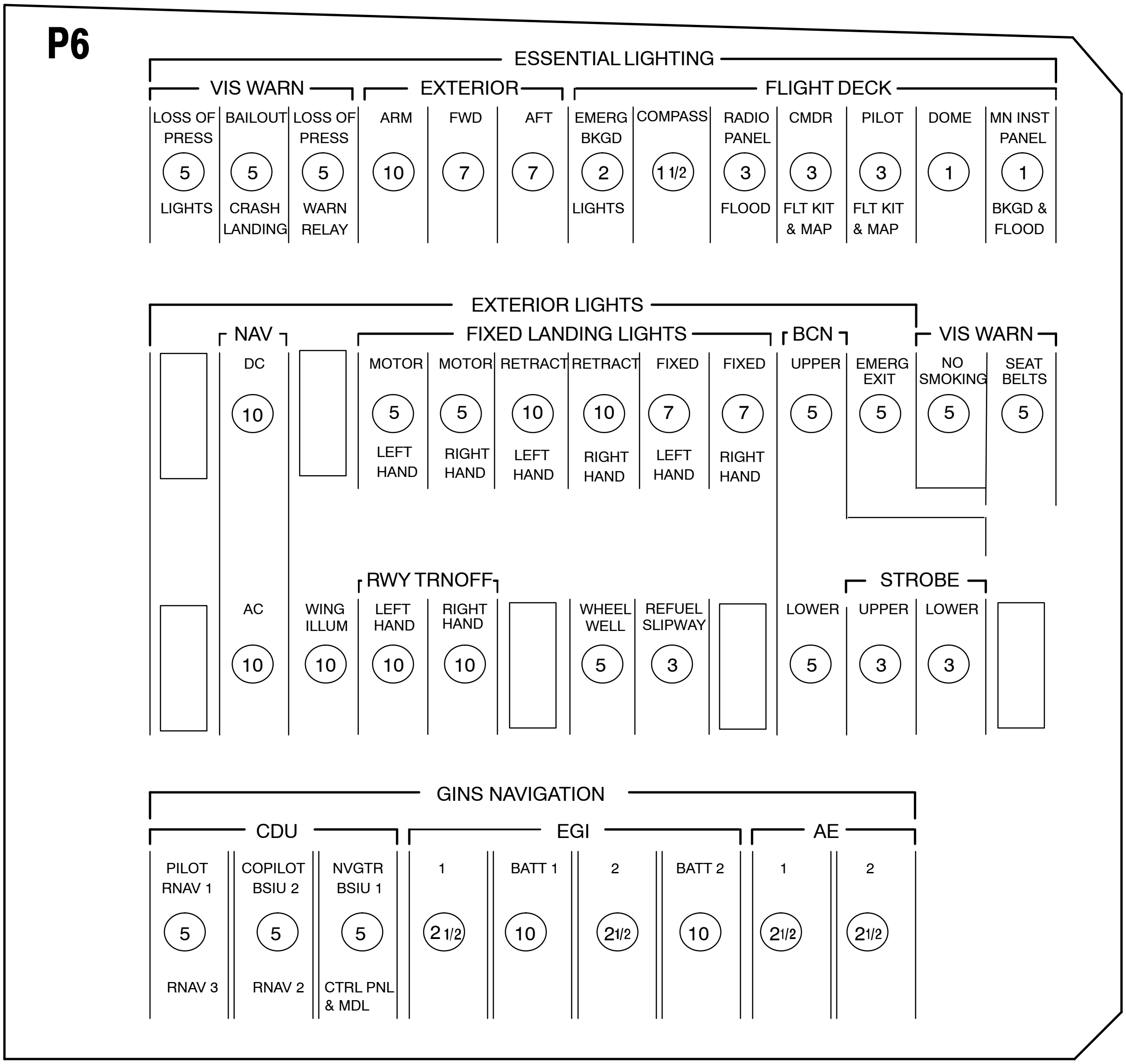
❷ **WITH F**

❸ COPILOT'S RADIO

D57 104 I

Figure 1–43A ◀

Circuit Breaker Panel P6



D57 105 I

Figure 1-44

Circuit Breaker Panel P7

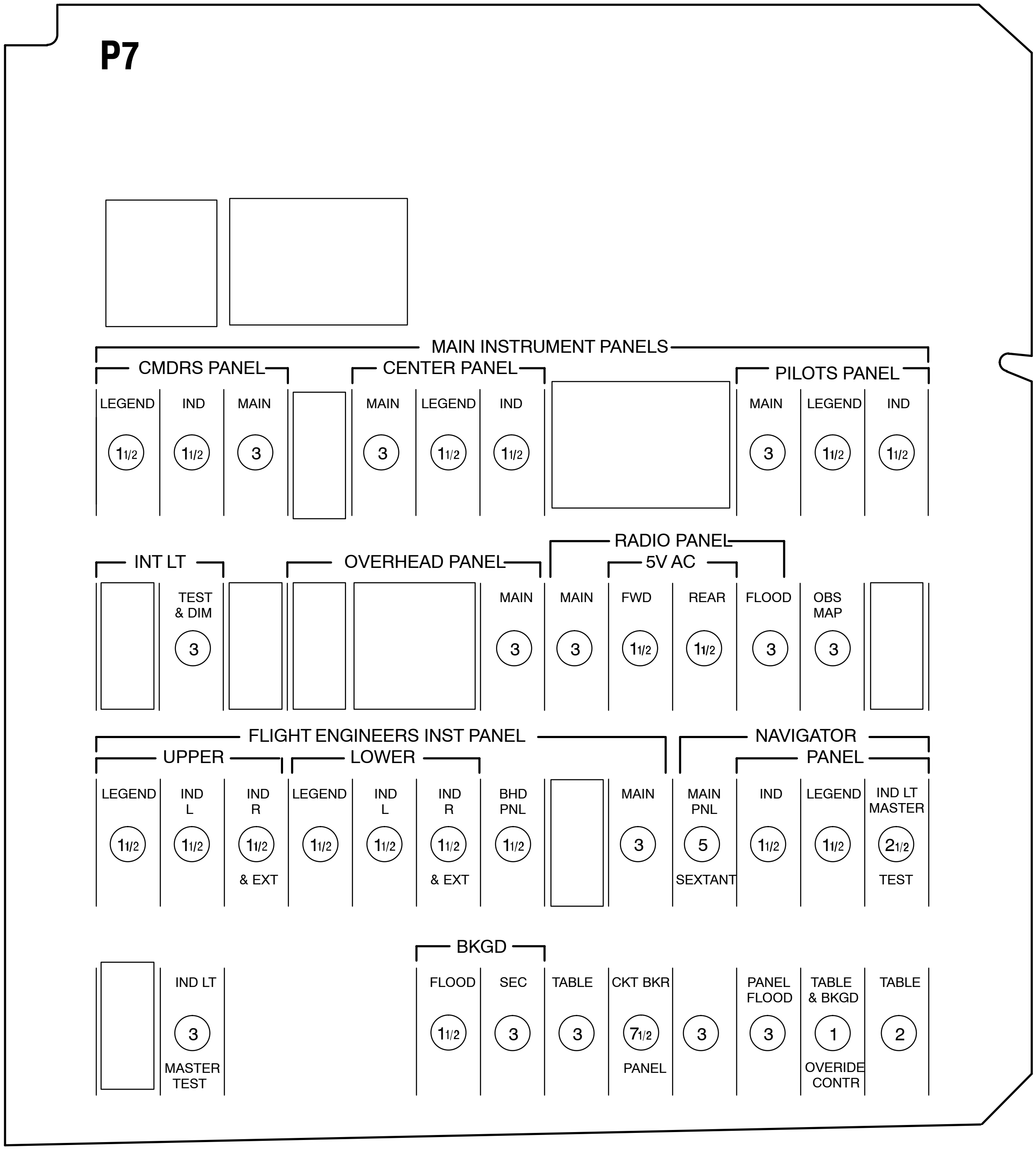
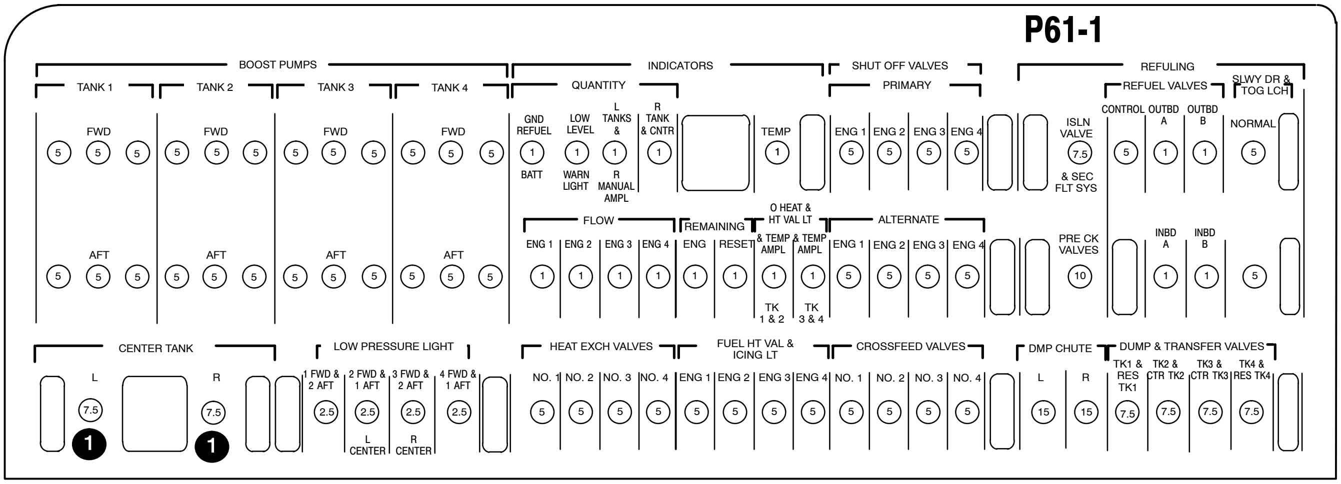


Figure 1-45

Circuit Breaker Panel P61



❶ With 1E–3–844, 10 Amp

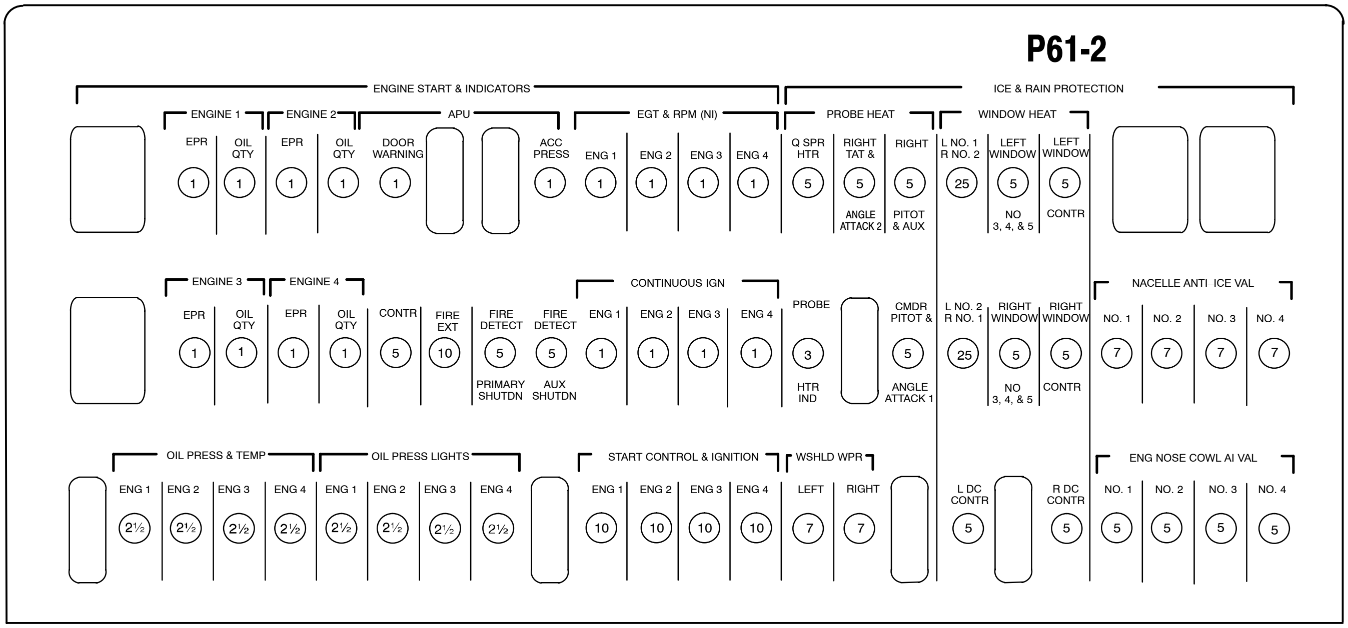


Figure 1-46 (Sheet 1 of 4)

Circuit Breaker Panel P61 (Continued)

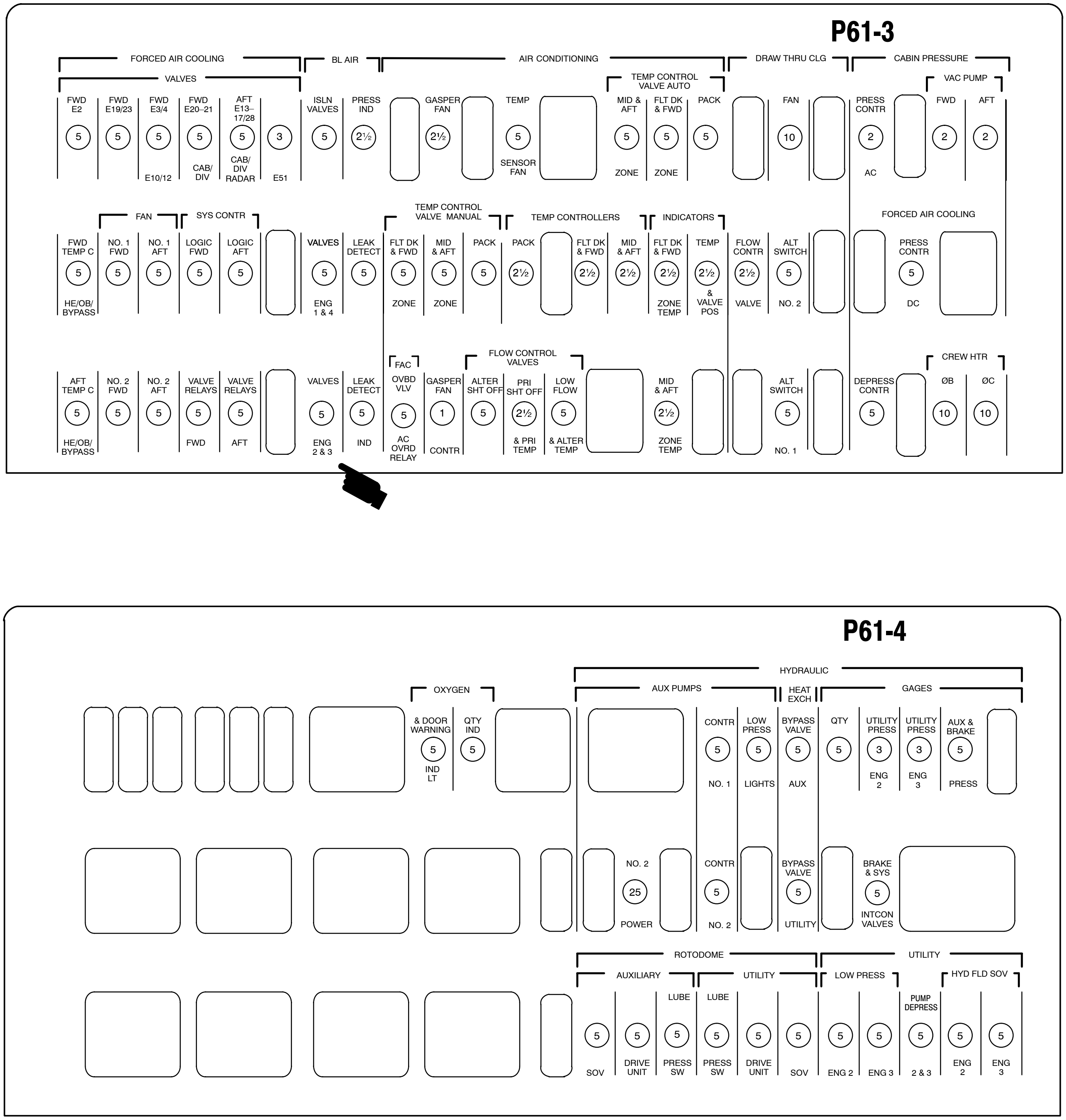
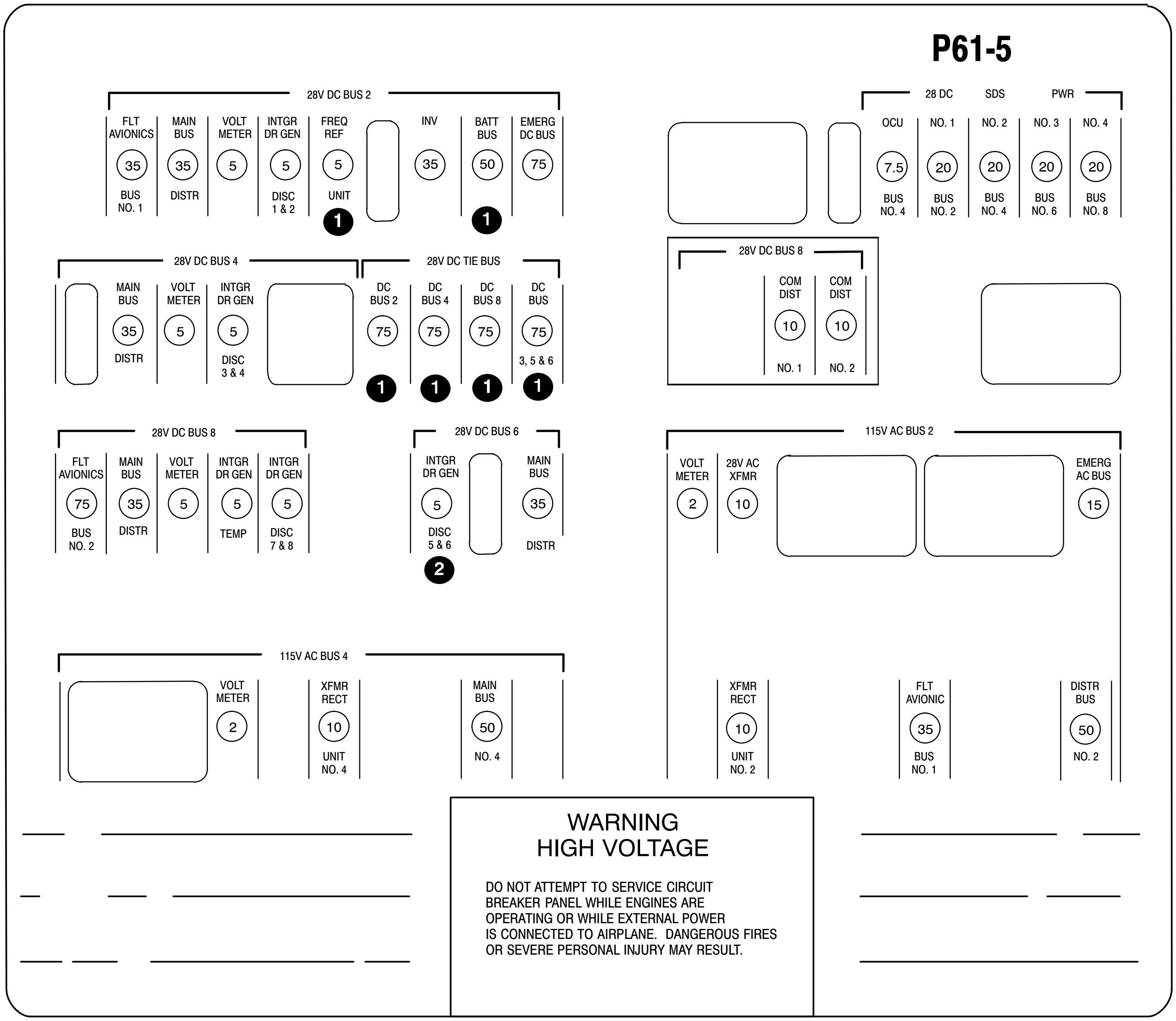


Figure 1-46 (Sheet 2 of 4)



WARNING
HIGH VOLTAGE

DO NOT ATTEMPT TO SERVICE CIRCUIT BREAKER PANEL WHILE ENGINES ARE OPERATING OR WHILE EXTERNAL POWER IS CONNECTED TO AIRPLANE. DANGEROUS FIRES OR SEVERE PERSONAL INJURY MAY RESULT.

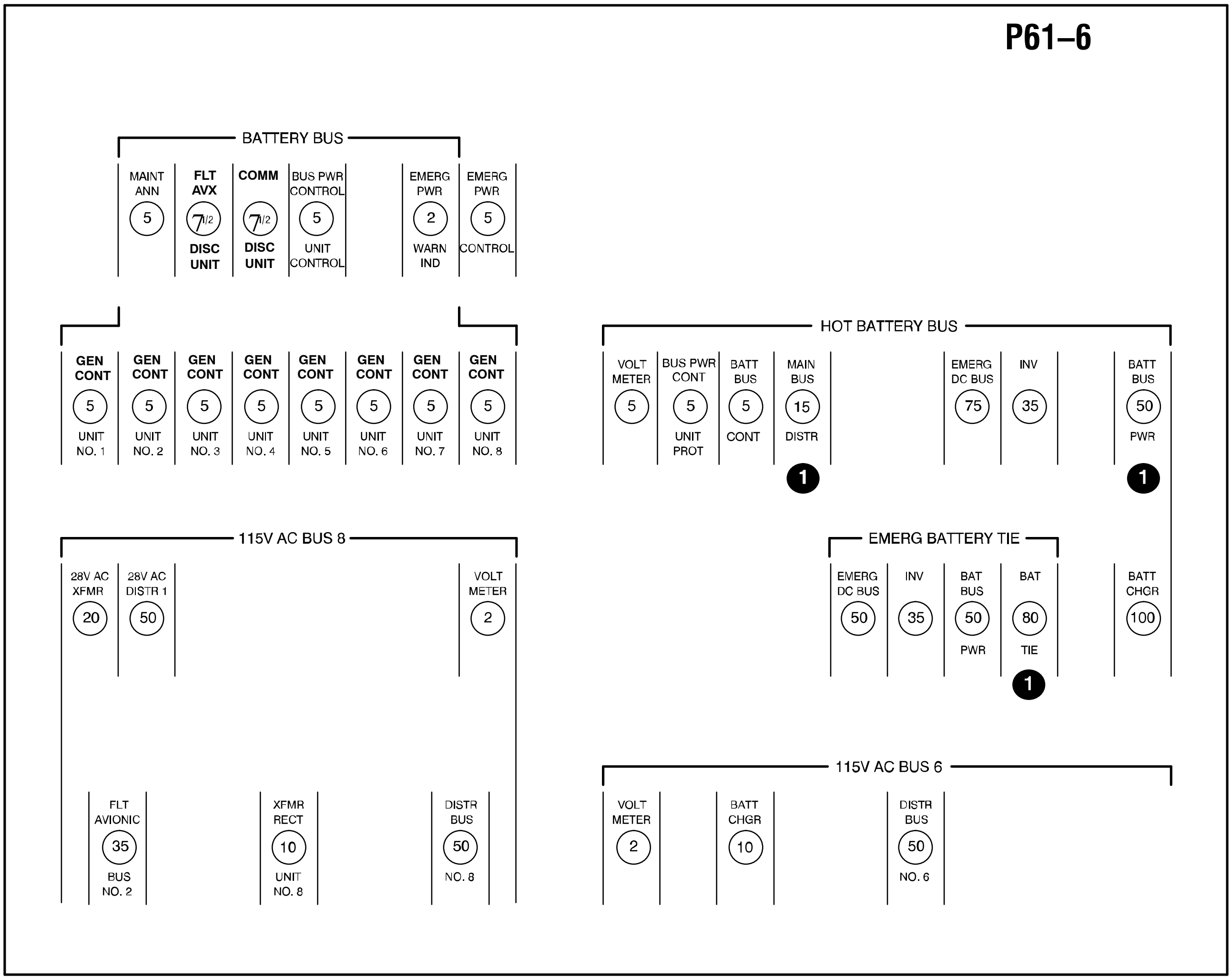
① BREAKERS OPENED DURING ELECTRICAL FIRE AND SMOKE CHECKLIST

② POWER SOURCE IS DC TIE BUS

D57 109 I

Figure1-46 (Sheet 3 of 4)

Circuit Breaker Panel P61 (Continued)



① BREAKERS OPENED DURING ELECTRICAL FIRE AND SMOKE CHECKLIST

D57 110 I

Figure1-46 (Sheet 4 of 4)

LESS IDG Circuit Breaker Panel P66

▬ INDICATES BREAKER CLOSED BY FLIGHT ENGINEER ON PREFLIGHT

❶ OPENED FOR ELECTRICAL FIRE CHECKLIST

❷ WITH AP ◀

❸ BANDED OPEN

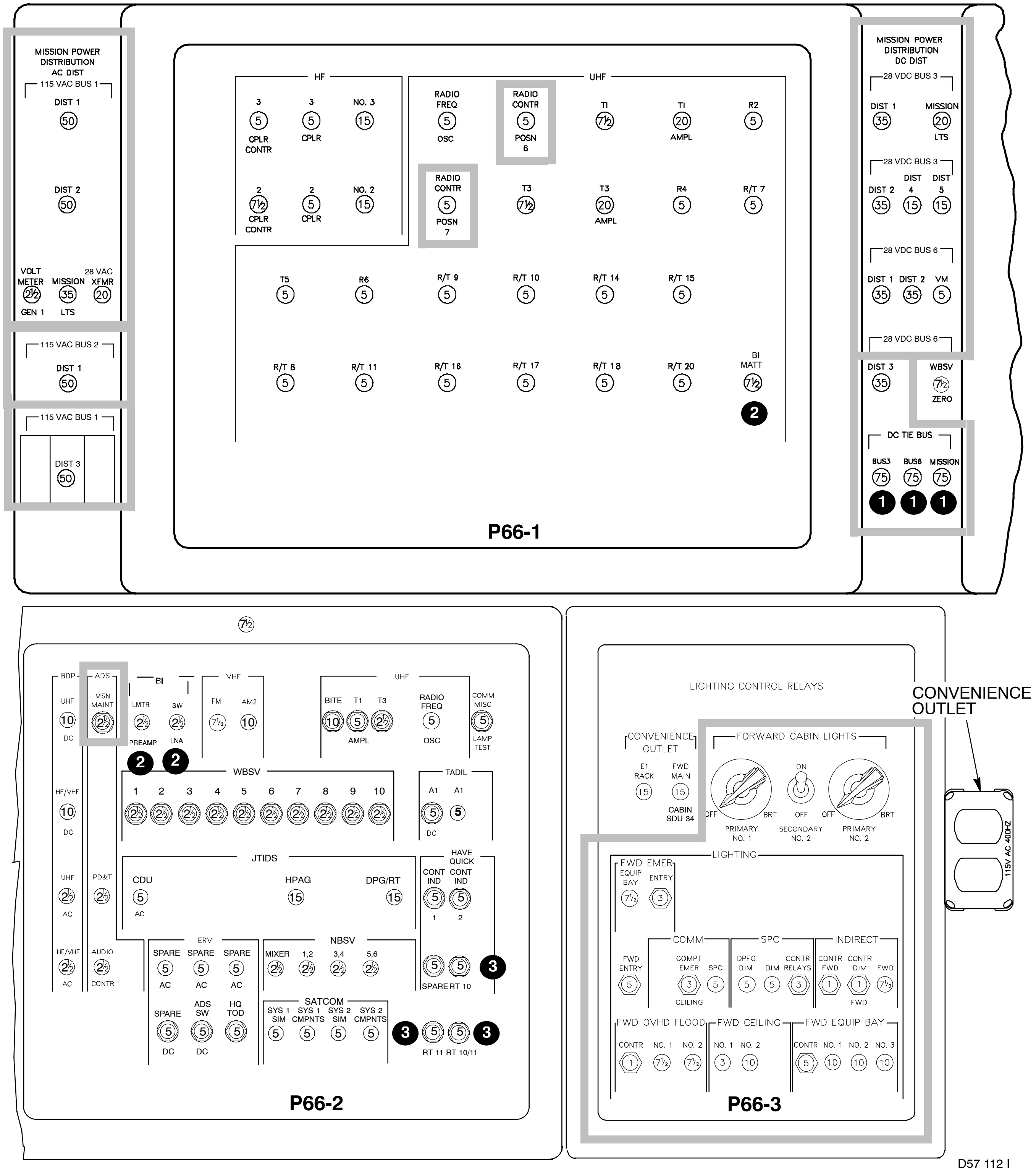


Figure 1-47 ◀

WITH IDG Circuit Breaker Panel P66

▬ INDICATES BREAKER CLOSED BY FLIGHT ENGINEER ON PREFLIGHT

❶ OPENED FOR ELECTRICAL FIRE CHECKLIST

❷ WITH AP ◀

❸ BANDED OPEN

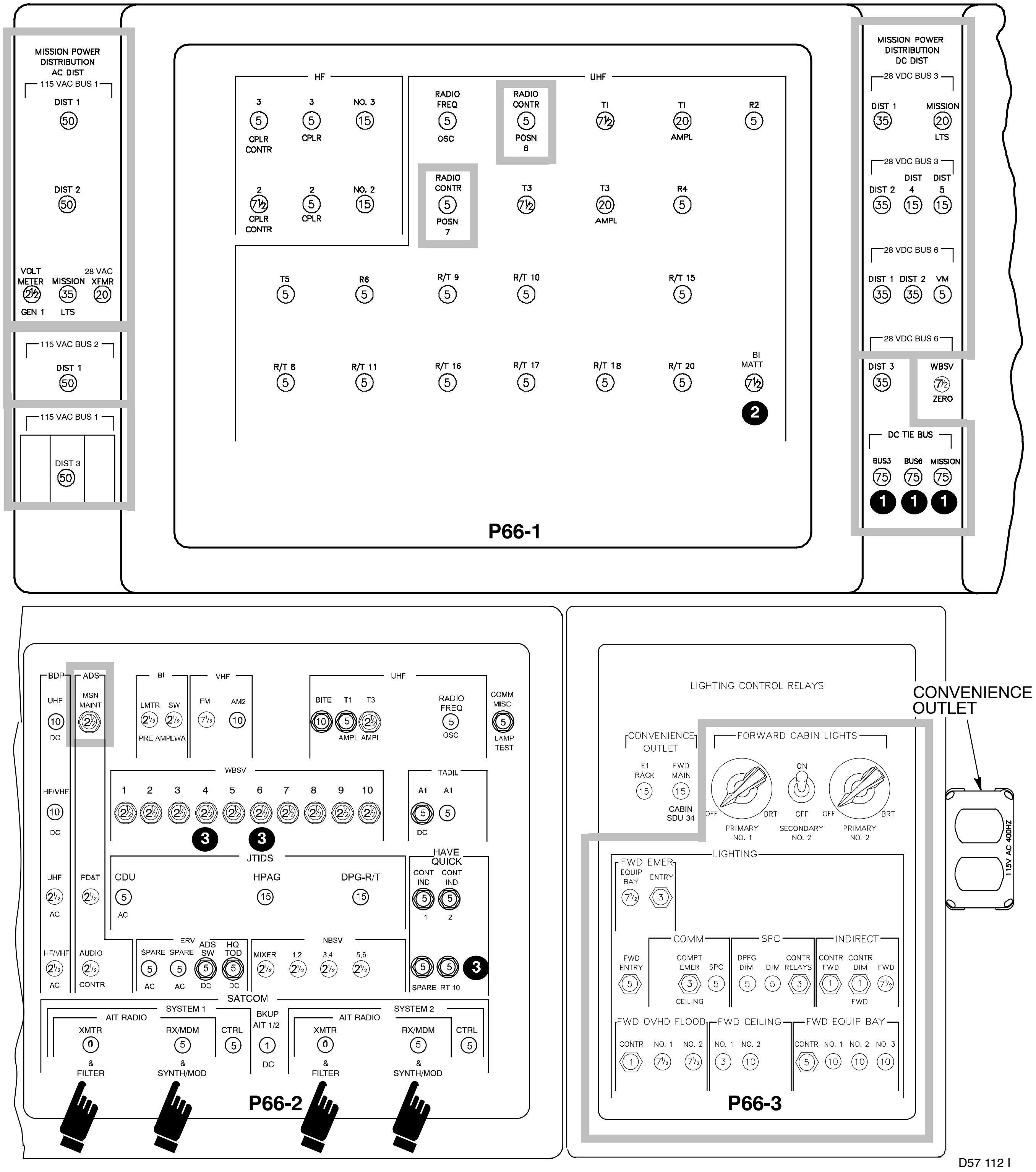
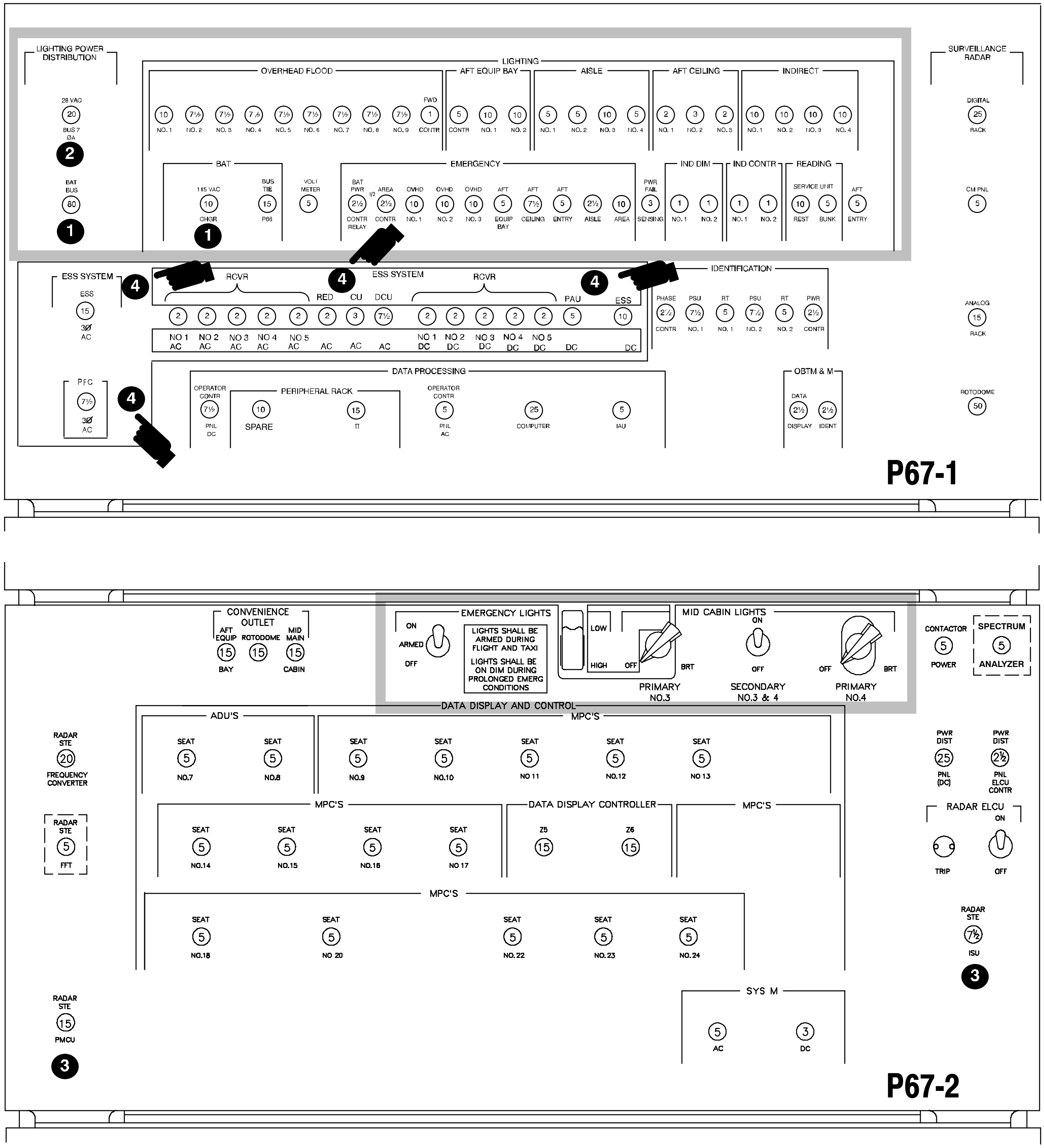


Figure 1–47A ◀

Circuit Breaker Panel P67



▬ INDICATES BREAKER CLOSED BY FLIGHT ENGINEER ON PREFLGHT

❶ OPENED IN ELECTRICAL FIRE CHECKLIST

❷ B BUS 5 ØB ◀

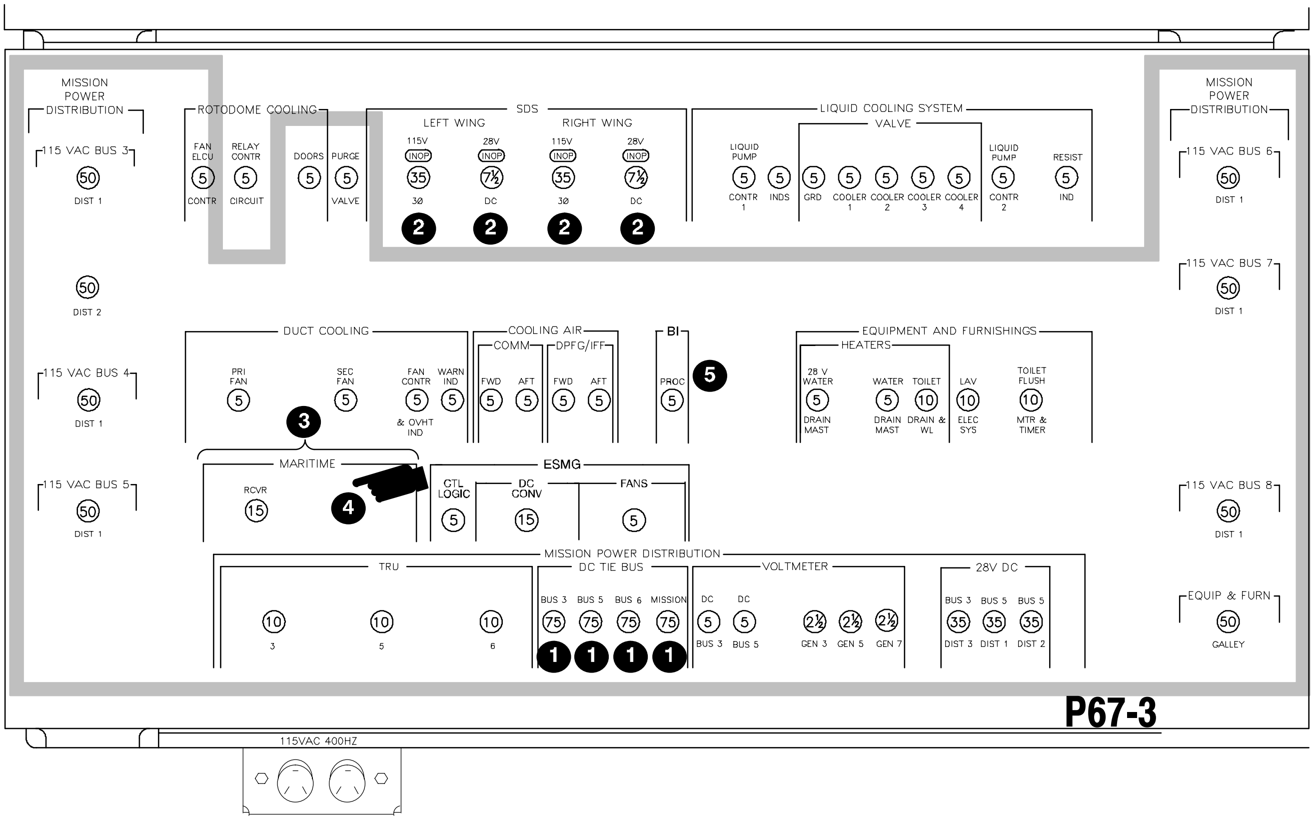
❸ BANDED OPEN (2)

❹ BANDED OPEN (17) TCTO 1E–3–845, ESS SYSTEM DISABLED

D57 113 I

Figure 1-48 (Sheet 1 of 2)

Circuit Breaker Panel P67 (Continued)



❶ OPENED FOR ELECTRIICAL FIRE CHECKLIST (4)

❷ BANDED OPEN (4)

❸ **APY-2**

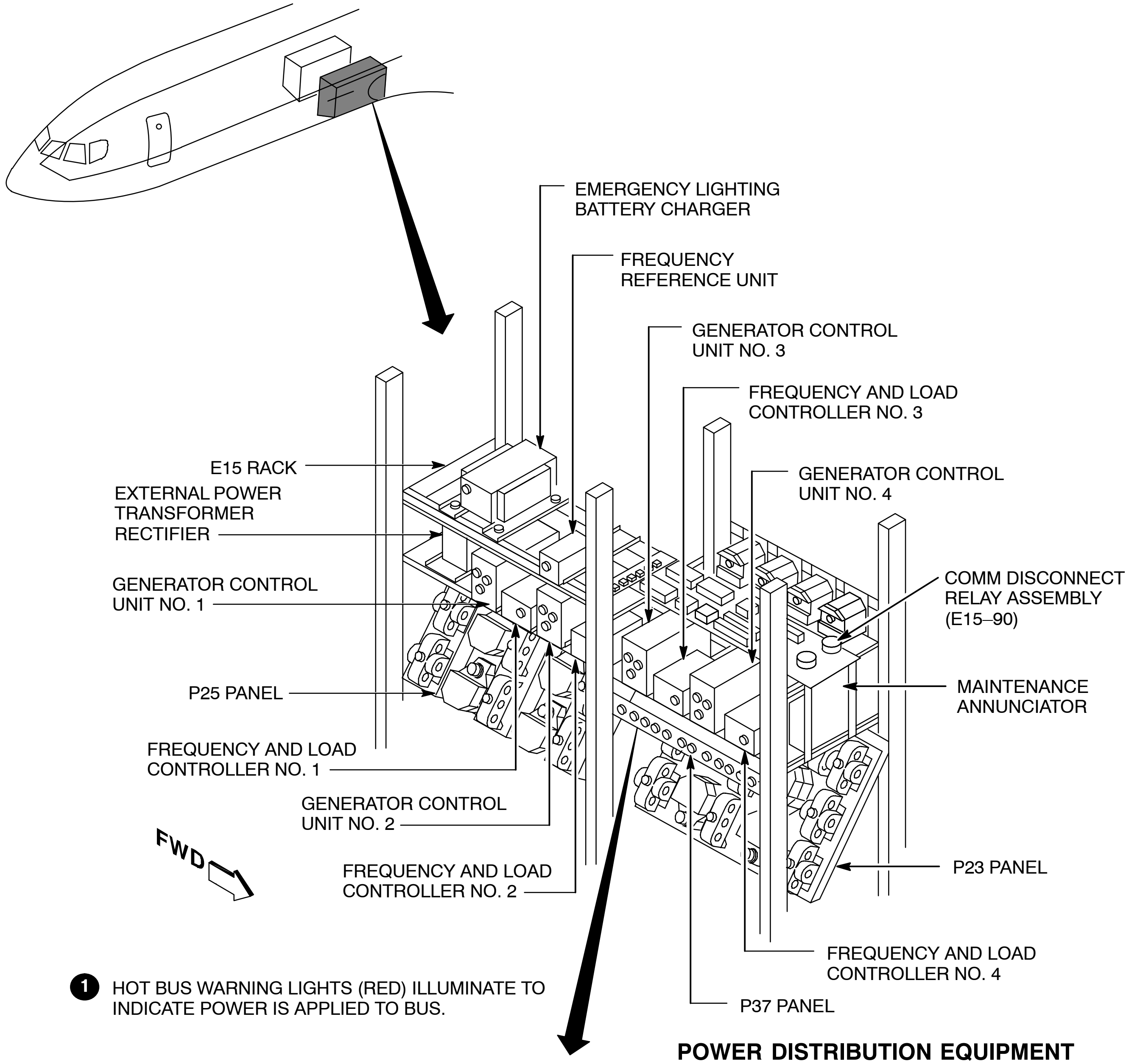
❹ REMOVED

❺ **WITH AP**

D57 114 I

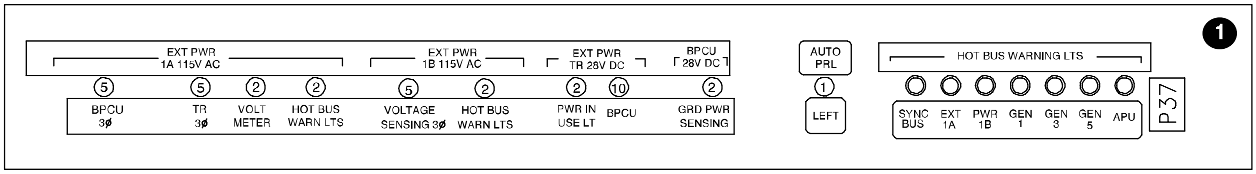
Figure 1-48 (Sheet 2 of 2)

Equipment Rack E15 and Circuit Breaker Panel P37



❶ HOT BUS WARNING LIGHTS (RED) ILLUMINATE TO INDICATE POWER IS APPLIED TO BUS.

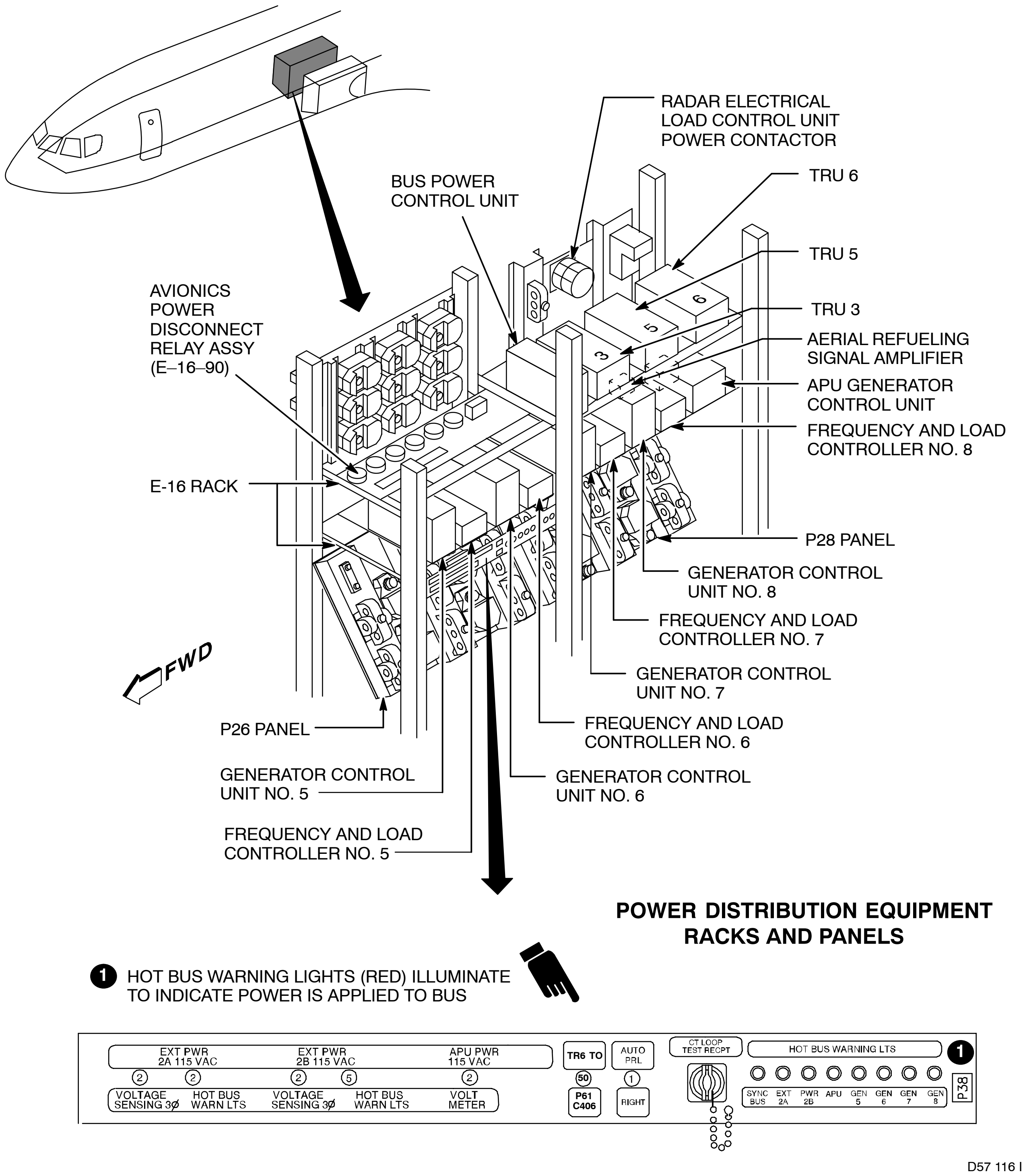
POWER DISTRIBUTION EQUIPMENT RACKS AND PANELS



D57 115 I

Figure 1-49

Equipment Rack E16 and Circuit Breaker Panel P38



POWER DISTRIBUTION EQUIPMENT RACKS AND PANELS

❶ HOT BUS WARNING LIGHTS (RED) ILLUMINATE TO INDICATE POWER IS APPLIED TO BUS

Figure 1-50

AC SYNC BUS

All ac buses are normally powered by the generators operating in parallel, through the tie (sync) bus. When the airplane is on the ground, APU or external power can be connected to the tie bus. The controls are on the engineer's panel. The APU power contactor and external power contactors are electrically interlocked through the BPCU with the main generator breakers so that it is not possible to parallel APU or external power with the main generators. All generator breakers trip when the APU power contactor or external power contactor is closed. Closing any generator breaker after engine start opens the APU power contactor or external power contactor.

NOTE

- If the battery is dead or disconnected, generator breakers 1, 2, 3 and 4 can be closed when generator 3 is turning. Generator breakers 5, 6, 7, and 8 can be closed when generator 7 is turning. The battery bus must be powered to close generator breakers 1, 2 and 4 if generator 3 is not turning. The battery bus must be powered to close generator breakers 5, 6 and 8 if generator 7 is not turning.
- If the battery is dead or disconnected, any bus tie breaker can be closed if the corresponding generator is turning.

PARALLEL OPERATION OF GENERATORS

The generators shall be operated in parallel, to provide uninterrupted power, except as required by abnormal or emergency operating procedures. There is no manual control of voltage or frequency for the generators. Generator synchronizing is automatically controlled by the generator control units, unless the APU generator or external power is on the sync bus. Load division is automatically controlled by the frequency and load controllers and generator control units.

To operate generators in parallel: Verify GEN CONTR ON switch is closed (line light illuminated). If not, press ON switch of GEN CONTR switch indicator. Verify line light illuminated in BUS TIE OPEN switch. If BUS TIE OPEN and GEN CONTR line lights do not illuminate, generator did not parallel. Repeat for other generators.

CAUTION

When transferring from external power or APU to the airplane generators, close only one generator breaker. When bus tie breaker recloses, the other generator breakers may be closed as rapidly as desired. Attempting to close the first two generator breakers at once on power transfer can damage generator drive.

To remove a generator from parallel operation, press the BUS TIE OPEN switch to open the bus-tie breaker. Refer to AIRPLANE OPERATIONAL LIMITS, section V, for limits with inoperative generators.

NOTE

To operate mission radar, at least six generators must be in parallel.

AC POWER SYSTEM FAULT PROTECTION

The ac power system automatically protects itself against most faults. Individual circuits are protected by thermal circuit breakers. Large loads are protected by electrical load control units (ELCUs). Generator feeders and the sync bus are protected by the generator breakers and bus tie breakers.

The generator breaker and bus tie breaker are opened by a differential fault on a generator feeder (between the generator breaker and bus tie breaker). Both breakers remain open. If power cannot be restored to a bus, all equipment on that bus is lost for the rest of the flight. See *figures 1-40* and *1-42*.

A differential fault on the sync bus trips all bus tie breakers. If power cannot be restored, the mission radar is lost but all generators can be operated isolated. APU or external power cannot be connected after landing.

The following faults trip the generator breaker and bus tie breaker (the bus tie breaker recloses automatically):

An open circuit in one phase, over- or under-frequency, over- or under-voltage and generator drive underspeed. (LOW RPM light illuminated.)

The following faults trip the bus tie breaker first and then can trip the generator breaker. (Bus tie breaker recloses.)

Over- or under-excitation of generator field (reactive load unbalance) trips the bus tie breaker. In this type of fault, the generator voltage usually is out of tolerance when the generator is isolated so the generator breaker trips and the bus tie breaker recloses. It can take several seconds for the bus-tie breaker to reclose after the generator breaker trips if voltage is low.

In a real load unbalance, the bus tie breaker trips. When the generator is isolated, the frequency is too high or too low, so the generator breaker trips within a few seconds. The bus-tie breaker recloses if the generator was not manually isolated. If generator loads are above 200 amperes, the system sometimes opens a bus tie breaker on a good generator instead of the faulty one. This can lead to more generators being isolated.

With a load of at least 80 amperes and a generator drive underspeed (LOW RPM light illuminated due to a faulty speed sensing circuit), the bus-tie breaker for the associated generator trips. Both generators on an engine trip if engine rpm is low. Even numbered generators are driven at a lower speed, so they usually trip off first when an engine slows down. If the isolated generator (voltage and frequency) does not remain in tolerance the generator breaker trips and the bus tie breaker closes.

NOTE

In all of these cases, the bus-tie breaker stays open if there is a differential fault on the main or sync bus.

AC POWER SYSTEM ABNORMAL OPERATION

The electrical system provides sufficient power for operation of all mission equipment with six generators paralleled. There are airplane operational limits with less than eight generators in parallel. To determine if a generator which is not operating properly can be shut down, consider mission requirements, airplane operating limitations and the possibility that the generator can fail. (Refer to AIRPLANE OPERATION LIMITATIONS, section V.) Operation of the ac power system in abnormal conditions is limited to one attempt to reset tripped circuit breakers, isolated generator operation, generator shutdown and IDG disconnect. All operation of the system, normal and abnormal, is through the control circuit logic.7

TRIPPED CIRCUIT PROTECTIVE DEVICE

CAUTION

- A tripped circuit protective device (circuit breaker, ELCU, or power contactor) indicates a possible fault in that circuit and can be the first indication of a fire or equipment damage. If a circuit breaker, ELCU, or contactor trips, investigate the cause, if possible. If the equipment is inaccessible, monitor system operation after a reset attempt. Only one reset attempt is permitted, unless otherwise specified. Repeated attempts to reset a protective device could result in electrical fire or equipment damage.
- The FREQ. REF. UNIT circuit breaker will not be reset.
- If an ELCU trips during power transfer, two reset attempts are permitted, since cause of tripping is known.
- If possible, set equipment switch to OFF before resetting a tripped protective device.
- If any combination of boost pump circuit breakers trip, set pump switch to OFF and open all breakers for that pump. In flight, unless required for safety of flight, leave circuit breakers open. Do not reset breakers until maintenance personnel inspect the system.

LOSS OF POWER ON AC TIE BUS

A differential fault in the ac tie bus causes all bus-tie breakers to open. Check that the BUS PWR CONT UNIT CONT circuit breaker and GEN CONT UNIT circuit breakers on panel P61-6 are closed. Refer to ALL BUS TIE BREAKERS OPEN, section IIIA.

LOSS OF ONE OR MORE GENERATORS

When a tie bus breaker opens, if the generator can still supply power, that main bus is still powered. However, if the generator has failed or fails after being isolated, there can be a delay of up to approximately five seconds before the bus tie breaker recloses (the main bus powered by that generator can be unpowered for up to approximately five seconds) depending on type of failure. Some of the consequences of loss of power to a main bus are: (see *figures 1-39, 1-40* and *1-42*). If bus tie breaker has been opened manually, it will not automatically reclose if generator fails. Bus tie breaker must be manually closed with GENERATOR OFF switch on FE's panel. Refer to ONE OR MORE GENERATORS INOPERATIVE, section III-A.)

NOTE

> Generator voltage and frequency cannot be read with the generator control switch off. Since the generator field breaker is open, there is no output.

Generator bus number 1: The radar ac power standby bus is not powered and the mission radar shuts down.

Generator bus number 2: Auxiliary hydraulic pump NO 1 stops. N_1, EGT and fuel flow gages on NO 1 engine and EPR gage on NO 2 engine are inoperative and CDU 1, RNAV panels 1 and 3, EGI 1 charger and CADC 1 are inoperative. EGI 1 runs on its battery.

Generator bus number 3: Power is lost to forward forced air cooling system fan NO 1.

Generator bus number 4: Power is lost to the draw through cooling system fan. The emergency lights powered by the airplane battery illuminate. Refer to LIGHTING for details of emergency light operation. N_1, EGT and fuel flow gages on NO 2 engine and EPR gage on NO 1 engine are inoperative. Auxiliary hydraulic pump NO 2 stops.

Generator bus number 5: Power is lost to certain mission radar power supplies and the mission radar shuts down; power is lost to the forward forced air cooling system fan number 2; the mission compartment emergency lights powered by the emergency lights batteries illuminate. Refer to LIGHTING for details of emergency light operation.

Generator bus number 6: If the liquid cooling system is being powered by liquid cooling pump number 2, the mission radar shuts down. Power is also lost to the mission radar phase shifter driver unit in the rotodome which causes mission radar transmission problems and can cause shutdown. N_1, EGT and fuel flow gages on NO 3 engine and EPR gage on NO 4 engine are inoperative.

Generator bus number 7: Power is lost to the rotodome cooling which can cause mission radar shutdown. Power is also lost to the aft forced air cooling system fan number 1.

Generator bus number 8: If the liquid cooling system is being powered by liquid cooling pump number 1, the mission radar shuts down. Power is also lost to the aft forced air cooling system fan number 2. N_1, EGT and fuel flow gages on NO 4 engine and EPR gage on NO 3 engine are inoperative. CDU 2, RNAV panel 2, AE 2, EGI 2 charger, BSIU 2, and CADC 2 are inoperative. EGI 2 runs on its battery.

LOSS OF ALL GENERATOR POWER

If all ac generator power is lost, as indicated by all GEN CONTR OFF caution lights illuminated, the airplane battery and emergency lighting battery provide electric power and sufficient light for emergency operation. In order to conserve battery power, certain switches and circuit breakers must be opened. A definite sequence of power restoration is required to reduce transient loads and to resume normal system operation as soon as possible. Refer to LOSS OF ALL GENERATORS, section III-A.

NOTE

> If the battery is dead or disconnected, generator breakers 1, 2, 3, and 4 can be closed when generator 3 is turning. Generator breakers 5, 6, 7, and 8 can be closed when generator 7 is turning. The battery bus must be powered to close generator breakers 1, 2, and 4 if generator 3 is not installed or not turning. The battery bus must be powered to close generator breakers 5, 6, and 8 if generator 7 is not installed or not turning.

ISOLATED OPERATION OF GENERATORS

Isolated operation of one or more generators can be required for performing emergency procedures or for continued operation after certain failures. To isolate a generator, press the BUS TIE OPEN switch (if the generator is not operating, press the GEN CONTR ON switch to place the generator in operation before opening the bus tie breaker). Verify the line light is illuminated in the GEN CONTR ON switch and the OPEN caution light is illuminated in the BUS TIE OPEN switch.

NOTE

> To operate mission radar, at least six generators must be in parallel.

GENERATOR OFF OR BUS TIE OPEN LIGHT ILLUMINATED

When a generator OFF or BUS TIE OPEN caution light illuminates, either a nuisance trip or a failure has occurred. One try to reset the system (press applicable generator ON and BUS TIE OPEN switches) is allowed. When resetting a generator breaker, operate generator isolated; monitor voltage and frequency until satisfied operation is normal, then press GEN CONTR ON switch to close bus tie breaker. Abnormal generator indications can be a sign of engine problems; check engine operation. Check the BUS PWR CONT UNIT CONT circuit breaker and the GEN CONT UNIT circuit breakers under BATTERY BUS on panel P61-6 to assure the controls are not part of the problem. If, after an attempt to reset, generator OFF caution light remains illuminated or illuminates again, refer to OPERATION WITH ONE OR MORE GENERATORS INOPERATIVE, section III-A.

If, after an attempt to reset, the BUS TIE OPEN light remains illuminated or illuminates again and the generator OFF caution light goes out, that main bus can be left to operate isolated. However, if the generator can be spared, shut the generator down by pressing the generator OFF switch for that generator so that the bus is powered from the tie bus. That generator can be used later in the flight, if needed. Do not disconnect the generator drive. Refer to OPERATION WITH ONE OR MORE GENERATORS INOPERATIVE, section III-A.

If both the generator OFF and associated BUS TIE OPEN caution lights remain illuminated, that generator and the equipment powered by that main bus are lost for the remainder of the flight. Refer to OPERATION WITH ONE OR MORE GENERATORS INOPERATIVE, section. See *figures 1-39* and *1-42* to determine equipment affected.

ABNORMAL FREQUENCY INDICATIONS

With the Frequency Reference Unit (FRU) operating, the frequency of all generators is 402 ± 0.1 Hz whether operating in parallel (on the tie bus) or not. Due to frequency meter tolerances, the frequency indicated at the flight engineer's panel is 402 ± 3 Hz. If the FRU fails, the generators on the tie bus continue to operate at the same frequency as each other but between 400 ± 8 Hz instead of 402 ± 3 Hz. During normal paralleled operation, it is not possible to detect a failed FRU by using the flight deck frequency meter. If the operating frequency of the generators on the tie bus drifts outside the 400 ± 5 Hz range, check the ammeters and if one paralleled generator is not sharing load (approximately 30 amps different from the others) and it can be spared, shut it down by pressing the OFF switch. The frequency of the generators remaining on the tie bus should return within the 400 ± 5 Hz operating range. An isolated generator operates at a frequency different from the other generators if the FRU is not operating. As the operating frequency of a generator approaches 390 or 410 Hz, the probability of an automatic trip increases. For ABNORMAL FREQUENCY INDICATION malfunction, refer to OPERATION WITH ONE OR MORE GENERATORS INOPERATIVE, section III-A.

WARNING

Engine fuel line damage can result from IDG case separation. Possible indications of case separation are generator failure, illumination of LOW RPM light, and abnormally high or low IDG oil temperature indication. If any of these conditions exist, check for abnormally high engine fuel flow before disconnecting IDG. If fuel leak is suspected, do not attempt IDG disconnect. Shut down engine if not needed for safety of flight.

CAUTION

If frequency of isolated generator is outside the range of 400 ± 8 Hz or fluctuates more than 4 Hz within the ±8 Hz range, check IDG oil temperature indicator and LOW RPM light. If indications are normal, shut down generator and disconnect IDG. If indications are abnormal, shut down generator and check for presence of fuel leak (abnormally high fuel flow). If fuel flow is normal, disconnect IDG.

NOTE

Because of meter tolerances, the airplane frequency meter cannot be used to troubleshoot a suspected malfunction of the frequency reference unit. It is sensitive to voltage and may indicate erroneously when the system is not at proper voltage. It is possible for the meter to indicate 380 to 385 Hz when selected to an unexcited IDG because of residual voltage.

ABNORMAL VOLTAGE INDICATIONS

All generators operating in parallel (on the tie bus) have the same voltage. Generators operating isolated can have different voltages depending on generator load. If the voltage for generators operating on the tie bus drifts outside the 115 ± 4 volt range, monitor amperage. If one generator is not sharing load (approximately 30 amps different than the others), operate generator isolated and check voltage. The voltage of the generators remaining on the tie bus should return within the 115 ± 4 volt operating range. Whether generators are on the tie bus or isolated, as the voltage approaches approximately 108 volts or 124 volts, the probability of an automatic generator trip becomes high. Notify the pilot and mission crew if a voltage reading of 110 volts or lower is seen, as some equipment can be receiving power below 106 volts.

CAUTION

Equipment malfunction and damage can occur if indicated voltage drops to 110 volts or lower. If indicated voltage of isolated generator is outside the range of 115 ± 4 volts, shut down generator.

ABNORMAL AMPERAGE INDICATION

Frequency and voltage are locked for generators operating in parallel (on the tie bus) so a difference in ammeter readings can indicate a generator malfunction. If a paralleled generator is not sharing load (approximately 30 amps different than the other generators on the tie bus) and it can be spared, shut it down by pressing the generator-OFF switch. When operating isolated, the load distribution is such that a generator cannot be overloaded.

IDG LOW RPM LIGHT ILLUMINATED

If the IDG DISC button has been pressed and the generator-OFF and LOW RPM lights illuminate steadily, the generator has been disconnected. Disconnect can be verified by checking that current is zero. If the LOW RPM light illuminates intermittently but the generator breaker does not trip (line light stays on) the cause is probably a fault in the speed sensing circuit.

If a generator drive LOW RPM indicator is illuminated and generator remains on bus, check the engine N_2 RPM and compare the amperage loads.

CAUTION

If LOW RPM light fails to go out when starting engine and generator breaker will not close, shut down the engine and have maintenance make a visual check for structural integrity and verify the IDG is reconnected before attempting restart. If LOW RPM stays illuminated after restart, disconnect IDG and resume operation with generator inoperative.

If engine N_2 RPM for the affected generator is low (below 50% N_2), the electrical load on the generator can cause the engine RPM to drop below that needed to maintain the generator minimum drive speed. However, if the engines are operated within the fuel flow limits in ENGINE LIMITATIONS in section V, low engine RPM or engine drag down should not be the problem. If advancing throttle does not increase engine RPM, refer to ENGINE STALL RECOVERY, section III.

Check all generator ammeters. If the affected generator(s) are not within ±30 amperes of the other generators, open the corresponding bus ties.

The affected generator can be operated isolated if the frequency is normal and the ammeter reading appears normal for the load on the isolated bus. If the frequency or ammeter reading does not appear normal, open the affected generator breaker and disconnect the IDG.

WARNING

> Engine fuel line damage can result from IDG case separation. Possible indications of case separation are generator failure, illumination of LOW RPM light, and abnormally high or low IDG oil temperature indication. If any of these conditions exist, check for abnormally high engine fuel flow before disconnecting IDG. If fuel leak is suspected, do not attempt IDG disconnect. Shut down engine if not needed for safety of flight.

CAUTION

> Generator drives can only be disconnected when the engines are operating at or above idle speed. If the IDG DISC switch is pressed when the engines are not running, or are turning at below idle speed, IDG damage may result at the next engine start.

If generator NO 2, 4, 6, or 8 is disconnected, power to certain engine instruments can be lost if that bus tie breaker opens. Refer to LOSS OF ONE OR MORE GENERATORS.

NOTE

> If generator NO 3 or 7 is disconnected, it can be impossible to reclose the generator breakers on that side if all generator breakers trip and battery is inoperative.

DC POWER SOURCES

DC power is supplied by the following: six transformer rectifier units (TRU), four batteries, and two battery chargers. Normally, the six TRUs supply all dc loads except the hot battery bus which is powered by the airplane battery or emergency light battery. The batteries supply power to certain essential loads when normal dc power is not available.

TRANSFORMER RECTIFIER UNITS (TRU)

There are six TRUs, each supplied by a generator ac bus (NO 2 through 6 and NO 8). Number 2, 4, and 8 TRUs are located in the E5 electrical equipment rack (*figure 1-50*) and TRU Nos. 3, 5, and 6 are in rack E16. Alternating current, 115-volt power is converted to 28-vdc power in the transformer/rectifier units. TRU output under no load is 33 ± 5 volts. This voltage decreases as load increases until, at a 45 amp load, the voltage is 26 ± 4 volts.

BATTERIES

There are two interchangeable pairs of 12-volt batteries, each pair connected in series to provide 24 volts, located in the forward lower compartment. The pair on the right side (airplane battery) provides power to the hot battery bus and, under certain conditions, to the battery buses and emergency dc bus. The pair on the left side of the airplane (emergency light battery) provides power to the emergency lights in the mission compartment and lower compartment, and is an alternate power source for the airplane battery. If airplane battery voltage is low, the emergency light battery supplies power to the EDC busbar and the hot battery bus. The interconnect circuit is protected by a diode to prevent emergency lights from discharging the airplane battery. (Refer to LIGHTING, subsection I-T.) Battery location and circuit protection are shown in *figure 1-37*.

BATTERY CHARGERS

There are two battery chargers; the airplane battery charger located in E5 rack (*figure 1-51*) and the emergency light battery charger located in E15 rack (*figure 1-49*). The airplane battery charger maintains the airplane battery in a charged condition based upon battery voltage and temperature. Normally, the charger supplies a constant charging current until the battery temperature rises to a preset level at which time the battery charger output is cut off. The output remains cut off until the battery voltage drops to a preset level at which time charging resumes. The charger charges the battery only if the battery temperature is between approximately –13° and +180°F.

The battery charger does not supply any dc loads except the battery and any hot battery bus loads which are drawing current while the battery charger is charging. Input power to the airplane battery charger is 115 vac from AVAC bus six.

The emergency lighting battery charger is a low amperage trickle charger which only supplies charging current to the emergency lighting battery when the EMERGENCY LIGHTS arming switch is set to ARMED. Also, if the emergency lights come on automatically, the charger is cut off. Input power to the battery charger is 115 vac from mission ac bus four.

DC POWER DISTRIBUTION

DC power is supplied from six, 75 ampere transformer/rectifier units (TRU) and the airplane battery or emergency light battery. DC loads are supplied by load buses, which can be operated individually (by opening various DC TIE BUS circuit breakers) or connected in parallel by means of the tie buses. The load buses are normally interconnected. See *figure 1-41* for the schematic of the dc distribution system. An additional TRU, the external power TRU, provides operating power for external power circuits.

AIRPLANE DC LOAD BUSES

There are four airplane dc buses. Three are powered by TRUs 2, 4, and 8 which receive ac power through circuit breakers on the P61 panel. The fourth, AVDC bus six, is powered only from the dc tie bus. Bus output is distributed through circuit breakers on the P5, P6, P7, and P61 panels and bus control relays controlled by switches on the AVIONICS POWER DISCONNECT panel on the flight deck. Circuit breakers and switch arrangement is shown in *figures 1-38* and *1-43* through *1-46*.

MISSION DC LOAD BUSES

There are three mission dc buses, powered by TRUs 3, 5, and 6 which receive ac power through circuit breakers on P67 panel. Bus output is distributed through circuit breakers on the P66 and P67 panels and bus control relays controlled by switches on the COMM DISCONNECT panel located in the mission compartment. Circuit breaker and switch arrangement is listed in *figures 1-38* and *1-47* through *1-48*.

DC TIE BUSES

The individual airplane and mission dc buses are interconnected by the dc tie buses to allow operation of all dc loads if power is interrupted on one TRU. There are circuit breakers located between the individual dc load buses and the dc tie buses which, when opened, allow isolated operation of each dc load bus. The exception is AVDC bus six which receives power only from the dc tie bus.

HOT BATTERY BUS

The hot battery bus is connected to the battery and is powered if the battery is installed. The battery charger will not supply power to the hot battery bus if the battery is removed or the battery temperature-voltage condition has caused the battery charger to cut off. The only source of power for the hot battery bus is the airplane battery or the emergency light battery.

BATTERY BUSES

Power from the aircraft battery is supplied to the hot battery bus, and when needed, to other battery buses, the flight deck UHF radio, the emergency dc bus, and the emergency inverter. See *figure 1-41* for the schematic of the DC Power Distribution system.

WARNING

> If the battery bus is inoperative, power to essential aircraft systems will be lost. If power cannot be restored, land as soon as possible. Review *figure 1-42*, Bus Distribution Diagram, to determine equipment lost.

The battery buses are powered by the battery only when power is not available from the TRUs and the BATTERY switch is ON. The flight deck UHF radio and the emergency dc bus are powered by the battery only when power is not available from the TRUs and the BATTERY switch is ON and the EMERGENCY POWER switch is set to NORMAL or MANUAL ON. The emergency inverter receives battery power only when power is not available from the TRU's and the BATTERY switch is ON. The inverter supplies the emergency ac buses only when the EMERGENCY POWER switch is set to MANUAL ON, or the EMERGENCY POWER switch is NORMAL and the ac power is not available. Power from the battery buses is distributed through the P61 panel (*figure 1-46*).

EMERGENCY DC POWER

The emergency dc bus (*figure 1-41*) supplies essential dc loads, such as flight instruments, which require uninterrupted power. The emergency dc bus is powered when the EMERGENCY POWER switch is not OFF. The bus receives dc power from AVDC bus two as long as power is available from the dc tie bus or the number two TRU. If AVDC bus two loses power, the battery bus transfer relay (BBTR) disconnects the battery bus, inverter, and emergency dc from AVDC bus two and causes the battery relay (BR) to connect these loads to the battery if the BATTERY switch is ON.

NOTE

If the BATTERY or EMERGENCY POWER switches are OFF, power is removed from central switching units CSU1 and CSU2, causing loss of all internal and external communication.

DC POWER FAULT PROTECTION

If a fault occurs between a TRU and the branch bus distribution circuit breakers, the tie bus circuit breaker(s) to that branch bus open. The isolated TRU now supplies all the power to the fault and because of the great amount of current being taken by the fault, the voltage on that branch bus approaches zero. Because the voltage on that branch bus is low (near zero), all equipment powered by that branch bus is lost for the remainder of the flight unless power can be restored. (See *figures 1-41* and *1-42*.) The ac supply circuit breaker for the affected TRU sometimes does not trip and must be opened manually.

DC POWER ABNORMAL OPERATION

If a dc tie bus circuit breaker trips, monitor the voltage and amperage from the corresponding TRU. If the voltage is very low (near zero), open the ac supply circuit breaker to the affected TRU. One try to reset the dc tie bus circuit breaker is allowed. If the dc tie bus circuit breaker(s) remain closed, one attempt to reset the ac supply circuit breaker is allowed.

CAUTION

- If a circuit breaker trips, it indicates a possible fault in the circuit, so only one attempt to reset the circuit breaker is permitted. (The FREQ REF UNIT circuit breaker will not be reset with generators turning.) Electrical fires or equipment damage could result from repeated attempts to reset circuit breakers.

- If the equipment powered by a tripped circuit breaker has a switch, turn the switch off before resetting the breaker.

- If dc bus two power is interrupted while ac generators are turning, open the FREQ REF UNIT circuit breaker (P61-5) before restoring power to dc bus two. Generator drives could be damaged or ac power lost if FRU is re-powered with generators turning. Do not restore FRU power for remainder of flight.

MAINTENANCE ANNUNCIATOR

The maintenance annunciator panel (*figure 1-49*) is located on the forward end of the E15 rack. The panel indicates electrical system faults until reset. The panel is used by maintenance personnel for troubleshooting. The panel does not monitor the entire system, so it cannot be used for complete analysis. Also, some combinations of faults can give misleading indications. Flight crew use of the panel is limited to recording fault indications, resetting the indicators (if no maintenance postflight/preflight is performed) and reporting faults.

E5 Equipment Rack

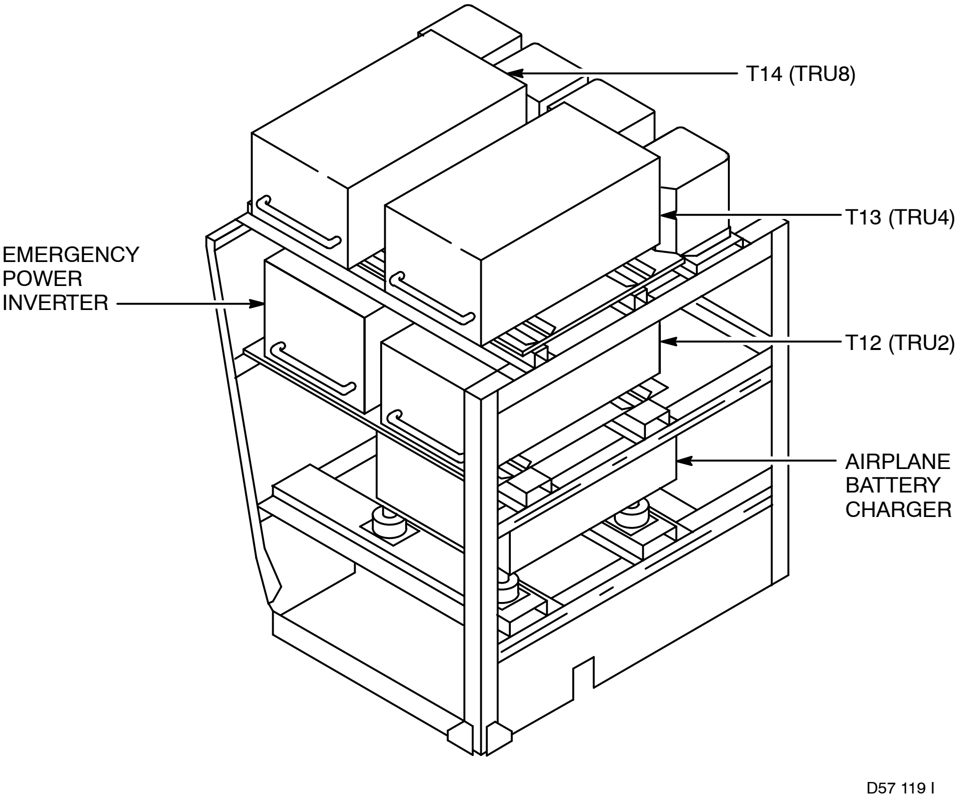


Figure 1-51

CIRCUIT BREAKER LISTS

Circuit breakers for airplane and mission systems are listed by system in *figure 1-52*. Additional lists for some airplane systems circuit breakers are at the end of the related subsections in section I.

AVIONICS AND COMMUNICATIONS POWER DISCONNECT OPERATION

Power to some avionics and communications equipment is controlled through switches on the AVIONICS POWER DISCONNECT panel (engineer station) and the COMM DISCONNECT panel (comm console). Switches on these panels control relays which apply or remove power to/from connected equipment.

CAUTION

> Ensure that cooling air is available to affected equipment, as required, before applying power.

See *figure 1-42* for relay and bus diagrams, *figure 1-53* for AVIONICS POWER DISCONNECT panel controls and indicators, and *figure 1-54* for affected equipment cooling requirements.

Power Distribution Circuit Breaker List

LEGEND

APD–CA – AVIONICS POWER DISCONNECT PANEL COMM AFT SWITCH
APD–CF – AVIONICS POWER DISCONNECT PANEL COMM FWD SWITCH
APD–FA1 – AVIONICS POWER DISCONNECT PANEL FLT AVIONICS BUS 1 SWITCH
APD–FA2 – AVIONICS POWER DISCONNECT PANEL FLT AVIONICS BUS 2 SWITCH
APU – AUXILIARY POWER UNIT
AVAC – AIR VEHICLE AC
AVDC – AIR VEHICLE DC
BAT BUS – BATTERY BUS
EAC – EMERGENCY AC
EDC – EMERGENCY DC
E.L. BAT – EMERGENCY LIGHTING BATTERY BUS
EXT PWR – EXTERNAL POWER
FAAC – FLIGHT AVIONICS AC
FAVDC – FLIGHT AVIONICS DC
GEN – GENERATOR
HOT BAT – HOT BATTERY
MAIN DIST – MAIN DISTRIBUTION
MAAC – MISSION AVIONICS AC
MADC – MISSION AVIONICS DC
TRU – TRANSFORMER RECTIFIER UNIT
28V AC – 28 VOLT AIR VEHICLE AC
28V MAC – 28 VOLT MISSION AC
XFMR – TRANSFORMER

NOTE

Notation in the BUS column such as BATTERY (C106) means the source of power to the circuit breaker in question comes from the battery via circuit breaker C106.

AIR CONDITIONING AND PRESSURIZATION

BUS	C.B. NOMENCLATURE	PH	PANEL
AVAC 4	AIR CONDITIONING – GASPER FAN	ABC	P61-3
AVAC 4	AIR CONDITIONING – TEMP CONTROL VALVE AUTO – FLT DK & FWD ZONE	A	P61-3
AVAC 4	AIR CONDITIONING – TEMP CONTROL VALVE AUTO – MID & AFT ZONE	A	P61-3
AVAC 4	AIR CONDITIONING – TEMP CONTROL VALVE AUTO – PACK	A	P61-3
AVAC 4	CABIN PRESSURE – PRESS CONTR AC	A	P61-3
AVAC 4	CABIN PRESSURE – VAC PUMP – AFT	B	P61-3
AVAC 4	CABIN PRESSURE – VAC PUMP – FWD	B	P61-3

Figure 1-52 (Sheet 1 of 42)

AIR CONDITIONING AND PRESSURIZATION (CONT.)

BUS	C.B. NOMENCLATURE	PH	PANEL
AVAC 6	AIR CONDITIONING – TEMP CONTROL VALVE MANUAL – FLT DK & FWD ZONE	B	P61-3
AVAC 6	AIR CONDITIONING – TEMP CONTROL VALVE MANUAL – MID & AFT ZONE	B	P61-3
AVAC 6	AIR CONDITIONING – TEMP CONTROL VALVE MANUAL – PACK	B	P61-3
AVAC 6	AIR CONDITIONING – TEMP SENSOR FAN	B	P61-3
AVDC 4 MAIN	AIR CONDITIONING – FLOW CONTROL VALVES – LOW FLOW & ALTER TEMP		P61-3
AVDC 4 MAIN	AIR CONDITIONING – GASPER FAN CONTR		P61-3
AVDC 4 MAIN	AIR CONDITIONING – INDICATORS – MID & AFT ZONE TEMP		P61-3
AVDC 8 MAIN	AIR CONDITIONING – INDICATORS – FLT DK & FWD ZONE TEMP		P61-3
AVDC 8 MAIN	AIR CONDITIONING – INDICATORS – TEMP & VALVE POS		P61-3
AVDC 8 MAIN	AIR CONDITIONING – TEMP CONTROLLERS – FLT DK & FWD		P61-3
AVDC 8 MAIN	AIR CONDITIONING – TEMP CONTROLLERS – MID & AFT		P61-3
AVDC 8 MAIN	AIR CONDITIONING – TEMP CONTROLLERS – PACK		P61-3
AVDC 8 MAIN	CABIN PRESSURE – PRESS CONTR DC		P61-3
BAT BUS	AIR CONDITIONING – FLOW CONTROL VALVES – ALTER SHT OFF		P61-3
BAT BUS	AIR CONDITIONING – FLOW CONTROL VALVES – PRI SHT OFF & PRI TEMP		P61-3
BAT BUS	CABIN PRESSURE – DEPRESS CONTR		P61-3
BAT BUS	ESSENTIAL LIGHTING – VIS WARN – LOSS OF PRESS LIGHTS		P6
BAT BUS	ESSENTIAL LIGHTING – VIS WARN – LOSS OF PRESS WARN RELAY		P6

APU

BUS	C.B. NOMENCLATURE	PH	PANEL
AVDC 4 MAIN	ENGINE START & INDICATORS – APU – FIRE DETECT AUX SHUT DN		P61-2
EAC	ENGINE START & INDICATORS – APU ACCU – PRESS		P61-2
HOT BAT MAIN DIST	APU – CONTR		P61-2

Figure 1-52 (Sheet 2 of 42)

Power Distribution Circuit Breaker List (Continued)

APU (CONT.)

BUS	C.B. NOMENCLATURE	PH	PANEL
HOT BAT MAIN DIST	APU – DOOR WARN		P61-2
HOT BAT MAIN DIST	ENGINE START & INDICATORS – APU – FIRE DETECT PRIMARY SHUT DN		P61-2
HOT BAT MAIN DIST	ENGINE START & INDICATORS – APU – FIRE EXT		P61-2

AUTOPILOT

BUS	C.B. NOMENCLATURE	SWITCH CONTROL	PH	PANEL
EDC	EMERGENCY FLIGHT AVIONICS – AUTO PILOT WARN			P5
FAAC 1	AUTOPILOT – 3Ø	APD–FA1		P5

BLEED AIR

BUS	C.B. NOMENCLATURE	PH	PANEL
AVAC 4	BL AIR – ISLN VALVES	C	P61-3
AVAC 6	BL AIR – LEAK DETECT CONTR	B	P61-3
AVDC 4 MAIN	BL AIR – LEAK DETECT IND		P61-3
AVDC 4 MAIN	BL AIR – VALVES ENG 2 & 3		P61-3
AVDC 8 MAIN	BL AIR – VALVES ENG 1 & 4		P61-3
28V AC 2	BL AIR – PRESS IND	C	P61-3

BRAKES AND ANTI–SKID

BUS	C.B. NOMENCLATURE	PH	PANEL
AVDC 8 MAIN	LANDING GEAR – ANTI–SKID – INBD	P5	P5
AVDC 8 MAIN	LANDING GEAR – ANTI–SKID – OUTBD	P5	P5
AVDC 8 MAIN	LANDING GEAR – PARK BREAK	P5	P5
28V AC 8 DIST 1	LANDING GEAR – ANTI–SKID – TEST	B	P5

Figure 1-52 (Sheet 3 of 42)

COMMUNICATIONS

BUS	C.B. NOMENCLATURE	SWITCH CONTROL	PH	PANEL
AVDC 8	COMMUNICATIONS – UHF G DC	APD–CF		P5
AVDC8 COMM DIST 1	COMMUNICATIONS – HF/VHF INTFC DC	APD–CF		P5
AVDC 8 COMM DIST 1	COMMUNICATIONS – VHF G	APD–CF		P5
AVDC 8 COMM DIST 2	COMMUNICATIONS – HF DC	APD–CA		P5
AVDC 8 COMM DIST 2	COMMUNICATIONS – UHF ADF DC	APD–CA		P5
EDC TRU 2 (C122)	EMERGENCY COMMUNICATIONS – UHF XCVR			P5
EAC	EMERGENCY COMMUNICATIONS – UHF XCVR CPLR		A	P5
EDC	EMERGENCY COMMUNICATIONS – UHF FDDRC			P5
EDC	EMERGENCY COMMUNICATIONS – **LESS IDG** VHF ◀ **WITH IDG** VHF 1 ◀			P5
EDC	EMERGENCY COMMUNICATIONS – ADS – CSU 1			P5
EDC	EMERGENCY COMMUNICATIONS – ADS – CSU 2 A/AV MAINT			P5
EDC	EMERGENCY COMMUNICATIONS – ADS – PA AMPL			P5
EDC	EMERGENCY COMMUNICATIONS – ADS – PA SPKR			P5
FAAC 1	COMMUNICATIONS – HF AC	APD–CA	ABC	P5
FAAC 1	COMMUNICATIONS – HF COUPLER	APD–CA	B	P5
FAAC 1	COMMUNICATIONS – UHF ADF AC	APD–CA	ABC	P5
FAAC 1	COMMUNICATIONS – UHF G AC	APD–CA	C	P5
MAAC 1 DIST 1	SPARE AC		A	P66-2
MAAC 1 DIST 1	SPARE AC		B	P66-2
MAAC 1 DIST 1	SPARE AC		C	P66-2
MAAC 1 DIST 1	JTIDS – CDU AC		A	P66-2
MAAC 1 DIST 1	JTIDS – HPAG		ABC	P66-2

Figure 1–52 (Sheet 4 of 42)

Power Distribution Circuit Breaker List (Continued)

COMMUNICATIONS (CONT.)

BUS	C.B. NOMENCLATURE	SWITCH CONTROL	PH	PANEL
MAAC 1 DIST 1	JTIDS – DPG – R/T		ABC	P66-2
MAAC 1 DIST 2	NBSV – 1, 2		A	P66-2
MAAC 1 DIST 2	NBSV – 3, 4		A	P66-2
MAAC 1 DIST 2	NBSV – 5, 6		A	P66-2
MAAC 1 DIST 2	TADIL – A1		A	P66-2
MAAC 1 DIST 3	BDP – HF/VHF AC	CDP-4	A	P66-2
MAAC 1 DIST 3	NBSV – MIXER	CDP-4	A	P66-2
MAAC 1 DIST 3	UHF – R2	CDP-3	ABC	P66-1
MAAC 1 DIST 3	UHF – R6	CDP-4	ABC	P66-1
MAAC 1 DIST 3	UHF – RADIO CONTR POSN 6	CDP-3	ABC	P66-1
MAAC 1 DIST 3	UHF – R/T 9	CDP-4	ABC	P66-1
MAAC 1 DIST 3	UHF – R/T 10	CDP-3	ABC	P66-1
MAAC 1 DIST 3	UHF – R/T 14 ①	CDP-4	ABC	P66-1
MAAC 1 DIST 3	UHF – R/T 15	CDP–4	ABC	P66-1
MAAC 1 DIST 3	UHF – R/T 16	CDP–4	ABC	P66-1
MAAC 1 DIST 3	UHF – R/T 17	CDP–3	ABC	P66-1
MAAC 1 DIST 3	UHF – R/T 18	CDP–3	ABC	P66-1

① LESS IDG

Figure 1-52 (Sheet 5 of 42)

COMMUNICATIONS (CONT.)

BUS	C.B. NOMENCLATURE	SWITCH CONTROL	PH	PANEL
MAAC 1 DIST 3	R/T 20	CDP–4	ABC	P66-1
MAAC 1 DIST 3	UHF – T1	CDP–4	ABC	P66-1
MAAC 1 DIST 3	UHF – T1 AMPL	CDP–4	ABC	P66-1
MAAC 1 DIST 3	UHF – T5	CDP–4	ABC	P66-1
MAAC 1 DIST 3	RADIO FREQ OSC	CDP–4	ABC	P66-2
MAAC 1 DIST 3	UHF – R/T 8	CDP–4	ABC	P66-1
MAAC 1 DIST 3	UHF – R/T 11	CDP–3	ABC	P66-1
MAAC 1 DIST 3	**WITH IDG** SATCOM – SYSTEM 2 – AIT RADIO – XMTR & FILTER		ABC	P66-2
MAAC 1 DIST 3	SATCOM – SYSTEM 2 – AIT RADIO – RX/MDM & SYNTH/MOD		ABC	P66-2
MAAC 2	SATCOM – SYSTEM 1 – AIT RADIO – XMTR & FILTER		ABC	P66-2
MAAC 2	SATCOM – SYSTEM 1 – AIT RADIO – RX/MDM & SYNTH/MOD		ABC	P66-2 ◀
MAAC 2	ADS – PD&T	CDP–1	C	P66-2
MAAC 2	ADS – AUDIO CONTR	CDP–1	A	P66-2
MAAC 2	BDP – UHF AC	CDP–1	B	P66-2
MAAC 2	**WITH AP** BI – MATT	CDP–4	C	P66-2 ◀
MAAC 2	HF – NO 2	CDP–4	ABC	P66-1
MAAC 2	HF – 2 CPLR	CDP–4	A	P66-1
MAAC 2	HF – NO 3	CDP–4	ABC	P66-1
MAAC 2	HF – 3 CPLR	CDP–4	A	P66-1
MAAC 2	UHF – R4	CDP–3	ABC	P66-1
MAAC 2	UHF – RADIO CONTR POSN 7	CDP–1	ABC	P66-1
MAAC 2	UHF – R/T 7 ①	CDP-4	ABC	P66-1

① **LESS IDG**

Figure 1-52 (Sheet 6 of 42)

Power Distribution Circuit Breaker List (Continued)

COMMUNICATIONS (CONT.)

BUS	C.B. NOMENCLATURE	SWITCH CONTROL	PH	PANEL
MAAC 2	UHF – T3	CDP-4	ABC	P66-1
MAAC 3	UHF – T3 AMPL	CDP-4		P66-1
MADC 3	MISSION POWER DISTRIBUTION DC DIST 28V DC – BUS 3 – DIST 1			P66-1
MADC 3	MISSION POWER DISTRIBUTION DC DIST 28V DC – BUS 3 – DIST 2			P66-1
MADC 3	MISSION POWER DISTRIBUTION DC DIST 28V DC – BUS 3 – MISSION LIGHTS			P66-1
MADC 3	MISSION POWER DISTRIBUTION VOLTMETER – DC BUS 3			P67-3
MADC 3	MISSION POWER DISTRIBUTION 28V DC – BUS 3 – DIST 3			P67-3
MADC 3 DIST 5	ADS – MSN MAINT	CDP–1		P66-2
MADC 3 DIST 5	BDP – UHF DC	CDP–1		P66-2
MADC 3 DIST 5	COMM MISC LAMP TEST	CDP–1		P66-2
MADC 3 DIST 1	UHF – BITE	CDP–5		P66-2
MADC 3 DIST 1	UHF – T1 AMPL	CDP–5		P66-2
MADC 3 DIST 1	UHF – T3 AMPL	CDP–5		P66-2
MADC 3 DIST 1	**LESS IDG** VHF – AM 2 ◀	CDP–5		P66-2
MADC 3 DIST 1	VHF – FM	CDP–5		P66-2
MADC 3 DIST 4	SPARE DC ①			P66-2
MADC 3 DIST 4	ADS SW DC			P66-2
MADC 3 DIST 4	HQ TOD			P66-2

① Banded Open

Figure 1-52 (Sheet 7 of 42)

COMMUNICATIONS (CONT.)

BUS	C.B. NOMENCLATURE	SWITCH CONTROL	PH	PANEL
MADC 3 DIST 4	**LESS IDG** SATCOM SYS 1 – CMPNTS			P66-2
MADC 3 DIST 4	SATCOM – SYS 1 SIM			P66-2 ◀
MADC 3 DIST 4	**WITH IDG** SATCOM SYSTEM 1 – CTRL			P66-2
MADC 3 DIST 4	SATCOM – BKUP – AIT 1/2 DC			P66-2 ◀
MADC 3 DIST 2	BDP – HF/VHF DC	CDP–5		P66-2
MADC 3 DIST 2	HF – 2 CPLR CONTR	CDP–5		P66-1
MADC 3 DIST 2	HF – 3 CPLR CONTR	CDP–5		P66-1
MADC 3 DIST 2	CONT IND 1	CDP–5		P66-2
MADC 6 DIST 1	WBSV – 1	CDP–2		P66-2
MADC 6 DIST 1	WBSV – 2	CDP–2		P66-2
MADC 6 DIST 1	WBSV – 3	CDP–2		P66-2
MADC 6 DIST 1	WBSV – 4 ①	CDP–2		P66-2
MADC 6 DIST 1	WBSV – 5	CDP–2		P66-2
MADC 6 DIST 1	WBSV – 6 ①	CDP–2		P66-2
MADC 3 DIST 2	**WITH AP** BI–SW–LNA	CDP–5		P66-2 ◀
MADC 3 DIST 2	**WITH AP** BI–LMTR–PREAMP	CDP–5		P66-2 ◀

① **WITH IDG** Banded open.

Figure 1-52 (Sheet 8 of 42)

Power Distribution Circuit Breaker List (Continued)

COMMUNICATIONS (CONT.)

BUS	C.B. NOMENCLATURE	SWITCH CONTROL	PH	PANEL
MADC 6 DIST 1	WBSV – 7	CDP-2		P66-2
MADC 6 DIST 1	WBSV – 8	CDP-2		P66-2
MADC 6 DIST 1	WBSV – 9	CDP-2		P66-2
MADC 6 DIST 1	WBSV – 10	CDP-2		P66-2
MADC 6 DIST 1	CONT IND 2	CDP-2		P66-2
MADC 6 DIST 2	TADIL – A1 DC			P66-2
MADC 6 DIST 2	WITH IDG VHF – AM 2 ②			P66-2◀
MADC 6 DIST 3	LESS IDG SATCOM SYS 2 CMPNTS			P66-2
MADC 6 DIST 3	SATCOM SYS 2 SIM			P66-2◀
MADC 6 DIST 3	WITH IDG SATCOM – SYSTEM 2 – CTRL			P66-2◀
MADC 3 DIST 4	ERV 2 DC			P66-2
MADC 3 DIST 4	ERV 2 DC ①			P66-2
MADC 3 DIST 4	ERV 3 DC ①			P66-2
TRU 6	MISSION POWER DISTRIBUTION DC DIST – 28V DC BUS 6 – WBSV ZERO			P66-2
MADC 6 DIST 3	HAVE QUICK RT 10 ①			P66-2
MADC 6 DIST 3	HAVE QUICK RT 11 ①			P66-2
MADC 6 DIST 3	HAVE QUICK RT 10/11 ①			P66-2
MAAC 7	WITH AP BI–PROC		C	P67–3◀

① Banded Open ② Pilot's VHF. Copilot's VHF is No. 1

Figure 1-52 (Sheet 9 of 42)

CREW ACCOMMODATIONS

BUS	C.B. NOMENCLATURE	PH	PANEL
AVAC 4	CREW HTR – ØB	B	P61-3
AVAC 4	CREW HTR – ØC	C	P61-3
AVAC 4	OXYGEN – QTY IND	B	P61-4
AVDC 2 MAIN	VIS WARN – NO SMOKING		P6
AVDC 2 MAIN	VIS WARN – SEAT BELTS		P6
AVDC 4 MAIN	OXYGEN & DOOR WARNING IND LT		P61-4
BAT BUS	ESSENTIAL LIGHTING – VIS WARN – BAILOUT CRASH LANDING		P6
GEN 8	MISSION POWER DISTRIBUTION – EQUIP & FURN – GALLEY (C3045)		P67-3
MAAC 6	EQUIPMENT AND FURNISHINGS – HEATER – WATER DRAIN MAST	C	P67-3
MAAC 7	EQUIPMENT AND FURNISHINGS – HEATERS – TOILET DRAIN & WL	A	P67-3
MAAC 7	EQUIPMENT AND FURNISHINGS – LAV ELEC SYS	B	P67-3
MAAC 7	EQUIPMENT AND FURNISHINGS – TOILET FLUSH MTR & TIMER		P67-3
28V MAC 5	EQUIPMENT AND FURNISHINGS – HEATERS – 28V WATER DRAIN MAST	B	P67-3

DATA DISPLAY AND CONTROL

BUS	C.B. NOMENCLATURE	PH	PANEL
MAAC 3	DATA DISPLAY AND CONTROL – ADU’S – SEAT NO 7		P67-2
MAAC 3	DATA DISPLAY AND CONTROL – ADU’S – SEAT NO 8		P67-2
MAAC 3	DATA DISPLAY AND CONTROL – MPC’S – SEAT NO 9		P67-2
MAAC 3	DATA DISPLAY AND CONTROL – MPC’S – SEAT NO 10		P67-2
MAAC 3	DATA DISPLAY AND CONTROL – MPC’S – SEAT NO 11		P67-2
MAAC 3	DATA DISPLAY AND CONTROL – MPC’S – SEAT NO 12		P67-2
MAAC 3	DATA DISPLAY AND CONTROL – MPC’S – SEAT NO 13		P67-2
MAAC 4	DATA DISPLAY AND CONTROL – DATA DISPLAY CONTROLLER – Z5		P67-2
MAAC 4	DATA DISPLAY AND CONTROL – DATA DISPLAY CONTROLLER – Z6		P67-2
MAAC 4	DATA DISPLAY AND CONTROL – MPC’S – SEAT NO 14		P67-2

Figure 1-52 (Sheet 10 of 42)

Power Distribution Circuit Breaker List (Continued)

DATA DISPLAY AND CONTROL (CONT.)

BUS	C.B. NOMENCLATURE	PH	PANEL
MAAC 4	DATA DISPLAY AND CONTROL – MPC'S – SEAT NO 15		P67-2
MAAC 4	DATA DISPLAY AND CONTROL – MPC'S – SEAT NO 16		P67-2
MAAC 4	DATA DISPLAY AND CONTROL – MPC'S – SEAT NO 17		P67-2
MAAC 3	DATA DISPLAY AND CONTROL – MPC'S – SEAT NO 18		P67-2
MAAC 3	DATA DISPLAY AND CONTROL – MPC'S – SEAT NO 20		P67-2
MAAC 3	DATA DISPLAY AND CONTROL – MPC'S – SEAT NO 22		P67-2
MAAC 3	DATA DISPLAY AND CONTROL – MPC'S – SEAT NO 23		P67-2
MAAC 3	DATA DISPLAY AND CONTROL – MPC'S – SEAT NO 24		P67-2

DATA PROCESSING

BUS	C.B. NOMENCLATURE	PH	PANEL
MAAC 3	DATA PROCESSING – COMPUTER		P67-1
MAAC 3	DATA PROCESSING – IAU		P67-1
MAAC 3	DATA PROCESSING – OPERATOR CONTR PNL AC		P67-1
MAAC 3	DATA PROCESSING – PERIPHERAL RACK – SPARE		P67-1
MAAC 3	DATA PROCESSING – PERIPHERAL RACK – II		P67-1
MADC 5 DIST 1	DATA PROCESSING – OPERATOR CONTR PNL DC		P67-1

DRAW THRU COOLING

BUS	C.B. NOMENCLATURE	PH	PANEL
AVAC 4	DRAW THRU CLG – FAN		P61-3
AVDC 4 MAIN	DRAW THRU CLG – ALT SWITCH NO 1		P61-3
AVDC 8 MAIN	DRAW THRU CLG – ALT SWITCH NO 2		P61-3
AVDC 8 MAIN	DRAW THRU CLG – FLOW CONTR VALVE		P61-3
GEN 4	DRAW THRU FAN HI SPEED (ELCU)		E-15

Figure 1-52 (Sheet 11 of 42)

ELECTRICAL

BUS	C.B. NOMENCLATURE	PH	PANEL
APU	APU PWR 115V AC – VOLTMETER (C1593)	A	P38
AVAC 2	115V AC BUS 2 – EMERG AC BUS (C1050)	A	P61-5
AVAC 2	115V AC BUS 2 – XFMR RECT UNIT NO 2 (C3046)		P61-5
AVAC 2	115V AC BUS 2 – 28V XFMR (C1097)	C	P61-5
AVAC 4	115V AC BUS 4 – XFMR RECT UNIT NO 4		P61-5
AVAC 6	115V AC BUS 6 – BATT CHGR		P61-6
AVAC 8	115V AC BUS 8 – XFMR RECT UNIT NO 8		P61-6
AVAC 8	115V AC BUS 8 – 28 VAC XFMR (C1119)	B	P61-6
AVDC 2	28V DC BUS 2 – BATT BUS (C176)		P61-5
AVDC 2	28V DC BUS 2 – EMERG DC BUS		P61-5
AVDC 2	28V DC BUS 2 – FLT AVIONICS BUS NO 1 ①		P61-5
AVDC 2	28V DC BUS 2 – FREQ REF UNIT		P61-5
AVDC 2	28V DC BUS 2 – INTGR DR GEN DISC 1 & 2		P61-5
AVDC 2	28V DC BUS 2 – INV		P61-5
AVDC 2	28V DC BUS 2 – MAIN BUS DISTR		P61-5
AVDC 2	28V DC BUS 2 – VOLTMETER		P61-5
AVDC 2	28V DC BUS 6 – MAIN BUS DISTR		P61-5
AVDC 4	28V DC BUS 4 – INTGR DR GEN DISC 3 & 4		P61-5
AVDC 4	28V DC BUS 4 – MAIN BUS DISTR		P61-5
AVDC 4	28V DC BUS 4 – VOLTMETER		P61-5
DC TIE	INTGR DR GEN DISC 5 & 6		P61-5
AVDC 8	28V DC BUS 8 – INTGR DR GEN DISC 7 & 8		P61-5
AVDC 8	28V DC BUS 8 – INTGR DR GEN TEMP		P61-5
AVDC 8	28V DC BUS 8 – MAIN BUS DISTR		P61-5
AVDC 8	28V DC BUS 8 – VOLTMETER		P61-5
BAT BUS	BATTERY BUS – BUS PWR CONT UNIT CONT		P61-6
BAT BUS	BATTERY BUS – EMERG PWR WARN IND		P61-6

① Controlled by Avionics Power Disconnect Panel – FLT AVIONICS BUS 1 DISCONNECT Switch

Figure 1-52 (Sheet 12 of 42)

Power Distribution Circuit Breaker List (Continued)

ELECTRICAL (CONT.)

BUS	C.B. NOMENCLATURE	PH	PANEL
BAT BUS	BATTERY BUS – GEN CONT UNIT NO 1		P61-6
BAT BUS	BATTERY BUS – GEN CONT UNIT NO 2		P61-6
BAT BUS	BATTERY BUS – GEN CONT UNIT NO 3		P61-6
BAT BUS	BATTERY BUS – GEN CONT UNIT NO 4		P61-6
BAT BUS	BATTERY BUS – GEN CONT UNIT NO 5		P61-6
BAT BUS	BATTERY BUS – GEN CONT UNIT NO 6		P61-6
BAT BUS	BATTERY BUS – GEN CONT UNIT NO 7		P61-6
BAT BUS	BATTERY BUS – GEN CONT UNIT NO 8		P61-6
BAT BUS	BATTERY BUS – MAINT ANN		P61-6
BAT BUS	BATTERY BUS – FLT AVX – DISC CONT		P61-6
BAT BUS	BATTERY BUS – COMM – DISC CONT		P61-6
BATTERY	HOT BATTERY BUS – BATT BUS CONT (C107)		P61-6
BATTERY	HOT BATTERY BUS – BATT BUS PWR		P61-6
BATTERY	HOT BATTERY BUS – BATTERY (C108)		NEXT TO BATT
BATTERY	HOT BATTERY BUS – BUS PWR CONT UNIT PROT (C200)		P61-6
BATTERY	HOT BATTERY BUS – EMERG DC BUS (C106)		P61-6
BATTERY	HOT BATTERY BUS – INV (C105)		P61-6
BATTERY	HOT BATTERY BUS – MAIN BUS DISTR (C103)		P61-6
BATTERY	HOT BATTERY BUS – VOLTMETER (C134)		P61-6
BATTERY CHARGER	HOT BATTERY BUS – BAT CHGR (C104)		P61-6
EMERG BATT TIE	BAT TIE		P61-6
EMERG BATT TIE	BAT BUS PWR		P61-6
EMERG BATT TIE	EMERG DC BUS		P61-6

Figure 1-52 (Sheet 13 of 42)

ELECTRICAL (CONT.)

BUS	C.B. NOMENCLATURE	PH	PANEL
EMERG BATT TIE	INV		P61-6
DC TIE	MISSION POWER DISTRIBUTION DC DIST – DC TIE BUS – BUS 3 (C548)		P66-1
DC TIE	MISSION POWER DISTRIBUTION DC DIST – DC TIE BUS – BUS 6 (C095)		P66-1
DC TIE	MISSION POWER DISTRIBUTION DC DIST – DC TIE BUS – BUS MISSION (C554)		P66-1
DC TIE	MISSION POWER DISTRIBUTION – DC TIE BUS – BUS 3		P67-3
DC TIE	MISSION POWER DISTRIBUTION – DC TIE BUS – BUS 5		P67-3
DC TIE	MISSION POWER DISTRIBUTION – DC TIE BUS – BUS 6		P67-3
DC TIE	MISSION POWER DISTRIBUTION – DC TIE BUS – MISSION		P67-3
DC TIE	28V DC TIE BUS – DC BUS 2		P61-5
DC TIE	28V DC TIE BUS – DC BUS 3, 5, & 6		P61-5
DC TIE	28V DC TIE BUS – DC BUS 4		P61-5
DC TIE	28V DC TIE BUS – DC BUS 8		P61-5
DC TIE	28V DC BUS 6 – INTGR DR GEN DISC 5 & 6 (C196)		P61-5
DC TIE	28V DC BUS 6 – MAIN BUS DISTR (C216)		P61-5
EXT PWR 1A	EXT PWR 1A 115V AC – BPCU 3Ø		P37
EXT PWR 1A	EXT PWR 1A 115V AC – HOT BUS WARN LTS	C	P37
EXT PWR 1A	EXT PWR 1A 115V AC – TR 3Ø (C3065)		P37
EXT PWR 1A	EXT PWR 1A 115V AC – VOLTMETER	A	P37
EXT PWR 1A TRU	BPCU 28V DC – GND PWR SENSING		P37
EXT PWR 1A TRU	EXT PWR TR 28V DC – BPCU		P37
EXT PWR 1A TRU	EXT PWR TR 28V DC – PWR IN USE LT		P37
EXT PWR 1B	EXT PWR 1B 115V AC – HOT BUS WARN LTS	C	P37
EXT PWR 1B	EXT PWR 1B 115V AC – VOLTAGE SENSING 3Ø		P37

Figure 1-52 (Sheet 14 of 42)

Power Distribution Circuit Breaker List (Continued)

ELECTRICAL (CONT.)

BUS	C.B. NOMENCLATURE	PH	PANEL
EXT PWR 2A	AUTO PRL – RIGHT	A	P38
EXT PWR 2A	EXT PWR 2A 115V AC – HOT BUS WARN LTS	C	P38
EXT PWR 2A	EXT PWR 2A 115V AC – VOLTAGE SENSING 3Ø		P38
EXT PWR 2B	EXT PWR 2B 115V AC – HOT BUS WARN LTS	C	P38
EXT PWR 2B	EXT PWR 2B 115V AC – VOLTAGE SENSING 3Ø		P38
TRU 8 (C215)	28V DC BUS POWER – FLT AV BUS 2 (C0319)		P5
GEN 1	BUS TIE BREAKER 1 (C3009)		P25
GEN 1	GENERATOR BREAKER 1 (C3001)		P25
GEN 1	MISSION POWER DISTRIBUTION AC DIST – MISSION LTS (C2559)	C	P66-1
GEN 1	MISSION POWER DISTRIBUTION AC DIST – 115V AC BUS 1 – DIST 1 (C3501)		P66-1
GEN 1	MISSION POWER DISTRIBUTION AC DIST – 28V AC XFMR (C2541)	B	P66-1
GEN 1	MISSION POWER DISTRIBUTION AC DIST – 115V AC BUS 1 – DIST 2 (C3502)		P66-1
GEN 1	MISSION POWER DISTRIBUTION AC DIST – VOLTMETER – GEN 1	C	P66-1
GEN 1	MISSION POWER DISTRIBUTION AC DIST – 115V AC BUS 1 – DIST 3 (C90021)		P66-1
GEN 2	BUS TIE BREAKER 2 (C3010)		P25
GEN 2	GENERATOR BREAKER 2 (C3002)		P25
GEN 2	MISSION POWER DISTRIBUTION AC DIST – 115V AC BUS 2 – DIST 1 (C3510)		P66-1
GEN 2	115V AC BUS 2 – DISTR BUS NO 2 (C3021)		P61-5
GEN 2	115V AC BUS 2 – FLT AVIONIC BUS NO 1 (C3062)		P61-5
GEN 2	115V AC BUS 2 – VOLTMETER	C	P61-5
GEN 3	BUS TIE BREAKER 3 (C3011)		P37
GEN 3	GENERATOR BREAKER 3 (C3003)		P23
GEN 3 (C3576)	MISSION POWER DISTRIBUTION – TRU – 3 (C3517)		P67-3
GEN 3	MISSION POWER DISTRIBUTION – 115V AC BUS 3 – DIST 1 (C3503)		P67-3

Figure 1-52 (Sheet 15 of 42)

ELECTRICAL (CONT.)

BUS	C.B. NOMENCLATURE	PH	PANEL
GEN 3	MISSION POWER DISTRIBUTION – 115V AC BUS 3 – DIST 2 (C3576)		P67-3
GEN 3	MISSION POWER DISTRIBUTION – VOLTMETER – GEN 3	C	P67-3
GEN 4	BUS TIE BREAKER 4 (C3012)		P23
GEN 4	GENERATOR BREAKER 4 (C3004)		P23
GEN 4 (C3511)	LIGHTING – BAT – 115V AC CHGR (C3071)		P67-1
GEN 4	MISSION POWER DISTRIBUTION – 115V AC BUS 4 – DIST 1 (C3511)		P67-3
GEN 4	115V AC BUS 4 – DISTR BUS NO 4 (C3022)		P61-5
GEN 4	115V AC BUS 4 – VOLTMETER	C	P61-5
GEN 4 (C3022)	115V AC BUS 4 – XFMR RECT UNIT NO 4 (C3047)		P61-5
GEN 5	BUS TIE BREAKER 5 (C3013)		P26
GEN 5	GENERATOR BREAKER 5 (C3005)		P26
GEN 5 (C3505)	$\boxed{B}$ LIGHTING POWER DISTRIBUTION – 28V AC BUS 5 (C2001)	A B	P67-1 ◀
GEN 5 (C3505)	MISSION POWER DISTRIBUTION – TRU – 5 (C3516)		P67-3
GEN 5	MISSION POWER DISTRIBUTION – 115V AC BUS 5 – DIST 1 (C3505)		P67-3
GEN 5	MISSION POWER DISTRIBUTION – VOLTMETER – GEN 5	C	P67-3
GEN 6	BUS TIE BREAKER 6 (C3014)		P26
GEN 6	GENERATOR BREAKER 6 (C3006)		P26
GEN 6 (C3512)	MISSION POWER DISTRIBUTION – TRU – 6 (C3560)		P67-3
GEN 6	MISSION POWER DISTRIBUTION – 115V AC BUS 6 – DIST 1 (C3512)		P67-3
GEN 6	115V AC BUS 6 – DISTR BUS NO 6 (C3023)		P61-6
GEN 6 (C3023)	115V AC BUS 6 – BATT CHGR (C3061)		P61-6
GEN 6	115V AC BUS 6 – VOLTMETER	C	P61-6
GEN 7	BUS TIE BREAKER 7 (C3015)		P28
GEN 7	GENERATOR BREAKER 7 (C3007)		P28

Figure 1-52 (Sheet 16 of 42)

Power Distribution Circuit Breaker List (Continued)

ELECTRICAL (CONT.)

BUS	C.B. NOMENCLATURE	PH	PANEL
GEN 7 (C3507)	C LIGHTING POWER DISTRIBUTION – 28V AC BUS 7 (C2001)	A	P67-1 ◀
GEN 7	MISSION POWER DISTRIBUTION – 115V AC BUS 7 – DIST 1 (C3507)		P67-3
GEN 7	MISSION POWER DISTRIBUTION – VOLTMETER – GEN 7	C	P67-3
GEN 8	BUS TIE BREAKER 8 (C3016)		P28
GEN 8	GENERATOR BREAKER 8 (C3008)		P28
GEN 8	MISSION POWER DISTRIBUTION – 115V AC BUS 8 – DIST 1 (C3509)		P67-3
GEN 8	115V AC BUS 8 – DISTR BUS NO 8 (C3027)		P61-6
GEN 8	115V AC BUS 8 – FLT AVIONIC BUS NO 2 (C3063)		P61-6
GEN 8	115V AC BUS 8 – VOLTMETER	C	P61-6
GEN 8 (C3027)	115V AC BUS 8 – XFMR RECT UNIT NO 8 (C3049)		P61-6
GEN 8 (C3027)	115V AC BUS 8 – 28V AC XFMR (C1098)	B	P61-6
MAAC 1 DIST 2	CONVENIENCE OUTLET – E1 RACK	C	P66
MAAC 1 DIST 2	CONVENIENCE OUTLET – FWD MAIN CABIN	C	P66
MAAC 3	MISSION POWER DISTRIBUTION – TRU – 3		P67-3
MAAC 5	MISSION POWER DISTRIBUTION – TRU – 5		P67-3
MAAC 8	CONVENIENCE OUTLET – AFT EQUIP BAY	C	P67-2
MAAC 8	CONVENIENCE OUTLET – MID MAIN CABIN	A	P67-2
MAAC 8	CONVENIENCE OUTLET – ROTODOME	B	P67-2
MADC 5	MISSION POWER DISTRIBUTION 28V DC – BUS 5 DIST 1		P67-3
MADC 5	MISSION POWER DISTRIBUTION 28V DC – BUS 5 DIST 2		P67-3
MADC 5	MISSION POWER DISTRIBUTION VOLTMETER – DC BUS 5		P67-3
MADC 6	MISSION POWER DISTRIBUTION DC DIST 28V DC BUS 6 – DIST 1		P66-1
MADC 6	MISSION POWER DISTRIBUTION DC DIST 28V DC BUS 6 – DIST 2		P66-1
MADC 6	MISSION POWER DISTRIBUTION DC DIST 28V DC BUS 6 – DIST 3		P66-1
MADC 6	MISSION POWER DISTRIBUTION DC DIST 28V DC BUS 6 – VM		P66-1

Figure 1-52 (Sheet 17 of 42)

ELECTRICAL (CONT.)

BUS	C.B. NOMENCLATURE	PH	PANEL
MADC 6	MISSION POWER DISTRIBUTION DC DIST 28V DC BUS 6 – WBSV ZERO		P66-1
TIE BUS	AUTO PRL – LEFT	A	P37
TIE BUS	AUTO PRL – RIGHT	A	P38
TRU 2 (C0122) BATTERY (C0106)	EMERG PWR CONT (C120)		P61-6
TRU 2 (C0176) BATTERY	HOT BATTERY BUS – BATT BUS PWR (C177)		P61-6
TRU 2 (C0097) TRU 4 (C0096) TRU 8 (C0094)	28V DC TIE BUS – DC BUS 3, 5 & 6 (C178)		P61-5
AVDC 2	28V DC BUS POWER – EMERG BUS (C318)		P5
TRU 2	28V DC BUS 2 – BATT BUS (C176)		P61-5
TRU 2	28V DC BUS 2 – EMERG DC BUS (C122)		P61-5
TRU 2	28V DC BUS 2 – FLT AVIONIC BUS NO 1 (C214)		P61-5
TRU 2	28V DC BUS 2 – FREQ REF UNIT (C190)		P61-5
TRU 2	28V DC BUS 2 – INTGR DR GEN DISC 1 & 2 (C192)		P61-5
TRU 2	28V DC BUS 2 – INV (C121)		P61-5
TRU 2	28V DC BUS 2 – MAIN BUS DISTR (C278)		P61-5
TRU 2	28V DC BUS 2 – VOLTMETER (C137)		P61-5
TRU 2	28V DC TIE BUS – DC BUS 2 (C097)		P61-5
TRU 3	MISSION POWER DISTRIBUTION DC DIST – DC TIE BUS – BUS 3 (C548)		P66-1
TRU 3	MISSION POWER DISTRIBUTION DC DIST – 28V DC BUS 3 – DIST 1 (C282)		P66-1
TRU 3	MISSION POWER DISTRIBUTION DC DIST – 28V DC BUS 3 – DIST 2 (C546)		P66-1

Figure 1-52 (Sheet 18 of 42)

Power Distribution Circuit Breaker List (Continued)

ELECTRICAL (CONT.)

BUS	C.B. NOMENCLATURE	PH	PANEL
TRU 3	MISSION POWER DISTRIBUTION DC DIST – 28V DC BUS 3 – MISSION LT (C610)		P66-1
TRU 3	MISSION POWER DISTRIBUTION – DC TIE BUS – BUS 3 (C322)		P67-3
TRU 3 (C322) TRU 5 (C597) TRU 6 (C323)	MISSION POWER DISTRIBUTION – DC TIE BUS – MISSION (C321)		P67-3
TRU 3	MISSION POWER DISTRIBUTION – VOLTMETER – DC BUS 3 (C600)		P67-3
TRU 3	MISSION POWER DISTRIBUTION – 28V DC – BUS 3 DIST 3 (C534)		P67-3
TRU 4	28V DC TIE BUS – DC BUS 4 (C096)		P61-5
TRU 4	28V DC BUS 4 – INTGR DR GEN DISC 3 & 4 (C194)		P61-5
TRU 4	28V DC BUS 4 – MAIN BUS DISTR (C279)		P61-5
TRU 4	28V DC BUS 4 – VOLTMETER (C136)		P61-5
TRU 5	MISSION POWER DISTRIBUTION – VOLTMETER – DC BUS 5 (C599)		P67-3
TRU 5	MISSION POWER DISTRIBUTION – DC TIE BUS – BUS 5 (C597)		P67-3
TRU 5	MISSION POWER DISTRIBUTION – 28V DC BUS 5 – DIST 1 (C535)		P67-3
TRU 5	MISSION POWER DISTRIBUTION – 28V DC BUS 5 – DIST 2 (C520)		P67-3
TRU 6	MISSION POWER DISTRIBUTION – DC TIE BUS – BUS 6 (C323)		P67-3
TRU 6	MISSION POWER DISTRIBUTION DC DIST – DC TIE BUS – BUS 6 (C095)		P66-1
TRU 6	MISSION POWER DISTRIBUTION DC DIST – 28V DC BUS 6 – DIST 1 (C284)		P66-1
TRU 6	MISSION POWER DISTRIBUTION DC DIST – 28V DC BUS 6 – DIST 2 (C536)		P66-1
TRU 6	MISSION POWER DISTRIBUTION DC DIST – 28V DC BUS 6 – DIST 3 (C547)		P66-1
TRU 6	MISSION POWER DISTRIBUTION DC DIST – 28V DC BUS 6 – VM (C135)		P66-1
TRU 8	28V DC BUS 8 – FLT AVIONIC BUS NO 2 (C215)		P61-5
TRU 8	28V DC BUS 2 – COMM DIST – NO 1 (C90014)		P61-5

Figure 1-52 (Sheet 19 of 42)

ELECTRICAL (CONT.)

BUS	C.B. NOMENCLATURE	PH	PANEL
TRU 8	28V DC BUS 2 – COMM DIST – NO 2 (C90013)		P61-5
TRU 8	28V DC BUS 8 – INTGR DR GEN DISC 7 & 8 (C198)		P61-5
TRU 8	28V DC BUS 8 – MAIN BUS DISTR (C280)		P61-5
TRU 8	28V DC BUS 8 – VOLTMETER (C138)		P61-5
TRU 8	28V DC TIE BUS – DC BUS 8 (C094)		P61-5
28 VAC 8	115V AC BUS 8 – 28V AC DIST 1		P61-6

ENGINE

BUS	C.B. NOMENCLATURE	PH	PANEL
AVAC 2	ENGINE START & INDICATORS – EGT & RPM (N_1) – ENG 1	A	P61-2
AVAC 2	ENGINE START & INDICATORS – ENGINE 2 – EPR	A	P61-2
AVAC 4	ENGINE START & INDICATORS – EGT & RPM (N_1) – ENG 2	C	P61-2
AVAC 4	ENGINE START & INDICATORS – ENGINE 1 – EPR	A	P61-2
AVAC 6	ENGINE START & INDICATORS – EGT & RPM (N_1) – ENG 3	C	P61-2
AVAC 6	ENGINE START & INDICATORS – ENGINE 4 – EPR	A	P61-2
AVAC 8	ENGINE START & INDICATORS – EGT & RPM (N_1) – ENG 4	A	P61-2
AVAC 8	ENGINE START & INDICATORS – ENGINE 3 – EPR	A	P61-2
AVDC 2 MAIN	ENGINE START & INDICATORS – ENGINE 2 – OIL QTY		P61-2
AVDC 2 MAIN	OIL PRESS LIGHTS – ENG 1		P61-2
AVDC 4 MAIN	ENGINE START & INDICATORS – ENGINE 1 – OIL QTY		P61-2
AVDC 4 MAIN	OIL PRESS LIGHTS – ENG 2		P61-2
AVDC 6	ENGINE START & INDICATORS – ENGINE 4 – OIL QTY		P61-2
AVDC 6	OIL PRESS LIGHTS – ENG 3		P61-2
AVDC 8 MAIN	ENGINE START & INDICATORS – ENGINE 3 – OIL QTY		P61-2
AVDC 8 MAIN	ENGINE START & INDICATORS – OIL PRESS LIGHTS – ENG 4		P61-2
EAC	ENGINE START & INDICATORS – APU ACCU PRESS	A	P61-2
EAC	ENGINE START & INDICATORS – CONTINUOUS IGN – ENG 1	A	P61-2

Figure 1-52 (Sheet 20 of 42)

Power Distribution Circuit Breaker List (Continued)

ENGINE (CONT.)

BUS	C.B. NOMENCLATURE	PH	PANEL
EAC	ENGINE START & INDICATORS – CONTINUOUS IGN – ENG 2	A	P61-2
EAC	ENGINE START & INDICATORS – CONTINUOUS IGN – ENG 3	A	P61-2
EAC	ENGINE START & INDICATORS – CONTINUOUS IGN – ENG 4	A	P61-2
28V AC 2	ENGINE START & INDICATORS – OIL PRESS & TEMP – ENG 1	C	P61-2
28V AC 2	ENGINE START & INDICATORS – OIL PRESS & TEMP – ENG 2	C	P61-2
28V AC 8	ENGINE START & INDICATORS – OIL PRESS & TEMP – ENG 3	B	P61-2
28V AC 8	ENGINE START & INDICATORS – OIL PRESS & TEMP – ENG 4	B	P61-2

ENGINE STARTING

BUS	C.B. NOMENCLATURE	PH	PANEL
BAT BUS	START CONTROL & IGNITION – ENG 1		P61-2
BAT BUS	START CONTROL & IGNITION – ENG 2		P61-2
BAT BUS	START CONTROL & IGNITION – ENG 3		P61-2
BAT BUS	START CONTROL & IGNITION – ENG 4		P61-2

ESMG

BUS	C.B. NOMENCLATURE	PH	PANEL
MAAC 3 DIST 1	ESMG – DC CONV		P67-3
MAAC 3 DIST 1	ESMG – FANS		P67-3
MADC 3 DIST 3	ESMG – CTL LOGIC	B	P67-3

Figure 1-52 (Sheet 21 of 42)

FIRE PROTECTION

BUS	C.B. NOMENCLATURE	PH	PANEL
AVDC 8 MAIN	FIRE PROTECTION – FIRE DETECTION – WHEEL WELL		P5
BAT BUS	FIRE PROTECTION – FIRE EXTINGUISHER – ENG 1		P5
BAT BUS	FIRE PROTECTION – FIRE EXTINGUISHER – ENG 2		P5
BAT BUS	FIRE PROTECTION – FIRE EXTINGUISHER – ENG 3		P5
BAT BUS	FIRE PROTECTION – FIRE EXTINGUISHER – ENG 4		P5
BAT BUS	FIRE PROTECTION – FIRE DETECTION – ENG 1		P5
BAT BUS	FIRE PROTECTION – FIRE DETECTION – ENG 2		P5
BAT BUS	FIRE PROTECTION – FIRE DETECTION – ENG 3		P5
BAT BUS	FIRE PROTECTION – FIRE DETECTION – ENG 4		P5
BAT BUS	FIRE PROTECTION – FIRE DETECTION – MASTER FIRE WARN		P5
BAT BUS	FIRE PROTECTION – SQUIB – ENG 1 (C128)		P5
BAT BUS	FIRE PROTECTION – SQUIB – ENG 2 (C129)		P5
BAT BUS	FIRE PROTECTION – SQUIB – ENG 3 (C130)		P5
BAT BUS	FIRE PROTECTION – SQUIB – ENG 4 (C131)		P5

FLIGHT CONTROLS

BUS	C.B. NOMENCLATURE	PH	PANEL
AVAC 8	FLIGHT CONTROLS – FLAPS – EMERG INBD MOTOR		P5
AVAC 8	FLIGHT CONTROLS – FLAPS – EMERG OUTBD MOTOR		P5
AVAC 8	FLIGHT CONTROLS – STAB TRIM – ACTR		P5
AVDC 8 MAIN	FLIGHT CONTROLS – FLAPS – BYPASS VALVE INBD		P5
AVDC 8 MAIN	FLIGHT CONTROLS – FLAPS – BYPASS VALVE OUTBD		P5
AVDC 8 MAIN	FLIGHT CONTROLS – FLAPS – LE POS IND		P5
AVDC 8 MAIN	FLIGHT CONTROLS – RUDDER – CONTROL		P5
AVDC 8 MAIN	FLIGHT CONTROLS – RUDDER – VALVE		P5
AVDC 8 MAIN	FLIGHT CONTROLS – SPOILER VAL – BYPASS INBD		P5
AVDC 8 MAIN	FLIGHT CONTROLS – SPOILER VAL – BYPASS OUTBD		P5

Figure 1-52 (Sheet 22 of 42)

Power Distribution Circuit Breaker List (Continued)

FLIGHT CONTROLS (CONT.)

BUS	C.B. NOMENCLATURE	PH	PANEL
AVDC 8 MAIN	FLIGHT CONTROLS – STAB TRIM – CONTROL		P5
EDC	EMERGENCY FLIGHT AVIONICS – YAW DMPR – PRL WARN		P5
EDC	EMERGENCY FLIGHT AVIONICS – YAW DMPR – SERIES WARN		P5
FAAC 1	YAW DAMPERS – SERIES ØA ①	A	P5
FAAC 2	YAW DAMPERS – PRL ØA ②	A	P5
28V AC 8 DIST 1	FLIGHT CONTROLS – FLAPS POS IND – INBD	A	P5
28V AC 8 DIST 1	FLIGHT CONTROLS – FLAPS POS IND – OUTBD	A	P5

① Controlled by APD–FLT AVIONICS – BUS 1.
② Controlled by APD–FLT AVIONICS – BUS 2.

FLIGHT INSTRUMENTS

BUS	C.B. NOMENCLATURE	PH	PANEL
AVDC 8 MAIN	FLIGHT CONTROLS – MACH WARN BELL ①		P5
WITH IDG FAVDC 1	FLIGHT NAVIGATION NO. 1 – ALT ALERT CMDR DC		P5◀
WITH IDG FAVDC 2	FLIGHT NAVIGATION NO. 1 – ALT ALERT PILOT DC		P5◀
WITH IDG EAC	EMERGENCY FLIGHT AVIONICS – VSI/TA CMDR	A	P5◀
WITH IDG EAC	EMERGENCY FLIGHT AVIONICS – VSI/TA PILOT	A	P5◀
EAC	EMERGENCY FLIGHT AVIONICS – NO 1 ATTD XFMR AC ②	A	P5
EDC	EMERGENCY FLIGHT AVIONICS – STBY ATTD IND		P5
EDC	EMERGENCY FLIGHT AVIONICS – XFR RELAY – CMDR INST		P5
EDC	EMERGENCY FLIGHT AVIONICS – XFR RELAY – PILOT INST		P5
FAAC 1	ATTD WARN – LEFT WING ØB (Including probe heater) ③	B	P5
FAAC 1	FLIGHT INSTRUMENTS NO 1 – AHRS ③		P5
FAAC 1	FLIGHT INSTRUMENTS NO 1 – FLT DIR – CMPTR ØA ③	A	P5
FAAC 1	FLIGHT INSTRUMENTS NO 1 – XFMR – BRG ØA ② ③	A	P5
FAAC 1	FLIGHT INSTRUMENTS NO 1 – XFMR – HDG ØA ② ③	A	P5
FAAC 1	AIR DATA – ØA (Also powers pilot's Mach counter)	A	P5
FAAC 2	AIR DATA – ØA ④ ⑥	A	P5
FAAC 2	ATTD WARN – RIGHT WING ØB (Including probe heater) ④	B	P5
FAAC 2	FLIGHT INSTRUMENTS NO 2 – AHRS ④	C	P5

Figure 1-52 (Sheet 23 of 42)

FLIGHT INSTRUMENTS (CONT.)

BUS	C.B. NOMENCLATURE	PH	PANEL
FAAC 2	FLIGHT INSTRUMENTS NO 2 – FLT DIR – CMPTR ØA ④	A	P5
FAAC 2	FLIGHT INSTRUMENTS NO 2 – XFMR – ATT ØA ② ④	A	P5
FAAC 2	FLIGHT INSTRUMENTS NO 2 – XFMR – BRG ØA ② ④	A	P5
FAAC 2	FLIGHT INSTRUMENTS NO 2 – XFMR – HDG ØA ② ④	A	P5
FAAC 2	CVR ØA ④	A	P5
FAAC 2	FLT LOADS – RCDR ØC ④ ⑤	C	P5
FAAC 2	DFDR ØA	A	P5
FAVDC 1	AIR DATA – ALTM VIB NO 1 ③		P5
FAVDC 1	ANGLE ATTACK NO 1 ③		P5
FAVDC 1	ATTD WARN – SHAKER DC 1 ③		P5
FAVDC 1	FLIGHT INSTRUMENTS NO 1 – FLT DIR – DC ③		P5
FAVDC 1	FLIGHT INSTRUMENTS NO 1 – TURN RATE DC ③		P5
WITH IDG 28 VAC 2	FLIGHT INSTRUMENTS NO. 2 – ALT ALERT CMDR AC	A	P5◀
WITH IDG 28 VAC 8 DIST 1	FLIGHT INSTRUMENTS NO. 2 – ALT ALERT PILOT AC	A	P5◀
FAVDC 2	AIR DATA – ALTM VIB NO 2 ④		P5
FAVDC 2	ANGLE ATTACK NO 2 ④		P5
FAVDC 2	ATTD WARN – SHAKER DC 2 ④		P5
FAVDC 2	CPI/FDR–CVR/DFDR DC ④		P5
FAVDC 2	CVR/DFDR DC ④		P5
FAVDC 2	FLIGHT INSTRUMENTS NO 2 – FLT DIR – DC ④		P5
FAVDC 2	FLIGHT INSTRUMENTS NO 2 – TURN RATE DC ④		P5
FAVDC 2	FLT LOADS – RCDR DC ④ ⑤		P5

① Also supplies power to takeoff warning system.

② Transformer supplies 26V AC.

③ Controlled by APD–FLT AVIONICS – BUS 1.

④ Controlled by APD–FLT AVIONICS – BUS 2.

⑤ Banded open except 3 5 ▶ 9 , 24 .

⑥ Also powers navigator's SAT and TAS gages, and copilot's Mach counter.

Figure 1-52 (Sheet 24 of 42)

Power Distribution Circuit Breaker List (Continued)

FORCED AIR COOLING

BUS	C.B. NOMENCLATURE	PH	PANEL
AVAC 4	FORCED AIR COOLING – VALVES – FWD E20/21 CAB/DIV	C	P61-3
AVAC 4	FORCED AIR COOLING – VALVES – E3/4/8 E10/12	C	P61-3
AVAC 4	FORCED AIR COOLING – VALVES – AFT E13/14/17/28 CAB/DIV RADAR	C	P61-3
AVAC 4	FORCED AIR COOLING – VALVES – AFT E51	B	P61-3
AVAC 4	FORCED AIR COOLING – VALVES – AFT TEMP C HE/OB/BYPASS	A	P61-3
AVAC 4	FORCED AIR COOLING – VALVES – FWD E19/23	B	P61-3
AVAC 4	FORCED AIR COOLING – VALVES – FWD E2	A	P61-3
AVAC 4	FORCED AIR COOLING – VALVES – FWD TEMP C HE/OB/BYPASS	A	P61-3
AVDC 4 MAIN	FORCED AIR COOLING – FAN – NO 2 AFT		P61-3
AVDC 4 MAIN	FORCED AIR COOLING – FAN – NO 2 FWD		P61-3
AVDC 4 MAIN	FORCED AIR COOLING – SYS CONTR – VALVE RELAYS AFT		P61-3
AVDC 4 MAIN	FORCED AIR COOLING – SYS CONTR – VALVE RELAYS FWD		P61-3
AVDC 8 MAIN	FORCED AIR COOLING – FAN – NO 1 AFT		P61-3
AVDC 8 MAIN	FORCED AIR COOLING – FAN – NO 1 FWD		P61-3
AVDC 8 MAIN	FORCED AIR COOLING – SYS CONTR – LOGIC AFT		P61-3
AVDC 8 MAIN	FORCED AIR COOLING – SYS CONTR – LOGIC FWD		P61-3
MADC 5 DIST 2	COOLING AIR – COMM – AFT		P67-3
MADC 5 DIST 2	COOLING AIR – COMM – FWD		P67-3
MADC 5 DIST 2	COOLING AIR – DPFG/IFF – AFT		P67-3
MADC 5 DIST 2	COOLING AIR – DPFG/IFF – FWD		P67-3
GEN 3	FWD AFAC NO 1 FAN LO SPEED (ELCU)		E15
GEN 3	FWD AFAC NO 1 FAN HI SPEED (ELCU)		E15

Figure 1-52 (Sheet 25 of 42)

FORCED AIR COOLING (CONT.)

BUS	C.B. NOMENCLATURE	PH	PANEL
GEN 5	FWD AFAC NO 2 FAN LO SPEED (ELCU)		E16
GEN 5	FWD AFAC NO 2 FAN HI SPEED (ELCU)		E16
GEN 7	AFT AFAC NO 1 FAN LO SPEED (ELCU)		E16
GEN 7	AFT AFAC NO 1 FAN HI SPEED (ELCU)		E16
GEN 7	ANTENNA PEDESTAL ECS FAN (ELCU)		E16
GEN 8	AFT AFAC NO 2 FAN LO SPEED (ELCU)		E16
GEN 8	AFT AFAC NO 2 FAN HI SPEED (ELCU)		E16
BAT BUS	FAC–OVBD VALVES–AC OVRD RELAYS		P61-3

FUEL

BUS	C.B. NOMENCLATURE	PH	PANEL
AVAC 2	BOOST PUMPS – TANK 1 – FWD ② ③	C	P61-1
AVAC 2	BOOST PUMPS – TANK 4 – AFT ② ③	C	P61-1
AVAC 2	INDICATORS – FLOW – ENG 1	C	P61-1
AVAC 2	REFUELING – DMP CHUTE – L	B	P61-1
AVAC 4	BOOST PUMPS – CENTER TANK – L	C	P61-1
AVAC 4	BOOST PUMPS – TANK 2 – FWD ② ③		P61-1
AVAC 4	BOOST PUMPS – TANK 3 – AFT ② ③		P61-1
AVAC 4	INDICATORS – FLOW – ENG 2	C	P61-1
AVAC 4	INDICATORS – QUANTITY – L TANKS & RMANNG AMPL ①	A	P61-1
AVAC 6	BOOST PUMPS – CENTER TANK – R		P61-1
AVAC 6	BOOST PUMPS – TANK 2 – AFT ② ③		P61-1
AVAC 6	BOOST PUMPS – TANK 3 – FWD ② ③		P61-1
AVAC 6	INDICATORS – FLOW – ENG 3	C	P61-1
AVAC 6	INDICATORS – QUANTITY – R TANK & CTR	A	P61-1

① Powers only, fuel quantity system for main tanks 1 and 2 and reserve tank 1.

② LESS SOTA Individual 3 amp breaker for each phase. ◀

③ WITH SOTA Individual 5 amp breaker for each phase. ◀

Figure 1-52 (Sheet 26 of 42)

Power Distribution Circuit Breaker List (Continued)

FUEL (CONT.)

BUS	C.B. NOMENCLATURE	PH	PANEL
AVAC 8	BOOST PUMPS – TANK 1 – AFT ② ③		P61-1
AVAC 8	BOOST PUMPS – TANK 4 – FWD ② ③		P61-1
AVAC 8	INDICATORS – FLOW – ENG 4	C	P61-1
AVAC 8	INDICATORS – REMAINING – IND	B	P61-1
AVAC 8	REFUELING – DMP CHUTE – R	C	P61-1
AVDC 2 MAIN	BOOST PUMPS – LOW PRESS LIGHT – 4 FWD & 1 AFT		P61-1
AVDC 2 MAIN	HEAT EXCH VALVES – NO 1		P61-1
AVDC 2 MAIN	INDICATORS – FUEL HT VAL & ICING LT – ENG 1		P61-1
AVDC 2 MAIN	INDICATORS – OHEAT & HT VAL LT – & TEMP AMPL TANK 1 & 2		P61-1
AVDC 2 MAIN	INDICATOR – QUANTITY – LOW LEVEL WARN LIGHT		P61-1
AVDC 2 MAIN	INDICATORS – REMAINING – RESET		P61-1
AVDC 2 MAIN	REFUELING – DUMP & TRANSFER VALVES – TK1 & RES TK1		P61-1
AVDC 2 MAIN	REFUELING – DUMP & TRANSFER VALVES – TK2 & L CTR TK		P61-1
AVDC 2 MAIN	REFUELING – SLWY DR & TOG LCH – MANUAL		P61-1
AVDC 2 MAIN	SHUTOFF VALVES – PRIMARY – ENG 1		P61-1
AVDC 4 MAIN	BOOST PUMPS – LOW PRESS LIGHT – 3 FWD & 2 AFT R CENTER		P61-1
AVDC 4 MAIN	HEAT EXCH VALVES – NO 2		P61-1
AVDC 4 MAIN	INDICATORS – FUEL HT VAL & ICING LT – ENG 2		P61-1
AVDC 4 MAIN	SHUTOFF VALVES – PRIMARY – ENG 2		P61-1
AVDC 6	BOOST PUMPS – LOW PRESS LIGHT – 2 FWD & 3 AFT L CENTER		P61-1
AVDC 6	HEAT EXCH VALVES – NO 3		P61-1
AVDC 6	INDICATORS – FUEL HT VAL & ICING LT – ENG 3		P61-1
AVDC 6	SHUTOFF VALVES – PRIMARY – ENG 3		P61-1
AVDC 8 MAIN	BOOST PUMPS – LOW PRESS LIGHT – 1 FWD & 4 AFT		P61-1
AVDC 8 MAIN	HEAT EXCH VALVES – NO 4		P61-1
AVDC 8 MAIN	INDICATORS – FUEL HT VAL & ICING LT – ENG 4		P61-1

② LESS SOTA Individual 3 amp breaker for each phase. ◀

③ WITH SOTA Individual 5 amp breaker for each phase. ◀

Figure 1-52 (Sheet 27 of 42)

FUEL (CONT.)

BUS	C.B. NOMENCLATURE	PH	PANEL
AVDC 8 MAIN	INDICATORS – OHEAT & HT VAL LT – & TEMP AMPL TANK 3 & 4		P61-1
AVDC 8 MAIN	REFUELING – DUMP & TRANSFER VALVES – TK3 & R CTR TK		P61-1
AVDC 8 MAIN	REFUELING – DUMP & TRANSFER VALVES – TK4 & RES TK4		P61-1
AVDC 8 MAIN	REFUELING – SLWY DR & TOG LCH – NORMAL		P61-1
AVDC 8 MAIN	SHUTOFF VALVES – PRIMARY – ENG 4		P61-1
BAT BUS	CROSSFEED VALVES – NO 1		P61-1
BAT BUS	CROSSFEED VALVES – NO 2		P61-1
BAT BUS	CROSSFEED VALVES – NO 3		P61-1
BAT BUS	CROSSFEED VALVES – NO 4		P61-1
BAT BUS	REFUELING – PRE CK VALVES		P61-1
BAT BUS	REFUELING – REFUEL VALVES – CONTROL		P61-1
BAT BUS	REFUELING – REFUEL VALVES – INBD A		P61-1
BAT BUS	REFUELING – REFUEL VALVES – INBD B		P61-1
BAT BUS	REFUELING – REFUEL VALVES – OUTBD A		P61-1
BAT BUS	REFUELING – REFUEL VALVES – OUTBD B		P61-1
EAC	INDICATORS – QUANTITY – GND REFUEL BATT	A	P61-1
HOT BAT MAIN DIST	REFUELING – ISLN VALVE & SEC FLT SYS		P61-1
HOT BAT MAIN DIST	SHUTOFF VALVES – ALTERNATE – ENG 1		P61-1
HOT BAT MAIN DIST	SHUTOFF VALVES – ALTERNATE – ENG 2		P61-1
HOT BAT MAIN DIST	SHUTOFF VALVES – ALTERNATE – ENG 3		P61-1
HOT BAT MAIN DIST	SHUTOFF VALVES – ALTERNATE – ENG 4		P61-1
28V AC 2	INDICATORS – TEMP	C	P61-1

Figure 1-52 (Sheet 28 of 42)

Power Distribution Circuit Breaker List (Continued)

HAVE SIREN

BUS	C.B. NOMENCLATURE	PH	PANEL
AVDC 4	28V DC SDS PWR – OCU BUS 4		P61-5
AVDC 2	28V DC SDS PWR – NO. 1 BUS 2		P61-5
AVDC 4	28V DC SDS PWR – NO. 2 BUS 4		P61-5
AVDC 6	28V DC SDS PWR – NO. 3 BUS 6		P61-5
AVDC 8	28V DC SDS PWR – NO. 4 BUS 8		P61-5
AVDC 6	TR6 TO P61		P38

HYDRAULICS

BUS	C.B. NOMENCLATURE	PH	PANEL
AVAC 4	HYDRAULIC – AUX PUMPS – NO 2 POWER	C	P61-4
AVDC 4 MAIN	HYDRAULIC – AUX PUMPS – CONTR NO 2		P61-4
AVDC 4 MAIN	HYDRAULIC – GAGES – BRAKE & SYS INTCON VALVES		P61-4
AVDC 4 MAIN	HYDRAULIC – HEAT EXCH – BYPASS VALVE UTILITY		P61-4
AVDC 4 MAIN	HYDRAULIC – UTILITY – LOW PRESS – ENG 2		P61-4
AVDC 4 MAIN	HYDRAULIC – UTILITY – LOW PRESS – ENG 3		P61-4
AVDC 4 MAIN	ROTODOME – UTILITY – DRIVE UNIT		P61-4
AVDC 4 MAIN	ROTODOME – UTILITY – LUBE PRESS SW		P61-4
AVDC 8 MAIN	HYDRAULIC – AUX PUMPS – CONTR NO 1		P61-4
AVDC 8 MAIN	HYDRAULIC – GAGES – QTY		P61-4
AVDC 8 MAIN	HYDRAULIC – HEAT EXCH – BYPASS VALVE AUX		P61-4
AVDC 8 MAIN	HYDRAULIC – UTILITY – PUMP DEPRESS 2 & 3		P61-4
AVDC 8 MAIN	ROTODOME – AUXILIARY – DRIVE UNIT		P61-4
AVDC 8 MAIN	ROTODOME – AUXILIARY – LUBE PRESS SW		P61-4
AVDC 8 MAIN	ROTODOME – AUXILIARY – SOV		P61-4
BAT BUS	HYDRAULIC – AUX PUMPS – LOW PRESS LIGHTS		P61-4
BAT BUS	HYDRAULIC – ROTODOME – SOV		P61-4
BAT BUS	HYDRAULIC – UTILITY – HYD FLD SOV – ENG 2		P61-4
BAT BUS	HYDRAULIC – UTILITY – HYD FLD SOV – ENG 3		P61-4
GEN 2	AUX HYD NO 1 PUMP (ELCU)		E-15
28V AC 2	HYDRAULIC – GAGES – UTILITY PRESS ENG 2	C	P61-4
28V AC 8	HYDRAULIC – GAGES – AUX & BRAKE PRESS	B	P61-4
28V AC 8	HYDRAULIC – GAGES – UTILITY PRESS ENG 3	B	P61-4

Figure 1-52 (Sheet 29 of 42)

ICE AND RAIN PROTECTION

BUS	C.B. NOMENCLATURE	PH	PANEL
AVAC 2	ICE & RAIN PROTECTION – WINDOW HEAT – LEFT WINDOW CONTR	B	P61-2
AVAC 2	ICE & RAIN PROTECTION – WINDOW HEAT – L NO 1 R NO 2	B	P61-2
AVAC 2	ICE & RAIN PROTECTION – WINDOW HEAT – LEFT WINDOW NO 3, 4 & 5	B	P61-2
AVAC 4	ICE & RAIN PROTECTION – PROBE HEAT – Q SPR HTR	A	P61-2
AVAC 4	ICE & RAIN PROTECTION – PROBE HEAT – RIGHT PITOT & AUX	C	P61-2
AVAC 4	ICE & RAIN PROTECTION – PROBE HEAT – RIGHT TAT & ANGLE ATTACK 2 (Also powers TAT gage)	B	P61-2
AVAC 6	ICE & RAIN PROTECTION – PROBE HEAT – CMDR PITOT & ANGLE ATTACK 1	C	P61-2
AVAC 6	ICE & RAIN PROTECTION – WINDOW HEAT – RIGHT WINDOW CONTR	B	P61-2
AVAC 6	ICE & RAIN PROTECTION – WINDOW HEAT – L NO 2 R NO 1	B	P61-2
AVAC 6	ICE & RAIN PROTECTION – WINDOW HEAT – RIGHT WINDOW NO 3, 4 & 5	B	P61-2
AVDC 2 MAIN	ICE & RAIN PROTECTION – ENG NOSE COWL AI VAL – NO 1		P61-2
AVDC 2 MAIN	ICE & RAIN PROTECTION – NACELLE ANTI–ICE VAL – NO 1		P61-2
AVDC 2 MAIN	ICE & RAIN PROTECTION – WINDOW HEAT – LDC CONTR		P61-2
AVDC 4 MAIN	ICE & RAIN PROTECTION – WSHLD WPR – LEFT		P61-2
AVDC 8 MAIN	ICE & RAIN PROTECTION – ENG NOSE COWL AI VAL – NO 4		P61-2
AVDC 8 MAIN	ICE & RAIN PROTECTION – NACELLE ANTI–ICE VAL – NO 4		P61-2
AVDC 8 MAIN	ICE & RAIN PROTECTION – WINDOW HEAT – RDC CONTR		P61-2
AVDC 8 MAIN	ICE & RAIN PROTECTION – WSHLD WPR – RIGHT		P61-2
BAT BUS	ICE & RAIN PROTECTION – ENG NOSE COWL AI VAL – NO 2		P61-2
BAT BUS	ICE & RAIN PROTECTION – ENG NOSE COWL AI VAL – NO 3		P61-2
BAT BUS	ICE & RAIN PROTECTION – NACELLE ANTI–ICE VAL – NO 2		P61-2
BAT BUS	ICE & RAIN PROTECTION – NACELLE ANTI–ICE VAL – NO 3		P61-2
28V AC 2	ICE & RAIN PROTECTION – PROBE HEAT – PROBE HTR IND	C	P61-2

Figure 1-52 (Sheet 30 of 42)

Power Distribution Circuit Breaker List (Continued)

IFF MISSION

BUS	C.B. NOMENCLATURE	PH	PANEL
MAAC 3	IDENTIFICATION – PHASE CONTR	A	P67-1
MAAC 3	IDENTIFICATION – PSU 1	C	P67-1
MAAC 3	IDENTIFICATION – PSU 2	B	P67-1
MAAC 3	IDENTIFICATION – RT 1 B	C	P67-1
MAAC 3	IDENTIFICATION – RT 2	B	P67-1
MADC 5 DIST 1	IDENTIFICATION – PWR CONTR		P67-1

LANDING GEAR

BUS	C.B. NOMENCLATURE	PH	PANEL
AVDC 8	FLIGHT CONTROLS – WARN HORN CUTOUT RELAY ①		P5
AVDC 8	LANDING GEAR – POS LIGHTS		P5
AVDC 8	LANDING GEAR – SAFETY – LEFT RLY		P5
AVDC 8	LANDING GEAR – SAFETY – RIGHT RLY & LEVER LATCH		P5
AVDC 8	LANDING GEAR – WARN HORN ②		P5

① Also provides power to cabin altitude (10,000 foot cabin switch) warning switch and EMERGENCY DEPRESS switch.

② Also acts as cabin altitude warning horn.

LIGHTING

BUS	C.B. NOMENCLATURE	PH	PANEL
AVAC 4	ESSENTIAL LIGHTING – FLIGHT DECK – DOME	C	P6
AVAC 4	EXTERIOR LIGHTS – BCN – UPPER	A	P6
AVAC 4	EXTERIOR LIGHTS – EMERG EXIT	C	P6
AVAC 4	EXTERIOR LIGHTS – LANDING LIGHTS – FIXED LEFT HAND	A	P6
AVAC 4	EXTERIOR LIGHTS – LANDING LIGHTS – FIXED RIGHT HAND	B	P6
AVAC 4	EXTERIOR LIGHTS – LANDING LIGHTS – RETRACT LEFT HAND	B	P6

Figure 1-52 (Sheet 31 of 42)

LIGHTING (CONT.)

BUS	C.B. NOMENCLATURE	PH	PANEL
AVAC 4	EXTERIOR LIGHTS – LANDING LIGHTS – RETRACT RIGHT HAND	C	P6
AVAC 4	FLIGHT ENGINEERS INST PNL – BKGD – FLOOD	C	P7
AVAC 4 (C1508)	FLIGHT ENGINEERS INST PNL – BKGD – SEC	A	P7
AVAC 4	FLIGHT ENGINEERS INST PNL – MAIN	C	P7
AVAC 4	FLIGHT ENGINEERS INST PNL – BHD PNL	C	P7
AVAC 4	FLIGHT ENGINEERS INST PNL – LOWER – IND L	C	P7
AVAC 4	FLIGHT ENGINEERS INST PNL – LOWER – IND R & EXT	C	P7
AVAC 4	FLIGHT ENGINEERS INST PNL – LOWER – LEGEND	C	P7
AVAC 4	FLIGHT ENGINEERS INST PNL – UPPER – IND L	C	P7
AVAC 4	FLIGHT ENGINEERS INST PNL – UPPER – IND R & EXT	C	P7
AVAC 4	FLIGHT ENGINEERS INST PNL – UPPER – LEGEND	C	P7
AVAC 4	NAVIGATOR – PANEL – TABLE	C	P7
AVAC 6	EXTERIOR LIGHTS – BCN – LOWER	C	P6
AVDC 2 MAIN	ESSENTIAL LIGHTING – EXTERIOR – AFT		P6
AVDC 2 MAIN	ESSENTIAL LIGHTING – EXTERIOR – ARM		P6
AVDC 2 MAIN	ESSENTIAL LIGHTING – EXTERIOR – FWD		P6
AVDC 2 MAIN	ESSENTIAL LIGHTING – FLIGHT DECK – RADIO PANEL FLOOD		P6
AVDC 2 MAIN	EXTERIOR LIGHTS – LANDING LIGHTS – MOTOR LEFT HAND		P6
AVDC 2 MAIN	EXTERIOR LIGHTS – LANDING LIGHTS – MOTOR RIGHT HAND		P6
AVDC 2 MAIN	EXTERIOR LIGHTS – NAV – DC		P6
AVDC 2 MAIN	EXTERIOR LIGHTS – BCN – STROBE – UPPER		P6
AVDC 2 MAIN	EXTERIOR LIGHTS – BCN – STROBE – LOWER		P6
AVDC 2 MAIN	FLIGHT ENGINEERS INST PNL – IND LT MASTER TEST		P7
AVDC 2 MAIN	MAIN INSTRUMENT PANELS – IND LT – TEST & DIM		P7
AVDC 2 MAIN	NAVIGATOR – PANEL – TABLE & BKGD OVERRIDE CONTR		P7
AVDC 2 MAIN	NAVIGATOR – PANEL – IND LT MASTER – TEST		P7

Figure 1-52 (Sheet 32 of 42)

Power Distribution Circuit Breaker List (Continued)

LIGHTING (CONT.)

BUS	C.B. NOMENCLATURE	PH	PANEL
BAT BUS	ESSENTIAL LIGHTING – FLIGHT DECK – CMDR FLT KIT & MAP		P6
BAT BUS LIGHTING	ESSENTIAL LIGHTING – FLIGHT DECK – EMERG BKGD LIGHTS		P6
BAT BUS	ESSENTIAL LIGHTING – FLIGHT DECK – PILOT FLT KIT & MAP		P6
E.L. BAT	LIGHTING – BAT – BUS TIE P66 (C307) ①		P67-1
E.L. BAT	LIGHTING – COMM – COMPT EMER CEILING (C291) ①		P66
E.L. BAT	LIGHTING – EMERGENCY – AFT CEILING (C300) ①		P67-1
E.L. BAT	LIGHTING – EMERGENCY – AFT ENTRY (C301) ①		P67-1
E.L. BAT	LIGHTING – EMERGENCY – AFT EQUIP BAY (C299) ①		P67-1
E.L. BAT	LIGHTING – EMERGENCY – AISLE (C302) ①		P67-1
E.L. BAT	LIGHTING – EMERGENCY – AREA (C303) ①		P67-1
E.L. BAT	LIGHTING – EMERGENCY – AREA CONTR (C295) ①		P67-1
E.L. BAT	LIGHTING – EMERGENCY – BAT PWR CONTR RELAY (C294) ①		P67-1
E.L. BAT	LIGHTING – EMERGENCY – OVHD NO 1 (C296) ①		P67-1
E.L. BAT	LIGHTING – EMERGENCY – OVHD NO 2 (C297) ①		P67-1
E.L. BAT	LIGHTING – EMERGENCY – OVHD NO 3 (C298) ①		P67-1
E.L. BAT	LIGHTING – FWD EMER – ENTRY (C292)		P66
E.L. BAT	LIGHTING – FWD EMER – EQUIP BAY (C290)		P66
EAC	ESSENTIAL LIGHTING – FLIGHT DECK – MN INST PANEL BKGD & FLOOD	A	P6
EAC	ESSENTIAL LIGHTING – FLIGHT DECK – COMPASS	A	P6
EMER LIGHTING BATTERY	LIGHTING – BATTERY (C326)		STA 370
EMER LIGHTING BATTERY	LIGHTING – BATTERY CHARGER (C305)		STA 370

① E.L. BATT Source of Power is via the Battery Bus and the C308 Circuit Breaker.

Figure 1-52 (Sheet 33 of 42)

LIGHTING (CONT.)

BUS	C.B. NOMENCLATURE	PH	PANEL
GEN 8 28V AC XFMR	115V AC BUS 8 – 28V AC DISTR 1	B	P61-6
MAAC 1 DIST 2	LIGHTING – FWD CEILING NO 1	C	P66
MAAC 1 LIGHTING	LIGHTING – COMM – SPC	C	P66
MAAC 1 LIGHTING	LIGHTING – INDIRECT – CONTR DIM FWD	C	P66
MAAC 1 LIGHTING	LIGHTING – INDIRECT – FWD	C	P66
MAAC 1 LIGHTING	LIGHTING – SPC – DIM	C	P66
MAAC 1 LIGHTING	LIGHTING – SPC – DPFG	C	P66
MAAC 4	LIGHTING – AFT CEILING – NO 1	A	P67-1
MAAC 4	LIGHTING – AFT CEILING – NO 2	A	P67-1
MAAC 4	LIGHTING – AFT CEILING – NO 3	A	P67-1
MAAC 4	LIGHTING – BAT – 115V AC CHGR	A	P67-1
MAAC 4	LIGHTING – IND DIM NO 1	B	P67-1
MAAC 4	LIGHTING – IND DIM NO 2	B	P67-1
MAAC 4	LIGHTING – INDIRECT – NO 1	A	P67-1
MAAC 4	LIGHTING – INDIRECT – NO 2	B	P67-1
MAAC 4	LIGHTING – INDIRECT – NO 3	C	P67-1
MAAC 4	LIGHTING – INDIRECT – NO 4	C	P67-1
MAAC 7	LIGHTING POWER DISTRIBUTION – 28V AC BUS 7	A	P67-3
MADC 3 LIGHTING	LIGHTING – FWD EQUIP BAY – CONTR		P66
MADC 3 LIGHTING	LIGHTING – FWD OVHD FLOOD – CONTR		P66
MADC 3 LIGHTING	LIGHTING – INDIRECT – CONTR FWD		P66

Figure 1-52 (Sheet 34 of 42)

Power Distribution Circuit Breaker List (Continued)

LIGHTING (CONT.)

BUS	C.B. NOMENCLATURE	PH	PANEL
MADC 3 LIGHTING	LIGHTING – SPC – CONTR RELAYS		P66
MADC 5 DIST 1	LIGHTING – AFT EQUIP BAY – CONTR		P67-1
MADC 5 DIST 1	LIGHTING – IND CONTR – NO 1		P67-1
MADC 5 DIST 1	LIGHTING – IND CONTR – NO 2		P67-1
MADC 5 DIST 1	LIGHTING – OVERHEAD FLOOD – FWD CONTR		P67-1
28V AC 2	MAIN INSTRUMENT PANELS – OVERHEAD PANEL – MAIN	C	P7
28V AC 2	MAIN INSTRUMENT PANELS – PILOTS PNL – IND	C	P7
28V AC 2	MAIN INSTRUMENT PANELS – PILOTS PNL – LEGEND	C	P7
28V AC 2	MAIN INSTRUMENT PANELS – PILOTS PNL – MAIN	C	P7
28V AC 2	NAVIGATOR – MAIN PNL SEXTANT	C	P7
28V AC 2	NAVIGATOR – PANEL – IND	C	P7
28V AC 2	NAVIGATOR – PANEL – LEGEND	C	P7
28V AC 2	RADIO PANEL – MAIN	C	P7
28V AC 2	RADIO PANEL – 5V AC – FWD	C	P7
28V AC 2	RADIO PANEL – 5V AC – REAR	C	P7
28V AC 8 DIST 1	EXTERIOR LIGHTS – NAV – AC	B	P6
28V AC 8 DIST 1	EXTERIOR LIGHTS – REFUEL SLIPWAY	B	P6
28V AC 8 DIST 1	EXTERIOR LIGHTS – RWY TURNOFF – LEFT HAND	B	P6
28V AC 8 DIST 1	EXTERIOR LIGHTS – RWY TURNOFF – RIGHT HAND	B	P6
28V AC 8 DIST 1	EXTERIOR LIGHTS – WHEEL WELL	B	P6
28V AC 8 DIST 1	EXTERIOR LIGHTS – WING ILLUM	B	P6

Figure 1-52 (Sheet 35 of 42)

LIGHTING (CONT.)

BUS	C.B. NOMENCLATURE	PH	PANEL
28V AC 8 DIST 1	FLIGHT ENGINEERS INST PNL – CKT BKR PANEL	B	P7
26V AC 8 DIST 1	FLIGHT ENGINEERS INST PNL – TABLE	B	P7
28V AC 8 DIST 1	MAIN INSTRUMENT PANELS – COMMANDERS PNL – IND	B	P7
28V AC 8 DIST 1	MAIN INSTRUMENT PANELS – COMMANDERS PNL – LEGEND	B	P7
28V AC 8 DIST 1	MAIN INSTRUMENT PANELS – COMMANDERS PNL – MAIN	B	P7
28V AC 8 DIST 1	MAIN INSTRUMENT PANELS – CENTER PNL – IND	B	P7
28V AC 8 DIST 1	MAIN INSTRUMENT PANELS – CENTER PNL – LEGEND	B	P7
28V AC 8 DIST 1	MAIN INSTRUMENT PANELS – CENTER PNL – MAIN	B	P7
28V AC 8 DIST 1	NAVIGATOR – PANEL – PANEL FLOOD	B	P7
28V AC 8 DIST 1	RADIO PANEL – FLOOD	B	P7
28V AC 8 DIST 1	OBS MAP	B	P7
28V MAC 1	LIGHTING – FWD CEILING NO 2	B	P66
28V MAC 1	LIGHTING – FWD ENTRY	B	P66
28V MAC 1	LIGHTING – FWD OVHD FLOOD – NO 1	B	P66
28V MAC 1	LIGHTING – FWD OVHD FLOOD – NO 2	B	P66
28V MAC 1	LIGHTING – OVERHEAD FLOOD – NO 1	B	P67-1
28V MAC 1	LIGHTING – OVERHEAD FLOOD – NO 2	B	P67-1
28V MAC 1	LIGHTING – OVERHEAD FLOOD – NO 3	B	P67-1
28V MAC 1	LIGHTING – FWD EQUIP BAY – NO 1	B	P66
28V MAC 1	LIGHTING – FWD EQUIP BAY – NO 2	B	P66
28V MAC 1	LIGHTING – FWD EQUIP BAY – NO 3	B	P66

Figure 1-52 (Sheet 36 of 42)

Power Distribution Circuit Breaker List (Continued)

LIGHTING (CONT.)

BUS	C.B. NOMENCLATURE	PH	PANEL
28V MAC 5	LIGHTING – AFT ENTRY	B	P67-1
28V MAC 5	LIGHTING – AFT EQUIP BAY – NO 1	B	P67-1
28V MAC 5	LIGHTING – AFT EQUIP BAY – NO 2	B	P67-1
28V MAC 5	LIGHTING – AISLE – NO 1	B	P67-1
28V MAC 5	LIGHTING – AISLE – NO 2	B	P67-1
28V MAC 5	LIGHTING – AISLE – NO 3	B	P67-1
28V MAC 5	LIGHTING – AISLE – NO 4	B	P67-1
28V MAC 5	LIGHTING – OVERHEAD FLOOD – NO 4	B	P67-1
28V MAC 5	LIGHTING – OVERHEAD FLOOD – NO 5	B	P67-1
28V MAC 5	LIGHTING – OVERHEAD FLOOD – NO 6	B	P67-1
28V MAC 5	LIGHTING – OVERHEAD FLOOD – NO 7	B	P67-1
28V MAC 5	LIGHTING – OVERHEAD FLOOD – NO 8	B	P67-1
28V MAC 5	LIGHTING – OVERHEAD FLOOD – NO 9	B	P67-1
28V MAC 5	LIGHTING – PWR FAIL SENSING (C1106)	B	P67-1
28V MAC 5	LIGHTING – READING – SERVICE UNIT – BUNK	B	P67-1
28V MAC 5	LIGHTING – READING – SERVICE UNIT – REST	B	P67-1
28V MAC 7	LIGHTING – AFT ENTRY		P67-1
28V MAC 7	LIGHTING – AFT EQUIP BAY – NO 1	B	P67-1
28V MAC 7	LIGHTING – AFT EQUIP BAY – NO 2	B	P67-1
28V MAC 7	LIGHTING – AISLE – NO 1	B	P67-1
28V MAC 7	LIGHTING – AISLE – NO 2	B	P67-1
28V MAC 7	LIGHTING – AISLE – NO 3	B	P67-1
28V MAC 7	LIGHTING – AISLE – NO 4	B	P67-1
28V MAC 7	LIGHTING – OVERHEAD FLOOD – NO 4	B	P67-1
28V MAC 7	LIGHTING – OVERHEAD FLOOD – NO 5	B	P67-1
28V MAC 7	LIGHTING – OVERHEAD FLOOD – NO 6	B	P67-1
28V MAC 7	LIGHTING – OVERHEAD FLOOD – NO 7	B	P67-1

Figure 1-52 (Sheet 37 of 42)

LIGHTING (CONT.)

BUS	C.B. NOMENCLATURE	PH	PANEL
28V MAC 7	LIGHTING – OVERHEAD FLOOD – NO 8	B	P67-1
28V MAC 7	LIGHTING – OVERHEAD FLOOD – NO 9	B	P67-1
28V MAC 7	LIGHTING – PWR FAIL SENSING	B	P67-1
28V MAC 7	LIGHTING – READING – SERVICE UNIT – BUNK	B	P67-1
28V MAC 7	LIGHTING – READING – SERVICE UNIT – REST	B	P67-1

LIQUID COOLING

BUS	C.B. NOMENCLATURE	PH	PANEL
GEN 8	LCS PUMP NO 1 (ELCU)		E16
GEN 6	LCS PUMP NO 2 (ELCU)		E16
MAAC 7	LIQUID COOLING SYSTEM – RESIST IND	C	P67-3
MADC 3 DIST 3	LIQUID COOLING SYSTEM – INDS		P67-3
MADC 3 DIST 3	LIQUID COOLING SYSTEM – VALVE – COOLER 2		P67-3
MADC 3 DIST 3	LIQUID COOLING SYSTEM – VALVE – COOLER 3		P67-3
MADC 3 DIST 3	LIQUID COOLING SYSTEM – VALVE – GRD		P67-3
MADC 5 DIST 2	LIQUID COOLING SYSTEM – LIQUID PUMP CONTR 2		P67-3
MADC 5 DIST 2	LIQUID COOLING SYSTEM – VALVE – COOLER 1		P67-3
MADC 5 DIST 2	LIQUID COOLING SYSTEM – VALVE – COOLER 4		P67-3
TRU 6	LIQUID COOLING SYSTEM – LIQUID PUMP CONTR 1 (C067)		P67-3

Figure 1-52 (Sheet 38 of 42)

Power Distribution Circuit Breaker List (Continued)

NAVIGATION

BUS	C.B. NOMENCLATURE	PH	PANEL
FAVDC 1	GINS NAVIGATION – CDU – PILOT – RNAV 1 – RNAV 3		P6
FAVDC 2	GINS NAVIGATION – CDU – COPILOT – BSIU 2 – RNAV 2		P6
HBATT	GINS NAVIGATION – CDU – NVGTR – BSIU 1 – CTRL PNL & MDL		P6
FAVDC 1	GINS NAVIGATION – EGI – 1		P6
FAVDC 1	GINS NAVIGATION – EGI – BATT 1		P6
FAVDC 2	GINS NAVIGATION – EGI – 2		P6
FAVDC 2	GINS NAVIGATION – EGI – BATT 2		P6
EAC	GINS NAVIGATION – AE – 1		P6
FAAC 2	GINS NAVIGATION – AE – 2		P6

NAVIGATION AIDS

BUS	C.B. NOMENCLATURE	PH	PANEL
EDC	LESS IDG EMERGENCY FLIGHT AVIONICS – AIMS XPDR		P5◀
	WITH IDG EMERGENCY FLIGHT AVIONICS – M4 CAUT/ZERO		P5◀
EDC	WITH IDG EMERGENCY FLIGHT AVIONICS – IFF XPNDR		P5◀
EDC	EMERGENCY FLIGHT AVIONICS – MARKER BEACON		P5
EDC	EMERGENCY FLIGHT AVIONICS – VHF NAV NO 1		P5

Figure 1-52 (Sheet 39 of 42)

NAVIGATION AIDS (CONT.)

BUS	C.B. NOMENCLATURE	PH	PANEL
FAAC 1	LESS IDG AIMS CMPTR ØB ①	B	P5◀
FAAC 1	WITH IDG TCAS CMPTR ①	A	P5◀
FAAC 1	FLIGHT NAVIGATION NO 1 – RADIO ALTM ØA①	A	P5
FAAC 1	FLIGHT NAVIGATION NO 1 – TACAN ØA①	A	P5
FAAC 2	FLIGHT NAVIGATION NO 2 – TACAN ØA②	A	P5
FAAC 2	FLIGHT NAVIGATION NO 2 – WEATHER RADAR ØA②	A	P5
FAVDC 1	FLIGHT NAVIGATION NO 1 – (LF)/ADF DC①		P5
FAVDC 1	FLIGHT NAVIGATION NO 1 – TACAN DC①		P5
FAVDC 1	RADAR XPDR DC①		P5
FAVDC 2	FLIGHT NAVIGATION NO 2 – VHF NAV ②		P5
FAVDC 2	FLIGHT NAVIGATION NO 2 – TACAN DC ②		P5

① Controlled by APD–FLT Avionics – Bus 1.

② Controlled by APD–FLT Avionics – Bus 2.

OBTM&M

BUS	C.B. NOMENCLATURE	PH	PANEL
MAAC 3	OBTM&M – DATA DISPLAY	A	P67-1
MAAC 3	OBTM&M – IDENT	A	P67-1

RADAR

BUS	C.B. NOMENCLATURE	PH	PANEL
GEN 1	RADAR XMTR STDBY PWR (ELCU)		E15
GEN 6	SURVEILLANCE RADAR – ROTODOME (C3558)		P67-1
MAAC 5	SURVEILLANCE RADAR – ANALOG RACK		P67-1
MAAC 5	SURVEILLANCE RADAR – CM PNL		P67-1

Figure 1-52 (Sheet 40 of 42)

Power Distribution Circuit Breaker List (Continued)

RADAR (CONT.)

BUS	C.B. NOMENCLATURE	PH	PANEL
MAAC 5	SURVEILLANCE RADAR – DIGITAL RACK		P67-1
MAAC 6	DUCT COOLING – PRI FAN		P67-3
MAAC 6	MARITIME RECEIVER \boxed{C}		P67-3
MAAC 6	MARITIME TAPE TRANSPORT \boxed{C}		P67-3
MAAC 6	ROTODOME COOLING – DOORS	A	P67-3
MAAC 6	ROTODOME COOLING – PURGE VALVE ①	B	P67-3
MAAC 7	DUCT COOLING – SEC FAN		P67-3
MAAC 8	SPECTRUM ANALYZER	A	P67-2
MAAC 8	RADAR STE – FREQUENCY CONVERTER		P67-2
MAAC 8	RADAR STE – ISU (BANDED OPEN)		P67-2
MAAC 8	RADAR STE – PMCU (BANDED OPEN)		P67-2
MADC 3 DIST 3	DUCT COOLING WARN IND		P67-3
MADC 3 DIST 3	ROTODOME COOLING – FAN – ELCU CONTR ②		P67-3
MADC 3 DIST 3	ROTODOME COOLING – RELAY CONTR CIRCUIT		P67-3
MADC 5 DIST 1	CM PNL DC		P67-2
MADC 5 DIST 1	CONTACTOR POWER		P67-2
MADC 5 DIST 2	DUCT COOLING – FAN CONTR & OVHT IND		P67-3
MADC 5 DIST 1	PWR DIST PNL (DC)		P67-2
MADC 5 DIST 1	PWR DIST PNL ELCU CONTR		P67-2

① Control power supplied through ROTODOME COOLING – FAN – ELCU CONTR circuit breaker.

② Supplies power to rotodome purge valve control relay.

Figure 1-52 (Sheet 41 of 42)

SDS

BUS	C.B. NOMENCLATURE	PH	PANEL
GEN 6	SDS LEFT WING – 115V 3Ø		P67-3
GEN 7	SDS RIGHT WING – 115V 3Ø		P67-3
MADC 3 DIST 3	SDS RIGHT WING – 28V DC		P67-3
MADC 6	SDS LEFT WING – 28V DC		P67-3

WITH F SMOKE DETECTOR

BUS	C.B. NOMENCLATURE	PH	PANEL
AVAC 8	SMOKE DETECTION – STANDBY POWER	A	P5
FAAC 1	SMOKE DETECTION – NORMAL POWER	A	P5
BAT BUS	SMOKE DETECTION – FAULT IND POWER		P5 ◄

SYSTEM M

BUS	C.B. NOMENCLATURE	PH	PANEL
MAAC 3 DIST 2	SYS M AC		P67-2
MADC 5 DIST 2	SYS M DC		P67-2

Figure 1-52 (Sheet 42 of 42)

Avionics Power Disconnect Panel Controls and Indicators

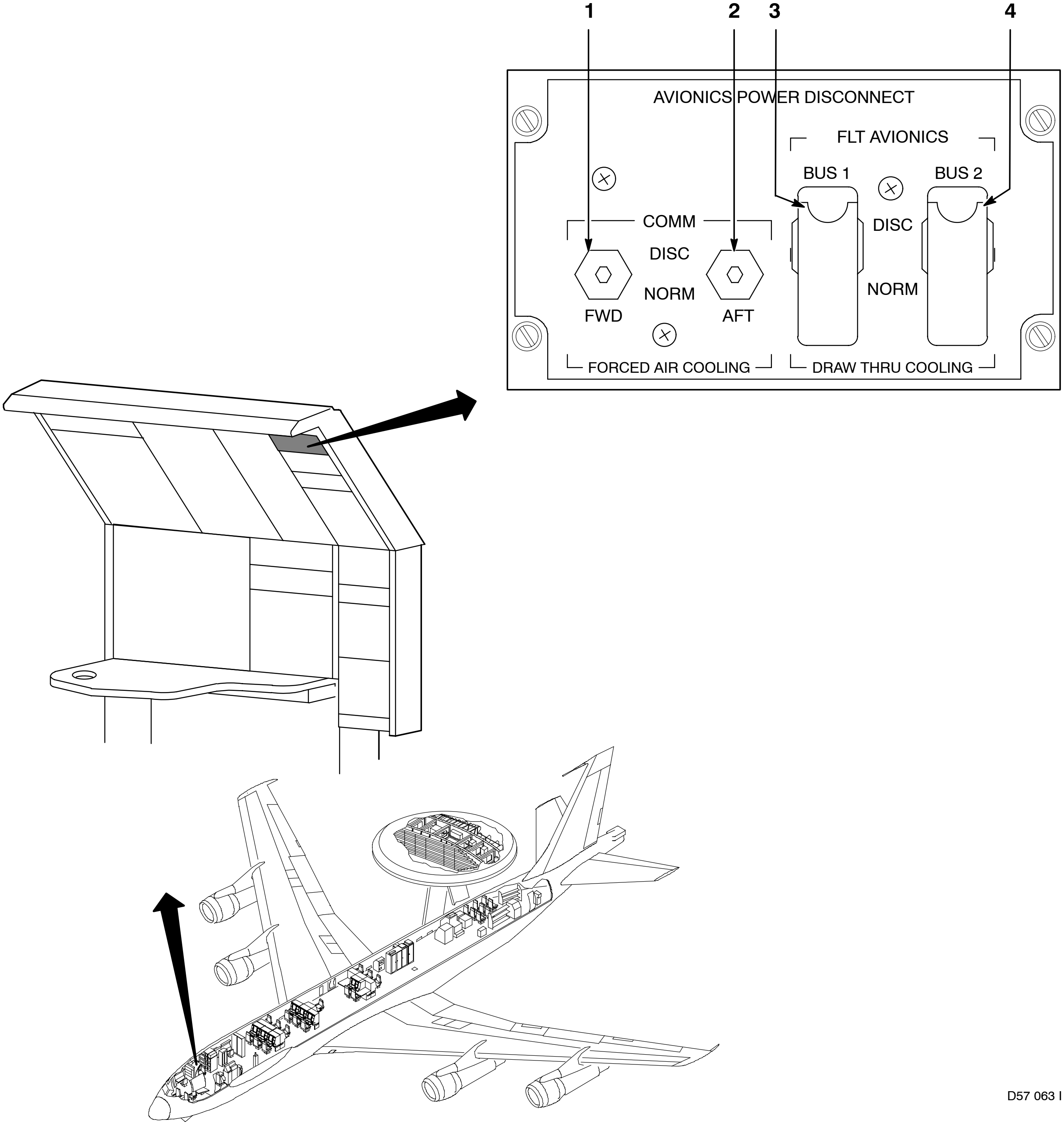


Figure 1-53 (Sheet 1 of 3)

NO.	CONTROL/INDICATOR	FUNCTION
1	COMM FWD Toggle Switch	When set to DISC, removes power to breakers as illustrated in *figure 1-54*. When set to NORM, applies power to breakers as illustrated in *figure 1-54*.

CAUTION

Ensure that forward forced air cooling is available prior to setting COMM FWD switch to NORM.

NOTE

FLT AVX DISC CONT on P61-6 must be set ON before FLT AVIONICS BUS 1 switch can function as described below.

2	COMM AFT Toggle Switch	When set to DISC, removes power to breakers as illustrated in *figure 1-54*. When set to NORM, applies power to breakers as illustrated in *figure 1-54*.

CAUTION

Ensure that aft forced air cooling is available prior to setting COMM AFT switch to NORM.

NOTE

FLT AVX DISC CONT on P61-6 must be set ON before FLT AVIONICS BUS 1 switch can function as described below.

3	FLT AVIONICS BUS 1 Switch (Guarded)	Guarded to NORM. When set to NORM, applies power to breakers as illustrated in *figure 1-54*. When set to DISC, removes power to breakers as illustrated in *figure 1-54*.

CAUTION

Ensure that draw through cooling air is available prior to setting FLT AVIONICS BUS 1 switch to NORM.

NOTE

FLT AVX DISC CONT on P61-6 must be set ON before FLT AVIONICS BUS 1 switch can function as described above.

Figure 1-53 (Sheet 2 of 3)

Avionics Power Disconnect Panel Controls and Indicators (Continued)

NO.	CONTROL/INDICATOR	FUNCTION
4	FLT AVIONICS BUS 2 Switch (Guarded)	Guarded to NORM. When set to NORM, applies power to breakers as illustrated in *figure 1-54*. When set to DISC, removes power to breakers as illustrated in *figure 1-54*.

CAUTION

Ensure that draw through cooling air is available prior to setting FLT AVIONICS BUS 2 switch to NORM.

NOTE

FLT AVX DISC CONT on P61-6 must be set ON before FLT AVIONICS BUS 2 switch can function as described above.

Figure 1-53 (Sheet 3 of 3)

Avionics Power and Comm Disconnect Cooling Requirements

PANEL/ SWITCH	COOLING REQUIRED	PANEL	AFFECTED CIRCUIT BREAKERS
CDP-1	FORWARD FORCED AIR OR DRAW THROUGH	P66-1	② UHF RADIO CONTR POSN 7
		P66-2	② COMM MISC– LAMP TEST
		P66-2	② ADS PD&T
		P66-2	② ADS AUDIO CONTR
		P66-2	② ADS MSN MAINT
		P66-2	③ BDP UHF AC
		P66-2	③ BDP UHF DC
CDP-2	FORWARD FORCED AIR	P66-2	WBSV 1
		P66-2	WBSV 2
		P66-2	WBSV 3
		P66-2	⑥ WBSV 4
		P66-2	WBSV 5
		P66-2	⑥ WBSV 6
		P66-2	WBSV 7
		P66-2	WBSV 8
		P66-2	WBSV 9
		P66-2	WBSV 10
CDP-3	FORCED AIR OR DRAW THROUGH	P66-1	① UHF R2
		P66-1	① UHF R4
		P66-1	② UHF RADIO CONTR POSN 6
		P66-1	③ UHF R/T 10
		P66-1	③ UHF R/T 11
		P66-1	③ UHF R/T 17
		P66-1	③ UHF R/T 18
CDP-4	FORWARD FORCED AIR	P66-1	UHF T1
		P66-1	UHF T1 AMPL
		P66-1	UHF T3
		P66-1	UHF T3 AMPL
		P66-1	UHF T5
		P66-1	UHF R6
		P66-1	④ UHF R/T 7

Figure 1-54 (Sheet 1 of 4)

Avionics Power and Comm Disconnect Cooling Requirements (Continued)

PANEL/ SWITCH	COOLING REQUIRED	PANEL	AFFECTED CIRCUIT BREAKERS	
		P66-1	UHF	R/T 8
		P66-1	UHF	R/T 9
		P66-1	④ UHF	R/T 14
		P66-1	UHF	R/T 15
		P66-1	UHF	R/T 16
		P66-1	HF	NO 2
		P66-1	HF	NO 3
		P66-1	HF	2 CPLR
		P66-1	HF	3 CPLR
		P66-2	BDP	HF/VHF AC
		P66-2	NBSV	MIXER
		P66-1	UHF	R/T 20
		P66-2	⑤ SATCOM – SYSTEM 2 – AIT RADIO – XMTR & FILTER	
		P66-2	⑤ SATCOM – SYSTEM 2 – AIT RADIO – RX/MDM & SYNTH/MOD	
		P66-2	⑤ SATCOM – SYSTEM 1 – AIT RADIO – XMTR & FILTER	
		P66-2	⑤ SATCOM – SYSTEM 1 – AIT RADIO – RX/MDM & SYNTH/MOD	
CDP-5	FORWARD FORCED AIR OR DRAW THROUGH	P66-1	③ HF	2 CPLR CONTR
		P66-1	③ HF	3 CPLR CONTR
		P66-2	② BDP	HF/VHF DC
		P66-2	③④ VHF	AM 2
		P66-2	③ VHF	FM
		P66-2	② UHF	BITE
		P66-2	③ UHF	T1 AMPL
		P66-2	③ UHF	T3 AMPL
APD COMM FWD	FORWARD FORCED AIR	P5	COMMUNICATIONS	VHF G
		P5	COMMUNICATIONS	HF/VHF INTFC DC
		P5	COMMUNICATIONS	UHF G AC
		P5	COMMUNICATIONS	UHF G DC

Figure 1-54 (Sheet 2 of 4)

PANEL/ SWITCH	COOLING REQUIRED	PANEL	AFFECTED CIRCUIT BREAKERS	
APD COMM AFT	AFT FORCED AIR	P5	COMMUNICATIONS	HF AC
		P5	COMMUNICATIONS	HF DC
		P5	COMMUNICATIONS	HF COUPLER
		P5	COMMUNICATIONS	UHF ADF AC
		P5	COMMUNICATIONS	UHF ADF DC
APD FLIGHT AVIONICS BUS 1	DRAW THROUGH	P5		ANGLE ATTACK NO 1
		P5		**LESS IDG** AIMS CMPTR ØB ◀
		P5		RADAR XPDR DC
		P5	ATTD WARN	SHAKER DC 1
		P5	ATTD WARN	LEFT WING ØB
		P5	AUTO PILOT	3Ø
		P5	AIR DATA	ALM VIB NO 1
		P5	AIR DATA	ØA
		P5	YAW DAMPERS	SERIES ØA
		P5	FLIGHT INSTR NO 1	AHRS
		P5	FLIGHT INSTR NO 1	TURN RATE DC
		P5	FLIGHT INSTR NO 1 FLT DIR	CMPTR ØA
		P5	FLIGHT INSTR NO 1 FLT DIR	DC
		P5	FLIGHT INSTR NO 1 XFMR	BRG ØA
		P5	FLIGHT INSTR NO 1 XFMR	HDG ØA
		P5	FLIGHT NAV NO 1	TACAN ØA
		P5	FLIGHT NAV NO 1	TACAN DC
		P5	FLIGHT NAV NO 1	(LF)/ADF DC
		P5	FLIGHT NAV NO 1	RADIO ALTM ØA

Figure 1-54 (Sheet 3 of 4)

Avionics Power and Comm Disconnect Cooling Requirements (Continued)

PANEL/ SWITCH	COOLING REQUIRED	PANEL	AFFECTED CIRCUIT BREAKERS
APD	DRAW THROUGH	P5	FLIGHT ANGLE ATTACK NO 2
FLIGHT AVIONICS BUS 2		P5	AIR DATA ALTM VIB NO 2
		P5	AIR DATA ØA
		P5	ATTD WARN SHAKER DC 2
		P5	CVR ØA
		P5	DFDR ØA
		P5	CVR/DFDR DC
		P5	FLT LOADS RCDR ØC
		P5	FLT LOADS RCDR DC
		P5	FLIGHT INSTR NO 2 AHRS
		P5	FLIGHT INSTR NO 2 FLT DIR DC
		P5	FLIGHT INSTR NO 2 TURN RATE DC
		P5	FLIGHT INSTR NO 2
			FLT DIR CMPTR ØA
		P5	FLIGHT INSTR NO 2
			XFMR ATTD ØA
		P5	FLIGHT INSTR NO 2
			XFMR BRG ØA
		P5	FLIGHT INSTR NO 2
			XFMR HDG ØA
		P5	FLIGHT NAV NO 2 VHF NAV
		P5	FLIGHT NAV NO 2 TACAN ØA
		P5	FLIGHT NAV NO 2 WEATHER
			RADAR ∅A
		P5	NO 2 TACAN DC
		P5	YAW DAMPERS PRL ØA

① Cooled by Aft Forced Air.
② Cooled by Draw Through Air.
③ Cooled by Forward Forced Air.
④ **LESS IDG** ☚
⑤ **WITH IDG** ☚
⑥ **WITH IDG** Banded open. ☚

Figure 1-54 (Sheet 4 of 4)

SUBSECTION I-F
HYDRAULIC POWER SYSTEMS

Table of Contents

SUMMARY

There are two hydraulic power systems, the utility hydraulic system and the auxiliary hydraulic system. The systems are essentially independent, with separate reservoirs, pumps and lines. Locations of major components of both hydraulic power systems are shown in *figure 1-55*. Hydraulic systems and brake accumulator charging pressures are also shown in *figure 1-55*. All inflight controls and indicators for both systems are shown in *figure 1-56.*

Both hydraulic systems operate at a nominal pressure of 3,025 psi measured at the pump. The utility system is pressurized by engine driven pumps mounted on engines number two and three (inboard engines). The auxiliary system is pressurized by two electric pumps. Both systems have variable capacity pumps. The amount of fluid pumped changes to meet the demands of the system. When hydraulic powered equipment is activated, pump output is increased to maintain system pressure. A general block diagram describing both hydraulic systems and how they are interconnected is shown in *figure 1-57*. Interconnect valves allow the number one auxiliary pump to pressurize the utility hydraulic system, either utility pump to pressurize the auxiliary system on the ground, for checkout while on the ground, or either auxiliary hydraulic pump to pressurize the brakes whether in flight or on the ground. Ground service connections and bypass valves for maintenance use are located in the wheel wells (*figure 1-55*).

UTILITY HYDRAULIC SYSTEM

The utility hydraulic system provides hydraulic power for operation of landing gear, nose wheel steering and alternate air refueling, flaps, outboard spoilers, brakes and rotodome drive at a pressure of 2,400 to 3,100 psi (as read at the flight engineer's panel). With no load on the system, the pump outlet pressure should be between 2,800 and 3,100 psi. The system is the alternate pressure source to the air refueling system. Two engine-driven pumps, operated by NO 2 and NO 3 engines, supply pressure for the utility system. A schematic of the utility hydraulic system is shown in *figure 1-58*.

The utility reservoir is located in the left wheel well. Although normally serviced to 7.3 gallons, the capacity of the reservoir and surge tank is 9.7 gallons. A quantity gage on the flight engineer's panel indicates from zero to F gallons. When the reservoir contains 6 or more gallons, the quantity gage is pegged at the full (F) mark. The reservoir is interconnected with the auxiliary reservoir, so that the auxiliary reservoir is filled from the utility reservoir. The interconnection is placed at the 3.2 gallon level, so that loss of fluid in the auxiliary system leaves a minimum of 3.2 gallons in the utility reservoir. The reservoir is pressurized to approximately 45 psi with engine bleed air from the inboard engines. The air is cooled to approximately 100°F by expansion through an orifice in the line. Fluid returned from the utility rotodome drive, outboard spoilers, and utility pump case drains is cooled by a heat exchanger in the NO 2 fuel tank. System pressure relief valves open at 3,500 psi (increasing) and close at 3,150 psi (decreasing). Fluid returning to the reservoirs passes through a filter.

The utility system has a 25 cubic inch accumulator located in the right wheel well (18, *figure 1-55*) which acts as a surge damper. The accumulator has a pressure gage (12, *figure 1-55*) mounted on the gas side to indicate either charging pressure (pumps off) or system pressure (pumps on). The utility system also pressurizes a 200 cubic inch brake accumulator, located in the right wheel well (24, *figure 1-55*). The brake accumulator is normally charged by the utility pumps, but it can be charged by the auxiliary pumps if the brake interconnect is open. The brake accumulator pressure gage (12, *figure 1-55*) is mounted on the gas side to indicate accumulator charging pressure (pumps off) or system pressure (pumps on). A pressure transmitter which operates the flight deck brake pressure gage is also mounted on the gas side of the accumulator.

AUXILIARY HYDRAULIC SYSTEM

The auxiliary hydraulic system provides hydraulic pressure to the rudder controls, inboard spoilers, rotodome drive, air refueling system, APU start accumulators, and through interconnect valves to the utility hydraulic system and brakes at a pressure of 2,600 to 3,200 psi (as read at the flight engineer's panel). With no load on the system, pump pressure should be between 2,800 and 3,200 psi. With auxiliary rotodome drive operating in XMIT (6 rpm), system pressure should be 2,600 to 3,200 psi (green band on the system pressure gage). There are two electric pumps with separate reservoirs in the system. A leak in auxiliary reservoir NO 1 (*figures 1-58* and *1-59*) depletes the utility reservoir to 3.2 gallons, but does not affect auxiliary reservoir NO 2. A leak in auxiliary reservoir NO 2 depletes the utility reservoir to 3.2 gallons and empties auxiliary reservoir NO 1. Pump NO 1 supplies pressure to the entire auxiliary system. If the interconnect valve is set to SYS, the NO 1 auxiliary pump can also pressurize the utility system when external power or APU is powering the sync bus. Pump NO 2 normally supplies only the rudder. When the interconnect valve is set to BRAKE, either pump can supply pressure to the brakes. Pressure switches operate low pressure (PRESS) caution lights (*figure 1-56*). The system relief valve opens at 3,500 psi and closes at 3,150 psi. Fluid returning from the auxiliary rotodome drive and the NO 1 auxiliary pump case drain is cooled by a heat exchanger in the NO 3 fuel tank. The auxiliary hydraulic system contains two 50 cubic inch accumulators which act as surge dampers and also provide a backup source of hydraulic fluid under pressure. The accumulators are located in the right wheel well (22, *figure 1-55*). A pressure gage (12, *figure 1-55*) is mounted on the gas side of the accumulators to measure charging pressure (pumps off) or system pressure (pumps on). A schematic of the auxiliary hydraulic system is shown in *figure 1-59*.

ROTODOME DRIVE

The rotodome is driven by either the utility or auxiliary hydraulic systems. Each rotodome drive has an independent lubrication system that lubricates the rotodome bearing when the associated drive is selected. A LOW PRESS caution light (one for each system) illuminates if the pressure within the lubrication system drops below a preset value. The LOW PRESS caution light is armed only when the associated rotodome drive is selected. The LOW PRESS caution light can remain on for up to four minutes at –54°C (–65°F). If the LOW PRESS caution light (for the selected drive) illuminates in flight, select the other drive. Rotodome drive controls are on the flight engineer's panel (*figure 1-56*). A schematic of the rotodome drives is shown in *figure 1-60*.

WARNING

> The rotodome drive must be depressurized when ground maintenance is being performed inside the rotodome. Injury to personnel could result from accidental rotodome rotation.

To maintain even wear on both rotodome drives, each drive is used every other mission. Switching rotodome drives requires the following actions:

a. Verify ROTODOME SHUTOFF switch is on (OFF light out) for non-operating drive. This action provides hydraulic pressure up to selected drive.

b. Set ROTODOME DRIVE SPEED switch to OFF. If changing drives in flight, notify mission crew commander.

CAUTION

> - When switching drives, wait 10 seconds after disconnecting one drive before connecting the other.
> - If AVDC (main) buses 4 and 8 lose power, such as during loss of all ac power, rotodome cannot be switched from one drive to the other.
> - The rotodome must be rotating when any engine is operating. Failure to comply can cause damage to rotodome bearing.

c. Set ROTODOME DRIVE system select switch to desired position, either UTIL or AUX.

d. Set ROTODOME DRIVE SPEED switch to desired position, either IDLE or XMIT. If high speed (XMIT) is not needed for mission system operation, use IDLE to reduce load on the hydraulic system.

WARNING

Do not operate auxiliary rotodome drive in XMIT for takeoff, landing or go-around.

AIR REFUELING SLIPWAY DOORS AND TOGGLE LATCHES

Normally, hydraulic pressure to operate the air refueling system slipway doors and toggle latches is supplied by the auxiliary hydraulic system number one pump. However, it is possible to operate the slipway doors and the toggle latches using pressure from the utility hydraulic system. To operate the air refueling system using utility system pressure, the landing gear lever must be set to UP, which allows pressure from the nose gear up line to reach the air refueling system. The system also contains an accumulator which acts as a surge damper to absorb fluid displaced by the toggle actuators in a brute force disconnect. A pressure gage, connected to the gas side of the accumulator, is located on the aft flight deck wall (1, *figure 1-56*). This allows the flight crew to monitor the air refueling system pressure when the doors are open. A schematic of the air refueling slipway doors and toggle latches is shown in *figure 1-61*.

NOTE

With the rotodome in XMIT (rotating at 6 RPM), and AUX rotodome drive selected, operation of air refueling slipway doors and toggle latches may be slower than normal.

HYDRAULIC SYSTEMS QUANTITY INDICATIONS

The airplane has two independent hydraulic systems which permit a failure to isolate itself to one system. Self-isolation in flight can result in the additional loss of as much as 7.3 gallons of fluid but unless a complete loss of fluid occurs, this additional loss has no appreciable effect on the operation of the hydraulic system.

The hydraulic quantity gage reflects all changes in the fluid level below 6 gallons of both the utility and auxiliary systems until the replenishing level of 3.2 gallons is reached. Therefore, some normal changes in fluid level (and slow leaks), can be reflected initially on the hydraulic system quantity indicator.

If the hydraulic quantity indication drops below 3.2 gallons, the leak is normally in the utility system. If the quantity indication stops at 3.2 gallons, the loss is normally from the auxiliary hydraulic system.

NOTE

Hydraulic quantity indication can be less than 3.2 gallons with an auxiliary hydraulic system leak depending on landing gear or flap movements when quantity has depleted to 3.2 gallons.

Utility hydraulic system quantity indications can vary considerably during a normal flight. The quantity of fluid indicated on the flight deck gage represents only a small percentage of the total hydraulic fluid in the systems. When fully serviced, the airplane systems contain approximately 55 gallons of hydraulic fluid. The loss of a gallon or more of fluid can be quite impressive when viewed on the indicator, but generally has little or no effect on operation of the systems.

At the start of preflight, the utility system quantity gage normally indicates full (F), which means the reservoir contains at least 6 gallons.

The flight engineer should note the hydraulic quantity before and after engine start. Also, the flight engineer should monitor the hydraulic quantity indication whenever major hydraulic powered components are operated, particularly the landing gear and flaps.

If the conditions which normally cause varying quantity and pressure indications are understood, fewer false hydraulic failures will be reported and the probability of detecting actual hydraulic failures increases.

The common indications of hydraulic quantity changes are:

Landing Gear – Indicated quantity increases by approximately one gallon when the landing gear is extended. This volume reflects the fluid displaced by the actuator piston rods when the gear is extended.

Flaps and Leading Edge Devices – Utility system indicated quantity decreases approximately 0.7 gallon when the flaps are extended and increases the same amount when the flaps are retracted. The volume reflects the fluid displaced by the leading edge devices actuator piston rods when all devices are retracted. Trailing edge flap operation does not cause a change in volume since power is supplied by hydraulic motors, through torque tubes to drive the jackscrews.

Electrical Failure of Hydraulic Quantity Indicator – Electrical power failure to the indicator causes the indicator needle to seek its electrical zero, which is not the same as gage zero. This fault can be demonstrated by pulling the circuit breaker. All other indications remain normal.

Air Trapped in the Hydraulic System – After hydraulic system maintenance, some air is usually trapped in the system and cannot escape until the hydraulic system is operated with the engines running. The hydraulic quantity gage can indicate full prior to engine start, but after start and after the hydraulic units are operated, the system can indicate the loss of a gallon or more of fluid as some of the entrapped air is eliminated.

If the loss is excessive or approaches a minimum level, shut down the engines and have the system reserviced and checked for leaks. If the loss is minor and no leak is indicated, note the new quantity prior to takeoff in order to evaluate properly any future changes in quantity.

Cold Soak – Contraction of hydraulic fluid and accumulator gas due to cold soak causes a gradual reduction in hydraulic fluid quantity. The amount of volume loss varies, depending upon the initial temperature of the fluid and the accumulator air and the ultimate temperature they reach after cooling by the ambient air.

Cold soak usually occurs during long periods of cruise at low outside air temperatures, in the hydraulic system which is not operating the rotodome drive and where there is little transfer of fluid to generate heat. Nearly all of the volume loss is regained after the airplane descends to warmer levels and the hydraulics are used.

HIGH OR LOW HYDRAULIC PUMP PRESSURE

Refer to HYDRAULIC SYSTEMS MALFUNCTION, Section III.

UTILITY SYSTEM HIGH PRESSURE

No-load system pressure is the higher of the two individual pump pressures indicated on the pump pressure gages (8 and 12, *figure 1-56*). A pump pressure reading of 3,500 psi indicates high system pressure as limited by system relief valves. High pump pressure can indicate an impending failure. Refer to UTILITY SYSTEM HIGH PRESSURE, Section III.

UTILITY SYSTEM LOW PRESSURE

Low system pressure is indicated by a low pressure reading on the pump pressure gages (8 and 12, *figure 1-56*). Heavy system loads such as landing gear, or flap actuation, can cause momentary system pressure drops. Under no-load conditions, a low pressure reading on both pump gages can indicate a leak or contaminated system. Pump pressure filters do not bypass and can cause low system pressure when clogged. As system pressure drops from 1,500 psig to 1,300 psig, priority valves begin to close, cutting off pressure to the flap system, thus assuring adequate pressure and flow to the landing gear extension and nose wheel steering systems. The valves are fully closed at 1,300 psig. The valves will once again restore pressure to the flap system at 1,500 ± 50 psig with increasing pressures. An individual pump low pressure reading can be caused by an inoperative gage, malfunctioning pump, or clogged pressure filter. Refer to UTILITY SYSTEM LOW PRESSURE, Section III.

NOTE

If only one pump is operating, do not operate flaps hydraulically when rotodome is in XMIT (6 RPM). High fluid demand can exceed the capacity of one pump at low engine rpm, causing slower operation of flaps and landing gear.

AUXILIARY SYSTEM HIGH PRESSURE

The auxiliary system pressure gage (20, *figure 1-56*) indicates the highest of the two auxiliary pump pressures (system pressure). There are three other pressure gages, but these only indicate the NO. 1 auxiliary pump pressure. The first two pressure gages are the APU accumulator gages (2, *figure 1-56*). These indicate output pressure of the NO. 1 auxiliary pump when the auxiliary rotodome shutoff valve is open and the auxiliary system has been pressurized for 5 minutes. Due to a flow limiter this pressure reading is inaccurate and should not be used as an indicator of pump output pressure. The third pressure gage is connected to the air refueling accumulator and provides an accurate indication of the NO. 1 auxiliary pump pressure when the slipway doors are open and the normal air refueling system is selected. High system pressure is limited to 3,500 psi by system pressure relief valves. Refer to AUXILIARY SYSTEM HIGH PRESSURE, Section III.

NOTE

- Pump pressure may indicate up to 3,500 psi during speed brake operation above 200 KIAS, due to spoiler blowdown.
- To reduce the load on the NO 1 auxiliary pump, when the NO 2 pump is shut down, utility rotodome drive should be selected.

AUXILIARY SYSTEM LOW PRESSURE

If both auxiliary hydraulic pumps are operating, a low output pressure from one pump is not detectable unless the pressure drops below the point at which the PRESS caution light illuminates. If only one pump is operating or the output pressure from both pumps drops, the low pressure condition can be detected on the pressure gage. If the AUX LUB LOW PRESS caution light (6, *figure 1-56*) illuminates and auxiliary rotodome is in use, the NO 1 auxiliary pump pressure may have dropped below 2,200 ± 100 psi priority valve operating pressure. Refer to AUXILIARY SYSTEM LOW PRESSURE, section III.

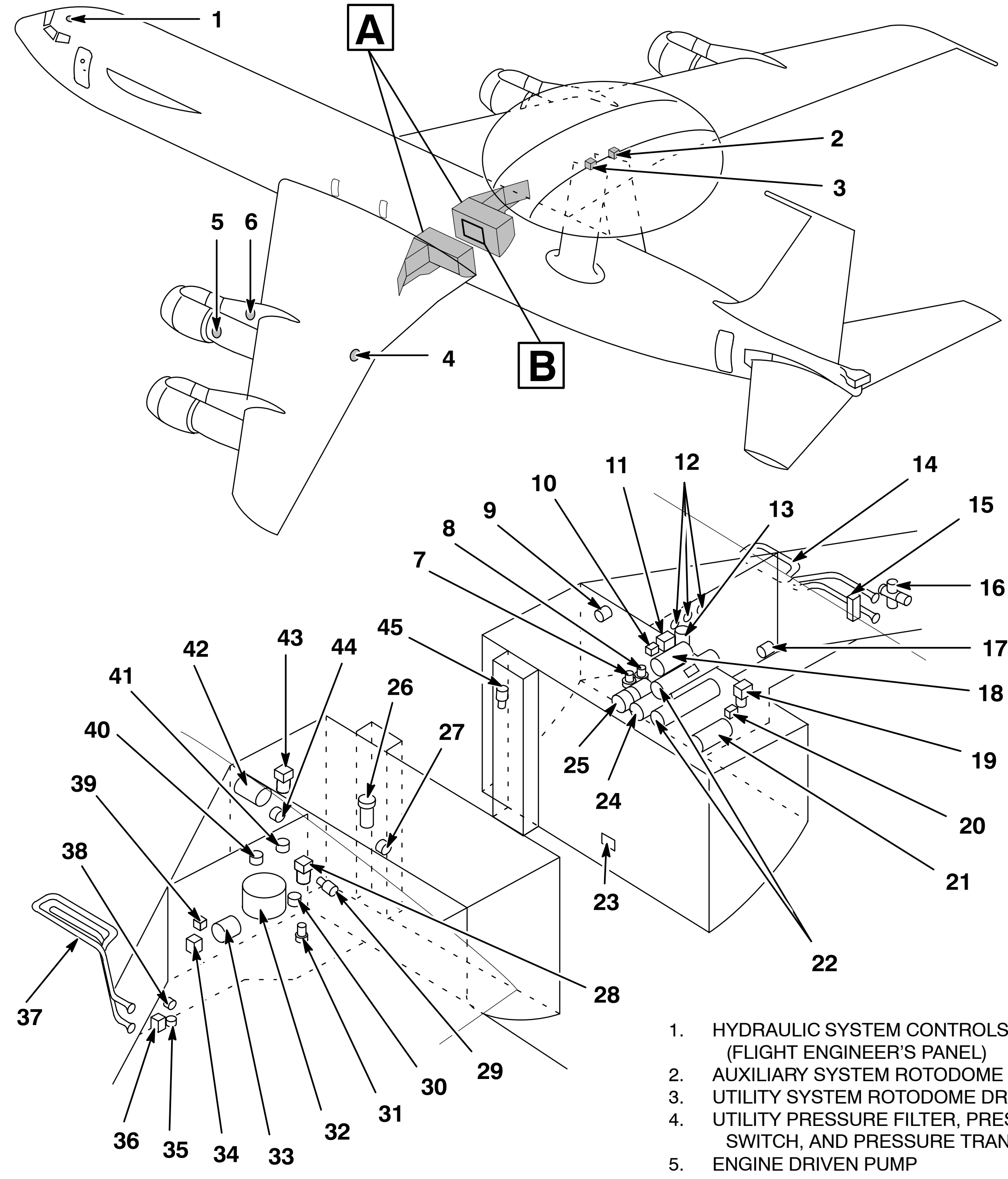
CAUTION

When power is interrupted in changing from APU or external power to airplane generators or from airplane generators to APU or external power, the ELCU for auxiliary hydraulic pump NO 1 can trip. If this happens, the PRESS caution light illuminates. Restart the pump immediately by pressing the PUMPS 1 RUD/SPOIL switch twice (setting switch to OFF then ON). Failure to restart the pump causes loss of inboard spoilers and can cause damage to rotodome bearing if auxiliary drive is in use and engines are operating.

HYDRAULIC SYSTEMS ELECTRIC POWER SOURCES

Hydraulic systems electric power sources are listed in *figure 1-62*.

Hydraulic System Component Locations



A **MAIN GEAR WHEEL WELLS**

1. HYDRAULIC SYSTEM CONTROLS (FLIGHT ENGINEER'S PANEL)
2. AUXILIARY SYSTEM ROTODOME DRIVE
3. UTILITY SYSTEM ROTODOME DRIVE
4. UTILITY PRESSURE FILTER, PRESSURE SWITCH, AND PRESSURE TRANSMITTER ①
5. ENGINE DRIVEN PUMP ①
6. CASE DRAIN FILTER
7. SUPPLY GROUND SERVICE CONNECTION
8. PRESSURE GROUND SERVICE CONNECTION
9. PRESSURE SWITCH
10. SUCTION SHUTOFF VALVE
11. NO. 2 (RH) AUXILIARY PRESSURE FILTER
12. ACCUMULATOR PRESSURE GAGES

① INSTALLATION ON NO. 3 ENGINE SIMILAR.

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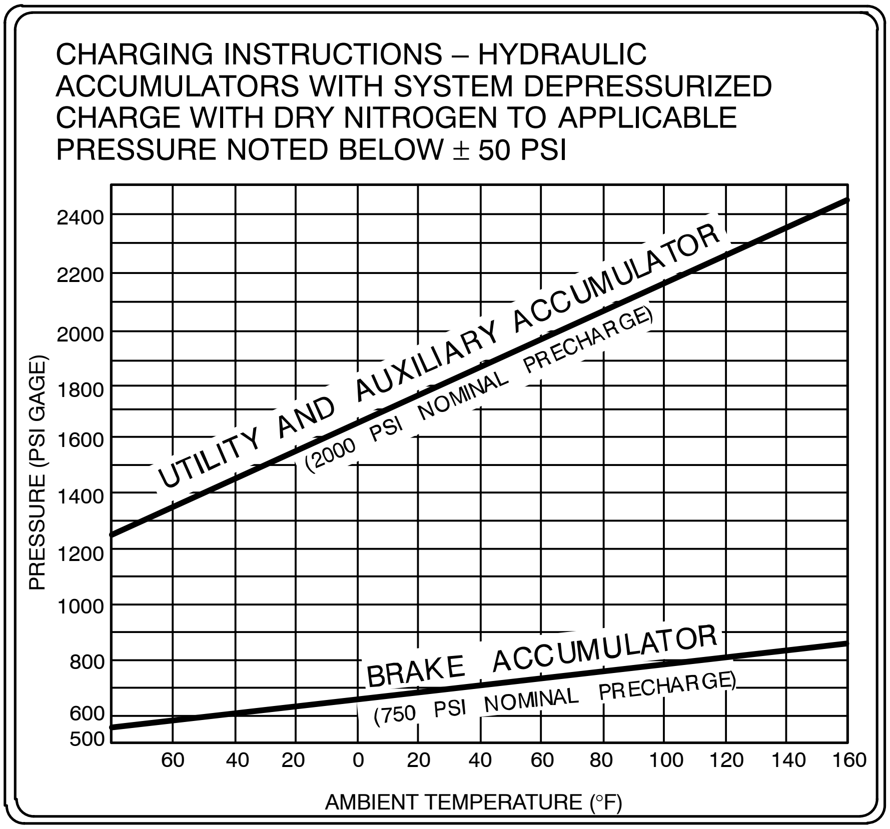
Figure 1-55 (Sheet 1 of 2)



CHARGING INSTRUCTIONS – HYDRAULIC ACCUMULATORS WITH SYSTEM DEPRESSURIZED CHARGE WITH DRY NITROGEN TO APPLICABLE PRESSURE NOTED BELOW ± 50 PSI

B **HYDRAULIC AND BRAKE ACCUMULATOR PRESSURES PLACARD**

13. BRAKE INTERCONNECT VALVE
14. AUXILIARY HEAT EXCHANGER
15. HEAT EXCHANGER BY-PASS VALVE
16. TEMPERATURE SENSOR SWITCH
17. PRESSURE TRANSMITTER
18. UTILITY ACCUMULATOR
19. NO 2 (RH) AUXILIARY RETURN FILTER
20. MANUAL BY-PASS VALVE
21. NO 2 (RH) AUXILIARY RESERVOIR
22. AUXILIARY ACCUMULATORS
23. HYDRAULIC AND BRAKE ACCUMULATOR PRESSURES DECAL
24. BRAKE ACCUMULATOR
25. NO 2 (RH) AUXILIARY PUMP
26. UTILITY RETURN FILTER
27. HYDRAULIC RESERVOIR PRESSURE FILL CONNECTOR
28. NO 1 (LH) AUXILIARY PRESSURE FILTER
29. NO 1 (LH) AUXILIARY PUMP
30. RESERVOIR VENT LINE FILTER
31. CHARGING VALVE
32. UTILITY RESERVOIR
33. NO 1 (LH) AUXILIARY RESERVOIR
34. SUCTION SHUTOFF VALVE
35. TEMPERATURE SENSOR SWITCH
36. HEAT EXCHANGER BY-PASS VALVE
37. UTILITY HEAT EXCHANGER
38. TEMPERATURE SENSOR SWITCH
39. RESERVOIR PRESSURE LINE FILTER
40. RESERVOIR PRESSURE REGULATOR
41. PRESSURE SWITCH
42. SURGE TANK
43. NO 1 (LH) AUXILIARY RETURN FILTER
44. RESERVOIR BLEED VALVE
45. SYSTEM INTERCONNECT VALVE

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Figure 1-55 (Sheet 2 of 2)

Hydraulic System Controls and Indicators

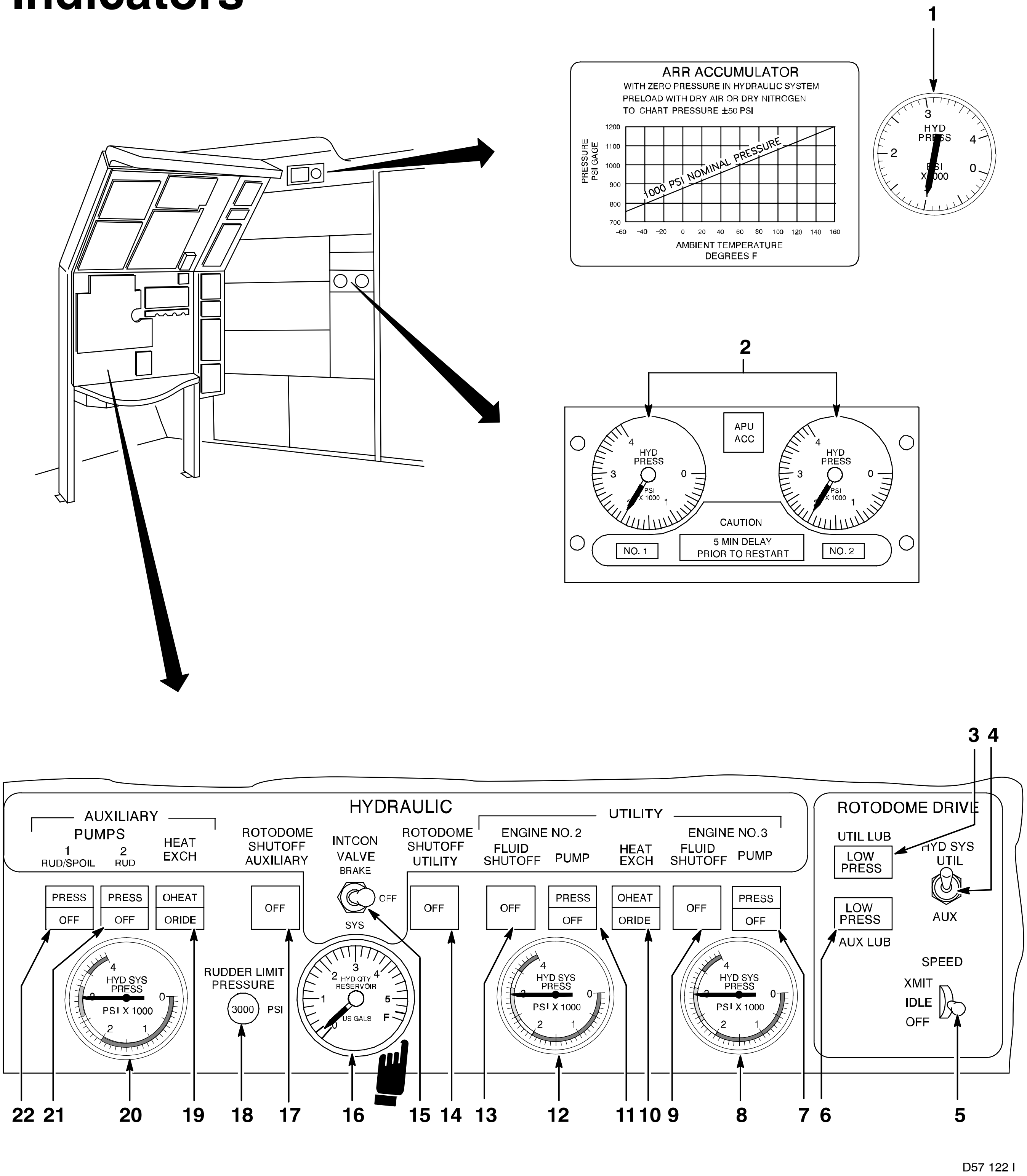

Figure 1-56 (Sheet 1 of 7)

NO.	CONTROL/INDICATOR	LOCATION	FUNCTION
1	Air Refueling Accumulator Pressure Gage	Engineer Auxiliary Panel	Indicates pressure in air refueling accumulator in thousands of psi when system is pressurized. Indicates accumulator precharge when system is depressurized.
2	APU Accumulator Pressure Gages	Engineer Auxiliary Panel	Indicate pressure in APU accumulators in thousands of psi.
3	UTIL LUB Caution Light (Amber)	Engineer Panel	When LOW PRESS caution light illuminates, indicates low pressure in utility rotodome drive lubrication. When utility drive is selected, LOW PRESS caution light should go out within two minutes at 70°F and should go out within four minutes at –65°F. Light can remain out for a brief period when drive is disconnected. Utility drive lubrication system operates only when utility drive is selected.
4	HYD SYS UTIL–AUX Switch (System Select Switch, Toggle)	Engineer Panel	Selects pressure source for rotodome drive. Switch must be pulled out to move. Switch is inoperative if AVDC 4 and AVDC 8 (mains) lose power. Valve remains in position selected when power failed.
5	SPEED Switch (Toggle, lever lock)	Engineer Panel	Switch must be pulled out to move. Controls speed of drive selected by system select (HYD SYS) switch (4). Switch is inoperative if AVDC 4 and AVDC 8 (main) buses lose power. Drive remains at selected speed if power fails.

Figure 1-56 (Sheet 2 of 7)

Hydraulic System Controls and Indicators (Continued)

NO.	CONTROL/INDICATOR	LOCATION	FUNCTION
	XMIT		Used during radar and IFF transmission. When set to XMIT, selected drive turns rotodome at a speed between 5.70 and 6.30 RPM. Drive operates within ±0.1 rpm of average speed.

WARNING

Do not operate auxiliary rotodome drive at 6 RPM for takeoff, landing or go-around.

CAUTION

- Set rotodome SPEED switch to OFF before changing drive source to prevent damage to drive.
- Rotodome must be rotating when airplane engine(s) are operating. Failure to comply can cause damage to rotodome turntable bearing.

NO.	CONTROL/INDICATOR	LOCATION	FUNCTION
	IDLE		When set to IDLE, selected drive turns rotodome at about 1/4 RPM. Used at all times any engine is operating, except when XMIT is used.
	OFF		Stops rotodome rotation.
6	AUX LUB Caution Light (Amber)	Engineer Panel	When LOW PRESS caution light illuminates, indicates low pressure in auxiliary rotodome drive lubrication. When auxiliary drive is selected, LOW PRESS caution light should go out within two minutes at 70°F and should go out within four minutes at –65°F. Light can remain out for a brief period when drive is disconnected. Auxiliary drive lubrication system operates only when auxiliary drive is selected.

Figure 1-56 (Sheet 3 of 7)

NO.	CONTROL/INDICATOR	LOCATION	FUNCTION
7	ENGINE NO 3 PUMP Switch/ Caution Light (Amber, Green) (Guarded)	Engineer Panel	When depressed, allows engine NO 3 hydraulic pump to pressurize utility system. Switch is blank when pump is on. PRESS caution light is illuminated when pressure is below 1,200 ± 250 psi. When in released position, pump output pressure is cut off from utility system but pump still rotates producing a small fluid flow which circulates within the pump and out through the case drain line to allow continuous pump cooling. Green OFF indicator illuminates.
8	ENGINE NO 3 HYD SYS PRESS Gage (Engine NO 3 Utility Pump Pressure Gage)	Engineer Panel	Indicates pressure output in thousands of psi (±100 psi) from engine NO 3 hydraulic pump.
9	ENGINE NO 3 FLUID SHUTOFF Switch/Indicator Light (Green) (Guarded)	Engineer Panel	When depressed, opens engine NO 3 hydraulic fluid shutoff valve and OFF light goes out. When in released position closes shutoff valve. OFF indicator is illuminated when valve is commanded closed. Valve is also closed when NO 3 FIRE switch is pulled.

CAUTION

Operation of hydraulic pumps for more than five minutes with fluid shutoff valve closed and engine rotating (windmilling or normal operation) can damage pumps. Pump operating time with shutoff closed will be recorded in AFTO Form 781.

NO.	CONTROL/INDICATOR	LOCATION	FUNCTION
10	HEAT EXCH (Utility Heat Exchanger Switch) Switch/Caution Light (Amber, Green) (Guarded)	Engineer Panel	OHEAT caution light illuminates when hydraulic fluid temperature exceeds 230 ± 5°F. OHEAT caution light goes out when temperature drops below 210°F. ORIDE indicator illuminates when switch is in released position. When in released position, commands heat exchanger bypass valve to close regardless of fluid temperature, routing all returning fluid through heat exchanger. When HEAT EXCH switch is depressed, bypass valve is controlled by a temperature sensor. Bypass valve opens at a fluid temperature below 15°F and valve closes at fluid temperature above 40°F.

Figure 1-56 (Sheet 4 of 7)

Hydraulic System Controls and Indicators (Continued)

NO.	CONTROL/INDICATOR	LOCATION	FUNCTION
11	ENGINE NO 2 PUMP Switch/ Caution Light (Amber, Green) (Guarded)	Engineer Panel	When depressed, allows engine NO 2 hydraulic pump to pressurize utility system. Switch is blank when pump is on. PRESS caution light is illuminated when pressure is below 1,200 ± 250 psi. When in released position, pump output pressure is cut off from utility system but pump still rotates producing a small fluid flow which circulates within the pump and out through the case drain line to allow continuous pump cooling. Green OFF indicator illuminates.
12	ENG NO 2 HYD SYS PRESS Gage (Engine NO 2 Utility Pump Pressure Gage)	Engineer Panel	Indicates pressure output in thousands of psi (±100 psi) from engine NO 2 hydraulic pump.
13	ENGINE NO 2 FLUID SHUTOFF Switch/Indicator (Green) (Guarded)	Engineer Panel	When depressed, opens engine NO 2 hydraulic fluid shutoff valve and OFF light goes out. OFF indicator is illuminated when valve is commanded closed. Valve is also closed when NO 2 engine FIRE switch is pulled.
14	ROTODOME SHUTOFF UTILITY (Utility Rotodome Shutoff) Switch/Indicator (Green) (Guarded)	Engineer Panel	When depressed, admits utility system pressure to left rotodome drive. When in released position OFF indicator is illuminated and utility system pressure is shut off from left rotodome drive.
15	INTCON VALVE (Interconnect Valve) Switch	Engineer Panel	Operates system interconnect valve. When set to BRAKE, connects auxiliary system to brakes whether in flight or on ground. When set to SYS, pressurizes utility system with NO 1 auxiliary pump if APU or external power on sync bus. When set to OFF, both interconnect valves close.
16	HYD QTY RESERVOIR Gage (Hydraulic Quantity Gage)	Engineer Panel	Indicates hydraulic fluid quantity in utility reservoir in gallons. Gage indicates full (F) whenever the reservoir contains six or more gallons.

CAUTION

Operation of hydraulic pumps for more than five minutes with fluid shutoff valve closed and engine rotating (windmilling or normal operation) can damage pumps. Pump operating time with shutoff closed will be recorded in AFTO Form 781.

Figure 1-56 (Sheet 5 of 7)

NO.	CONTROL/INDICATOR	LOCATION	FUNCTION
17	ROTODOME SHUTOFF AUXILIARY (Auxiliary Rotodome Shutoff) Switch/Indicator (Green) (Guarded)	Engineer Panel	When depressed, admits auxiliary system pressure to right rotodome drive. Switch is blank when auxiliary system pressure is available to right rotodome drive. When in released position, auxiliary system pressure is shut off from right rotodome drive and OFF indicator is illuminated. Also supplies hydraulic pressure to recharge APU hydraulic accumulators when open.
18	RUDDER LIMIT PRESSURE Indicator (Rudder Mode Indicator)	Engineer Panel	Indicates operation of rudder airspeed switches in flight or RUDDER TEST PRESSURE switch (17, *figure 1-13*) on ground. When both airspeed switches are open in flight or when rudder test switch is set to 3,000 on ground, indicator displays 3,000. When 175 knot switch is closed in flight or rudder test switch is set to 2,290 on ground, indicator displays 2,290. When 250 knot switch is closed in flight, or rudder test switch is set to 1,450 on ground, indicator displays 1,450.

WARNING

Observe airspeed limits in section V when in 3,000 or 2,290 mode.

NO.	CONTROL/INDICATOR	LOCATION	FUNCTION
19	HEAT EXCH (Auxiliary Heat Exchanger) Switch/Caution Light (Amber, Green) (Guarded)	Engineer Panel	OHEAT caution light illuminates when hydraulic fluid temperature exceeds 230 ± 5°F. OHEAT caution light goes out when temperature drops below 210°F. ORIDE indicator illuminates when switch is in released position. When in released position, commands heat exchanger bypass valve to close regardless of fluid temperature, routing all returning fluid through heat exchanger. When HEAT EXCH switch is depressed, bypass valve is controlled by a temperature sensor. Bypass valve opens at a fluid temperature below 15°F and valve closes at a fluid temperature above 40°F.
20	HYD SYS PRESS Gage (Auxiliary System Pressure Gage)	Engineer Panel	When RUDDER switch is set to ON, indicates auxiliary system pressure in thousands of psi (±100 psi). Pressure transmitter is in rudder supply line.

Figure 1-56 (Sheet 6 of 7)

Hydraulic System Controls and Indicators (Continued)

NO.	CONTROL/INDICATOR	LOCATION	FUNCTION
21	PUMPS 2 RUD Switch/Caution Light (NO 2 Auxiliary Pump Switch) (Amber) (Guarded)	Engineer Panel	When depressed, turns NO 2 auxiliary pump on. Amber PRESS caution light illuminates when pump outlet pressure drops below 1,200 (+150, –500) psi. When released, OFF illuminates green and pump is turned off.
22	PUMPS 1 RUD/SPOIL Switch/ Caution Light (NO 1 Auxiliary Pump Switch) (Amber Green) (Guarded)	Engineer Panel	When depressed, turns NO 1 auxiliary pump on. Amber PRESS caution light illuminates when pump outlet pressure drops below 1,200 (+150, –500) psi. When released, OFF illuminates green and pump is turned off.

CAUTION

When power is interrupted in changing from APU or external power to airplane generators or from airplane generators to APU or external power, the ELCU for auxiliary hydraulic pump NO 1 can trip. If this happens, the PRESS caution light illuminates. Restart the pump immediately by pressing the PUMPS 1 RUD/SPOIL switch twice (setting switch to off and then on). Failure to restart the pump causes loss of inboard spoilers and can cause damage to rotodome bearing if auxiliary drive is in use and engines are operating.

NOTE

The pressure switches for the PRESS caution lights (system schematic, *figure 1-60*) are located between the pump outlet and the pump check valve. The pressure transmitter for the pressure gage is in the rudder hydraulic line. Therefore, it is possible for the PRESS caution light to illuminate or go out before the gage indicates 1,200 (+150, –500) psi. If this occurs, it is not a discrepancy and will not be recorded on AFTO Form 781.

Figure 1-56 (Sheet 7 of 7)

Hydraulic Systems Block Diagram

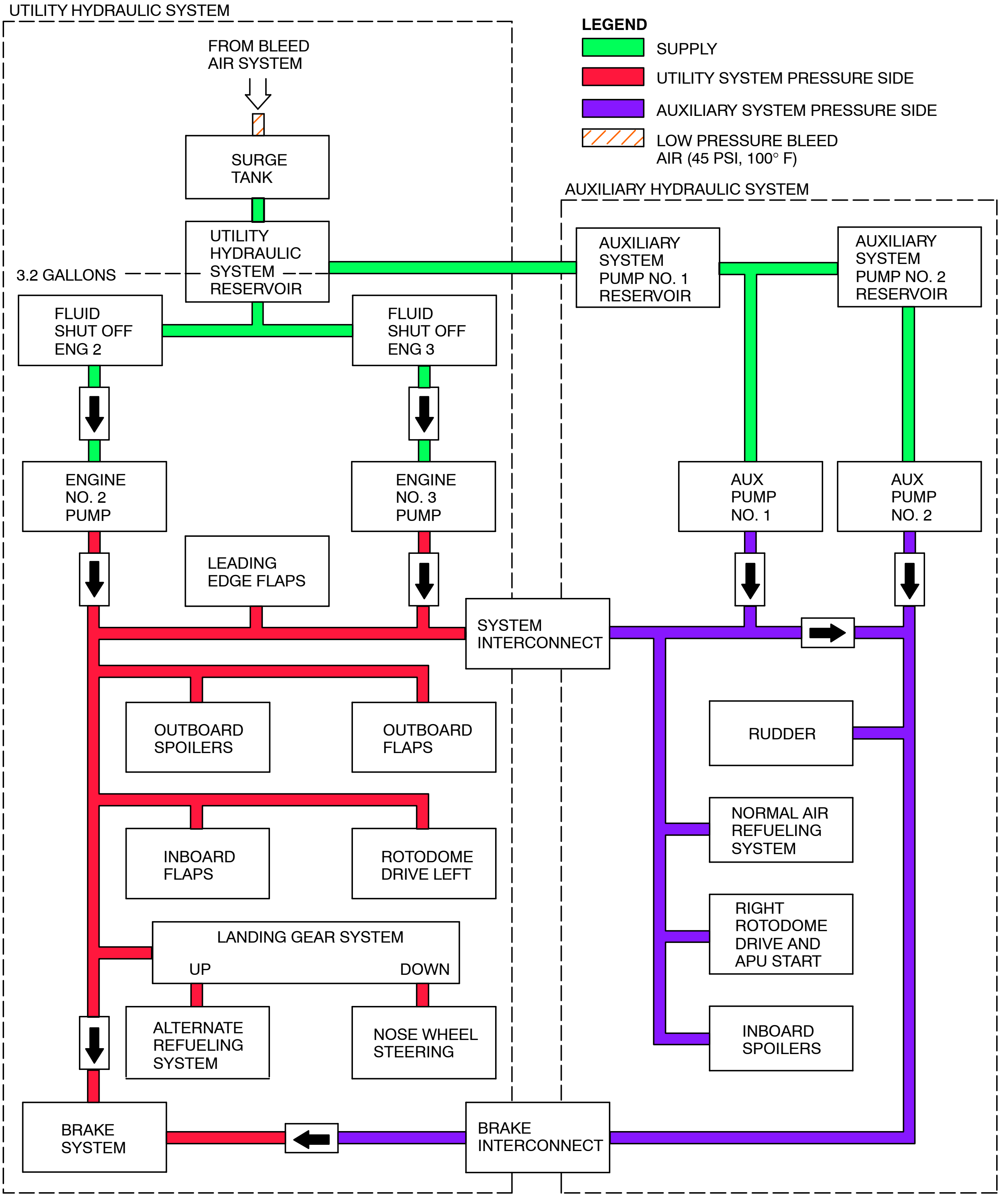

Figure 1-57

Utility Hydraulic System Schematic

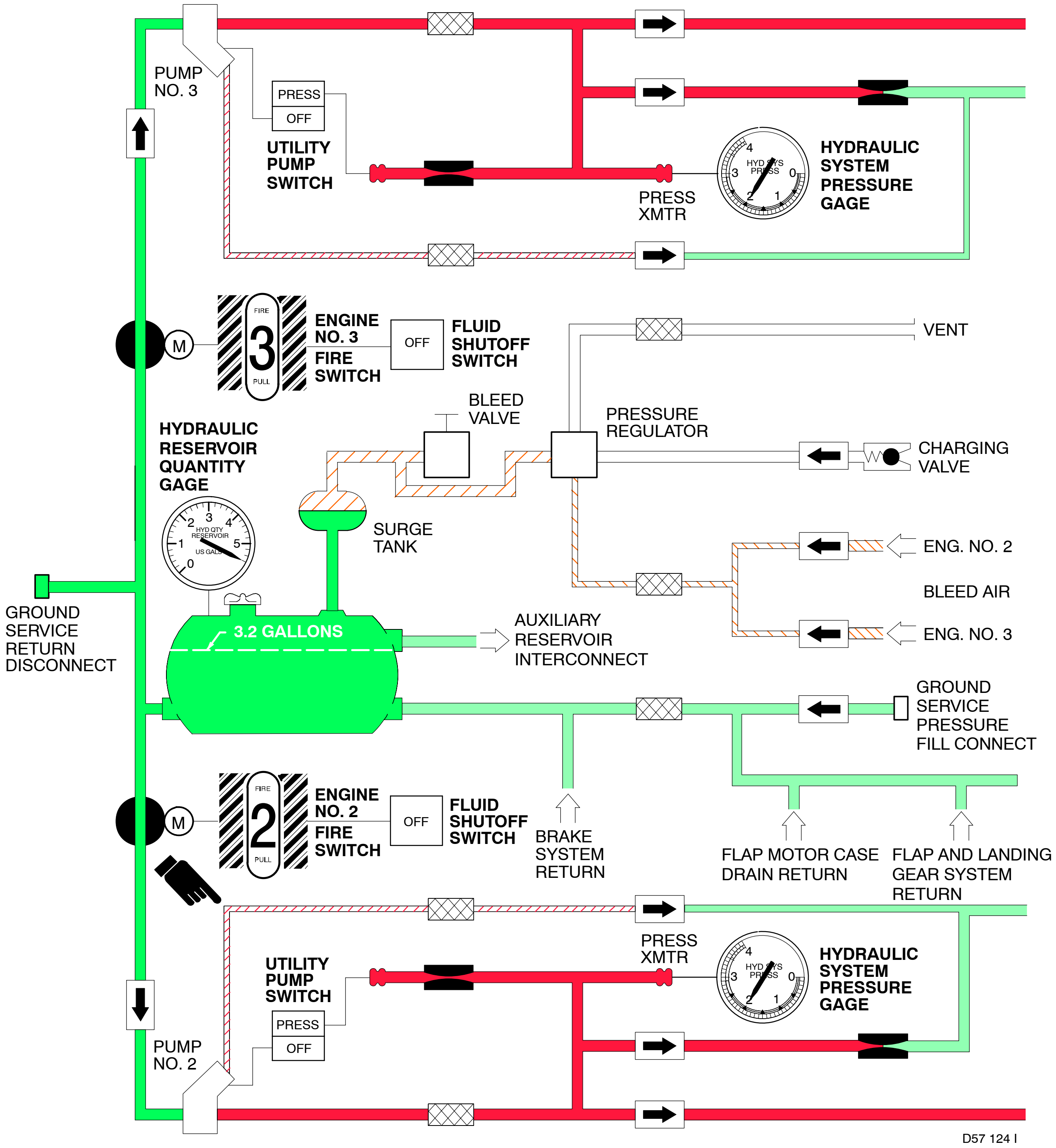

Figure 1-58 (Sheet 1 of 2)

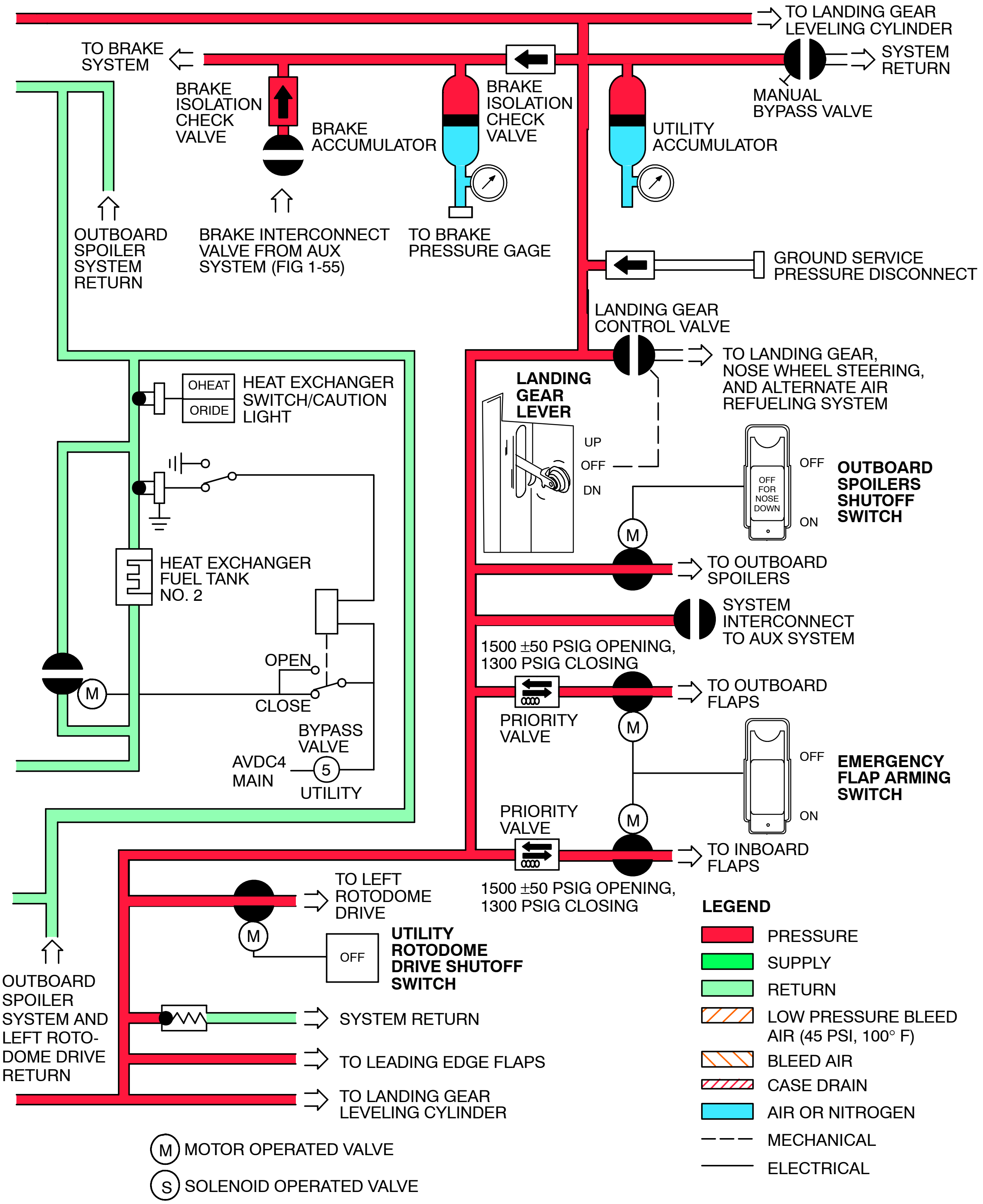

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Figure 1-58 (Sheet 2 of 2)

Auxiliary Hydraulic System Schematic

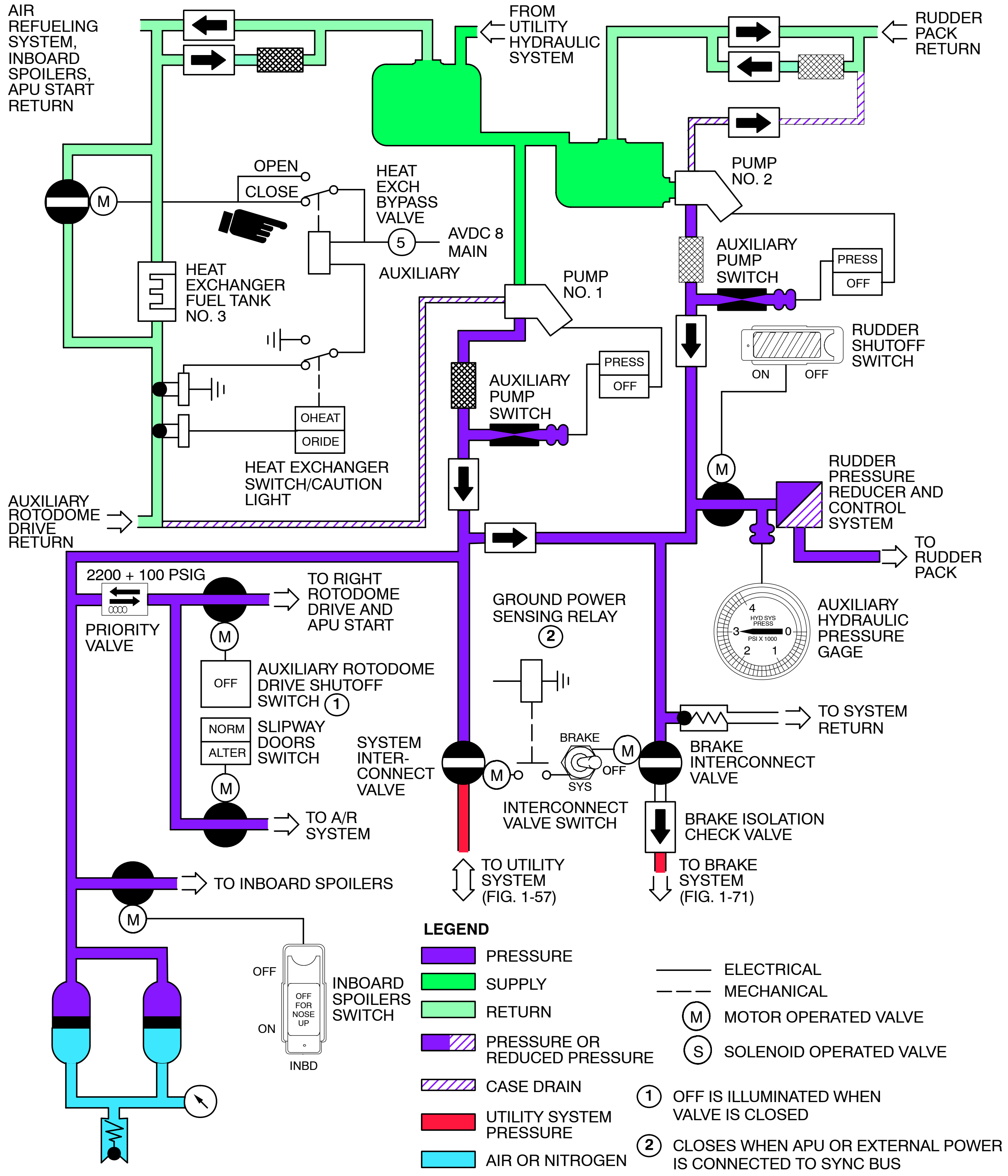

Figure 1-59

D57 126 I

Rotodome Drive Schematic

(SYSTEM SHOWN WITH UTILITY DRIVE SELECTED AND SPEED AT IDLE)

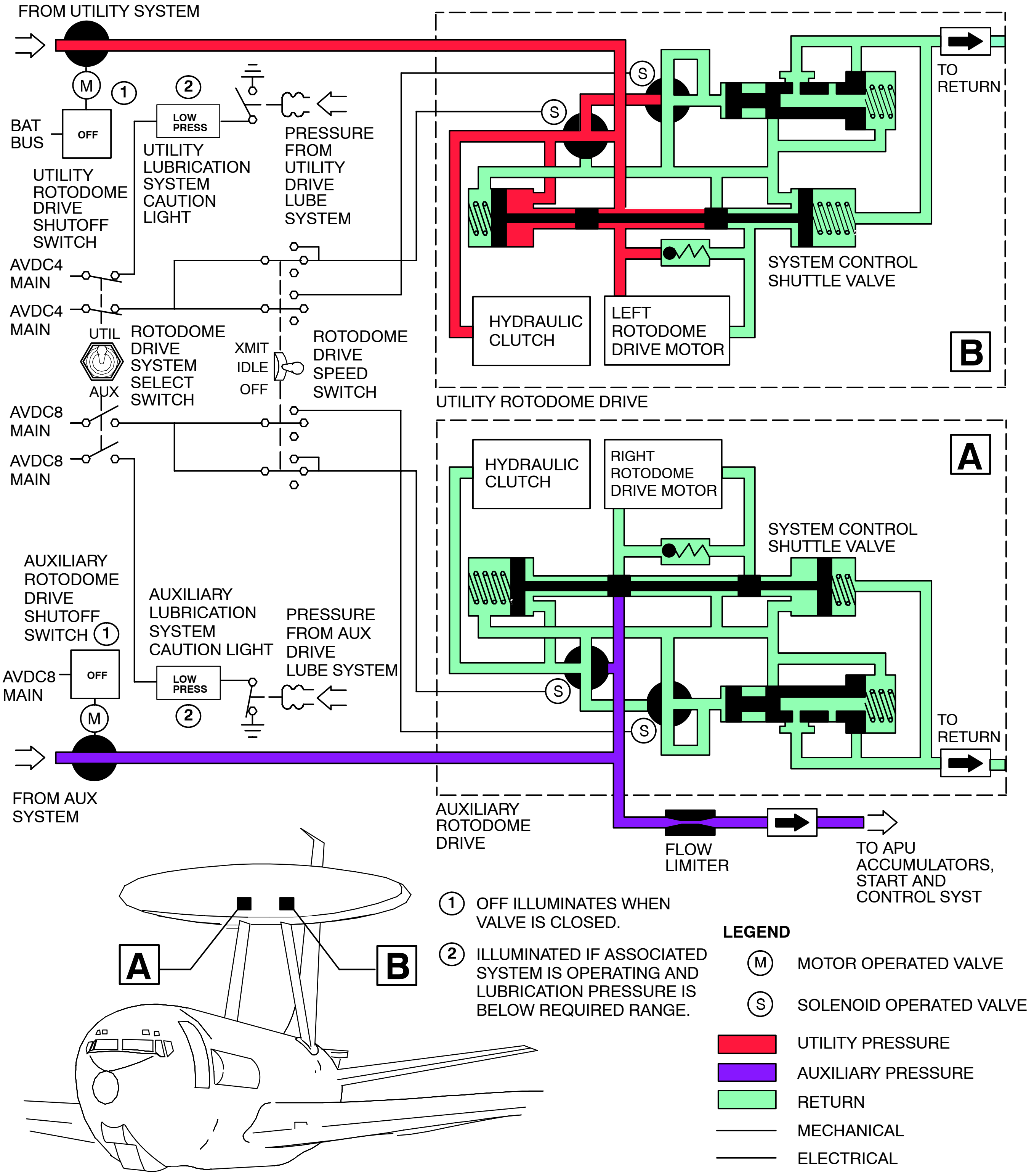

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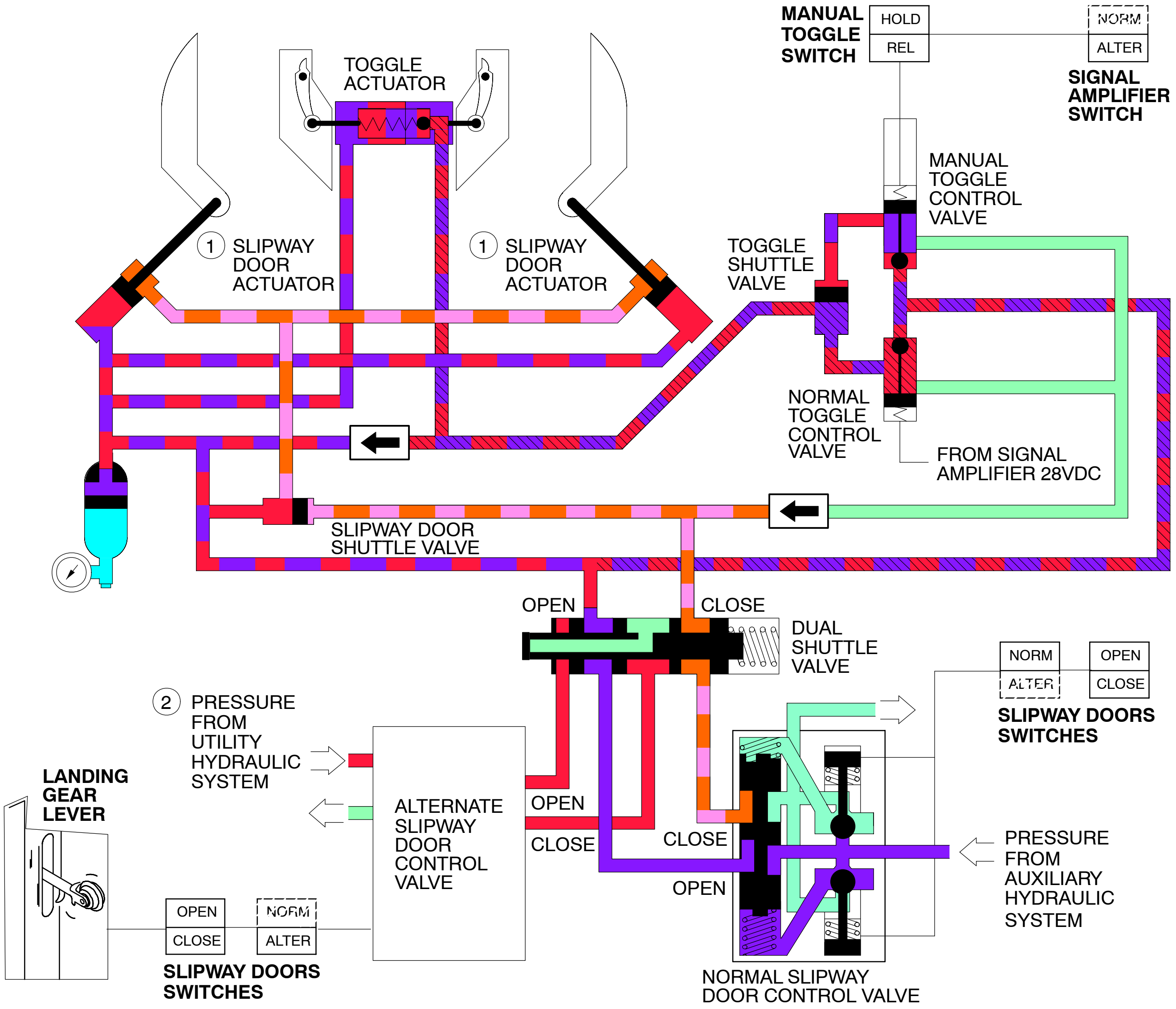
Figure 1-60

Air Refueling Hydraulic System Schematic



LEGEND

🟥 UTILITY SYSTEM PRESSURE

🟪 AUXILIARY SYSTEM PRESSURE

🟥🟪 DOOR OPEN AND TOGGLE RELEASE LINES

🟧🟪 SLIPWAY DOORS CLOSE LINE

▨▨ NORMAL TOGGLE HOLD LINE

🟥🟪 MANUAL TOGGLE HOLD LINE

🟩 RETURN

🟦 AIR OR NITROGEN

① WHEN THE DOORS OPEN OR TOGGLES LATCH, PRESSURE IS APPLIED TO BOTH SIDES OF THE ACTUATOR PISTON. DUE TO THE GREATER AREA ON THE "OPEN" OR "LATCH" SIDE OF THE PISTON, THE ACTUATOR EXTENDS.

② PRESSURE AVAILABLE FROM UTILITY SYSTEM WHEN LANDING GEAR LEVER IS SET TO UP.

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Figure 1-61

Hydraulic System Electric Power Sources

EQUIPMENT/SYSTEM	TYPE OF POWER	POWER SOURCE	CIRCUIT BREAKER LOCATION/LABEL
AUX PUMPS			
No 1 Control ①	28V DC	AVDC Bus 8 ② ③	P61-4 HYDRAULIC – AUX PUMPS – CONTR NO 1
No 2 Control ①	28V DC	AVDC Bus 4	P61-4 HYDRAULIC – AUX PUMPS – CONTR NO 2
No 2 Motor	115V AC	AVAC Bus 4	P61-4 HYDRAULIC – AUX PUMPS – NO 2 POWER
Low Pressure Caution Lights	28V DC	BAT BUS	P61-4 HYDRAULIC – AUX PUMPS – LOW PRESS LIGHTS
Auxiliary Heat Exchanger Bypass Valve ① ③	28V DC	AVDC Bus 8	P61-4 HYDRAULIC – HEAT EXCH – BYPASS VALVE AUX
UTILITY PUMPS			
Pump Depressurization Switches ①	28V DC	AVDC Bus 8	P61-4 HYDRAULIC – UTILITY – PUMP DEPRESS 2 & 3
Low Pressure Caution Light, Engine 2 ①	28V DC	AVDC Bus 4	P61-4 HYDRAULIC – UTILITY – LOW PRESS – ENG 2
Engine No 2 Fluid Shutoff	28V DC	BAT BUS	P61-4 HYDRAULIC – UTILITY – HYD FLD SOV – ENG 2
Low Pressure Caution Light, Engine 3 ①	28V DC	AVDC Bus 4	P61-4 HYDRAULIC – UTILITY – LOW PRESS – ENG 3
Engine No 3 Fluid Shutoff	28V DC	BAT Bus	P61-4 HYDRAULIC – UTILITY – HYD FLD SOV – ENG 3
Interconnect Valve ① ③	28V DC	AVDC Bus 4	P61-4 HYDRAULIC – GAGES – BRAKE & SYS INTCON VALVES
Utility Heat Exchanger Bypass Valve ① ③	28V DC	AVDC Bus 4	P61-4 HYDRAULIC – HEAT EXCH – BYPASS VALVE UTILITY
Hydraulic Fluid Quantity Gages ①	28V DC	AVDC Bus 8	P61-4 HYDRAULIC – GAGES – QTY

Figure 1-62 (Sheet 1 of 2)

Hydraulic System Electric Power Sources (Continued)

EQUIPMENT/SYSTEM	TYPE OF POWER	POWER SOURCE	CIRCUIT BREAKER LOCATION/LABEL
PRESSURE GAGES			
Utility Engine No 2	28V AC	28V AC Bus 2	P61-4 HYDRAULIC – GAGES – UTILITY PRESS ENG 2
Utility Engine No 3	28V AC	28V AC Bus 8	P61-4 HYDRAULIC – GAGES – UTILITY PRESS ENG 3
Auxiliary Hydraulic System Pressure	28V AC	28V AC Bus 8	P61-4 HYDRAULIC – GAGES – AUX & BRAKE PRESS
APU Accumulator	115V AC	EAC	P61-2 ENGINE START & INDICATORS – APU ACCUM PRESS
ROTODOME DRIVE			
Utility Drive Unit ③	28V DC	AVDC Bus 4	P61-4 ROTODOME – UTILITY – DRIVE UNIT
Utility Shutoff Valve	28V DC	BAT BUS	P61-4 ROTODOME – UTILITY – SOV
Utility Lube Pressure Switch ①	28V DC	AVDC Bus 4	P61-4 ROTODOME – UTILITY – LUBE PRESS SW
Auxiliary Drive Unit ① ③	28V DC	AVDC Bus 8	P61-4 ROTODOME – AUXILIARY – DRIVE UNIT
Auxiliary Shutoff Valve ① ③	28V DC	AVDC Bus 8	P61-4 ROTODOME – AUXILIARY – SOV
Auxiliary Lube Pressure Switch ①	28V DC	AVDC Bus 8	P61-4 ROTODOME – AUXILIARY – LUBE PRESS SW

① Inoperative if ac power is lost to TRU and dc tie bus circuit breakers are open.

② AVDC 8 also powers rudder shutoff valve via RUDDER shutoff switch, and rudder load limiter.

③ Valve remains in position selected at time of power failure.

Figure 1-62 (Sheet 2 of 2)

SUBSECTION I-G
LANDING GEAR, BRAKES AND ANTISKID

Table of Contents

LANDING GEAR

The landing gear has two main gear trucks with four wheels each and a dual wheel nose gear. See *figures 1-63* through *1-67*. All three gears are actuated hydraulically by independent hydraulic actuators controlled by cables operated by the landing gear lever (*figure 1-63*). Pressure for operation of the gear is supplied by the utility hydraulic system (*figure 1-64*). The main gears are retracted inboard into the wheel well areas of the fuselage (*figure 1-64*) and are covered in flight by the main gear doors, which are hinged to the keel beam. The nose gear retracts forward into a well which is closed by two sets of clamshell doors. A T-shaped air deflector is attached to the lower torsion link on the nose gear shock strut. The air deflector is used to reduce airloads on the nose bar shock strut doors. Normal operation of the landing gear requires about 10 to 15 seconds for extension or retraction. Each main gear truck is leveled by a hydraulic cylinder pressurized by the utility system through the lockout-deboost valve. The nose gear is automatically centered by cams in the strut during the last 4 inches of extension. The landing gear lever has a solenoid-operated lock to prevent retraction until both main trucks are level (at right angles to the struts) and either strut is fully extended. In an emergency, the lock can be bypassed by pulling out the override trigger on the gear lever. When the main gear struts extend or retract, they actuate safety (squat) switches which operate several relays that apply liftoff or touchdown signals to certain airplane systems. See *figure 1-68*.

LANDING GEAR DOORS

The landing gear doors on the main and nose gear are hydraulically operated. Door operation is controlled by sequence valves operated by the landing gear. Position of the doors controls operation of landing gear sequence valve. Manual door operating handles are provided to open the doors and lock them open for ground maintenance. The main gear doors may be opened manually in flight without lowering the gear.

LANDING GEAR WARNING AND POSITION INDICATIONS

The door and gear warning lights (1 and 2, *figure 1-63*) and landing gear warning horn provide indication of possible unsafe landing gear conditions. The DOOR warning light (1) illuminates when any landing gear door is not fully closed and locked. The GEAR warning light (2) illuminates under the following conditions: any landing gear is unlocked (regardless of landing gear lever position); any gear is not in the position indicated by landing gear lever (down for DN or up for UP); any gear up and locked and any throttle retarded near idle (pull HORN SILENCE switch to turn off light).

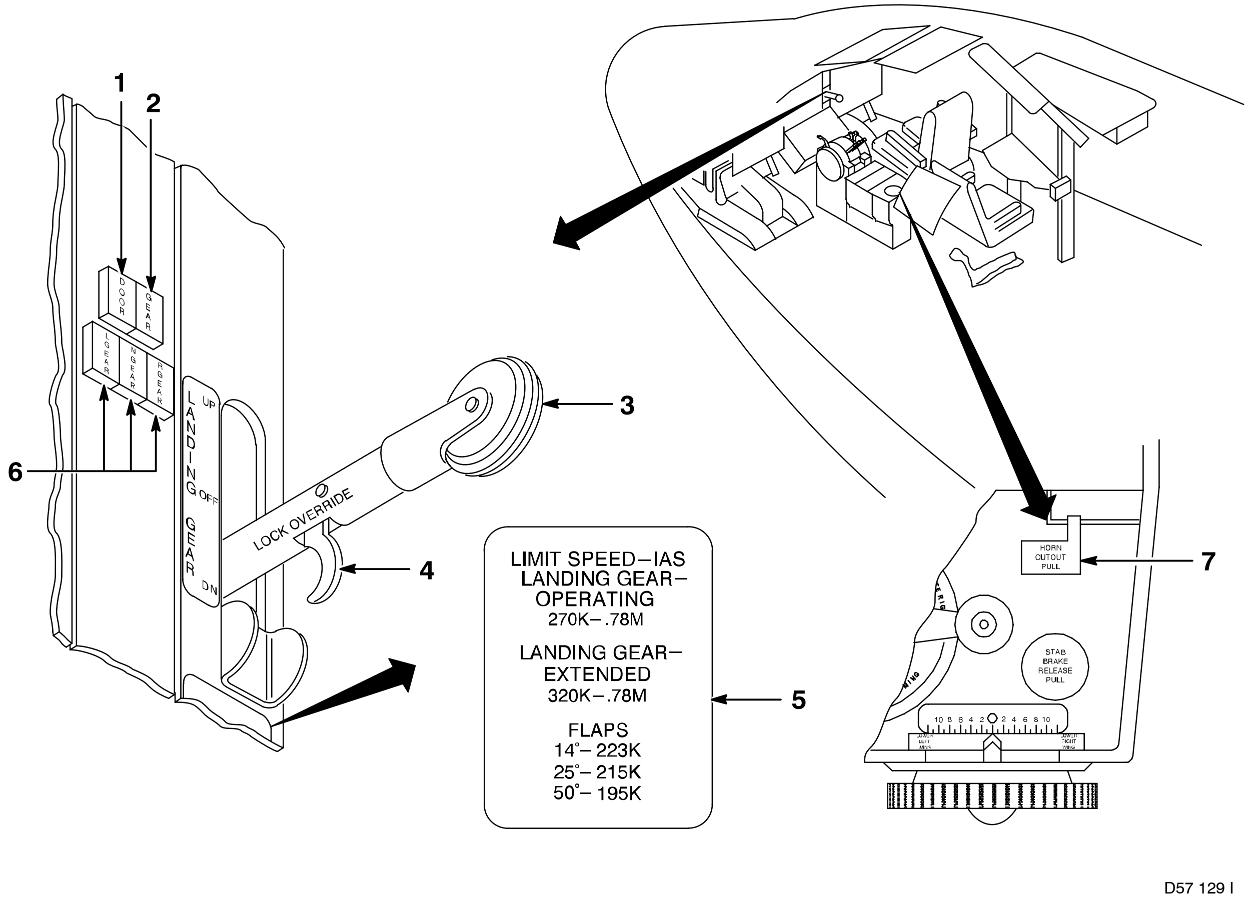
With landing gear lever OFF (as in manual gear extension), the GEAR warning light illuminates as each gear is unlocked and goes out when gear is locked. The GEAR and DOOR warning lights are inoperative if AC power is lost.

When each gear reaches the down position and locks, the green light (6, *figure 1-63*) for that gear illuminates. Since the three retraction systems are independent, the three lights do not always illuminate or go out at the same time. The nose gear usually locks down last. The gear down (green) lights are inoperative if ac power is off or if the landing gear position relays malfunction.

The warning horn sounds steadily when any gear is not down and locked and the flaps are beyond 25. When flaps are at 14 or 25, the horn can be silenced by pulling the HORN SILENCE lever. When flaps are at 40 or 50 the horn can be shut off (for an intentional gear up landing or ditching) by opening the WARN HORN circuit breaker on P5 panel. The horn is inoperative if ac power is off.

The warning horn also sounds intermittently on the ground for warning of unsafe takeoff condition (refer to TAKEOFF WARNING SYSTEM) and in flight for warning of loss of cabin pressure (refer to CABIN PRESSURIZATION SYSTEM).

Landing Gear Controls and Indicators



NO.	CONTROL/INDICATOR	FUNCTION
1	DOOR Warning Light (Red)	Illuminates if any gear door not closed and locked. Inoperative if ac power is lost.
2	GEAR Warning Light (Red)	Illuminates when any gear is unlocked (regardless of landing gear lever position) or any gear is not in position indicated by landing gear lever or any gear up and locked and any throttle retarded near idle (can be shut off by pulling HORN SILENCE lever). Inoperative if ac power is lost.
3	LANDING GEAR Lever (Gear Lever)	Lever has three detent positions: UP – OFF – DN. (Push lever into detent when operating.) Refer to LANDING GEAR OPERATION.

Figure 1-63 (Sheet 1 of 2)

NO.	CONTROL/INDICATOR	FUNCTION
	UP	Mechanically positions landing gear control valve to open doors, raise gear, and close doors in retraction sequence. Provides hydraulic pressure to air refueling alternate (ALTER) system from the nose gear retract pressure line.
	OFF	Mechanically positions landing gear selector valve to cause pressure to be blocked in up and down lines depressurize brakes and landing gear systems. Normal flight position.
	DN	Mechanically positions landing gear selector valve to open doors, drop gear, and close doors in the extension sequence. Refer to LANDING GEAR OPERATION.

CAUTION

Do not set gear lever to OFF on ground. Collapse of nose gear can result.

4	LOCK OVERRIDE Trigger	When pulled, overrides gear lever solenoid lock and allows gear retraction. Solenoid lock prevents raising gear lever until either main landing gear strut is extended and both trucks have been levelled (rotated perpendicular to gear strut) after takeoff. Solenoid is inoperative if ac power is lost.

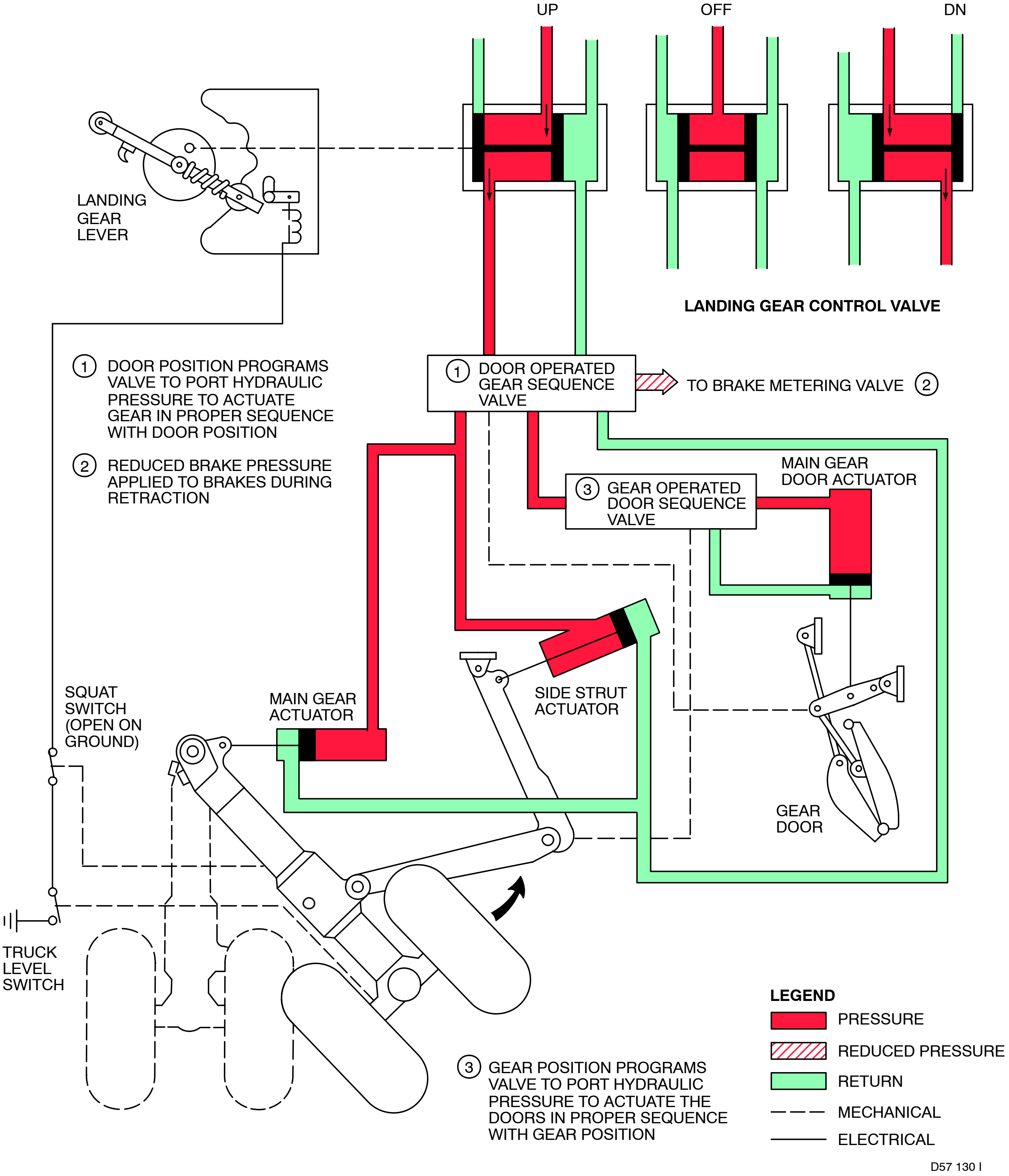
CAUTION

Use LOCK OVERRIDE only in extreme emergencies. Gear retracts whether in correct position or not. Gear could hit doors or structure, causing damage.

5	Flight Limit Speed Placard	Lists maximum allowable airspeeds for normal landing gear operation and for flying with landing gear or flaps extending/ retracting. Refer to section V for other limits.
6	LANDING GEAR Down Indicators (Lights) (Green)	LGEAR, NGEAR, RGEAR, each illuminate when corresponding gear is down and locked. Inoperative if ac power is lost or landing gear position relays malfunction.
7	HORN SILENCE Lever	When pulled, mechanically resets throttle-operated switches to silence warning horn. When landing gear lever is OFF and any gear is not down and locked, also shuts off GEAR WARNING light.

Figure 1-63 (Sheet 2 of 2)

Main Landing Gear Hydraulic System



① DOOR POSITION PROGRAMS VALVE TO PORT HYDRAULIC PRESSURE TO ACTUATE GEAR IN PROPER SEQUENCE WITH DOOR POSITION

② REDUCED BRAKE PRESSURE APPLIED TO BRAKES DURING RETRACTION

③ GEAR POSITION PROGRAMS VALVE TO PORT HYDRAULIC PRESSURE TO ACTUATE THE DOORS IN PROPER SEQUENCE WITH GEAR POSITION

Figure 1-64

Nose Landing Gear Hydraulic System

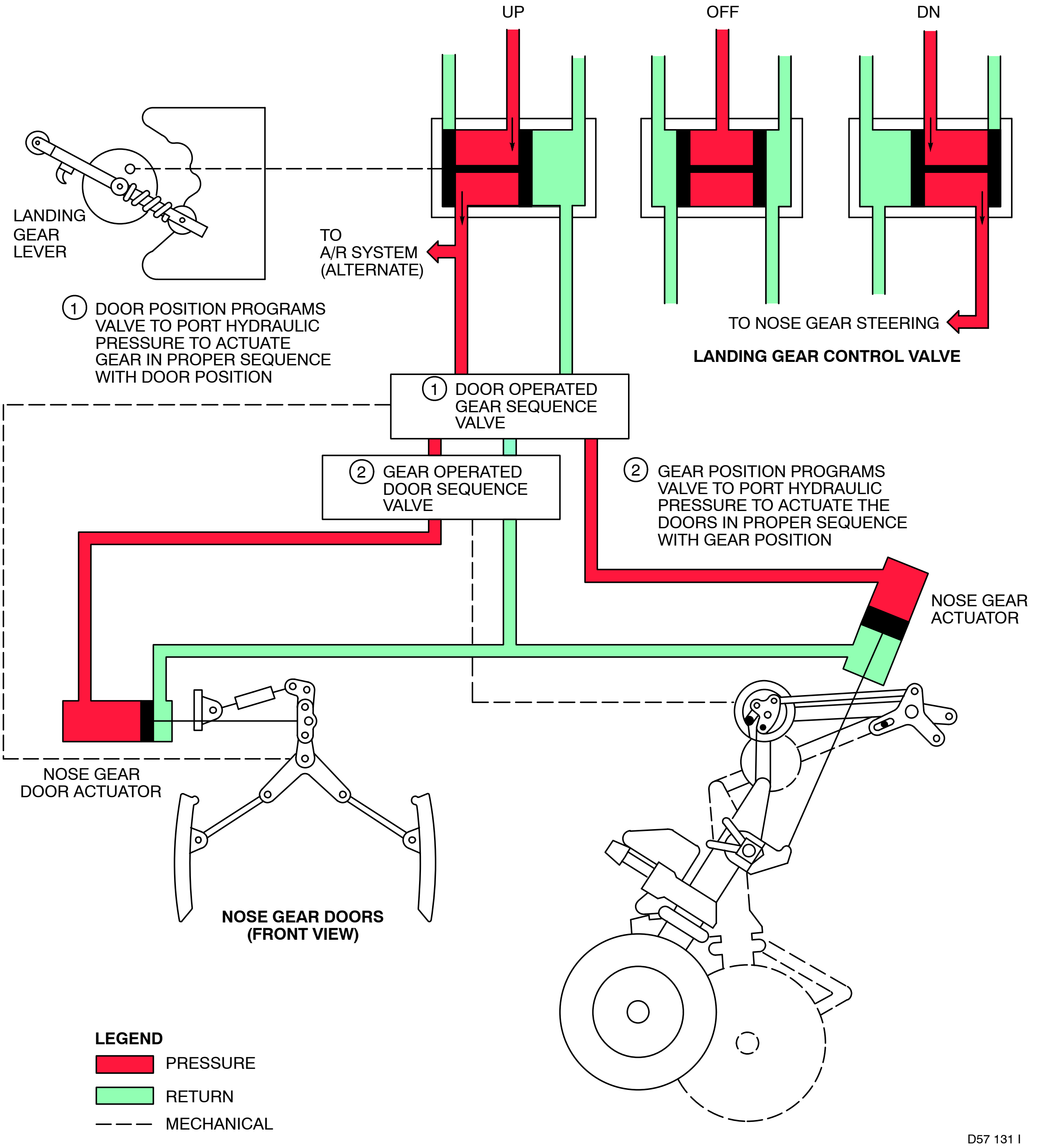
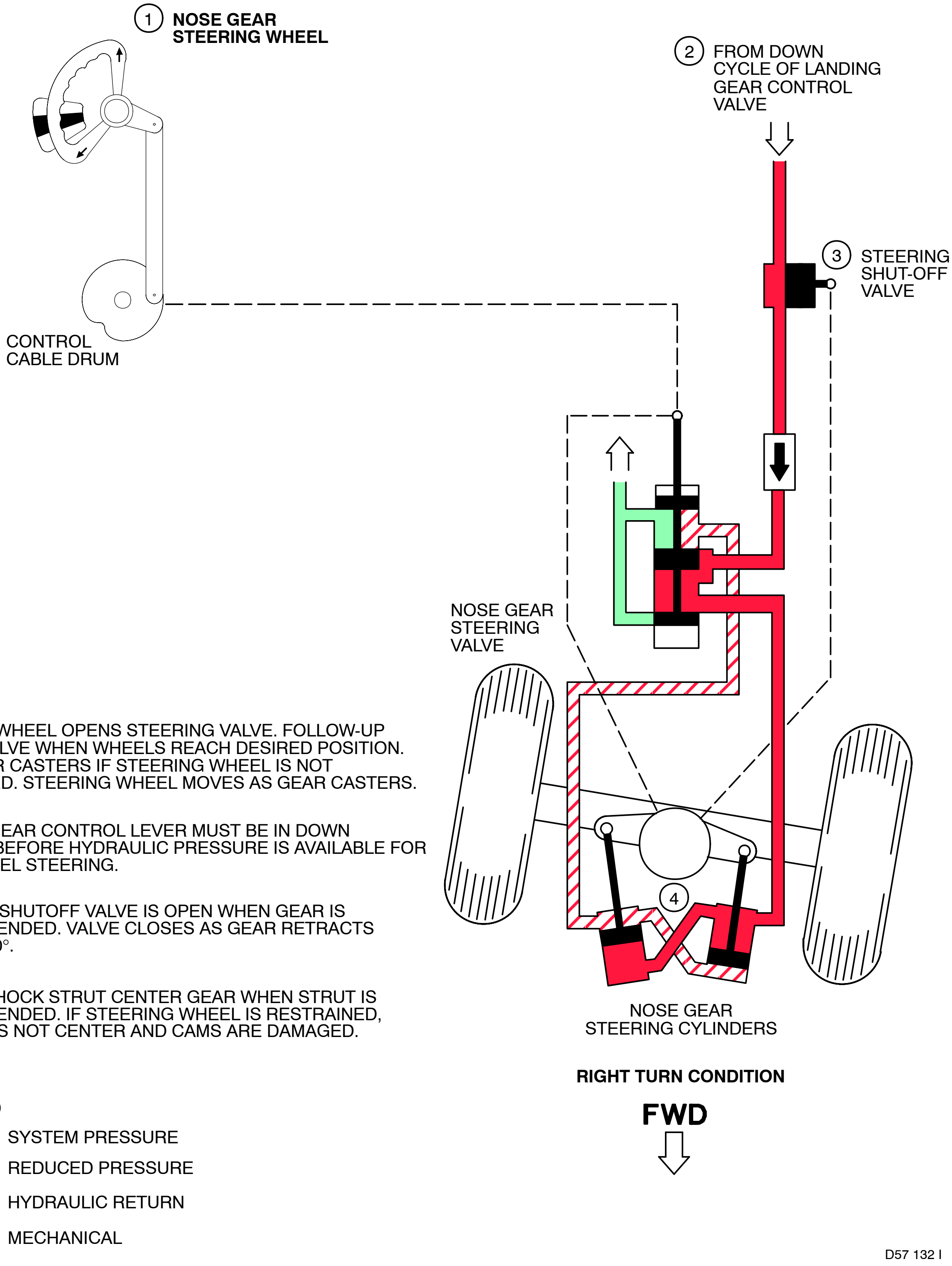


Figure 1-65

Nose Gear Steering System



① STEERING WHEEL OPENS STEERING VALVE. FOLLOW-UP CLOSES VALVE WHEN WHEELS REACH DESIRED POSITION. NOSE GEAR CASTERS IF STEERING WHEEL IS NOT RESTRAINED. STEERING WHEEL MOVES AS GEAR CASTERS.

② LANDING GEAR CONTROL LEVER MUST BE IN DOWN POSITION BEFORE HYDRAULIC PRESSURE IS AVAILABLE FOR NOSE WHEEL STEERING.

③ STEERING SHUTOFF VALVE IS OPEN WHEN GEAR IS FULLY EXTENDED. VALVE CLOSES AS GEAR RETRACTS BEYOND 10°.

④ CAMS IN SHOCK STRUT CENTER GEAR WHEN STRUT IS FULLY EXTENDED. IF STEERING WHEEL IS RESTRAINED, GEAR DOES NOT CENTER AND CAMS ARE DAMAGED.

LEGEND

🟥 SYSTEM PRESSURE
▨ REDUCED PRESSURE
🟩 HYDRAULIC RETURN
— — — MECHANICAL

Figure 1-66

Landing Gear Position Indicating System

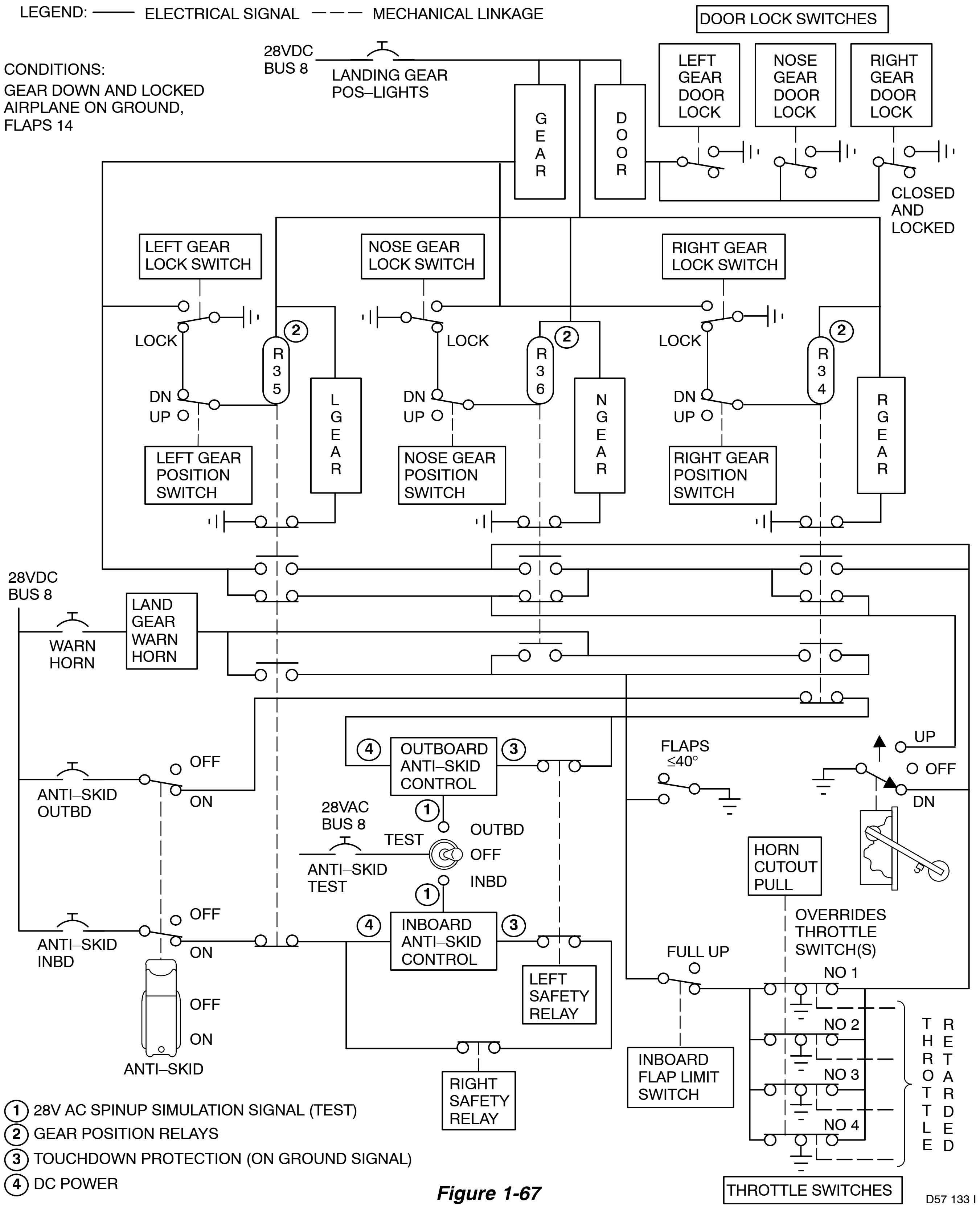
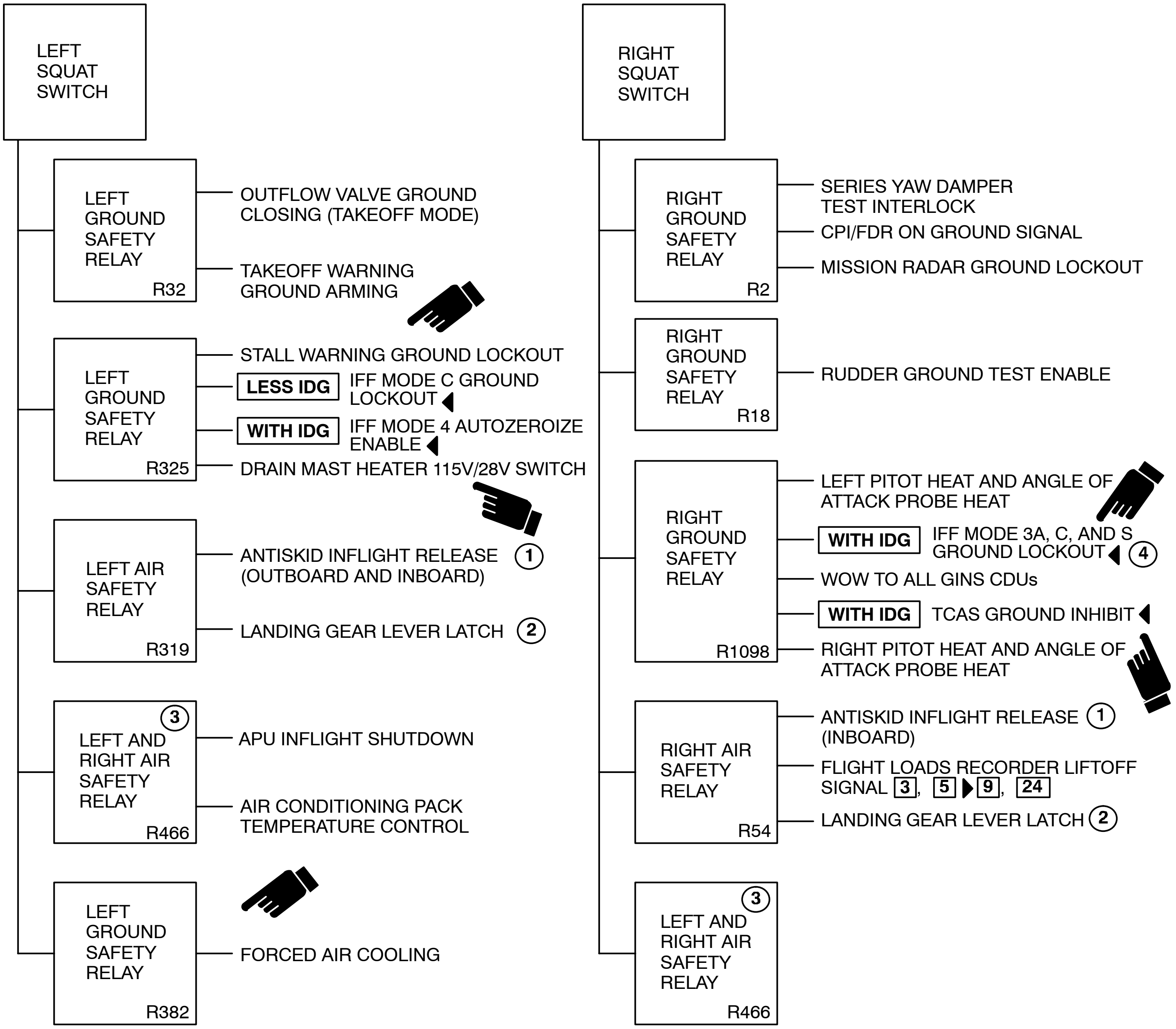


Figure 1-67

Landing Gear Safety Relay Functions



① BOTH RELAYS R319 AND R54 MUST CLOSE TO ENERGIZE INBOARD ANTISKID. LEFT RELAY R319 MUST CLOSE TO ENERGIZE OUTBOARD ANTISKID.

② EITHER LEFT (R319) OR RIGHT (R54) RELAY AND BOTH TRUCK LEVEL SWITCHES MUST BE IN FLIGHT POSITION TO ENERGIZE LEVER LATCH SOLENOID.

③ EITHER LEFT OR RIGHT SQUAT SWITCH IN FLIGHT POSITION ENERGIZES R466 THROUGH R319 OR R54, RESPECTIVELY.

④ **WITH IDG** LOCKS OUT MODE 3A, C, AND S ALL CALL RESPONSES. DOES NOT LOCK OUT SQUITTER OR RESPONSE TO SELECTIVE INTERROGATION. HOWEVER, SQUITTER CONTAINS AN ON–GROUND STATUS THAT CAUSES ATC RADARS TO CEASE SELECTIVE INTERROGATION UNLESS MANUALLY OVERRIDDEN AT ATC. ◀

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Figure 1-68

LANDING GEAR VISUAL INSPECTION PORTS

Inspection ports allow inflight viewing of the landing gear downlocks and inspection of wheel wells (*figure 1-69*). The main gear downlocks are viewed through ports in the mission compartment floor.

The nose gear inspection port is on top of the nose gear well and is viewed with a mirror. (The correct viewing position is with the eye level with the mirror and slightly to the left of the centerline of the nose wheel well.) The landing gear is locked when red stripes on the lock mechanism are aligned.

A shield is installed on the nose gear lock strut so that the lock stripes (17, *figure 1-69*) cannot be seen when the nose gear is up.

LANDING GEAR OPERATION

The landing gear lever mechanically controls the landing gear control valve, which controls utility system pressure to two sequence valves. As the airplane leaves the ground, the landing gear struts extend, centering the nose gear and closing the main gear safety (squat) switches. The squat switches operate a set of landing gear safety relays which provide liftoff and touchdown signals to various airplane systems. A list of these functions is in *figure 1-68*. The truck leveling cylinders automatically move the trucks to the level position at right angles to the strut, closing a level switch in each strut. When either safety switch and both level switches are closed, the landing gear lever lock solenoid is energized and the gear lever can be set to UP.

CAUTION

> Always make sure the nose gear steering wheel is centered before retracting the landing gear. Attempting to turn the nose gear could damage the centering cams.

Main Gear Operation

When the landing gear lever is set to UP, utility system pressure is directed through the door sequence valve to open the doors (DOOR warning light illuminates) and through the brake metering valves to apply brakes. Low pressure braking is applied to stop wheel rotation, to reduce noise, and to reduce gyroscopic forces on the struts. (See *figure 1-64*.)

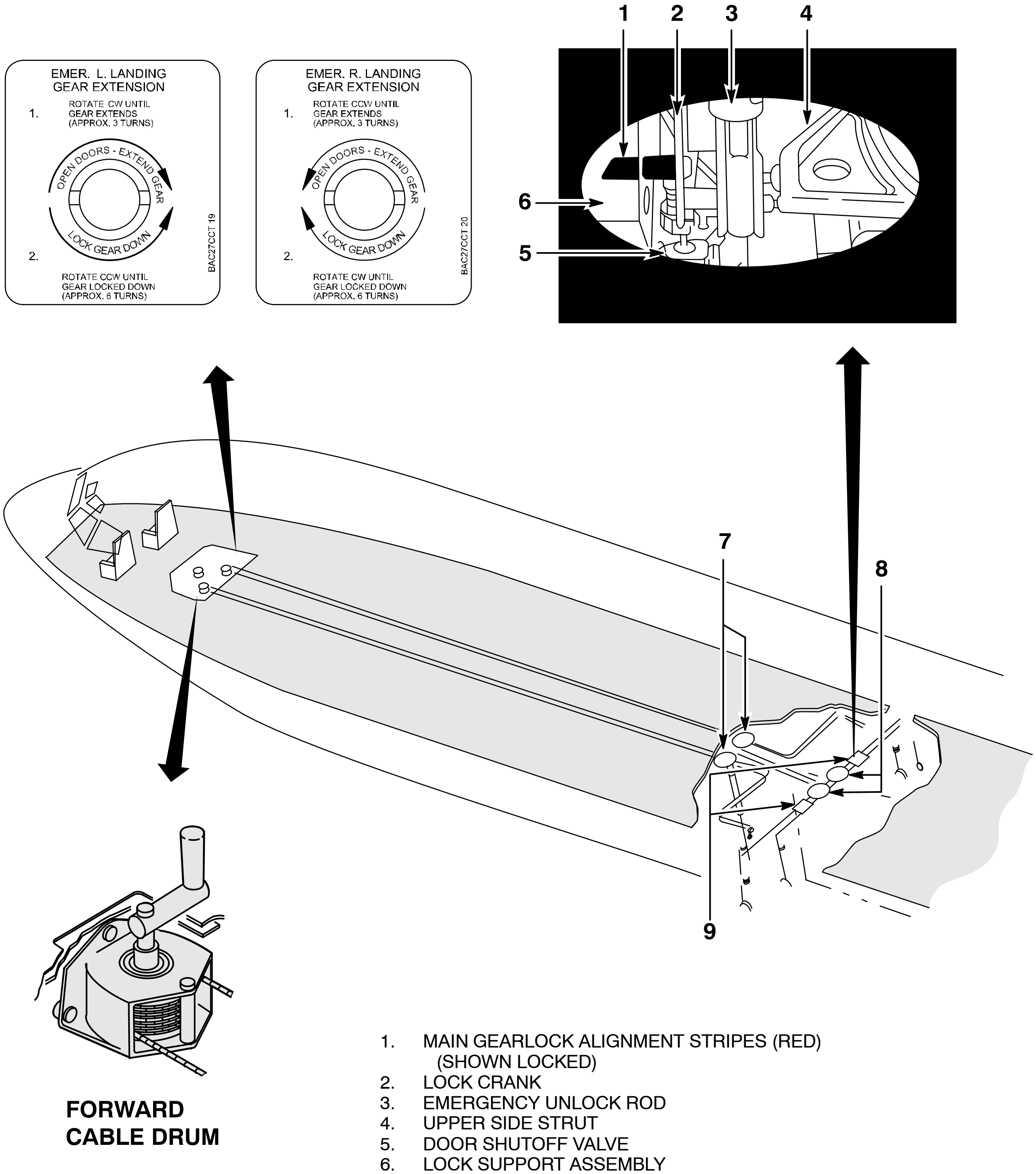
CAUTION

> Do not apply brakes with brake pedals while retracting landing gear. The forces generated by rapid stopping of wheels could damage truck leveling mechanism. If pedals are applied, record in AFTO Form 781 so maintenance can check the strut.

When the doors are fully open, the landing gear sequence valve directs pressure to release the main gear downlocks. When the downlock rotates, the door sequence valve is rotated to lock the doors (GEAR warning light illuminates, and green indicators go out). When the landing gear reaches the retracted position, the uplock rotates to the locked position, opening the door sequence valve and the GEAR warning light goes out (if main and nose gear are up). Hydraulic pressure is now ported to close the doors and the DOOR warning light goes out. When the landing gear handle is set to OFF, hydraulic pressure is removed from gear and door lines, the strut settles against the uplock, and mechanical locks hold the door actuators closed.

When the landing gear lever is set to DN (down), the lever operates the control valve mechanically, routing hydraulic pressure through the sequence valve to open the doors, illuminating the DOOR warning light. When the doors are fully opened, the gear sequence valve directs pressure to unlock the uplock, releasing the landing gear and illuminating the GEAR warning light. When the uplock rotates, the door sequence valve is moved to lock the doors open. Hydraulic pressure from the gear sequence valve is sent to the extend side of the landing gear and side strut actuators to extend the gear. When the main strut is fully down, the GEAR warning light goes out, if all landing gear are down and locked, the green position indicator illuminates, and the door sequence valve opens and allows pressure to close the doors. The door closing and locking is the same as during retraction.

Manual Landing Gear Extension



1. MAIN GEARLOCK ALIGNMENT STRIPES (RED) (SHOWN LOCKED)
2. LOCK CRANK
3. EMERGENCY UNLOCK ROD
4. UPPER SIDE STRUT
5. DOOR SHUTOFF VALVE
6. LOCK SUPPORT ASSEMBLY
7. DOOR RELEASE ACCESS PORTS
8. DOWN LOCK VIEWING PORTS
9. VIEWING PORT ACCESS PANELS

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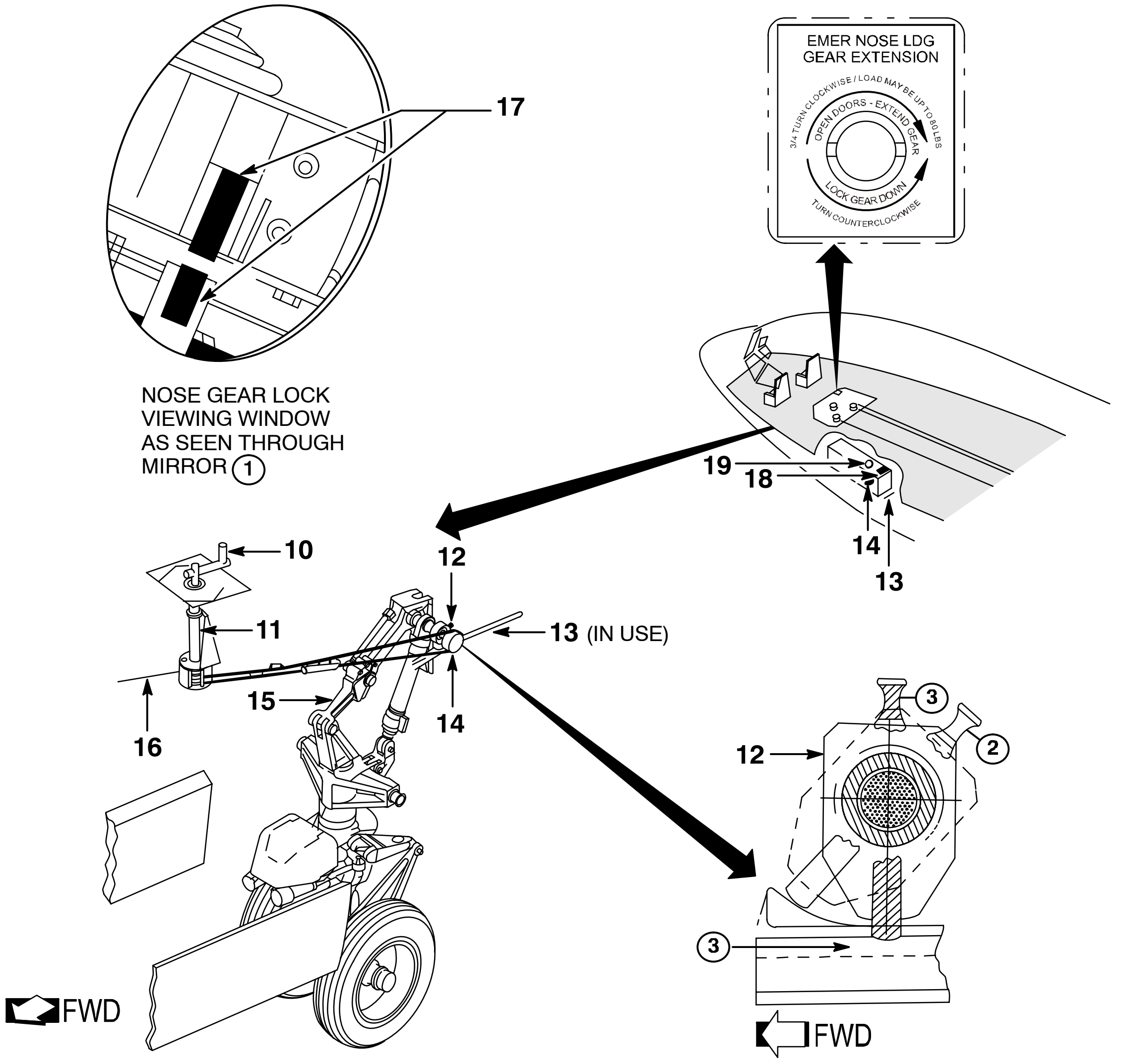
Figure 1-69 (Sheet 1 of 2)



① STRIPES VISIBLE ONLY WHEN GEAR IS DOWN.

② RELEASED POSITION.

③ LOCKED POSITION. PIN SHOULD BE FLUSH WITH, OR BEYOND, INSIDE OF HOLE.

10. HAND CRANK
11. HAND CRANK DRUM ASSEMBLY
12. EMERGENCY LOCK PIN
13. EMERGENCY EXTENSION LEVER
14. RELEASE DRUM
15. DRAG STRUT
16. DOOR RELEASE CABLE
17. NOSE GEAR LOCK ALIGNMENT STRIPES (RED) (SHOWN LOCKED) ①
18. INSTRUCTION PLACARD
19. VIEWING MIRROR

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Figure 1-69 (Sheet 2 of 2)

Manual Landing Gear Extension (Cont)

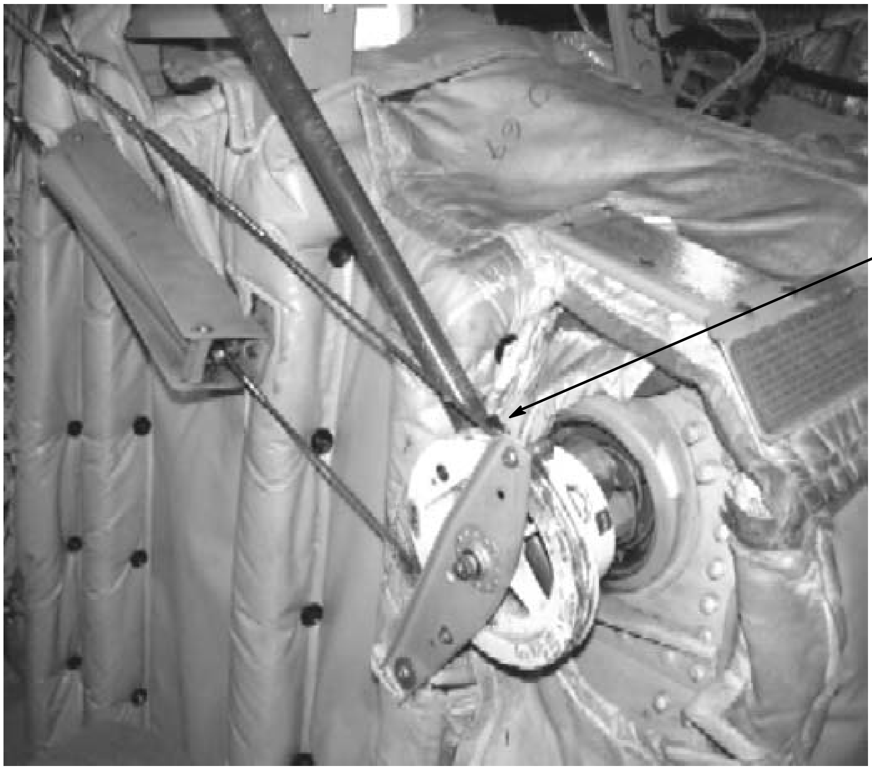
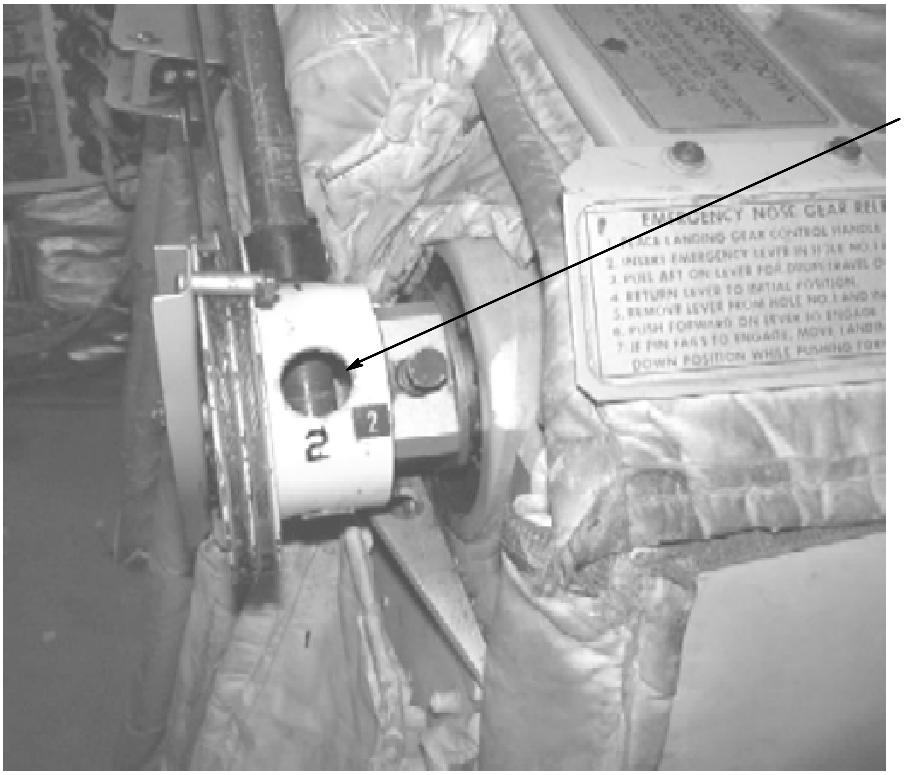
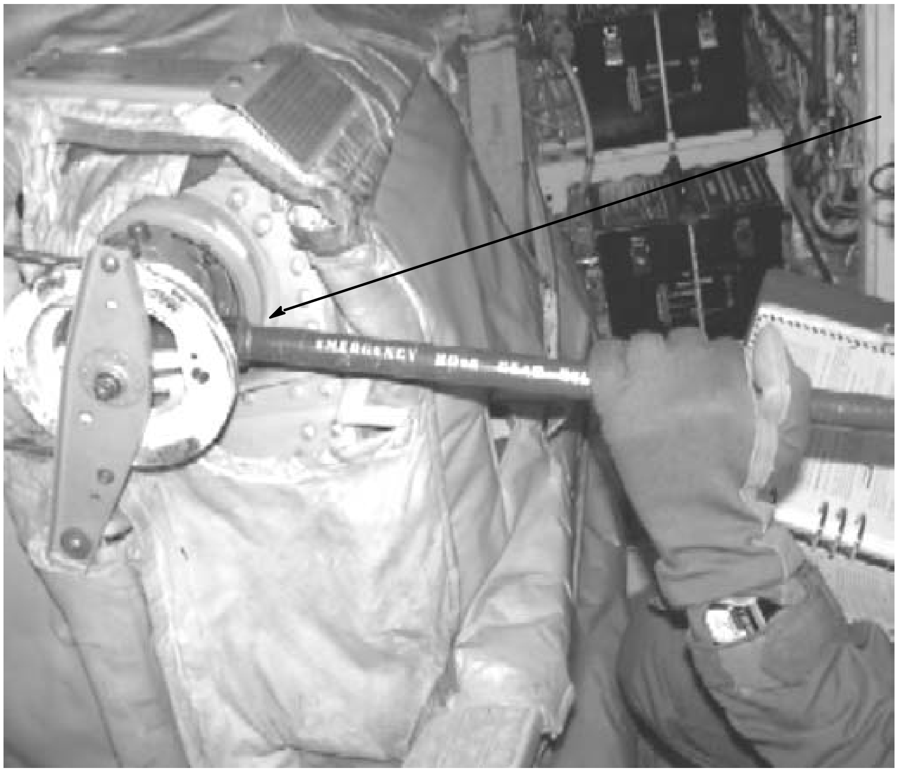


Figure 1-69 (Sheet 3 of 5)

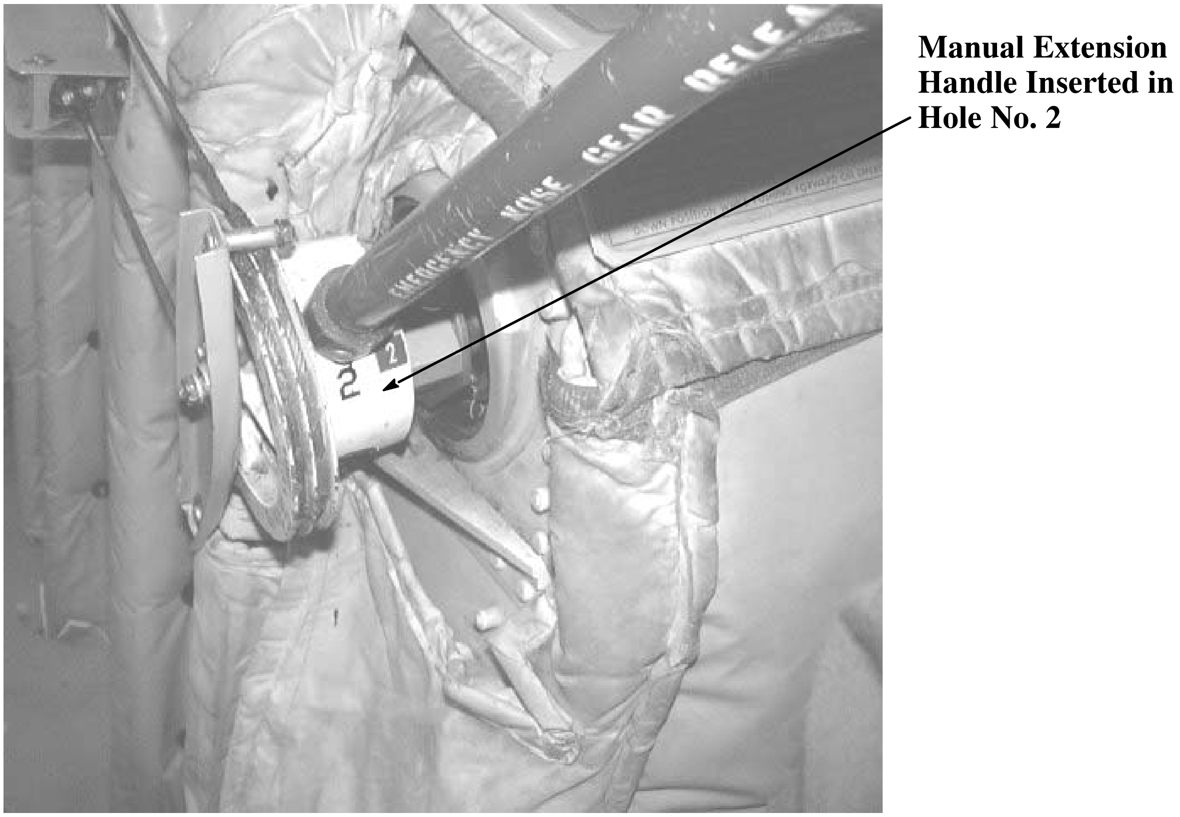


Manual Extension-Handle Inserted in Hole No. 1 (Forward View)



Manual Extension-Handle Inserted in Hole No. 1 (Rotated Aft)

Figure 1-69 (Sheet 4 of 5)



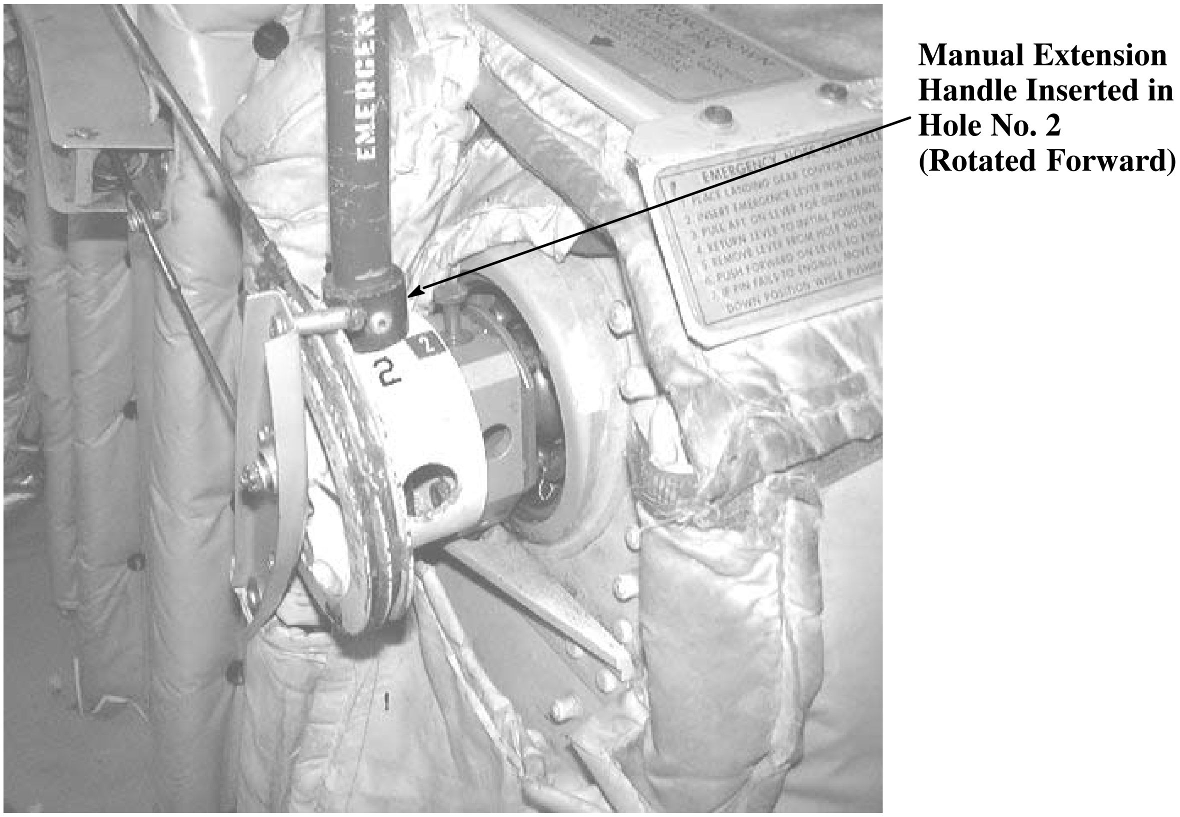


Figure 1-69 (Sheet 5 of 5)

Nose Gear Operation

As the airplane rotates to takeoff attitude, the nose strut extends, causing the centering cams to center the nosewheel steering. When the landing gear lever is set to UP, hydraulic pressure is routed through the door sequence valve (operated by the nose gear) to open the doors, illuminating the DOOR warning light. When the doors are fully open, the lock retention actuator is pressurized, unlocking the nose gear, illuminating the GEAR warning light. The green NGEAR indicator goes out. The doors are held open during nose gear retraction by pressure from the nose gear UP hydraulic line. When the strut is fully up, the GEAR warning light goes out if all landing gear are up and locked, and the door sequence valve opens, allowing hydraulic pressure to close the doors. The DOOR warning light goes out. The doors are held closed by a spring cylinder. The strut is locked up by a spring-loaded lock. (See *figure 1-65*.)

When the landing gear lever is set to OFF, pressure is blocked at the landing gear control valve.

When the landing gear lever is set to DN (down), the landing gear control valve is operated to allow fluid to open the nose gear doors, illuminating the DOOR warning light. The doors are held open by hydraulic pressure from the gear down line. When the doors are fully open, the door operated gear sequence valve applies pressure to the lock actuator (illuminating the GEAR warning light) and to the strut actuator. (The gear is prevented from moving during door operation by fluid locked in the actuator by the sequence valve.) When the strut is fully extended, the GEAR warning light goes out and the green NGEAR indicator illuminates, the door sequence valve closes the doors, the DOOR warning light goes out, and the gear sequence valve pressurizes the downlock actuator. The doors are spring locked closed.

WHEEL WELL FIRE DETECTOR

A fire detection circuit is provided in the main wheel wells to detect a fire in the wheel well. Operation of the unit is similar to the engine fire detector. A fire in the wheel well causes the W/WELL FIRE warning light (*figure 1-23*) on the overhead panel to illuminate, rings the fire bell, and illuminates the master fire warning lights on the glare shield panel. Pressing the master fire warning light silences the bell and resets the system. There is no fire extinguishing system for the wheel well. Refer to Wheel Well Fire, section III.

DOOR GROUND RELEASE HANDLES

Door control handles are provided for each main landing gear door and for the nose gear doors. Refer to Ground Servicing Manual. These handles allow opening either main gear door, or both main gear doors, or both nose gear doors, for ground maintenance without entering the airplane. The handles are provided with a latch position to prevent accidental closing of doors while personnel are in the wheel well. All door actuating linkage is equipped with quick-disconnect fittings to release the actuators from the doors for maintenance.

WARNING

> Prior to entering, or at any time personnel are in wheel well, ensure manual door release handles are down and latched. Hydraulic pressure will close doors rapidly if applied with handle up. Verify wheel well areas are clear before setting door handle to close or pressurizing hydraulic system.

MAIN GEAR LEVELING CYLINDERS

Each main gear leveling cylinder is pressurized with reduced hydraulic pressure from a lockout-deboost valve in the wheel well.

The lockout-deboost valve reduces system pressure in the line leading to the cylinder and isolates the system from the cylinder. If a leak occurs down stream of the valve, fluid loss is limited to the fluid in the line and cylinder. The valve is color coded (red-green-red bands) to indicate proper fluid level and also has a reset handle.

CAUTION

> On preflight inspection, the reset handle must be in the green band if the system is pressurized. If the handle is in the inner red band, replenish the fluid by pulling out on the handle. If the handle cannot be reset to the green band, check the system for leaks. If the handle is in the outer red band, the valve is defective. Valve will be replaced before flight.

The leveling cylinder maintains the truck beam perpendicular to the strut and acts as a snubber as the truck rotates to perpendicular after liftoff. The truck beam operates a level switch to unlock the landing gear lever lock and allow the landing gear to retract. For proper truck leveling, deboost valve handle should be in the green band on preflight inspection. Refer to EXTERIOR INSPECTION, section II.

GROUND LOCKS

The main strut mechanism is mechanically locked down when there is weight on the strut. Mechanical ground locks are also provided for maintenance use (*figure 1-70*).

The nose gear is locked by hydraulic pressure when extended. A mechanical lock is used when the system is unpressurized. (See *figure 1-71*.)

Main Gear Ground Locks

Two locks (*figure 1-70*) act as safety aids for ground maintenance. The main landing gear cannot retract with the weight of the airplane on the gear. The locks are pins, which are pushed through the hinges of the main gear side struts, and must be removed before flight or the main gear cannot retract. Red warning streamers are attached for visibility.

Nose Gear Ground Locks

The nose gear ground lock handle (*figure 1-71*) is placed in the lock mechanism and turned to lock the nose gear down. The lock handle must be inserted any time the airplane is parked and the utility hydraulic system is not pressurized. Before taxiing, turn the lock in the opposite direction and remove it. If the handle is left in the locked position, the gear cannot retract. A hole is provided in the nose gear drag brace for a maintenance ground lock.

EMERGENCY EXTENSION

The landing gear can be extended manually by a handcranked mechanism (*figure 1-69*) in the flight deck floor. The hand crank (67, *figure 1-3*) is stowed on the aft flight deck bulkhead. An emergency lock pin locks the nose gear lock to airplane structure when the nose gear is extended manually. Access port (7, *figure 1-69*) in the mission compartment floor allows manual release of doors if release cables break.

WARNING

- The nose gear emergency lock pin must be inserted manually before a landing if the utility hydraulic system is depressurized.
- Do not release manual gear extension hand crank until unlocking/locking cycle is completed. Cable loads can cause crank to rotate and cause injury.
- Use care when inserting or removing nose gear lock pin. Spring load tends to rotate spring rapidly to unlocked position.

NOTE

- Manual door release ports are partially obscured by mission consoles.

The landing gear cannot be retracted with the emergency system. Landing gear and doors remain down until raised by the normal system.

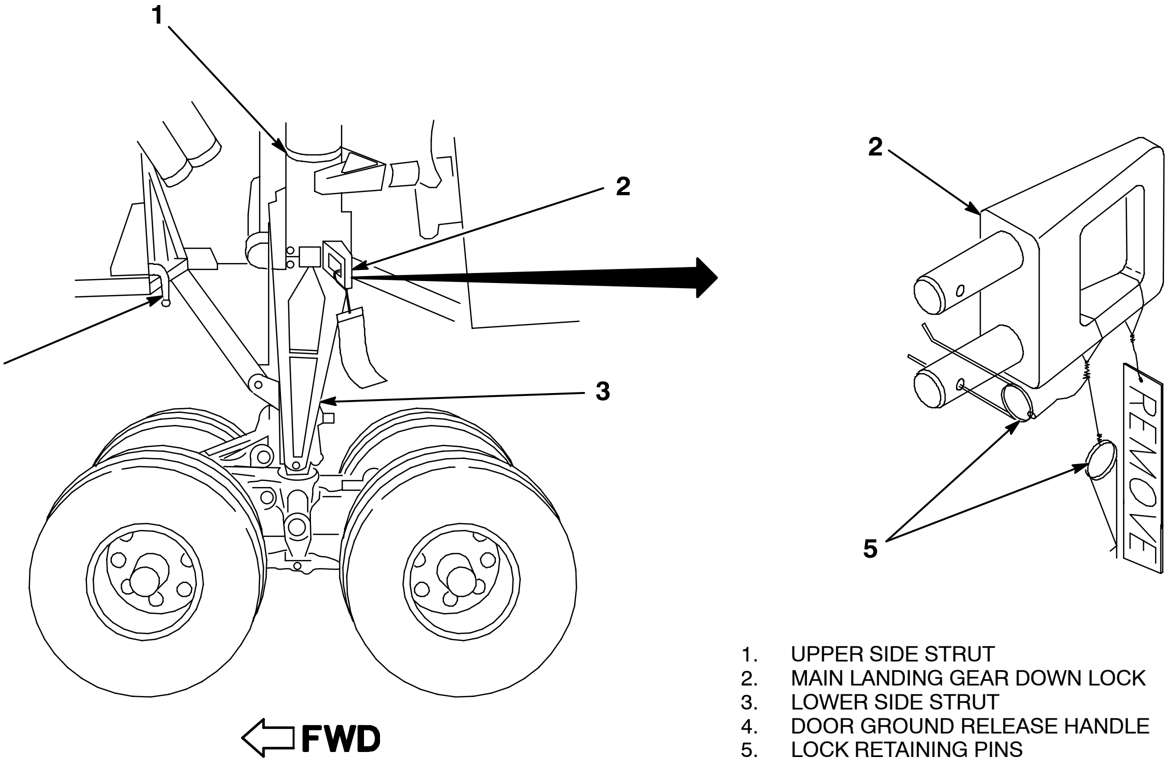
Separate manual extension systems are provided for each gear. The systems are actuated by the hand crank stowed on the aft flight deck wall, behind the navigator’s seat. The three systems are similar, consisting of a crank receptacle on the floor with placard instructions, indicators, and extension mechanisms. The doors remain open after manual extension.

NOTE

Both ADF receivers are unreliable with the doors open.

Manual nose gear extension can require use of the nose gear emergency release lever to mechanically release and lock the gear. This lever is stowed on the aft side of the nose gear well housing in the forward lower compartment. Operating instruction placards are located near the lever (13, *figure 1–69).* (Refer to MANUAL LANDING GEAR EXTENSION, section III.)

Main Landing Gear Lock



1. UPPER SIDE STRUT
2. MAIN LANDING GEAR DOWN LOCK
3. LOWER SIDE STRUT
4. DOOR GROUND RELEASE HANDLE
5. LOCK RETAINING PINS

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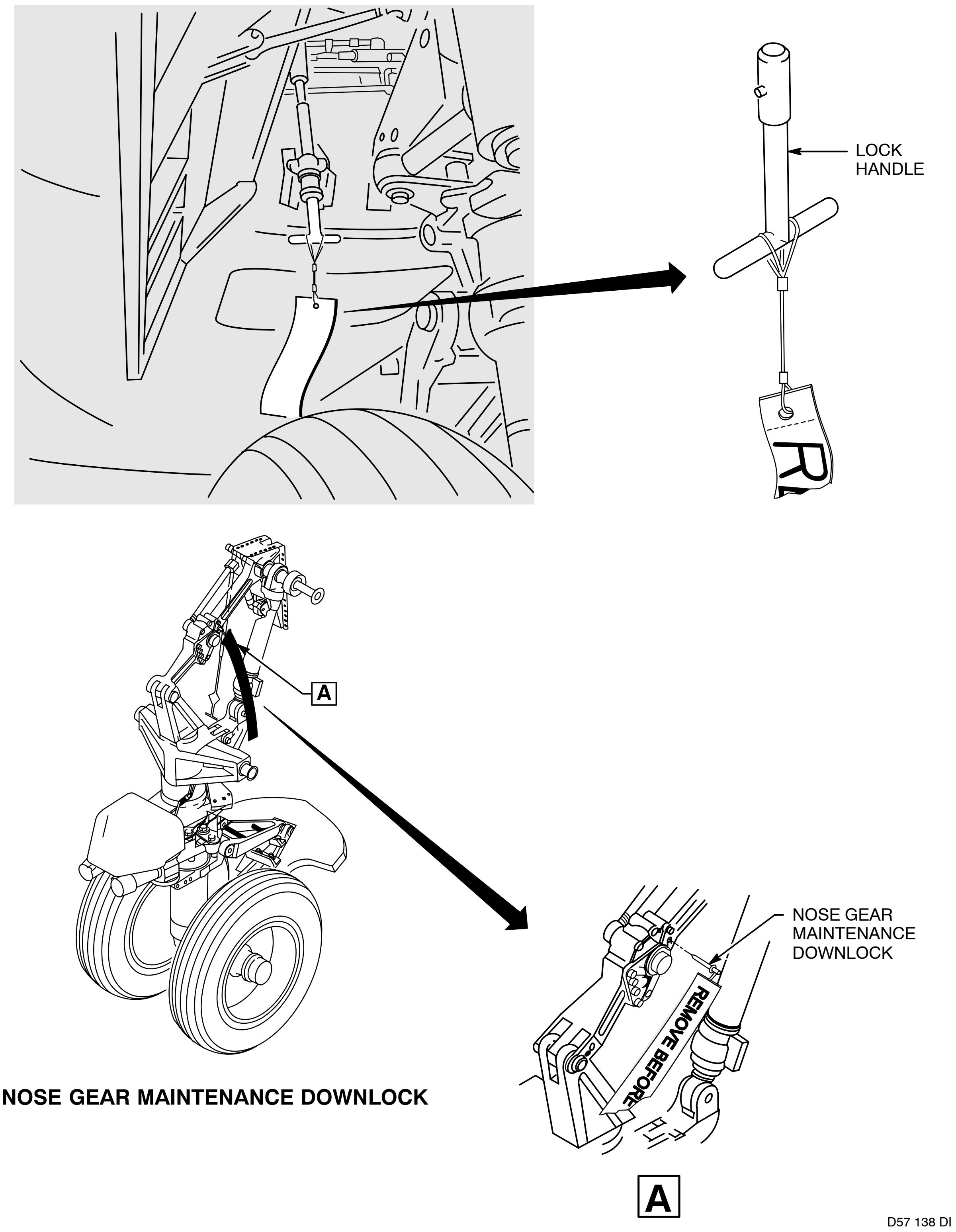
Figure 1-70

Nose Landing Gear Lock



NOSE GEAR MAINTENANCE DOWNLOCK

Figure 1-71

NOSE GEAR STEERING SYSTEM

The nose gear is steered hydraulically by two steering cylinders mounted on the strut and controlled by a steering wheel on the pilot's sidewall panel (*figure 1-10*). The nose wheel can be turned approximately 60 degrees either side of center. See *figure 2-5* for taxi clearance dimensions.

Nose wheel steering hydraulic pressure is supplied by the utility hydraulic system when the landing gear lever is set to DN. The flight deck steering wheel actuates the steering valve through control cables. The steering valve ports hydraulic pressure to opposite ends of the steering cylinders (*figure 1-66*). Piston rods from the steering cylinders move the strut to the desired angle. When the strut is rotated to the desired angle, the cables center the steering valve which stops the strut. Nose wheel deflection is proportional to deflection of the steering wheel. If the nose wheel is deflected by an object on the runway, the control cable follow-up system causes the nose wheel to return to its original position. A shutoff valve prevents nose gear steering operation until the nose strut is down. The nose wheel is centered automatically by centering cams which operate during the last 4 inches of strut extension.

CAUTION

- Do not turn the nose steering wheel until the nose wheel is on the ground. The centering cams can be damaged by attempting to turn the strut against the cams.

- Avoid using nose gear steering during heavy braking or at speeds above 80 KIAS, except as directed in TAKEOFF procedures, section II, or in an emergency. Excessive loads can result in damage to tires, strut and airplane structure.

- Avoid differential braking during taxi to aid nose wheel steering. Make minimum radius turns with engine power and nose gear steering. Use of brakes in turns causes excessive tire wear and strut loads.

- When parking, taxi the airplane a few feet with nose gear centered to relieve strut side loads.

NOTE

- At low engine rpm or with only one utility hydraulic pump operating, using nosewheel steering while extending or retracting flaps can cause flaps to stop. Refer to subsection I-F.

- The nose gear steering system contains a fixed bleed bypass. This bleed gradually depressurizes the utility accumulator when the airplane is parked with hydraulic pressure unavailable.

NOSE GEAR STEERING OPERATION

To turn the nose gear to the left, turn the nose steering wheel to the left. To turn the nose gear to the right, turn the wheel to the right. To center the nose wheel, align the arrow mark on the wheel with the arrow on the side panel. Use pressure to move the steering wheel smoothly. Remember that you are ahead of the nose wheel (*figure 2-5*). You must overshoot your turn point before entering a turn with more than 10 to 15 degrees of nose gear turn angle. Remember wingtip and tail clearances. Refer to TAXI, section II.

BRAKE SYSTEMS

HYDRAULIC BRAKE SYSTEM

Multiple disc brakes on each main landing gear wheel (*figure 1-72*) are normally operated by utility system hydraulic pressure. Auxiliary system hydraulic pressure, from the brake interconnect valve, may also be used on the ground to operate the wheel braking system.

Hydraulic pressure stored in an accumulator, pressurized to more than 750 psi, permits several brake applications, if both utility and auxiliary system hydraulic pressure is lost. The accumulator is normally pressurized to 3,000 psi. Normal overpressure is 3,500 psi.

NOTE

Hydraulic pressure lines to the brakes are isolated by check valves, so that hydraulic failures on the pump side of the brake isolation check valves do not affect brake operation as long as the brake accumulator is pressurized above the precharge pressure.

Brakes and Antiskid System

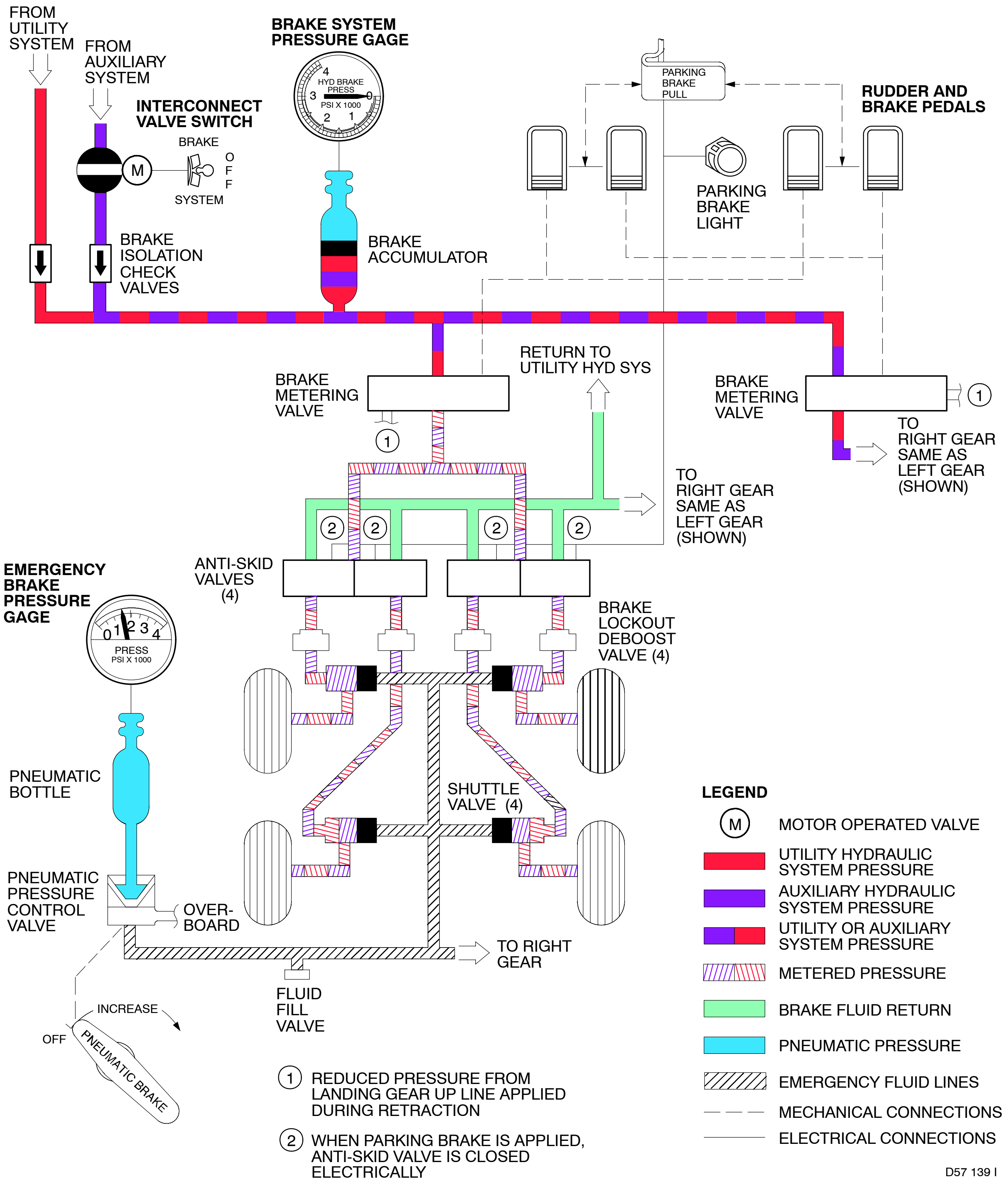


Figure 1-72

The brakes are controlled by the brake pedals on the pilots' rudder pedals. The brakes can be locked for parking by pulling up on the parking brake lever while holding the brake pedals depressed. To release the brakes, depress the brake pedals. Braking pressure is controlled by two pedal-operated metering valves and individual wheel antiskid valves. A lockout-deboost valve in each brake line reduces system pressure to the brakes and isolates the system from the brakes. If a leak occurs downstream of the deboost valve, fluid loss is limited to the fluid in the line from the deboost valve to the brakes. A reset handle can be used to service the lockout-deboost valve.

WARNING

> There are two types of lockout-deboost valves. The older type has red, green, red bands. The newer type has a yellow (silver) colored band between the green and outer red bands. With brakes on, reset handle must be in green range. If reset handle is in inner red range, pull handle out to replenish brake lines. If handle is in outer red or yellow (silver) range, valve must be replaced. Airplane will not be taxied.

NOTE

> For lockout-deboost valves with yellow/silver band, with brakes released and utility system pressurized, the lockout-deboost valve reset handle should be in the yellow (silver) range. If the reset handle is in the outer red range, the brake system must be bled.

Fuse plugs on all wheels allow tires to deflate in case of severe brake overheat.

WARNING

> If all tires deflate due to high temperatures, resulting from heavy braking, the wheels may be cooled by use of a dry chemical fire extinguisher. (Fog or foam is also acceptable.) If one or more tires remain inflated after others have deflated, do not attempt to cool the wheels. Maintain a watch in case of fire. Do not approach a hot wheel from the side.

CAUTION

> Do not open wheel well doors after a high energy stop. If tires deflate, open doors could contact ground, causing damage to doors.

A failure in the utility hydraulic system on the pump side of the brake isolation check valves (*figure 1-72*) does not affect hydraulic brake operation, as long as the brake accumulator is pressurized to more than 750 psi. The accumulator holds enough fluid for a normal braking stop.

See *figure 1-73* for brake system controls and indicators.

PARKING BRAKE

The parking brake is applied by latching the brake in the depressed position mechanically and by closing the return side of the antiskid valves electrically. A loss of electric power to the antiskid valves can result in a gradual loss of pressure in the brakes.

EMERGENCY BRAKE SYSTEM

An alternate system for application of brakes uses high pressure compressed air (*figures 1-73, 1-74* and *1-75*). Pressure is modulated by a handle on the pilot's instrument panel. Pneumatic pressure acts on hydraulic fluid in a transfer tube applying hydraulic pressure equally to all brakes through a shuttle valve on each brake. An overboard vent line prevents brake application due to thermal expansion of the hydraulic fluid. No differential braking or antiskid protection is available with pneumatic braking. Operating procedure for the pneumatic brakes is in section III.

BRAKE ENERGY CAPACITY

Brakes are limited in the amount of energy they can absorb and still function properly. All of the kinetic energy absorbed by the brake is converted to heat. The heat added to the brakes by individual brake applications during a stop or during taxi is not radiated in the short time required for a normal landing or taxi operation. The amount of heat added depends on airplane gross weight and ground speed at the time of application. Extended taxiing does not affect brake temperatures, unless brakes are used. The main effect of taxiing is to increase tire pressure. Tire temperature can increase up to 20°C per nautical mile of taxi distance. Tire pressure increases about 6 percent for each nautical mile of taxi or 1 percent for each 3°C of temperature change. If a tire is below normal pressure, tire flexing and heating increase. See section V, Brake Limitations chart, for energy limits and cooling requirements.

NOTE

- Brake application during taxi can add large amounts of heat to the brakes. For example, at sea level, on a standard day (15°C) a 320,000 pound airplane, braking to reduce taxi speed from 30 knots to 15 knots would add 0.9 million foot pounds per brake.
- The same amount of heat is generated by the brakes in stopping the airplane from a given speed regardless of whether the brakes are applied in one steady application or in a series of short applications. The internal heat generated by the brakes does not reach the outer surface of the wheel-brake assembly for 15 minutes or more while the ground roll requires only a few seconds; therefore, all the heat generated by the brakes remains in the brake assembly for the duration of the ground roll.
- Heat dissipates slowly from the brakes. In the first half hour (of ground cooling) after a stop, only 20 to 40 percent of the heat leaves the brakes. After one hour, 40 to 60 percent, and after two hours, 60 to 80 percent of the heat generated by the stop is lost from the brakes.

The airplane wheels have thermal fused screws (fuse plugs). The plugs are designed to release air pressure in the tires when the tie bolt radius temperature reaches a certain level. This temperature is reached in any stop or series of stops totaling approximately 24 to 28 million foot-pounds kinetic energy per brake.

Maximum effort stops can be required when it is necessary to stop in a minimum distance. The section V brake limitations chart gives the foot-pounds of kinetic energy absorbed in stopping under variables of gross weight, airspeed, and pressure altitude. A maximum effort stop made as a result of a refused takeoff requires absorbing more foot-pounds of energy than does a stop from a landing condition, due to the thrust output of the engines.

ANTISKID SYSTEM

The antiskid system protects against wheel skids by reducing brake pressure as selected by the pilot through the brake metering valves to the maximum level that allows the wheel to decelerate as long as deceleration does not exceed a preset rate and the wheel rotates at the same speed as the other wheels. The antiskid system includes a control circuit and antiskid valve for each main wheel, a wheel speed detector in each main wheel hub, and locked wheel speed comparison circuits for inboard and outboard wheels. The locked wheel circuits are disabled at wheel speeds of about 17 knots or less, so brakes are not released during slow speed taxiing and antiskid does not have to be turned off for taxi or towing. The interconnection with the brake system is shown in *figure 1-72*. Controls and indicators are shown in *figure 1-75*.

If wheel deceleration exceeds the preset limit, the control circuit compares the wheel speed with the speed of the other wheels and opens the antiskid valve, reducing brake pressure to that wheel. When the wheel accelerates to a speed above the preset value, brake pressure is restored, at a level slightly below the original pressure, reducing the possibility of a skid.

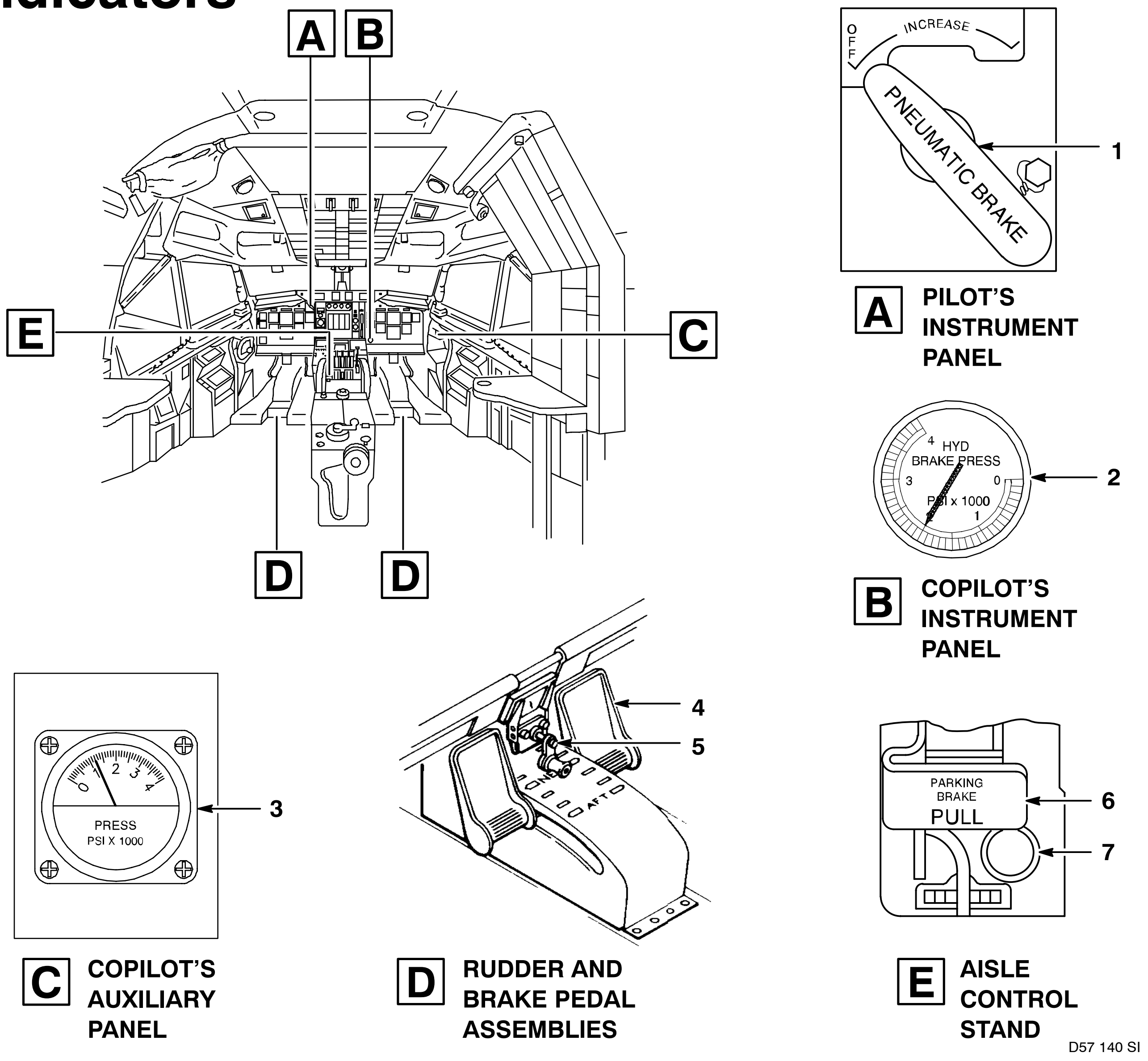
If one wheel in a group (inboard or outboard) decelerates faster than the others, indicating an approaching skid, the locked wheel circuit releases all brake pressure on that wheel until it accelerates to the same speed as the other wheels in the group and then restores brake pressure.

The TEST switch (*figure 1-75*) simulates a spinup signal on the selected set of inboard (INBD) or outboard (OUTBD) wheels. The test circuit applies this signal to the locked wheel circuits and the opposite set of wheels are released (outboard with switch set to INBD and inboard with the switch set to OUTBD). The REL indicators for the released brakes illuminate. When the switch is released, all four REL indicators flash momentarily. (The system senses an instantaneous stop.)

CAUTION

Do not operate TEST switch while taxiing. If brakes are in use, TEST switch releases one set of brakes.

Brake System Controls and Indicators



NO.	CONTROL/INDICATOR	FUNCTION
	A PILOT'S INSTRUMENT PANEL	
1	PNEUMATIC BRAKE Handle (Emergency brake handle)	Handle controls a modulating valve which meters high pressure air or nitrogen acting on hydraulic fluid which applies hydraulic pressure equally to all brakes. To apply brakes, rotate handle clockwise through INCREASE range. To release brakes, rotate handle counter-clockwise to OFF. Refer to LANDING WITH PNEUMATIC BRAKES, section III.

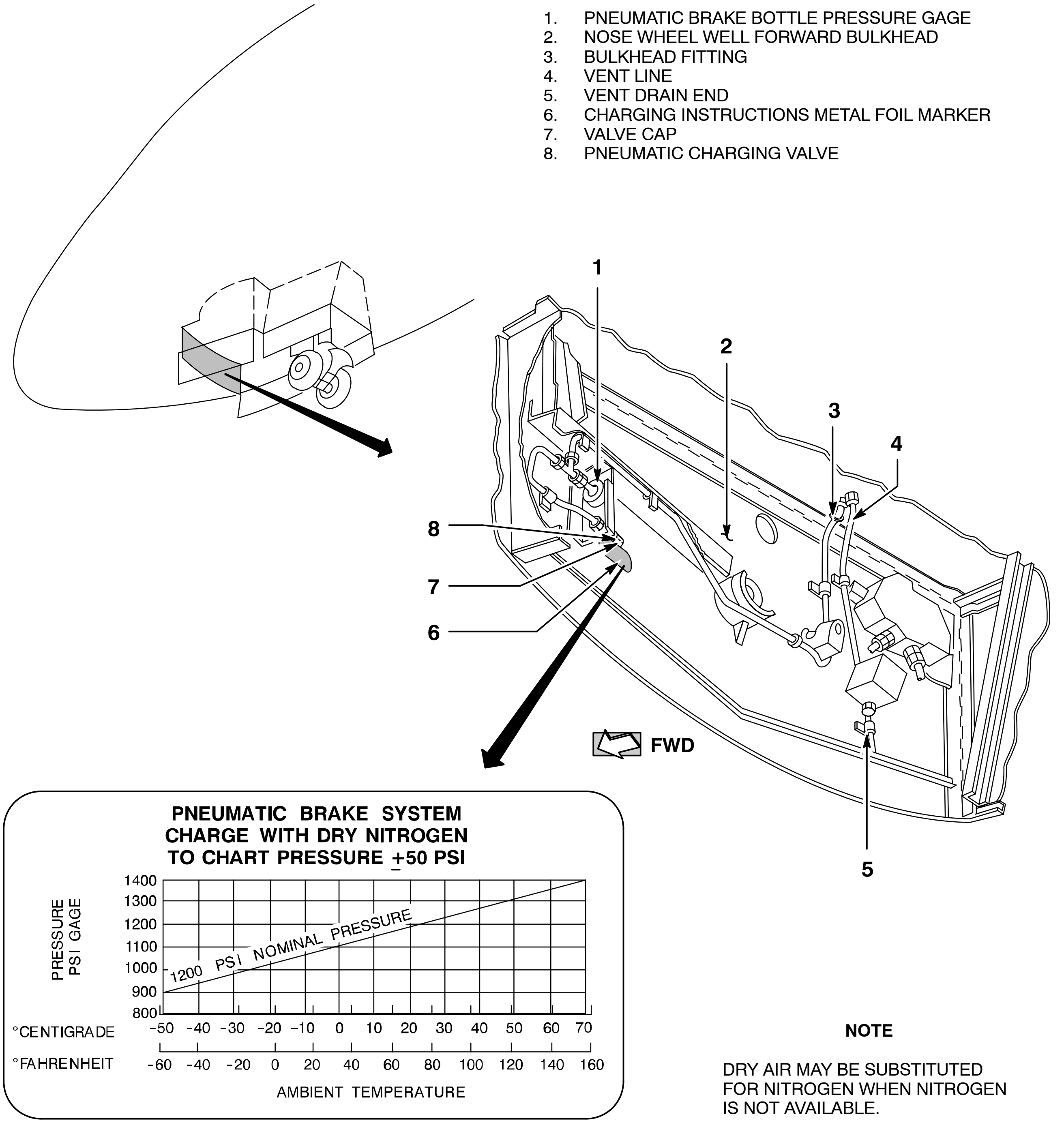
Figure 1-73 (Sheet 1 of 2)

NO.	CONTROL/INDICATOR	FUNCTION
		B COPILOT'S INSTRUMENT PANEL
2	HYD BRAKE PRESS Gage	This gage (and direct reading gage in wheel well) indicates pressure on air side of brake accumulator. Normal pressure reading should be 3,000 psi, but can be up to 3,500 psi after spoiler blowdown.
		C COPILOT'S AUXILIARY PANEL
3	Emergency Brake PRESS Gage	Gage indicates pressure in pneumatic brake system air bottle. Fully charged system indicates approximately 1,200 psi (+100, –75 psi) at 20°C (68°F).
		D RUDDER AND BRAKE PEDAL ASSEMBLIES
4	Brake Pedals	When toe pressure is applied to left, right or both brake pedals, brakes are applied to all wheels on left, right or both landing gear trucks. The pilot's and copilot's brake pedals are interconnected.
5	Rudder Pedal Adjustment Crank	When crank is rotated clockwise, rudder pedals move toward nose of airplane. When crank is rotated counterclockwise, rudder pedals move aft toward pilot seat.
		E AISLE CONTROL STAND
6	PARKING BRAKE Lever	Pulling lever when both brake pedals are depressed latches brake pedals in depressed position and closes valve in return side of antiskid valve electrically. Brakes are released by pressing both brake pedals, allowing valves to open, latch to release, and handle to return to normal position. Parking brake is applied only if hydraulic pressure is available and brake pedals are depressed.
		WARNING Hold both brake pedals depressed while setting parking brake and make sure both pedals are fully depressed after setting parking brake to insure brakes are applied to both left and right trucks. **CAUTION** Parking brake is not reliable if antiskid system is inoperative.
7	PARK BRAKE (Parking Brake) Warning Light (Red)	Illuminated when parking brake handle is pulled.

Figure 1-73 (Sheet 2 of 2)

Pneumatic Brake System Pressure

1. PNEUMATIC BRAKE BOTTLE PRESSURE GAGE
2. NOSE WHEEL WELL FORWARD BULKHEAD
3. BULKHEAD FITTING
4. VENT LINE
5. VENT DRAIN END
6. CHARGING INSTRUCTIONS METAL FOIL MARKER
7. VALVE CAP
8. PNEUMATIC CHARGING VALVE

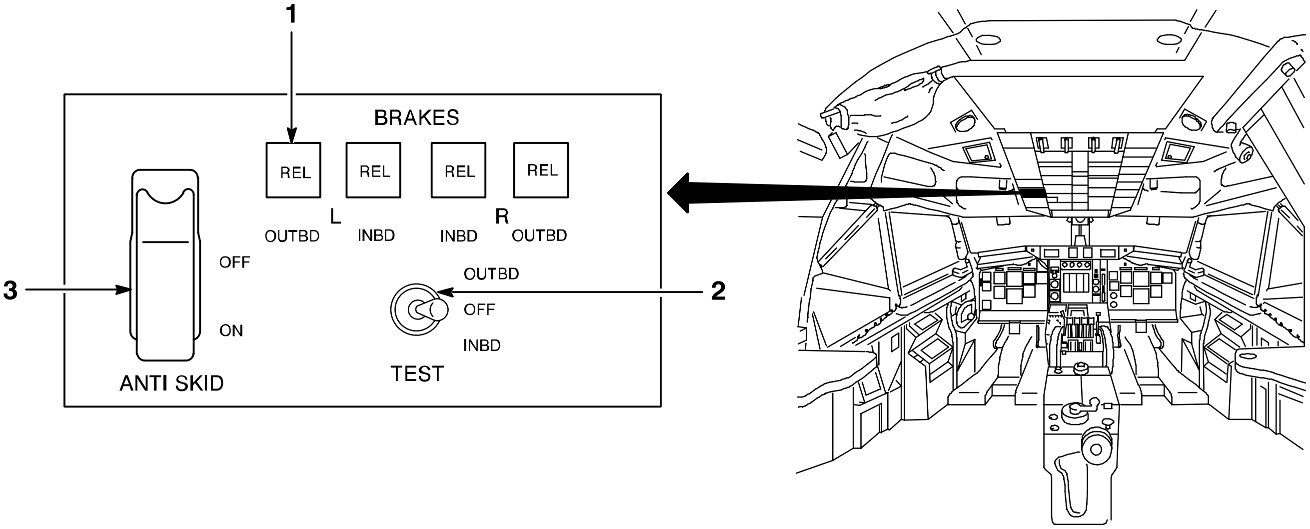


NOTE

DRY AIR MAY BE SUBSTITUTED FOR NITROGEN WHEN NITROGEN IS NOT AVAILABLE.

Figure 1-74

Antiskid System Controls and Indicators



NO.	CONTROL/INDICATOR	FUNCTION
1	BRAKES REL Indicator L – Left Truck R – Right Truck OUTBD – Outboard Wheels INBD – Inboard Wheels	Come on when either or both of a pair (front and rear) of brakes is released by antiskid system action on ground, or when gear is down and locked in flight and antiskid system ON.
2	Antiskid TEST Switch	When set to OUTBD or INBD, simulates a spin up condition on selected wheels. The set of wheels selected shows blank in REL indicator. The other set senses its non-rotation as a skid and shows a release (REL) indication. Switch is spring-loaded OFF. When switch is released, all REL lights illuminate momentarily.

CAUTION

Do not operate TEST switches while taxiing. If brakes are being used, TEST switch can release brakes.

3	ANTI SKID Control Switch (Guarded On)	In ON position, energizes antiskid system. In OFF position, de-energizes antiskid system.

Figure 1-75

In flight, with landing gear down and locked, wheels not rotating, and antiskid on, the squat switches cause the antiskid valves to open, releasing the brakes. The REL indicators illuminate and brakes cannot be applied until the squat switch is in the ground position or the wheels reach a rotating speed of about 17 knots. At normal landing weights and speeds, this rotating speed is reached on any runway surface, except when extremely icy or hydroplaning conditions exist.

CAUTION

- If a squat switch (both for inboard brakes, left for outboard brakes) does not move to ground position on landing, wheels must reach a wheel speed of 17 knots before brakes can be applied. In icy or hydroplaning conditions, braking can be delayed until wheels spin up. In patchy ice or snow, rapid cycling of individual antiskid valves is normal, until the system finds the reduced brake pressure which allows smooth, skid-free deceleration. If the pilot cycles the brake pedals, as in antiskid-off operation, effective braking is delayed, since the reduction process starts again each time pedal pressure is applied.

- If after lowering gear one or more antiskid REL indicators fail to illuminate, then use antiskid inoperative procedures and data for landing.

NOTE

- If one or more REL lights fail to illuminate on preflight test, and the red and green gear lights give normal indications, then the airplane may be accepted for flight provided that antiskid inoperative procedures and data must be used.

- If after lowering gear, a main gear green light fails to illuminate (red gear light may also remain illuminated) and the two corresponding antiskid REL indicators fail to illuminate (outboard REL lights correspond to RGEAR green light; inboard REL light corresponds to LGEAR green light), then the main gear indicated by the unilluminated green light is not locked down. Perform the portion of the manual landing gear extension checklist for the indicated main gear to extend it and lock it down. If the three lights (one green Gear light and two REL lights) do not then illuminate, obtain visual confirmation of gear locking (*figure 1-69*). If gear is locked down, a gear position switch or relay has failed; use antiskid inoperative procedures and data for landing. If gear is not locked down, then use antiskid inoperative procedures and data for landing, leave gear lever down, and retain utility hydraulic system pressure until ground locks are installed.

LANDING GEAR, BRAKE, AND ANTISKID ELECTRIC POWER SOURCES

Electric power sources for the landing gear, brakes, and antiskid systems are listed in *figure 1-76*.

Landing Gear, Brake and Antiskid Electric Power Sources

EQUIPMENT/SYSTEM	TYPE OF POWER	POWER SOURCE	CIRCUIT BREAKER LOCATION/LABEL
Gear Position Lights ①	28V DC	AVDC Bus 8	P5, LANDING GEAR POS LIGHTS ②
Warning Horn ①	28V DC	AVDC Bus 8	P5, LANDING GEAR WARN HORN
Warning Horn Cutoff Relay ①	28V DC	AVDC Bus 8	P5, WARN HORN CUTOUT RELAY
Parking Brake ④	28V DC	AVDC Bus 8	P5, PARK BRAKE
Safety Switches and Lever Lock ①	28V DC	AVDC Bus 8	P5, SAFETY – LEFT RLY, P5, RIGHT RLY & LEVER LATCH
Antiskid ① ③			
Outboard Wheels	28V DC	AVDC Bus 8	P5, ANTI-SKID, OUTBD
Inboard Wheels	28V DC	AVDC Bus 8	P5, ANTI-SKID, INBD
Test	28V AC	28V AC Bus 8	P5, ANTI-SKID TEST
Brake Pressure Gage ①	28V AC	28V AC Bus 8	P61-4, RUDDER & BRAKE PRESS
Interconnect Valve ①	28V DC	AVDC Bus 4	P61-4, BRAKE & SYS INTCON VALVE
Wheel Well Fire Detector ①	28V DC	AVDC Bus 8	P5, WHEEL WELL

① Inoperative if ac power is lost to TRU and dc tie bus circuit breakers are open.

② Also supplies power to gear position relays. These relays must be powered (indicated by landing gear down indicators illuminated) for antiskid to be operative.

③ Both relays must close at touchdown for inboard antiskid to operate. Left relay must close at touchdown for outboard antiskid to operate.

④ Parking brake is unreliable if electric power to antiskid valves is lost.

Figure 1-76

SUBSECTION I-H
FLIGHT CONTROLS

Table of Contents

SUMMARY

The primary flight controls are ailerons, elevators, and a rudder. See *figure 1-77*. The ailerons and elevators are operated by control tabs and assisted by aerodynamic balance panels. The rudder is normally hydraulically powered and automatically returns to manual operation (through control tabs) with reduced travel if hydraulic pressure is lost.

Spoilers on the upper wing surfaces operate as speed brakes and with the inboard ailerons to augment lateral control. Outboard ailerons, which are locked in the faired position with the flaps retracted, operate with increasing travel as the outboard flaps are extended. Full outboard ailerons travel is obtained at approximately 23° outboard flap extension. Double slotted inboard and outboard flaps, single slotted fillet flaps and leading edge flaps and slats provide lift and drag control for slow-speed flight. Trim is accomplished through the aileron and rudder control systems and through a variable-incidence stabilizer. The airplane autopilot operates the elevators and ailerons, spoilers and the stabilizer in the same manner as the pilot.

A stall warning system (stick shaker) is incorporated to shake the control column if the airplane approaches a stall condition in flight.

A takeoff warning system sounds a horn (and operates the stick shaker if flaps are up) if stabilizer trim, flaps or speedbrakes are not in safe condition for takeoff when the NO 3 throttle is advanced.

Gust snubbers, attached to the inboard ailerons and elevators, provide protection against tail winds to 65 knots, eliminating the need for control locks. The rudder power control unit acts as a snubber for the rudder. To prevent gust damage to the outboard ailerons, they should be locked faired by retracting the flaps.

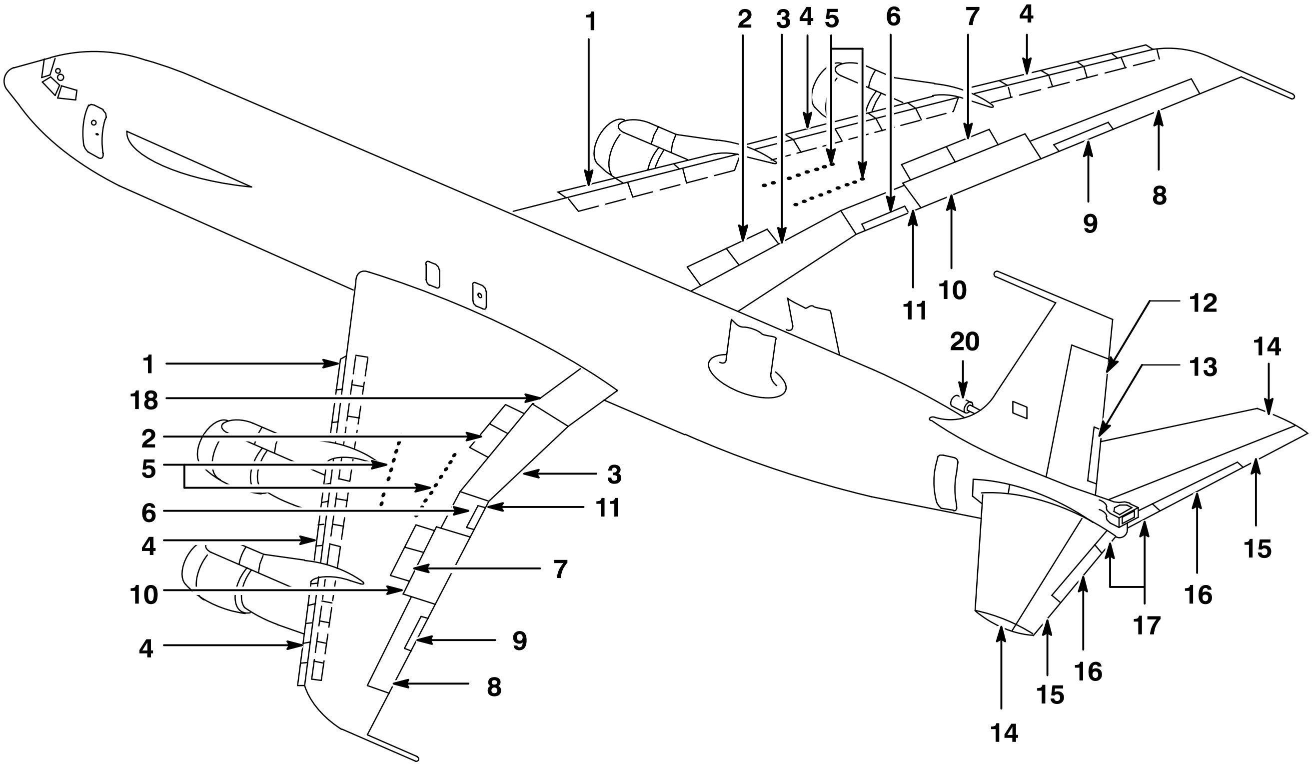
Tab-operated aileron and elevator control surfaces can be checked for full deflection on the ground by stops in the tab control linkages which contact and move the control surfaces after full tab travel. The rudder travel is 13° with boost off and 26 1/2° with boost on. The rudder tab acts as an antibalance tab when the rudder boost is on and as a control tab when the rudder boost is off.

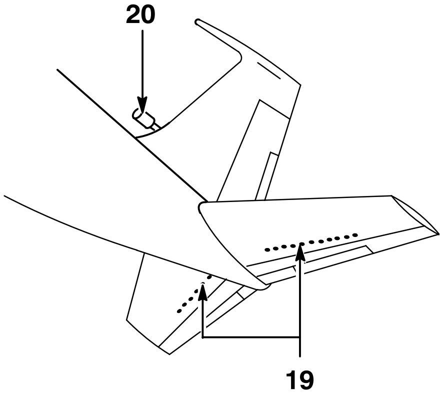
NOTE

> Tailwinds or crosswinds can load up the control surfaces so that it becomes difficult to make the normal ground check. This condition is indicated by a partial travel requiring high forces on the control wheel, or rudder pedal (boost off). Refer to FLIGHT CONTROLS ABNORMAL OPERATION.

All hydraulically powered flight controls (spoilers, rudder, flaps) can be depressurized by electric motor-driven hydraulic bypass valves. This allows isolation of a malfunctioning control and split flap and spoiler operation to change wing lift distribution for pitch trim in the event of a jammed stabilizer. If electrical power fails, the bypass valve remains in the last selected condition.

Flight Controls





1. LEADING EDGE FLAPS (2 PLACES)
2. INBOARD SPOILER (2 PLACES)
3. INBOARD FLAP (2 PLACES)
4. LEADING EDGE SLATS
5. VORTEX GENERATORS (WING) (2 PLACES)
6. INBOARD CONTROL TAB (2 PLACES)
7. OUTBOARD SPOILER (2 PLACES)
8. OUTBOARD AILERON (2 PLACES)
9. OUTBOARD AILERON BALANCE TAB (2 PLACES)
10. OUTBOARD FLAP (2 PLACES)
11. INBOARD AILERON (2 PLACES)
12. RUDDER
13. RUDDER CONTROL TAB
14. HORIZONTAL STABILIZER (2 PLACES)
15. ELEVATOR (2 PLACES)
16. ELEVATOR CONTROL TAB (2 PLACES)
17. STABILIZER ACTUATED TAB
18. FILLET FLAP
19. VORTEX GENERATORS (STABILIZER)
20. RUDDER FEEL SYSTEM (Q-SPRING) PITOT TUBE

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Figure 1-77

Shear points allow normal operation of essential flight control systems in the event of failure or jamming of related or interconnected secondary systems.

RUDDER CONTROL SYSTEM

The rudder control system includes the rudder, rudder pedals, rudder trim and feel unit, and the rudder power control system (*figures 1-78, 1-79* and *1-80*). Dutch roll is reduced by two yaw dampers. Rudder hydraulic pressure is supplied by the auxiliary hydraulic system. The rudder is controlled by conventional rudder pedals, hinged for toe operation of the hydraulic brakes. They can be adjusted for leg length by use of cranks just under the instrument panel on each side. Movement of either of the interconnected pairs of pedals is transmitted by cable and linkage to the valve in the hydraulic rudder power unit in the vertical fin, which deflects the rudder. During powered operation, feel pressure on the pedals proportional to the deflection and airspeed is derived from signal-opposing cams and dynamic air pressure q-bellows in the linkage. The q-spring inlet (20, *figure 1-77*) is electrically heated to prevent ice formation. Refer to ICE AND RAIN PROTECTION, subsection I-S. If hydraulic pressure fails or is turned off, the tab is unlocked and the pedal motion operates the control tab to move the rudder with the help of aerodynamic balance panels. In this case, maximum rudder deflection is about one-half and pedal pressures required are doubled for any given control effect. System controls are shown in *figure 1-78*.

If the RUDDER switch (normally guarded to ON), is set to OFF, hydraulic pressure to the rudder system is cut off, the auxiliary hydraulic system pressure gauge goes to zero and the rudder automatically shifts to tab control. The tab is moved opposite to the rudder in so-called balance position. When the airplane is parked, or moving slowly on the ground, further rudder pedal movement moves the entire rudder after the tab reaches the stop. With hydraulic power available, the tab linkage is locked at the power unit and the tab moves in the same direction as the rudder (antibalance) to give it more curvature and lift.

The hydraulic pressure actually applied to the rudder power control unit varies with pedal deflection. Full pressure is not applied until the pedal reaches the stop. System pressure is normally reduced by the load limiter in two stages (*figure 1-78*) controlled by airspeed switches. At airspeeds below 170 KIAS, full auxiliary hydraulic system pressure is available. The actual amount of rudder deflection available decreases at speeds above 130 KIAS.

Between 165 to 185 KIAS and 250 ± 15 KIAS, one airspeed switch is closed, moving a solenoid valve to port pressure from the load limiter to the auxiliary hydraulic system return. Rudder hydraulic pressure in this speed range is limited to about 2,290 psi, reducing available rudder movement to about three fourths of maximum.

Between 235 and 265 KIAS, the second airspeed switch closes moving a second solenoid valve to port more pressure to the auxiliary system return. Maximum pressure available to the power control unit in this speed range is about 1,450 psi, reducing rudder travel to about one half of maximum.

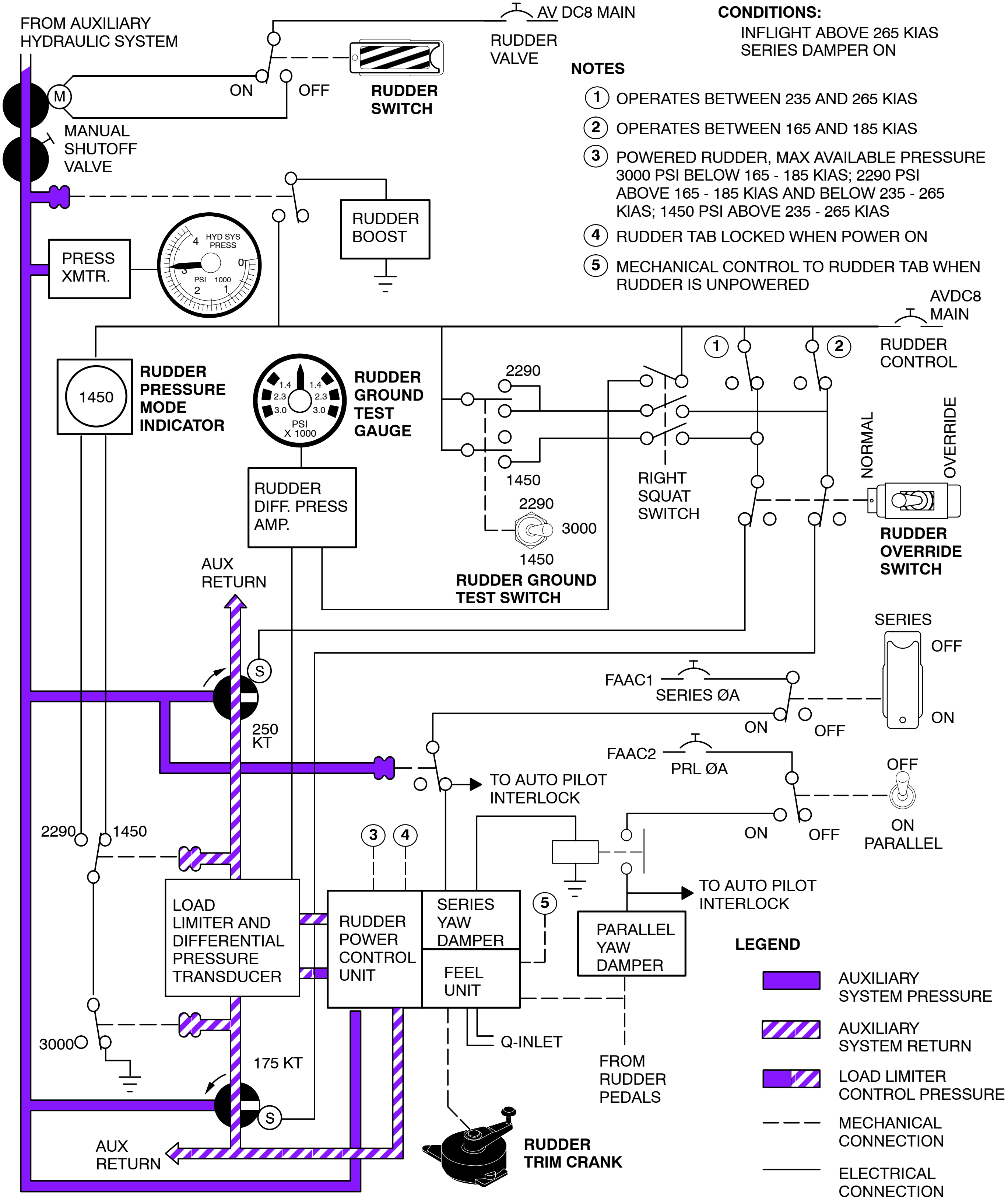
If full rudder deflection is required in the 170 to 250 KIAS range or if a large deflection is required and pedal pressures are high, the rudder override switch (2, *figure 1-79*) may be used to bypass the airspeed switches and return the solenoid valves to the low speed, 3,000 psi position. This reduces the pedal pressure required for the same deflection.

WARNING

- The override switch guard has a slot to give positive identification by feel.
- Before actuating either RUDDER (lower) or OVERRIDE (upper) switch in flight, physically identify both switches to make sure proper switch is actuated. Operation of wrong switch could cause loss of control or structural failure.
- When setting RUDDER switch to ON in flight, ensure rudder and rudder trim are in neutral (centered) position. This is to prevent excessive structural loads caused by rapid increase in rudder deflection and to maintain aircraft control during the transition to powered rudder.
- Do not set rudder override switch to OVERRIDE above 250 KIAS. Structural damage could result from full or rapid rudder movement with full rudder pressure.
- If rudder mode does not change to 2,290 psi at airspeeds above 185 KIAS or to 1,450 psi at airspeeds above 265 KIAS, either limit airspeed to below 250 KIAS, or shut off rudder boost, disengage series yaw damper and engage parallel yaw damper until airspeed is below 250 KIAS.

- A full or nearly full rudder deflection in one direction followed by a full or nearly full rudder deflection in the opposite direction, or certain combinations of sideslip angle and opposite rudder deflection can result in potentially dangerous loads on the vertical stabilizer, even at speeds below the design maneuvering speed. There are no flight crew procedures that require this type of rudder input. The airplane is not designed for a rapid return of the rudder to neutral from an over–yaw condition, nor are they designed for full authority rudder reversals while in a sideslip. Sequential full or nearly full authority rudder reversals nay not be within the structural design limits of the airplane, regardless of airspeed. The airplane is designed with the structural capability to accommodate a rapid and immediate rudder pedal input when going in one direction from zero input to full deflection.
- At altitudes below 29,000 ft, fly at or below 0.74M, unless an operational need exists. If an operational need exists to fly above 0.74M, fly at 0.78M and minimize operations in the 0.75M through 0.77M range. This speed restriction does not apply for altitudes at or above 29,000 ft. When aircraft speeds approach 0.76M, the airflow through the struts produces air separation and shock wave effects equivalent to flying at 1.0M. This shock wave effect has been determined to be the contributing factor for the extensive vertical fin and rudder panel cracks leading to the reduction in panel service life. This effect is only applicable at speeds ranging from 0.75M to 0.77M.

Rudder Control System



CONDITIONS:

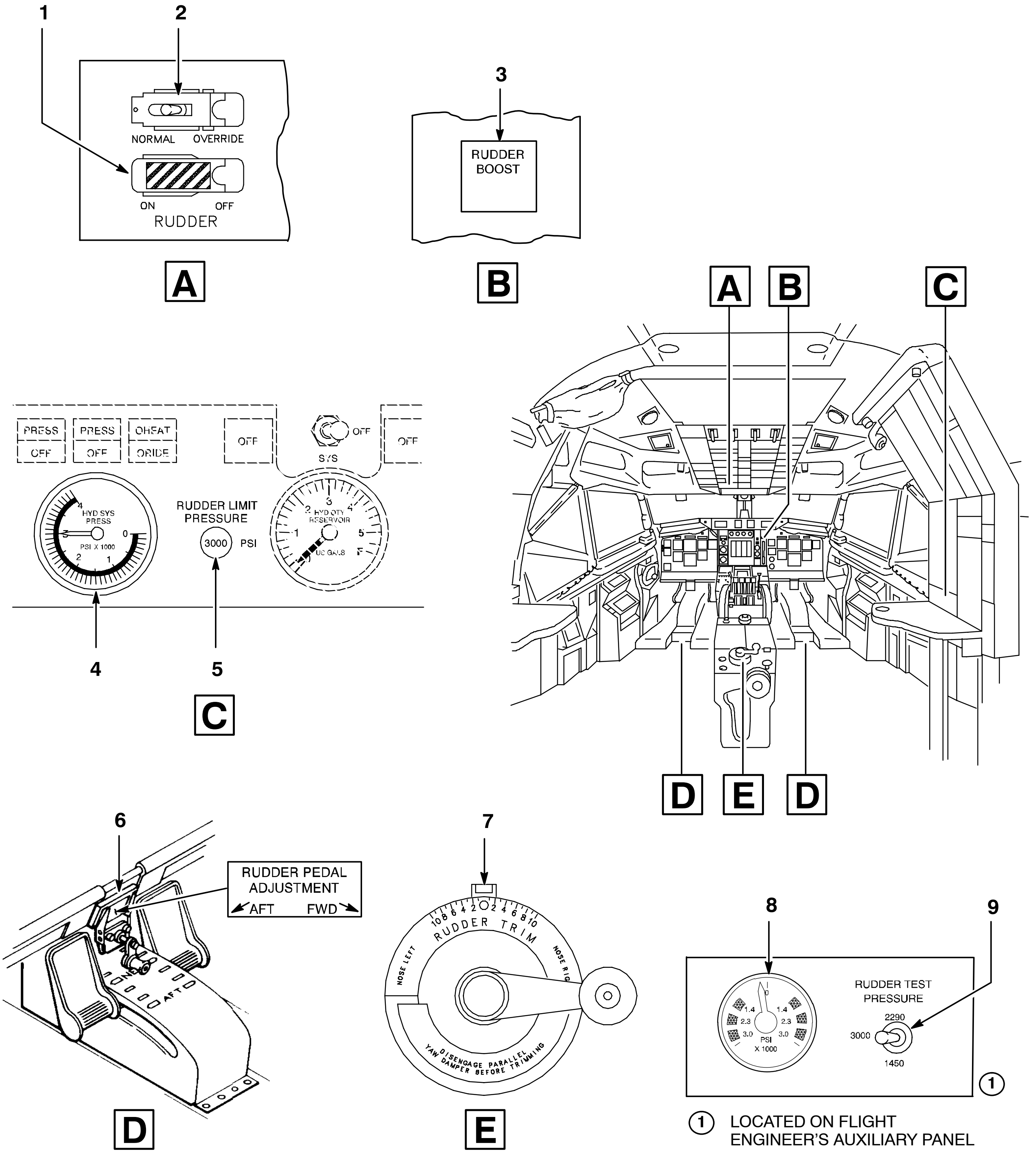
INFLIGHT ABOVE 265 KIAS
SERIES DAMPER ON

NOTES

① OPERATES BETWEEN 235 AND 265 KIAS
② OPERATES BETWEEN 165 AND 185 KIAS
③ POWERED RUDDER, MAX AVAILABLE PRESSURE 3000 PSI BELOW 165 - 185 KIAS; 2290 PSI ABOVE 165 - 185 KIAS AND BELOW 235 - 265 KIAS; 1450 PSI ABOVE 235 - 265 KIAS
④ RUDDER TAB LOCKED WHEN POWER ON
⑤ MECHANICAL CONTROL TO RUDDER TAB WHEN RUDDER IS UNPOWERED

Figure 1-78

Rudder Controls and Indicators



① LOCATED ON FLIGHT ENGINEER'S AUXILIARY PANEL

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Figure 1-79 (Sheet 1 of 3)

Rudder Controls and Indicators (Continued)

NO.	CONTROL/INDICATOR	FUNCTION
1	RUDDER Switch (Guarded)	When set to ON, opens hydraulic valve to auxiliary system pressure gage (4) and rudder power unit. When set to OFF, rudder power unit and gage are depressurized.

WARNING

- When setting RUDDER switch to ON in flight, make sure rudder is in neutral (centered) position. Structural loads caused by rapid rudder movement (if deflected) could cause damage to airplane.
- Before actuating either RUDDER (lower) or override (upper) switch in flight, physically identify both switches to make sure proper switch is actuated. Operation of wrong switch could cause loss of control or structural damage.

NO.	CONTROL/INDICATOR	FUNCTION
2	RUDDER NORMAL–OVERRIDE Switch (Rudder Override Switch)	Allows manual selection of 3,000 psi rudder system limit pressure. When set to NORMAL, airspeed switches control load limiter. When set to OVERRIDE, bypasses airspeed switches, placing load limiter in 3,000 psi mode, allowing full hydraulic system pressure to reach rudder power control unit at full pedal deflection. Guard has slot for positive identification by feel.
3	RUDDER BOOST Low Pressure Warning Light (Red)	When on, indicates pressure in supply line to rudder power control unit is below approximately 2,500 psi.
4	AUXILIARY HYD SYS PRESS Gage (Auxiliary System Pressure Gage)	Indicates pressure in auxiliary hydraulic system in thousands of psi, if RUDDER switch is ON.
5	RUDDER LIMIT PRESSURE Indicator (Rudder Mode Indicator)	Indicates position of rudder load limiter solenoid valves, and maximum pressure available to rudder power control unit at full pedal deflection. When 3,000 psi is displayed, full auxiliary system hydraulic pressure (appx. 3,000 psi) is available to rudder power control unit. When 2,290 psi is displayed the 175 knot solenoid valve closes, blocking hydraulic pressure to one side of the load limiter and reducing maximum pressure available at power control unit to 2,290 psi. When 1,450 psi is displayed, both solenoid valves close blocking pressure to both sides of load limiter, reducing maximum pressure available at rudder power control unit to 1,450 psi. (Pressure values shown are based on 3,000 psi system input pressure.)

CAUTION

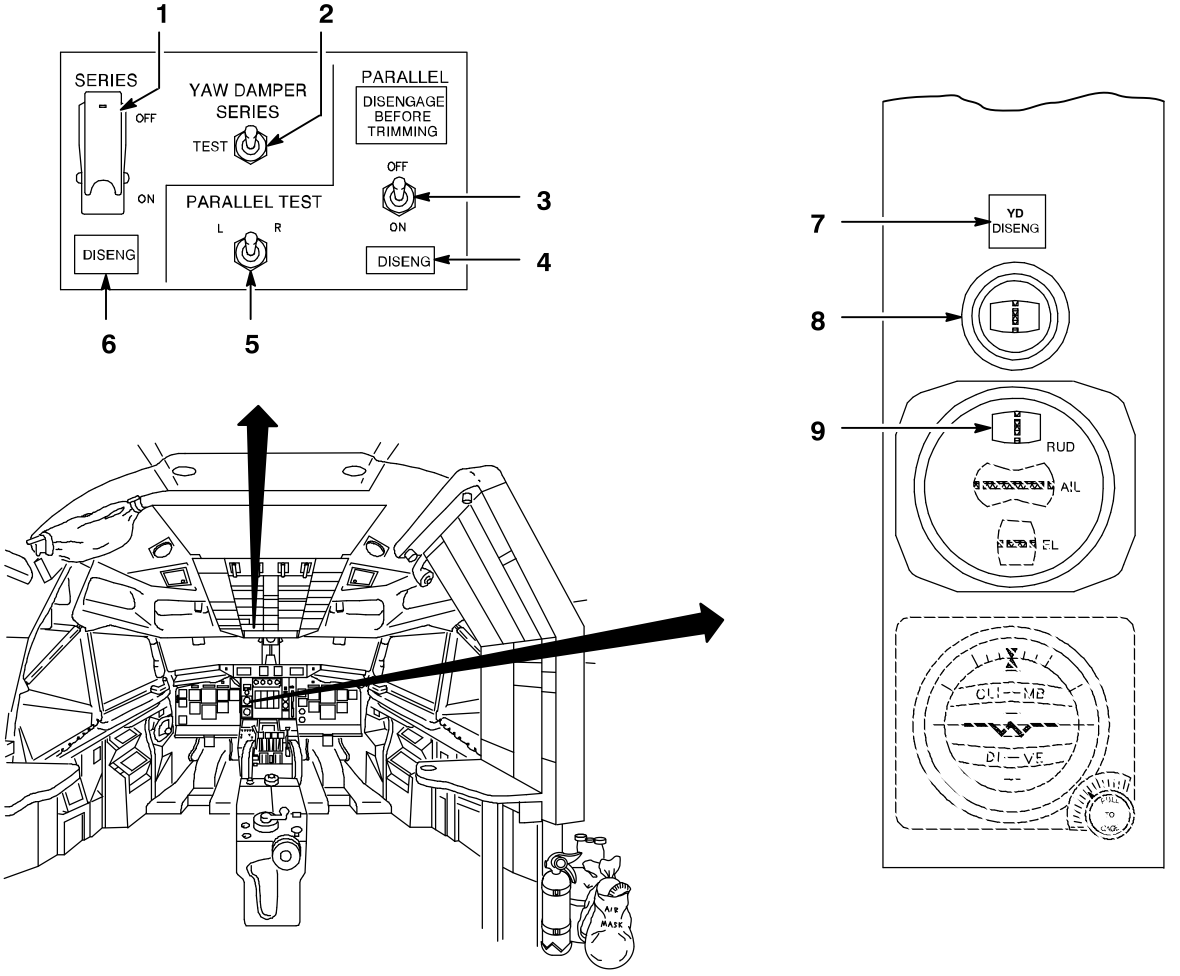
Observe airspeed limits in section V when in 3,000 or 2,290 mode.

Figure 1-79 (Sheet 2 of 3)

NO.	CONTROL/INDICATOR	FUNCTION
6	Rudder Pedals and Adjustment Crank	Rudder pedals may be adjusted forward and aft by adjustment crank. Turning crank clockwise moves pedals forward. Turning crank counterclockwise moves pedals aft.
7	RUDDER TRIM Handle and Indicator	Handle controls amount of rudder trim. Handle movement clockwise trims rudder to right. Counterclockwise movement trims rudder to left. Trim is applied by power unit when rudder is powered and applied by trim tab when rudder is unpowered. Scale indicates relative amount of trim in arbitrary units. Actual amount of rudder movement is less with power off.
	NOTE If rudder trim is applied against a rudder motion (without pedal input in trim direction) a brake in trim mechanism causes a ratcheting sound.	
8	HYD PRESS Gage (Rudder Ground Test Gage)	Indicates pressure in rudder actuator when airplane is on ground. Gage moves same direction as rudder and indicates maximum pressure only when rudder is fully deflected. Gage is inoperative in flight.
9	RUDDER TEST PRESSURE Switch (Rudder Test Switch)	Selects pressure mode of rudder pressure reducer when airplane is on ground. Switch is spring loaded to center (3,000) position. Other positions are momentary, selecting 2,290 or 1,450 psi modes.
	NOTE Rudder ground test gage (8) and rudder mode indicator (5) should indicate pressure selected by test switch when airplane is on ground and rudder is fully deflected. Pressure can be up to 250 psi below selected value in 2,290 or 1,450 mode.	
10	Autopilot and Boom Disconnect Button (On pilot's control wheels) (Not Shown)	When pressed, with parallel yaw damper engaged, disconnects parallel damper. Also disconnects autopilot (if engaged) and boom latching toggles (during air refueling).

Figure 1-79 (Sheet 3 of 3)

Yaw Damper Controls and Indicators



NO.	CONTROL / INDICATOR	LOCATION	FUNCTION
1	SERIES Yaw Damper Switch (Guarded in ON position)	Overhead Panel	When set to ON, engages series yaw damper if rudder boost is on. When set to OFF, disengages series yaw damper. Must be OFF to engage parallel damper. PARALLEL switch returns to OFF when series yaw damper is engaged.
2	SERIES TEST Switch	Overhead Panel	When set to TEST, tests operation of series yaw damper by applying simulated left turn input to yaw damper. Rudder moves left, then right (shown on three axis trim indicator). Switch spring loaded to neutral (central) position. Inoperative in flight.

Figure 1-80 (Sheet 1 of 2)

NO.	CONTROL	LOCATION	FUNCTION
3	PARALLEL Yaw Damper Switch	Overhead Panel	When set to ON, engages parallel yaw damper. (Series yaw damper must be disengaged to engage parallel yaw damper.) When set to OFF, disengages parallel yaw damper.
4	PARALLEL DISENG (Disengage) Caution Light (Amber) (Under PARALLEL switch)	Overhead Panel	Illuminates when parallel yaw damper is disengaged, whether automatically or through use of PARALLEL yaw damper switch.
5	PARALLEL TEST Switch	Overhead Panel	When set to L, tests operation of parallel yaw damper by applying simulated left turn signal to yaw damper. With rudder boost on, rudder and pedals move left, then right (shown on parallel yaw damper trim indicator). If rudder boost is off and PARALLEL TEST switch is actuated, rudder tab moves instead of rudder but in opposite direction. Spring loaded to off. Inoperative in flight. When set to R, applies simulated right turn signal to yaw damper.
6	SERIES DISENG (Disengage) Caution Light (Amber) (Under SERIES switch)	Overhead Panel	Illuminates when series damper disengaged and SERIES switch is ON.
7	YD DISENG (Yaw Damper Disengage) Caution Light (Amber)	Center Panel	On when both yaw dampers disengaged.
8	Rudder and Parallel Damper Trim Indicator (Not marked)	Center Panel	Displacement of indicator indicates output of parallel yaw damper, if engaged. If parallel yaw damper is not engaged, trim indicator centers.
9	Three-Axis Trim Indicator RUD Indicator	Center Panel	Displacement of indicator indicates output of series yaw damper, if engaged. If series damper is not engaged, RUD indicator centers.

Figure 1-80 (Sheet 2 of 2)

The RUDDER BOOST warning light illuminates any time the pressure in the supply line to the rudder pressure limiter decreases below 2,500 psi.

With auxiliary rotodome drive in use, it is possible for the RUDDER BOOST warning light to illuminate momentarily during large rudder movements at airspeeds above 250 KIAS. If large rudder movements are required (as in case of engine failure) switch to utility rotodome drive.

A manual shutoff valve in the right wheel well allows blocking the rudder hydraulic line for maintenance. This valve must be safety wired in the OPEN position before flight.

The rudder trim crank (7, *figure 1-79*) is used to trim the rudder system. An indicator indicates the amount of trim applied. Turning the crank moves a cam to apply pressure proportional to pedal deflection against the control linkage to hold it in the desired position. When rudder pressure is available, the trim mechanism operates the power control unit to move the rudder so the tab moves in the same direction as the rudder. In manual operation, the trim crank moves the control tab but the resulting rudder deflection per unit of trim is less than with boost on.

Rudder pedal feel proportional to dynamic pressure q, is provided during hydraulic rudder operation by a cam connected to the q-spring. When the rudder pedals are moved (and airspeed is constant), rudder pedal forces increase as rudder deflection increases. When rudder deflection is held constant and airspeed increases, pedal force increases. If large deflections must be held in the 170 to 250 KIAS range, pedal force can be reduced by using the rudder override switch.

NOTE

- In most cases, a change of rudder trim affects roll trim. Refer to ROLL AND DIRECTIONAL TRIM TECHNIQUE, section VI.
- If rudder trim is applied against a rudder load (without pedal input in trim direction) a brake in the trim system causes a ratcheting sound.

YAW DAMPERS

The airplane is equipped with two yaw dampers (*figures 1-78* through *1-80*), a series yaw damper (intended for primary use) and a parallel yaw damper (for backup use if the series damper fails). When engaged, either damper provides automatic yaw control by sensing yaw rate and then computing a control signal which is applied to the rudder to control dutch roll.

SERIES YAW DAMPER

The series yaw damper is intended for full time operation. The damper operates the rudder through the rudder power unit, so there is no motion of the rudder pedals when the damper operates. Interlocks cause the yaw damper to disengage when hydraulic pressure is lost, or rudder boost fails or is turned off.

NOTE

Disengagement of the series yaw damper causes the autopilot to disengage. Engaging the parallel yaw damper allows re-engagement of the autopilot.

Engagement of the series yaw damper does not affect the normal operation of the flight controls, since it allows opposing pedal force from the yaw damper. Yaw damper action is not felt in the rudder pedals. The yaw damper can command plus or minus 4 degrees rudder travel from any rudder position. This 4 degree mechanical limitation on yaw damper authority provides protection against a yaw damper hardover. No unusual procedures are required when using the series yaw damper. The system is designed so that normal pilot reaction to a system failure corrects the input from the failure. Series yaw damper operation is monitored by observing the three-axis trim indicator for rudder motion during turn entry.

PARALLEL YAW DAMPER

A parallel yaw damper is installed as a backup system in case of failure of the series damper. Since the parallel damper operates through the control cables, damper operation is felt in the rudder pedals. The parallel damper must be disengaged when moving rudder trim and for takeoff and landing. The parallel damper switch is spring loaded to OFF when the series damper is engaged. The parallel yaw damper also disengages if either autopilot disconnect button is pressed.

YAW DAMPER CONTROLS AND INDICATORS

Yaw damper controls and indicators consist of a switch for each damper (*figure 1–80*), a disengaged caution light for each damper, a test switch for each damper, a master disengage light, a trim indicator for the parallel yaw damper and the rudder trim meter in the three-axis trim indicator. The engage switches, test switches, and disengaged caution lights are mounted on the pilot's overhead panel (*figure 1-80*). The trim indicators and master disengage light are mounted on the pilot's center panel (*figure 1-80*).

Self-test switches and indicators are provided on the yaw damper boxes in the electronic compartment. Power for the yaw dampers is 115vac.

NOTE

> If either test switch (on the yaw damper boxes) is not set to off, the DISENG caution light for that yaw damper flashes.

ROLL CONTROL SYSTEMS

The pilots' control wheels operate the aileron and spoiler surfaces for roll control. (See *figure 1-81)*. To reduce wing twisting at high speeds, the ailerons are divided into two sections, inboard and outboard. The amount of outboard aileron motion caused when the inboard ailerons move depends upon the outboard flap position. The outboard ailerons are locked in neutral (faired) position when outboard flaps are up. A cable system operates inboard aileron control quadrants to position inboard aileron control tabs and spoiler control valves. Resultant motion of the inboard ailerons is transmitted to the outboard ailerons through a bus cable system.

When the outboard flaps are extended, the outboard aileron travel increases gradually until full travel is available when the outboard flaps reach approximately 23 degrees. A servo (balance) tab on each outboard aileron assists the balance panels so that very little additional load is placed on the aileron control system.

NOTE

> When using split flaps for pitch control on a jammed stabilizer landing, at least 14 degrees outboard flap should be used if possible to assure adequate outboard aileron operation for lateral control.

Aileron trim is controlled by the aileron trim wheel on the aisle stand (4, *figure 1-82*). Use of aileron trim can require coordination with rudder trim. Refer to ROLL AND DIRECTIONAL TRIM TECHNIQUE, section VI.

SPEED BRAKES

The SPEED BRAKE lever actuates the spoilers symmetrically for braking purposes (*figure 1-82*) to increase airplane drag or to reduce lift after landing and to increase weight on the brakes. Utility system pressure powers the outboard spoilers and auxiliary NO 1 pump pressure powers the inboard spoilers. (See *figures 1-57* and *1-59*.) The spoilers have structural stops at 0 degrees (faired) and at 60 degrees.

Final spoiler angle is the result of any combination of control wheel and SPEED BRAKE lever positions and is limited by structural stops or airloads (spoiler blowdown). If airborne, the airplane experiences mild buffet when the spoiler angles are greater than about 30 degrees. Full speed brakes are used on the landing roll to decrease wing lift, provide more wheel brake effectiveness, and to increase aerodynamic drag.

The SPEED BRAKE lever can be moved from 0 degrees to 60 degrees with a lock detent at 0 degrees and a feel detent at 30 degrees. An adjacent scale shows the position of the lever. The scale is marked in 10-degree increments between 0 degrees and 60 degrees. A cable system from the lever controls the spoiler follow up linkages. This action meters hydraulic fluid to raise all spoilers to the selected angle, unless limited by airspeed or modified by control wheel movement. Full speed brake extension (60 degrees) is obtained only at speeds below approximately 200 KIAS. For higher roll rates at airspeeds above 310 KIAS, use the 30° detent position. Airplane roll rates are higher when control wheel is deflected and spoilers are raised less than 60 degrees (spoiler blow down or SPEED BRAKE lever set to less than 60 degrees). Full roll input on control wheel gives 40 degrees difference between spoiler positions. If the spoilers are not at 60 degrees, one set is raised to 60 degrees and one set is lowered to 20 degrees, increasing roll rate. Refer to ROLL CONTROL, section VI. The takeoff warning horn is actuated if the SPEED BRAKE lever is more than 2 to 5 degrees out of the 0 degree detent and NO 3 throttle is advanced while the airplane is on the ground. Refer to TAKEOFF WARNING SYSTEM.

Roll Control, Speedbrakes and Trim

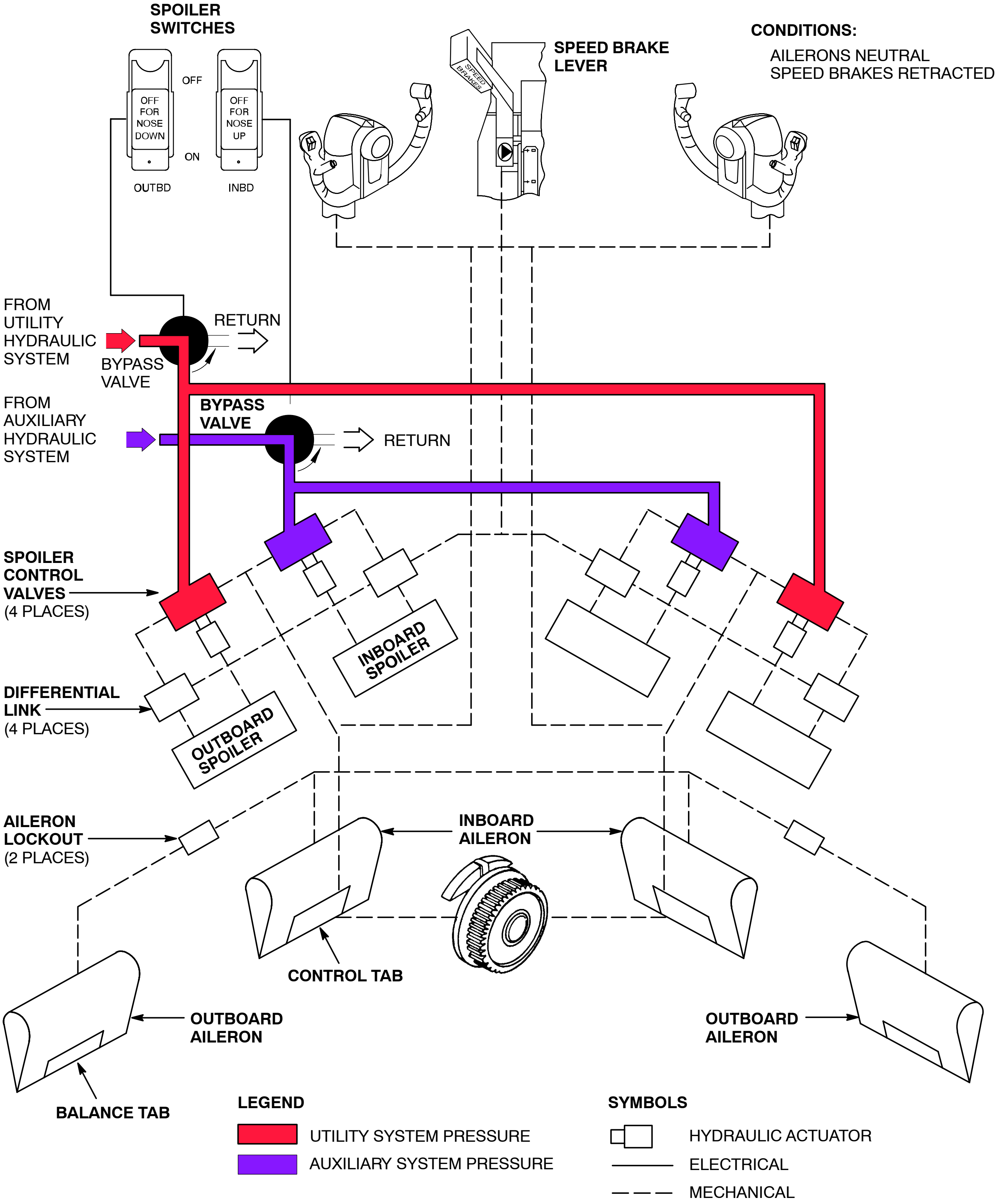


Figure 1-81

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Roll and Speedbrake Controls and Indicators

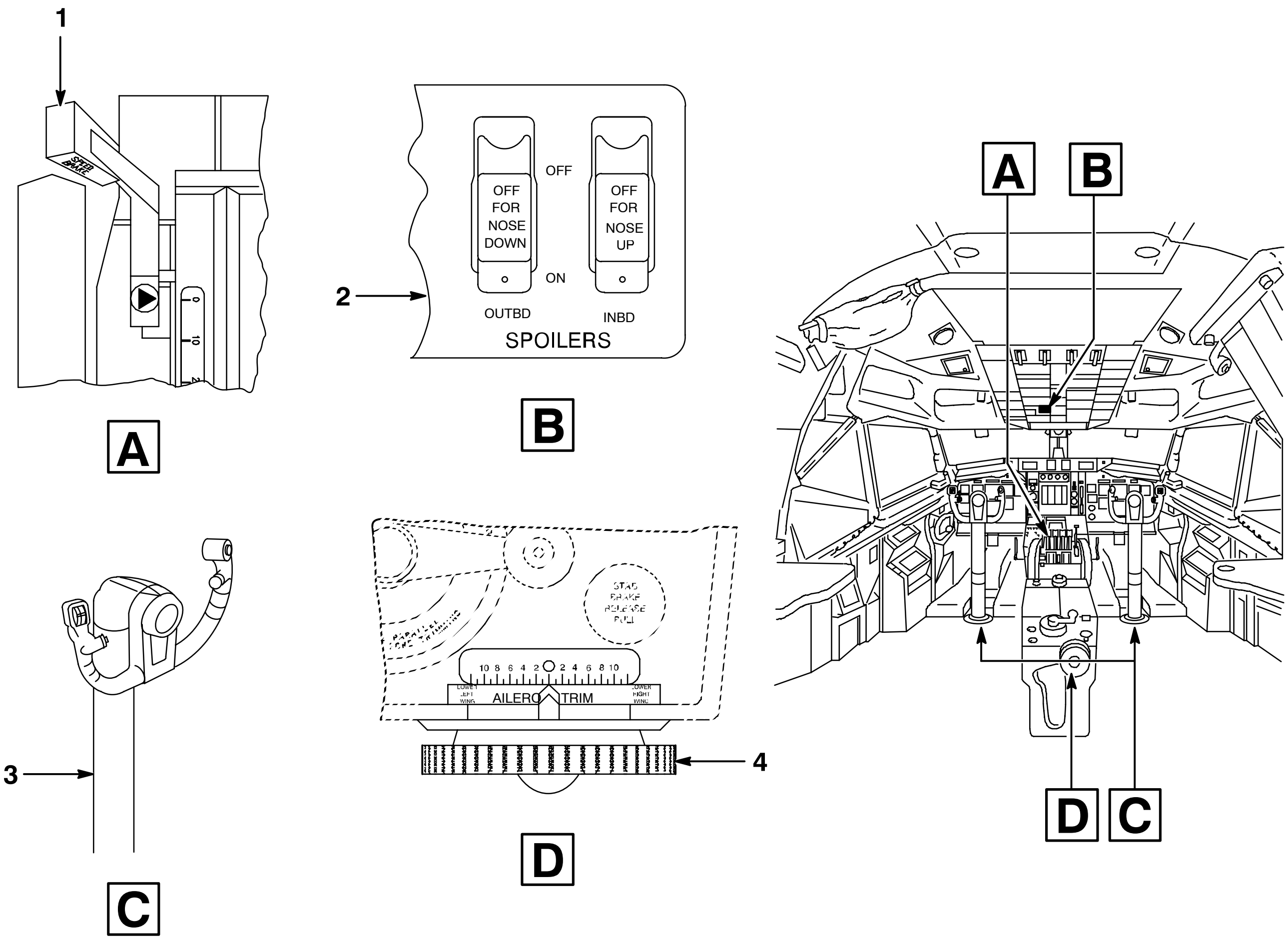


Figure 1-82 (Sheet 1 of 2)

Roll and Speedbrake Controls and Indicators (Continued)

NO.	CONTROL/INDICATOR	FUNCTION
1	SPEED BRAKE Lever	When pulled in rearward direction, operates spoiler valves mechanically which causes spoilers to deflect. Moving handle to full rear position deflects spoilers fully at airspeeds below approximately 200 KIAS. Intermediate handle positions deflect spoilers the number of degrees shown on scale at handle position. There is a detent at the 30 degree position. A pressure relief feature (spoiler blowdown) in the spoiler control mechanism allows spoilers to move down below control handle setting value if air loads on spoilers exceed relief setting.
2	SPOILERS Switches (Guarded On)	When set to ON, sets spoiler bypass valves for normal spoiler operation. When set to OFF, INBD switch sets inboard spoiler bypass valve to prevent operation of inboard spoiler, causing nose up pitching moment if spoilers are deployed. When set to OFF, OUTBD switch sets outboard spoiler bypass valve to prevent operation of outboard spoilers, resulting in nose down pitching moment if spoilers are deployed.
		NOTE When set to OFF, SPOILERS switches set spoiler bypass valves which dump fluid in the spoiler actuators to return. This allows the spoilers to blow down.
3	Control Wheel	When rotated, mechanically positions aileron control tabs and spoiler control valves to control roll attitude of airplane.
4	AILERON TRIM Wheel and Indicator	When rotated, operates aileron control tab linkage to provide lateral trim. Adjacent pointer indicates amount of trim provided on scale. Scale markings are not in any standard units.
		NOTE Large amounts of aileron trim result in increased airplane drag because spoilers deflect with ailerons. Refer to ROLL AND DIRECTIONAL TRIM TECHNIQUE, section VI.

Figure 1-82 (Sheet 2 of 2)

Separate switches (2, *figure 1-82*), allow either set of spoilers to be shut off, while operating the remaining set. The switches operate bypass valves which dump fluid in the actuators to return, locking spoilers down. The spoiler switches can be used for pitch trim if the stabilizer trim is inoperative or if control forces are high. (Refer to JAMMED STABILIZER LANDING, section III and PITCH CHANGES, section VI.) Inboard spoilers are usually shut off in descent to reduce structural vibration.

PITCH CONTROL SYSTEM

Pitch control is provided by tab-controlled elevators and pitch trim is provided by varying the angle of incidence of the horizontal stabilizer. See *figure 1-83*. The elevators are positioned by outboard control tabs, manually operated by dual cable systems connected to the control column. Smaller inboard tabs, actuated by the horizontal stabilizer, fair the elevators to the stabilizer and provide proper elevator control force gradients in extreme airplane nose-down stabilizer positions.

NOTE

The left and right elevators are not interconnected; consequently, with the airplane parked, they can assume different angular positions.

Stabilizer position, as shown on the trim indicator on each side of the control stand, is expressed in units of stabilizer movement, from 3 1/2 units airplane nose down trim to 11 units airplane nose up trim. Stabilizer position is changed by driving the surface with a jackscrew actuator. Normally, the actuator is powered by a main electric drive unit or by a two-speed automatic electric drive unit. Interconnected manual trim wheels on the control stand are directly connected by cable and gearing to the actuator. The trim wheels always turn whenever the actuator operates, regardless of the method of drive. A disconnect clutch is incorporated to permit disconnecting either electric drive unit from the actuator by manually stopping the trim wheels on the control stand. If a runaway electric trim condition occurs, moving the control column to counteract the pitch effect with the elevator sets a stabilizer trim brake on the chain drive from the trim wheel to the cable system. The brake is set when the elevator control is moved in opposition to the operating stabilizer. A brake release on the control stand can be used to disable the brake function. The trim brake engages if control column motion or force is in the direction opposite trim motion. If the column motion or force is in the same direction as trim motion, a ratcheting sound is heard from the trim brake, located under the flight deck floor. The ratcheting sound only occurs when the column is two degrees or more out of neutral position and stops when the trim brake release knob is pulled.

WARNING

The retractable handles on the trim wheels should be retracted when not in use. Injury can be sustained from an extended handle when the stabilizer is driven electrically.

System controls are shown in *figure 1-84*.

The main electric trim drive unit is controlled by double or split switches on the outboard horns of the pilot's and copilot's control wheels. Movement of one-half of the split switch controls the unidirectional main electric trim motor. Movement of the other half controls the magnetic directional drive clutches. Both halves of the switch must be pressed simultaneously to operate the stabilizer trim actuator. Releasing either or both halves of the switch stops the actuator motion. Operation of either the pilot's or copilot's stabilizer trim control switch disengages the autopilot.

NOTE

- If power to stabilizer trim system has incorrect phase sequence, missing phases, or low voltage, the autopilot does not engage.
- Instantaneous reversing of stabilizer trim direction can cause momentary ratcheting of the disconnect clutch due to the high inertia forces involved.

The auto trim drive unit is controlled by the autopilot. A series of interlock circuits prevents more than one source of control at a time for the stabilizer trim system. Two cutout switches on the aisle control stand, one for each electric drive system, can be used to shut off all power to the applicable drive system. The motors in the drive units are operated at different speeds and torque values; the main electric drive is the fastest and has the highest torque output.

The electric trim systems operate the stabilizer from 2.4 units airplane nose down to 10.4 units airplane nose up, sufficient for the speed, weight and center of gravity variations encountered in normal operation. Full stabilizer travel can be reached only by using the manual trim wheels. However, electric trim can be used to trim away from the full travel positions.

Pitch Controls and Trim

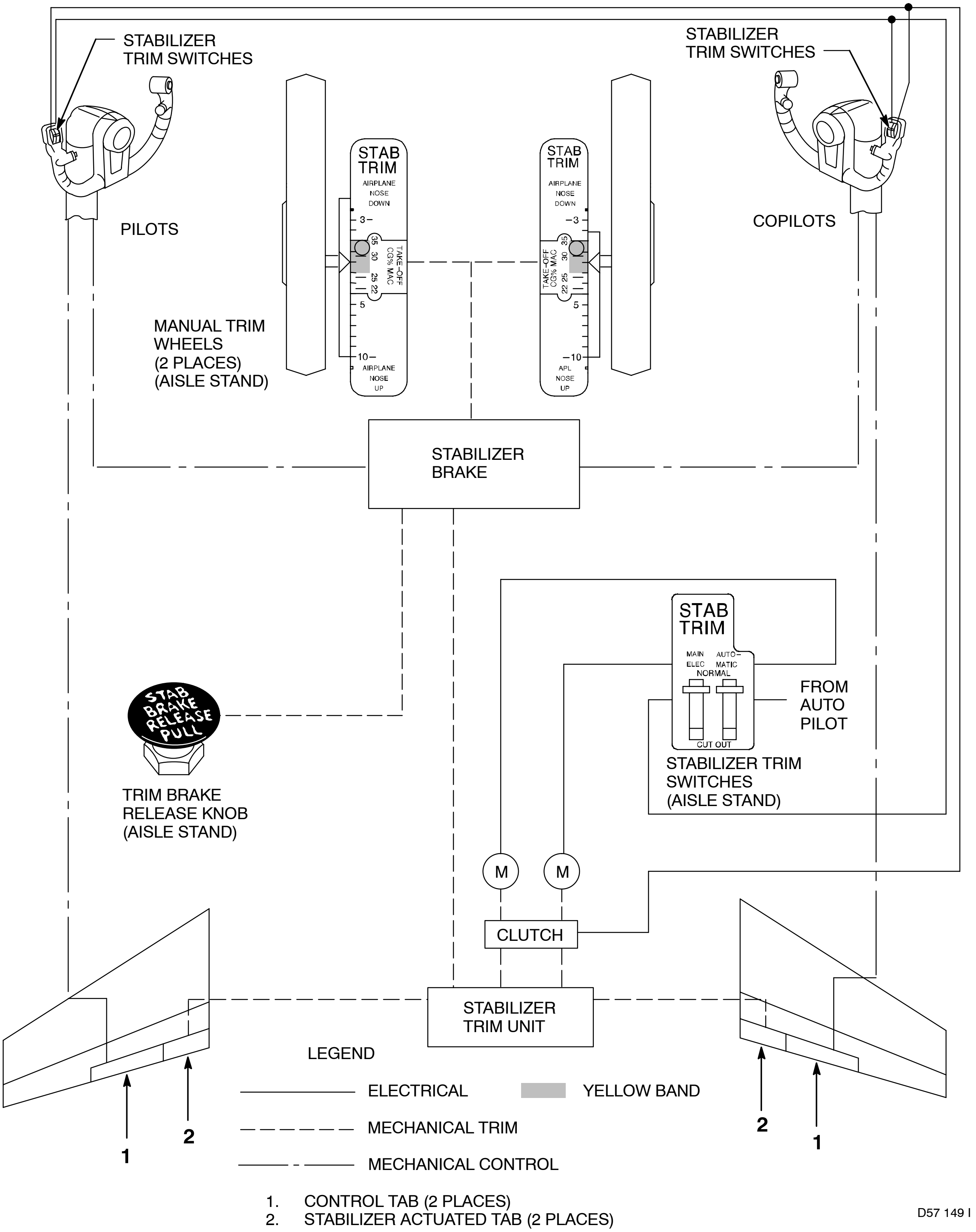
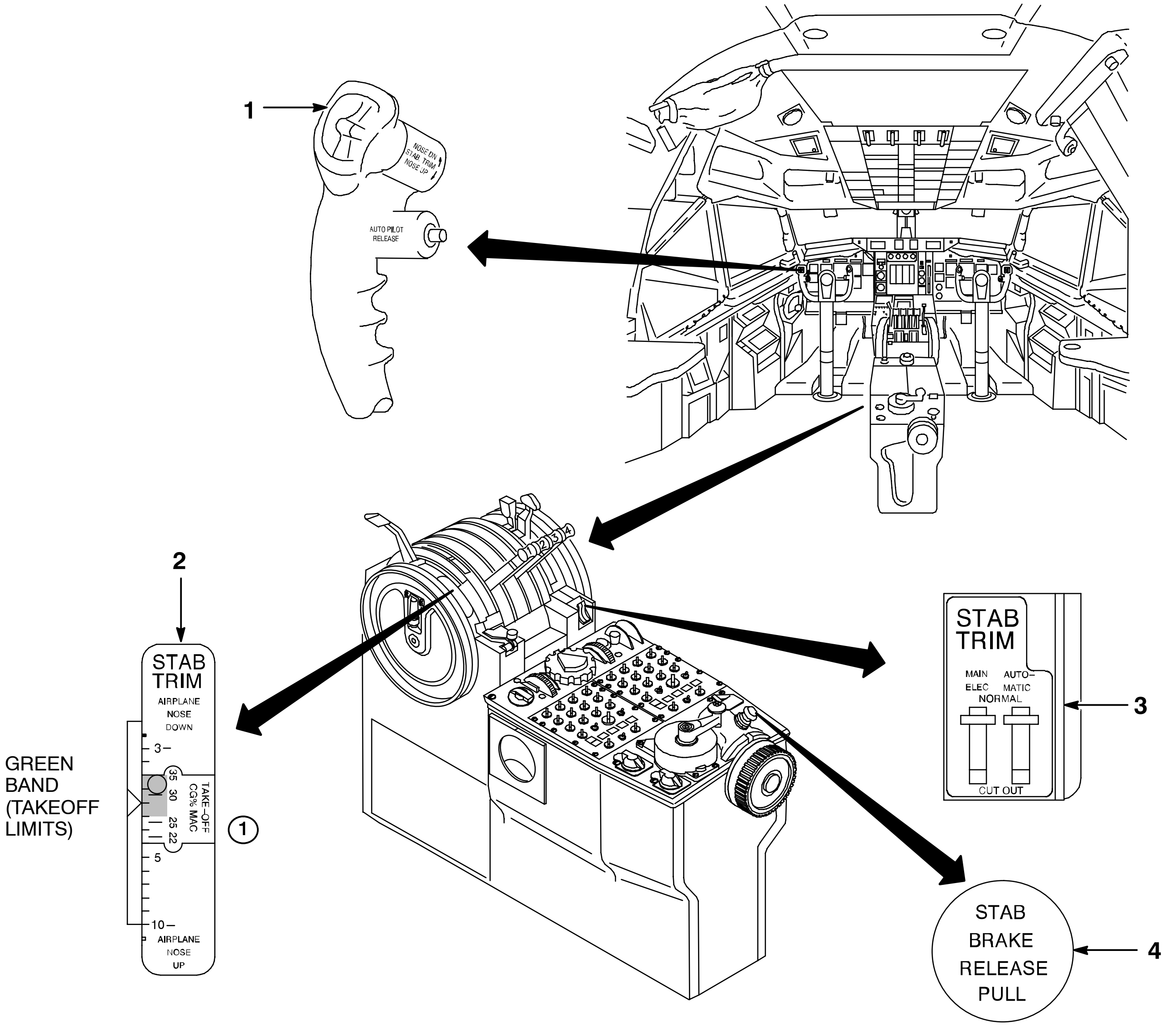


Figure 1-83

Pitch Controls and Indicators



WARNING

① DISREGARD TAKEOFF CG% MAC.
SCALE ON STABILIZER TRIM DECAL.
USE CHART IN T.O. 1E-3A-1-1.

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Figure 1-84 (Sheet 1 of 2)

Pitch Controls and Indicators (Continued)

NO.	CONTROL/INDICATOR	FUNCTION
1	Stabilizer Trim Control Switches (Each pilot's control wheel)	Two switches on outboard horn of each pilot's control wheel. One switch controls electric trim drive motor. Other switch controls drive motor electric clutch. When raised center portion is pressed upward (away from pilot's hand) switch completes circuit for nose down trim. When raised center portion is pressed down (toward pilot's hand), switch completes circuit for nose up trim. When either switch is released, trim does not operate.
2	STAB TRIM Indicators (Two Places)	Two scales, one on each side of aisle stand, indicate stabilizer position in units of approximately one degree. Indicator green band from 1 unit nose down to 3.5 units nose up shows allowable trim range for takeoff. Yellow band from 1 unit nose down to 2 units nose up indicates trim/c.g. range where pull force at rotation can be higher than normal. Warning horn will sound when NO 3 throttle is advanced on the ground if stabilizer is not in green band. Zero stabilizer trim position corresponds to position of rivet on green band. Indicator can be ±1/2 unit from actual stabilizer position due to system tolerances and cable slippage.
3	STAB TRIM CUTOUT Switches (Stabilizer Trim Cutout Switches)	One switch for each electric trim system. When set to NORMAL, trim system is enabled. When set to CUTOUT, trim system is disabled. MAIN ELEC switch controls main trim drive, operated by pilot's stabilizer trim switches. AUTOMATIC switch controls autopilot trim drive.
4	STAB BRAKE RELEASE Knob (Stabilizer Trim Brake Release)	When pulled, releases manual stabilizer trim brake.

Figure 1-84 (Sheet 2 of 2)

Manual trim requires 12.3 turns of the trim wheel per unit of trim. When electric trim is operated from the pilot's trim switches, the trim wheels move approximately 5 turns per second and trim changes one unit in 2.5 seconds. When trim is applied by the autopilot, the trim wheels rotate approximately 1/2 turn per second and trim changes one unit in 22.5 seconds. Autopilot trim with flaps down or the turn knob out of the detent is 1.67 turns of the trim wheel per second or 7.5 seconds per unit.

A green range on the placard indicates the range of takeoff trim settings for different cg positions. Trim should be set carefully at the proper value within this range. The takeoff warning horn sounds if the NO 3 throttle is advanced for takeoff with the trim pointer out of the green range. Refer to TAKEOFF WARNING system for a complete description of conditions under which takeoff warning horn sounds.

NOTE

- If takeoff trim setting is in the yellow band, check the takeoff data. Trim settings in yellow band require higher than normal pull force at rotation (at gross weights over 250,000 pounds).

- The indicator can show up to 1/2 unit difference from actual trim position, due to mechanical slippage and cable stretch. 1/2 unit of mis-trim can increase rotation forces by ten pounds at forward cg limit and maximum gross weight.

STALL WARNING SYSTEM (STICK SHAKER)

The stall warning system (*figure 1-85*) alerts the pilots to a flight condition approaching a stall or to an extreme nose-high takeoff ground attitude. When the system is armed and the airplane angle of attack is near the stall, a shaker on the pilot's control column vibrates both columns to simulate stall buffet.

The stall warning system components are: stall warning vanes (one on each wing), two flap transmitters mounted on the flap control valve in the main wheel wells, a pair of summing units, a control column shaker motor, and test switches on the overhead panel. The left main landing gear oleo-operated (squat) switch, NO 3 throttle-operated switch, and/or the OLEO BYPASS switch are used to arm anti-icing and system testing. When NO 3 throttle is advanced for takeoff, power to the stall warning vanes heaters switches from 28vdc to 115vac.

The system is armed automatically on the ground when NO 3 throttle is advanced to the takeoff position, or on lift-off by the left main gear safety (squat) switch.

The stall warning vanes convert air pressure into electrical signals in relation to the airplane angle of attack. The signal is modified for variation in flap position. If an angle of attack near the stalling angle of attack is reached, a signal is sent which actuates the stick shaker on the pilot's control column. On the ground, with flaps up, the takeoff warning system actuates the stick shaker when NO 3 throttle is advanced more than 3 inches.

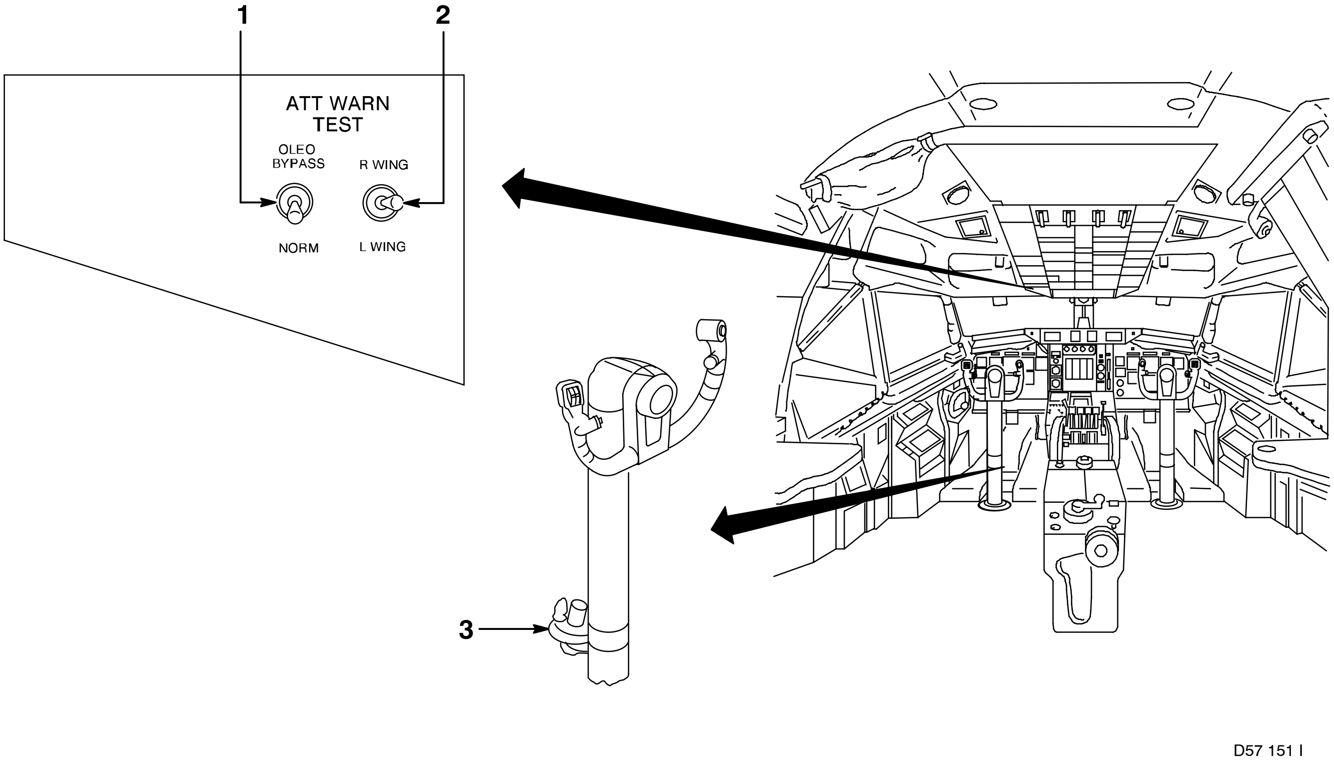
STALL WARNING TEST SWITCHES

These switches (*figure 1-85*) are provided to test the stall warning system on the ground. The OLEO BYPASS switch is spring-loaded to NORM. The R WING/L WING switch is spring-loaded to the center off position. The NO 3 throttle must be from just above idle to cutoff, the OLEO BYPASS switch must be held in the OLEO BYPASS position against spring tension from NORM position, and at the same time, the R WING/L WING switch must be held against spring tension in R WING or L WING to send a simulated stall signal into the corresponding summing unit and shake the pilot's control column. The wing flaps must be extended to at least 14° for an effective check.

TAKEOFF WARNING SYSTEM

The takeoff warning system, if activated, indicates that flaps, speed brakes, or stabilizer trim are not in the proper configuration for takeoff. The takeoff warning system receives inputs from the flaps, stabilizer trim, speed brake lever, and the NO 3 throttle. The system is wired through the left squat switch, so it only operates on the ground. The takeoff warning system uses the same horn (located under the flight engineer's table), that is used for landing gear warning and cabin pressure warning. When actuated by the takeoff warning system, the horn sounds intermittently. Power (28v dc) to the takeoff warning system is provided by the AVDC 8 bus through the MACH WARN BELL and the LANDING GEAR WARN HORN circuit breakers located on the P5 panel.

Stall Warning System



NO.	CONTROL/INDICATOR	FUNCTION
1	ATT WARN TEST OLEO BYPASS–NORM Switch (Oleo Bypass Switch)	When held in BYPASS, bypasses landing gear safety relay, simulating flight condition for ground testing stall warning system. When set to NORM, removes bypass. Has no function in flight.
2	ATT WARN TEST R WING L WING Switch (Attitude Warning Test Selector Switch)	When held in R WING position, with oleo bypass switch set to BYPASS, causes a simulated stall signal to the right signal summing unit which then causes the stick shaker to operate. When held in L WING position, same function is performed in left signal summing unit which then causes stick shaker to operate.
3	Stick Shaker (Pilot’s Control Column Only)	When actuated, vibrates both control columns.

Figure 1-85

The takeoff warning system is activated when the NO 3 throttle is advanced approximately 2/3 of the distance from idle (approximately 3 inches) and one or more of the following conditions exists: Speed brake lever more than 2° to 5° out of zero detent, and/or the inboard and outboard trailing edge flaps are not set to 14°, and/or stabilizer trim out of green band on scale.

NOTE

- If the takeoff warning system is activated with flaps up, the stick shaker is also activated.
- Since there can be up to 1/2 unit of difference between actual and indicated stabilizer position, the takeoff warning horn can sound at any point between 3.0 and 4.0 units of nose up trim, if the airplane is adjusted within limits. If the horn sounds at any position except 3.5 units nose up, note amount and direction of difference and compare with amount and direction of difference on zero check in exterior inspection.

WING FLAPS AND SLATS

Double-slotted trailing edge main flaps inboard and outboard of the inboard aileron, single-slotted wing fillet flaps, and leading edge flaps and slats on each wing provide lift and drag control for low speed flight, takeoff and landing. See *figures 1-86* and *1-87*. Cove lip doors on the wing lower surface ahead of the trailing edge flaps are positioned by the main flaps to provide smooth airflow at all flap settings. Three slots in each main flap segment smooth the airflow about the flap tracks and jackscrew actuators.

The main flap drive units are hydraulic motors supplied with utility system pressure. Flow-limiting valves govern the speed of operation and priority valves reserve pressure for gear operation and nose wheel steering during flap operation. The flaps cannot starve the landing gear or steering system. The control valves supplying hydraulic pressure to the drive units are both cable controlled by a single handle on the pilots' control stand. Two electric flap drive motors operate flaps if hydraulic pressure is lost. These units are controlled by emergency flap switches on the overhead panel.

TRAILING EDGE FLAPS

The trailing edge flaps (*figure 1-86*) are driven by torque tubes and jackscrews powered by the inboard and outboard flap drive units in the left and right wheel wells, respectively. The fillet flaps are driven by a transfer mechanism from the inboard flap drive unit. The inboard and outboard trailing edge flap drives are independent units powered by reversible hydraulic motors supplied with utility pressure from two control valves. The control valves are cable-connected to the flap control lever on the control stand. Follow-up mechanisms are cable-driven by the flap drive units to shut off hydraulic pressure when the selected flap position is reached.

A flow limiting valve is mounted in the utility pressure line to each flap control valve. The flow limiting valve establishes rate of flap operation by restricting maximum hydraulic flow to a value corresponding to full flap travel in 30 ± 5 seconds. One utility hydraulic pump can supply the required flow. A priority valve is also mounted in the utility pressure line to each flap control valve. The priority valves prevent trailing edge flap motors from dropping system pressure below 1300 psig when hydraulic pump output capacity is limited, such as when only one utility pump is operating. Thus in flight they prevent flaps from stopping motion of the landing gear and outboard spoilers, and on the ground they prevent flaps from reducing nose wheel steering effectiveness during taxi with engines at idle. The priority valves close and stop flap motion before pressure drops below 1300 psig. They re-open as pressure increases to 1500 ± 50 psig. On the ground when operating the utility system from auxiliary pump number 1 through the system interconnect, it is normal for operation of the flaps to drop auxiliary system pressure to as low as 1300 psig because the flap motor demand is greater than the pump capacity. Trailing edge flaps move incrementally as the priority valves are able to open.

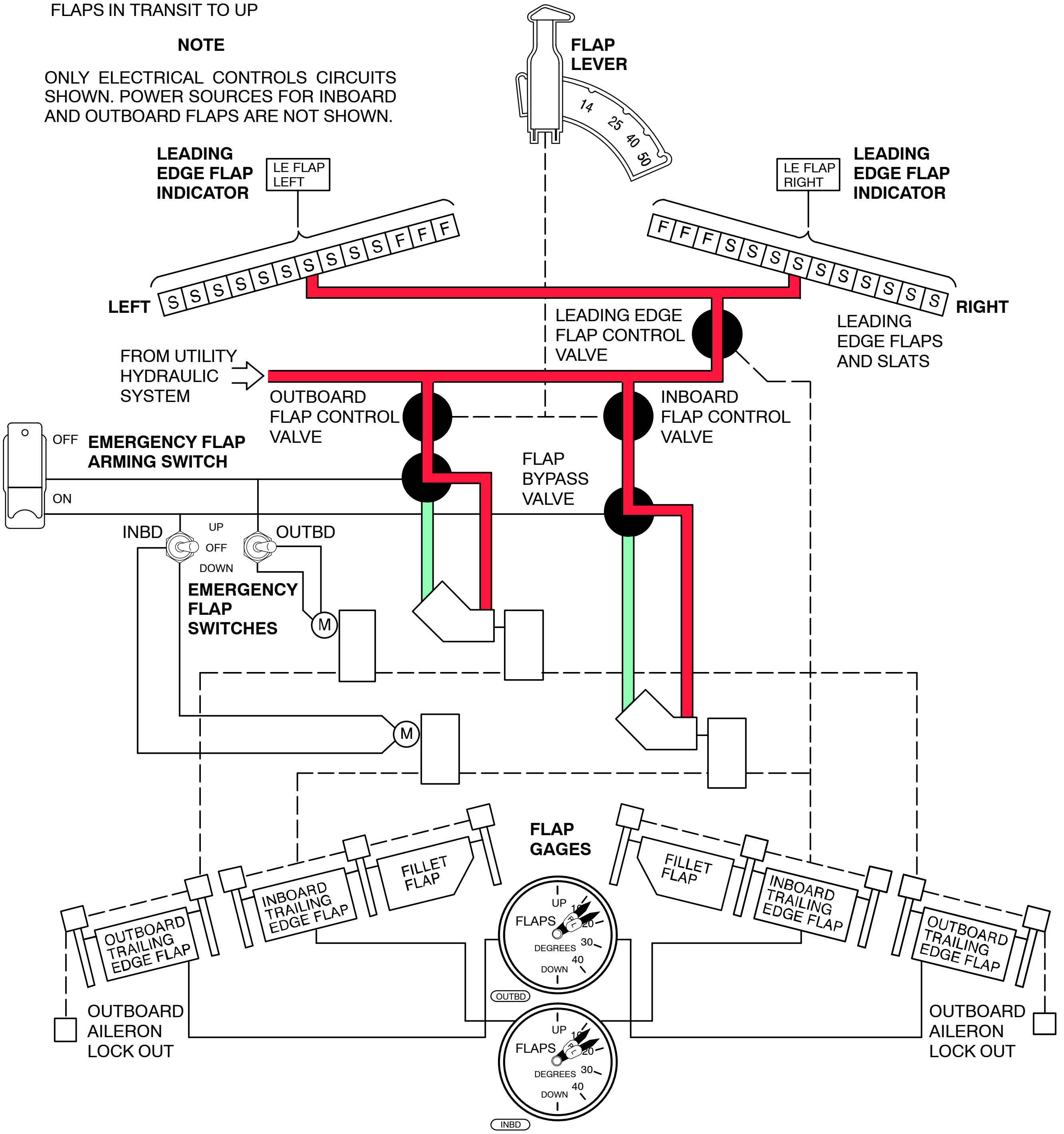
Wing Flaps and Slats

CONDITION:

FLAPS IN TRANSIT TO UP

NOTE

ONLY ELECTRICAL CONTROLS CIRCUITS SHOWN. POWER SOURCES FOR INBOARD AND OUTBOARD FLAPS ARE NOT SHOWN.



LEGEND

🟥 UTILITY SYSTEM PRESSURE

🟩 RETURN

SYMBOLS

F LEADING EDGE FLAP

S LEADING EDGE SLAT

MECHANICAL ACTUATOR

ELECTRICAL CONTROL

MECHANICAL LINKAGE

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Figure 1-86

Wing Flap and Slat Controls and Indicators

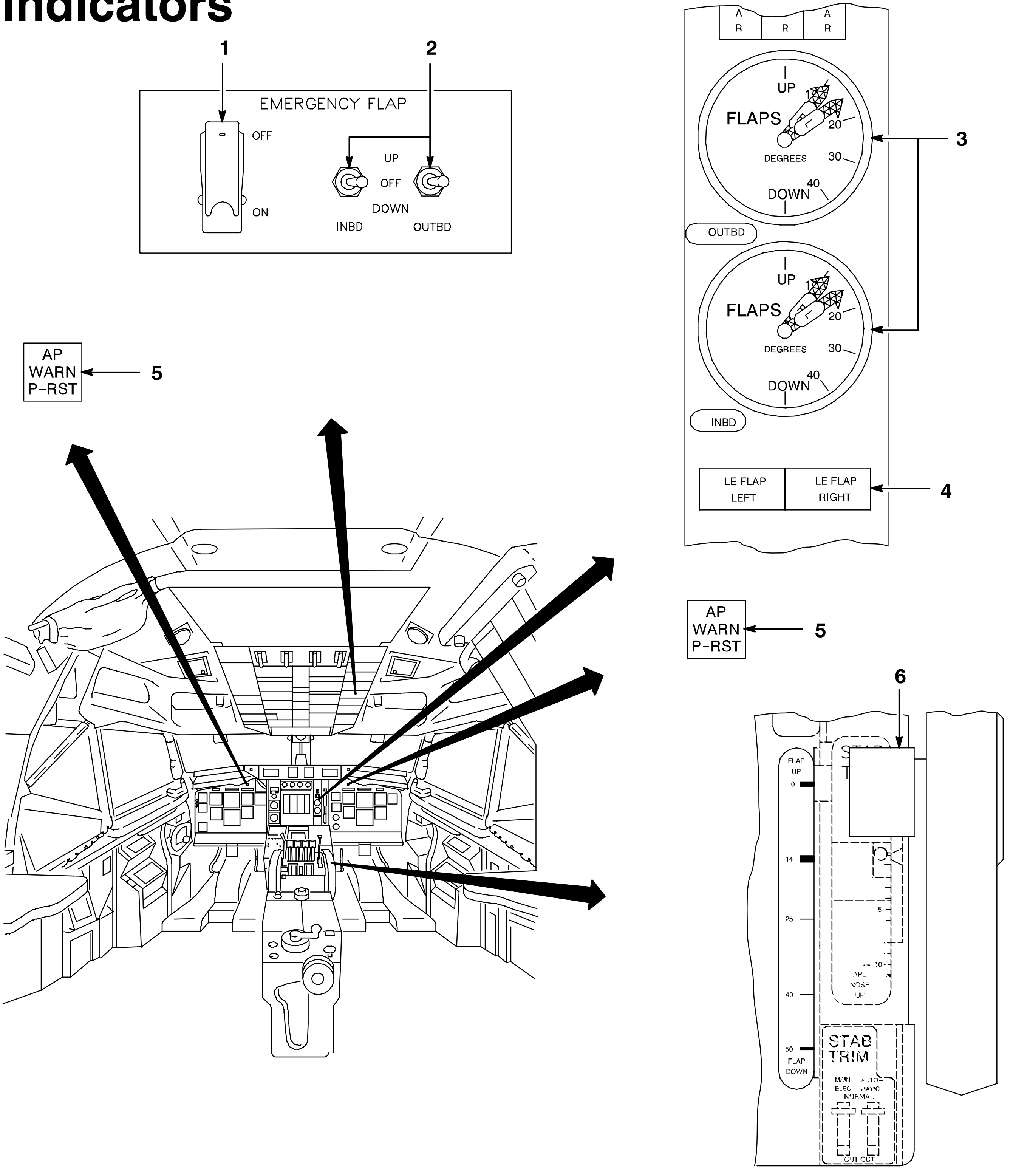

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Figure 1-87 (Sheet 1 of 2)

Wing Flap and Slat Controls and Indicators (Continued)

NO.	CONTROL/INDICATOR	FUNCTION
1	EMERGENCY FLAP (Arming) Switch (Guarded Off)	In OFF position, deactivates emergency flap system. In ON position, operates bypass valve in each trailing edge flap hydraulic system and arms emergency flap switches.
2	Emergency Flap Switches	Will remain in UP or OFF position but are spring loaded from DOWN to OFF. When set to UP, switch energizes electric motor to drive associated flap to full up from full down in approximately three minutes. When set to DOWN, must be held in position to energize electric motor to drive associated flap to full down from full up in approximately three minutes. Spring loaded to OFF position which de-energizes motor.
3	FLAPS Gages	Display position of trailing edge flaps, both inboard and outboard, in degrees, with a tolerance of ±3° at extreme flap positions, or 6° between pointers.
4	LE FLAP Indicators (Leading Edge Flap Indicators) (Green)	Illuminate when all the associated leading edge flaps are fully extended.
5	A/P WARN Warning Light (Autopilot Disengage Warning Light) (Red) (Two lights)	When illuminated steady, indicates one or both flap switches have not operated and autopilot elevator servo and pitch trim are still in flaps down mode. Flashing light indicates autopilot has disengaged. Reset light by pressing the light itself or either autopilot disconnect button. (Refer to AUTOPILOT SYSTEM)
6	Flap Lever	Controls both inboard and outboard hydraulic flap drive units. Controls leading edge flaps through valve operated by trailing edge flaps at 7° ± 3° flap extension. Detents are provided at 0, 14, 25, 40 and 50 degrees extension.

CAUTION

When operating flaps electrically with utility hydraulic pressure available, set flap lever to a position at or beyond desired degree of extension in direction of flap motion to prevent damage to hydraulic drives.

Figure 1-87 (Sheet 2 of 2)

The flap lever (6, *figure 1-87*) controls both inboard and outboard hydraulic drive units. The takeoff warning horn is actuated if the flaps are not in a takeoff position (14°) and the NO 3 throttle is advanced when the airplane is on the ground.

CAUTION

Observe flap placard speeds (Section V) when flying with any flap not fully retracted.

Dual flap position gages for the main trailing edge flaps indicate the position of the inboard and outboard trailing edge flaps.

NOTE

Due to tolerances of instruments and flap rigging, L and R pointers on flap position gages do not always indicate exactly the same.

ALTERNATE FLAP OPERATION

Three switches (1 and 2, *figure 1-87*) are used to operate the flaps electrically. An arming switch with OFF–ON positions operates two bypass valves and arms two adjacent directional control switches marked INBD and OUTBD. The directional control switches are used to drive the flaps electrically to the desired position as observed on the flap position gages (3, *figure 1-87*). The flaps operate electrically through full travel. Leading edge flaps operate normally if utility hydraulic power is available.

CAUTION

- Allow 6 seconds for bypass valves to operate between turning EMERGENCY FLAP switch on and operating electric drive motors.
- Wait at least 6 seconds for clutches to disengage before reversing flap travel or returning the system to normal hydraulic operation. Damage to electrical emergency flap motors results if centrifugal clutches are not allowed time to disengage.
- If airplane is on the ground, allow 30 minutes cooling after one complete extension and retraction using electric drive motors.
- When actuated, the flap bypass valve blocks the line from the control valve and connects the two ports of the motor so that fluid can circulate freely within the motor. To operate the electric flap drive motors up or down, after turning the EMERGENCY FLAP Arming switch ON, set the flap lever in a position at or beyond the desired flap position in the direction of flap motion prior to operation of the electric drive motors.
- If an electric drive torque limiter releases, wait 6 seconds, reverse flap operation to reset torque limiter, then operate the flaps at a lower airspeed.

LEADING EDGE FLAPS AND SLATS (LEADING EDGE FLAPS)

Three leading edge flaps are located at the inboard section of each wing, while 10 leading edge slats are at the center and outboard sections of each wing. Both flaps and slats are high lift devices, but they differ in method of operation. Leading edge flaps are hinged at the forward end and fold down and forward to the extended position. Slats are hinged in such a way that, in the fully extended position, a space is provided between the slat and the leading edge of the wing; air flowing through this space energizes the boundary layer and delays turbulent airflow over the wing. The leading edge flaps (*figure 1-86*) are powered by the utility hydraulic system, controlled by a valve mechanically linked to the inboard flap drive unit. They are extended by hydraulic actuators when the inboard main flaps reach 7° ± 3° of extension. Each leading edge flap light illuminates only if all sections on that wing are extended. A blocking valve in each section (inboard, center, and outboard) of leading edge flaps and slats keeps them extended for about one minute if hydraulic pressure fails after flap extension.

NOTE

If trailing edge flaps are extended electrically, but utility hydraulic pressure is available, leading edge flaps and slats extend when the trailing edge flaps reach 7° ± 3° extension.

FLIGHT CONTROLS ABNORMAL OPERATION

All primary flight control (ailerons, elevators, and rudder) include provisions (shear rivets, spring detents, or disconnects) to allow separation of a jammed control from the input cable. Since all aileron and elevator cables are duplicated, operation of those systems is still possible by the remaining cable. Refer to FLIGHT CONTROL SYSTEM, Section III. However, there are situations where abnormally high control forces (due to air loads) can be experienced.

HIGH CONTROL FORCES DURING GROUND CHECKOUT

High control forces during ground checkout of the ailerons, elevators, and rudder (if boost is off) can be caused by wind loads in a tailwind or crosswind on the ground. Since all of the primary flight controls use control tabs to reduce control forces during manual operation and tab area is small compared to control surface area, control forces can be extremely high during ground checks in a tailwind.

Ailerons

High forces during checkout are most often noticed in the ailerons, especially when checking aileron movement with flaps down (outboard ailerons unlocked). *Figure 1-86* shows the aileron linkage. When the control wheel is first moved from neutral, only the inboard aileron tabs move until the tabs reach the stops (① through ⑤, *figure 1-88*). When the linkage reaches the stop, wheel forces increase, since the entire aileron is being moved. The lever arm which rotates the aileron (on the ground) is short (⑧, *figure 1-88*), so wheel forces are high. Since there is no airflow over the wing, there is no pressure difference across the balance panels.

If an aileron is fully deflected and the wheel is returned to neutral, the tab stop is reached as the wheel approaches neutral, where higher control forces again occur. However, increased force on the control wheels should move the aileron.

NOTE

> In case of high control forces during ground checkout of the ailerons, retract flaps to 0° to lock outboard ailerons, and repeat the check. If inboard aileron operation is satisfactory, extend flaps to 14° and check outboard ailerons.

Elevators

High control forces during ground checkout of the elevators can occur in a similar manner to the ailerons. There are three possible combinations of elevator position, since the two elevators are not physically connected. These combinations are:

1. Both elevators deflected in the same direction (full up or full down) with a tailwind. Control column moves freely one way only (*figure 1-89*).
2. One elevator neutral and one fully deflected (in a much stronger wind than 1 above). Control column moves freely one way only.
3. Both elevators deflected, but in opposite directions. Control column requires extremely high force to move in either direction.

Rudder

When rudder boost is on, rudder operation is not affected by wind during ground checks. When rudder boost is off, a condition similar to that in aileron operation can occur. In addition, there is a spring detent in the linkage which can separate at a pedal force of approximately 165 pounds. A clunking sound is heard (and felt through the pedals) when the detent separates. If the detent separates when the rudder has reached the stop, it is not a malfunction. If the detent separates at light pedal forces or when the rudder is not at the stop, it is a malfunction and will be reported on AFTO Form 781.

INABILITY TO TRIM STABILIZER IN FLIGHT

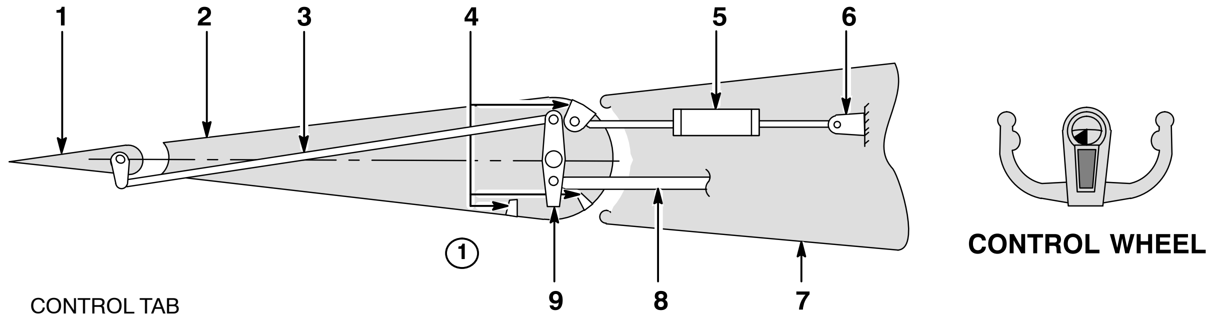
When the elevators are moved in flight, the resulting air loads are transferred to the stabilizer jackscrew. Any time the stabilizer trim wheel is moved, these loads must be overcome in order to rotate the jackscrew. If there is a control column force of 25 to 35 pounds, it can be difficult or impossible for one man to turn the trim wheel. Loads of 80 to 100 pounds can stop electric trim.

Proper airplane trim can be restored by temporarily releasing (or reversing) the force on the control column and rapidly moving the manual trim wheel. Also, column forces opposing the trim motion actuate the trim brake. The brake can be released by pulling the STAB BRAKE RELEASE knob (4, *figure 1-84*). In extreme cases, split speed brake operation can be used for additional trim. The spoiler switches are placarded to indicate which set should be used for nose up and nose down trim. Shutting off outboard spoilers gives nose down trim. Shutting off inboard spoilers gives nose up trim. Refer to JAMMED STABILIZER, Section III, and RUNAWAY STABILIZER, Section IIIA.

FLIGHT CONTROLS ELECTRIC POWER SOURCES

Electric power sources for flight controls are listed in *figure 1-90*.

Aileron Control Ground Checkout



1. CONTROL TAB
2. AILERON
3. CONTROL TAB PUSH ROD
4. AILERON STRUCTURE
5. SNUBBER
6. WING STRUCTURE
7. WING
8. CONTROL ROD
9. CONTROL CRANK

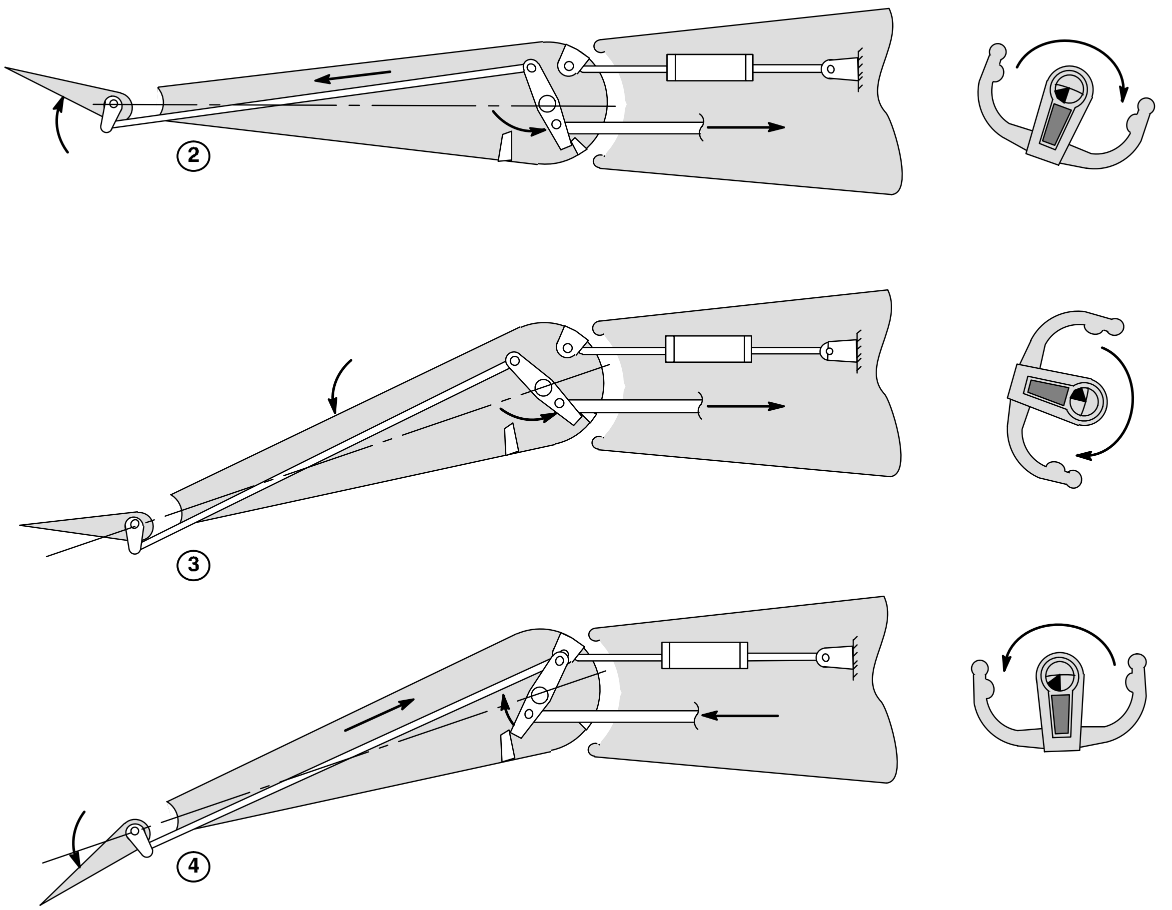


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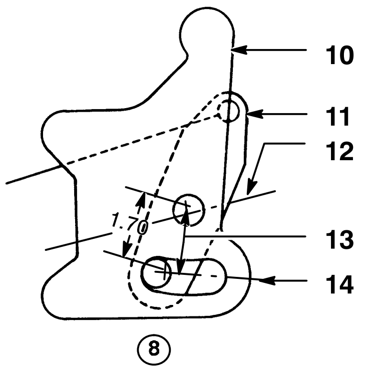
Figure 1-88 (Sheet 1 of 2)

Aileron Control Ground Checkout (Continued)

CONDITIONS

Normal ground check of aileron control system. A cross section of the left inboard aileron is shown looking outboard. ① Control wheel is in neutral. Control tab is faired with the aileron which is faired with the wing. ② Control wheel is turned clockwise. Control tab moves up until aileron control crank makes contact with aileron structure. ③ Continued movement of control wheel in clockwise direction exerts force on aileron structure moving aileron down until snubber is fully extended. ④ As the control wheel is moved counterclockwise toward neutral, the control tab moves from up to down and the control tab link contacts with the other stop.
⑤ Continued movement exerts force on aileron and moves it through the faired position to up position until the aileron snubber is completely compressed.

⑥ A tail wind blows aileron down. The control wheel does not move but since the distance between the aileron hinge and the tab hinge remains constant and the length of the control tab rod is fixed, the tab moves around its hinge point in the same direction as the aileron. Note: Any attempt to move the control wheel counterclockwise will exert a force on the aileron at the tab stop. Resisting Component Of Wind Load is an equivalent force caused by the wind blowing against the aileron surface and is a function of aileron area and wind velocity. ⑦ The control wheel is turned clockwise. The tab moves from down to up while the aileron remains full down. ⑧ This shows the actual shape of the control crank, the aileron structure, and the short moment arm of the applied force (1.70 inches).



10. AILERON STRUCTURE
11. CONTROL CRANK
12. AILERON REFERENCE LINE
13. CONTROL ROD MOMENT ARM
14. CONTROL ROD

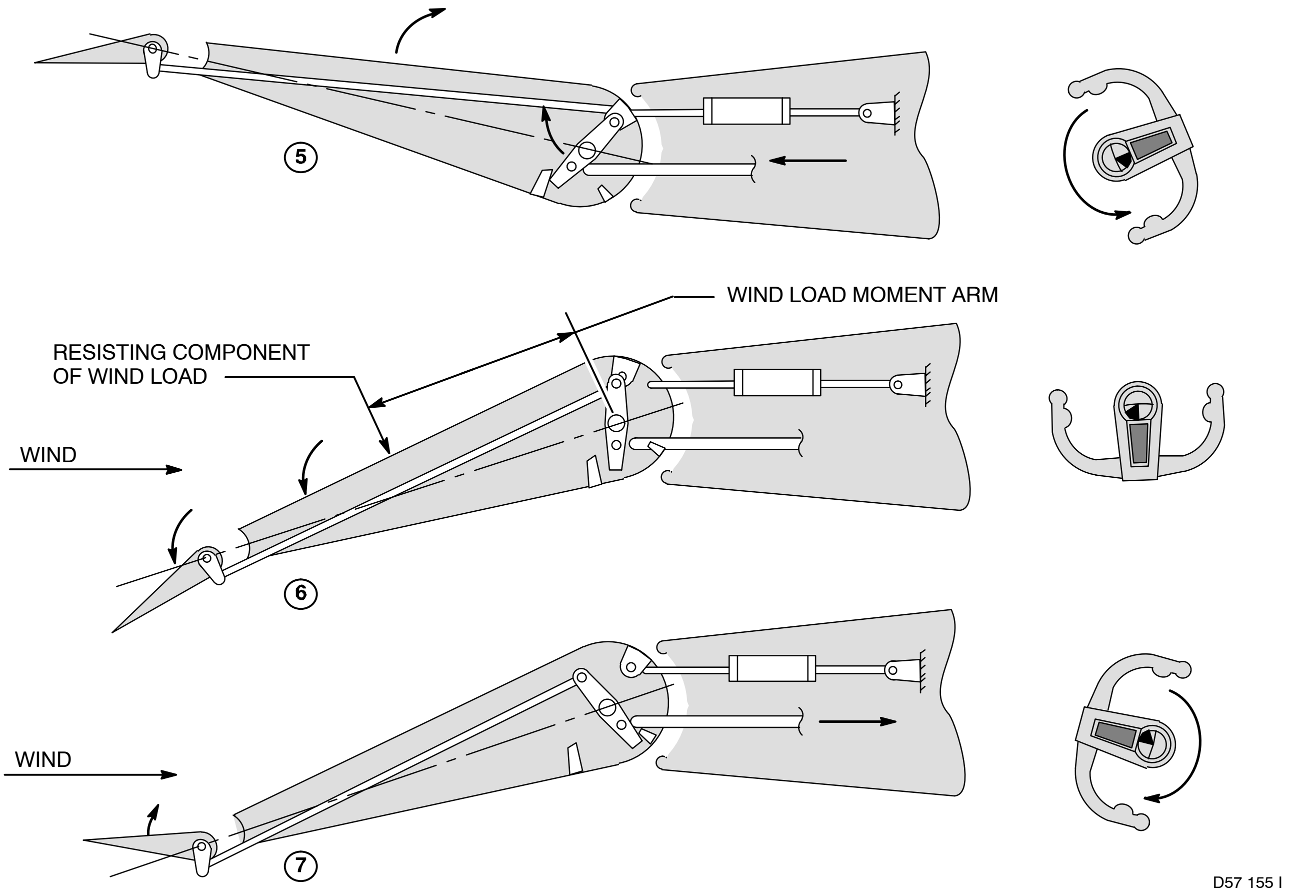


Figure 1-88 (Sheet 2 of 2)

Elevator Control Ground Checkout

ELEVATOR MOVEMENT WHEN AIRPLANE IS AT REST IN A TAILWIND

① Pushing elevator controls from aft position moves tab from down to up until the control rod crank contacts the tab stops. Any additional forward movement of controls from the position shown would tend to move the elevators against the wind. ② Control column in neutral position with the left elevator up and the right elevator down due to a tailwind. ③ Exerts force on control tab stop which is a part of elevator structure. ④ The control column is pulled aft. The right elevator moves up since the tab is already against the stop. The left elevator does not move but the tab starts down. ⑤ The control column is in the full aft position. Both tabs are down, both control rod cranks are against the stops, and both elevator snubbers are completely depressed.

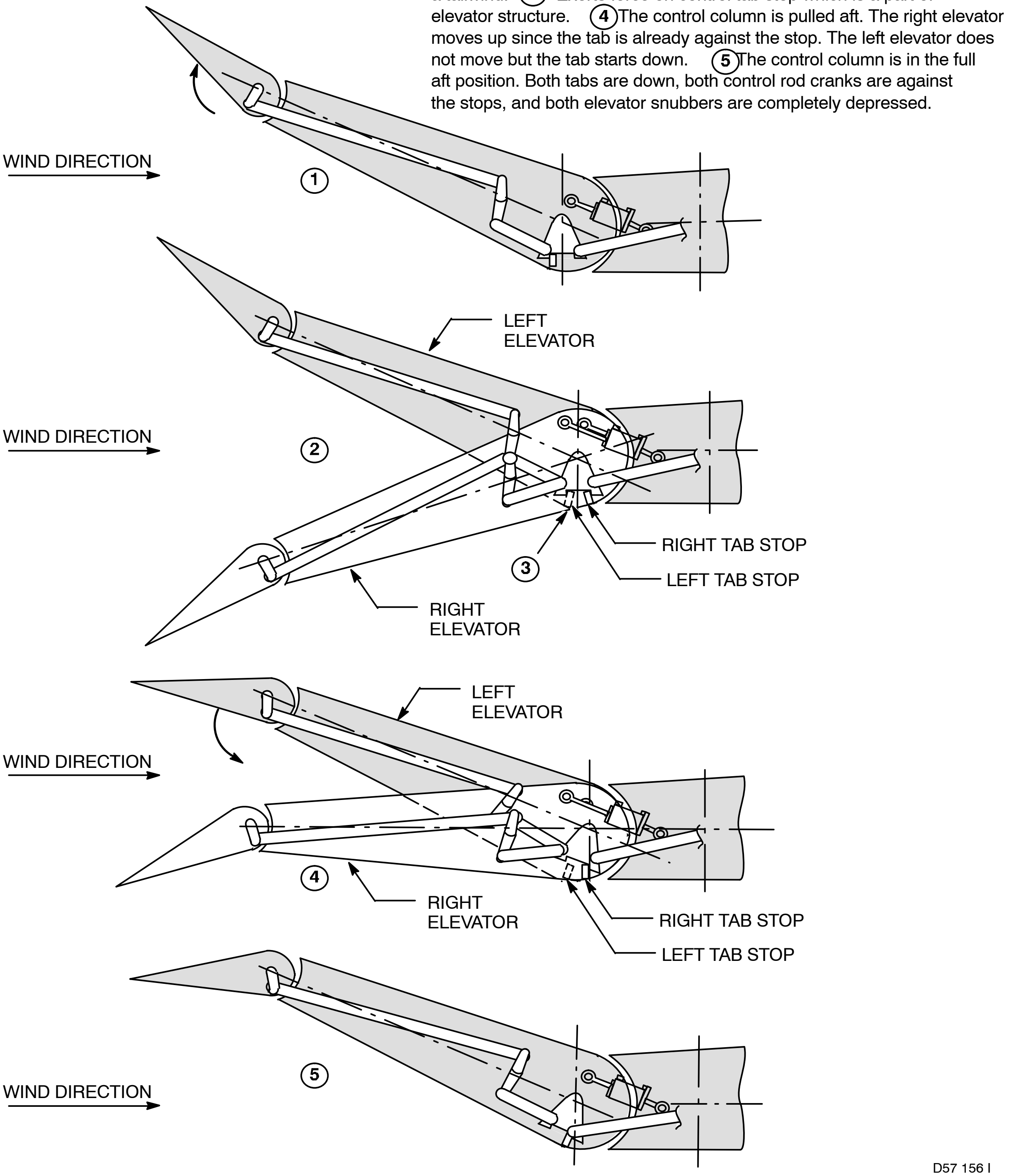


Figure 1-89

Flight Controls Electric Power Sources

EQUIPMENT/SYSTEM	TYPE OF POWER	POWER SOURCE	CIRCUIT BREAKER LOCATION/LABEL
Stabilizer Trim Actuator	115V AC	AVAC Bus 8	P5, STAB TRIM–ACTR
Stabilizer Trim Control ①	28V DC	AVDC Bus 8	P5, STAB TRIM–CONTROL
Flap Emergency Drive			
Inboard	115V AC	AVAC Bus 8	P5, FLAPS EMERG–INBD MOTOR
Outboard	115V AC	AVAC Bus 8	P5, FLAPS EMERG–OUTBD MOTOR
Flap Bypass Valve ① ②			
Inboard	28V DC	AVDC Bus 8	P5, FLAPS–BYPASS VALVE INBD
Outboard	28V DC	AVDC Bus 8	P5, FLAPS–BYPASS VALVE OUTBD
Flap Indicators			
Inboard	28V AC	28V AC Bus 8 Dist 1	P5, FLAPS POS IND–INBD
Outboard	28V AC	28V AC Bus 8 Dist 1	P5, FLAPS POS IND–OUTBD
Takeoff Warning Horn ①	28V DC	AVDC Bus 8	P5, WARN HORN CUTOUT RELAY
Mach Warning Bell ①	28V DC	AVDC Bus 8	P5, MACH WARN BELL
Stall Warning ③			
Left Side and Shaker	28V DC	FAVDC Bus 1	P5, ATTD WARN–SHAKER DC1
Right Side and Shaker	28V DC	FAVDC Bus 2	P5, ATTD WARN–SHAKER DC2
Left Side Vane	115V AC	FAAC Bus 1	P5, ATTD WARN–LEFT WING O/B
Right Side Vane	115V AC	FAAC Bus 2	P5, ATTD WARN–RIGHT WING O/B
Leading Edge Flap Lights ①	28V DC	AVDC Bus 8	P5, LE POS IND
Rudder ①	28V DC	AVDC Bus 8	P5, RUDDER VALVE
	28V DC	AVDC Bus 8	P5, RUDDER CONTROL
Spoiler Bypass Valve ① ②			
Inboard	28V DC	AVDC Bus 8	P5, SPOILER VAL–BYPASS INBD
Outboard	28V DC	AVDC Bus 8	P5, SPOILER VAL–BYPASS OUTBD
Yaw Dampers ③			
Parallel, Warning	28V DC	EDC Bus	P5, YAW DMPR–PRL WARN
Parallel, Power	115V AC	FAAC Bus 2	P5, YAW DAMPERS–PRL ØA
Series, Warning	28V DC	EDC Bus	P5, YAW DMPR–PRL WARN
Series, Power	115V AC	FAAC Bus 1	P5, YAW DAMPERS–SERIES ØA

① Inoperative when ac power is lost to TRU and dc tie bus circuit breakers are open.

② Valve remains in last selected position when power is lost.

③ FLT AVIONICS BUS 1 and/or BUS 2 switches on AVIONICS POWER DISCONNECT panel control power to EQUIPMENT/SYSTEM circuit breakers referenced by this note.

Figure 1-90

SUBSECTION I-J
FLIGHT INSTRUMENTS

Table of Contents

SUMMARY

This subsection describes all instruments used by the flight crew to determine airplane attitude, heading, and airspeed, and all additional instruments such as clocks and temperature indicators. Signal source selection switches for navigation systems are also described. For a description of the flight director system, refer to subsection I-K. For description of navigation equipment, refer to subsection I-N.

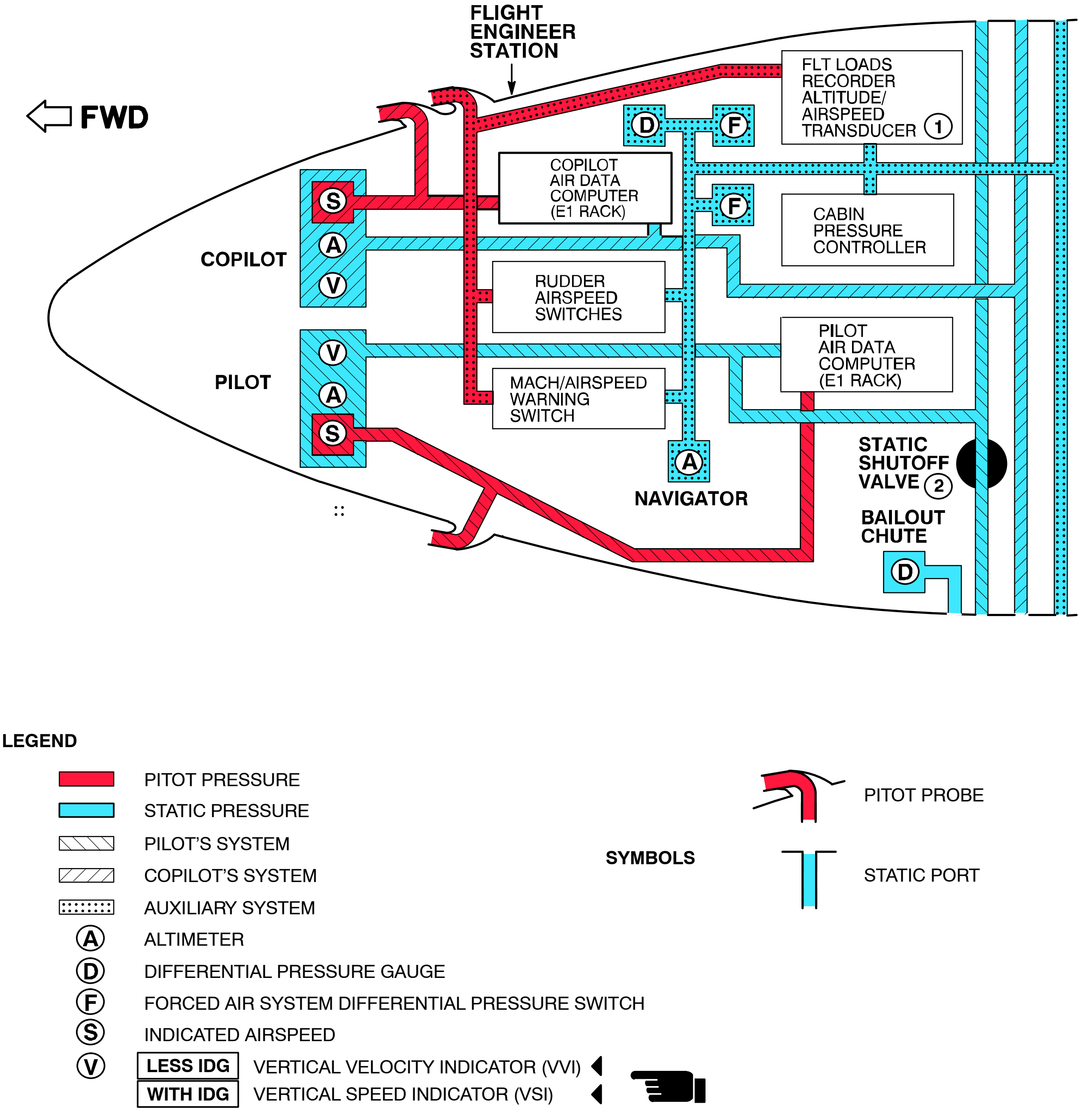
PITOT-STATIC SYSTEMS

There are three pitot-static systems (*figure 1-91*): the pilot, copilot, and auxiliary pitot-static systems. Each system includes pitot probes for measuring total pressure, static ports for measuring ambient (static) pressure, and connecting tubing. The pressures measured are used to determine airspeed, altitude, Mach number and vertical velocity. Pressure from the pitot-static systems also operates the Mach-airspeed warning switch, the rudder airspeed switch, and the central air data computers.

PITOT SYSTEMS

There are three pitot (total pressure) probes on the airplane, one on the left side and two on the right. The pitot heads are connected individually to their respective systems. The probe on the left is the source for the pilot's pitot system. This system supplies the pilot's instruments and the air data computer. The lower pitot head on the right side is connected to the copilot's instruments and air data computer. The upper probe on the right side is connected to the auxiliary system, supplying the Mach and airspeed warning switch, rudder airspeed switch and flight loads recorder altitude/airspeed transducer. The probes are equipped with heaters for ice protection. The PROBE HEATERS switches are on the anti-ice panel on the pilot's overhead panel (*figure 1-7*). Refer to ICE AND RAIN PROTECTION SYSTEMS, subsection I-S, and FLIGHT WITH UNRELIABLE AIR SPEED/MACH INDICATIONS, Sections IIIA and VII.

Pitot Static Systems



① Airplanes 1 ▶ 9, 24 (Airplanes 1, 2 4 have transducer, but do not have recorder).

② Closed mechanically when bailout chute is extended.

Figure 1-91

Figure 1-91

STATIC SYSTEMS

Static, or ambient, pressure is sensed by three ports on each side of the fuselage. One port on each side is connected to each of the three static systems. One pair is connected to the pilot's instruments and air data computer. A second pair is connected to the copilot's instruments and air data computer. A third pair is connected to the auxiliary pitot-static system. The auxiliary static system supplies static pressure to the navigator's altimeter, cabin differential pressure gage, cabin pressure controller, Mach-airspeed warning switch, rudder airspeed switches, flight loads recorder altitude/airspeed transducer (airplane, 1 ▶ 9, 24), and forced-air cooling differential pressure switches.

NOTE

> WITH IDG Operation in an RVSM environment requires accurate input to the ADC. Damage to static ports or surrounding fuselage skin can adversely affect accuracy of altitude that is displayed to flight crew and provided to other systems. To maintain airplane RVSM qualification, ports and surrounding skin must be visually inspected during the Exterior Inspection preflight. Verify that flush static ports are clear, clean, and show no signs of blockage or corrosion. Also verify that surrounding skin is free from any defects in approximately a two foot square around the static ports. Noticeable surface irregularities such as skin waviness, dents/bulges, scratches, broken or loose fasteners, and/or patched areas must be reported to maintenance for a limitation assessment. ◀

PITOT-STATIC INSTRUMENTS

Pitot-static instruments include the airspeed portion of the Mach/airspeed indicators, the pilots' altimeters (when in STBY mode), the navigator's altimeter, and the LESS IDG vertical velocity indicators (VVI), ◀ WITH IDG vertical speed indicator (VSI). ◀ Since the Mach meter portion of the Mach/airspeed indicators and the altimeters (when in RESET mode) use information supplied by the air data computer, both instruments are described under the air data system. The pilot's and copilot's LESS IDG vertical velocity indicators ◀ WITH IDG vertical speed indicators ◀ use uncorrected static pressure from the respective pitot-static system to determine rate of climb or descent. *Figure 1-92* shows the LESS IDG vertical velocity indicator. ◀ *Figure 1–95F* shows the WITH IDG vertical speed indicator. ◀

NOTE

> When the bailout chute spoiler is extended, the pilot's left static port is mechanically shut off to prevent erratic static pressure readings and the copilot's pitot static system is unreliable due to flow disturbance caused by the extended bailout chute spoiler. The data in FLIGHT WITH UNRELIABLE AIRSPEED/MACH INDICATIONS, Section III, may be used as a backup.

MACH AND AIRSPEED WARNING SYSTEM

The Mach and airspeed warning system alerts the flight crew when the airplane approaches VH or MH. The warning system includes a pitot-static pressure operated switch, an interrupter unit and a warning bell. The switch contains two sets of contacts, operated by individual bellows, which are in parallel to the interrupter unit and bell. The airspeed bellows senses pitot and static pressure and is set to VH (+4, -0) KIAS. The Mach bellows is operated by pitot pressure only and is set at $M_H \pm 0.015$ Mach. In general, the Mach contacts close first at high altitudes. When the switch contacts close, the interrupter is energized. The interrupter unit then causes the warning bell to ring intermittently until the switch contacts are opened. Operating power for the system is 28 vdc with circuit protection on circuit breaker panel P5. The MACH WARN TEST switch (12, *figure 1-7*) is on the pilot's overhead panel. Pressing this switch closes the electrical circuit to the interrupter and causes the warning bell to ring, indicating that the bell is operative.

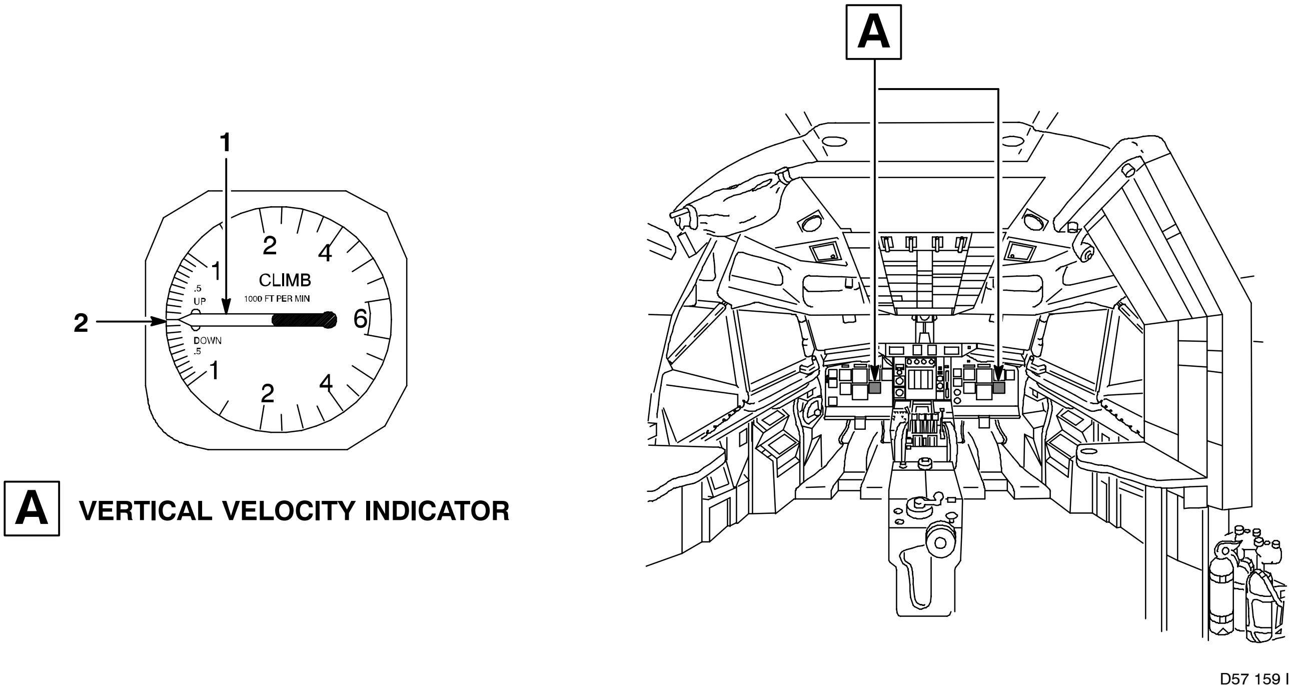
AIR DATA SYSTEM

The Air Data System (ADS) (*figure 1-93*) computes and provides air data information to instrument displays, the flight director system, autopilot system, GINS, IFF transponder (automatic altitude reporting), fuel system, and the Digital Flight Data Recorder (DFDR). The ADS uses static pressure, pitot pressure and total air temperature as inputs. The navigator's altimeter is not connected to the air data system.

LESS IDG ADS SIGNAL FLOW AND DISPLAY

The Air Data Computers (ADC) use pitot and static pressures and total air temperature to compute outputs for the various systems. These outputs represent functions of altitude, airspeed, Mach number, true airspeed and static air temperature.

Vertical Velocity Indicator



NO.	CONTROL/INDICATOR	FUNCTION
1	Vertical Velocity Pointer	Displays vertical velocity in thousands of feet per minute.
2	Vertical Velocity Scale	Scale is divided into UP and DOWN portions from zero to 6,000 feet per minute. The first 1,000-foot mark is further divided into 100-foot increments for both the UP and DOWN direction.

Figure 1-92

The ADS provides the following:

a. Altitude position error correction, derived from Mach number signals, to the pilots' servo-pneumatic altimeters (*figure 1–94*) when in the servo mode (above approximately 200 KIAS).

b. Altitude to the IFF transponder.

c. Altitude error to the flight director system.

d. Altitude error and airspeed to the autopilot system.

e. Mach number to the pilots' Mach/airspeed indicator (*figure 1–94*).

f. True airspeed to the navigator's true airspeed indicator (*figure 1–14*).

g. Static air temperature to SAT indicator (*figure 1–14*) on navigator's instrument panel.

h. Barometric altitude via GINS to data processor system.

i. Altitude and indicated airspeed to the DFDR/CVR/CPL. There are two altitude signals to the DFDR/CVR/CPL. The ADC sends a coarse altitude signal directly to the DFDR/CVR/CPL. The more accurate fine signal is switched through the mode switch on the copilot's altimeter.

j. Altitude to the fuel temperature indicating system.

k. ADC 1 provides analog signals to the pilot position, and ADC 2 to copilot and navigator positions, DFDR/CVR/CPL, AIMS, and fuel temperature indicating system. Both ADCs are connected to the 1553 bus and provide airspeed, temperature, pressure, and altitude data to GINS.

ADS/DATA PROCESSING SYSTEM INTERFACE

The ADS provides altitude information to the data processor via the GINS. The GINS reformats the altitude information and sends it to the data processor as part of a digital message. If a complete ADS failure occurs, the data processor continues to use the last altitude value received prior to the failure. If required, the mission crew can update this altitude manually from a situation display (multipurpose) console. If the ADS failure was intermittent, the input of altitude data from the GINS to the data processor automatically resumes. Any time ADS altitude data fails, advise the mission crew commander.

WITH IDG AIR DATA SYSTEM SIGNAL FLOW AND DISPLAY

The ADC SOURCE SELECT switch (*figure 1–93A*) selects ADC 1 or ADC 2 to provide the following:

a. Airspeed signal, corrected for position error, to the autopilot computer. Also, with autopilot altitude hold engaged, the autopilot receives an altitude deviation signal from the selected ADC.

b. Altitude corrected for position error to the IFF mode S transponder, used for mode C altitude reporting and as part of the mode S squitter transmissions. This altitude data is subsequently shared by the mode S transponder computer with the TCAS computer; it is not provided directly from the selected ADC to TCAS, but originates in the selected ADC.

c. Altitude corrected for position error to the two RVSM altitude alerters.

In addition to the signals through the ADC SOURCE SELECT switch, ADC 1 directly provides the following:

a. Mach to the pilot's Mach/airspeed indicator. (The airspeed indicator is a direct pressure reading instrument.)

b. Altitude corrected for position error to the pilot's altimeter when in RESET mode.

c. Altitude deviation to the pilot's flight director computer when flight director altitude hold is engaged.

d. Altitude, corrected for position error, to GINS CDU 1, EGI 1, and the CPS.

In addition to the signals through the ADC SOURCE SELECT switch, ADC 2 directly provides the following:

a. Mach to the copilot's Mach/airspeed indicator. (The airspeed indicator is a direct pressure reading instrument.)

b. Altitude corrected for position error to the copilot's altimeter when in RESET mode.

c. Airspeed and coarse altitude to the DFDR, and fine altitude to the DFDR through the copilot's altimeter when the copilot's altimeter is in RESET mode.

d. Altitude deviation to the copilot's flight director computer when flight director altitude hold is engaged.

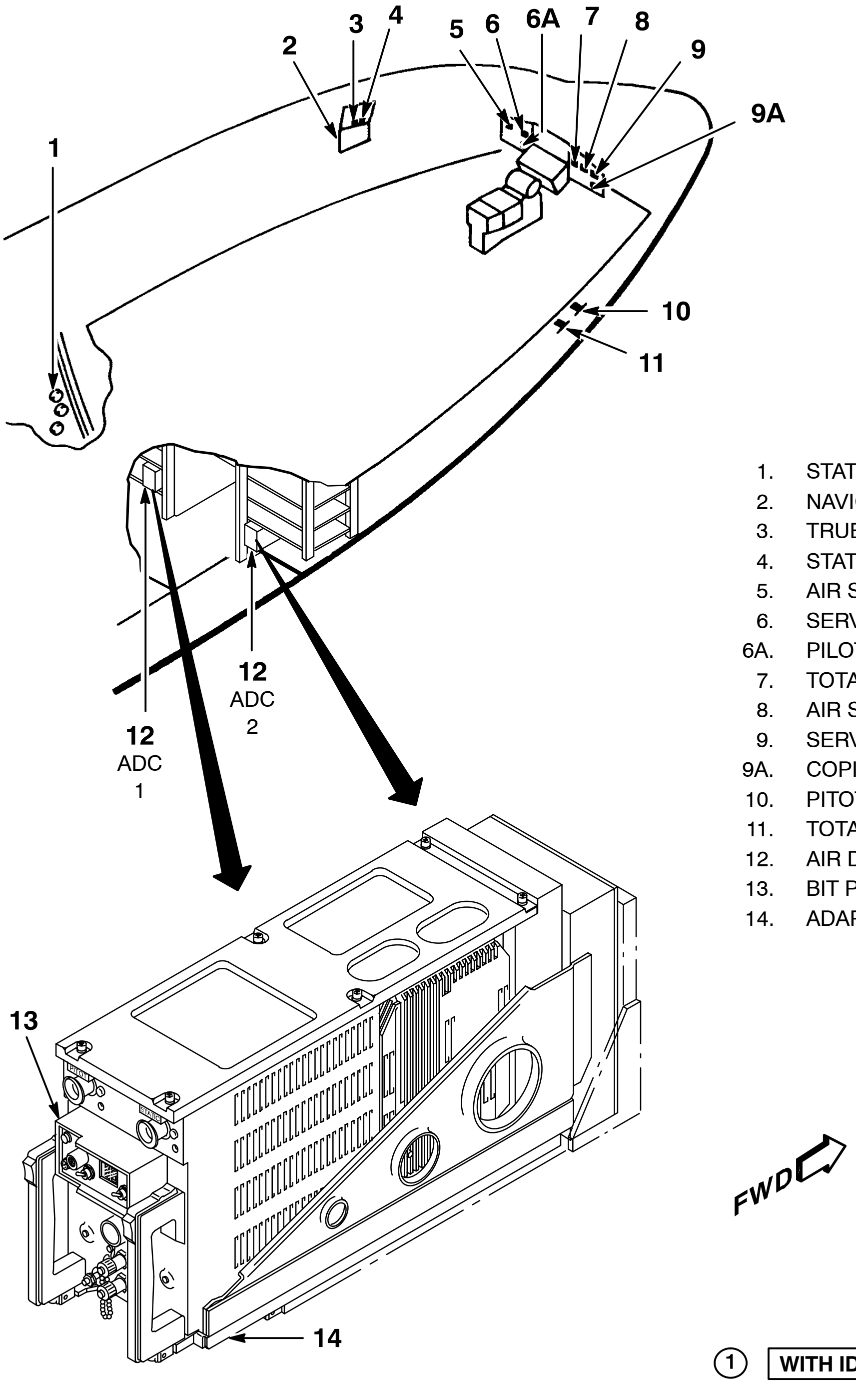
e. Static air temperature to the navigator's static air temperature indicator.

f. True airspeed to the navigator's TAS indicator.

g. Altitude, corrected for position error, to GINS CDU 2, EGI 2, and the CPS.

h. Altitude to the fuel temperature system. ◀

Air Data System



1. STATIC PORTS (TYPICAL BOTH SIDES)
2. NAVIGATOR'S INSTRUMENT PANEL
3. TRUE AIR SPEED INDICATOR
4. STATIC AIR TEMPERATURE INDICATOR
5. AIR SPEED/MACH INDICATOR
6. SERVO PNEUMATIC ALTIMETER

6A. PILOT'S ALTITUDE ALERTER ①

7. TOTAL AIR TEMPERATURE INDICATOR
8. AIR SPEED/MACH INDICATOR
9. SERVO PNEUMATIC ALTIMETER

9A. COPILOT'S ALTITUDE ALERTER ①

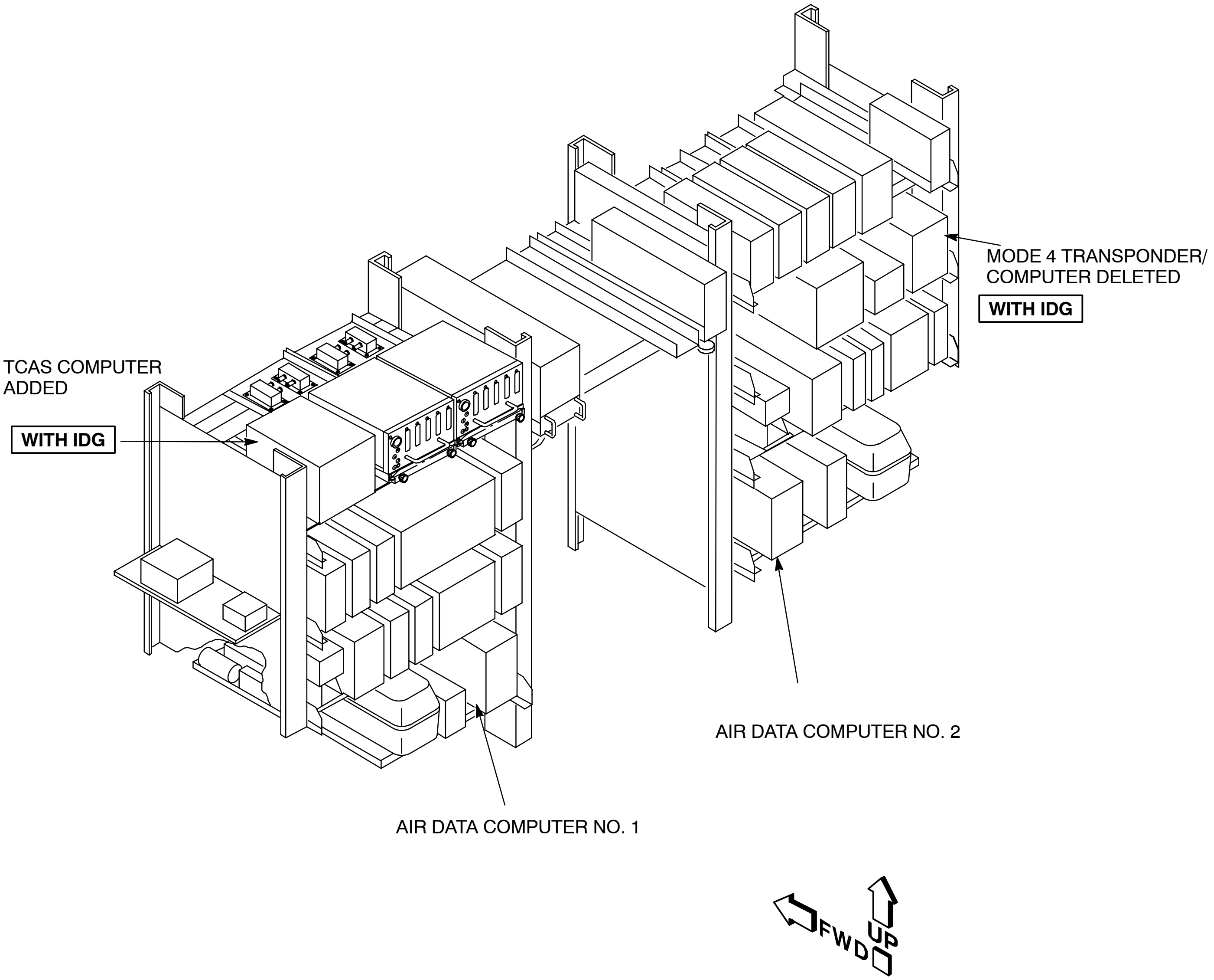
10. PITOT HEAD
11. TOTAL AIR TEMPERATURE PROBE
12. AIR DATA COMPUTER (2)
13. BIT PANEL
14. ADAPTER TRAY

① **WITH IDG**

D57 160 I

Figure 1-93 (Sheet 1 of 4)

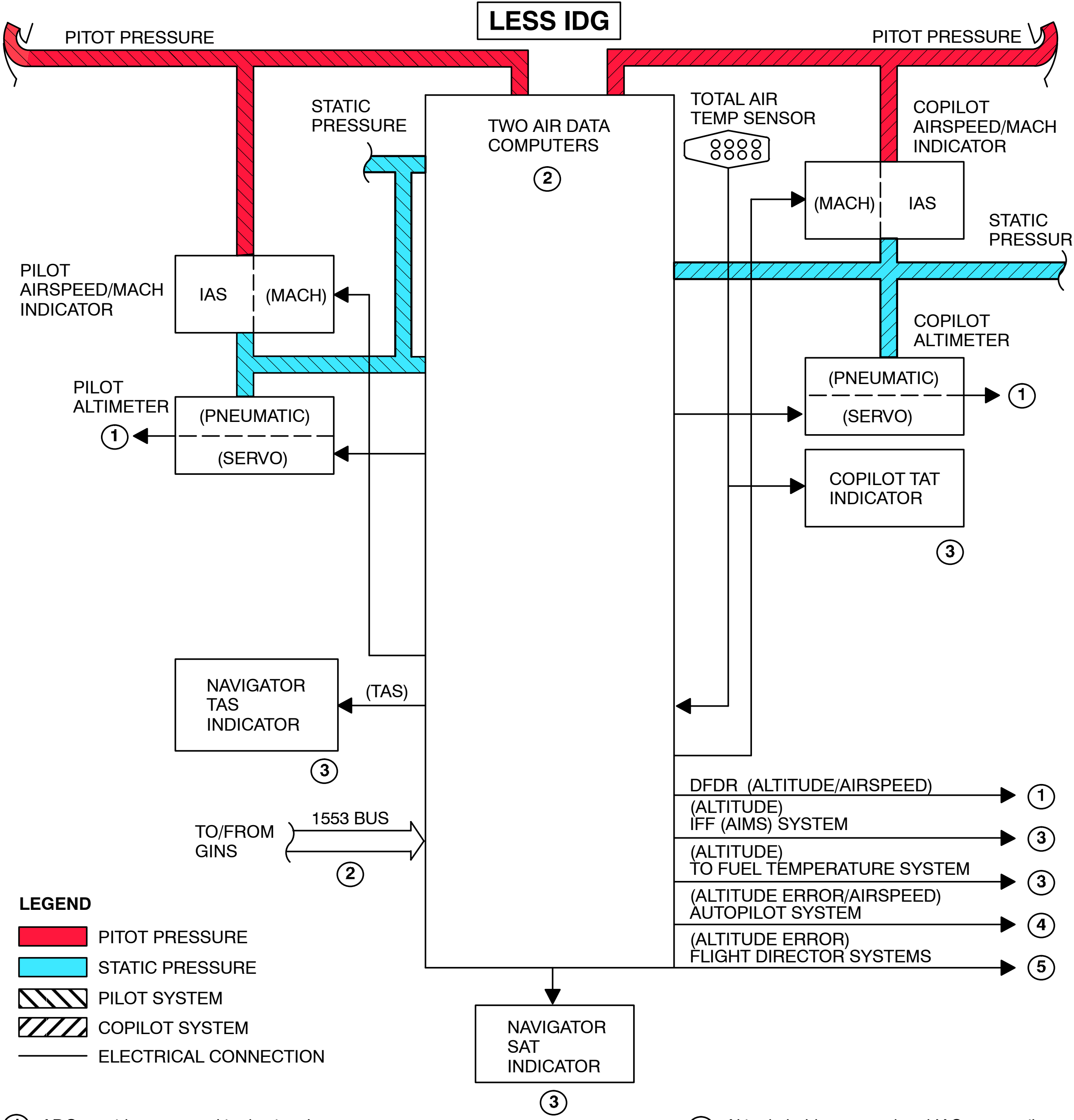
Air Data System (Continued)



D57 626 I

Figure 1-93 (Sheet 2 of 4)

Air Data System (Continued)



① ADC provides coarse altitude signal to DFDR. Copilot altitude provides fine altitude signal to DFDR (if in servo mode).

② Each ADC is connected to GINS via 1553 bus.

③ ADC 1 has analog interfaces with pilot station. ADC 2 has analog interfaces with copilot and navigator stations.

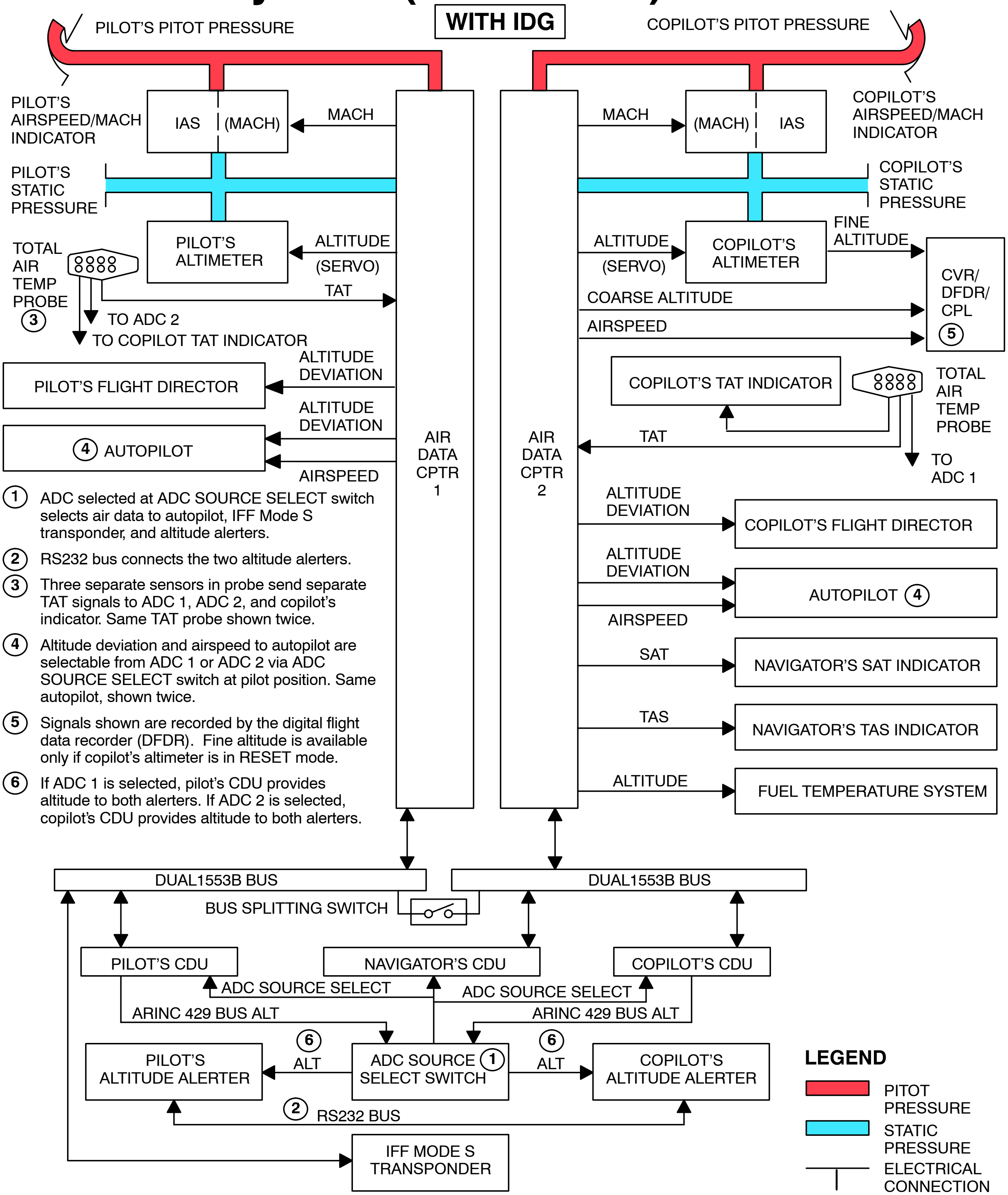
④ Altitude hold command and IAS to autopilot are switchable between ADC 1 and ADC 2 at pilot position.

⑤ ADC 1 to flight director 1; ADC 2 to flight director 2.

D57 162 I

Figure 1-93 (Sheet 3 of 4) ◀

Air Data System (Continued)



① ADC selected at ADC SOURCE SELECT switch selects air data to autopilot, IFF Mode S transponder, and altitude alerters.

② RS232 bus connects the two altitude alerters.

③ Three separate sensors in probe send separate TAT signals to ADC 1, ADC 2, and copilot's indicator. Same TAT probe shown twice.

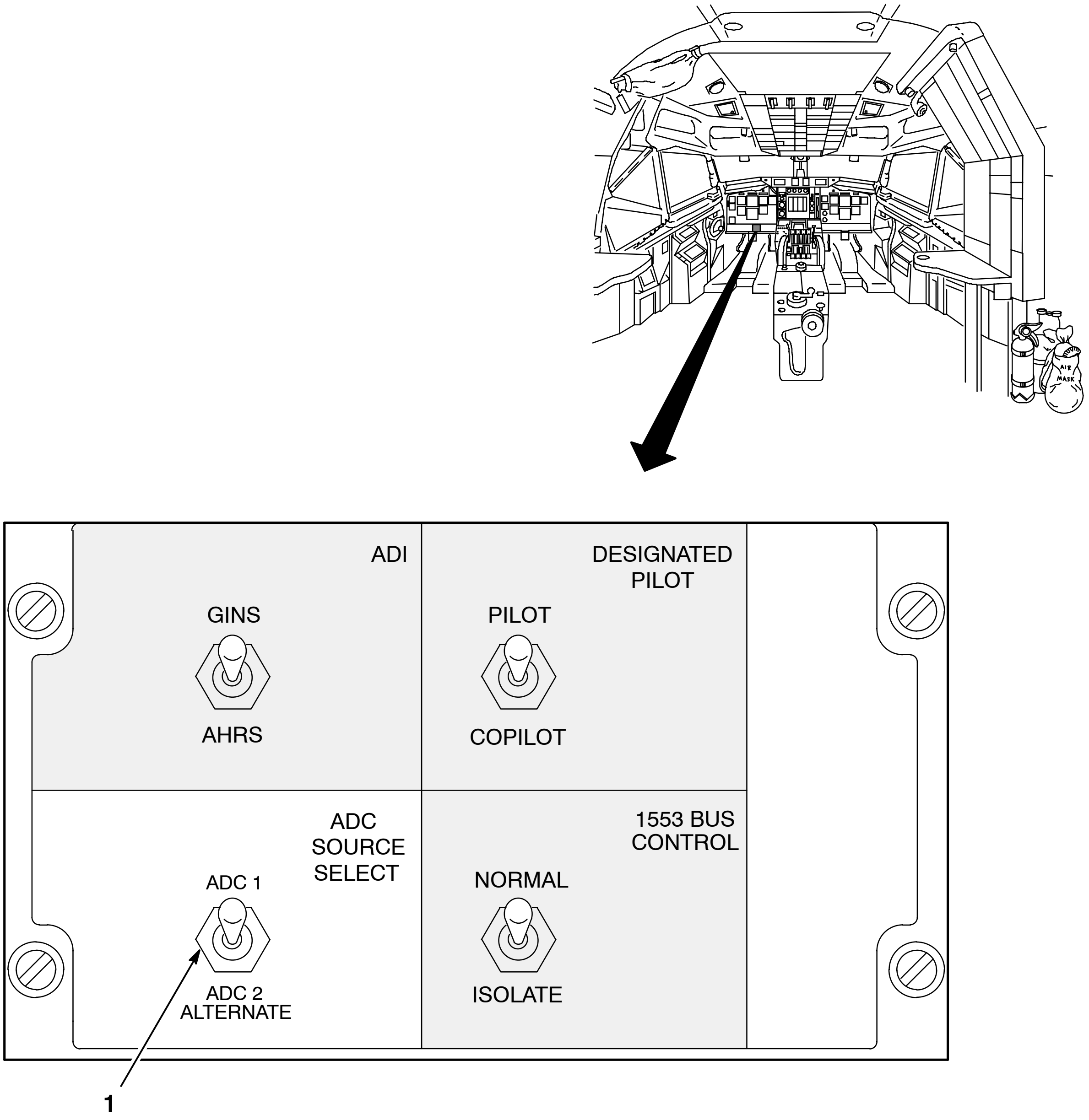
④ Altitude deviation and airspeed to autopilot are selectable from ADC 1 or ADC 2 via ADC SOURCE SELECT switch at pilot position. Same autopilot, shown twice.

⑤ Signals shown are recorded by the digital flight data recorder (DFDR). Fine altitude is available only if copilot's altimeter is in RESET mode.

⑥ If ADC 1 is selected, pilot's CDU provides altitude to both alerters. If ADC 2 is selected, copilot's CDU provides altitude to both alerters.

Figure 1-93 (Sheet 4 of 4) ◀

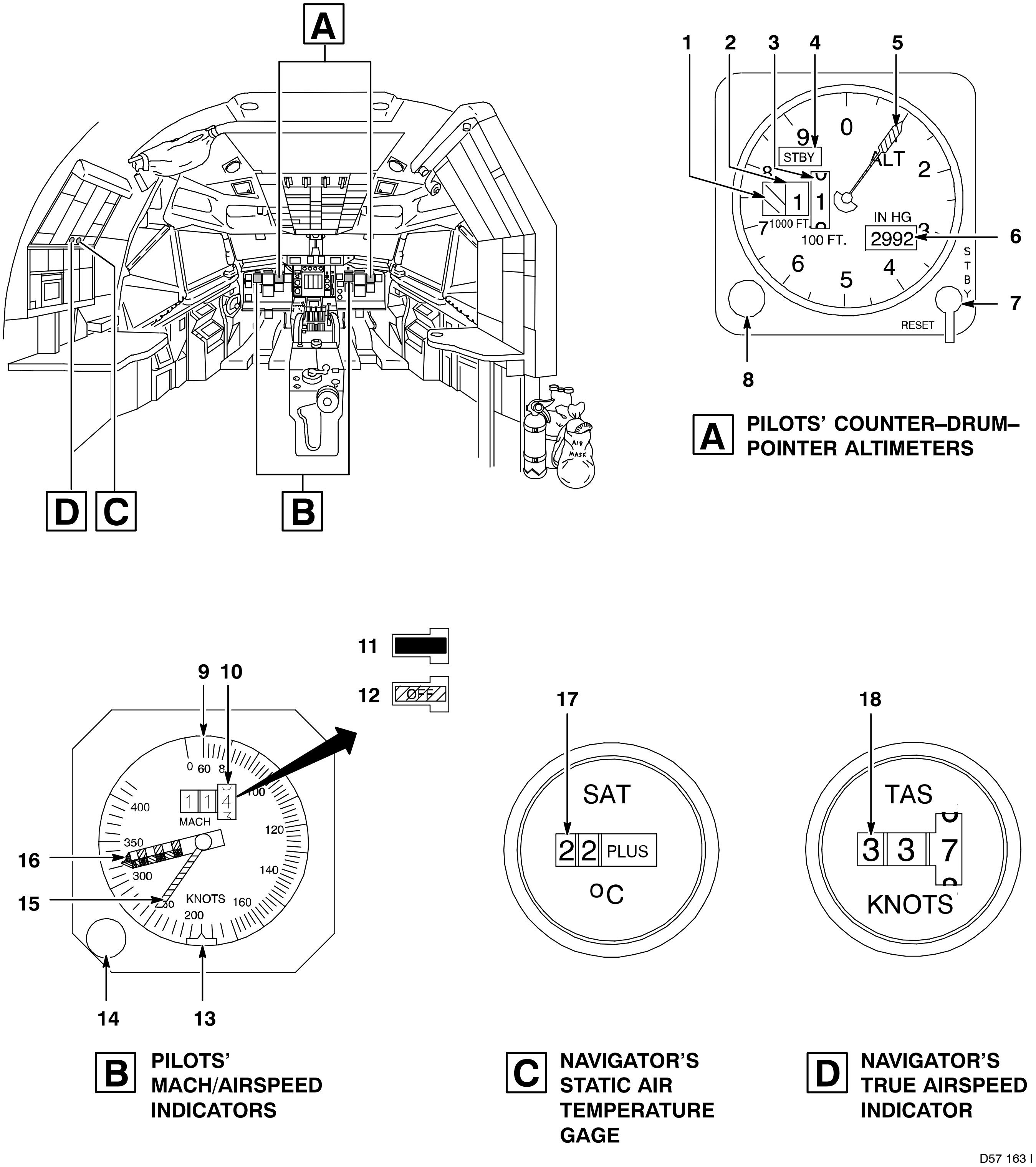
WITH IDG ADC Source Select Switch



NO.	CONTROL/INDICATOR	FUNCTION
1	ADC SOURCE SELECT Switch	Selects air data computer source of altitude and airspeed inputs to autopilot, IFF transponder and altitude alerters. Not redundant to CADC select function available on CDU Aiding Page.

Figure 1-93A ◀

Air Data Instruments



A PILOTS' COUNTER–DRUM–POINTER ALTIMETERS

B PILOTS' MACH/AIRSPEED INDICATORS

C NAVIGATOR'S STATIC AIR TEMPERATURE GAGE

D NAVIGATOR'S TRUE AIRSPEED INDICATOR

Figure 1-94 (Sheet 1 of 3)

NO.	CONTROL/INDICATOR	FUNCTION
		A PILOTS' COUNTER–DRUM–POINTER ALTIMETERS
1 2 3	Altitude Counters	Indicate altitude corrected by air data computer (RESET) or from static pressure system (STBY) in thousands and hundreds of feet. Left hand drum (1) indicates ten thousands of feet and has striped lines in place of zero digit to show attitude is below 10,000 feet. Center drum (2) shows thousands of feet and revolves once in 10,000 feet. Right hand drum (3) shows hundreds of feet and revolves once each 1,000 feet. Counter windows are labeled 1,000 feet (1, 2) and 100 feet (3).
4	STBY (Standby) Flag	When in view, indicates static pressure system is signal source for respective altimeter.
5	100 Foot Pointer	Indicates altitude in hundreds of feet with reference to graduated scale. Pointer makes one revolution for each 1,000 feet of altitude and is positively geared to 100-foot (right hand) drum.
6	Baro Counter	Indicates barometric pressure in inches of mercury as set by the bar set control.
7	Altimeter Mode Selector	When held in RESET (can require up to 3 seconds), switches altimeter to servo mode. When in servo mode, the altimeters display altitude from their respective ADC. This altitude is corrected for static source error. Vibrator is cut off when servo mode is selected. Manual correction for position error is required only in standby mode when airspeed is above approximately 200 KIAS. When set to STBY, vibrator is powered and altimeter is operated solely from airplane static pressure system. STBY flag is in view. Altimeter mode selector is spring loaded to STBY. Vibrator operates.
8	Baro Set Knob	When rotated clockwise, increases altimeters barometric correction value (displayed by baro counter) in the range of 28.10 through 31.00 inches of mercury.

Figure 1–94 (Sheet 2 of 3)

Air Data Instruments (Continued)

NO.	CONTROL/INDICATOR	FUNCTION
		B PILOTS' MACH/AIRSPEED INDICATORS
9	Airspeed Scale	Shows indicated airspeed from 60 through 420 knots.
10 11 12	Mach Counters	Indicate air data computer derived Mach number through the range 0.400 to 0.999 Mach. Below 0.400 mach counters are covered by a black flag (11). Mach counters are covered by a striped red and white OFF flag (12) if signal from air data computer is lost.
13	Airspeed Reference Pointer (Bug)	Used to indicate a reference airspeed.
14	Airspeed Bug Set Knob	Used to set airspeed bug. When rotated clockwise, rotates airspeed bug clockwise.
15	Airspeed Pointer	Displays indicated airspeed from 60 to 420 knots.
16	Limit Speed Pointer	Colored pointer indicates maximum allowable operating airspeed of the airplane as a function of altitude. Speed increases from 325 KIAS at sea level to 336 KIAS at approximately 25,000 feet, then decreases to show the airspeed corresponding to 0.78 Mach. (See *figure 5–5*.)
		C NAVIGATOR'S STATIC AIR TEMPERATURE GAGE
17	Temperature Display	Indicates static air temperature in range of +50°C to –99°C. Displayed temperature is derived within ADC 2 by correcting total air temperature for ram rise. Negative temperature values are indicated when MINUS is displayed. If output from ADC 2 is lost or gage power is interrupted, OFF flag covers display.
		D NAVIGATOR'S TRUE AIRSPEED INDICATOR
18	Speed Display	Indicates true airspeed from ADC 2 between 150 and 650 (±4.5) knots on a three drum display. A red and white malfunction flag appears if power to the gage fails or ADC 2 output fails.

Figure 1–94 (Sheet 3 of 3)

PILOTS' SERVO-PNEUMATIC ALTIMETERS

The pilots' altimeters are type AAU-19/A (*figure 1–94*). Each altimeter has a counter-drum-pointer display. The counters (1 and 2) and drum (3) provide a direct digital readout in hundreds and thousands of feet. The single pointer (5) repeats the 100-foot indications of the drum, serving both as a vernier for the drum and as a quick indication of the rate and direction of altitude change. The altimeter can be operated in either the servo (ADC altitude) mode or the standby (static pressure) mode as selected by the altimeter mode selector (7). The altimeter mode selector is spring-loaded to an unmarked neutral position between RESET and STBY positions. When in the standby mode, a STBY flag (4) is in sight on the instrument face. A barometric pressure set knob (8) and barometric scale (6) allow adjustment of the altimeter setting.

SERVO MODE

Servo (RESET) mode is the more accurate mode of operation. In the servo mode, the indicated altitude is servo-driven by the respective ADC and a static source error correction is applied.

NOTE

- In STBY (pneumatic) mode, the altitude indication on the AAU-19/A altimeter is computed mechanically.
- The allowable difference between two AAU-19/A altimeters, both in servo (RESET) mode, is shown in *figure 5-14.*
- **WITH IDG** Both pilots' altimeters are required to be in RESET mode. If, while in RVSM airspace, one or both pilots' altimeters default to STBY and cannot be set to RESET mode, notify ATC. ◀

The altimeter is placed in servo mode by momentarily setting the altimeter mode selector to RESET after power is available to altimeter and respective ADC. It can be necessary to hold the selector in the RESET position up to three seconds. The STBY flag disappears. An internal failure monitor circuit automatically returns the altimeter to standby mode (STBY flag appears) for any of the following malfunctions:

Primary power failure or interruption

Servo amplifier or motor failure

Switch failure

Relay failure

Monitor failure

A failure which results in an altitude differential between the servo and pneumatic modes of 4,500 feet or more.

The AAU–19/A altimeter is designed to accept signals from its air data computer which differ from the pneumatic altitude (standby mode) by as much as ± 4500 feet without the altimeter monitor switching the altimeter to the standby mode. This large differential permits correct readings to be obtained in RESET mode for as long as possible in the event that the altimeter aneroid chamber experiences a slow air leak and begins to differ significantly from the ADC synchro signal. The synchro motor easily overpowers the altimeter aneroid mechanism. The altimeter monitor disconnects the synchro signal at a 4500 foot differential to prevent the synchro from damaging the altimeter aneroid mechanism in the event that it is the synchro signal that is in error. The navigator's altimeter can be used as crosscheck and backup since it does not receive inputs from an air data computer and also operates from a separate static source.

WARNING

- **LESS IDG** If ADC No. 2 fails or is delivering erroneous data as indicated on copilot's altimeter, set IFF mode C enabling switch to OUT and advise ATC. ◀
- **WITH IDG** If either ADC fails or is delivering erroneous data as indicated on associated altimeter, ensure ADC SOURCE SELECT switch is set to functional ADC and, if in RVSM airspace, advise ATC. If both ADCs fail, de–select mode C and, if in controlled airspace, advise ATC. ◀

If the altimeter switches to standby mode automatically, attempt to reset to the servo mode. If the malfunction was intermittent, the altimeter should reset. If the fault remains, the altimeter continues to operate in the standby mode. Position error correction is required.

STANDBY MODE

In the standby mode, the altimeter operates solely from the static pressure system. A black-on-red STBY flag is in view, indicating that the altimeter is providing an uncorrected altitude reading. The altimeter is in standby mode when airplane power is first applied and remains in standby mode until the altimeter mode selector is momentarily placed to RESET. The altimeter is shifted from servo to standby mode by holding the altimeter mode selector in the STBY position until the STBY flag appears. Normally one to three seconds are required for this to happen due to the time delay built into the instrument to prevent nuisance trip-offs. When the altimeter is in the standby mode, an internal vibrator operates continuously. The vibrator minimizes mechanical friction, allowing a smoother operation during altitude changes. If the vibrator fails, the altimeter continues to function but a less smooth movement of the instrument display occurs with changes in altitude. The copilot's and pilot's altimeter vibrators require dc power.

WARNING

If the altimeter internal vibrator is inoperative, the 100-foot pointer can hang up momentarily when passing through 0 or 12 o'clock position. Minimize pointer hangup by tapping the altimeter case. This failure is most likely when displayed altitude lies within the 800 to 1,000-foot part of the scale, such as 1,800 to 2,000 feet or 2,800 to 3,000 feet. Use any appropriate altitude backup information available to avoid use of inaccurate altitude data.

CAUTION

Momentary locking of the baro-counters is possible during normal use. If this occurs, do not force the setting. Application of force can cause internal gear disengagement and result in excessive altitude errors in both standby (STBY) and servo (RESET) modes. If locking occurs, the required setting can sometimes be established by rotating the knob a full turn in the opposite direction and approaching the setting carefully.

ALTIMETER CORRECTIONS

Position error is removed from the pilots' altimeters in servo (RESET) mode. When in standby mode, position error charts must be used to fly corrected altitude. Charted position error corrections also must be applied when using the navigator's altimeter because there is no ADC input to this altimeter.

Refer to T.O. 1E-3A-1-1, Part I, for correction charts. The allowable difference between two AAU-19/A altimeters, both in RESET, both in STBY, and one in RESET and one in STBY (or navigator's altimeter), is shown in *figure 5-14.*

WITH IDG ALTITUDE ALERTING SYSTEM

The altitude alerting system allows the setting of a target altitude and provides visual and aural alerts for arrival at and deviation from the target altitude, as illustrated in *figure 1-95A*.

ALERTER PANELS AND HORN

Two identical altitude alerter panels (*figure 1-95B*) are installed in the forward instrument panels to allow the pilots to set and display a target altitude. An audible alert (horn) is installed in the overhead panel. The alerter panels are able to operate in two modes: Altitude Alert and MDA mode. The altitude alerter capabilities also include means to set the barometric pressure and then apply barometric correction internally to the received air data signal. An RS232 data bus operates between the two alerters to synchronize their operation. The panels have a built–in–test capability that can be commanded by switch actuation on either panel.

ALTITUDE ALERT MODE

A target altitude is inserted into the panels by selecting altitude alert mode (MDA not shown on alerter panel display) and adjusting the altitude display to show the target altitude (zero to 50,000 feet or 15,000 meters). See *figure 1-95B*. When the aircraft comes within 1000 feet of the set altitude, aural and visual alerts are activated. The aural alert lasts for two seconds. The visual alert continues until 200 feet from set altitude, or it can be acknowledged and reset manually by pressing the alert caution light. Any departure from set altitude of more than 200 feet generates the aural and visual alerts. See *figure 1-95A*.

MDA MODE

A target MDA is inserted into the panels by selecting MDA mode (MDA shown on alerter panel display) and adjusting the altitude display to show the target MDA. See *figure 1-95B*. As the aircraft reaches 200 feet above MDA a visual alert is given and maintained down to 100 feet above MDA. At this point the visual alert is removed and a two–second tone is issued from the horn. Descending through MDA another two–second tone is issued from the horn and the alert caution light flashes three times. If the aircraft climbs above MDA the visual alert is reset and flashes three times if the aircraft again descends below MDA. MDA operating range is zero to 9999 feet or 3048 meters. See *figure 1-95A*.

HYSTERESIS

In order to prevent instability of alert light illumination when flying on the boundary of an alert band that switches the alert light on and off crossing the boundary, the system applies a hysteresis (delay) that separates the on and off altitudes by 20 feet. In the target altitude mode this applies to the inner alert altitudes only, not to the outer alert altitudes. In MDA mode it applies to the upper and lower boundaries of the alert band. Hysteresis delays the switch action in the outbound direction (up or down) from the target altitude and up from the MDA. See *figure 1-95A*.

BUILT IN TEST MODE

Each alerter panel tests separately and independently of the other. After the alerter panels are powered, the test is commanded by pressing the mode select switch for 5 ±1 seconds. See *figure 1-95B*. A one–second tone is issued from the horn, then the following sequence of nine display groups is shown on the alerter panel being tested:

11110 FT **1111**	**44440** **444**	**77770** **777**
22220 Ⓡ **2222**	**55550** M **555**	**88880** MB **888**
33330 MDA **3333**	**66660** **666**	**99990** IN.HG **9.99**

Each display group shows for one second. After the last group shows, the panel reverts to non–test status. If the mode select switch is pressed while the 9s group shows, the panel enters configuration mode, which shows panel displays that do not interface with any operational capability in this installation.

SPONTANEOUS DISPLAYS

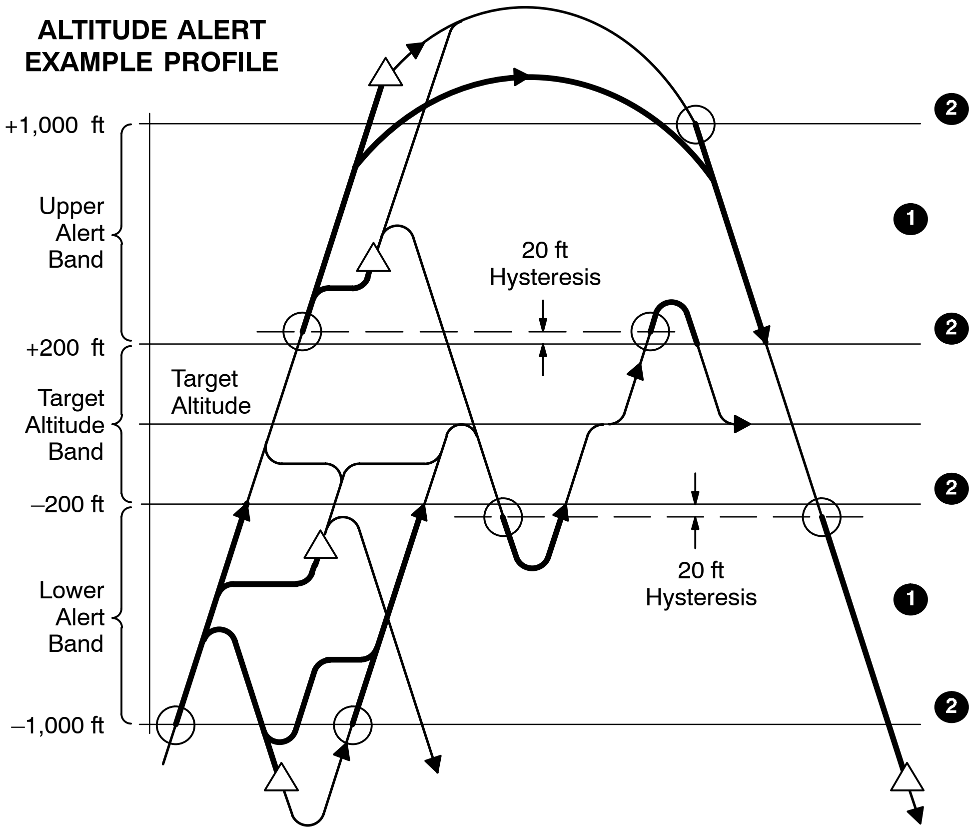
If the alerter panel display is blank, ensure the four P5 panel ALT ALERT circuit breakers are closed. If circuit breakers are closed and display remains blank, the panel is unserviceable.

The display of OFF by an altitude alerter indicates a loss of DC power to the alerter while AC power is still being provided, or ADC failure.

If OFF is displayed on one alerter but not on the other, check the corresponding P5 ALT ALERT (DC) circuit breaker. If OFF is displayed on both alerters at once, then check both DC breakers. If the breakers are not tripped, select the alternate ADC via the ADC SOURCE SELECT switch.

WITH IDG Altitude Alert Profiles

ALTITUDE ALERT EXAMPLE PROFILE



NOTE

- In altitude alert mode, climbing and descending profiles have vertical symmetry with regard to alert caution light operation and horn operation.
- If a difference exists between pilots' altimeters per *figure 5–14*, alert altitudes agree more closely with altimeter corresponding to ADC source selection.

LEGEND

○ Tone.

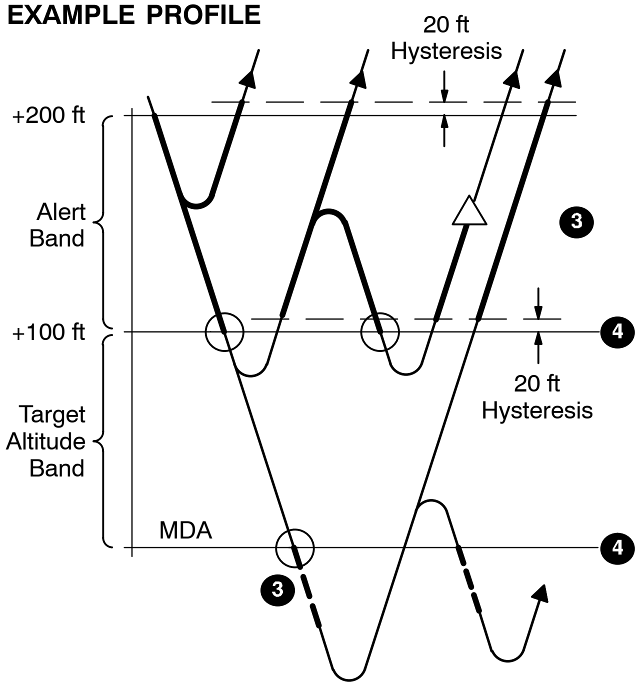
△ Manually reset alert caution light and tone by pressing illuminated alert caution light / mode select switch or by setting new target altitude or MDA.

┃ Alert caution light illuminated.

┇ Alert caution light illuminated and out three times.

│ Alert caution light out.

MDA EXAMPLE PROFILE



❶ Alert caution light illuminates entering alert band and goes out entering target altitude band. Light re–illuminates if airplane departs target altitude band. Once illuminated, light remains illuminated at all altitudes outside target altitude band until manually reset by pressing the illuminated alert caution light or by setting a new target altitude.

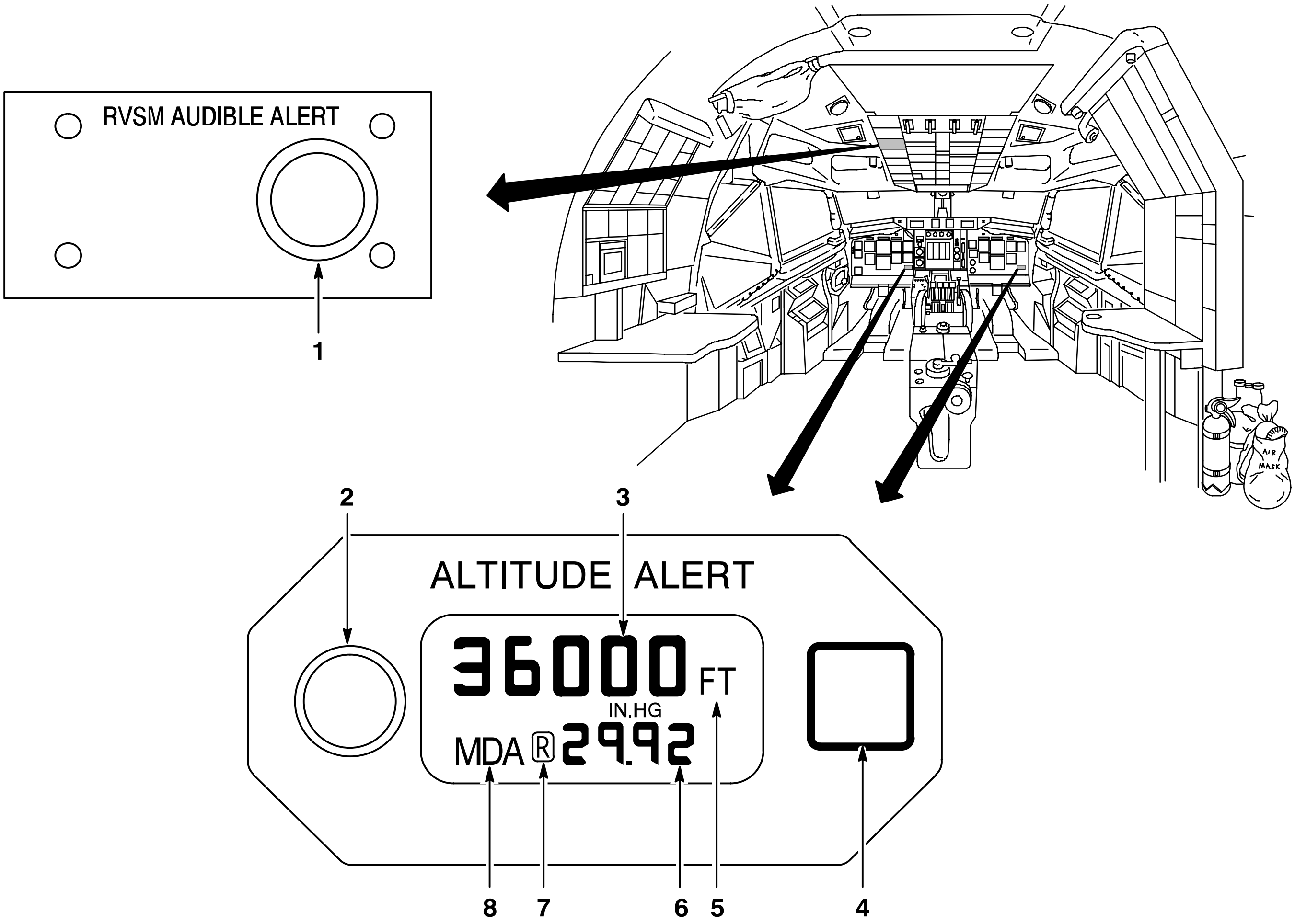
❷ Tone sounds for two seconds on entering alert band from the non–target altitude side, provided that alerter is reset (alert caution light out) before entering alert band, and sounds for two seconds on departing target altitude band.

❸ Alert caution light illuminates entering alert band from either direction, and goes out departing alert band in either direction. Alert caution light gives three flashes (1/3 second on, 1/3 second off) when descending below MDA (each occurrence).

❹ Tone sounds for two seconds at descent into target altitude band (each occurrence) and again for two seconds upon arrival at MDA (first occurrence only).

Figure 1-95A ◀

WITH IDG Altitude Alerter Panels



NO.	CONTROL/INDICATOR	FUNCTION
1	Audible Alert Horn	Sounds for one second after initiation of built in test. In altitude alert mode, provided that alert is reset (alert caution light not already illuminated), sounds for two seconds as airplane climbs or descends to within 1000 feet of target altitude. After capturing (within 200 feet of) target altitude, sounds when airplane deviates from target altitude by more than 200 feet. In MDA mode sounds for two seconds as airplane descends to within 100 feet of MDA setting, and again as airplane descends more than 100 feet below the first sounding, at MDA. Horn does not sound again with excursions through MDA nor departing MDA at visual descent point.

Figure 1-95B (Sheet 1 of 3)

WITH IDG Altitude Alerter Panels (Continued)

NO.	CONTROL/INDICATOR	FUNCTION
2	Function Control Knob (Rotary)	In all modes cw rotation increases displayed value and ccw rotation decreases displayed value. Knob has 32 detents per revolution. Detent values are 100 ft (50 meters) in altitude alert mode, 0.01 in. Hg (one mb) in baro mode, and one foot (one meter) in MDA mode. MDA mode is accessed via Mode Select Switch, item 4.
	Altitude Alert Mode (Default)	When rotated, changes altitude display. Increased rotation speed increases rate of display change.
	Baro Mode	When pressed and released in less than one second, altitude display blanks and barometer setting shows. Range is 21.80 to 31.00 in. Hg or 748 to 1048 mb.
	Units Select Mode	When pressed, and held for more than 3 seconds, cycles through displayed units sets as follows: IN. HG FT MB FT MB M (meters) (and repeats) Each display shows for 3 seconds. Set that shows when knob is released is selected for operation. If knob is held through two complete cycles (approx 18 seconds), display stops at IN. HG/FT with baro setting per last input. After 5 seconds of no input to the knob, or if knob is pressed again, altitude alert mode is re-established.
3	Target Altitude Display	Displays up to five digits to indicate target altitude as set by function control knob, item 2. When alerter is in altitude alert mode, desired altitude is displayed from 0 to 50,000 feet (15,000 meters). When alerter is in MDA mode, desired altitude is displayed from 0 to 9999 feet (3048 meters).
4	Mode Select Switch / Alert Caution Light (Pushbutton) (Amber)	When pressed, alert light illuminates (power on), with additional results as a function of press duration. When pressed and released in less than one second (alert function not active), selects between altitude alert and MDA modes. When pressed and held for 5 ± 1 seconds and released, following power application or during non-alert conditions, causes a one second audio alert and initiates the built in test. When pressed for more than 25 ± 5 seconds, alerter reverts to altitude alert mode. When alert light is illuminated, for alerting purpose, pressing mode select switch causes the alert light to go out, and stops tone.

Figure 1-95B (Sheet 2 of 3)

NO.	CONTROL/INDICATOR	FUNCTION
4 CONT		Alert caution light illuminates in altitude alert bands, as follows: In altitude alert mode, climbing or descending, illuminates entering alert band at 1000 feet above or below target altitude and remains illuminated until reaching target altitude band at 200 feet above or below target altitude. Illuminates again if airplane departs target altitude band. Once illuminated it remains illuminated until airplane returns to target altitude band, or alert is manually reset, or a new target altitude is selected. In MDA mode, illuminates at 200 feet above MDA setting and remains illuminated for the next 100 feet of descent to 100 feet above MDA. If airplane descends below MDA, light flashes three times (1/3 second on, 1/3 second off). If airplane climbs back to MDA and again descends through MDA, light again flashes three times (but horn does not sound). At aircraft power up, the altitude alerter comes up in the same mode it was in at shutdown. It also retains in non–volatile memory the last entered target altitude and MDA.
5	Scale Display	Displays FT or M (meters) to indicate the scale of the target altitude counter. During the display test, both FT and M are displayed.
6	Barometer Setting	Four digit display shows barometer setting. Baro setting can be shown in MB or IN. HG; both units abbreviations are displayed during the display test.
7	R (Remote) Display	Illuminates on either alerter panel when a setting change is entered in the other panel. Both panels show the changed setting.
8	MDA Display	When MDA is displayed, alerter is operating in MDA mode. If display is blank, indicates alerter is operating in altitude alert mode.

Figure 1-95B (Sheet 3 of 3) ◀

WITH IDG TRAFFIC ALERT AND COLLISION AVOIDANCE SYSTEM

The Traffic Alert and Collision Avoidance System (TCAS), as installed on the E–3, is known commercially as TCAS II, Version 7. TCAS requires the installation of a mode S transponder which is described in subsection I–M. TCAS is considered a backup system to the see and avoid concept and the ATC radar environment.

TCAS SYSTEM COMPONENTS, POWER, CONTROLS AND INTERFACES

Refer to *figure 1-95I* for block diagram of TCAS. The TCAS system consists of a TTR-921 computer and receiver/transmitter unit, two directional TRE-920 transmit/receive antennas (upper and lower), two TVI-920 vertical speed indicators (VSIs) (pilot and copilot), and an overhead speaker. The computer is powered by 115 vac from FAAC bus 1 (ØA) through P5 circuit breaker labeled TCAS CMPTR. The only means provided to remove power from TCAS is to open the circuit breaker (TCAS CMPTR). The TCAS computer in E1-1 rack is cooled by convection.

The speaker is driven directly from the computer, does not feed through the audio distribution system, has no pilot accessible on/off or volume controls and cannot be turned off except by selecting TCAS inactive. The VSIs are powered by 115 vac from the emergency flight avionics bus through P5 circuit breakers labeled EMERGENCY FLIGHT AVIONICS – VSI/TA CMDR and – VSI/TA PILOT. The vertical speed indicating portion of the VSI instruments is a direct reading static pressure primary flight instrument and functions at all times that the EAC bus is powered, and is completely independent of TCAS operation.

The TCAS mode selection is accomplished via the IFF pages on the GINS CDU (see *figure 1–125C*). TCAS interfaces with the mode S transponder to obtain roll call information on other mode S equipped aircraft, and coordinates resolution advisories with other TCAS (TCAS II, Version 6.04 and Version 7) equipped aircraft via mode S message exchange.

While airborne the VSIs provide continuous traffic situation display that cannot be deselected except by selecting SENS:STBY on the tcas/iffcontrol page. Range and block altitude selections for the traffic situation display are made via pushbuttons on the front of the VSIs. (See *figure 1-95F*.)

TCAS receives altitude from the Low Range Radio Altimeter (LRRA) to inhibit traffic advisories and resolution advisories based upon height above ground level (*figure 1-95H*). At all altitudes TCAS requires a discrete signal from LRRA indicating the LRRA is powered. If the LRRA is switched OFF via the RADIO ALTIMETER Switch (9, *figure 1–122*), power remains available to the LRRA but transmissions are inhibited. The discrete signal remains available to TCAS indicating the LRRA is still powered. When switched OFF the LRRA provides no height output and TCAS operates in TA-only mode. The VSIs show the ONLY TA flag (14, *figure 1-95F*). If power is removed from the LRRA by opening the circuit breaker RADIO ALTM ØA, P5 panel (FAAC bus 1), the VSIs display the TCAS flag (30, *figure 1-95F*) and TCAS is inoperative in both TA and RA modes.

TCAS receives pressure altitude from the mode S computer which gets it from the selected ADC.

TCAS receives flap transmitter flap position for resolution advisory inhibits involving climb rate capability. Flap inhibits are controlled by flap transmitter signals from the right wing flap transmitter. If the copilot's AOA indicator shows an OFF flag, the flap inhibits are inoperative and TA-only mode should be manually selected when flaps are extended.

Squat switch interface through the right ground safety relay R1098 prevents TCAS with weight on wheels.

TCAS receives a synchro magnetic heading signal from AHRS 2. Compass heading is used to smooth the traffic situation display as own aircraft turns. Loss of synchro heading does not disable TCAS situation display.

Signal interference suppression is performed between TCAS and own mode S transponder, TACANs 1 and 2, ESM, and mission IFF.

VERTICAL SPEED INDICATOR

The TVI–920 vertical speed indicator (VSI) is a combination vertical speed indicator, traffic situation display, and resolution advisory display. Vertical speed is displayed in the traditional manner and operates as a direct reading static pressure instrument (no ADC input). The traffic situation display maps the relative position (bearing and range) of traffic to a selected range (3, 5, 10, 20 or 40 nm) within a selected altitude block. (See VSI control and indicator table, *figure 1-95F*.) The front panel has manual pushbuttons for altitude block and display range selection. The traffic situation display cannot be deselected as long as TCAS is enabled in either TA–only or TA/RA mode, and airborne with transponder operating. Surveillance range is not limited by the selected display range. A maximum of 30 intruders can be displayed. The symbols to be displayed are each assigned one of five priority levels. If more than one symbol is called for at a location, the one with the highest priority is displayed.

VSI Panel Lighting

The VSIs are back–lit by a variable intensity fluorescent tube which produces the light that passes through LCD color filters. The light intensity is controlled by a circuit card inside the VSI using inputs from the IND LIGHTS – COMMANDER and IND LIGHTS – PILOT panel light control knobs on the center instrument panel, or from an ambient light sensor on the top face of the VSI casing. When the panel rheostats are turned OFF the VSI displays go to high intensity for daylight operation. When the panel rheostats are out of the OFF position the lighting circuit card proportions VSI display intensity to the rheostat position and light sensor input to obtain an intensity level compatible with the conventionally lighted instruments also controlled by the panel rheostat.

TCAS DESCRIPTION AND THEORY OF OPERATION

TCAS is an aircraft–to–aircraft proximity monitoring system, independent of ground based systems. However, Version 7 is capable of downlinking to properly equipped ground stations. It provides an onboard traffic situation display and aural and visual advisories to pilots on conflicting or potentially conflicting traffic. It monitors other traffic in the vicinity and assesses the risk of collision by interrogating altitude reporting transponders (mode C and mode S). TCAS can track up to 150 intruders and display up to 30. TCAS computes range and rate of closure. CPA (closest point of approach) is computed from the rate of change in closure rate. The system issues an advisory when another aircraft is close and has a large closure rate and a small rate of reduction in the closure rate. A return that is a potential advisory outside the selected display range displays as a half symbol on the outer edge of the VSI situation display, inside the circle of the vertical speed scale. A potential advisory, or threat, is an intruder whose CPA lies inside the threshold distance and altitude for either a TA or an RA, but has not yet met the time to CPA criteria for issuance of an advisory. TCAS provides collision avoidance protection between aircraft with a horizontal closure rate of up to 1200 knots, and vertical closure rate of up to 10,000 feet per minute.

If TCAS calculates a risk of collision, it first issues a traffic advisory (TA) that is informative and assists pilots in visually acquiring traffic, but requires no evasive maneuver. Then, if the threat level increases, it issues a resolution advisory (RA). The RA recommends an evasive maneuver in the vertical to resolve the collision hazard.

The relative bearing, range, and relative altitude of other aircraft are computed from their transponder replies to interrogations from own TCAS receiver–transmitter. Range is determined from the signal propagation speed (speed of light) and the time the signals take to propagate between the antennas of the two aircraft. Range is the most accurate parameter that TCAS computes. Traffic altitude is decoded from their mode C message replies and is displayed in relative (above or below own aircraft) format. Relative bearing is determined from received signal carrier phase angle difference between pairs of segments in the four–segment planar phased array TCAS transmit/receive antennas. This gives only approximate bearing and sometimes the system is unable to resolve a bearing. This can be due to a turn placing own aircraft surfaces in the direct line of signal reception of both antennas, multiple path reception, a weak signal that is received on only one pair of segments in the TCAS antenna, or rapidly changing relative bearing.

If unable to resolve relative bearing, TCAS can still issue traffic advisories, but does so in text format rather than situation display map on the VSI screens. Also, without relative bearing, TCAS can issue RAs if altitude information is available, but again, provides no traffic situation display on the VSIs, only a text message and a vertical speed command on the VS scale.

The VSI traffic situation display can stop displaying traffic symbology for traffic that has a rapidly changing relative bearing, usually at close range. This would change to a text message type of advisory. As many as two text message advisories can be displayed. At normal traffic speeds the relative bearing change rate can make traffic undisplayable when the traffic is passing abeam in the opposite direction, or crossing, at ranges less than 900 feet. Traffic that is on a collision course does not change relative bearing rapidly and is more likely to remain displayed at close range.

TCAS does not detect another aircraft unless the other aircraft has an active ATC transponder. TCAS interrogates only mode C. However, it is a characteristic of mode 3/A transponders to respond to a mode C all call interrogation. Therefore, TCAS does track mode 3/A transponders. But TCAS cannot issue an RA against a mode 3/A transponder due to lack of altitude information. If the LRRA is switched OFF via the overhead toggle switch (9, *figure* 1-122) power remains available to the LRRA but transmissions are inhibited. TCAS detects aircraft having mode C or 3/A regardless of whether or not the other aircraft has either mode S or TCAS. The main advantage of other aircraft having mode S is that from the squitter message a roll call is established in own TCAS that reduces transponder frequency congestion in high density traffic areas by allowing own TCAS to selectively interrogate mode C from all mode S equipped aircraft. If an aircraft has TCAS then it also has mode S, but the converse is not necessarily true. Some aircraft have mode S without TCAS.

TCAS does process replies without altitude, and conservatively assumes that non–altitude reporting traffic are within the selected altitude display block, and displays the traffic on the VSI situation display without relative altitude information. TCAS can issue TAs on this kind of traffic, but does not issue RAs on replies that do not contain altitude.

In order to compute relative altitude, or to generate a TA or an RA, TCAS must have own aircraft pressure altitude data. The TCAS computer receives pressure altitude from the mode S computer which gets it from the controlling CDU which gets it from the selected ADC (*figure 1-93*). Own pressure altitude received by TCAS is in mode C format (Q_{NE} to the nearest 100 feet). Above 2350 feet AGL the time to CPA algorithm for issuance of an advisory is based on pressure altitude.

TCAS provides aircraft–to–aircraft proximity information to TCAS equipped aircraft. TCAS II Version 7 also makes available to properly equipped ground stations the ability to interrogate the mode S transponder for data pertaining to RAs issued by own TCAS. Additionally, when TCAS II Version 7 issues an RA it transmits in the blind from the TCAS antennas a message containing all essential information about the RA. This information is available to appropriately equipped ground stations. However, at the time of this writing few ground stations are so equipped. One cannot be certain that an ATC controller on the ground is receiving RA information. A controller thus might give directions conflicting with an RA. In this event, immediately inform the air traffic controller that you are complying with a TCAS resolution advisory, and the controller is temporarily relieved of his responsibility to maintain vertical separation between the aircraft involved. However, the air traffic controller is still the controller and may still direct horizontal turns while a resolution advisory is in effect, especially for a preventive RA that maintains but does not change vertical path.

Pilots are authorized to deviate from an ATC clearance to the extent necessary to comply with an TCAS RA. However pilots are not authorized to perform maneuvers that deviate from an ATC clearance based solely on a TA or on traffic symbology displayed on the VSI traffic situation display. If already climbing or descending, modest changes in vertical speed based on VSI traffic display are permissible and are not considered to be evasive maneuvering.

TCAS does resolve multiple aircraft encounters. If the situation involves two RAs, two red arcs might be shown on the VS scale.

TCAS can issue RAs against other aircraft that are equipped with either mode S or mode C. For intruders not equipped with TCAS, TCAS assumes that own aircraft will do all of the maneuvering to avoid a collision. However, if the conflicting traffic is also equipped with TCAS (TCAS II Version 6.04 or 7), the two TCAS computers attempt to coordinate complementary RAs, via mode S message exchange. Complementary RAs can reduce the time of maneuvering by both aircraft while also giving mutual consideration to their respective performance limitations, flight configurations, and altitude above ground level, via the associated RA inhibits. Unfortunately, there is presently no indication provided as to whether or not an RA is coordinated with another aircraft's TCAS. Failure to comply with a coordinated RA can cause an increase RA to be issued by the other airplane's TCAS. The fact that an RA might be coordinated is another reason why pilots should comply with an RA first if the ATC controller gives instructions that conflict with an RA. By the time that an RA is issued by TCAS, the ATC controller does not have sufficient time to issue separate verbal instructions to two conflicting aircraft, and one pilot complying with a controller's instructions while the other complies with the coordinated RA can result in a dangerous encounter.

TCAS TERMINOLOGY

CPA (Closest Point of Approach)

Depending upon context, the term CPA can represent the instant of time, or the distance between two aircraft, or the point in space at which one aircraft comes closest to another. The distance definition is the most common; CPA is usually quantified in feet of aircraft separation. The CPA is the computed minimum distance that will exist at any time in the future between two aircraft, provided that the two aircraft continue their current straight line courses (including vertical) and speed. CPA is not the minimum distance between the two tracks.

The CPA has the interesting property that all traffic at their CPA have exactly zero relative closure rate. Furthermore, any traffic attaining zero relative closure rate is then at its CPA. And all traffic approaching their CPA experience rapidly decreasing closure rate, unless they are on a collision course, in which case there is no change in closure rate until collision. This is true regardless of the direction of approach, including vertical. Thus, by knowing the current distance to traffic, the closure rate, and the rate of change of closure rate, the CPA and time to CPA can be computed without knowing the relative bearing or relative track, or even the relative altitude of the traffic. In this manner, traffic advisories are computed even if TCAS is unable to establish a relative bearing or a relative altitude.

A resolution advisory can also be computed without relative bearing information. Resolution advisories, however, since they give vertical path guidance, require relative altitude information in addition to distance and closure rate information. The accuracy limitation of the TCAS directional antennas in establishing relative bearing does not facilitate the use of relative bearing in computing the relative velocity of other aircraft. The primary use of relative bearing is to establish a point on the VSI situation display at which to present traffic symbology so that the pilots know approximately where to look in order to establish visual contact with traffic.

Protected Airspace and Threshold Airspace

Protected airspace is defined by the slant range and altitude block in which an intruder can exist at the moment TCAS issues an advisory against that intruder. The protected airspace is larger than the threshold airspace in which the computed CPA must exist in order for an advisory to be issued. All advisories (TAs and RAs) are based on time to CPA (not intruder distance), provided that CPA is greater than zero but less than the threshold distance limit for CPA. Thus, the higher the speed and closure rate of an intruder is, the greater the range of protected airspace is for that intruder.

If computed CPA = 0, particularly at close range, then a real threat of collision exists, and the protected airspace is increased by an offset equal to the threshold distance. If computed CPA > 0, then a collision is less likely, and the range of the protected airspace is only increased by an amount equal to the computed CPA distance.

In those cases where CPA > 0, the protected airspace is represented by the formula:

Range of Protected Airspace = (Closure Rate x Time to CPA) + CPA Distance

And in those cases where CPA = 0, the protected airspace is represented by the formula:

Range of Protected Airspace = (Closure Rate x Time to CPA Threshold) + Threshold Distance

Intruder

An intruder is any transponder equipped aircraft of interest to TCAS. There are four levels of intruder defined:

Other Traffic

An other traffic intruder is either at greater than 6 nm slant range distance or, by mode C encoded altitude, is 1200 feet or more separated in altitude from own aircraft (if altitude information is available). Traffic not providing altitude information is displayed if it meets only the distance criteria. Other traffic is displayed as a cyan (blue) open diamond symbol. Relative altitude and climbing/descending arrow are displayed, as appropriate, if altitude data is available. Other traffic is not displayed, even as text, if relative bearing is not available. No aural messages are associated with other traffic.

Proximate Traffic

A proximate traffic intruder is at less than 6 nm slant range and also less than 1200 feet altitude separation from own aircraft (if altitude information is available) and is not projected via its closure rate and its vertical rate to be a threat. Traffic not providing altitude information is displayed if it meets only the distance criteria. Proximate traffic is displayed as a solid cyan (blue) diamond symbol. Relative altitude and climbing/descending arrow are displayed, as appropriate, if data is available. Proximate traffic are not considered threatening, but are displayed for the purpose of aiding the pilots in establishing visual contact. Proximate traffic is not displayed, even as text, if relative bearing is not available. No aural messages are associated with proximate traffic.

Traffic Advisory

Proximate traffic is upgraded to a traffic advisory (TA) based upon time criteria determined from distance and closure rate, *figure 1-95C*. All TCAS advisories are based on time criteria rather than distance criteria, although certain distance thresholds are considered. Additional criteria for a TA are based upon own radio altitude or own pressure altitude, relative altitude (if traffic altitude is available), and computed closest point of approach (CPA). Traffic not providing altitude information is displayed if it meets only the distance criteria. A TA is displayed as a solid yellow circle symbol. Relative altitude and climbing/descending arrow are displayed, as appropriate, if altitude data is available. A TA can be generated without relative bearing or relative altitude. A TA is displayed as yellow text if relative bearing is not available. The aural message TRAFFIC; TRAFFIC is annunciated. A TA does not require evasive maneuvering, but should alert pilots to be prepared for evasive maneuvering if the TA is upgraded to an RA.

WITH IDG Traffic Advisory Criteria

Own Aircraft Altitude (feet)	Time to CPA or Time to Threshold if CPA = 0 (seconds)	CPA Distance Threshold (nm)	Relative Altitude Threshold (feet)
Up to 1000 AGL (radio altitude)	20	0.30	± 850
1000 – 2350 AGL	25	0.33	± 850
2350 AGL – 5000 (barometric altitude – Q_{NE})	30	0.48	± 850
5000 – 10,000	40	0.75	± 850
10,000 – 20,000	45	1.00	± 850
20,000 – 42,000	48	1.30	± 850
> 42,000	48	1.30	± 1200

NOTE

- CPA distance threshold (column three) and relative altitude threshold (column four) define threshold airspace around own aircraft.
- If CPA = 0, TCAS computes time remaining for arrival of traffic at the boundary of threshold airspace. If CPA > 0, and CPA remains inside threshold airspace, TCAS computes time remaining for arrival of traffic at CPA. TCAS issues a TA when the time criterion (column two) is met, provided that CPA remains inside threshold airspace.

Figure 1-95C

As proximate traffic gets closer, TCAS attempts to compute a CPA. Zero CPA implies collision, but all traffic has zero CPA until it gets close enough that a more accurate CPA can be computed. Computed CPA tends to increase as the traffic approaches, unless the traffic is on a collision course. At some point, for traffic not on a collision course, the rate of closure starts to decrease and then a CPA greater than zero can be computed. Proximate traffic is upgraded to a TA if the distance and rate of closure project the traffic to be within 20 to 48 seconds (depending on own altitude) from CPA, or from threshold airspace if CPA = 0. If a CPA significantly greater than zero can be computed, then a collision will not occur, but the TA continues as long as the CPA is within the threshold airspace defined by a slant range distance threshold and a relative altitude threshold (if traffic altitude is available), and the traffic is still approaching CPA. If a CPA greater than zero can be computed, and the CPA is within the threshold airspace, then the time to CPA is greater than the time to threshold airspace, and the system then monitors time to CPA instead of time to threshold airspace. If computed CPA increases enough to go outside threshold airspace, the TA reverts back to proximate traffic (yellow symbols turn cyan, and CLEAR OF CONFLICT aural annunciation is issued). A TA also reverts to proximate traffic as soon as range begins to increase. *Figure 1-95C* illustrates the criteria for proximate traffic to be upgraded to a TA.

Resolution Advisory

An RA is computed in basically the same way as a TA, with time to CPA criteria being somewhat less, and with altitude and relative altitude coming into play for the determination of direction of vertical maneuver and for certain RA inhibits, *figure 1-95D*. A TA is upgraded to an RA based upon time criteria determined from distance and closure rate. All TCAS advisories are based on time criteria rather than distance criteria, although certain distance thresholds are considered. Additional criteria for an RA are based upon own radio altitude or own pressure altitude, relative altitude of traffic, and computed closest point of approach (CPA). Traffic cannot be upgraded to an RA unless it is providing altitude information. An RA is displayed as a solid red square symbol. Relative altitude and climbing/descending arrow (as appropriate) are also displayed. An RA can be generated without relative bearing. An RA is displayed as red text if relative bearing is not available. An RA is aurally annunciated with a command message that describes the required vertical maneuver or climb restriction (*figure 1-95G*) and corresponds to the visual indication presented on the VSI scale. An RA can require evasive vertical maneuvering (corrective RA) or can restrict vertical maneuvering (preventive RA).

A TA is upgraded to an RA if the distance and rate of closure project the intruder to be within 15 to 35 seconds (depending on own altitude) from CPA, or from CPA threshold airspace if CPA = 0. If a CPA significantly greater than zero can be computed, then a collision will not occur, but the RA continues as long as the CPA is within the threshold airspace, defined by a slant distance limit to CPA and a relative altitude threshold, and the traffic is still approaching CPA. If a CPA greater than zero can be computed, and CPA remains within the threshold airspace, then the time to CPA is greater than the time to threshold airspace, and the system then monitors time to CPA instead of time to threshold airspace. If computed CPA increases enough to go outside the threshold airspace for an RA but remains within the threshold airspace for a TA, the RA can change to a TA, but only if the traffic is still approaching CPA. Once past the CPA, an intruder becomes proximate traffic. An RA can also be downgraded to a modified RA if the vertical separation goal is achieved before the intruder reaches CPA and CPA remains within RA threshold limits. When the distance to intruder starts to increase, the intruder becomes proximate traffic, and CLEAR OF CONFLICT is annunciated.

RAs are inhibited at certain altitudes and under some conditions of limited aircraft performance. For a complete list of RA inhibits, refer to *figure 1-95H*.

Although RA inhibits are established to prevent an RA from exceeding the airplane's performance capabilities, the inhibits are not comprehensive. If an RA vertical command exceeds current climb capability, the best vertical separation is obtained by complying with the direction of the maneuver but respecting the stick shaker or initial buffet at all times.

RA maneuver guidance symbols are red and green arcs superimposed on the vertical speed scale of the VSI (see *figure 1-95F*).

RAs are of two fundamental types, preventive and corrective.

A preventive RA maintains current vertical path, or restricts a climb, or restricts a descent, in order to prevent a traffic conflict. A green arc is displayed around the VS pointer telling how much deviation from current vertical speed is permissible. A red arc indicates a danger zone of vertical speed. An aural message, MONITOR VERTICAL SPEED, is annunciated. In case of conflict with two intruders, red arcs can occur on both sides of the green arc.

WITH IDG Resolution Advisory Criteria

Own Aircraft Altitude (feet)	Time to CPA or Time to Threshold if CPA = 0 (seconds)	CPA Distance Threshold (nm)	Relative Altitude Threshold for Corrective RAs (feet)
Below 900 AGL (radio altitude) – Descending	(RA inhibited)	(RA inhibited)	(RA inhibited)
Below 1100 AGL – Climbing	(RA inhibited)	(RA inhibited)	(RA inhibited)
From Inhibited Altitude Up to 2350 AGL	15	0.20	± 300
2350 AGL – 5000 (barometric altitude – Q_{NE})	20	0.35	± 300
5000 – 10,000	25	0.55	± 350
10,000 – 20,000	30	0.80	± 400
20,000 – 42,000	35	1.10	± 600
> 42,000	35 (Climbing RA inhibited)	1.10 (Climbing RA inhibited)	± 700 (Climbing RA inhibited)

NOTE

- CPA distance threshold (column three) and relative altitude threshold (column four) define threshold airspace around own aircraft.
- If CPA = 0, TCAS computes time remaining for arrival of traffic at the boundary of threshold airspace. If CPA > 0, and CPA remains inside threshold airspace, TCAS computes time remaining for arrival of traffic at CPA. TCAS issues an RA when the time criterion (column two) is met, provided that CPA remains inside threshold airspace.
- Relative altitude thresholds (column four) are for corrective RAs. Relative altitude thresholds for preventive RAs range from ± 500 to ± 800 feet, with increasing altitude.
- In TCAS Version 7 the relative altitude thresholds were reduced to account for the reduction in vertical separation to 1000 feet above FL290 in RVSM airspace.

Figure 1-95D ◀

A corrective RA directs a change in vertical speed. Refer to *figure 1-95G* for a list of all aural annunciations. A corrective RA can direct a climb, an increase climb, a descent, an increase descent, or a reversal of either a climb or a descend RA. Pilots should act on the advice within 5 seconds. A red arc initially covers the current vertical speed, directing vertical speed toward a green arc. A corrective advisory may contain two red arcs, as for example, when two intruders are involved.

An RA is normally downgraded to proximate traffic as soon as the threat aircraft begins to diverge in range. Vertical guidance is removed. CLEAR OF CONFLICT is annunciated. Pilot may return to flight plan clearance or controller's instructions.

A corrective RA can also be downgraded and re–issued as a modified RA (essentially the same as a preventive RA) in the event that the required vertical separation is achieved before the intruder reaches CPA. This is to avoid unnecessary or excessive altitude deviation. The difference between a modified and a preventive RA is only in the voice annunciation, ADJUST VERTICAL SPEED; ADJUST, instead of, MONITOR VERTICAL SPEED.

Threat

Threat is a general term used to refer to any intruder that has the possibility of collision. A threat aircraft can be outside the parameters for a TA if on a course that will lead to a TA. In specific usage, a threat is an intruder whose computed CPA lies inside threshold airspace for either a TA or an RA, but has not yet met the time to CPA criteria for issuance of an advisory.

Off–Scale Traffic Advisory

Traffic that meets the requirements of a TA or an RA that is outside the selected display range is displayed as one–half of the appropriate symbol, at the edge of the display, on the relative bearing, with relative altitude and climb/descent symbology, as appropriate.

No–Bearing Advisories

If there is traffic that meets the requirements of a TA or an RA, but the TCAS directional antennas are not able to resolve a relative bearing to the traffic, it is displayed as text just below the own airplane symbol on the VSI, *figure 1-95F*.

GROUND OPERATION

In the E–3 the squat switch inhibits TCAS transmissions ons on the ground, except as provided for under controlled maintenance conditions. Self test, initiated through mode S IBIT on the iff test page (*figure 1-125C, sheet 7*), tests IFF mode S as well as TCAS. IFF must be in NORM and IFF transmissions occur. This test is inhibited when airborne. All aircraft systems providing inputs to TCAS must be operating in their normal mode during IBIT to avoid faults being recorded unnecessarily. The IFF should be selected to STBY for ground operations other than the IFF mode IBITs. Select NORM just prior to takeoff.

WARNING

WITH IDG On the ground the IFF transponder transmits if the IFF TRANSPONDER power switch is ON and IFF:Norm is selected on the IFF Control page.It must be selected to NORM to run any of the mode IBITs. During transmission the minimum personnel safety distance is 10 feet from either antenna. Minimum electro–explosive device distance is 25 feet. ◀

TCAS warmup time is about 10 seconds.

NOTE

TCAS self test (using MS IBIT on iff test page) can only be performed on the ground.

AIRBORNE OPERATION

WARNING

If TCAS commands an RA vertical maneuver that cannot be complied with, such as while own aircraft is turning at low airspeed, or while flaps are being raised, or when the pre–programmed RA inhibits are insufficient due to performance degradation resulting from operation at high field elevation or high outside air temperature (>ISA+50°F), maintain aircraft control first, respect the stick shaker or initial buffet at all times, and comply with the RA when able to do so safely.

NOTE

- With an engine failure or other abnormal flight condition that reduces climb capability, set TCAS to TA-only mode via the CDU tcas/iff control page. This prevents TCAS from coordinating an RA with other TCAS equipped aircraft and inhibits RAs from being issued by own TCAS. Other TCAS equipped aircraft then respond to E-3 as if E-3 were not TCAS equipped.
- Respond to TAs by attempting to establish visual contact with the intruder aircraft. For any traffic that is acquired visually, continue to maintain or attain safe separation in accordance with ATC standards and good operating practices.

- If operating IFR in controlled airspace, all resolution advisories should be reported to ATC. Even though preventive RAs do not usually require deviation from ATC clearance or current flight path, the appearance of the RA indicates a closer encounter with another aircraft than ATC guidelines permit for IFR operation in controlled airspace.

- Use thrust, as required, to maintain climb rate when responding to a climb RA in cruise flight. If high speed buffet occurs when responding to an RA, relax control pressure enough to reduce buffet but continue the maneuver.

All corrective RA responses, that is, those requiring a change in vertical flight path, must be hand flown. Autopilot pitch control is not responsive enough to meet the requirements of an RA. If the conflicting traffic is sighted and the pilot then elects to increase the maneuver, or if an increase RA or reversal RA is issued by TCAS, the increased evasive action requires immediate access to manual controls. The RA algorithm permits the pilot 5 seconds to initiate control movements, and, if the pilot takes that long, the algorithm then requires a +1.25 g pullup (an increase of 0.25 g from level flight), or a +0.75 g pushover (a decrease of 0.25 g from level flight) vertical acceleration to the minimum recommended vertical speed (green arc). In case of an increase RA or reversal RA the algorithm then requires a control response within 2½ seconds and a +1.35 g pullup or a +0.65 g pushover to the recommended vertical speed. Watch the VSI and ADI, not the accelerometer. The VSI, even though it is a direct reading static pressure instrument, does not have the instrument delay associated with older mechanical diaphragm instruments; it provides nearly instantaneous vertical speed display. From level flight, proper response to a corrective RA typically results in an overall altitude deviation of only 300 to 500 feet in order to successfully resolve a traffic conflict. Evasive maneuvering should be limited to the minimum required to comply with the RA.

Following a corrective RA, as soon as a projected safe vertical separation (500 feet) is achieved from an intruder, a modified RA might be issued. The modified RA directs level flight until the conflicting traffic starts to move farther away in slant range. The green arc is re–positioned to direct level flight, (±500 ft). The magnitude(s) of the red arc(s) decrease(s) and the voice message ADJUST VERTICAL SPEED; ADJUST is announced through the overhead speaker. The modified RA is intended to minimize displacement from original altitude until the conflicting traffic has passed. This RA remains displayed until CLEAR OF CONFLICT is announced on the overhead speaker and the vertical speed commands are removed from the VSI. Following a CLEAR OF CONFLICT advisory, the pilot should expeditiously return to the applicable ATC clearance unless otherwise directed by ATC.

NOTE

If threat aircraft altitude data is lost during an RA, the RA becomes a TA and the CLEAR OF CONFLICT aural annunciation is not issued. If threat aircraft range data is lost during an RA, the RA terminates without a CLEAR OF CONFLICT voice annunciation, it does not become a TA, and the traffic display is lost.

If a CLIMB RA is issued while in an intermediate (or final) landing configuration, initiate normal go–around procedures. This should not happen on short final as RAs are inhibited by radio altitude less than 900 feet. It is not recommended to routinely disable RAs manually, by selecting TA mode, because they are automatically inhibited under the appropriate flight conditions for normal operation (*figure 1-95H*). However, if dense traffic exists in an airport traffic area, TA-only mode may be selected at pilot's discretion or may be directed by the controlling agency. Pilot should manually select TA-only mode if unable to comply with RA performance requirements due to loss of an engine or other abnormal configuration. This prevents RAs from being coordinated with opposing traffic; prevents own system from issuing RAs; and allows continued monitoring of other traffic through TAs only.

WITH IDG TCAS Surveillance Area

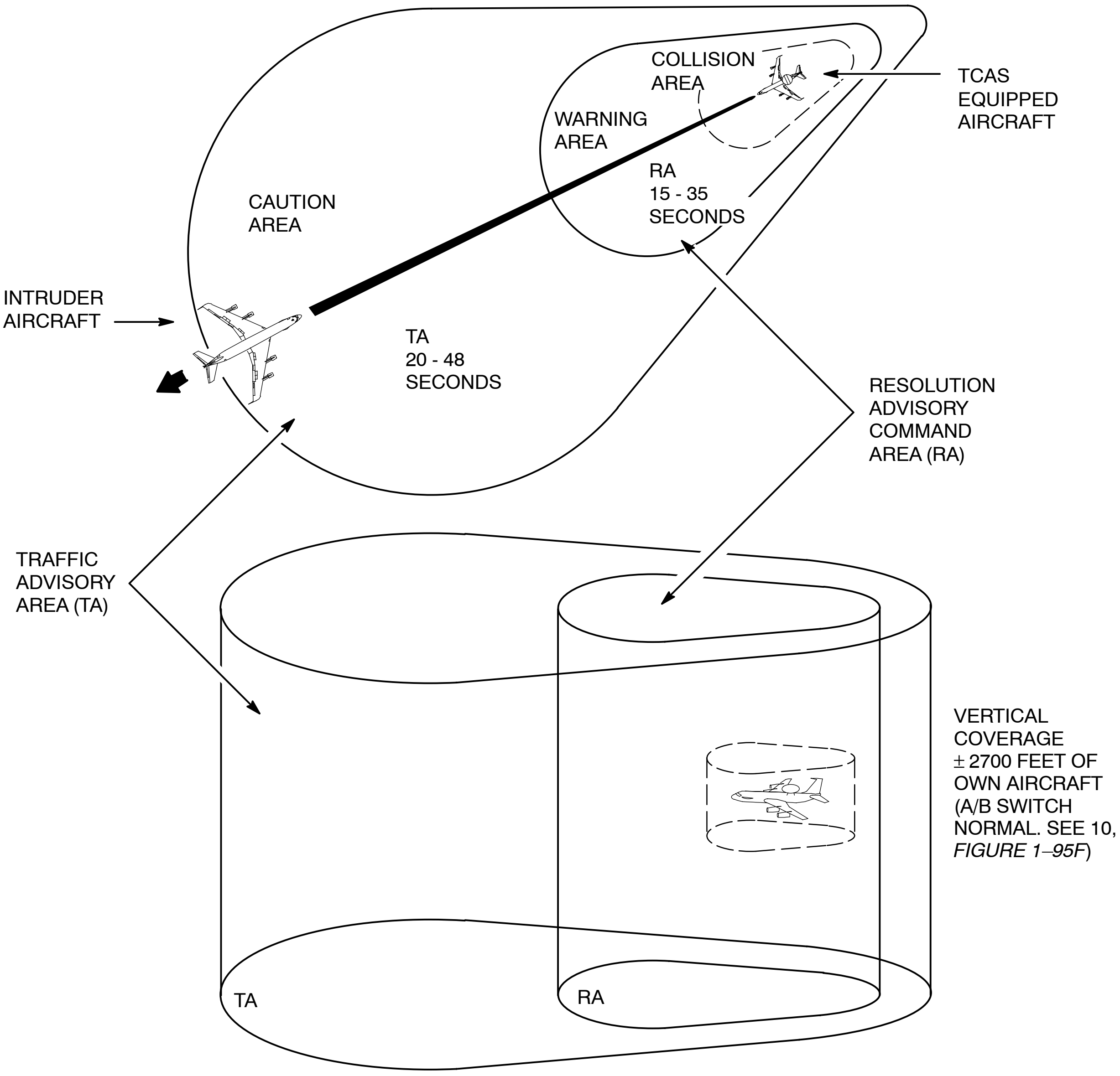
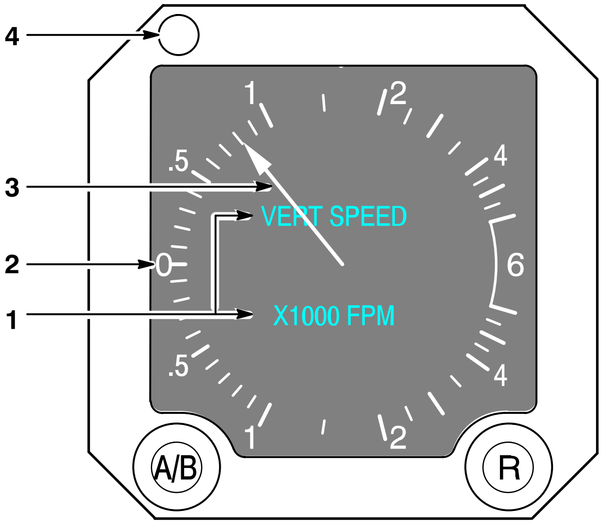


Figure 1-95E

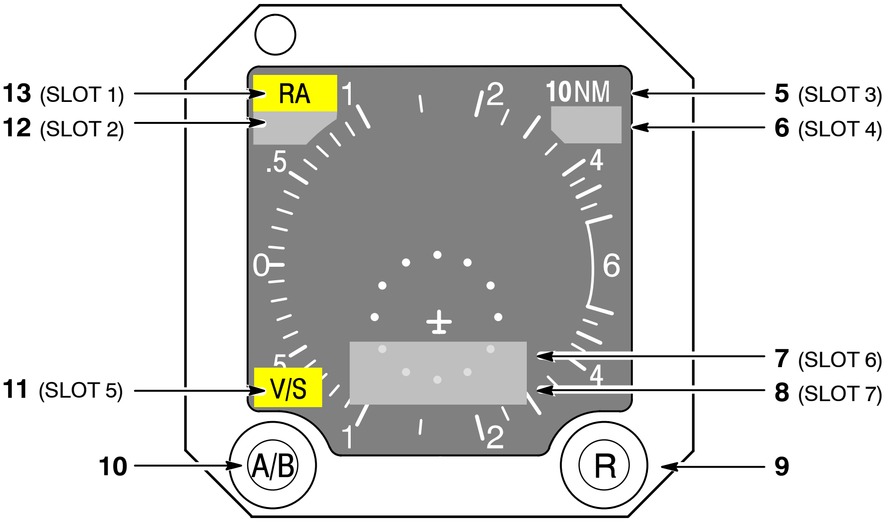
WITH IDG Vertical Speed Indicator Controls and Indicators



CONDITION: TYPICAL VSI DISPLAY WITH TCAS POWERED OFF

NO.	CONTROL/INDICATOR	FUNCTION
1	VERTICAL SPEED X1000 FPM Legend (Blue)	Shown only with TCAS powered off.
2	Vertical Speed Scale (White)	Visible when EAC bus powered. Part of the direct reading primary flight instrument that does not require TCAS operation.
3	Vertical Speed Pointer (White)	Visible when EAC bus powered. Vertical speed is computed inside this instrument, a direct reading primary flight instrument that does not require TCAS operation. Vertical speed needle is not displayed unless vertical speed data is valid. Illustration shows 800 FPM rate of climb.
4	Ambient Light Sensor	Provides an input to the display intensity control circuit card inside the instrument. The circuit card is programmed to take inputs from the panel lighting control rheostat and the ambient light sensor and makes the VSI back-lit LCD display intensity ergonomically compatible with the conventionally lighted instruments in the panel under all ambient light conditions with manual inputs from only the panel rheostat.

Figure 1-95F (Sheet 1 of 9)



CONDITION: PARTIAL DISPLAY TO ILLUSTRATE MESSAGE SLOT LOCATIONS AND PUSHBUTTONS

NOTE

- The indicator has seven slots, all but two of which are outside the circular traffic display area that is inside the vertical speed scale, in which various flags and messages are displayed.
- Vertical speed is computed inside the instrument as a direct reading from static pressure, so the needle should always be displayed when the instrument is powered. If the needle is not displayed there is a fault in the vertical speed computation within the instrument and the flag V/S might also be displayed.

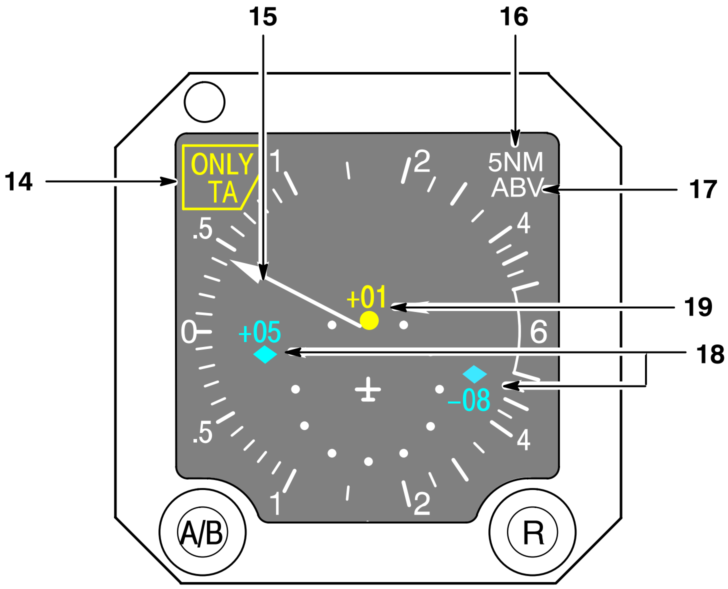
NO.	CONTROL/INDICATOR	FUNCTION
5	Message Slot 3	Displays forward surveillance range (3, 5, 10, 20, or 40 nm). Aft range is always ½ of forward range. R pushbutton (item 9) cycles through available range selections. Also used in conjunction with message slot 4 to display certain messages requiring two lines.
6	Message Slot 4	Displays BLW (below) or ABV (above) if these display options are selected via the A/B pushbutton (item 10). Used as an extension of message slot 3 when two lines are required for a message, such as: TCAS OFF.

Figure 1-95F (Sheet 2 of 9)

WITH IDG Vertical Speed Indicator Controls and Indicators (Continued)

NO.	CONTROL/INDICATOR	FUNCTION
7	Message Slot 6	Displays TEST during TCAS self test. Message slots 6 and 7 work together to display TAs and RAs when relative bearing cannot be computed. No more than two threats can be displayed, the higher threat message above the lower. TA threats are displayed in yellow, RA threats are displayed in red.
8	Message Slot 7	Message slots 6 and 7 work together to display TAs and RAs as text messages when relative bearing cannot be computed. No more than two threats can be displayed, the higher threat message above the lower. TA threats are displayed in yellow, RA threats are displayed in red.
9	Range Selector (Pushbutton)	Pushbutton R selects range (3, 5, 10, 20, or 40 nm). Range extends from center of airplane symbol to inner part of VSI scale at 12 o'clock position. Aft range is 1/2 of forward range. See *Figure 1-95F (Sheet 9 of 9)*
10	Above/Below Selector (Pushbutton) (Also called the A/B switch)	Selects altitude block for traffic display. Sequences through three options: ABV (above), no selection (no indication), or BLW (below). ABV and BLW are indicated in message slot 4 (item 6). ABV is recommended for climb, no selection for cruise, and BLW is recommended for descent. ABV selects display altitude block +9900 to -2700 feet relative altitude. No selection gives altitude block +2700 to -2700 feet relative altitude. BLW selects +2700 to -9900 feet relative altitude. A/B switch does not select surveillance altitude block, only the display altitude block.
11	Message Slot 5	Indicates instrument failure. There are two ways that this VSI can be installed to receive vertical speed data. It can be connected to static port pressure and sense vertical speed internal to the instrument, or it can receive digital vertical speed data from an air data computer. The latter option is not used in this airplane; the certification standards for this airplane require direct pressure reading primary flight instruments. If the instrument is connected to receive digital data from an air data computer the V/S flag indicates the absence of digital data. If installed to sense vertical speed internal to the instrument, the V/S flag indicates instrument failure. The V/S flag is not displayed in the TCAS self test display (sheet 8) because it is not a TCAS function. The flag is not seen in normal operation and cannot be tested by the flight crew.
12	Message Slot 2	Used as an extension of message slot 1 when two lines are required for a message, such as: ONLY TA.
13	Message Slot 1	Displays RA or TCAS flags (black on yellow), or ONLY TA (yellow on black). RA indicates resolution advisories cannot be generated due to a system malfunction. TCAS flag indicates TCAS functions have failed. ONLY TA is displayed if RAs are inhibited by manual selection or automatically.

Figure 1-95F (Sheet 3 of 9)

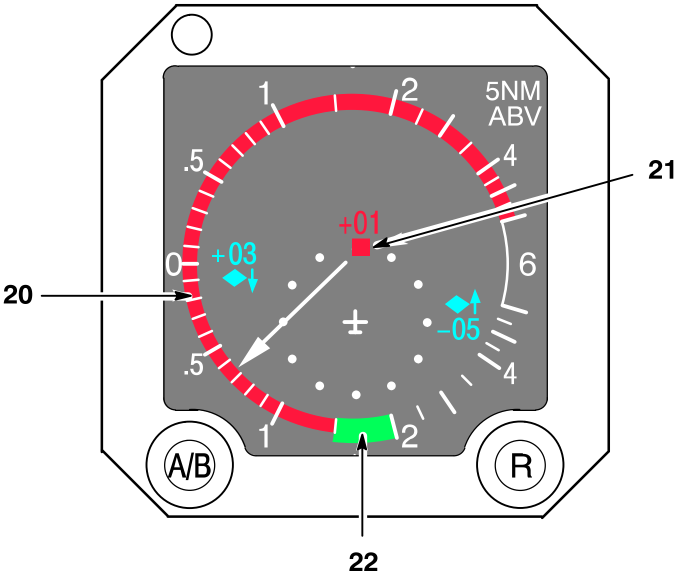


CONDITION: PARTIAL DISPLAY TO ILLUSTRATE ONLY TA

NO.	EXPLANATION
14	ONLY TA is displayed if TA mode is selected on tcas/iff control page and is displayed automatically if the radio altimeter indicates below 1100 feet AGL. This flag also appears if the radio altimeter is switched OFF, due to inhibits associated with low radio altitude. (Radio altimeter outputs a zero radio altitude signal when switched OFF and still provides an RA-valid discrete to TCAS, unless RADIO ALTM circuit breaker is opened. Loss of RA-valid discrete disables TCAS and TCAS flag (30) appears.)
15	Needle operates independently of TCAS.
16	Range set for 5 NM via R pushbutton (9). Range extends from center of airplane symbol to inner part of VSI scale at 12 o'clock position for all selected ranges (3, 5, 10, 20, 40 NM). Aft range is $^1/_2$ of forward range. Dotted circle around own aircraft is 2NM for ranges 3, 5, 10, and 20 NM. 40 NM range has dashed circle that represents 20 NM around own aircraft. (See *figure 1-95F, Sheet 9 of 9*).
17	Set with A/B pushbutton (10). Normally set to ABV during climb and BLW during descent. Select normal (no display) during cruise.
18	Two intruders are displayed as proximate traffic (solid blue diamonds). One is at 10 o'clock, 3 nm, 500 feet above. The other is at 3 o'clock, 4 nm, 800 feet below. Arrows are shown to the right of the symbol when vertical speed reaches or exceeds 500 FPM.
19	Indicates a TA at 12 o'clock, 2 nm, 100 feet above. Absence of accompanying arrow indicates that intruder vertical speed is < 500 fpm. On the speaker TRAFFIC; TRAFFIC is annunciated, and on the VSI situation display a solid yellow circle appears with appropriate symbology.

Figure 1-95F (Sheet 4 of 9)

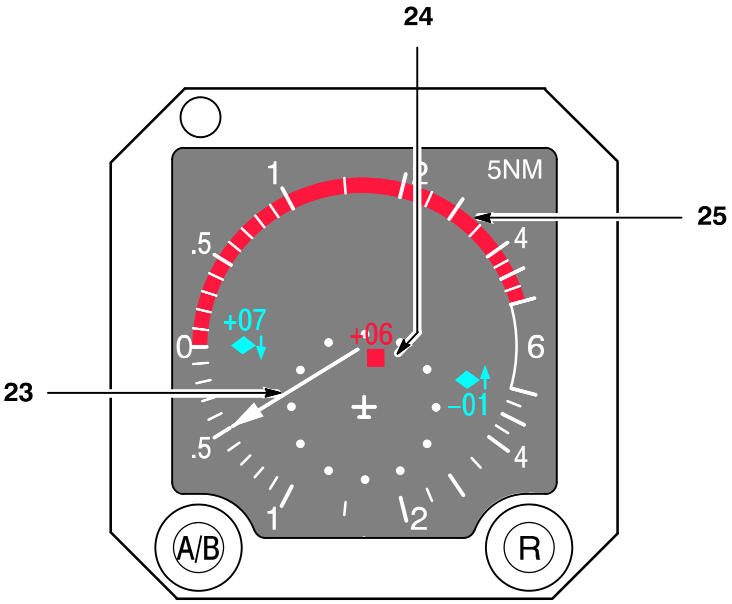
WITH IDG Vertical Speed Indicator Controls and Indicators (Continued)



CONDITION: CORRECTIVE RESOLUTION ADVISORY

NO.	EXPLANATION
20	Vertical speed in the red colored arc is insufficient to ensure safe separation from the intruder. Increase descent rate until needle is in the green arc.
21	An RA display symbol is a solid red square with associated symbology. At the same time the RA is displayed, the vertical speed scale displays a red arc and green arc, indicating action to take to avoid intruder. Simultaneously, the TCAS speaker annunciates the appropriate voice command. For this example it annunciates, DESCEND; DESCEND. The intruder is now at 12 o’clock, 2 nm, 100 feet above. Vertical speed is < 500 fpm (no arrow).
22	The green colored arc on the VS scale commands a descent rate between 1500 and 2000 FPM to ensure safe separation from intruder.

Figure 1-95F (Sheet 5 of 9)



CONDITION: PREVENTIVE RESOLUTION ADVISORY

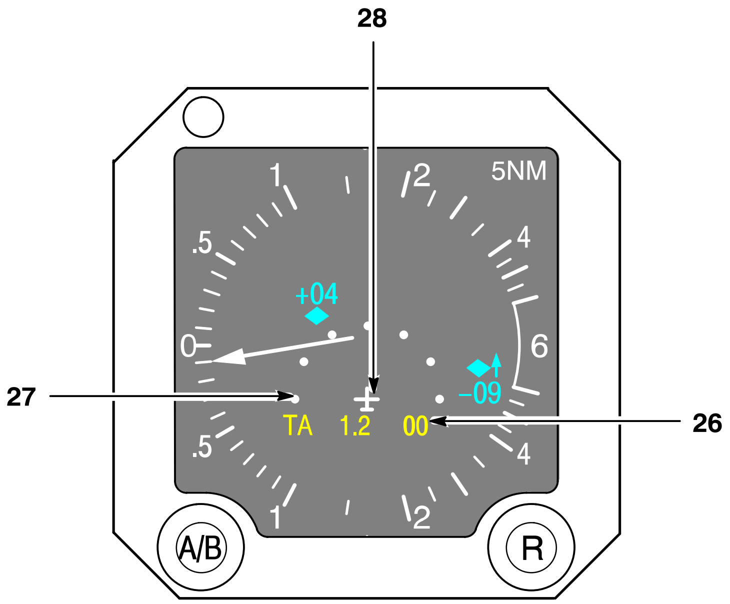
NO.	EXPLANATION
23	VSI indicates 500 FPM rate of descent.
24	The intruder causing the preventive RA is immediately ahead, 600 feet above. On the TCAS speaker MONITOR VERTICAL SPEED is annunciated.
25	The red arc advises do not climb, in order to meet the minimum vertical separation criteria.

NOTE

A corrective RA overrides a preventive RA.

Figure 1-95F (Sheet 6 of 9)

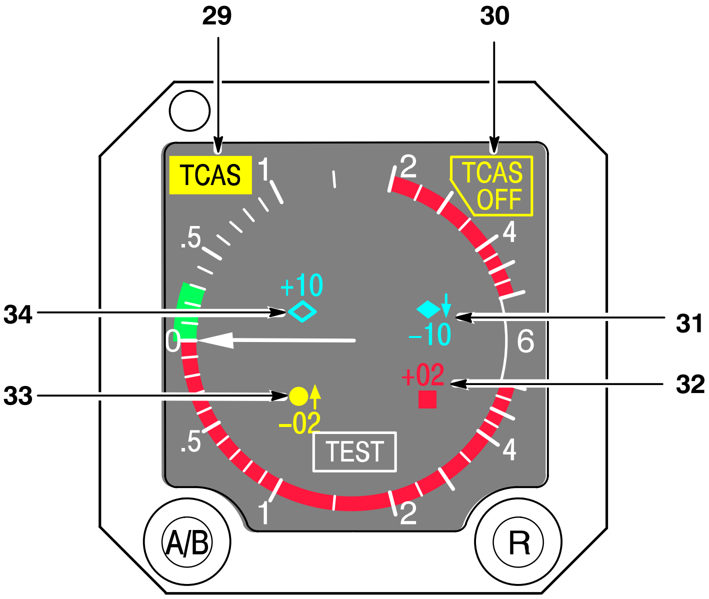
WITH IDG Vertical Speed Indicator Controls and Indicators (Continued)



CONDITION: NO–BEARING TRAFFIC ADVISORY

NO.	EXPLANATION
26	A no-bearing traffic advisory (in yellow) or no-bearing RA (in red) is displayed in slot 6 (and slot 7 if there are two). TAs and RAs do not require relative bearing in order to be computed, only to be displayed as traffic symbology on the VSI situation display. In this TA example, traffic is at 1.2 nm range, same altitude, and vertical speed is less than 500 fpm (no arrow). The TA could still be issued without the relative altitude information, and it would display as blank relative altitude instead of 00. An RA is not generated without relative altitude information.
27	Two-mile circle (two miles at all ranges, except when display range is 40 nm. 40 NM range has dashed circle that represents 20 NM around own aircraft). A no-bearing advisory covers up the lower portion of the two-mile circle below own aircraft symbol. (See *figure 1-95F, Sheet 9 of 9*).
28	Own aircraft symbol.

Figure 1-95F (Sheet 7 of 9)

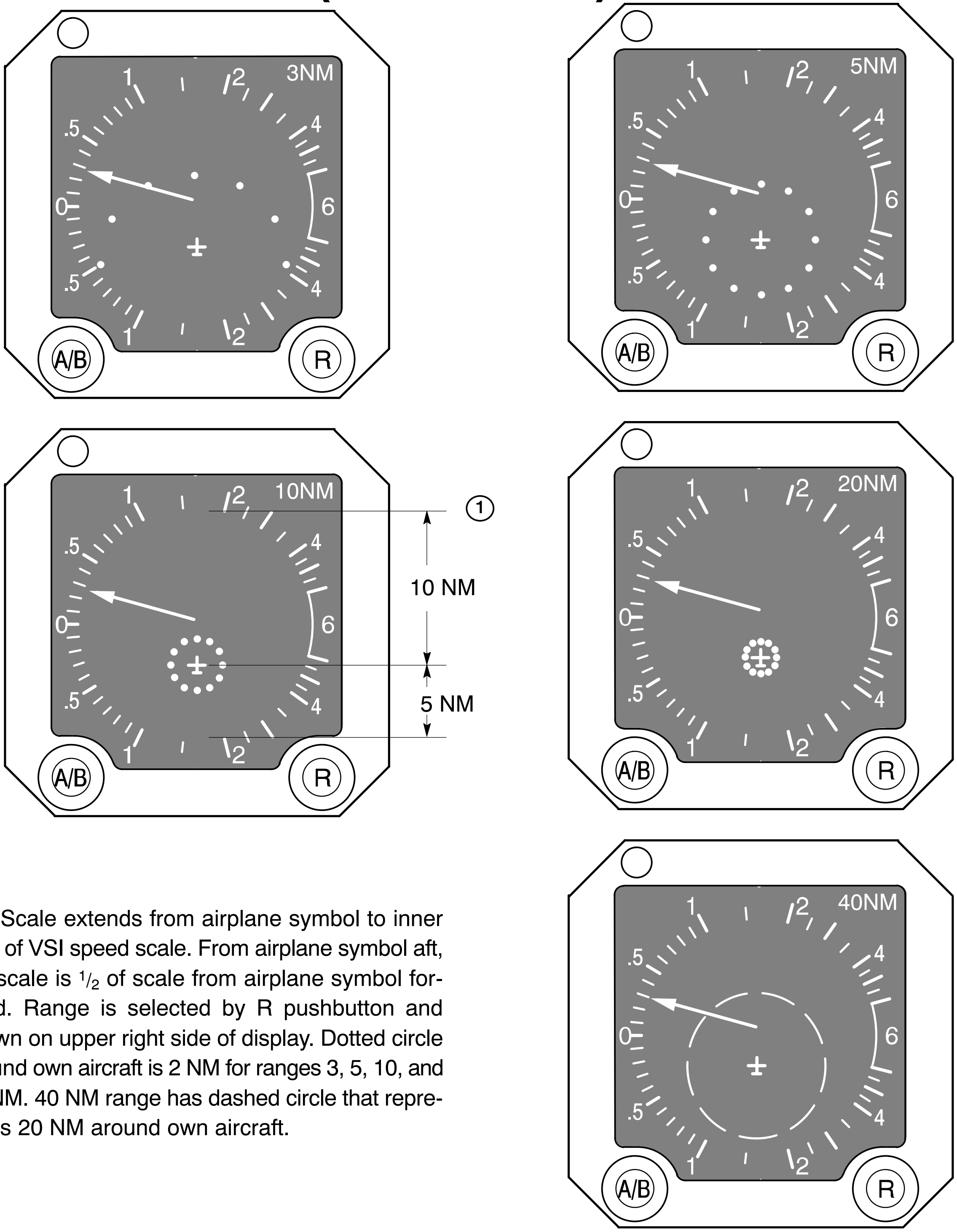


CONDITION: DISPLAY TEST PATTERN, INITIATED BY PRESSING LS7 ON IFF TEST PAGE (GINS CDU)

NO.	EXPLANATION
29	TCAS inoperative flag is displayed during ground self test, and when TCAS fails. This flag also appears if RADIO ALTM circuit breaker (P5) is open, IFF TRANSPONDER Switch – OFF, IFF:STBY on iff control page, M3A/MC out, or TCAS is powered off (SENS:STBY in tcas/iff control page).
30	TCAS OFF flag is displayed during self test, IFF TRANSPONDER Switch – OFF, IFF:STBY on iff control page, TCAS in STBY (SENS:STBY in tcas/iff control page), M3A/MC OUT, or MS OUT.
31	Solid blue diamond is symbol for proximate traffic. The -10 means 1000 feet below. Down arrow means descending at or greater than 500 FPM.
32	Solid red square is symbol for resolution advisory (RA) intruder. The +02 means 200 feet above.
33	Solid yellow circle is symbol for traffic advisory (TA) intruder. The up arrow means climbing at 500 FPM or greater.
34	The open diamond is symbol for other traffic, that is, traffic at greater than 6 nm range, and/or greater than ±1200 feet vertical separation, projected to be no threat.

Figure 1-95F (Sheet 8 of 9)

WITH IDG Vertical Speed Indicator Controls and Indicators (Continued)



① Scale extends from airplane symbol to inner side of VSI speed scale. From airplane symbol aft, the scale is $^{1}/_{2}$ of scale from airplane symbol forward. Range is selected by R pushbutton and shown on upper right side of display. Dotted circle around own aircraft is 2 NM for ranges 3, 5, 10, and 20 NM. 40 NM range has dashed circle that represents 20 NM around own aircraft.

CONDITION: TYPICAL DISPLAYS

Figure 1-95F (Sheet 9 of 9) ◀

WITH IDG TCAS Visual and Voice Annunciations

VSI ARC DISPLAY ③	VOICE MESSAGE	INTERPRETATION
Traffic Advisory – No Maneuver Advised		
None	TRAFFIC; TRAFFIC (Not issued when an RA is downgraded to a TA.)	Observe VSI for TA traffic situation display; obtain visual contact if possible. Prepare for possible RA.
Corrective Resolution Advisories – Begin Maneuver Within Five Seconds		
 Climb	CLIMB; CLIMB	Climb at rate shown on VSI (1500 - 2000 FPM).① ②
	CLIMB CROSSING, CLIMB; CLIMB CROSSING, CLIMB	Same as “CLIMB, CLIMB” except that it further indicates that vertical flight path crosses intruder’s flight path at some altitude. Climb at rate shown on VSI (1500 - 2000 FPM). TCAS algorithms are biased to avoid the crossing of vertical flight paths if that can be done within the timing and acceleration criteria for RAs. ① ②
 Descend	DESCEND; DESCEND	Descend at rate shown on VSI (1500 - 2000 FPM).
	DESCEND CROSSING, DESCEND; DESCEND CROSSING, DESCEND	Same as “DESCEND, DESCEND” except that it further indicates that vertical flight path crosses intruder’s at some altitude. Descend at rate shown on VSI (1500 - 2000 FPM). TCAS algorithms are biased to avoid the crossing of vertical flight paths if that can be done within the timing and acceleration criteria for RAs.
Increased Action Resolution Advisories – Begin Maneuver Within $2\frac{1}{2}$ Seconds		
 Increase Climb (Strengthening Advisory)	INCREASE CLIMB; INCREASE CLIMB	Following a climb RA, now an increase climb RA is in effect. Climb at the rate shown on VSI (2500-3000 FPM). ① ②

Figure 1-95G (Sheet 1 of 4)

WITH IDG TCAS Visual and Voice Annunciations (Continued)

VSI ARC DISPLAY	VOICE MESSAGE	INTERPRETATION
Increased Action Resolution Advisories – Begin Maneuver Within $2\frac{1}{2}$ Seconds (Continued)		
 Increase Descent (Strengthening Advisory)	INCREASE DESCENT; INCREASE DESCENT	Following a descend RA, now an increase descent RA is in effect. Descend at the rate shown on VSI (2500 - 3000 FPM).
Reversal Resolution Advisories – Begin Maneuver Within $2\frac{1}{2}$ Seconds		
 Reversal to Climb	CLIMB, CLIMB NOW; CLIMB, CLIMB NOW	Following a descend RA, now a reversal RA is in effect. Climb at the rate shown on VSI. ① ②
 Reversal to Descend	DESCEND, DESCEND NOW; DESCEND, DESCEND NOW	Following a climb RA, now a reversal RA is in effect. Descend at the rate shown on VSI.

Figure 1-95G (Sheet 2 of 4)

VSI ARC DISPLAY	VOICE MESSAGE	INTERPRETATION
Preventive Resolution Advisories – Comply With Vertical Restriction		
 Monitor Vertical Speed	MONITOR VERTICAL SPEED	Monitor VSI. E-3 is in level flight or approximately level flight. The VS needle is pointing to a green arc that encompasses zero vertical speed and tells how much deviation is permitted from level flight. Red arcs on one or both sides of the green arc show the vertical speeds to avoid.
 Maintain Vertical Speed (Maintain Climb)	MAINTAIN VERTICAL SPEED; MAINTAIN	Monitor VSI. E-3 is climbing or descending. Maintain present vertical speed. The VS needle is pointing to a green arc that does not encompass zero vertical speed and tells how much deviation is permitted from current vertical speed. Red arcs on one or both sides of the green arc show the vertical speeds to avoid.
	MAINTAIN VERTICAL SPEED CROSSING; MAINTAIN	Same as “MAINTAIN VERTICAL SPEED, MAINTAIN” except that a flight path crossing is predicted and being monitored by TCAS. Monitor VSI. E-3 is climbing or descending. Maintain present vertical speed. The VS needle is pointing to a green arc that tells how much deviation is permitted from current vertical speed. Red arcs on one or both sides of the green arc show the vertical speeds to avoid. E-3 flight path will vertically cross intruders.

Figure 1-95G (Sheet 3 of 4)

WITH IDG TCAS Visual and Voice Annunciations (Continued)

VSI ARC DISPLAY	VOICE MESSAGE	INTERPRETATION
Modified Resolution Advisory – Reduce Vertical Maneuver or Restriction		
 Adjust Vertical Speed (Multi–Threat Advisory)	ADJUST VERTICAL SPEED; ADJUST	Following a corrective RA, the required vertical separation has been achieved by the vertical maneuver, but the intruder is still approaching CPA. Reduce climb or descent rate to that shown on VSI (usually level flight). After intruder passes CPA, the RA becomes proximate traffic. Following a preventive RA, the required vertical separation has been achieved by the vertical restriction, but the intruder is still approaching CPA. E-3 may resume progress toward vertical objective, but maintain VS within green arc on VSI. After intruder passes CPA, the RA becomes proximate traffic.
Other Annunciations		
None	CLEAR OF CONFLICT	Issued at termination of RA to indicate intruder is no longer a threat. Resume normal flight.
Refer to *Figure 1-95F* (Sheet 8 of 9)	TCAS SYSTEM TEST OKAY	Issued after completion of successful self test.
	TCAS SYSTEM TEST FAIL	Issued after completion of failed self test.

WARNING

① If TCAS commands an RA vertical maneuver that cannot be complied with, such as while own aircraft is turning at low airspeed, or while flaps are being raised, or when the pre–programmed RA inhibits are insufficient due to performance degradation resulting from operation at high field elevation or high outside air temperature (>ISA+505F), maintain aircraft control first, respect the stick shaker or initial buffet at all times, and comply with the RA when able to do so safely.

NOTE

② Use thrust, as required, to maintain climb rate when responding to a climb or increase climb RA in cruise flight. If high speed buffet occurs, relax control pressure enough to reduce buffet but continue the maneuver.

③ Examples of possible visual representations with accompanying voice annunciations. VSI needle represents state of own airplane when annunciation is received. Red/green arcs represent action to be taken for aircraft avoidance.

Figure 1-95G (Sheet 4 of 4)

WITH IDG TCAS Advisory Inhibits

ADVISORY (RA or TA) and ANNUNCIATION	INHIBIT PARAMETERS
Increase Descent RA: INCREASE DESCENT; INCREASE DESCENT	Inhibited below 1650 ft AGL (radio altitude) climbing. Inhibited below 1450 ft AGL descending or level.
Descend RA: DESCEND; DESCEND	Inhibited below 1200 ft AGL climbing. Inhibited below 1000 ft AGL descending or level.
All Resolution Advisories ①	Inhibited below 1100 ft AGL climbing. Inhibited below 900 ft AGL descending or level. (TCAS automatically reverts to TA-only mode.)
TA Aural Annunciation: TRAFFIC; TRAFFIC	Inhibited below 600 ft AGL climbing. Inhibited below 400 ft AGL descending or level.
Climb RA (1500 - 2000 FPM): CLIMB; CLIMB	Inhibited with flaps 25 or greater.
Increase Climb RA (2500 - 3000 FPM) INCREASE CLIMB; INCREASE CLIMB	Inhibited with flaps 14 or greater.
All Voice Annunciations	Inhibited below 600 ft AGL climbing. Inhibited below 400 ft AGL descending or level.

NOTE

① TCAS may be disabled by selecting SENS:STBY on the tcas/iff control page in preparation for air-to-air refueling, as desired. To track the tanker with the TCAS situation display on the VSI, realize that the bearing is only approximate, use TA-only mode, and expect the TRAFFIC; TRAFFIC annunciation.

Figure 1-95H ◀

WITH IDG TCAS Block Diagram

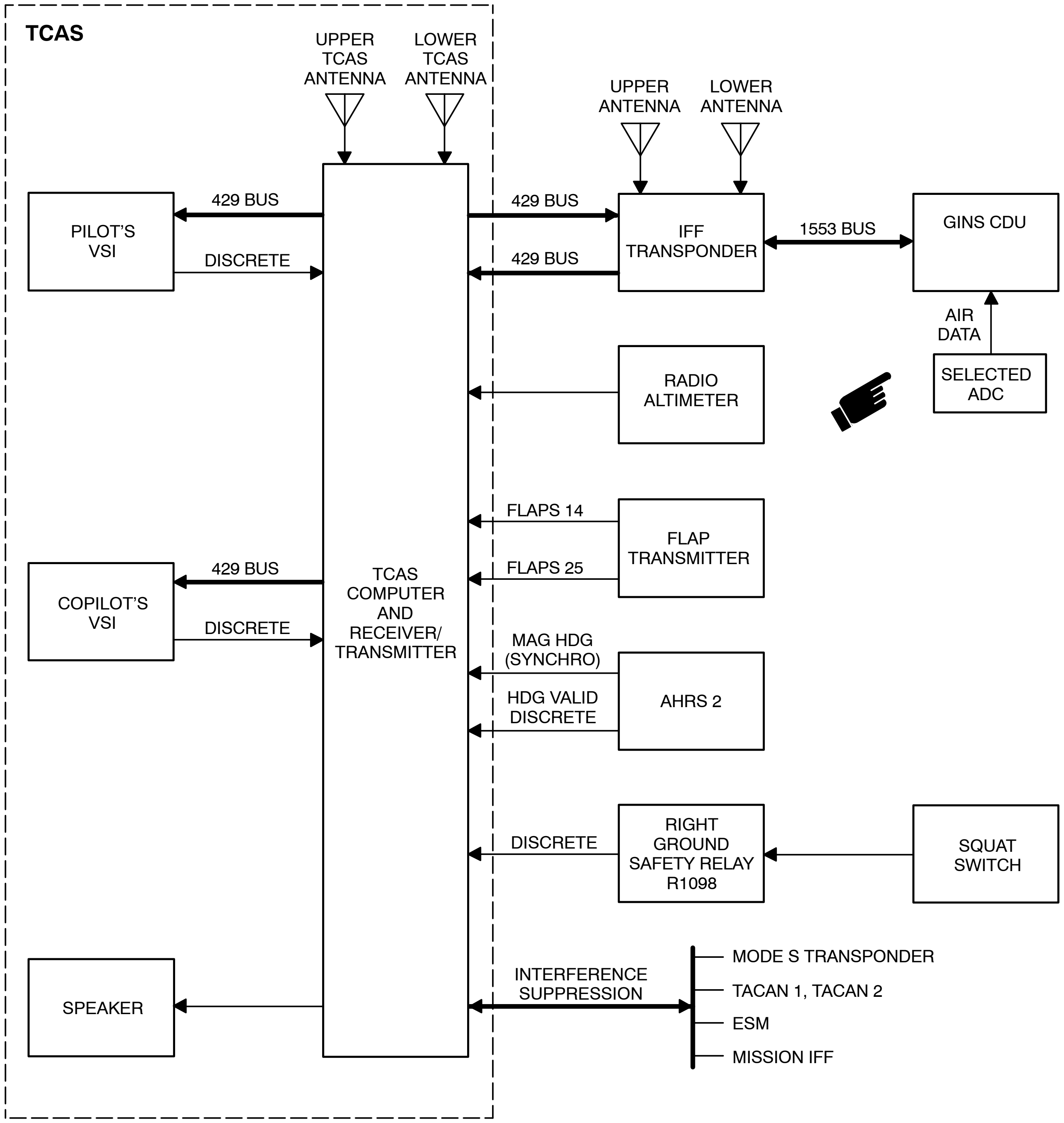


Figure 1-95I

MACH/AIRSPEED INDICATOR

The Mach/airspeed indicators (*figure 1-94*) display indicated airspeed from 60 to 420 knots and Mach number from 0.400 to 0.999 Mach. The indicated airspeed display is operated by direct pitot and static pressure. The Mach number display is electronically derived within each air data computer. Any time the Mach output from either air data computer fails, a red and white OFF flag appears to cover the Mach counters on the affected side. ADC 1 provides air data to the pilot's Mach/airspeed indicator, as doesADC 2 to the copilot's. Below 0.400 Mach, a black flag covers the Mach counters.

There is a tolerance in airspeed indicator readings. A six knot difference is permitted between the pilot's and copilot's indicators.

STATIC AIR TEMPERATURE GAGE

The Static Air Temperature (SAT) gage, located on the navigator's upper panel, provides instantaneous readout of the ambient outside temperature. The indicator is driven electrically by the air data computer number two. The temperature is derived within the air data computer by correcting total air temperature for the temperature increase due to airplane speed (ram rise). See *figure 1-94* for a description of the SAT gage.

TRUE AIRSPEED INDICATOR

The True Airspeed (TAS) indicator provides a direct readout of airplane true airspeed. The true airspeed display is driven electrically by the air data computer number two. The signal is derived within the air data computer by correcting indicated airspeed for air temperature. See *figure 1-94* for a description of the TAS indicator.

ANGLE OF ATTACK SYSTEM

There are two independent AOA systems, one for each pilot. Each system consists of a heated airflow sensing probe (on the fuselage side), a computer located in the flight avionics rack in the forward lower compartment, and an indicator mounted on the pilot's (or copilot's) instrument panel. See *figure 1-96* for AOA system component locations and *figure 1-97* for a schematic of the system. The heater systems operate on 115 vac, with the left AOA system heater controlled by the left PROBE HEATERS switch (16, *figure 1-7*) and the right angle of attack system heater controlled by the right PROBE HEATERS switch (16, *figure 1-7*). Refer to ICE AND RAIN PROTECTION, subsection I-S.

ANGLE OF ATTACK INDICATOR

The Angle Of Attack (AOA) indicator (*figure 1-96*) presents a display of AOA which is indicated in percent of lift by the pointer on a zero to 1.0 scale. The 0 (zero) position on the scale represents the zero lift reference AOA (AOA for zero G flight) and the maximum scale reading of 1.0 represents an AOA which produces a lift condition between initial buffet and stall. This method of displaying AOA information is referred to as Normalized AOA. The normalized AOA reading is electrically shifted when the flaps reach each of the standard (0, 14, 25, 40, and 50 degrees) positions. This adjusts the approach and stall reference AOA to compensate for flap position. The indication is not accurate when the flaps are moving between positions. Index markings on the AOA indicator show the normalized AOA for climbout with flaps 14 and flaps up and for landing approach with any standard flap setting. Index markings also show maximum endurance and long range cruise in the clean configuration. The approach index (0.6 normalized AOA) indication is amplified, damped, and then repeated on the attitude director indicator FAST-SLOW indicator when the flaps are set to 50. A slow indication on the FAST-SLOW indicator means the airspeed is slower than 0.6 AOA approach speed. The OFF flag indicates that power to the system or indicator has failed.

WARNING

- The AOA system senses inboard flap position only. The indications are not correct when flying with split or asymmetric flaps.
- Do not use AOA indicator with any leading edge flaps inoperative, with split or asymmetric flaps, or with nose radome missing. AOA readings can be unreliable in these conditions.

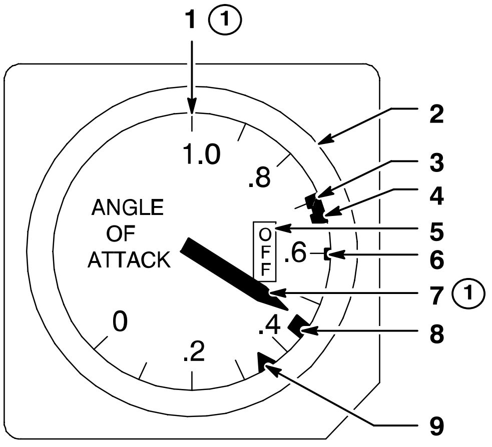
NOTE

Since the pilot's and copilot's AOA systems are independent of each other, it is possible for the two indicators to show different readings. In a sideslip (or out-of-trim) condition, the airflow angle can be different on the two sides of the airplane. Also, because of system tolerances, it is possible for each system to indicate ±0.05 from the correct value. Therefore, it is possible for a difference of 0.1 to exist between the two indicators in a zero sideslip condition. If there is a continuous difference between indicators, check airplane trim. Refer to ROLL AND DIRECTIONAL TRIM TECHNIQUE, section VI.

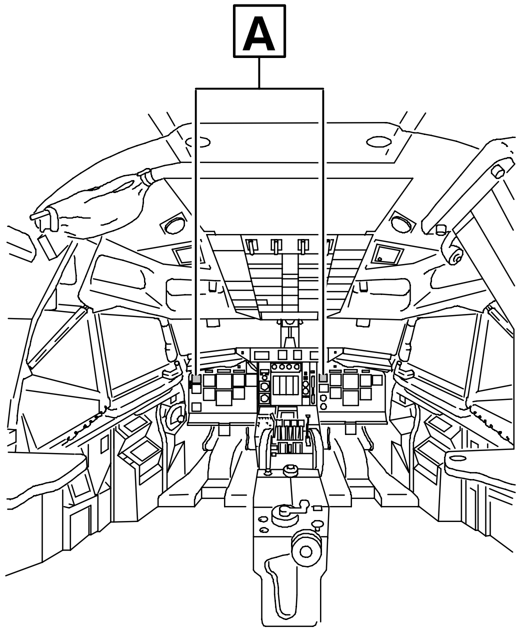
ANGLE OF ATTACK SYSTEM POWER

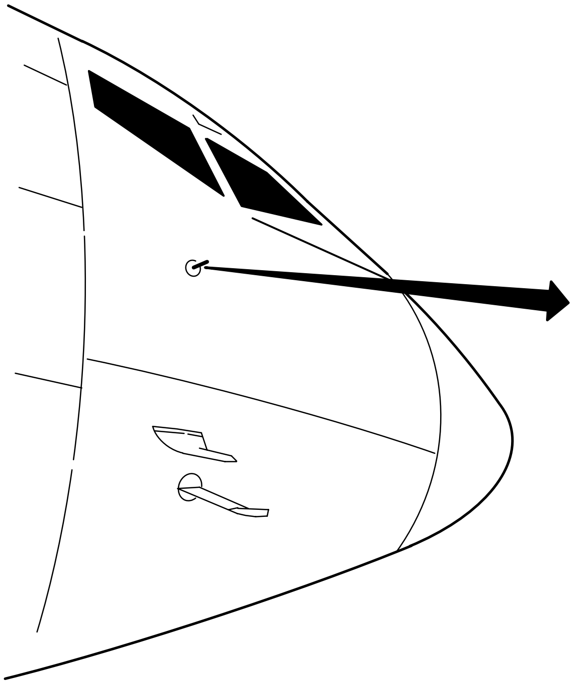
There are no switches for power to the indicators. The indicators receiver 28 vdc power when the ANGLE ATTACK NO 1 and ANGLE ATTACK NO 2 circuit breakers on the P5 panel are closed. The probes operate when the PROBE HEATERS switches are on and the CMDR PITOT & ANGLE ATTACK 1 (pilot's system) RIGHT TAT & ANGLE ATTACK 2 (copilot's system) circuit breakers are closed.

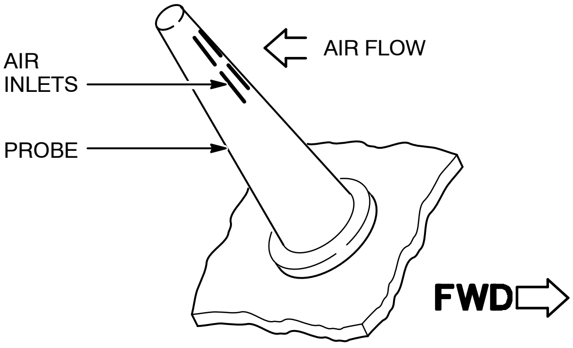
Angle of Attack System Component Locations



A ANGLE OF ATTACK INDICATOR







B ANGLE OF ATTACK PROBE

1. STALL
2. INDICATOR SCALE
3. CLIMBOUT INDEX FLAPS 14 AND STALL RECOVERY INDEX
4. CLIMBOUT INDEX FLAPS UP
5. POWER OFF FLAG
6. APPROACH INDEX
7. ANGLE OF ATTACK POINTER
8. MAXIMUM ENDURANCE INDEX (FLAPS UP)
9. LONG RANGE CRUISE INDEX (FLAPS UP)

① DUE TO SYSTEM TOLERANCES, POINTER INDICATION CAN BE ±.05 FROM COMPUTED VALUE.

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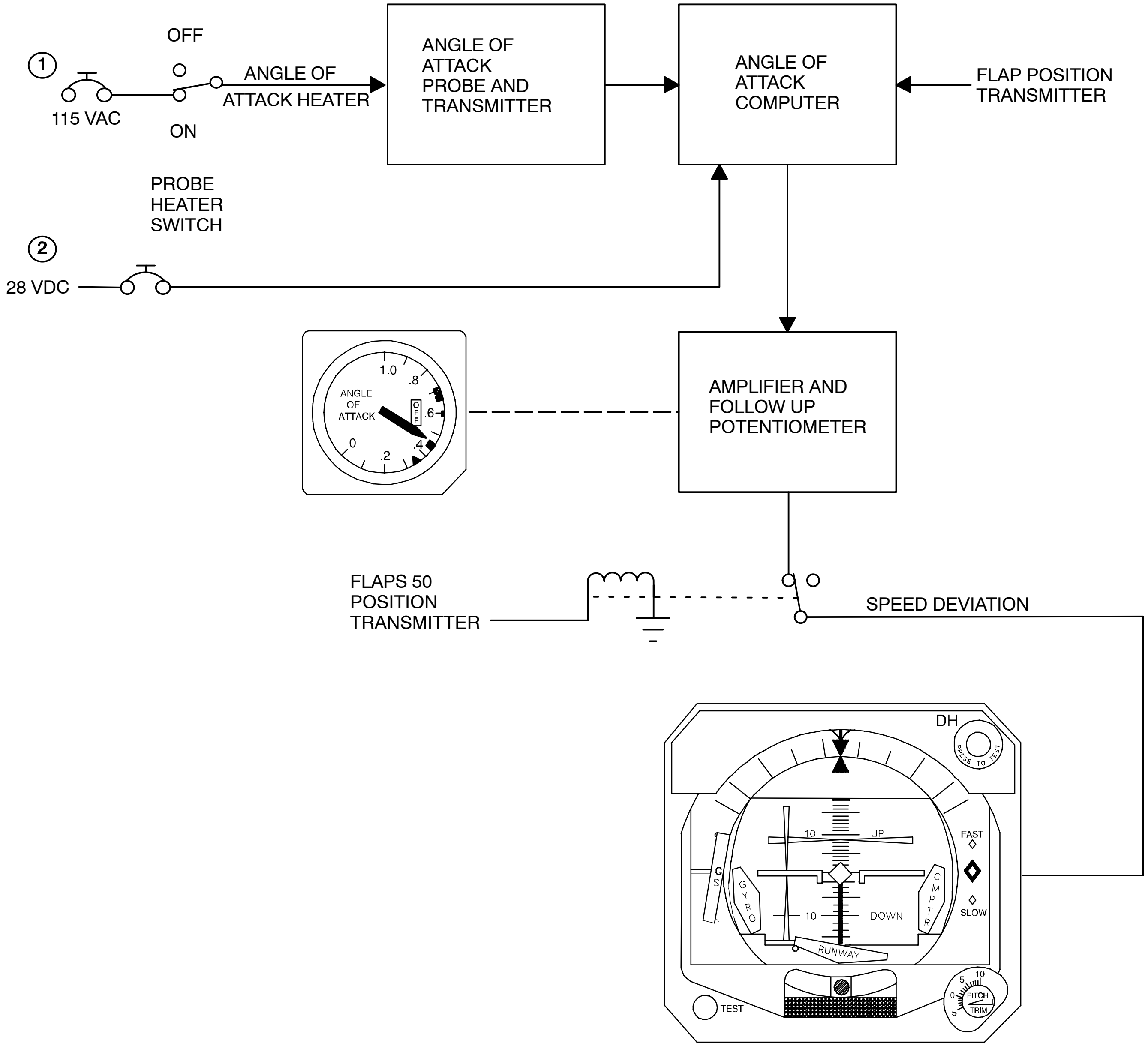
Figure 1-96

Angle of Attack System Schematic



ATTITUDE DIRECTOR INDICATOR

① POWER FOR PILOT'S ANGLE OF ATTACK TRANSMITTER AND PROBE HEATER COMES FROM AVAC BUS 6 VIA THE PROBE HEAT – CMDR PITOT & ANGLE ATTACK 1 CIRCUIT BREAKER ON P61-1 PANEL.

POWER FOR COPILOT'S ANGLE OF ATTACK TRANSMITTER AND PROBE HEATER COMES FROM AVAC BUS 4 VIA THE PROBE HEAT – RIGHT TAT & ANGLE ATTACK 2 CIRCUIT BREAKER ON P61-2 PANEL.

② POWER FOR PILOT'S ANGLE OF ATTACK COMPUTER AND INDICATOR COMES FROM FAVDC BUS 1 VIA THE ANGLE ATTACK NO 1 CIRCUIT BREAKER ON P5 PANEL.

POWER FOR COPILOT'S ANGLE OF ATTACK COMPUTER AND INDICATOR COMES FROM FAVDC BUS 2 VIA THE ANGLE ATTACK NO 2 CIRCUIT BREAKER ON P5 PANEL.

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Figure 1-97

NAVIGATOR'S ALTIMETER

The navigator's altimeter (A, *figure 1-98*) is a type AAU-27A barometric altimeter. There is no ADC input to this altimeter. The altimeter operates from the auxiliary static system. Position correction data in T. O. 1E-3A-1-1 must be applied to fly corrected altitude or before crosschecking the pilot's altimeters. Crosscheck tolerance is shown in *figure 5-14*. An internal vibrator is powered by the lighting circuit.

WARNING

> If the altimeter internal vibrator is inoperative, the 100-foot pointer can hang up momentarily when passing through 0 or 12 o'clock position. Minimize pointer hangup by tapping the altimeter case. This failure is most likely when displayed altitude lies within the 800 to 1,000-foot part of the scale, such as 1,800 to 2,000 feet or 2,800 to 3,000 feet. Use any appropriate altitude backup information available to avoid use of inaccurate altitude data.

CAUTION

> Momentary locking of the baro-counters is possible during normal use. If this occurs, do not force the setting. Application of force can cause internal gear disengagement and result in excessive altitude errors. If locking occurs, the required setting can sometimes be established by rotating the knob a full turn in the opposite direction and approaching the setting carefully.

TOTAL AIR TEMPERATURE INDICATING SYSTEM

Ambient air temperature plus the rise in temperature due to compression of the air in flight (ram rise) yields total air temperature. Total air temperature is used in determining engine thrust settings and is also used by the air data computer for computation of static air temperature and true airspeed. Total air temperature is displayed on a total air temperature gage (*figure 1-98*) on the pilot instrument panel. Power to the gage is 115 V AC from the RIGHT TAT & ANGLE ATTACK 2 circuit breaker on P61-2 panel.

A Total Air Temperature (TAT) probe is externally mounted on the right forward fuselage. The probe contains **LESS IDG** two ◀ **WITH IDG** three ◀ sensing elements. Temperature variations of the airflow through the probe cause the element resistance to vary, thus providing temperature data for the air data systems. The probe senses 100% ram rise, therefore no correction is required. The probe is electrically anti-iced with no effect on temperature sensing in flight. Temperature readings are high on the ground with probe heat on.

One sensing element in the probe feeds the copilots TAT gage.

WITH IDG A second sensing element in the probe feeds ADC 2 and the third sensing element feeds ADC 1. The TAT signal is used by both ADCs as one of the inputs required to compute SAT and TAS. The navigator has the only SAT indicator, and also the only TAS indicator. Only ADC 2 feeds these two indicators. SAT and TAS from ADC 1 are not currently utilized. ◀

WARNING

> Do not use the total air temperature or static air temperature gage as a source of temperature data for takeoff calculations.

STANDBY ATTITUDE INDICATOR

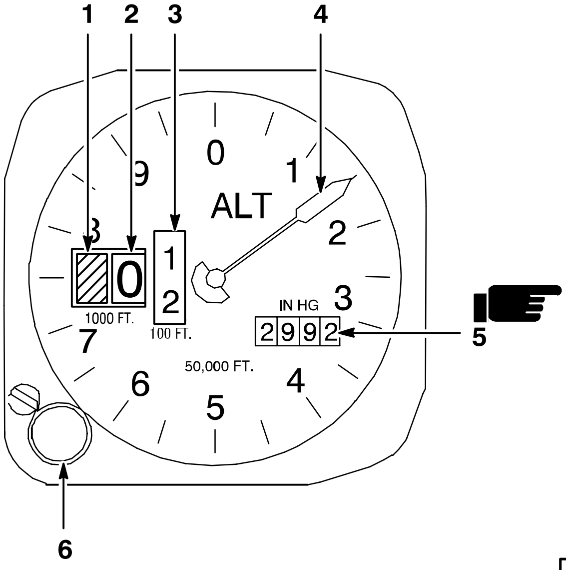
The standby attitude indicator, *figure 1-98* is a continuously operating attitude source in case of failure of either ADI or of the attitude sources. The indicator has 360 degrees freedom in roll and 90° nose up (climb), 80° nose down (dive) freedom in pitch. The standby attitude indicator is powered by 18V 400 Hz ac from its own inverter. The inverter receives 28 V DC from the emergency dc bus.

When the airplane is wings level, an internal erection mechanism keeps the sphere aligned with the true vertical. If the airplane is in a continuous turn, the erection mechanism may be affected by the g force due to the turn. During continuous turns, slight errors, not to exceed 3° in either pitch or roll, can occur. This is not a malfunction.

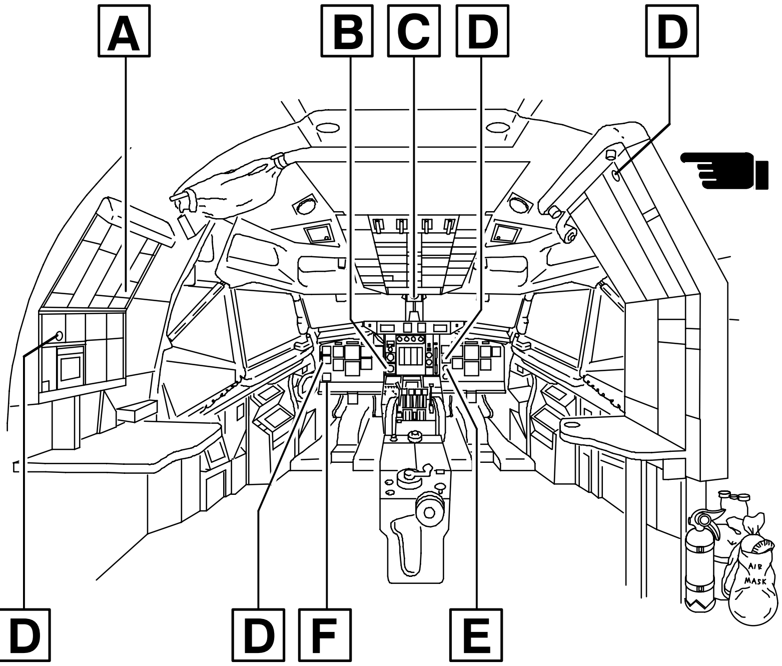
NOTE

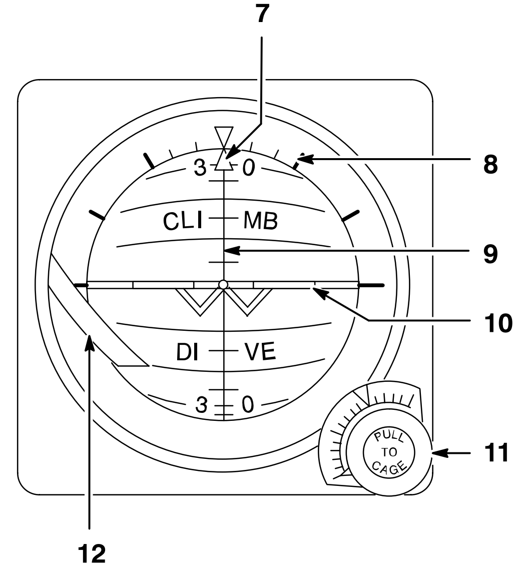
- If this condition occurs, wait until airplane is wings level. These errors should be corrected by the internal erection mechanism.
- If sphere tumbles or precesses while airplane is in wings level flight, a malfunction has occurred.

Miscellaneous Instruments

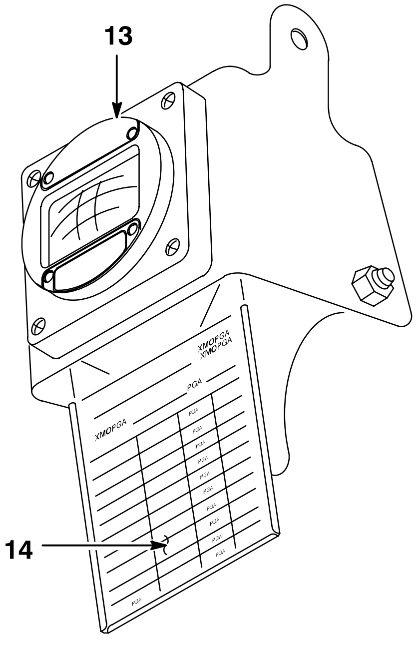


A NAVIGATOR'S ALTIMETER





B STANDBY ATTITUDE INDICATOR



C STANDBY COMPASS

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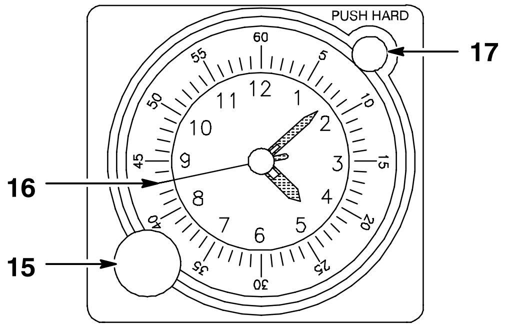
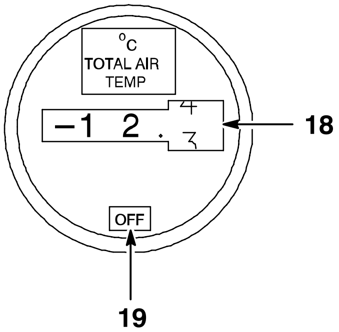
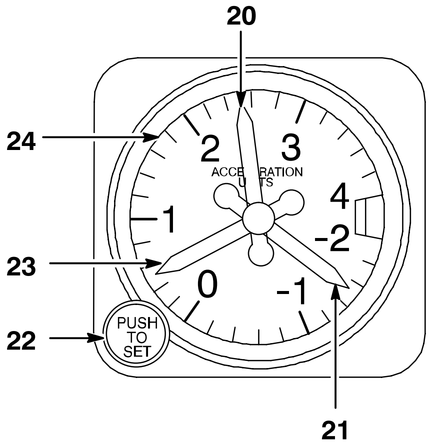
Figure 1-98 (Sheet 1 of 4)



D CLOCKS



E TOTAL AIR TEMPERATURE GAGE



F ACCELEROMETER

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NO.	CONTROL/INDICATOR	FUNCTION
		A NAVIGATOR'S ALTIMETER
1 2 3	Altitude counters (3)	Left digit (1) indicates tens of thousands of feet, second digit (2) indicates thousands of feet, third digit (3) indicates hundreds. Left digit is masked below 10,000 feet.
		NOTE This is not a servo-corrected altimeter. Position error correction must be applied to indicated reading.
4	Altitude Pointer	Indicates hundreds of feet of altitude. Smallest scale division is 50 feet.
5	Altimeter Setting Display	Indicates barometric pressure which has been set by setting knob.
6	Setting Knob	Sets altimeter mechanism for changing barometric pressure. Setting is indicated by altimeter setting display (5).
		B STANDBY ATTITUDE INDICATOR
7	Bank Index	Reference point for true vertical.
8	Bank Scale	Reading opposite bank index is roll attitude of airplane. Scale graduations are 10°, 20°, 30°, 60°, 90°.
9	Pitch Scale	Horizon (zero pitch line) is horizontal reference. Reading at airplane symbol indicates airplane pitch attitude. Long scale graduations are 10 degree increments. Short graduations are 5 degree increments.

Figure 1-98 (Sheet 2 of 4)

Miscellaneous Instruments (Continued)

NO.	CONTROL/INDICATOR	FUNCTION
10	Airplane Symbol	Provides airplane horizontal reference.
11	Pitch Adjustment and Caging Knob (Caging Knob)	When rotated, moves airplane symbol up or down to get Caging Knob zero pitch reference. When pulled, cages sphere to airplane vertical and zero pitch indication. Normally pushed in.
12	Warning Flag	When in view, indicates caging knob is pulled or power to indicator has failed. Power is supplied from the EDC bus.

C STANDBY COMPASS

13	Compass	Magnetic compass, graduated in 10 degree increments.
14	Compass Correction Card	Indicates compass corrections.

NOTE

Compass is calibrated with landing gear lever lock solenoid energized (flight condition). Compass can show up to 10 degrees error on ground due to magnetic effects of lock solenoid.

D CLOCKS

15	Winding and Setting Knob	When rotated, winds clock mechanism. When pulled and rotated sets clock.
16	Sweep Second Hand	Indicates seconds of elapsed time. Controlled by sweep hand control (17).
17	Sweep Hand Control	When pressed, starts sweep second hand (16). When pressed again, stops sweep second hand. When pressed third time, resets hand to zero.

E TOTAL AIR TEMPERATURE GAGE

18	Temperature Display	Indicates outside total air temperature in degrees centigrade. Temperature is sensed by total air temperature probe.

NOTE

Probe is heated. If probe heat is on and airplane is parked, the temperature reading is inaccurate.

19	Warning Flag	When in view, indicates that power to gage has failed.

Figure 1-98 (Sheet 3 of 4)

NO.	CONTROL/INDICATOR	FUNCTION
	F ACCELEROMETER	
20	Maximum Positive G Pointer	Records maximum positive G attained in flight. Resets to 1 when reset button is pressed.
21	Maximum Negative G Pointer	Records maximum negative G attained in flight. Resets to 1 when reset button is pressed.
22	PUSH TO SET (Reset) Button	When pressed, resets maximum positive and negative G pointers to position of G pointer.
23	G Pointer	Provides instantaneous readout of load factor (G force) currently acting at the instrument.
24	G Scale	Displays load factor in G units between –2 and 4 Gs.

Figure 1-98 (Sheet 4 of 4)

CLOCKS

Clocks are provided at both pilot stations (*figures 1-4* and *1-98*), the flight engineer's station (*figure 1-11*), and the navigator's station (*figure 1-15*). Clock controls are shown in *figure 1-98*.

ACCELEROMETER

An accelerometer (*figure 1-98*), graduated in g units, is provided on the pilot's instrument panel. The instrument has a main pointer, showing the current vertical acceleration value. Two auxiliary pointers indicate the maximum value of positive (+g) or negative (–g) acceleration at the instrument. A reset button allows the auxiliary pointers to be reset to the main pointer. In normal straight and level flight the instrument should indicate +1g.

ATTITUDE AND HEADING REFERENCES

All airplane systems that require an attitude or heading input receive this information from one of two sources, either the Attitude Heading Reference System (AHRS) or the GINS. Certain airplane systems, such as the compasses, receive inputs from only one system; while others, such as the weather radar, Attitude Director Indicators (ADI) and Horizontal Situation Indicators (HSI), can be switched between the two systems. A schematic of the attitude and heading references signal flow is shown in *figure 1-99*. Refer to NAVIGATION EQUIPMENT for a description of the GINS.

ATTITUDE HEADING REFERENCE SYSTEMS

There are two attitude heading reference systems installed on each airplane. These are designated AHRS No. 1 and AHRS No. 2. Each AHRS provides pitch, roll, and magnetic heading information for display and as an input to certain navigation equipment. Each AHRS consists of an attitude/directional gyro, rate gyro, compass adapter, associated amplifiers and switching networks, and a compass controller. The controller only provides limited control of the directional gyro. All other functions of the AHRS are automatic once power is applied. All AHRS components, except the control panels and magnetic azimuth detectors (flux valve), are located in equipment rack E1. See *figure 1-100*.

The controllers (6, *figures 1-7* and *1-101*) are located on the overhead control panel. B The flux valves are located in the left wing tip. ◀ C Flux valves are in the base of the vertical fin. ◀ Each AHRS requires 115V AC, 3-phase power for proper operation. AHRS No. 1 is powered when FAAC bus 1 is powered. AHRS No. 2 is powered when FAAC bus 2 is powered.

NOTE

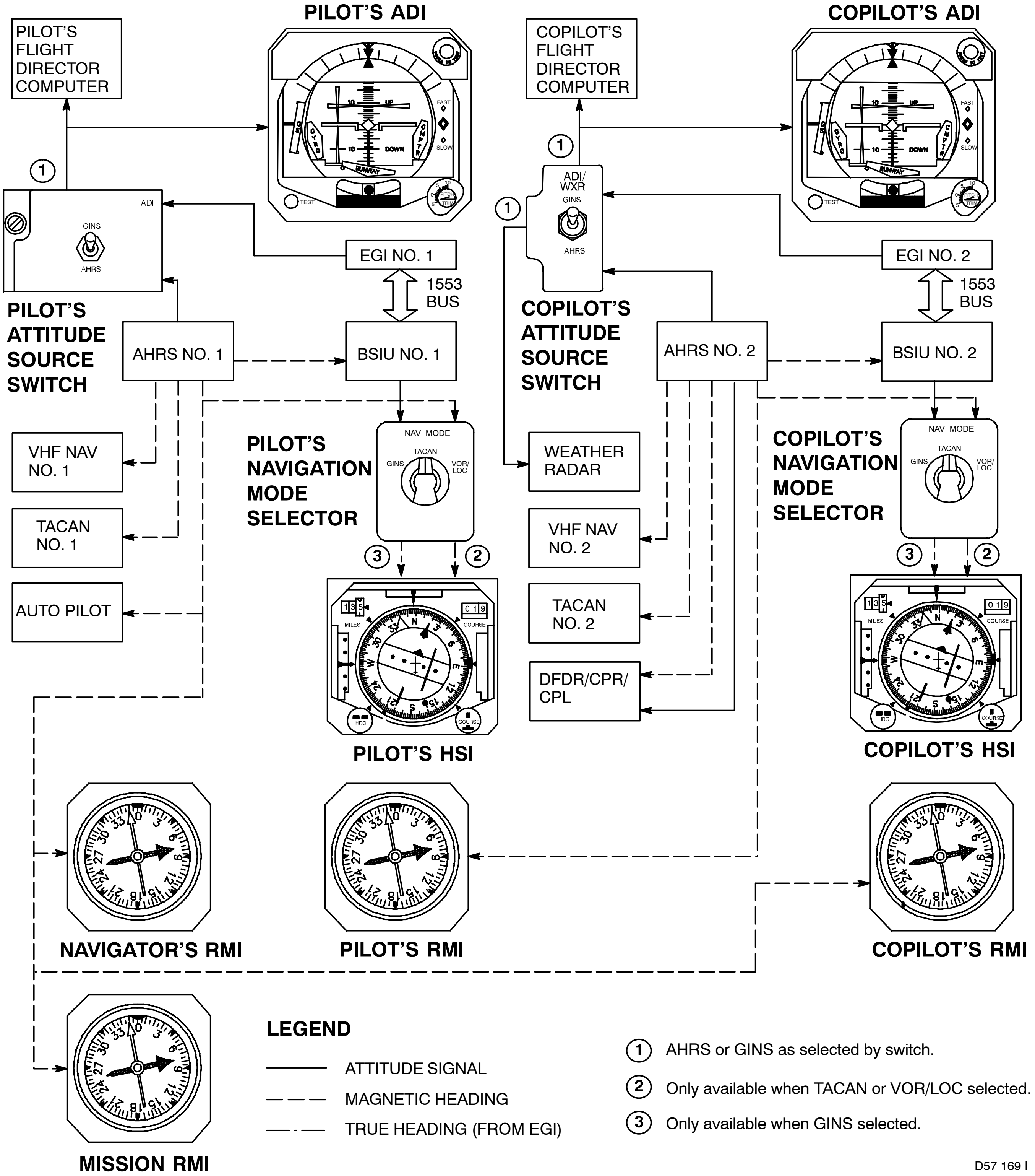
- If AHRS attitude synchro power is lost (GYRO flag visible on ADI) an INS DATA INVALID signal is sent to the GINS. Check the NO 1 ATTD XFMR AC and XFMR ATTD ØA circuit breakers on P5 panel (*figure 1-43*).
- If one ADI is using AHRS as attitude source and one is using GINS , the two indicators do not always show exactly the same pitch and roll values, especially in turns.
- After prolonged turns, ensure AHRS is synchronized (SYNC-IND pointer centered) prior to use as a heading reference.
- If AHRS NO 1 fails, disconnect the AHRS inputs from the autopilot by opening FLIGHT INSTRUMENTS NO 1 – AHRS circuit breaker on the P5 panel. Set both the pilot's ADI attitude source selector switch and the pilot's navigation mode selector switch to GINS . Switch the autopilot mode selector switch to NAV/LOC. With a fully operational GINS providing inputs to the autopilot, the autopilot can be engaged and operated in all modes (including pattern steering and waypoint steering) except HDG.
- If either AHRS fails, the signals routed to the appropriate ADI and HSI are erroneous and GINS should be used to provide signals to the ADI and the HSI. To prevent confusion, open the appropriate FLIGHT INSTRUMENT – AHRS circuit breaker on the P5 panel. Verify that ADI is working by pressing the ADI TEST button. Switch the appropriate ADI attitude source selector switch and the NAV MODE selector switch to GINS . Verify that warning flags are out of view.

The number one AHRS provides pitch and roll data to the pilot's ADI and flight director if the pilot's attitude source (ADI) switch (*figure 1-102*) is set to AHRS. The No. 1 AHRS rate gyro also provides the input to the pilot's ADI turn needle. Magnetic heading data from the No. 1 AHRS is sent to TACAN and VHF Nav one, autopilot, and GINS. These magnetic heading signals are displayed on the copilot's, navigator's, and mission RMIs, and when the pilot's NAV MODE selector is set to TACAN or VOR/LOC, they are also displayed on the pilot's HSI.

The number two AHRS provides pitch and roll data to the copilot's ADI and flight director if the copilot's attitude source (ADI) switch (*figure 1-102*) is set to AHRS. The number two AHRS also supplies pitch and roll data to the weather radar and flight data recorder. The number two AHRS rate gyro provides the input to the copilot's ADI turn needle. Magnetic heading data from the number two AHRS is sent to TACAN and VHF NAV two, flight recorder, and GINS . Number two AHRS magnetic heading data is displayed on the pilot's RMI, and when the copilot's NAV MODE selector is set to TACAN or VOR/LOC, on the copilot's HSI. For a complete description of the AHRS signal switching, refer to NAVIGATION SYSTEMS INSTRUMENT SWITCHING.

Heading flag appears if AHRS heading input is lost or 26 vac synchro power is lost or dc power to the indicator is lost. The RMI annunciators illuminate when a valid TACAN or VOR signal is present and selected. If TACAN or VOR signal is selected and the appropriate annunciator fails to illuminate, the signal is not being received. This indicates a possible failure of the selected radio.

Attitude and Heading References Signal Flow



LEGEND

———	ATTITUDE SIGNAL
— — —	MAGNETIC HEADING
—·—	TRUE HEADING (FROM EGI)

① AHRS or GINS as selected by switch.

② Only available when TACAN or VOR/LOC selected.

③ Only available when GINS selected.

Figure 1-99

AHRS Equipment

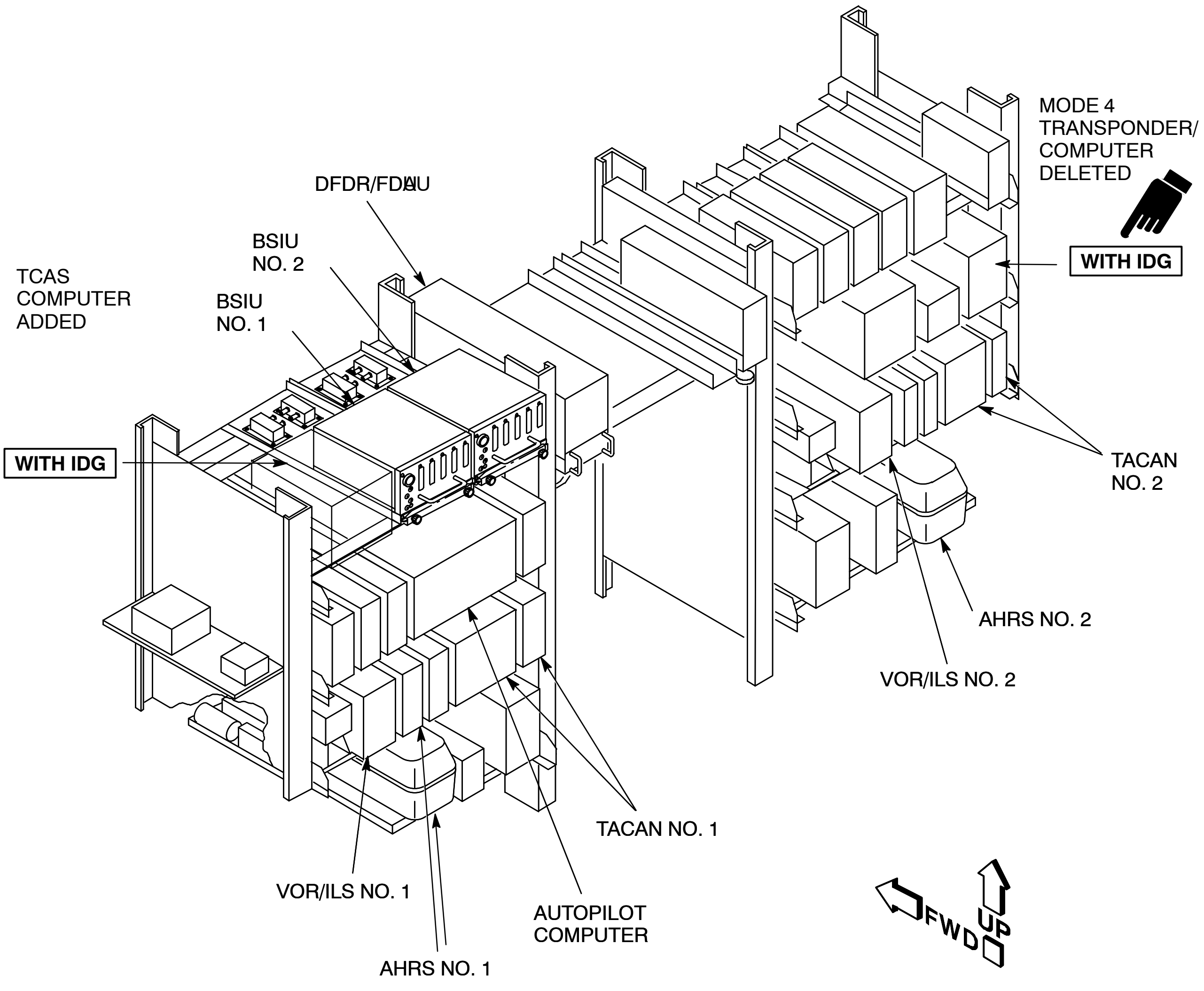
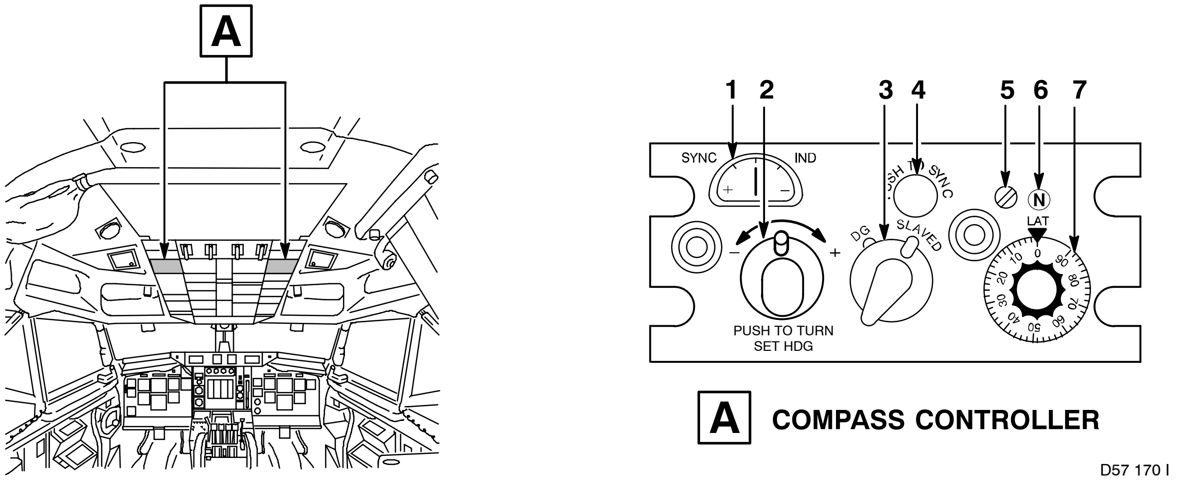


Figure 1-100

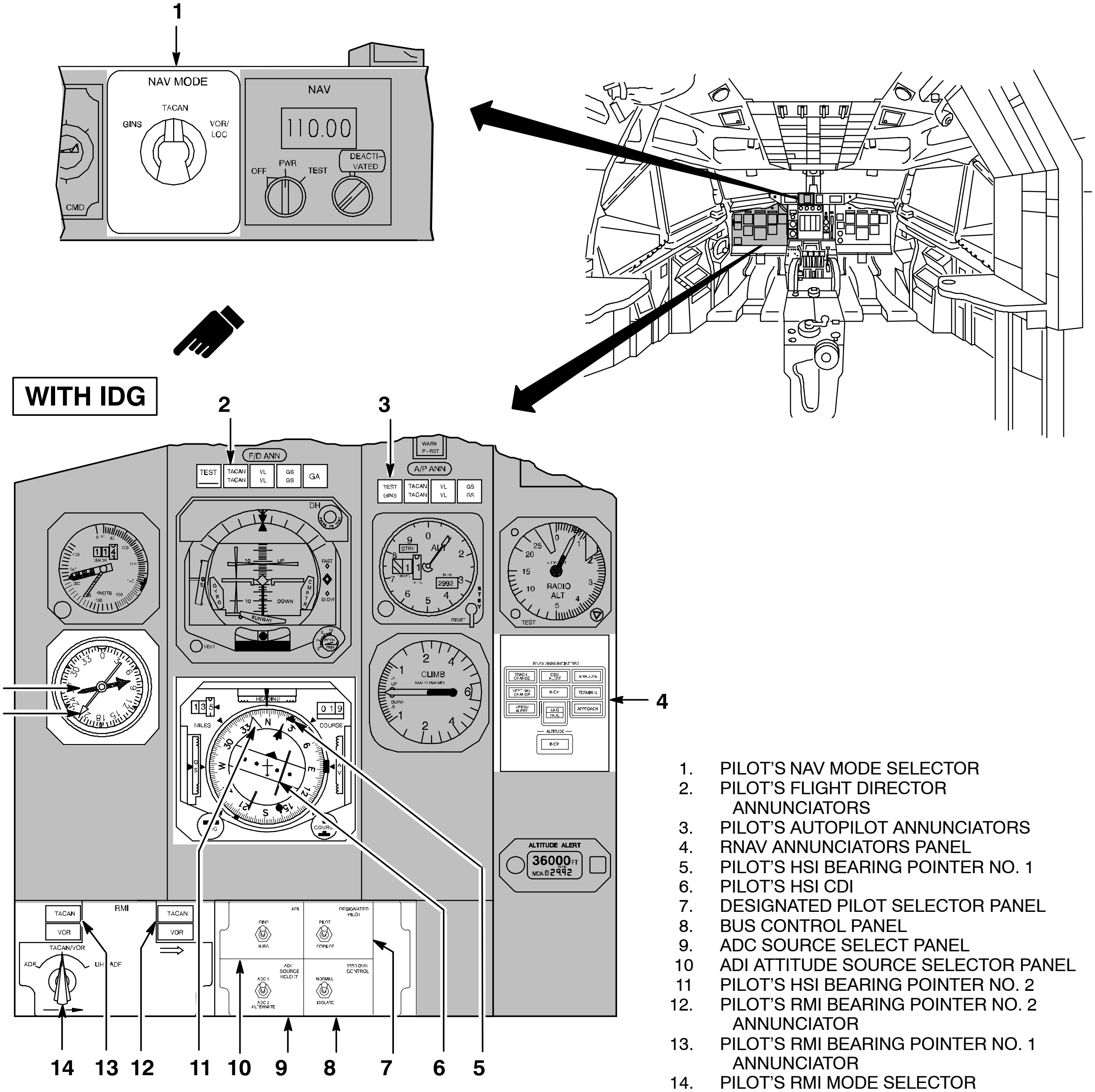
Compass Controllers



NO.	CONTROL/INDICATOR	FUNCTION
1	SYNC IND (Synchronization Indicator)	Indicates direction of gyro slaving signal. Pointer is displaced to + or – when gyro is not synchronized. Pointer at mark midway between + and – indicates gyro is synchronized. Indicator is inoperative in DG mode.
2	SET HDG (Heading Control)	Rotary control spring loaded to center position. Provides manual setting of heading on using equipment and displays. Selected heading is displayed by pointer on HSIs and RMIs. Slewing speed is proportional to displacement of control. If depressed in SLAVED mode, synchronization is lost.
3	DG–SLAVED Switch	Provides selection of desired mode of system operation.
	DG	Heading reference maintained by stability of free running directional gyro. Used for grid navigation.
	SLAVED	Heading reference maintained by slaving directional gyro signal to magnetic field of the earth.
4	PUSH TO SYNC Switch	Used to achieve fast synchronization of the azimuth system to flux valve heading signal when operating in SLAVED mode. Depress and hold until the SYNC IND pointer is centered between + and – symbols.
5	Hemisphere Selector	Used to select direction of latitude compensation. Set by screwdriver. N or S, used in respective hemisphere, is displayed in indicator above latitude control.
6	Hemisphere Indicator	Displays N or S as set by hemisphere selector.
7	LAT (Latitude Control)	Used to set latitude for compensation in DG mode. Reduces directional gyro apparent precession due to earth's rotation. Set as appropriate for operating latitude.

Figure 1-101

Navigation Systems Instrument Switches, Indicators, and Annunciators



1. PILOT'S NAV MODE SELECTOR
2. PILOT'S FLIGHT DIRECTOR ANNUNCIATORS
3. PILOT'S AUTOPILOT ANNUNCIATORS
4. RNAV ANNUNCIATORS PANEL
5. PILOT'S HSI BEARING POINTER NO. 1
6. PILOT'S HSI CDI
7. DESIGNATED PILOT SELECTOR PANEL
8. BUS CONTROL PANEL
9. ADC SOURCE SELECT PANEL
10 ADI ATTITUDE SOURCE SELECTOR PANEL
11 PILOT'S HSI BEARING POINTER NO. 2
12. PILOT'S RMI BEARING POINTER NO. 2 ANNUNCIATOR
13. PILOT'S RMI BEARING POINTER NO. 1 ANNUNCIATOR
14. PILOT'S RMI MODE SELECTOR
15. PILOT'S RMI BEARING POINTER NO. 1
16. PILOT'S RMI BEARING POINTER NO. 2

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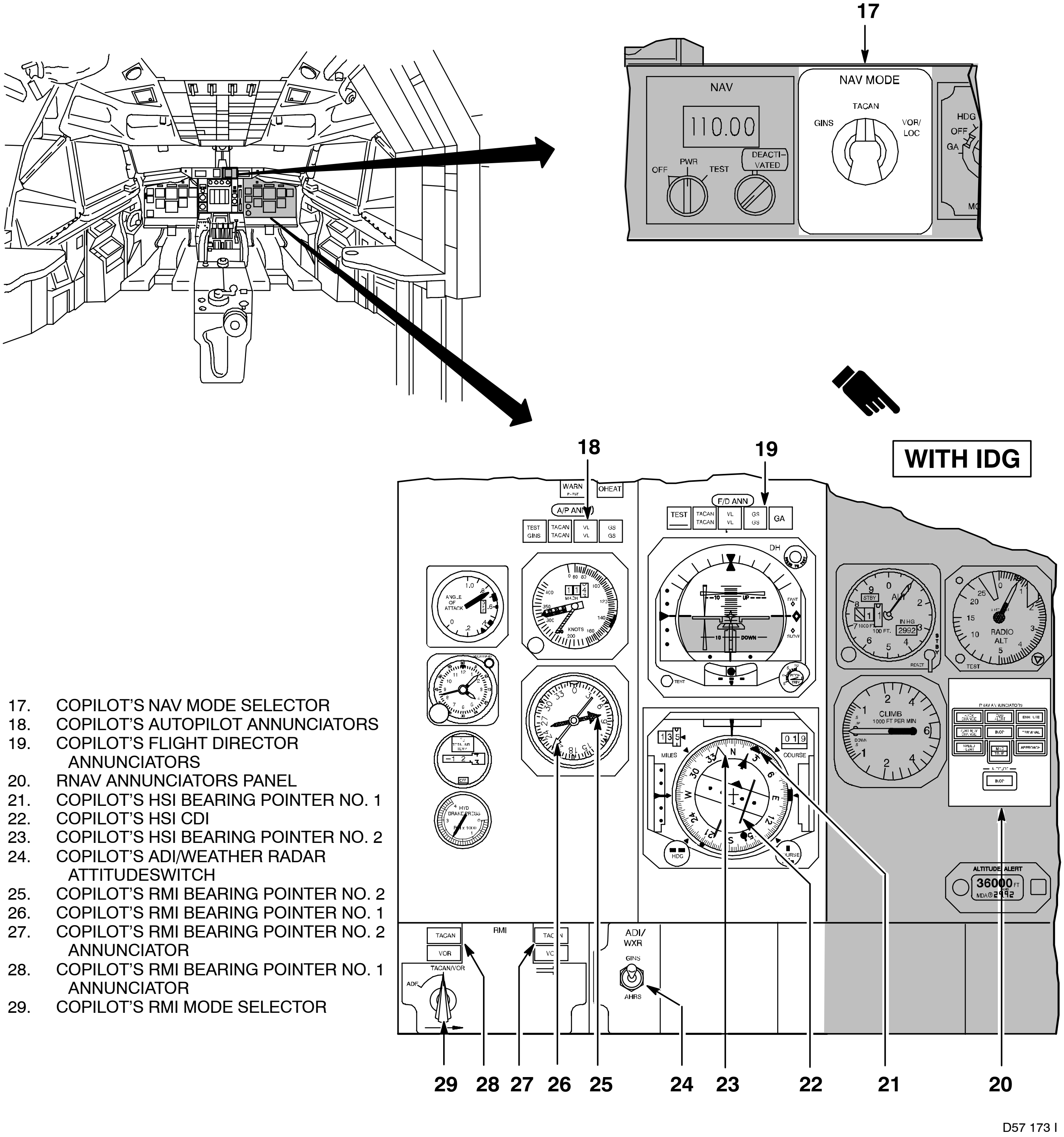
Figure 1-102 (Sheet 1 of 2)



17. COPILOT'S NAV MODE SELECTOR
18. COPILOT'S AUTOPILOT ANNUNCIATORS
19. COPILOT'S FLIGHT DIRECTOR ANNUNCIATORS
20. RNAV ANNUNCIATORS PANEL
21. COPILOT'S HSI BEARING POINTER NO. 1
22. COPILOT'S HSI CDI
23. COPILOT'S HSI BEARING POINTER NO. 2
24. COPILOT'S ADI/WEATHER RADAR ATTITUDESWITCH
25. COPILOT'S RMI BEARING POINTER NO. 2
26. COPILOT'S RMI BEARING POINTER NO. 1
27. COPILOT'S RMI BEARING POINTER NO. 2 ANNUNCIATOR
28. COPILOT'S RMI BEARING POINTER NO. 1 ANNUNCIATOR
29. COPILOT'S RMI MODE SELECTOR

Figure 1-102 (Sheet 2 of 2)

RADIO MAGNETIC INDICATOR (RMI)

Three RMIs are installed, one each at the pilot's, copilot's and navigator's stations. The navigation station RMI signal source is controlled by switches on the navigator's panel. TACAN bearing is supplied to the pilot and copilot RMI bearing pointer number two if the NAV MODE selectors are set to VOR/LOC or GINS . The number one needle on the pilot and copilot respective RMIs receives TACAN bearing if the NAV MODE selectors are set to VOR/LOC or GINS and the RMI mode selectors are set to TACAN/VOR. Both the pilot and copilot can select ADF for display on their respective RMI number one bearing pointer by setting their RMI mode selectors to ADF. Only the pilot's RMI displays UHF-ADF. This is done by setting the pilot's RMI mode selector to UHF/ADF.

NOTE

- As shown in *figure 1-99*, each pilot's RMI receives heading information from the other pilot's AHRS.
- Interference with the TACAN can occur during JTIDS operation, particularly in the high power mode. This interference can result in loss of TACAN bearing lock-on, but DME is not affected. If this interference is degrading operation, and bearing information is needed, request the CSO/CT reduce the time slot recurrence rate. For additional information about JTIDS, refer to T.O. 1E-3A-43-1-1.

COMPASS CONTROLLERS

Two compass controllers (6, *figure 1-7* and *figure 1-101*) provide controls for setting the compass portion of the AHRS (left controller – AHRS NO 1, right controller – AHRS NO 2). Operation of the controller is conventional. When setting the latitude for unslaved compass operation, the N-S switch above the LAT knob must be set with a screwdriver to the proper value. The DG-SLAVED switch allows selection of slaved or free gyro operation. The SET HDG switch allows setting the compass card to any desired reference heading. The PUSH to SYNC pushbutton provides fast slaving capability.

NOTE

- When the airplane is in a turn, it is possible for the two compass systems to indicate as much as 10° difference in heading.
- During air refueling operations at high latitudes, where tankers must use USAF grid navigation, pilot's compass (pilot's HSI, copilot's RMI, and navigator's RMI) will be operated in DG mode and referenced to grid. Refer to GRID NAVIGATION in Section IV.
- When changing to grid navigation, the autopilot must be in GINS mode or disengaged.
- If it is desired to operate both compass systems in grid, complete change to grid on one compass, before changing second compass.

To change from slaved to DG mode:

1. Set pilot's NAV MODE selector to GINS .
2. Change pilot's compass controller switch to DG.
3. Use SET HDG switch to set desired headings.
4. Engage autopilot in MAN or HDG mode to fly grid headings. NAV LOC mode may be used with GINS if desired (autopilot receives true heading from GINS). AHRS heading is sent to TACAN and VHF Nav one, autopilot, and GINS .

NAVIGATION SYSTEMS INSTRUMENT SWITCHING

Selector switches located on the glare shield (1 and 17 , *figure 1-102*) and on the pilot's and copilot's instrument panel (10, 14, 24 and 29) allow selection of VOR, TACAN, GINS or AHRS outputs for use by the flight directors, flight instruments, and autopilot. There are no provisions for cross-switching the copilot's (number two) radios to the autopilot. The following sections describe each of the selector switches and its functions. See *figure 1-103* for a tabular presentation of the switch positions and the resulting display indications.

PILOT'S NAV MODE SELECTOR

The pilot's NAV MODE selector (1 , *figure 1-102*) controls the signal source for the autopilot steering input, pilot's HSI and RMI, and the pilot's flight director. The pilot's NAV MODE selector and RNAV ANNUNCIATOR PANEL MAG/TRUE switch also control selection of magnetic heading or true heading output from GINS. See *figure 1-104* for detailed information on HSI displays with NAV MODE selector set to each position.

GINS Position

When set to GINS, the pilot's NAV MODE selector causes the source of navigation data shown on the pilot's flight instruments to be the pilot's (No. 1) EGI and BSIU. It also enables MAG/TRUE mode selection at pilot's (only) RNAV ANNUNCIATORS panel. In GINS mode, the selector routes steering signals from steering solution source selected on DESIGNATED PILOT panel (7, *figure 1-102*), to the autopilot. Flight director pitch commands are not displayed by the ADI, except in ALT HOLD or GA mode and roll commands are not displayed on the ADI, except in HDG mode. Also, in the GINS position, the NAV MODE selector limits the choice of inputs to the pilot's RMI bearing pointer number one (15, *figure 1-102*) to either ADF signals or signals from number one TACAN set or UHF/ADF signals; and automatically routes TACAN two signals to the pilot's RMI bearing pointer number two (16), which causes the pilot's RMI bearing pointer number two annunciator (12) TACAN indicator to illuminate. The position of the pilot's RMI mode selector (14), (refer to description of pilot's RMI mode selector) determines whether the ADF or TACAN or UHF/ADF signal is actually displayed by the pilot's RMI bearing pointer number one (15). If the pilot's RMI mode selector is set to TACAN/VOR, with the pilot's NAV MODE selector set to GINS, TACAN one signals are routed to the pilot's RMI bearing pointer number one (15), which causes the pilot's RMI bearing pointer number one TACAN annunciator (13), to illuminate.

TACAN Position

When set to TACAN, the NAV MODE selector routes TACAN one signals to the autopilot, pilot's flight director, pilot's HSI bearing pointer number one (5, *figure 1-102*) and CDI (6), and illuminates the pilot's flight director annunciator (3), TACAN indicator. AHRS number one magnetic heading data is sent to the autopilot and the pilot's HSI compass card when the pilot's NAV MODE selector is set to TACAN. In the TACAN position, the NAV MODE selector routes TACAN two signals to the pilot's HSI bearing pointer number two (11), and number two VHF NAV set VOR signals to the pilot's RMI bearing pointer number two (16), which causes the pilot's RMI bearing pointer number two annunciator (12), VOR indicator to illuminate. Also, when in the TACAN position, the NAV MODE selector limits the choice of inputs to the pilot's RMI bearing pointer number one (15), to either ADF signals, or VOR signals from VHF NAV number one, or UHF/ADF signals. The position of the pilot's RMI mode selector (14), (refer to description of pilot's RMI mode selector) actually determines whether ADF or VOR or UHF/ADF signals are routed to the pilot's RMI bearing pointer number one. If the pilot's RMI mode selector is set to TACAN/VOR, with the NAV MODE selector set to TACAN, VOR signals from the number one VHF NAV set are routed to the pilot's RMI bearing pointer number one, which causes the pilot's RMI bearing pointer number one annunciator (13), VOR indicator to illuminate.

Navigation Signal Source Selection

SELECTOR SWITCHES		PILOT'S NAV MODE SELECTOR POSITION			PILOT'S NAVIGATION EQUIPMENT AND INDICATORS
		GINS	TACAN	VOR/LOC	
		GINS 1 Bearing to Waypoint	TACAN 1 Bearing	VHF NAV 1 Bearing If VOR Frequency Is Tuned. Unreliable If Localizer Frequency Is Tuned. ①	HSI Bearing Pointer No 1
		GINS 1 Bearing to Waypoint	TACAN 2 Bearing	VHF NAV 2 Bearing If VOR Frequency Is Tuned. Unreliable If Localizer Frequency Is Tuned. ①	HSI Bearing Pointer No 2
		GINS 1 Cross Track Deviation	TACAN 1 Course Deviation	VHF NAV 1 (Or Localizer 1) Course Deviation	HSI CDI
		GINS 1 Distance to Waypoint	TACAN Distance	TACAN Distance	HSI Distance Display
PILOT MAG/ TRUE SEL	**TRUE**	True Heading	Magnetic Heading or DG	Magnetic Heading or DG	HSI Lubber Line
	MAG	Mag Heading			
(NO SWITCH)		Off, Except GA, ALT HOLD, And HDG Mode	TACAN 1	VHF NAV 1	Flight Director
DESIGNATED PILOT SELECTOR POSITION	**PILOT**	②	TACAN 1	VHF NAV 1	Autopilot Steering
	COPILOT	③	TACAN 1	VHF NAV 1	
RMI MODE SELECTOR POSITION	**ADF**	ADF Bearing	ADF Bearing	ADF Bearing	RMI Bearing Pointer No 1
	TACAN/VOR	TACAN 1 Bearing	VHF NAV 1	TACAN 1 Bearing	
	UHF/ADF	UHF/ADF	UHF/ADF	UHF/ADF	
(NO SWITCH)		TACAN 2 Bearing	VHF NAV 2 Bearing	TACAN 2 Bearing	RMI Bearing Pointer No 2

① Pointer stowed at 3 o'clock position if localizer is tuned.
② Based on pilot selected navigation solution and active flight plan.
③ Based on copilot selected navigation solution and active flight plan.

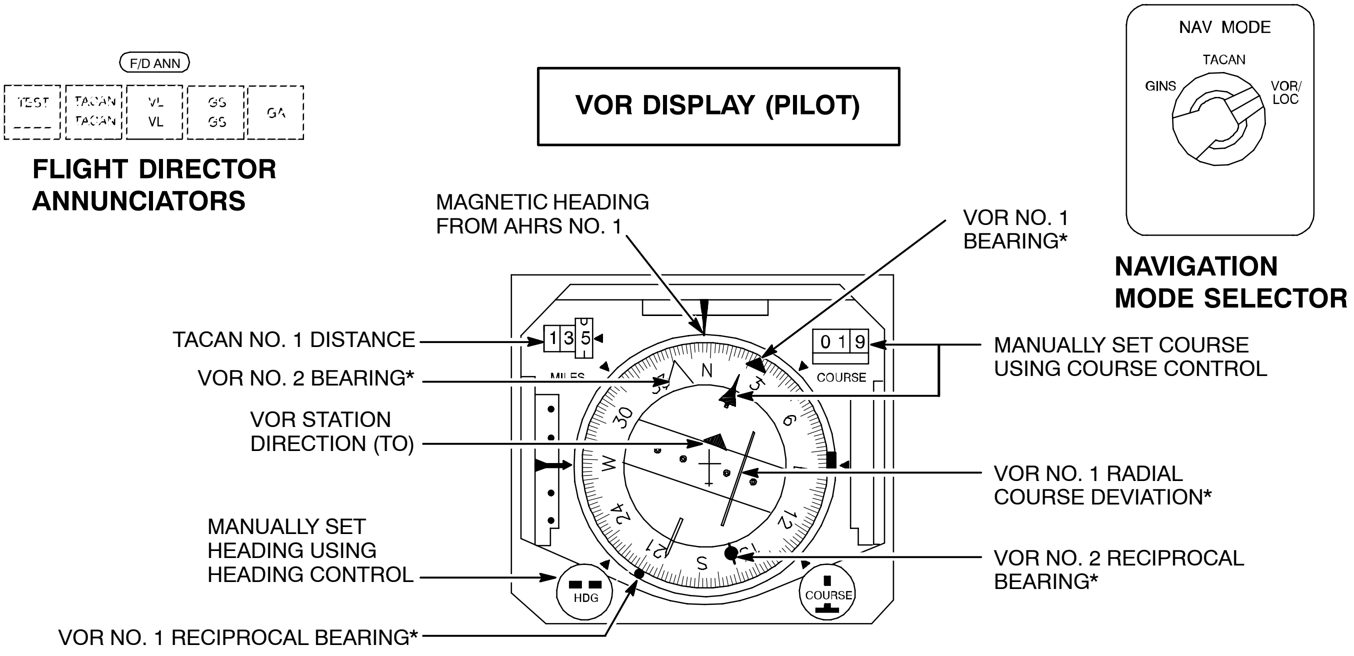
Figure 1-103 ((Sheet 1 of 2)

SELECTOR SWITCHES		**COPILOT'S NAV MODE SELECTOR POSITION**			**COPILOT'S NAVIGATION EQUIPMENT AND INDICATORS**
		GINS	**TACAN**	**VOR/LOC**	
		GINS 2 Bearing to Waypoint	TACAN 1 Bearing	VHF NAV 1 Bearing If VOR Frequency Is Tuned. Unreliable If Localizer Frequency Is Tuned. ①	HSI Bearing Pointer No 1
		GINS 2 Bearing to Waypoint	TACAN 2 Bearing	VHF NAV 2 Bearing If VOR Frequency Is Tuned. Unreliable If Localizer Frequency Is Tuned. ①	HSI Bearing Pointer No 2
		GINS 2 Cross Track Deviation	TACAN 2 Course Deviation	VHF NAV 2 (Or Localizer 2) Course Deviation	HSI CDI
		GINS 2 Distance to Waypoint	TACAN Distance	TACAN Distance	HSI Distance Display
PILOT MAG/ TRUE SEL	**TRUE**	True Heading	MAGNETIC Heading or DG	MAGNETIC Heading or DG	HSI Lubber Line
	MAG	Mag Heading			
(NO SWITCH)		Off, Except GA, ALT HOLD, And HDG Mode	TACAN 2	VHF NAV 2	Flight Director
RMI MODE SELECTOR POSITION	**ADF**	ADF Bearing	ADF Bearing	ADF Bearing	RMI Bearing Pointer No 1
	TACAN/VOR	TACAN 1 Bearing	VHF NAV 1 Bearing	TACAN 1 Bearing	
(NO SWITCH)		TACAN 2 Bearing	VHF NAV 2 Bearing	TACAN 2 Bearing	RMI Bearing Pointer No 2

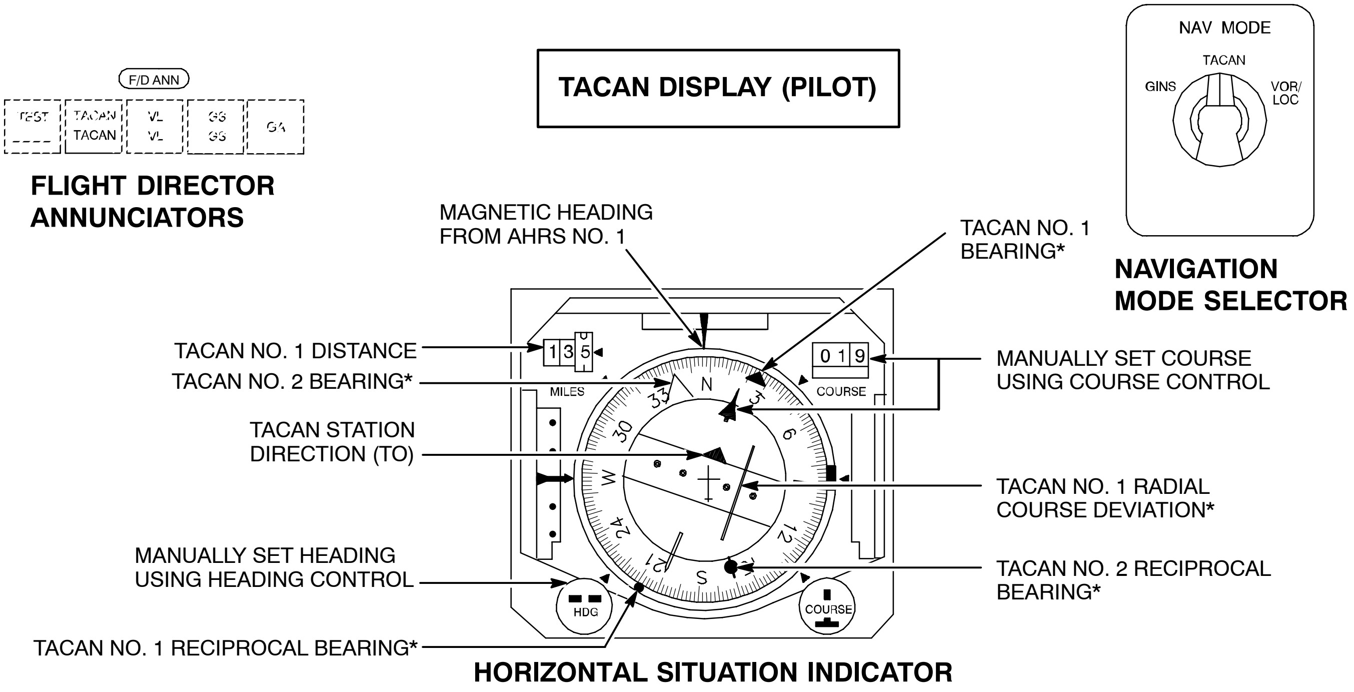
① Pointer stowed at 3 o'clock position if localizer is tuned.

Figure 1-103 (Sheet 2 of 2)

Horizontal Situation Indicator Displays



*On copilots HSI: No. 1 bearing pointer receives inputs from No. 1 VHF radio, CDI represents VHF NAV No. 2 course deviation, bearing pointer No. 2 receives inputs from VHF NAV set No. 2, magnetic heading is from AHRS No. 2.



*On copilots HSI: No. 1 bearing pointer receives inputs from No. 1 TACAN set, CDI represents TACAN No. 2 course deviation, bearing pointer No. 2 receives inputs from TACAN set No. 2, magnetic heading is from AHRS No. 2.

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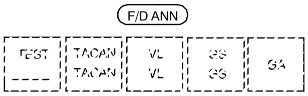
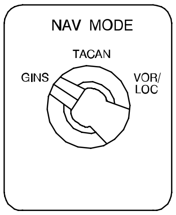
Figure 1-104 (Sheet 1 of 2)

Horizontal Situation Indicator Displays (Continued)

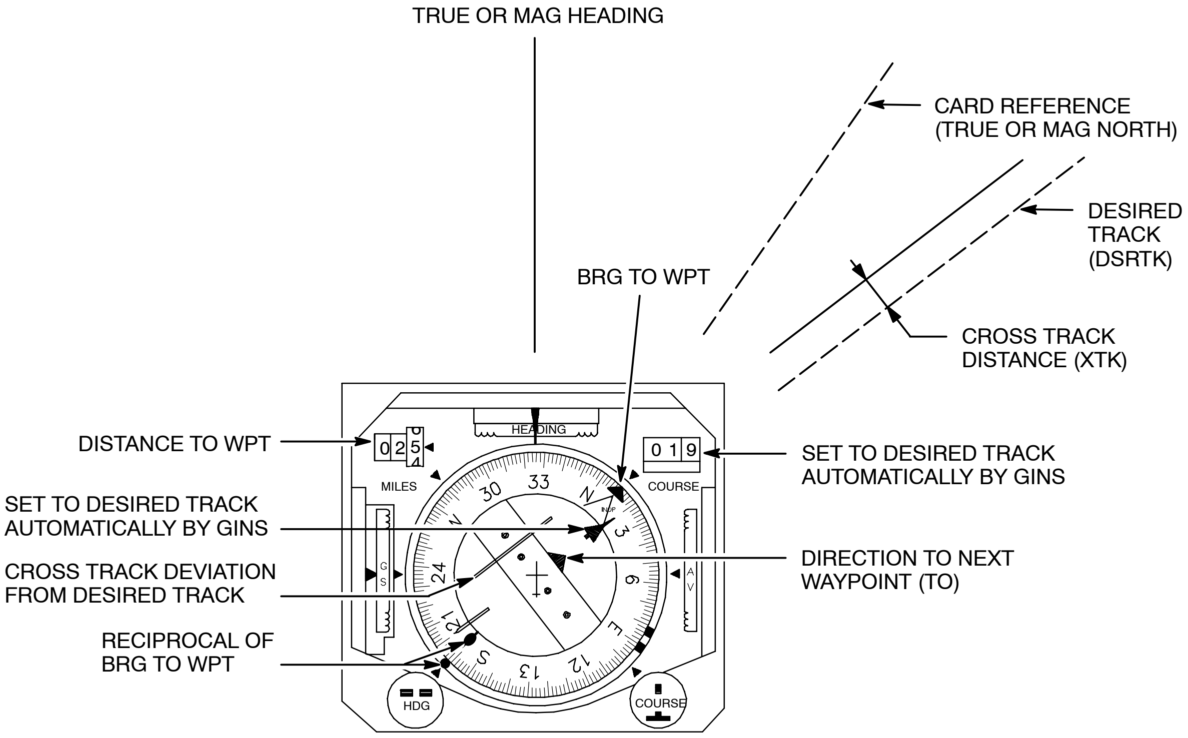
GINS DISPLAY*



FLIGHT DIRECTOR ANNUNCIATORS



NAVIGATION MODE SELECTOR



HORIZONTAL SITUATION INDICATOR

*For pilot HSI all GINS inputs are from EGI 1. For copilot HSI all inputs are from EGI 2.

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Figure 1-104 (Sheet 2 of 2)

VOR/LOC Position

When set to VOR/LOC, the NAV MODE selector routes signals from VHF NAV set number one to the autopilot, pilot's flight director, HSI bearing pointer number one (5, *figure 1-102*) and CDI (6) and causes pilot's flight director annunciator (3), VL indicator to illuminate. AHRS number one magnetic heading data is sent to the autopilot and pilot's HSI compass card when the pilot's NAV MODE selector is set to VOR/LOC. In the VOR/LOC position, the NAV MODE selector routes VHF NAV set number two VOR signals to the pilot's HSI bearing pointer number two (11), and TACAN set two signals to the pilot's RMI bearing pointer number two (16), which causes the pilot's RMI bearing pointer number two annunciator (12), TACAN indicator to illuminate. Also, when in the VOR/LOC position, the NAV MODE selector limits the choice of inputs to the pilot's RMI bearing pointer number one to either ADF inputs, signals from the number one TACAN, or UHF/ADF signals. The position of the pilot's RMI mode selector (14) (refer to description of pilot's RMI mode selector) determines whether ADF or TACAN or UHF/ADF signals are routed to the pilot's RMI bearing pointer number one. If the pilot's RMI mode selector is set to TACAN/VOR with the NAV MODE selector set to VOR/LOC, signals from the number one TACAN set are routed to the pilot's RMI bearing pointer number one (15), which causes the pilot's RMI bearing pointer number one annunciator (13), TACAN indicator to illuminate.

NOTE

Interference with the TACAN can occur during JTIDS operation particularly in the high power mode. This interference can result in loss of TACAN bearing lock-on, but DME is not affected. If this interference is degrading operation, and bearing information is needed, request the ST/CT reduce the time slot recurrence rate. For additional information about JTIDS, refer to T.O. 1E-3A-43-1-1.

PILOT'S RMI MODE SELECTOR

The pilot's RMI mode selector (14, *figure 1-102*) selects input signals for display on the pilot's RMI bearing pointer number one (15), from sources other than those determined by the pilot's NAV MODE selector. The selector has three positions, ADF, TACAN/VOR, and UHF/ADF. When set to ADF, signals from the ADF set are routed to the pilot's RMI bearing pointer number one, regardless of the pilot's NAV MODE selector setting. When set to TACAN/VOR, the pilot's NAV MODE selector determines whether VOR or TACAN data is displayed and causes the appropriate pilot's RMI bearing pointer number one annunciator to illuminate if a reliable signal is received. (Refer to pilot's NAV MODE selector description.) When set to UHF/ADF, signals from the UHF/ADF are routed to the pilot's RMI bearing pointer number one, regardless of the pilot's NAV MODE selector setting.

PILOT'S ATTITUDE SOURCE (ADI) SWITCH

The pilot's ADI switch (10, *figure 1-102*) selects the attitude source for the pilot's ADI and flight director. When set to GINS , attitude signals from number one EGI are routed to the pilot's ADI and flight director. When set to AHRS, attitude signals from the number one AHRS are routed to the pilot's ADI and flight director.

WARNING

The ADI switch will be set to AHRS if inflight alignment of INU NO 1 is in progress. If AHRS NO 1 fails during inflight alignment of INU NO 1, pilot should select GINS on the ADI switch after the inflight alignment is complete. Exercise caution when using INU only/EGI blended navigation inputs until alignment is complete and INU checked.

AUTOPILOT EGI SOURCE SELECTION

The DESIGNATED PILOT switch (7, *figure 1-102*) selects either the pilot or copilot steering, and EGI 1 or EGI 2 attitude, to be sent to the autopilot. Each (pilot and copilot) steering can use any of the following basic navigational solutions: INAV 1, INAV 2, INU 1, INU 2, GPS 1, or GPS 2. The default (power up) selection is always the last one used. See INAV and STEER function in CDU Menus data, subsection I-N-3.

NOTE

- INUs can enter alignment at startup or due to operational event. Inflight alignment cannot be commanded by operator, but can occur automatically due to operational event.

- If an INU enters alignment from NAV MODE while in flight, and the affected INU is functioning in designated pilot navigation solution, CDU scratch pad displays INU 1 IFA or INU 2 IFA. If affected INU is not functioning in designated pilot navigation solution, annunciation is not posted, and ALIGN state shows on Inav page for affected INU.

COPILOT'S NAV MODE SELECTOR

The copilot's NAV MODE selector (17, *figure 1-102*) controls the radio signal source for the copilot's HSI, RMI, and flight director. See *figure 1-104* for detailed information on HSI displays with NAV MODE selector set to each position.

GINS Position

In GINS position, the NAV MODE selector routes EGI 2 and BSIU 2 signals (such as true heading and course deviation) to the copilot's HSI. Flight director pitch commands are not displayed by the ADI, except in ALT HOLD or GA mode and roll commands are not displayed on the ADI, except in HDG mode. In the GINS position, the NAV MODE selector limits the choice of inputs to the copilot's RMI bearing pointer number one (26, *figure 1-102*) to either ADF signals or signals from TACAN set number one, and automatically routes TACAN set two signals to the copilot's RMI bearing pointer number two (25), which causes the copilot's RMI bearing pointer number two annunciator (27), TACAN indicator to illuminate. The position of the copilot's RMI mode selector (29), (refer to description of copilot's RMI mode selector) determines whether the ADF or TACAN signal is displayed by the copilot's RMI bearing pointer number one (26). If the copilot's NAV MODE selector is set to GINS with the copilot's RMI mode selector set to TACAN/VOR, TACAN set one signals are routed to the copilot's RMI bearing pointer number one, which causes the copilot's RMI bearing pointer number one annunciator (28) TACAN indicator to illuminate.

TACAN Position

When set to TACAN, the copilot's NAV MODE selector routes signals from the number two TACAN set to the copilot's flight director, HSI bearing pointer number two (23, *figure 1-102*) and CDI (22), and illuminates the copilot's flight director annunciator (27), TACAN indicator. AHRS number two magnetic heading data is sent to the copilot's HSI compass card when the copilot's NAV MODE selector is set to TACAN. In the TACAN position, the NAV MODE selector routes TACAN one signals to the copilot's HSI bearing pointer number one (21) and VOR signals from the number two VHF NAV set to the copilot's RMI bearing pointer number two (25), which causes the copilot's RMI bearing pointer number two annunciator VOR indicator (27) to illuminate. Also, when in the TACAN position, the NAV MODE selector limits the choice of inputs to the copilot's RMI bearing pointer number one (26) to either ADF signals or VOR signals from the number one VHF NAV set. The position of the copilot's RMI mode selector (29) (refer to description of copilot's RMI mode selector) determines whether ADF or VOR signals are routed to the copilot's RMI bearing pointer number one. If the copilot's RMI mode selector is set to TACAN/VOR with the NAV MODE selector set to TACAN, VOR signals from the number one VHF NAV set are routed to the copilot's RMI bearing pointer number one, which causes the copilot's RMI bearing pointer number one annunciator (28) VOR indicator to illuminate.

VOR/LOC Position

When set to VOR/LOC, the copilot's NAV MODE selector routes VHF NAV set number two signals to the copilot's flight director, HSI bearing pointer number two (23, *figure 1-102*) and CDI (22) and illuminates the copilot's flight director annunciator (19) VL indicator. AHRS number two magnetic heading data is sent to the copilot's HSI compass card when the copilot's NAV MODE selector is set to VOR/LOC. In the VOR/LOC position, the NAV MODE selector routes VHF NAV set number one VOR signals to the copilot's HSI bearing pointer number one (26) and TACAN set two signals to the copilot's RMI bearing pointer number two (25), which causes the copilot's RMI bearing pointer number two annunciator (27) TACAN indicator to illuminate. Also, when in the VOR/LOC position, the NAV MODE selector limits the choice of inputs to the copilot's RMI bearing pointer number one to either ADF signals or signals from the number one TACAN set. The position of the copilot's RMI mode selector (29) (refer to description of copilot's RMI mode selector) determines whether ADF or TACAN signals are routed to the copilot's RMI bearing pointer number one. If the copilot's RMI mode selector is set to TACAN/VOR, with the NAV MODE selector set to VOR/LOC, signals from the number one TACAN set are routed to the copilot's RMI bearing pointer number one, which causes the copilot's RMI bearing pointer number one annunciator (28) TACAN indicator to illuminate.

COPILOT'S RMI MODE SELECTOR

The copilot's RMI mode selector (29, *figure 1-102*) selects input signals for display on the copilot's RMI bearing pointer number one (26), from sources other than those determined by the copilot's NAV MODE selector. The selector has two positions, ADF and TACAN/VOR. When set to ADF, signals from the ADF are routed to the copilot's RMI bearing pointer number one (26), regardless of the NAV MODE selector setting. When set to TACAN/VOR, the copilot's NAV MODE selector determines whether VOR or TACAN information is displayed and causes the appropriate copilot's RMI bearing pointer number one annunciator (28) indicator to illuminate if a reliable signal is received.

COPILOT'S ATTITUDE SOURCE (ADI/WXR) SWITCH

The copilot's ADI/WXR switch (24, *figure 1-101*) selects the attitude source for the copilot's ADI and flight director. When set to GINS , attitude signals from the EGI are routed to the copilot's ADI and flight director. When set to AHRS, attitude signals from the number two AHRS are routed to the copilot's ADI and flight director.

WARNING

The ADI/WXR switch will be set to AHRS if inflight alignment of INU NO 2 is in progress. If AHRS NO 2 fails during inflight alignment of INU NO 2, pilot should select GINS on the ADI switch after the inflight alignment is complete. Exercise caution when using INU only/EGI blended navigation inputs until alignment is complete and INU checked.

NOTE

- INUs can enter alignment at startup or due to operational event. Inflight alignment cannot be commanded by operator, but can occur automatically due to operational event.

- If an INU enters alignment from NAV MODE while in flight, and the affected INU is functioning in designated pilot navigation solution, CDU scratch pad displays INU 1 IFA or INU 2 IFA. If affected INU is not functioning in designated pilot navigation solution, annunciation is not posted, and ALIGN state shows on Inav page for affected INU.

FLIGHT INSTRUMENT ELECTRIC POWER SOURCES

Electric power sources for the flight instruments are listed in *figure 1-105*.

Flight Instrument Electric Power Sources

EQUIPMENT/SYSTEM	TYPE OF POWER	POWER SOURCE	CIRCUIT BREAKER LOCATION/LABEL
Attitude Excitation, Pilot's Instruments	115V AC ①	EAC Bus	P5, NO 1 ATTD XFMR AC
Standby Attitude Indicator	28V DC	EDS Bus	P5, STBY ATTD IND
Pilot's Instrument Switching Relay	28V DC	EDC Bus	P5, XFR RELAY – CMDR INST
Copilot's Instrument Switching Relay	28V DC	EDC Bus	P5, XFR RELAY – PILOT INST
AHRS No. 1 ②	115V AC	FAAC Bus 1	P5, FLT INSTRUMENTS NO 1 – AHRS
AHRS No. 2 ②	115V AC	FAAC Bus 2	P5, FLT INSTRUMENTS NO 2 – AHRS
Flight Director Computer ②	115V AC	FAAC Bus 1	P5, FLT INSTRUMENTS NO 1 – FLT DIR – COMPTR ØA
	28V DC	FAVDC Bus 1	P5, FLT INSTRUMENTS NO 1 – FLT DIR – DC
Bearing Excitation, Pilot's Instruments ②	115V AC ①	FAAC Bus 1	P5, FLT INSTRUMENTS NO 1 – XFMR – BRG ØA
Hearing Excitation, Pilot's Instruments ②	115V AC ①	FAAC Bus 1	P5, FLT INSTRUMENTS NO 1 – XFMR – HDG ØA
WITH IDG TCAS Computer	115V AC	FAAC 1, ØA	P5, TCAS CMPTR
Pilot's TCAS Vertical Speed Indicator	115V AC	EAC Bus	P5, EMERGENCY FLIGHT AVIONICS – VSI/TA CMDR
Copilot's TCAS Vertical Speed Indicator	115V AC	EAC Bus	P5, EMERGENCY FLIGHT AVIONICS – VSI/TA PILOT ◄
Air Data Computer No. 2 (TAS and SAT gages) ②	115V AC	FAAC Bus 2	P5, AIR DATA – ØA
Air Data Computer No. 1	115V AC	FAAC Bus 1	P5, AIR DATA – ØA
Copilot's Flight Director Computer ②	115V AC	FAAC Bus 2	P5, FLT INSTRUMENTS NO 2 – FLT DIR – COMPTR ØA
	28V DC	FAVDC Bus 2	P5, FLT INSTRUMENTS NO 2 – FLT DIR – DC
Attitude Excitation, Copilot's Instruments ②	115V AC ①	FAAC Bus 2	P5, FLT INSTRUMENTS NO 2 – XFMR – ATTD ØA

Figure 1-105 (Sheet 1 of 2)

EQUIPMENT/SYSTEM	TYPE OF POWER	POWER SOURCE	CIRCUIT BREAKER LOCATION/LABEL
Bearing Excitation, Copilot's Instruments ②	115V AC ①	FAAC Bus 2	P5, FLT INSTRUMENTS NO 2 – XFMR – BRG ØA
Heading Excitation, Copilot's Instruments ②	115V AC ①	FAAC Bus 2	P5, FLT INSTRUMENTS NO 2 – XFMR – HDG ØA
Pilot's Altimeter Vibrator ②	28V DC	FAVDC Bus 1	P5, ALTM VIB NO 1
WITH IDG Altitude Alerter	28V AC	28V AC 2	P5, ALT ALERT CMDR AC
Altitude Alerter	28V AC	28V AC 8 DIST 1	P5, ALT ALERT PILOT AC
Altitude Alerter	28V DC	FAVDC 1	P5, ALT ALERT CMDR DC
Altitude Alerter	28V DC	FAVDC 2	P5, ALT ALERT PILOT DC ◀
Pilot's Angle of Attack System ②	28V DC	FAVDC Bus 1	P5, ANGLE ATTACK NO 1
Pilot's Turn Rate Needle ②	28V DC	FAVDC Bus 1	P5, FLT INSTRUMENTS NO 1 – TURN RATE DC
Copilot's Altimeter Vibrator ②	28V DC	FAVDC Bus 2	P5, ALTM VIB NO 2
Copilot's Turn Rate Needle ②	28V DC	FAVDC Bus 2	P5, FLT INSTRUMENTS NO 2 – TURN RATE DC
Copilot's Angle of Attack System ②	28V DC	FAVDC Bus 2	P5, ANGLE ATTACK NO 2
Total Air Temperature Gage ②	115V AC	AVAC Bus 4	P61-2 RT TAT & ANGLE ATTACK NO 2
Autopilot	115V AC	FAAC Bus 1	P5, AUTOPILOT 3Ø
Autopilot Warning Light	28V DC	EDC Bus	P5, AUTOPILOT WARN

① 115 VAC reduced to 26 VAC by transformers

② FLT AVIONICS BUS 1 and/or BUS 2 switches on AVIONICS POWER DISCONNECT panel control power to EQUIPMENT/SYSTEM circuit breakers referenced by this note.

Figure 1-105 (Sheet 2 of 2)

Pages 1–365 through 1–372 Deleted.

SUBSECTION I-K
FLIGHT DIRECTOR SYSTEM

Table of Contents

There are two independent flight director systems. Each flight director system has the following primary equipment: Attitude Director Indicator (ADI), Horizontal Situation Indicator (HSI), flight director controls, a steering computer containing separate pitch and roll computers, signal amplifier, and warning monitor circuits. Annunciators on the flight instrument panel display the mode of operation selected. See *figure 1-106* for a detailed explanation of the ADI, HSI, and flight director control panel.

Inputs are received from the following systems: VOR/ILS and TACAN navigation radio systems, low range radio altimeter system, marker beacon receiver GINS, central air data system, and Attitude Heading Reference System (AHRS).

FLIGHT DIRECTOR SYSTEM SIGNAL FLOW

The inputs to the flight director system from various navigation systems are shown in *figure 1-107*. When these inputs are processed in the steering computer, pitch and roll steering commands are displayed by the ADI pitch and roll steering bars to command the desired attitude for the mode of operation selected.

ROLL STEERING COMMANDS

The roll steering command signals are generated in the steering computer for display on the ADI roll steering bar. The signals are proportional in phase and amplitude to the direction and degree of roll necessary to fly the airplane to intercept or hold a selected course or heading. The steering computer generates a roll steering command from the heading error, course datum, bank attitude, and VOR, localizer or TACAN deviation signal inputs. The flight director operating mode determines which of these input signals are used in computing roll steering commands.

NOTE

- The signal, which causes ADI roll steering bar to extend, is removed by the flight director steering computer when the NAV MODE selector is set to GINS, and the flight director mode selector is set to any position other than GA or HDG or if the CMPTR flag is in view.
- Disregard roll steering commands on back course ILS approaches. Roll steering directional sensing is reversed on a back course ILS approach.

The heading error signal is determined from the difference between the HSI preset heading and actual airplane heading. The course error signal is similarly derived form the HSI preset course and actual airplane heading. Navigation radio signals provide a navigation deviation signal which is the lateral deviation from the selected VOR, localizer or TACAN course.

To obtain a roll steering signal, the computed roll signal is compared with the bank attitude signal from the attitude heading reference system or GINS. Any difference between the two signals causes the steering computer to produce a roll steering command signal which is applied to the ADI roll steering bar. As the airplane attains the bank attitude commanded, the roll signal equals the computed roll signal and the roll steering bar is centered.

PITCH STEERING COMMANDS

The pitch command signals are generated by the steering computer. The signals are proportional to the direction and degree of pitch necessary to fly the airplane to the desired descent, climb, or level flight path. The steering computer generates a pitch steering command from the altitude error, pitch attitude, glide slope deviation, and manual pitch command signal. The flight director operating mode determines which of these input signals are required for computing pitch steering commands. The steering computer also receives a middle marker, altitude trip and flag monitor, and approach mode signals for glide slope gain programming.

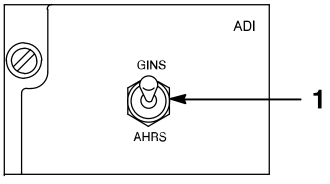
The altitude error signal is derived from the amount of deviation from a reference barometric altitude and is used in altitude hold mode. The manual pitch command signal is produced by setting the pitch command knob on the flight director control panel, and is proportional to the difference between the desired pitch attitude selected and the actual attitude as determined by the selected attitude reference. The glide slope deviation signal from the VOR/ILS navigation unit is proportional to the direction and amount of airplane vertical deviation from the glide path.

The computed pitch signal is compared with the pitch attitude signal from the selected attitude reference. Any difference between the computed pitch signal and the actual pitch signal causes the steering computer to produce a pitch steering command signal. The pitch steering command signal is then applied to the ADI pitch steering bar and, as the error is corrected to zero, the pitch steering bar centers.

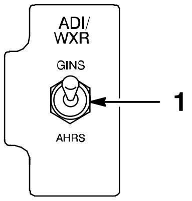
NOTE

The signal, which causes ADI pitch steering bar to extend, is removed by the flight director steering computer when the NAV MODE selector is set to GINS, and the flight director mode selector is set to any position other than GA or HDG or if the CMPTR flag is in view.

Flight Director Controls and Indicators

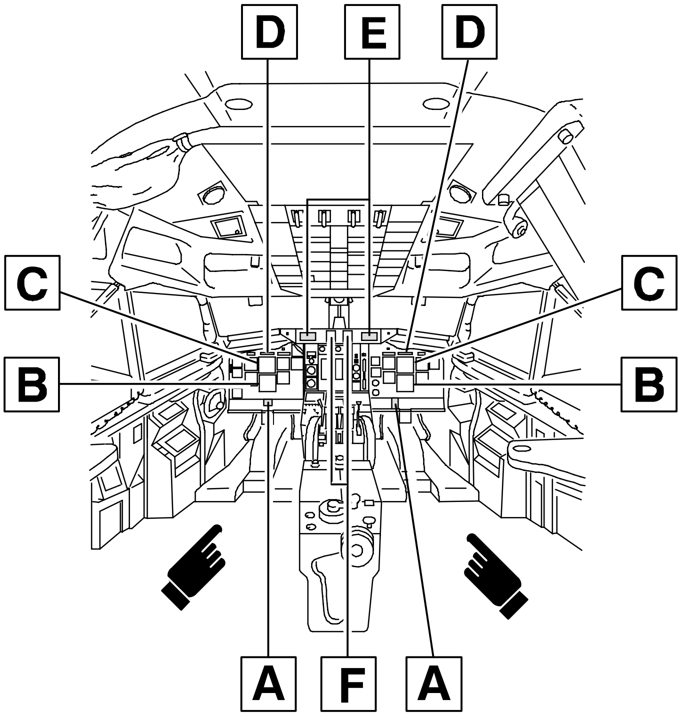


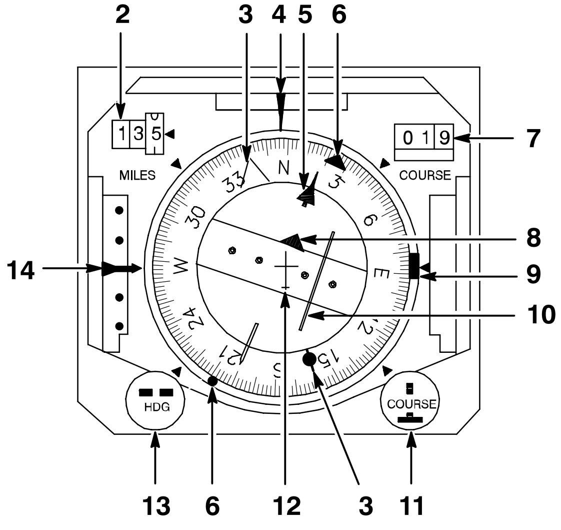
PILOT



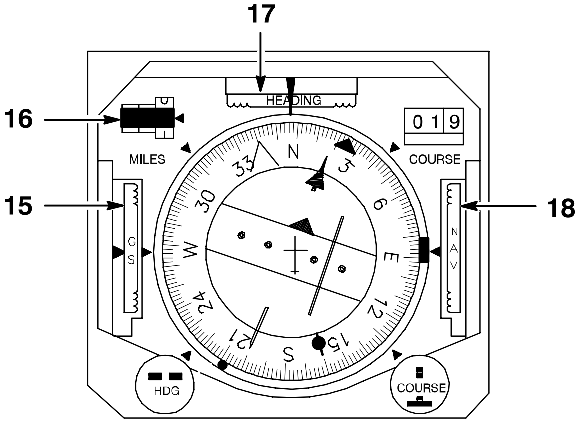
COPILOT

A ADI ATTITUDE SOURCE SELECTOR SWITCH





B HSI INDICATOR WITHOUT WARNING FLAGS



B HSI INDICATOR WITH WARNING FLAGS

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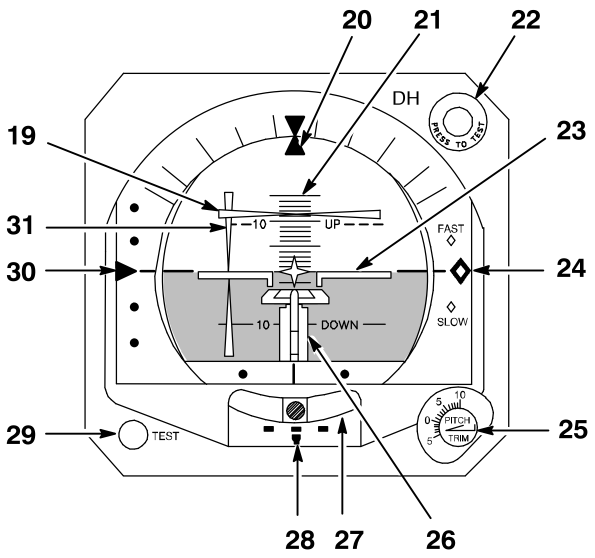
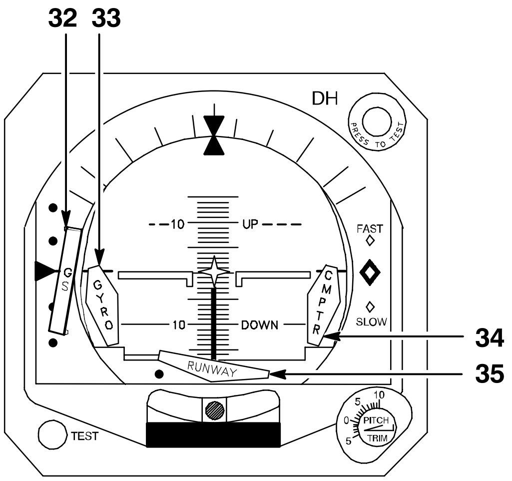
Figure 1-106 (Sheet 1 of 11)

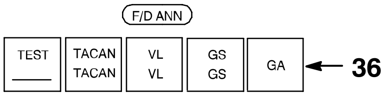
Flight Director Controls and Indicators (Continued)



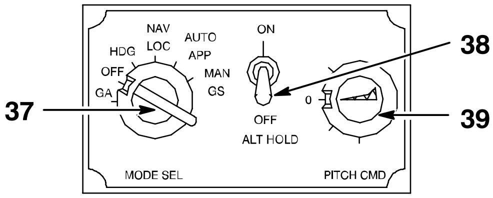
C ADI WITHOUT WARNING FLAGS



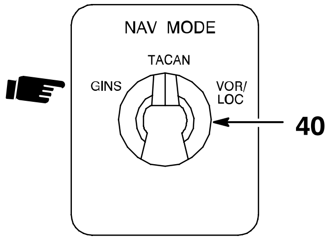
C ADI WITH WARNING FLAGS



D FLIGHT DIRECTOR ANNUNCIATORS



E FLIGHT DIRECTOR CONTROL PANEL



F NAV MODE SELECTOR

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Figure 1-106 (Sheet 2 of 11)

NO.	CONTROL/INDICATOR	FUNCTION
	A ADI ATTITUDE SOURCE SELECTOR SWITCH	
1	ADI (or ADI/WXR) (Attitude Source Selector) Switch	Selects attitude source for ADI display and flight director computer (and weather radar on copilot's switch). For a complete description of this switch refer to NAVIGATION SYSTEMS INSTRUMENT SWITCHING.
	B HORIZONTAL SITUATION INDICATOR (HSI)	
2	MILES Display	With NAV MODE selector set to GINS, displays slant range in nautical miles to next waypoint.
3	Bearing Pointer No. 2 (Green) Arrow (Head) Dot (Tail)	Displays bearing to station tuned on No. 2 receiver of system selected on NAV MODE selector (40), (VOR/LOC or TACAN). Indicator bearing to waypoint when GINS selected. Refer to NAVIGATION SYSTEMS INSTRUMENT SWITCHING for a more detailed explanation of displays.
4	Lubber Line and Compass Card	Lubber line represents nose of airplane when VOR and TACAN are selected on NAV MODE selector. Compass card then shows magnetic directions. When in GINS mode, lubber line and card indicate true or magnetic heading and direction, according to pilot's NAV MODE and MAG/TRUE switch settings. Refer to NAVIGATION SYSTEMS INSTRUMENT SWITCHING.
5	Course Arrow	When VOR/LOC or TACAN selected on NAV MODE selector, arrow indicates magnetic course selected by course knob (11). When GINS selected on NAV MODE selector, indicates desired track of airplane. Refer to NAVIGATION SYSTEMS INSTRUMENT SWITCHING.

NOTE

If a waypoint change is made in GINS operation which results in a change of exactly 180 degrees in desired track, the course arrow can hang up momentarily until airplane heading or track angle changes enough to unbalance the synchro signal which drives the course arrow.

Figure 1-106 (Sheet 3 of 11)

Flight Director Controls and Indicators (Continued)

NO.	CONTROL/INDICATOR	FUNCTION
6	Bearing Pointer No. 1 (Magenta) Arrow (Head) Dot (Tail)	Displays bearing to station tuned on No. 1 receiver of system selected on NAV MODE selector (VOR/LOC or TACAN). When GINS selected, displays ground track. Refer to NAVIGATION SYSTEMS INSTRUMENT SWITCHING.
7	COURSE Selector Window	Displays magnetic direction of selected radial of VOR or TACAN station or inbound course of localizer. Set by COURSE knob (11). When NAV MODE selector set to GINS displays desired track. Automatically set by INS. Refer to NAVIGATION SYSTEMS INSTRUMENT SWITCHING.
8	TO–FROM Indicator	Indicates direction to selected VOR or TACAN station or next waypoint along selected course. When passing VOR or TACAN station, TO arrow disappears and FROM arrow appears on opposite side of deviation scale. (TO arrow is illustrated.)
9	Heading Marker (Heading Bug) (Yellow)	Indicates heading set by HDG knob (13).
10	Course Deviation Indicator (CDI)	Center moving portion of course arrow represents selected radial (VOR or TACAN) localizer course, or desired track when using GINS. Scale dots indicate deviation from desired course, 5 degrees per dot on VOR or TACAN, approximately 1 1/4 degrees per dot on localizer, 3.75 nm crosstrack error per dot, on 2 nm error per dot in enroute mode, one–half nm error per dot in terminal mode, and 0.15 nm per dot in approach mode.
11	COURSE Knob	Sets desired VOR, localizer, or TACAN magnetic course on course arrow, course display and in flight director computer. Pilot's knob also sets autopilot. Knob must be pulled out to operate manually, and be pushed in for GINS operation.

CAUTION

Knob must be pushed in for remote GINS course setting. If knob is left out, drag of manual setting mechanism can cause erroneous displays and can damage clutch mechanisms.

Figure 1-106 (Sheet 4 of 11)

NO.	CONTROL/INDICATOR	FUNCTION
12	Miniature Airplane Symbol	Represents position and heading of airplane on CDI scale and compass card.
13	HDG (Heading) Knob	Sets position of heading bug. Sets desired heading in flight director computer. Pilot’s HDG knob also sets desired heading in autopilot. Knob must be pulled out to set manually. No GINS drive is provided.
14	Glide Slope Pointer and Scale	With ILS frequency received, indicates deviation from center of glide slope beam. Pointer represents beam center. Center of scale represents airplane. Pointer is in view when VOR/LOC selected on NAV MODE selector (40) (except when HDG or GA mode selected) or if indication is unreliable or if CMPTR flag is in view. With NAV MODE selector set to GINS, indicates vertical deviation (±500 ft per dot in ENROUTE and TERMINAL modes; ±0.35° per dot in APPROACH mode).
15	GS (Glide Slope) Warning Flag (Red)	When in view, indicates that glide slope information is not reliable. Flag is in view if glide slope signal is lost or if receiver malfunctions. Flag removed from view when localizer frequency not selected or when flight director is not in ILS mode.
16	MILES Display Bar (Black)	Covers distance display when TACAN DME is selected for display by NAV MODE selector set to any position other than GINS and DME signal is not reliable. With NAV MODE set to GINS, covers display when distance to waypoint is invalid.
17	HEADING Warning Flag (Red)	When in view, indicates that power to compass system (AHRS), or HSI has failed or heading servo has malfunctioned. On pilot MAG/TRUE switch, select TRUE mode and check displayed true heading on HSI vs (true) HEADING line in nav data page for applicable INU. Monitor CDU annunciations line for changes in EGI/INU status. Call up applicable EGI Status page. Out of view in normal operation.

Figure 1-106 (Sheet 5 of 11)

Flight Director Controls and Indicators (Continued)

NO.	CONTROL/INDICATOR	FUNCTION
18	NAV (Navigation) Warning Flag (Red)	When in view, indicates CDI is unreliable (or navigation signal selected is unreliable). When GINS selected on NAV MODE selector, flag in view indicates GINS output data unreliable. Flag out of view in normal operation.
	$\boxed{\text{C}}$ ATTITUDE DIRECTOR INDICATOR (ADI)	
19	Pitch Steering Bar	Displays pitch command computed by flight director pitch computer of pitch attitude hold, altitude hold, or glide slope tracking. Bar retracts automatically when GINS selected on NAV MODE selector (40) (except GA mode selected or ALT HOLD switch is on) or when indication is unreliable or if CMPTR flag is in view.
20	Bank Index and Scale	Index mark shows airplane bank angle in degrees on scale. Reference tic marks are located on 0, 10, 20, 30, 45 and 60 degrees.
21	Attitude Tape	Indicates airplane pitch and roll attitude. Pitch scale is read by noting position of airplane symbol (23) against scale. Graduations are at one degree interval to 25 degrees, then 5 degree intervals to 90 degrees. Tape has 360 degree roll capability and ±90 degree pitch capability. Tape is driven by source selected on ADI attitude source switch (1). Normal source is GINS (NO 1 for pilot, NO 2 for copilot). Alternate source AHRS (NO 1 for pilot, NO 2 for copilot).
22	DH (Decision Height) Light (Amber)	When illuminated, indicates airplane at or below altitude set on radio altimeter. Has press–to–test capability.
23	Miniature Airplane Symbol	Fixed diamond shape and two bars; provides basic airplane reference to pitch tape and flight director command bars. Pitch and roll commands are satisfied when intersection of bars is behind diamond symbol.
24	FAST–SLOW Indicator	Indicates speed deviation from approach speed (0.6 AOA) for 50 degrees flap setting only. Out of view at other flap settings.

WARNING

Do not use FAST–SLOW pointer if leading edge flaps are not extended or when using split flaps. Angle of attack system is unreliable in these conditions.

Figure 1-106 (Sheet 6 of 11)

NO.	CONTROL/INDICATOR	FUNCTION
25	Pitch Trim Knob	Adjusts pitch tape in relation to airplane symbol (23) so that a particular attitude can be maintained. Limits are 5 degrees down to 10 degrees up. Rotating knob clockwise increases pitch setting.
26	Runway Symbol/Localizer Pointer	Represents runway and localizer centerline. Dots represent 1–1/4 degrees deviation from centerline. Symbol is in view when VOR/LOC selected on NAV MODE selector (40) and localizer frequency is tuned. Out of view when TACAN or GINS selected. Vertical motion of rising runway is controlled by radio altimeters starting at 200 feet. Graduations are at 50 foot intervals. Moves up to contact airplane symbol at touchdown.

NOTE

Runway directional sensing is reversed on back course ILS approach. Disregard runway pointer on back course approaches.

NO.	CONTROL/INDICATOR	FUNCTION
27	Slip Indicator	Conventional slip indicator ball.
28	Turn Indicator Pointer and Scale	Pointer indicates rate of turn (yaw rate) sensed by yaw rate gyro (pilot's from AHRS NO 1, copilot's from AHRS NO 2). Marks indicate 3 degree per second turn rate. Space between center mark and side marks indicates 1 1/2 degree per second turn rate. Covered by shutter if yaw rate gyro fails.
29	TEST Button	When pressed, causes attitude tape to indicate 10 degree pitch up and 20 degree right roll. Gyro warning flag (33) is in view at same time. In flight, pitch and roll displays move 10 degrees nose up and 20 degrees right roll from attitude at time button is pressed.
30	Glide Slope Pointer and Scale	Indicates deviation from center of glide slope beam. Pointer represents beam center. Center of scale represents airplane. Pointer is in view when VOR/LOC selected on NAV MODE selector and VHF NAV radio tuned to localizer frequency.
31	Roll Steering Bar	Displays roll command computed by flight director roll computers for heading, VOR/TACAN, or localizer tracking modes. Bar retracts automatically if GINS selected on NAV MODE selector (40) (except when HDG or GA mode selected) or if indication is unreliable or if CMPTR flag is in view.

Figure 1-106 (Sheet 7 of 11)

Flight Director Controls and Indicators (Continued)

NO.	CONTROL/INDICATOR	FUNCTION
	NOTE Disregard roll steering commands on back course ILS approaches. Roll command directional sensing is reversed on a back course ILS approach.	
32	GS (Glide Slope) Warning Flag (Red)	In view if glide slope signal or glide slope receiver is unreliable. Out of view when VHF NAV radio tuned to VOR frequency.
33	GYRO Warning Flag (Red)	When in view, indicates unreliable attitude source or that attitude TEST button is pressed, or that ADI power has been lost.
34	CMPTR (Computer) Warning Flag (Red)	When in view, indicates malfunction in flight director pitch or roll computer. Also is in view if power is lost to ADI. Steering bars are biased out of view when CMPTR flag in view, except when power to ADI is lost.
35	RUNWAY Warning Flag (Red)	When in view, indicates runway pointer, radio altimeter or localizer signal is unreliable. Out of view when GINS or TACAN selected on NAV MODE selector or VOR tuned on VHF NAV radio.
	D FLIGHT DIRECTOR ANNUNCIATORS	
36	Flight Director Annunciators – (Green/Amber) (One switch and four indicators/caution lights.)	Indicate operating mode of flight director computer.
	TEST	When pressed, tests lamps in annunciators.
	TACAN	Indicates flight director computer is in NAV/LOC mode, using TACAN signals (TACAN selected on NAV MODE selector (40).) Amber TACAN illuminates when mode is selected; green TACAN illuminates when selected radial is captured.
	VL	Indicates computer is in NAV/LOC mode and VOR/LOC is selected on NAV MODE selector. VL illuminates amber when mode is selected; illuminates green when selected radial is captured.

Figure 1-106 (Sheet 8 of 11)

NO.	CONTROL/INDICATOR	FUNCTION
	G/S	Indicates a glide slope mode (AUTO APP or MAN G/S) is selected. Amber G/S illuminates before glide slope capture (AUTO APP mode); green G/S illuminates after glide slope is captured. When MAN G/S is selected, green G/S illuminates at once.
	GA	When green GA illuminates, indicates GA mode (go–around) has been selected.

E FLIGHT DIRECTOR CONTROL PANEL

NO.	CONTROL/INDICATOR	FUNCTION
37	MODE SEL Switch (Flight Director Mode Selector)	Used to select flight director mode of operation. Determines inputs used by respective flight director computer in computing commands and displays.
	GA	Selected manually or by pressing autopilot disconnect button on either pilot's control wheel. Provides wings–level 8 ±2 degrees up pitch angle to provide attitude reference during cleanup phase of missed approach.

NOTE

GA does not provide heading or speed commands. Select another mode for missed approach.

NO.	CONTROL/INDICATOR	FUNCTION
	OFF	Steering bars retracted out of view. CMPTR flag not in view. Flight director computer is off. ADI operates as attitude indicator.
	HDG (Heading)	Roll steering bar directs flight on heading indicated by heading marker on respective pilot's HSI. Pitch steering bar active in altitude hold or selected pitch command.
	NAV/LOC (Navigation/Localizer)	Roll steering bar directs flight enabling intercept and tracking of VOR or TACAN radials and ILS localizers with automatic crosswind correction. Before radial capture, bank steering bar operates as in HDG mode. Capture begins at one dot deviation of CDI (5 degrees) on VOR/TACAN or 2 dot deviation (2 1/2 degrees) on localizer. During capture, bank steering bar is governed by VOR/TACAN or localizer deviation signals directing flight along beam center. Pitch steering bar active in altitude hold or selected pitch command during VOR/TACAN operation or during ILS operation prior to glide slope capture.

Figure 1-106 (Sheet 9 of 11)

Flight Director Controls and Indicators (Continued)

NOTE

Do not use NAV/LOC, AUTO APP, or MAN GS modes on a back course ILS approach. Roll steering bar directional sensing is reversed on a back course ILS approach.

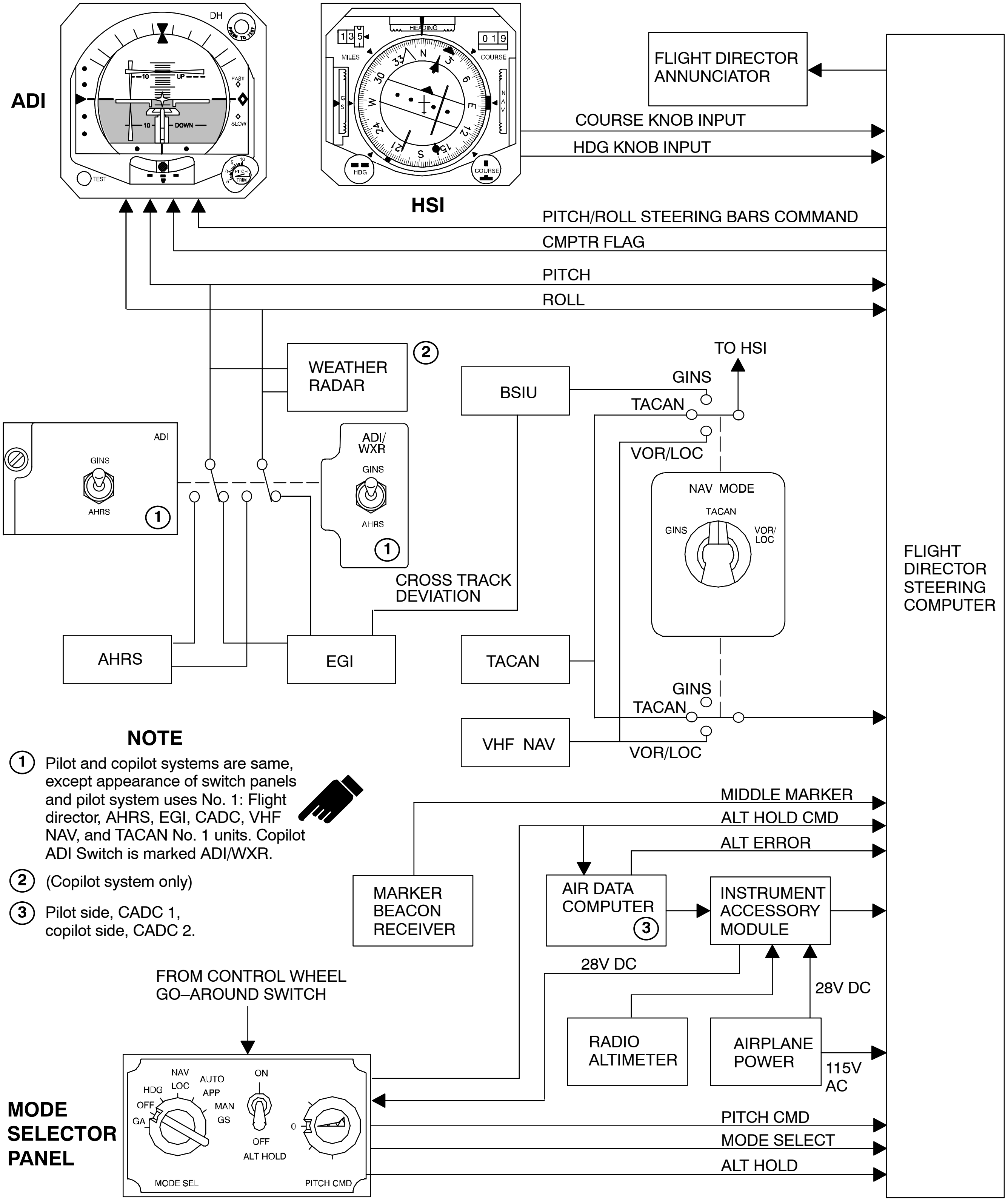
NO.	CONTROL/INDICATOR	FUNCTION
	AUTO APP (Automatic Approach)	Roll steering bar directs flight enabling intercept and tracking of VOR/TACAN radial and ILS localizers as in NAV LOC mode. Pitch steering bar operates as in NAV LOC mode during VOR/TACAN operation or during ILS operation prior to glide slope capture. Capture begins at approximately 1/3 deviation of glide slope pointer. During glide slope capture, pitch steering bar is governed by glide slope deviation signals directing beam tracking. Cannot be selected if autopilot disengage switch is pressed.
	MAN GS (Manual Glide Slope)	MAN GS mode enables immediate capture of localizer, and glide slope when beam cannot be captured automatically. Roll steering bar directs fixed angle (30 degrees) intercept of localizer until within two dots of the center of the beam, then roll steering bar provides commands to intercept and track the localizer beam. Pitch steering bar immediately provides steering commands to fly toward the glide slope beam and track the beam when intercepted. Operation is the same as in AUTO APP mode when on beam center.
38	ALT (Altitude) HOLD Switch	Engages altitude hold mode in HDG, NAV LOC, or AUTO APP mode before glide slope capture. Magnetically held in ON, spring loaded to OFF.
	ON	Pitch steering bar directs climb or descent to maintain a constant pressure altitude. Altitude maintained is that existing when switch is set to ON.
	OFF	Switch automatically returns to OFF at glide slope capture or when mode selector is in MAN GS position.

Figure 1-106 (Sheet 10 of 11)

NO.	CONTROL/INDICATOR	FUNCTION
39	PITCH CMD (Command) Knob	Used to set desired pitch angle of airplane for climb or descent. Pitch steering bar directs pitch attitude to maintain the selected pitch angle. Control is operational in HDG mode except when ALT HOLD is on. It is also operational in NAV LOC and AUTO APP modes (the latter prior to glide slope capture) provided the NAV mode selector is NOT in GINS. Turning control clockwise directs pitch up to a maximum of approximately 10 degrees (5 degrees per index mark). Counterclockwise rotation directs pitch down to maximum of 10 degrees (5 degrees per index mark).
F NAV MODE SELECTOR		
40	NAV MODE Selector (One on each side of glare shield)	Selects navigation signal source for HSIs and flight directors. Pilot also selects steering signal source for autopilot. Also determines whether TACAN or VOR signals are available for display on the pilots' RMI indicators. Refer to NAVIGATION SYSTEMS INSTRUMENT SWITCHING for a detailed explanation of the individual switch positions.

Figure 1-106 (Sheet 11 of 11)

Flight Director System Signal Flow



NOTE

① Pilot and copilot systems are same, except appearance of switch panels and pilot system uses No. 1: Flight director, AHRS, EGI, CADC, VHF NAV, and TACAN No. 1 units. Copilot ADI Switch is marked ADI/WXR.

② (Copilot system only)

③ Pilot side, CADC 1, copilot side, CADC 2.

Figure 1-107

FLIGHT DIRECTOR SYSTEM OPERATION

PREFLIGHT

The following check may be performed for either flight director at the pilot's discretion. Prior to performing the check, ensure that all electrical buses are powered, appropriate circuit breakers closed, and attitude/heading reference system and GINS systems are on and operating. Perform asterisk steps if preflighting only the heading and pitch command portion of the flight director. For a complete preflight perform all steps.

*1. Set flight director mode selector to OFF.

Check steering bars are out of view.

2. Check attitude director indicator.

Depress ADI TEST switch and check for attitude display of approximately 20 degrees right bank, 10 degrees climb and GYRO flag in view.

*3. Set flight director mode selector to HDG.

Check steering bars are in view and ADI warning flags are out of view.

*4. Using HSI heading control set heading marker under lubber line.

Check roll steering bar is centered.

*5. Using HSI heading control set heading marker either side of lubber line.

Check roll steering bar directs bank toward heading marker.

6. Set NAV MODE selector to VOR/LOC or TACAN and flight director Mode Selector to NAV/LOC.

Tune to receivable VOR or TACAN station and check HSI navigation warning flag out of view. Note appropriate flight director annunciator is on.

7. Set flight director mode selector to NAV/LOC.

Check F/D VL annunciator is amber (CDI display greater than one dot deviation).

8. Slowly rotate HSI course knob to center CDI (within one dot deviation).

Check flight director roll steering bar directs bank toward course arrow.

9. Using HSI course knob set course arrow on bearing to station.

Check CDI is centered, F/D VL annunciation changes to green, roll steering bar is centered and TO–FROM indicator indicates TO.

*10. Rotate flight director PITCH CMD control through full range.

Check pitch steering bar commands a pitch–up attitude when PITCH CMD control is rotated clockwise and a pitch–down attitude when PITCH CMD control is rotated counterclockwise.

11. Set altitude hold switch to ON.

Check pitch steering bar directs zero pitch command.

12. Rotate ADI PITCH TRIM control to move ADI attitude tape.

Check attitude tape moves in appropriate direction when PITCH TRIM control is rotated.

13. Tune VHF NAV radio to localizer frequency.

With NAV MODE selector in VOR/LOC position, HSI bearing pointer stows at three o'clock position if connected VOR/ILS radio is tuned to localizer frequency.

14. Set flight director mode selector to MAN GS.

Check ALT HOLD switch returns to OFF.

15. Press autopilot disconnect switch.

Flight director mode selector returns to GA position.

NOTE

Roll steering bar centers but pitch steering bar directs a pitch attitude of approximately eight degrees which allows minimum altitude loss during a go–around.

BEFORE TAKEOFF

If the flight director system is to be used for initial climb after takeoff, set the mode selector in the desired position. Preset heading and course controls as required for departure and set NAV MODE selector to VOR/LOC or TACAN, as required.

For a takeoff in HDG mode, perform the following procedure:

1. Set flight director mode selector to HDG.
2. Using HSI HDG knob set HSI heading marker to runway heading.

NOTE

> After moving onto the runway, heading marker may be reset to exact runway heading to center roll steering bar.

3. Using pitch command control, set pitch steering bar to maximum. Do not fly pitch steering bar command after takeoff. Perform normal climbout procedures and fly airplane at required performance attitude.

INFLIGHT

The inflight operation of the flight director is described in the following paragraphs by mode of operation. Six modes of operation are provided for attitude director indicator display. These modes are: GA (GO AROUND), OFF, HDG (heading), NAV LOC (navigation/localizer), AUTO APP (automatic approach), and MAN GS (manual glide slope). The ALT HOLD (altitude hold) mode is available in HDG, NAV LOC, or AUTO APP modes.

GA (Go Around) Mode

The roll steering bar shows wings level command and the pitch steering bar directs a pitch attitude of approximately 8 degrees which gives a positive rate of climb.

OFF Mode

In the OFF mode of operation, the ADI command bars are out of view and basic attitude display is presented. Pitch and bank attitude are displayed by the pitch tape relative to the airplane symbol. Roll angle is displayed by the bank index against the roll scale. A level flight condition shows the center point of the miniature airplane symbol and attitude reference bars on the pitch tape white horizontal line. (See *figure 1-107*). The turn needle shows rate of turn and the slip indicator displays slip or skid. If the VOR/ILS radio receiver is tuned to a localizer frequency while in OFF mode, the glide slope pointer shows glide slope deviation, and the runway symbol displays localizer deviation and radio altimeter altitude (200 feet to zero).

NOTE

> For all modes, the basic attitude function is displayed as in OFF mode. Warning flags are in or out of view as a function of system mode and navigation receiver tuning. If a subsystem or sensor is not in use, its flag is out of view.

HDG (Heading) Mode

The HDG (heading) mode is manual mode of operation in which the HSI heading marker is set to the desired heading using the HSI HDG Knob and the ADI roll steering bar displays the bank required to attain and maintain the selected heading.

WARNING

> The roll steering bar does not provide an attitude reference when the ADI GYRO flag is in view.

NOTE

> The HSI heading warning flag is in view when power is interrupted to the respective HSI compass system (or GINS heading input when selected). The flag does not monitor the heading marker.

Pitch commands displayed by the pitch steering bar can be controlled manually by the pitch command knob (7, *figure 1-107*) or automatically by the altitude hold switch (6). The roll steering bar can command up to approximately 30 degrees of bank and the pitch steering bar, 15 degrees up, 10 degrees down, depending on turn or pitch required. If the airplane is maneuvered to follow the steering bars, a smooth rollout on the selected heading results. After rollout, minor deviations may be indicated by the steering bars and, if followed, maintain the airplane on the selected heading.

NAV LOC (Navigation/Localizer) Mode

The NAV LOC mode is a combination heading and radio navigation mode of operation. Selection of NAV LOC mode from HDG mode causes the roll steering bar to command a constant heading as set by the HSI HDG knob and arms the flight director system for radio beam capture, which causes the appropriate flight director annunciator (either TACAN or VL) to illuminate amber. The radio course signals are provided by either the TACAN or VHF NAV (VOR/ILS) receiver. Selection of TACAN or VOR/ILS is controlled by the NAV MODE selector (*figure 1-107*) on the flight instrument panel.

Course selection is made on the HSI using the COURSE knob. Prior to capture of the radio course, the pilot can select any intercept heading desired and the roll steering bar will display commands to follow the selected heading. When the radio course is captured (intercept capture angle should be 90 degrees or less), the flight director system switches from heading hold to tracking computation and the roll steering bar directs flight along the selected course. Also, the appropriate flight director annunciator switches from amber to green. The roll steering bar commands up to approximately 30 degrees of bank on intercepting the course depending on intercept angle, and if followed, provides a smooth rollout on course. Once course capture is completed, steering commands are limited to 25 degrees roll and 12 degrees of pitch. Capture point of a TACAN or VOR radial is approximately 5 degrees displacement (inner dot on the HSI course deviation scale). When the TACAN or VOR capture point is reached, the commanded intercept angle reduces from 30 degrees to 17 degrees. When a localizer capture point is reached, no changes to commanded intercept angle occur (remains 30 degrees). Capture point of a localizer course is approximately 2.5 degrees (outer reference dot). In NAV LOC mode, crosswind correction is automatically computed after radio course capture. Pitch commands displayed by the ADI pitch steering bar are controlled, as in HDG mode, by the pitch command control or altitude hold switch.

NOTE

Do not change the position of the course arrow after radio course capture except over a VOR or TACAN station when the course change is 10 degrees or less. Select HDG mode to establish a new intercept angle if the course change is more than 10 degrees or whenever a new frequency is selected on the navigation receiver.

A fixed angle intercept can be made to the selected course by moving the flight director mode selector to MAN GS position and then to NAV LOC position. The roll steering bar then displays steering commands to intercept the VOR or TACAN radial at a fixed intercept angle of 30 degrees. When the radio course is captured, the flight director system switches to tracking computation and directs flight along the selected course and the appropriate flight director annunciator switches from amber to green.

NOTE

The flight director system fixed angle intercept feature can be used in the event course capture is lost.

In NAV LOC mode, the roll steering bar also displays commands to follow a localizer course (LOC submode) when the VOR/ILS receiver is tuned to a localizer frequency. Heading commands to intercept the course are controlled and displayed as in the navigation (NAV) submode. The glide slope pointer and runway symbol appear on the ADI when the localizer frequency is tuned; however, glide slope information is not provided to the pitch steering bar. Pitch commands are still controlled by the pitch command control or altitude hold switch.

AUTO APP (Automatic Approach) Mode

The AUTO APP mode provides steering commands for intercepting and tracking a localizer beam and glide slope path. When the VOR/ILS receiver is tuned to the localizer frequency and AUTO APP is selected, the flight director system is armed for localizer capture indicated by the amber VL flight director annunciator illuminating. The system operates in heading mode prior to capture; and at the localizer capture point (two dots on the CDI scale), the system is armed for glide slope capture (if a glide slope signal is received), which causes the flight director amber GS annunciator to illuminate and the VL annunciator to switch from amber to green. The roll steering bar commands a bank (up to 30 degrees) to turn onto the selected course. The intercept heading is set on the HSI HDG knob and can be any heading which intercepts the course at an angle of 90 degrees or less. The pitch commands, displayed by the pitch steering bar, are controlled by the PITCH CMD knob or altitude hold switch until glide slope capture. When the center of the glide slope beam is reached, the flight director pitch steering bar displays commands which, if followed, result in glide slope capture. Also, the amber GS flight director annunciator goes out and the green GS flight director annunciator illuminates. At glide slope capture, an initial 2–degree pitch down command is generated. After glide slope capture, the system automatically switches to glide slope tracking (if selected, altitude hold switch moves to OFF) and computes the pitch attitude required to command flight on the glide slope. Also, the roll steering bar maximum bank angle command is reduced to 15 degrees. Gain programming (beginning at 1,500 feet radio altitude) is provided in the system to compensate for the gain increase of the glide slope beam during the approach. On a signal from the radio altimeter system at 200 feet radio altitude (or middle marker beacon), the gain of the glide slope command signal is further refined to provide a smooth steering bar display for close–in glide slope tracking.

WARNING

> If the autopilot is disconnected automatically or manually during the approach, the mode selector moves back to GA mode (from AUTO APP or MAN GS) and the pitch and roll steering bars display a fixed pitch command of approximately 8 ± 2 degrees nose up and a wings level roll command.

In the AUTO APP mode, the runway symbol on the attitude director indicator appears when the localizer is tuned and provides lateral and vertical displacement display for the low approach. As the runway is approached, the runway symbol moves up toward the airplane symbol to indicate descent from 200 feet to touchdown. At touchdown, the runway symbol is at the base of the aircraft symbol. Raw glide slope displacement is displayed by the glide slope pointers on both the ADI and HSI when the localizer is tuned and glide slope signals are received. The glide slope pointers show the angular displacement from the glide slope beam and are used as a reference for glide slope capture.

MAN GS (Manual Glide Slope) Mode

The MAN GS mode provides an immediate localizer and glide slope capture display. The steering bars show the bank, and climb or descent required to track the localizer and glide slope beams. A fixed course intercept angle of 30 degrees is commanded if course displacement is beyond localizer capture point. The vertical commands to capture the glide slope are displayed up to the pitch limit of the pitch steering bar. The pitch command control and altitude hold switch do not function in MAN GS mode. The ADI and HSI display function is the same in MAN GS mode as AUTO APP mode after localizer and glide slope capture. Glide slope gain programming in MAN GS mode is the same as AUTO APP mode. As soon as MAN GS is selected, the GS flight director annunciator illuminates green.

ALT HOLD (Altitude Hold) Mode

The ALT HOLD mode can be engaged only if the flight director is in HDG, NAV/LOC or AUTO APP modes. If the air data computer fails, ALT HOLD switch automatically returns to OFF. When AUTO APP mode is engaged and glide slope capture occurs, the ALT HOLD switch automatically returns to OFF so the glide slope is followed.

ABNORMAL OPERATION AND MALFUNCTIONS

Operation of the flight director system is possible after certain malfunctions.

GYRO Flag Visible

If the GYRO warning flag in the ADI is in view, select the other position on the ADI source selector. Also check AHRS and/or GINS circuit breakers. Use standby attitude indicator if GYRO flag remains in view.

CMPTR Flag Visible

If the CMPTR warning flag is in view, check the mode selector is not at OFF, then check the FLIGHT INSTRUMENTS circuit breakers on P5 panel. If power cannot be restored, flight director is not usable. ADI is usable if GYRO flag not in view.

RUNWAY Flag Visible

Check radio altimeter is operating. If radio altimeter is inoperative, gain scheduling in AUTO APP and MAN GS modes is inoperative. All other modes are available.

Pages 1–391 and 1–392 deleted

SUBSECTION I-L
AUTOPILOT SYSTEM

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SUMMARY

The autopilot system provides automatic maneuvering control of the airplane to maintain heading, altitude, and attitude and to follow selected navigation signals from VOR, TACAN, ILS or steering signals from either inertial navigation system.

Inputs to the autopilot are provided by AHRS NO 1 (heading only), TACAN NO 1, VOR/ILS NO 1, the air data computer and either INS either EGI. See *figure 1-108* for signal sources and tie-in diagram. Primary components of the autopilot system are a control panel, three-axis trim indicator, autopilot annunciators, amplifier and computer, autopilot adapter, disengage warning unit and lights, trim servo, power junction box, interlock monitor and aileron and elevator servos. Power for the autopilot system is 115vac from the Flight Avionics AC Bus No. 1 and 28vdc from the Emergency DC Bus. Various power voltages for the system equipment are supplied by the autopilot power junction box.

NOTE

- If both GINS attitude references are lost, the autopilot cannot be operated.
- When switching number one (pilot's) compass to DG mode (grid navigation) ensure autopilot is either disengaged or engaged in GINS steering. Otherwise, the airplane rolls into a turn when the compass heading is changed to the grid heading.

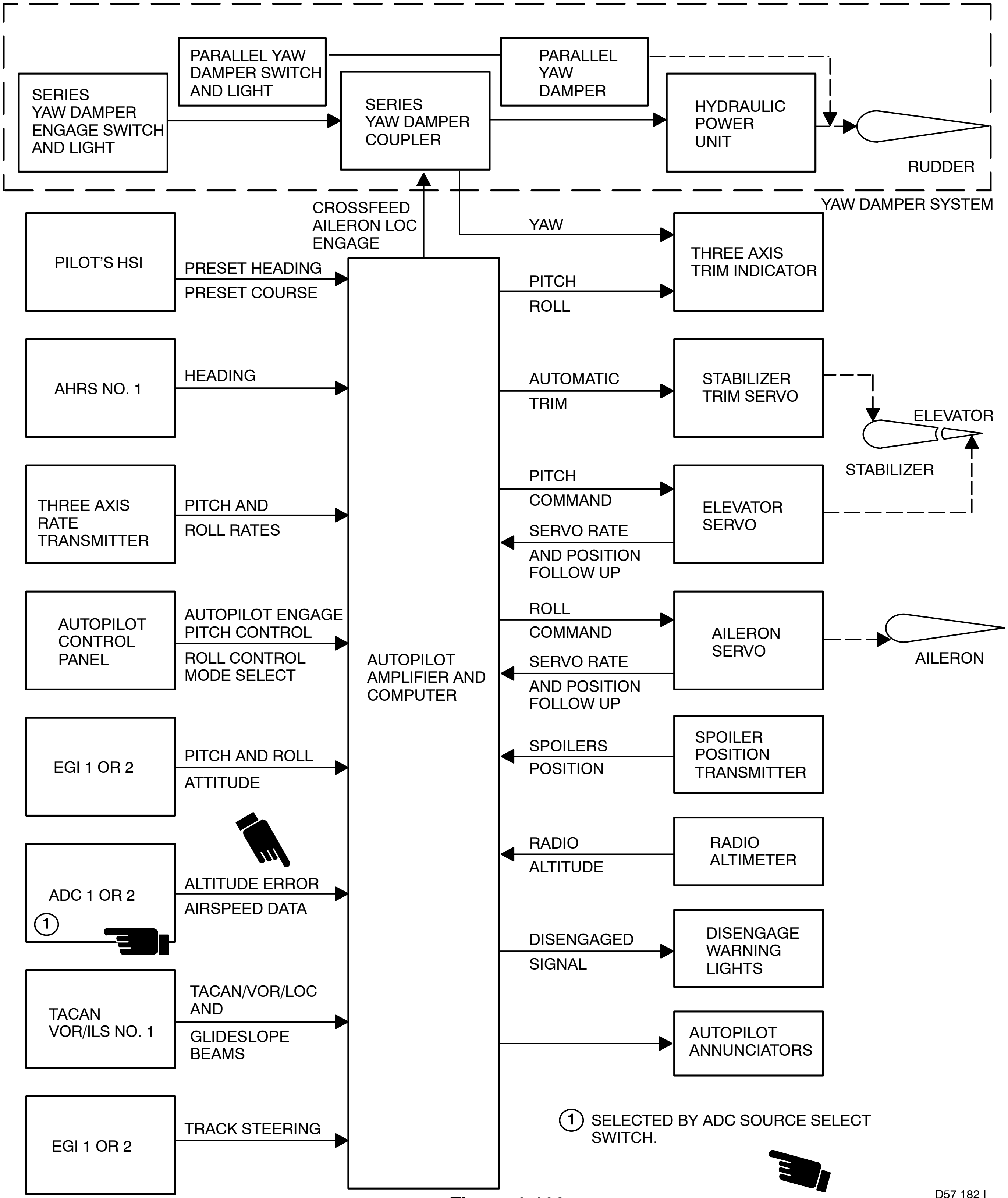
AUTOPILOT SYSTEM SIGNAL FLOW

The autopilot is engaged when the engage switch (10, *figure 1-109*) is moved to AUTOPILOT position and the interlock circuit is closed. Manual mode of operation is assumed automatically at engagement and pitch and bank are controlled manually by the pitch and turn controls. The mode selector can select one of five modes of operation as shown in *figure 1-109*. The autopilot control signals are processed in the amplifier and computer to operate control surfaces and trim servos. In conjunction with the amplifier and computer, an autopilot adapter provides gain limits for certain follow-up attitude correction and bank limiting signals to adapt the autopilot response to the flight characteristics of the airplane.

ROLL SIGNAL FLOW

The autopilot roll channel operates the aileron servo to move the aileron control tabs which roll the airplane into or out of a bank. Before autopilot engagement, continuous synchronization is maintained by the aileron servo and the amplifier and computer. Pre-engagement roll attitude signal from the attitude reference EGI 1 or EGI 2 is provided to the amplifier and computer to establish zero bank angle as the engagement reference even though the bank at engagement is other than zero. Upon engagement, the autopilot controls the airplane to maintain the airplane heading (GINS or AHRS) existing at the time of engagement. If the autopilot is engaged in a turn, the airplane rolls wings level and maintains the heading existing at the time the autopilot is engaged.

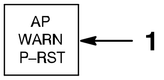
Autopilot Signal Flow



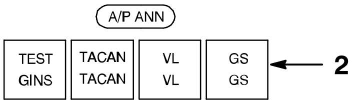
① SELECTED BY ADC SOURCE SELECT SWITCH.

Figure 1-108

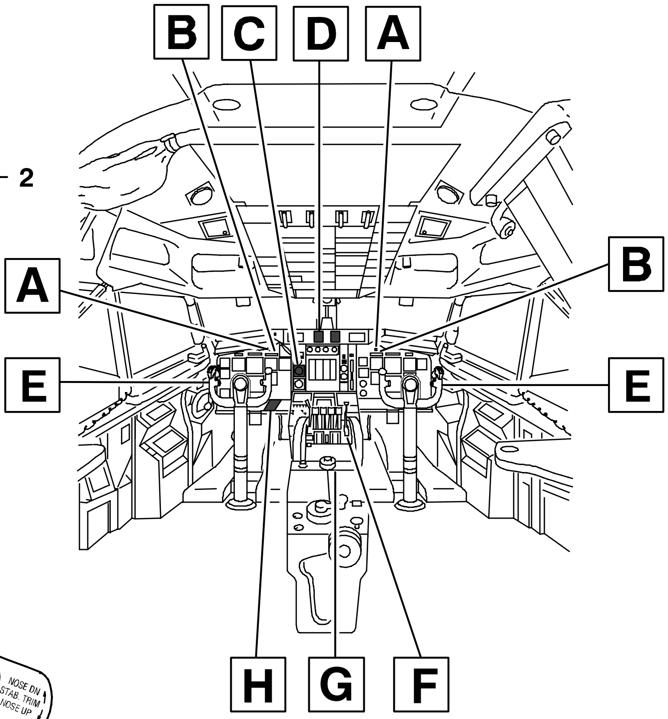
Autopilot Controls and Indicators

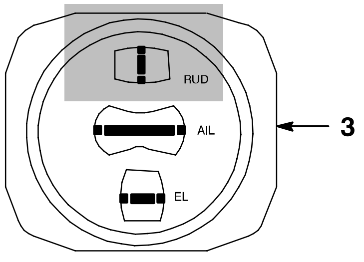


A **AUTOPILOT WARNING LIGHT**

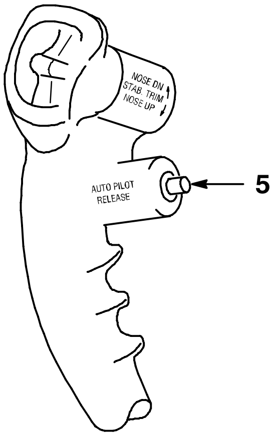


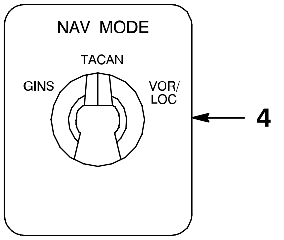
B **AUTOPILOT ANNUNCIATOR**

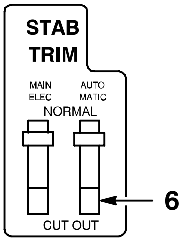




C **THREE AXIS TRIM INDICATOR**



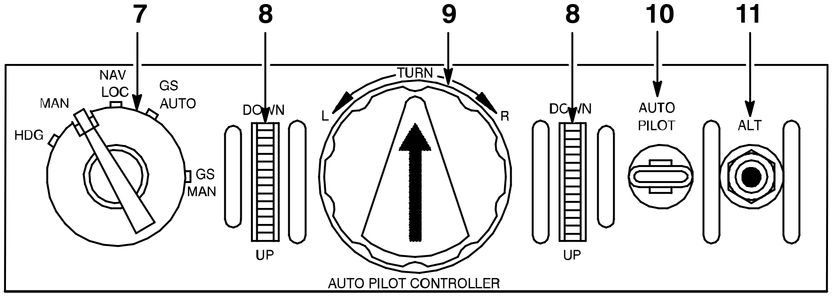




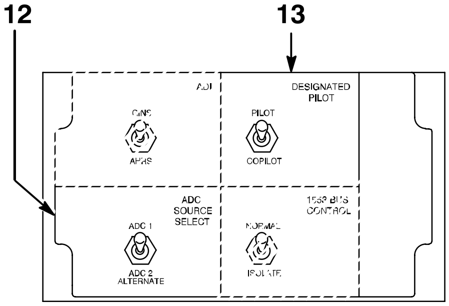
D **NAVIGATION MODE SELECTOR (2 PLACES)**

E **CONTROL WHEEL GRIP (TYPICAL)**

F



G **AUTOPILOT CONTROL PANEL**



H **AUTOPILOT ATTITUDE SOURCE SELECTOR SWITCH**

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Figure 1-109 (Sheet 1 of 5)

Autopilot Controls and Indicators (Continued)

NO.	CONTROL/INDICATOR	FUNCTION
	A AUTOPILOT WARNING LIGHT	
1	A/P WARN (Autopilot Disengage) Warning Light (Red) (2)	
	(Flashing)	A single flash when flaps are extended from zero (or raised to zero) indicates both flap switches did not operate at the same time. Annunciators (2) do not change. Repeated flashes indicate autopilot disengagement for any reason. Annunciators (2) go blank, mode selector (7) goes to MAN, autopilot engage switch (10) moves to OFF. Reset flashing light by pressing light or by pressing autopilot disconnect switch. If A/P WARN light is flashing and flight director mode selector is set to AUTO APP, flight director automatically switches to GA.
	(Steady)	Steady light indicates one or both flap switches did not operate and that autopilot elevator servo is in high torque mode and pitch trim is in high speed.

WARNING

If autopilot disengage warning light illuminates continuously, after flap retraction, at least one flap limit switch has malfunctioned. Autopilot pitch servo is in high torque mode and pitch trim is in high speed. Avoid large, rapid pitch knob motions.

NO.	CONTROL/INDICATOR	FUNCTION
	B AUTOPILOT ANNUNCIATOR	
2	Autopilot Annunciators Green/Amber (two sets of three indicators and one switch/indicator each).	TEST switch, when pressed, causes all annunciators to illuminate. GINS illuminates green when autopilot controller is in NAV/LOC mode and using GINS data. TACAN illuminates amber when autopilot controller is in NAV LOC mode, using TACAN signal. TACAN illuminates green when selected radial is captured (within 5° of course or 1 dot deviation on HSI). VL illuminates amber when autopilot controller is in NAV LOC mode, using VOR or localizer signal. VL illuminates green, when selected course is captured (within 5° of course or 1 dot for VOR, or 2.5° or 2 dots for localizer). GS illuminates amber when GS AUTO and NAV LOC selected. GS illuminates green when glide slope captured (2 dots) in GS AUTO and illuminates green immediately when GS MAN selected.

Figure 1-109 (Sheet 2 of 5)

NO.	CONTROL/INDICATOR	FUNCTION
	C THREE AXIS TRIM INDICATOR	
3	RUD–AIL–EL (Three Axis Trim) Indicator	Position of three index bars indicates direction and relative amount of autopilot torque applied to ailerons (AIL) and elevators (EL). RUD indicator shows series yaw damper movement of the rudder.
	D PILOT'S NAVIGATION MODE SELECTOR	
4	NAV MODE Selector	Pilot's NAV MODE selector selects navigation system input for autopilot, pilot's flight director, HSI and RMI. For a complete description of switch position refer to NAVIGATION SYSTEMS INSTRUMENT SWITCHING.
	E CONTROL WHEEL GRIP	
5	Autopilot and Boom Disconnect Button (Autopilot Disconnect Button) Outboard Horn of Each Control Wheel	When pressed, disengages autopilot and parallel yaw damper (if engaged). If flight director is in AUTO APP or GS MAN mode, causes flight director to switch to GA mode. If pressed when autopilot disengage light is flashing, resets light. When pressed during air refueling operation, releases boom latch toggles (DISC caution light illuminates).
	F AUTOPILOT STABILIZER TRIM SWITCH	
6	Autopilot STAB TRIM (Stabilizer Trim) Cutout Switch	When set to NORMAL, applies power to autopilot stabilizer trim actuator circuit. Trim speed depends on flap setting and turn knob position. (Refer to FLIGHT CONTROLS.)
	G AUTOPILOT CONTROL PANEL	
7	Autopilot Mode Selector	Controls operating mode of autopilot computer. Magnetically held in all positions except MAN.
	MAN (Manual)	Spring loaded to MAN from any position. When set to MAN, autopilot can be manually controlled by pitch and turn knobs. When selected, airplane maintains attitude and compass heading at time of autopilot engagement.
	HDG (Heading)	When set to HDG, autopilot tracks heading selected on horizontal situation indicator (HSI).

Figure 1-109 (Sheet 3 of 5)

Autopilot Controls and Indicators (Continued)

NO.	CONTROL/INDICATOR	FUNCTION
	NAV LOC (Navigation/Localizer)	When set to NAV/LOC, tracks GINS (pattern steering and waypoint steering), VOR, TACAN or localizer signals, as selected on pilot's NAV MODE selector.
	GS AUTO (Glide Slope, Automatic)	When set to GS AUTO, follows airplane heading at time of engagement until within approximately 2.5° of localizer centerline (two dots deviation on HSI) and then switches to localizer tracking. Automatic crosswind correction is supplied from GINS. When glide slope signal is received, begins to track glide slope at 1/2 degree from center (one dot). Glide slope sensitivity reduced by input from radio altimeter starting at 1,500 feet.
	GS MAN (Manual Glide Slope)	When set to GS MAN, operation is same as GS AUTO, except autopilot immediately tracks glide slope.
8	Autopilot Pitch Knob (Two Knobs)	Controls pitch attitude of airplane when autopilot is in any mode except altitude hold, GS AUTO (after glide slope capture), or GS MAN. Pushing knob forward toward DOWN moves nose down. Control movement is proportional to knob deflection. Moving knob toward UP moves nose up. Maximum pitch is ±30°.
9	Autopilot TURN Knob	Operates roll axis of autopilot when in MAN mode. Airplane turns in same direction as knob movement. Bank angle (up to 35°) proportional to amount of deflection. If turn knob is out of center detent, autopilot does not engage. If knob is turned while autopilot is in any mode other than MAN, autopilot switches to MAN.
10	AUTOPILOT – OFF (Autopilot Engage) Switch	When set AUTOPILOT, engages autopilot. Magnetically held at AUTOPILOT, spring loaded to OFF. When autopilot disconnect button is pressed, moves to OFF and autopilot disengage lights illuminate.

NOTE

It can be necessary to hold the switch in the AUTOPILOT position for up to five seconds in order to engage autopilot. When latching of switch occurs, autopilot is engaged.

Figure 1-109 (Sheet 4 of 5)

NO.	CONTROL/INDICATOR	FUNCTION
11	Altitude Hold (ALT) Switch	When set to ALT, engages altitude hold mode, in all modes except GS MAN. In GS AUTO mode, switch engages or remains set to ALT until glide slope capture, then moves to OFF. Spring loaded to OFF.
	H ADC SOURCE SELECT AND DESIGNATED PILOT SWITCHES	
12	ADC SOURCE SELECT Switch	Selects air data computer source of altitude and airspeed inputs to autopilot. Not redundant to CADC select function available on CDU Aiding page.
13	DESIGNATED PILOT Selector Switch	Selects steering input to autopilot (from EGI 1 or EGI 2). Also see Pilot and Copilot Steer and Steer Select pages in CDU menus.

Figure 1-109 (Sheet 5 of 5)

PITCH SIGNAL FLOW

The autopilot controls the elevator control tab to hold the airplane in level flight, climb or descent, or follow an ILS glide slope. The elevator servo is synchronized with the elevator so the pitch angle at the time of engagement is the reference pitch attitude. The autopilot elevator channel also provides a signal to drive the horizontal stabilizer to trim the airplane automatically in pitch. There are two stabilizer trim rates:

1. One half turn of the trim wheel per second, or 22.5 seconds per unit with flags up and turn knob in detent.

2. 1.67 turns of the trim wheel per second or 7.5 seconds per unit with flaps down, or turn knob out of detent.

Refer to PITCH TRIM, subsection I-H.

AUTOPILOT OPERATION

ENGAGEMENT

The turn control must be in detent (center) position for the autopilot to engage. After engagement, in MAN (manual) mode, rotating the turn control right or left causes the autopilot bank in the direction selected. When the turn control is returned to detent position, the airplane attempts to maintain the heading existing at the time the turn control was centered. Heading, navigation and approach modes of operation are available and a specific operation of the autopilot is provided in each mode.

Electrical interlock circuits prevent engagement and operation of the autopilot unless all conditions necessary to the proper functioning of the system are satisfied.

When engaging the autopilot, hold the autopilot engage switch in the AUTOPILOT position until magnetic lock occurs (on initial engagement, approximately 1/2 second; on engagement after disengagement, up to five seconds).

NOTE

- The autopilot does not engage if both yaw dampers are disengaged or if applicable EGI (1 or 2), as selected via DESIGNATED PILOT switch, is not in NAV mode or applicable ATTD RDY (1 or 2) annunciation is not (or has not been) displayed on a CDU. The autopilot disengages each time the selected yaw damper switches are set to OFF.
- It can be necessary to hold the autopilot engage switch in the AUTOPILOT position for up to five seconds in order to engage the autopilot. When the switch is magnetically latched, the autopilot is engaged.

DISENGAGEMENT

The autopilot disengage warning unit and circuits provide either a flashing warning light or steady light (*figure 1-109*) depending on the condition affecting the autopilot system.

NOTE

- A flashing light indicates an autopilot disconnect. A steady light indicates that the autopilot pitch trim is still operating in high speed and elevator servo is in high torque mode (with flaps up). One or both flap limit switches did not operate. Steady light does not reset.
- When manually disengaging autopilot in flight, avoid pitch or roll transients by waiting until three-axis trim indicator (and parallel damper indicator if using parallel yaw damper) shows servos are in trim condition.
- If the AUTOPILOT circuit breaker on the P5 Panel trips, both EGIs will report an ANL ATT NGO. This NGO does not affect the EGI's ability to navigate and can be corrected by closing the AUTOPILOT circuit breaker.

The disengaged warning lights flash on when (autopilot disengages):

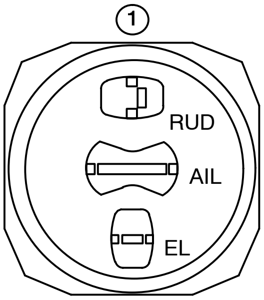
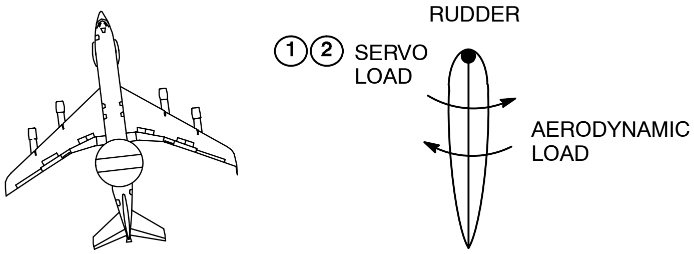
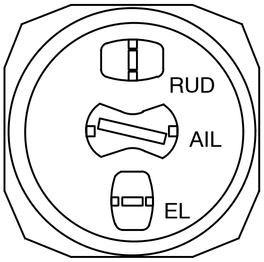
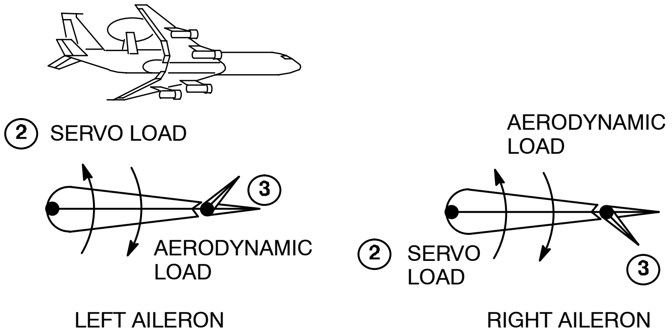
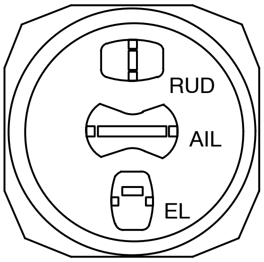
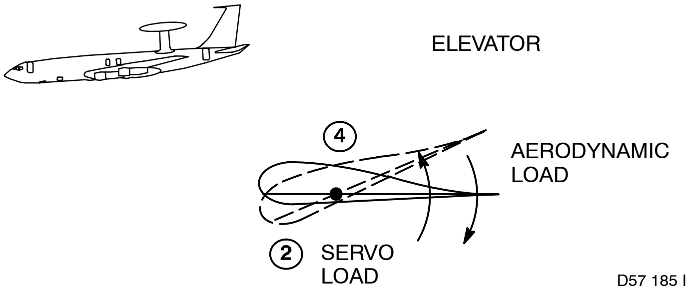
1. Any component necessary for operation has failed.
2. Either pilot stabilizer trim control switch is actuated.
3. Autopilot engage switch is set to OFF.
4. Either pilot autopilot disconnect switch is actuated (AP WARN light flashes only while autopilot disconnect switch is pressed).
5. Automatic stabilizer trim cutout switch is set to CUTOUT.
6. Autopilot attitude source is switched.
7. Both yaw dampers are disengaged.

   To turn off the flashing AP WARN lights, press either pilot autopilot disconnect switch or either AP WARN light.

INFLIGHT

The inflight operation of the autopilot is described in the following paragraphs by phase of flight to describe the various modes in a typical operational environment. If the flight director system is used to monitor autopilot operation, slight disagreement between the flight director bank and pitch commands displayed and autopilot operation can be observed. This condition exists since the autopilot and flight director use separate computers as the source for steering commands and the tolerances within the systems are not exactly the same. See *figures 1-108* through *1-115*

Three Axis Trim Indicator

INDICATION	CORRECTION REQUIRED	CONDITIONS PRIOR TO CORRECTION
	NOSE RIGHT	
	RIGHT WING DOWN	
	NOSE UP	

① Parallel yaw damper indicator operation is similar when parallel yaw damper is engaged.

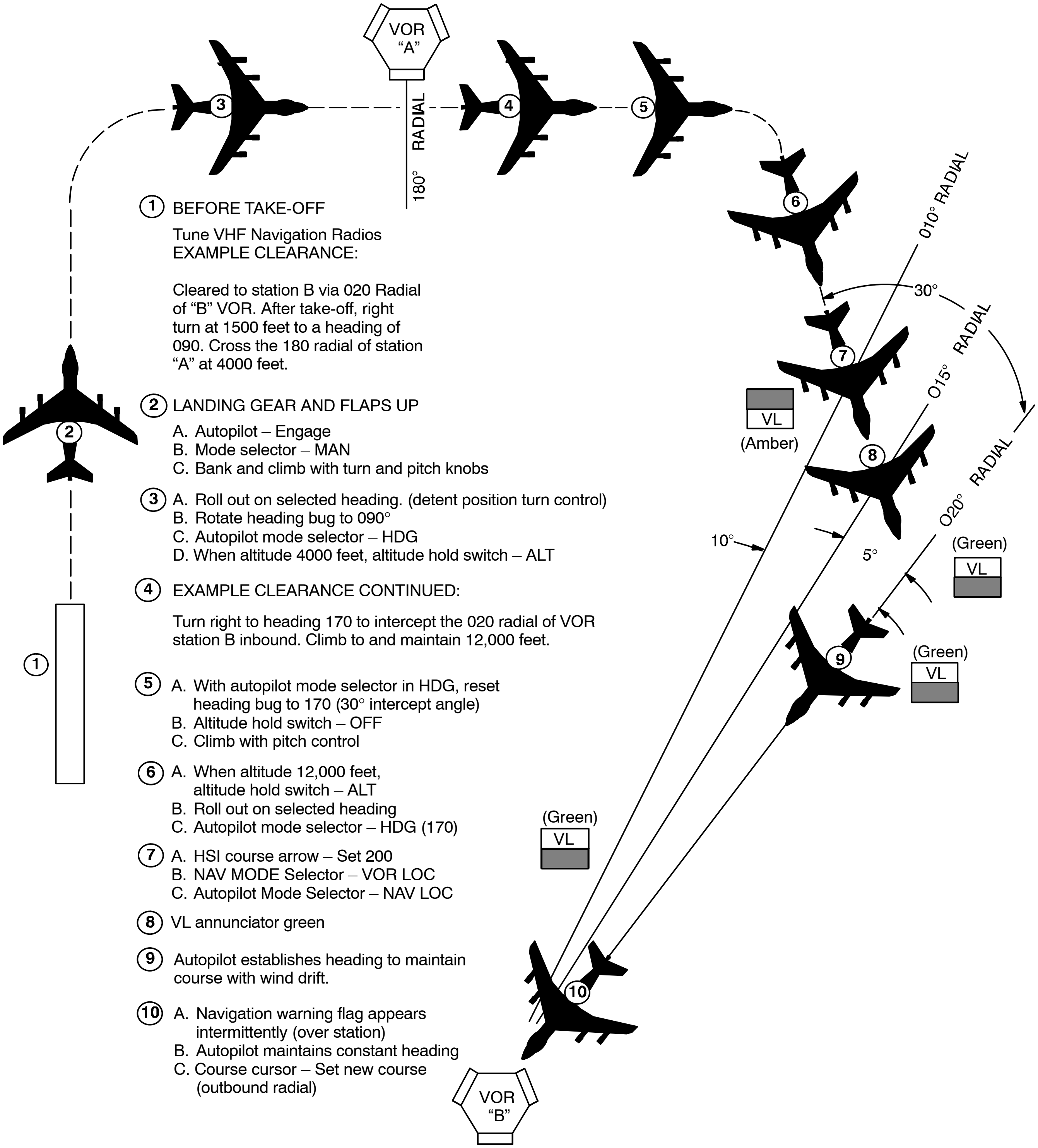
② Steady-state servo load required to oppose aerodynamic load (servo load causes indication).

③ Control tab setting required to remove servo load.

④ Stabilizer setting required to remove servo load.

Figure 1-110

Autopilot Operation - Takeoff and Departure (Typical)



① BEFORE TAKE-OFF

Tune VHF Navigation Radios
EXAMPLE CLEARANCE:

Cleared to station B via 020 Radial of "B" VOR. After take-off, right turn at 1500 feet to a heading of 090. Cross the 180 radial of station "A" at 4000 feet.

② LANDING GEAR AND FLAPS UP

A. Autopilot – Engage
B. Mode selector – MAN
C. Bank and climb with turn and pitch knobs

③ A. Roll out on selected heading. (detent position turn control)
B. Rotate heading bug to 090°
C. Autopilot mode selector – HDG
D. When altitude 4000 feet, altitude hold switch – ALT

④ EXAMPLE CLEARANCE CONTINUED:

Turn right to heading 170 to intercept the 020 radial of VOR station B inbound. Climb to and maintain 12,000 feet.

⑤ A. With autopilot mode selector in HDG, reset heading bug to 170 (30° intercept angle)
B. Altitude hold switch – OFF
C. Climb with pitch control

⑥ A. When altitude 12,000 feet, altitude hold switch – ALT
B. Roll out on selected heading
C. Autopilot mode selector – HDG (170)

⑦ A. HSI course arrow – Set 200
B. NAV MODE Selector – VOR LOC
C. Autopilot Mode Selector – NAV LOC

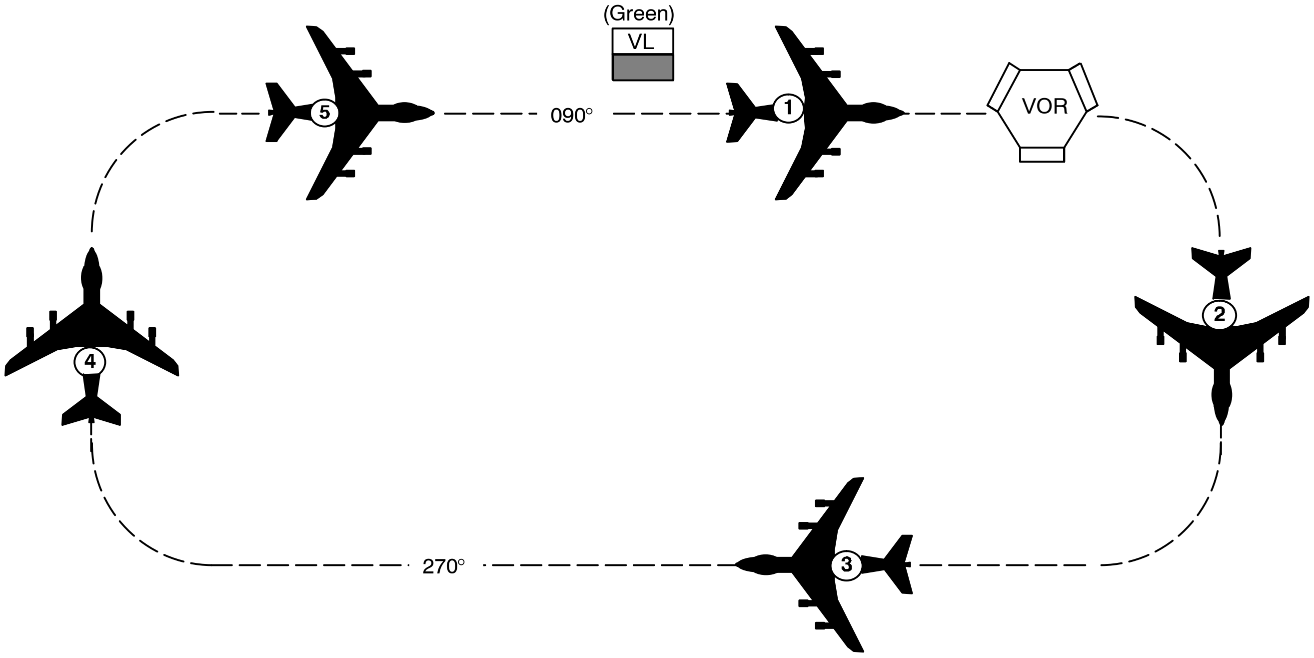
⑧ VL annunciator green

⑨ Autopilot establishes heading to maintain course with wind drift.

⑩ A. Navigation warning flag appears intermittently (over station)
B. Autopilot maintains constant heading
C. Course cursor – Set new course (outbound radial)

Figure 1-111

Autopilot Operation - Holding



① A. Autopilot Mode Selector – NAV LOC
B. Course Arrow – 090°
C. Heading Bug – 270°
D. Altitude Hold Switch – ALT

② Bank with Turn Knob
(Mode Selector Returns to Man Mode)

NOTE

IF HDG MODE IS SELECTED OVER THE STATION, THE AUTOPILOT WILL NOT NECESSRILY TURN RIGHT

③ A. Roll out on Outboard Heading (Approximately 270°)
B. Mode Selector HDG
C. The Heading Bug May Be Reset to Compensate for Wind Drift and Turn Inbound

④ A. Heading Bug – 90°
(Corrected for Drift)

⑤ A. Maneuver to Within Approximately 1/2 Dot of Course Using Heading Bug

B. Mode Selector – NAV LOC

C. Autopilot VL Annunciator – Green

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Figure 1-112

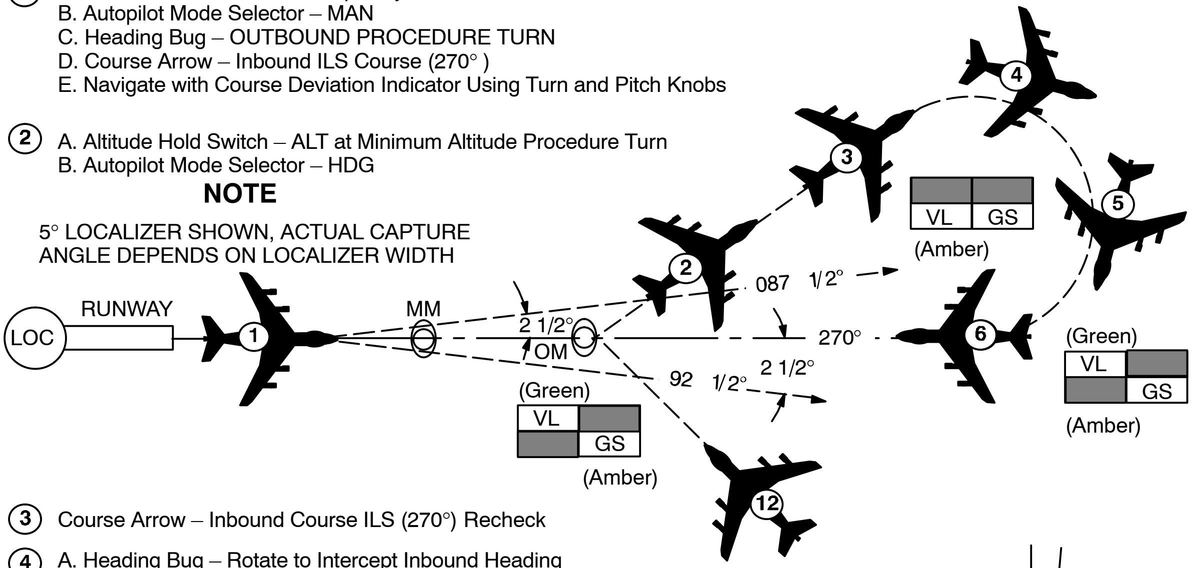
Autopilot Operation - ILS Approach

① A. VOR Radio No. 1 – ILS Frequency
B. Autopilot Mode Selector – MAN
C. Heading Bug – OUTBOUND PROCEDURE TURN
D. Course Arrow – Inbound ILS Course (270°)
E. Navigate with Course Deviation Indicator Using Turn and Pitch Knobs

② A. Altitude Hold Switch – ALT at Minimum Altitude Procedure Turn
B. Autopilot Mode Selector – HDG

NOTE

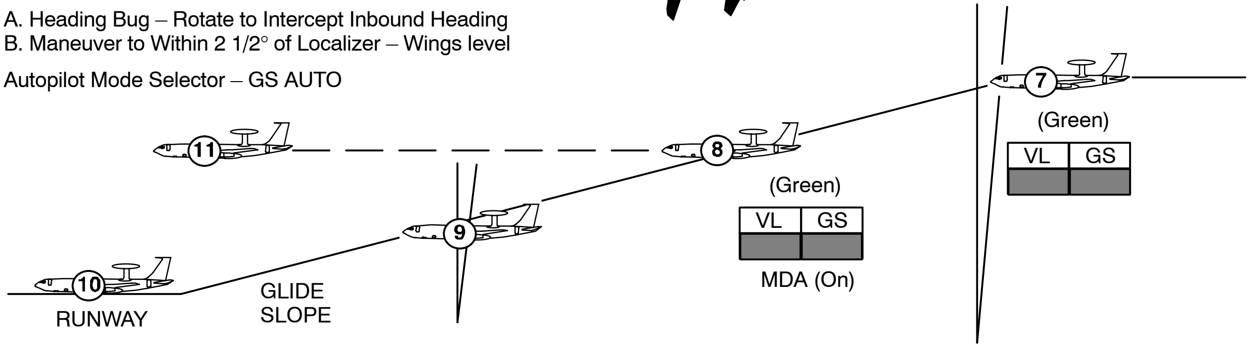
5° LOCALIZER SHOWN, ACTUAL CAPTURE ANGLE DEPENDS ON LOCALIZER WIDTH



③ Course Arrow – Inbound Course ILS (270°) Recheck

④ A. Heading Bug – Rotate to Intercept Inbound Heading
B. Maneuver to Within 2 1/2° of Localizer – Wings level

⑤ Autopilot Mode Selector – GS AUTO



⑥ Autopilot Begins Capture of Localizer Course

⑦ A. Autopilot Mode Selector – GS AUTO
B. Altitude Hold Switch – OFF (AUTOMATICALLY)

⑧ DECISION HEIGHT

Autopilot Disconnect Switch – Press to Disengage AUTO-PILOT

⑨ MIDDLE MARKER

⑩ TOUCHDOWN

⑪ GO AROUND

A. Go-Around Checklist – Completed
B. Autopilot – Re-engage (when desired)
C. Use turn and pitch knobs to establish pitch and heading

⑫ ALTERNATE APPROACH (VECTOR TO OUTER MARKER)

A. Autopilot Mode Selector – GS AUTO
B. Altitude Hold – ALT
C. Autopilot Begins Capture at 92 1/2°

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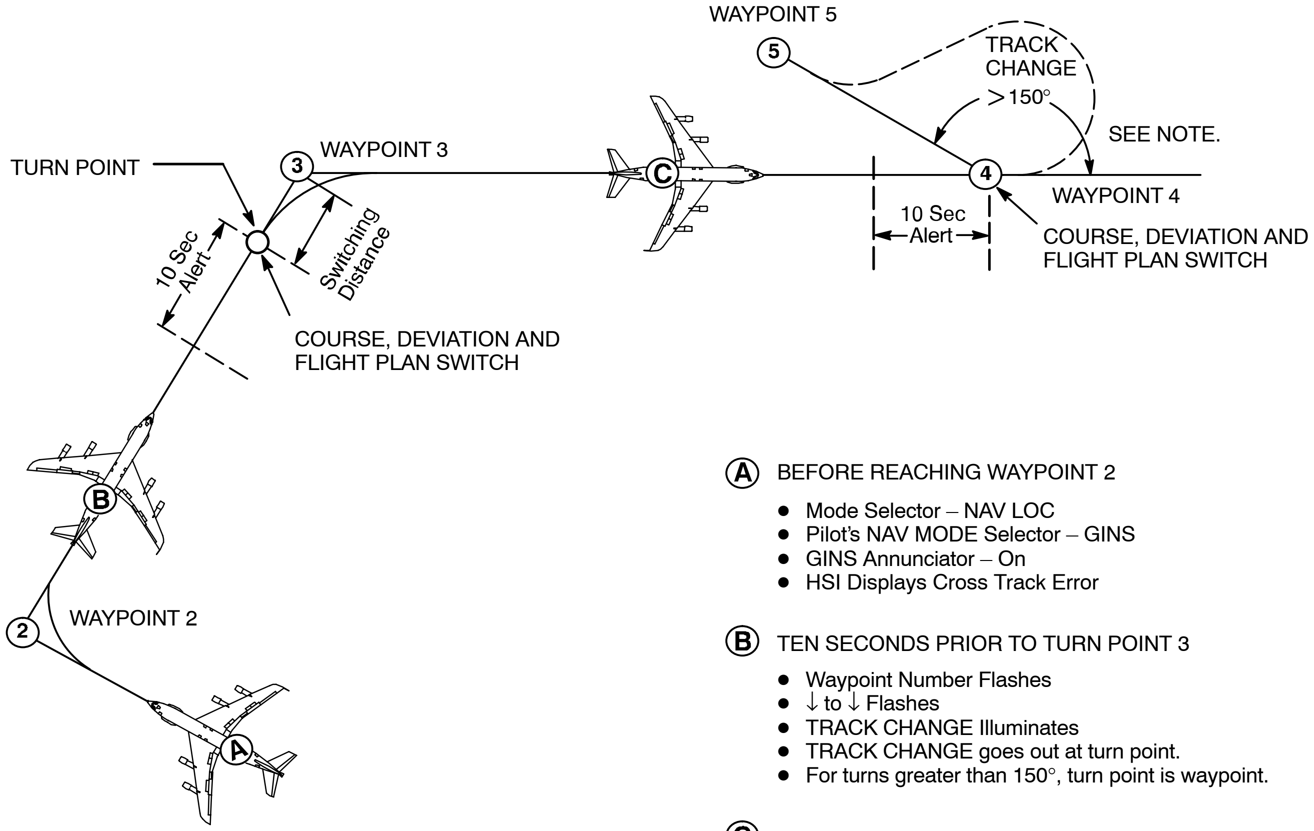
Figure 1–114 deleted.

Figure 1-113

Autopilot Operation - GINS Navigation



Ⓐ BEFORE REACHING WAYPOINT 2

- Mode Selector – NAV LOC
- Pilot's NAV MODE Selector – GINS
- GINS Annunciator – On
- HSI Displays Cross Track Error

Ⓑ TEN SECONDS PRIOR TO TURN POINT 3

- Waypoint Number Flashes
- ↓ to ↓ Flashes
- TRACK CHANGE Illuminates
- TRACK CHANGE goes out at turn point.
- For turns greater than 150°, turn point is waypoint.

Ⓒ ON COURSE

- TRACK CHANGE – Out
- HSI – Centered
- GINS Annunciator – On
- TO Next Waypoint

NOTE

For track changes greater than 150 degrees, waypoint is over flown and teardrop turn is made to intercept next leg.

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Figure 1-115

Takeoff and Climb

Prior to takeoff, tune navigation radios to desired frequencies, select desired HSI presentation and set heading marker and course arrow to heading and course selections. Autopilot may be engaged any time after takeoff after flaps are up and climb power is set. When engaged, autopilot operates in manual mode and maintains the airplane wings-level and in the climb pitch attitude. The pitch and turn knobs may be used as desired to maneuver the airplane on departure course. If a preset heading is required, select HDG mode. In this mode, the autopilot turns to and maintains the heading set on the pilot's HSI heading marker. When heading changes are required, rotate the HSI HDG knob to set the new heading when the turn to the heading is required.

When flaps are extended, the gain of the autopilot pitch axis is increased automatically, causing larger elevator deflections for a given pitch change command. When flaps are retracted, the gain is reduced automatically.

WARNING

If autopilot warning light illuminates continuously after flap retraction, at least one flap limit switch has malfunctioned. Autopilot pitch servo is in high torque mode and pitch trim is in high speed. Avoid large, rapid pitch knob motions.

NOTE

- In HDG mode, selection of a new heading with the pilots' HSI HDG knob causes the autopilot to turn the airplane immediately to the selected heading.
- Maximum bank angle in HDG mode is 30°. In MAN mode, the maximum bank angle is 35° at full movement of the turn knob.
- Maximum pitch using the pitch knob is ±30° from the pitch reference attitude sensed at time of engagement.
- Airplane roll rate produced by the autopilot is 2-1/4 degrees per second in VOR localizer mode and 4 1/2 degrees per second in all other modes.

Continue departure in HDG mode or MAN mode until use of a navigation radio or GINS is desired. Control pitch manually with the autopilot pitch knob. Altitude hold mode can be used during the departure if a level off at some point during climb is required.

Altitude Hold

The altitude hold mode can be used in any autopilot mode of operation except GS MAN. In GS AUTO, altitude hold mode cannot be used after glide slope capture. Selection of altitude hold mode is made by placing the autopilot altitude hold switch to ALT position. The airplane then maintains the altitude sensed at the time the switch was engaged.

NOTE

- If the altitude hold switch is switched to the ALT position with the airplane in climb or descent, the autopilot uses the altitude at the time of switching as the reference altitude and levels the airplane to this altitude.
- For best results, limit the rate of climb or descent to 500 fpm when engaging ALT mode to prevent excessive overshoot of desired altitude.
- Altitude data inputs are supplied to the autopilot by the ADC 1 or ADC 2, as selected at ADC SOURCE SELECT panel. If the altitude error signal is lost, altitude hold mode is inoperative, but manual pitch and glide slope functions can still be used for autopilot pitch control.

When altitude hold is engaged a signal is sent to both air data computers simultaneously that commands each ADC to independently remember the altitude it was indicating at engagement, and to report altitude deviation back to the autopilot. The autopilot uses the altitude deviation signal from the selected ADC. If ADC Source Selector is switched during altitude hold engagement, altitude hold remains engaged and no altitude change is experienced even if the ADCs are indicating different altitudes. While the ADC altitudes might be slightly different, the deviations are the same. If selected altitude deviation signal is lost, altitude hold disconnects. If altitude hold is manually disconnected, or disconnects automatically for any reason, both ADCs forget their hold altitude, until re–engaged.

Cruise

During climb enroute or at cruise altitude, the autopilot may be operated in heading mode or navigation modes.

NOTE

At low airspeed and aft c.g. the autopilot can cause the airplane to oscillate a few degrees in roll. This is not a malfunction.

NAV/LOC (Navigation Localizer) Mode

The NAV/LOC mode uses navigation signals from GINS, VOR, TACAN, ILS localizer, or steering pattern data from the GINS.

Pages 1–409 through 1–412 deleted.

GINS Mode

With NAV MODE set to GINS and autopilot set to NAV LOC, analog steering commands are generated in the BSIU selected by the DESIGNATED PILOT switch. Steering commands are based on airplane position and velocity in relation to the flight plan route or selected steering pattern currently active in the bus controller CDU.

Desired track is computed in this mode and cannot be set manually in the HSI. The course setting knob on the HSI must be pushed in to avoid clutch wear.

GINS does not compute an intercept angle to the desired track. The pilot must determine an intercept angle that intercepts the desired track and then turn to that heading using manual controls, autopilot HDG mode, or autopilot MAN mode. When on the desired intercept heading, set autopilot mode selector to NAV LOC. The autopilot maintains heading until course capture. Course capture begins within seven miles of desired track, based upon track intercept geometry.

After intercepting the track, the autopilot maintains the airplane on the flight plan. A switching distance is calculated which establishes a turn point prior to waypoint so that airplane turns inside the waypoint to intercept the outbound track without overshoot. Switching distance is based upon angle of turn, wind and true airspeed, 30° max bank, and is not greater than seven miles from waypoint. Ten seconds prior to the calculated turn point the waypoint number in the CDU Fpln page flashes, the ↓ to ↓ display on the Lateral Steer page(s) flashes, and the RNAV ANNUNCIATORS panel TRACK CHANGE indicator illuminates. When the turn point is reached, the autopilot banks to intercept the new track at the calculated turn point, and the TRACK CHANGE annunciator goes out. The Fpln page identifies the next waypoint as the TO waypoint.

Pattern Steering

The GINS submode is used to follow steering patterns. Refer to Holding Patterns and Mission Flight Patterns, this subsection, and subsection I-N-3, GINS TYPICAL OPERATION, MFP DEFINITION. When GINS senses a cross track error, it corrects by rolling the airplane toward the track.

VOR/LOC Submode

The VOR/LOC submode is used when it is desired to automatically capture and track a VOR, TACAN or localizer beam. To enter this mode, the autopilot must be engaged and the airplane turned to approach the selected course at an intercept angle of 90 or less.

NOTE

- The pilot's NAV MODE selector must be set to either VOR/LOC or TACAN for VOR/LOC submode of operation. The course arrow on the pilot's HSI must be set to the desired radial to provide a reference course to the autopilot system.
- Do not perform VOR or TACAN self test in flight with autopilot engaged. Airplane follows bearing pointer movements.

Until radio beam capture, the autopilot bank command signal is referenced to compass heading input as in manual mode. Variable headings for intercept of the beam can be made by use of the turn control prior to selecting VOR/LOC submode. If desired, the HDG mode can be used to provide preset heading selections.

At beam capture point (2 1/2° from selected course), the autopilot turns the airplane (in a bank up to 30°) to intercept the selected course and then maintains the airplane on course. When VOR/LOC submode is first selected, the autopilot V/L annunciator illuminates amber to indicate mode selection. At beam capture, the amber display becomes green to indicate capture. The annunciator provides amber and green displays in VOR, TACAN and localizer operation.

NOTE

> In VOR/LOC submode, the radio signal commands are suppressed when flying over the station. The autopilot maintains the airplane on the course selected to provide smooth station passage.

Pitch control in VOR/LOC submode is maintained manually by use of the autopilot pitch knob or automatically by use of the altitude hold switch.

Descent

The descent can be manually controlled by the pitch knob until nearing the approach area. If desired, the airplane can be flown by the autopilot on VOR/ TACAN course or INS track during descent. Instrument selections and autopilot mode selections are as described under cruise.

Holding

For typical holding procedures, see *figure 1-111*.

Approach Procedures

The autopilot provides two approach modes for ILS approaches, GS AUTO and GS MAN. (See *figure 1-113.*) The GS AUTO mode is normally used for the approach; however, if the glide slope is approached from above, automatic capture of the glide slope is delayed until passing through the glide slope beam. In this condition, it may be necessary to switch to GS MAN for immediate glide slope capture. The GS MAN mode provides the same autopilot operation as GS AUTO, except for the automatic glide slope capture feature. Therefore, it is desirable to be within capture range (1/4 distance between dots on HSI GS indicator) of the glide slope when selecting GS MAN.

NOTE

> Maximum pitch limit in the GS AUTO and GS MAN modes is 8 1/2°.

Starting at 1,500 feet, the localizer and the glide slope beam signal are desensitized in the autopilot amplifier and computer as a function of radio altitude. This provides smoother localizer and glide slope beam tracking as the approach is made. The autopilot bank limit also decreases gradually from 30° at 1,500 feet to 5° at 80 feet radio altitude.

WARNING

> Below 1,000 feet above the runway, the pilot should follow through on all controls and disconnect the autopilot if performance is not satisfactory. The GS AUTO or GS MAN mode should not be initially engaged or re-engaged below 800 feet above the runway.

NOTE

- Vehicles in the vicinity of the ILS or airplanes on approach can distort localizer or glide slope beams and degrade coupled operation.
- If the radio altimeter is off or inoperative (warning flag in view), glideslope and localizer gain is not reduced within autopilot. Also, autopilot bank limit is not reduced.

In GS AUTO or GS MAN modes, the autopilot can remain engaged under instrument conditions down to category I decision height. The autopilot can control the airplane during an ILS approach with one engine inoperative if the pilot maintains proper airplane trim. If an excessive out of trim condition develops, the autopilot cannot command enough control torque to overcome out of trim condition and maintain proper track.

For intercepting the localizer, GS AUTO mode should be used in preference to LOC submode. In the GS AUTO or GS MAN mode with localizer captured, an aileron crossfeed signal is fed to the yaw damper as a function of rate of change of beam deviation. This provides faster capture and tighter tracking of the localizer course by causing the yaw damper to move the rudder so as to aid in turning the airplane. Rudder movement is reduced to ±2.5°.

The following steps list the procedures necessary for a typical ILS approach:

– – – Outbound – – –

1. Set VHF NAV 1 to an ILS localizer frequency.

   Selecting the localizer frequency automatically selects the associated glide slope frequency.

2. Set Pilot's NAV MODE selectors to VOR/LOC.

   Check Pilot's HSI navigation warning flags and glide slope warning flag out of view.

3. Set inbound front course of ILS localizer in Pilot's COURSE selector window.

   The autopilot will not track a localizer course when the sensing is reversed (outbound front course). Select the inbound front course of the ILS with the COURSE knob.

4. Set autopilot mode selector to MAN.

   Fly the course deviation indicator on the Pilot's HSI, which displays correct sensing, using the turn knob and maintain proper altitude, using the pitch knob in the MAN mode.

NOTE

The altitude hold switch can be set to ALT when the level off or procedure turn altitude is reached.

– – – Procedure Turn – – –

5. Set Pilot's heading bug to outbound procedure turn heading.

6. Set autopilot mode selector to HDG.

   Set the autopilot mode selector to HDG when reaching point where procedure turn is required.

7. Reset heading marker as required to perform procedure turn.

   Maneuver airplane within 2 to 2.5° of front course.

– – – Inbound Front Course – – –

8. Set autopilot mode selector to GS AUTO.

   Check VL annunciator is amber. When 2 to 2.5° (2 dots) from the inbound front course, the autopilot begins capture of the localizer course (blank limit to 30°). On localizer course (capture complete), VL annunciator turns green and the autopilot integrates the wind drift to follow the course and give a relatively constant heading.

9. Check GS annunciator turns green when glide slope is intercepted.

   Check glide slope indicators on HSI and attitude director indicator for glide slope interception. Flight director pitch steering bar also indicates glide slope steering commands if flight director system is set for an ILS approach. Refer to FLIGHT DIRECTOR SYSTEM.

10. Press either autopilot disconnect switch to disengage autopilot.

    The pilot should hold the controls for a possible out of trim condition at the time of autopilot disengagement. Check the autopilot three axis trim indicator prior to disengaging to see if an out of trim condition exists.

NOTE

The autopilot can be used during a back course approach, if desired. The mode selector must be placed in MAN and the inbound front course set on the HSI. Follow procedures as listed for the outbound front course.

Grid Navigation

The autopilot must be in GINS mode or disengaged when changing between magnetic compass and grid. (Refer to GRID NAVIGATION section IV.) The autopilot can be operated in MAN or HDG modes to fly grid headings. GINS mode can be used to fly true headings with the compass set to grid.

HOLDING PATTERNS

One holding pattern can be applied to a single fixed waypoint in the flight plan. Holding guidance is activated when the waypoint identified as the holding fix is passed the first time. At that time all displays reference the inbound course for the pattern, and leg sequencing is suspended. The holding pattern is entered regardless of the sequencing mode selected upon crossing the fix. A summary of holding pattern logic is shown below.

HOLDING PATTERN LOGIC CHARACTERISTICS

CONDITION	RESPONSE
Arrival at holding waypoint.	Holding pattern guidance activated, flight displays now reference inbound holding course.
Cancelling holding pattern while active (that is, deleting holding attribute).	Pattern definition parameters reset to default values when pattern is exited. (See NOTE below.)
Exiting the holding pattern by Direct To a later waypoint.	Pattern definition parameters reset to default values.
Associated waypoint deleted from flight plan.	Pattern definition parameters reset to default values.
Disassociating holding attribute from a future waypoint, but not deleting waypoint.	All parameters remain.

NOTE

If attribute for a holding pattern is deleted, pattern definition is disassociated from fix and a new pattern can be defined and inserted into flight plan while current pattern is being terminated. After sequencing past current fix, pattern definition parameters are not reset to default values if hold definition has been attached to a flight plan waypoint. However, hold cannot be reattached to TO waypoint. If an attempt is made to attach hold to TO waypoint, HOLD IS ACTIVE scratchpad message is displayed.

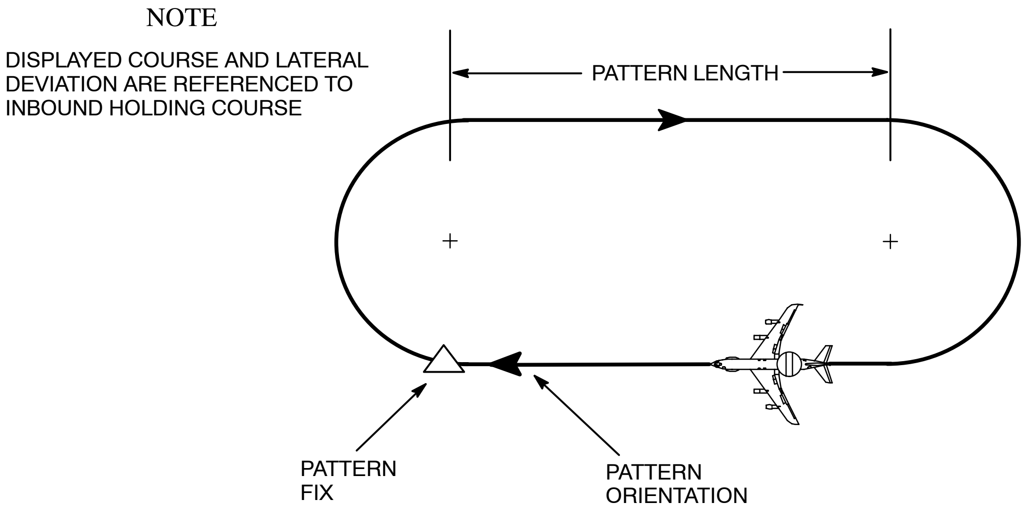
The defining parameters for the holding pattern are as follows:

1. Pattern Orientation – defined as the course into the fix parallel to the pattern center line. When the holding pattern is inserted into the flight plan, the inbound course is fixed.
2. Pattern Length – in nautical miles. This is defined to be the distance between the turn centers of the holding pattern parallel to the center line.
3. Turn Direction – right or left. This is defined to be the direction of turn.
4. Holding Speed – IAS in knots desired for the holding pattern. The speed alert is generated while the pattern is being flown based on this desired holding speed.
5. Expect Further Clearance Time – in hours past midnight UTC. This is the time the crew expects to exit the holding pattern.

Default parameters are provided for all of the defining parameters (except fix point and the EFC) of the holding pattern.

The defining parameters for a holding pattern are as shown in figure 116.

DEFINING PARAMETERS FOR A HOLDING PATTERN



NOTE

DISPLAYED COURSE AND LATERAL DEVIATION ARE REFERENCED TO INBOUND HOLDING COURSE

D57 195 I

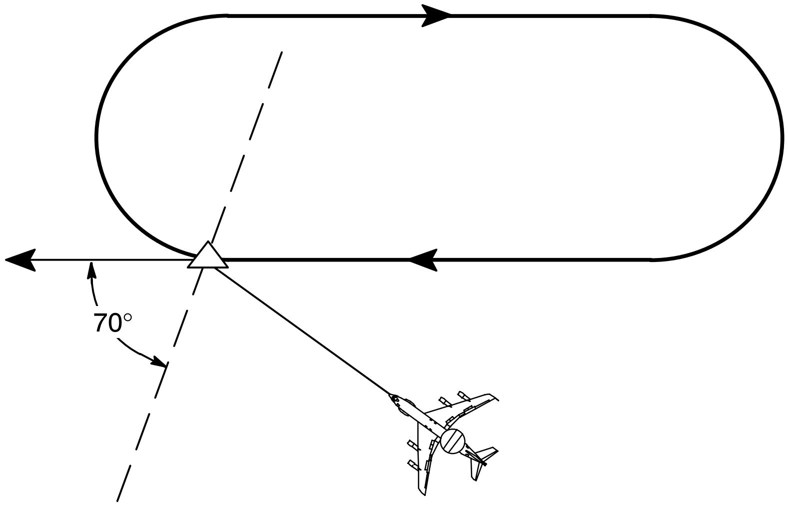
The crew has the option to hold at present position. When this option is selected, the airplane begins execution of a standard holding pattern, using the parameters defined on the Hold page. If no parameters have been entered on the Hold page, defaults are provided. The airplane holds at present position even if it is executing a parallel offset, but the offset is cancelled.

The crew also has the option to specify an EFC time in hours past midnight UTC. This allows for the computation of future ETAs. If the EFC is smaller than the ETA by 30 minutes or less, the EFC is assumed to be in history and all future ETAs are invalid. However, the EFC time is not used for computing ground speed commands for the TNAV function.

The entry into the pattern is defined by the relative geometry of the course inbound to the pattern fix and current track into the pattern fix. The possible entry modes are Direct, Teardrop, and Parallel. Entry mode geometry for a holding pattern is defined below. For left-hand turns, a mirror image of the entry procedures applies. An advisory for the entry method is displayed in accordance with standard FAA procedures.

A direct entry is executed for course changes between –110° and 70°.

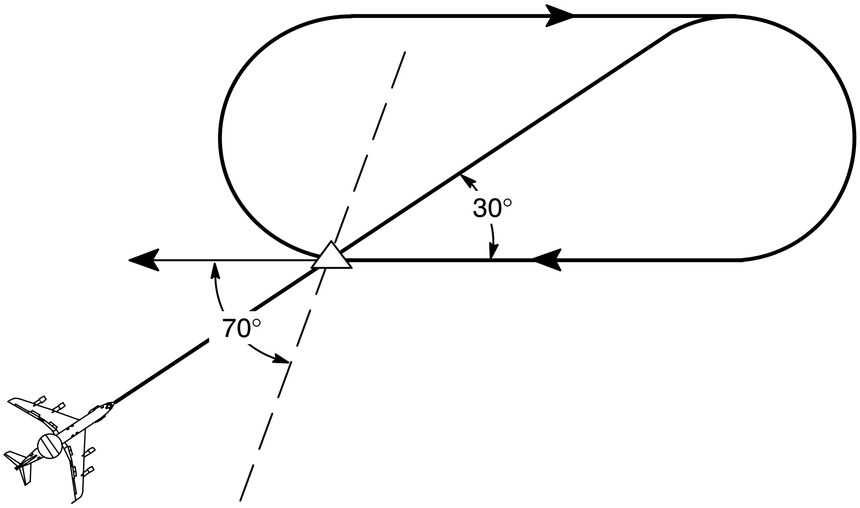
DIRECT ENTRY



D57 196 I

A teardrop entry is executed for course changes between –110° and –180°. After the pattern fix is crossed, the outbound course of the pattern is captured with a course intercept of 30°.

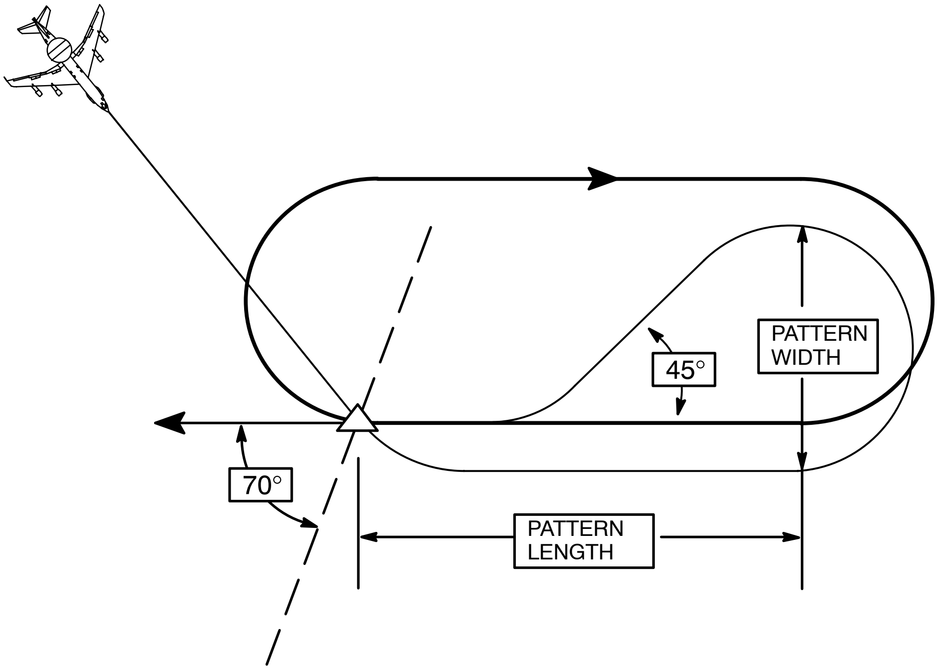
TEARDROP ENTRY



D57 197 I

A parallel entry is executed for course changes between 70° and 180°. After the pattern fix is crossed, an offset course parallel to the inbound course is created, based on airplane speed, wind, and course geometry. At a specified distance (equal to the pattern length), a turn inbound is executed to allow a 45° intercept of the inbound course to the pattern fix.

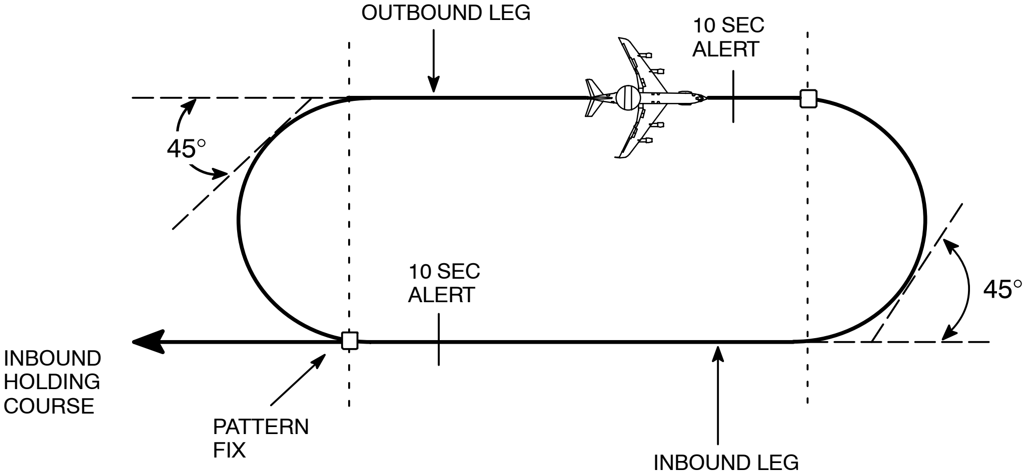
PARALLEL ENTRY



D57 198 I

The holding pattern execution begins by creating the inbound leg based on the pattern fix and inbound course. The outbound leg is then created based on the 25° bank angle. A turn point for each leg of the pattern is computed, which allows a maximum bank angle turn until a 45° course intercept is achieved. At this point, a standard course capture is performed. A waypoint alert is generated 10 seconds prior to the turn point, signalling turn anticipation. The maximum bank angle for a standard holding pattern is 30°. When the holding pattern is being executed, the HOLD ACTIVE annunciation is displayed on the CDU.

HOLDING PATTERN EXECUTION



D57 199 I

The guidance displays of desired track, bearing, distance, TO/FROM indication, deviation and time-to-go reference the pattern orientation and the fix point at all times.

The crew can modify the defining parameters for the holding pattern before pattern activation, or while the pattern is active.

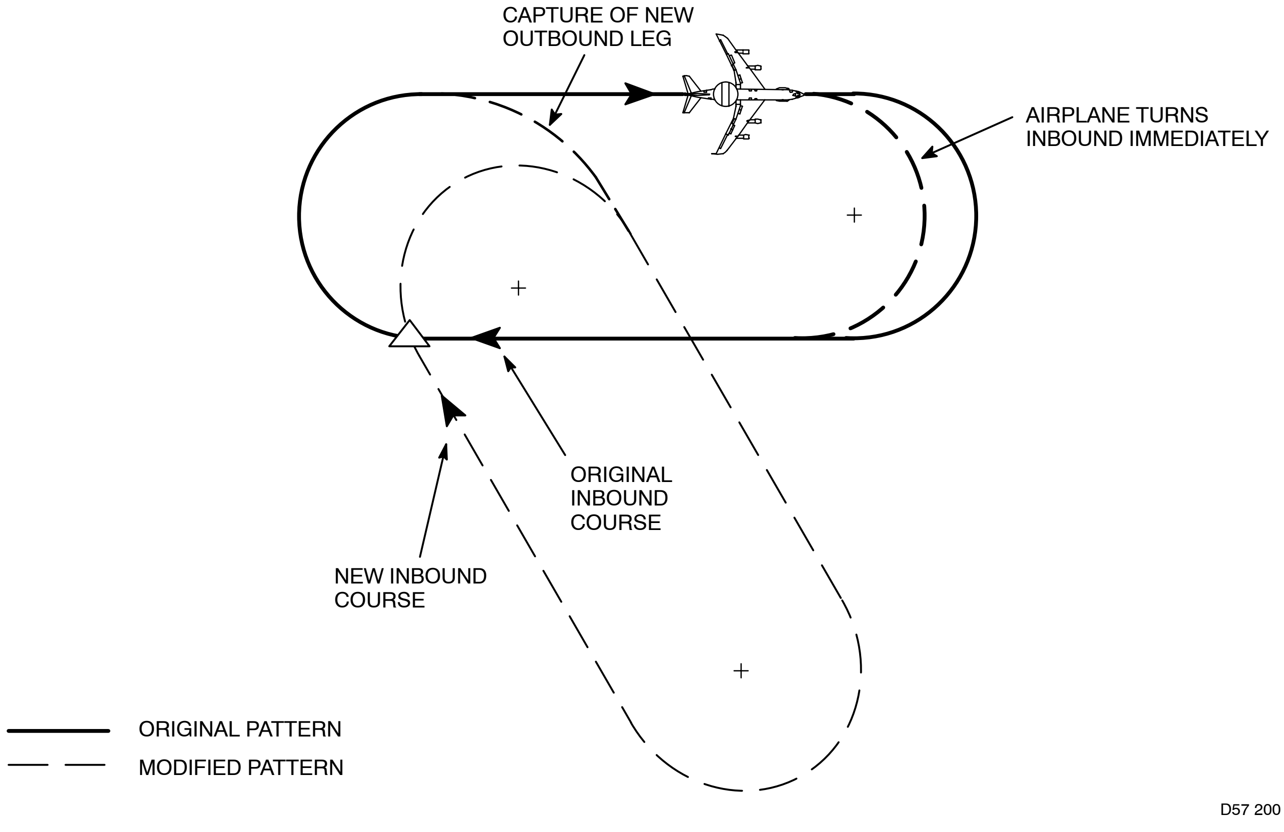
a. Before Pattern – All parameters can be modified prior to the activation of the pattern. Any changes made prior to entry take effect when the pattern becomes active.

b. After Pattern Activation

  (1) Pattern Fix – Course edits on the Flight Plan page are no longer allowed while the holding guidance is active. Also, the active waypoint cannot be deleted nor can a different waypoint be inserted as the active waypoint. Attempting to delete or modify the fix causes the HOLD IS ACTIVE scratchpad message to be displayed.

  (2) Pattern Orientation – If the crew chooses to change the inbound course, the airplane begins a turn immediately to the current inbound leg. Upon overflying the fix, the airplane begins capture of the new outbound leg.

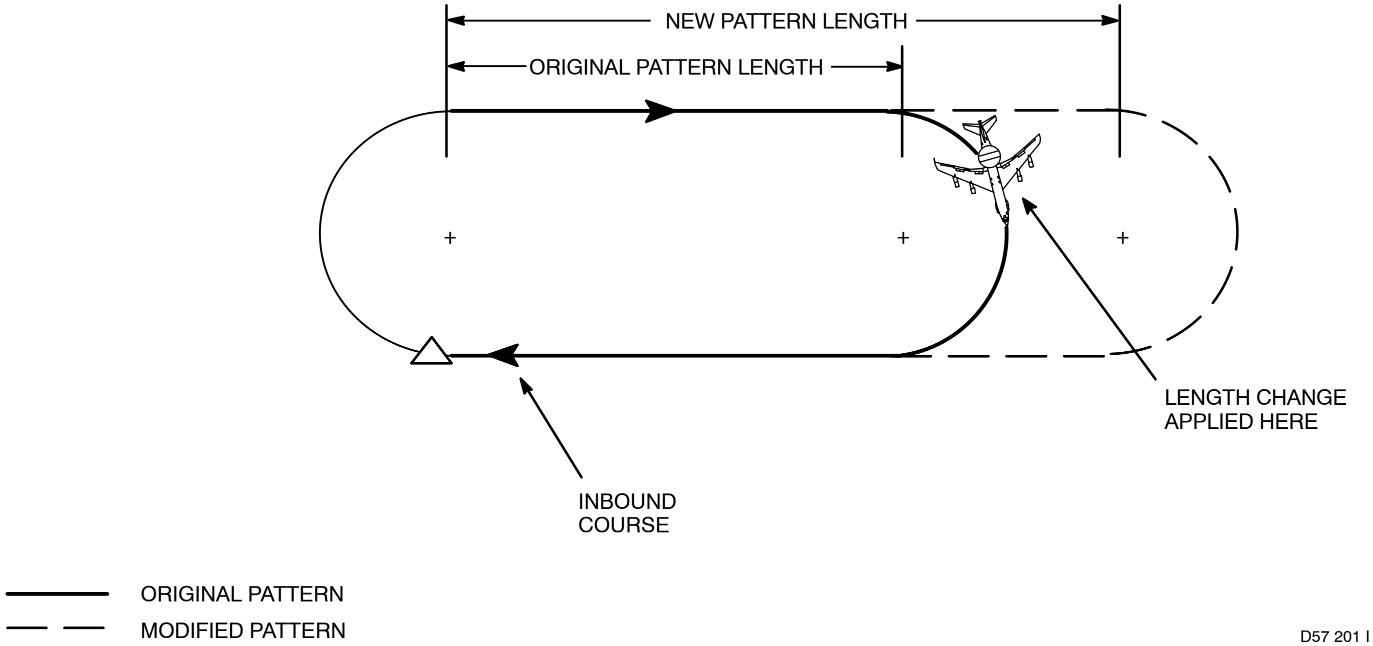
HOLDING PATTERN ORIENTATION EDIT



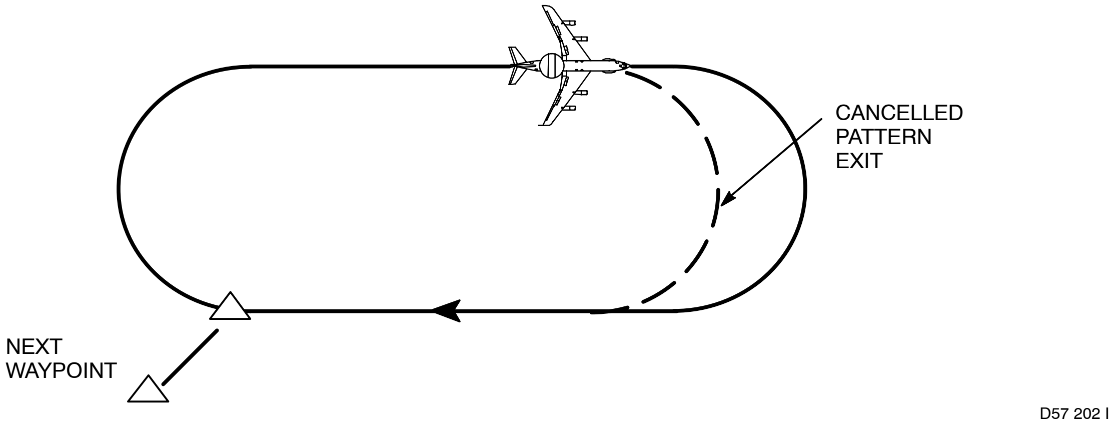
(3) Pattern Length – The pattern length can be modified at any time and takes effect immediately. If the airplane is already past the turn point for the new outbound leg, it turns inbound. If the length change is made while the airplane is executing a turn, the leg it is turning onto is intercepted at the same point as for the old pattern length. The new pattern length is then applied.

(4) Turn Direction – If the turn direction is changed, the airplane turns inbound immediately and the new turn direction is applied when the fix is overflown.

HOLDING PATTERN LENGTH EDIT WHILE TURNING



HOLDING PATTERN EXIT BY CANCELLATION



Holding patterns can be terminated in two ways: by cancellation, in which case a leg switch to the next flight plan waypoint occurs when the fix is crossed again (if automatic flight plan advancing is selected), or Direct-To to a waypoint is executed, removing the holding fix from the flight plan. When the holding pattern is terminated by cancellation, the airplane turns inbound immediately and overflies the fix. The HOLD ACTIVE annunciation remains displayed until the fix is overflown. If a Direct-To is performed to the pattern fix, the pattern is deactivated (the HOLD ACTIVE annunciation is removed) and the system performs a Direct-To to the fix. The pattern is re-entered upon crossing the fix unless the pattern attribute is removed prior to arrival at the fix.

Mission Orbit Patterns

An MOP can be defined at any waypoint in the flight plan or alternate flight plan. However, the number of MOPs is limited to 20 per plan. The five possible types of MOPs are the racetrack (orbit), figure eight, circle, refuel and closed random pattern (CRP). A waypoint designated as an MOP is the center of the capture lobe for circle, figure eight and racetrack patterns and the pattern fix for closed random patterns and refuel patterns.

The execution of a racetrack, figure eight, or circle MOP begins when the capture criteria are met regardless of the flight plan sequencing mode. CRP MOPs are entered only if automatic sequencing mode is selected upon reaching the fix. If manual sequencing mode is selected and a CRP MOP fix is reached, the airplane overflies the fix. The CRP is not entered until the sequencing mode is subsequently switched to automatic mode. A refuel pattern is entered when the control point (CP) is the TO waypoint and the pattern is enabled.

Execution of any MOP is terminated when a Direct-To to another waypoint is commanded by the flight crew. If a Direct-To is performed to an MOP pattern center or pattern fix location, the pattern is deactivated (the xxx ACTIVE annunciation is removed). The pattern is re-entered upon meeting the capture criteria unless the pattern attribute is removed from the waypoint prior to meeting the capture criteria.

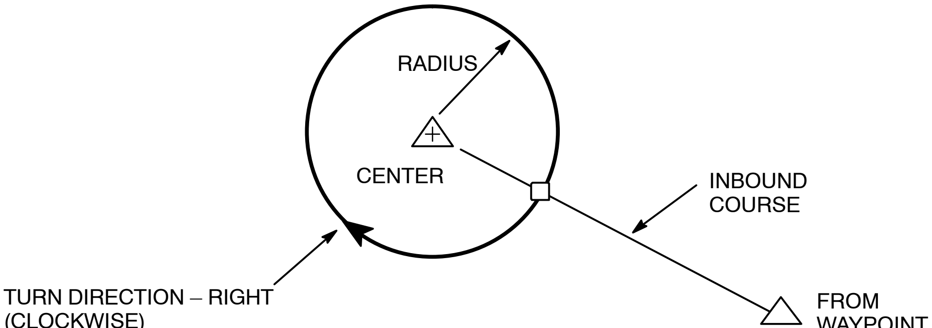
While a racetrack, figure eight, or circle pattern is active, the crew can modify pattern parameters or scroll through pattern types to change the type of pattern. After confirming a change to the pattern type and/or any pattern parameter, a Direct To is performed to the pattern capture lobe and the pattern is deactivated (xxx ACTIVE is not displayed, where xxx is the current pattern) until the capture criteria are met.

The crew has the option to specify an ETD in hours past midnight UTC. This is the time the crew expects to depart from pattern execution. The entry of this time allows for the computation of future ETAs and ETEs. If a desired time of arrival has been specified for a point after an MOP, the ground speed command is invalid until the MOP is exited. If the ETD is smaller than the ETA at the pattern fix by 30 minutes or less, the ETD is assumed to be in history and all future ETAs are invalid.

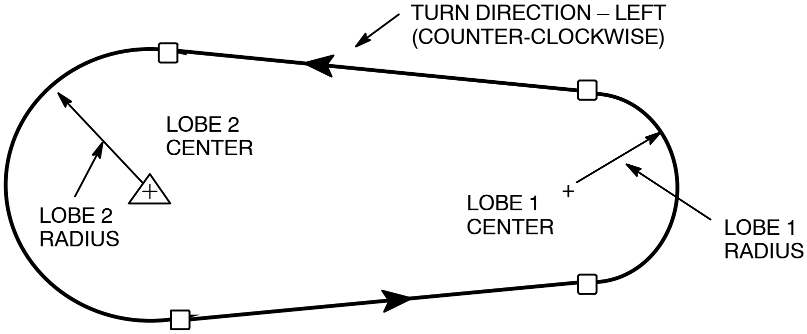
Circularized Patterns – Circle, Racetrack and Figure Eight

Circularized patterns are those defined by one or two circle center locations with a radius defining the perimeter of the circle or circles and an associated turn direction. For dual lobe patterns, one of the lobes is designated the capture lobe for initial pattern entry. For a circle pattern, the capture lobe is the circle defined by the pattern. Pattern transition points are calculated points used in guidance computations and navigation displays for segments of the pattern. The center of the capture lobe is a waypoint on the flight plan. The altitude specified for the capture lobe center, the flight plan waypoint, is the altitude for the entire pattern.

STANDARD PARAMETERS FOR CIRCULARIZED PATTERNS



CIRCLE PATTERN



RACETRACK PATTERN

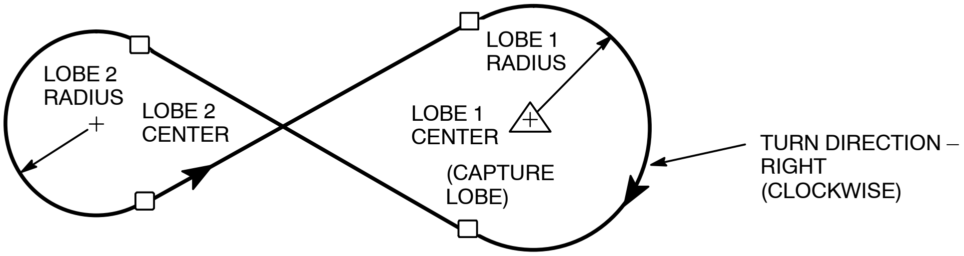


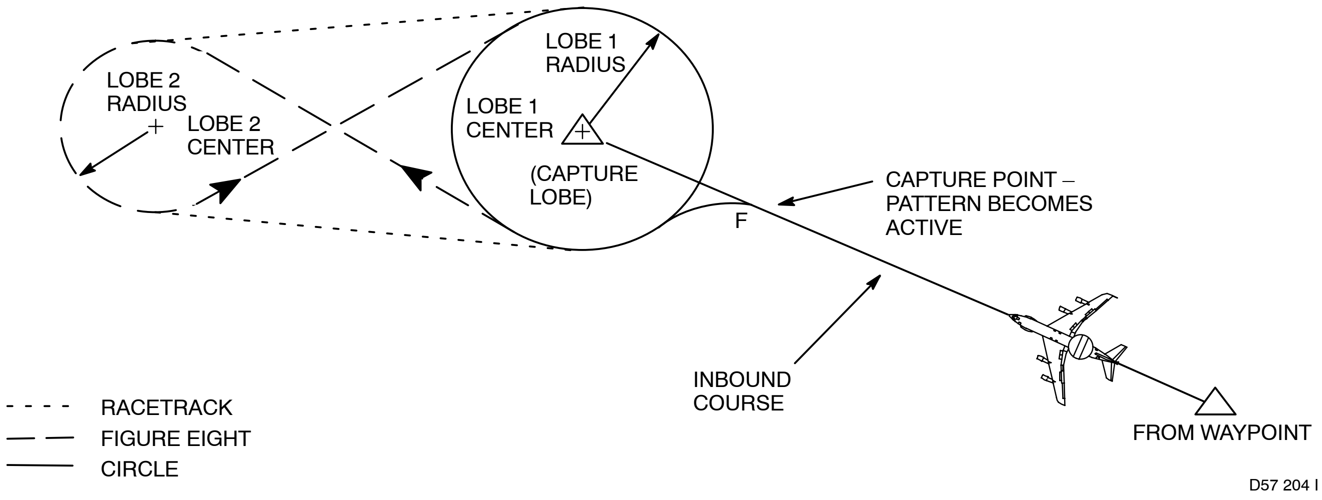
FIGURE EIGHT PATTERN

+ CIRCLE CENTER
□ TRANSITION POINT
△ CAPTURE LOBE CENTER

D57 203 I

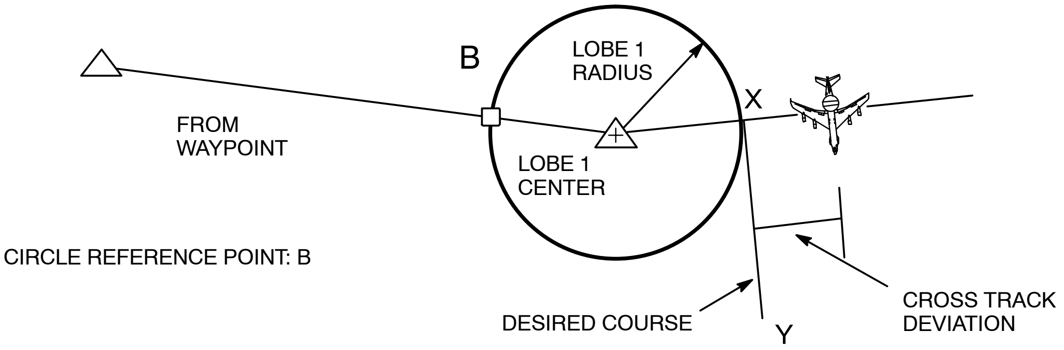
The course into the pattern as displayed on the flight plan page is the course determined by the preceding flight plan waypoint and the capture lobe center. When the capture lobe center becomes the TO waypoint, a capture switching distance is computed based upon a 90 degree course change, current airplane speed, and current wind. The pattern becomes active when the airplane is within the capture switching distance of the capture lobe circle along the inbound course as illustrated below. When the pattern is active the xxx ACTIVE annunciation is displayed on the CDU, where xxx represents CIR for circle, RTK for racetrack or FG8 for figure eight.

INITIAL CAPTURE OF A PATTERN

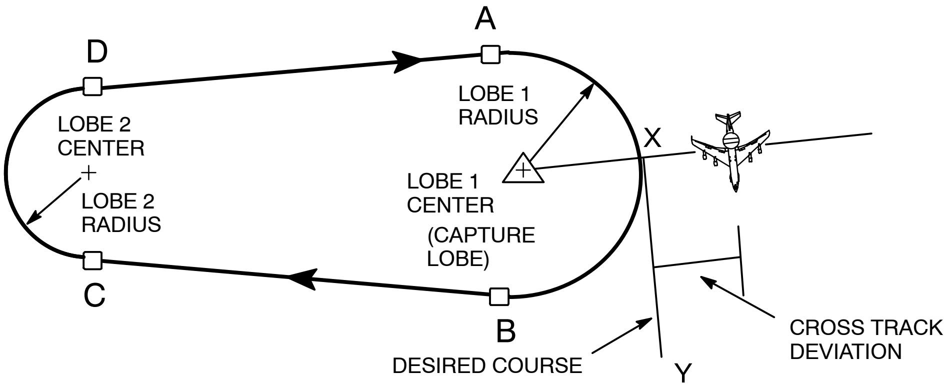


Pattern execution begins when the pattern capture criteria have been met. Upon capture, the transition points are determined and the airplane transitions to flying the capture lobe circle. For a circle pattern, the transition point is a single point on the perimeter of the circle determined by the course the airplane would fly if it flew directly to the center of the circle from the previous waypoint during the initial capture of the pattern. For racetrack or figure eight patterns, the transition points consist of roll in and roll out points as shown in the execution diagram, turning into the constant radius turn for a lobe and turning out of that constant radius turn. The airplane flies the capture lobe circle until the criteria are met for capture of the great circle leg portion of the pattern. The guidance displays of desired course, bearing, distance, TO/FROM indication, deviation and time-to-go reference the pattern orientation and the next transition point at all times. Guidance in the pattern consists of guidance during turns, guidance along the great circle course between lobes, and transitions between the lobes and great circle paths.

EXECUTION OF CIRCULARIZED PATTERNS



CIRCLE PATTERN



RACETRACK PATTERN

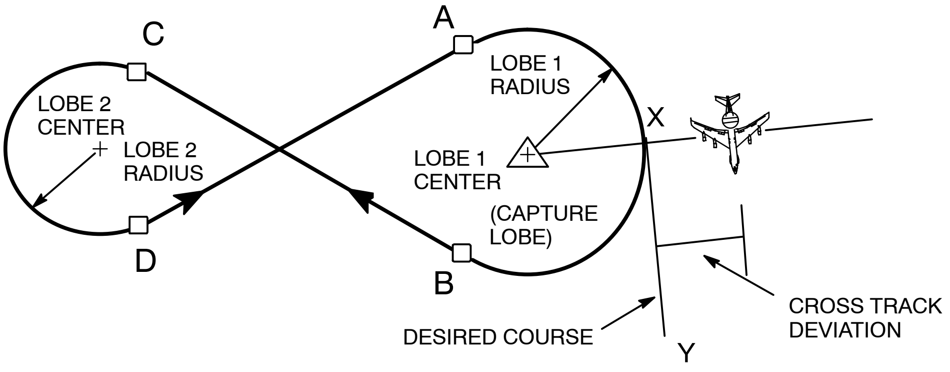


FIGURE EIGHT PATTERN

ROLL-IN POINTS: A, C
ROLL-OUT POINTS: B, D

D57 205 I

Constant radius turns are executed when flying the circle pattern or either lobe circle of the racetrack or figure eight patterns. When on the path determined by roll in point A and roll out point B, the desired track, cross track deviation, distance to go, time to go, bearing and the bank command are determined as follows.

a. Desired track for right patterns is determined by adding 90 degrees to the angle determined by airplane location and the lobe 1 center. For left patterns, 90 degrees are subtracted from the angle.

b. Cross track deviation is the difference between the lobe radius length and the distance between the airplane and the lobe center location.

c. Distance to go is the distance along the lobe from the intersection of the lobe circle and a line determined by the airplane and the lobe center (location X) and the next transition point (B in the execution diagram).

d. Time to go is distance to go divided by ground speed.

e. Bearing is the angle from the present position to the next transition point (location B).

f. The bank command is generated to ensure the airplane remains on the lobe (cross track deviation is zero).

When on the great circle path determined by roll out point D and roll in point A, the desired track, cross track deviation, distance to go, time to go, bearing and the bank command are determined as in normal waypoint to waypoint flight with location D as the FROM and location A as the TO. These parameters are computed analogously when on the great circle path from roll out point B to roll in point C.

A waypoint alert is provided 10 seconds prior to reaching a transition point.

A transition from constant radius turn guidance on the lobe to the great circle path guidance between locations B and C in the execution diagram occurs when the distance to go is less than 0.25 nm. The transition from lobe 2 to the great circle path from D to A occurs in a similar manner.

The crew can modify the defining parameters for circularized patterns prior to pattern activation or while the pattern is active.

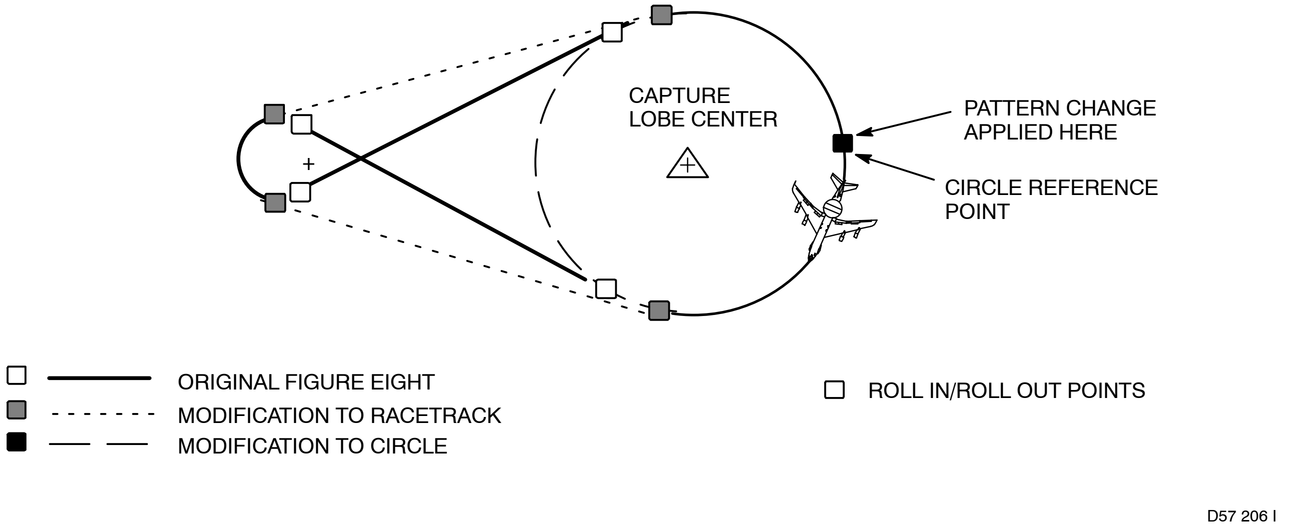
a. Before Pattern Activation – all parameters including the capture lobe can be modified prior to the activation of the pattern. Any changes made prior to entry take effect when the pattern becomes active. If the pattern has been inserted into the flight plan, modifying the capture lobe replaces the existing flight plan waypoint with the new capture lobe center.

b. After Pattern Activation

    (1) Changes can be made to any pattern parameter when the pattern is active. These changes can be implemented singly or in multiples. When a change is made, the message CONFIRM PAT CHANGE is displayed in the scratchpad. Clearing this message and entering an additional parameter change allows multiple simultaneous changes to the pattern.

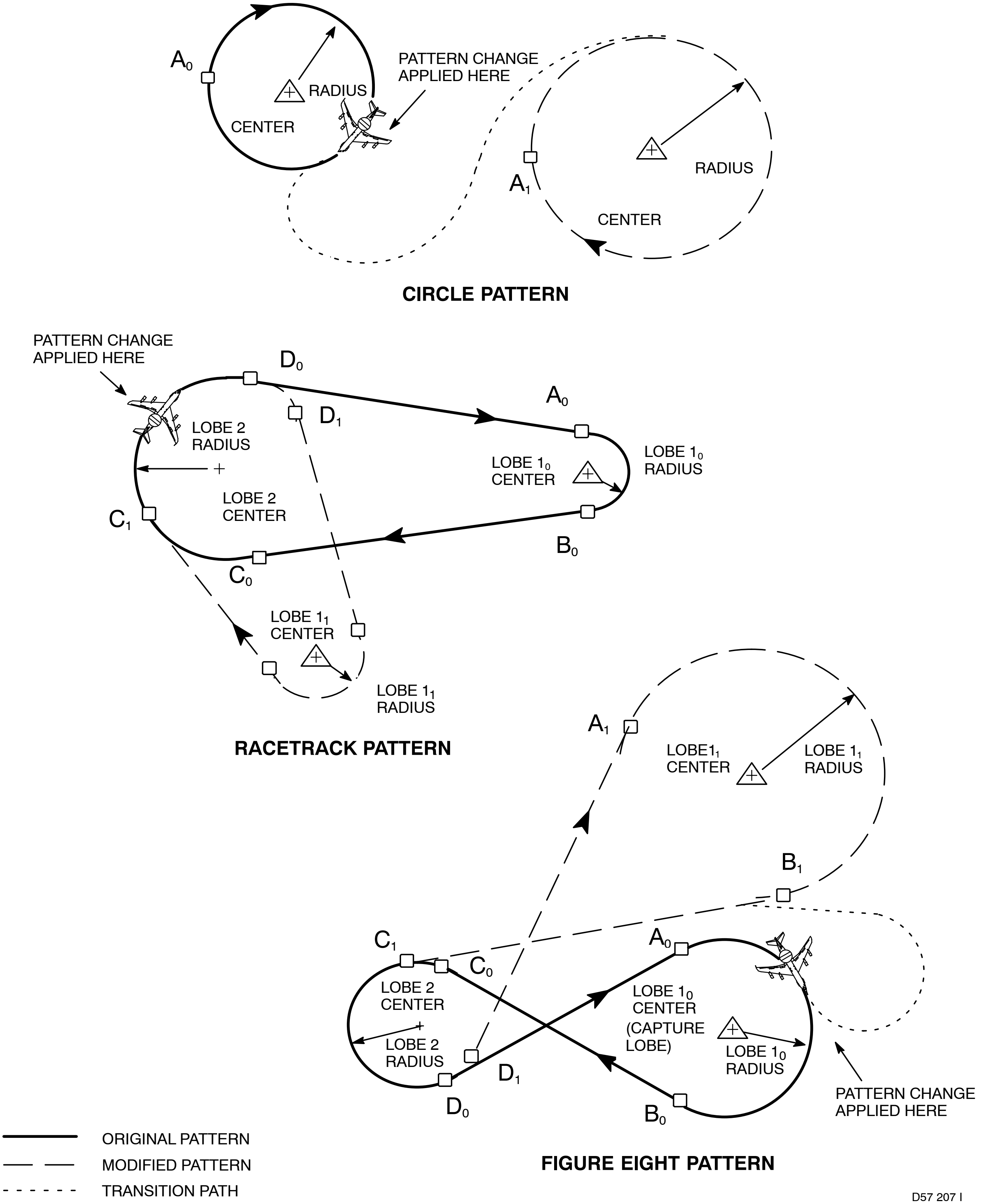
    (2) The pattern type can be modified at any time by scrolling through the pattern selections of circle, racetrack and figure eight. The original pattern is flown until the change is confirmed, at which time the airplane performs a Direct-To to the capture lobe of the new circle, racetrack or figure eight pattern. If the airplane is currently flying the identical constant radius turn of the capture lobe, it continues the constant radius turn. When a roll out point for the new pattern is reached, it then begins the transition to the new great circle leg of the new pattern for racetrack and figure eight patterns or it continues on the constant radius turn for a circle pattern.

PATTERN EDIT TO PATTERN TYPE



(3) Confirming a modification to the center location of the capture lobe inserts the new location as a waypoint in the existing flight plan with its associated pattern, and the old pattern and capture lobe center are maintained in history. When the change is confirmed, all of the associated changes with the capture lobe center are treated as a new pattern and a Direct-To is performed to the new pattern capture lobe.

PATTERN EDIT TO THE CAPTURE LOBE CIRCLE CENTER



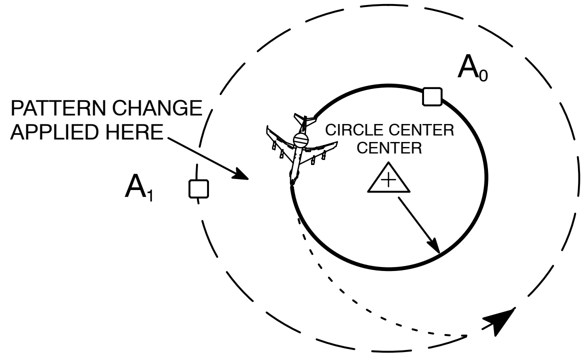
CIRCLE PATTERN

RACETRACK PATTERN

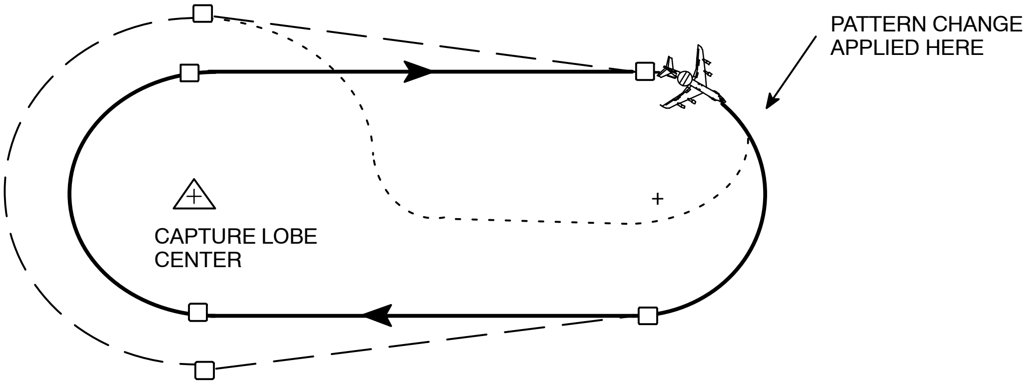
FIGURE EIGHT PATTERN

(4) Confirming a modification to the radius of the capture lobe causes a modification of the flight plan waypoints and the creation of a new pattern. The old pattern and capture lobe center are maintained in history. When the change has been confirmed, the new pattern is inserted into the flight plan after the active pattern, then a Direct-To is performed to the pattern capture lobe. Upon meeting the new capture criteria, the new pattern becomes active. If the airplane is currently flying on the capture lobe, as shown in the circle and figure eight diagrams below, it flies away from the capture lobe center to the perimeter of the new capture lobe as defined by the new radius.

PATTERN EDIT TO CAPTURE LOBE RADIUS



CIRCLE PATTERN



RACETRACK PATTERN

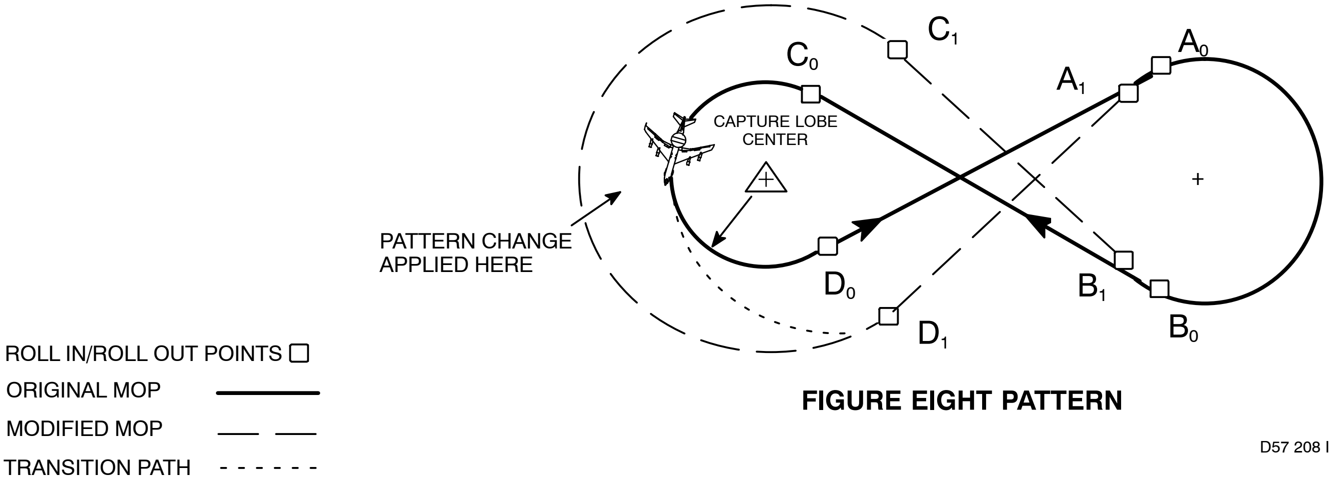
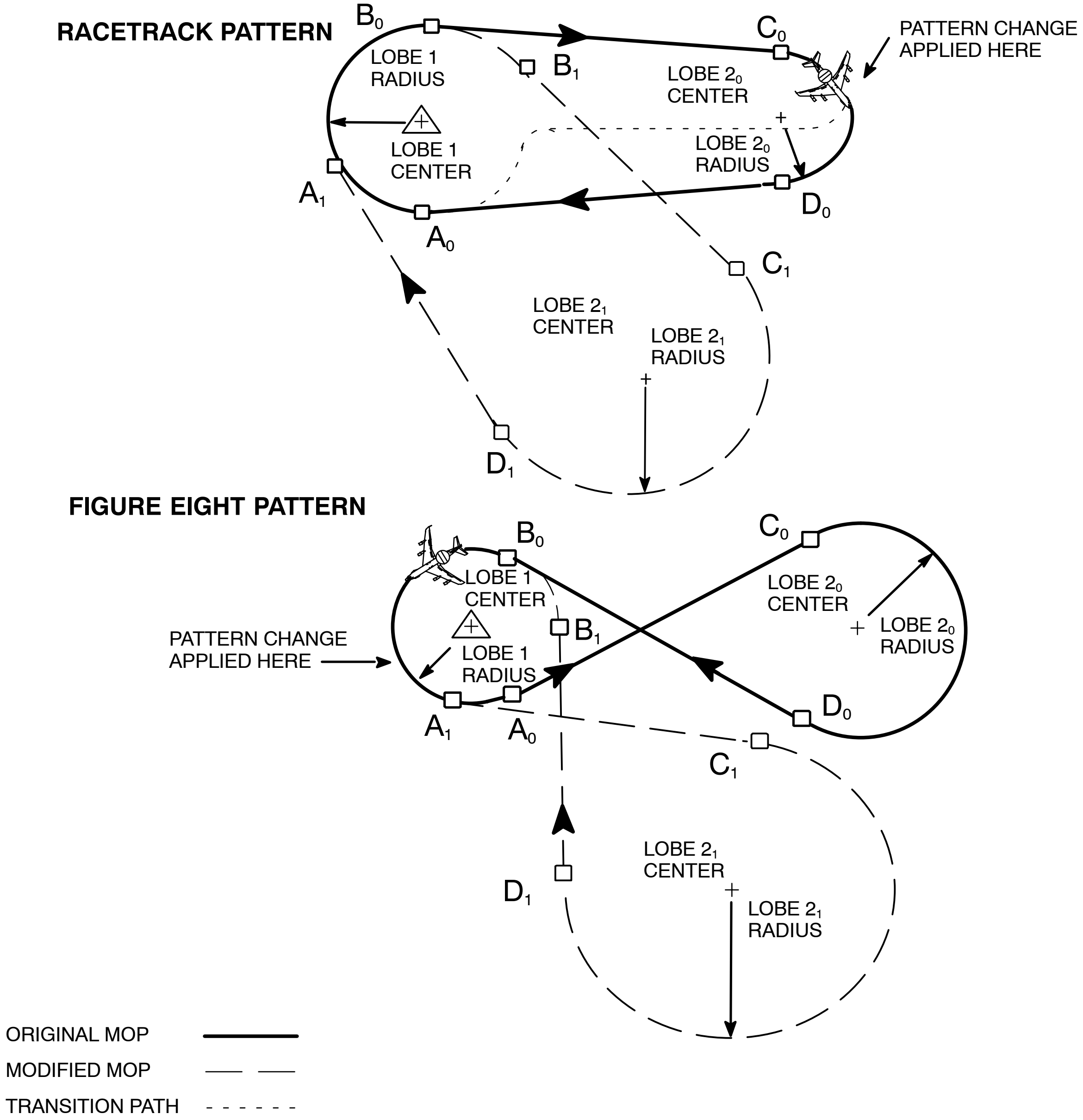


FIGURE EIGHT PATTERN

(5) Confirming a modification to the lobe center and/or radius of the secondary lobe causes a modification of the flight plan waypoints and the creation of a new pattern. The old pattern and capture lobe center are maintained in history. When the change has been confirmed, the new pattern is inserted into the flight plan after the active pattern, then a Direct-To is performed to the pattern capture lobe. Upon meeting the new capture criteria, the new pattern becomes active. If the airplane is currently on the capture lobe flying the identical constant radius turn, the new pattern becomes active immediately. The airplane continues on the constant radius turn until the new roll-out point (B_1) is transitioned, then it continues on the great circle leg to the roll-in point (C_1) of the revised secondary lobe.

PATTERN EDIT TO SECONDARY LOBE PARAMETERS



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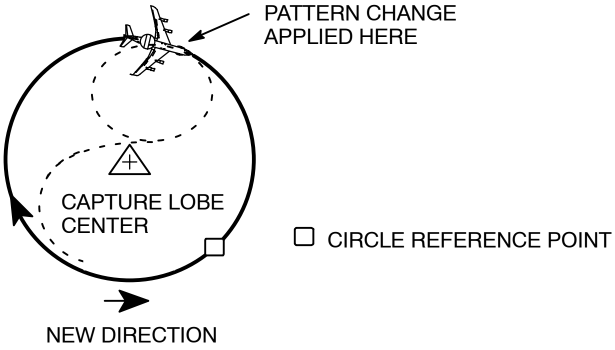
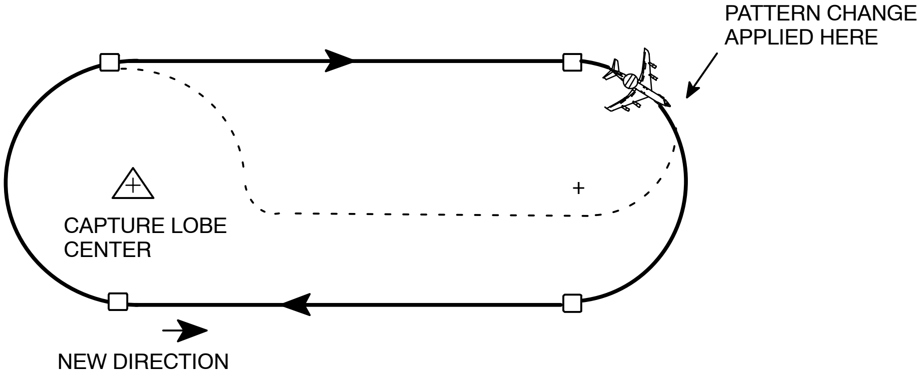
(6) Confirming a modification to the initial turn direction of the pattern causes a modification of the flight plan waypoints and the creation of a new pattern. The old pattern and capture lobe center are maintained in history. When the change has been confirmed, the new pattern is inserted into the flight plan after the active pattern, then a Direct-To is performed to the pattern capture lobe. If the airplane is currently on the capture lobe, it reverses direction to reenter the constant radius turn on the capture lobe and begins flying the pattern in the opposite direction. Upon meeting the new capture criteria, the new pattern becomes active. If this change is implemented while on the secondary lobe or while flying away from the capture lobe, the airplane can leave the pattern as shown in the racetrack and figure eight diagrams. Upon meeting the new capture criteria, the new pattern becomes active.

PATTERN EDIT TO TURN DIRECTION



CIRCLE PATTERN



RACETRACK PATTERN

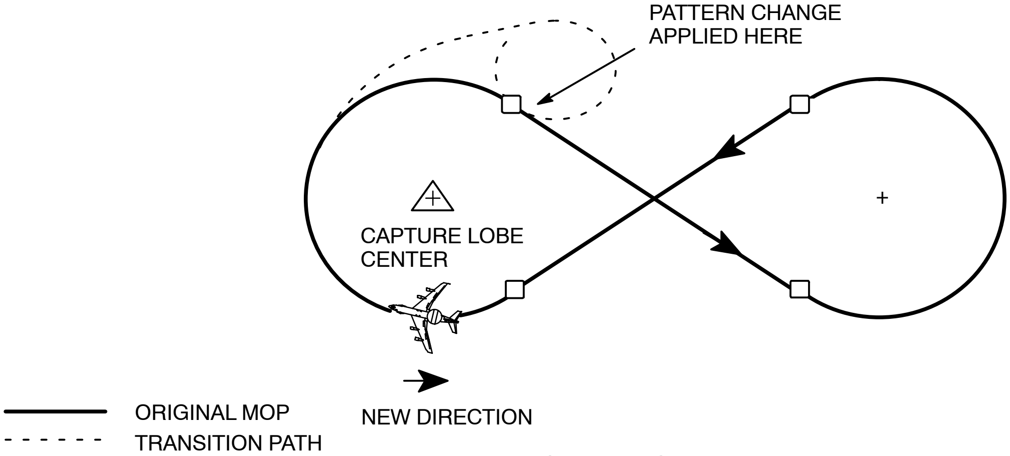


FIGURE EIGHT PATTERN

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(7) Confirming a modification of the capture lobe indicator causes a modification of the flight plan waypoints and the creation of a new pattern. The old pattern and capture lobe center are maintained in history. When the change has been confirmed, the new pattern is inserted into the flight plan after the active pattern, then a Direct-To is performed to the new pattern capture lobe. Upon meeting the new capture criteria, the new pattern becomes active.

Closed Random Patterns

A CRP is defined as a sequence of random waypoints (maximum of 10 including the fix) that are executed repeatedly (that is, when the last waypoint in the CRP list is passed, the fix of the CRP becomes the TO waypoint). The waypoints that make up the CRP list are entered by the crew and can be at any arbitrary location.

The defining parameters for a closed random pattern are as described below.

a. Pattern – fix is to be displayed on the Flight Plan page with an MOP attribute identifying it as a fix for the MOP. The fix point can be an entered point on the Closed Random Pattern MOP page or a point in the active flight plan.

b. CRP Points – nine (maximum) are allowed.

c. Maximum Bank Angle – applies to, and is allowed for all turns in the pattern. This parameter is specifiable for the pattern fix only and is applied to all subsequent waypoints in the CRP.

d. Forward or Reverse – pattern is to be executed in a forward (that is, fix, 1, 2, . . . , 9) or reverse (that is, 9, 8, 7, . . . , fix) manner.

The altitude and bank angle limit specified for the pattern fix point are assumed for all points in the pattern. The crew cannot enter an altitude or bank angle limit for any point other than the fix.

The CRP is entered by overflying the fix and then performing a course capture to the first leg.

When the CRP is being executed, the CRP ACTIVE annunciation is displayed on the CDU. While a CRP is active, ETA and ETE calculations are provided for waypoints in the CRP as described in the Data page menu. Course guidance is performed in the same manner as for the flight plan.

The crew can also elect to perform a TNAV to the CRP fix point prior to pattern activation. The crew cannot perform a TNAV function to any point in the CRP other than the fix point.

A Direct-To can also be performed to any point in the closed random pattern. When this option is selected, guidance is provided from the airplane present position to the TO waypoint. Sequencing then resumes in a normal pattern after executing the Direct-To function. The points in the pattern which are bypassed remain in the pattern definition.

The flight crew can modify the defining parameters for the closed random pattern prior to activation or while the pattern is active.

a. Before Pattern Activation – All parameters except the fix can be modified prior to the activation of the pattern. Any changes made prior to entry take effect when the pattern becomes active. If the pattern has been inserted into the flight plan, the fix is not modifiable. If an attempt is made to modify the fix when the pattern is in the flight plan or alternate flight plan, the PATTERN DEFINED scratchpad message is displayed.

b. After Pattern Activation.

  (1) Pattern Fix – The pattern fix is not modifiable while the pattern is active. The flight crew can enter the new fix point in the flight plan and attach an MOP to it, or define and insert a new pattern into the active flight plan. A Direct-To to the new fix point can then be performed. An attempt to modify the fix when the pattern is active causes the CRP IS ACTIVE scratchpad message to be displayed.

  (2) Maximum Bank Angle – A change to the maximum bank angle is applied immediately.

  (3) Sequencing – If the crew changes the sequencing during pattern execution, the change occurs immediately. As soon as the sequencing is toggled, the previous FROM point becomes the TO waypoint.

  (4) Pattern Points – Pattern points can be added (until there are nine), deleted or modified during execution. The changes are applied immediately.

The guidance displays of desired track, bearing, distance, TO/FROM indication, deviation and time-to-go reference each point in the pattern when that point is the TO.

REFUEL PATTERNS

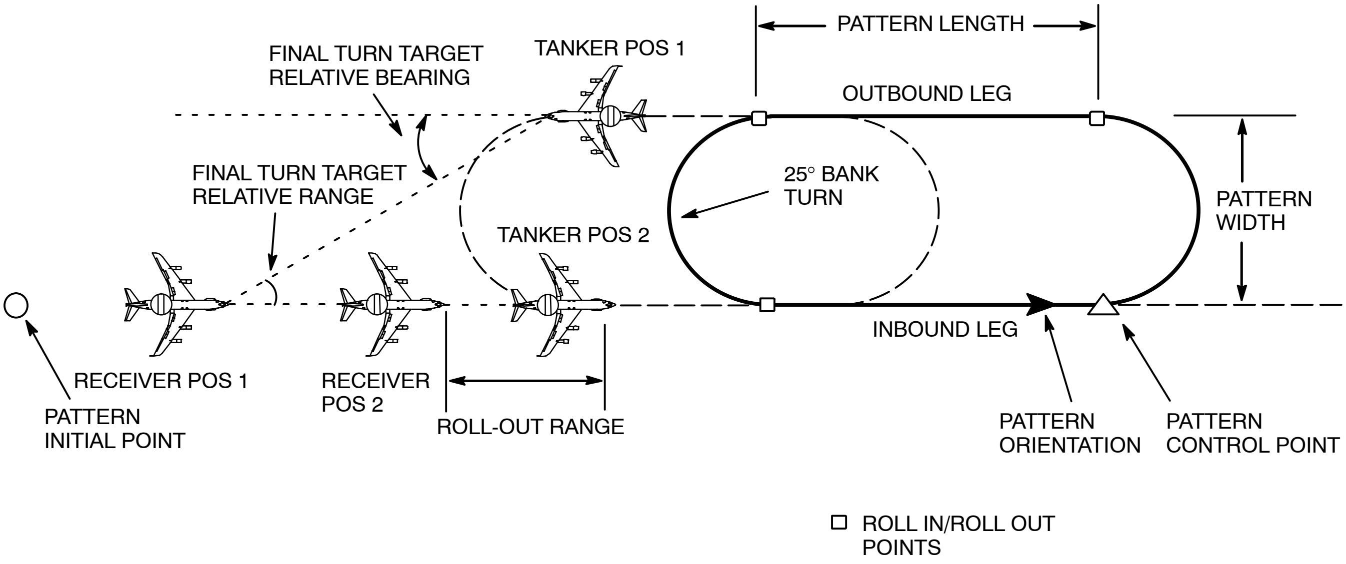
The defining parameters for a refuel MOP are as described below.

a. Pattern Control Point – identified on the Flight Plan page with an MOP attribute identifying it as a fix for the pattern. The control point can be an entered point on the Refuel A MOP page or a point in the active flight plan. The altitude specified for the control point is the altitude for the entire pattern.

b. Pattern Initial Point – is an entered point on the Refuel A MOP page. The course between the initial point and pattern control point defines the pattern orientation. This course is referenced to true north and noted as such on the CDU.

c. Pattern Length – defined as the distance (in nautical miles) between the roll in/roll out points parallel to the center line of the pattern. The default value for the pattern length is 14 nautical miles.

DEFINING PARAMETERS FOR THE REFUEL MOP



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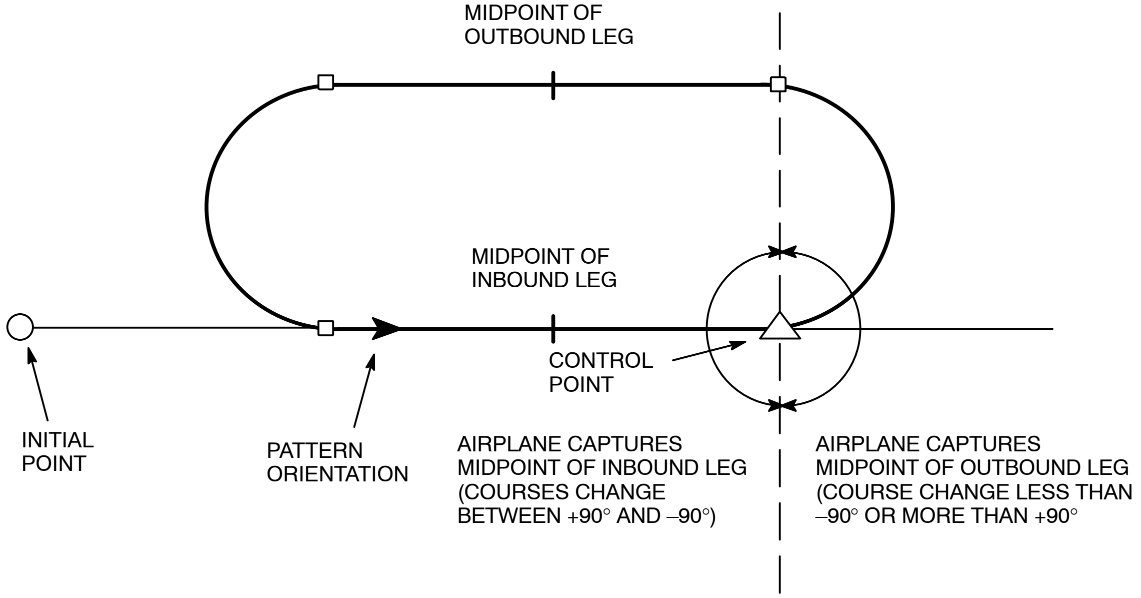
The pattern is entered with direct entries only. The airplane enters the pattern at the midpoint of either the inbound or the outbound leg. Pattern entries are the same as waypoint sequencing to the leg midpoint using lateral turn anticipation.

The refuel pattern execution begins when the mode is toggled from DISABLED on the Refuel B MOP page and the TO waypoint is the CP. First, the inbound leg is created based on the pattern initial point, pattern control point, and pattern length. The outbound leg is then created based on the computed pattern width and left turn. All refuel patterns are left hand patterns. The pattern width is determined by the wind, tanker true airspeed, and a 25 degree bank angle, all referenced to the turn from the outbound leg to the inbound leg. The airplane then captures the midpoint of either the inbound or the outbound leg. The leg to capture is selectable between inbound, outbound, or AUTO, in which case the appropriate leg is determined automatically. The criteria for determining the capture leg are based on the course change from the course into the CP and the pattern orientation. If the course change is between –90° and +90°, the inbound leg is captured. If the course change is less than –90° or greater than +90°, the outbound leg is captured. The course change is limited to ±180° by adding or subtracting 360° as necessary. When the pattern is enabled and the CP becomes the TO, the direct course from present position to the entry point (not the CP) is computed and displayed until the switching point for capturing the pattern leg is reached. A turn point for each leg of the pattern is computed. An external waypoint alert is provided when within the waypoint alert time prior to reaching the turn point on each leg of the pattern. If there is a valid wind, the width of the pattern remains at the value computed for the turn from the outbound leg to the inbound leg. In this case, when a turn from the inbound leg to the outbound leg is completed, the outbound course must be captured. The width is recalculated each time the airplane overflies the control point.

LEG CAPTURE WITH TOGGLE SET TO AUTO



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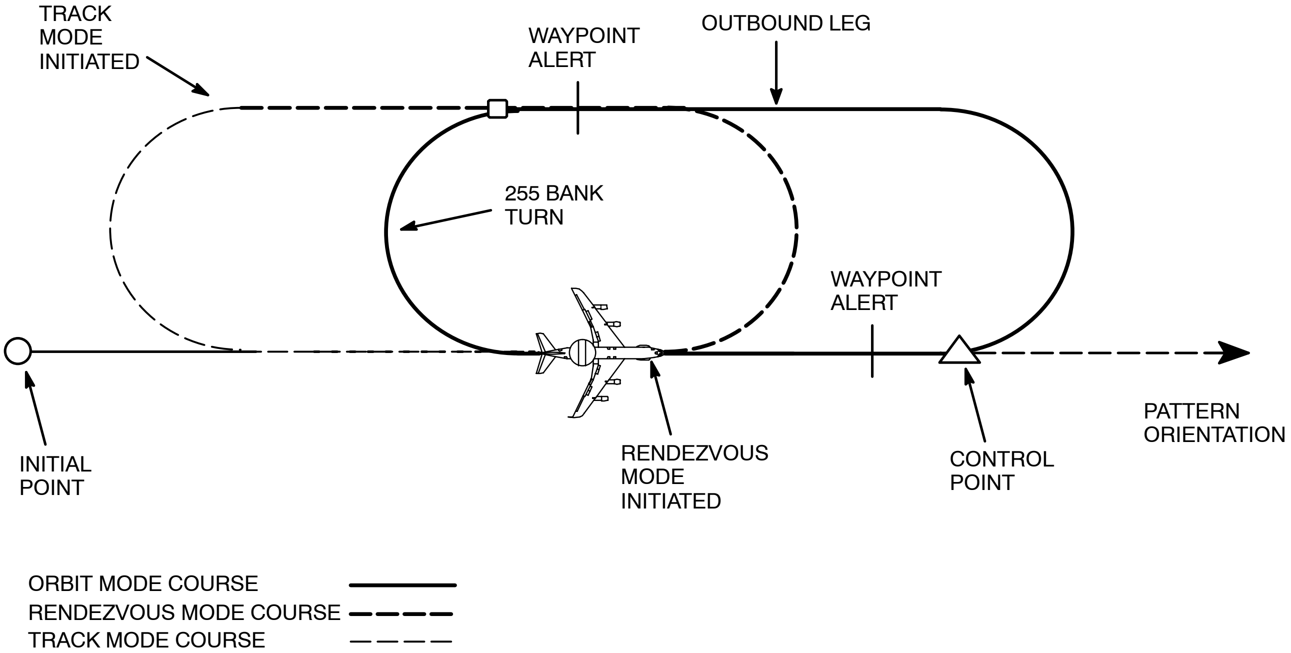
At some point during orbit mode, the pilot can initiate rendezvous mode by selecting the toggle on the Refuel B MOP page. If the airplane is on the inbound leg, it turns immediately to capture the outbound leg. If the airplane is already on the outbound leg, it maintains that course. If the airplane is turning outbound when the mode is switched to rendezvous, it completes the turn and maintains the outbound course. If the airplane is turning inbound when the mode selection is made, it completes the inbound and then turns immediately to capture the outbound course. The airplane maintains the outbound course until the final turn is initiated. There is no waypoint alert in the rendezvous or track modes.

The pilot begins the final turn when the actual values for relative bearing and range to the receiver, as determined from sources such as TACAN or radar, are equal to the values calculated with the desired roll-out range and receiver true airspeed and displayed on the Refuel B MOP page. The final turn is initiated by switching the mode toggle on the Refuel B MOP page to TRACK. The airplane turns immediately to the inbound course with a 25° bank angle turn. The airplane maintains this course until the pilot performs a Direct-To or re-enters orbit mode by selecting the toggle. Note that when a pattern is entered, the DISABLED selection on the mode toggle at **LS4** on the Refuel B MOP page is no longer available until the pattern is terminated with a Direct-To.

While the refuel MOP is executed, the RFL ACTIVE annunciation is displayed on the CDU.

REFUEL MOP EXECUTION



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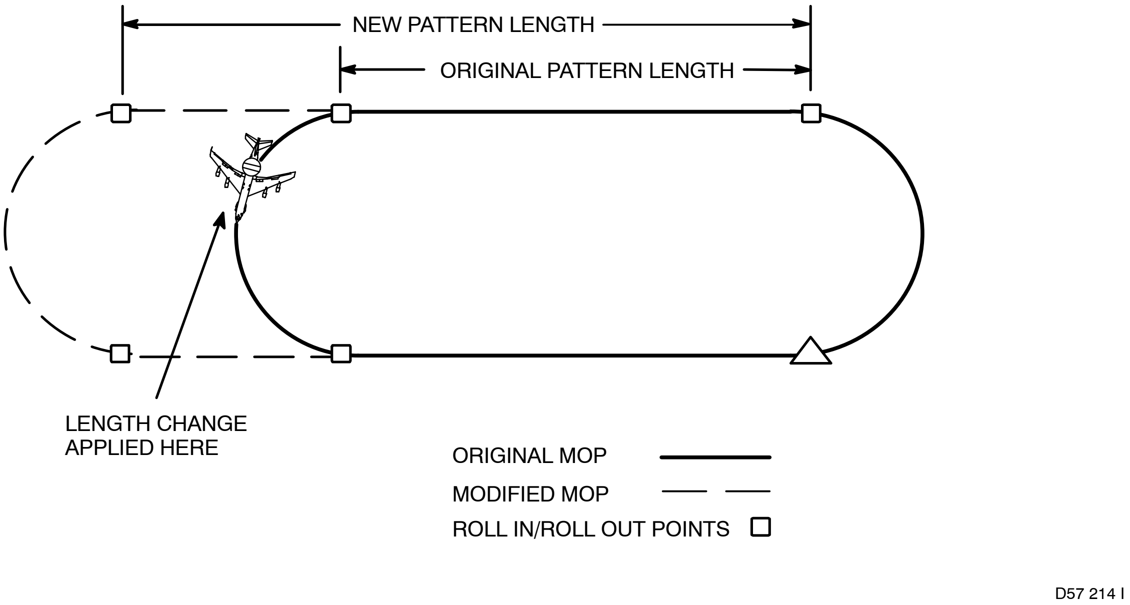
The guidance displays of desired track, bearing, distance, TO/FROM indication, deviation and time-to-go reference the inbound course and the control point while on the inbound leg. The displays reference the outbound course and turn point while on the outbound leg. The displays switch reference to the outbound course when the control point is overflown and switch reference to the inbound course when the turn point on the outbound leg is overflown. When the airplane is in rendezvous mode, the displays reference the outbound course and turn point. When the airplane is in track mode, the displays reference the inbound course and control point.

REFUEL PATTERN LENGTH EDIT WHILE TURNING INBOUND



The crew can modify the pattern length for the refuel pattern prior to pattern activation or while the pattern is active in orbit mode.

a. Before Pattern Activation – no defining parameters except the pattern length are modifiable after the insertion of the pattern into the flight plan or alternate flight plan. Any attempt to modify the parameters when the pattern is in the flight plan or alternate flight plan causes the PATTERN DEFINED scratchpad message to be displayed.

b. After Pattern Activation.

   (1) Pattern Control Point – The pattern control point is not modifiable while the pattern is active. The crew can enter the new control point into the flight plan and attach an MOP to it, or define and insert a new pattern into the active flight plan. A Direct-To to the new control point can then be performed. After the Direct-To is performed, the toggle at **LS4** on the Refuel B MOP page must be switched from DISABLED in order to enter the pattern. An attempt to modify the control point when the pattern is active causes the RFL IS ACTIVE scratchpad message to be displayed.

   (2) Pattern Initial Point – The pattern initial point is not modifiable while the pattern is active. An attempt to modify the initial point when the pattern is active causes the RFL IS ACTIVE scratchpad message to be displayed.

   (3) Pattern Length – The pattern length can be modified at any time while in orbit mode and takes effect immediately. If the airplane is already past the turn point for the new outbound leg it turns inbound. If the length change is made while the airplane is executing a turn, the leg it is turning onto is intercepted at the same point as for the old pattern length. The new pattern length is then applied.

SUBSECTION I-M
NAVIGATION RADIO AIDS

Table of Contents

SUMMARY

Navigation radio aids installed include TACAN, VOR/ILS, direction finders, marker beacon receiver, IFF/SIF, and radio altimeter. A Crash Position Indicator/Flight Data Recorder (CPI/FDR) is also installed. *Figure 1-117* indicates the position of navigation aids antennas.

TACAN SYSTEM

Dual TACAN systems provide continuous bearing and slant range to a ship–or–ground based TACAN station. In A/A T/R mode, both bearing and distance information can be obtained if the other airplane is properly equipped. In A/A REC mode, only bearing can be obtained. The system operates in the 962 to 1213 MHz band and has an operating range up to approximately 390 miles depending on line of sight.

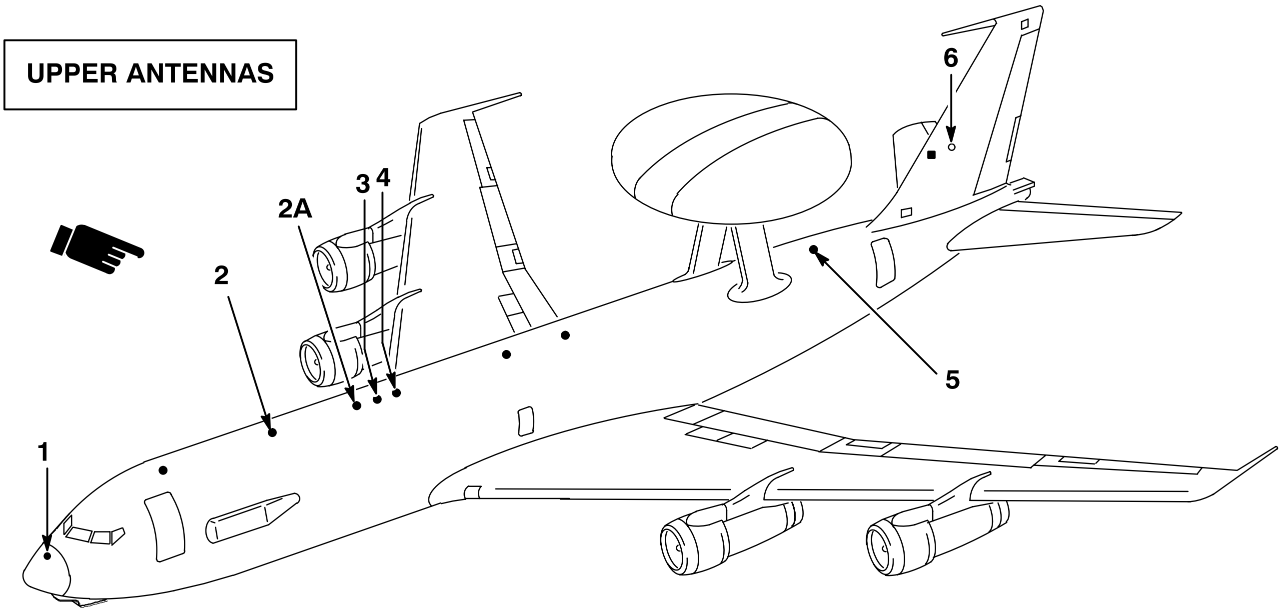
TACAN avionics are located in the E1 rack, forward lower compartment. See *figure 1-118*.

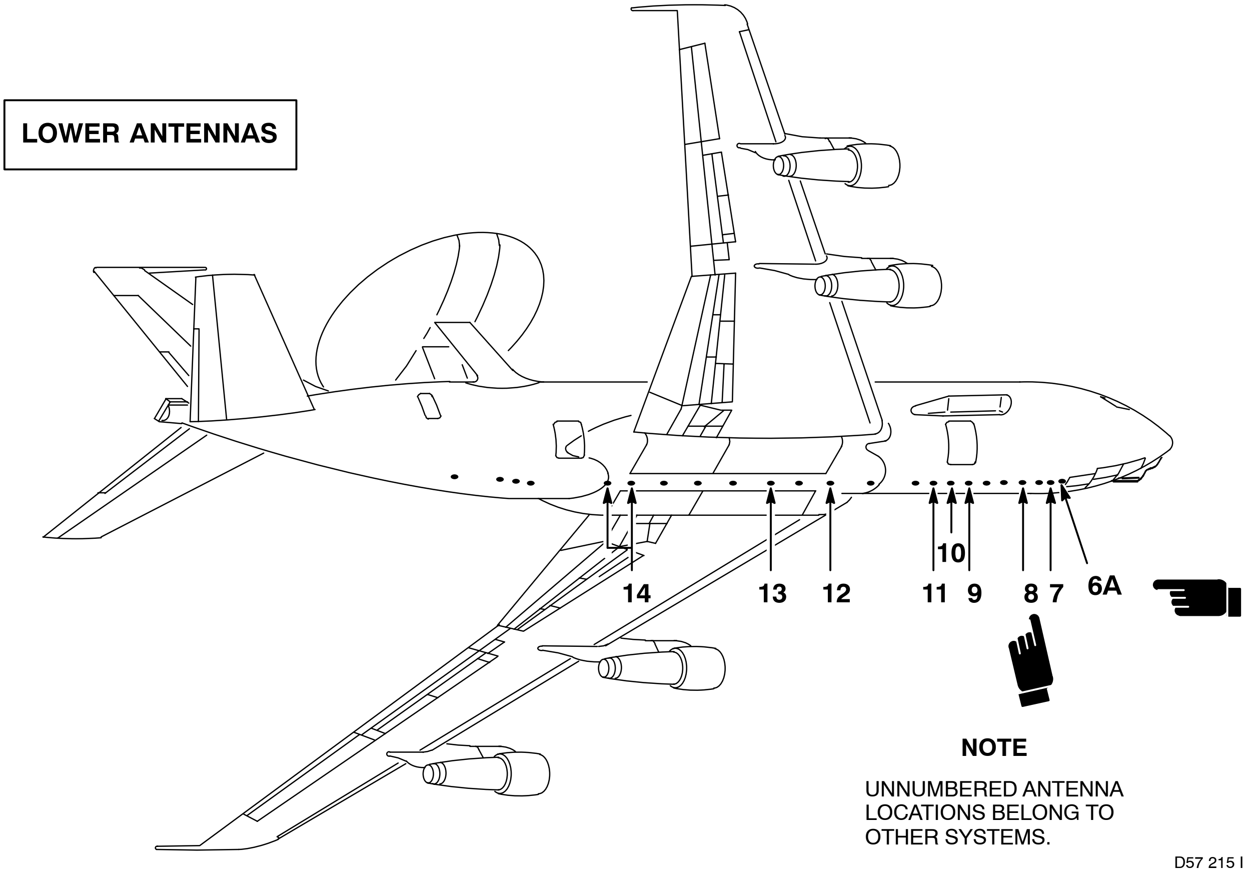
The components of a single TACAN system include a Receiver–Transmitter (R/T) unit, signal data converter, control panel, two antennas (one each on top and bottom of airplane, *figure 1-117*), and an antenna switching relay. The R–T unit and signal data converter contain circuits which select the operating channel for both the receiver and transmitter, process bearing and distance signals and detect station identifier signals. A built–in test feature allows remote checking of the system, except for the antenna. System is remotely controlled and tested from the control panel located on the pilot's overhead panel. Controls and indicators are described and shown in *figure 1-119*. The antenna switching relay allows the antenna sensing assembly to select automatically whichever of the two antennas is providing a usable signal. TACAN identity tone can be monitored through any one of the flight deck audio panels.

TACAN SYSTEM POWER

Power for the TACAN system is 115 vac for the R/T unit and signal data converter. The system also uses 26 vac from the AHRS bearing transformer for bearing excitation.

Radio Navigation Aids Antenna Locations





NOTE

UNNUMBERED ANTENNA LOCATIONS BELONG TO OTHER SYSTEMS.

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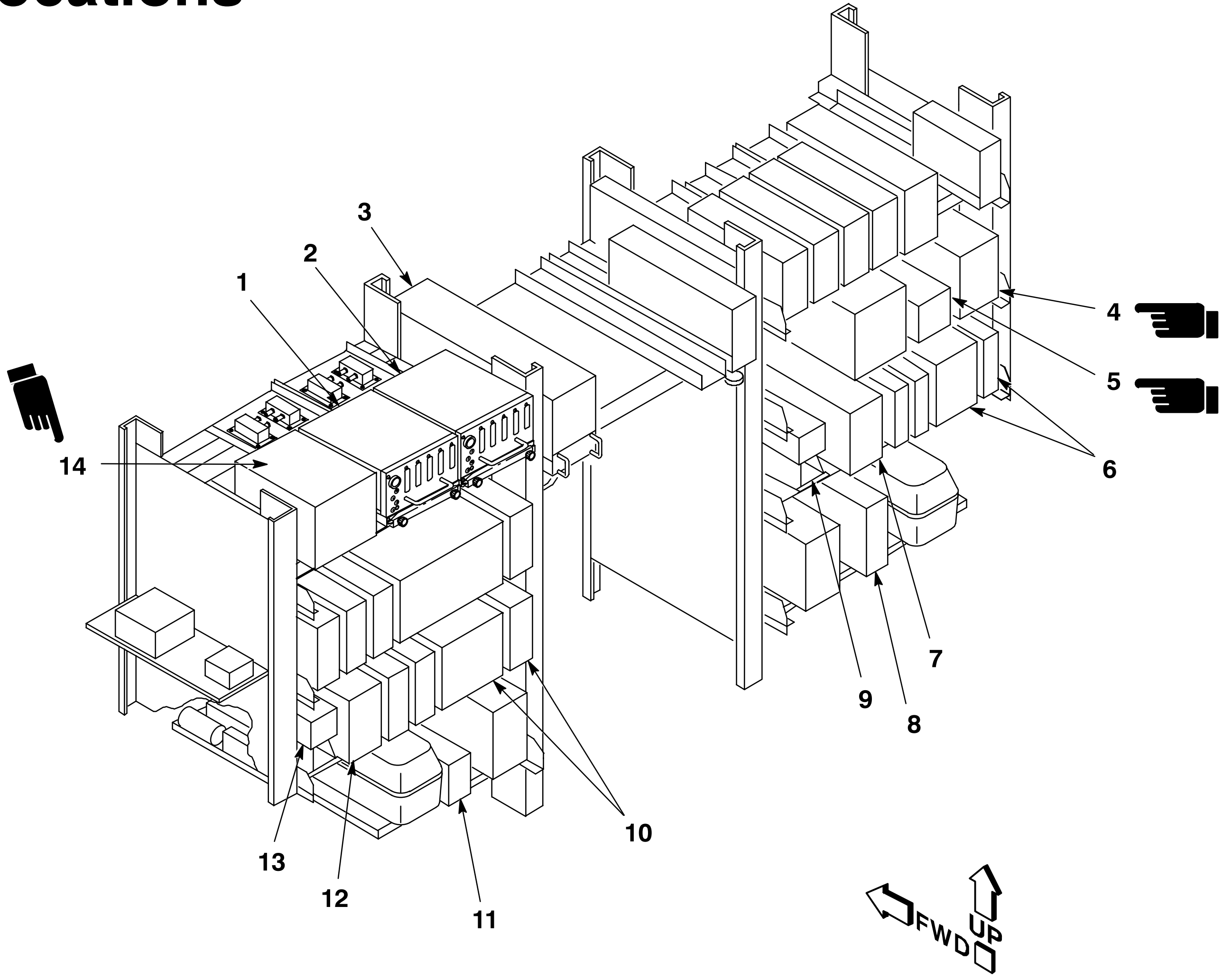
Figure 1-117 (Sheet 1 of 2)

NO.	ITEM	STATION LOCATION NO	TYPE
1	GLIDE SLOPE ANTENNA	178	ROD
2	WITH IDG TCAS UPPER ANTENNA ①	470	PLANAR ARRAY ◀
2A	TACAN NO 1	510	BLADE
3	IFF	590	BLADE
4	TACAN NO 2	600F + 10	BLADE
5	CRASH POSITION LOCATOR	1230	BLADE
6	VOR/LOCALIZER	FIN	DUAL PLATE
6A	LESS IDG UHF HIGH POWER TRANSMIT ANTENNA	408	BLADE ◀
6A	WITH IDG TCAS LOWER ANTENNA ①	408	PLANAR ARRAY ◀
7	TACAN NO 1	430	BLADE
8	LESS IDG IFF	504	BLADE ◀
8	WITH IDG FLIGHT CREW LOW POWER UHF TRANSMIT/IFF ①	504	BLADE ◀
9	TACAN NO 2	604	BLADE
10	MARKER BEACON	600D + 8	ENCLOSED WIRE
11	ADF LOOP	600E – 10	FIXED LOOP
12	ADF SENSE	720	FIXED LOOP
13	UHF ADF ANTENNA	889	LOOP
14	LOW RANGE RADIO ALTIMETER	1011 and 1030	FLAT PLATE

① WITH IDG The only coverage for TCAS found in Navigation Aids, Subsection I–M, is antenna locations. TCAS system description is found in instruments, Subsection I–J, due to VSI interface.

Figure 1-117 (Sheet 2 of 2)

Navigation Radio Aids Equipment Locations



1. BSIU 1
2. BSIU 2
3. DFDR/FDU
4. **LESS IDG** MODE 4 TRANSPONDER/COMPUTER ◀
5. **LESS IDG** IFF MODE 2 ◀ **WITH IDG** IFF MODE S ◀
6. TACAN NO. 2
7. VOR/ILS NO. 2
8. ADF RECEIVER
9. VOR/ILS AMPLIFIER
10. TACAN NO. 1
11. MARKER BEACON RECEIVER
12. VOR/ILS NO. 1
13. VOR/ILS AMPLIFIER
14. **WITH IDG** TCAS COMPUTER ◀

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Figure 1-118

TACAN SYSTEM SIGNAL FLOW AND DISPLAY

Distance is determined by the elapsed time of round trip travel by radio pulse signals between the airplane radio set and surface or airborne beacon. Distance displays on the HSIs and navigator's dual distance display indicate distance to selected TACAN station when Receive–Transmit (R–T) function or Air–to Air (A/A) function is selected on the control panel.

The surface beacon transmits reference bearing and variable bearing signals which are processed in the R–T. Phase differences between the signals is converted into bearing signals which can be displayed on the pilot, copilot and navigation station RMIs. Bearing signals from number one and two TACAN are also displayed on the pilot and copilot HSIs, if the NAV MODE selectors are set to TACAN. Refer to NAVIGATION SYSTEMS INSTRUMENT SWITCHING, subsection I–J.

NOTE

Distance to waypoint is displayed on HSI when corresponding NAV MODE selector is set to GINS. DME distance is displayed when NAV MODE selector is set to TACAN or VOR/LOC. Navigators dual distance display is also hardwired to the TACAN distance outputs.

Deviation from a preset TACAN course can be selected and displayed on the pilot's HSIs and also transmitted to the respective flight director computers, if the NAV MODE selectors are set to TACAN. To set a course in HSI course window, course set knob must be pulled out.

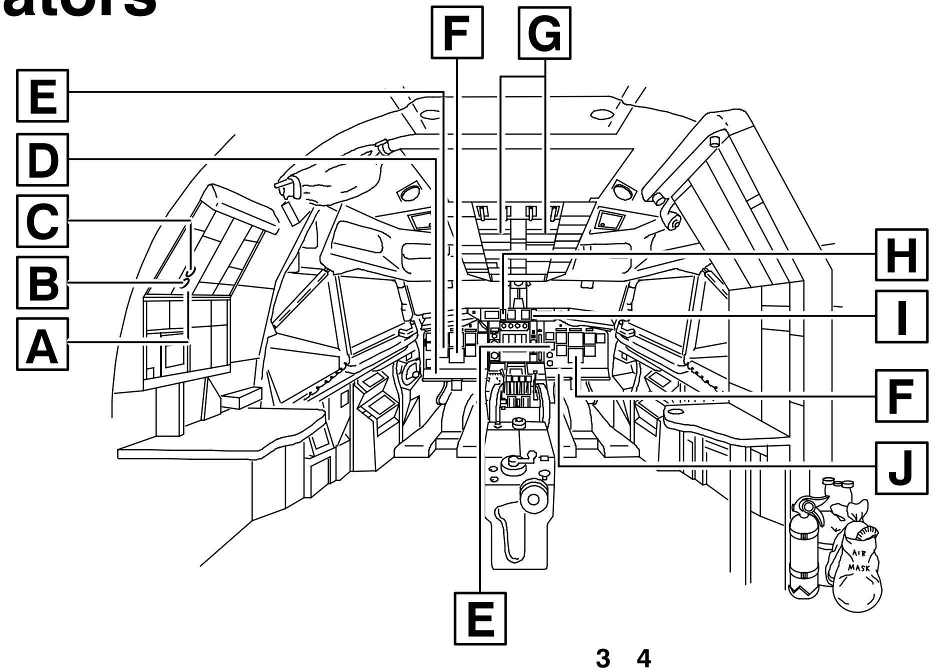
NOTE

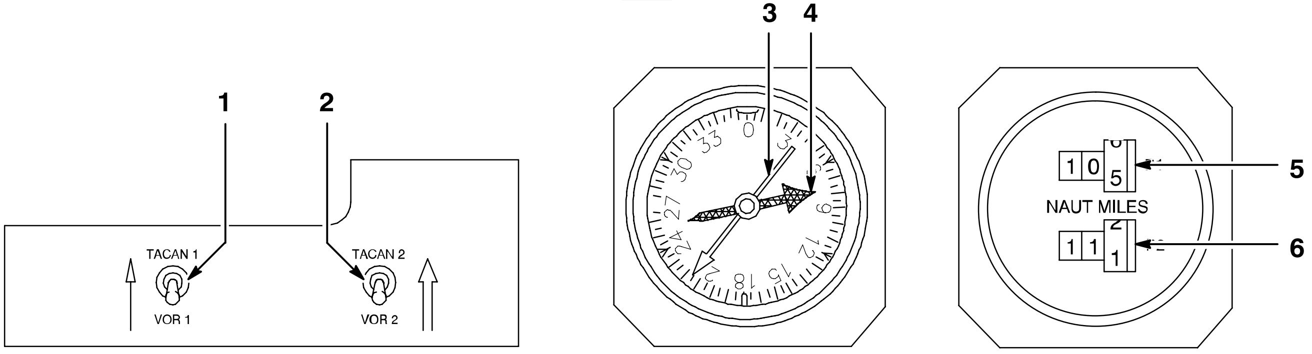
- HSI course set knob must be pushed in, when NAV MODE selectors are set to GINS. Pushing course set knob in releases knob clutch mechanism so the GINS can automatically set desired track in HSI course selector window.
- Interference with the TACAN can occur during JTIDS operation, particularly in the high power mode. This interference can result in loss of TACAN bearing lock–on, but DME is not affected. If this interference is degrading operation, and bearing information is needed, request the CSO/CT reduce the time slot recurrence rate. For additional information about JTIDS, refer to T.O. 1E–3A–43–1–1.

At regular intervals the surface beacon transmits a series of pulse signals which are keyed with International Morse code characters. When these signals are received by the TACAN set, they are converted into a keyed audio tone. Volume of the TACAN audio signal is adjusted from each flight crew audio panel. Audio identifying signals are not provided in the air–to–air mode.

Since TACAN operates in the same band as IFF, a suppression circuit is connected between the TACAN sets and the IFF transponder. This suppression circuit prevents simultaneous transmission that would result in interference.

TACAN and VOR/ILS Controls and Indicators

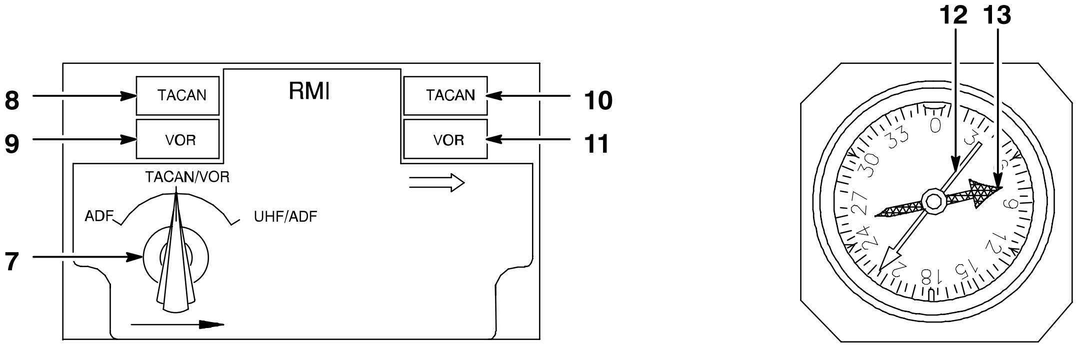




A NAVIGATOR'S RMI SOURCE SELECTOR PANEL

B NAVIGATOR'S RMI

C NAVIGATOR'S DUAL DISTANCE DISPLAY



D PILOT'S RMI SOURCE SELECTOR PANEL

E RMI (PILOT AND COPILOT)

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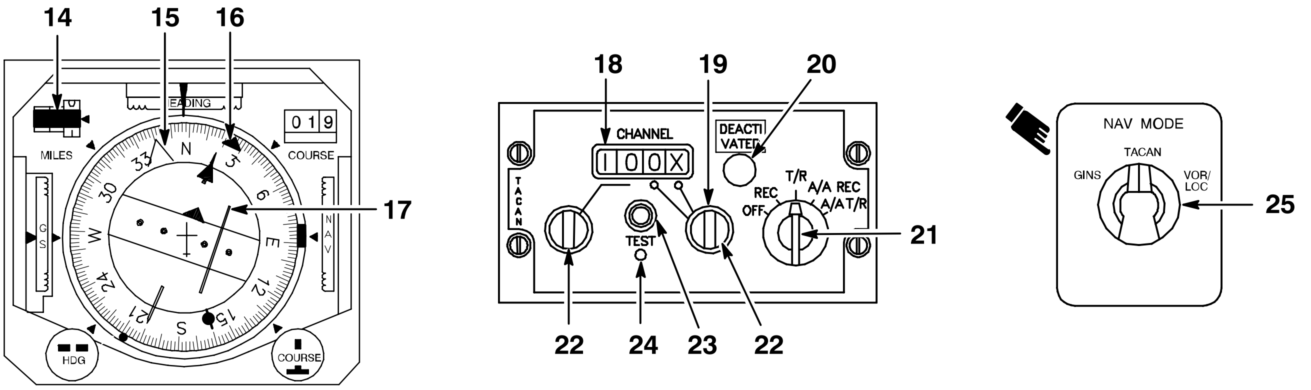
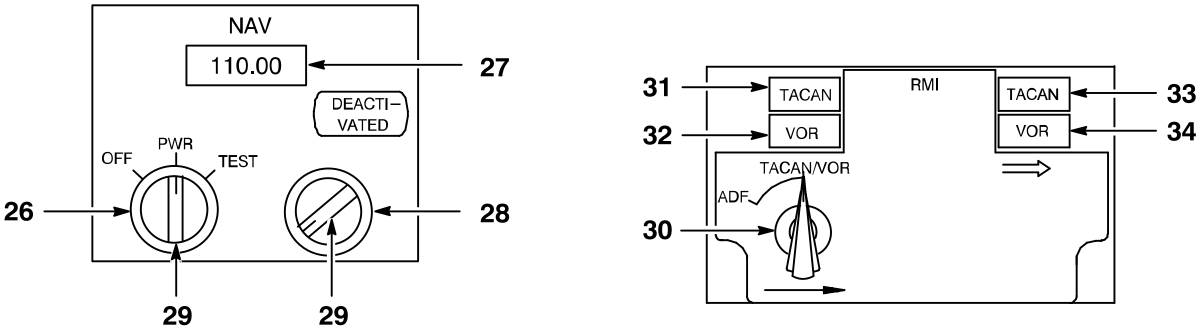
Figure 1-119 (Sheet 1 of 7)



F HORIZONTAL SITUATION INDICATOR (TYPICAL)

G TACAN CONTROL PANEL, ARN.118 (TYPICAL)

H PILOT'S/COPILOT'S NAV MODE SELECTOR



I VHF NAV CONTROL PANEL (TYPICAL)

J COPILOT'S RMI MODE SELECTOR PANEL

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NO.	CONTROL/INDICATOR	FUNCTION
	A NAVIGATOR'S RMI SOURCE SELECTION PANEL	
1	TACAN 1/VOR 1 Switch	When set to TACAN 1, selects number one TACAN outputs for display by number one bearing pointer of navigator's RMI. When set to VOR 1, selects number one VHF NAV outputs for display by number one bearing pointer of navigator's RMI.
2	TACAN 2/VOR 2 Switch	When set to TACAN 2, selects number two TACAN outputs for display by number two bearing pointer of navigator's RMI. When set to VOR 2, selects number two VHF NAV outputs for display by number two bearing pointer of navigator's RMI.

Figure 1-119 (Sheet 2 of 7)

TACAN and VOR/ILS Controls and Indicators (Continued)

NO.	CONTROL/INDICATOR	FUNCTION
		B NAVIGATOR'S RMI
3	NO 1 Bearing Pointer	Indicates magnetic bearing to TACAN station tuned in number one TACAN set when TACAN 1/VOR 1 switch is set to TACAN 1. Indicates magnetic bearing to VOR station tuned in number one VHF NAV when TACAN 1/VOR 1 switch is set to VOR 1. If reliable bearing signal not received or no station tuned, pointer rotates continuously.
4	NO 2 Bearing Pointer	Indicates magnetic bearing to TACAN station tuned in number two TACAN set when TACAN 2/VOR 2 switch is set to TACAN 2. Indicates magnetic bearing to station tuned in number two VHF NAV set when TACAN 2/VOR 2 switch is set to VOR 2. If reliable bearing signal not received or no station tuned, pointer rotates continuously.
		C NAVIGATOR'S DUAL DISTANCE DISPLAY
5	Display #1	Displays slant range distance in NM to TACAN station selected in number one TACAN set.
6	Display #2	Displays slant range distance in NM to TACAN station selected in number two TACAN set.
		D PILOT'S RMI MODE SELECTOR PANEL
7	Pilot's RMI Mode Selector	Refer to NAVIGATION SYSTEMS INSTRUMENT SWITCHING, subsection I-J.
8	TACAN Annunciator (TACAN number one) (Green)	When illuminated, indicates TACAN information from TACAN one is displayed by number one bearing pointer and signal has adequate strength.
9	VOR Annunciator (VHF NAV NO 1) (Green)	When illuminated, indicates reliable VOR information from VHF NAV number one is displayed by number one bearing pointer and signal has adequate strength.
10	TACAN Annunciator (TACAN number two) (Green)	When illuminated, indicates TACAN information from TACAN two is displayed by number two bearing pointer and signal has adequate strength.
11	VOR Annunciator (VHF NAV NO 2) (Green)	When illuminated, indicates reliable VOR information from VHF NAV number two is displayed by number two bearing pointer and signal has adequate strength.

Figure 1-119 (Sheet 3 of 7)

NO.	CONTROL/INDICATOR	FUNCTION
	E RMI (TWO PLACES, PILOT AND COPILOT PANEL)	
12	NO 1 Bearing Pointer	With the respective NAV MODE selector set to VOR/LOC and respective RMI mode selector set to TACAN/VOR, indicates magnetic bearing to TACAN station tuned in NO 1 TACAN. With the respective NAV MODE selector set to TACAN and respective RMI mode selector set to TACAN/VOR, indicates magnetic bearing to VOR station tuned in NO 1 VHF NAV. Stows at 3 o'clock case position when localizer is tuned. If reliable TACAN or VHF bearing signal not received or no station is tuned, pointer rotates continuously.
13	NO 2 Bearing Pointer	With the respective NAV MODE selector set to VOR/LOC and respective RMI mode selector set to TACAN/VOR, indicates magnetic bearing to TACAN station tuned in NO 2 TACAN. With the respective NAV MODE selector set to TACAN and respective RMI mode selector set to TACAN/VOR, indicates magnetic bearing to VOR station tuned in No. 2 VHF NAV. Stow at 3 o'clock case position when localizer is tuned. If reliable TACAN or VHF bearing signal not received or no station is tuned, pointer rotates continuously.
	F HORIZONTAL SITUATION INDICATOR (TYPICAL)	
14	HSI Distance Display	Displays slant range distance in NM to selected TACAN station except when in GINS mode displays distance to waypoint. Pilots HSI distance display indicates distance to TACAN station set in number one TACAN while copilots HSI distance display is to TACAN station set in number two TACAN.
15	HSI Bearing Pointer No. 2	When the associated NAV MODE selector is set to TACAN, indicates magnetic bearing to TACAN station tuned in No. 2 TACAN. When the associated NAV MODE selector is set to VOR/LOC, indicates magnetic bearing to VOR station tuned in No. 2 VHF.

Figure 1-119 (Sheet 4 of 7)

TACAN and VOR/ILS Controls and Indicators (Continued)

NO.	CONTROL/INDICATOR	FUNCTION
16	HSI Bearing Pointer No. 1	When the associated NAV MODE selector is set to TACAN, indicates magnetic bearing to TACAN station tuned in No. 1 TACAN. When the associated NAV MODE selector is set to VOR/LOC, indicates magnetic bearing to VOR station tuned in No. 1 VHF.
17	Course Deviation Indicator (CDI)	When the associated NAV MODE selector is set to TACAN, movable center position of course arrow represents segment of TACAN course. Pilot’s CDI is connected to No. 1 TACAN, and the Copilot’s CDI is connected to No. 2 TACAN. When the associated NAV MODE selector is set to VOR/LOC, movable center portion of course arrow represents segment of VOR or localizer course. Pilot’s CDI is connected to No. 1 VHF NAV, and the Copilot’s CDI is connected No. 2 VHF NAV.
	G TACAN CONTROL PANEL	
18	Channel Indicator	Indicates selected TACAN channel and channel operating mode (X or Y).
19	Channel Mode Switch	When set to X, provides 126 channels of operation. When set to Y, provides an additional 126 channels with a different frequency distribution.
20	VOL Control	Inoperative. (TACAN audio signal intensity is controlled by individual flight crew audio panel TACAN knob.) Refer to subsection I–P.
21	Function Selector	
	OFF	Removes power from TACAN set.
	REC	Powers TACAN receiver to provide bearing information and station identity (audio) only. No distance information is available.
	T/R	Powers both the receiver and transmitter to provide bearing and distance information and station audio.
	A/A REC	Bearing to another airplane is displayed if other airplane has proper equipment. Bearing pointer rotates continuously if other airplane not equipped for bearing transmission. Do not use this position unless specifically briefed.

Figure 1-119 (Sheet 5 of 7)

NO.	CONTROL/INDICATOR	FUNCTION
	A/A T/R	Distance to another airplane is displayed on HSI's and navigator's distance display. Bearing to another airplane is displayed if other airplane is properly equipped. Bearing pointer rotates continuously if other airplane not equipped for bearing transmission.
22	CHAN Selectors (2 places)	Selects desired receiver–transmitter operating frequency. Left selector selects tens/hundreds on 13 positions for digital readout of 1 to 12 as selector is rotated clockwise. Right selector selects units and has 10 positions with digital readout of zero to tune as selector is rotated clockwise.
23	TEST Pushbutton	When pressed initiates self-test of system (except antenna). With NAV MODE selectors set to TACAN, HSI COURSE selector set to 180°, and TACAN mode selector (21) set to T/R, test lamp (24) illuminates momentarily (for lamp test), then HSI bearing pointer rotates to 270° for about 7 seconds. Bearing pointer then rotates to 180°. CDI centers with a to indication, distance displays on HSI and navigator's panel indicate 0 ± 0.5 NM for about 7 seconds. Displays then return to pre-test condition. Test lamp (24) illuminates if test is not satisfactory. With NAV MODE selectors set to VOR/LOC, RMI mode selectors set to TACAN/VOR and navigator's RMI selectors set to TACAN, RMI bearing pointers rotate to 270° and 180° as described above.

NOTE

- The TACAN self-test feature tests the entire system, except the antenna. If the self-test is within tolerance and a station identifier can be received (the antenna is checked), the system is satisfactory.
- If using TACAN for autopilot source, do not perform TACAN self-test in flight with autopilot engaged. Airplane heading would change as bearing pointers move.
- Interference with the TACAN can occur during JTIDS operation particularly in the high power mode. This interference can result in loss of TACAN bearing lock-on, but DME is not affected. If this interference is degrading operation, and bearing information is needed, request the CSO/CT reduce the time slot recurrence rate. For additional information about JTIDS, refer to T.O. 1E-3A-43-1-1.

NO.	CONTROL/INDICATOR	FUNCTION
24	Test Lamp (Red)	Illuminates to indicate malfunction in TACAN.

Figure 1-119 (Sheet 6 of 7)

TACAN and VOR/ILS Controls and Indicators (Continued)

NO.	CONTROL/INDICATOR	FUNCTION
	H PILOT'S/COPILOT'S NAV MODE SELECTOR	
25	NAV MODE Selector	Refer to NAVIGATION SYSTEMS INSTRUMENT SWITCHING, subsection I-J.
	I VHF NAV CONTROL PANEL (TYPICAL)	
26	Function Switch	When set to OFF, removes power from associated VHF NAV receiver. When set to PWR, turns on associated VHF NAV receiver. When set to TEST, initiates receiver self-test. See VOR preflight procedures.
27	Frequency Indicator	Displays selected frequency in MHz as set by frequency selectors.
28	Volume Control	Control deactivated. Volume of VOR audio is controlled from individual crew audio panels.
29	Frequency Selectors (Inner knobs of function selection and volume control)	Changes frequency of operation (VOR 108.00 to 117.95 MHz. LOC 108.10 to 111.95 MHz). Left selector knob changed frequency from 108 to 117 MHz in one MHz increments, when rotated clockwise. When rotated clockwise, right selector knob changes frequency in 50 KHz increments from .00 to .95.
	J COPILOT'S RMI MODE SELECTOR PANEL	
30	Copilot's RMI Mode Selector	Refer to NAVIGATION SYSTEMS INSTRUMENT SWITCHING, subsection I-J.
31	TACAN Annunciator (TACAN number one) (Green)	When illuminated, indicates TACAN information from TACAN one is displayed by number one bearing pointer and signal has adequate strength.
32	VOR Annunciator (VHF NAV NO 1) (Green)	When illuminated, indicates reliable VOR information from VHF NAV number one is displayed by number one bearing pointer and signal has adequate strength.
33	TACAN Annunciator (TACAN number two) (Green)	When illuminated, indicates TACAN information from TACAN two is displayed by number two bearing pointer and signal has adequate strength.
34	VOR Annunciator (VHF NAV NO 2) (Green)	When illuminated, indicates reliable VOR information from VHF NAV number two is displayed by number two bearing pointer and signal has adequate strength.

Figure 1-119 (Sheet 7 of 7)

TACAN SYSTEM OPERATION

Preflight

The following check will be performed for each TACAN. Prior to performing the checks, ensure all electrical buses are powered, appropriate circuit breakers closed, and AHRS is on and operating.

1. Set function selector to T/R.
2. Set channel mode switch to X unless specifically briefed to use Y channel. Set desired channel in channel indicator. Identify station.

NOTE

- After a time delay of approximately 85 seconds, channel selector mechanism channels and the azimuth and (T/R mode) range circuits start searching. After approximately two minutes, equipment reaches operating temperature.
- The TACAN ground station transmits an identifier each 36 seconds. Signal from selected station is considered unreliable when station identifier fails. To listen to identifier, rotate flight deck audio panel TACAN 1, TACAN 2, and MASTER VOL controls clockwise.

3. Set NAV MODE selectors to TACAN and RMI mode selectors to TACAN/VOR.
4. Check and compare HSI and RMI indications.

   Check navigation warning flags on pilot's and copilot's HSI out of view.

NOTE

To check RMI indications, NAV MODE selectors must be set to VOR/LOC.

5. Center CDI and check course counters read the same as, or 180° from, the bearing pointers. Rotate COURSE knob and check for proper CDI displacement and TO-FROM indication changes when selected course is approximately 90° to bearing pointer.

NOTE

When checking the TACAN at a designated ground check point, allowable bearing error is ±4 degrees for each system, but not over 4 degrees between systems 1 and 2. Range indication should be within one-half mile or 3 percent of the distance to the station, whichever is greater.

Perform steps 6 through 14 for a self test of the TACAN.

6. Set both HSI COURSE knobs to 180°.
7. Press TACAN 1 and 2 TEST buttons.

   Test lamp illuminates momentarily to check lamp. Bearing pointers on HSI (NO 1 for TACAN 1, NO 2 for TACAN 2) rotate to 270° for about 7 seconds, then rotate to 180°. CDI centers (TO - FROM pointer indicates TO), and distance displays (on HSI and navigator's panel) read 0 ± .5 NM for about 7 seconds. Indicators return to starting condition.

8. Check test lamps.

   Test lamp illuminates if either range or bearing test is not satisfactory.

– – – If Test Lamp Not Illuminated, Omit Steps 9 and 10 – – –

9. Set TACAN mode selectors to REC.
10. Repeat step 7.

    If test lamp does not illuminate at end of this step, the distance portion (DME) is inoperative, but bearing can be used.

– – – If Bearing Test Satisfactory, Perform Steps 11 through 13 – – –

11. Set both NAV MODE Selectors to VOR.

12. Set both pilot's RMI mode selectors to TACAN/VOR, set navigator's RMI switches to VOR.

NOTE

Interference with the TACAN can occur during JTIDS operation, particularly in the high power mode. This interference can result in loss of TACAN bearing lock-on, but DME is not affected. If this interference is degrading operation, and bearing information is needed, request the CSO/CT reduce the time slot recurrence rate. For additional information about JTIDS, refer to T.O. 1E-3A-43-1-1.

13. Press TACAN 1 and 2 TEST buttons.

    RMI bearing pointers (NO 1 for TACAN 1, NO 2 for TACAN 2) rotate to 270° for about 7 seconds, rotate to 180° for about 7 seconds, then return to original position.

14. Set TACAN 1 and 2 as required for departure.

Inflight

Operation in T/R or A/A mode is automatic after channel and mode selection is made. If distance display does not lock on, set function selector to REC until a usable signal is received, then return to desired selection. Use of TACAN course deviation signals is described under FLIGHT DIRECTOR SYSTEM.

In A/A mode, operation with other airplanes equipped with air-to-air TACAN requires the two sets of equipment to be separated by 63 channels to complete the air-to-air link. As an example, if channel 5Y is used, the other airplane must select channel 68Y. In A/A mode, the TACAN system can transmit distance reply signals to the interrogations of as many as five other sets. At the same time, replies from interrogated sets are received and distance display is locked on to strongest signal.

NOTE

- Bearing pointer that is connected to a TACAN operating in A/A REC mode (or A/A T/R if other airplane is not properly equipped) does not show bearing information. Bearing pointer continually rotates.
- T/R and A/A T/R modes should not be used when radio silence operation is desired.
- When using any A/A mode, do not use channels 3, 6, 66, or 69 (X or Y) to avoid possible interference with IFF or TACAN in other airplanes.
- Interference with the TACAN can occur during JTIDS operation particularly in the high power mode. This interference can result in loss of TACAN bearing lock-on, but DME is not affected. If this interference is degrading operation, and bearing information is needed, request the CSO/CT reduce the time slot recurrence rate. For additional information about JTIDS, refer to T.O. 1E-3A-43-1-1.

UHF-ADF SYSTEM

UHF-ADF system operates in conjunction with the mission UHF communication system and is controlled by the NO 13 UHF radio. The UHF-ADF system consists of a direction finder (DF) antenna (*figure 1-117*) and an amplifier relay assembly. Power for the system is 115 vac, 28 vdc and 26 vac, used for bearing excitation. See *figure 1-120* for controls.

The UHF direction finder automatically determines the magnetic bearing of radio signals in the frequency range of 225.0 to 399.9 MHz. Signals are received by the DF antenna and processed in UHF NO 13 receiver. To monitor UHF-ADF audio signals, rotate the flight deck audio panel UHF-ADF knob clockwise. The UHF-ADF is tuned at the communication operator's console.

To tune the UHF-ADF receiver, when the communications operator is not onboard; refer to COMMUNICATIONS SYSTEM, Flight Without Mission Crew, subsection I-P.

UHF/ADF Controls and Indicators

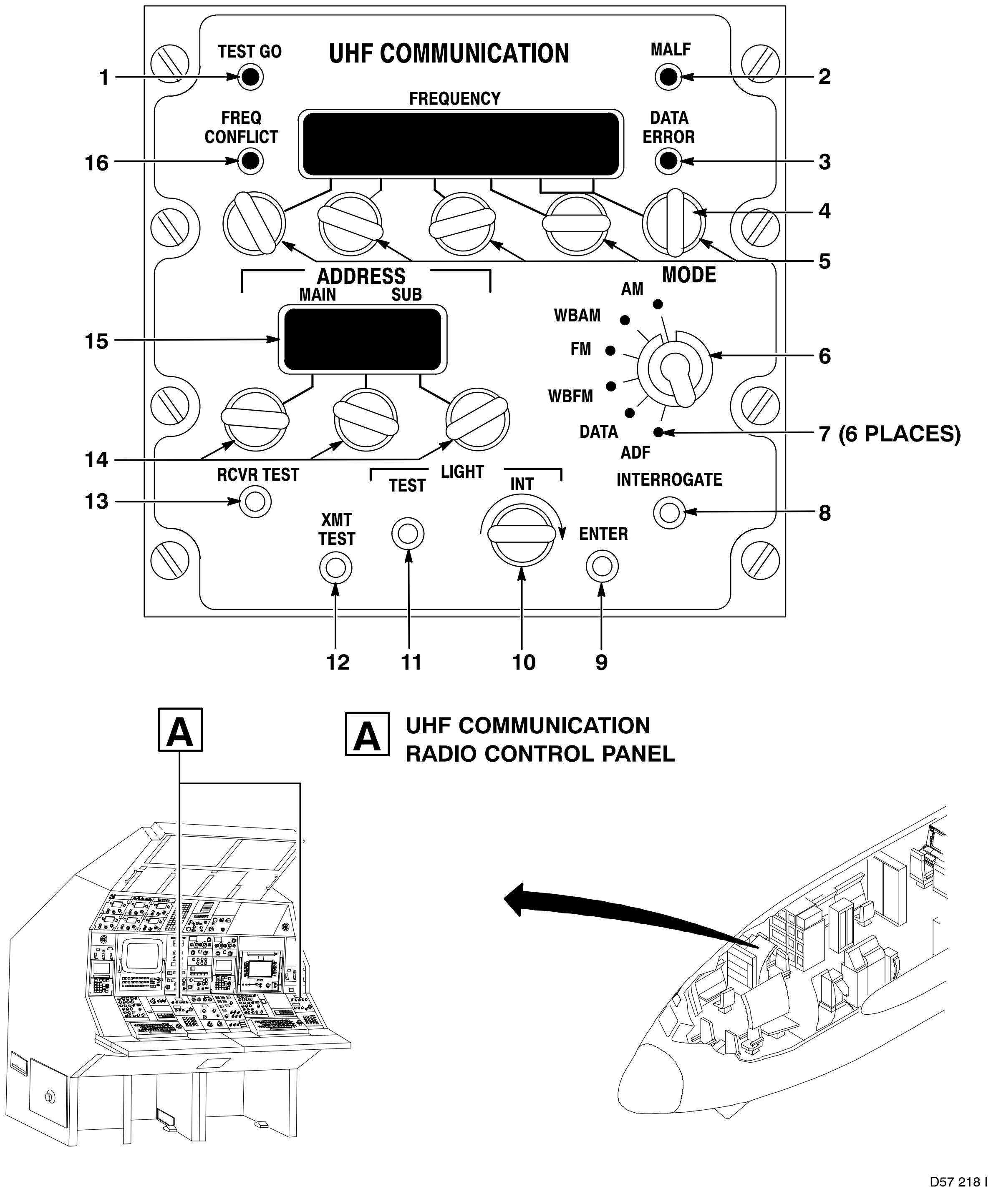
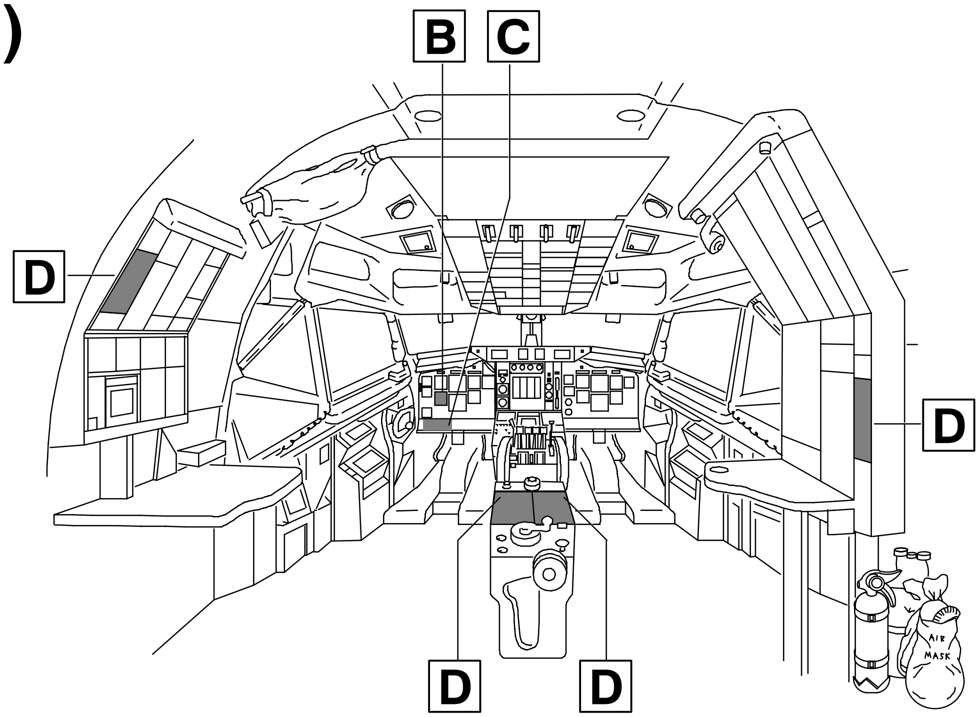
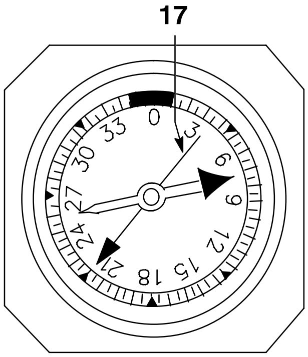


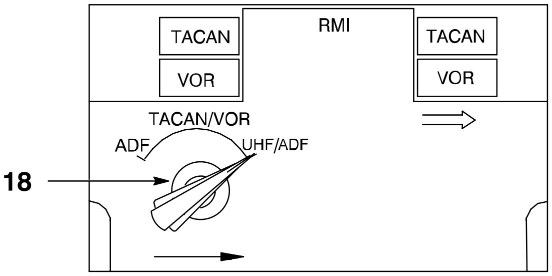
Figure 1-120 (Sheet 1 of 5)

UHF/ADF Controls and Indicators (Continued)

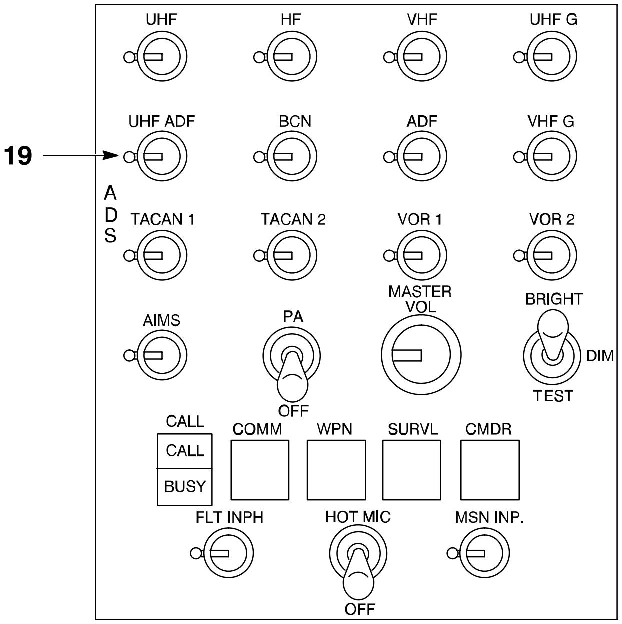




B PILOT'S RMI



C PILOT'S RMI MODE SELECTOR PANEL



D FLIGHT DECK ADS PANEL (4 PLACES)

D57 219 I

Figure 1-120 (Sheet 2 of 5)

NO.	CONTROL/INDICATOR	FUNCTION
	A UHF COMMUNICATIONS RADIO CONTROL PANEL	
1	TEST GO Indicator (Green)	When illuminated steady, indicates a successful receiver or transmitter test depending on which system is being tested.
2	MALF Warning Light (Red)	When illuminated, indicates that the frequency and mode information returned, when the ENTER button is pressed, is not the same as the information transmitted. Also indicates a parity error in received information when the INTERROGATE, RCV TEST or XMT TEST pushbuttons are depressed.
3	DATA ERROR Caution Light (Amber)	When illuminated, indicates the control lines are busy and data transmission is momentarily delayed. Goes out when the data is transmitted. This may occur when the ENTER, INTERROGATE, RCV TEST or XMT TEST buttons are depressed. Caution light will also illuminate when the INTERROGATE button is depressed if the frequency or mode settings of the control are set to something other than that of the equipment addressed. Caution light goes back out when the button is released. If either the RCV TEST or XMT TEST button is pressed and the DATA ERROR caution light illuminates while the TEST GO indicator remains off, a NO-GO has been obtained from the transceiver. However, if the frequency or mode select switches are not programmed to the same information as the digital data modules addressed when one of the pushbuttons is pressed, the DATA ERROR caution light will illuminate and stay on, even after the TEST GO indicator illuminates. If the front panel switches (address select, frequency select, mode select) on the MDRC are set to the same settings as the information stored in the digital decoder module addressed, the DATA ERROR caution light remains illuminated after the TEST GO light illuminates if the mission data radio control determines that the data being transmitted and the data returned do not agree. The DATA ERROR caution light remains illuminated until the pushbutton is released or until a good data check is obtained.
4	FREQUENCY Display Window	Light Emitting Diode (LED) display of frequency selected by frequency selector knobs.
5	FREQUENCY Selector Knobs	Used to dial in the desired frequency. Lines between knobs and windows show which digit is controlled by each knob.
6	MODE Selector Knob	Selects the modes of radio operation, as follows:
	AM	Amplitude Modulation. Used primarily for clear voice operation.

Figure 1-120 (Sheet 3 of 5)

UHF/ADF Controls and Indicators (Continued)

NO.	CONTROL/INDICATOR	FUNCTION
	WBAM, FM, WBFM, DATA	Not used by flight crew. Refer to T.O. 1E-3A-43-1-1.
	ADF	Automatic Direction Finding (AN/ARA-50). Used to tune UHF/ADF transceiver.
7	MODE Warning Lights (Six, Red)	When illuminated, indicate the mode of operation.
8	INTERROGATE Pushbutton	When momentarily depressed, causes the frequency and mode of the addressed equipment to be displayed in the FREQUENCY window and or the MODE warning lights. If the displayed information is different from what was dialed in on the frequency knobs and selected by the MODE knob, the DATA ERROR caution light illuminates. If the control detects a parity error in the returned information, the MALF warning light illuminates.
9	ENTER Pushbutton	When momentarily depressed, causes the frequency and mode information, displayed in the FREQUENCY display window and indicated by the illuminated MODE warning lights to be transmitted to the digital decoder modules of the equipment addressed, shown in ADDRESS display window. This switch action is only valid when the indicated SUB ADDRESS is 0.
10	LIGHT INTEN Knob	Adjusts the intensity of the LED frequency and address displays, the TEST GO indicator, DATA ERROR caution lights, and the MODE and MALF warning lights.
11	LIGHT TEST Pushbutton	When momentarily depressed, illuminates all indicators, caution and warning lights controlled by LIGHT INTEN knob.
12	XMT TEST Pushbutton	When momentarily depressed, initiates the transmitter test. A good test is indicated when the TEST GO indicator illuminates steady.
13	RCV TEST Pushbutton	When momentarily depressed, initiates the receiver test. A good test is indicated when the DATA ERROR caution light initially illuminates and the TEST GO indicator blinks and then the DATA ERROR caution light goes out and the TEST GO indicator illuminates steady.
14	ADDRESS Selector Knobs	Two MAIN ADDRESS knobs are used to dial in the address of a UHF radio and its associated equipment. Main address of any UHF transceiver is the same as its reference designator. For example, address of UHF/ADF radio is 13.

Figure 1-120 (Sheet 4 of 5)

NO.	CONTROL/INDICATOR	FUNCTION
		SUB ADDRESS knob is used to address various UHF equipment primarily during interrogation or troubleshooting. 0 = transceiver 1 = transmit filter 2 = receive filter 3 = power amplifier Numbers 4 through 9 are unused.
15	MAIN/SUB ADDRESS Display Window	Displays address selected by address knobs.
16	FREQ CONFLICT Caution Light (Amber)	When illuminated, indicates that the frequency analysis program has determined that the frequency just entered conflicts with other radios in use or is in the prohibited frequency list. Controlled by the computer.
	B PILOT'S RMI	
17	Pilot RMI Bearing Pointer No. 1	Indicates magnetic bearing to station tuned in UHF/ADF set when pilot's RMI mode selector is set to UHF/ADF.
	C PILOT'S RMI MODE SELECTOR PANEL	
18	Pilot's RMI Mode Selector	Refer to NAVIGATION SYSTEMS INSTRUMENT SWITCHING. Must be set to UHF/ADF to display UHF/ADF signal on NO 1 bearing pointer.
	NOTE Display on NO 2 bearing pointer depends on setting of pilot's NAV MODE selector. Refer to NAVIGATION SYSTEMS INSTRUMENT SWITCHING.	
	D FLIGHT DECK ADS PANEL	
19	UHF ADF Knob	When rotated clockwise increases volume of audio received by the UHF ADF radio.

Figure 1-120 (Sheet 5 of 5)

Magnetic bearing to a ground or airborne transmitter is displayed by the NO 1 bearing pointer on the pilot's RMI when the pilot's RMI mode selector is set to UHF-ADF.

NOTE

- The UHF-ADF is normally tuned to 243.0. Frequency changes should be coordinated with communications operator. The direction finder antenna is located on the bottom centerline of the fuselage (see *figure 1-117*). To provide correct UHF-ADF bearing indications, ensure that airplane structure does not obstruct line of sight reception from tuned UHF-ADF signal.
- For air refueling rendezvous operations, the UHF-ADF will be tuned to the primary air refueling UHF channel and the pilot will select UHF-ADF on the RMI mode selector. No suppression is provided, so each time a transmission is made, bearing pointer oscillates.

VHF NAVIGATION SYSTEM

Two separate systems are installed. Each system provides information on airplane position with respect to VHF omnirange (VOR) stations or Instrument Landing System (ILS) localizer (LOC) and Glide Slope (GS) beams. Independent tuning of each system is possible through control panels on the glare shield panel (*figure 1-5*). Reception of VHF NAV audio is available at each flight crew interphone panel. VOR and ILS information is displayed on navigation instruments and is also transmitted to the flight director and autopilot. VOR information is bearing/radial only. There is no distance information.

Each system includes a receiver and control panel. See *figure 1-117* for VOR/LOC and GS antenna locations. A single VOR/LOC antenna is installed in the vertical fin. The antenna consists of two elements, one on each side of the fin connected by a phasing cable. Separate feedpoints are provided for each VOR/ILS receiver. A single GS antenna is installed in the nose radome to serve both systems. Each receiver unit is a combination VOR/LOC/GS receiver.

VHF NAVIGATION SYSTEM POWER

Power for the VHF navigation system is 28 vdc and is applied to the VOR/ILS receivers when the NAV function switches are set to ON. Power is supplied through circuit breakers on the P5 panel. Additional 26 vac power for instrument indications is supplied through instrument transformers.

VHF NAVIGATION SYSTEM SIGNAL FLOW AND DISPLAY

The VOR/ILS aural identification signal is received at the respective receiver unit and transmitted through the VHF NAV control panel to the airplane interphone system. VOR and heading reference signals are processed by the receiver unit to generate a bearing output. VOR bearing information is supplied to the pilot and copilot HSI bearing pointers by the respective NAV MODE selector. For a discussion of instrument switching, refer to NAVIGATION SYSTEMS INSTRUMENT SWITCHING, subsection I-J.

In VOR operation, course information is supplied to the HSIs to enable pilots to select, identify and maintain a predetermined course by electronically referring to a VOR ground station. Annunciators indicate when VOR or localizer is selected for use with each flight director and the autopilot. In ILS operation, information is supplied for lateral and vertical guidance of the airplane during an instrument landing approach. The localizer and glide slope signals are fed to each pilot's flight director system and, when coupled, from VHF/NAV receiver number one to the autopilot. (Pilot NAV MODE selector must be in VOR/LOC and the flight director mode selector must be in NAV/LOC.) Refer to FLIGHT DIRECTOR OPERATION and AUTOPILOT OPERATION, for VOR/ILS operation with these systems.

A glide slope receiver in each VHF/NAV receiver is automatically powered when a localizer frequency is selected. The glide slope receivers operate in a frequency range of 329.3 to 335 MHz and provide vertical guidance during airplane descent. Selection of a localizer frequency automatically selects the paired glide slope frequency.

VOR OPERATION

Preflight

The following check will be performed for each VOR. Prior to performing the checks, ensure all electrical buses are powered, appropriate circuit breakers are closed, and AHRS is on and operating.

1. Set NAV function switches to PWR.
2. Set frequency selectors to receivable VOR station.
3. Rotate flight deck audio panels VOR1 and VOR2 controls clockwise until identifier is heard.

4. Set NAV MODE selectors to VOR/LOC and RMI mode selectors to TACAN/VOR.

5. Check and compare RMI/HSI indications.

   Check navigation warning flags on pilot's and copilot's HSIs out of view.

NOTE

- To check RMI indications, NAV MODE selectors must be set to TACAN.
- When a new VOR station is selected, navigation warning flag comes into view until bearing pointer is within two degrees of correct bearing and course deviation signal is usable. When a change is made from an ILS station to a VOR station, the navigation warning flag remains in view until bearing pointer has rotated from the three o'clock position to within 2 degrees of correct bearing.
- Check pilot's and copilot's HSI and navigation station RMI bearing pointers indicate approximately same bearing. (The navigators RMI source selector panel TACAN 1/VOR 1 and TACAN 2/VOR 2 switches must be set to VOR 1 and VOR 2 respectively, to preflight navigation station RMI).

6. Center the CDI and check course counters read the same, or 180° from the bearing pointer. Rotate COURSE knob and check for proper CDI displacement and TO-FROM indication changes when selected course is approximately 90° to bearing pointer.

VOR Selftest

To test the HSI bearing pointers, ensure both NAV MODE selectors are set to VOR/LOC before proceeding with test. To test the pilot's RMIs bearing pointers, ensure both NAV MODE selectors are set to TACAN and both RMI mode selectors are set to TACAN/VOR before proceeding with test. If desired, navigation station RMI can also be checked by setting navigator's RMI source selector panel switches to VOR 1 and VOR 2 before proceeding with test. Navigator's RMI tests regardless of NAV MODE selector setting.

NOTE

- The VHF-NAV receiver generates its own signal which tests the receiver system, except for the antenna. If the self-test is within tolerance and a station identifier is heard (antenna is checked) the system is satisfactory.
- To use the VOR self-test feature, the VHF-NAV receivers must be set to a VOR frequency.
- The VOR self-test cannot be performed if autopilot is engaged and in NAV LOC, GS AUTO, or GS MAN mode, or if the flight director mode selector is set to NAV/LOC or an approach position, due to an interlock which prevents test initiation.
- Do not use the test switch while navigating, using VOR, or during an ILS approach, since erroneous signal indications will result.

1. Set 180 in course selector windows on pilots' HSIs.

2. Set NAV MODE selectors to VOR/LOC for HSI test or TACAN for RMI test.

3. Set NAV function switches to TEST.

   HSI CDIs center, TO-FROM indicator's indicate TO, and HSI or RMI bearing pointers indicate 180 degrees.

4. Set NAV function switches to PWR.

   HSIs or RMIs (including navigators) return to pretest condition.

Inflight

The VOR receiver is normally used with the flight director (subsection I-K) or the autopilot (subsection I-L). Bearing information can be displayed on the RMI (subsection I-J).

NOTE

To obtain distance information from a VORTAC station (or ILS/DME) a TACAN receiver must be used.

LOCALIZER/GLIDE SLOPE OPERATION

Preflight

The following check will be performed for each VOR/ILS receiver. Prior to performing the checks ensure that all electrical buses are powered, appropriate circuit breakers are closed, and the AHRS is on and operating.

1. Ensure VHF NAV 1 and 2 on; receivable localizer frequency tuned and identified.
2. Set NAV MODE selectors to VOR/LOC.
3. Set published front course.
4. Check navigation and glide slope warning flags out of view.

   Check HSI and ADI warning flags out of view and HSI bearing pointers stow at 3 o'clock position.
5. Check ADI and HSI for proper indication and relationship to localizer and glide slope.

NOTE

- If warning flags disappear, glide slope pointers should move up or down depending upon relationship between aircraft and glide slope beam. CDI moves left or right if a valid localizer signal is received.
- During ILS operation, if navigator selects VOR for display on navigation station RMI, display is unreliable. (Pointers stow at 3 o'clock position, regardless of airplane heading.)

LOCALIZER SELF-TEST

NOTE

- The VHF-NAV receiver generates its own test signal which tests the receiver system, except for the antenna. If the self-test is within tolerance and a station identifier is heard (antenna is checked) the system is satisfactory.
- To use the ILS self-test feature, the VHF-NAV receiver must be set to a localizer frequency.
- The ILS self-test cannot be performed if autopilot is engaged and in NAV LOC, GS AUTO, or GS MAN mode or flight director mode selector is set to NAV/LOC or an approach position, due to an interlock which prevents test initiation.

1. Set NAV function switches to TEST.

   During a good test, HSI and ADI glide slope pointers move upward about one dot and HSI CDI moves left about one dot. Also, check ADI runway symbol moves left.
2. Return NAV function switches to PWR.

   ADIs and HSIs return to pretest condition.

Inflight

Localizer and glide slope information is normally used with the flight director (subsection I-K) or autopilot (subsection I-L). Raw data ILS information is displayed on the ADI (*figure 1-106*) and the HSI (*figure 1-104*).

MARKER BEACON SYSTEM

The marker beacon system provides both visual and aural indication of airplane passage over a 75 MHz marker beacon transmitter. The system is used as a navigation and landing aid by indicating passage over airway fan markers, station location Z markers, and ILS inner, middle and outer markers. The marker beacon system consists of a receiver with integral power supply, an antenna on the fuselage bottom centerline (*figure 1-117*), two sets of indicator lights and a control panel. See *figure 1-121* for location and description of marker beacon controls and indicators.

Marker Beacon Controls and Indicators

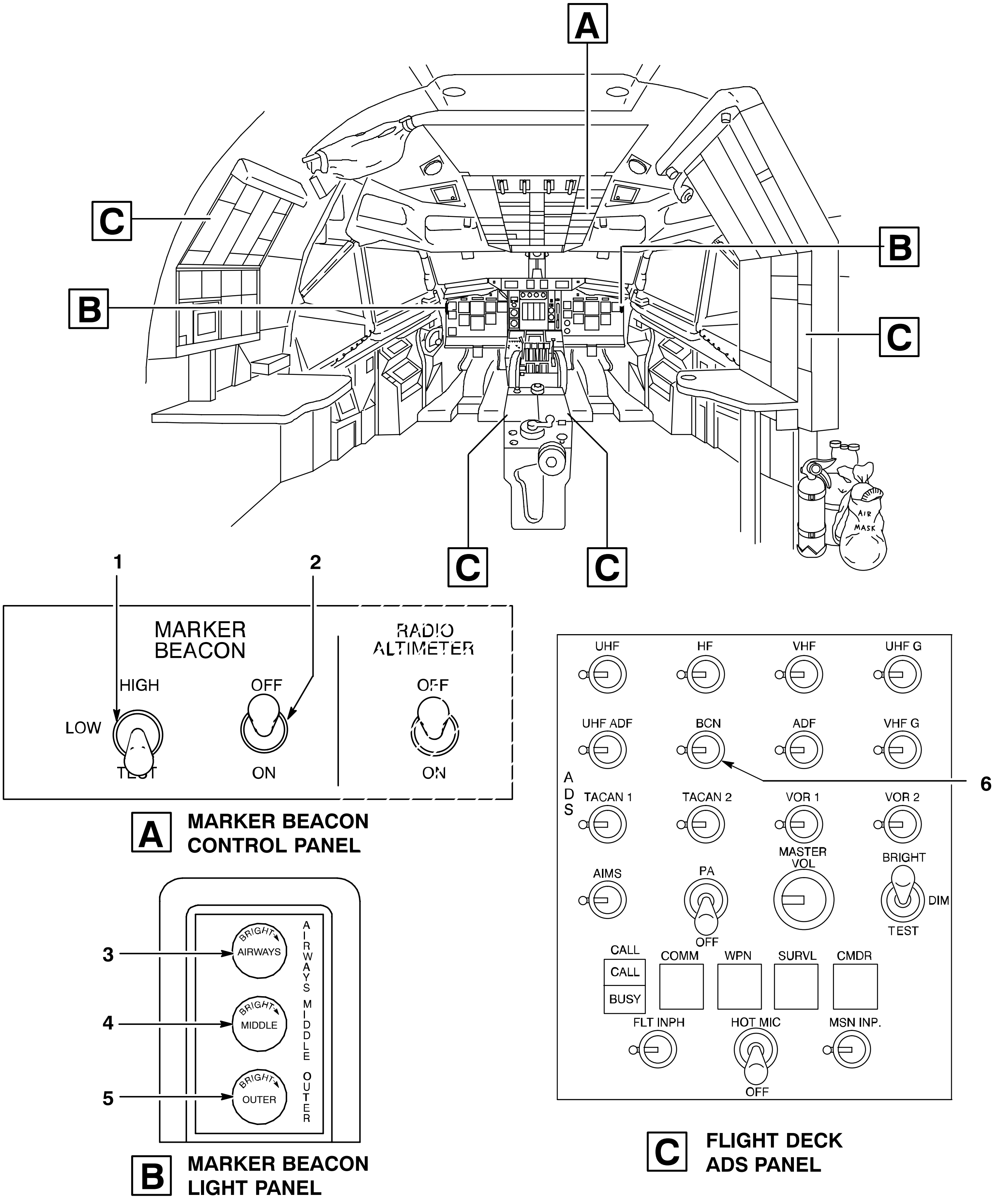


Figure 1-121 (Sheet 1 of 2)

Marker Beacon Controls and Indicators (Continued)

NO.	CONTROL/INDICATOR	FUNCTION
	A MARKER BEACON CONTROL PANEL	
1	MARKER BEACON Sensitivity Switch	When held in TEST, causes marker beacon lights to illuminate in sequence and also generates appropriate tone for each marker beacon light. Test lasts 5 seconds. When set to HIGH, receiver has maximum sensitivity to marker beacon transmitter signals. When set to LOW, receiver sensitivity to marker beacon transmitter signals is reduced by approximately 80%.
2	MARKER BEACON Power Switch	When set to OFF, turns off all power to marker beacon receiver. When set to ON, turns on marker beacon receiver power.
	B MARKER BEACON LIGHT PANEL	
3	AIRWAYS Light (Clear)	Illuminates steady whenever marker beacon receiver detects a steady 3,000 Hz signal from station Z marker beacon. Illuminates intermittently (flashing) whenever marker beacon receiver detects keyed 3,000 Hz signal from airways fan marker beacon. Is also illuminated intermittently when receiver detects 3,000 Hz ILS inner marker beacon (some airports) located between middle marker and landing threshold. Light has press-to-test feature.
4	MIDDLE Light (Amber)	Illuminates flashing whenever receiver detects keyed 1,300 Hz signal from ILS middle marker beacon. Light has press-to-test feature.
5	OUTER Light (Blue)	Illuminates flashing whenever receiver detects keyed 400 Hz signal from ILS outer marker beacon. Light has press-to-test feature.
	C FLIGHT DECK ADS PANEL	
6	BCN Knob	When rotated clockwise, increases volume of audio from the marker beacon system.

Figure 1-121 (Sheet 2 of 2)

MARKER BEACON SIGNAL FLOW AND DISPLAY

The ground marker beacon transmitters operate on a fixed frequency of 75 MHz and are modulated by one of three audio tones which are keyed with an identifying signal, depending on the type of beacon. The signals, received by the airborne receiver as the airplane passes over the transmitter, cause indicator lights on each pilot panel to flash at the keying rate or steady. A keyed or steady audio signal, corresponding to the light indication, is also available from the receiver at each crew audio panel by rotating the BCN knob clockwise until the signal is heard. The reception area of the aural signal is larger than that of the visual signal. ILS middle marker signal information is also transmitted to the flight director system for use in glide slope gain programming. Refer to FLIGHT DIRECTOR SYSTEM. Receiver sensitivity is variable as determined by position of the MARKER BEACON sensitivity switch on the pilot overhead panel. The sharpest indication of the location of a marker beacon, over which the airplane is flying, can be obtained with the least amount of sensitivity consistent with good reception. The marker beacon transmits only in a vertical direction, thus high sensitivity is desired at high altitudes and low sensitivity at low altitudes for approaches and landings.

MARKER BEACON SYSTEM OPERATION

During preflight, set MARKER BEACON sensitivity switch to HIGH or LOW (as desired), MARKER BEACON power switch to ON, and rotate flight deck audio panel BCN control clockwise. Check operation of marker beacon lights by pressing to test. If all marker beacon lights function, set MARKER BEACON sensitivity switch to the momentary TEST position. Ensure marker beacon tone is correct and corresponds with marker beacon lights as they illuminate.

NOTE

For instrument landing approaches set MARKER BEACON sensitivity switch to LOW prior to starting approach. This results in most accurate indication of station passage.

LOW RANGE RADIO ALTIMETER

A single, Low Range Radio Altimeter (LRRA) system (with dual indicators installed) provides an accurate indication of airplane altitude above the terrain from a maximum of 2,500 feet to touchdown. The system consists of a receiver-transmitter, a transmitting antenna, a receiving antenna, two radio altimeter indicators, two low altitude caution lights (one on each radio altimeter indicator), and two Decision Height (DH) lights (one on each ADI).

LOW RANGE RADIO ALTIMETER POWER

Power to the low range radio altimeter system is 115 vac. The power is controlled by the RADIO ALTIMETER switch (*figure 1-122*) on the pilots overhead panel. See *figure 1-117* for antenna locations.

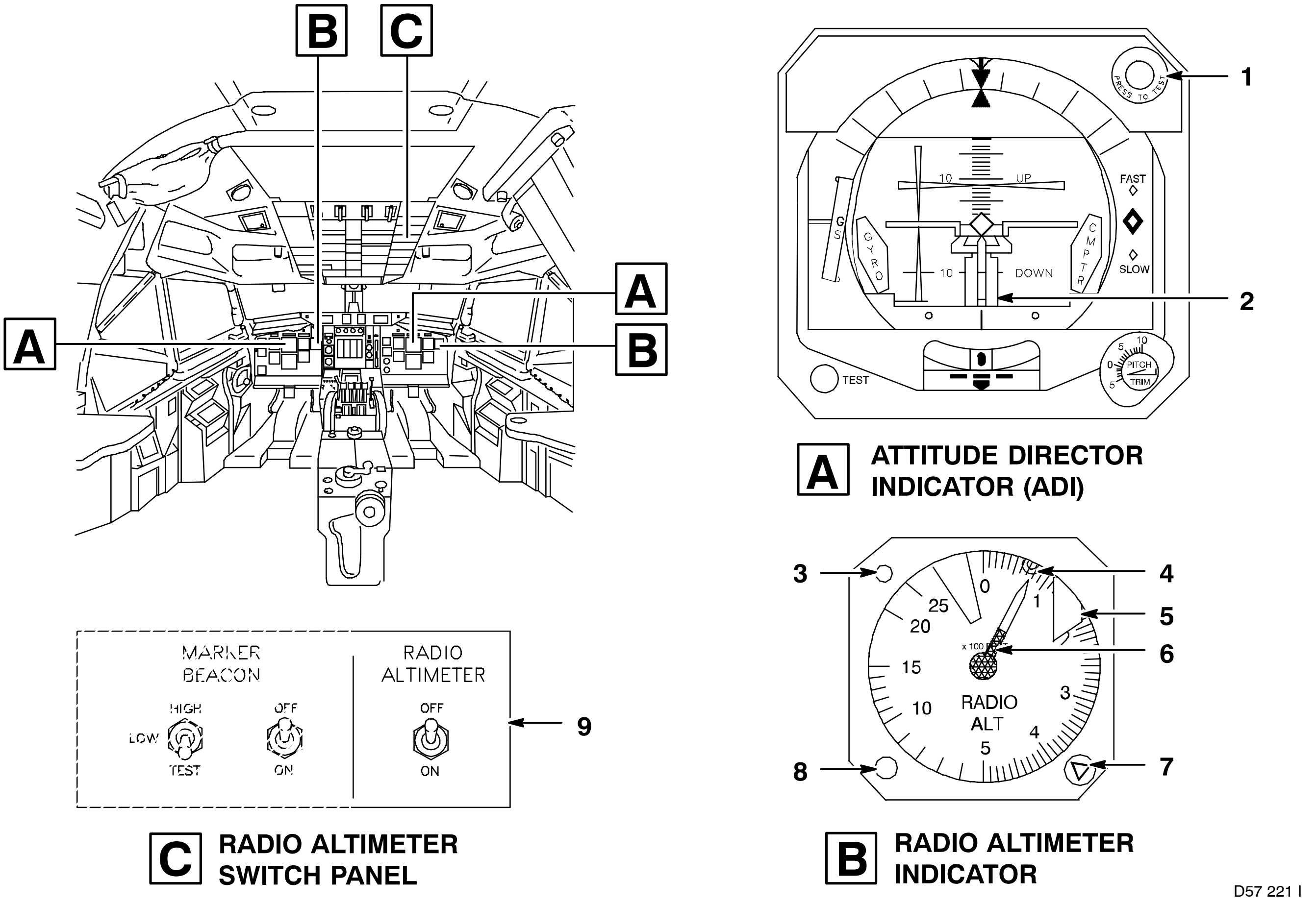
LOW RANGE RADIO ALTIMETER SIGNAL FLOW AND DISPLAY

The receiver-transmitter transmits frequency sweeps from 4,230 to 4,370 MHz and back 160 times a second. This radio energy is directed through the transmitting antenna to the earth's surface. The receiving antenna receives the radio energy reflected from the ground. The time delay in reception of the return signal measures airplane height above ground. This radio altitude information is displayed on both radio altimeter indicators (*figure 1-122*). Altitude trip signals are transmitted to the flight director system at 1,500 and 200 feet for glide slope gain programming and at 200 feet for ADI runway symbol operation. Refer to FLIGHT DIRECTOR SYSTEM (subsection I-K). An altitude signal is transmitted to the autopilot for gain programming. Refer to AUTOPILOT SYSTEM (subsection I-L).

Any altitude, at which a visual indication of reaching is desired, can be selected on the radio altimeter indicator by setting the low altitude marker bug to the desired altitude. When the selected altitude is reached, all low altitude caution lights and DH lights illuminate.

A self-test provision in the radio altimeter system provides for inflight or ground test of the system. An interconnection to the autopilot system prevents testing the radio altimeter when the autopilot is in the GS AUTO or GS MAN mode. There is also a built in fault monitoring system. If a fault lasts longer than five seconds, a fault warning flag appears in the radio altimeter indicator and the ADI RUNWAY symbol is covered by a warning flag.

Low Range Radio Altimeter Controls and Indicators



A ATTITUDE DIRECTOR INDICATOR (ADI)

C RADIO ALTIMETER SWITCH PANEL

B RADIO ALTIMETER INDICATOR

NO.	CONTROL/INDICATOR	FUNCTION
		A ATTITUDE DIRECTOR INDICATOR (ADI)
1	DH Light (Amber)	When illuminated, airplane is at or below altitude indicated by low altitude marker. Has press-to-test capability.
2	Runway Symbol	Vertical movement of rising runway symbol is controlled by an operating low range radio altimeter (LRRA) and indicates absolute altitude below 200 feet. Graduations are in 50 feet increments. Moves vertically (up) below 200 feet to simulate airplane vertical clearance above terrain. Touches bottom of airplane symbol at touchdown. Runway symbol biased to 200 feet when LRRA fails below 200 feet; however, RUNWAY flag is not in view.

Figure 1-122 (Sheet 1 of 2)

NO.	CONTROL/INDICATOR	FUNCTION
	B RADIO ALTIMETER INDICATOR	
3	Low Altitude Caution Light (Amber)	When illuminated, airplane is at or below altitude indicated by bug.
4	Low Altitude Marker (Bug)	Indicates altitude, read against scale, at which low altitude indicator and DH light illuminate.
5	Warning Flag	In view during self-test, or in the event of power failure, loss of return signal or incorrect altitude tracking. Indicates altitude information is unreliable.
6	Altitude Pointer	Indicates absolute altitude above terrain when read against scale. Not in view above 2,500 feet.
7	Low Altitude Marker Set Control	Used to control position of low altitude marker (bug).
8	TEST Pushbutton	When pressed, causes pointer on radio altimeter to indicate 40 feet, and warning flag to come into view. Low altitude caution light and DH light illuminate if bug setting is 40 feet or greater. Low altitude caution light and DH light go out if bug setting is less than 40 feet.
	C RADIO ALTIMETER SWITCH PANEL	
9	RADIO ALTIMETER Switch	When set to ON, power is provided to system and indicator is operative. When set to OFF, removes power from transmitter, needle stows, and WITH IDG ONLY TA flag appears in VSI. ◀

NOTE

WITH IDG Radio altimeter must be powered for TCAS to operate. Opening P5 RADIO ALTM circuit breaker causes TCAS flag in VSI, and TCAS is inoperative. Switching RADIO ALTIMETER OFF leaves RA valid discrete signal to TCAS powered so that TCAS remains operational, but TCAS inhibits cause TCAS to operate in TA-only mode due to zero radio altitude indication.◀

Figure 1-122 (Sheet 2 of 2)

LOW RANGE RADIO ALTIMETER OPERATION

Preflight

The following check will be performed by each pilot.

1. Set RADIO ALTIMETER switch to ON.

2. Set low altitude marker (bug) to 20 feet.

   Check all low altitude caution lights and DH lights illuminated and altitude pointers indicate approximately minus two feet.

3. Press and hold TEST pushbutton on either radio altimeter indicator.

   Check all low altitude caution lights and DH lights go out, warning flags in both radio altimeter indicators appear, warning flags cover both ADI RUNWAY symbols (if runway symbols in view), and radio altimeter altitude pointer drives to 40 ± 4 feet.

4. Release test pushbutton.

   When switch is released, altitude indicator pointer moves completely around dial to maximum position behind mask, and then returns to zero altitude indication. Flag goes out of view.

Normal Operation

1. Perform preflight check.

2. Ensure RADIO ALTIMETER switch is ON.

3. Set bug to desired altitude.

   Radio altimeter is now ready for operation.

AUTOMATIC DIRECTION FINDER (ADF)

One low frequency radio/ADF system is installed which receives signals from radio range stations, broadcast stations and low frequency navigation aid stations in the 190 to 1,750 kHz frequency range. The system provides both automatic (ADF) and manual Radio Direction Finding (RDF) capability in addition to receiving radio broadcast or course-oriented radio range signals. Aural monitoring of the ADF system is accomplished through individual interphone panels.

ADF SYSTEM COMPONENTS

The ADF system includes a receiver, a loop antenna, a sense antenna and a control panel. The receiver is mounted in an electronic equipment rack and receives signals from the sense and loop antennas. The fixed loop antenna is flush mounted on the bottom center line of the fuselage (*figure 1-117*). Circuits in the receiver determine the bearing of radio stations and transmit the information to the pilots RMIs. Audio signals from the receiver are monitored through the interphone panel by rotating the ADF knob on the flight deck audio panels clockwise. A control panel (*figure 1-123*) provides remote control of the system.

ADF SYSTEM POWER

The ADF system requires 28 vdc for operation and 26 vac from the heading excitation transformer for tuning.

ADF SYSTEM SIGNAL FLOW AND DISPLAY

The ADF receiver has inputs from the loop antenna through an error corrector, and from the sense antenna through the sense antenna coupler. The receiver converts the received radio signal to a synchro output to operate the bearing pointers on the RMIs. The receiver also sends an audio monitoring signal to the interphone system.

The loop antenna is fixed. RF signals from the antenna are coupled to the receiver through an error corrector. A resolver within the receiver determines the amplitude and phase of the loop RF signal. The resolver rotor can rotate in either direction and always drives one of two nulls toward the signal source when the function selector is set to ADF. The sense antenna signal is used to select the null that is actually pointing to the station. Null positioning is accomplished manually when the function selector is set to LOOP. (An ambiguity check establishes which null is toward the station.)

The Beat Frequency Oscillator (BFO) injects a signal that creates an audio beat frequency which can be used to assist in tuning. The BFO is also used to obtain an audible tone for CW reception. When properly tuned, the audio beat note is reduced to zero. The BFO can be switched on or off as desired by the BFO switch. ADF gain is controlled automatically when function selector is set to ADF. When function selector is set to LOOP, gain is controlled manually.

The bearing pointers on the pilots' RMIs display magnetic bearing to the received low frequency station, when the respective RMI mode selectors are set to ADF. In the event of a compass system malfunction, relative bearing to the station is displayed on the RMIs.

ADF SYSTEM NORMAL OPERATION

ADF Tuning

1. Adjust ADF audio receive control on the flight deck audio panels as desired.
2. Set function selector to ANT.
3. Set frequency band selector as required.
4. Using TUNE control, select desired frequency.

   Tune to the desired frequency for best audible signal.

   NOTE

   Under conditions of static or interference, a weak station can sometimes be tuned by using LOOP position of function selector. BFO function can also be used for weak station reception.

5. Identify station.
6. Set function selector to ADF.
7. Using TUNE control readjust frequency.

   Retune for maximum deflection of tuning meter.

RDF Tuning

1. Adjust ADF audio receive control as desired.
2. Set function selector to ADF.
3. Set frequency band selector as required.
4. Using TUNE control, select desired frequency.

   Tune to desired frequency for best audible signal.

   NOTE

   If necessary, use BFO function for better reception.

5. Identify station.
6. Set function selector to LOOP.
7. Set BFO switch to BFO.
8. Rotate LOOP control for maximum reception.
9. Using TUNE control, retune for high pitch solid tone.
10. Rotate LOOP control to locate null.
11. Adjust GAIN control.

    Adjust volume for 5° to 8° null width.

    NOTE

    - RDF procedures require manual positioning of the bearing pointer to determine bearing information. Bearing information is obtained by locating the aural null or area of minimum signal strength; solving the ambiguity of the loop by turning the airplane to place the null on a wing tip and noting null movement; and noting bearing pointer reading for selected null. If pointer moves clockwise, station is to the right.
    - The ADF can also be used to receive consol or consolan signals.

LF/MF ADF Controls and Indicators

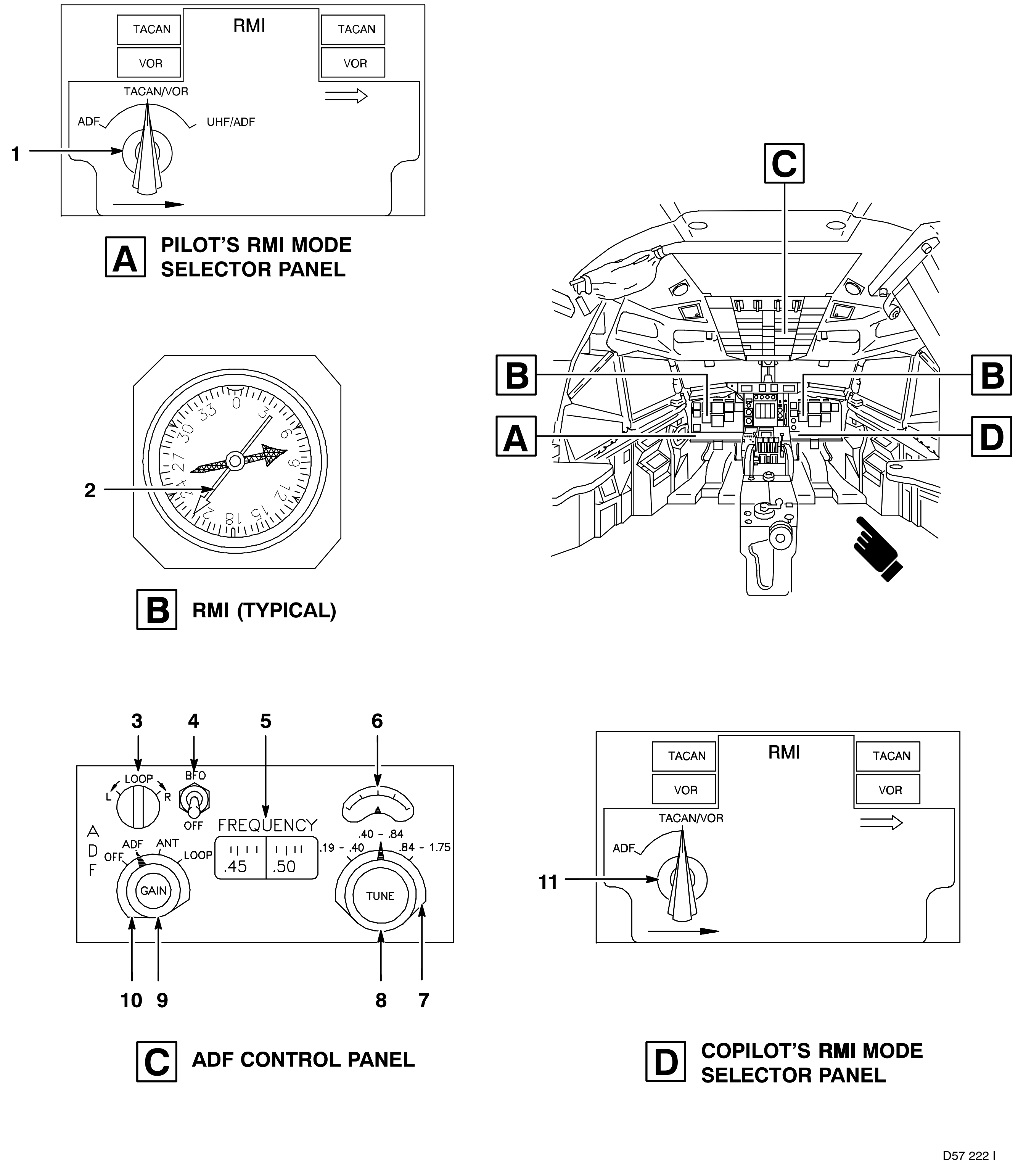


Figure 1-123 (Sheet 1 of 3)

NO.	CONTROL/INDICATOR	FUNCTION
A PILOT'S RMI MODE SELECTOR PANEL		
1	RMI Mode Selector (Pilot Panel)	When set to ADF, displays ADF bearing on NO 1 pointer. NO 2 pointer display depends on setting of NAV MODE selector. Refer to NAVIGATION SYSTEMS INSTRUMENT SWITCHING.
B RMI (TYPICAL)		
2	NO 1 Bearing Pointer (Pilot and Copilot RMI)	Indicates magnetic bearing to ADF station tuned when associated RMI mode selector is set to ADF.
C ADF CONTROL PANEL		
3	LOOP Control	Used when function selector is in LOOP position to find null position of antenna. Rotating LOOP control to left (L) or right (R) locates either one of two nulls located 180 degrees apart. A mark at the midpoint of either extreme switch position indicates correct position for slow loop rotation. Rotating control to an extreme position causes loop to rotate at high speed in selected direction. Determination of null point is achieved by observing tuning meter or listening to audio output for null signal.
4	BFO Switch	When set to BFO, powers beat frequency oscillator. When set to OFF, removes power from beat frequency oscillator. Switch allows zero beat tuning of weak voice or range stations. BFO position also provides audio for CW reception.
5	FREQUENCY Indicator	Displays selected frequency in megahertz under index mark as set by TUNE control. Only selected frequency range is visible in indicator.
6	Tuning Meter	Provides relative indication of received signal strength. During tuning, TUNE control is adjusted to produce maximum tuning meter deflection. Also used during manual direction finding to determine minimum signal point (null) and accurate bearing determination.
7	Frequency Band Selector	Three-position switch selects .19–.40, .40–.84 or .84–1.75 MHz band for display in FREQUENCY indicator.
8	TUNE Control	Adjusts receiver frequency within band selected by frequency band selector. Exact station tuning is indicated by maximum deflection of tuning meter pointer.

Figure 1-123 (Sheet 2 of 3)

LF/MF ADF Controls and Indicators (Continued)

NO.	CONTROL/INDICATOR	FUNCTION
9	GAIN Control	Controls audio output (volume) from ADF receiver to interphone system. Rotate clockwise to increase volume. RF gain is automatically controlled except when LOOP function is selected.
10	Function Selector	When set to OFF, system power is removed. When set to ADF, receiver is energized and circuits are selected to automatically determine bearing to received station. Both the sense and loop antennas operate. Bearing can be displayed on pilot and copilot RMIs. When set to ANT, sense antenna is used to receive audio signals such as weather broadcasts and radio range signals. No directional information is displayed. When set to LOOP, loop antenna is manually controlled by LOOP control. RMI bearing pointer rotates when LOOP control is displaced from midpoint. Null in reception is determined by monitoring tuning meter or audio output. Bearing displayed on RMIs is to station or the reciprocal. LOOP position may be used for audio reception under conditions of severe precipitation static since loop antenna is shielded.
	D COPILOT'S RMI MODE SELECTOR PANEL	
11	RMI Mode Selector (Copilot's Panel)	Must be set to ADF to display ADF bearing on NO 1 bearing pointer. Information displayed on NO 2 bearing pointer depends on setting of copilot's NAV MODE selector.

Figure 1-123 (Sheet 3 of 3)

DIGITAL FLIGHT DATA RECORDER/COCKPIT VOICE RECORDER/CRASH POSITION LOCATOR (DFDR/CVR/CPL)

The DFDR and CVR provide automatic recording of flight events and flight crew communications. The DFDR records the last 25 hours of flight data. The digital flight data recorder records flight data, such as airspeed, altitude, fuel flow, and control position. The CVR records the last 30 minutes of flight crew communications. The CPL is an emergency radio beacon for identification of an airplane crash site. It transmits a distress signal on 121.5 MHZ and 243.0 MHZ when activated. It is activated by a switch in the cockpit or by an impact which produces acceleration greater than 4 g's. The transmitted signals are detectable at distances in excess of 40 miles and are emitted for a minimum of 24 hours. The DFDR and CVR are located in the aft equipment rack. A Flight Data Acquisition Unit (FDAU), which processes the flight data for recording on the DFDR, is located in the E1 equipment rack. The CPL and CPL transmitting antenna are located in the top of the fuselage just aft of the base of the rotodome. Power to operate the DFDR and CVR comes from circuit breakers on the P5 circuit breaker panel. See *figure 1-124* for controls and indicators.

Both of the units require 115–volt, single phase AC and 28 VDC for proper operation. Power to operate the CPL comes from a battery within the unit. The DFDR and the CVR are on and operating at all times when APU or airplane generator power is on.

NOTE

> If the CPL is activated inadvertently, report the position and time of activation to the appropriate agency immediately.

LESS IDG IFF SYSTEM (AN/APX–101)

The IFF system provides automatic identification and altitude information responses to pulsed interrogations from ground, or airborne stations. The system enables friendly aircraft to identify themselves individually and provides a means of transmitting a special coded signal known as an emergency reply. The system receives, detects, decodes, encodes and transmits signals. Operation is possible in any one of five modes as follows:

Mode 1 – Security Identification

Mode 2 – Discrete Airplane Identification

Mode 3/A – Position Identification for Air Traffic Control

Mode C – Altitude Reporting for Air Traffic Control

Mode 4 – Crypto Secure Identification (Classified Codes)

The system consists of a transponder (receiver/transmitter), two blade antennas (*figure 1-117*), and control panel. See *figure 1-125* for IFF controls and indicators.

IFF SYSTEM FUNCTIONS

The transponder is a receiver-transmitter that receives ATC or IFF interrogations from an interrogating station and transmits coded reply signals.

The unit operates on frequencies of 1,030 MHz and 1,090 MHz. To prevent interference, a suppression circuit is connected between the IFF and other equipment operating near the IFF frequencies.

Altitude Reporting (Mode C)

An automatic altitude reporting function is included using digital outputs from the central air data computer system. When M-C switch is set to ON, transponder replies to interrogations with coded signals indicating airplane pressure altitude in hundreds of feet.

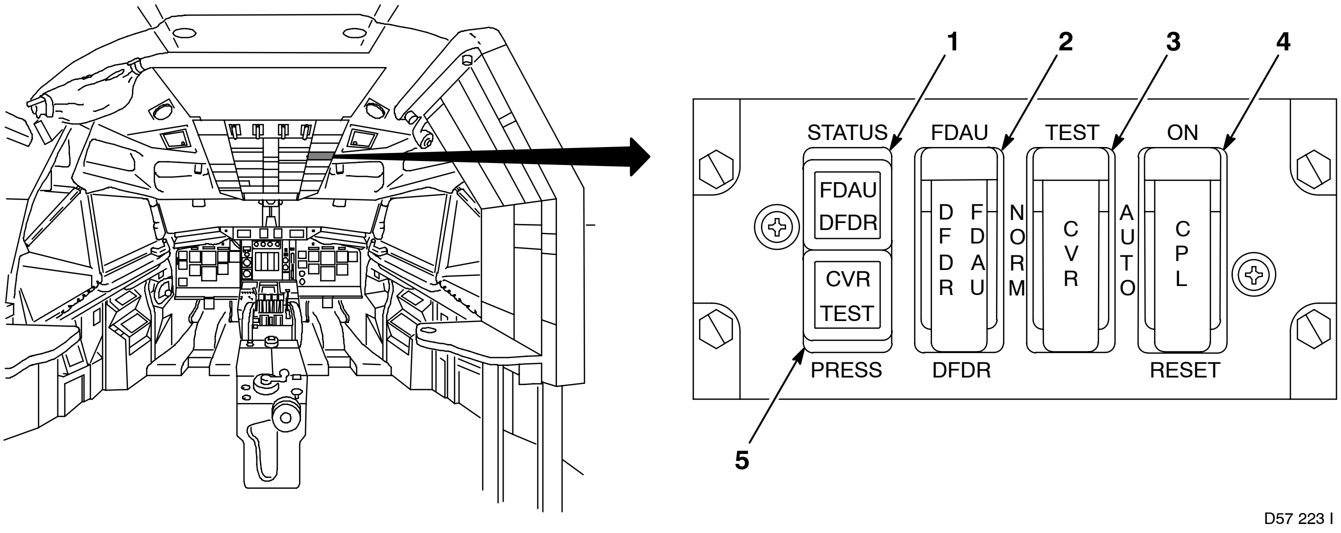
Identification/Position

An identification (IDENT) special reply can be transmitted for approximately 20 seconds each time selected. This special signal, added to Modes 1, 2, or 3/A pulses changes the receiving station display to distinguish between two aircraft displaying identical coding or to establish the position of any given aircraft. The identification pulse can be manually initiated by setting the IDENT-MIC switch to IDENT. When the IDENT-MIC switch is set to MIC, the IDENT signal is automatically transmitted if the flight deck UHF radio set is keyed by closing the microphone switch.

Emergency Transmission

An emergency signal can be added to Modes 1, 2, 3/A or C to indicate an inflight emergency by setting the master switch to EMER. The emergency signal is transmitted on the respective mode(s) when the transponder is interrogated. The Mode 3 signal is the same as code 7,700.◀

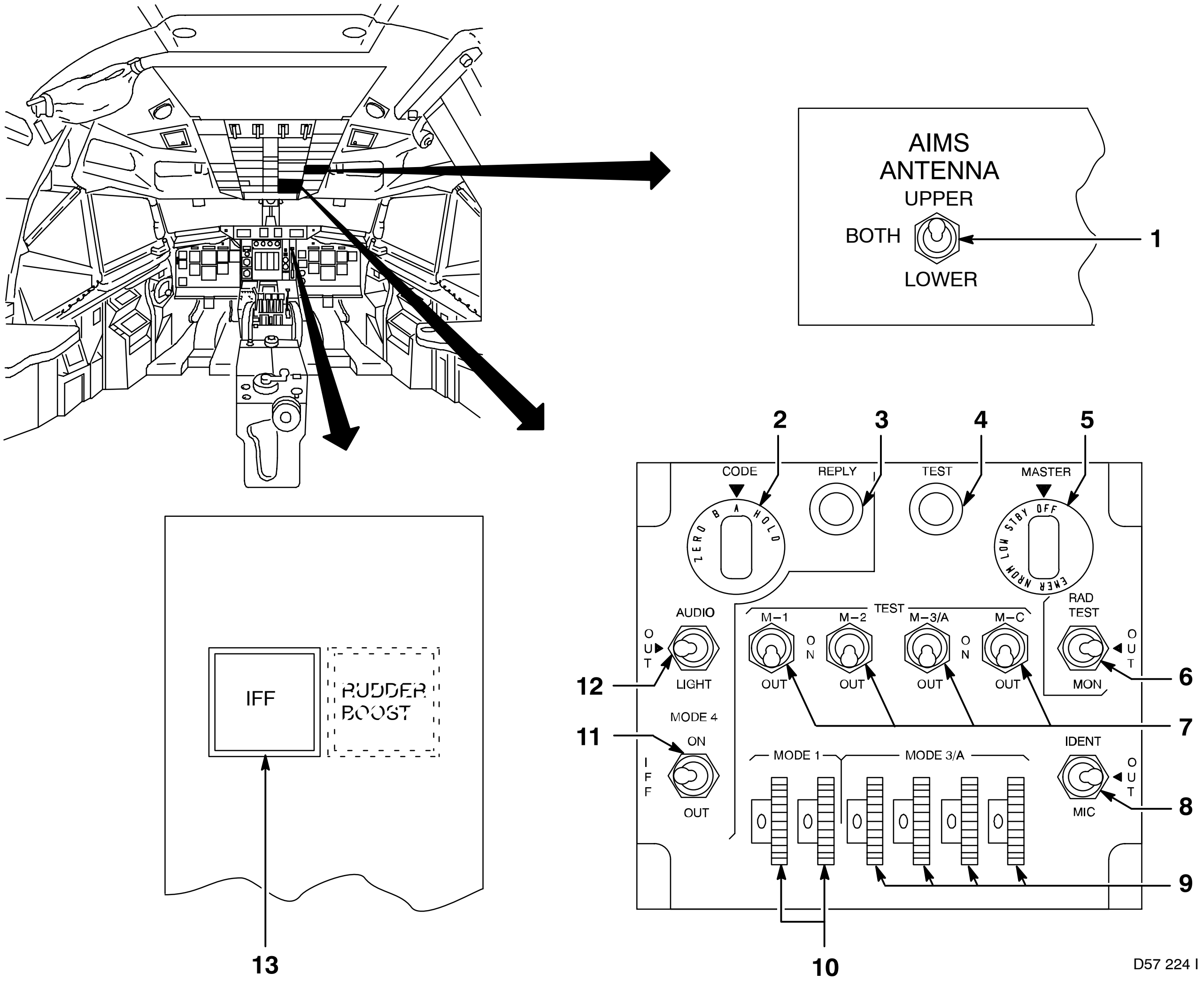
DFDR/CVR/CPL Controls and Indicators



NO.	CONTROL/INDICATOR	FUNCTION
1	FDAU/DFDR Indicators	When illuminated, indicate fault in FDAU or DFDR.
2	DFDR/FDAU Switch	Three-position toggle switch, used to initiate self test of DFDR and FDAU. When set to DFDR, DFDR is tested. When set to FDAU, FDAU is tested. In NORM position, no testing is performed.
3	CVR TEST Switch	Two-position toggle switch. When set to TEST, begins self test of CVR. Causes CVR portion of CVR/TEST indicator to illuminate. In NORM position, no testing is performed.
4	CPL ON–RESET–AUTO Switch (CPL Control Switch)	Three position toggle switch. Used to control and test CPL. When set to ON, activates CPL; when set to RESET, deactivates CPL; when set to AUTO, CPL is set for automatic activation by acceleration sensor (g-switch).
5	CVR/TEST Pushbutton/Indicator	Momentary pushbutton/indicator. When pressed, causes all indicators on control panel to illuminate.

Figure 1-124

LESS IDG IFF Controls and Indicators



NO.	CONTROL/INDICATOR	FUNCTION
1	AIMS ANTENNA Switch	When set to UPPER, selects upper antenna to receive interrogations and transmit replies. When set to LOWER, selects lower antenna to receive interrogations and transmit replies. When set to BOTH, receiver-transmitter transmits through the antenna over which the strongest signal was last received.
2	CODE Switch	When rotated counterclockwise and held in HOLD, for 15 seconds while transponder power is on, overrides zeroing function and causes transponder computer to retain Mode 4 code setting when airplane is on the ground. When released, returns to position A.

NOTE

If switch is not set to HOLD before landing, Mode 4 codes are automatically set to zero when airplane weight is on squat switches.

Figure 1-125 (Sheet 1 of 3)

LESS IDG IFF Controls and Indicators (Continued)

NO.	CONTROL/INDICATOR	FUNCTION
		When set to A, causes transponder to respond to code A interrogations. When set to B, causes transponder to respond to code B interrogations. When pulled out and rotated clockwise to ZERO, cancels Mode 4 code settings from transponder computer. IFF caution light illuminates when codes are set to zero.
3	REPLY Indicator (Green)	When illuminated, transponder is replying to Mode 4 interrogation. Light has press to test feature.
4	TEST Indicator (Green)	When illuminated, indicates proper transponder response to self-test of Modes 1, 2, 3/A or C or to external interrogations if RAD TEST-MON switch is set to MON. Light has press to test feature.
5	MASTER Switch	When set to OFF, removes power from transponder set and transponder computer. When set to STBY, provides power to transponder receiver and computer. Transponder transmitter remains unpowered. Switch should remain in STBY a minimum of one minute for standard temperature conditions and 5 minutes under extreme low temperature conditions. When set to LOW, transponder operates at reduced receiver sensitivity. When set to NORM, transponder operates at normal receiver sensitivity. When set to EMER, causes automatic transmission of emergency reply signals to Mode 1, 2, 3/A or C interrogations, regardless of code settings.
6	RAD TEST–MON Switch	RAD TEST switch position is inoperative. Switch is spring-loaded to OUT. When set to OUT, TEST indicator receives power only when TEST switches are held in TEST. When set to MON, TEST indicator illuminates any time transponder replies to Mode 1, 2, 3/A or C interrogations.
7	TEST Switches (M–1, M–2, M–3/A, M–C)	

NOTE

TEST position of each switch is spring-loaded to return to ON.

NO.	CONTROL/INDICATOR	FUNCTION
		When held in TEST, causes built-in test feature to interrogate transponder while also powering transponder receiver. Built-in test feature evaluates characteristics of reply signal and causes TEST light to illuminate when reply is satisfactory. When set to ON, causes transponder to reply to selected mode interrogations. When set to OUT, turns off selected mode.

Figure 1-125 (Sheet 2 of 3)

NO.	CONTROL/INDICATOR	FUNCTION
8	IDENT–MIC Switch	When set to IDENT, generates coded replies for Mode 1, 2, or 3/A interrogations. Mode C is not affected. Pulse trains are transmitted for approximately 20 seconds, plus length of time switch is held in IDENT. When set to OUT, ident function is disabled. When set to MIC, causes transponder to transmit IDENT replies while cockpit microphone switch is closed, provided a flight deck UHF radio set is operating and an interphone control panel associated with microphone switch has UHF radio selected.
9	MODE 3/A Code Selectors (Four thumbwheels)	When set to a numbered position, selects Mode 3/A codes. Thumbwheels are continuously rotatable with no stops. Each wheel has eight positions, numbered 0 through 7 consecutively. Do not tune through 7,500, 7,600 or 7,700 when transmitter is powered.
10	MODE 1 Code Selectors (Two thumbwheels)	When set to a numbered position, selects Mode 1 codes. Thumbwheels are continuously rotatable with no stops. Left wheel has eight positions, numbered 0 through 7 consecutively. Right wheel is numbered 0 through 3 appearing twice, once on each half of drum.
11	MODE 4 ON–OUT Switch (Mode 4 Switch)	When set to ON, causes transponder to reply to Mode 4 interrogations. When set to OUT, turns off Mode 4 computer.
12	AUDIO–LIGHT Switch	When set to AUDIO, causes short bursts of 300 to 400 Hz buzz to be heard over flight deck interphone (if AIMS is selected on flight crew audio distribution panel) when transponder receives Mode 4 interrogations. Also causes REPLY indicator to illuminate when transponder replies to Mode 4 interrogation. When set to OUT, aural and visual monitoring of Mode 4 is disabled. When set to LIGHT, only REPLY indicator illuminates when transponder replies to Mode 4 interrogations.
13	IFF Caution Light (Amber)	When illuminated, Mode 4 interrogation was received but transponder failed to reply, no code is loaded, or Mode 4 is selected and code has been zeroized by landing without setting CODE switch to HOLD.

Figure 1-125 (Sheet 3 of 3)

LESS IDG Self-Test

The receiver-transmitter provides a built-in test function by generating interrogation pulse pairs for Modes 1, 2, 3/A or C. Setting respective TEST switch to TEST enables the test of that mode. Test pulses are routed to the transponder which in turn replies. If the reply is within desired tolerances, TEST indicator illuminates. An improper reply results in TEST indicator not illuminated. Due to low test set signal strength, the self-test feature causes the TEST indicator to illuminate only when the MASTER switch is set to NORM.

IFF SYSTEM OPERATION

Preflight or Inflight Test

1. Set MASTER switch to STBY.

   Allow system to warm up in STBY mode for one minute in standard temperature conditions, five minutes in extreme low temperature conditions, before selecting an operating mode.
2. Set AIMS ANTENNA switch to BOTH.
3. Set RAD TEST-MON switch to OUT.
4. Set Mode 1 and 3/A code selectors to zero.
5. Set MASTER switch to NORM.
6. Hold desired TEST switch (M-1, M-2, M-3/A or M-C) to TEST until TEST indicator illuminates, indicating proper operation of that mode. Release and switch returns to ON.

   NOTE

   Inflight checking of IFF can be accomplished in conjunction with ground radar sites. Modes 1, 2, 3/A and C can be checked on low and normal sensitivity in addition to checking IDENT operation. Altitude input for mode C can be read out on copilot’s vnav str page.
7. Set MASTER switch as desired.
8. Set Mode 4 switch to ON.
9. Check IFF caution light out after Mode 4 code is loaded.

   NOTE

   If IFF appears to be inoperative, check the 3-ampere fuse located on the R/T unit in the E1 rack. A spare fuse is provided.

Normal Operation

To place IFF system in operation:

1. Set MASTER switch to STBY.

   Allow system to warm up in STBY mode for one minute in standard temperature conditions, five minutes in extreme low temperature conditions, before selecting an operating mode.
2. Set TEST switches (M-1, 2, 3/A, C) as required.
3. Set IDENT-MIC switch as desired.
4. Set Mode 1 and 3/A code selectors as required.

   Mode 2 codes are preset on front panel of receiver/transmitter.
5. Program Mode 4 according to applicable directives.
6. Set AIMS ANTENNA switch to BOTH.
7. Set MASTER switch to LOW or NORM.

   NOTE

   Setting RAD TEST-MON switch to MON causes TEST indicator to illuminate when IFF transponder replies to interrogations.

Emergency Operation

To place IFF system in emergency operation, pull MASTER switch and rotate to EMER position. ◀

WITH IDG IFF MODE S SYSTEM (AN/APX–119)

The AN/APX–119 transponder is herein referred to as the IFF mode S, or simply the IFF transponder. Military operating modes are designated with numbers (1, 2, 3, 4); civil air traffic control modes are designated with letters (A, C, S). The letter S in Mode S comes from the word selective, regarding the selective interrogation feature of Mode S.

Two frequencies (1030 MHz aircraft receive, 1090 MHz aircraft transmit) are used by the system for all modes.

The transponder always receives on both antennas and transmits on the antenna which received the strongest interrogation signal.

FEATURES

Mode 1 – Military Identification Friend or Foe IFF), mission identifier

Mode 2 – Military Selective Identification Feature (SIF), unique aircraft identifier

Mode 3/A – Military Mode 3, and Civil Air Traffic Control Mode A, 4096 code identifier

Mode C – Altitude Reporting

Mode 4 – Military Crypto Secure Response to Interrogations

I/P (IDENT) – Identification of Position (I/P), also called IDENT or special position identifier (SPI), terms all associated with Mode 3/A and having the same meaning

EMER – Emergency Squawk, affecting Modes 1, 2, 3/A and C

Mode S – Air Traffic Control Selective Interrogation mode

Mode S provides squitter, selective interrogation and all call response.

Squitter is a feature that, without interrogation, omnidirectionally broadcasts aircraft identification and location. It is received by collision avoidance systems (TCAS) in other aircraft and it is one of the methods used by ground radar for initial traffic acquisition.

With Mode S aircraft can be interrogated individually (selective interrogation) to eliminate overlapping responses and permit the radar to handle a greater volume of traffic, or all aircraft in a scan beam can be interrogated simultaneously (all call) to pick up new traffic entering a sector. By providing for unique aircraft addressing it reduces the requirement for pilots to change the Mode 3/A code when handed off from one radar sector to another.

COMPONENTS

Airplane hardware consists of the GINS control and display unit (CDU), receiver/transmitter, Mode 4 computer, and upper and lower antennas.

Control And Display Unit (CDU)

The GINS control and display unit (CDU) located at the pilot's, copilot's and navigator's station have the principal controls and indicators (*figure 1-125A*) for the transponder. The CDU also controls the activation, testing, and mode selection for TCAS, but does not provide power to TCAS.

INPUT/OUTPUT

The IFF transponder interfaces with other systems on the airplane as follows, *figure 1-125D*:

- Receives pressure altitude from the selected air data computer. Processes and outputs altitude to Mode C, Mode S, and TCAS.
- Receives keying signal from communications radio UHF R/T 19 for MIC function.
- Receives ground/air discrete from right landing gear ground safety relay R1098 fpr all modes 3/A, C,and S ground lockout of responses to "all call" interrogations.
- Receives ground/air discrete from right landing gear ground safety relay R1098 for Modes 3A, C, and S ground lockout of responses to 'all call' interrogations.

NOTE

> Squitter continues to transmit on the ground (in NORM) and transmits an on–ground status that usually inhibits ATC radars from selectively interrogating ground targets. However, Mode S does respond to selective interrogations while on the ground (in NORM) and ATC can choose to selectively interrogate Mode S targets whose squitter indicates they are on the ground.

- Provides audio output to flight deck ADS panels (AIMS knob) for Mode 4 refusal to reply.
- Has interference suppression with mission IFF, TACAN, TCAS, and ESM.

Altitude Data Flow

The IFF computer processes altitude from the bus controller CDU and transmits it as Mode C altitude, puts it into Mode S responses, and provides it to TCAS. Mode C, Mode S, and TCAS altitudes are to the nearest 100 feet, accurate to ±51 feet in comparison to ADC altitude.

TCAS receives intruder altitude from either Mode C or Mode S signals. Mode C and Mode S signals from intruders can have altitude data with least significant bits of 25 to 100 feet. Intruder Mode C altitude (in comparison to CDU altitude) is used for uncoordinated resolution advisories; intruder Mode S altitude (in comparison to CDU altitude) is used for coordinated resolution advisories.

MODES OF OPERATION

The transponder replies in all modes properly interrogated that are enabled by the crew. Each mode can be individually enabled/disabled. Squitter is part of Mode S and is enabled whenever Mode S is selected.

BUILT–IN TEST OPERATION

The transponder system performs self–tests during power–up and during normal operation to detect failures. If faults are detected by Power–up or Continuous BIT, the FAIL annunciation is displayed on the CDU and information can be viewed on the iff xpndr status page. Built–in test (BIT) continuously monitors all IFF modes. Receiver frequency, receiver sensitivity, transmitter power output, transmitter frequency, antenna voltage standing wave ratio (VSWR), diversity performance, Mode S squitter monitoring, Mode 4 internal applique status, and Mode 4 load status are evaluated in a complete end–to–end test. Evaluation is provided as GO/NO–GO status displays on the CDUs.

Power–Up BIT (PBIT)

When power is applied (usually, when IFF switch is turned ON) PBIT occurs. PBIT takes 11 seconds. PBIT runs in STBY even if the controlling CDU is selected to NORM. No IFF transmissions occur during PBIT. After PBIT is passed, the transponder assumes the modes commanded by the controlling CDU.

If the IFF does not pass PBIT the TCAS flag appears on the VSI, the RT or ANT fault latching indicator on the front of the transponder in the E1 rack turns white, and the transponder does not operate in any mode. Performing any of the mode IBITs also retests all PBIT failure conditions and clears any fail indication for which the failure no longer exists. Call maintenance.

Continuous BIT (CBIT)

CBIT functions during operation in STBY or NORM modes. CBIT monitors some modules continuously and others on each transmitted reply. In STBY, CBIT is performed with no RF transmission. CBIT begins and runs constantly whenever the transponder is powered up, but not when performing IBIT or when dumping the contents of NVM. Each CBIT test cycle is completed within 30 seconds. RF power sensing during transmission, voltage sensing, and wrap around are used to monitor operation of the system. Test results of CBIT are stored in NVM.

Initiated BIT (IBIT)

There is a separate IBIT for each Mode: 1, 2, 3A, C, 4, and S. IBITs can only be run in NORM. A mode must be ON for its IBIT to run. Mode S/TCAS IBIT can only be performed on the ground. All other modes can be tested on the ground or in the air. The iff test page is used to perform IBIT and to display test results. During IBIT, the transponder interrupts normal operation and stimulates internal functions with defined signals. The resultant responses are monitored and compared against acceptance masks. Upon completion of IBIT, the transponder reverts to its previous condition. Test results of IBIT are stored in NVM. IBIT takes 11 seconds.

WARNING

On the ground the IFF transponder transmits if selected to NORM. It must be selected to NORM to run any of the mode initiated built in tests (IBITs). During transmission the minimum personnel safety distance is 10 feet from either antenna. Minimum electro–explosive device distance is 25 feet.

IFF Preflight

The IFF TRANSPONDER switch may be turned on at any time, before or after the first CDU is turned on.

If the IFF TRANSPONDER switch is turned on first, it completes its PBIT and sits in STBY awaiting commands from a CDU. When a CDU is then turned on , the CDU default settings for IFF take effect, and the IFF remains in STBY until changed by an operator.

If a CDU is turned on first, the CDU defaults to a safe IFF configuration (STBY, with all modes ON) and the IFF commands do not take effect until the IFF is turned on and completes its PBIT. A CDU may be configured for other than the default IFF settings before the IFF is turned on, in which case the IFF assumes the configuration commanded by the controlling CDU immediately after it completes its own PBIT.

Configuring the CDU for IFF operation is usually done by the navigator, as the navigator usually turns the CDUs on. Mode 4 codes, if required, should be loaded by the CT before the navigator arrives at the airplane. The mode 4 codes may be loaded without either the IFF or the CDU being on. The CT can verify successful code load by illumination of the green light on the M4 applique, which operates with IFF OFF.

The mode IBITs should be run with a ground safety observer to assure personnel are clear of the IFF antennas. The safety observer does not necessarily have to be on headset. The IBIT portion of the IFF preflight should be delayed to Before Start checklist if a safety observer is not available prior to that time.

WITH IDG IFF Mode S Controls and Indicators

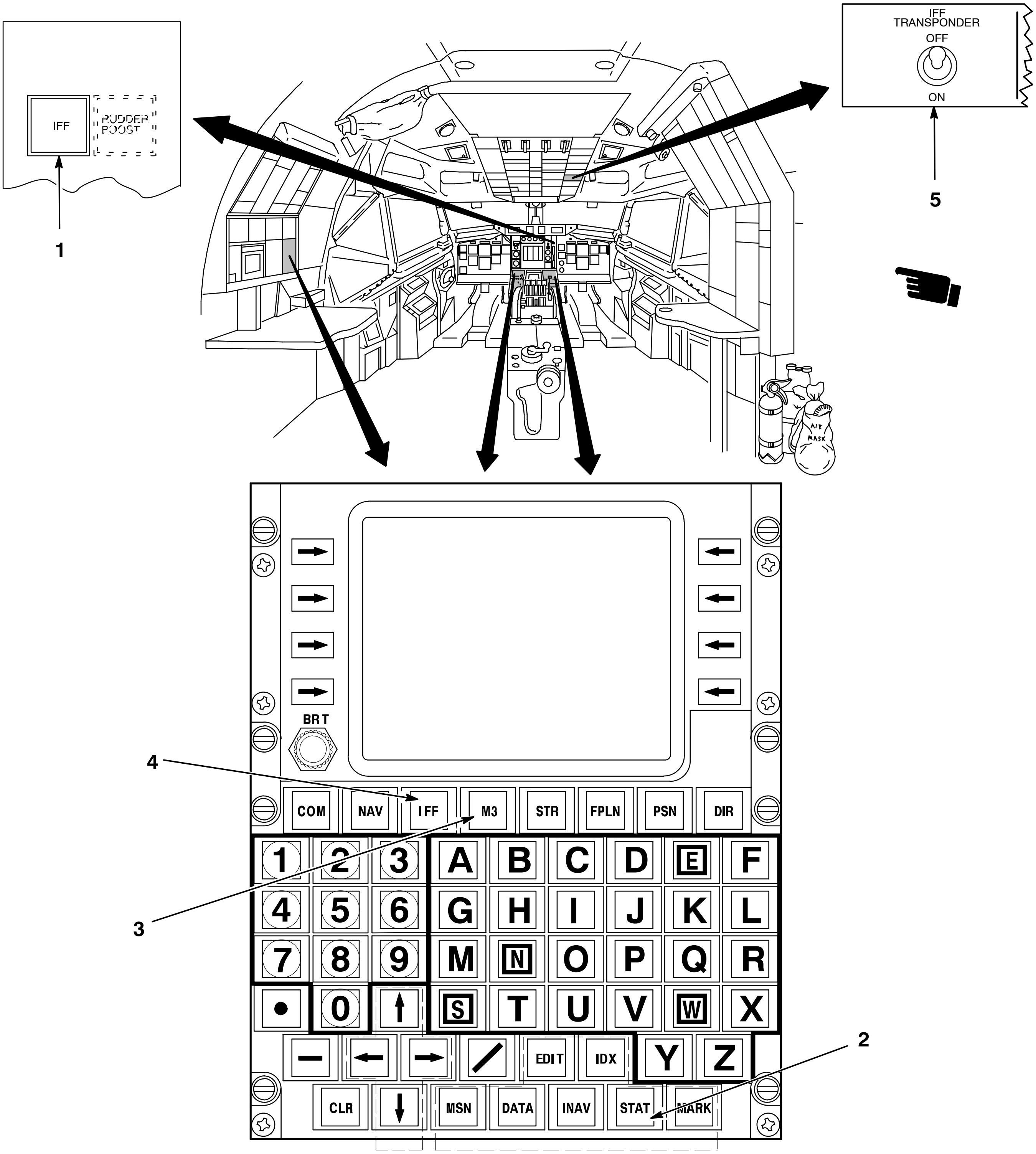


Figure 1-125A (Sheet 1 of 2)

WITH IDG IFF Mode S Controls and Indicators (Continued)

NO.	CONTROL/INDICATOR	FUNCTION
1	IFF Caution Light (Amber)	Illuminates steadily under the following conditions: ● IFF is configured for Mode 4 operation (M4 ON, NORM selected) but codes are not loaded. ● The Mode 4 applique determines that an interrogation is valid and commands a response, but the transponder fails to feed back a 'response sent' status to the applique. This is not the same condition as a refusal to reply; the IFF light does not illuminate with a legitimate refusal to reply resulting from code mis–match. ● The Mode 4 applique fails IBIT or continuous self test, in NORM. ● Illuminates for a few seconds during M4 IBIT.

NOTE

- The conditions for an M4 WARN annunciation and an IFF caution light illumination are exactly the same. The only condition that can give one without the other is if the M4 CAUT/ZERO circuit breaker is open; then it is possible to get an M4 WARN when the light is out.
- Removal of Mode 4 applique disables IFF caution light.
- STBY disables IFF caution light.

2	CDU Status Key	Accesses the iff status page, by way of the fms status page and the nav status page.
3	M3 Key	If pressed with scratchpad empty, commands IFF to ident. If pressed with entry in scratchpad, the entry is range checked, and if valid, inserted into Mode 3A location on the iff mode 1/2/3/c page.

NOTE

If user wants to ident using the newly entered code, M3 must be pressed again.

4	IFF Key	Accesses the tcas/iff control page.
5	IFF TRANSPONDER Power Switch	Controls a relay inside the transponder. OFF removes power from everything inside the transponder except the relay itself. Switch, relay, and transponder are all on the EDC bus. This switch should be used in lieu of circuit breaker to remove power from transponder.

Figure 1-125A (Sheet 2 of 2) ◀

WITH IDG IFF CDU Page Trees

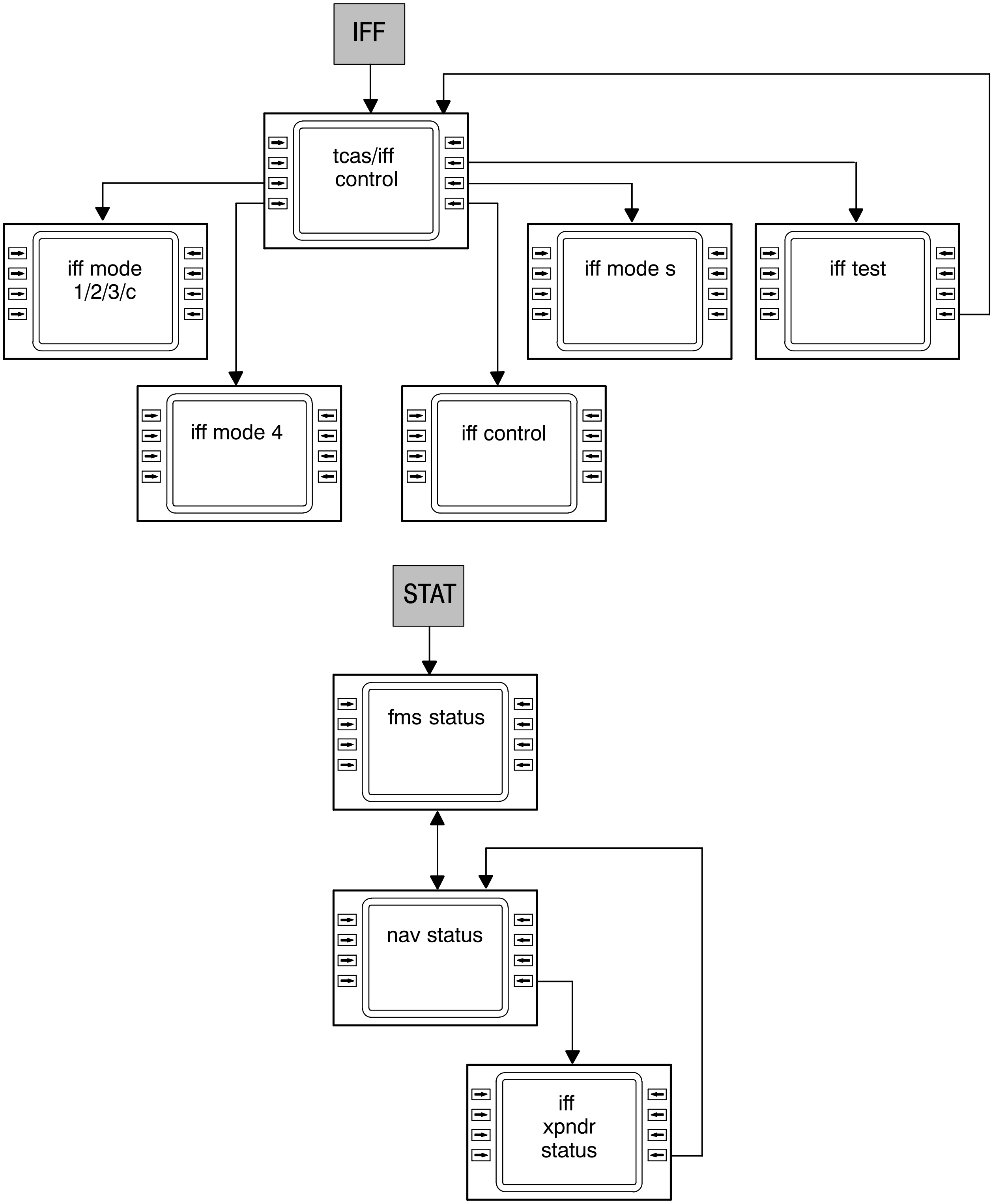
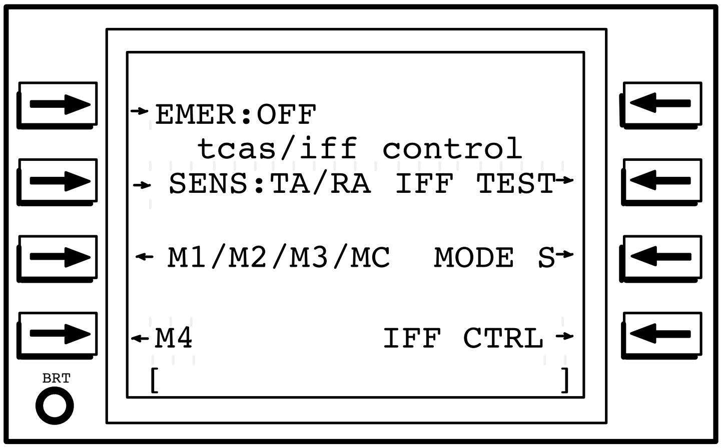


Figure 1-125B

WITH IDG IFF CDU Pages

tcas/iff control page

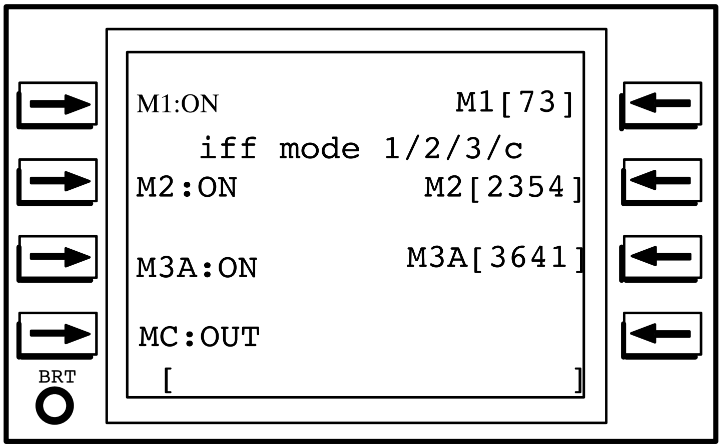


```
→EMER:OFF
   tcas/iff control
→ SENS:TA/RA  IFF TEST→

← M1/M2/M3/MC   MODE S→

←M4           IFF CTRL →
[                       ]
```

LINE	DESCRIPTION
LS1	Selects EMER ON or OFF. Confirmation is required to turn emergency function ON. No confirmation required to turn emergency function OFF. Default is OFF. When EMER is selected ON, the IFF selection on the iff control page goes from STBY or NORM to EMER; Modes 1, 2, 3A, C and S turn ON if they were OUT, and the transponder transmits the emergency reply codes for all modes regardless of the codes that are entered. The emergency reply code 7700 is transmitted for Mode 3/A and is included in the Mode S message. Mode 4 is not affected.
Title	Displays page title. If TCAS or IFF transponder is not available, or a failure is detected, ✓ is displayed before the title.
LS2	Selects TCAS between modes TA/RA, TA, or STBY. Default is TA/RA. If LS2 is selected when IFF is in STBY mode, (IFF:STBY on iff control page), ✓ POWER appears in scratchpad. If LS2 is selected when Mode S is disabled (OUT), “SET MODE S ON” appears in scratchpad.
LS3	Accesses iff mode 1/2/3A/c page. This page is used to enable or disable IFF modes and to view or change code settings.
LS4	Accesses iff mode 4 Page. This page is used to enable/disable Mode 4 operation, control the handling of mode 4 crypto key variables, and control the Mode 4 audio and visual alarm indicators.
LS6	Accesses iff test page. This page is used to enable IBIT testing and to display IBIT test results.
LS7	Accesses iff mode s page. This page is used to enable or disable IFF Mode S, and view or change Mode S address.
LS8	Accesses iff control page. This page is used to control operation of IFF transponder and antennas.

Figure 1-125C (Sheet 1 of 8)

iff mode 1/2/3/c page



M1:ON M1[73]

iff mode 1/2/3/c

M2:ON M2[2354]

M3A:ON M3A[3641]

MC:OUT

[ ]

LINE	DESCRIPTION
LS1	Selects Mode 1 ON/OUT. Default at CDU power-on is ON. When M1 is ON, transponder is enabled to reply to Mode 1 interrogations. When M1 is OUT, transponder is disabled from replying to Mode 1 interrogations. If IFF emergency mode is ON, Mode 1 is enabled automatically if previously OUT. Pressing LS1 when in emergency mode results in the EMERGENCY ENGAGED scratchpad message.
LS2	Selects Mode 2 ON/OUT. Default at CDU power-on is ON. When M2 is ON, the transponder is enabled to reply to Mode 2 interrogations. When M2 is OUT, transponder is disabled from replying to Mode 2 interrogations. If IFF emergency mode is ON, Mode 2 is enabled automatically if previously OUT. Pressing LS2 when in emergency mode results in the EMERGENCY ENGAGED scratchpad message.
LS3	Selects Mode 3/A ON/OUT. Default at CDU power-on is ON. Mode 3/A is disabled by squat switch on the ground. When M3A is ON, transponder is enabled to reply to Mode 3/A interrogations. Mode C interrogation includes a Mode 3A interrogation. Separate M3A interrogations are no longer issued by any ATC radars. When M3A is OUT, transponder is disabled from replying to Mode 3A and Mode C interrogations. M3A defaults to ON when EMER is ON. Pressing LS3 when in emergency mode results in the EMERGENCY ENGAGED scratchpad message.
LS4	Selects Mode C ON/OUT. Default at CDU power-on is ON. The ON setting enables Mode C replies with altitude when airborne. Mode C is disabled by squat switch on the ground. When MC is OUT, transponder is disabled from replying to Mode C interrogations but if M3/A is ON, M3A does respond to a Mode C all call, but without altitude. Pressing LS4 when in emergency mode results in the EMERGENCY ENGAGED scratchpad message. Mode C and Mode S operate independently of each other. Mode C cannot be selected ON unless M3A is ON. Selecting M3/A ON automatically selects MC ON, and then MC may be selected OUT, if required.

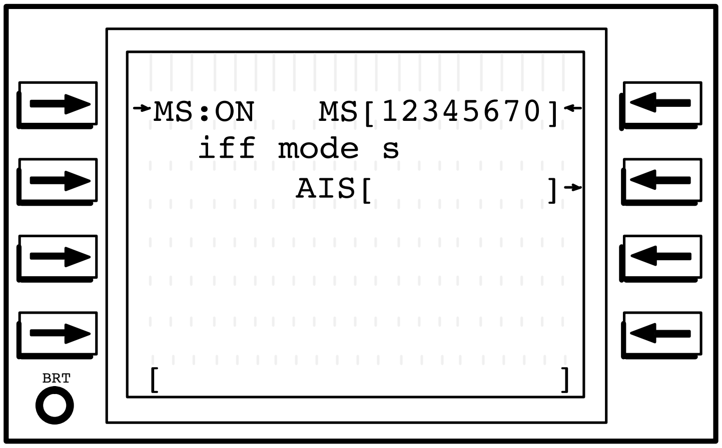
Figure 1-125C (Sheet 2 of 8)

WITH IDG IFF CDU Pages (Continued)

LINE	DESCRIPTION
LS5	Displays or changes Mode 1 code. Stored code is displayed. When changing Mode 1 code, code is entered into scratchpad and LS5 is pressed to set and display code. Mode 1 code is a two–digit code whose first digit can be between 0–7 and second digit is 0–3. Improper entry of a number results in the message INVALID ENTRY and the entered number alternating in scratchpad. Mode 1 code is stored in non–volatile memory but is erased if system is zeroized.
LS6	Displays or changes Mode 2 code. Stored code is displayed. When changing Mode 2 code, code is entered into scratchpad and LS6 is pressed to set and display the code. Mode 2 code is a four–digit code whose digits are octal. Improper entry of a number results in the message INVALID ENTRY and the entered number alternating in the scratchpad. The Mode 2 code is stored in non–volatile memory and is not erased by any of the zeroization options.
LS7	Displays or changes Mode 3/A code. Stored code is displayed. When changing Mode 3/A code, code is entered into scratchpad and LS7 is pressed to set and display the code. Mode 3 code is a four–digit code whose digits are octal. Improper entry of a number results in the message INVALID ENTRY and the entered number alternating in the scratchpad. Automatically changes to 7700 when EMER is ON. Mode 3/A code returns to prior value when EMER is set to OFF. Mode 3/A code is stored in non–volatile memory but is erased if system is zeroized.

Figure 1-125C (Sheet 3 of 8)

iff mode s page

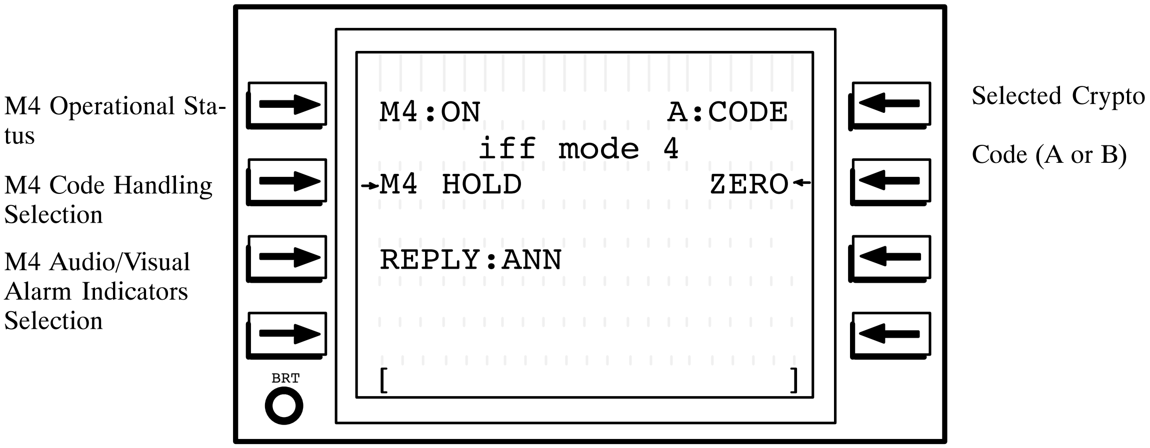


LINE	DESCRIPTION
LS1	Selects mode S ON/OUT. Default at CDU power-on is STBY. Mode 3/A is disabled by squat switch on the ground. When MS is ON, in NORM, on the ground, squitter and selective response are active and all call response is disabled; in the air, all call response is also active. When MS is OUT, squitter, all call response, and selective response are disabled. **NOTE** When MS is selected OUT, TCAS OFF flag appears on VSI and TCAS is inoperative.
LS5	Displays or changes mode S address. Mode S address can be changed by entering a new value into the field at LS5. Mode S address can be changed in the air. Mode S is an eight–digit octal code. The mode S address can be between 00000001 and 77777776. Improper entry of a number results in the message INVALID ENTRY and the entered number alternating in the scratchpad. Mode S address is stored in non–volatile memory and is not erased by any of the zeroization options. If MS is blank, IFF fails PBIT. This can only occur after initial loading of CDU OFP software.
LS6	Sets aircraft identification sub–code (AIS). AIS is alphanumeric up to 8 characters. A dash “–” entered from scratchpad blanks the AIS. AIS is stored in non–volatile memory and is not erased by any of the zeroization options.

Figure 1-125C (Sheet 4 of 8)

WITH IDG IFF CDU Pages (Continued)

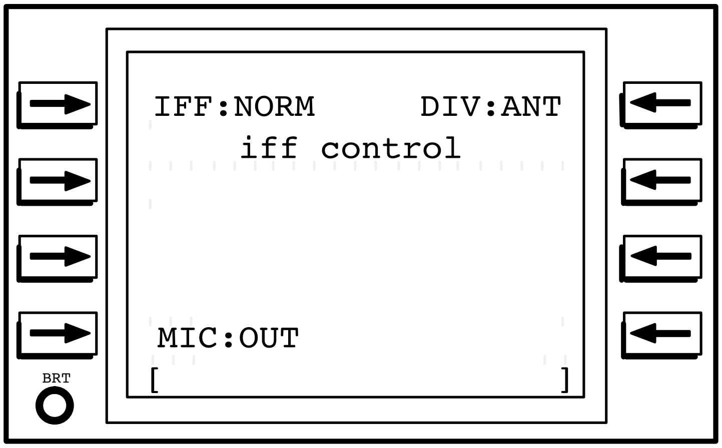
iff mode 4 page



LINE	DESCRIPTION
LS1	Selects Mode 4 ON/OUT. Default at CDU power-on is ON. When M4 is ON, transponder is enabled to reply to Mode 4 interrogations. When M4 is OUT, the transponder is disabled from replying to Mode 4 interrogations.
LS2	M4 HOLD is a label for the LS2 key and does not change to indicate status or selection. The arrow changes to an asterisk for 11 seconds each time the LS key is pressed whether the HOLD function is actually selectable or not. The codes are automatically in a HOLD status at initial loading on the ground. In HOLD status, the codes are not zeroized with any number of power down/up cycles. When airborne the HOLD status is removed and codes are vulnerable to autozeroization with loss of EDC power or by switching IFF OFF, (IFF:STBY on iff control page, or when IFF Transponder switch is selcted to OFF), and HOLD cannot be selected even though the arrow is replaced by the asterisk for 11 seconds when the key is pressed. After landing the codes remain vulnerable to power loss unless HOLD is selected. The HOLD function is enabled by weight on wheels. The only time the HOLD function is enabled is after a complete squat switch cycle (takeoff followed by landing). If HOLD is selected after landing the memory of having been airborne is erased and the system reverts to an initial code loading condition where the codes are held with any number of power down/up cycles. HOLD may be used to retain codes for a planned quick turn–around. Comply with command security directives. Do not rely upon autozeroization to erase the codes at power down.
LS3	Selects ANN/AUD/OUT audio and visual Mode 4 response indications. Default (controlled by CDU power on, not IFF power on) is ANN. The ANN selection enables CDU annunciations of M4 REPLY when a Mode 4 reply occurs. The AUD selection enables CDU annunciations of M4 REPLY and also enables ADS audio tone under the AIMS knob when Mode 4 refuses to reply to an interrogation. The OUT selection disables both the M4 REPLY annunciation and the audio tone. None of these selections has any effect on the M4 WARN annunciation. **WARNING** The ADS AIMS tone is quite loud and should be initially monitored with a single detent of volume.
LS5	Controls which Mode 4 code (A or B) is being used for the validation of Mode 4 interrogations and the generation of Mode 4 replies. Default is A.
LS6	Commands zeroizing. When enabled, the CDU commands the IFF to zeroize Mode 4 codes. This selection requires confirmation.

Figure 1-125C (Sheet 5 of 8)

iff control page



IFF:NORM DIV:ANT

iff control

MIC:OUT

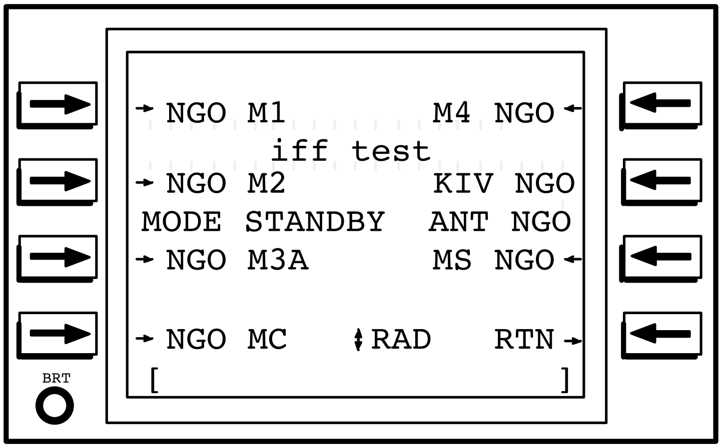
[ ]

LINE	DESCRIPTION
LS1	Selects IFF STBY/NORM. Default at CDU power–on is STBY. In STBY IFF enables receiving functions but inhibits transmission of replies. NORM enables normal operation. Line displays IFF: EMER if EMER is selected ON via tcas/iff control page, *sheet 1*. When EMER is displayed, change of operating mode is inhibited.
LS4	Selects MIC (Microphone) ON/OUT. In the ON setting, modes 1,2,3/A respond with ident (special position identification) when interrogated during transmission on UHF 19. Ident response remains enabled for 18 seconds after UHF 19 is unkeyed to ensure that a radar sweep catches the ident. Default is OUT.
LS5	Selects IFF antennas TOP/BOT/DIV. TOP selects top antenna, BOT bottom antenna, and DIV enables auto selection. Default is DIV. Returns to DIV after one minute. Must be on the ground or GROUND ONLY error message results. MS must be OUT or MODE S ON error message results. In the air, the status is always DIV and cannot be changed.

Figure 1-125C (Sheet 6 of 8)

WITH IDG IFF CDU Pages (Continued)

iff test page



```
→ NGO M1         M4 NGO ←
       iff test
→ NGO M2         KIV NGO
MODE STANDBY     ANT NGO
→ NGO M3A        MS NGO ←

→ NGO MC    ↕RAD    RTN →
[                       ]
```

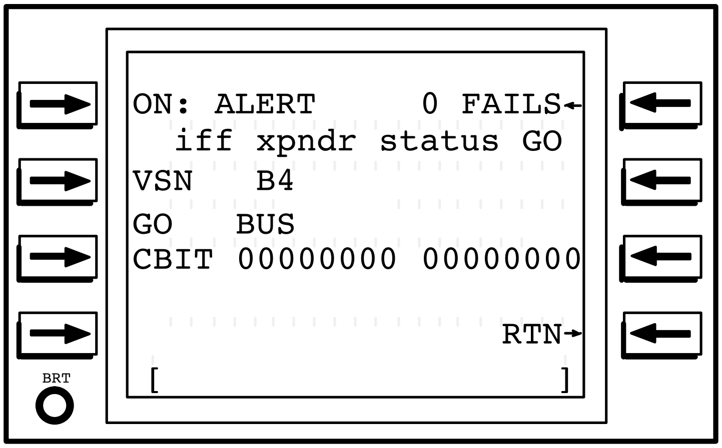
NOTE

Status displayed is the result of last completed IBIT, not necessarily the current mode status.

LINE	DESCRIPTION
LS1	Initiates IBIT for mode 1. IBIT can only be performed in NORM and IFF transmissions occur. Asterisk replaces arrow and TST is displayed while test is in progress.
LS2	Initiates IBIT for mode 2. IBIT can only be performed in NORM and IFF transmissions occur. Asterisk replaces arrow and TST is displayed while test is in progress.
DL2	Displays mode 4 KIV status resulting from IBIT.
LS3	Initiates IBIT for mode 3/A. IBIT can only be performed in NORM and IFF transmissions occur. Asterisk replaces arrow and TST is displayed while test is in progress.
LS4	Initiates IBIT for mode C. IBIT can only be performed in NORM and IFF transmissions occur. Asterisk replaces arrow and TST is displayed while test is in progress.
DL4	Contains the radiation (RAD) maintenance test. Not required for IBIT check. When initiated will cause antennae to radiate. Done only with maintenance equipment connected and in conjunction with required maintenance test of unit. To enable this test, IFF must be in NORM, M4 ON, then scroll up or down. This sets the M4 VER 1 bit enabling mode 4 reply to a compatible M4 interrogation. Also enables modes C, S and 3A ground reply to all call by overriding the ground lockout for a few seconds. This test has been observed to invoke the TCAS self test, intermittently.
LS5	Initiates IBIT for mode 4. IBIT can only be performed in NORM and IFF transmissions occur. Asterisk replaces arrow and TST is displayed while test is in progress.
LS7	Initiates IBIT for mode S and TCAS. MS IBIT test is a ground test only. IBIT can only be performed in NORM and IFF transmissions occur. Asterisk replaces arrow and TST is displayed while test is in progress.
LS8	Returns to tcas/iff control page.

Figure 1-125C (Sheet 7 of 8)

iff transponder status page



```
ON: ALERT     0 FAILS←
  iff xpndr status GO
VSN   B4
GO   BUS
CBIT 00000000 00000000

                  RTN→
 [                   ]
```

LINE	DESCRIPTION
Title	Contains top level LRU status.
DL1	Contains ALERT function and failure counter. When ALERT is set to ON, a failure causes the ✓STATUS annunciation and illuminates CDU ALERT caution light. When ALERT is set to OFF, failures do not cause ✓STATUS annunciation and do not illuminate CDU ALERT caution light. ALERT defaults to ON when EDC power is removed for longer than 30 seconds. When selected OFF, failure history continues to be recorded. The failure counter increments when the title line changes between GO and NGO or upon IFF bus failure.
LS1	Selects the ✓STATUS annunciation ALERT, ON or OFF. Default at CDU power–on is ON. When ALERT is set to ON, a failure causes ✓STATUS annunciation and illuminates CDU ALERT caution light on RNAV ANNUNCIATOR panel. When ALERT is set to OFF, failures do not cause the ✓STATUS annunciation and do not illuminate CDU ALERT caution light.
LS2	Displays IFF transponder software version number.
Info	Displays 1553 bus status: (1) GO (2) NGO–A (1553 bus A channel) (3) NGO–B (1553 bus B channel) (4) NGO–T (1553 bus terminal)
DL3	Displays CBIT results. Only bits 15 and 16 are used. A “1” in bit 15 indicates a terminal failure; in bit 16 indicates a subsystem failure.
LS5	Resets failure counter to 0. Occurs within the CDU only – does not reset the IFF’s internal failure counter.
LS8	Returns to nav status page.

Figure 1-125C (Sheet 8 of 8) ◀

WITH IDG IFF Mode S Transponder System Block Diagram

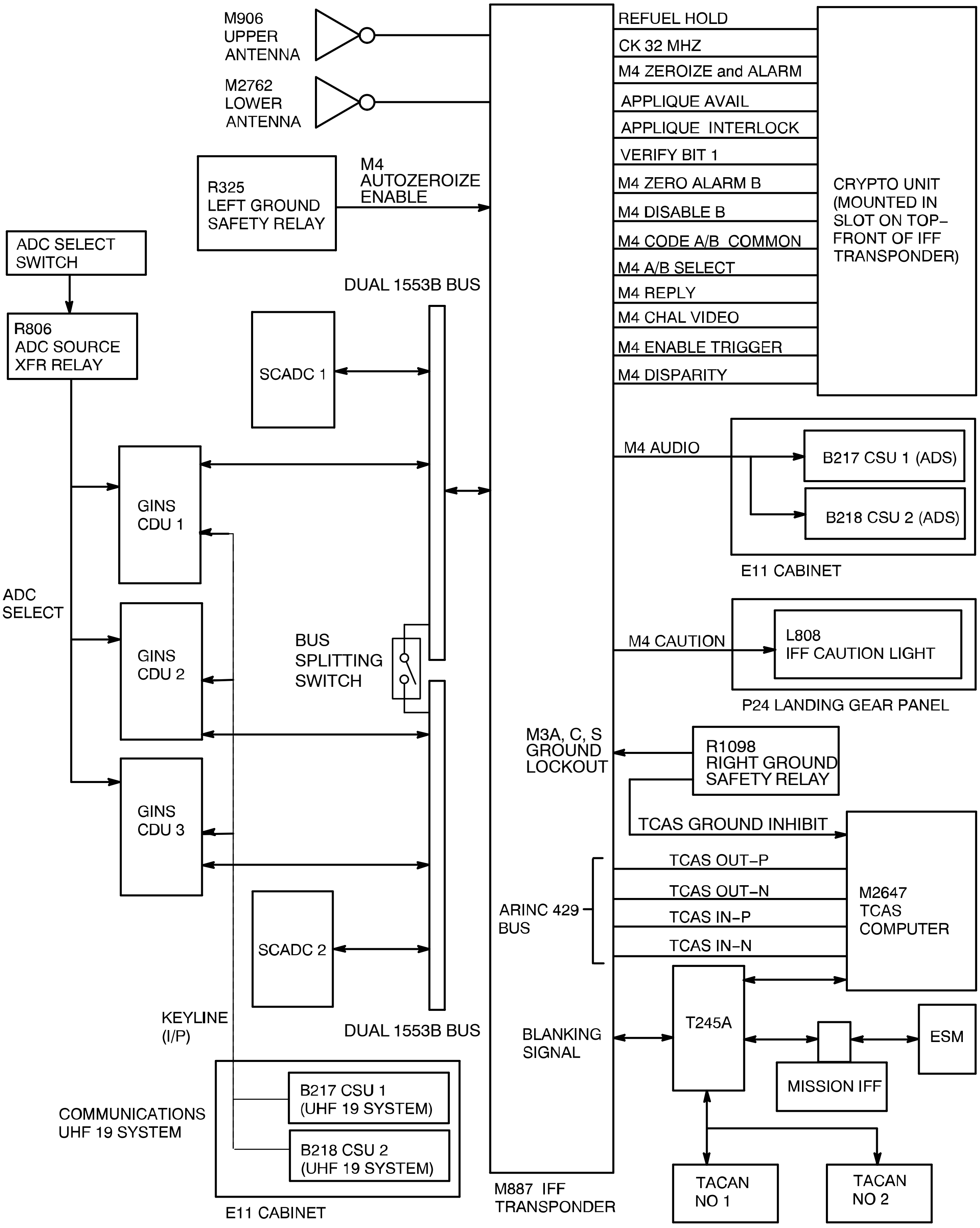


Figure 1-125D ◀

WITH IDG IFF/MODE S TRANSPONDER OPERATION

The IFF TRANSPONDER switch may be turned on at any time, before or after the first CDU is turned on.

If the IFF TRANSPONDER switch is turned on first, it completes its PBIT and sits in STBY awaiting commands from a CDU. When a CDU is then turned on, the CDU default settings for IFF take effect, and the IFF remains in STBY until changed by an operator.

If a CDU is turned on first, the CDU defaults to a safe IFF configuration (STBY, with all modes ON) and the IFF commands do not take effect until the IFF is turned on and completes its PBIT. A CDU may be configured for other than the default IFF settings before the IFF is turned on, in which case the IFF assumes the configuration commanded by the controlling CDU immediately after it completes its own PBIT.

Configuring the CDU for IFF operation is usually done by the navigator, as the navigator usually turns the CDUs on. Mode 4 codes, if required, should be loaded by the CT before the navigator arrives at the airplane. The Mode 4 codes may be loaded without either the IFF or the CDU being on. The CT can verify successful code load by illumination of the green light on the M4 applique, which operates with IFF OFF.

The mode IBITs should be run with a ground safety observer to assure personnel are clear of the IFF antennas. The safety observer does not necessarily have to be on headset. The IBIT portion of the IFF preflight should be delayed to Before Start checklist if a safety observer is not available prior to that time.

WARNING

> On the ground, the IFF transponder transmits if selected to NORM. It must be selected to NORM to run any of the mode IBITs. During transmission the minimum personnel safety distance is 10 feet from either antenna. Minimum electro–explosive device distance is 25 feet.

Before Leaving Airplane

1. Mode 4 Codes – Zeroized, As Required

Normal procedures call for transponder off prior to aircraft power down. Transponder operates without AC power. If AC power is removed from airplane with transponder set to NORM, CBIT can generate nuisance failure reports on interfacing equipment powered by AC.◀

NAVIGATION AIDS ELECTRIC POWER SOURCES

Electric power sources for the navigation radio aids are listed in *figure 1–126*.

Navigation Aids Electric Power Sources

EQUIPMENT/SYSTEM	TYPE OF POWER	POWER SOURCE	CIRCUIT BREAKER LOCATION/LABEL
TACAN Set No 1 ③	115V AC	FAAC Bus 1	P5, FLIGHT NAVIGATION NO 1 – TACAN ØA
TACAN Set No 2 ③	115V AC	FAAC Bus 2	P5, FLIGHT NAVIGATION NO 2 – TACAN ØA
VHF NAV Set No 1 ③	28V DC	EDC Bus	P5, VHF NAV NO 1
VHF NAV Set No 2 ③	28V DC	FAVDC Bus 2	P5, FLIGHT NAVIGATION NO 2 – VHF NAV
TACAN No 1 and VHF NAV No 1 Heading Excitation ③	115V AC 26V AC ①	FAAC Bus 1	P5, FLIGHT INSTRUMENTS NO 1 – XFMR – HDG ØA
TACAN No 1 and VHF NAV No 1 Bearing Excitation ③	115V AC 26V AC ①	FAAC Bus 1	P5, FLIGHT INSTRUMENTS NO 1 – XFMR – BRG ØA
TACAN No 2 and VHF NAV No 2 Heading Excitation ③	115V AC 26V AC ①	FAAC Bus 2	P5, FLIGHT INSTRUMENTS NO 2 – XFMR – HDG ØA
TACAN No 2 and VHF NAV No 2 Bearing Excitation ③	115V AC 26V AC ①	FAAC Bus 2	P5, FLIGHT INSTRUMENTS NO 2 – XFMR – BRG ØA
TACAN No 1 and No 2 Panel Lighting	28V AC	28V AC Bus 2	P7, OVERHEAD PANEL – MAIN
UHF NAV No 1 and No 2 Panel Lighting	28V AC	28V AC Bus 8 DIST 1	P7, CENTER PNL – IND
Marker Beacon ③	28V AC	EDC Bus	P5, MARKER BEACON
Radio Altimeter ③	115V AC	FAAC Bus 1	P5, RADIO ALTM ØA
Radio Altimeter Indicator Lighting	28V AC	28V AC Bus 8 DIST 1	P7, COMMANDERS PNL – LEGEND
ADF System ③	28V DC	FAVDC Bus 1	P5, FLIGHT NAVIGATION NO 1 (LF)/ADF DC
ADF Bearing Excitation ③	115V AC 26V AC ①	FAAC Bus 1	P5, FLIGHT INSTRUMENTS NO 1 – XFMR – HDG ØA
DFDR ③	115V AC 28V DC	FAAC Bus 2 FAVDC Bus 2	P5, DFDR ØA P5, CPI/FDR – CVR DFDR DC

Figure 1-126 (Sheet 1 of 2)

Navigation Aids Electric Power Sources (Continued)

EQUIPMENT/SYSTEM	TYPE OF POWER	POWER SOURCE	CIRCUIT BREAKER LOCATION/LABEL
CVR ③	115 AC 28V DC	FAAC Bus 2 FAVDC Bus 2	P5, CPI/FDR–CVR ØA P5, CPI/FDR–CVR DFDR DC
CVR/DFDR/CPL ③	28V AC	28V AC Bus 2	P7, OVERHEAD PANEL – MAIN
LESS IDG IFF ③	115V AC 28V DC	FAAC Bus 2 EDC Bus	P5, AIMS CMPTR ØB P5, AIMS XPDR ◀ ②
WITH IDG IFF Mode S Transponder	28V DC	EDC Bus	P5, EMERGENCY FLIGHT AVIONICS – IFF XPNDR
IFF Mode 4 Caution Light	28V DC	EDC Bus	P5, M4 CAUT/ZERO ◀ ④
IFF ③	115V AC 28V DC	FAAC Bus 2 EDC Bus	P5, AIMS CMPTR ØB P5, AIMS XPDR ②
IFF Control Panel Lighting	28V AC	28V AC Bus 2	P7, OVERHEAD PANEL – MAIN

① System reduces 115V AC to 26V AC for excitation power.

② A 3-ampere fuse is located on the R/T unit in the E-1 rack (RH side), along with a spare fuse.

③ FLT AVIONICS BUS 1 and/or BUS 2 switches on AVIONICS POWER DISCONNECT panel control power to EQUIPMENT/SYSTEM circuit breakers referenced by this note.

④ WITH IDG Powers IFF mode 4 caution light and CDU manual mode 4 code zeroization circuit. Opening this breaker disables mode 4 code zeroization from all CDU selections that would normally zeroize mode 4 codes, including the GINS control panel MASTER ZEROIZE switch that operates through the CDUs. Opening this breaker does not disable any CDU–initiated code zeroizations other than mode 4. Autozeroization at IFF power down, and the applique ZERO switch operation are not affected by this breaker. ◀

Figure 1-126 (Sheet 2 of 2)

Pages 1-493 through 1-556 are deleted.

SUBSECTION I-N-2
WEATHER RADAR

Table of Contents

WEATHER RADAR (APS-133)

The primary purpose of the weather radar is to detect thunderstorms or heavy precipitation. Refer to THUNDERSTORM AVOIDANCE WITH WEATHER RADAR, section VII. Secondary purposes are ground mapping, air-to-air mapping or skin paint, and beacon detection/identification for air refueling rendezvous.

The system includes two indicators and controls, located on the forward electronic panel (*figure 1-8*) and the navigator's lower panel (*figure 1-15)* the Receiver/Transmitter (R/T) unit; the antenna (see *figure 1-146* for hazard areas); and the system control panel, located on the navigator's lower panel (*figures 1-15*, and *1-147*). System controls and displays are described in *figures 1-147* and *1-148*.

DISPLAYS

The radar indicator displays all returns as digitized information on a color display. See *figures 1-147* and *1-148* for display description. In TEST mode, the system displays a test pattern, but does not radiate. In weather (WX) mode, the returns are displayed in three colors: green for lowest rainfall intensity up to 1/6 inch (or 4 mm) per hour, yellow for medium intensity from 1/6 to 1/2 inch (4 to 12 mm) per hour, and red for severe intensity above 1/2 inch (12 mm) per hour. Severe turbulence can be expected in red and yellow areas.

In mapping (MAP1, MAP2) modes, colors are shown as: blue, least reflective; yellow, more reflective; and red, most reflective.

In beacon (BCN) mode, only beacon returns are shown.

ANTENNA BEAM PATTERNS

In weather and beacon modes, a pencil beam about 2.9 degrees wide is automatically selected. The beam width is about 300 feet (0.05 nautical mile) per mile of range. In map modes, either the pencil beam or a fan-shaped beam (up to 40 degrees from top to bottom) can be selected. See *figure 1-149*.

WEATHER RADAR STABILIZATION

The antenna is stabilized by AHRS NO 2 or GINS NO 2, as selected by the copilot's ADI source selector switch (11, *figure 1-6*, and 1, *figure 1-106*), when the antenna stabilization switch (21, *figure 1-147*) is set to ON. (When the antenna stabilization switch is set to OFF, the antenna vertical axis is locked to airplane vertical axis and antenna tilt is referenced to airplane pitch axis).

Stabilization limits are ±25 degrees in pitch and ±43 degrees in roll. Because of tolerances in the stabilization source and in the mechanism, the antenna does not always stay at the exact tilt selected.

Pitch stabilization can be tested in level flight by setting the tilt knob so that ground targets show at the maximum range of the display. If a further down tilt of two degrees or less shows ground targets of the minimum range, pitch stabilization is operating correctly. If ground targets show at about the same range on both sides of the indicator, in level flight, roll stabilization is operating correctly. In turns, the system can vary a few degrees from level if AHRS NO 2 is used for stabilization. A one degree tilt error can cause one side of the beam to drop 10,000 feet at 100 nautical miles. After long periods of turning flight, re-synchronize AHRS NO 2 to reduce tilt errors. If possible, select GINS NO 2 as stabilization source when on-station.

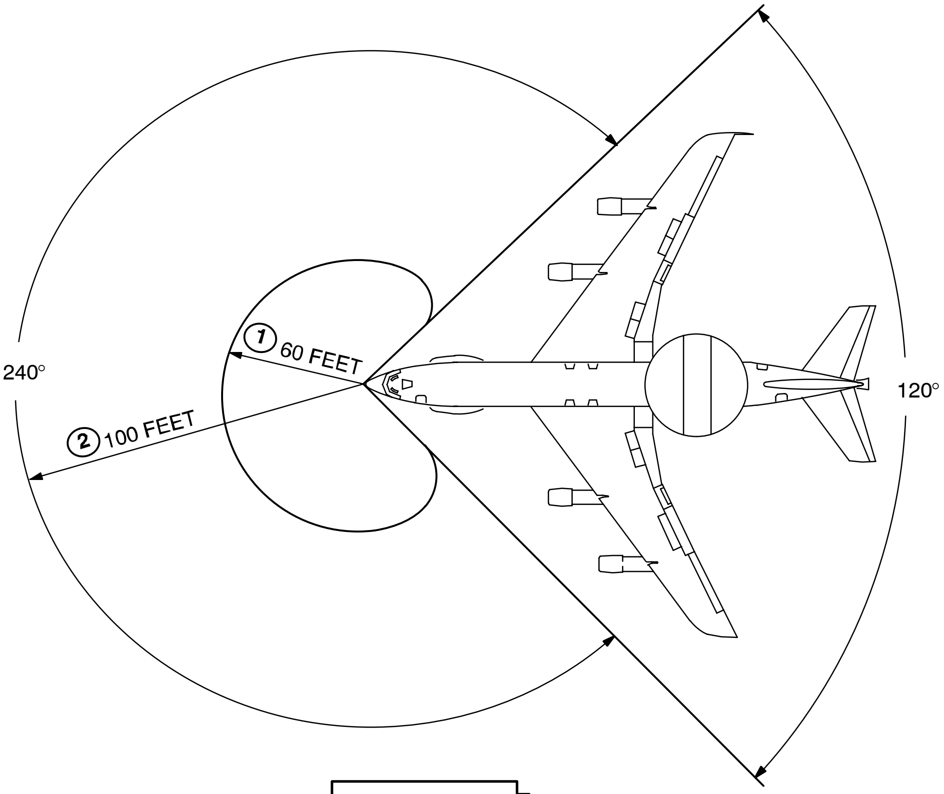
WEATHER RADAR RANGE

The range of any weather radar depends on the line of sight distance to the horizon. As an approximation, the horizon distance in nautical miles is the square root of the airplane altitude in feet above the ground, multiplied by 1.23.

For example:

Altitude – Feet	**Distance – NM**
10,000	123
20,000	174
30,000	213
40,000	246

Weather Radar Radiation Hazard Area



WARNING

① 60 FOOT AREA HAZARDOUS TO PERSONNEL

② WITHIN 100 FEET AREA OF POSSIBLE FUEL IGNITION AND ELECTRO EXPLOSIVE DEVICE DETONATION

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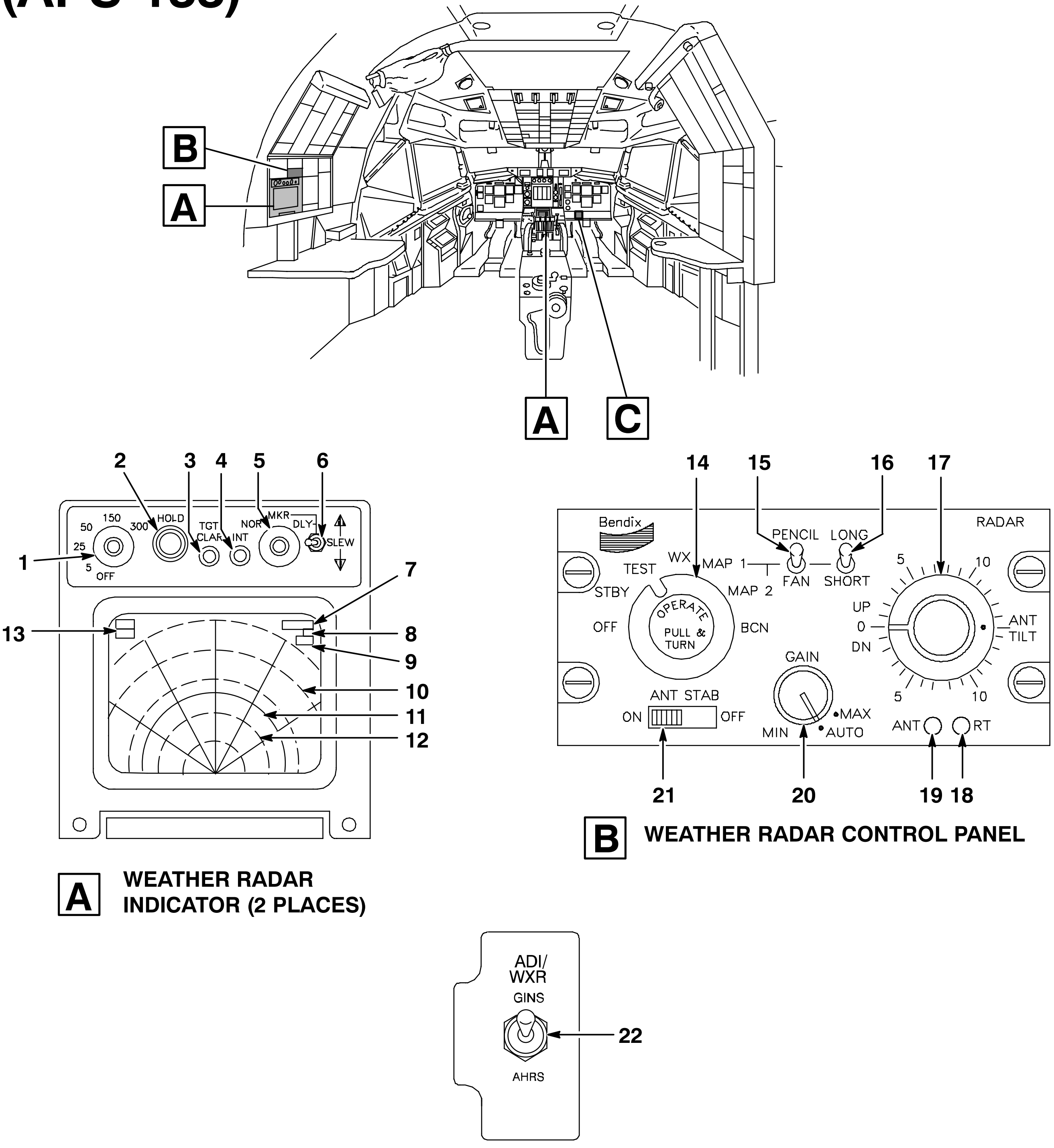
Figure 1-146

Weather Radar Controls and Indicators (APS-133)



A WEATHER RADAR INDICATOR (2 PLACES)

B WEATHER RADAR CONTROL PANEL

C COPILOT'S ADI ATTITUDE SOURCE SELECTOR SWITCH

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Figure 1-147 (Sheet 1 of 5)

NO.	CONTROL/INDICATOR	FUNCTION
	A WEATHER RADAR INDICATOR	
1	Range Knob	Rotary switch selects range to be displayed and spacing of range marks, or turns indicator off. Selected range and range mark spacing are displayed in location (7). For example: 150/30.
	OFF	Indicator power is off. R/T unit power is controlled by mode selector (14).
	5	Selects 5 NM range and 1 NM range marks spacing.
	25	Selects 25 NM range and 5 NM range marks spacing.
	50	Selects 50 NM range and 10 NM range marks spacing.
	150	Selects 150 NM range and 30 NM range mark spacing.
	300	Selects 300 NM range and 60 NM range mark spacing.
	NOTE Target visibility on 150 and 300 NM ranges depends on line of sight distance and target altitude.	
2	Hold Pushbutton	When pressed, freezes display and HOLD is displayed (alternating once per second with selected mode) in mode display (13). When pressed again or range selector is moved, display returns to normal.
3	TGT CLAR (Target Clarity) Knob	Rotating knob sets clockwise increases amount of low intensity echoes displayed (green in WX or BCN modes, blue in MAP 1 or MAP 2).
4	INT (Intensity) Knob	Adjusts brightness of display. Rotate clockwise to increase brightness.
5	NOR–MKR–DLY (Sweep Delay) Switch	Selects normal display or variable range delay.
	NOR (Normal)	Normal display. Range begins at zero.
	MKR (Marker)	Adds variable (yellow) marker (11) to display. Range to marker controlled by SLEW switch (6) and displayed in upper right corner (8) of display.

Figure 1-147 (Sheet 2 of 5)

Weather Radar Controls and Indicators (APS-133) (Continued)

NO.	CONTROL/INDICATOR	FUNCTION
	DLY (Delay)	Sets sweep delay. Display range begins at marker (11) setting displayed in location (8). Sweep extends for number of miles selected on range knob (1). For example, if marker (11) set to 100 NM and range knob is set to 25, display extends from 100 to 125 NM.

NOTE

Delay is mainly used to identify beacon returns and to expand distant weather echoes. Target shape is distorted.

NO.	CONTROL/INDICATOR	FUNCTION
6	SLEW Switch (Momentary, spring loaded to neutral)	Moves range marker (11) if Sweep Delay Switch (5) set to MKR or DLY. Setting switch to up (↑) increases range. Setting switch to down (↓) decreases range. Range to marker is displayed in upper right corner of indicator in location (8). Speed of marker movement increases as switch is moved from neutral.
7	Range Selection Display (Blue in TEST WX, or BCN; Green in MAP)	Numbers to left of slash (/) are range selected by range knob (1). Numbers to right of slash are spacing of range marks.
8	Marker Range Display (Blue in TEST, WX, or BCN; Green in MAP)	When MKR or DLY selected by range delay switch (5), shows range to range marker (11).
9	Color Bar	Shows the colors used in mode selected by mode selector (14). In WX mode, displays red (heavy) with letter H, yellow (medium), and green (light) with letter L. In MAP, displays red (heaviest) with letter H, yellow (medium), and blue (lightest) with letter L. In BCN, bar is green.
10	Range Marks (5) (Blue in TEST, WX, or BCN; Green in MAP)	5 dashed arcs, spaced 1/5 of range selected by range knob. Spacing is displayed in range selection display (7).
11	Range Marker (Yellow)	Displayed in MKR and DLY settings of range delay knob (5). Position of marker controlled by SLEW switch (6).
12	Azimuth Markers (Blue in TEST, WX, or BCN; Green in MAP)	5 markers, representing airplane centerline (0°), 30°, and 60° left and right of centerline.
13	Mode Display (Blue in TEST, WX, or BCN; Green in MAP)	Upper location displays TEST, WX, MAP 1, MAP 2, or BCN to show mode selected by mode selector (14). Displays HOLD (alternating once per second with selected mode) when HOLD button is pressed. Lower location shows sweep delay mode (MKR or PLY).

Figure 1-147 (Sheet 3 of 5)

NO.	CONTROL/INDICATOR	FUNCTION
	B WEATHER RADAR CONTROL PANEL (NAVIGATOR'S LOWER PANEL)	
14	Mode Selector Switch	Seven position rotary switch. Must be pulled out to turn.
	OFF	All power to system is removed. No antenna stabilization.
	STBY (Standby)	Used for warmup or when antenna radiation is not desired. Antenna stabilization can be used.
	TEST	System self-test with no radiated signal. Test pattern is displayed (*figure 1-148*). TEST is displayed in mode display (13).
	WX (Weather)	Displays weather returns in green (low), yellow (medium) and red (highest intensity). WX display in mode display (13). Pencil beam and long pulse are selected automatically.
	MAP 1	Used primarily for long range ground mapping and skin paint. Sensitivity-Time Control (STC) circuit is disabled. Returns displayed in red (most reflective), yellow (medium), and blue (least). MAP 1 is displayed in mode display (13). Beam width selectable by PENCIL–FAN switch (15).
	MAP 2	Used for skin paint at very short ranges. May also be used for ground mapping. MAP 2 displayed in mode display (13). Display colors same as MAP 1. Beam width selectable by PENCIL–FAN switch (15).
	BCN	Beacon targets are displayed in green. BCN is displayed in mode display (13). Radar transmits an interrogation pulse length of exactly 2.35 microseconds, at 9375 MHz, that is recognized by all standard I-band beacon transponders.
15	PENCIL–FAN Switch	Selects pencil or fan beam for mapping modes. (See *figure 1-149*).
16	LONG–SHORT Switch	Selects pulse length for mapping mode. LONG selects a pulse length of 5.0 microseconds; SHORT selects a pulse length of 0.5 microsecond. Switch is inoperative in WX (pulse length of 5.0 microseconds automatically selected) of BCN (pulse length of 2.35 microseconds automatically selected).
17	Tilt Knob	Selects antenna pitch direction relative to horizon (0). Maximum tilt is 15° up or down. If stabilization switch (21) is off, 0 is airplane pitch axis.

Figure 1-147 (Sheet 4 of 5)

Weather Radar Controls and Indicators (APS-133) (Continued)

NO.	CONTROL/INDICATOR	FUNCTION
18	RT Fault Caution Light (Yellow)	Illuminates in test mode during three minute warmup and to show fault in R/T unit.

NOTE

A fault is detected by an improper display and only illuminates in the test mode. Switch to test mode to determine lighted fault indications.

19	ANT Fault Caution Light (Yellow)	Illuminates in test mode to show fault in antenna.

NOTE

A fault is detected by an improper display and only illuminates in the test mode. Switch to test mode to determine lighted fault indications.

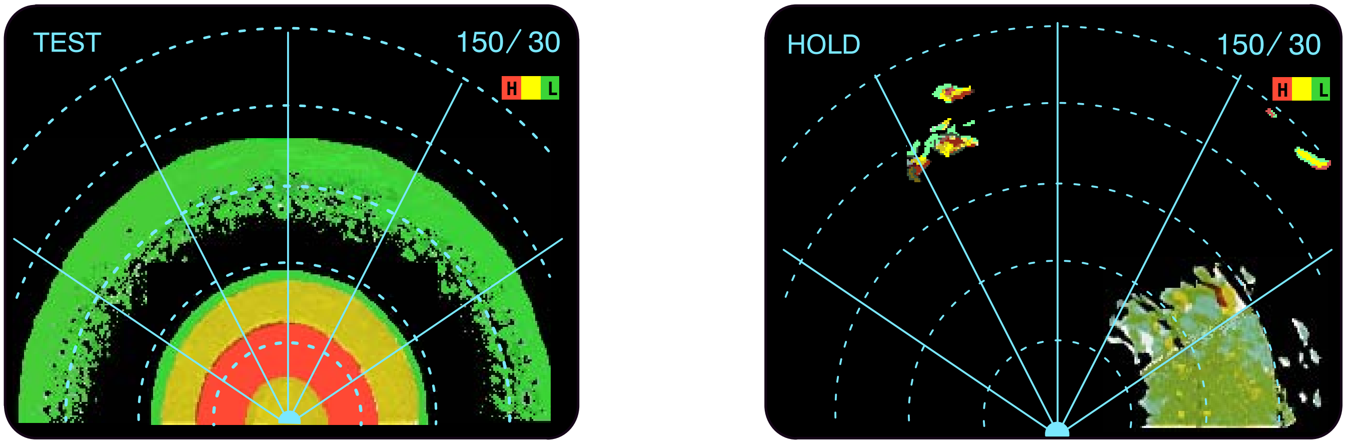
20	GAIN Knob	Adjusts receiver gain. MIN is minimum. MAX is maximum. AUTO gives automatic gain control.
21	ANT STAB (Stabilization) Switch	When set to ON, antenna is stabilized using horizontal reference from INS 2 or AHRS 2 as selected by copilot’s attitude source selector switch (22). When set to OFF, antenna reference is airplane axis.

C COPILOT’S ADI ATTITUDE SOURCE SELECTOR SWITCH

22	ADI/WXR (Copilot’s ADI Attitude Source Selector) Switch	Selects attitude source for stabilization. GINS is preferred source. Select AHRS for inflight alignment.

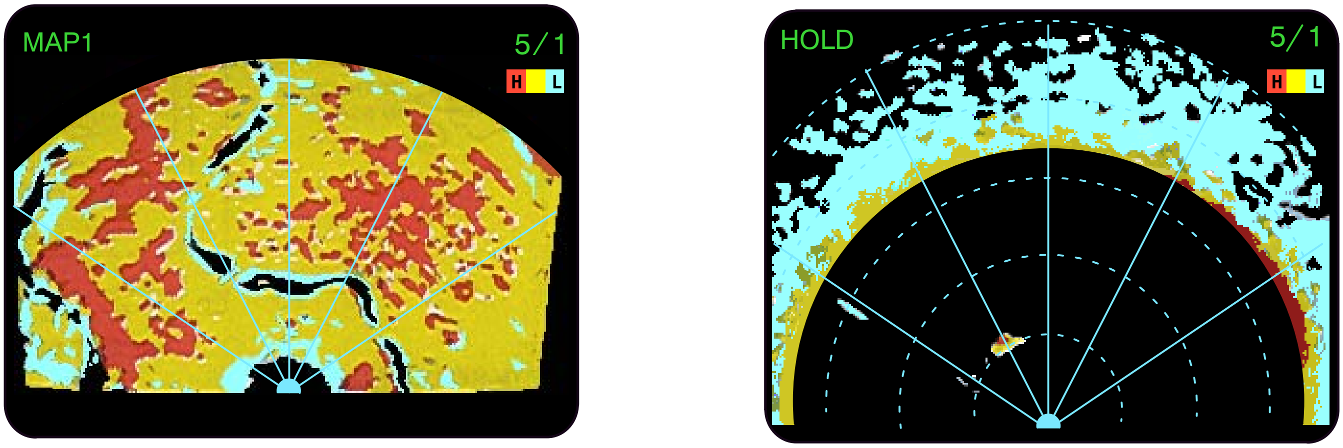
Figure 1-147 (Sheet 5 of 5)

Weather Radar Displays (APS-133)



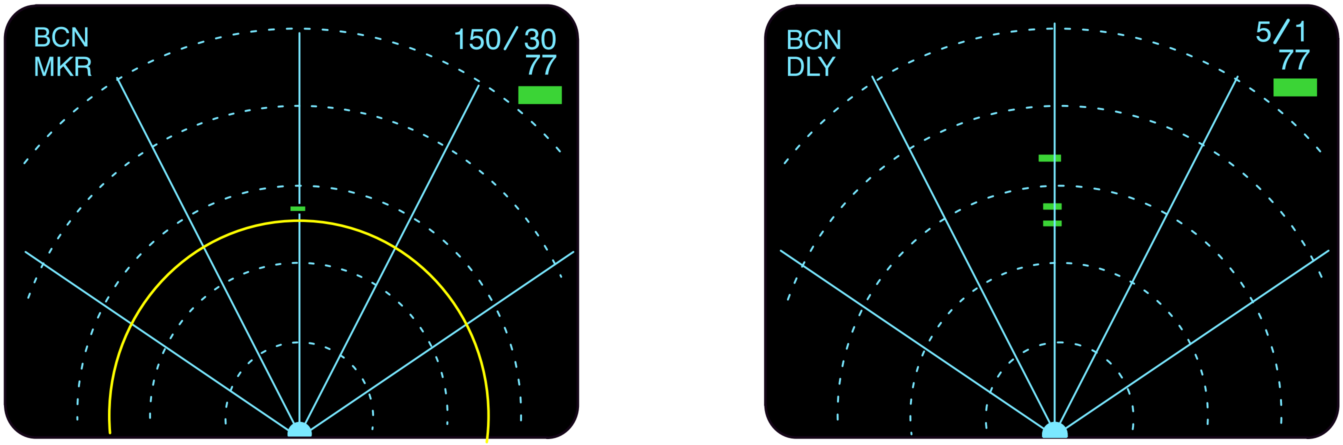
A TEST PATTERN

B WEATHER MODE (WX)



C GROUND MAPPING (MAP 1)

D AIR-TO-AIR MAPPING (MAP 2)



E BEACON
(With Range Marker at 77 NM)

F SWEEP DELAY
(Display from 77 to 82 NM)

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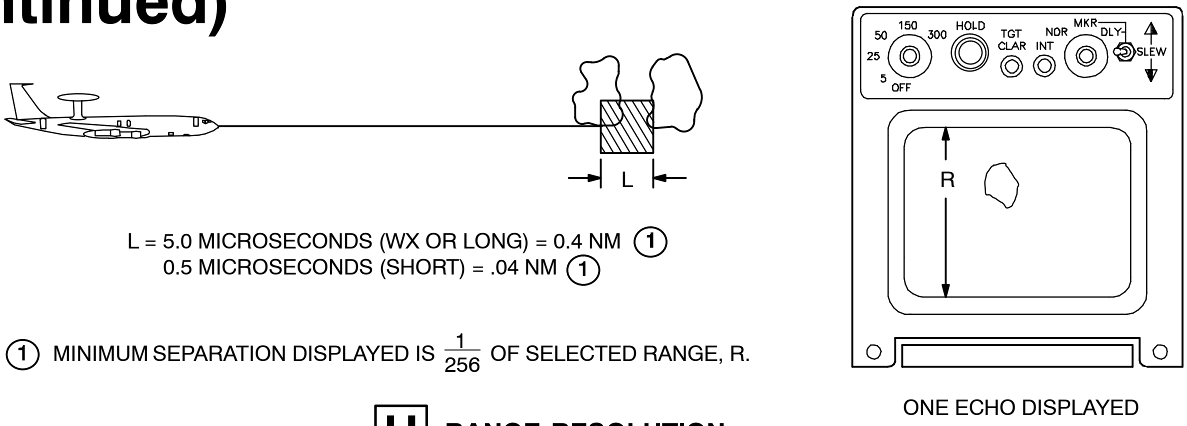
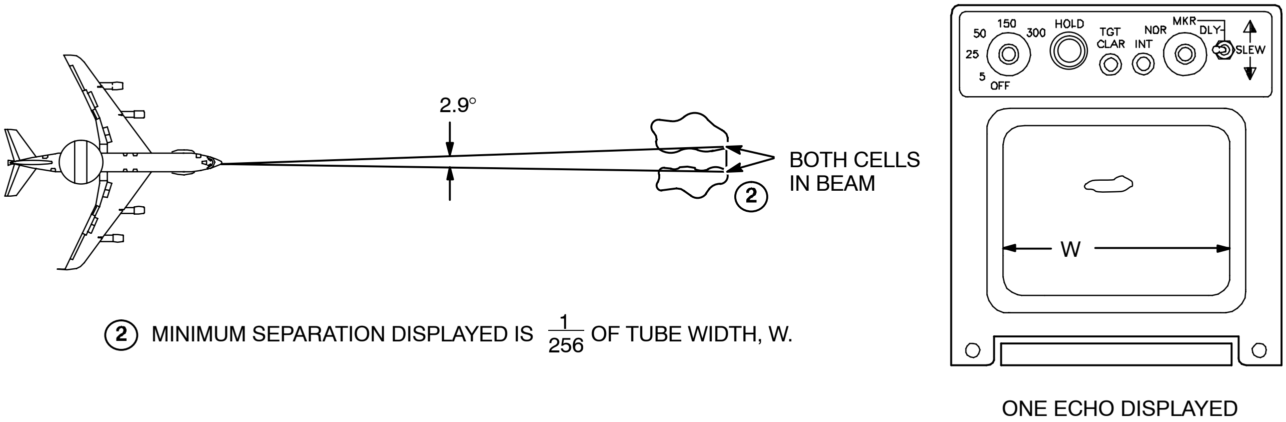
Figure 1-148 (Sheet 1 of 2)

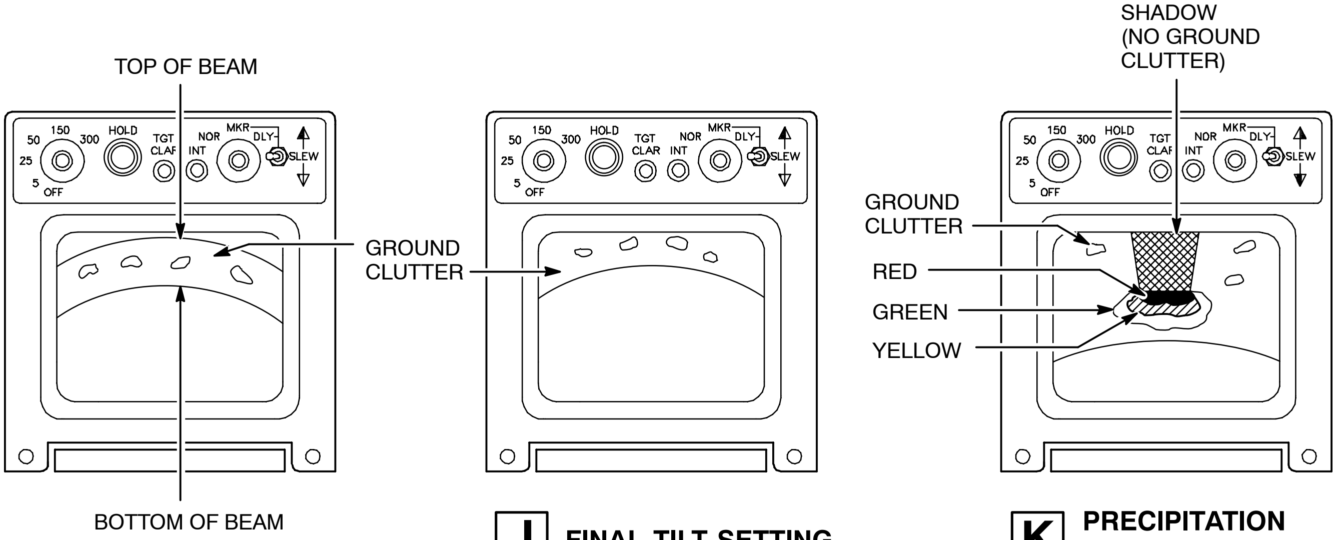
Weather Radar Displays (APS-133) (Continued)



H **RANGE RESOLUTION**



G **BEARING/AZIMUTH RESOLUTION**



I **INITIAL TILT SETTING**

J **FINAL TILT SETTING**

K **PRECIPITATION SHADOW**

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Figure 1-148 (Sheet 2 of 2)

Weather Radar Beam Patterns (APS-133)

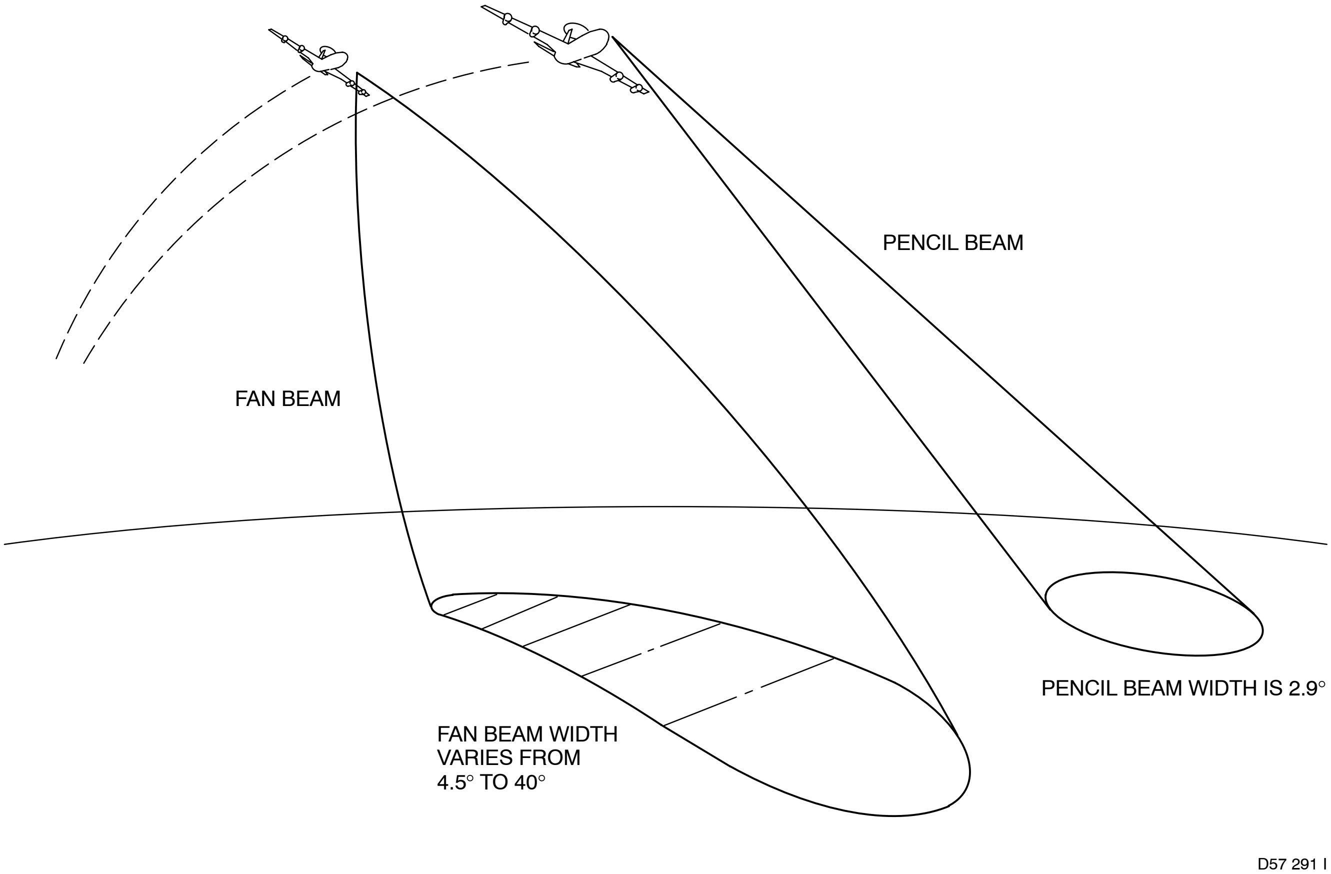


Figure 1-149

WEATHER RADAR OPERATION

The weather radar is normally warmed up and tested during the navigator's interior inspection (Section IV). For scramble operation, the radar may be started in flight.

Warmup and Self-Test

A three-minute warmup is necessary before the radar is ready to operate. Perform the following steps:

1. Verify that EGI NO 2 (preferred source) or AHRS NO 2 is operating.
2. Set control panel as follows:
   a. Mode Selector – TEST

      RT fault light illuminates during 3-minute warmup.

   b. TILT Knob – Full UP (15°)
   c. GAIN Knob – AUTO
   d. ANT STAB Switch – OFF
3. Set controls on navigator's radar indicator as follows:
   a. Range Knob – 150
   b. TGT CLAR Knob – Mid Range
   c. INT Knob – Mid Range
   d. Range Delay Knob – NOR

4. Check test pattern as follows (*figure 1-148*):

    a. Five color bands in lower 1/3 of range scale (50 miles) green, yellow, red, yellow, green. Width of bands is not critical. Any absent band indicates a possible fault. ANT and RT fault lights out.

    b. Noise band gradually increasing (green) from outer edge of last green test band to about 80 NM range. Fairly uniform band of green noise from 80 to 100 NM. Uniform noise level or missing 80 to 100 NM band shows RT fault. (Check RT fault light.)

    c. If random noise displayed beyond 100 NM, reduce TGT CLAR Knob setting to eliminate noise.

NOTE

If radar was not in STBY, wait three minutes before checking test pattern. Indicator either stays blank or shows bands of color until three minute warmup is complete.

Weather Mode Operation

To enter weather mode, complete warmup (and self-test if desired), then perform these steps:

1. Control Panel – Set

    a. Mode Selector – WX

    b. ANT STAB Switch – ON

CAUTION

With ANT STAB switch set to ON and weather radar mode selector switch set to other than OFF or STBY the selected attitude source gyro must be operating. If the attitude source is not on, the weather radar antenna can be damaged as it searches for a reference.

    c. GAIN Knob – AUTO

WARNING

With gain set in other than AUTO mode, erroneous color intensities can be displayed resulting in possible misinterpretation or failure to detect thunderstorm activity.

2. Indicators – Set

    a. TGT CLAR Knob – Mid-Range

    b. INT Knob – Mid-Range

    c. Range Delay Switch – NOR

    d. Range – As Desired

NOTE

Three-minute warmup is required before usable weather display is available.

Display now shows WX in upper left corner (13, *figure 1-147*) and three color bar (green with L, yellow with M, and red with H) in upper right corner (7, *figure 1-147*).

3. INT Knob – As Desired

4. TGT CLAR Knob – As Desired

    Adjust to show desired amount of green areas.

5. Tilt – Set

    Adjust tilt so that ground returns show a band in outer portion of indicator (I, *figure 1-148*). Then tilt antenna up until ground returns are in outer third of range (J, *figure 1-148*). This allows detection of shadows caused by heavy precipitation (K, *figure 1-148*).

To scan above or below present tilt setting, adjust tilt knob in 1/2 degree increments. Wait for one or two scans between changes. On descent, raise antenna one degree for each 10,000 feet of descent.

Mapping Mode Operation

To enter either MAP 1 or MAP 2 mode, complete warmup (and self test, if desired) then perform these steps:

1. Control Panel – Set
    a. Mode Selector – As Desired

       Set to MAP 1 for Ground Mapping at long range. Set to MAP 2 for short range mapping.

    b. ANT STAB Switch – ON

CAUTION

With ANT STAB switch set to ON and weather radar mode selector switch set to other than OFF or STBY, the selected attitude source gyro must be operating. If the attitude source is not on, the weather radar antenna can be damaged as it searches for a reference.

    c. GAIN Knob – AUTO
    d. Beam Width – As Desired

       Select FAN for MAP 2.

    e. Pulse – As Desired

       Use Long Pulse for MAP 1 at long ranges. Use Short Pulse for MAP 1 or MAP 2 at short ranges for better resolution.

2. Indicators – Set
    a. TGT CLAR Knob – Mid-Range
    b. INT Knob – Mid-Range
    c. Range Delay Knob – NOR
    d. Range – As Desired

NOTE

Three-minute warmup is required before usable mapping returns are displayed.

    e. Tilt – As Required

       Set to display required area.

    f. TGT CLAR Knob – As Desired

       Set to reduce background noise.

Skin-paint Operation

For best skin-paint operation, select MAP 1, tilt and range, as required, long pulse, and fan beam. When target changes to red, reduce gain until target is yellow or blue. Select short pulse for better resolution at short range (see *figure 1-148*).

NOTE

If gain is not reduced as range decreases, target can spread distorting actual bearing display.

Set range to 5 when desired. If target is still red in MAP 1 with GAIN Knob turned full left, select MAP 2 and set GAIN Knob to AUTO.

Beacon Mode Operation

To enter beacon mode, perform warmup (and self test, if desired) then perform the following steps:

NOTE

- Three-minute warmup is required before usable display is available.
- Weather targets are not displayed in beacon mode. Navigator should check weather mode frequently.

1. Control Panel – Set
    a. Mode Selector – BCN
    b. ANT STAB Switch – ON

       With ANT STAB switch set to ON and weather radar mode selector switch set to other than OFF or STBY, the selected attitude source gyro must be operating. If the attitude source is not on, the weather radar antenna can be damaged as it searches for a reference.

    c. GAIN Knob – AUTO

2. Indicators – Set
    a. Range Knob – As Desired
    b. Range Delay Switch – NOR

   c. INT Knob – Mid-Range

   d. TGT CLAR Knob – Mid-Range

Beacon target is displayed as single green arc, three or four degrees wide. The nearest bar is at true range. As range decreases, select range so that beacon return is in upper half of indicator. BCN is displayed in upper left corner of indicator (13, *figure 1-147*).

Range Delay Operation

To identify a beacon target (multiple signal) or enlarge a weather echo in range:

1. Set range delay switch to MKR.
2. Set SLEW switch to move marker to slightly less than target range. Range to marker is shown in 0.1 NM increments in marker range display up to 5 NM, then 1 NM increments (8, *figure 1-147*).
3. Set range delay switch to DLY.
4. Set range knob as desired.

   Display is marker range plus range knob setting. For example: marker range 75, range knob 5 – display is 75 to 80 nautical miles. Closest arc is actual target range.
5. Reduce marker range with SLEW switch to keep target in middle of display.
6. Reduce gain as target range decreases.
7. Return to NOR when target identified.

Radar Shutdown

To shut down the radar:

1. Indicators – OFF
   a. Range Knob – OFF
   b. Range Delay Switch – NOR
   c. INT Knob – Mid-Range
   d. TGT CLAR Knob – Mid-Range
2. Control Panel – OFF
   a. Mode Selector – OFF
   b. TILT Knob – Full UP
   c. ANT STAB Switch – OFF
   d. GAIN Knob – AUTO

Standby Operation

Setting the mode selector to STBY stops transmission and shuts down high-voltage circuits in the indicators.

Fault Lights

The fault lights illuminate to indicate a fault in the antenna or R/T unit. Fault lights illuminate only in TEST mode. If display is normal, radar may be used. If not, shut down radar.

DISPLAY RESOLUTION

The design of the digitizing circuits affects the size of targets that can be displayed (G, *figure 1-148*), and the spacing required for two closely separated targets to be displayed. The pulse length is 5.0 microseconds (long pulse) in WX mode and is automatically selected. Pulse lengths are 5.0 microseconds (long pulse) or 0.5 microsecond (short pulse) in MAP mode, as selected by the operator. The equivalent minimum separations are 0.4 NM in long pulse and 0.04 NM in short pulse. However, the display is divided into 256 parts in each direction, so the minimum range difference that can be shown is 1/256 of the selected range, as shown below:

Range (NM) Selected	Minimum Separation (NM) Long Pulse	Short Pulse
5	0.4	0.04
25	0.4	0.1
50	0.4	0.2
150	0.6	0.6
300	1.2	1.2

Targets closer together than the beam width cannot be separated. The approximate minimum separations are shown below (see H, *figure 1-148*):

Range (NM)	Separation (NM)
5	0.25
25	1.25
50	2.5
150	7.5
300	15

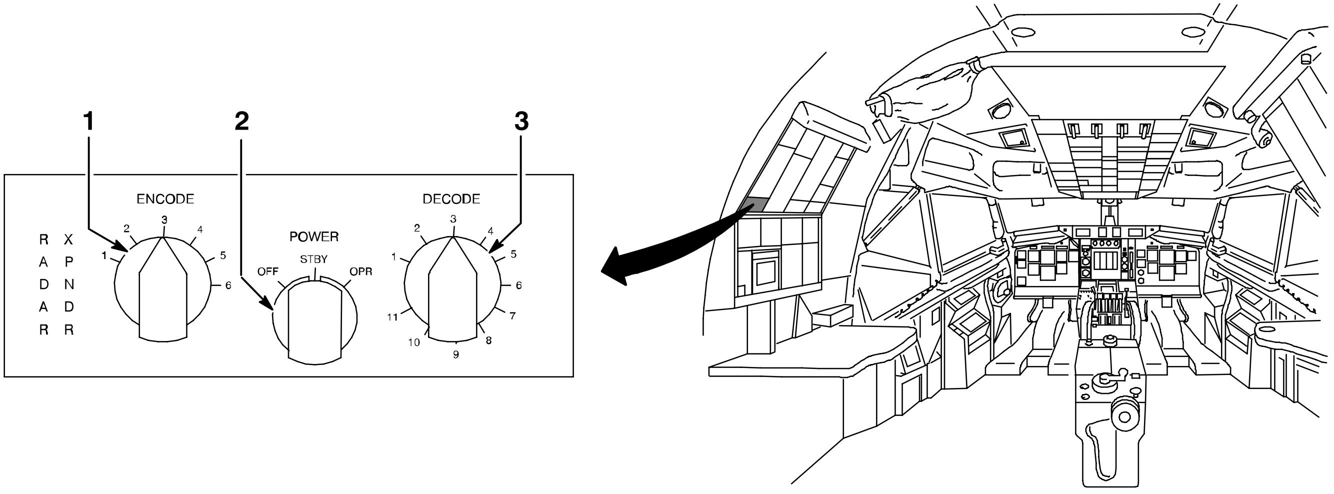
RENDEZVOUS RADAR BEACON (AN/APX-78)

The rendezvous radar beacon is used primarily as a navigational aid for air refueling. The system operates in the X band and has one antenna on the bottom of the airplane. After the equipment is energized and the desired codes are selected, the beacon operates automatically. During flight, coded reply signals are transmitted when the beacon responds to interrogation pulses from any suitable equipped radar. The beacon response is indicated by a bar or bars on the scope of the interrogating radar. The nearest bar is the true position of the beacon. The operator of the interrogating radar can then identify the beacon-equipped airplane and determine its range and bearing. The interrogating radar and reply code are selected by setting selectors on the control panel. When the beacon transmits, the weather radar return is suppressed to avoid interference on the weather radar indicator. The radar beacon system operates on 28 VDC from the FAVDC bus one through the RADAR XPDR DC circuit breaker on the P5 panel. Panel lighting power (28 VAC, phase A) is supplied from 28 VAC bus two through the MAIN PANEL SEXTANT circuit breaker on the P7 panel. Rendezvous radar beacon antenna location is shown in *figure 1-152.* The beacon controls (*figure 1-150*) are located at the navigation station.

SEXTANT AND WEATHER RADAR ELECTRIC POWER SOURCES

Electric power sources for the sextant and weather radar are listed in *figure 1-151*.

Rendezvous Radar Beacon Controls and Indicators



NO.	CONTROL/INDICATOR	FUNCTION
1	ENCODE Selector (Six positions, 1 through 6)	Used to select identifying signal to be transmitted to an interrogating radar. When set to 1, radar beacon responds to an interrogation with a single pulse. When set to 2 through 6, radar beacon responds with pulse pairs of the following spacings: Encode Switch Position — Pulse Spacing 2 — 4 NM 3 — 6 NM 4 — 8 NM 5 — 10 NM 6 — 12 NM
2	POWER Selector	When set to OFF, turns off all power to rendezvous beacon. When set to STBY, warms set up. In standby mode, unit does not receive or transmit, but set is in a ready-to-operate state. When set to OPR, allows set to reply to interrogations.
3	DECODE Selector (Eleven positions, 1 through 11)	Used to select one of eleven codes that differentiate between received radar interrogation signals. When set to 1, radar beacon responds to single or multiple pulse combinations in the proper frequency band. When set to positions 2 through 11, radar beacon responds only to pulse pairs of the selected spacing. Use 1 unless specifically briefed otherwise.

Figure 1-150

Sextant and Weather Radar Electric Power Sources

EQUIPMENT/SYSTEM	TYPE OF POWER	POWER SOURCE	CIRCUIT BREAKER LOCATION/LABEL
Panel Edge Lighting/Sextant	28V AC	28VAC Bus 2	P7, MAIN PNL SEXTANT
Rendezvous ①	28V DC	FAVDC 1	P5, RADAR XPDR DC
Weather Radar ①	115V AC	FAAC 2	P5, WEATHER RADAR ØA

① FLT AVIONICS BUS 1 and/or BUS 2 switches on AVIONICS POWER DISCONNECT panel control power to EQUIPMENT/SYSTEM circuit breakers referenced by this note.

Figure 1-151

Pages 1-573 through 1-582 deleted, to include figures 1-144, Sheet 1 through 5, and Figure 1-145,

SUBSECTION I-N-3
NAVIGATION EQUIPMENT

Table of Contents

SUMMARY

Navigation equipment on this airplane includes the GPS integrated navigation system (GINS). GINS is the primary navigation system for the airplane. GINS also provides position, attitude, pressure altitude, heading, and velocity data to the mission equipment.. See *figure 1–152.*

GPS INTEGRATED NAVIGATION SYSTEM

GINS consists of three Control Display Units (CDU), two Embedded GPS/INUs (EGI), MIL-STD-1553B dual redundant interconnecting bus (1553 bus), two Bus Subsystem Interface Units (BSIU), a data loader, two GPS signal receiving antennas, and two Antenna Electronics (AE) units.

Other onboard equipment that functions with, or provides signal inputs to, GINS includes the AHRS, the ADCs, the flight director computers, the HSIs, the ADIs, the autopilot, **WITH IDG** the altitude alerters, the IFF transponder system ◀ and the JTIDS data link. See *figure 1–153.*

GINS can be operated to perform the following functions:

a. Initialization and startup

b. Navigation

c. Guidance and flight instruments operating signal inputs

d. Flight plan management

e. Navigation sensor management

f. Alternate flight plan management

g. Data loader/data storage

h. Emergency operations on EGI battery power

i. Status monitoring and failure alerting (Continuous Built-in Test, CBIT)

j. Initiated Built-in Test (IBIT, ground operation only)

k. System zeroizing

l. Miscellaneous functions

m. **WITH IDG** Control of IFF transponder and TCAS ◀

CONTROL DISPLAY UNITS

The three CDUs are the primary flight crew interface for controlling and monitoring GINS. Each CDU has full alphanumeric data entry and specific function select capabilities. Each has a display with eight lines of twenty two characters each. The CDUs have 1553 bus interface capability which permits them to operate on the bus as either bus controller or remote terminal. All three CDUs have the capability to operate as bus controller. See *figure 1-154.*

EGIs

Each EGI contains one laser-gyro-stabilized Inertial Navigation Unit (INU) and one Global Positioning System (GPS) signal receiver. See *figures 1-155* through *1-159.*

The INUs contain a gyro assembly consisting of three zero-lock laser gyroscopes; also three precision accelerometers, sensor electronics, and processor electronics. The INUs provide pitch, roll, heading, and attitude signals for GINS, and the flight directors.

Each GPS receiver receives satellite signals via a dedicated antenna and AE set.

BUS SUBSYSTEM INTERFACE UNITS

There are two identical BSIUs on the 1553 bus. They operate as remote terminals on the bus and provide functional interfaces with navigation equipment that is not connected to the bus. See *figure 1-160.* There are four identifiable main functional blocks in each BSIU; an I/O controller, a microprocessor, a power supply, and four System Interface Modules (SIM). The SIMs interface with the non–GINS navigation equipment.

GINS ANTENNAS

There are two GINS (receive only) antennas located on the top centerline of the fuselage at stations 410 and 430. These can be either GPS Antenna System (GAS-1) CRPA or Controlled Reception Pattern Antenna (CRPA2). See *figure 1-152.*

ANTENNA CONTROL UNITS OR ANTENNA ELECTRONICS UNITS

The GAS-1 antenna is connected to an Antenna Control Unit (ACU). The CRPA2 antenna is connected to an AE unit. These units function as antenna controller, pre-amplifier and down-converter of received Radio Frequency (RF) to Intermediate Frequency (IF). Each ACU or AE feeds IF to one GINS receiver within the EGI.

GINS CONTROLS AND INDICATORS

The GINS controls and indicators include the CDUs, the GINS CONTROL PANEL, the ADI/ADC/PILOT/BUS select switches, and the RNAV ANNUNCIATORS panel. Locations of these items are shown in *figure 1-152.* Controls and indicators for other equipment that functions with, or provides signal inputs to, GINS are described in subsections pertaining to that equipment.

Control Display Units

The CDUs are the primary devices through which the crew operates GINS and monitors the information available from GINS and its interfacing equipment. See *figure 1-161.* The CDUs require 28 vdc to operate, and are turned on and off at the GINS CONTROL PANEL. CDU No. 3, at the navigator's station, is powered from the hot battery bus; therefore it continues to operate independently of any power interrupts that may occur in the normal dc power distribution circuits.

CDU panel lighting intensity is controlled by station panel lighting switches and rheostats.

GINS Control Panel

The GINS CONTROL PANEL is located on the navigator's lower panel. It contains power switch/indicators for the CDUs, BSIUs and EGIs, crypto zeroize and master zeroize switches, EGI battery–on and fault lights, and switch to allow auto or specified selection of which EGI output goes to the CPS. See *figure 1-162.*

Mission Data Loader

GINS provides access to a two-receptacle data loader for storage and retrieval of flight data via the 1553 bus. See *Figure 1–161A.* Insertable 85 MB PCMCIA cards are used to store GINS flight data. GINS allows any number of PCMCIA cards to be utilized during flight, although a single PCMCIA card is capable of storing data for an entire mission.

RNAV ANNUNCIATORS Panel

There are three RNAV ANNUNCIATORS panels; one each located on the pilot's instrument panel, the copilot's instrument panel, and the navigator's lower panel. Each contains, indicators, lights that illuminate in accordance with conditions or status, as labeled, and one switch that is active at the pilot's panel only. See *figure 1-163.*

ADI/ADC/PILOT/BUS Selector Panel

The ADI/ADC/PILOT/BUS selector panel (ADAB panel) is located on the pilot's instrument panel. It contains toggle switches to select between GINS and AHRS for the ADI, ADC 1 or 2 for altitude and airspeed inputs to the autopilot, pilot and copilot for designated pilot navigation solution source to the autopilot, and 1553 bus NORMAL (intact) or ISOLATE (split). See *figure 1-164.*

KEY LOAD (Crypto) Module

Two crypto modules are located on the E14 rack. The crypto modules provide the interface for loading crypto keys from crypto key loader to the receivers. The crypto modules have no power requirements. See *figure 1-165* for key load module controls and indicators. Procedures for loading keys are in T.O. 1E–3A–43–1–1, subsection II–E.

GLOBAL POSITIONING SYSTEM

GPS provides precise position, velocity, and time data under all weather conditions. GPS consists of earth satellites, a ground control system, and receiving sets.

Satellites, Orbits and GDOP

GPS has 24 earth satellites, four satellites in each of six circular rings. Twenty–one active satellites constitute a full constellation; three satellites are spares. The satellites have a 12–hour orbital period. The user typically receives transmissions from six to eleven satellites simultaneously. The receiver tracks five satellites simultaneously and selects the best four signals for its navigation solution. The best combination of four satellites to use in the navigation equations is a compromise between adequate reception and minimum Geometric Dilution of Precision (GDOP). The optimum GDOP situation occurs when one of the satellites is at the user's zenith and the other three are each 10° above the horizon (antenna reception cone) and 120° apart in azimuth.

Although reception is usually adequate from any satellite in the antenna reception cone, better reception sometimes occurs from satellites at higher elevations. When fewer than four satellites are available, useful information can still be obtained, but operation is degraded.

Ground Control System

The ground control system tracks the satellites, monitors and controls satellite orbits, and updates the satellite navigation data message. The ground control system consists of a Master Control Station (MCS) at Falcon AFB, Colorado, and monitor stations around the world at Ascension Island, Diego Garcia, Kwajalein, and Hawaii. Almanac data is uplinked once each day. Ephemeris data is uplinked about once every two hours. Refer to GPS THEORY OF OPERATION.

GPS provides accurate time and status to MDS/LINK 16 via the 1553 bus, and time to HAVE QUICK via a direct line, if selected by the communications technician. JTIDS and HAVE QUICK operation are covered in T.O. 1E-3A-43-1-1.

GPS THEORY OF OPERATION

To receive satellite signals, the receiver must have the information (almanac) to locate every satellite. The almanac is provided to the receiver by any satellite. After one satellite is found, the others can be located more easily. The satellite data is called the navigation data message. The navigation data message contains two sets of data called almanac and ephemeris data. Each satellite transmits almanac data for all satellites. Each satellite transmits ephemeris data for itself only. Almanac data is gross position forecast for the satellite constellation on a six-month projection. Almanac data enables a receiver to know where in the sky to look for satellites. Ephemeris data gives precise satellite orbital information, and provides the precise clock correction, both applicable only to the satellite from which the data is received.

Four satellites are required to accurately provide both position (including altitude) and time. If the receiving set clock remained perfectly synchronized with the satellites, then accurate position (including altitude) could be obtained with only three satellites. Use of four satellites by receivers eliminates the need for receivers to be equipped with atomic clocks.

All the satellite clocks are synchronized by the ground control system. The following paragraphs explain how the receiver uses four satellite signals to synchronize its own navigation clock with the satellites, and to compute estimated position error.

The computed distance (radius) of a receiver from a satellite is the difference in time between transmission and reception of a signal, multiplied by the speed of light. The time of satellite signal transmission (according to a satellite clock) is digitally encoded in the satellite transmission and is read by the receiver. The time of signal reception is measured by the receiving set clock.

A radius from each of three different satellites establishes a three-dimensional position for the receiver. In a group of four satellites there are four combinations of three satellites (1,2,3 / 1,2,4 / 2,3,4 / 3,4,1), and from each combination of three satellites an independent position (point) is computed. With no errors the four points would all be the same point. Since, usually, the four points are not the same point, this indicates that there is error in the system. The most likely source of error is the receiver's clock. Adjusting the receiver's clock moves each of the four points and can usually move the points closer together. The best correction to the receiver's clock is found in this manner, by a mathematical solution for a clock time which moves the four points closest together.

After the receiver's clock is corrected as much as possible, the four points are very close together. Using a preconceived probability model, an exact position is predicted inside the remaining envelope, and the size of the remaining envelope defined by the four points gives an exact limit on estimated position (and time) errors. Estimated errors are displayed to the user in a normalized variable called Figure of Merit (FOM).

GPS computes velocity using doppler frequency shift to compute the radial speed (range rate) relative to each satellite. Similar arguments to those given above for position measurement and accuracy apply also to velocity measurement.

When a satellite is lost, if another known radius can be found then the solution accuracy can be restored. Using CADC altitude aiding, the radius from earth's center to the receiver can be used in the solution.

Types of Error and Correction Methods

The process of computing satellite range is called ranging. For satellite ranging to provide accurate position the system must correct the following three types of errors:

a. Satellite clock and satellite position errors

b. Navigation set (receiver) clock error

c. Atmospheric delay and bending of satellite signals

Satellite Clock and Position Error Correction

A correction for satellite clock error and the difference in position between almanac and actual satellite position are received in the ephemeris data transmitted by each satellite. This is good data if the satellite is stable in its orbit and its clock is stable. It can take several hours for a satellite's stable clock and stable orbit errors to be updated in its ephemeris data. If a satellite suddenly becomes unstable, either in clock or orbit, its ephemeris data is useless. **WITH RAIM** In this event, the GPS receiver might not know which satellite is causing the problem, but is nevertheless capable of notifying the user if the position envelope expands beyond allowable error limits. This capability is called Receiver Autonomous Integrity Monitoring (RAIM). If at least six satellites are visible, then, by comparing solutions using various combinations of satellites, the receiver can also determine which is the bad satellite and can replace the bad satellite with a good satellite in the navigation solution. This capability is called Fault Detection and Exclusion (FDE). See RAIM/FDE description under EGI THEORY OF OPERATION, later in this subsection. ◀

Receiver Clock Error Correction

Navigation set (receiver) clock error is computed continually by the receiver when three or four satellites are available.

Atmospheric Error Correction

Atmospheric delay of satellite signal is different for each satellite and depends upon the angle at which the signal penetrates the atmosphere, and other factors. There are two regions of atmospheric delay, tropospheric and ionospheric. Atmospheric corrections can amount to as much as 30 meters, although the combined tropospheric and ionospheric correction is usually less than 5 meters.

The troposphere is the lower region of the atmosphere. Tropospheric delay can be predicted from the user's altitude and elevation angle of the satellite.

The ionosphere is the very upper atmosphere from 60 to 300 miles high. Ionospheric delay is usually more significant than tropospheric delay. Ionospheric delay is caused by the integrated ion/electron count after the ray bending effect is accounted for. The ionosphere experiences seasonal and hourly variations. The amount of delay for a given geometry varies with thickness of the ionosphere, recent solar activity, whether the signal crosses the magnetic equator, day or night, and other factors. Ionospheric delay is computed by the receiver for each satellite in the following manner: Each satellite broadcasts two signals (L1 and L2) at different frequencies, phase-correlated. The amount of ionospheric delay is frequency dependent. The receiver processor estimates the amount of total delay for both signals by the difference in phase shift between the actual signals received and a predicted phase shift model.

Signal Structure

Each satellite broadcasts two UHF wide band signals called Link 1 (L1, 1575.42 MHz) and Link 2 (L2, 1227.60 MHz). Spread spectrum techniques enable all satellites to simultaneously transmit on the same two frequencies. Both L1 and L2 are continuously modulated with the navigation data message. The navigation data message contains a handover word used in acquiring the precision code after the coarse/acquisition C/A code is acquired.

L1 (only) is modulated periodically (once each millisecond) with the C/A code. The C/A code is available to all users. The C/A code is a short group of intense pulses in the L1 message. The C/A code is unique for each satellite and initially identifies each satellite. C/A code is easier to acquire than the precision code (P-code).

Both L1 and L2 are modulated on a one millisecond cycle by the P-code which provides the more accurate positioning. The P-code is also unique for each satellite. P-code can be encrypted for U.S. military operations to deny access to other users, in which case it is called Y-code instead of P-code. All users have access to the P-code unless it is encrypted.

Navigation Data Processing and Output

Two EGIs each contain a GPS receiver and an all-attitude INU. An EGI outputs GPS-only position and velocity data, free running inertial-only position and velocity data, and a blended solution that combines GPS, JTIDS Rel Nav, inertia data, and manual position updates to provide position and velocity data.

The BC CDU selects as the preferred EGI, the EGI to first achieve a GPS solution convergence. Convergence occurs when the four position points of a solution are brought as close together as possible by adjustment of the receiver's clock, and is synonymous with synchronization of the receiver's clock with GPS time. The preferred EGI is swapped automatically only by failure, but may be manually selected via the aiding page. The preferred EGI is the GINS-recommended navigation data source to the mission system, provided that AUTO is selected as CPS NAV SOURCE on the GINS control panel. The mission Data Analysis Programming Group (DAPG), however, always has access to the output of both EGIs and can override either the GINS preferred EGI recommendation (whether automatic or manual) or the navigator's switch selection of CPS NAV SOURCE, if the DAPG determines that the preferred (or selected) EGI data is invalid. The Navigator will receive a CDU MASTER caution if DAPG switches the preferred EGI.

The EGI GPS-only output goes to the BSIUs where additional digital smoothing of the solution occurs before the position and velocity data is fed to the bus controller CDU which applies it to the flight plan to generate digital guidance data which is fed back to the BSIUs where it is converted to analog signals to drive flight instruments and autopilot.

The BC CDU commands a message from the preferred EGI to JTIDS. This message to JTIDS is called the GPS background navigation message, and contains position, velocity, status, the time at which the message was generated by the GPS receiver, difference between geoid vertical position and ellipsoid vertical position, and other parameters. A second message to JTIDS from the preferred EGI contains Precise Time and Time Interval (PTTI) data including date and Time Figure of Merit (TFOM). The preferred EGI receiver also provides time (UTC) to HAVE QUICK through switching logic.

Maps, Ellipsoids and Datums

The BC CDU converts the navigation solution to map coordinates selected by the user. Maps are referenced to a particular earth model. The earth is irregular in shape, but is modeled as an ellipsoid. An ellipsoid is slightly larger in diameter at the equator, and flatter at the poles, than a sphere. Since the earth is irregular in shape, different regions of the earth are more closely fit with ellipsoids having slightly different dimensions. The CDU software has a file of 11 different earth model ellipsoids. An ellipsoid assigned to some particular part of the earth is called a geodetic datum. GINS can compute positions within 47 different geodetic datums. GINS normally provides navigation in a global reference rather than a local reference. The DoD standardizes on use of the World Geodetic System 1984 (WGS-84) (datum 47) and it is implemented in this system as the default selection which should not be changed by flight crews. Flight crews will use only datum 47.

GPS Time and UTC Time

Because of time correction jumps and discontinuity in the international standard definition of UTC, GPS cannot run exactly on UTC. GPS has its own time system which closely parallels UTC. The receivers compute UTC time automatically by applying to internal receiver navigation clock time a delta correction which is transmitted in the satellite navigation message. Internal GPS navigation clock time cannot be displayed and is not output on any data bus; only UTC is displayed and output. GPS time is provided to the JTIDS terminal and to HAVE QUICK radios.

Protective Features

The GPS system contains several features which protect against unauthorized usage, interference, jamming, and spoofing.

Protection From Unauthorized Use

The SA/AS capability is protected from unauthorized use by GPS cryptovariable keys. Y-code (encrypted P-code) cannot be received unless the proper daily Cryptovariable (CVd) has been obtained through the use of a Key Production Key (KPK). The two types of KPKs currently capable of being loaded during preflight are a Weekly Cryptovariable (CVw) or a Group Unique Variable (GUV). Standard operating procedure is for the GUV to be loaded.

The CVw is used for the self-contained generation of CVd keys within the GPS receiver. Since a PPS capable receiver can derive the CVd directly, it can generate the CVd before it tracks any GPS Space Vehicles (SV). A receiver containing the CVw can immediately transition from the SPS to the PPS as soon as it starts to track GPS signals. As a result of its special capability, the CVw key has limited distribution to those users who demonstrate a valid need to initially acquire GPS satellite signals in a minimal amount of time (fast acquisition) and the immediate access to the PPS service. The CVw has a cryptoperiod of one week and can be used to generate seven CVd keys.

The GUV is used to decrypt a portion of the GPS navigation message that contains an encrypted version of the CVd. However, a PPS capable receiver that has the GUV loaded must first track the signal from a GPS SV, download the navigation message that is embedded in that signal, and decrypt the CVd that is contained in a portion of the nav message before it can transition from SPS to PPS operations. The act of downloading the navigation message from the GPS signal in order to get the CVd can take as long as 12.5 minutes. The GUV has a cryptoperiod of approximately 60 weeks.

Interference and Jamming Protection

P-code is less susceptible to interference than the public access C/A code. Its higher bandwidth signal requires more energy to intentionally or unintentionally degrade reception.

Null Generation

Null generation also provides protection from jamming and interference. The receiver treats jamming the same as interference. Jamming is noise intentionally generated by an enemy to degrade the signal to noise ratio. Jamming, by definition, does not contain deceptive intelligence, only noise. Interference is unintentional noise from any source. The receiver is capable of determining the direction of noise source and of blocking out reception from the antenna in that direction. The area of blocked reception is called an antenna null. Null generation is automatic and can occur with or without decryption capability.

Selective Availability and Anti-Spoofing (SA/AS)

Selective Availability (SA) and Anti-Spoofing (A-S) are two separately enabled transmission features which require the intended receiver to have decryption capability.

A-S, when enabled, encrypts the precision codes, which performs two functions: 1) it denies the unauthorized user access to precise positioning service, and 2) it enables the authorized user to identify and ignore an enemy signal which contains false information. A-S does not deny any receiver access to standard positioning service.

SA introduces intentional errors into the transmitted signals which can only be removed through the use of crypto keys. Standard positioning service (without SA) has an accuracy to less than 150 feet.

If the user is authorized, that is, has correct crypto variables, the user has no way of knowing that either A-S or SA is enabled. If the user is unauthorized, and A-S is enabled, Figure of Merit (FOM) and Estimated Horizontal Error (EHE) increase.

Accuracy of Figure of Merit

When GPS signals are unencrypted, or are encrypted with only A-S enabled, then FOM and EHE provide correct confidence limits on the size of the uncertainty envelope whether or not the receiver has decryption capability.

JTIDS/LINK 16 RELATIVE NAVIGATION

JTIDS/Link 16 is a theater level communication system requiring an accurate time clock to permit time division multiplexing of transmissions from the various terminals. When operating on a JTIDS/Link 16 net, the JTIDS/Link 16 terminal determines airplane position by measuring time differences between transmission and reception of signals in the net and by using the speed of light to determine relative position of terminals in the net. Knowing the relative position of all terminals, and knowing the geodetic position of at least one terminal (usually a ground station), the geodetic position of all terminals, including your own, is determined. To have a REL NAV function there must be at least three other terminals in the JTIDS/Link 16 net.

Normally, the blended solution from the EGI is aided by its own GPS. Failure of one GPS results in a crossfeed of GPS data from the good GPS to both EGIs. If both GPSs become invalid, and if the aiding page shows the default aiding configuration JTIDS:INU1, for JTIDS to be aided by INU 1, then the bus controller CDU automatically substitutes JTIDS REL NAV aiding for the discontinued GPS aiding in the blended solution of EGI 1, provided that JTIDS REL NAV is available. JTIDS REL NAV aiding to the INU is not used if GPS is available. But JTIDS REL NAV aiding to the EGI blended solution is automatic if JTIDS REL NAV is available while GPS aiding is lost, and if INU 1 aiding to JTIDS is not deselected. JTIDS aids the blended solution of EGI 2 if JTIDS: INU2 is selected on the aiding page.

Navigation Equipment Locations

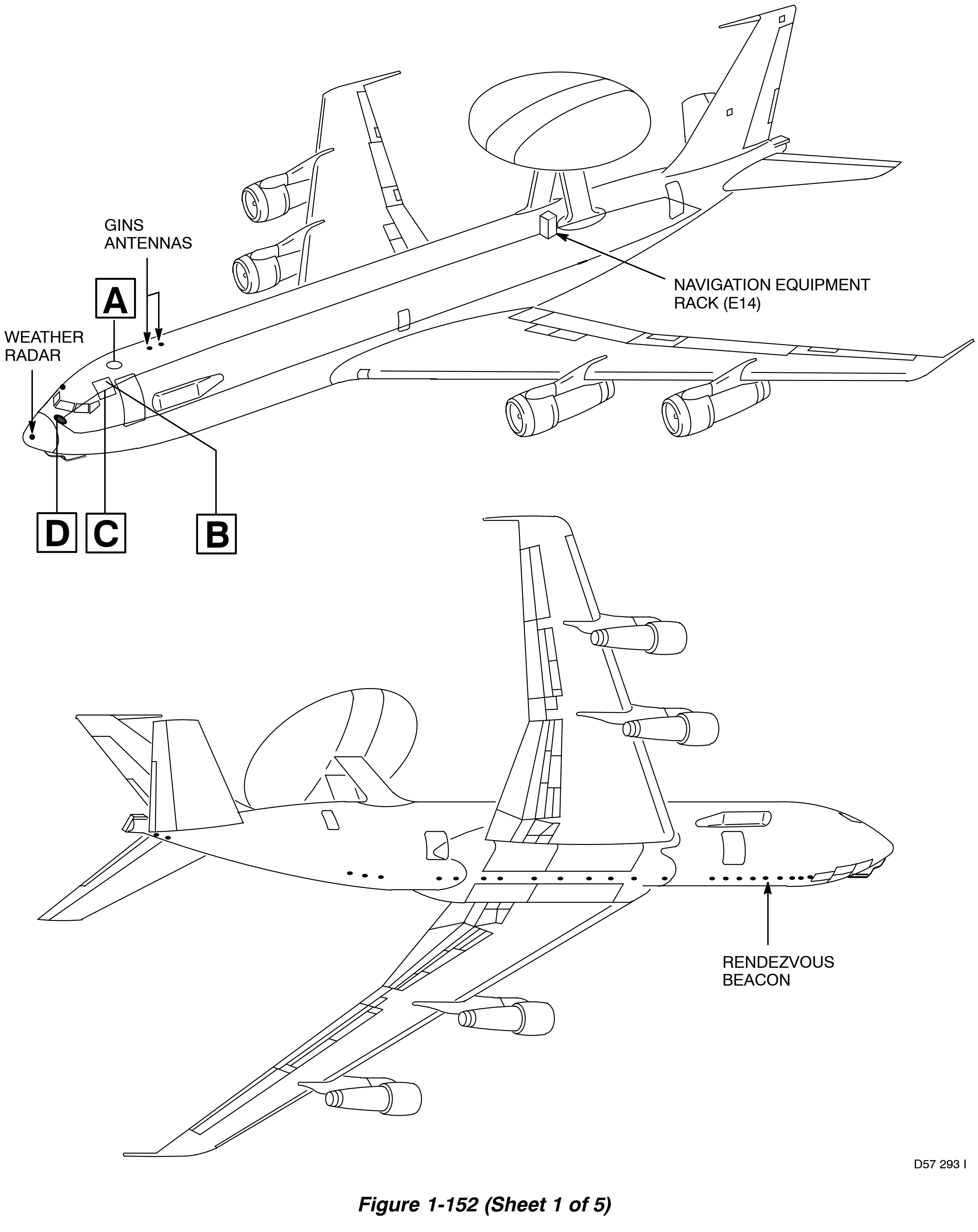
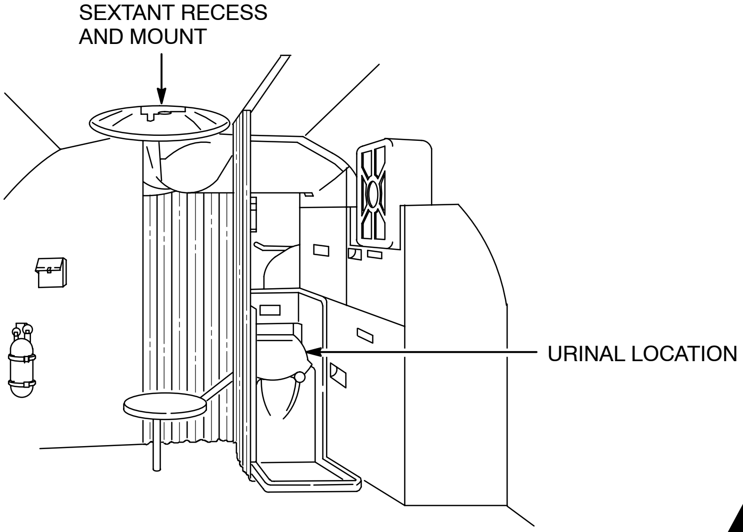
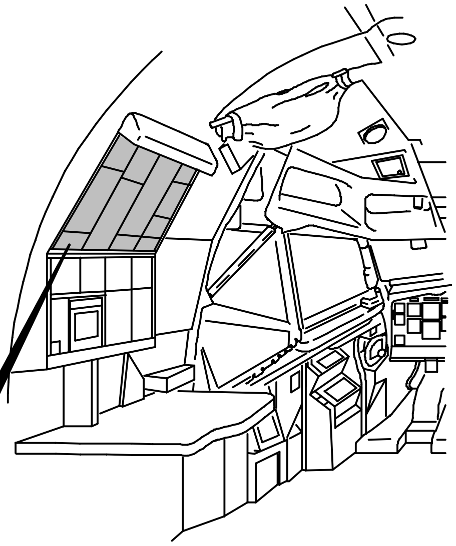


Figure 1-152 (Sheet 1 of 5)

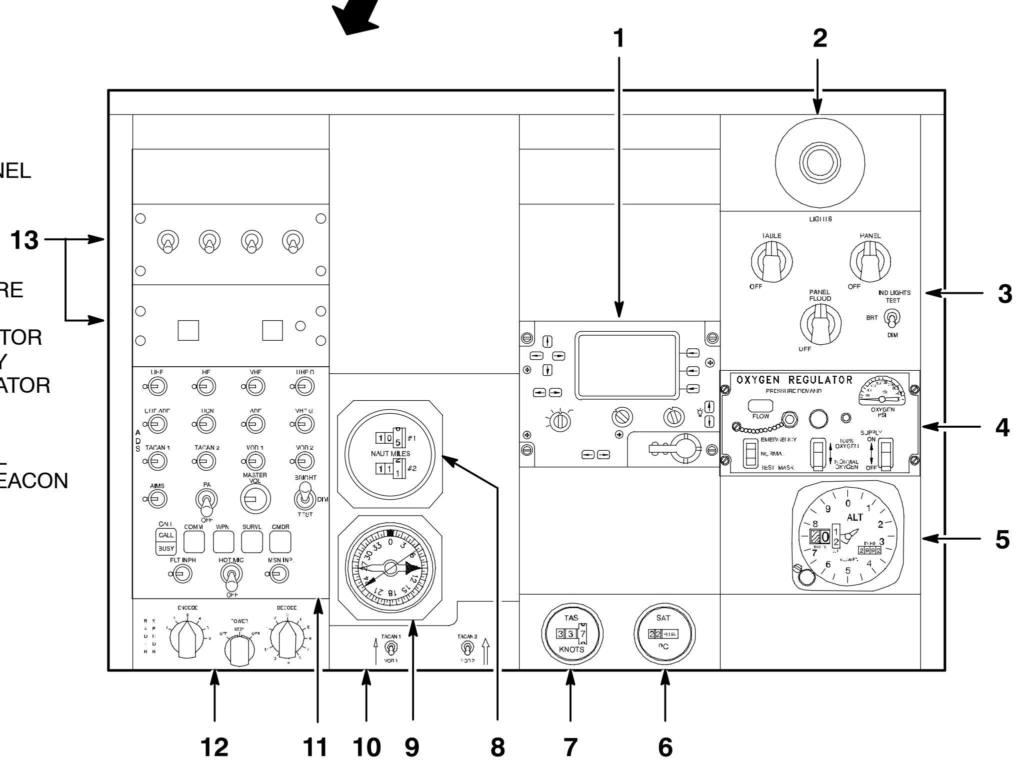
Navigation Equipment Locations (Continued)



A **SEXTANT MOUNT POSITION**



B **NAVIGATOR'S UPPER PANEL**



1. HF RADIO CONTROL PANEL
2. GASPER AIR
3. LIGHTING CONTROLS
4. OXYGEN REGULATOR
5. ALTIMETER
6. STATIC AIR TEMPERATURE INDICATOR
7. TRUE AIR SPEED INDICATOR
8. DUAL DISTANCE DISPLAY
9. RADIO MAGNETIC INDICATOR (RMI)
10. RMI SELECTOR PANEL
11. AUDIO SELECTOR PANEL
12. RENDEZVOUS RADAR BEACON CONTROL PANEL
13. HAVE SIREN CONTROLS

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Figure 1-152 (Sheet 2 of 5)

C NAVIGATOR'S LOWER PANEL

14. CLOCK
15. AUTOPILOT GINS SOURCE DISPLAY
16. WEATHER RADAR CONTROL PANEL
17. RNAV ANNUNCIATORS PANEL
18. GINS MISSION DATA LOADER
19. GINS CONTROL DISPLAY UNIT
20. GINS CONTROL PANEL
21. WEATHER RADAR INDICATOR

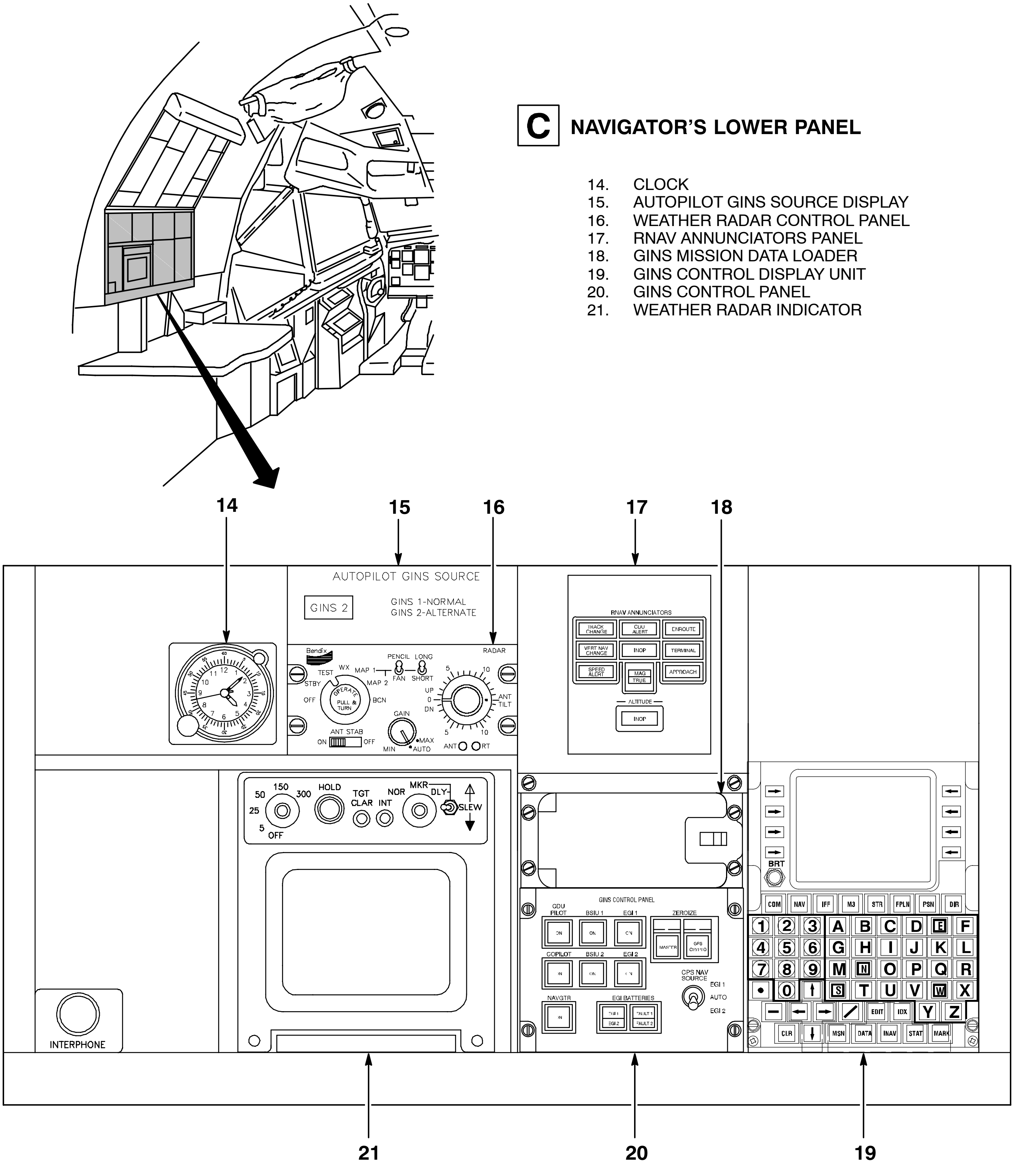
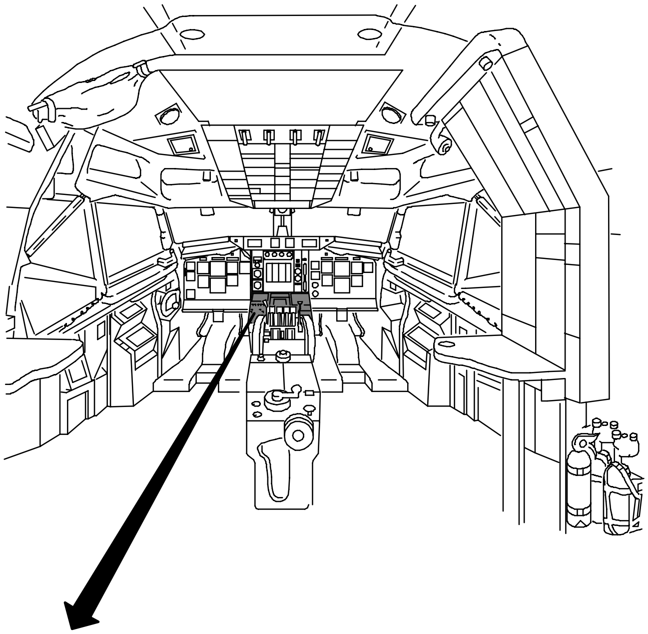


Figure 1-152 (Sheet 3 of 5)

Navigation Equipment Locations (Continued)



D **FORWARD ELECTRONIC PANEL**

22. UHF RADIO CONTROL PANEL
23. WEATHER RADAR INDICATOR
24. GINS CONTROL DISPLAY UNIT (2 PLACES)
25. DELETED

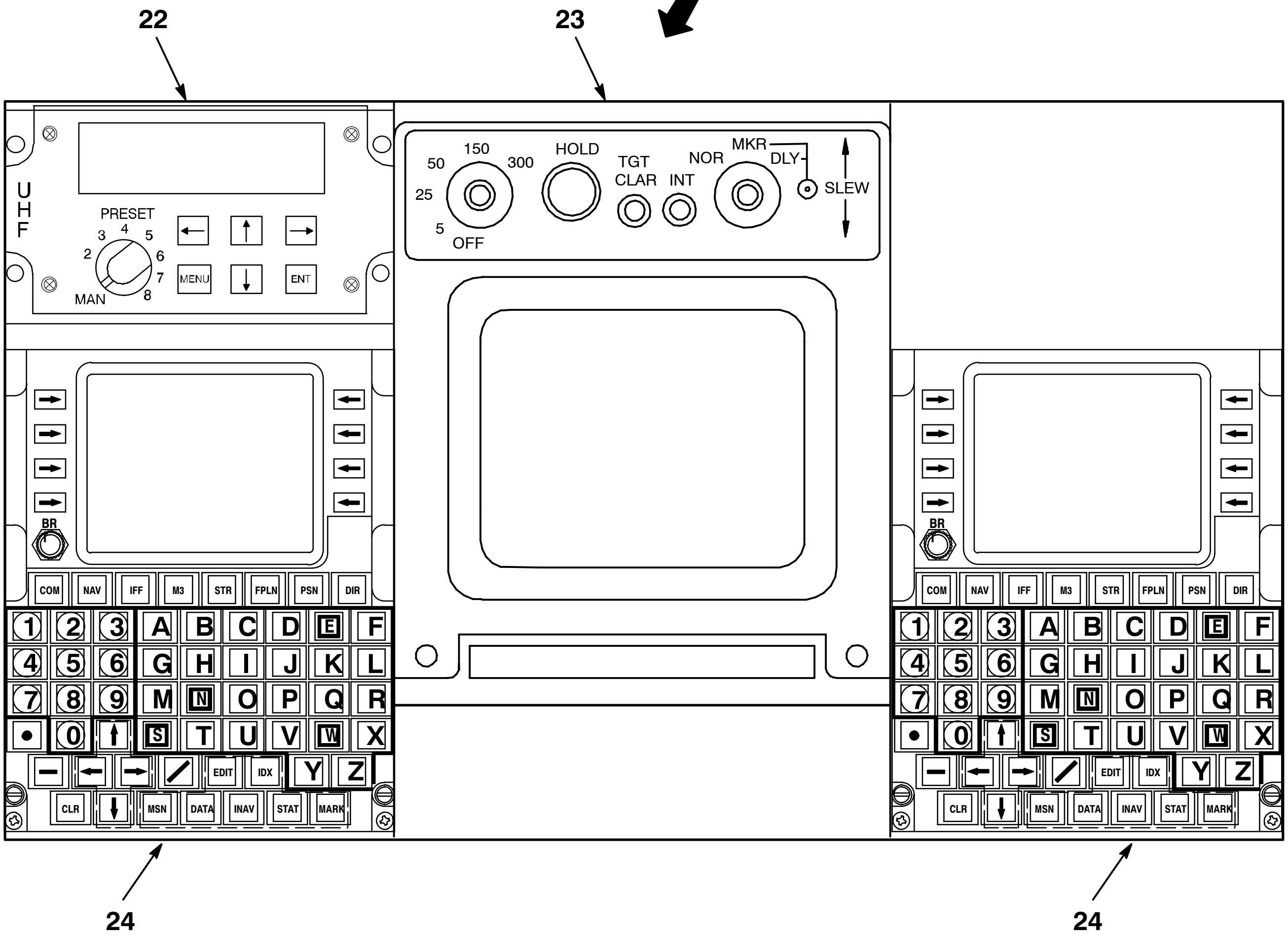


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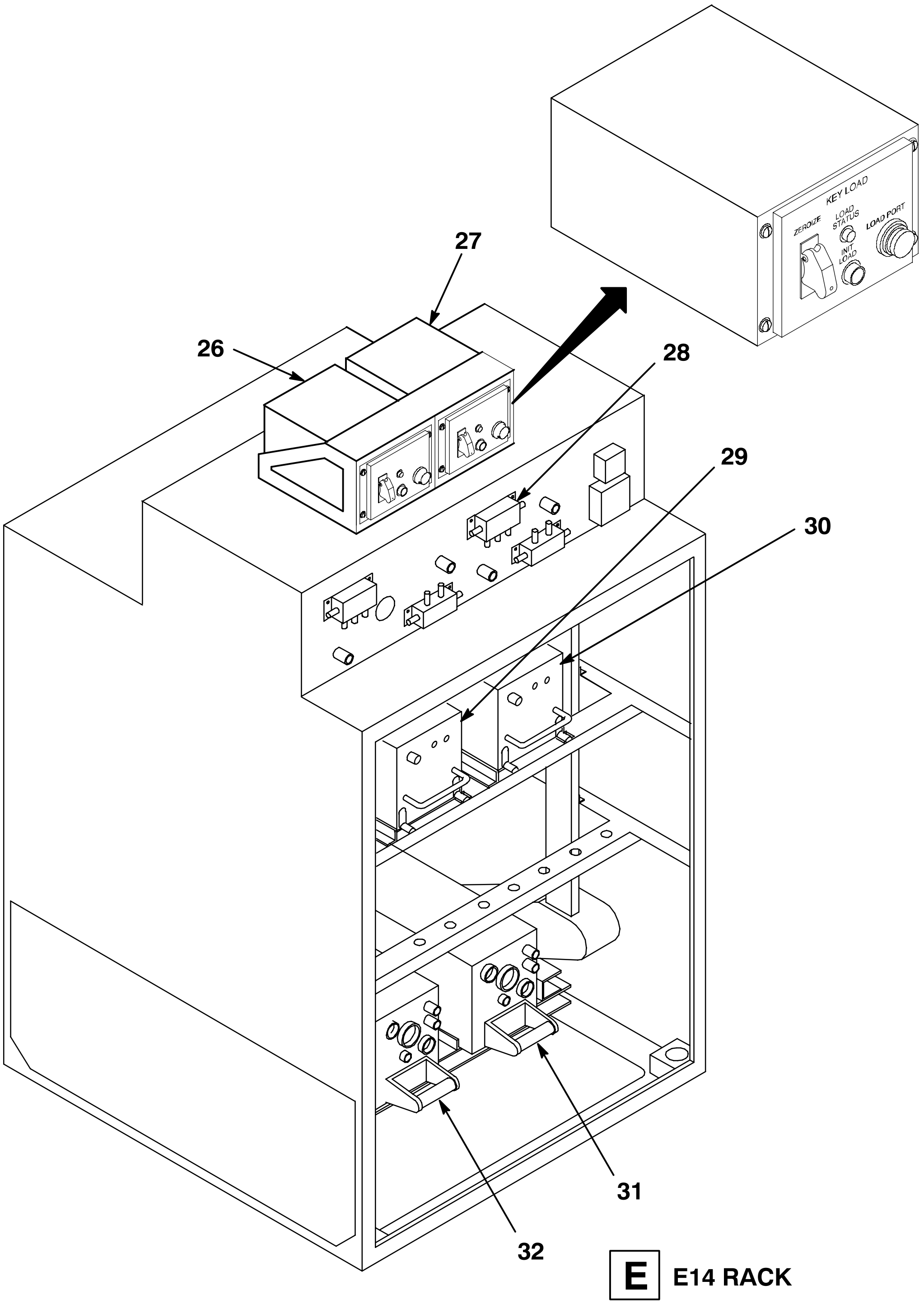
Figure 1-152 (Sheet 4 of 5)



26. KEY LOAD MODULE 1
27. KEY LOAD MODULE 2
28. BUS COUPLER (4)
29. BATTERY 1
30. BATTERY 2
31. EGI 2
32. EGI 1

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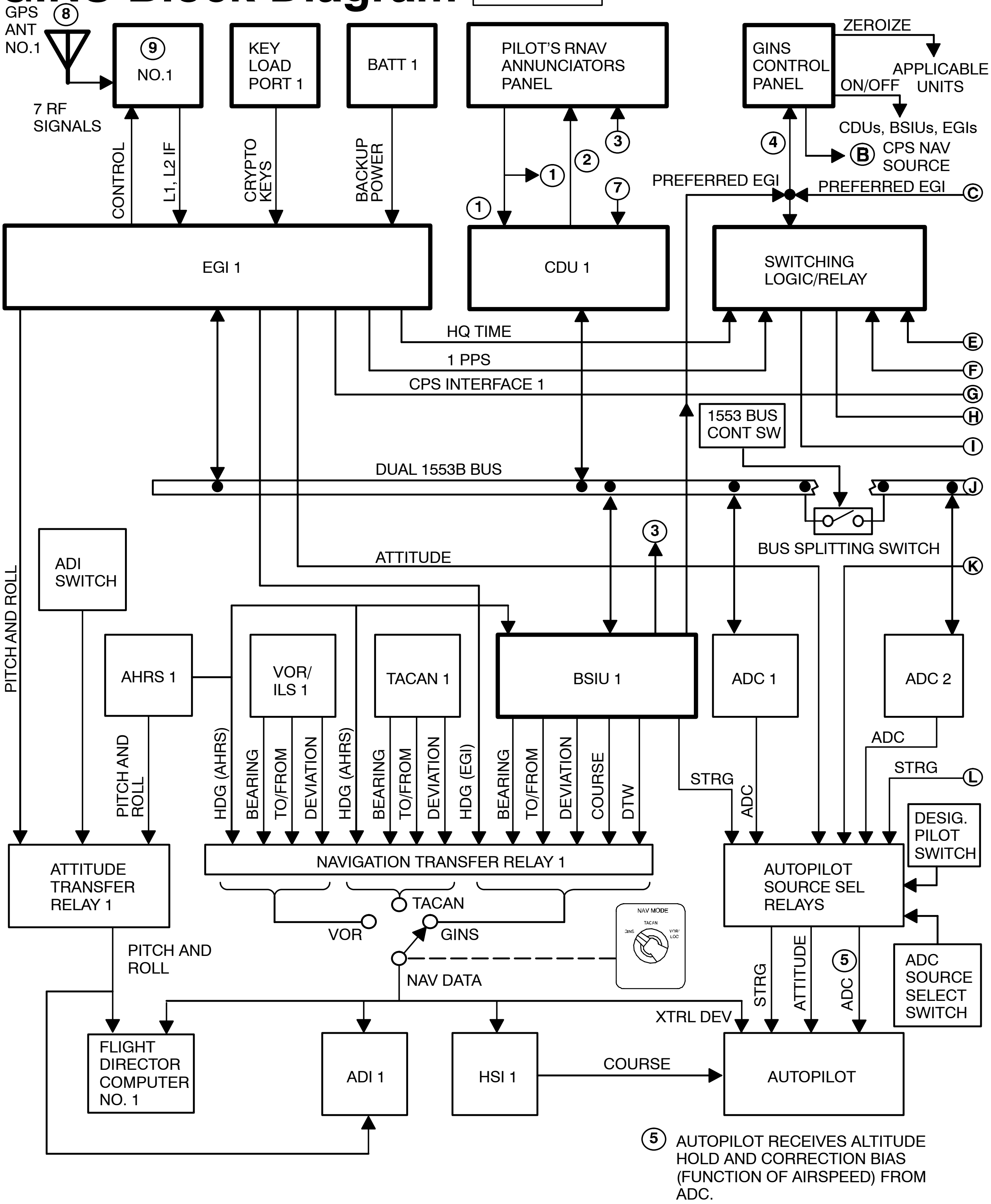
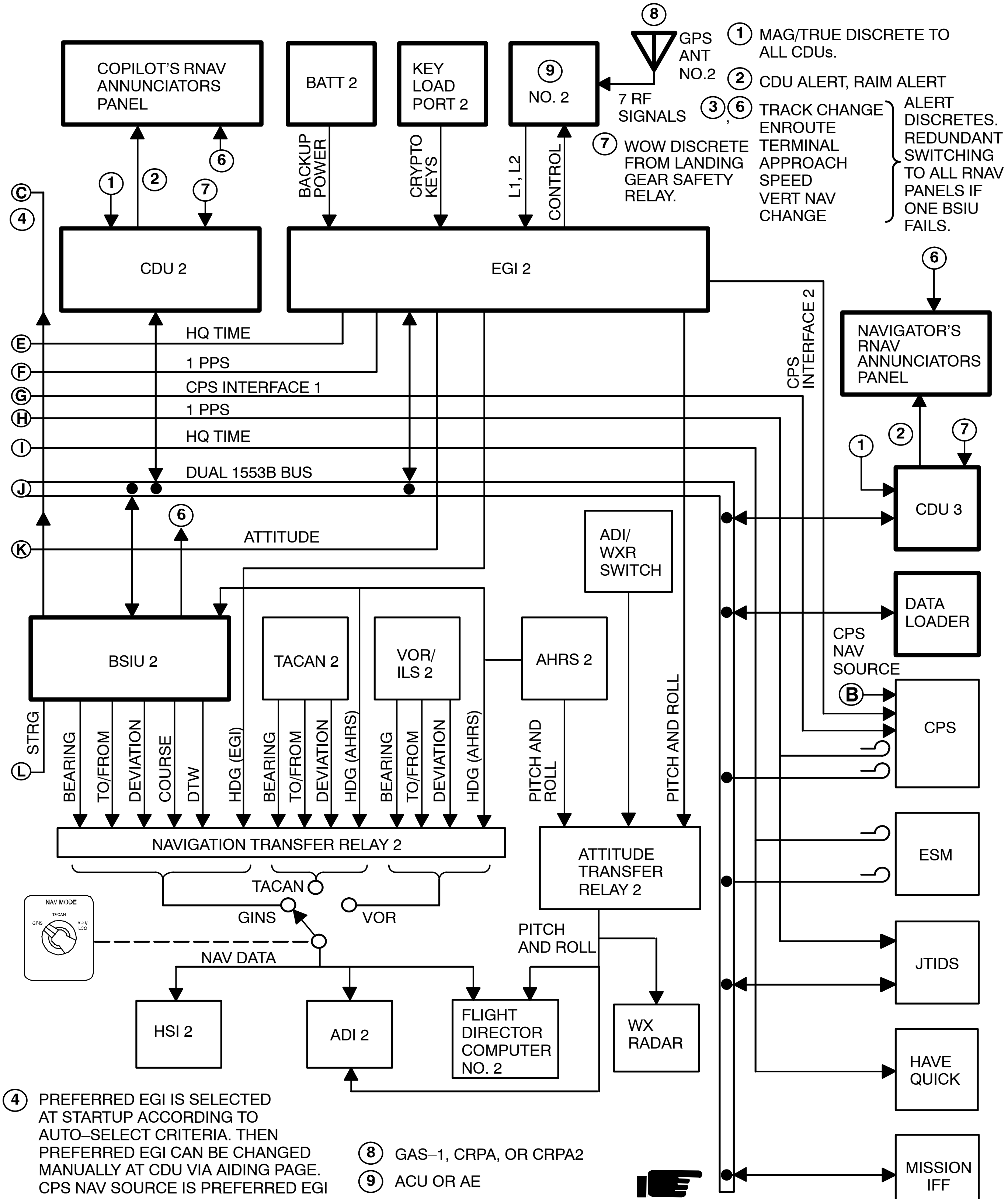
Figure 1-152 (Sheet 5 of 5)

GINS Block Diagram LESS IDG



⑤ AUTOPILOT RECEIVES ALTITUDE HOLD AND CORRECTION BIAS (FUNCTION OF AIRSPEED) FROM ADC.

Figure 1-153 (Sheet 1 of 4)



① MAG/TRUE DISCRETE TO ALL CDUs.

② CDU ALERT, RAIM ALERT

③,⑥ TRACK CHANGE, ENROUTE, TERMINAL, APPROACH, SPEED, VERT NAV CHANGE — ALERT DISCRETES. REDUNDANT SWITCHING TO ALL RNAV PANELS IF ONE BSIU FAILS.

⑦ WOW DISCRETE FROM LANDING GEAR SAFETY RELAY.

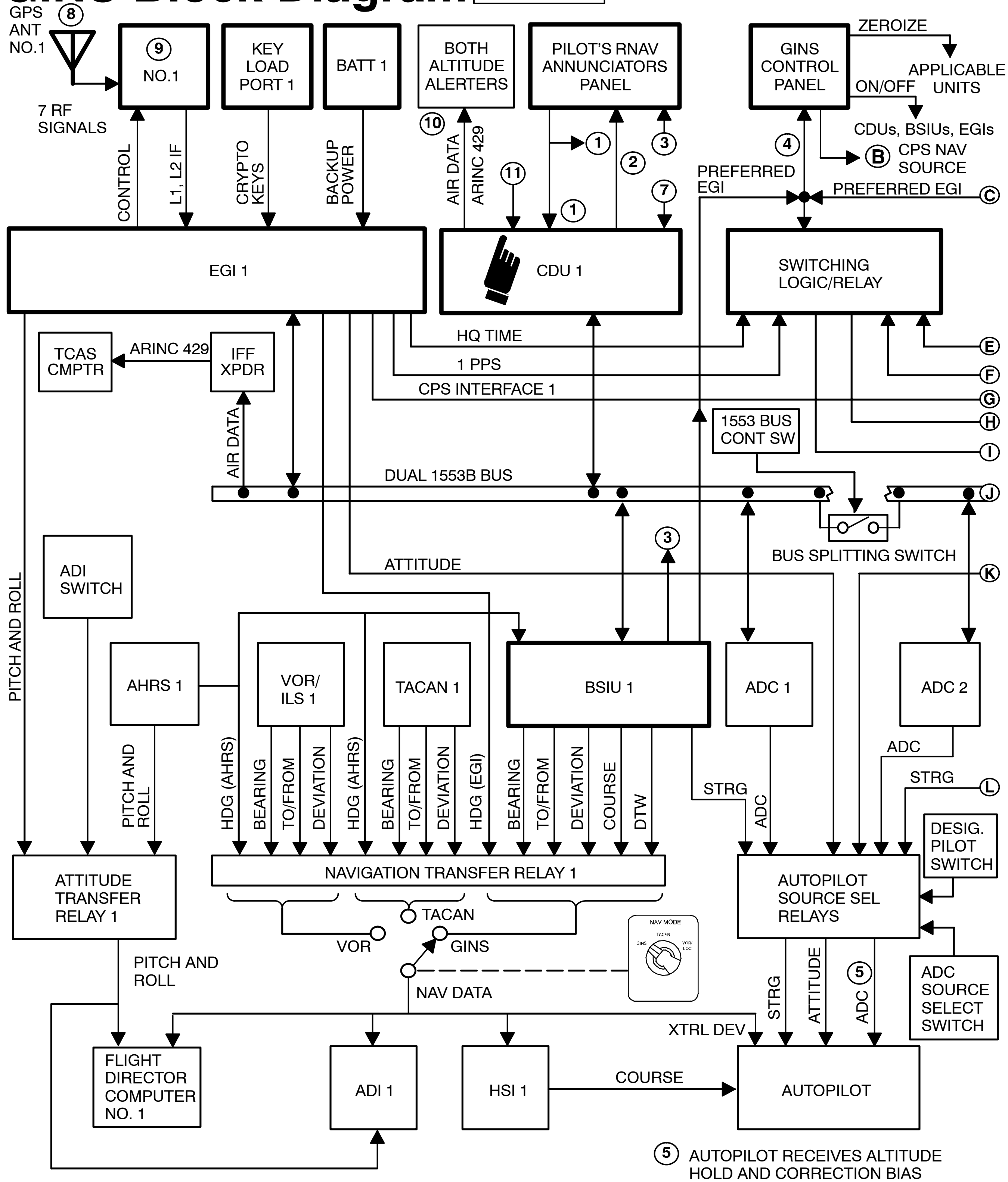
④ PREFERRED EGI IS SELECTED AT STARTUP ACCORDING TO AUTO–SELECT CRITERIA. THEN PREFERRED EGI CAN BE CHANGED MANUALLY AT CDU VIA AIDING PAGE. CPS NAV SOURCE IS PREFERRED EGI IF CPS NAV SOURCE SWITCH IS IN AUTO.

⑧ GAS–1, CRPA, OR CRPA2

⑨ ACU OR AE

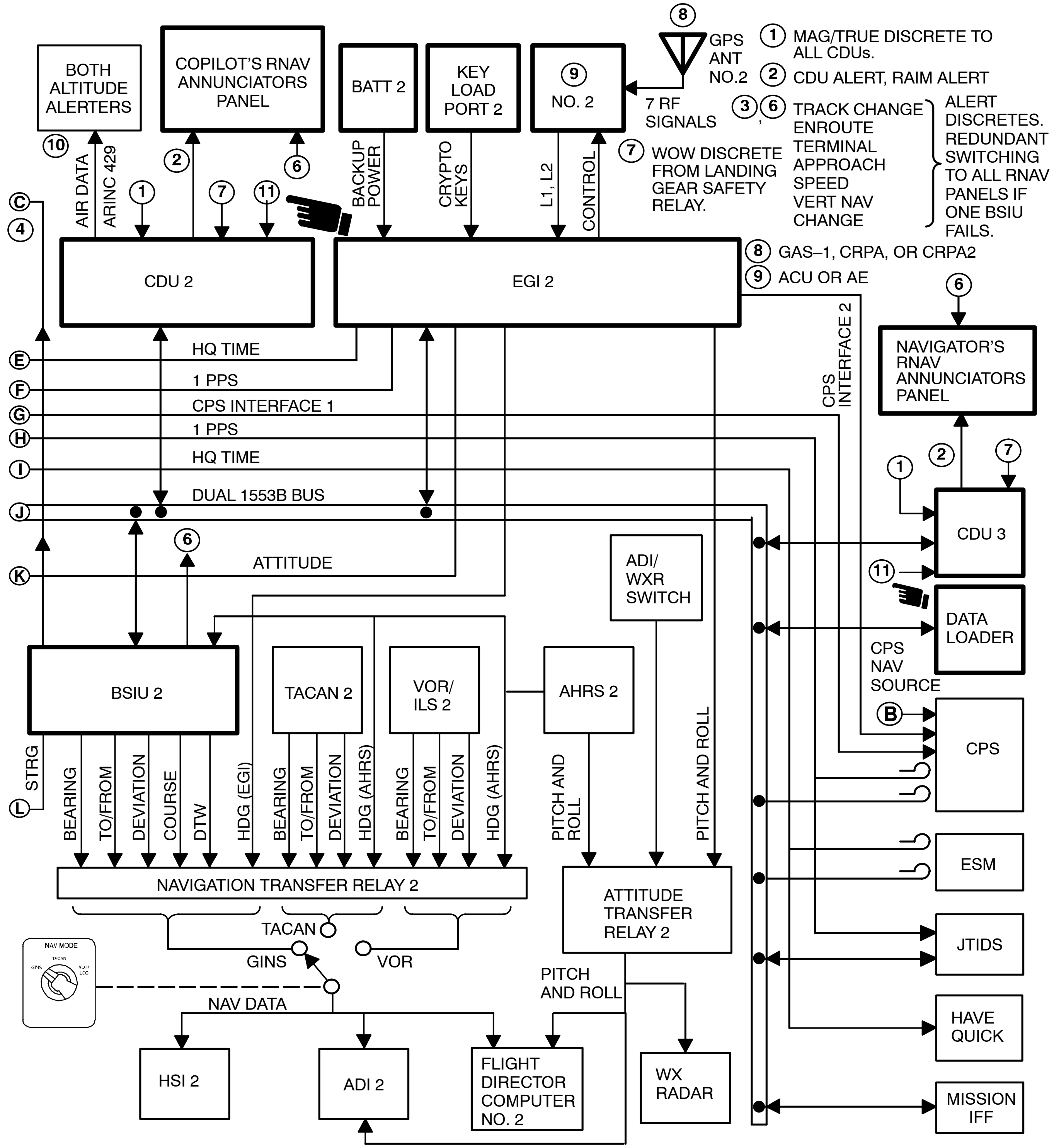
Figure 1-153 (Sheet 2 of 4) ◀

GINS Block Diagram WITH IDG



⑤ AUTOPILOT RECEIVES ALTITUDE HOLD AND CORRECTION BIAS (FUNCTION OF AIRSPEED) FROM ADC.

Figure 1–153 (Sheet 3 of 4)



④ PREFERRED EGI IS SELECTED AT STARTUP ACCORDING TO AUTO– SELECT CRITERIA. THEN PREFERRED EGI CAN BE CHANGED MANUALLY AT CDU VIA AIDING PAGE. CPS NAV SOURCE IS PREFERRED EGI IF CPS NAV SOURCE SWITCH IS IN AUTO.

⑩ ADC SOURCE SELECT SWITCH POSITION DETERMINES IF CDU 1 (ADC 1) OR CDU 2 (ADC 2) PROVIDES AIR DATA TO BOTH ALERTERS.

☛ ⑪ KEYLINE FROM UHF 19 FOR MODES 1, 2, 3/A IDENT USING THE MIC:ON SELECTION (IFF CONTROL PAGE, LS4, FIG 1–125C, SHEET 6.)

Figure 1–153 (Sheet 4 of 4) ◀

CDU Block Diagram

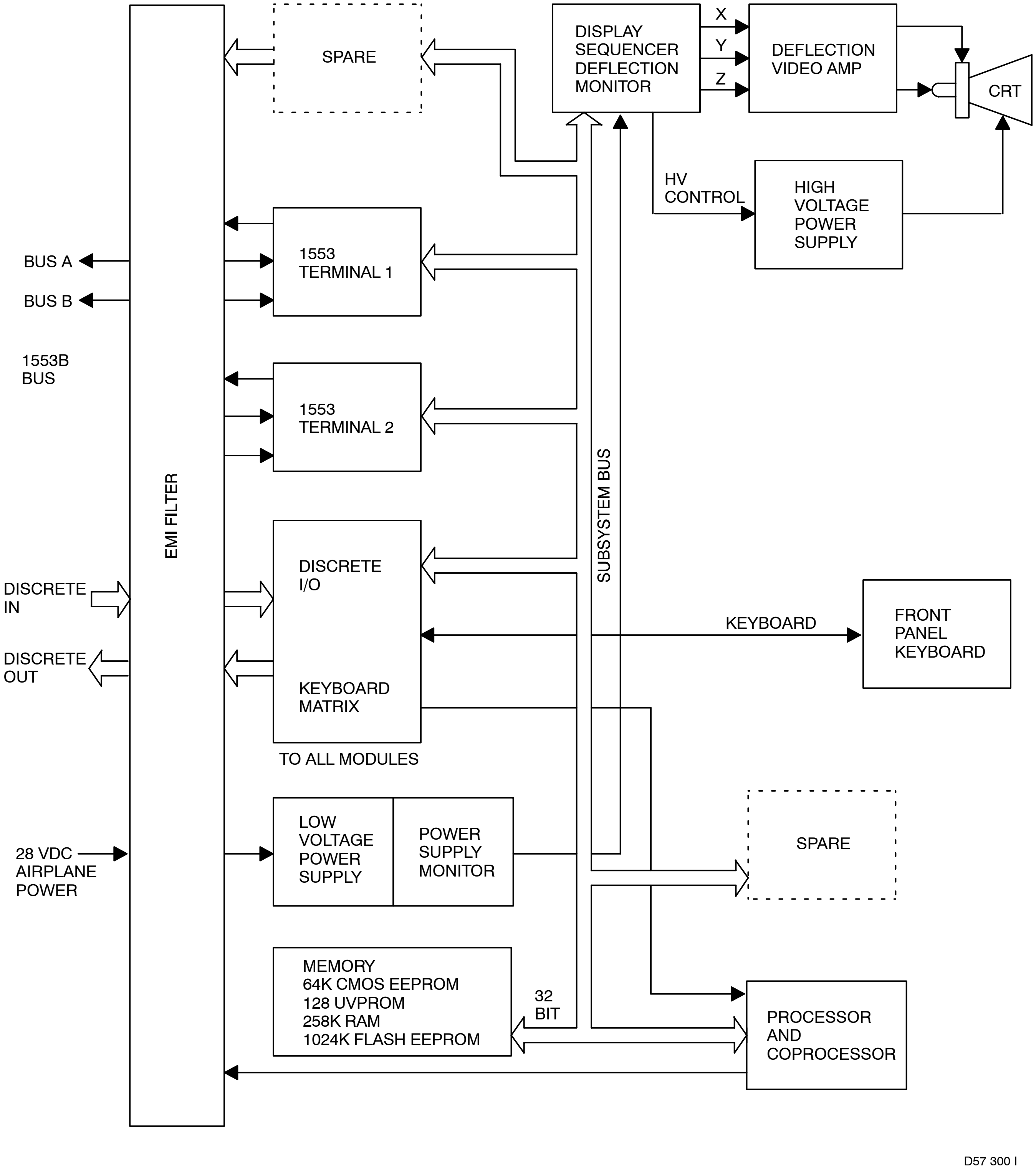


Figure 1-154

EGI Block Diagram

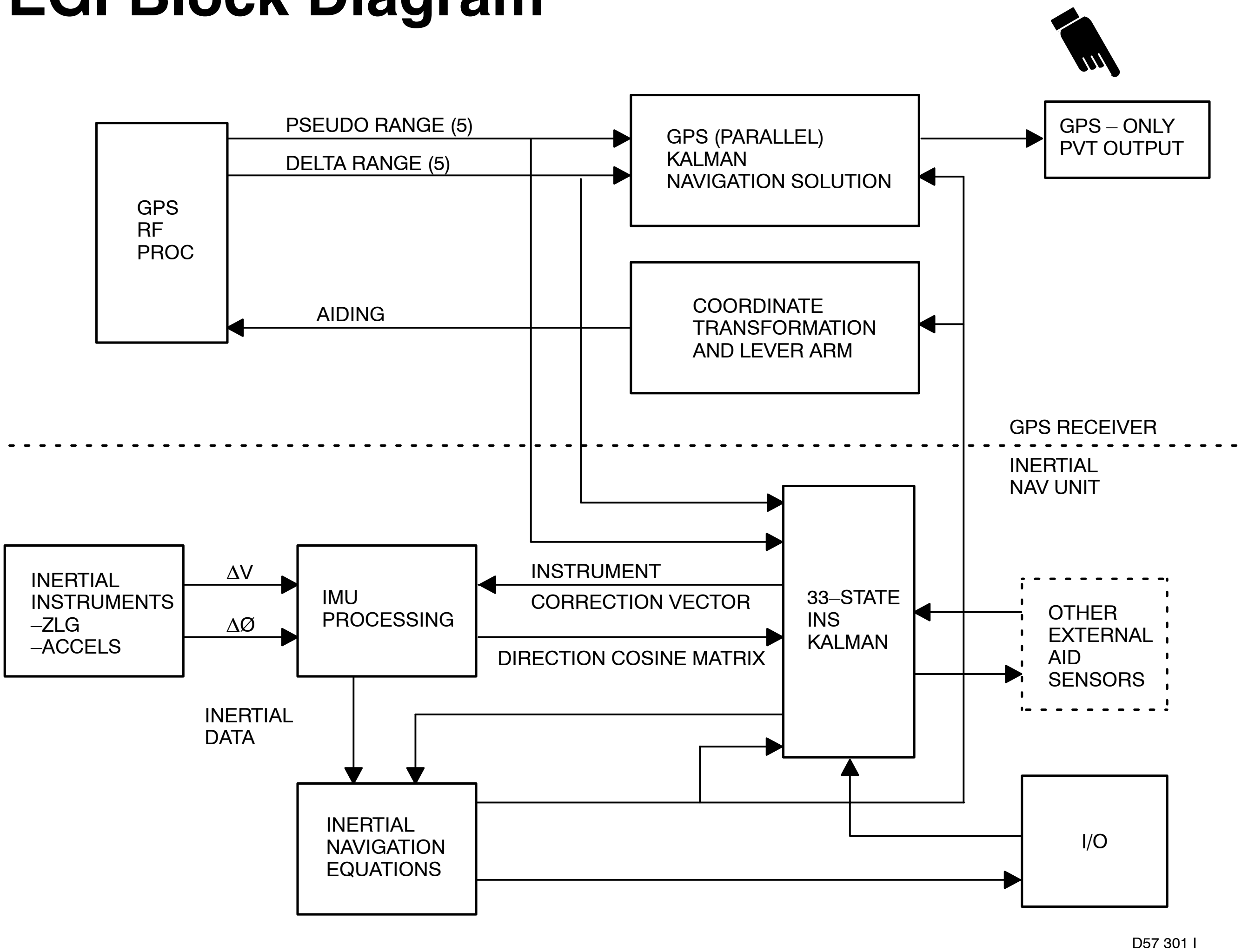


Figure 1-155

EGI THEORY OF OPERATION

Each EGI, operating as an integrated device, is an all–altitude navigation system, providing outputs of linear and angular acceleration, velocity, position, attitude (roll, pitch and platform azimuth), magnetic and true heading, altitude, body angular rates, time tags, and UTC synchronized time. It receives and processes power control commands, mode commands, initialization data, and pressure altitude data from the 1553 data bus, and GPS Intermediate Frequency (IF) data from the connected GPS antenna electronics unit. Each EGI transmits navigational outputs on the 1553 data bus, on the Control Power Supply data bus, as discrete outputs to the autopilot and also transmits commands to its connected antenna electronics unit. EGI navigational data on the 1553 bus can be GPS only, INU only and blended GPS/INU. The Embedded GPS Receiver (EGR) is capable of tracking a minimum of five space vehicles simultaneously. The EGIs can be operated in any physical orientation.

WITH RAIM RAIM/FDE Description

If a satellite suddenly becomes unstable, either in clock or orbit, its ephemeris data is useless. In this event, the GPS receiver might not know which satellite is causing the problem, but is nevertheless capable of notifying the user if the position envelope expands beyond allowable error limits for current scaling mode as shown on RNAV annunciator panels (3,4,5,8 in *figure 1-163*; and RAIM WRN, *figure 1-174* sheet 5B). This capability is called Receiver Autonomous Integrity Monitoring (RAIM).

A RAIM WRN status on the inav GPS screen and a RAIM ALERT light on the RNAV annunciators occur simultaneously. If a RAIM WRN/RAIM ALERT occurs, establish position by other navigation aids. Check the status of the other EGI. It is possible, but not considered likely, that a RAIM WRN/RAIM ALERT can occur on one EGI but not the other, since the source of the error is usually external. However, if a RAIM WRN and a COMPARE GPS annunciation occur simultaneously, then there is a very good chance that one EGI has a good position and and one EGI has an unreliable position. An immediate switch to the reliable EGI should be accomplished.

A NO RAIM annunciation occurs on the CDUs if RAIM processing is on and fewer than five satellites are visible (four for the navigation solution and one for channel five) or if GPS navigation is interrupted for more than 30 seconds, as can occur due to loss of a satellite signal or for other reasons. Even though a complete navigation solution can be obtained with only three or four satellites by use of earth radius via altitude aiding, RAIM processing does not occur when earth radius is used in the solution. NO RAIM overrides a RAIM WRN/RAIM ALERT.

De-selection of RAIM in a jamming environment can help retain signal acquisition.

A COMPARE GPS annunciation, *figure 1-174* sheet 5C, is generated by the controlling CDU if the two EGI GPS-only positions differ by a distance exceeding the requirements for the current scaling mode as indicated on the RNAV annunciator panels. If a RAIM WRN and COMPARE GPS occur simultaneously, there is a good chance that the other EGI has a better solution. If the non-preferred EGI has been deselected for cause, such as bad internal position, expect the COMPARE GPS annunciation during RAIM processing. If the COMPARE GPS annunciation occurs unexpectedly, try to determine which EGI is in error by comparing GPS-only and INU-only solutions or by use of other references, and select the better EGI.

If at least six satellites are visible, then, by comparing solutions using different combinations of satellites, the receiver can determine which is the bad satellite(s) and can replace the bad satellite with a good satellite in the navigation solution. This capability is called Fault Detection and Exclusion (FDE). The exclusion criteria are not related to scaling mode accuracy requirements and a change of scaling mode has no effect on exclusions. In addition to the five satellites currently received when RAIM is active, as many as three more candidate satellites can be evaluated periodically and held in queue in order to speed up the process of re-acquiring a solution in the event of an exclusion. In most cases if FDE is possible a RAIM WRN does not occur and no indication of an exclusion is provided to the user. If an exclusion occurs and it takes longer than 30 seconds to re-establish a navigation solution, then a NO RAIM annunciation occurs until the solution is re-established. The purpose of polling up to three candidate replacement satellites, is to prevent a NO RAIM from happening, however, maneuvering the airplane can cause satellites to be lost from view and cause a NO RAIM even under the best of conditions. ◀

Satellite Selection

Each EGI prioritizes the selection of visible satellites for initial acquisition, reacquisition and tracking. When four or more healthy satellites are available, the satellite selection function uses one or a combination of the following criteria to make this selection:

a. Geometric Dilution of Precision (GDOP)

b. All–In–View healthy satellites

c. User Range Accuracy (URA)

d. Elevation angle

e. Fixed set of satellites

f. Commanded selection

If the satellite selection criteria command the EGI to track a satellite or set of satellites that cannot be tracked, the EGI provides a message over the 1553 bus to alert the operator of this condition.

Each EGI is capable of resisting a specified level of spoofing attacks intended to deny or degrade the Position, Velocity, and Time (PVT) service.

Lever Arm Corrections

When attitude data is available each EGI has the capability to offset its GPS navigation solution, from its antenna to another point relative to the airplane. The offset point is located by lever arm coordinates, relative to airframe, stored in non–volatile memory. Each EGI can store two sets of lever arm coordinates. The set command is used to enter or change the lever arm coordinates. A label at the navigator’s station lists the lever arm coordinates required to offset a perfect GPS solution from the antenna to a point inside the E14 cabinet centered on the associated INU. These values prevent the fuselage distance from GPS antenna to INU from being a small but constant source of error between GPS position and INU position.

Boresight Values

Boresight values represent the angular difference between INU platform and mission radar so that pitch, roll and heading outputs of the selected EGI can be used to level and point (sight) the radar beam (bore), within the radar capability. The term boresight is adopted from systems used to aim and stabilize the gun bores on battle tanks and ships while the vehicle is moving. The boresight values to be loaded into the EGIs are shown on a label at the navigator's station, for maintenance use only.

World Models

Each EGI uses world models as defined by WGS-84, to develop the navigation reference. Each EGI can provide position definitions in, and transformations between, the following coordinate systems:

a. Altitude referenced to mean sea level or the selected local datum.

b. Horizontal angular quantities referenced to true, grid and magnetic north.

c. Horizontal position in local datum latitude/longitude and Military Grid Reference System.

EGI Altitude Aiding and Altitude Output

Each EGI INU receives and processes digital barometric altitude from an air data computer. Barometric altitude is used to aid INU computation of airplane radius from earth center. An INU, however, is capable of determining airplane radius from earth center inertially without barometric altitude aiding, if necessary. Digital barometric altitude aiding is also provided as an aiding input to each GPS receiver and is used to stabilize GPS geometric altitude, if available. If barometric altitude aiding is not available, GPS still outputs unaided geometric altitude.

If barometric altitude aiding is available, each EGI provides inertially smoothed barometric altitude to the mission data processor.

GPS geometric altitude is output via the 1553 bus to JTIDS. JTIDS does not use barometric altitude.

GPS Aiding From Other EGI

In event of failure of the internal GPS receiver in an EGI, each EGI can process the GPS Position, Velocity, Time (PVT) solution from the other EGI.

Magnetic Variation

Each EGI derives magnetic variation via a real time algorithm and 1553 inputs of date, latitude and longitude. The EGI is capable of updating the magnetic variation coefficients via the 1553 data bus. A 1553 input command is used to specify use of internal or external magnetic variation. When available, each EGI accepts digital or manual entry of magnetic variation with a range of plus or minus 180 degrees.

NOTE

The magvar algorithm is not used for NAVAID RPIDs. They are assigned actual station variation. This may be different than the magnetic variation calculated by the algorithm. A bearing to a point defined off of a NAVAID RPID using the offset bearing/distance function is based on station variation. This bearing can be slightly different from the desired track to the point from the RPID, which is calculated using the magvar algorithm.

Normal Start

The EGI initiates a normal start if the Embedded GPS Receiver (EGR) has a valid almanac, position and time. A normal start results in acquisition of sufficient satellites for normal operation in approximately two minutes.

Cold Start

In the absence of valid almanac data, the GPS collects satellite almanac data. This capability is also utilized when the EGI has been commanded into navigate mode and there are no visible satellites based upon initial position, initial time and almanac data. A present position estimate should be entered prior to cold start if the EGR does not already contain a position estimate. The EGR transitions into the normal start sequence when sufficient almanac and/or ephemeris data has been collected.

Embedded GPS Receiver

The EGR is able to receive C/A, P and Y codes, and can process L1 and L2 signals. Both L1 and L2 are used to compensate for ionospheric errors. If either L1 or L2 is unavailable, the performance is degraded in a manner consistent with the loss of the ionospheric error correction capability. The EGR is an IF receiver.

Multipath Signal Discrimination

To reduce acquisition of GPS signals which have traveled by indirect, often variable paths (multipath signals), the EGI incorporates an approach to enhance the acquisition of the most direct (non–reflected or delayed) signal. The EGI performs periodic testing for multipath conditions on each navigation channel and applies the results to avoid performance degradation.

Maneuver Resistance

EGI performance is required to be sustainable without degradation through maneuvers up to the maximum limits specified in *figure 1-156*.

EGI Maximum Dynamic Rates

	ROLL	PITCH	YAW
Angular Rate	420°/sec	420°/sec	420°/sec
Angular Acceleration	1500°/sec/sec	1500°/sec/sec	1500°/sec/sec
Note: All three axes can maneuver through any angle.			
	X	Y	Z
Linear Velocity	3937 ft/sec	3937 ft/sec	3937 ft/sec
Linear Acceleration	322 ft/sec/sec	322 ft/sec/sec	322 ft/sec/sec
Jerk	328 ft/sec/sec/sec	328 ft/sec/sec/sec	328 ft/sec/sec/sec

Figure 1-156

Free Inertial Only Navigation Solution

While operating in an autonomous (free inertial) mode, each EGI performs as shown in *figure 1-157*. This performance is available following the completion of a four-minute gyrocompass ground alignment at latitudes between 45°N and 45°S. At latitudes between 45° and 80°, extended alignment times of x minutes are probable where x is defined as follows:

$$x = \frac{2.83}{\text{cosine latitude}^\circ}$$

In addition, the multiplication factor, defined as x, above, is applied to True Heading in *figure 1-157* for latitudes between 45° and 80°. Each EGI senses platform pitch, roll, azimuth, body rates and accelerations and provides signals to interfacing avionics equipment. A free inertial navigation solution is available from each EGI at all times. The only source of external aiding input to the free inertial solution is the barametric altimeter.

The 0.8 nm/hour drift rate value displayed on an INU INAV page **WITH GA** prior to entering MODE NAV◀ for the INU alignment quality is the Circular Error Probable (CEP) free inertial performance. This means drift rates higher than 0.8 nm/hour may be experienced 50% of the time. The 0.8 nm/hour value should not be used to determine if the system is operating properly.

The manufacturer expects the EGI to provide a free inertial solution with a one nm/hour free inertial drift rate. EGI drift rates lower than two nm/hour can be expected 95% of the time. Drift rates in excess of two nm/hour can be considered abnormal performance, and therefore, maintenance should be informed of the observation. If a free inertial solution (INU1 or INU2) drifts more than two nm per hour (on a flight of two hours or more), annotate observation in AFTO Form 781.

Compute drift rate as follows:

a. Flights less than two hours are not long enough to quantify a drift rate. Drift on these flights should not be considered when determining if EGI maintenance is required.

b. The flight duration used for the drift rate is from takeoff time until the final parking position is recorded, or from completion of the last in-flight alignment until the final parking position is recorded.

c. Use the difference between the free inertial position and an accurate current position (a good GPS fix is the best source of true position). The easiest method is to use the difference observation on the INU INAV page, as long as the designated pilot's position is accurate.

d. Note any discrepancies observed during the alignment of the system. If the system is not aligned at the true start position, or if a poor in-flight alignment quality was observed (above 0.8 nm/hour, CEP), this could be the cause of the high drift rate, rather than an EGI problem.

INU Performance (Free Inertial)

PARAMETER	PERFORMANCE	METRIC APPROXIMATION
Position (CEP)	1 nm/hr ①	~1.9 Km/hr (1 hour)
LESS GA Position (95%) ◄	LESS GA 2.4 nm/hr ① ◄	LESS GA ~4.4 Km/hr (1 hour) ◄
WITH GA (95%) ◄	WITH GA 2.1 nm/hr ◄	WITH GA ~4.0 Km/hr (1 hour) ◄
Position (CEP)	0.8 nm/hr ②	~1.5 Km/hr (2 hour)
LESS GA Position (95%) ◄	LESS GA 2 nm/hr ② ◄	LESS GA ~3.7 Km/hr (2 hour) ◄
WITH GA (95%) ◄	WITH GA 1.7 nm/hr ◄	WITH GA ~3.1 Km/hr (2 hour) ◄
Altitude (RMS) ③	50 ft	~15 m
Velocity X,Y (RMS)	3.0 ft/sec	~0.9 m/sec
Velocity Z (RMS)	2.0 ft/sec	~0.6 m/sec
Acceleration X,Y,Z (RMS)	0.064 ft/sec/sec	~0.02 m/sec/sec
Pitch, Roll (RMS)	0.05 deg	
Platform Azimuth (RMS)	0.05 deg	
True Heading (RMS)	0.1 deg	
Magnetic Heading (RMS)	0.5 deg	
Pitch, Roll (synchro)	±0.1 deg	
Heading (synchro)	±0.1 deg	

① After less than two hours in navigation mode
② After more than two hours in navigation mode
③ Relative to barometric altimeter input

Figure 1-157

GPS Only Navigation Solution

After initialization, each EGI performs in accordance with classified requirements when employing Precise Positioning Service (PPS) and operating under specified satellite interface conditions. When employing Standard Positioning Service (SPS) and operating under specified satellite interface conditions, each EGI provides position information accurate to 100 meters (95% horizontal) and timing information accurate to less than 155 nsec RMS. The GPS Only navigation solution utilizes Y-code signals if available. If neither the Y-code signal nor the C/A-code is available, the GPS is reported not valid.

The Embedded GPS Receiver (EGR) computes a navigation solution once per second . This solution is provided to the BSIU where the GPS navigation data is combined with true airspeed from an air data computer and heading from an AHRS. These inputs compute smoothed navigation data ten times per second, which can be used for computation of bank angle commands to the autopilot.

GPS only operation does not preclude the use of INU data or other velocity sensor data to aid GPS tracking loops. In this mode, each EGI selects space vehicles in such a manner as to optimize navigation performance. The GPS only solution is available whenever four satellites are visible and being tracked, and heading and airspeed are available.

Aiding data from the INU or other aiding sensors can be input to the EGR during satellite acquisition and tracking in state 3 (see satellite data screen, *figure 1-174*). Aiding is turned on or off via data fields in the Aiding page when displayed on a CDU.

GPS/INU Navigation Solution

The GPS/INU (blended) solution does not degrade the available GPS only solution, nor cause the EGI performance to be degraded below the inertial only performance. For this solution, the output is the best estimate of position, velocity, time, attitude based on a combination of GPS, INU, and additional sensor data. The EGI provides a blended solution as shown in *figure 1-158*. The levels of performance specified in *figure 1-158* for SPS performance parameters are a function of SA and the indicated performance levels assume typical values for SA corruption. The blended solution is available at all times. The EGI processes GPS data inputs into the blended solution when tracking one or more satellites whenever the EGI estimates of GPS errors indicate that the GPS information can aid the EGI in providing the required performance.

The EGI uses both GPS and inertial data, when the inertial has been properly aligned per *figure 1-157,* or has successfully completed an IFA as described in Inflight Alignment/Update, and the GPS has been properly initialized per Normal Start or Cold Start description to produce the navigation solution for output. For this function, the inertial data as well as sensor inputs defined in the E-3 specification, are required not to degrade the available GPS performance. The GPS/INU external sensor aiding includes PVT from the other EGI or position updates from JTIDS navigation correction updates. The quality of the internal and external data determine aiding utilization.

Blended GPS/INU Performance

PARAMETER	PERFORMANCE
Position	
SPS	100 meters (95% Horizontal)
PPS	16 meters SEP
Velocity (RMS)	
SPS	N/A
PPS	0.1 m/sec
Time (RMS)	
SPS	<155 nsec
PPS	<100 nsec
Pitch, Roll (RMS)	0.05 deg
Platform Azimuth (RMS)	0.05 deg

Figure 1-158

In-Flight Alignment/UPDATE

When the inertial performance is poor due to incorrect or lost alignment, and GPS is available, an inflight alignment may be performed.

The EGI can perform IFA or realignment when the airplane is in motion. The operator can initiate an IFA by cycling affected EGI off, waiting 10 seconds, then repowering. Both SPS and PPS GPS signals support this mode. The IFA is complete when the alignment filter projects a free inertial accuracy equivalent to or better than that achieved with a normal gyrocompass alignment per *figure 1-157*. All three navigation functions (GPS/INU, GPS only, and INU only) are available after an IFA.

If the airplane takes off before a GC ground alignment has been completed, the INU transistions automatically to inflight alignment mode. Following a 30 second coarse alignment on the ground, the EGI completes the IFA within 5 minutes, providing there has been continuous GPS coverage with a 95% error of 0.1 nm or better.

NOTE

Do not taxi airplane within one minute of initiating ground alignment. Failure to comply can result in poor alignment quality and excessive INU drift rate.

If the IFA is initiated after airborne, without the benefit of a 30 second coarse ground alignment, the EGI completes the IFA in about 10 minutes, providing there has been continuous GPS coverage with a 95% error of 0.1 nm or better. The EGI utilizes host vehicle dynamics for IFA. In addition to GPS, the EGI continuously processes all manual input data and/or sensor data including GPS data from the other EGI and JTIDS navigation data via the 1553 data bus.

Estimated Horizontal Error

Each EGI monitors performance and computes an Estimated Horizontal Error (EHE) for the GPS Only and GPS/INU navigation solutions. The INU/GPS and GPS INAV pages display the expected position error for the three navigation solutions, defined as 95% ERR expressed in units of nm.

On the satellite data page the EGI makes available for operator display:

a. Which satellites are being tracked, and

b. Tracking state for the GPS-only and GPS/INU navigation solutions.

EGI Operating Modes

Off	
Initialization	Auto-Initialization Initial BIT Data Load Commanded Initialization
Alignment	Gyro Compass (GC) Directional Gyro (DG)
In-Flight Alignment	GPS aided
Navigate	Blended GPS/INU GPS only Inertial only
Test	Initial BIT (Startup) Periodic BIT (Automatic, interleaved on-line) Initiated BIT (off-line; not available in flight)

Figure 1-159

EGI Operating Modes

The EGI operating modes are as summarized in *figure 1-159*.

Off

OFF mode applies to both the EGR and the INU within the EGI. Upon receiving a power down command via the GINS control panel ON/OFF switch, the EGI performs an orderly shut down sequence, storing information in non-volatile memory to modify calibration values affecting inertial performance at the next power up. An orderly shutdown does not occur if power is removed from an EGI using circuit breakers. The EGI maintains a nonvolatile data base and allows **LESS RAIM** cold keying ◀ **WITH RAIM** cold or hot keying ◀ (insertion of Selective Availability/Anti-Spoofing codes) via the crypto key loader. Cold keying means with EGI off; hot keying means with EGI on.

Init

The EGI implements two Init modes: auto and commanded.

Auto Initiate

Following power on, the EGI enters the auto mode. While in the auto mode, the GPS data outputs are set to zero, null or invalid as appropriate. All input messages are received and processed and the EGI responds to all 1553 bus data requests. The following functions are enabled:

a. Self Test (set faults as required)

b. Loading of initial position, velocity, time (PVT) estimates

c. Performance monitoring and/or initialization testing

d. Coordinate systems transformations

e. Loading almanac data

f. Loading ephemeris data

g. Maintaining time estimate

Commanded Initiate

Commanded initiate mode applies only to the EGR. If it is determined that an EGR is not tracking SV, the operator may command the EGR into initiate mode by selecting the appropriate GPS INIT LS on the start 2 page.

WARNING

Pressing INIT GPS with frozen or inaccurate initial position corrupts the blended solution of the associated EGI. If this occurs to the designated pilot's solution and/or the preferred EGI while airborne, the autopilot turns the airplane and/or the mission situation display shifts to a new position, possibly dropping tracks.

Align

LESS RAIM The GC alignment mode applies only to the INU within the EGI. This is the primary inertial alignment mode. In this mode, present position is entered, then a gyrocompass alignment is performed in azimuth to determine the vehicle true heading. ◀ Heading becomes valid approximately one minute after initiation of alignment. This is indicated by Attitude Ready message displayed on the CDU and the removal from view of the heading flag on the HSI if GINS is selected on the pilot's or copilot's NAV Mode selector. During alignment, the INU computes, and makes available for display to the operator, information on alignment status. A 0.8 nm CEP is displayed on the INU INAV page if the alignment is successful. The EGI provides a NAV ready message via the 1553 bus when the INU can provide full GC performance in accordance with *figure 1-157*. An interruption of the GC alignment (due to taxi or movement without GPS data availability) prolongs the alignment time no more than the period of alignment suspension plus twenty seconds. If the NAV READY message is displayed, but the INU is still in ALIGN mode, the airplane can be moved with no adverse effect on the capability to transition directly to NAV mode.

NAV

The EGI maintains a best estimate of position, velocity, acceleration, time, attitude, heading, and body axis angular rates. In this mode the EGI utilizes all available sensor inputs, including inertial, GPS, and barometric altimeter to produce an optimal estimate of the vehicle state. When both GPS and inertial are fully operational, the performance is at least as good as *figure 1-158*. All three independent solutions (GPS only, blended GPS/INU, and INU only) are available for simultaneous output at all times.

Test

The EGI BIT is comprised of initial BIT, Periodic BIT (PBIT) and Initiated BIT (IBIT) as defined in the following three paragraphs:

Initial BIT

When the EGI is switched from off to any operating mode, initial BIT checks the system for faults and out–of–specification conditions. The initial BIT routine includes a combination of periodic and initiated BIT and emphasizes the testing of components that can cause total loss of navigation capability. EGI contains sufficient test provisions so that at least 95 percent of all electronic system failures result in an indication to the host platform.

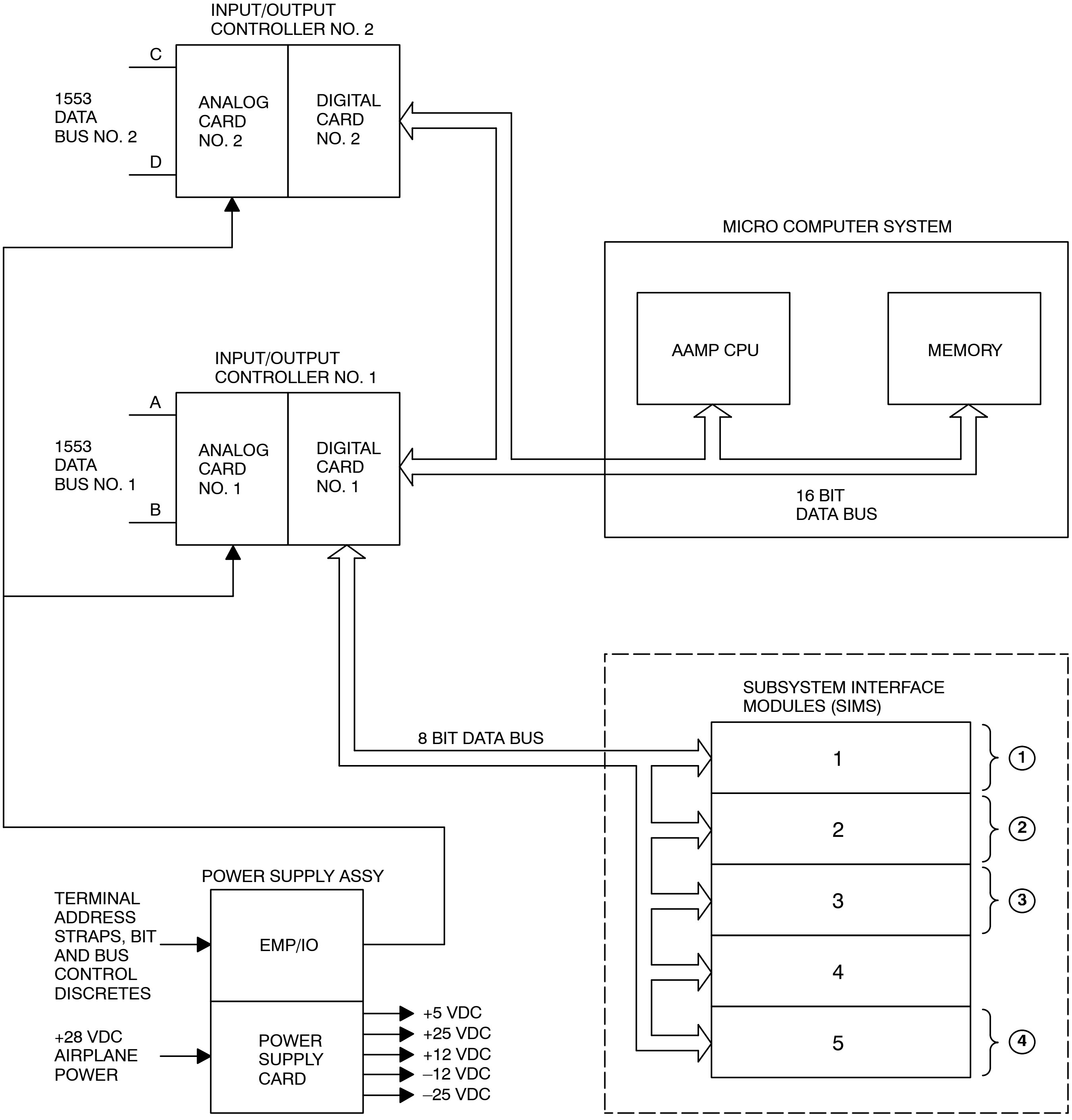
Periodic BIT

Periodic BIT (PBIT) operates automatically after completion of initial BIT. PBIT capable of performing preflight, postflight and in–flight diagnostics to detect faults and identify the faulty Shop Replaceable Unit (SRU).

Initiated BIT

IBIT is initiated by a bus command and is not available in flight. IBIT causes momentary suspension of INU alignment.

BSIU Block Diagram



NOTE

SEE SHEET 2 FOR ANALOG SIGNALS DETAILS.

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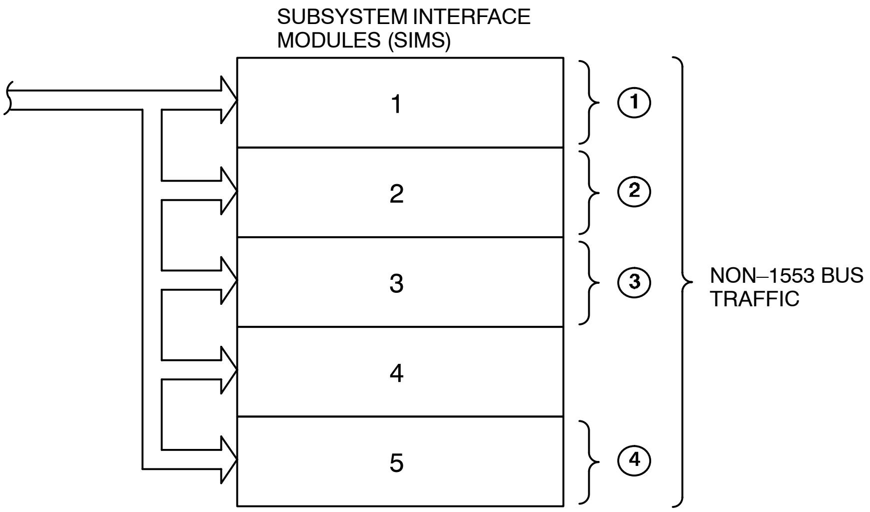
Figure 1-160 (Sheet 1 of 2)



①
- → NEXT WPT BRG; TO HSI
- → COURSE TO HSI
- ← 26 VAC EXCITATION TO SIM 1
- → WPT 10 SEC TRK CH ALERT TO ANNUNC PNLS
- → TOC/BOD 10 SEC ALT ALERT TO ANNUNC PNLS
- → SPEED ALERT TO ANNUNC PNLS

③
- ← 28 VDC AIRPLANE POWER
- ← MAG HEADING FROM AHRS
- ← MAG HDG VALID FROM AHRS
- → VERT. DEV. TO HSI AND ADI
- → BANK CMD VALID TO AUTOPILOT
- → BANK CMD DISPLAY TO HSI AND ADI
- → PREFERRED EGI DISCRETE TO GINS CONTROL PNL, AND TO SWITCHING RELAYS FOR ONE PPS AND HAVE QUICK SOURCE SELECTION.

②
- → ENROUTE ALERT ANNUNC PNLS
- → TERMINAL ALERT TO ANNUNC PNLS
- ← 26 VAC EXCITATION TO SIM 2
- → NAV VALID TO HSI
- → APPROACH ALERT TO ANNUNC PNLS
- ← 28 VDC AIRPLANE POWER
- → COURSE DEVIATION (L OR R) TO HSI
- → TO – FROM FLAG TO HSI

④
- → DISTANCE, HUNDREDS, DRUM DRIVE, TO HSI
- → DISTANCE, TENS, DRUM DRIVE, TO HSI
- → DISTANCE, UNITS, DRUM DRIVE, TO HSI
- → DISTANCE INVALID
- ← 26 VAC EXCITATION TO SIM 5

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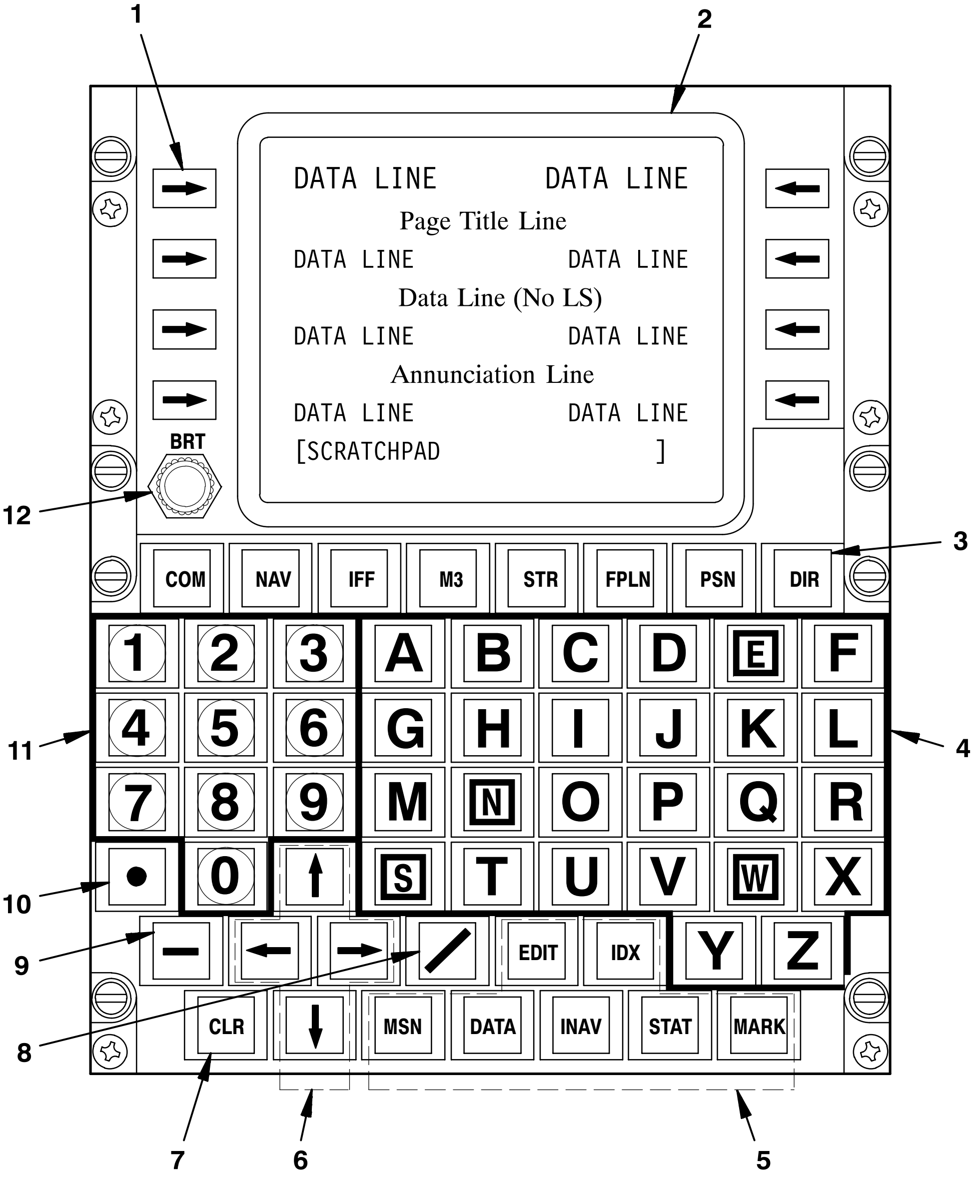
Figure 1-160 (Sheet 2 of 2)

GINS CDU Controls and Indicators



1. LINE SELECTS (LS) (8)
2. CRT DISPLAY
3. STANDARD FUNCTION KEYS (8)
4. ALPHA KEYPAD
5. STANDARD FUNCTION KEYS (7)
6. SCROLL (ARROW) KEYS (4)
7. CLEAR KEY
8. DELIMETER TO SEPARATE BEARING/ DISTANCE WHEN ENTERING OFFSET WAYPOINTS, TO SEPARATE MONTH/ DAY/YEAR WHEN ENTERING DATE, AND TO ENTER OR DELETE WAYPOINT NAMES
9. NEGATION OR DELETION KEY. [WITH – IN SCRATCHPAD, LS DELETES ITS DATA LINE]
10. DECIMAL POINT OR PERIOD
11. NUMERIC KEYPAD
12. CRT BRIGHTNESS ADJUSTMENT

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Figure 1-161 (Sheet 1 of 6)

NO.	CONTROL/INDICATOR	FUNCTION
1	Line Select (LS) Keys (8)	Used to access lower level pages, to toggle or advance mode/function, or to enter data. As referred to in this text, numbered top to bottom: LS1 refers to top left LS; LS5 refers to top right LS. CDU responds to LS entries within one second. System responds to LS according to symbolic aids as follows:
	If Display Arrow Points To LS: ← DATA LINE or DATA LINE →	LS advances to lower level display page.
	If Display Arrow Points To Line: → DATA LINE or DATA LINE ←	LS selects item or enables mode. Then asterisk appears: * DATA LINE or DATA LINE*
	If Asterisk Displayed: * DATA LINE or DATA LINE*	Function is on or enabled. Next LS press disables function and arrow returns to display indicating item is selectable: → DATA LINE or DATA LINE ←
	If Colon Displayed: : DATA LINE or DATA LINE :	LS rotates selection amongst several modes. Next press makes another selection.
	Brackets: [ ]	LS transfers data from scratchpad to brackets. Dashes [—— / —] indicate no data yet entered, or data cannot be computed but may be entered manually.
2	CRT Display	Eight lines of twenty–two characters each. Odd numbered lines 1, 3, 5 and 7 are data lines, in two–column format, right and left justified, with an LS key on the right pointing to right column, and an LS key on the left pointing to left column. Line 2 is page title. Line 4 is an unreserved data line (has no LS key). Line 6 is an annunciation line. Line 8 is a scratchpad where operator composes entries for transfer to data lines. Operator entries are all upper case letters. System–generated displays may contain lower case. If a computed output quantity is too large for its display field, display field is filled with asterisks.

Figure 1-161 (Sheet 2 of 6)

GINS CDU Controls and Indicators (Continued)

NO.	CONTROL/INDICATOR	FUNCTION
3	Standard Function Keys	Call up highest level display pages for:
	COM, NAV, LESS IDG IFF, M3 ◀	Not used.
	WITH IDG IFF	Accesses TCAS/IFF control pages.
	M3	Activates the IFF ident function or loads mode 3/A code from scratchpad. ◀
	STR	Accesses pilot and copilot steering pages.
	FPLN	Accesses flight plan pages for active flight plan.
	PSN	Accesses pilot and copilot present position and track pages.
	DIR	Enables immediate establishment of Direct – To waypoint.
4	Alpha Keypad	Writes to scratchpad. N, S, E, and W are boxed for quick identification for entering lat/lon.
5	Standard Function Keys	Call up highest level display pages for:
	EDIT	Accesses flight plan edit page.
	IDX	Index. Provides access to a variety of support functions required to operate and maintain the hardware.
	MSN	Not Used.
	DATA	Enables display of expanded data for any selected waypoint.
	INAV	Accesses comprehensive data pages for GPS, INUs, and GPS/INU navigation solutions.
	STAT	System Status. Accesses fault codes for Initiated and Continuous Built–In Test (IBIT and CBIT) for maintenance of LRUs.
	MARK	Writes present position into scratchpad and stores it in markpoint list.

Figure 1-161 (Sheet 3 of 6)

NO.	CONTROL/INDICATOR	FUNCTION
6	Scroll (Arrow) Keys	Scroll pages or lines of display, vertically or horizontally. Active when two/four–headed arrows displayed on CRT.
	↔	Horizontal scrolling is available.
	↕	Vertical scrolling is available.
	✥	Vertical and horizontal scrolling are available.
7	Clear Key	When scratchpad is not blank, one press clears last character entry; holddown repeats character deletion. When scratchpad is blank, acknowledges and clears system annunciations and error messages on line 6 or scratchpad, if any.
8	Slash Key (/)	Used as a delimiter between identifier/bearing/distance components of an offset waypoint entry (CID/320/13), or to enter name of a waypoint (/TOWER).
9	Negation or Deletion Key (–)	Negation: Used to enter negative numbers (negation), such as for a waypoint elevation below sea level. Deletion: When entered as only character in scratchpad, and a line select key is pressed, deletes data on line, if line contains editable data.
10	Decimal Point or Period	Decimal delimiter for floating point numeric entries. Alpha character (period) for non–numeric entries.
11	Numeric Keypad	Numeric keypad.
12	BRT Knob	CRT brightness adjustment. (Cannot burn CRT.)

NOTE

- When a CDU is first powered on from a cold start and has completed power–up BIT, it displays *Start 1 Position/Time page*. Power on operation from a non–cold start configuration displays last page accessed on that particular CDU.
- When a CDU is executing powerup BIT, a blank page with a self–test message is displayed. Upon completing test, CDU displays its last accessed page, except from cold start.

Figure 1-161 (Sheet 4 of 6)

GINS CDU Controls and Indicators (Continued)

NO.	CONTROL/INDICATOR	FUNCTION

- CDU page data is refreshed (rebuilt) by bus controller CDU at either one or five hertz or whenever operator activates a line select or arrow key. Refresh rate is one hertz unless otherwise specified for unique page requirements.

- If a CDU fails to detect valid display data for more than 3.5 seconds, it displays a blank page with No Input centered. Resumption of valid display data causes CDU to resume normal display operations.

- Depressing and holding an alpha or numeric key causes only one activation of the key (that is, alpha and numeric keys do not repeat if held).

- Software protection against stuck keys is programmed so that CDU identifies and ignores a stuck key until it is no longer stuck. The CDU treats stuck arrow keys as if the key were being held purposely. Once a different key is pressed, however, arrow key is then ignored like any other key until it is no longer stuck.

- Scratchpad is a buffer to hold alphanumeric keystrokes prior to executing an entry. Pressing any alphanumeric key causes corresponding ASCII character to appear left justified in scratchpad. If scratchpad contains nineteen characters, additional alphanumeric keypresses do not affect display.

- CLR key clears scratchpad. First press of CLR removes last character entered. Additional presses of CLR delete one character at a time. Depressing and holding CLR removes entire contents of scratchpad. To prevent unintentional deletions of scratchpad while pressing CLR, there is a 600 millisecond delay between deleting first character and entire scratchpad.

- Scratchpad is also used to display messages and data to operator as defined below:

  a. Overwrite current contents of scratchpad with a computer–generated message. First press of CLR deletes computer–generated message.

  b. Overwrite current contents of scratchpad with computer–generated data. Each press of CLR deletes right–most character; holding CLR key deletes entire scratchpad.

  c. Alternate a computer–generated message with operator scratchpad entry. Alternating rate is 350 milliseconds for computer–generated message and 650 milliseconds for operator entry. First press of CLR deletes computer–generated message and scratchpad display returns to displaying operator entry.

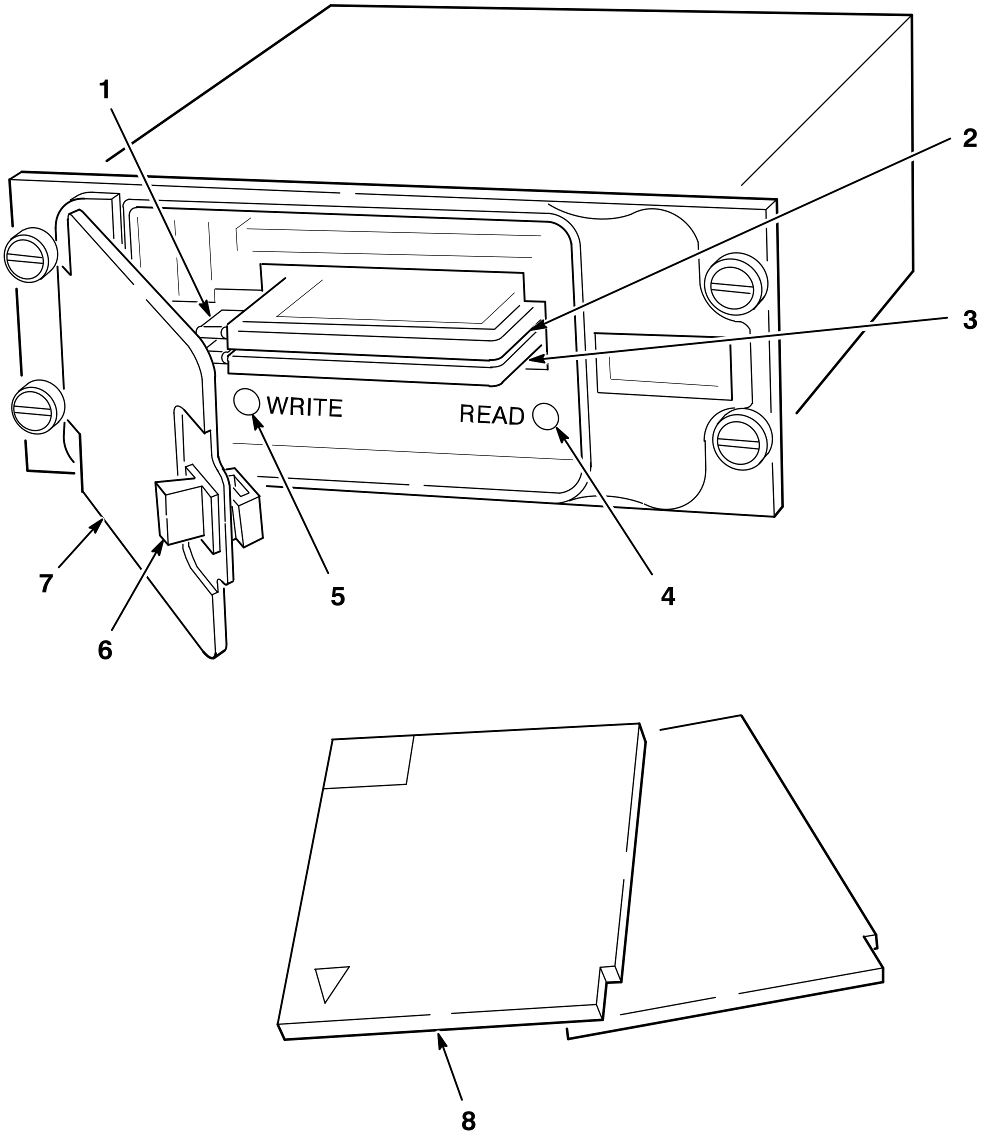
  d. Clear contents of scratchpad without CLR presses. For instance, if a line key is pushed for valid scratchpad entry, scratchpad is cleared.

Figure 1-161 (Sheet 5 of 6)

NO.	CONTROL/INDICATOR	FUNCTION
• Selection of certain functions that involve destruction of significant data or functions which significantly alter state of system require confirmation before execution. This condition is indicated when function is selected by displaying CONFIRM xxx in scratchpad, where xxx is a message unique to item requiring confirmation. Confirm scratchpad message is cleared by reselecting appropriate line select to confirm selection, or by pressing CLR if function is not required. • Operator enterable data can, in most circumstances, be copied into scratchpad so same data can be used for other functions without operator re–entry. After moving data from scratchpad to a data field, and scratchpad still empty, data can be duplicated from just–filled data field back to scratchpad by pressing data field line select. Data remains in data field, and is also available in scratchpad for repeated placement. If copy function is not specifically identified for a field, it is not applicable for that data. Generally not available where a toggle or page change function is involved. • Entering a – in scratchpad and pressing a line select key adjacent to a valid deletion field either deletes operator entered data or sets default value. Performing deletions on fields that have already been deleted or contain default value does not cause a change to field. If delete function is not specifically identified for a field, it is not applicable for that data. • Selection of DATA key prompts DATA FOR? message to be displayed in scratchpad. Selection of any operator entered waypoint in system displays Data page with information for selected waypoint. An attempt to call up Data page by selecting a non–position entry causes INVALID ENTRY scratchpad message to be displayed. • Annunciation line is reserved for page independent messages to flight crew advising them of system events which may require an operator response. Annunciation line is divided into two fields of variable length, left and right justified on line. Left field displays up to 12 characters; right field up to 9. Left and right fields have independent display queues and priority schemes. At any time, onset of conditions for a higher priority annunciation preempts display of a lower priority annunciation. Annunciations are removed from display queue in two ways: automatically by system when conditions causing activation are eliminated, or by operator pressing CLR with an empty scratchpad. See *figure 1-177*. Each CLR actuation clears highest priority annunciation from both fields and displays next lower priority annunciation. Some annunciations are non–clearable: CLR actuation displays next lower priority annunciation and places non–clearable annunciation back at bottom of display queue, non–clearable annunciations being always visible in a cyclic display queue until removal of conditions causing them. CLR deletes scratchpad messages and data before it affects annunciation line. Therefore, several actuations of CLR first delete scratchpad line entries and then reset annunciations displayed on annunciation line.		

Figure 1-161 (Sheet 6 of 6)

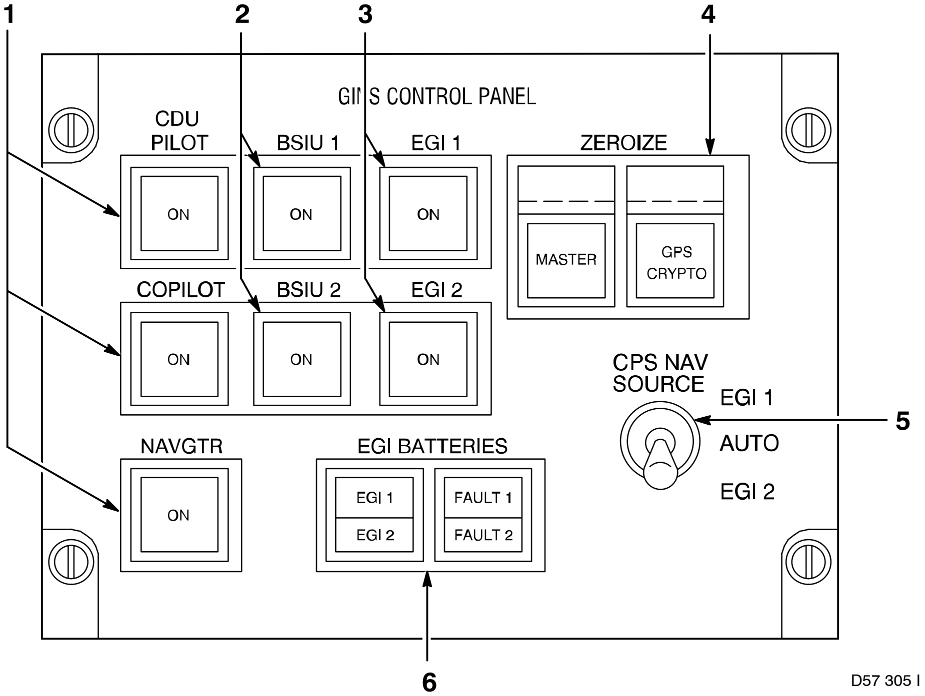
Mission Data Loader



1. CARD RELEASE BUTTONS (2)
2. SLOT 1
3. SLOT 2
4. READ INDICATOR
5. WRITE INDICATOR
6. LATCH
7. DOOR
8. FLASH MEMORY CARD (PCMCIA DATA CARD)

Figure 1–161A ◀

GINS Control Panel Controls and Indicators



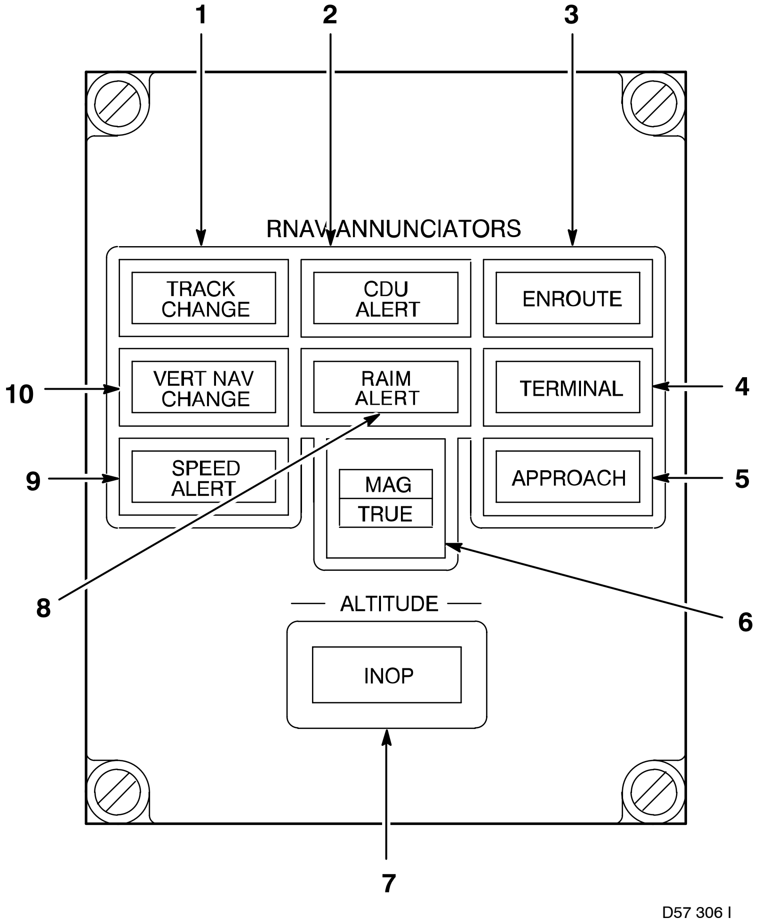
NO.	CONTROL/INDICATOR	FUNCTION
1	CDU Switch/ Indicators (Green)	When depressed, each applies power to CDU, as labeled. When released, removes power. Switch is illuminated ON in depressed position; blank in released position.
2	BSIU Switch/Indicators (Green)	When depressed, each applies power to BSIU, as labeled. When released, removes power. Switch is illuminated ON in depressed position; blank in released position.
3	EGI Switch/Indicators (Green)	When depressed, each applies power–on signal to EGI, as labeled. When released, removes power–on signal and causes loss of INU alignment as well as satellite reception. Switch is illuminated ON in depressed position; blank in released position.
4	ZEROIZE Switch/Indicators	When depressed, cause zeroizing functions as labeled.
	MASTER (White) (Guarded)	When depressed, causes zeroizing of all data in GINS that is subject to zeroizing, including data loader cartridge. Switch is illuminated MASTER in depressed position; blank in released position. **NOTE** Zeroized data includes EGIs present position, causing both EGIs to lose alignment and all navigation solutions to become invalid.

Figure 1-162 (Sheet 1 of 2)

NO.	CONTROL/INDICATOR	FUNCTION
	GPS CRYPTO (White) (Guarded)	When depressed, causes zeroizing of crypto codes only, in GPS receivers. Switch is illuminated GPS CRYPTO in depressed position; blank in released position. **NOTE** Depressing either ZEROIZE switch while the other is depressed interferes with intended functioning of both switches. Depress only switch whose function is wanted. Monitor zeroize results on lock – zeroize screen. See *figure 1-168*.
5	CPS NAV Source Switch	Selects AUTO or specified assignment of EGI source for navigation data to CPS.
	EGI 1 or EGI 2	Specifies a preferred EGI for CPS feed.
	AUTO	Allows CPS feed from preferred EGI, as selected by bus-controller CDU or as selected by LS3 key on CDU Aiding page. **NOTE** DAPG evaluates EGI nav data inputs, for validity, versus criteria contained in its software, and can switch its acceptance of EGI source independently of all other controls.
6	EGI BATTERIES Warning and Caution Lights	Indicate battery-on and/or fault condition.
	EGI 1 and EGI 2 Caution Lights (Amber)	When illuminated, indicate corresponding EGI is being powered by its battery.
	FAULT 1 and FAULT 2 Caution Lights (Red)	When illuminated, indicate corresponding EGI battery is failing one or more EGI-applied condition checks. Battery voltage, state of charge, and/or charger on-off status are uncertain.

Figure 1-162 (Sheet 2 of 2)

RNAV Annunciators Panel Controls and Indicators



NO.	CONTROL/INDICATOR	FUNCTION
1	TRACK CHANGE Indicator (White)	When illuminated, BSIU has sent signal that next turn is 10 seconds away.
2	CDU ALERT Caution Light (Amber)	When illuminated, CDU has issued a Master Alert. Check CDU screen and *figure 1-177*.
3	ENROUTE Indicator (Green)	When illuminated, BSIU has sent signal that GINS is in enroute scaling mode.
4	TERMINAL Indicator (Green)	When illuminated, BSIU has sent signal that GINS is in terminal scaling mode.
5	APPROACH Indicator (Green)	When illuminated, BSIU has sent signal that GINS is in approach scaling mode.

Figure 1-163 (Sheet 1 of 3)

NO.	CONTROL INDICATOR	FUNCTION				
		PILOT HSI & AUTOPILOT HEADING		COPILOT HSI HEADING		ALL CDU SCREEN DATA
6	MAG/TRUE Switch/Indicator (alternate action, connected for control at pilot position only)	PILOT NAV MODE SELECTOR		COPILOT NAV MODE SELECTOR		
		GINS	TACAN or VOR/LOC	GINS	TACAN or VOR/LOC	
	MAG (released position)	MAG from EGI 1	MAG from AHRS 1	MAG from EGI 2	MAG from AHRS 2	MAG from preferred EGI true and CDU Magvar
	TRUE (depressed position)	TRUE from EGI 1	MAG from AHRS 1	TRUE from EGI 2	MAG from AHRS 2	TRUE from preferred EGI

NOTE

- The annunciators indicate the same for all three positions, and indicate the GINS directional reference mode selected by pilot. Pilot selects GINS TRUE mode by setting MAG/TRUE switch to TRUE.

- RMIs display only AHRS magnetic heading, never GINS.

- CDUs never display AHRS magnetic heading.

- True heading always comes from the preferred EGI. The conversion from true reference to GINS magnetic reference uses one of two magvar databases, one contained in the bus controller CDU, the other contained in the preferred EGI. In order for the GINS MAG mode to function correctly the CDUs must have a worldwide magnetic variation (magvar) database in nonvolatile memory, and each waypoint in a flight plan must also have a magnetic variation (station declination) stored with it in the flight plan. If a magvar database exists at the time of waypoint selection for a flight plan, and the waypoint does not contain a declination from its database, the system then automatically computes and stores a magnetic variation with the waypoint as it is selected or entered into the flight plan. The magvar database is used to compute real time magnetic desired track displayed on the CDUs and HSI course arrows for present position. HSI magnetic heading in the GINS MAG mode is computed by the EGIs using the EGI magnetic variation database which is independent of the CDU worldwide magvar database.

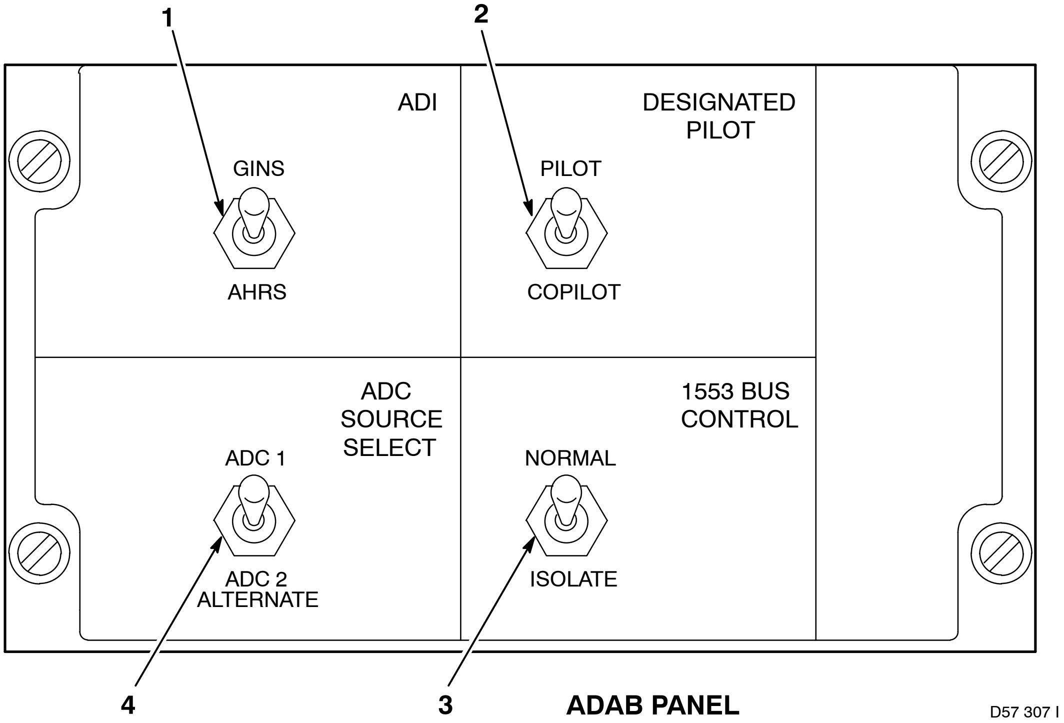
Figure 1-163 (Sheet 2 of 3)

RNAV Annunciators Panel Controls and Indicators (Continued)

NO.	CONTROL/INDICATOR	FUNCTION
7	ALTITUDE ALERT Caution Light (Amber)	Not used.
8	RAIM ALERT Caution Light (Amber)	When illuminated, indicates RAIM WRN status exists on preferred EGI inav GPS screen because the integrity alarm limit for selected scaling mode, as indicated on RNAV annunciator panels, has been exceeded for more than 10 seconds in enroute scaling mode or more than 2 seconds in approach or terminal scaling modes. (See *figure 1-174* sheet 5B, information line description, RAIM WRN status).
9	SPEED ALERT Caution Light (Amber)	When illuminated, indicates airplane speed is deviating from commanded speed by more than deviation range entered on data line 1 of CDU Pilot Steer Select page.
10	VERT NAV CHANGE Indicator (White)	When illuminated, indicates one of following, with details on CDU Flight Plan, Flight Plan Waypoint, Steer, and/or Vertical Steer page(s): Ten seconds prior to vertical capture, or to capture when a MAP is next TO waypoint. One thousand feet above BOD or below TOC.

Figure 1-163 (Sheet 3 of 3)

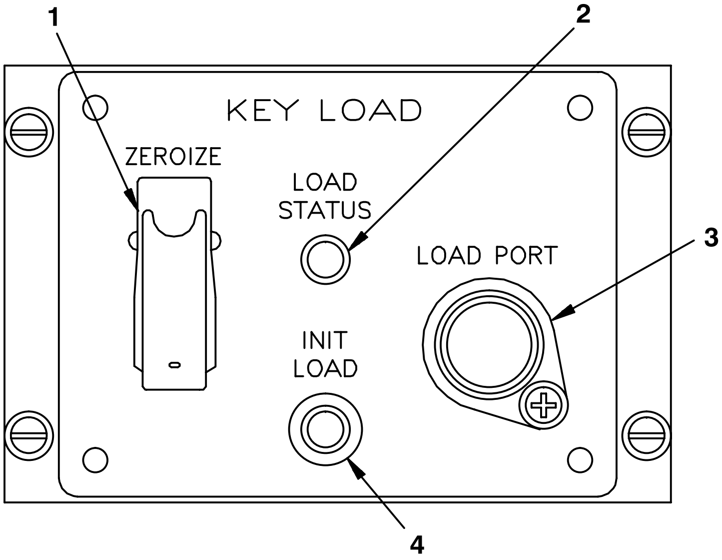
ADI/ADC/Pilot/Bus Select Panel Controls and Indicators



NO.	CONTROL/INDICATOR	FUNCTION
1	ADI Source Select Switch	Selects attitude source for ADI display and flight director computer. Also see NAVIGATION SYSTEMS INSTRUMENT switching.
2	DESIGNATED PILOT Selector Switch	Selects pilot or copilot steering for autopilot, default startup initialization, flight plan waypoint advance, turn anticipation calculation, and intercept calculation. Also see Pilot and Copilot Steer and Steer Select pages, this subsection.
3	1553 BUS CONTROL Selector Switch	When positioned to NORMAL, bus splitting switch contacts in 1553 bus are closed. All bus traffic is available to all terminals on bus. When positioned to ISOLATE, bus splitting switch contacts are open, isolating two sections of bus from each other. See GINS Block Diagram illustration, this subsection.
4	ADC SOURCE SELECT Switch	Selects air data computer source of altitude and airspeed inputs to autopilot, WITH IDG IFF transponder Mode S and altitude alerters.◀ Not redundant to CADC select function available on CDU Aiding Page.

Figure 1-164

GINS KEY LOAD Module Controls and Indicators



NOTE

- It is possible to load or zeroize SA/AS codes without airplane power and with all CDUs OFF. However, to confirm zeroization status, an EGI and a CDU must be operating (ac and dc power required).
- KEY LOAD MODULE 1: The LOAD PORT loads EGI 1 only, and the ZEROIZE toggle switch zeroizes EGI 1 only.
- KEY LOAD MODULE 2: The LOAD PORT loads EGI 2 only, and the ZEROIZE toggle switch zeroizes EGI 2 only.

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NO.	CONTROL/INDICATOR	FUNCTION
1	ZEROIZE toggle switch	Momentary switch; zeroizes crypto codes (but nothing else) in critical memory and also zeroizes crypto variables in receiver operating memory if receiver is powered up.
2	LOAD STATUS lamp	Illuminates within 5 seconds, for 1/2 second, after a crypto code is entered to indicate that loading is successful.
3	LOAD PORT connector	Receptacle for crypto key loader.
4	INIT LOAD (initialize load) pushbutton	Momentary switch; pressed to initialize (begin) loading of crypto codes. Codes are loaded into receiver critical memory only.

Figure 1-165

CDU OPERATION

COLD STARTS

The effects of CDU cold start are summarized below. The CDU performs a cold start when the capacitor–backed RAM has discharged from the previous powerup. Normal discharge time is approximately 30 seconds.

a. Pressing INAV displays the INU1/XXXX page.

b. Pressing STR displays pilot str page.

c. Pilot str select page, data line 1, XTK alert display defaults to dashes and scaling mode defaults to ENROUTE.

CDU BUILT–IN TEST

The CDU can perform three levels of BIT: Powerup BIT, Continuous BIT (CBIT), and Initiated BIT (IBIT).

Powerup BIT executes only during a cold start application of power. Any failures that are detected during powerup BIT are incorporated into the CBIT results, and failures are annunciated in the same manner as failures found during CBIT.

CBIT executes during normal operation with power applied to the CDU. Results of CBIT tests are available for display on the CDU Status page. Any CBIT failure in a CDU is annunciated to the crew via √STATUS display on CDU annunciation line.

IBIT executes only after specific action by the operator. IBIT causes the CDU to go offline, and RAM contents are destroyed during the test. The CDU displays the results of IBIT on the CDU Test page. The IBIT results shown on the CDU Test page are the results of the last IBIT performed.

NOTE

IBIT is inhibited by squat switch control function, to avoid interfering with navigation system operation in flight.

1553 BUS CONTROL

Each CDU operates on the 1553 bus as either a bus controller (BC) or a remote terminal/backup bus controller. Any single CDU has all the required resources to operate the system. The CDU that is functioning as bus controller performs all guidance computations, builds all page displays, communicates with all external equipment and performs all other computations required to support operation. The remote terminal CDUs process keystrokes and display pages built by the BC CDU and perform continuous BIT.

Each CDU contains identical bus control capability. Any CDU can function as the bus controller. All other CDUs then assume remote terminal status and act as backup bus controllers. Bus controller operation transfers between CDUs only occur when the current bus controller CDU is taken offline (via commanded self test, failures or bus disconnects) or the OFP load operation is commanded by the operator (ground only).

Normally, the first CDU powered on is the bus controller until some event causes the bus control function to be transferred. The transfer of bus control between CDUs is determined by lack of bus activity over a specified time interval. Each CDU is assigned a quiet bus time–out value, as shown below. A remote terminal CDU becomes a bus controller after it does not detect bus activity for a period of time that meets or exceeds its timeout value.

QUIET BUS TIMEOUT VALUES

LOCATION	TIMEOUT (MSEC)
Pilot CDU	600
Copilot CDU	900
Navigator CDU	1200

If a bus controller CDU detects non–commanded bus traffic, it reverts to remote terminal mode. The timeout scheme described above applies in order to regain bus control.

Bus Control Validity Checks

Detected BIT failures (except for non–volatile memory (NVM) and graphics generator status) cause a CDU to revert to remote terminal mode if it is a bus controller or prevent it from becoming a bus controller if it is in remote terminal mode. A failure in the bus controller CDU causes one of the other CDUs to become the new bus controller via the quiet bus timeout scheme.

Bus Controller Bus Retry Selection

The bus controller CDU hardware is responsible for retry bus selection. A single retry is initiated automatically by the bus controller CDU hardware whenever there is no response from the remote terminal.

The bus that is selected for the retry is dependent upon previous messages. When three consecutive failures have been detected on a remote terminal bus, that bus is marked as failed. Remote terminal buses are checked once per second; any failed buses are marked as passed upon the first successful message.

When a remote terminal bus is marked as failed, messages that are sent to that remote terminal are initiated on the opposite bus. When a retry is required and the opposite remote terminal bus has not failed, the retry is performed on the opposite bus. If the opposite bus has failed, the retry is performed on the same bus as the initial transfer.

Remote Terminal Bus Status Reporting

The CDU displays the bus status of remote terminals that it is communicating with on the Status pages. If both buses to a remote terminal have failed, the CDU annunciates the failure √STATUS to the operator via the CDU annunciation line.

Upon CDU powerup, all remote terminal buses are marked as failed until valid responses are received. This prevents nuisance failure annunciations and false fault history logs when equipment has not been powered up or is slower than the CDU to power up.

CDU NON–VOLATILE MEMORY MANAGEMENT

The CDU is capable of retaining selected data types through warm and cold starts. Also, the CDU retains some data when transitioning between being a bus controller or remote terminal through bus control swaps. Data that needs to be maintained through cold start power outages is stored in CDU NVM whereas data that is required to be maintained through bus control swaps might not be saved in NVM. Data that is stored in the NVM of one CDU is maintained in the NVM of the other CDUs also. This transfer of data occurs only when the remote terminal CDUs have the same software version as the bus controller CDU.

Data required to be maintained through cold start power outages and bus control swaps consists primarily of data that is entered by the crew. Also included are crew selected functional modes and system or display states. Other data that must be retained includes some data types that are stored on the data loader and system status data. Data that is required to be maintained only through bus control swaps includes the current page on each CDU and some crew selections and crew–entered data.

The two hundred reversionary reference point data base and its associated effectivity period that are obtained from a data loader cartridge are retained in CDU NVM.

The magnetic variation data base and its associated date/time stamp that is obtained from a data loader cartridge are retained in CDU NVM. This data base is updated any time a magnetic variation data base is available on the cartridge and the date/time stamp associated with the cartridge version is later than the date/time stamp associated with the version stored in CDU NVM.

System status failure data and a start date/time stamp are retained in CDU NVM. When a command is given to clear system status, the date and time of the request are used as the end date/time stamp for the stored period and the start date/time stamp for the new recording period.

LESS GA If valid (that is, not in NAV FAIL mode), the latitude and longitude of the designated pilot's steering source are retained in CDU NVM once upon each touchdown, to be used as a default for cold start power up conditions. ◀ **WITH GA** Upon aircraft touchdown, when the designated pilot's source ground speed falls below two knots, the designated pilot's steering source latitude and longitude are written initially to CDU NVM. The position is updated at one minute intervals for five minutes as long as ground speed remains below five knots. If ground speed rises above five knots, the process starts over again when ground speed falls below two knots. ◀ This position is also retained whenever the position is frozen using the FREEZE selection on the Start 1 Position/Time page.

Figure 1-166 contains a list of data types associated with each CDU page defined herein. For each data type, the table identifies if that data type is retained through bus control cold starts, through bus control swaps and whether or not the data type is local to the CDU (that is, the pilot's NVM data is local to the pilot CDU; copilot's and navigator's NVM data is local to their respective CDUs) upon which the information is displayed. Pages that do not retain crew selections (for example, Index 1 page) and pages that only display data (for example, GPS Integrated Navigation page) are not included in *figure 1-166*. Also, for CDU selections that require the display of an asterisk for three seconds, this asterisk display is not preserved through cold starts or through bus control swaps (this is not described in *figure 1-166*).

CDU Data Retention

ASSOCIATED PAGE	DATA TYPE	COLD START	BUS SWAP	LOCAL CDU
altn fpln	fpln replace select			
	rvrs altn select			
	erase altn select			
	fpln add select			
aiding	CADC1 aiding EGI1 select		X	
	CADC2 aiding EGI2 select		X	
	INU1 aiding GPS1 select		X	
	INU2 aiding GPS2 select		X	
	GPS1 aiding JTIDS select		X	
	INU1 aiding JTIDS select		X	
	INU1 aiding IFF select		X	
circle	lobe center location	X	X	
	lobe radius	X	X	
	estimated time of departure	X	X	
	left/right turn select	X	X	
closed random wpt	fwd/rev sequence select	X	X	
	estimated time of departure	X	X	
	pattern fix point	X	X	
	point in CRP	X	X	
chart datums	active datum	X	X	
data	FROM wpt/psn selection		X	X
	TO wpt/DIR TO entry		X	X
	ground speed		X	
	wpt/leg selection		X	X
	lat–long/mgrs selection		X	X
data loader 1	alternate flight plan number	X	X	
	master load select			
	master save select			
	altn load select			
	altn save select			
	MKPT/WPT load select			
	MKPT/WPT save select			
data loader 2	almanac load select			
	almanac save select			
	OFP load select			
	status save select			

Figure 1-166 (Sheet 1 of 5)

CDU Data Retention (Continued)

ASSOCIATED PAGE	DATA TYPE	COLD START	BUS SWAP	LOCAL CDU
debug	scrolling enable select			
	memory address			
	address mode select			
	entered data			
	display mode format			
egi1, 2 install	dist. INU aft of (x) GPS antenna		X	
	dist. INU port of (y) GPS antenna		X	
	dist. INU up (z) from GPS antenna		X	
	roll boresight		X	
	pitch boresight		X	
	yaw boresight		X	
figure 8	lobe center location, 1 and 2	X	X	
	lobe radius, 1 and 2	X	X	
	capture lobe indicator	X	X	
	estlimated time of departure	X	X	
	left/right turn select	X	X	
fms approach	glide path angle	X	X	
	touch down zone elevation	X	X	
	minimum descent altitude	X	X	
fpln	course	X	X	
	paralled course offset	X	X	
	position	X	X	
	auto/man sequence select	X	X	
fpln wpt	altitude	X	X	
	descent/climb select	X	X	
	TNAV time	X	X	
	max. bank angle	X	X	
	degrees/fpm select	X	X	
	vertical nav angle or degrees rate	X	X	
fuel	approach fuel allowance	X	X	
	extra weight/time selection		X	X
	extra fuel in weight	X	X	
	extra fuel in time	X	X	
	total weight/time selection		X	X
	total fuel (weight and hours)	X	X	
hold	IAS for holding	X	X	
	course	X	X	
	pattern length	X	X	
	EFC time	X	X	
	left/right turn select	X	X	

Figure 1-166 (Sheet 2 of 5)

ASSOCIATED PAGE	DATA TYPE	COLD START	BUS SWAP	LOCAL CDU
WITH IDG IFF Control	IFF Standby/Normal Microphone Key Select Emergency Mode Select IFF Antenna Select	X X X X	X X X X	
IFF Mode 1/2/3/C	Mode 1 Enable Mode 1 Code Mode 2 Enable Mode 2 Code Mode 3/A Enable Mode 3/A Code Mode C Enable	X X X X X X X	X X X X X X X	
IFF Mode 4	Mode 4 Enable Mode 4 Code Hold Mode 4 Audio Enable (Reply) Mode 4 Code B Select	X X X	X X X	
IFF Mode S	Mode S Enable Mode S Code AIS Code	X X X	X X X ◀	

Figure 1–166 (Sheet 2A of 5)

ASSOCIATED PAGE	DATA TYPE	COLD START	BUS SWAP	LOCAL CDU
init	time to climb	X	X	
	air distance to climb	X	X	
	fuel to climb	X	X	
	avg. climb wind speed/direction	X	X	
	total fuel prior to startup	X	X	
	zero fuel weight prior to start	X	X	
	ground fuel allowance	X	X	
intercept a wpt	position	X	X	
	target ground track	X	X	
	true/mag track select	X	X	
	target ground speed	X	X	
	along track trail distance	X	X	
	time of target report	X	X	
	fpln remove select			
intercept b wpt	TAS for alternate solution	X	X	
INU inav	enab nav			
INU nav data	pole type toggle		X	
leg 01a	initial point on leg 01	X	X	
	TO waypoint	X	X	
	leg TAS	X	X	
	leg wind aloft	X	X	
leg 01b	leg departure time	X	X	
	avg. fuel consumption rate	X	X	
	arrival time at end of leg	X	X	
leg 01c	desired altitude for VNAV	X	X	
	estimated loiter time	X	X	
	avg. fuel consumption rate	X	X	
	onload/off–load select	X	X	
	on/off load of fuel for leg	X	X	
	maximum bank angle	X	X	
lock–zeroize	three character password	X	X	
markpoint list	entered waypoint and mark time	X	X	
model aircraft	running/stopped toggle			
	model aircraft heading			
	model aircraft TAS			
	wind speed/direction			
	model aircraft altitude			

Figure 1-166 (Sheet 3 of 5)

CDU Data Retention (Continued)

ASSOCIATED PAGE	DATA TYPE	COLD START	BUS SWAP	LOCAL CDU
patterns	number of MOPs in flight plan	X	X	
	number of MOPs in alt. fpln	X	X	
pilot, copilot psn	millibars/inches select	X	X	X
	baroset (millibars & inches)	X	X	
pilot, copilot str	GS toggle select	X	X	X
	DA/TKE toggle select	X	X	X
pilot, copilot str select	XTK deviation alert distance		X	
	speed alert		X	
	crew selected source	X	X	
	scaling select		X	
racetrack	lobe center location, 1 and 2	X	X	
	lobe radius, 1 and 2	X	X	
	capture lobe indicator	X	X	
	estimated time of departure	X	X	
	left/right turn select	X	X	
refuel a	pattern initial point	X	X	
	pattern control point	X	X	
	pattern orientation			
	pattern width			
	estimated time of departure	X	X	
	pattern length	X	X	
	roll–out range	X	X	
refuel b	receiver true airspeed	X	X	
	turn relative bearing/range			
start 1 psn/time	position	X	X	
	freeze toggle	X	X	
	date			
	datum	X	X	
	UTC display toggle	X	X	
	UTC (time)			
start 2 nav/init	GPS1 initialization			
	GPS2 initialization			
	INU1 alignment type select	X	X	
	INU1 alignment initiate			
	INU1 auto select	X	X	
	INU2 alignment type select	X	X	
	INU2 alignment initiate			
	INU2 auto select	X	X	

Figure 1-166 (Sheet 4 of 5)

ASSOCIATED PAGE	DATA TYPE	COLD START	BUS SWAP	LOCAL CDU
start 3 fpln/load	altn number	X	X	
	altn load select			
	fpln erase			
	fpln replace			
	flt/data erase			
	flt/data load			
status (all)	on/off alert select		X	
	fail count	X	X	
WITH IDG tcas/iff control	TCAS sensitivity		X ◄	
test (all)	initiated test			
	IBIT word		X	
timers	timer 1 on/off select		X	X
	timer 1 entry		X	X
	timer 1 lap select		X	X
	timer 2 on/off select		X	X
	timer 2 entry		X	X
	timer 2 lap select		X	X
	timer 3 on/off select		X	X
	timer 3 entry		X	X
	timer 3 lap select		X	X
update	update source select			
	check point position			
	quality of position update			
	freeze			
waypoint list	waypoints	X	X	

Figure 1-166 (Sheet 5 of 5)

GINS TYPICAL OPERATION

The following operating sequences show how to use the CDU to accomplish typical operations with GINS. These sequences use illustrations of the applicable CDU screen pages, with accompanying explanations, to step through each operation. Comprehensive detailing of the CDU menus, grouped according to CDU major function key menu trees, is shown in *figures 1-167* through *1-175*. CDU alerts, annunciations and scratchpad messages, and annunciation line priorities, are compiled in *figures 1-176* through *1-178*.

INITIALIZATION PROCEDURES

With airplane electrical power available, and applicable circuit breakers closed, GINS equipment starts operating when powered up at the GINS CONTROL PANEL. The receivers seek satellites and process satellite signals; the first CDU powered up acts as bus controller (BC), sends out a continuous bus traffic sync signal stream, designates as preferred EGI the first EGI whose GPS data meets certain criteria, and performs other functions; the BSIUs convert a series of discrete solutions from the EGIs to a smooth analog signal for generating flight instrument displays and guidance data. The non–BC CDUs operate as remote terminals on the 1553 bus, able to process switch actions and to display screens concurrently and without mutual interference, and also to assume the BC function if it is dropped by the currently–acting BC.

A normal preflight GINS posturing procedure is as follows:

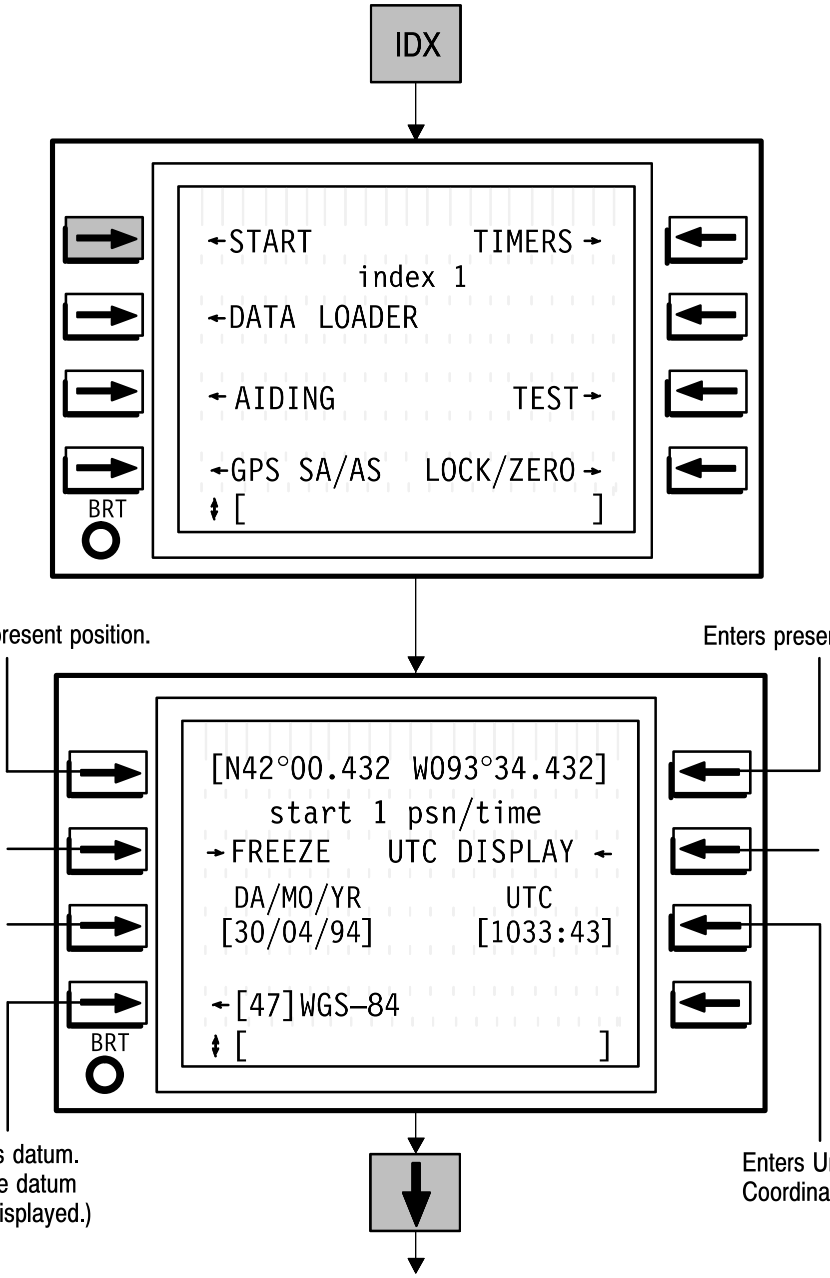
1. Verify or enter position, time, date and chart datum on the Start 1 Page. Normally, GPS provides correct position, time, and date shortly after GPS power is turned on.
2. If initial position or time is erroneous, enter correct values and initialize GPS on Start 2 Page.
3. Initiate alignment on Start 2 Page. If automatic switching to navigate mode is desired, select AUTO NAV. This causes INU to switch to navigate mode upon completion of minimum alignment requirements.
4. Scrolling to Start 3 Page, verify effectivity date of ICAO data base is correct. If a new flight plan and mission data are to be entered manually, select ERASE FPLN. If a new plan is to be loaded from cartridge, first enter desired flight plan number or toggle to desired number and then select ALTN LOAD. After loading is complete (asterisk disappears), select FPLN REPLACE. This transfers alternate flight plan data into active flight plan so that both plans are identical at beginning of mission. Also, crew select FLT/DATA LOAD to load all remaining preplanned mission data, including waypoint and markpoint list points.
5. Access Pilot and Copilot Steer Select Pages to select navigation solution sources for pilot and copilot guidance displays. Set flight phase to ENROUTE, and XTK alert limit as desired. See *figure 1-170*.

After selection, each navigation solution source has its own display page (INAV page) that shows current position and navigational status. Refer to NAVIGATIONAL SOURCE DISPLAYS, this subsection, and *figure 1-174*.

NAVIGATIONAL CHART DATUMS

The USAF standard chart datum is WGS–84. If the crew enters a – as the Start 1 Page chart datum, the system defaults to datum 47, WGS–84.

START 1 POSITION/TIME INITIALIZATION



Enters present position.

Enters present position.

Freezes/unfreezes position on line 1.

Displays UTC on annunciation line (or remove).

Enters date.

Selects datum. (Ensure datum 47 is displayed.)

Enters Universal Coordinated Time.

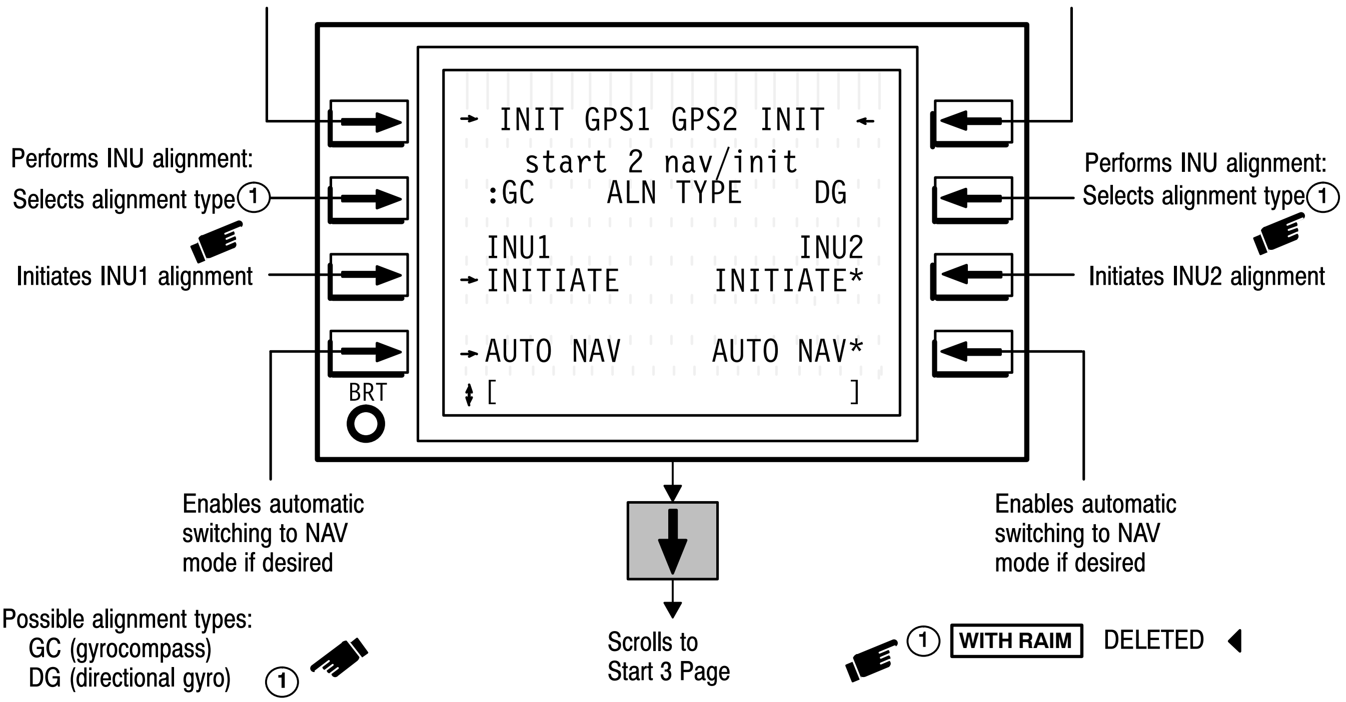
Scrolls to Start 2 Page.

NOTE

Position, time, and date are updated periodically with GPS data when it is valid.

D57 309 I

START 2 NAVIGATION/INITIALIZATION



Commands GPS1 initialization.

Commands GPS2 initialization.

Performs INU alignment:
Selects alignment type ①

Initiates INU1 alignment

Performs INU alignment:
Selects alignment type ①

Initiates INU2 alignment

Enables automatic switching to NAV mode if desired

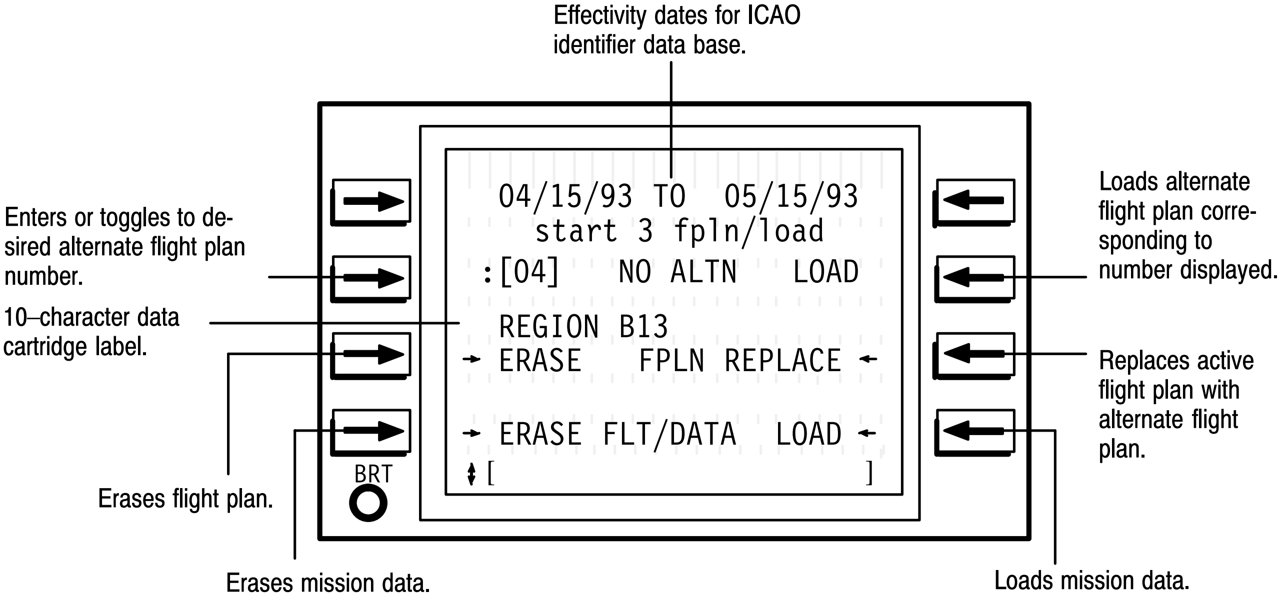
Enables automatic switching to NAV mode if desired

Possible alignment types:
GC (gyrocompass)
DG (directional gyro) ①

Scrolls to Start 3 Page

① **WITH RAIM** DELETED ◀

START 3 FLIGHT PLAN/LOAD



Effectivity dates for ICAO identifier data base.

Enters or toggles to desired alternate flight plan number.

10–character data cartridge label.

Erases flight plan.

Erases mission data.

Loads alternate flight plan corresponding to number displayed.

Replaces active flight plan with alternate flight plan.

Loads mission data.

NOTE

If no ICAO identifier data base is available, line 1 displays the effectivity dates of CDU reversionary data base if one exists.

D57 310 I

FLIGHTPLAN FUNCTIONS

The active flight plan is an ordered list of up to 60 waypoints, stored in the order they are to be flown. See *figure 1-169*. The flight plan is maintained through addition, modification or deletion of waypoints. When a waypoint is passed, it is retained in the flight plan history list, where the last five such passed waypoints are maintained in order. History waypoints can be viewed by scrolling the Flight Plan Page upward. The crew can delete history waypoints (using a – entry), but can not enter waypoints into history.

The guidance function assists in execution of the flight plan by determining deviations from the desired flight plan and controlling the sequencing of waypoints. When automatic leg advance is selected, a switching point is determined as a function of ground speed and magnitude of course change to provide turn anticipation. An alert is generated 10 seconds prior to reaching the switching point for the next leg.

The waypoint to which all flight instrument and CDU guidance displays are referenced is referred to as the active or TO waypoint. Pressing the FPLN key on the CDU accesses their Flight Plan Page with the active waypoint displayed as the ↓to↓ (or ↓from↓) waypoint. Associated with the active waypoint are the following parameters which are displayed on the Flight Plan Page:

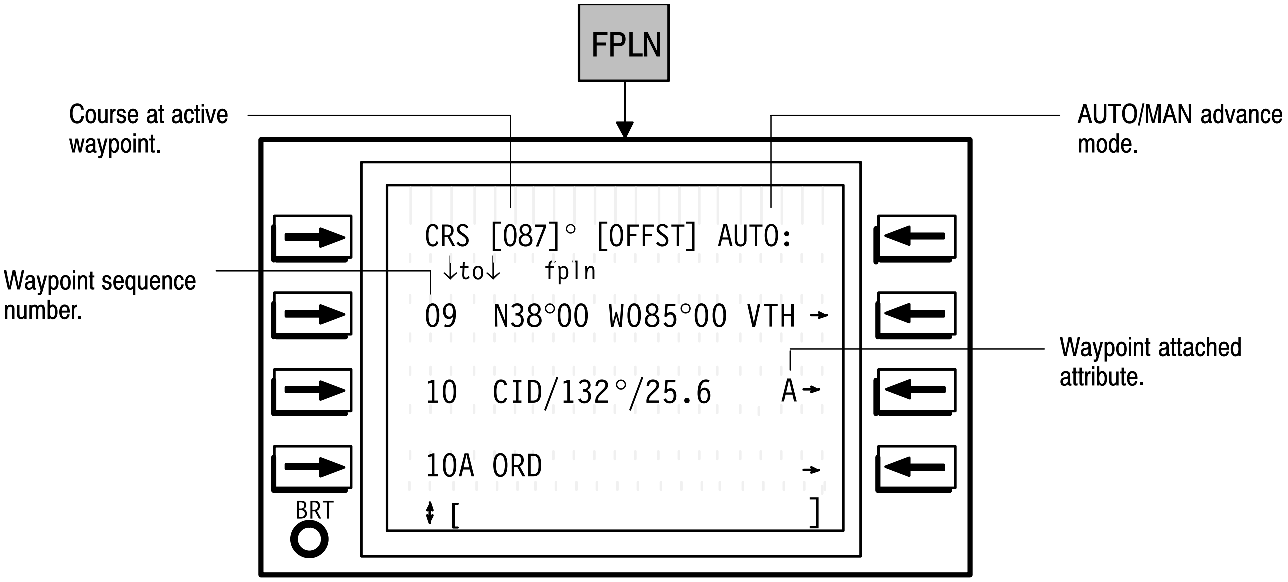
a. Current desired inbound course measured at the waypoint (not current desired track)

b. Waypoint number in flight plan sequence

c. User – defined label (optional)

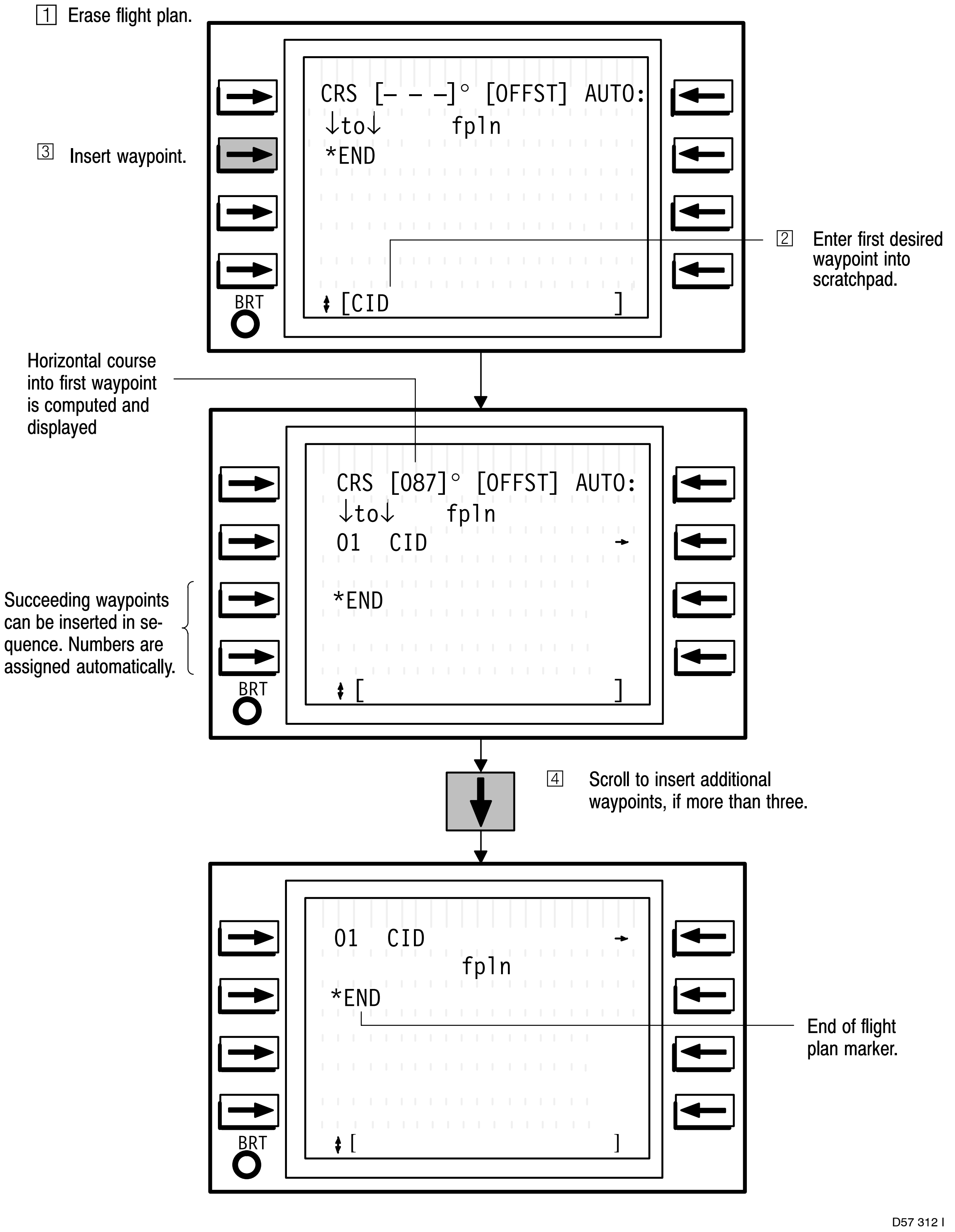
d. Waypoint attached attribute (such as hold)

The Flight Plan Page is shown below as it appears when initially accessed. See also screens following, and *figure 1-169*.



```
CRS [087]° [OFFST] AUTO:
 ↓to↓   fpln
09  N38°00 W085°00 VTH →
10  CID/132°/25.6    A→
10A ORD                →
↕[                      ]
```

INSERTING FLIGHT PLAN WAYPOINTS IN SEQUENCE



1 Erase flight plan.

3 Insert waypoint.

2 Enter first desired waypoint into scratchpad.

```
CRS [- - -]° [OFFST] AUTO:
↓to↓      fpln
*END

↕[CID                    ]
```

Horizontal course into first waypoint is computed and displayed

Succeeding waypoints can be inserted in sequence. Numbers are assigned automatically.

```
CRS [087]° [OFFST] AUTO:
↓to↓    fpln
01  CID                  →

*END

↕[                       ]
```

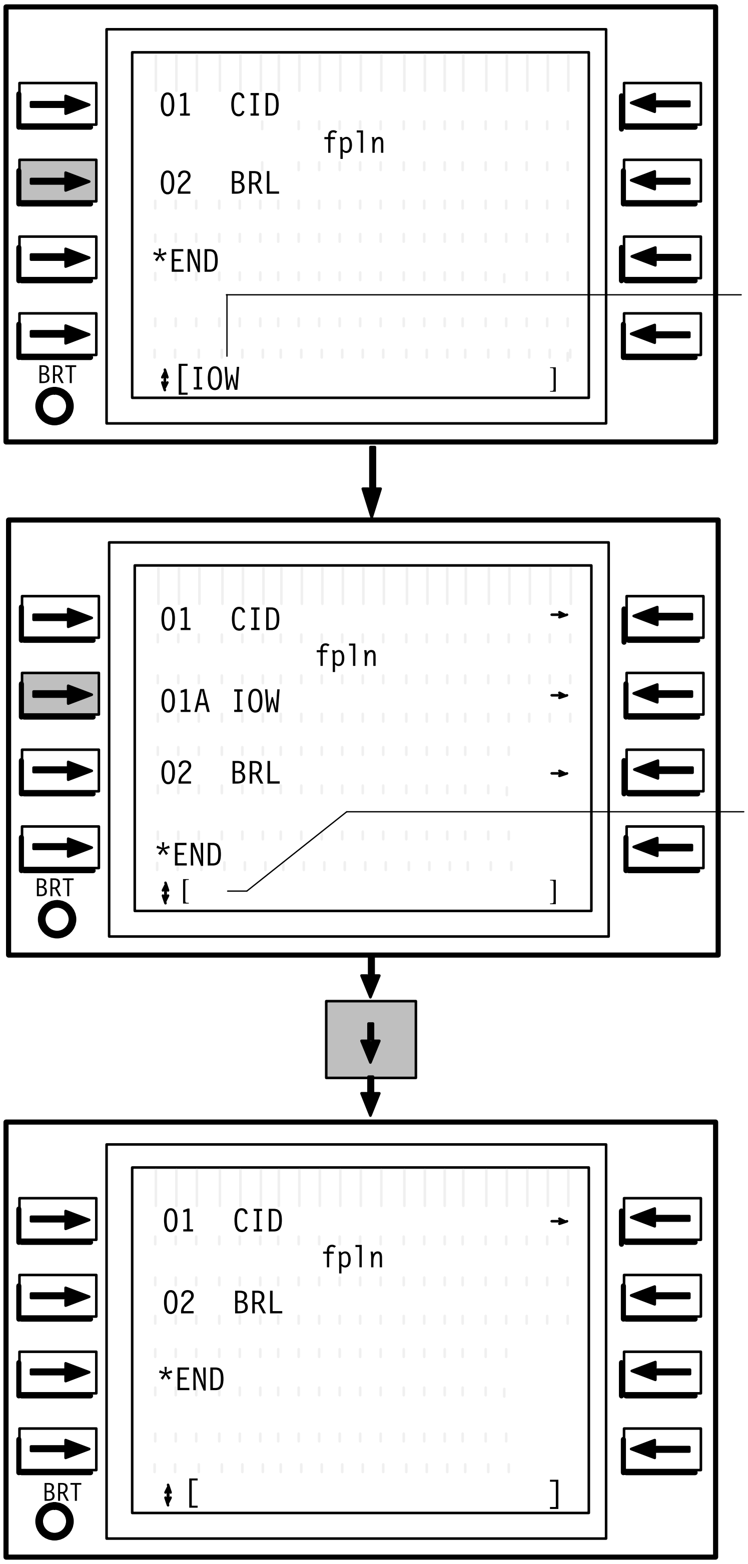
4 Scroll to insert additional waypoints, if more than three.

```
01  CID                  →
          fpln
*END

↕[                       ]
```

End of flight plan marker.

D57 312 I

INSERTING/DELETING INTERMEDIATE FLIGHT PLAN WAYPOINTS



Inserts waypoint, moving BRL down in flight plan list.

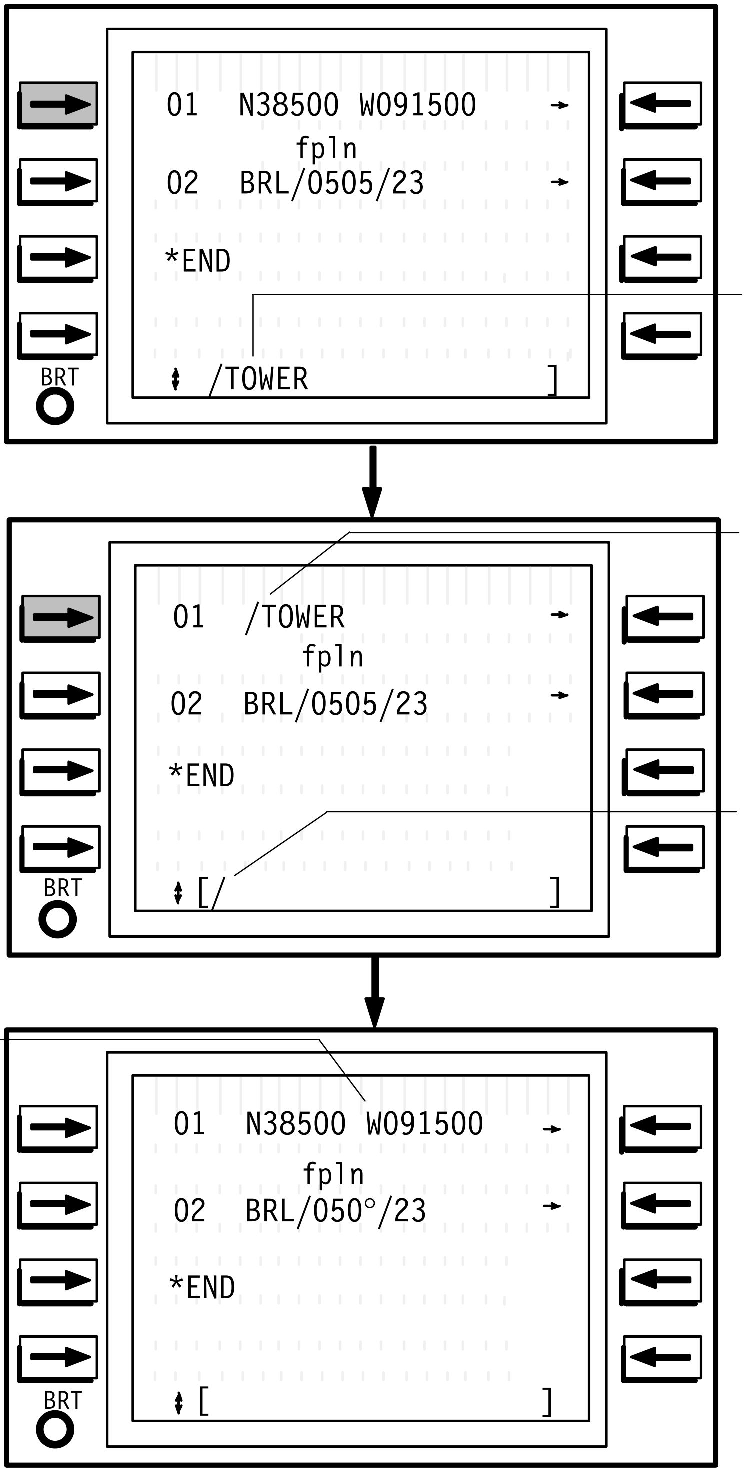
Enters next desired waypoint into scratchpad.

Deletes waypoint, closing up hole created in flight plan.

Enters – in scratchpad to delete future waypoints.

D57 313 I

ADDING/DELETING USER–DEFINED LABELS



Attaches label to waypoint.

Enters label in scratchpad, prefixed with a /.

Label is now attached to waypoint, with scratchpad cleared.

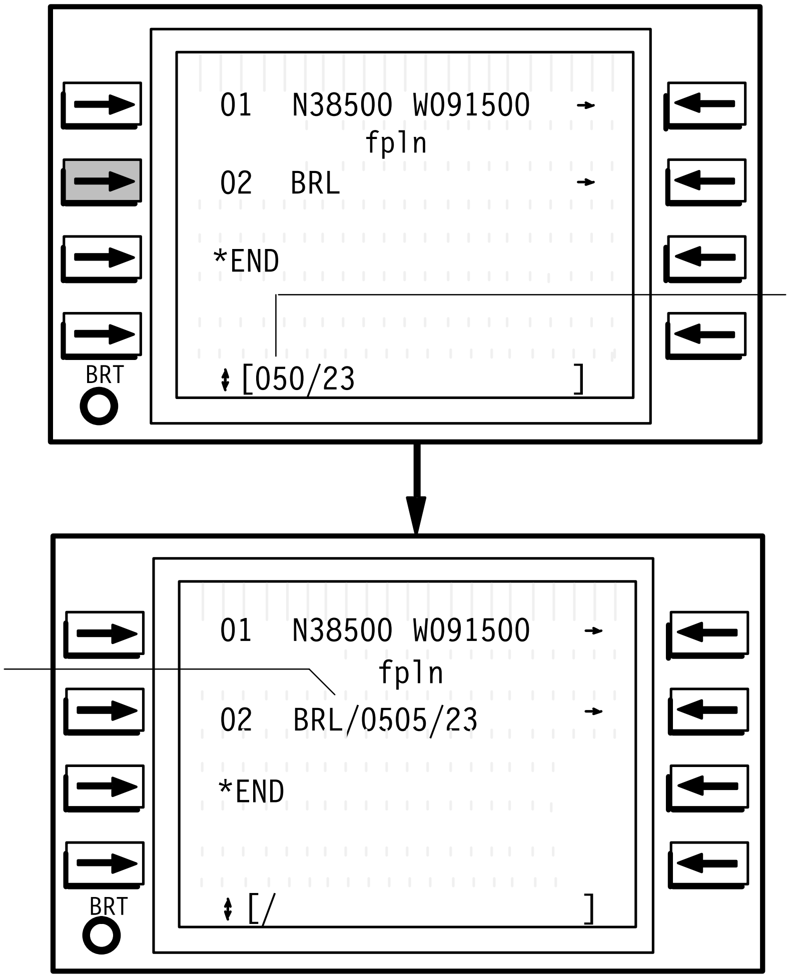
Removes label from waypoint.

Enters / in scratchpad to remove user–defined label.

Label is now removed from waypoint, with scratchpad cleared.

D57 314 I

MODIFYING ICAO IDENTIFIER LOCATIONS



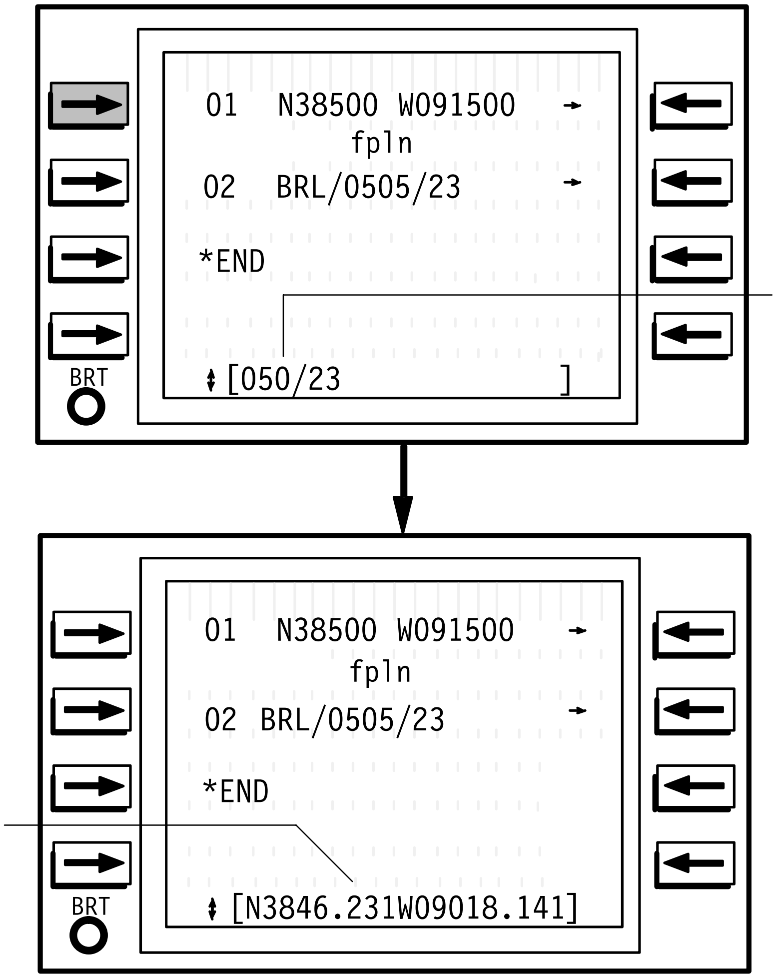
Attaches offset to BRL.

Enters bearing/ distance offset into scratchpad.

Original waypoint is offset to desired bearing/distance.

D57 315 I

MODIFYING LATITUDE–LONGITUDE LOCATIONS



Attaches offset to a lat–long.

```
01   N38500 W091500   →
         fpln
02   BRL/0505/23      →

*END

↕[050/23              ]
```

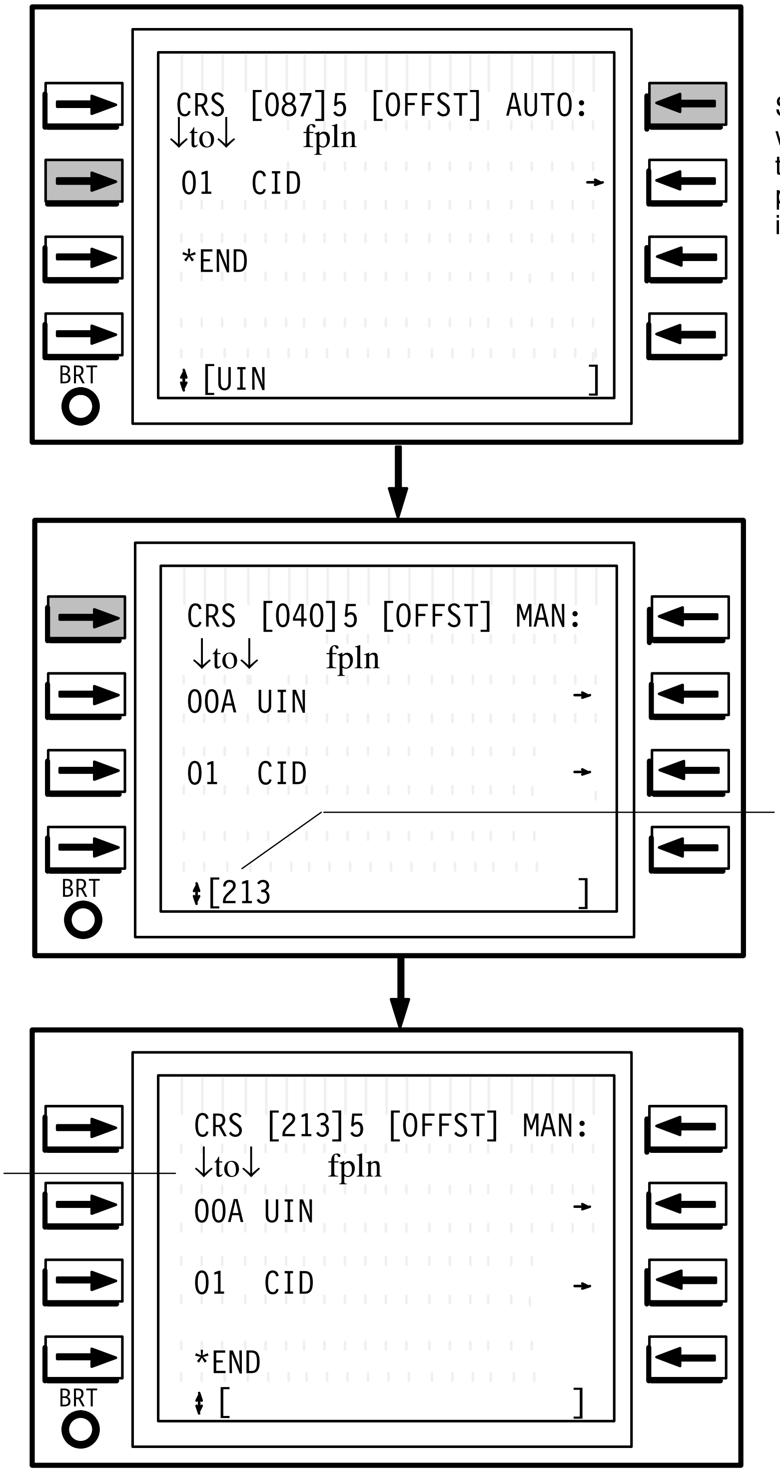
Enters bearing/ distance offset in scratchpad.

```
01   N38500 W091500   →
         fpln
02  BRL/0505/23       →

*END

↕[N3846.231W09018.141]
```

Computed lat–long is displayed in scratchpad and is available for entry into flight plan (original waypoint may be deleted manually if desired).

D57 316 I

TACAN EMULATION: MANUAL ADVANCE AND COURSE ENTRY



Enters TACAN identifier or waypoint.

Selects MAN advance (if desired) to prevent waypoint passage into history.

Enters course to/from waypoint.

Enters desired/published course in scratchpad.

↓to↓ indicator switches to ↓from↓ when station is passed; waypoint does not move into history.

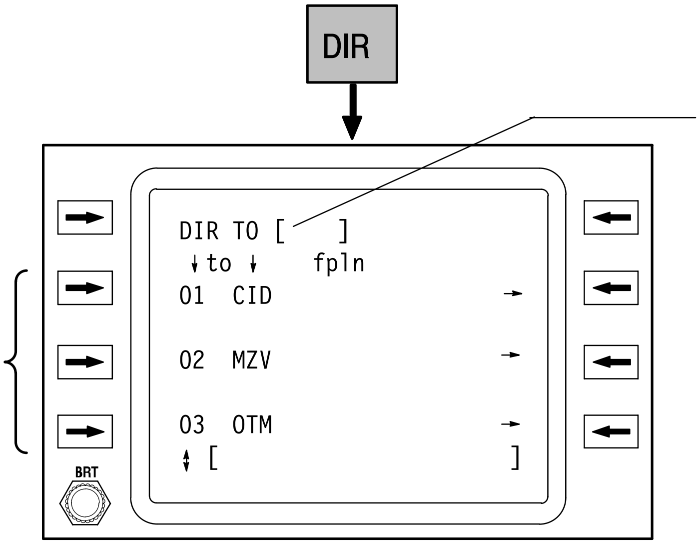
D57 317 I

DIRECT–TO FUNCTIONS

Direct–To courses are used to either bypass existing waypoints in the flight plan or insert an impromptu waypoint, interrupting the current leg. In each case, a system generated turn point is inserted along the present track, to provide turn anticipation and prevent S turns during capture of the course to the waypoint. (This point is not displayed.) The Direct–To function differs from simple active waypoint entry in that the resulting course is from airplane position rather than from the last history waypoint. When used in relation to vertical navigation (VNAV), the Direct–To function computes an immediate climb or descent path to a waypoint with an altitude crossing assigned. See *figure 1-169* for the use of the Direct–To function for VNAV.

When the DIR key is pressed, the Flight Plan Page is accessed with DIR TO [ ] displayed on the top line, as shown below.

After selecting a waypoint for the Direct–To operation, the normal Flight Plan Page display is returned. To cancel the Direct–To function, the operator must select another CDU page.



Flight plan edits (such as, waypoint insertion and deletion, and labeling) are permitted.

DIR TO [ ] label remains on line 1 as waypoints are scrolled to indicate that only Direct–To operations are possible.

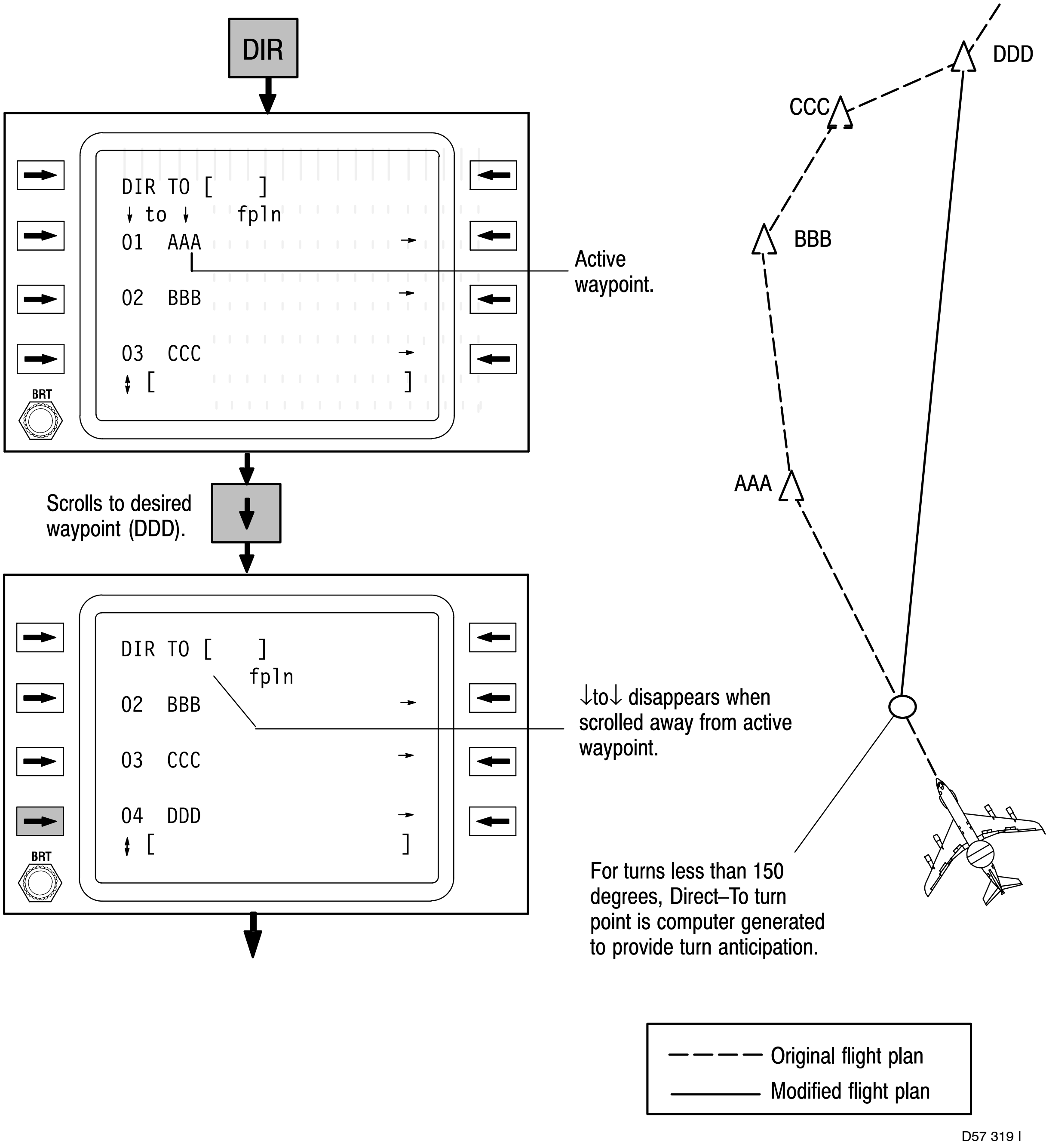
NOTE

After DIR is pressed, if DIR TO [ ] is line selected or if ↓TO↓ waypoint is line selected with a waypoint in scratchpad, that waypoint is entered in flight plan as Direct–To destination, causing immediate course change to go there. If any other waypoint is line selected, then the scratchpad waypoint is inserted into flight plan and DIR TO function remains hot/active. Line selecting any flight plan waypoint completes DIR TO action, causing immediate course change to that point.

D57 318 I

DIRECT–TO FLIGHT PLAN WAYPOINTS

A Direct–To course may be initiated to any existing flight plan waypoint, including history waypoints. DIR TO [ ] remains on the top line as the flight plan is scrolled to indicate that Direct–To selections can be performed. If the waypoint selected for the Direct–To operation is a future waypoint, all intermediate waypoints except the TO waypoint are deleted from the flight plan. If the selected waypoint is a history waypoint, then the history waypoints following the selected Direct–To waypoint are repeated in their original sequence.



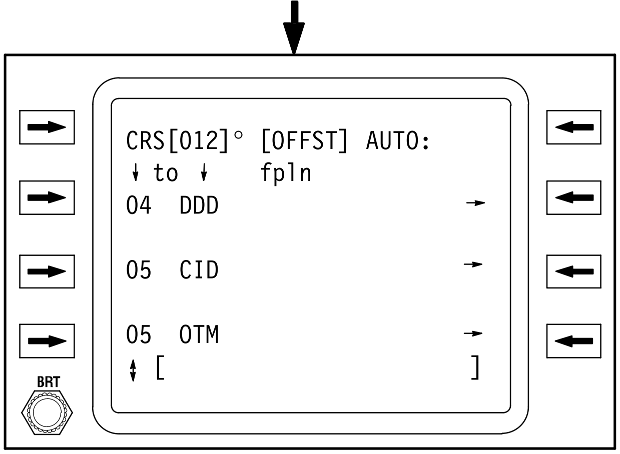
Active waypoint.

Scrolls to desired waypoint (DDD).

↓to↓ disappears when scrolled away from active waypoint.

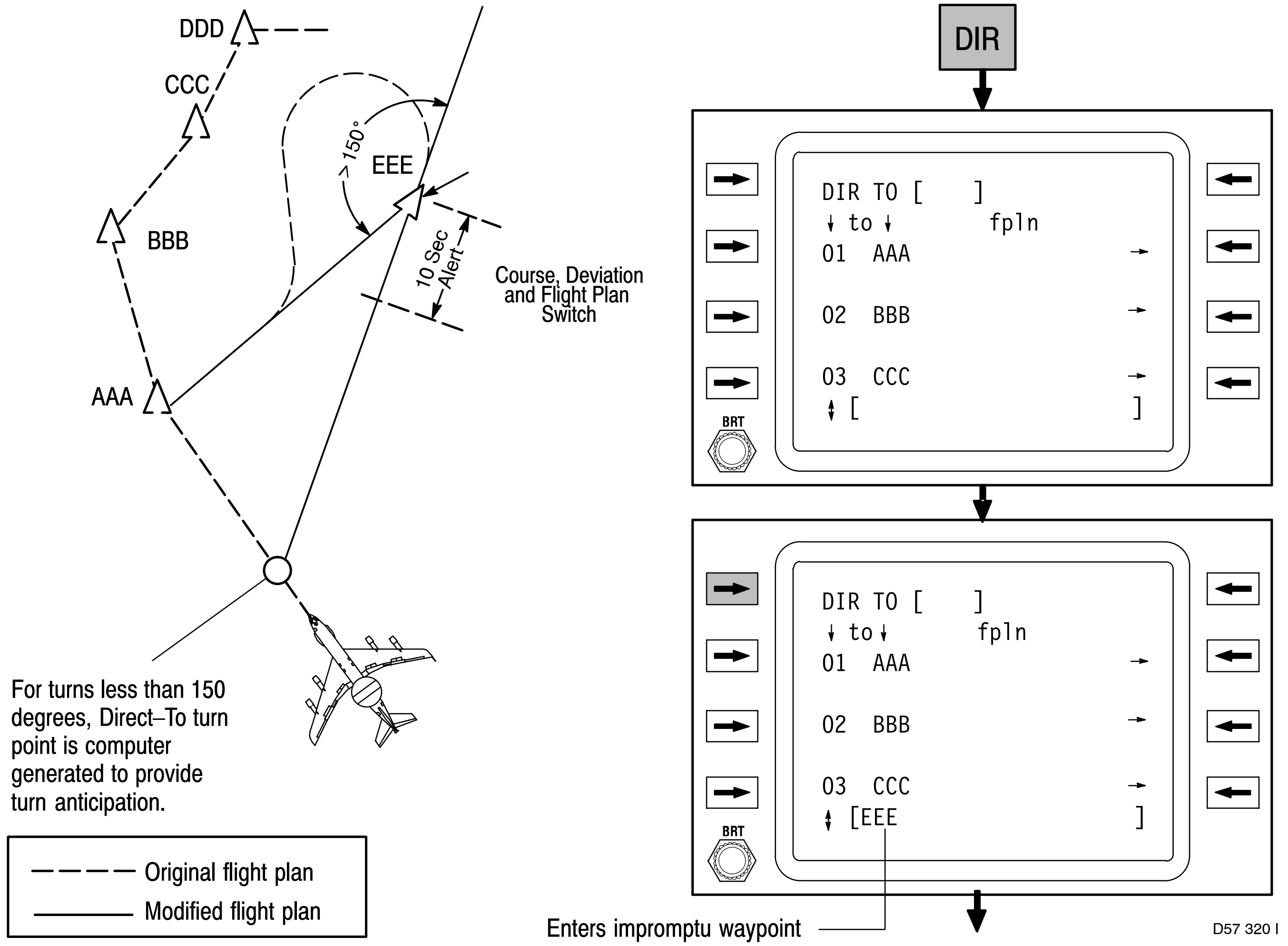
For turns less than 150 degrees, Direct–To turn point is computer generated to provide turn anticipation.

DIRECT–TO FLIGHT PLAN WAYPOINTS – CONTINUED



```
CRS[012]° [OFFST] AUTO:
↓ to ↓    fpln
04  DDD                    →

05  CID                    →

05  OTM                    →
↕ [                        ]
```

Impromptu waypoints can be inserted into the flight plan, interrupting execution of the current flight plan leg. The impromptu point can be any valid waypoint format. If the selected point for inserting the Direct–To waypoint is a future waypoint, all intervening waypoints except the TO waypoint are deleted from the flight plan. Thus, to fly directly to an impromptu point and then return to the flight plan, bypassing intermediate points, the impromptu point should first be entered into the flight plan at the proper location and then selected as the Direct–To waypoint.



Course, Deviation and Flight Plan Switch

For turns less than 150 degrees, Direct–To turn point is computer generated to provide turn anticipation.

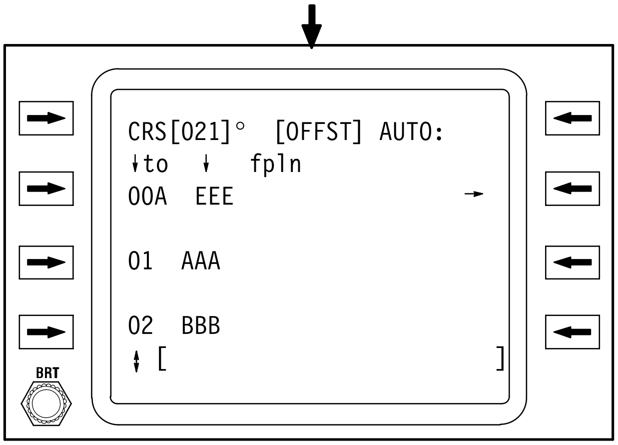
```
DIR TO [    ]
↓ to ↓       fpln
01  AAA                    →

02  BBB                    →

03  CCC                    →
↕ [                        ]
```

```
DIR TO [    ]
↓ to ↓       fpln
01  AAA                    →

02  BBB                    →

03  CCC                    →
↕ [EEE                     ]
```

Enters impromptu waypoint

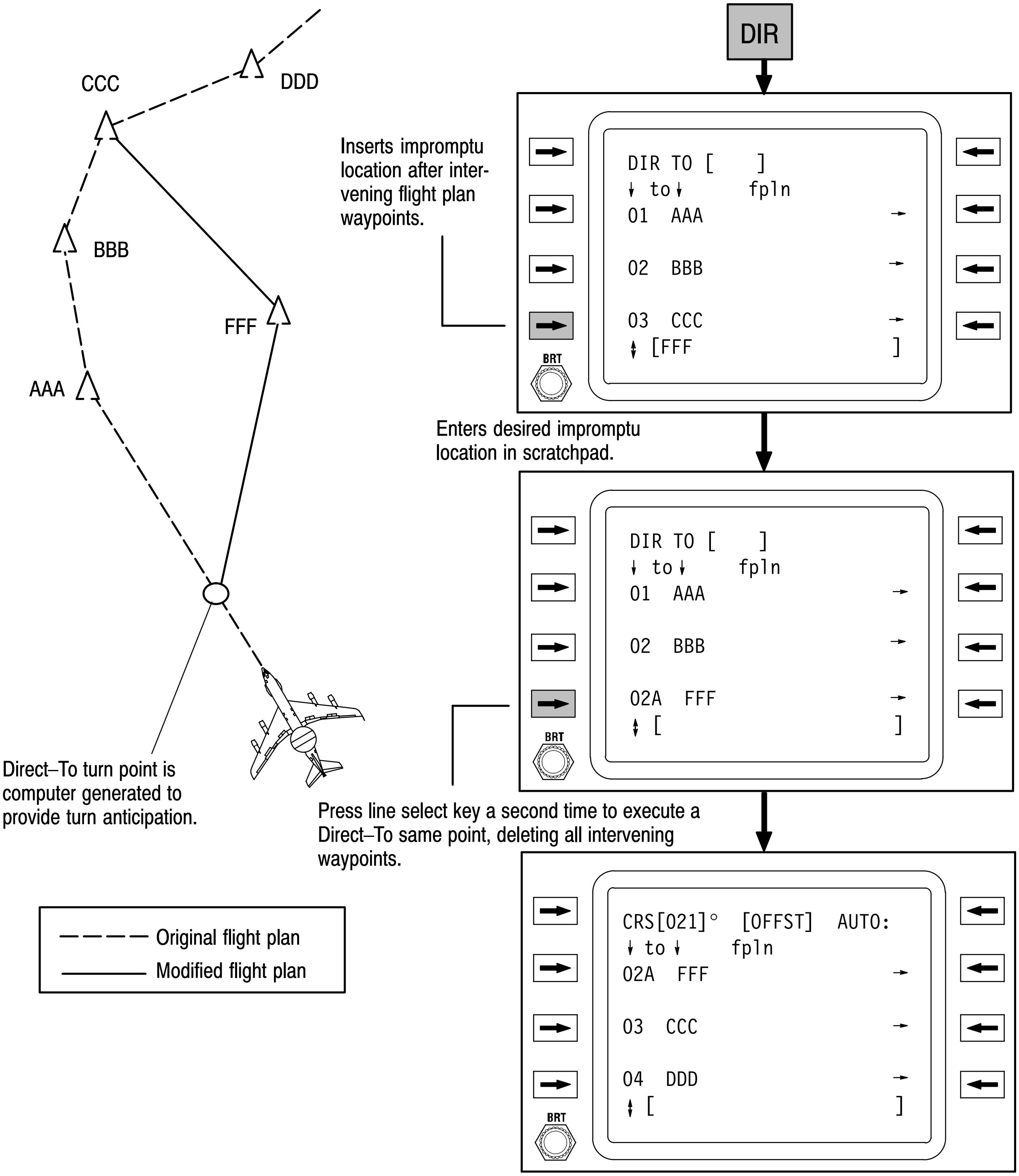
D57 320 I

DIRECT–TO FLIGHT PLAN WAYPOINTS – CONTINUED



D57 321 I

DIRECT–TO IMPROMPTU WAYPOINTS INSERTED AS A FUTURE FLIGHT PLAN WAYPOINT



Inserts impromptu location after intervening flight plan waypoints.

```
DIR TO [    ]
↓ to ↓      fpln
01  AAA              →

02  BBB              →

03  CCC              →
↕ [FFF               ]
```

Enters desired impromptu location in scratchpad.

```
DIR TO [    ]
↓ to ↓     fpln
01  AAA              →

02  BBB              →

02A  FFF             →
↕ [                  ]
```

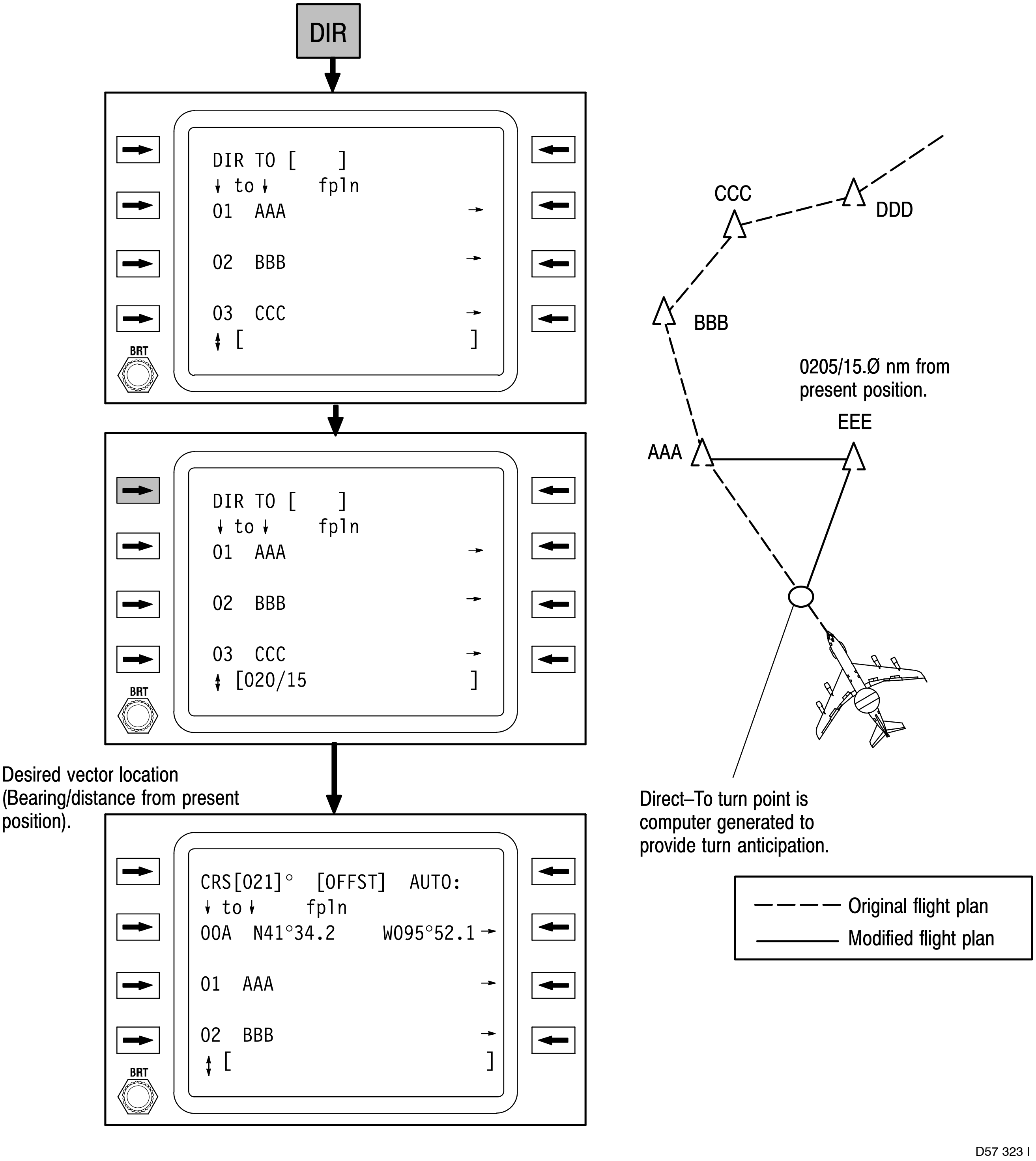
Press line select key a second time to execute a Direct–To same point, deleting all intervening waypoints.

```
CRS[021]°  [OFFST]  AUTO:
↓ to ↓     fpln
02A  FFF             →

03  CCC              →

04  DDD              →
↕ [                  ]
```

Direct–To turn point is computer generated to provide turn anticipation.

D57 322 I

DIRECT–TO VECTOR FROM PRESENT POSITION



```
DIR TO [    ]
↓ to ↓     fpln
01  AAA              →

02  BBB              →

03  CCC              →
↕ [                  ]
```

```
DIR TO [    ]
↓ to ↓     fpln
01  AAA              →

02  BBB              →

03  CCC              →
↕ [020/15            ]
```

```
CRS[021]°  [OFFST]  AUTO:
↓ to ↓     fpln
00A  N41°34.2    W095°52.1 →

01  AAA                    →

02  BBB                    →
↕ [                        ]
```

Desired vector location (Bearing/distance from present position).

0205/15.Ø nm from present position.

Direct–To turn point is computer generated to provide turn anticipation.

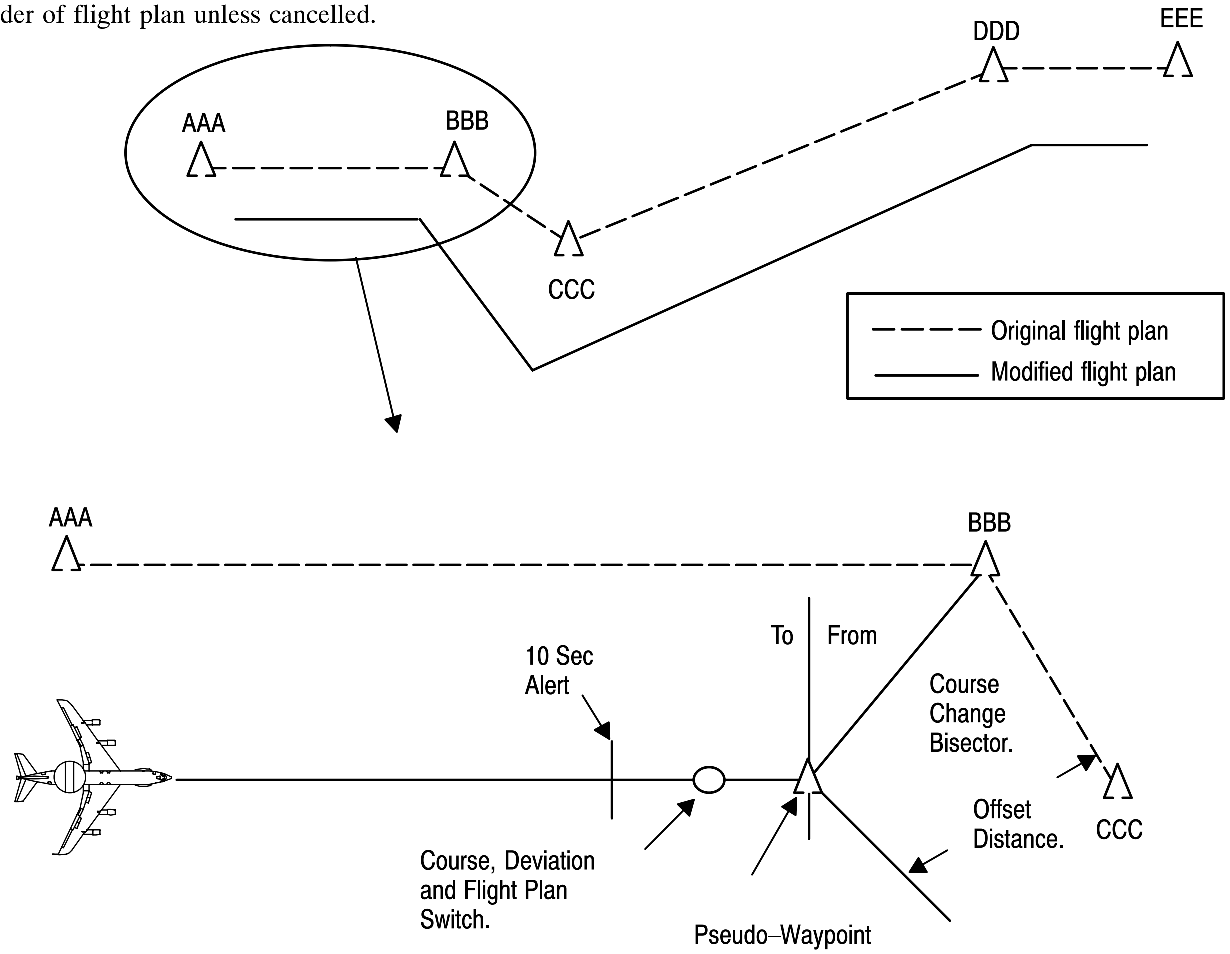
PARALLEL OFFSETS

A parallel course offset can be applied to the flight plan for weather or traffic avoidance or when assigned by ATC. When an offset is applied, all displays keyed to the active waypoint (such as, time and distance to go, TO/FROM flag) become referenced to pseudo–waypoint at the intersection of the course change angle bisector and the offset course. Likewise the leg switch point and the associated ten second alert are computed relative to the pseudo–waypoint. See *figure 1-169*. Crosstrack deviation is computed relative to the offset course. The following sketch illustrates the geometry associated with waypoint switching when a parallel offset is applied.

PARALLEL COURSE OFFSET GEOMETRY

NOTE

Offsets can be defined to left or right of original course. Once applied, they remain in effect for remainder of flight plan unless cancelled.

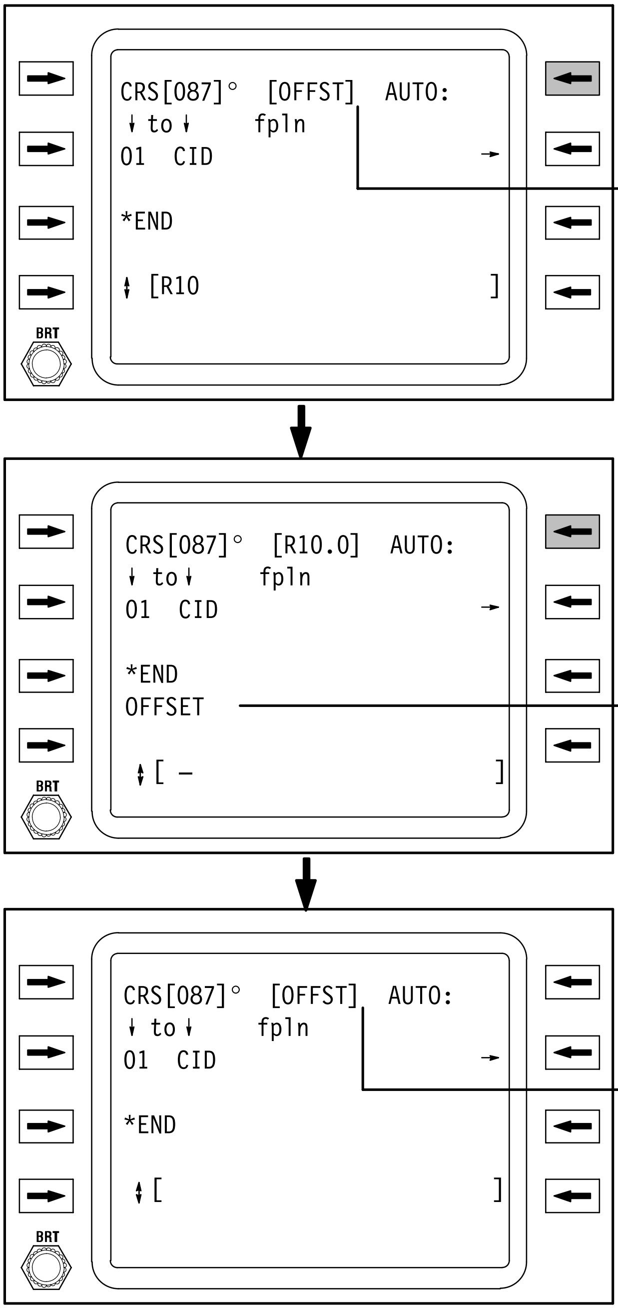


PARALLEL OFFSET INITIATION, TERMINATION OR CHANGE

Parallel course offsets can be applied, changed or deleted any time the active waypoint is not identified as a holding pattern, MOP, MAP, or FAF. The screens shown below illustrate application and deletion of a parallel course offset.

If the waypoint identified as a holding pattern fix becomes the active waypoint while an offset is defined, then the offset is automatically cancelled. If a holding pattern is applied to the active waypoint with an offset applied, the offset is automatically cancelled. Initiation of Direct–To function automatically cancels the parallel offset.

ENTERING AND DELETING PARALLEL OFFSETS



```
CRS[087]°  [OFFST]  AUTO:
↓ to ↓     fpln
01  CID                  →

*END

↕ [R10                   ]
```

Inserts a parallel course offset. Right or left must be specified as first character (for example, R1.1, L12.0).

Current value for parallel course offset or OFFST if none is defined.

```
CRS[087]°  [R10.0]  AUTO:
↓ to ↓     fpln
01  CID                  →

*END
OFFSET

↕[ –                     ]
```

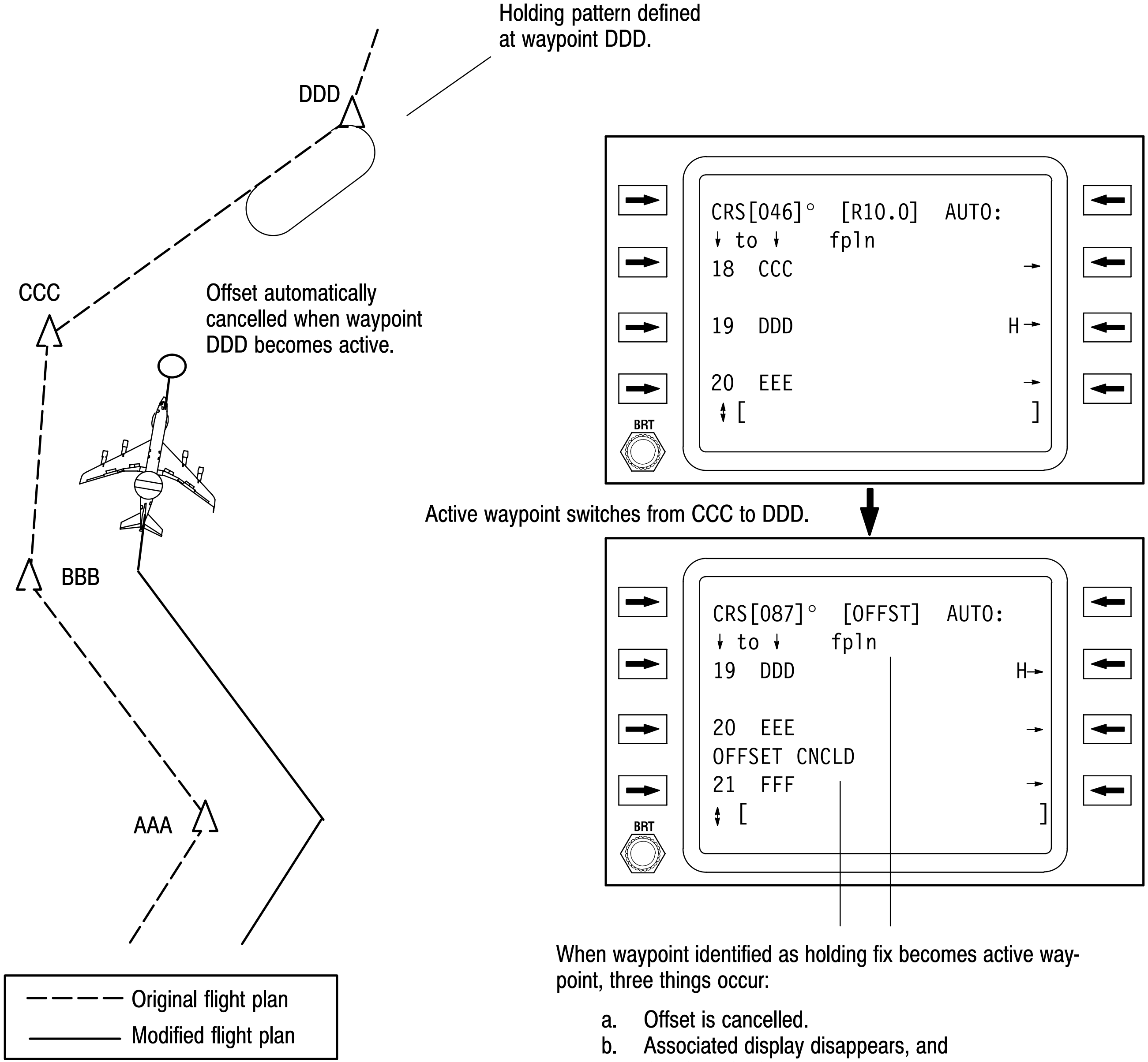
Deletes a parallel course offset if scratchpad contains –, 0.0, 0., .0 or 0.

OFFSET annunciation indicates flight plan is offset until offset is cancelled.

```
CRS[087]°  [OFFST]  AUTO:
↓ to ↓     fpln
01  CID                  →

*END

↕[                       ]
```

Display is returned to [OFFST].

AUTOMATIC CANCELLATION OF PARALLEL COURSE OFFSETS



Holding pattern defined at waypoint DDD.

Offset automatically cancelled when waypoint DDD becomes active.

```
CRS[046]°  [R10.0]  AUTO:
↓ to ↓    fpln
18  CCC                  →

19  DDD                 H→

20  EEE                  →
↕[                        ]
```

Active waypoint switches from CCC to DDD.

```
CRS[087]°  [OFFST]  AUTO:
↓ to ↓    fpln
19  DDD                 H→

20  EEE                  →
OFFSET CNCLD
21  FFF                  →
↕ [                       ]
```

When waypoint identified as holding fix becomes active waypoint, three things occur:

a. Offset is cancelled.
b. Associated display disappears, and
c. OFFSET CNCLD annunciation appears.

Defining active waypoint to be holding fix has same effect.

NOTE

Executing Direct–To a waypoint cancels a parallel course offset if one has been applied. In this case, OFFSET CNCLD annunciation does not appear since cancellation is due to operator actions.

D57 326 I

VNAV OVERVIEW

The system VNAV function provides guidance for a climb or descent to an assigned altitude at a waypoint or crossing fix, such as in a STAR or initial approach procedure. It also provides situational awareness for climb and descent planning and allows fuel–efficient descents with adjustment for actual wind. See *figure 1-170*.

Assigning an Altitude or Flight Level

All VNAV guidance requires first that an altitude or Flight Level (FL) be entered at a waypoint in the flight plan. If an active flight plan is transferred from the alternate flight plan, all altitudes assigned at waypoints are also transferred. If an altitude has been assigned to a waypoint, it is indicated by a V attribute on the right side of the Flight Plan Page waypoint line. To delete this altitude assignment, enter a – and press the adjacent right line select key.

To enter an altitude, select the Flight Plan Waypoint Page for the waypoint where it is to be assigned. Altitudes are entered in feet and are referenced automatically to the local baroset entered on the Pilot or Copilot Position Page. If a flight level is desired, enter FL, followed by the three–digit flight level. This indicates that the altitude is referenced to the flight level pressure datum (29.92 in. Hg) instead of the local barometric pressure. The system automatically computes the guidance through the transition altitude (climbs) or transition flight level (descents) if the above procedure is followed regardless of where the transition takes place, which may vary in different countries.

If the waypoint is a GINS approachMissed Approach Point (MAP), the altitude is blanked and no entry is permitted.

Entry and Display of Climb or Descent Path

If only an altitude/flight level is entered and no climb or descent path is specified, the climb/descent path is undefined until that waypoint becomes the flight plan active waypoint. GINS defaults to a direct climb/descent path to the waypoint with the assigned altitude.

If two consecutive waypoints are assigned altitudes/flight levels, the default path is a straight–line climb or descent between them, such as for a published profile descent.

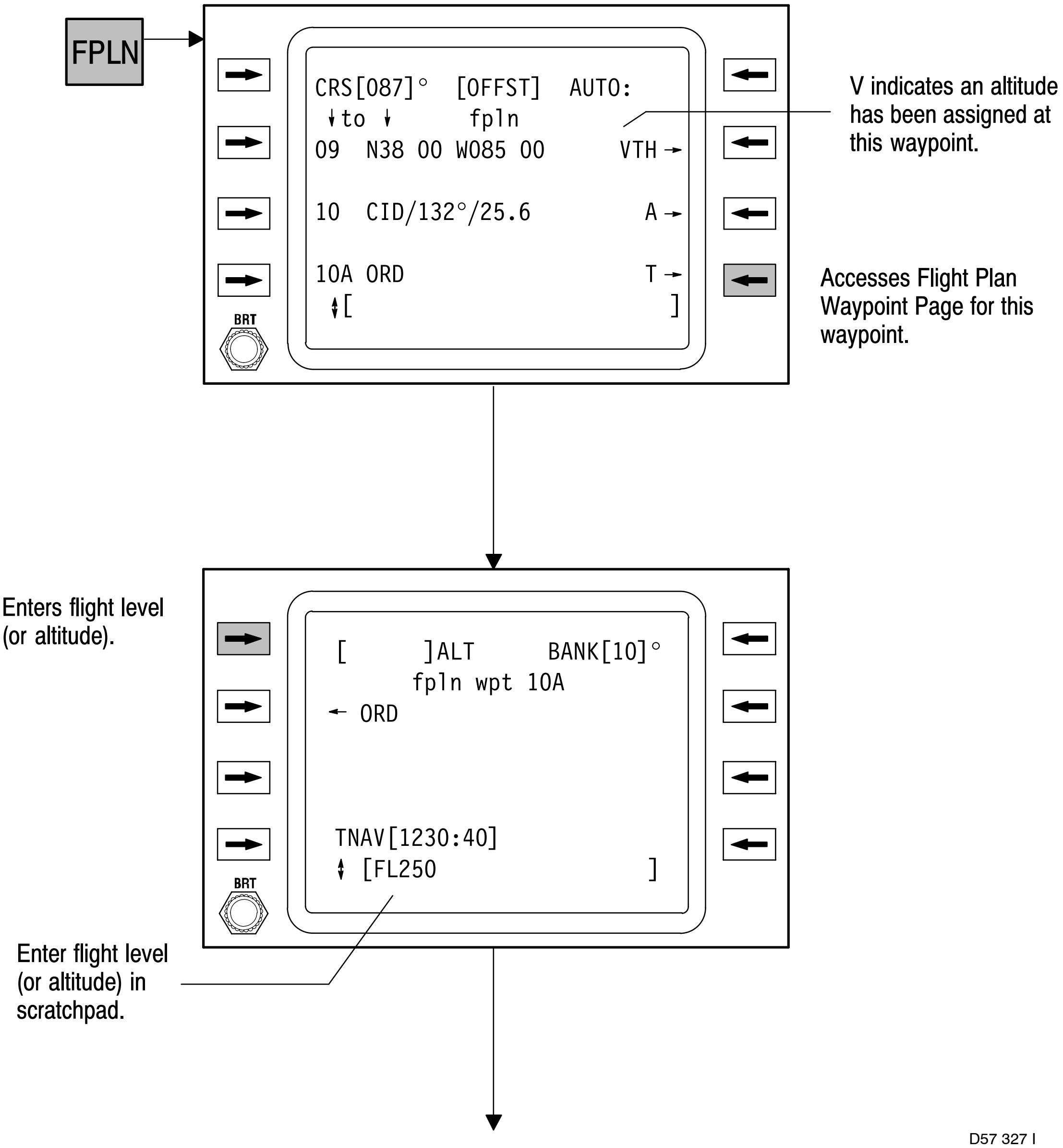
To specify a climb/descent path other than the default, first enter the desired angle (0.0 to 6.0°) or initial vertical rate (0 to 3500 fpm), then toggle the VNAV line select key to CLIMB or DESCNT as necessary.

If the vertical rate/angle display is subsequently toggled, the CDU shows the computed value corresponding to the entered parameter. For example, if an angle is entered, the vertical rate corresponds to that angle at current ground speed. Alternately, if the initial vertical speed is entered, the angle is likewise computed, until the vertical capture point at the Bottom Of Climb (BOC) or Top Of Descent (TOD) is reached. After that point, the angle becomes fixed and only the vertical speed varies. The fixed or entered parameter is indicated by an asterisk.

Direct Climb or Descent Path Display

The DIRECT CLIMB/DESCNT vertical rate or angle on the Flight Plan Waypoint Page is computed for any waypoint with an altitude assigned, not just for the active waypoint. This advisory enables the pilot to plan his climb or descent and to be apprised of the actual vertical maneuver required if, for example, ATC delays his climb/descent clearance beyond the planned BOC or TOD. This is also the value which is inserted if the pilot were to select a VNAV Direct–To.

ENTRY AND DISPLAY OF VNAV PARAMETERS



```
CRS[087]°  [OFFST]  AUTO:
 ↓to ↓      fpln
09  N38 00 W085 00      VTH →

10  CID/132°/25.6         A →

10A ORD                   T →
 ↕[                          ]
```

V indicates an altitude has been assigned at this waypoint.

Accesses Flight Plan Waypoint Page for this waypoint.

```
 [      ]ALT     BANK[10]°
       fpln wpt 10A
 ← ORD



 TNAV[1230:40]
 ↕ [FL250                  ]
```

Enters flight level (or altitude).

Enter flight level (or altitude) in scratchpad.

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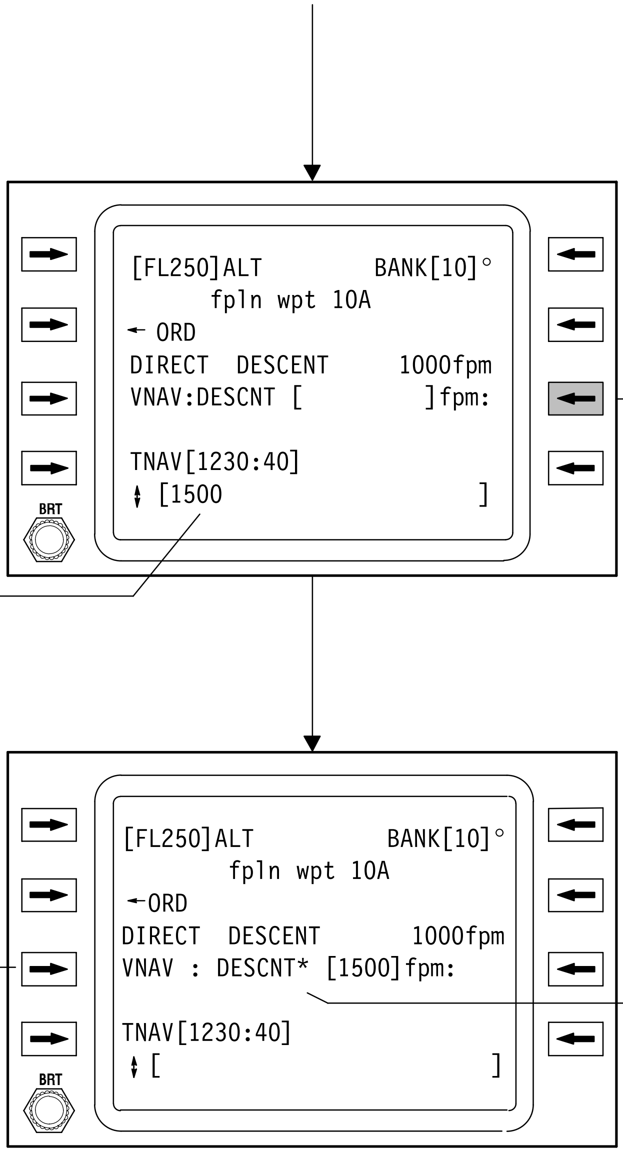
ENTRY AND DISPLAY OF VNAV PARAMETERS – CONTINUED



```
[FL250]ALT        BANK[10]°
      fpln wpt 10A
← ORD
DIRECT  DESCENT     1000fpm
VNAV:DESCNT [        ]fpm:

TNAV[1230:40]
↕ [1500                  ]
```

VNAV information displayed.

Press to enter rate (or angle); if scratchpad is empty, this line select toggles between vertical rate and angle.

Enters vertical rate (or angle) in scratchpad.

```
[FL250]ALT          BANK[10]°
        fpln wpt 10A
←ORD
DIRECT  DESCENT      1000fpm
VNAV : DESCNT* [1500]fpm:

TNAV[1230:40]
↕ [                      ]
```

Toggles between CLIMB and DESCNT selections.

Asterisk indicates rate is fixed (entered) quantity; after VNAV capture, angle becomes fixed and vertical speed becomes variable with ground speed.

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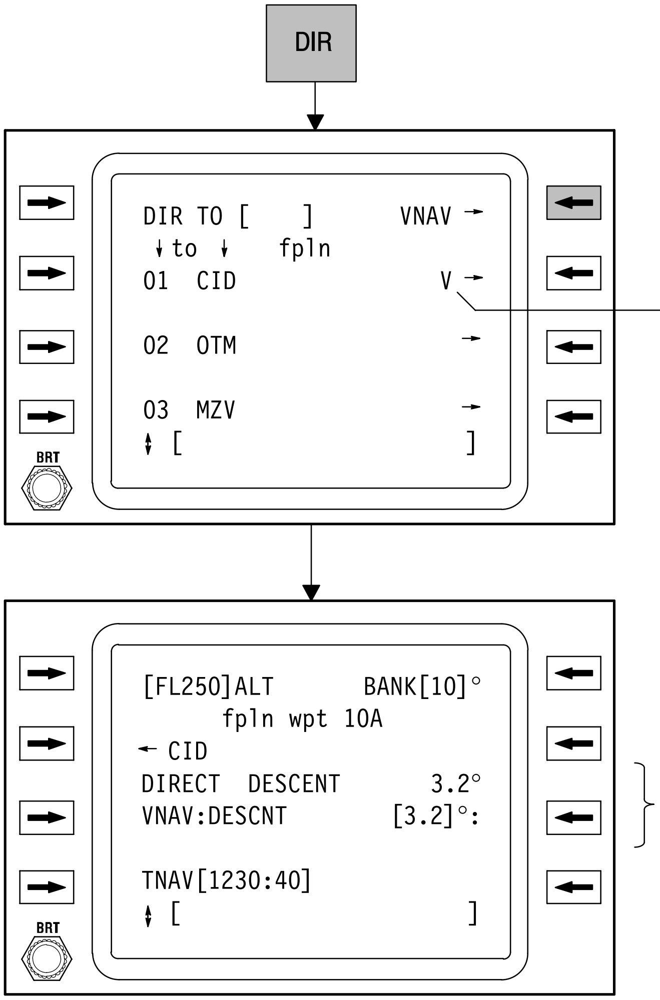
VNAV Direct–To

To perform a VNAV Direct–To climb or descent, press the DIR function key and follow the procedure shown below.

VNAV DIRECT–TO



```
DIR TO [    ]      VNAV →
↓to ↓    fpln
01  CID             V →

02  OTM               →

03  MZV               →
↕ [                   ]
```

Select VNAV Direct–To active waypoint, if it has an altitude/flight level assigned (indicated by V attribute); VNAV label is blanked if waypoint on line 3 does not have an altitude/flight level assigned.

```
[FL250]ALT      BANK[10]°
      fpln wpt 10A
← CID
DIRECT  DESCENT       3.2°
VNAV:DESCNT       [3.2]°:

TNAV[1230:40]
↕ [                   ]
```

VNAV CLIMB/DESCENT path synchronizes to Direct–To path.

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VNAV Guidance and Alerting

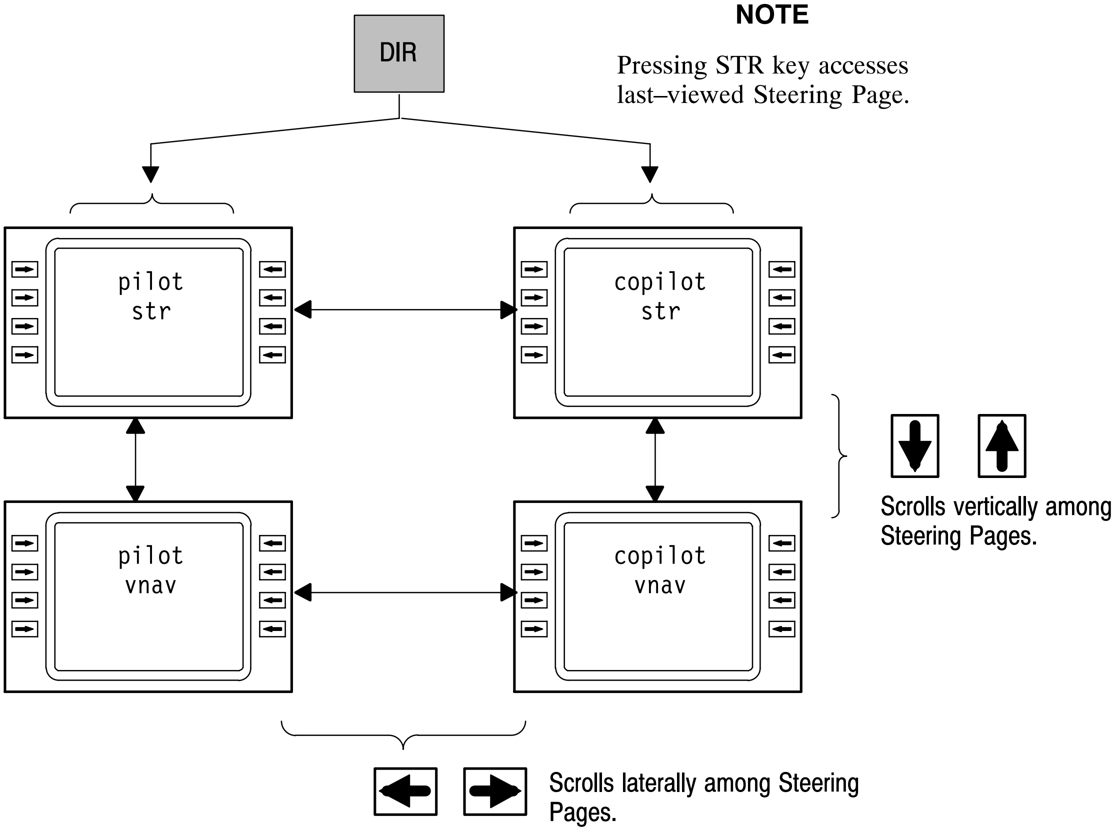
After a waypoint with an altitude becomes active, the FMS provides vertical steering to fly the entered or default VNAV climb or descent path. On the Pilot and Copilot VNAV Steering Pages, the specified VNAV path parameters are displayed on line 1, and the continuously updated altitude, vertical rate and angle for direct flight to the waypoint are presented on line 5.

Prior to VNAV capture, the distance to the BOC/TOD is displayed. This display is dashed after the VNAV path is captured.

VNAV STEERING PAGES

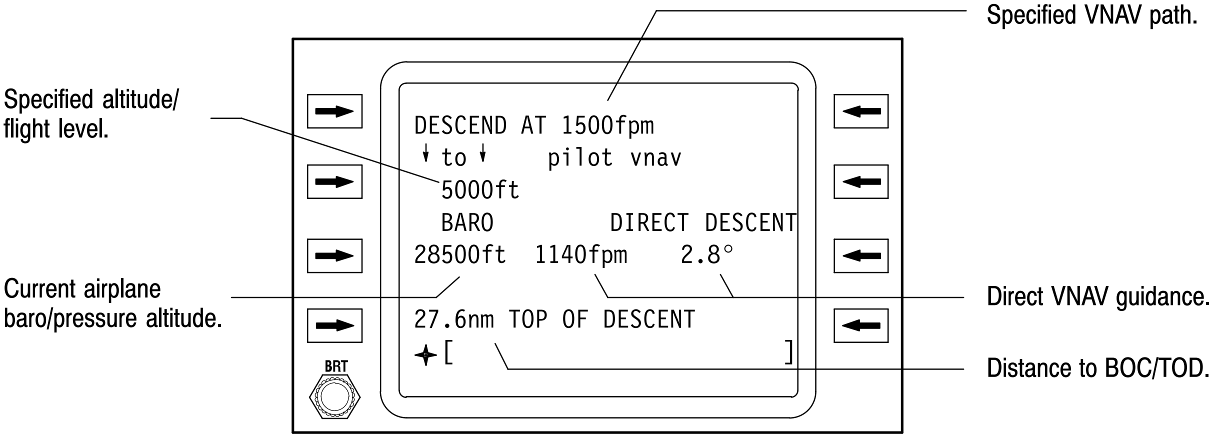
NOTE

Pressing STR key accesses last–viewed Steering Page.



Scrolls vertically among Steering Pages.

Scrolls laterally among Steering Pages.



Specified VNAV path.

Specified altitude/ flight level.

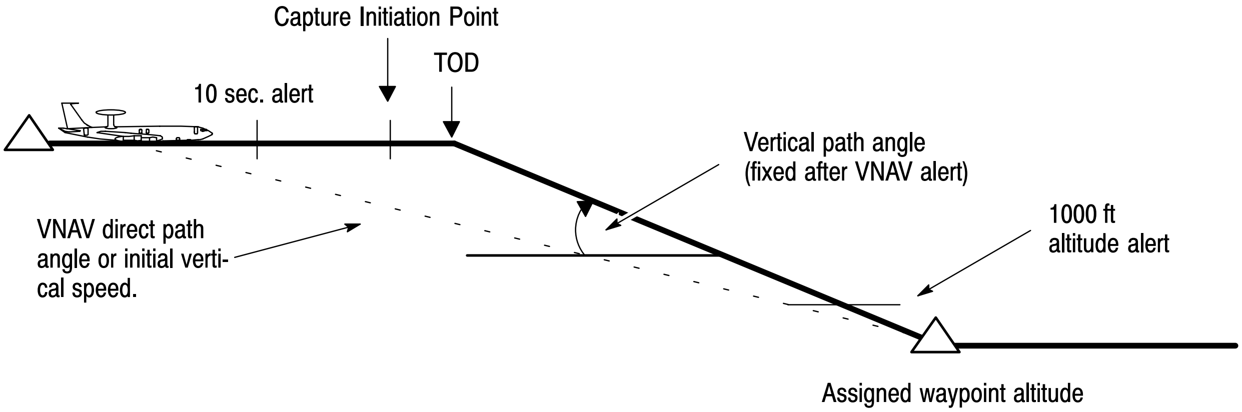
Current airplane baro/pressure altitude.

Direct VNAV guidance.

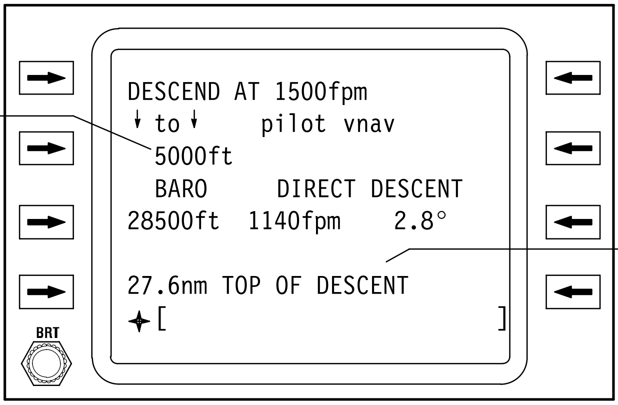
Distance to BOC/TOD.

Profile below is a typical VNAV sequence, with the alerts associated with the VNAV capture and termination. Ten seconds prior to the VNAV path capture, the CDU page alerts shown in the example screens flash and the external VNAV annunciator illuminates. Also, at an altitude 1000 ft below/above the waypoint crossing altitude, a second alert is issued as shown.

When the active waypoint for the VNAV guidance passes into history or is deleted, the VNAV steering parameters become invalid or are reset to their default values for the next vertical waypoint in the flight plan.



Altitude flashes at 1000 feet above/below waypoint crossing altitude.

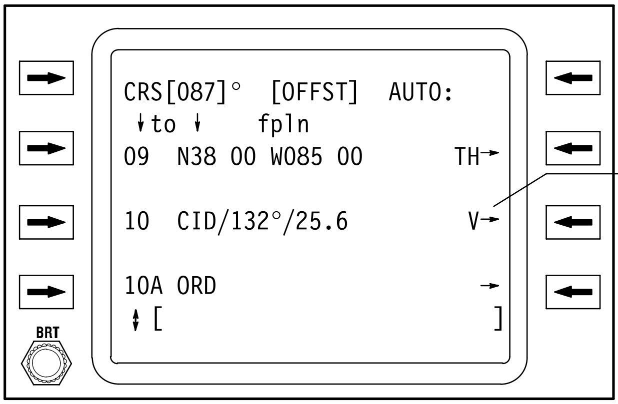


```
DESCEND AT 1500fpm
↓ to ↓    pilot vnav
 5000ft
  BARO     DIRECT DESCENT
28500ft  1140fpm    2.8°

27.6nm TOP OF DESCENT
✦[                          ]
```

TOP OF DESCENT label flashes 10 seconds prior to VNAV capture (same for BOC).

VNAV Steering Page



```
CRS[087]°  [OFFST]  AUTO:
 ↓to ↓    fpln
09  N38 00 W085 00      TH→

10  CID/132°/25.6        V→

10A ORD                   →
↕[                         ]
```

V attribute flashes 10 seconds prior to VNAV capture and at 1000 feet above/below waypoint crossing altitude.

Flight Plan Page

NOTE

External VNAV annunciator also illuminates for 10 seconds prior to BOC/TOD and at 1000 feet below/above assigned waypoint altitude.

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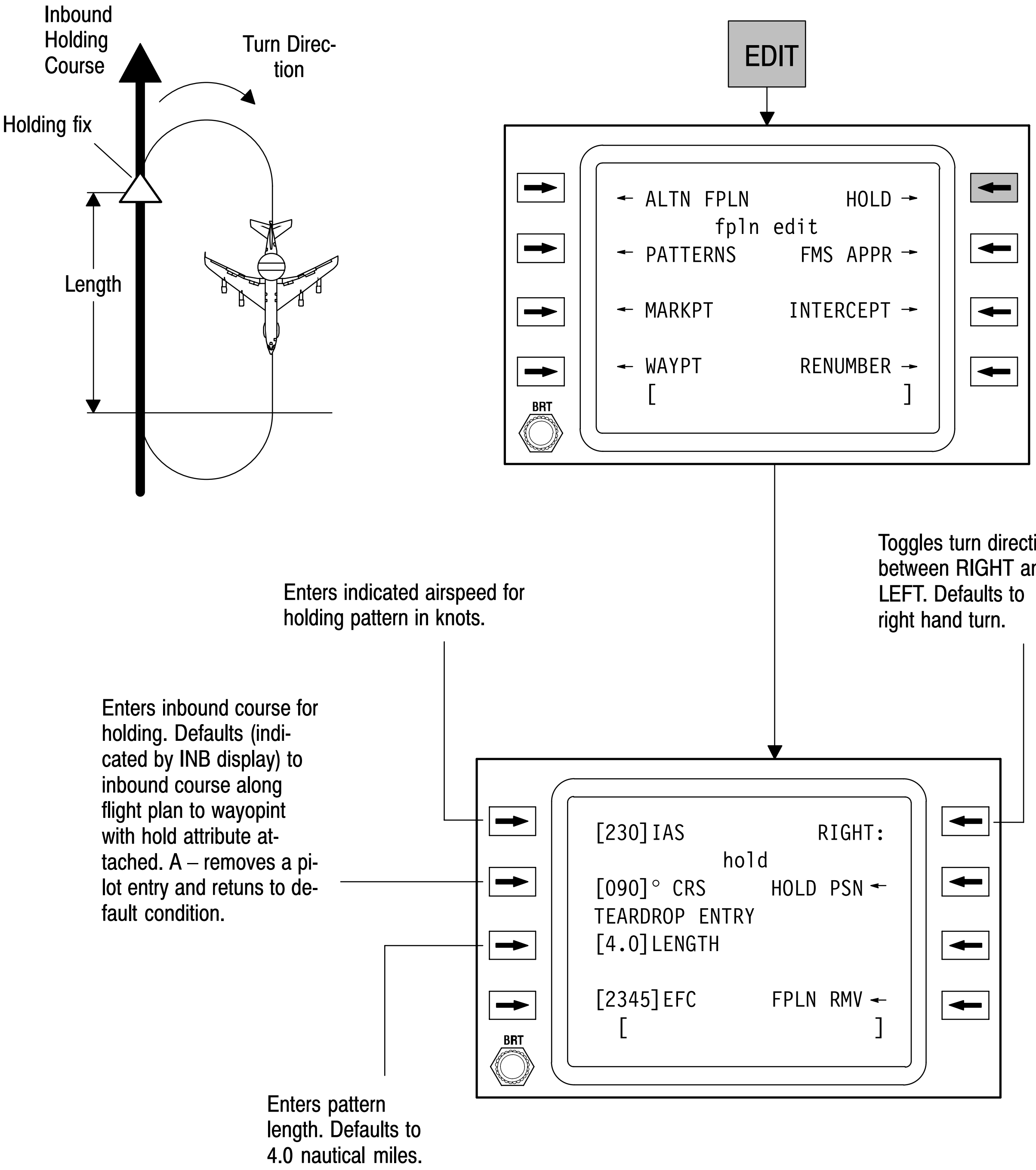
HOLDING PATTERN OVERVIEW

A holding pattern can be associated with one fixed waypoint in the flight plan, called the holding fix. When the airplane crosses the holding fix, holding guidance is activated, suspending normal leg advance until the holding pattern is cancelled. Three parameters define the holding pattern: inbound course, turn direction and pattern length. Holding pattern geometry definitions are shown below. Also see *figure 1-172*.

HOLDING PATTERN DEFINITIONS



```
← ALTN FPLN        HOLD →
       fpln edit
← PATTERNS     FMS APPR →

← MARKPT      INTERCEPT →

← WAYPT        RENUMBER →
  [                    ]
```

```
[230]IAS           RIGHT:
         hold
[090]° CRS     HOLD PSN ←
TEARDROP ENTRY
[4.0]LENGTH

[2345]EFC      FPLN RMV ←
 [                     ]
```

Enters indicated airspeed for holding pattern in knots.

Toggles turn direction between RIGHT and LEFT. Defaults to right hand turn.

Enters inbound course for holding. Defaults (indicated by INB display) to inbound course along flight plan to wayopint with hold attribute attached. A – removes a pilot entry and retuns to default condition.

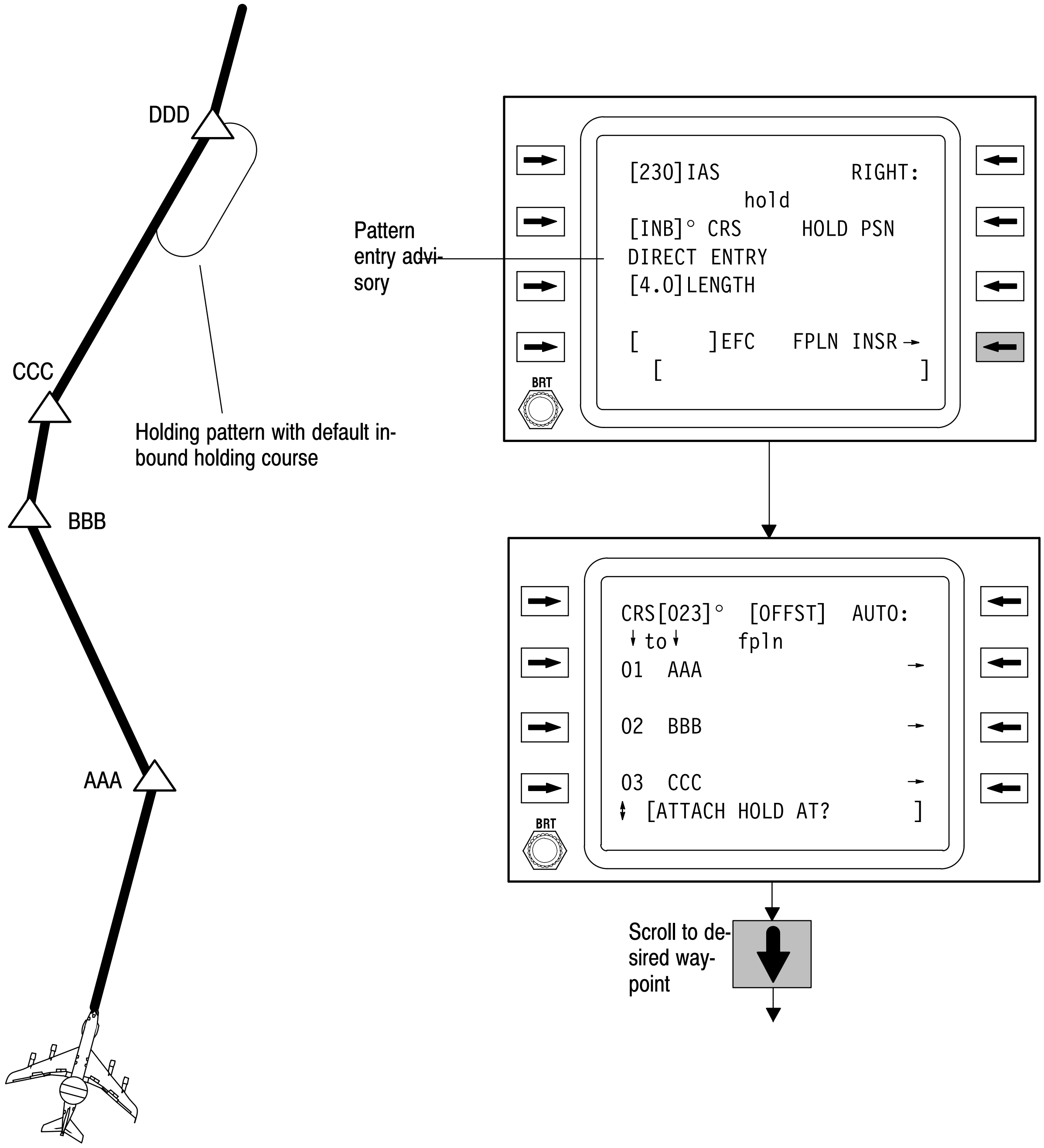
Enters pattern length. Defaults to 4.0 nautical miles.

Designation of the Holding Fix

After the holding pattern definition parameters have been entered, the active waypoint or a future fixed waypoint may be designated as the holding fix. After pressing the FPLN INSR key on the Hold Page, the Flight Plan Page is accessed with the message ATTACH HOLD AT? in the scratchpad.

After flight plan is scrolled to the desired location, the associated waypoint can be identified as the holding fix by pressing the adjacent line select. An H is displayed to the right of the designated waypoint as a reminder that it has been designated as the holding fix. The screen sequence below illustrates the process of designating the holding fix.

DESIGNATION OF HOLDING FIX



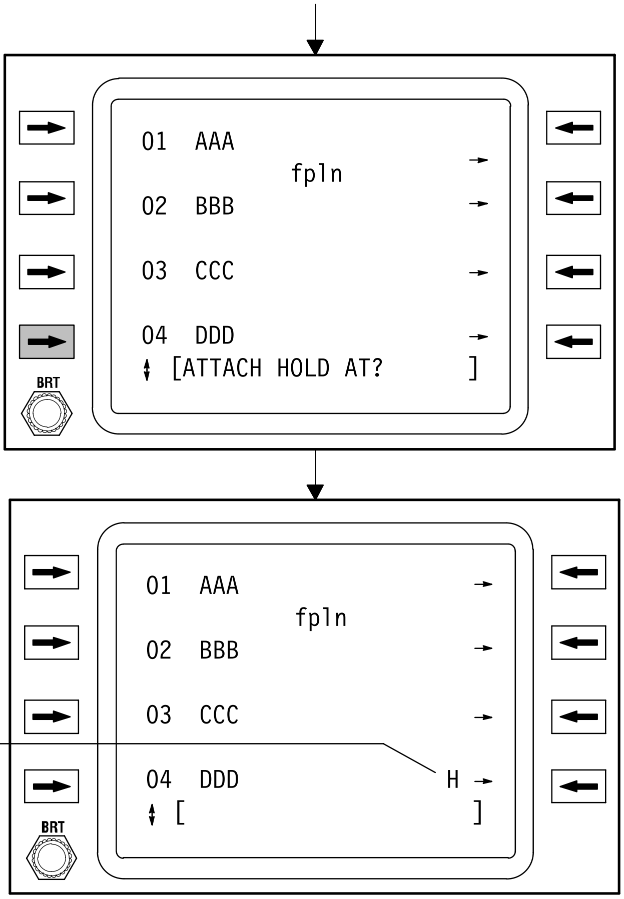
```
[230]IAS          RIGHT:
         hold
[INB]° CRS     HOLD PSN
DIRECT ENTRY
[4.0]LENGTH

[      ]EFC   FPLN INSR→
  [                    ]
```

```
CRS[023]°  [OFFST]  AUTO:
 ↓to↓      fpln
01  AAA                →

02  BBB                →

03  CCC                →
↕ [ATTACH HOLD AT?      ]
```



H indicates which flight plan waypoint has been designated as holding fix.

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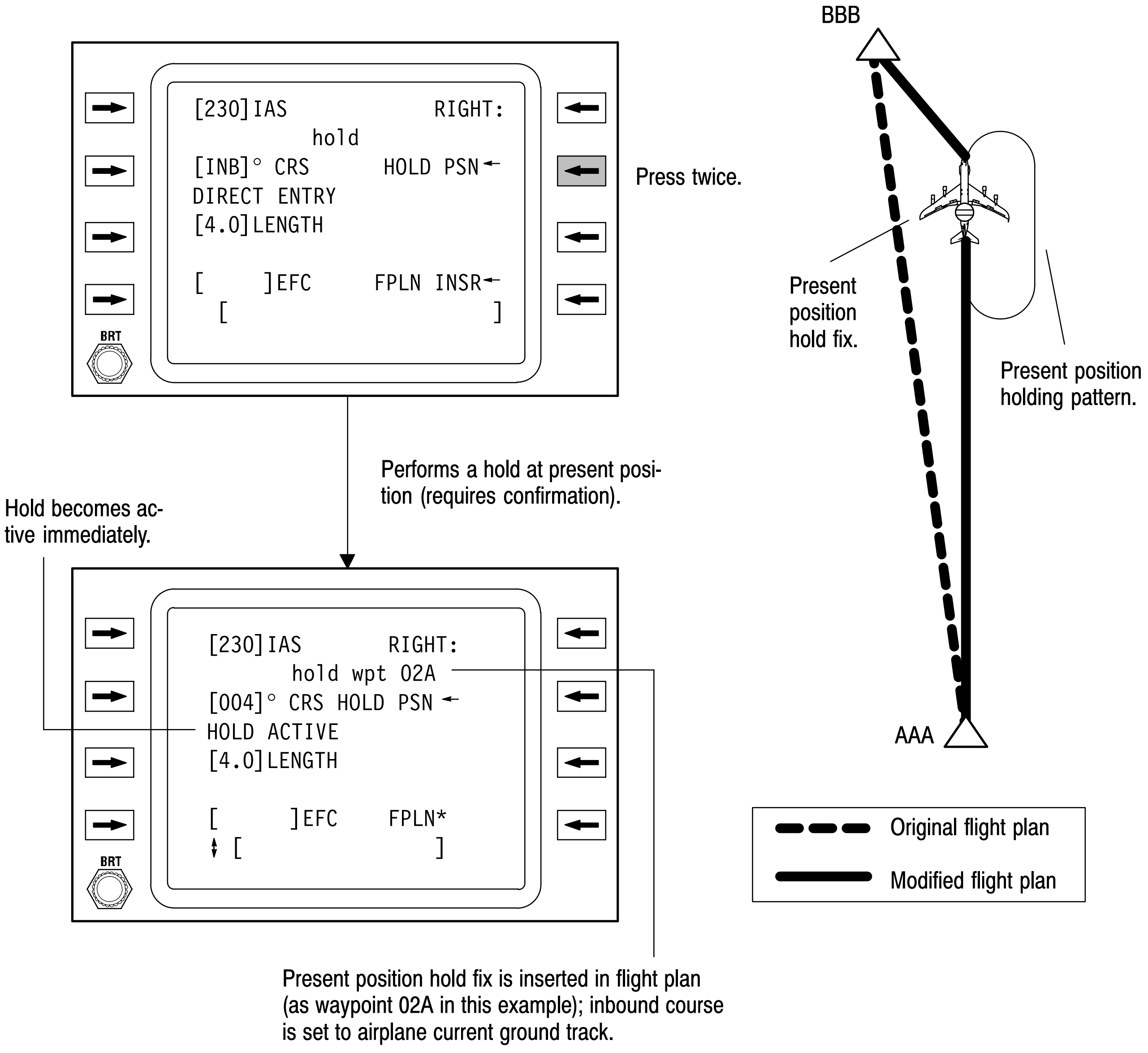
Immediate Present Position Hold

If it becomes necessary to hold present position, access the Hold Page, press the HOLD PSN line select key, and confirm the selection by pressing it again. This procedure, illustrated below, immediately enters the airplane present position into the flight plan as the active waypoint, interrupting the current flight plan leg, and activates a holding pattern at that fix with either the entered or default parameters on the Hold Page. Once entered, this pattern and its holding fix are treated the same as a preplanned hold at a flight plan waypoint, and all parameters can be edited.

HOLDING PRESENT POSITION



```
[230]IAS           RIGHT:
         hold
[INB]° CRS      HOLD PSN←
DIRECT ENTRY
[4.0]LENGTH

[     ]EFC     FPLN INSR←
  [                     ]
```

Press twice.

Performs a hold at present position (requires confirmation).

Hold becomes active immediately.

```
[230]IAS       RIGHT:
       hold wpt 02A
[004]° CRS HOLD PSN ←
HOLD ACTIVE
[4.0]LENGTH

[      ]EFC    FPLN*
↕ [              ]
```

Present position hold fix is inserted in flight plan (as waypoint 02A in this example); inbound course is set to airplane current ground track.

Present position hold fix.

Present position holding pattern.

Holding Course Edits

If no holding pattern inbound course has been entered then the inbound course to the fix is used when holding guidance is activated. If an inbound course has been entered, however, the inbound holding course is fixed but can be edited.

Holding Pattern Activation and Execution

When the holding fix is passed for the first time, holding guidance computations are activated. At that time several changes occur, both in flight plan operation and page displays:

a. Automatic leg advance is suspended.

b. Flight plan inbound course is automatically copied to the Hold Page as the inbound holding course if no inbound holding course condition was entered. Course edits on the Flight Plan Page can no longer be made. Inbound holding course edits can be made on the Hold Page.

c. All displays reference the inbound course displayed on the Hold Page.

If holding pattern definition parameters are changed while in the pattern, the changes are applied after the airplane passes the holding fix (transition from TO to FROM) except for the pattern length, which takes effect immediately if on the outbound leg. To edit a holding pattern once it is in the flight plan, press the line select key on the Flight Plan Waypoint Page adjacent to the H attribute.

When holding guidance has been activated, all course and lateral deviation displays now reference the inbound holding course, irrespective of whether the airplane is on the inbound or outbound leg of the holding pattern. However, the 10 second turn alert is computed on the outbound leg to alert the crew of the upcoming turn to the inbound leg.

Holding Speed and Expected Further Clearance Time

The commanded holding speed and expected further clearance (EFC) time entries and displays assist the pilot in executing a holding pattern in accordance with FAA air traffic control procedures and permit future waypoint ETAs to be calculated more realistically.

Entry and Display of Holding Speed

If no holding speed is entered or if a – is entered, this display (see screen below) defaults to 230 knots IAS. Beginning three minutes prior to arrival at the holding fix, the holding speed becomes the commanded speed reference, on the Lateral Steering Pages, for the ADI fast/slow indicator and for the speed threshold alert function. Upon exiting the holding pattern, the speed command function reverts to its normal mode.

Entry and Display of EFC Time

To permit more realistic future waypoint ETAs, the Hold Page allows an optional entry of the ATC EFC or otherwise planned departure time from the holding fix. If an EFC is entered (in UTC), then all future waypoint ETAs are calculated from that holding fix departure reference. If no EFC is entered or it is deleted, then all future ETAs are calculated as if no loiter time is to be spent in the holding pattern.

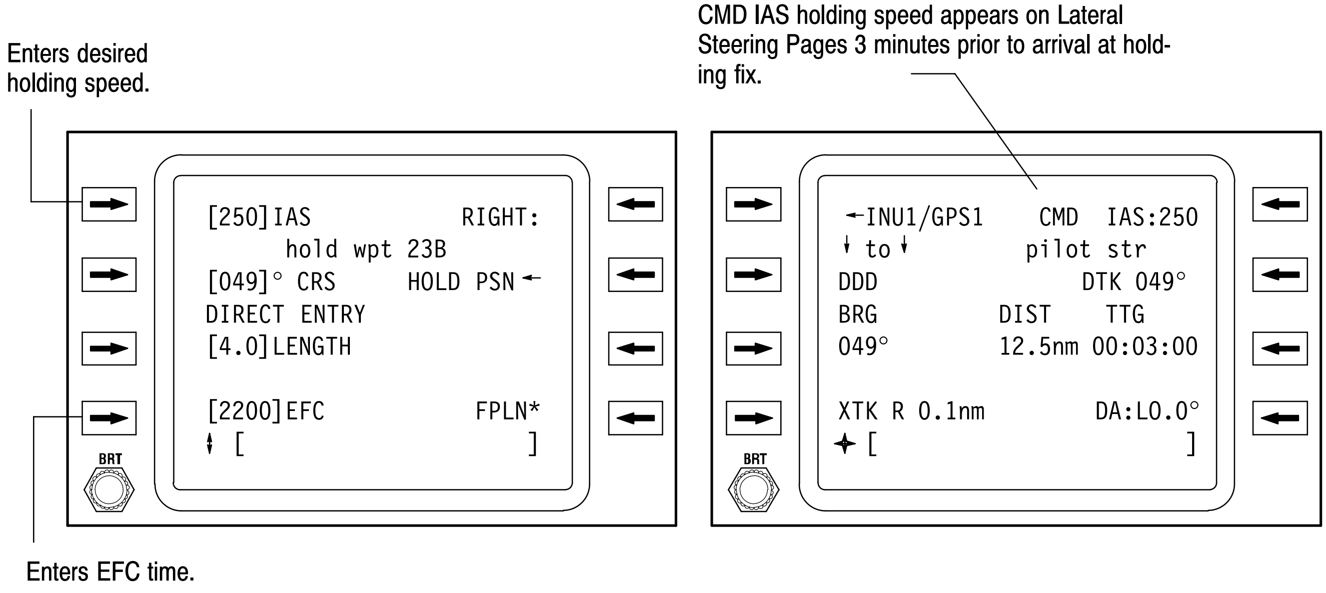
Exiting the Holding Pattern

Holding patterns may be terminated in two ways:

a. By cancellation. In this case a leg switch to the next flight plan waypoint occurs when the fix is crossed again (if automatic flight plan advancing is selected).

b. Direct–To another waypoint besides the holding fix.

HOLDING AIRSPEED AND EFC TIME ENTRY AND DISPLAY



Enters desired holding speed.

Enters EFC time.

CMD IAS holding speed appears on Lateral Steering Pages 3 minutes prior to arrival at holding fix.

```
[250]IAS          RIGHT:
     hold wpt 23B
[049]° CRS     HOLD PSN←
DIRECT ENTRY
[4.0]LENGTH

[2200]EFC          FPLN*
↕ [                     ]
```

```
←INU1/GPS1    CMD  IAS:250
↓ to ↓          pilot str
DDD                DTK 049°
BRG         DIST    TTG
049°        12.5nm 00:03:00

XTK R 0.1nm        DA:LO.0°
✦ [                      ]
```

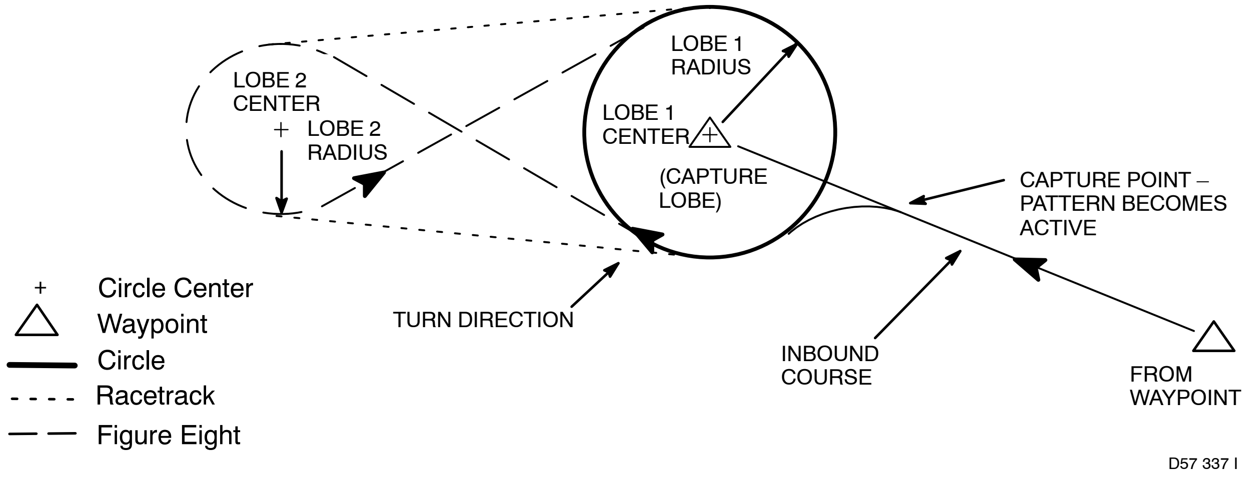
MOP DEFINITION

Definition of MOPs is performed on the MOP pages, one for each type of pattern. To create a new MOP, access the MOP pages from the patterns page. Three parameters define the circle pattern: lobe center location, radius and turn direction.

Racetrack and figure eight patterns require three additional parameters for the second lobe: lobe 2 center location, lobe 2 radius, and capture lobe indicator. The capture lobe circle center is the flight plan waypoint.

MOP geometry definitions are shown following.

MOP GEOMETRY



ENTERING MOPS INTO FLIGHT PLANS

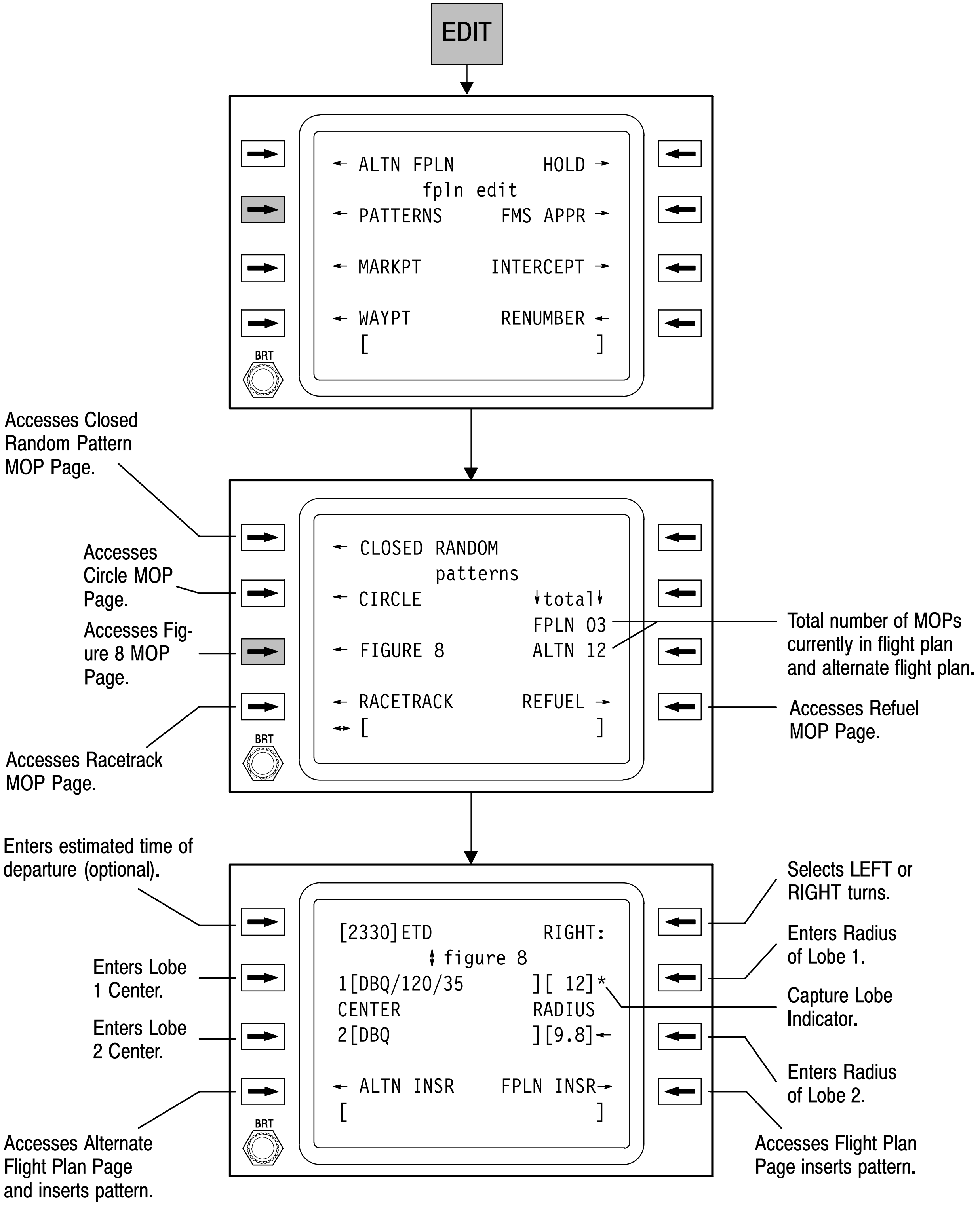
The capture lobe center of an MOP must be in the flight plan to enable execution of the pattern. A waypoint can be specified as an MOP capture lobe center either directly on the MOP page or by attaching an MOP to an existing flight plan waypoint.

To specify the flight plan waypoint on the MOP page and insert it in the flight plan, the waypoint must be entered as a lobe center. For a racetrack or figure eight pattern, press either LS6 or LS7 to specify the desired flight plan waypoint as the capture lobe. Then press the FPLN INSR line select key on the MOP Page. This accesses the flight plan page with INSERT xxx BEFORE? in the scratchpad, where xxx is FG8, RTK or CIR depending on which type of MOP was defined. After the flight plan is scrolled to the desired location, press the line select key adjacent to the waypoint, which will follow the pattern.

To attach an MOP to an existing flight plan waypoint, define the MOP but leave one lobe center blank on the MOP page. For a circle pattern, the circle center location cannot be entered. Then press the FPLN INSR key to access the flight plan page with the message ATTACH xxx AT? in the scratchpad, where xxx is FG8, RTK or CIR depending on which type of MOP was defined. After the flight plan is scrolled to the desired location, press the line select key adjacent to the waypoint where is the pattern is to be defined. This waypoint is the capture lobe center for the pattern.

A P is displayed to the right of the designated waypoint to indicate that there is a pattern defined for this waypoint. The MOP parameters can be viewed and modified by pressing the line select key adjacent to the associated P symbol on the flight plan page twice, once to access the associated flight plan waypoint page and a second time to access the MOP waypoint page.

MOP PAGE ACCESS FROM PATTERNS PAGE



Accesses Closed Random Pattern MOP Page.

Accesses Circle MOP Page.

Accesses Figure 8 MOP Page.

Accesses Racetrack MOP Page.

Total number of MOPs currently in flight plan and alternate flight plan.

Accesses Refuel MOP Page.

Enters estimated time of departure (optional).

Enters Lobe 1 Center.

Enters Lobe 2 Center.

Accesses Alternate Flight Plan Page and inserts pattern.

Selects LEFT or RIGHT turns.

Enters Radius of Lobe 1.

Capture Lobe Indicator.

Enters Radius of Lobe 2.

Accesses Flight Plan Page inserts pattern.

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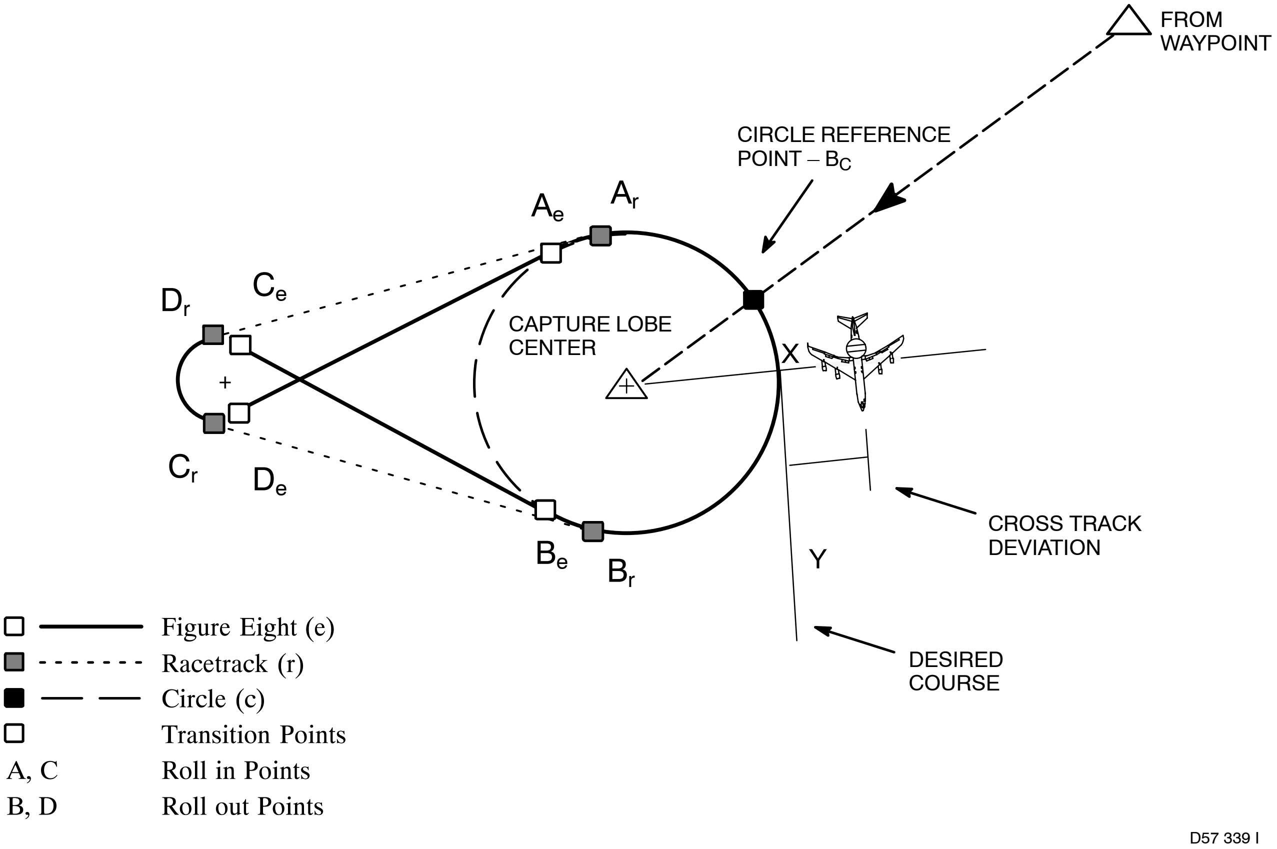
MOP PATTERN EXECUTION



MOP ACTIVATION AND EXECUTION

The following paragraphs describe activation and execution of racetrack, figure eight, and circle MOPs. CRPs are described later.

The course into the pattern is determined by the preceding flight plan waypoint and the capture lobe center. When the capture lobe center becomes the TO waypoint, capture switching distance is computed based upon a 90 degree course change, current airplane speed and current wind.

When the airplane is within the capture switching distance, pattern guidance computations are activated. At that time several changes occur, both is flight plan operation and page displays:

a. Automatic leg advance is suspended.

b. Transition points are calculated and all displays reference the computed course (not the inbound course displayed on the flight plan).

c. The pattern becomes active.

d. Flight guidance begins to fly to the next transition point.

Transition points for the racetrack and figure eight pattern consist of roll in points from the great circle leg to the constant radius turn and roll out points from constant radius turns to the great circle leg as illustrated. For a circle, the intersection of the circle perimeter and the great circle connecting the FROM waypoint and the circle center is the circle reference point. These points are displayed as the current destination on the pilot and co-pilot lateral steering page for the active pattern. A waypoint alert is provided 10 seconds prior to reaching a transition point.

When on the great circle path determined by roll out point D and roll in point A in the MOP Patterns Execution diagram, the desired track, cross track deviation, distance to go, time to go and the bank command are determined as in normal waypoint to waypoint flight with location D as the FROM and location A as the TO. These parameters are computed in the same manner when on the great circle path from roll out point B to roll in point C.

A transition from constant radius turn guidance on the lobe to the great circle path guidance between locations B and C in the MOP Pattern Execution diagram occurs when the distance to go is less than 0.25nm.

When on the path determined by roll in point A and roll out point B, the desired track, cross track deviation, distance to go, time to go and the bank command are determined as follows:

a. Desired track for right patterns is determined by adding 90 degrees to the angle determined by airplane location and the lobe 1 center. For left patterns, 90 degrees are subtracted from the angle.

b. Cross track deviation is the difference between the radius and the distance between the airplane and the lobe center location.

c. Distance to go is the distance along the lobe from the intersection of the lobe circle and a line determined by the airplane and the lobe center (location X in the MOP Patterns Execution diagram) and the roll out point or circle reference point (location B).

d. Time to go is distance to go divided by ground speed.

e. Bearing is the angle from present position to the roll out point.

f. The bank command is generated to ensure the airplane remains on the lobe (cross track deviation is zero).

MODIFYING MISSION ORBIT PATTERNS

Changes can be made to the pattern type and any defining parameter at any time. Changes made prior to activation of the pattern take effect when the pattern becomes active. Changes made to an active pattern create a new waypoint and pattern.

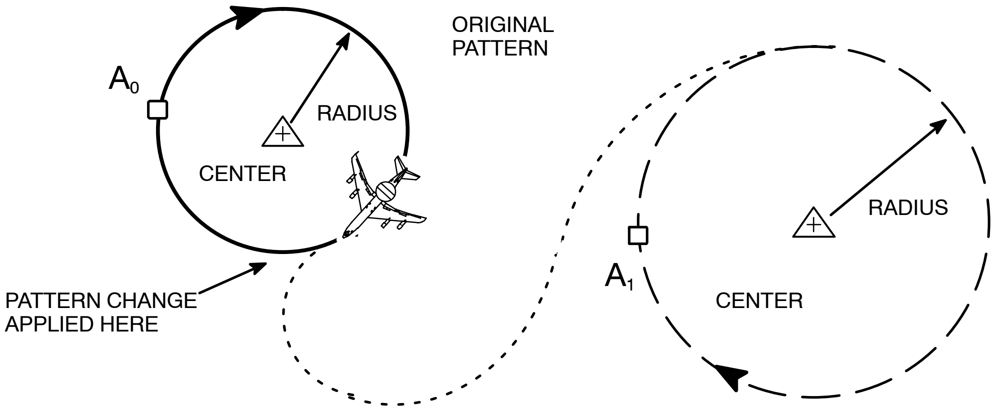
Modifying a pattern requires confirmation. When a change is confirmed for an active pattern, a Direct–To is performed to the capture lobe of the new pattern. The old pattern is maintained in history and can be reflown using the Direct–To function.

Pattern parameters can be viewed and modified by pressing the line select key adjacent to the associated P symbol on the flight plan page twice, once to access the associated flight plan waypoint page and a second time to access the MOP definition page. After entering new parameters, the message CONFIRM PAT CHANGE is displayed in the scratchpad. Clearing this message allows for multiple changes. The pattern type can be changed by scrolling vertically through the racetrack, figure eight and circle MOP pages. Confirming the change causes the guidance function to execute a Direct–To to the new capture lobe immediately. If the airplane is currently flying on the identical constant radius turn of the capture lobe (desirable in most cases), the airplane continues on the constant radius turn to the next transition point.

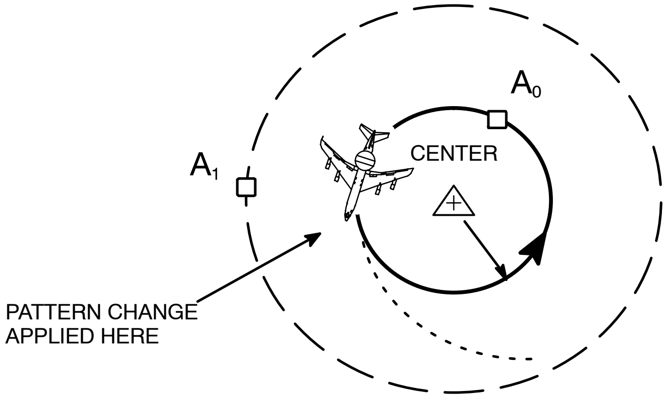
The transition between patterns is determined by the location of the airplane when the pattern change is confirmed. Diagrams following illustrate several possible scenarios where confirming the change can minimize transition time and avoid possible confusion. Cases where better choices as to when to confirm the pattern change are described in the diagrams.

Pattern changes can be designed and implemented to minimize the transition course between patterns. The Multiple Pattern Execution diagram illustrates multiple changes to patterns with no transition time. This is accomplished by selecting a pattern type, defining the secondary location and radius, then designating the current lobe as the capture lobe and confirming the change. Awkward situations can be avoided by steering manually in the preferred direction prior to confirming the change.

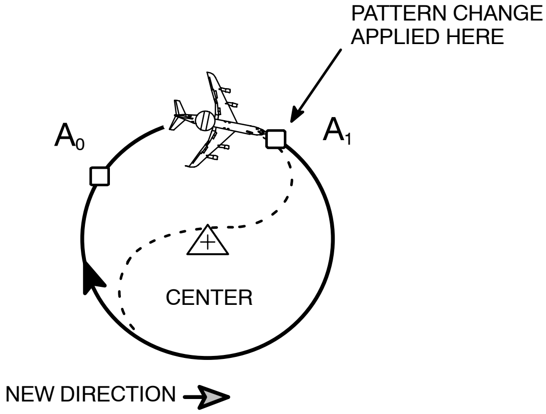
MODIFYING CIRCLE PATTERNS



CIRCLE CENTER EDIT



CIRCLE RADIUS EDIT



—— Original Pattern
— — Modified Pattern
- - - - - - Transition Path

CIRCLE TURN DIRECTION EDIT

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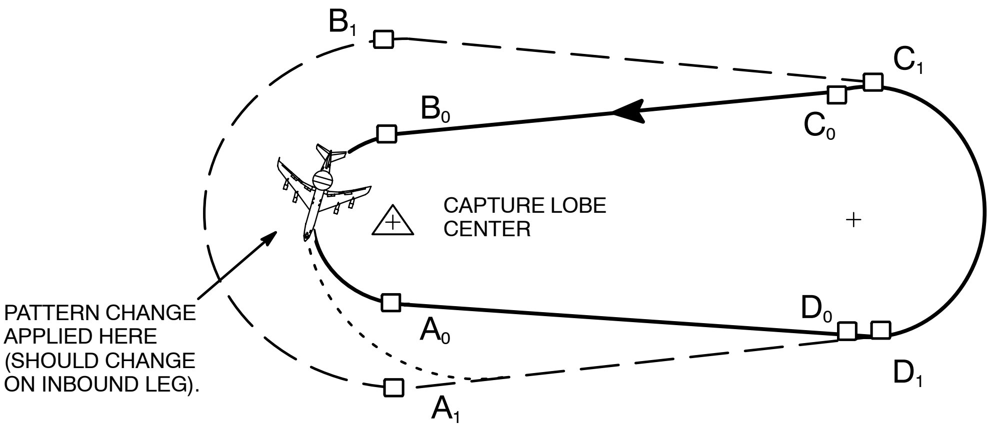
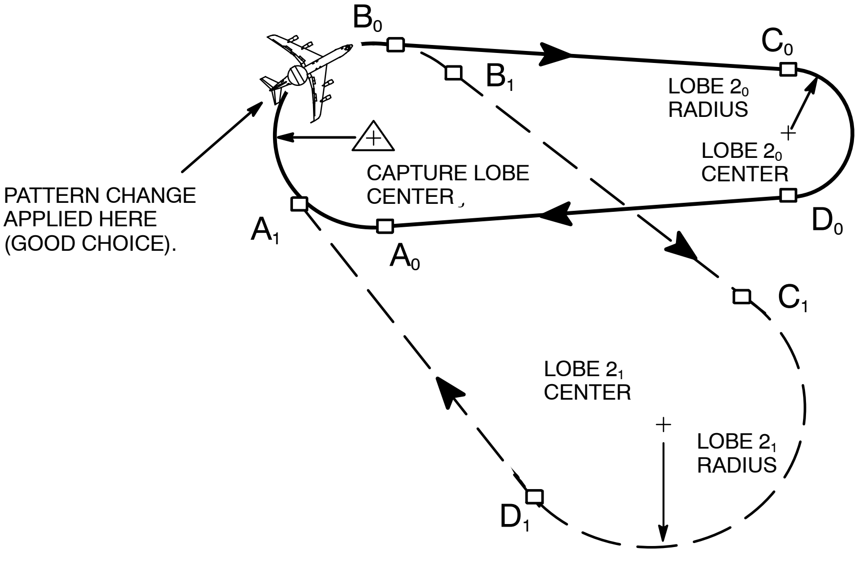
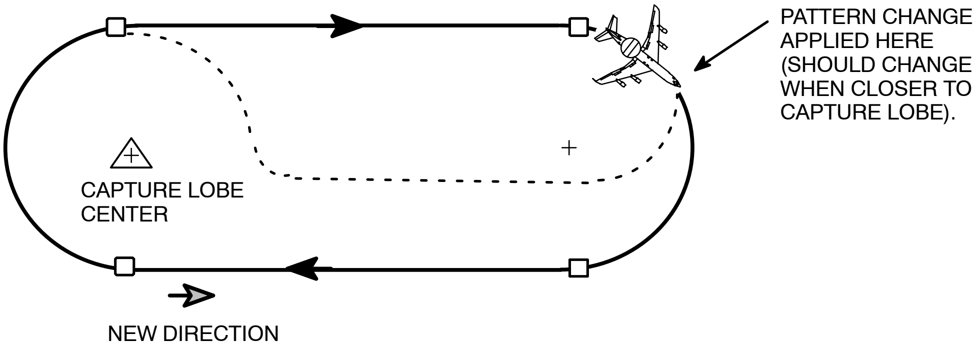
MODIFYING RACETRACK PATTERNS



RACETRACK RADIUS EDIT



RACETRACK LOBE 2 EDIT



RACETRACK TURN DIRECTION EDIT

━━ Original MOP
— — Modified MOP
- - - - - - Transition Path
☐ Roll in/Roll out Points

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MODIFYING FIGURE EIGHT PATTERNS

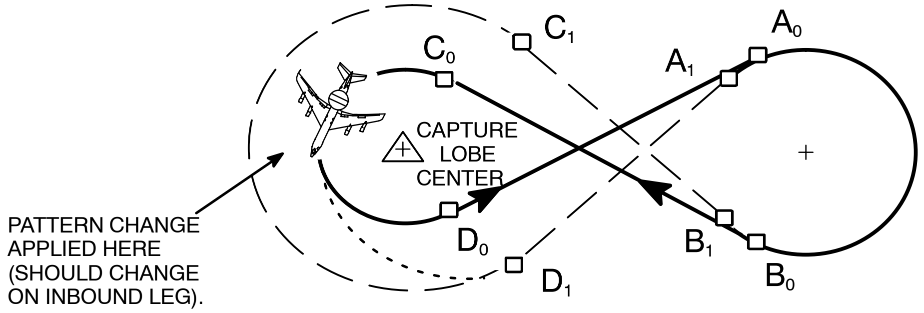


FIGURE EIGHT RADIUS EDIT

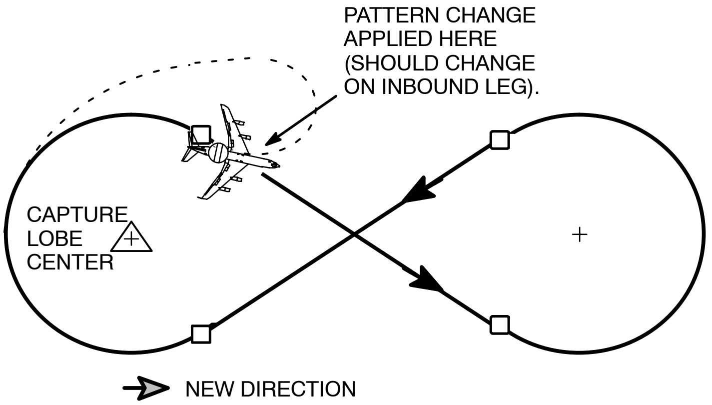
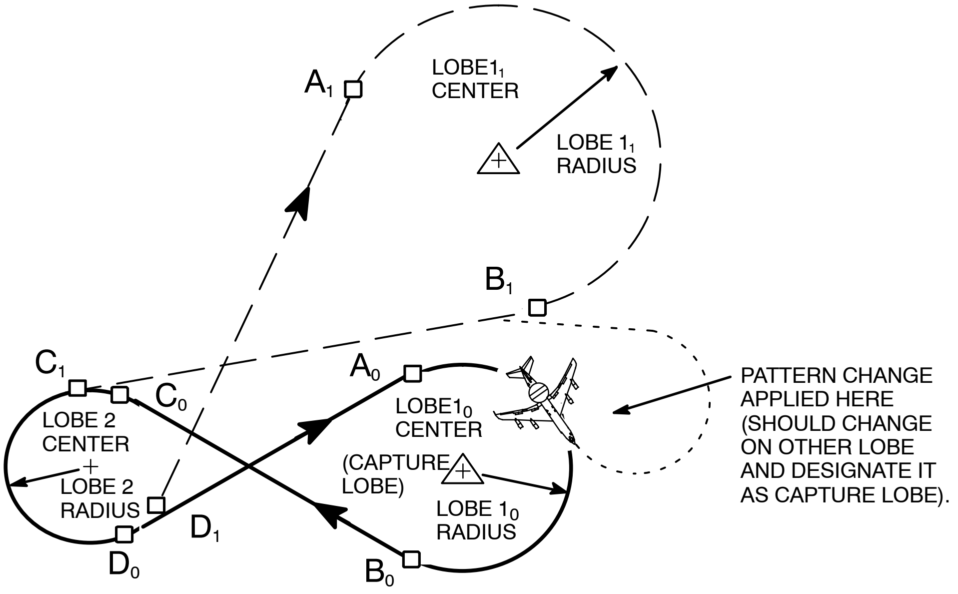


FIGURE EIGHT TURN DIRECTION EDIT



━━ Original Pattern
— — Modified Pattern
- - - - - - Transition Path

FIGURE EIGHT CAPTURE LOBE EDIT

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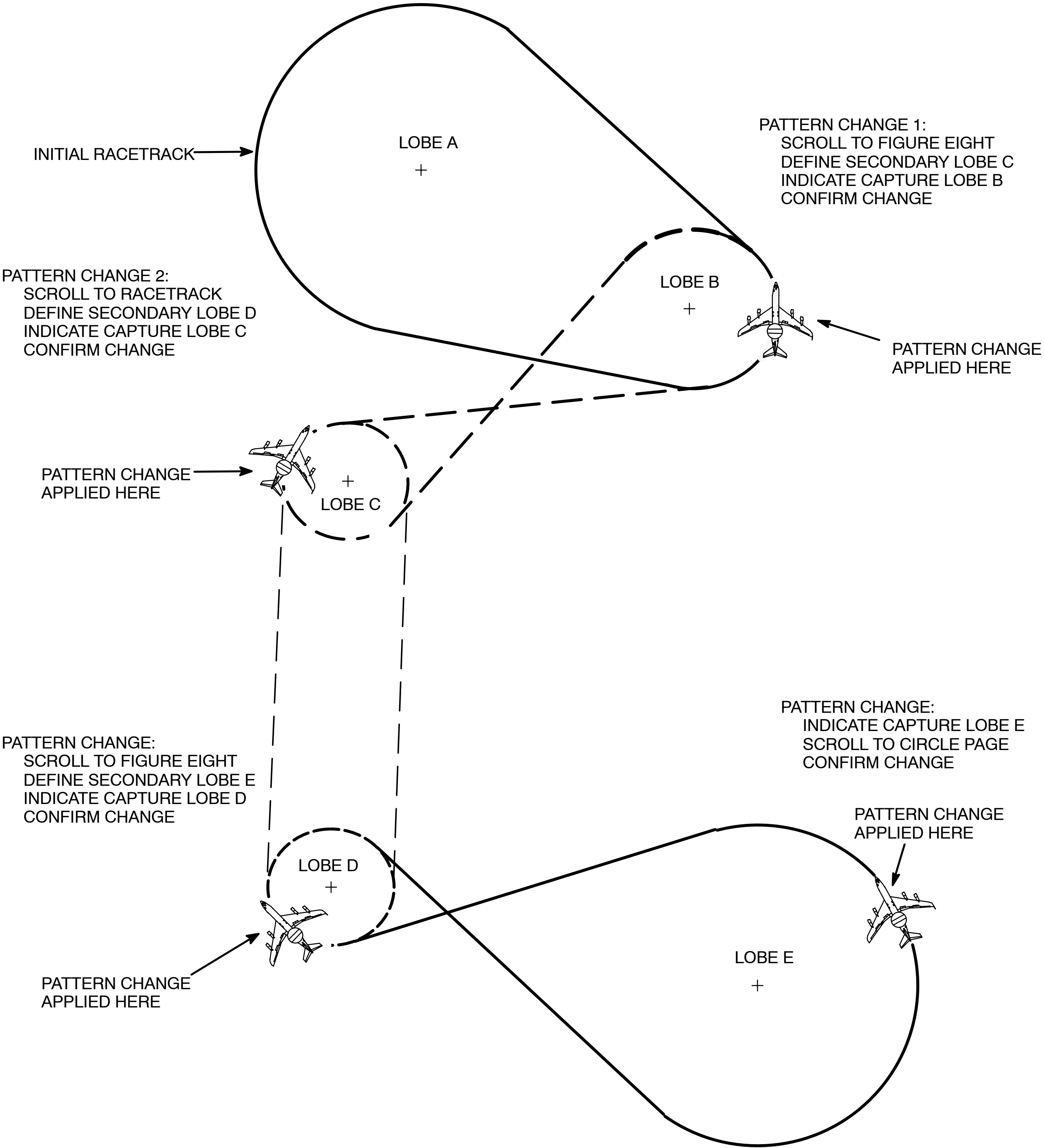
MULTIPLE PATTERN EXECUTION



COMPOSITE PATTERNS

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CRP DEFINITION AND EXECUTION

CRPs are defined by entering points, such as identifiers, latitude-longitude positions, on the CRP MOP pages 1 through 3. Any number of waypoints (in addition to the fix point, which is optional) can be specified up to a maximum of nine. To specify the MOP fix on the CRP MOP pages, enter the position at the FIX line on CRP MOP page 1.

CRPs are executed only upon arrival at the CRP fix if AUTO advance mode is selected. If manual (MAN) advance mode is selected, the fix is overflown. To enter the pattern, the advance mode must be toggled to AUTO.

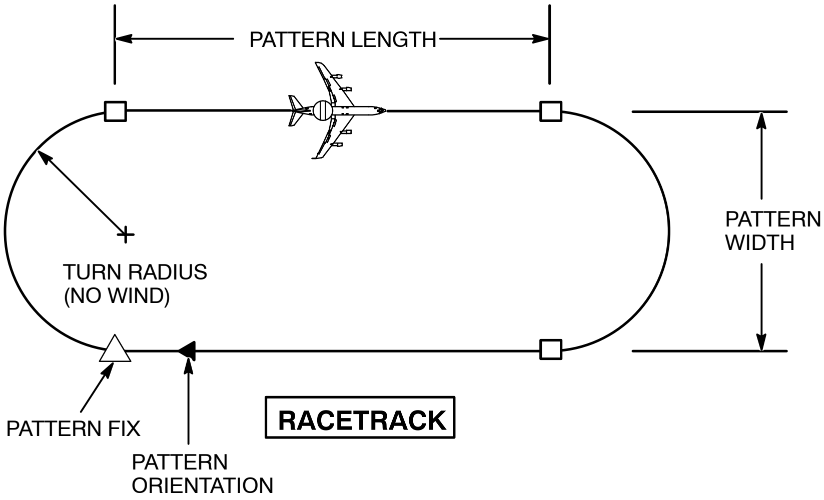
Once the CRP is being executed, guidance is provided to all points in the CRP as if they were flight plan waypoints. An asterisk is displayed adjacent to the CRP waypoint number of the current TO waypoint on the associated CRP MOP waypoint page.

ESTIMATED TIME OF DEPARTURE

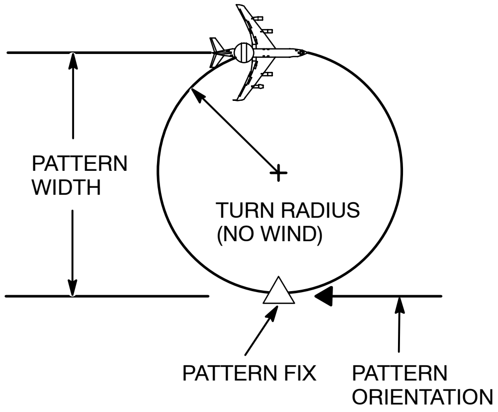
The ETD entry permits future waypoint ETAs to be calculated more realistically. If an ETD is entered (in UTC), then all future waypoint ETAs are calculated from that pattern fix departure reference. If no ETD is entered or it is deleted, then all future ETAs are calculated as if no loiter time is to be spent in the MOP.

EXITING THE MOP

MOPs can be terminated only by performing a Direct-To another waypoint besides the pattern fix. The pattern waypoint and MOP parameters remain as defined as one of the five history waypoints, to allow the pattern to be reflown.



RACETRACK



CIRCLE

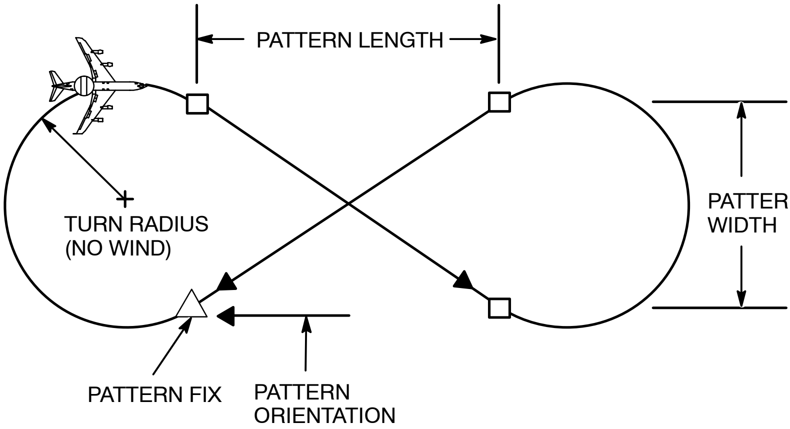
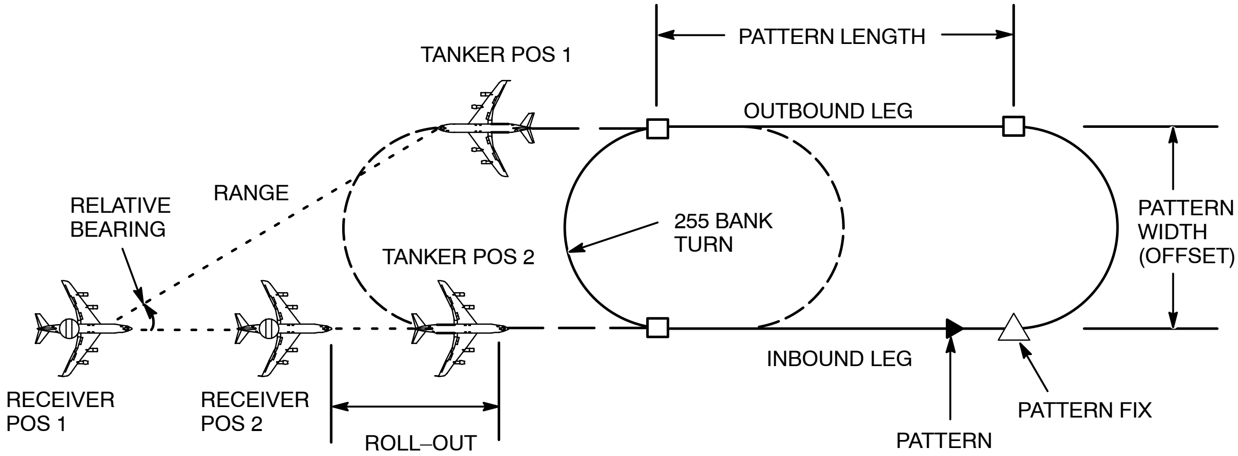


FIGURE 8



REFUEL

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INTERCEPT CALCULATIONS

Up to ten moving targets can be defined simultaneously. Intercept solutions to these targets can be used in two ways:

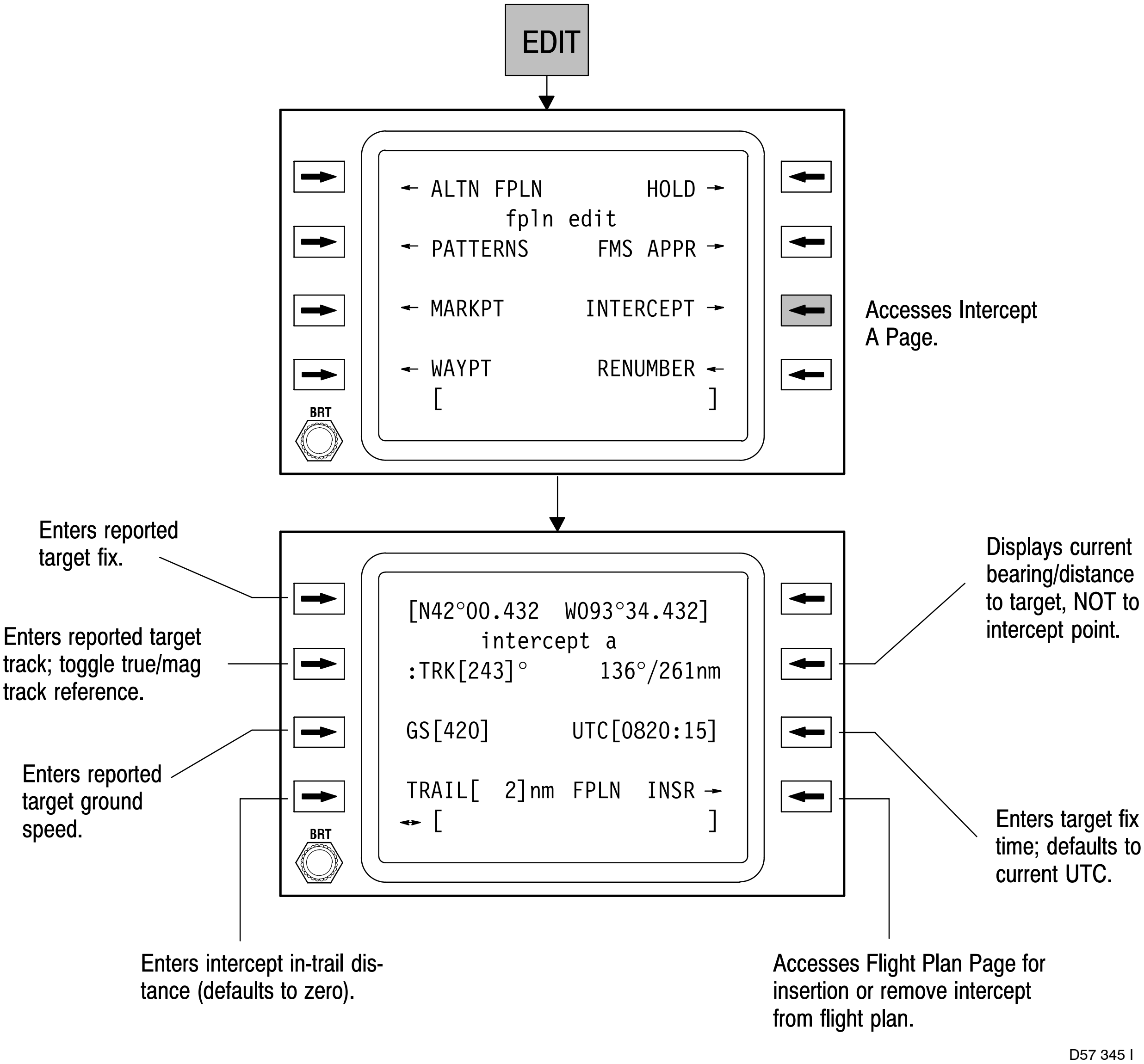
a. The intercept solution can be inserted as the active waypoint for immediate (Direct–To) execution.

b. The intercept solution can be inserted as a future waypoint to implement a future intercept of a moving target.

The intercept computations determine the true minimum time intercept to the moving waypoint, not a homing type solution. If intercept is not possible, a point is computed 1000 miles down-track from the target fix location.

Solutions are computed cyclically for all intercepts, whether inserted in the flight plan or not. If an intercept has not been inserted, the computations are performed as with Direct–To intercepts.

INTERCEPT DEFINITION



Accesses Intercept A Page.

Enters reported target fix.

Enters reported target track; toggle true/mag track reference.

Enters reported target ground speed.

Enters intercept in-trail distance (defaults to zero).

Displays current bearing/distance to target, NOT to intercept point.

Enters target fix time; defaults to current UTC.

Accesses Flight Plan Page for insertion or remove intercept from flight plan.

Direct Intercepts

When an intercept is the active waypoint, the intercept location is updated cyclically, based on the following:

a. Current own airplane position and speed

b. Moving target definition

c. Current wind.

The intercept point location is adjusted as required and the inbound course is edited to match the current Direct–To course into the waypoint. To perform a direct intercept, enter the desired parameters on the Intercept A Page, press the FPLN INSR line select key, and press line select adjacent to the TO waypoint location on Flight Plan Page (see following).

Planned Intercepts

When the intercept is inserted as a future waypoint, then the intercept location is updated cyclically, based on the following:

a. Location of the flight plan waypoint immediately prior to the intercept.

b. Distance along the flight plan to that waypoint.

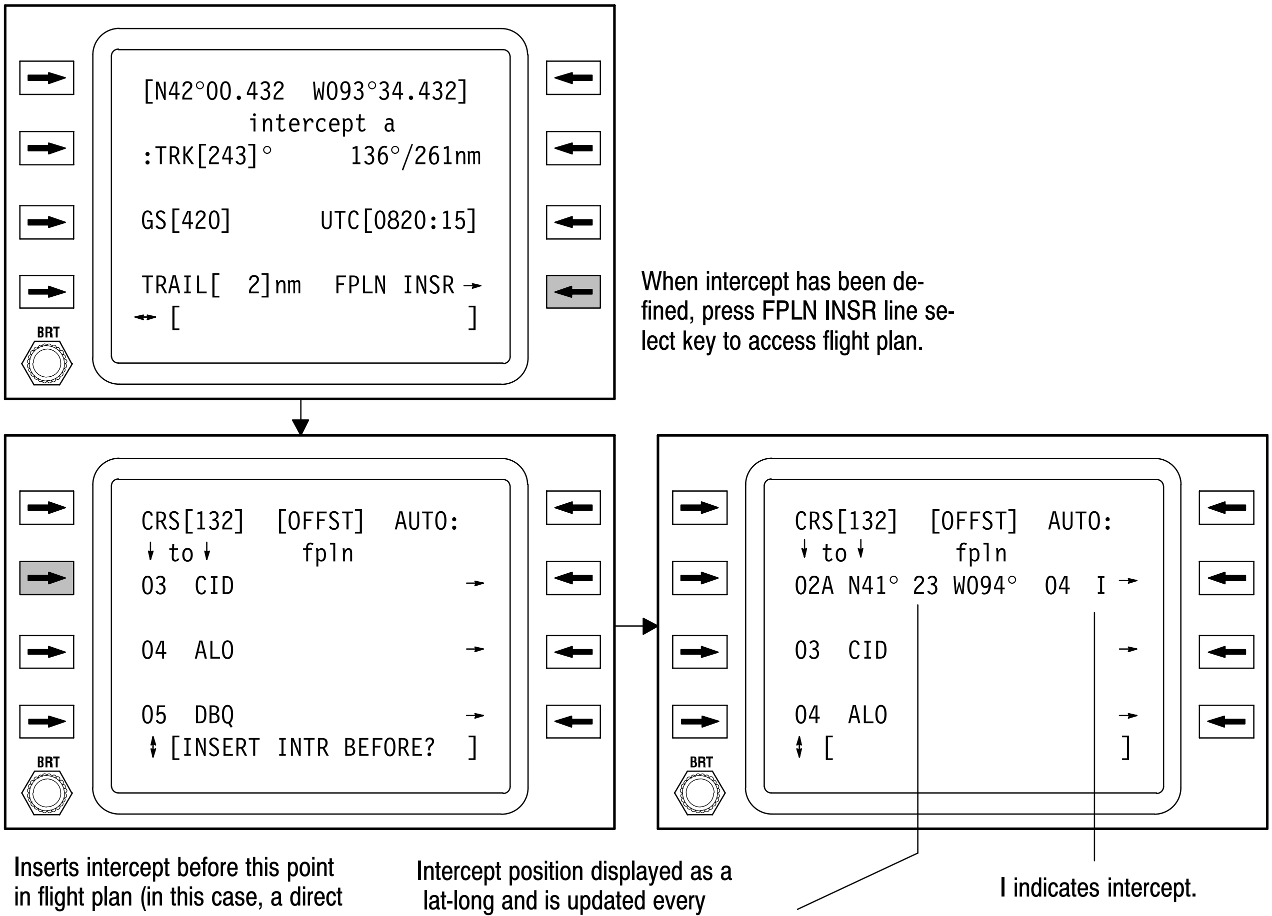
c. Current own airplane speed

d. Moving target definition

e. Current wind.

The estimated time of arrival at the waypoint immediately prior to the intercept is computed. Then the intercept point is computed from that point and time in exactly the same manner as the direct case. The intercept is executed exactly as the direct intercept when it becomes active.

INTERCEPT INSERTION (DIRECT INTERCEPT EXAMPLE)



```
[N42°00.432  W093°34.432]
        intercept a
:TRK[243]°      136°/261nm

GS[420]       UTC[0820:15]

TRAIL[  2]nm   FPLN INSR →
↔ [                      ]
```

When intercept has been defined, press FPLN INSR line select key to access flight plan.

```
CRS[132]  [OFFST]  AUTO:
↓ to ↓       fpln
03  CID                  →

04  ALO                  →

05  DBQ                  →
↕ [INSERT INTR BEFORE?  ]
```

```
CRS[132]  [OFFST]  AUTO:
↓ to ↓       fpln
02A N41° 23 W094°  04  I →

03  CID                  →

04  ALO                  →
↕ [                     ]
```

Inserts intercept before this point in flight plan (in this case, a direct intercept is being performed).

Intercept position displayed as a lat-long and is updated every 20 seconds.

I indicates intercept.

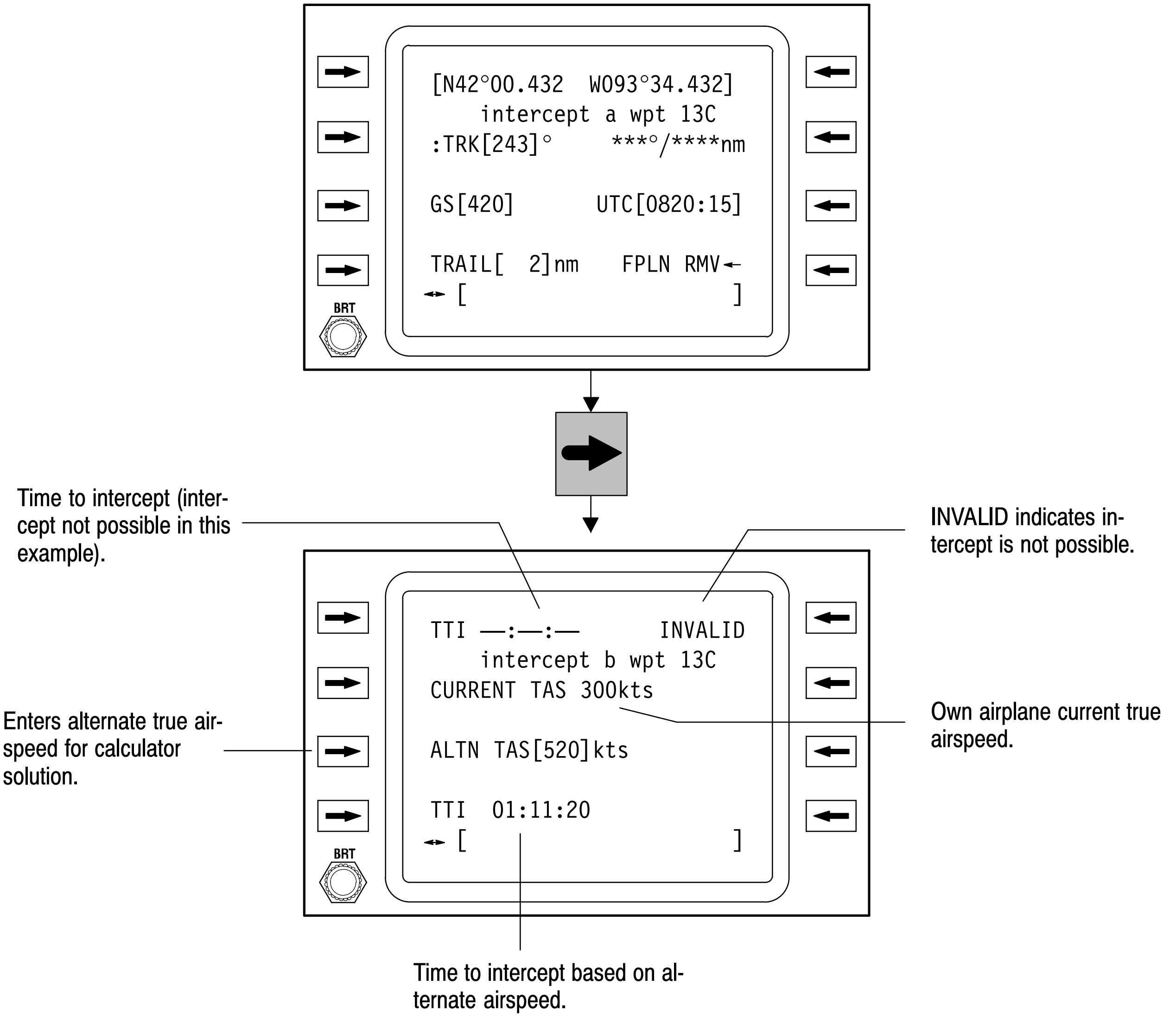
Multiple Intercepts

Ten moving waypoint (intercept) definitions can be inserted in the flight plan. Each intercept solution is computed independently and flown in the flight plan sequence.

Alternate Intercept Solution

A calculator function is provided to allow the crew to enter an alternate true airspeed and see the effect on the intercept. This calculator is available for an intercept not inserted into the flight plan and for the next intercept in the flight plan. (See below.)

INTERCEPT FUNCTION CALCULATOR



```
[N42°00.432  W093°34.432]
    intercept a wpt 13C
:TRK[243]°     ***°/****nm

GS[420]       UTC[0820:15]

TRAIL[  2]nm   FPLN RMV←
↔ [                     ]
```

```
TTI —:—:—        INVALID
    intercept b wpt 13C
CURRENT TAS 300kts

ALTN TAS[520]kts

TTI  01:11:20
↔ [                     ]
```

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WAYPOINT MARK AND LIST OVERVIEW

GINS maintains a markpoint list of up to 10 markpoints and a waypoint list of up to 20 manually entered waypoints. The lists are stored in nonvolatile memory. Each list is maintained on separate pages, both of which are accessed from the Flight Plan Edit Page. See *figure 1-172*. To access the Markpoint List Page, press the MARKPT line select key on the Flight Plan Edit Page. To access the Waypoint List Page, press the WAYPT line select key.

Markpoint List

To create a markpoint, press the MARK function key when the desired position is overflown. Pressing the MARK key writes the designated pilot's present position solution into the scratchpad and automatically adds the position to the markpoint list (on the Markpoint List Page), assigns the markpoint a unique letter identifier (A through J), and records the mark time. The Markpoint List Page need not be displayed to use this function.

Once the markpoint is on the Markpoint List Page, it is treated like any other waypoint and therefore can be copied and inserted elsewhere, deleted, or assigned a user-defined label. The marked position in the scratchpad can be inserted as a waypoint or position or cleared with the CLR key.

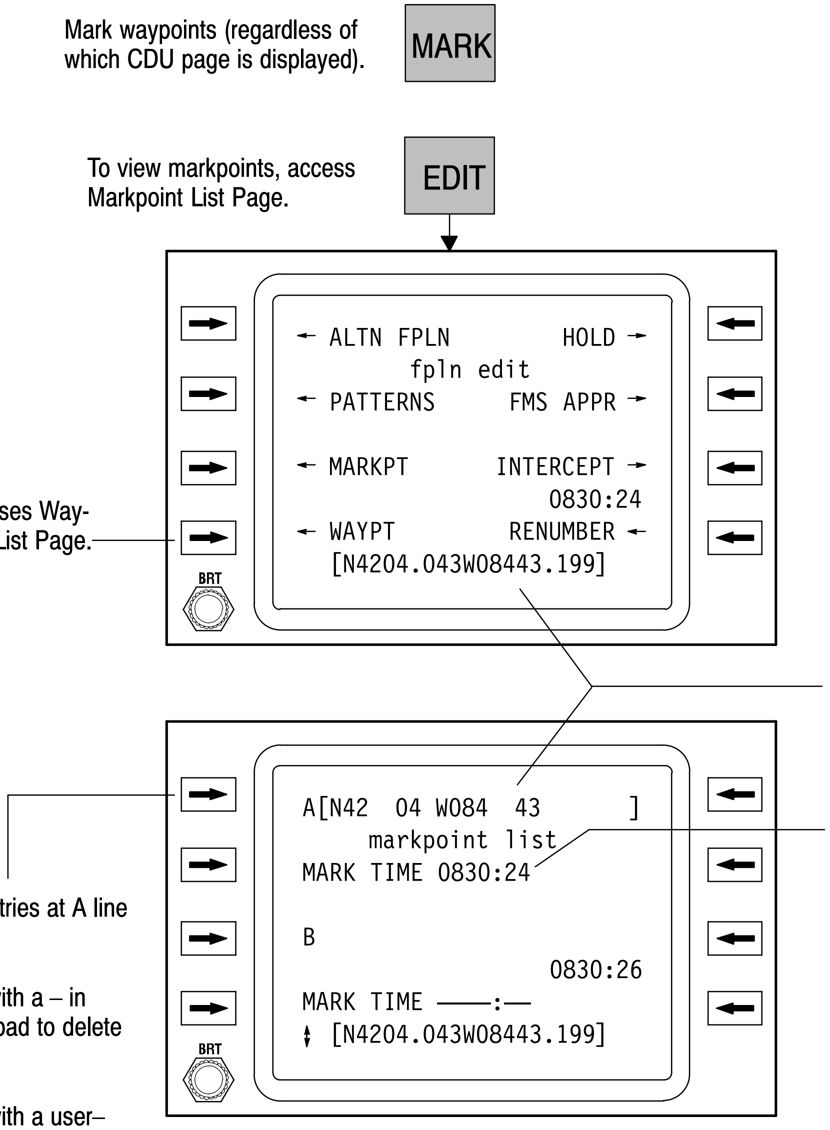
If 10 markpoints exist on the Markpoint List Page and another mark is performed, the new mark overwrites the oldest mark in the list. A subsequent mark overwrites the next oldest, and so on.

Manual position entries are not allowed on the Markpoint List Page. To store manually entered waypoints, use the Waypoint List Page.

Waypoint List

The waypoint list is maintained on the Waypoint List Page. Any type of waypoint can be entered in the waypoint list, such as latitude-longitudes, identifiers, identifier/bearing/distances, and MGRS waypoints. Each waypoint is identified with a unique letter (A through T). These waypoints are treated like any other waypoint and can be copied and inserted elsewhere, deleted, or assigned a user-defined label.

MARKPOINT LIST AND WAYPOINT LIST PAGE ACCESS AND USE



Mark waypoints (regardless of which CDU page is displayed).

To view markpoints, access Markpoint List Page.

Accesses Waypoint List Page.

Mark position recorded in scratchpad and in markpoint list.

Mark time recorded automatically.

Possible entries at A line select key:

a. Press with a – in scratchpad to delete point.

b. Press with a user–defined label in scratchpad to label point.

c. Press with empty scratchpad to copy point to scratchpad.

NOTE

Scrolling vertically shows other markpoints.

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DATA PAGE OVERVIEW

Independent of the active and alternate flight plans, the FMS computes, on demand, the bearing/distance and ETE/ETA for a variety of FROM–TO waypoint pairs and direct options, as selected by the crew. These options include:

a. FROM any active flight plan waypoint TO the next succeeding flight plan waypoint

b. FROM any flight plan waypoint TO any other flight plan waypoint

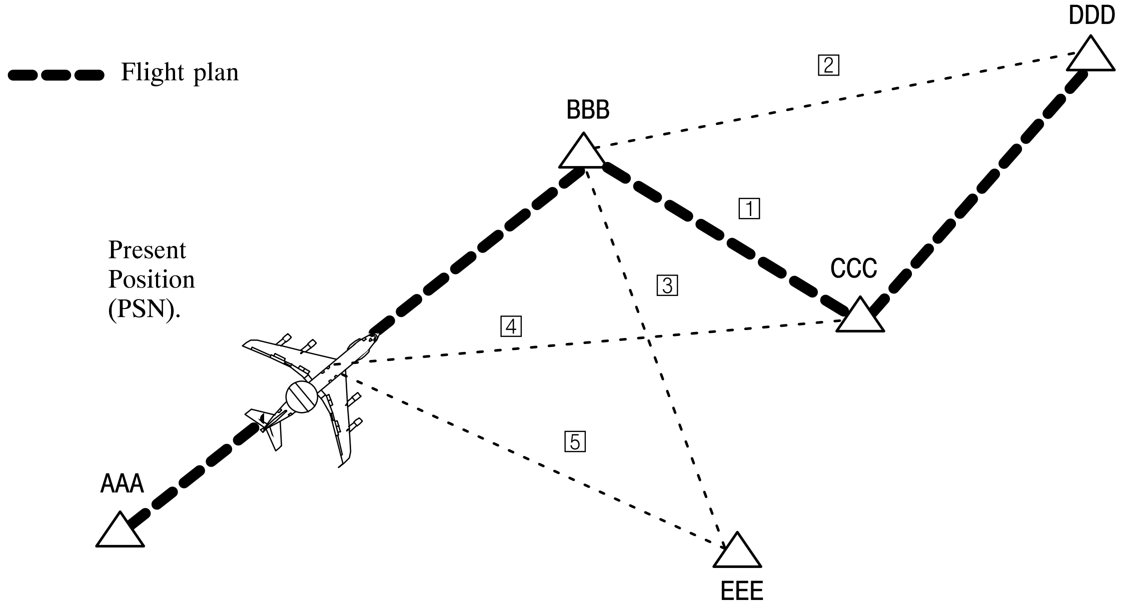
c. FROM any flight plan waypoint TO a non-flight plan waypoint

d. FROM airplane present position TO any flight plan waypoint

e. FROM airplane present position TO any non-flight plan waypoint

These options are shown below.

FROM–TO OPTIONS FOR THE DATA PAGE (EXAMPLES ONLY)



Option a:	BBB to CCC (flight plan waypoint to next flight plan waypoint)
Option b:	BBB to DDD (flight plan waypoint to other flight plan waypoint)
Option c:	BBB to EEE (flight plan waypoint to non-flight plan waypoint)
Option d:	PSN to CCC (Present position to flight plan waypoint)
Option e:	PSN to EEE (Present position to non-flight plan waypoint)

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Data Page Access and Waypoint Entry

To access the Data Page, press the DATA function key, then press the line select key adjacent to any waypoint in either the active flight plan, alternate flight plan, waypoint list, or markpoint list. See below for an example of Data Page access.

After the Data Page has been accessed, other TO waypoints can be selected or entered and FROM–TO display options selected.

If the initially selected waypoint is a flight plan waypoint, press the ⬇ or ⬆ arrow key to scroll leg by leg through the flight plan. This is option a. in examples illustration.

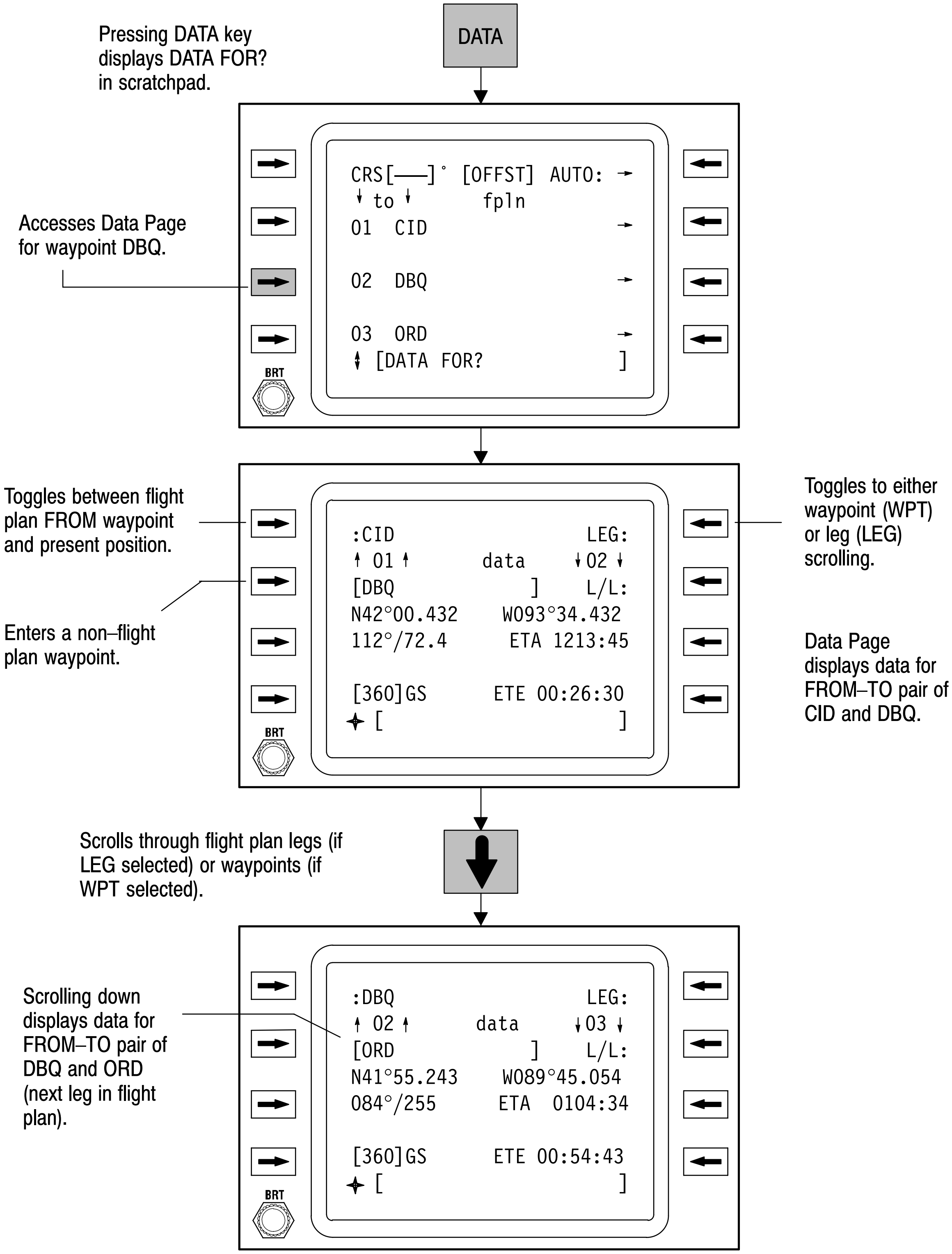
To freeze the FROM waypoint, toggle the upper right line select key from LEG to WPT. Then press the ⬇ or ⬆ arrow keys to scroll waypoint by waypoint through the flight plan while retaining the same FROM waypoint. This is illustrated option b.

To view a direct segment FROM a flight plan waypoint TO a non-flight plan waypoint, scroll the flight plan in the LEG mode until the desired FROM waypoint is at the top of the page. Then enter the desired TO waypoint on the third line in place of the existing TO waypoint. This is illustrated option c.

To view data from present position to any flight plan waypoint, scroll the flight plan so that the desired TO waypoint is on line 3; then toggle the top left line select key to present position, indicated by ↑PSN↑ on line 2. This is illustrated option d.

To view data from present position to a non-flight plan waypoint, toggle the FROM waypoint to present position, indicated by ↑PSN↑ on line 2. Then enter the desired waypoint in place of the TO waypoint on line 3. This is illustrated option e.

DATA PAGE ACCESS AND LEG OR WAYPOINT SCROLLING/SELECTION



Pressing DATA key displays DATA FOR? in scratchpad.

Accesses Data Page for waypoint DBQ.

```
CRS[——]° [OFFST] AUTO: →
↓ to ↓      fpln
01  CID                →

02  DBQ                →

03  ORD                →
↕ [DATA FOR?           ]
```

Toggles between flight plan FROM waypoint and present position.

Enters a non–flight plan waypoint.

Toggles to either waypoint (WPT) or leg (LEG) scrolling.

Data Page displays data for FROM–TO pair of CID and DBQ.

```
:CID                 LEG:
↑ 01 ↑      data    ↓02 ↓
[DBQ             ]   L/L:
N42°00.432    W093°34.432
112°/72.4      ETA 1213:45

[360]GS      ETE 00:26:30
✦ [                     ]
```

Scrolls through flight plan legs (if LEG selected) or waypoints (if WPT selected).

Scrolling down displays data for FROM–TO pair of DBQ and ORD (next leg in flight plan).

```
:DBQ                 LEG:
↑ 02 ↑      data    ↓03 ↓
[ORD             ]   L/L:
N41°55.243    W089°45.054
084°/255      ETA  0104:34

[360]GS      ETE 00:54:43
✦ [                     ]
```

NOTE

Numbered steps correspond to Option a and b examples in illustration.

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Data Page Displayed Information

The Data Page presents data related to the selected DATA FOR? waypoint (shown on line 3 of the CDU in figure below), which is called in this section the TO waypoint of the FROM–TO waypoint pair. It also shows data for the FROM–TO leg and the ETA for a hypothetical flight either via the active flight plan routing to the FROM waypoint and then to the TO waypoint along the displayed leg, or directly FROM airplane present position TO the displayed waypoint. The present position in this case is the position of the designated pilot's navigational solution.

If the FROM and/or TO waypoints are in the active flight plan, then their corresponding flight plan waypoint numbers are displayed as shown in figure below.

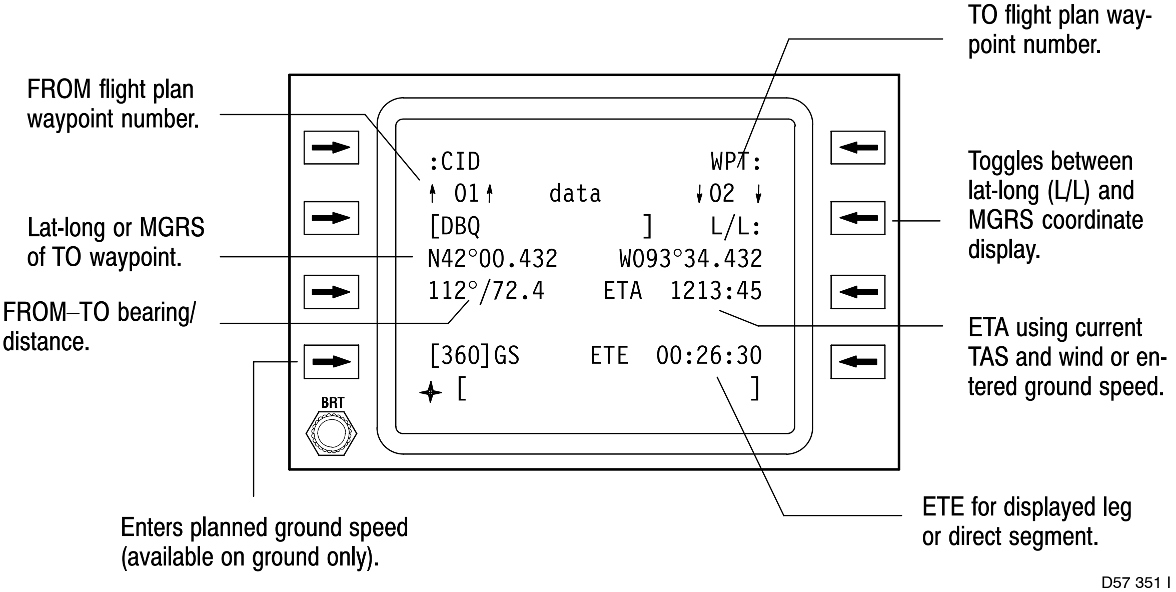
The coordinates of the TO waypoint are shown on line 4 of the display and can be toggled between latitude-longitude and MGRS grid coordinates using the right line select key.

The bearing and great circle distance between the FROM and TO waypoints are shown on line 5, along with the ETA at the TO waypoint, assuming current TAS and wind (or entered ground speed if not airborne).

If the FROM waypoint on the Data Page is a flight plan waypoint and if a holding pattern or MOP is in the flight plan at or prior to that point, the ETA at the TO waypoint assumes the airplane will depart the holding fix at the entered expected further clearance time, or depart the MOP pattern fix at the expected time of departure, if entered. Otherwise, no holding or pattern on-station loiter time is included in the ETA calculation.

The ETE is for the displayed FROM–TO leg only.

DATA PAGE DISPLAYED INFORMATION



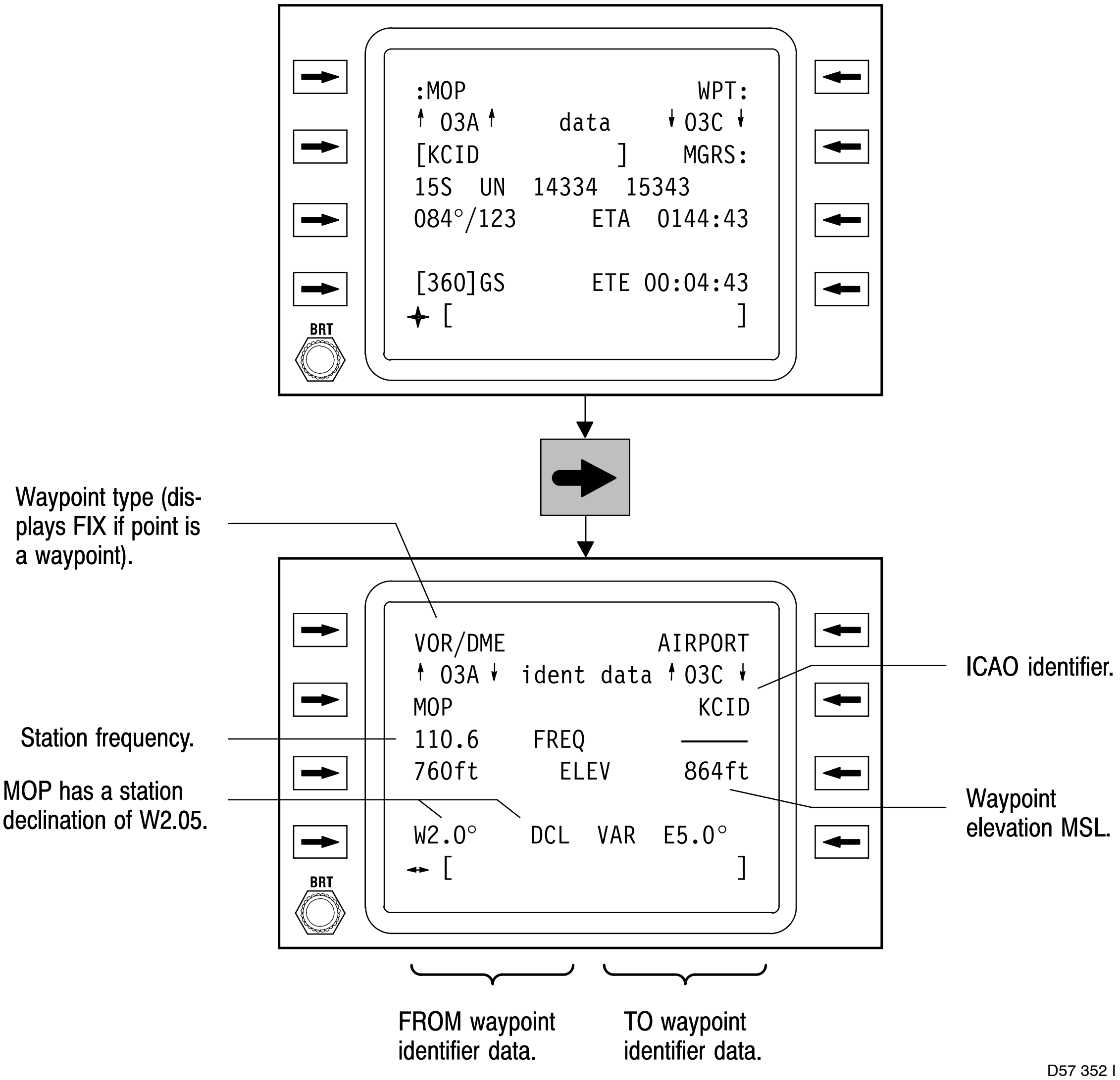
```
:CID                WPT:
↑ 01↑    data       ↓02 ↓
[DBQ           ]    L/L:
N42°00.432     W093°34.432
112°/72.4    ETA  1213:45

[360]GS     ETE  00:26:30
✦ [                     ]
```

Selection and Display of Waypoint Identifier Data

To view the ICAO data base information for identifier-referenced waypoints, select or enter the waypoint identifier or leg pair on the Data Page and press one of the ◀ or ▶ arrow keys to scroll to the corresponding Ident Data Page for the FROM–TO pair. See example below.

If either the FROM or TO waypoint on the Data Page selected leg is an ICAO identifier-referenced waypoint (including identifier/bearing/distance waypoints), its corresponding data base information is presented: FROM on the left, TO on the right. The waypoint type, identifier, station frequency (if applicable), and elevation MSL are displayed. If the waypoint is a navaid with a station declination, it is displayed as DCL; if not, the GINS-computed magnetic variation for that location is displayed as VAR.

IDENT DATA PAGE ACCESS AND DISPLAYED INFORMATION



```
:MOP                 WPT:
↑ 03A ↑    data    ↓ 03C ↓
[KCID         ]    MGRS:
15S  UN  14334  15343
084°/123      ETA  0144:43

[360]GS       ETE 00:04:43
✦ [                      ]
```

```
VOR/DME           AIRPORT
↑ 03A ↓  ident data ↑ 03C ↓
MOP                  KCID
110.6    FREQ       ———
760ft      ELEV     864ft

W2.0°    DCL  VAR  E5.0°
↔ [                      ]
```

Waypoint type (displays FIX if point is a waypoint).

Station frequency.

MOP has a station declination of W2.05.

ICAO identifier.

Waypoint elevation MSL.

FROM waypoint identifier data.

TO waypoint identifier data.

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ALTERNATE FLIGHT PLAN OVERVIEW

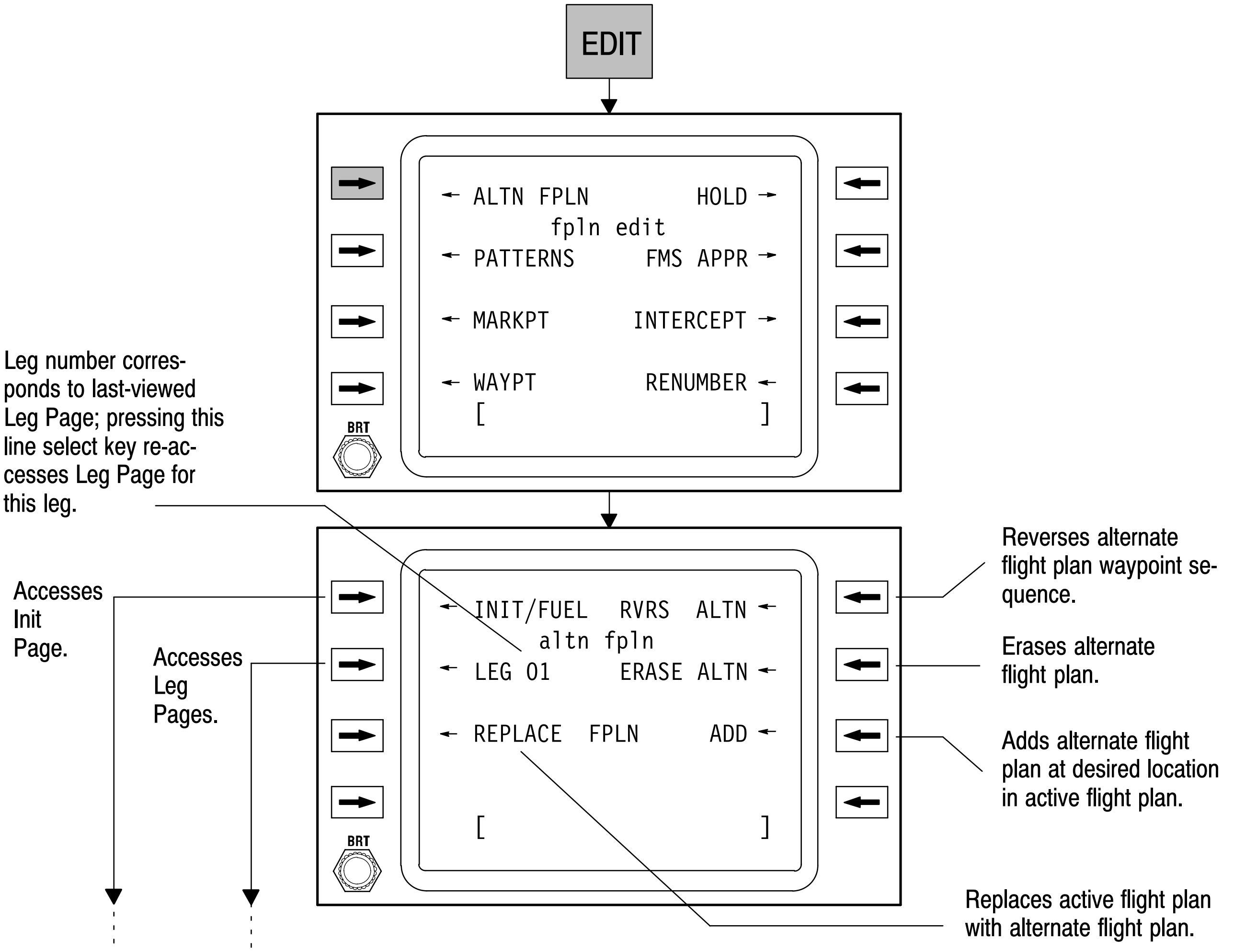
The alternate flight plan is a complete plan for a mission or a mission segment which includes a route of up to 60 waypoints, along with calculations of courses, distance, time, gross weight, and fuel requirements, including automatic reserve allocations. It includes the standard AF FM70 flight planning data and provides an electronic hard copy of the flight plan in GINS which can be modified or updated at any time.

Ten alternate flight plans may be stored on the data cartridge from either a mission planning ground station or laptop facility, or by manual entry via the CDU on the airplane. On the airplane, one alternate flight plan at a time can be selected and transferred into the CDU for viewing and the operations described in this text. This alternate flight plan is separate from the active flight plan and does not sequence or change unless the crew modifies it. It can be transferred to, or added to, the active flight plan and thereafter operates as described in the text and examples pertaining to flight plan. The alternate flight plan remains intact following any transfer.

Alternate Flight Plan Structure

The alternate flight plan operates as a spreadsheet calculator wherein the crew inputs the flight plan routing, wind, and airplane performance; GINS calculates the individual leg data as well as flight totals. The legs of the plan (1 through 60) are accessed by vertical scrolling on the CDU. The complete data for each leg can be accessed by lateral scrolling among leg pages with suffixes a, b, and c. See example below, and *figure 1-172*.

ALTERNATE FLIGHT PLAN ACCESS



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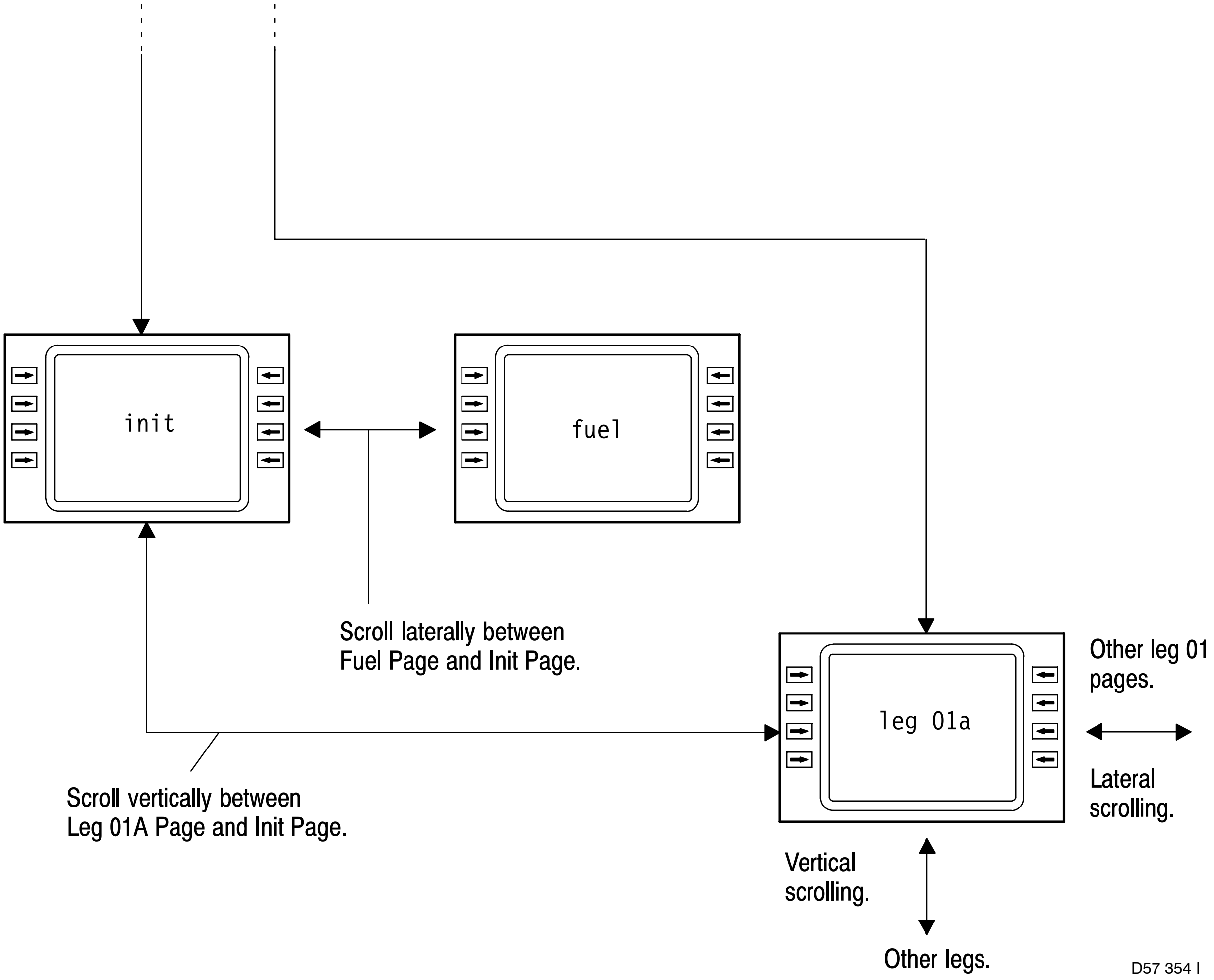
ALTERNATE FLIGHT PLAN ACCESS (CONTINUED)



Alternate Flight Plan Access and Transfer

On the Alternate Flight Plan Page, various top-level access and transfer options are offered to the crew (see below). When an alternate flight plan is transferred to, or added to, the active flight plan, only the sequence of waypoints and some waypoint attributes (altitude, bank angle, required time) are transferred. All other active flight plan parameters are calculated by GINS using sensed data rather than the planned parameters of the alternate flight plan.

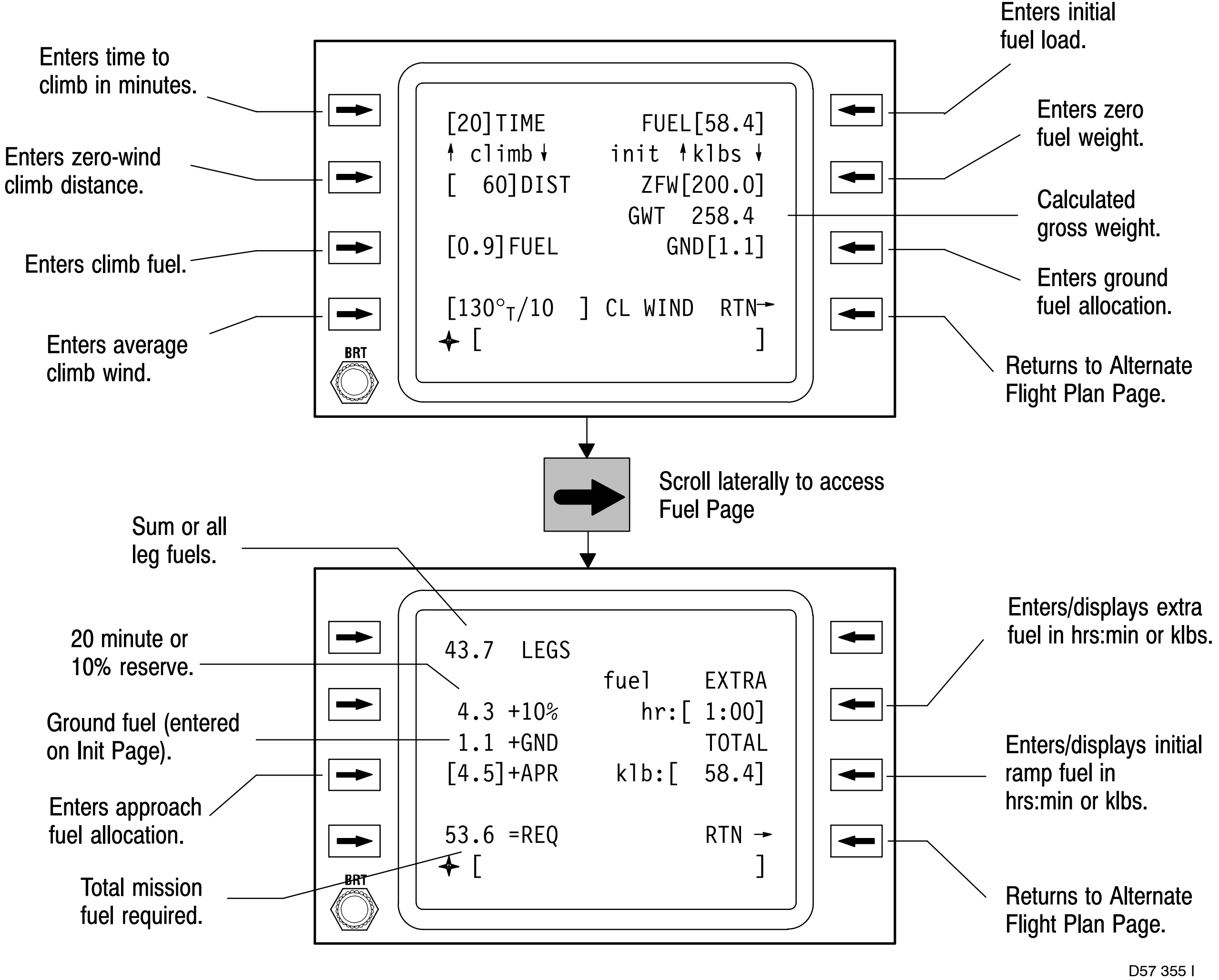
Alternate Flight Plan Initial Time, Fuel, and Weight

The alternate flight plan initial time, fuel, and weight entries are optional. If the alternate flight plan is to be added to an existing active flight plan, the crew might not desire to include climb parameters.

Alternate Flight Plan Fuel Summary

The Fuel Page presents a summary of the fuel requirements for the alternate flight plan. If no approach, (APR) fuel is entered, then no approach time allocation is assumed. If an approach fuel is entered, a standard 15 minutes time allotment is added to the total flight time, regardless of the amount of fuel entered. If an initial ramp fuel has been entered, the EXTRA fuel is calculated by subtracting the required (REQ) from the TOTAL. If an EXTRA value is entered (in hours or kilo-pounds), the required initial ramp fuel is calculated and shown as the TOTAL. If an aerial refueling (ONLOAD) is entered at a waypoint in the alternate flight plan, an EXTRA entry is not permitted.

ALTERNATE FLIGHT PLAN INIT, AND FUEL PAGES



```
[20]TIME       FUEL[58.4]
↑ climb↓     init ↑klbs ↓
[  60]DIST     ZFW[200.0]
              GWT  258.4
[0.9]FUEL        GND[1.1]

[130°T/10  ] CL WIND  RTN→
✦[                      ]
```

```
43.7  LEGS
             fuel    EXTRA
 4.3 +10%      hr:[ 1:00]
 1.1 +GND          TOTAL
[4.5]+APR    klb:[  58.4]

53.6 =REQ          RTN →
✦[                      ]
```

Entry and Display of Alternate Flight Plan Legs

Unless entered by the crew, the default starting point for the first leg is the current airplane position at the time a new plan is created (see below). Waypoints can be entered and deleted on the Leg a pages in the same manner as for the active flight plan.

The angle displayed on the Leg a Page is the inbound course to the end waypoint for that leg.

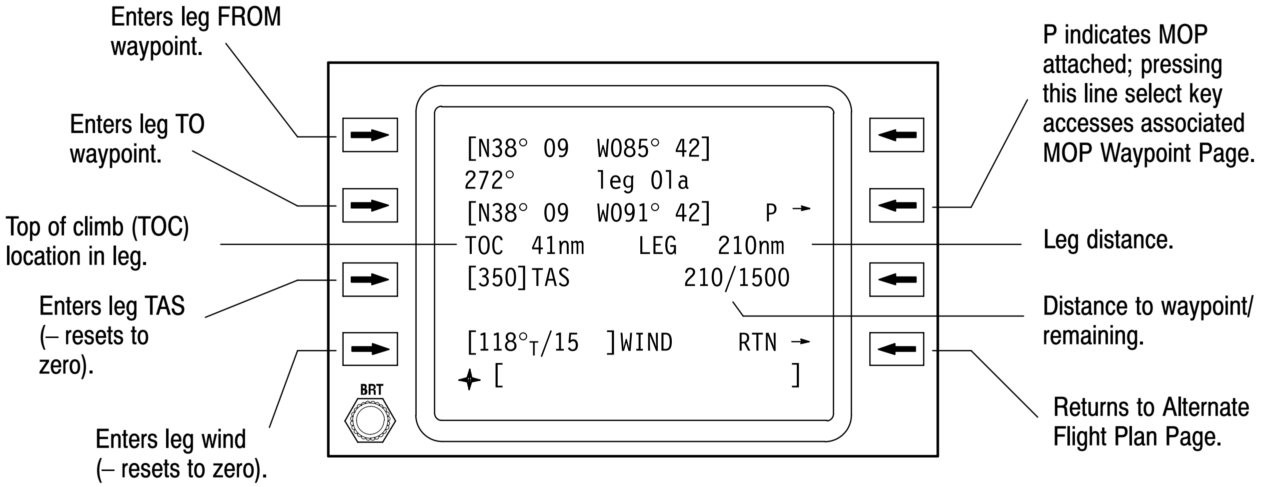
The top of climb (TOC) readout appears on the leg with the distance into that leg that the TOC is planned to occur, given the average climb wind and performance data entered on the Init Page.

Below the leg length on the right side is displayed the total distance from the alternate flight plan origin to that waypoint, followed by the remaining distance to go from that point to the end of the plan.

If time and/or fuel calculations are desired, then enter the TAS and forecast wind at the cruising altitude on this page. If no following leg TAS or wind exists, then this leg entry also copies to the following legs.

Patterns can also be entered or attached to waypoints in the alternate flight plan. When entered or attached, a P on the right side of line 3 indicates such and also allows direct access to that pattern's definition page for review or modification.

ALTERNATE FLIGHT PLAN LEG A PAGE



```
[N38° 09  W085° 42]
272°      leg 01a
[N38° 09  W091° 42]    P →
TOC  41nm    LEG   210nm
[350]TAS        210/1500

[118°T/15  ]WIND     RTN →
✦ [                    ]
```

Enters leg FROM waypoint.

Enters leg TO waypoint.

Top of climb (TOC) location in leg.

Enters leg TAS (– resets to zero).

Enters leg wind (– resets to zero).

P indicates MOP attached; pressing this line select key accesses associated MOP Waypoint Page.

Leg distance.

Distance to waypoint/ remaining.

Returns to Alternate Flight Plan Page.

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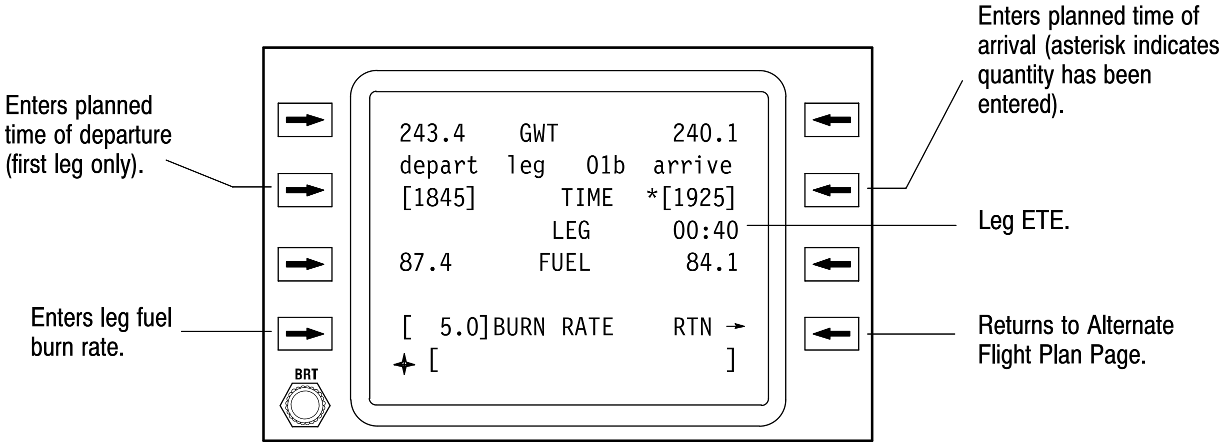
Entry and Display of Alternate Flight Plan Leg Time, Fuel, and Weight

Scrolling laterally from the Leg a Page to the Leg b Page (see below), the pilot can enter parameters to compute the time, fuel, and gross weights for that leg.

The waypoint departure and arrival times for each leg show elapsed time from takeoff (that is, they assume a default takeoff time of 00:00) unless a required departure or waypoint arrival time is entered, in which case they are UTC.

Only one required time can be in the alternate flight plan; either the first departure time or any waypoint arrival time. The asterisk indicates an entered required time versus a computed departure or arrival time. If a loiter/hold/pattern on-station elapsed time is entered on the Leg c Page, the arrival and departure times for a waypoint differ by that planned loiter time. Likewise, if a fuel onload or cargo offload is entered at a waypoint, the arrival and departure fuel and/or gross weight differs by the entered amount.

ALTERNATE FLIGHT PLAN LEG B PAGE



Enters planned time of departure (first leg only).

Enters leg fuel burn rate.

Enters planned time of arrival (asterisk indicates quantity has been entered).

Leg ETE.

Returns to Alternate Flight Plan Page.

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Entry and Display of Planned Altitude and Bank Command Limit

On the Leg c Page (see below), optional entries of planned cruise altitude/flight level and bank command limit for each leg can be made. If no BANK entry is made or if a – is entered at the BANK line select key, the bank limit defaults to 25°.

Each altitude/flight level and bank command limit entry is transferred to the active flight plan when the alternate flight plan is transferred.

Entry and Display of On-station Loiter Time and Fuel Parameters

If the planned mission includes an aerial refueling pattern, holding pattern, MOP, or other loiter on-station at a waypoint, then enter the planned loiter time and fuel burn rate on the Leg c Page. This causes the total mission time and fuel calculations to accommodate the planned loiter. If an intermediate landing without refueling is planned, enter the ground time with no fuel burn (or use another alternate flight plan for the next segment).

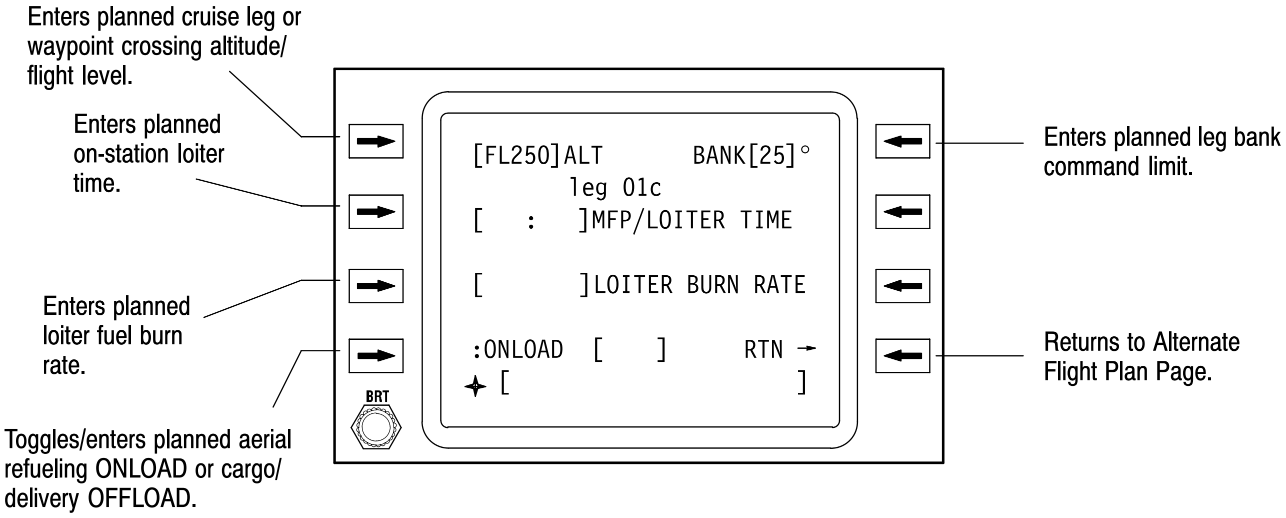
Entry and Display of Fuel/Weight Onload/Offload

If an aerial refueling/delivery or cargo airdrop is planned, then toggle the left line select key on the Leg c Page to ONLOAD or OFFLOAD for the waypoint where it is to occur (see below), enter the onload/offload quantity in the scratchpad, and press the ONLOAD/OFFLOAD line select key.

If an onload is entered, the FMS assumes that the loaded quantity is usable fuel and increments both the departure gross weight and fuel remaining at that waypoint (see below). In this case, the REQUIRED and TOTAL (mission) fuel on the Fuel Page are greater than the initial ramp fuel loaded on the Init Page (see below).

If an offload is entered, the FMS assumes that it is either an airdrop payload or a tanker aerial refueling offload; that is, it reduces the gross weight but not the usable fuel remaining at that waypoint.

ALTERNATE FLIGHT PLAN LEG C PAGE



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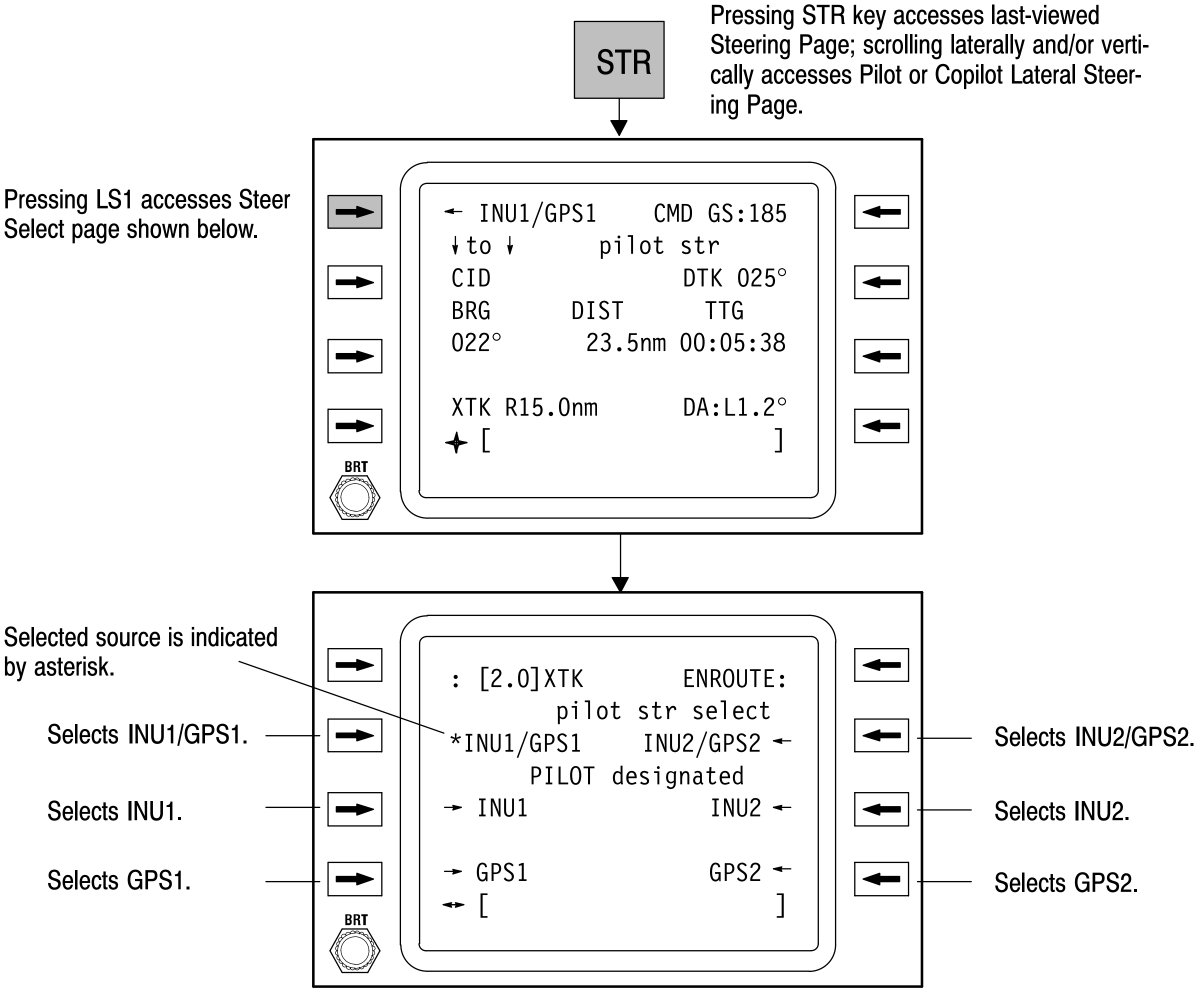
LATERAL STEERING AND STEER SELECT PAGES

The navigational sources being used for the pilot's and copilot's steering are indicated on the Pilot and Copilot Lateral Steering Pages as shown below. These selections can be changed on the Pilot and Copilot Steer Select Pages, also shown below.

PILOT LATERAL STEERING AND STEER SELECT PAGES



Pressing STR key accesses last-viewed Steering Page; scrolling laterally and/or vertically accesses Pilot or Copilot Lateral Steering Page.

Pressing LS1 accesses Steer Select page shown below.

```
← INU1/GPS1    CMD GS:185
↓to ↓      pilot str
CID              DTK 025°
BRG      DIST      TTG
022°      23.5nm 00:05:38

XTK R15.0nm      DA:L1.2°
✦[                      ]
```

Selected source is indicated by asterisk.

Selects INU1/GPS1.

Selects INU1.

Selects GPS1.

Selects INU2/GPS2.

Selects INU2.

Selects GPS2.

```
: [2.0]XTK       ENROUTE:
      pilot str select
*INU1/GPS1    INU2/GPS2 ←
     PILOT designated
→ INU1             INU2 ←

→ GPS1             GPS2 ←
↔ [                     ]
```

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POSITION, TRACK, AND AIR DATA DISPLAYS

The steering selections determine the sources of the data for the Pilot and Copilot Position Pages shown below. The air data shown on these pages comes from CADC1 or CADC2 as indicated by the TAS1 or TAS2 label, respectively. These sources can be selected on the Aiding Page. The baroset input sets the local barometric pressure in both CADCs for VNAV enroute, terminal, and approach guidance.

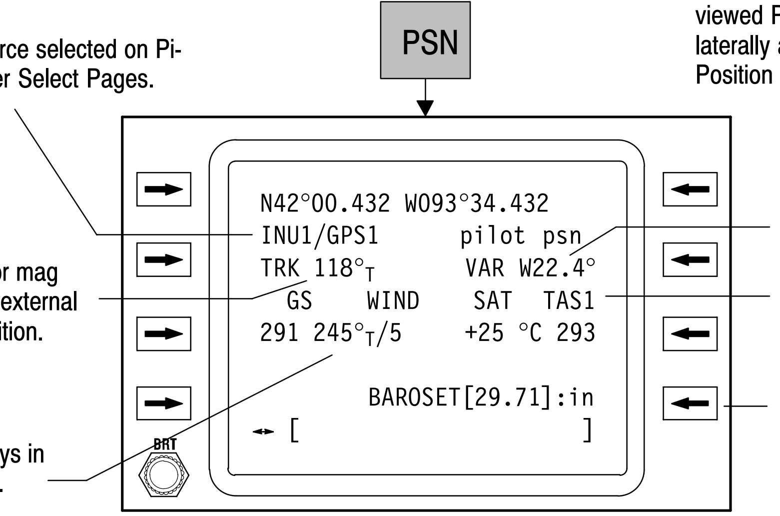
The status and validity of the selected navigational sources are indicated on the title lines of the Pilot and Copilot Position Pages. Any automatic downgrading of the navigational source is announced on the CDU. Only the designated pilot's navigational source is tied to the external CDU alert annunciator and can activate the NAV FAIL alert on the CDUs.

The NAV FAIL alert and the HSI flags are dependent on the status of the selected navigation sensors and the 95% error compared to a threshold determined by the current flight plan guidance mode: ENROUTE, TERMINAL, or APPROACH.

PILOT POSITION PAGE

NOTE

Pressing PSN key accesses last-viewed Position Page; scrolling laterally accesses Pilot or Copilot Position Page.



```
N42°00.432 W093°34.432
INU1/GPS1      pilot psn
TRK 118°T      VAR W22.4°
  GS    WIND    SAT  TAS1
291 245°T/5    +25 °C 293

           BAROSET[29.71]:in
◂▸ [                      ]
```

Navigation source selected on Pilot/Copilot Steer Select Pages.

Track displays true or mag track, depending on external true/mag switch position.

Wind is always in degrees true.

Computed mag var at present position.

TAS1/TAS2 indicates source of air data, CADC1 or CADC2.

Toggles between inches and millibars with empty scratchpad, or enters baroset from scratchpad.

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NAVIGATIONAL SOURCE DATA DISPLAYS

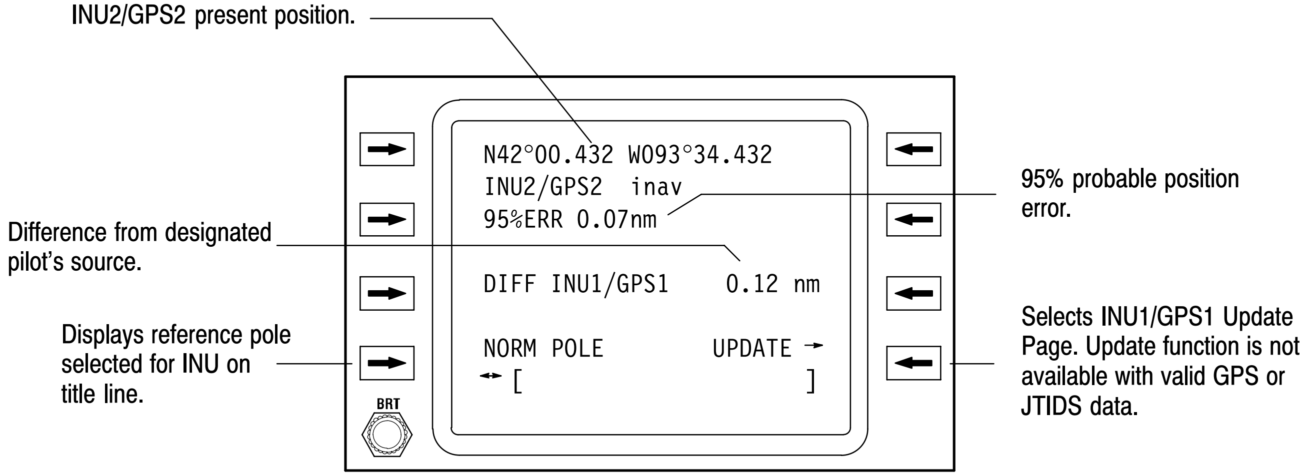
Each source of a navigation solution has its own Integrated Navigation (INAV) Page that provides a display of current position and navigational status. This display is available whether or not that source is being used as either pilot's steering selection. See *figure 1-174*.

INU1/GPS and INU2/GPS Displays

The INU1/GPS1 and INU2/GPS2 INAV Pages show the computed present position of those integrated navigation solutions, along with a 95% error for the probable system accuracy given the current INU alignment and GPS satellite navigational quality. The position error is within the displayed value at least 95% of the time. This page also shows the difference between its navigational position and that of the designated pilot's selected steering solution (if it is a different source).

If GPS data becomes unavailable en route, the previously-computed INU corrections continue to be applied to this navigational solution, so it is more accurate than the uncorrected INU (free-running inertial) solution. However, to enable the crew to update the solution manually if necessary, the UPDATE line select key becomes available and can be used as described under INU AND INTEGRATED NAVIGATION UPDATES.

INU2/GPS2 INTEGRATED NAVIGATION PAGE



INU2/GPS2 present position.

Difference from designated pilot's source.

Displays reference pole selected for INU on title line.

95% probable position error.

Selects INU1/GPS1 Update Page. Update function is not available with valid GPS or JTIDS data.

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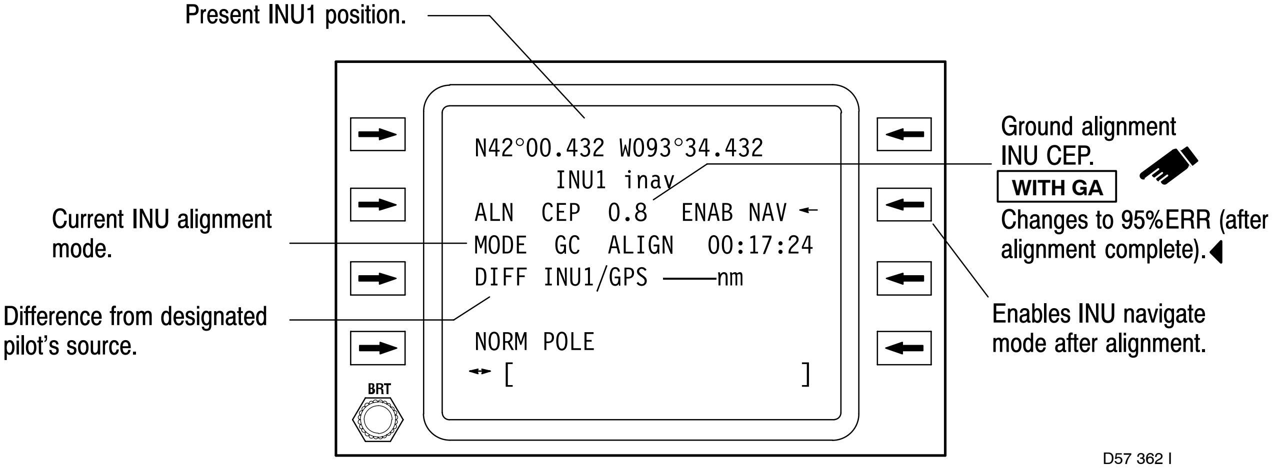
INU1 and INU2 Displays

The INU1 and INU2 inav Pages show the present position from the respective INUs, along with the alignment CEP (see below). The current alignment mode and the elapsed alignment time during alignment are also displayed. The DIFF readout shows the difference between the INU position and the designated pilot's selected steering solution (if it is a different source).

If AUTO NAV has not been selected on the Start 2 Page, the INU can be put into the navigate mode using the ENAB NAV line select key. If the INU is not in navigate mode and the airplane begins to move, the alignment counter will freeze and the alignment is suspended until after the airplane stops moving. If the airplane goes airborne prior to entering navigate mode, the INU will automatically begin an inflight alignment.

WITH GA Once the INU has entered MODE NAV, either by AUTO NAV or by ENAB NAV switch actions, ALN CEP changes to 95% EPR (95% probable position error). ◀

INU INTEGRATED NAVIGATION PAGE



```
N42°00.432 W093°34.432
      INU1 inav
ALN  CEP  0.8   ENAB NAV ←
MODE  GC  ALIGN   00:17:24
DIFF INU1/GPS ——nm

NORM POLE
←→ [                       ]
```

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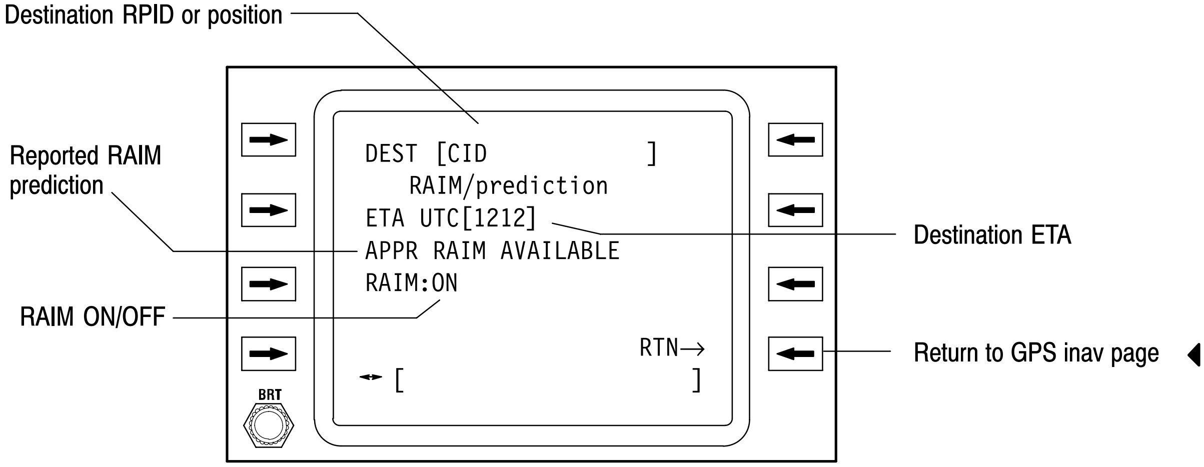
WITH RAIM RAIM Prediction Request

The RAIM/prediction page shows destination (as RPID or geographic position), ETA at that destination, the results of the last completed RAIM prediction request, and RAIM function ON or OFF.

If a valid position and valid time have been entered, a RAIM request is initiated each time the RAIM/prediction page is accessed. Changing entered position or time before results of initiated request are reported cancels the original request and causes a changed request using the new value(s).

RAIM/PREDICTION PAGE



```
DEST [CID            ]
   RAIM/prediction
ETA UTC[1212]
APPR RAIM AVAILABLE
RAIM:ON

                   RTN→
←→ [                   ]
```

GPS Display

The GPS INAV Page shows the present position output from the GPS receiver, along with a 95% error figure of merit for the probable system accuracy, given the current GPS satellite navigational quality (satellite tracking state and geometry) as shown below. The position error is within the displayed value at least 95% of the time. If GPS1/A/H is indicated on the title line, the FMS is using airspeed and heading sensor inputs to smooth the data from GPS1. This is required to have a valid bank (roll) command output to the flight director and autopilot.

The MODE indicates the current GPS receiver tracking/aiding mode: INIT, TEST, NAV/INU, or NAV/PVA. If in the NAV/INU mode, the GPS satellite tracking performance is enhanced over the NAV/PVA mode in the presence of jamming and while maneuvering.

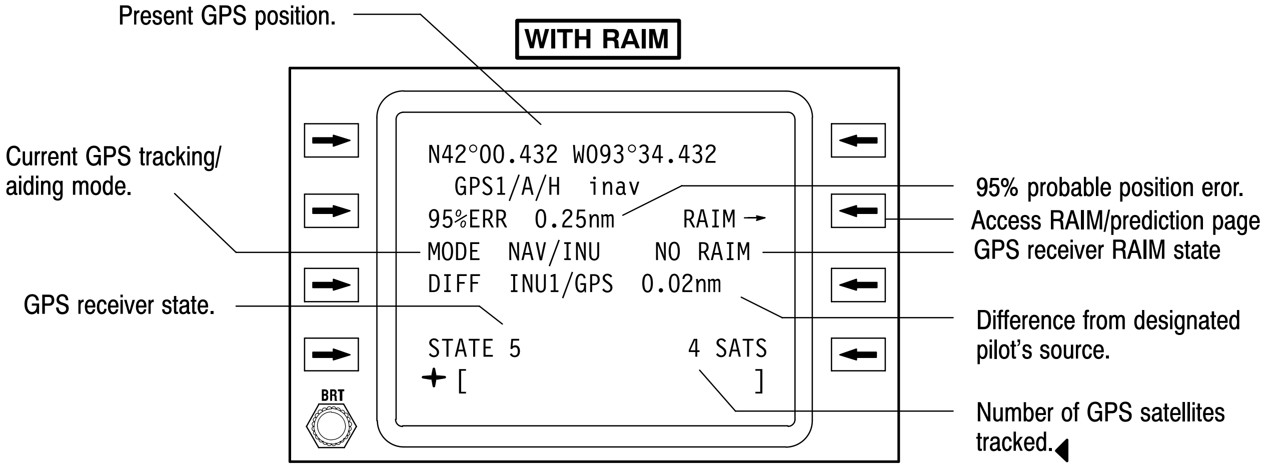
WITH RAIM GPS receiver capabilities are used to monitor the quality of the navigation solutions generated in the receivers (Receiver Autonomous Integrity Monitoring, RAIM). RAIM processing provides two functions: the integrity monitor function continuously monitors the GPS navigation solution quality and annunciates its status; and the RAIM prediction function predicts the availability of sufficient satellites for the integrity monitor function at a given location and time. ◀

The STATE indicates the lowest tracking state of the four primary satellite tracking channels: STATE 1 is acquisition, STATE 3 is code track only (in jamming) and STATE 5 is code and carrier lock (no jamming).

The number of satellites being tracked for primary navigational purposes is also indicated; the normal fully determined number is 4. Less than 4 may result in GPS data invalidity.

GPS INTEGRATED NAVIGATION PAGE

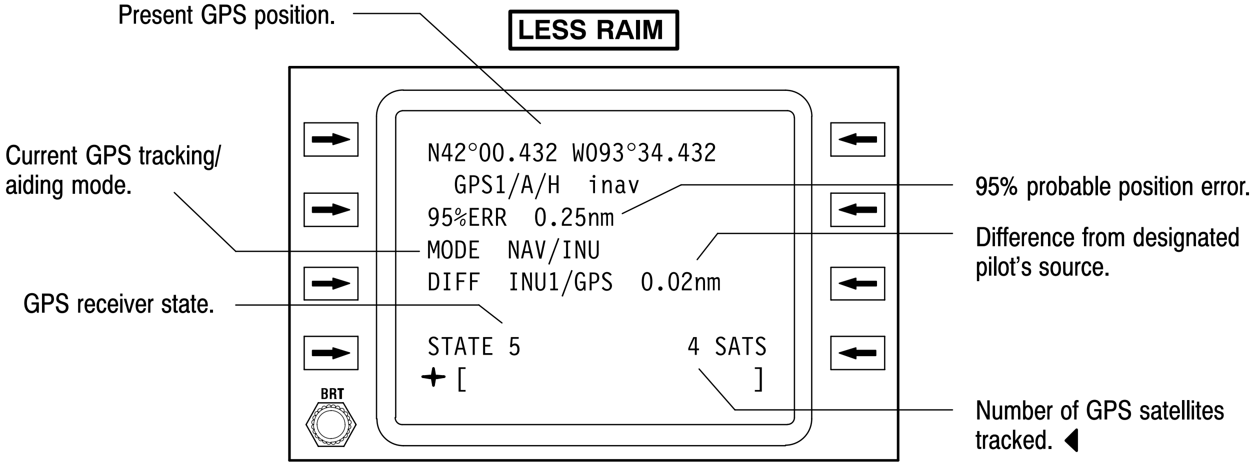
WITH RAIM



```
N42°00.432 W093°34.432
  GPS1/A/H  inav
95%ERR  0.25nm     RAIM →
MODE  NAV/INU    NO RAIM
DIFF  INU1/GPS  0.02nm

STATE 5            4 SATS
+[                      ]
```

LESS RAIM



```
N42°00.432 W093°34.432
  GPS1/A/H  inav
95%ERR  0.25nm
MODE  NAV/INU
DIFF  INU1/GPS  0.02nm

STATE 5            4 SATS
+[                      ]
```

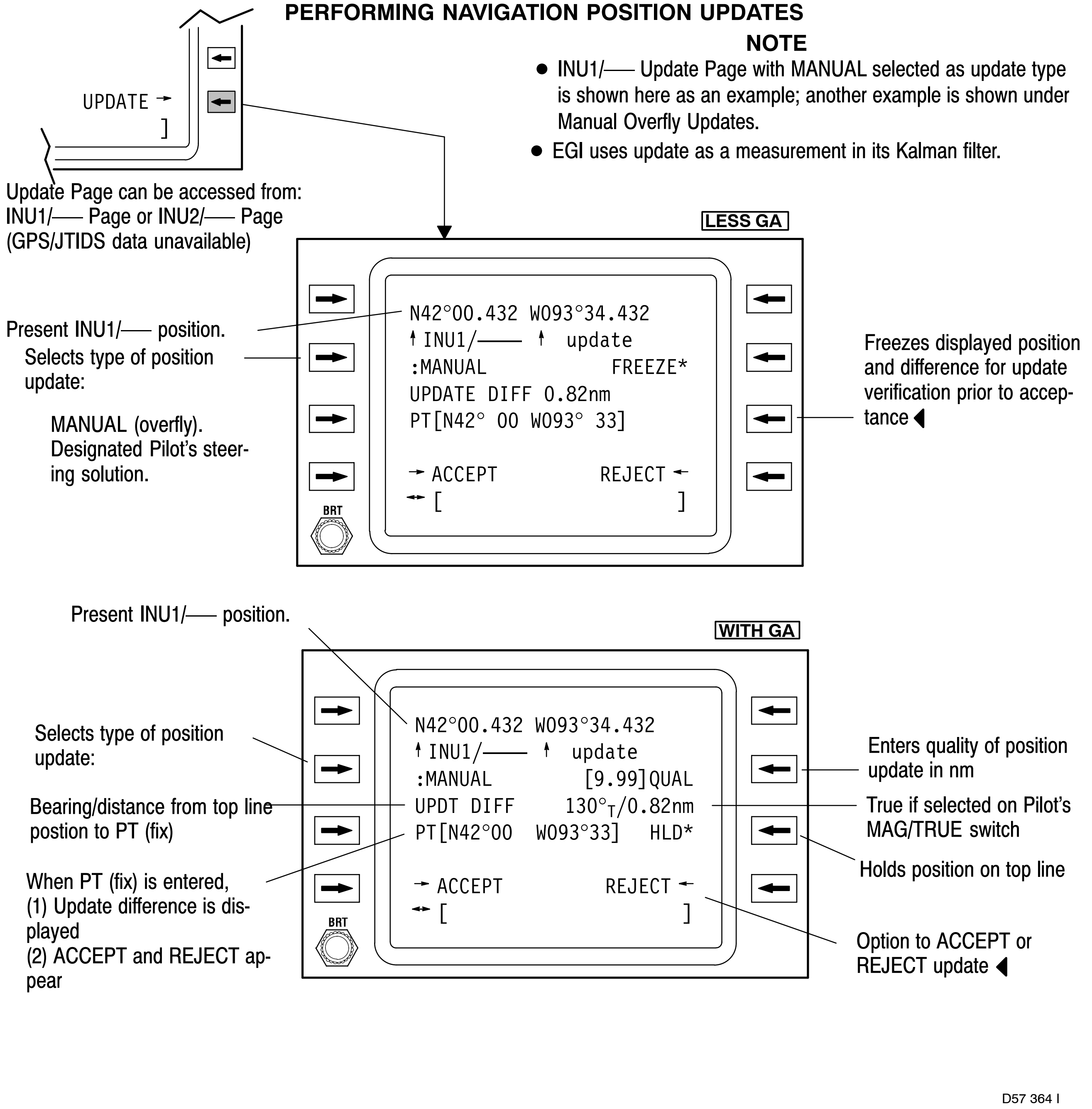
INU AND INTEGRATED NAVIGATIONAL POSITION UPDATES

To update the INU1/GPS1 or the INU2/GPS2 navigational solutions when GPS data is unavailable, select the UPDATE line select key on the respective inav Page (see below) to access the Update Page. Then select the type of update desired using the left line select key second from the top as shown. The updates are as follows:

a. MANUAL. Updates present position (on line 1) to displayed checkpoint (PT) position on line 5.

b. INU1/GPS1, INU2/GPS2, INU1, INU2, GPS1 or GPS2 (whichever is currently selected as the designated pilot's steering solution). Updates present position to the displayed navigation solution position.

PERFORMING NAVIGATION POSITION UPDATES



NOTE

- INU1/— Update Page with MANUAL selected as update type is shown here as an example; another example is shown under Manual Overfly Updates.
- EGI uses update as a measurement in its Kalman filter.

Update Page can be accessed from: INU1/— Page or INU2/— Page (GPS/JTIDS data unavailable)

LESS GA

```
N42°00.432 W093°34.432
↑INU1/——  ↑  update
:MANUAL           FREEZE*
UPDATE DIFF 0.82nm
PT[N42° 00 W093° 33]

→ ACCEPT         REJECT ←
↔ [                     ]
```

Present INU1/— position.

Selects type of position update:

MANUAL (overfly).
Designated Pilot's steering solution.

Freezes displayed position and difference for update verification prior to acceptance ◀

WITH GA

```
N42°00.432 W093°34.432
↑INU1/——  ↑  update
:MANUAL        [9.99]QUAL
UPDT DIFF    130°T/0.82nm
PT[N42°00  W093°33]  HLD*

→ ACCEPT         REJECT ←
↔ [                     ]
```

Present INU1/— position.

Selects type of position update:

Bearing/distance from top line postion to PT (fix)

When PT (fix) is entered,
(1) Update difference is displayed
(2) ACCEPT and REJECT appear

Enters quality of position update in nm

True if selected on Pilot's MAG/TRUE switch

Holds position on top line

Option to ACCEPT or REJECT update ◀

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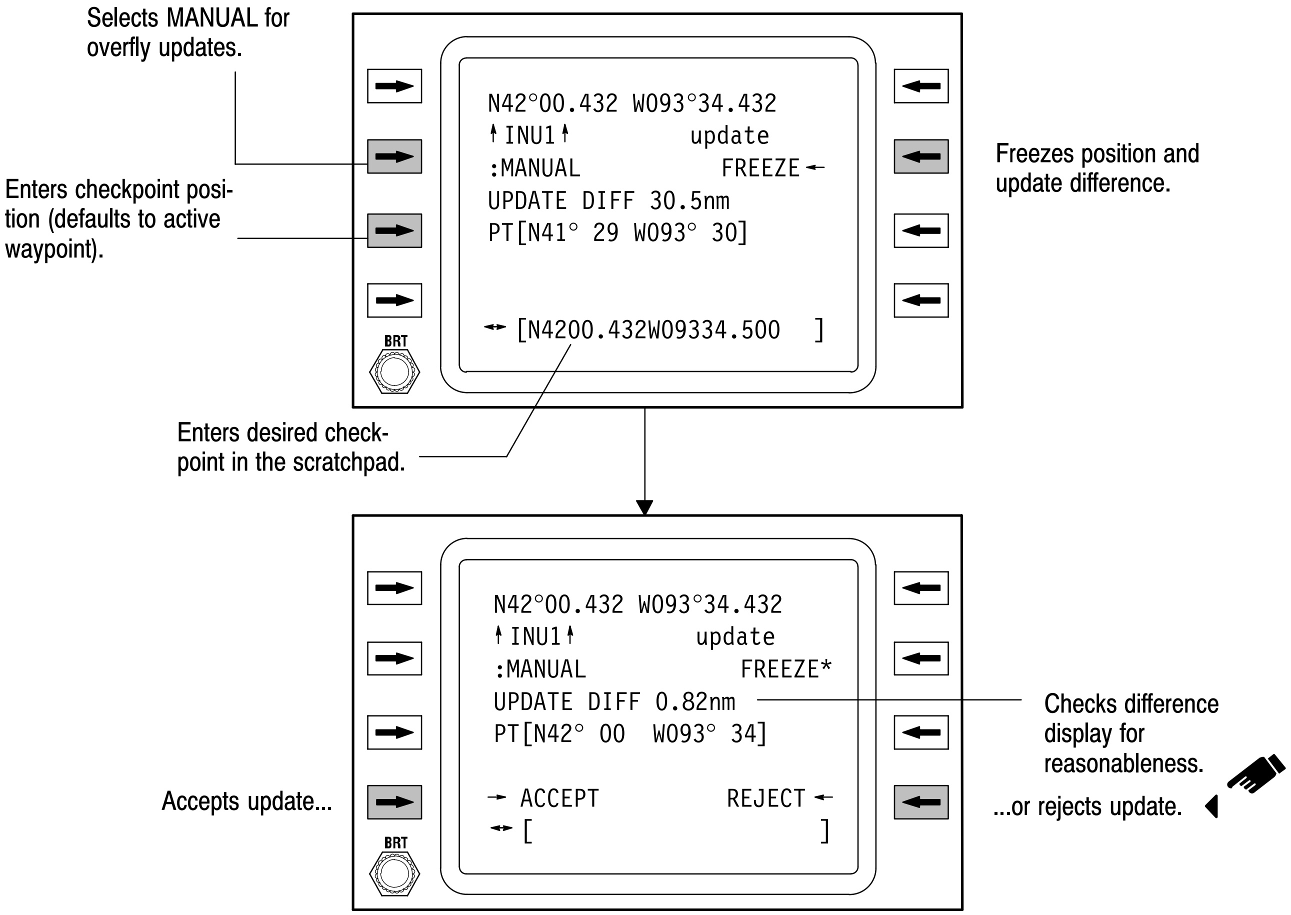
LESS GA MANUAL Overfly Updates

To perform a manual overfly update, toggle the left line select key second from the top to MANUAL on the Update Page. The PT coordinates automatically default to the current active waypoint in the flight plan. If another checkpoint is desired, enter the coordinates, identifier, or identifier/bearing/distance checkpoint as the PT, as shown below. To return to the active waypoint default, enter a – at the PT line select key. When directly on top of the update location, freeze the display to review the displayed update difference (DIFF) for reasonableness by pressing the FREEZE line select key. Press the ACCEPT line select key to accept the updated position difference correction or the REJECT line select key to reject it.

MANUAL OVERFLY POSITION UPDATE



Selects MANUAL for overfly updates.

Enters checkpoint position (defaults to active waypoint).

Freezes position and update difference.

Enters desired checkpoint in the scratchpad.

Checks difference display for reasonableness.

Accepts update...

...or rejects update.

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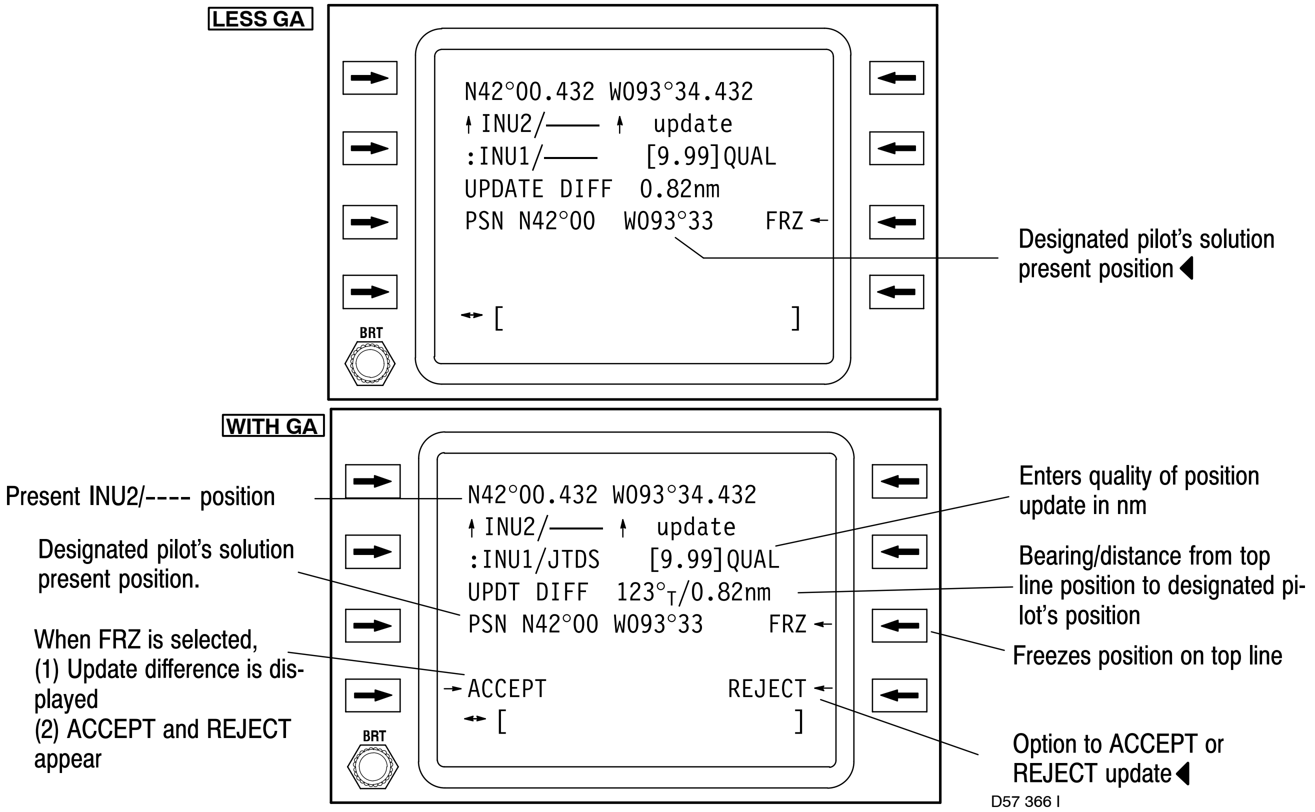
Updates to Designated Pilot Solution Position

To update the navigational solution to that of the current designated pilot's steering solution (see below), toggle the left line select key second from the top to show the current solution; FREEZE the position and update difference (DIFF) displays; verify the reasonableness of the difference displayed; ACCEPT or REJECT the difference correction.

Note that if GPS data is not available and the pilot desires to update both navigational solutions (INU1/– and INU2/–) to the same position, the optimum procedure is first to update the selected designated pilot steering solution using a MANUAL update, then update the other to the designated pilot solution. This effectively provides both navigators with the same update.

UPDATE PAGE, DESIGNATED PILOT AS UPDATE SOURCE



```
N42°00.432 W093°34.432
↑INU2/——— ↑  update
:INU1/———    [9.99]QUAL
UPDATE DIFF  0.82nm
PSN N42°00  W093°33    FRZ←

↔[                        ]
```

Designated pilot's solution present position◀

```
N42°00.432 W093°34.432
↑INU2/——— ↑  update
:INU1/JTDS   [9.99]QUAL
UPDT DIFF  123°T/0.82nm
PSN N42°00 W093°33     FRZ←

→ACCEPT            REJECT←
↔[                        ]
```

Present INU2/---- position

Designated pilot's solution present position.

When FRZ is selected,
(1) Update difference is displayed
(2) ACCEPT and REJECT appear

Enters quality of position update in nm

Bearing/distance from top line position to designated pilot's position

Freezes position on top line

Option to ACCEPT or REJECT update◀

INU, GPS, and JTIDS Aiding

Sensor aiding configurations are provided automatically by the FMS when power is applied. The crew can modify the configuration at any time. Sensor aiding includes CADC aiding to the EGIs, INU aiding to the GPS units, GPS aiding to JTIDS and INU/JTIDS aiding.

To change the aiding configuration, access the Aiding Page from the Index 1 Page and toggle the selected aiding configuration as desired (see below). The crew is not allowed to change the aiding configuration for JTIDS if the alternate aiding source is not valid. Once a JTIDS aiding configuration has been established, GINS does not modify the configuration automatically unless an aiding source becomes invalid.

The default configuration of air data aiding to the INUs upon system power-up, and INU aiding to the GPSs, is as follows:

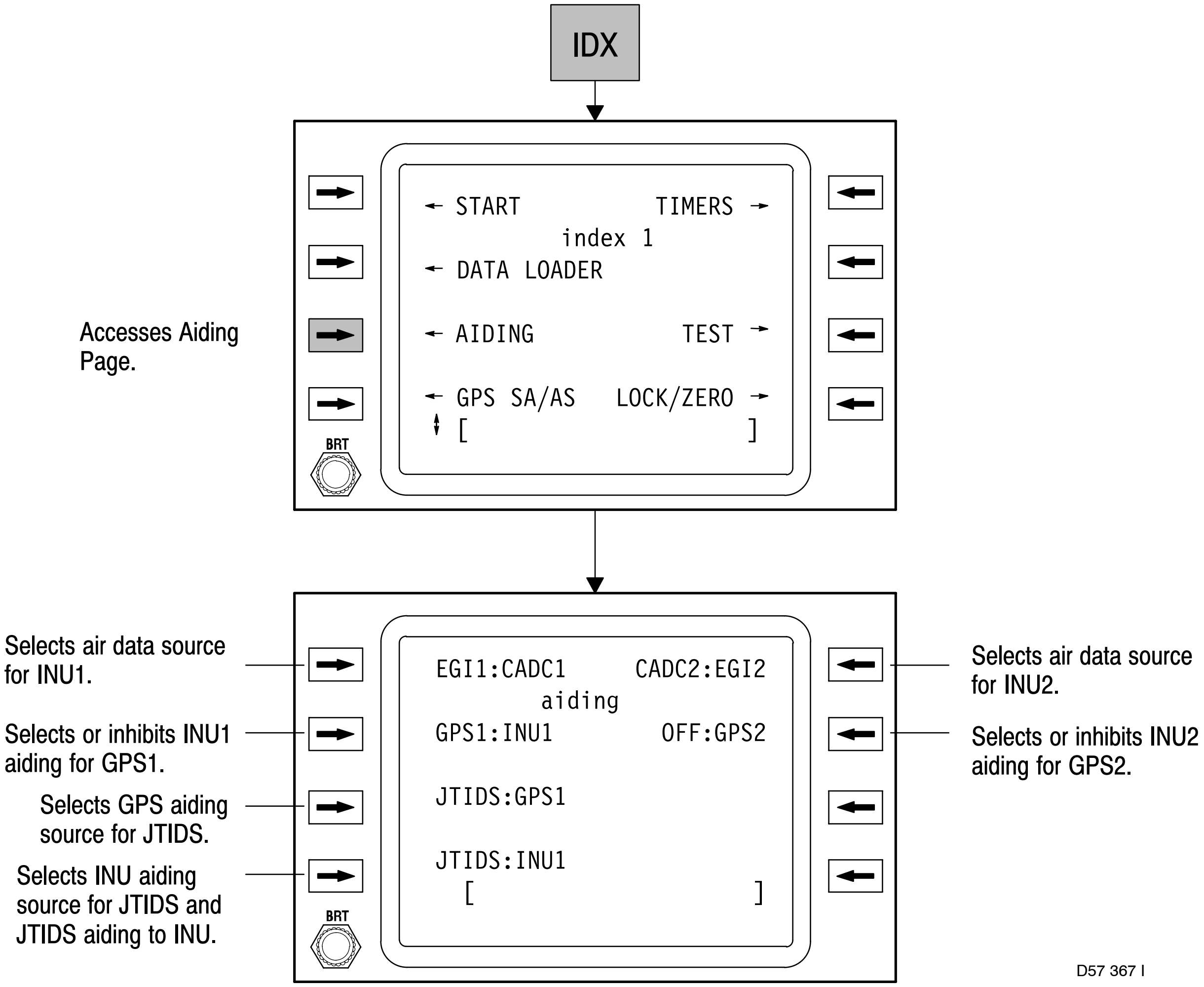
- INU1 aided by CADC1
- INU2 aided by CADC2
- GPS1 aided by INU1
- GPS2 aided by INU2

The crew can modify the CADC configuration via a toggle and can inhibit INU aiding to the GPS within the EGI via a line select toggle.

GINS provides GPS aiding to JTIDS and sets the Preferred EGI discrete based upon the validity of GPS. Normally, GPS1 is used as the source of aiding data for the JTIDS. If GPS1 is not valid or if the crew selects GPS2 as the aiding source, and GPS2 is valid, it is used as the aiding source for JTIDS.

GINS provides 1553 bus message traffic between one of the INUs and the JTIDS based upon the validity of INU. This traffic consists of INU aiding data to the JTIDS, and JTIDS solution data to that same INU. Normally, the 1553 bus message traffic is between the INU in the Preferred EGI and JTIDS, provided the INU data in the Preferred EGI is valid. If the INU in the Preferred EGI is not valid, or if the crew selects the other INU as the INU/JTIDS aiding source, and the other INU is valid, it is used as the aiding source for JTIDS.

AIDING PAGE ACCESS AND USE



Accesses Aiding Page.

Selects air data source for INU1.

Selects or inhibits INU1 aiding for GPS1.

Selects GPS aiding source for JTIDS.

Selects INU aiding source for JTIDS and JTIDS aiding to INU.

Selects air data source for INU2.

Selects or inhibits INU2 aiding for GPS2.

LOADING FLIGHT DATA

The following data can be loaded from the data cartridge if available:

Up to 10 alternate flight plans with a maximum of 60 waypoints each

Markpoint and waypoint lists

GPS almanac data

Operational Flight Program (not a flight crew function)

Each of these files can be loaded individually on the Data Loader Pages. To load all data listed above with one command, access the Data Loader Page with the MASTER LOAD selection and press the associated line select key. See *figure 1-168*.

SAVING FLIGHT DATA

The following data can be saved individually to the data cartridge:

Up to 10 alternate flight plans with a maximum of 60 waypoints each

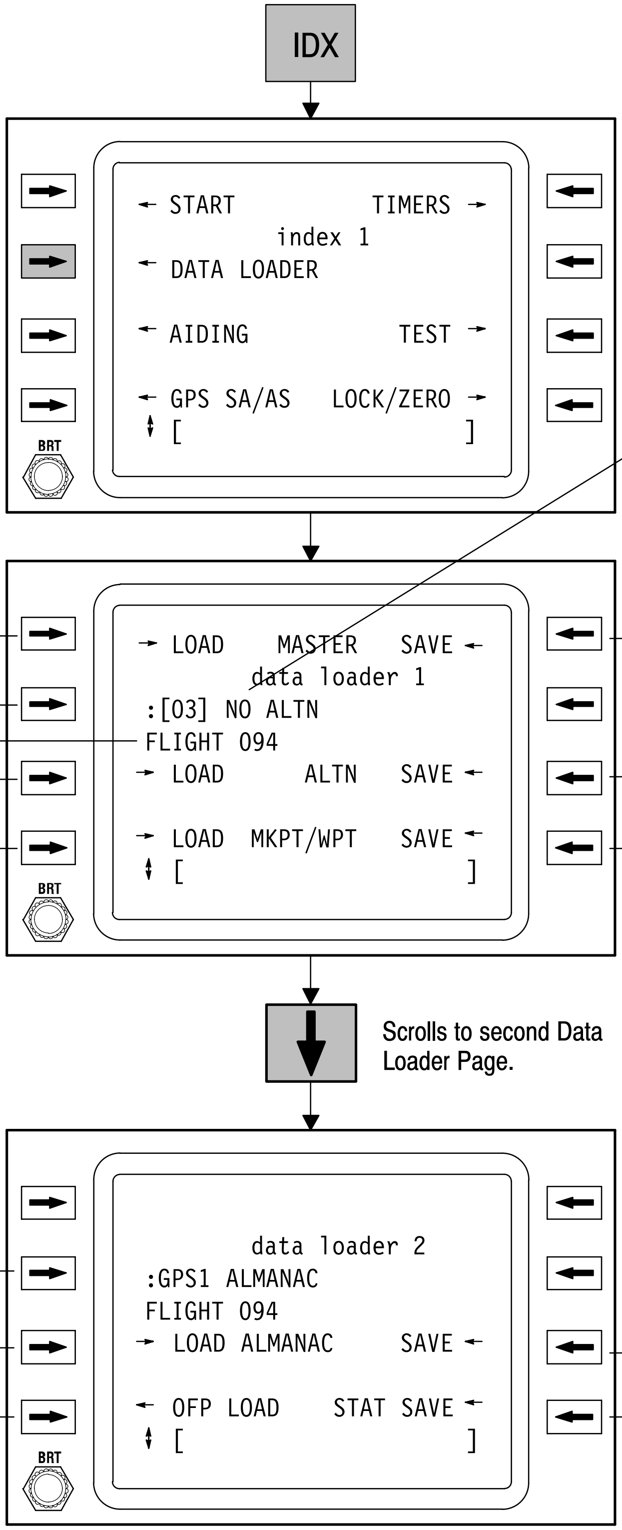
Markpoint and waypoint lists

GPS almanac data

System fail history of all avionic LRUs including continuous BIT fail history, most recent initiate BIT results, and bus status fail history

To save all data listed above with one command, access the Data Loader Page with the MASTER SAVE selection and press the associated line select key.

DATA LOADER PAGE ACCESS AND USAGE



Accesses Data Loader Pages.

Loads all mission data from cartridge.

NO indicates no alternate flight plan is available for number currently displayed.

Enters or toggles to desired alternate flight plan number.

Saves all mission data to the cartridge.

10–character data cartridge label.

Saves alternate flight plan to cartridge and identify it with the number displayed (03 in this example).

Loads alternate flight plan corresponding to number displayed.

Saves markpoint and waypoint lists to cartridge.

Loads markpoint and waypoint lists.

Scrolls to second Data Loader Page.

Toggles between GPS1 and GPS2 for almanac data transfers.

Loads GPS almanac data and transfer it to GPS.

Saves current GPS almanac data to cartridge.

OFP load page access. (Ground maintenance function only.)

Saves fault history of all avionics LRUs to cartridge.

NOTE

All load/save selections require confirmation prior to execution by pressing same key a second time to acknowledge confirmation message.

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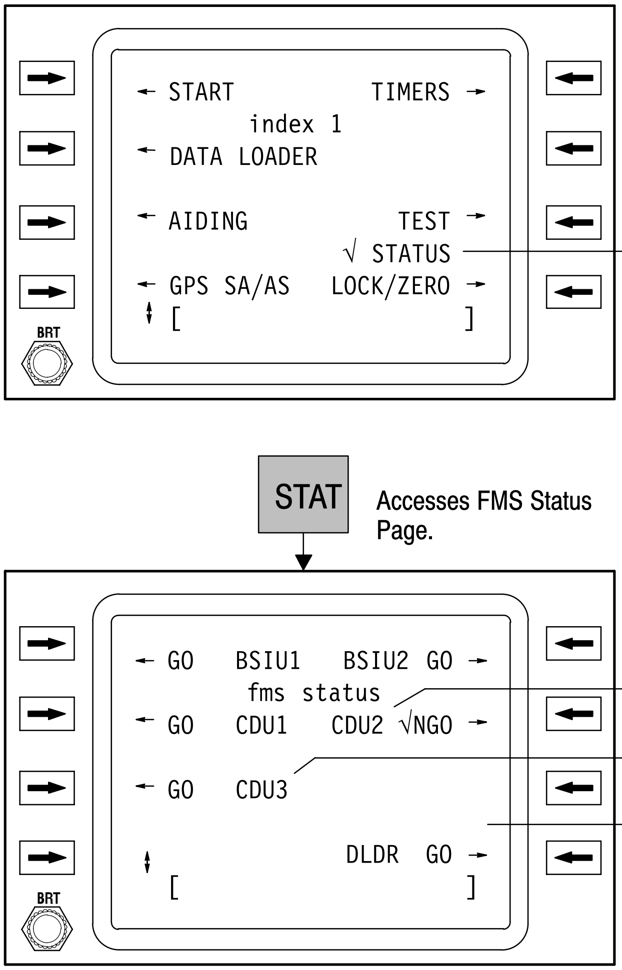
STATUS MONITORING

The Status Pages display the status of all the LRUs in the system and provide access to the individual LRU detail status pages. See *figure 1-175*. Check marks designate which LRU caused the √STATUS annunciation when a failure is detected. The LRU check mark is cleared when the detailed status page for the failed LRU is accessed.

The results of CBIT by each LRU are displayed on detailed status pages, which are accessed by pressing the line select key adjacent to the respective LRU display on the Status Pages.

TOP LEVEL SYSTEM STATUS PAGE



/STATUS indicates that a failure has occurred.

Accesses FMS Status Page.

/ indicates that CDU2 has reported a failure and detailed CDU2 Status Page has not been accessed since failure. CDU3 has previously failed but CDU3 Status Page has already been accessed.

/STATUS is cleared when FMS Status Page is accessed. It can also be cleared with CLR key while on other pages.

NOTE

Scroll down to access Navigation Status Page.

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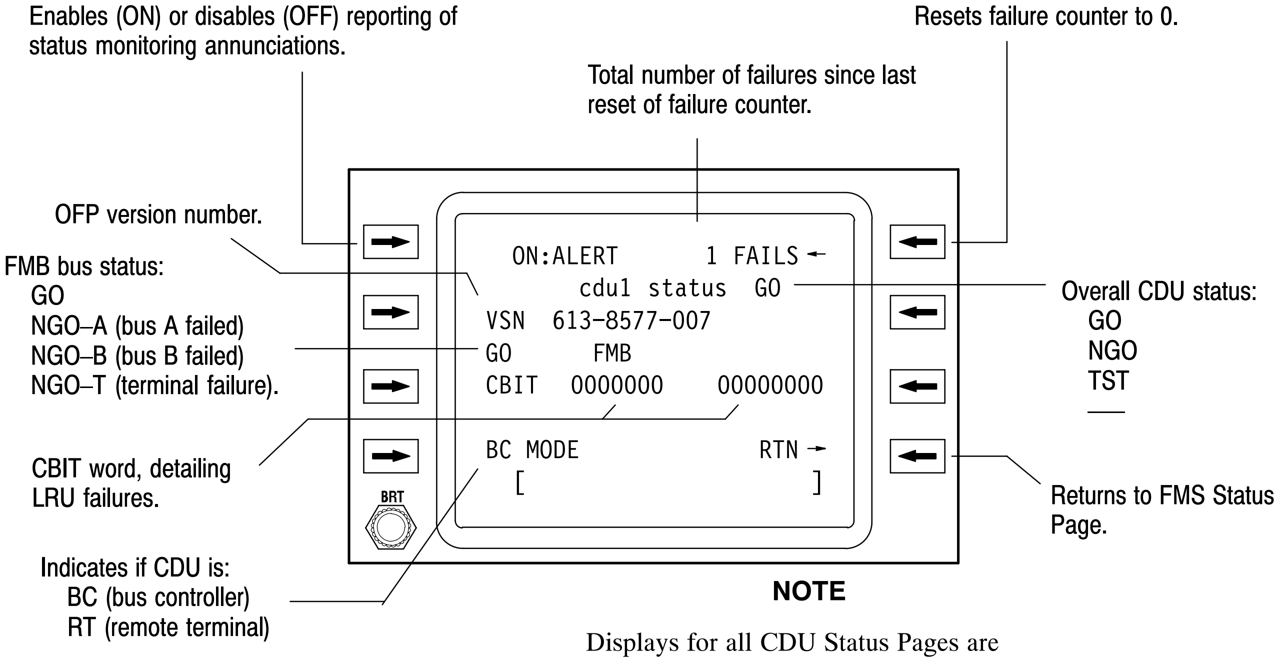
Unknown status (such as bus controller unable to communicate with an LRU) is indicated with dashes in the top level status field. A failure counter is provided on all detailed status pages to indicate the total number of hardware and 1553 bus failures. Status monitoring can be disabled for any LRU on its individual status pages (for example, if an intermittent failure is causing nuisance alerts). This prohibits the √STATUS annunciation from being displayed and the CDU master alert light from being illuminated. All status monitoring results continue to be displayed on the detailed status page. The state of this toggle is always reset to enable reporting of failures at power up. Two examples of LRU detailed status pages are shown below.

NOTE

If the AUTOPILOT circuit breaker on the P5 panel trips, both EGIs will report an ANL ATT NGO. This NGO does not affect the EGIs ability to navigate and can be corrected by closing the AUTOPILOT circuit breaker.

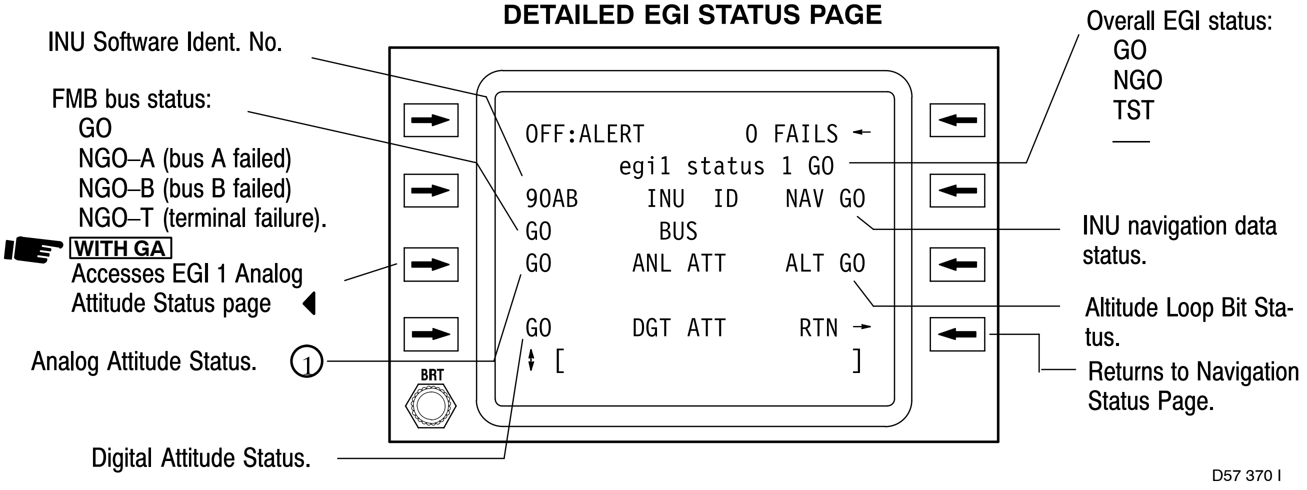
TOP LEVEL SYSTEM STATUS PAGE


```
   ON:ALERT      1 FAILS←
        cdu1 status  GO
VSN  613-8577-007
GO      FMB
CBIT  0000000    00000000

BC MODE              RTN→
  [                     ]
```

NOTE

Displays for all CDU Status Pages are identical except for number on title line.

DETAILED EGI STATUS PAGE

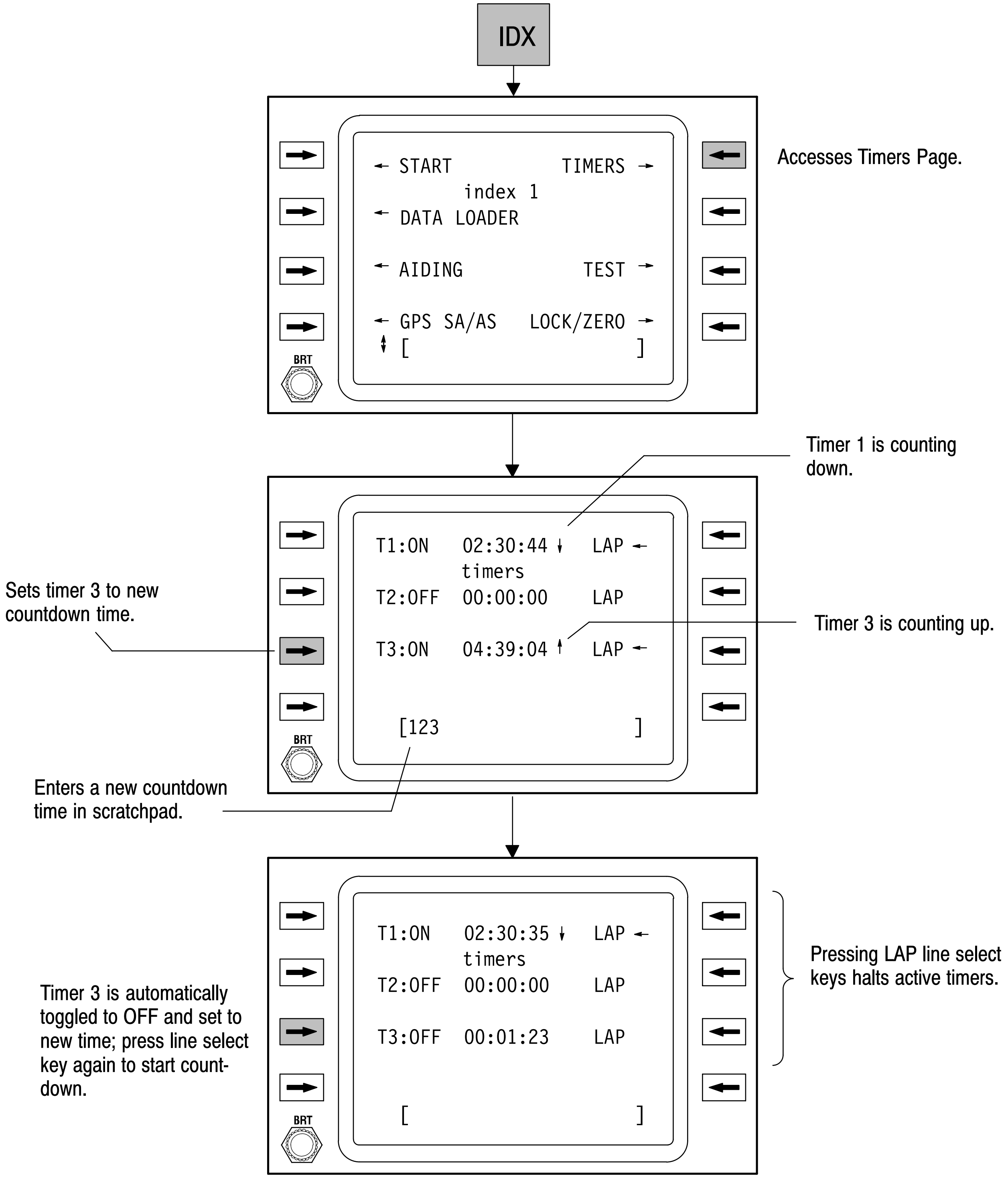

```
OFF:ALERT       0 FAILS←
      egi1 status 1 GO
90AB     INU  ID    NAV GO
GO         BUS
GO       ANL ATT    ALT GO

GO       DGT ATT     RTN→
↕ [                     ]
```

① If ANL NO GO appears, verify AUTOPILOT circuit breaker on P5 CB panel is closed.

TIMER FUNCTION

Access the timers by pressing the TIMERS line select key on the Index 1 Page. The three timers can be used independently to display elapsed time, counting up to 23:59:59, or counting down to 00:00:00, and can be halted at any time. See example below, and *figure 1-168*.

TIMER PAGE ACCESS AND USE



```
← START          TIMERS →
       index 1
← DATA LOADER

← AIDING            TEST →

← GPS SA/AS   LOCK/ZERO →
↕ [                    ]
```

Accesses Timers Page.

```
T1:ON   02:30:44 ↓  LAP ←
        timers
T2:OFF  00:00:00    LAP

T3:ON   04:39:04 ↑  LAP ←


  [123                 ]
```

Timer 1 is counting down.

Sets timer 3 to new countdown time.

Timer 3 is counting up.

Enters a new countdown time in scratchpad.

```
T1:ON   02:30:35 ↓  LAP ←
        timers
T2:OFF  00:00:00    LAP

T3:OFF  00:01:23    LAP


  [                    ]
```

Timer 3 is automatically toggled to OFF and set to new time; press line select key again to start countdown.

Pressing LAP line select keys halts active timers.

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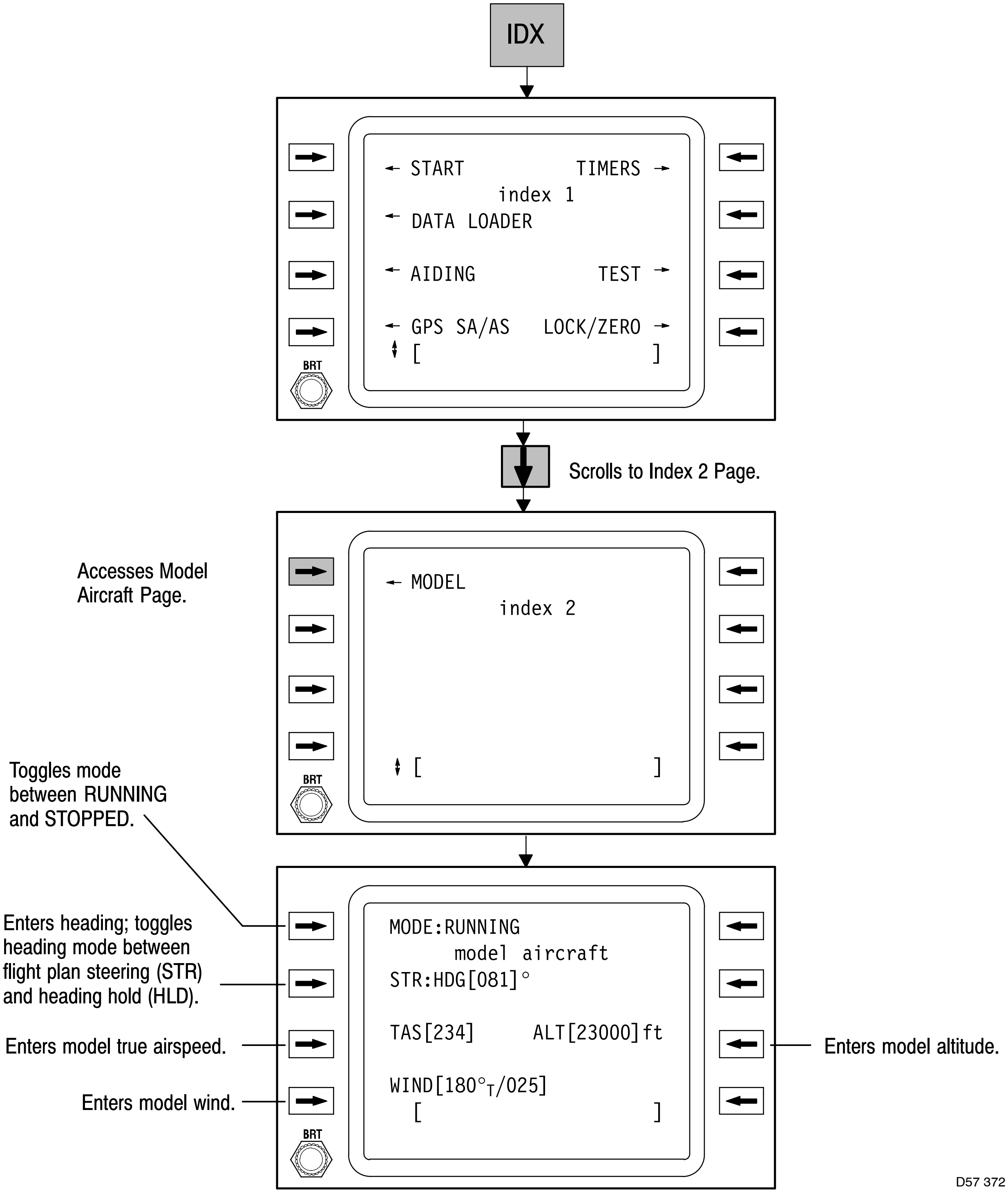
MODEL AIRPLANE FUNCTION

The model airplane is a real-time mission simulation capable of following all flight plan maneuvers to include holding patterns, vertical navigation and intercepts. The model airplane can only be operated when the weight on wheels discrete indicates the host airplane is on the ground. See *figure 1-168*.

Prior to accessing the Model Aircraft Page, the desired initial present position should be entered on the Start 1 Page.

MODEL AIRCRAFT PAGE ACCESS AND USE



SAVING AND CLEARING GPS SELECTIVE AVAILABILITY/ANTI-SPOOFING KEYS

To zeroize the SA/AS keys, access the Lock/Zeroize Page and press the ZERO ALL line select key twice. If, after a zeroize attempt, the GPS SA/AS keys were not zeroized for any reason, a NO KEYS ZERO annunciation appears. Otherwise, a SAFE KEYS annunciation is displayed.

Saving GPS Almanac Data

To save the GPS almanac data, access the Data Loader Pages and press the ALMANAC SAVE line select key twice (for confirmation). Almanac data can be saved from either GPS. See *figure 1-168*.

Saving System Status Data

To save status data to the data cartridge, access the Data Loader Pages and press the STATUS SAVE line select key twice (for confirmation). The fail history file contains start and end dates of the record. A new fail history record begins whenever the crew saves the status data to the cartridge.

ZEROIZING SYSTEM DATA

The Lock/Zeroize Page permits selective blanking of data within CDU nonvolatile memory and the data loader cartridge. In addition to selective blanking, a single key commands a master zeroize of all data stored in the system, including the GPS selective availability/anti-spoofing keys. The example following shows the Lock/Zeroize Page and its associated operations in blanking different portions of system memory.

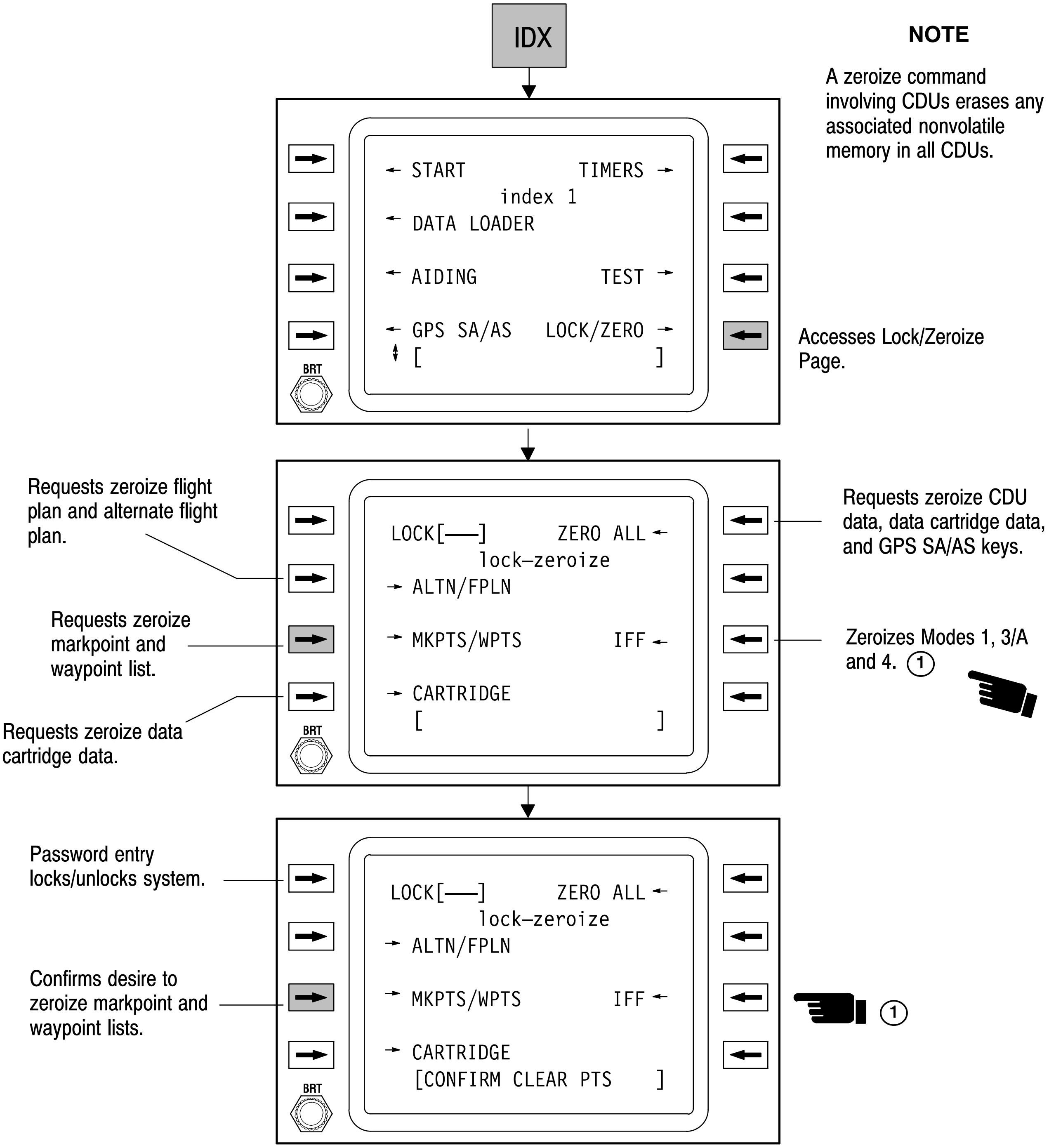
When using the Lock/Zeroize Page to erase data from the CDUs, it happens instantly on the CDU on which the action is initiated, but propagates slowly to the other CDUs. The zeroization command can take up to three minutes to propagate to all CDUs because it is a low priority message on the 1553 bus. If the zeroization command does not fully propagate before GINS power down, and another CDU is powered up first on the next flight, the first CDU powered up becomes the 1553 bus controller and propagates its internal data to the other CDUs. If the first CDU powered up still contains in NVM the data that was intended to be zeroized, it is restored to all CDUs. Thus, the crewmember initiating the zeroization should do so at least three minutes before power down. This does not apply to use of any of the zeroization switches (MASTER or GPS CRYPTO ZEROIZE), only to the data controlled by the Lock/Zeroize Page.

LOCKING THE SYSTEM

The system lock, when activated with a password entry, disables the CDU function keys with the exception of two line select keys: one which unlocks the system with the entry of the same password, and one which zeroizes system data.

To lock the system, access the Lock/Zeroize Page, enter a three-character password in the scratchpad, and press the LOCK line select key. All CDUs display the Lock/Zeroize Page and display the LOCKED annunciation, indicating the system is locked. No function keys or line selects (other than the LOCK and ZERO ALL line select keys) are operational at this point. Once the system is locked, it can only be unlocked (and full functionality restored to the CDUs) by re-entering the same password in the scratchpad of any CDU and pressing the LOCK line select key, or pressing the ZERO ALL line select key twice on any CDU to zeroize system data.

ZEROIZING OR LOCKING UP SYSTEM DATA



NOTE

A zeroize command involving CDUs erases any associated nonvolatile memory in all CDUs.

Accesses Lock/Zeroize Page.

Requests zeroize flight plan and alternate flight plan.

Requests zeroize markpoint and waypoint list.

Requests zeroize data cartridge data.

Requests zeroize CDU data, data cartridge data, and GPS SA/AS keys.

Zeroizes Modes 1, 3/A and 4. ①

Password entry locks/unlocks system.

Confirms desire to zeroize markpoint and waypoint lists.

① WITH IDG

NOTE

All functions on this page delete significant amounts of data stored in CDU or other subsystem nonvolatile memory. They all require confirmation prior to execution by pressing same key a second time to acknowledge confirmation message.

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CDU Screens – Alphabetical Locator

SCREEN	FIGURE, SHEET	ACCESS ①
Aiding	1-168, 14	IDX LS3
Altn Fpln (series)	1-172, 4	EDIT LS1
Circle	1-172, 19	EDIT LS2 LS2
Clsd random	1-172, 25	EDIT LS2 LS1
Data	1-173, 2	DATA
Data loader 1	1-168, 9	IDX LS2
2	1-168, 11	IDX LS2 ↓
Direct–To	1-169, 10	DIR
Figure 8	1-172, 19	EDIT LS2 LS3
Fms Appr	1-172, 39	EDIT LS6
Fpln	1-169, 2	FPLN
Edit	1-172, 2	EDIT
Wpt	1-169, 12	FPLN LS6,7,8
Fuel	1-172, 9	EDIT LS1 LS1
GPS SA/AS	1-168, 20	IDX LS4
GPS satellite data	1-174, 6	INAV → GPS inav ↓
Hold	1-172, 36	EDIT LS5
Ident data	1-173, 5	FPLN DATA LS2,3,4 →
Index 1	1-168, 2	IDX
2	1-168, 25	IDX ↓
Inav (series)	1-174, 2 thru 5	INAV →
Init	1-172, 6	EDIT LS1 LS1 →
Intercept a	1-172, 41	EDIT LS7
b	1-172, 43	EDIT LS7 →
Lateral steer	1-170, 10	STR
Legs a, b, c	1-172, 11	EDIT LS1 LS2
Lock/zeroize	1-168, 23	IDX LS8
Markpoint list	1-172, 34	EDIT LS3
Model aircraft	1-168, 26	IDX ↓ LS2
Para offset	1-169, 2	FPLN
Patterns	1-172, 18	EDIT LS2
Position	1-171, 1	PSN
Racetrack	1-172, 20	EDIT LS2 LS4
Refuel a	1-172, 29	EDIT LS2 LS8
b	1-172, 31	EDIT LS2 LS8 →
Renumber	1-172, 2	EDIT LS8
Start 1	1-168, 4	IDX LS1
2	1-168, 6	IDX LS1 ↓
3	1-168, 7	IDX LS1 ↑
Status, fms (series)	1-175, 2, 4, 6, 7	STAT
nav (series)	1-175, 9, 10, 11, 13, 14	STAT ↓
Steer select	1-170, 12	STR LS1
WITH IDG TCAS/ IFF control	1–125C, 1	IFF ◀
Test (series)	1-168, 2	IDX LS7
Timers	1-168, 21	IDX LS5
Vnav steer	1-170, 14	STR ↓
Waypoint list	1-172, 35	EDIT LS4

① Direct access from top-level menus. Other access possible from other screens.

Figure 1-167

CDU Menus – Index

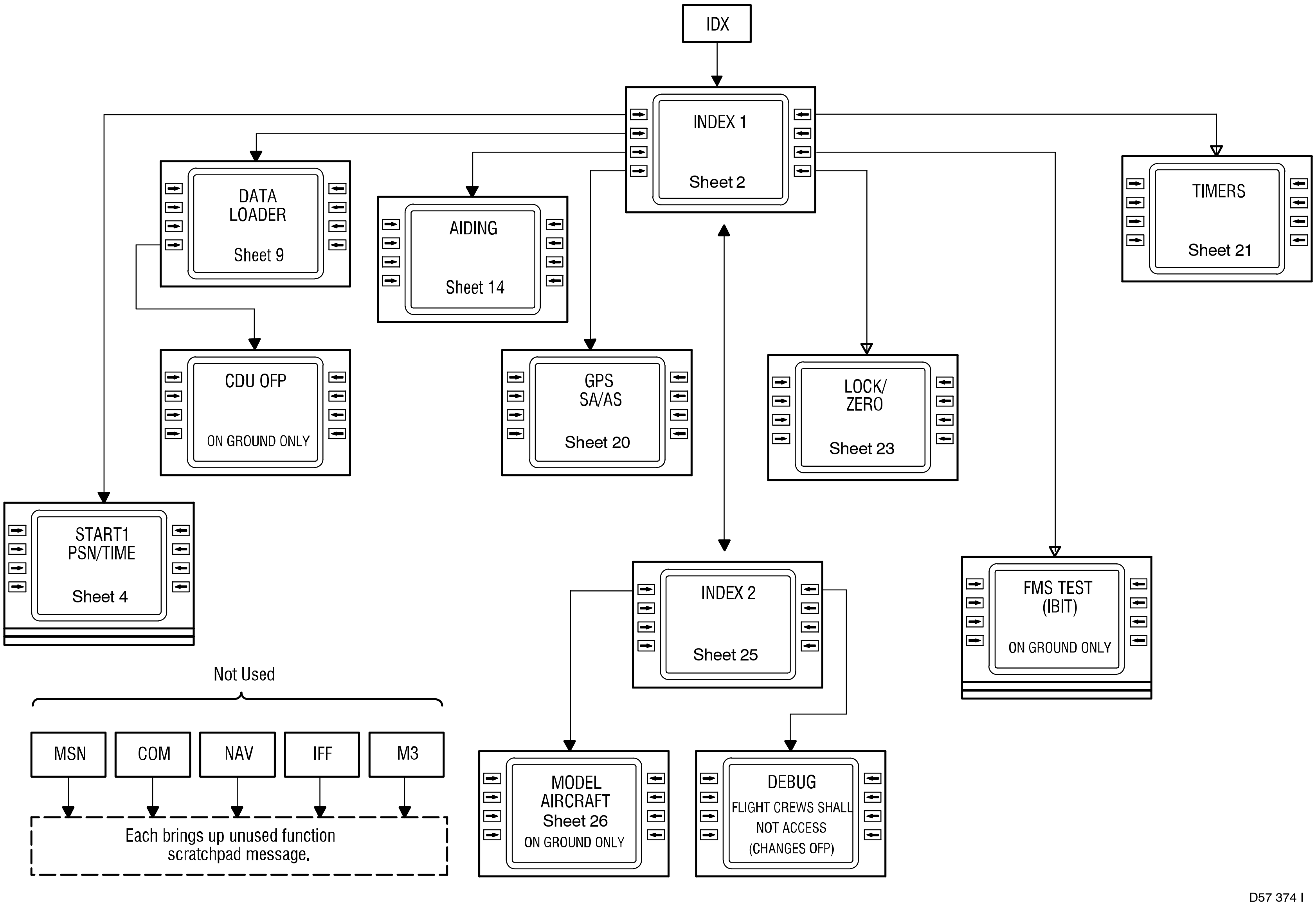
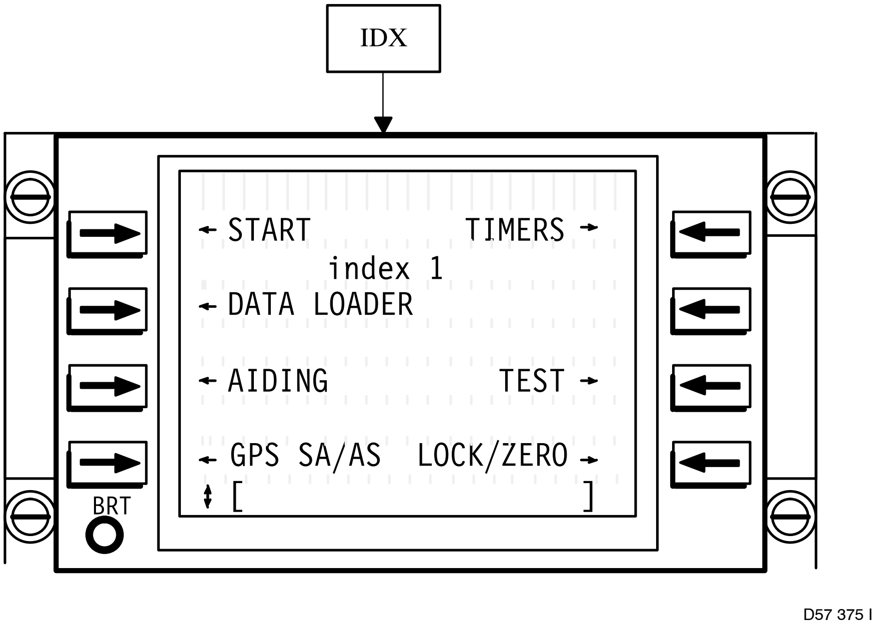


Figure 1-168 (Sheet 1 of 28)

CDU Menus – Index (Continued)



NOTE

Index 1 page is accessed by pressing IDX key or by vertical scrolling from Index 2 page.

LS1	Accesses Start pages.
LS2	Accesses Data Loader pages.
LS3	Accesses Aiding page.
LS4	Accesses GPS Selective Availability/Anti–Spoof (SA/AS) pages.
LS5	Accesses Timers page.
LS7	Accesses Test pages.
LS8	Accesses Lock/Zeroize pages.

Vertical scrolling accesses Index 2 page, and wraps around.

Figure 1-168 (Sheet 2 of 28)

(GPS START)

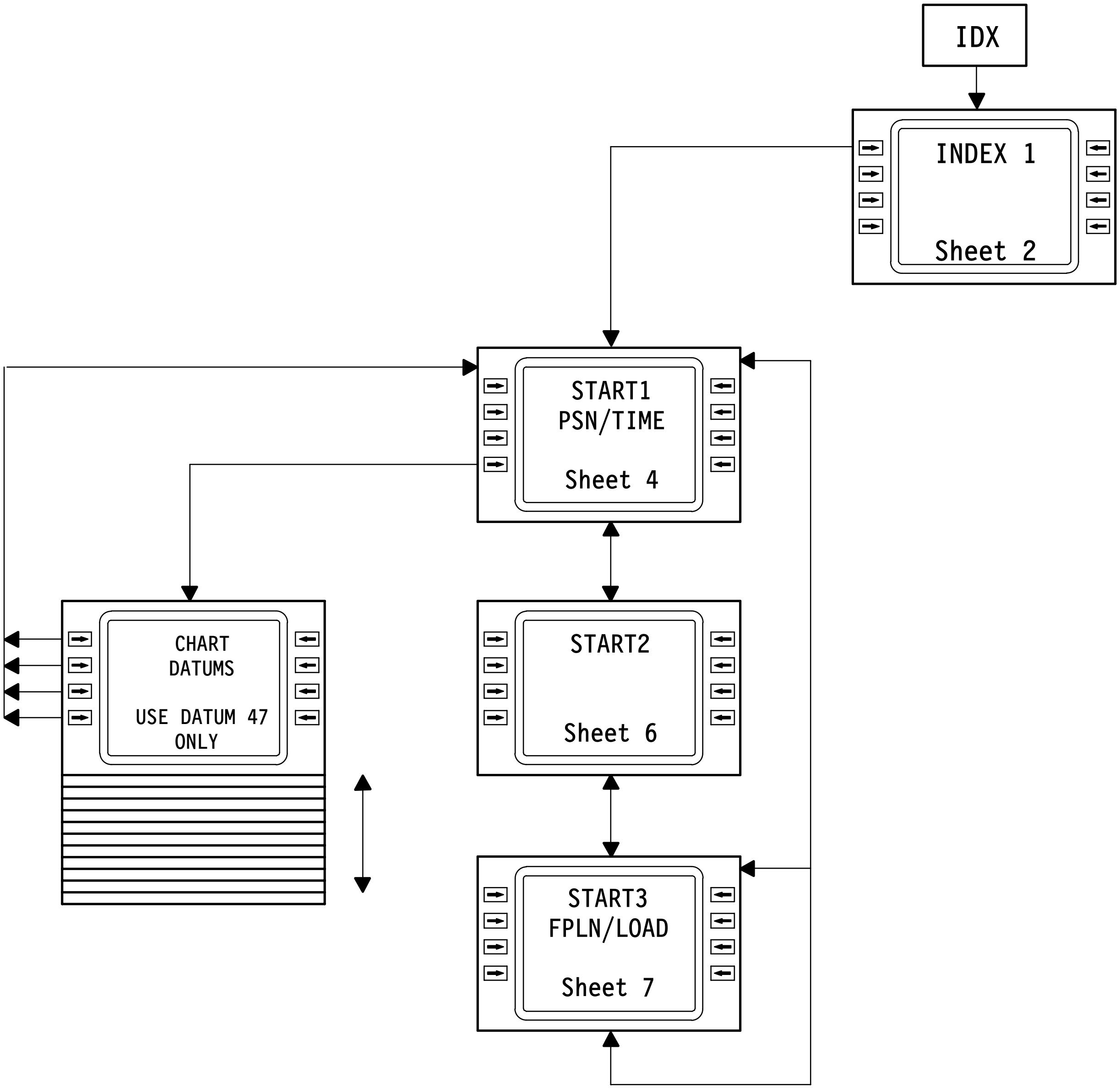
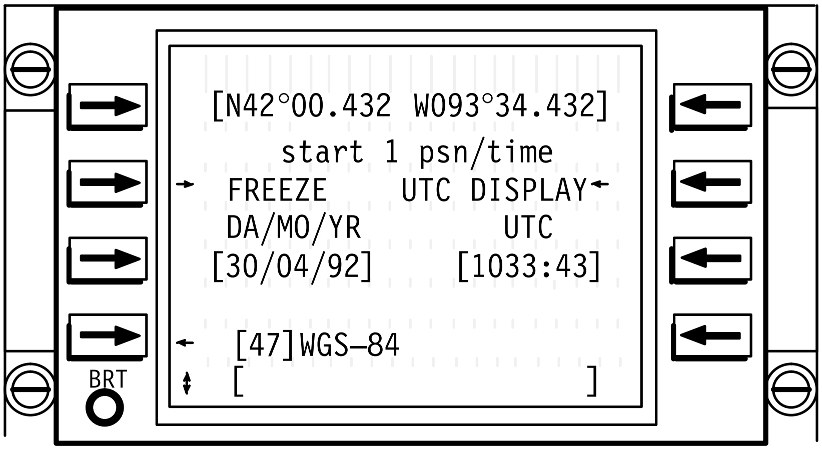


Figure 1-168 (Sheet 3 of 28)

CDU Menus – Index (Continued)

(GPS Start) Continued



NOTE

Start 1 psn/time page is accessed from index 1 page, and by LS1 thru LS4 from each Chart Datums page.

Data line 1 displays initialization position in format Ndd°mm.mmm Wddd°mm.mmm.
LESS GA Position on data line 1 is stored in NVM at airplane touchdown (based on Weight on Wheels discrete) as well as when it is frozen.◄
WITH GA Upon aircraft touchdown, when the designated pilot's source ground speed falls below two knots, the designated pilot's steering source latitude and longitude are written initially to CDU NVM. The position is updatedat one minute intervals for five minutes as long as ground speed remains below five knots. If ground speed rises above five knots, the process starts over again when ground speed falls below two knots. ◄ When an asterisk is displayed adjacent to LS2, location on data line 1 is fixed. When an arrow is displayed adjacent to LS2, location on data line 1 reflects GPS1 Present Position Latitude and Present Position Longitude (assuming they are valid). If they are not valid, GPS2 Present Position Latitude and Present Position Longitude are used (assuming they are valid). If neither GPS position is valid, designated pilot's solution is used; and if designated pilot's solution is invalid, non-volatile memory (NVM) position is used. Furthermore, if neither GPS position is valid, causing operator to resort to INU only operation, initial present position may be inserted manually. Manual present position is overwritten by GPS when GPS position becomes valid. However, manual present position overwrites the designated pilot's solution and/or the NVM position. If manual position is entered in error and GPS position is not valid, reinsert the correct coordinates.

Data line 3 displays date and time (Day of Year, Month, Year, UTC Time). Manually entered date and time are overwritten by GPS when GPS time is valid. GPS1 data has priority over GPS2 data.

Data line 4 displays Current GPS Datum next to LS4. USAF has standardized on Datum 47, WGS-84, for worldwide use. Always assure that Datum 47 is displayed. The other standard datums, 1 through 46, and 48, are stored in the CDUs, but shall not be used for USAF operations.

Figure 1-168 (Sheet 4 of 28)

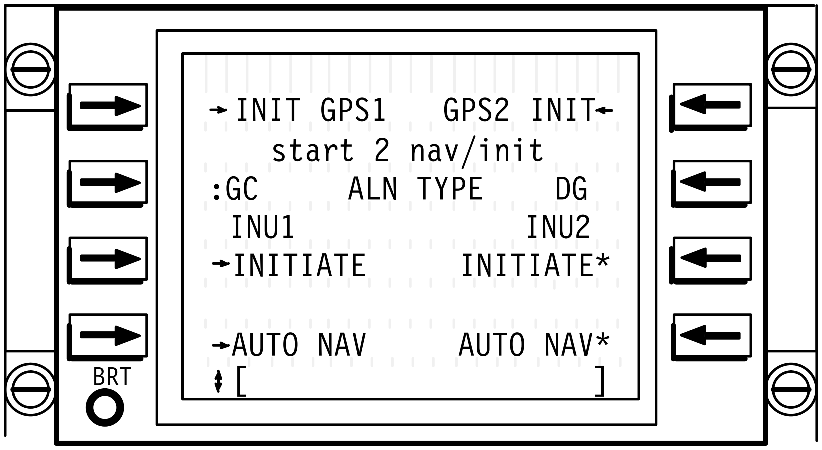
LS1,5	With a valid position (entered as any valid location but always displayed as a latitude/longitude) in scratchpad, enters that position, changes arrow adjacent to LS2 to an asterisk, and freezes location. With a blank scratchpad, copies displayed position into scratchpad.
LS2	When an arrow is displayed, changes arrow to an asterisk and freezes position display on data line 1. When an asterisk is displayed, changes asterisk to an arrow and discontinues freeze function on position display on data line 1.
LS3	With a valid date in scratchpad, enters that date for system date. With a blank scratchpad, copies date into scratchpad.
LS4	With a valid chart number in scratchpad, enters that datum as System Datum. Default is 47. With – in scratchpad, sets datum to default. With a blank scratchpad, accesses chart datums page for datum displayed, which should always be datum 47. Function is superfluous as long as one, and only one, datum is to be used.
LS6	When an arrow is displayed, changes arrow to an asterisk and displays UTC time on annunciation line in form XXXX:XX. When an asterisk is displayed, changes asterisk to an arrow and blanks display of UTC time on annunciation line.
LS7	With a valid time in scratchpad, enters that time for system time. With a blank scratchpad, copies time into scratchpad.

Vertical scrolling upward accesses Start 3 Flight Plan/Load page. Downward scrolling accesses Start 2 Navigation/Initialization page.

Figure 1-168 (Sheet 5 of 28)

CDU Menus - Index (Continued)

(GPS Start) Continued



NOTE

Start 2 Navigation/Initialization page is accessed by vertical scrolling from Start 1 or Start 3 page.

LS1 or LS5 causes arrow to change to an asterisk until GPS completes its initialization (GPS Mode transitions from INIT to NAV). A GPS receiver is initialized when commanded manually. To initialize a receiver, GPS Init Data Valid word provides status of initialization data. Entered Date and Entered Time, Entered Latitude and Entered Longitude are displayed as indicated on Start 1 Position/Time page.

NOTE

LESS RAIM DG align is completed very quickly. The ADI GYRO flag disappears about three seconds after alignment start, indicating alignment is complete. Pitch and roll can be verified on the INU nav data pages. No other DG align-related indications are displayed. When a DG alignment is selected, attitude information only is available; there is no navigation capability. If GINS navigation is desired, the system must be reinitialized and a GC alignment performed. ◀

LS3 or LS7 causes arrow to change to an asterisk, and colon adjacent to associated alignment type directly above to be blanked, until respective INU completes its initialization (EGI Alignment Complete).

LS4 or LS8 causes arrow to change to an asterisk to indicate this selection is armed.

Figure 1-168 (Sheet 6 of 28)

LS1,5 With an arrow or asterisk displayed, activates an initialization (Present Position Latitude, Present Position Longitude, UTC Time, and GPS Lever ARM) of respective GPS.

LS2,6 **LESS RAIM** When a colon is displayed, toggles through INU alignment types: gyrocompass (GC) and directional gyro (DC). GC is default.

Non-operational when no colon is displayed. ◀

WITH RAIM Indicates gyrocompass (GC) INU alignment type. Non-selectable. ◀

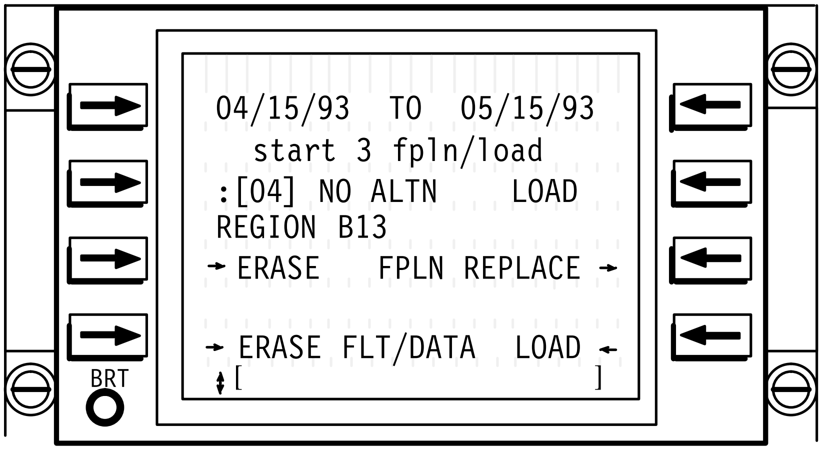
LS3,7 When arrow is displayed, initiates an alignment of type displayed on data line 2 for selected INU.

LS4,8 When arrow is displayed, activates AUTO–NAV function in which selected INU is automatically commanded to selected NAV mode when INU alignment is complete.

NOTE

If AUTO NAV is activated, INU switches to NAV mode at minimum allowed align quality. If it is desired to enter NAV mode with better align quality, status of align quality can be monitored by watching progressive reduction of CEP on INU INAV page(s), and commanding NAV mode entry via ENAB NAV LS (after NAV READY is displayed) when desired.

Vertical scrolling upward accesses Start 1 Position/Time page. Downward scrolling accesses Start 3 Flight Plan/Load page.



```
04/15/93  TO  05/15/93
  start 3 fpln/load
:[04] NO ALTN    LOAD
REGION B13
→ERASE   FPLN REPLACE→

→ERASE FLT/DATA  LOAD←
↕[                    ]
```

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NOTE

Start 3 Flight Plan/Load page is accessed by vertical scrolling from Start 1 or Start 2 page.

Information line displays cartridge label (up to 10 characters) associated with currently installed data loader cartridge. If either no cartridge is installed in data loader or an installed cartridge contains no data, this line displays REV DATA if a reversionary data base is contained in NVM. If no reversionary data base exists, this line is blank.

Figure 1-168 (Sheet 7 of 28)

CDU Menus - Index (Continued)

(GPS Start) Continued

Data line 1 displays effective period of reference point identifier (RPID) data base that is stored on data loader cartridge. If no data base is available (no cartridge, no data base on cartridge, or a data loader failure), date fields display effective period of reversionary data base, if one is stored in NVM. If neither data base is available, date fields contain dashes.

Data line 2 displays selected alternate flight plan number. If data loader cartridge does not contain an alternate flight plan associated with currently displayed number, NO is displayed on data line 2 adjacent to ALTN.

Actuation of LS3, LS4, or LS7 changes arrow to an asterisk for three seconds.

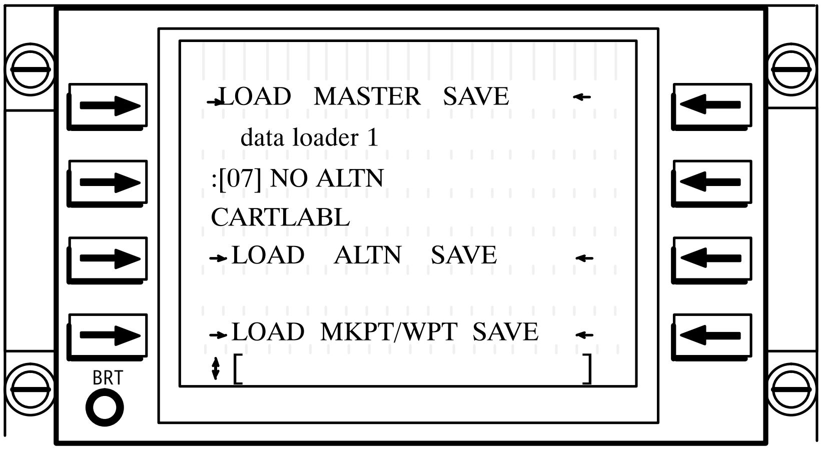
Actuation of LS6 or LS8 changes arrow to an asterisk for duration of file transfer.

LS2	With a blank scratchpad, each actuation of LS2 increments alternate flight plan number (range 1 to 10) and wrap around. With a valid alternate flight plan number in scratchpad, enter desired plan number.
LS3	Erases flight plan. Requires confirmation indicated by a CONFIRM ERASE FPLN scratchpad message.
LS4	Erases flight data. Requires confirmation indicated by a CONFIRM ERASE DATA scratchpad message. Flight data consists of markpoint and waypoint lists.
LS6	Loads alternate flight plan corresponding to number displayed on data line 2 from data loader cartridge. Requires confirmation indicated by a CONFIRM LOAD ALTN scratchpad message.
LS7	Replaces flight plan with alternate flight plan. Requires confirmation indicated by a CONFIRM RPLACE FPLN scratchpad message.
LS8	Loads Flight Data. Requires confirmation indicated by a CONFIRM LOAD DATA scratchpad message. Flight data consists of markpoint and waypoint lists.

Vertical scrolling upward accesses Start 2 Navigation/Initialization page. Downward scrolling accesses Start 1 Position/Time page.

Figure 1-168 (Sheet 8 of 28)

INDEX FUNCTIONS
(Data Loader)



```
→LOAD  MASTER  SAVE      ←
   data loader 1
:[07] NO ALTN
CARTLABL
→LOAD   ALTN   SAVE      ←

→LOAD  MKPT/WPT  SAVE    ←
↕[                        ]
```

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NOTE

> Data Loader pages are accessed from Index 1 page or by vertical scrolling between Data Loader pages. Two Data Loader pages are available to control loading and storing of flight data.

Data line 2 displays selected alternate flight plan number. If no alternate flight plan exists for currently displayed number, NO is displayed on data line 2, adjacent to ALTN.

Information line displays cartridge label associated with currently installed data cartridge. If either no data cartridge is installed in data loader, or an installed cartridge contains no data, this line is blank.

An asterisk replaces arrows adjacent to associated line selects while data is being transferred.

LS1 Loads following flight data into CDU from data cartridge. This function requires confirmation indicated by a CONFIRM LOAD ALL scratchpad message:

alternate flight plan displayed on data line 2

markpoint and waypoint lists

GPS almanac does not load upon selection of master load. This is done via LOAD ALMANAC on Data Loader page 2.

LS2 With a blank scratchpad, each press of LS2 increments alternate flight plan number (range 1 to 10), and wraps around.

With a valid alternate flight plan number in scratchpad, enters desired plan number.

LS3 Loads alternate flight plan corresponding to number on data line 2 from data cartridge. Requires confirmation, indicated by CONFIRM LOAD ALTN scratchpad message.

Figure 1-168 (Sheet 9 of 28)

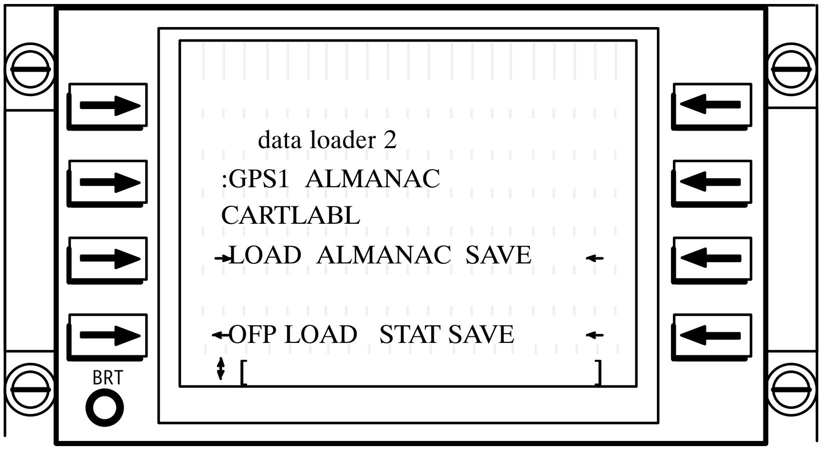
CDU Menus - Index (Continued)

(Data Loader) Continued

LS4	Loads markpoint and waypoint lists into CDU from data cartridge. Requires confirmation, indicated by CONFIRM LOAD PTS scratchpad message.
LS5	Saves following flight data from CDU to data cartridge. Requires confirmation, indicated by CONFIRM SAVE ALL scratchpad message: alternate flight plan displayed on data line 2 markpoint and waypoint lists System status and GPS almanac are not saved upon selection of master save. These operations are only performed individually via Data Loader page 2.
LS7	Saves alternate flight plan displayed on data line 2 from CDU to data cartridge. Requires confirmation, indicated by CONFIRM SAVE ALTN scratchpad message.
LS8	Saves markpoint and waypoint lists from CDU to data cartridge. Requires confirmation, indicated by CONFIRM SAVE PTS scratchpad message.

Vertical scrolling accesses Data Loader page 2, and wraps around.

Figure 1-168 (Sheet 10 of 28)



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NOTE

Data Loader page 2 is accessed by vertical scrolling from Data Loader page 1.

Information line displays cartridge label associated with currently installed data cartridge. If either no data cartridge is installed in data loader, or an installed cartridge contains no data, this line is blank.

An asterisk replaces arrows adjacent to associated line selects while data is being transferred.

LS2	Toggles between GPS1 and GPS2.
LS3	Loads almanac data from data cartridge to GPS as selected on Data Line 2. Requires confirmation, indicated by CONFIRM LOAD ALMANAC scratchpad message.
LS4	Accesses OFP Load page when on ground. (Ground Maintenance function only.)
LS7	Saves GPS almanac data from GPS, as selected on Data Line 2, to data cartridge. Requires confirmation, indicated by CONFIRM SAVE ALMANAC scratchpad message.
LS8	Saves system status information from CDU to data cartridge. Requires confirmation, indicated by CONFIRM SAVE STATUS scratchpad message.

Vertical scrolling accesses Data Loader page 1, and wraps around.

Figure 1-168 (Sheet 11 of 28)

CDU Menus - Index (Continued)

(Data Loader) Continued

In storing and retrieving data, any number of cartridges can be utilized per flight, although a single cartridge is capable of storing mission data for an entire mission. BC CDU controls data loader using following bus messages:

To Data Loader:

Set Address Pointer
Write Data Cartridge
Initiate Subsystem Self Test
Zeroize Data Cartridge

From Data loader:

Read Address Pointer
Read Data Cartridge
Transmit Self Test Data
Transmit Vector Word
Transmit BIT Word Mode Code

Upon power up or insertion of a new cartridge in data loader, bus controller CDU automatically receives following data files if they are stored on cartridge:

10-character cartridge label
Reversionary identifier data base (200 navaids)
World wide magnetic variation tables
Magnetic variation table date/time stamp
Effective period of reference point data base

NOTE

Magnetic variation tables are transferred only if date/time stamp of those tables is more recent than that currently stored in CDU NVM.

Waypoint data for one waypoint at a time is transferred to CDU upon operator request. Reversionary data base, magnetic variation table, and magnetic variation table date stamp are stored in NVM of all three CDUs.

Cartridge data is stored in individual data files. Cartridge files are never stored or saved in partial form. For example, if a new markpoint is added and a markpoint list save is requested, entire markpoint list is sent to data cartridge for storage; not just added markpoint. Storage capability is as follows:

Alternate flight plans (maximum 10), each with up to 60 points, including up to 20 MOPs.
Markpoint list
Waypoint list
GPS almanac data
System status data, including IBIT, CBIT and fail count failures

A LOAD FAIL annunciation is provided if a failure occurs when downloading to data cartridge. A NO CARTRIDGE scratchpad message is displayed when a download to cartridge is attempted and no data cartridge is installed.

Figure 1-168 (Sheet 12 of 28)

Bus Controller CDU retrieves data from cartridge, transferred as complete files. Following data can be retrieved manually:

Alternate flight plans (maximum 10), each with up to 60 points, including up to 20 MOPs.
Markpoint list
Waypoint list
GPS almanac
Waypoint data from RPID data base (a maximum of LESS GA 20,000◀ WITH GA 120,000◀ RPIDs)
OFP

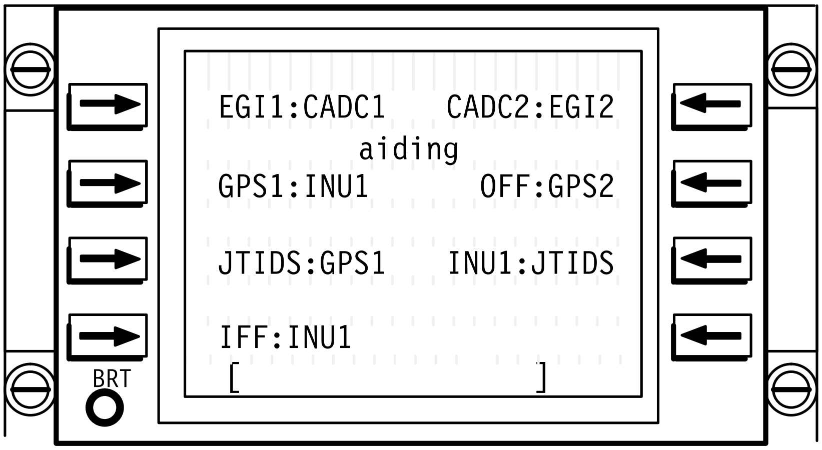
If operator attempts to search for identifier data on cartridge while data loader is in use, CARTRIDGE IN USE scratchpad message is displayed and search is inhibited. A LOAD FAIL annunciation is displayed if a failure occurs during data upload. A NO CARTRIDGE scratchpad message is displayed when an attempt to read data cartridge is performed and no cartridge is installed in loader. A NOT STORED scratchpad message is displayed when a desired RPID cannot be found on data cartridge or in reversionary data base or when no data file selected for loading can be found on data cartridge.

WITH GA Upon automatic transfer of cartridge data, if the navigation database RPID list is greater than 120,000 points, the bus controller CDU truncates the RPID list at 120,000 points and generates the DB TRUNCATED annunciation.◀

Figure 1-168 (Sheet 13 of 28)

CDU Menus - Index (Continued)

(Aiding)



```
EGI1:CADC1   CADC2:EGI2
      aiding
GPS1:INU1      OFF:GPS2

JTIDS:GPS1   INU1:JTIDS

IFF:INU1
[                    ]
```

NOTE

- Aiding page is accessed from Index 1 page.
- INU–to–GPS aiding data consists of X, Y, and Z velocities.

Data line 3 displays current status of aiding from GPS1 or GPS2 to JTIDS. This selection is established automatically when power is applied to nav system, but can be overwritten by crew. Sensor aiding configuration does not change unless crew modifies selection or a sensor failure occurs.

Data line 4 displays current status of aiding between INU1 or INU2 and JTIDS. This selection is established automatically when power is applied to nav system, but can be overwritten by crew. Sensor aiding configuration does not change unless crew modifies selection or a sensor failure occurs.

LS1	Toggles between CADC1 and CADC2 as air data sensor input to EGI1.
LS2	Toggles between INU1 (allows INU1 aiding data to GPS1) and OFF (inhibits INU1 aiding data to GPS1).
LS3	Toggles between GPS1 and GPS2 as sensor input to JTIDS. This selection also controls Preferred EGI discrete.
LS4	Toggles between INU1 and INU2 as sensor input to IFF. Default configuration is INU1. (Function not active until E17 rack RTDP hardware update is implemented.)
LS5	Toggles between CADC1 and CADC2 as air data sensor input to EGI2.
LS6	Toggles between INU2 (allows INU2 aiding data to GPS2) and OFF (inhibits INU2 aiding data to GPS2).
LS7	Toggles between INU1 and INU2 as sensor input to JTIDS. This selection also controls message traffic from JTIDS to EGI associated with INU selected.

Figure 1-168 (Sheet 14 of 28)

NOTE

- GINS has, or interfaces with, two EGIs, two AHRSs, two CADCs, and JTIDS. Each EGI contains an INU and a GPS. Each EGI generates an integrated navigation solution using its INU solution corrected by independent sensor input from GPS1, GPS2, JTIDS or manual updates.
- Bus controller (BC) CDU designates a preferred EGI to provide GPS data to JTIDS terminal. When power is applied, preferred EGI is selected, based upon validity of GPS, as follows: 1553 bus status is GO; receiver has obtained at least two satellites; GPS data is valid, GPS is in NAV mode, and GPS UTC is valid. First EGI that has valid GPS data is selected, by BC CDU, as preferred EGI. That EGI remains preferred EGI unless data from GPS within that EGI becomes invalid and alternate GPS is providing valid data, in which case alternate EGI becomes preferred EGI. Selection of preferred EGI is displayed on *Aiding page*.
- BC establishes 1553 bus message traffic between one INU and JTIDS.
- BC CDU controls GPS receiver aiding in each EGI by associated INU. On/off switching of inertial aiding for each GPS receiver is provided on Aiding page. At power on, aiding of each GPS by associated INU is set to ON. This aiding input consists solely of X, Y, Z velocity vectors.
- BC CDU provides true airspeed and pressure altitude data to EGI. TAS and altitude data are obtained from aiding CADC.
- GINS controls several GPS functions for GPS receiver (EGR) units, as follows:

  a. BC CDU provides 1553 bus synchronize mode code command to EGIs at 0.5 Hz. Following is a summary of other 1553 bus messages input to GPS receiver (EGR) units from BC CDU and data transmitted from EGR units to BC CDU.

  b. GPS Input Messages:

    (1) GPS Almanac Data

    (2) SA/AS Input Message

  c. GPS Output Messages:

    (1) Background GPS Output

    (2) GPS Almanac Data

    (3) Time Mark Pulse Output 2

Figure 1-168 (Sheet 15 of 28)

CDU Menus - Index (Continued)

(Aiding) Continued

d. GPS receiver mode is controlled by EGI and is set to NAV mode except under following conditions:

   (1) GPS mode is set to Test when EGI is commanded into test mode.

   (2) GPS mode is set to Initialize when position, time or lever arm data is received from BC CDU.

e. BC CDU designates a GPS to provide time and date data for GINS. Time and date data are obtained from GPS associated with preferred EGI. Operator can view data from that GPS by accessing Start 1 Position/Time page.

f. To overwrite displayed GPS data, new data can be entered on Start 1 Position/Time page, and initialization of either GPS can be commanded on Start 2 Navigation/Initialization page. When GPS initialization starts, BC CDU sends new Entered Latitude, Entered Longitude, Entered Time, and Entered Date parameters to specified GPS.

g. GPS UTC Time and date are considered valid based upon data validity bits in 1553 bus messages from GPS. Validity of Navigation Data from either GPS is independent from UTC and date validity. Manually entered date and time data are propagated internally if neither GPS is valid. Manually entered data is overwritten by preferred GPS date and time should either GPS subsequently become valid. Once a valid UTC and date are received, time and date data are monitored so data used internally is consistent with GPS time/date data.

h. Once GPSs are providing valid navigation data, independent displays of position, mode, Estimated Horizontal Error (EHE), and number of tracked satellites from GPS1 and 2 are provided on Integrated Navigation pages. Displays of GPS steering data and navigation state data are provided on Steer pages and Position pages respectively, when GPS1 or 2 has been selected for pilot or copilot navigation source.

i. Independent displays of satellite numbers, satellite frequencies and tracking states for satellites being used by GPS1 and GPS2 are provided on GPS Satellite Data page. See *figure 1-174*.

j. BC CDU initiates 1553 bus commands to either GPS unit to enable transfer of GPS Almanac Data from EGI to BC CDU. BC CDU also initiates commands to transfer almanac data from BC to either GPS unit.

k. Entry of GPS lever arm lengths is performed on EGI Install pages. The bus controller CDU sends GPS Lever Arm data to GPSs as part of a GPS initialization command. Lever arm data does not change unless EGI installation changes, which is a ground maintenance function only.

l. BC CDU commands each GPS unit to provide cross side EGI with navigation aiding data.

Figure 1-168 (Sheet 16 of 28)

m. Several annunciations are associated with GPS sensors. If GPS has been selected as a sensor in designated pilot solution, and GPS fails, a √GPS annunciation is displayed. This ensures crew is aware of loss of GPS due to, for example, loss of satellites. This annunciation is also displayed if an attempt is made to select a mode for designated pilot solution that contains GPS when a valid GPS navigation solution is not available.

- GINS controls several INU functions for embedded Inertial Navigation Units.

  a. BC CDU provides a 1553 bus synchronize mode code command at 0.5 Hz. Following is a summary of other 1553 bus messages input to INUs from BC CDU and data transmitted from INUs within EGIs to BC CDU.

  b. Input Messages:

    (1) Mode Control

    (2) Input Data

    (3) Calibration

  c. Output Messages:

    (1) Status

    (2) EGI Blended Output 1

    (3) Calibration

    (4) EGI Blended Output 2

    (5) Free Inertial Output

    (6) GPS/INU Output 3

    (7) Precise Time and Time Interval

    (8) BIT Fault Log

    (9) Current BIT Status

  d. BC CDU provides control of following INU modes:

    (1) Alignment mode (gyrocompass or directional gyro)

    (2) Navigation mode

    (3) Test mode

Figure 1-168 (Sheet 17 of 28)

CDU Menus - Index (Continued)

(Aiding) Continued

e. Selection of either or both INUs to receive ground alignments is done via Start 1 Position/Time page. BC CDU sends alignment command and position data to INU(s). During INU alignment, CDU annunciations are displayed indicating current level of alignment reached by INU. When INU indicates attitude mode can be achieved with current alignment, ATTD RDY X is displayed on annunciation line of all CDUs, (where X = 1 or 2), depending on which INU is being aligned. When INU can be commanded into navigation mode, NAV READY X is displayed. If AUTO NAV mode is selected on start 2 nav/init page, transition from ALIGN to NAV is automatic when NAV criteria are met (NAV READY X displayed).

f. When INUs are in NAV mode, independent displays of position, mode, and probable align circular error of EGI1 and 2 free inertial navigation solutions are shown on INAV pages. INAV pages also provide displays of position and 95% probable position error of EGI1 and 2 integrated navigation solutions. Displays of EGI1 and 2 steering data and navigation state data are displayed on Steer pages and Position pages respectively, when an EGI integrated solution or free inertial solution has been selected for pilot or copilot navigation source.

WITH GA When the EGI is in NAV mode, the CEP display on the INAV page changes from ALN CEP to 95%ERR. The value on the ground is initially the same as the blended solution value for the 95%ERR. After takeoff, the value grows at a rate of 1.7 nm/hr, to reflect the actual value of the free inertial 95% error. The maximum value possible from this display is 21.6 nm, which is reached approximately 13 hrs after takeoff. After reaching this value, "***" is displayed for the 95%ERR. If the EGI mode changes to GC, IFA, or TEST, the display returns to the ALIGN CEP indication. ◀

g. Overfly updates (position updates) of either EGI integrated solution can be performed via (INAV series) update pages. If update is accepted, BC CDU computes change in position (delta latitude/longitude) and sends it to EGIs via bus. Operator-commanded air aligns are not permitted.

h. BC CDU can command EGIs into test mode via bus. In flight, this causes CBIT to be performed, with results available from status pages. IBIT is not available in flight.

i. Several annunciations are associated with INU sensors. If commanded mode to an INU is not same as actual mode of INU, a √INUX MDE annunciation is shown (where X = 1 or 2.) This ensures crew is aware of any failure in communication with INUs. If an INU has been selected as a sensor in designated pilot solution, and an inflight alignment is being performed by INU, and INUX IFA annunciation is shown, (where X = 1 or 2.)

WITH GA The CDU monitors for a loss of INU alignment condition by monitoring the CEP provided by the EGI. When the CEP is 0.9 or greater for 60 seconds, or rate of change of EHE indicates an INU drift rate of 0.9 nm/hr or greater for 3 minutes, then a √INUX ALN (where X = 1 or 2) is displayed. ◀

Figure 1-168 (Sheet 18 of 28)

- GINS controls inputs from two AHRS as follows:

  a. GINS receives Magnetic Heading and Magnetic Heading Valid from each AHRS through Synchro/Analog SIMs of BSIUs (BSIU1 receives heading from AHRS1, BSIU2 receives heading from AHRS2).

  b. True Heading data is received by BC CDU, which selects AHRS magnetic heading source based on following criteria:

    (1) If AHRS1 is valid and in slaved mode, AHRS1 magnetic heading is used.

    (2) If AHRS1 is valid and in free mode and AHRS2 is invalid, AHRS1 magnetic heading is used.

    (3) If AHRS1 is valid and in free mode and AHRS2 is valid and in slaved mode, AHRS2 magnetic heading is used.

    (4) If AHRS1 is invalid and AHRS2 is valid, AHRS2 magnetic heading is used.

    (5) If AHRS1 is invalid and AHRS2 is invalid, neither AHRS magnetic heading is used.

  c. **WITH GA** When the heading from one AHRS disagrees with the heading from the other AHRS by more than 10 deg, and the heading from the blended solution from the same side by more than 10 deg, the VFY AHRSn (where n = 1 or 2) annunciation is displayed.◀

  d. **WITH GA** When one AHRS disagrees with both headings from the blended solutions by more than 10 deg, the VFY AHRS HDG annunciation is displayed. If this annunciation is raised by one AHRS, it is not raised for the other AHRS unless the annunciation was reset. For AHRS heading to be valid for these annunciation tests (VFY AHRSn and VFY AHRS HDG), a valid MAG VAR must be available so sensed magnetic headings can be converted to true headings. ◀

- Heading data is converted to true and sent to EGIs in True Heading Input.

- GINS controls two CADCs as follows via BC CDU on 1553 bus using a subset of CADC messages.

  a. The subset of messages includes:

    (1) Input Message

    (2) Wrap Around Test

    (3) Main Output Message

  b. Psn page allows operator entry of current local sea level barometric pressure. BC CDU sends entered barometric pressure to CADCs via bus.

Figure 1-168 (Sheet 19 of 28)

CDU Menus - Index (Continued)

(Aiding) Continued

c. BC CDU initiates self test of either CADC via bus. Results of self test are received via bus. CADCs do not support a continuous builtin test function (CBIT). Rather, BC CDU monitors CADC status via the 1553 bus status word. CADC status is shown on nav status page.

d. Independent displays of true airspeed and static air temperature for CADC1 and 2 are shown on psn pages.

e. Selection of either CADC to aid either or both EGIs is done via Aiding page. Power on defaults are as follows:

  (1) CADC1 aiding EGI1

  (2) CADC2 aiding EGI2

f. WITH GA When one CADC true airspeed disagrees with the other by greater than 6 knots, the VFY TAS annunciation is displyed. ◄

- GINS controls 1553 messages between EGI and JTIDS. BC commands messages from EGI1 or EGI2 to JTIDS and establishes Preferred EGI discrete based upon validity of GPS data within EGI.
- When power is applied to GINS, GPS messages and Preferred EGI discrete are associated with EGI1 if GPS1 data is valid. If GPS1 data is not valid and GPS2 data is valid, GPS messages and Preferred EGI discrete are associated with EGI2. If neither GPS has valid data, GPS message traffic and Preferred EGI discrete are associated with EGI1; validity for each GPS is monitored continuously in this case to establish GPS message traffic and Preferred EGI discrete associated with EGI for which GPS data becomes valid. Once bus traffic and Preferred EGI discrete have been established, they do not change automatically unless associated GPS fails and other GPS is valid, in which case GPS messages and Preferred EGI discrete are associated with EGI that contains valid GPS.
- BC commands following JTIDS message traffic: JTIDS Nav Data message from EGI1 or EGI2 to JTIDS; JTIDS Update message from JTIDS to EGI1 or EGI2. The EGI used for this message traffic is based upon validity of INU data within each EGI.

WITH GA The JTDS RELNAV update quality is from the JTDS internal quality index (1–15, with 15 being highest). One of the intents for this annunciation message (JTDS RELNAV) was to warn the operator when JTDS updating is being used, and JTDS RELNAV quality is low. The operator determined update quality values are subjective, based on confidence in their DME–DME fix quality.The JTDS RELNAV annunciation is displayed when any of the following conditions exist for one minute:

a. CBIT indicates all data to JTIDS is invalid.

b. CBIT indicates latitude/longitude data is invalid.

c. Flight mode is ENROUTE and JTIDS RELNAV relative position update quality is less than 3 (figure of merit ≤ 4500 ft).

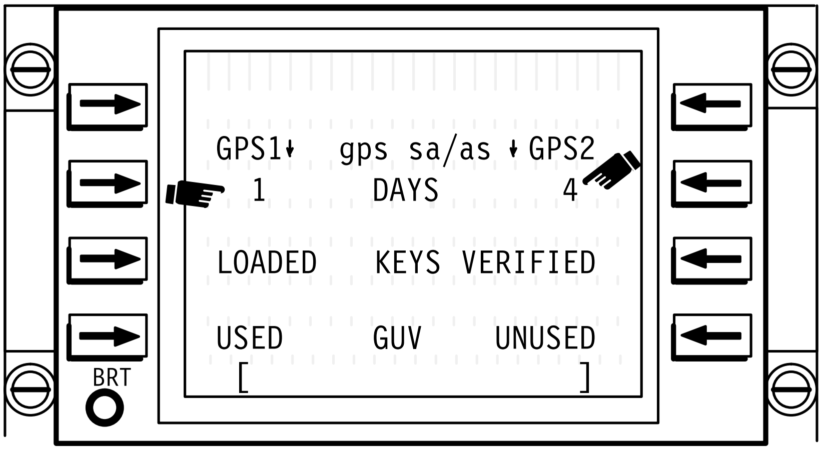
Figure 1-168 (Sheet 20 of 28)

d. Flight mode is TERMINAL and JTIDS RELNAV relative position update quality is less than 4 (figure of merit ≤ 2260 ft).

e. Flight mode is APPROACH and JTIDS RELNAV relative position update quality is less than 8 (figure of merit ≤ 565 ft).◀

- Configuration established for aiding traffic between EGIs and JTIDS is displayed on Aiding page.

(SA/AS)



D57 383 I

NOTE

GPS SA/AS page is accessed from Index 1 page.

Data line 2 (left side) contains GPS Mission Duration for GPS1, and right hand side for GPS2. Mission duration is number of consecutive, valid daily keys, beginning with current day key, contained in set.

Data line 3 displays mode setting of GPS keys. Three possible displays are, LOADED (keys have been loaded, but not verified), VERIFIED (keys have been loaded and verified), and NONE (no SA/AS keys present in box). Left hand side of data line 3 displays SA/AS key mode for GPS1, and right hand side of data line 3 displays SA/AS key mode for GPS2.

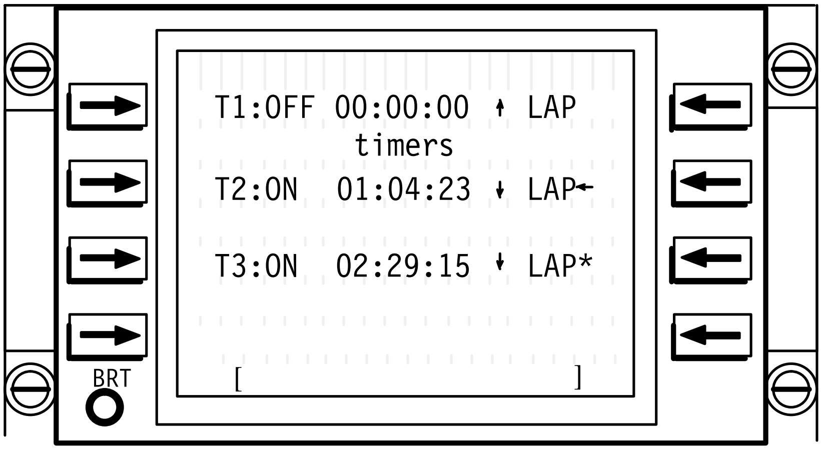
Data line 4 displays GUV mode setting for each GPS. The GUV (Group Unique Variable) is used to decrypt the GPS classified sections of the GPS nav message that is modulated onto the GPS link. This enables your GPS receiver to have access to the full GPS military positioning accuracy. Two possible displays are USED or UNUSED. Left hand side of data line 4 displays GUV mode setting for GPS1, and right hand side of data line 4 displays GUV mode setting for GPS2.

Bus controller CDU obtains and displays GPS Mission Duration data. Mission duration is displayed on GPS SA/AS page. There are several CDU annunciations related to SA/AS functions. KEYX ALRT is displayed to indicate SA/AS keys expire in two hours in selected GPS where X = 1 or 2. After successfully zeroizing SA/AS keys via zeroize function, SAFE KEYS X is displayed. After a failed attempt to zeroize SA/AS keys via zeroize function, NO KEYX ZERO is displayed. KEYX ERR is displayed where X = 1 or 2 to indicate GPS has received incorrect keys.

Figure 1-168 (Sheet 21 of 28)

CDU Menus - Index (Continued)

(Timers)



D57 384 I

NOTE

Timers page is accessed from Index 1 page.

LS1 thru 3 With a blank scratchpad, toggles operation of associated timer between ON and OFF.

With a zero in scratchpad, toggles associated timer OFF, resets counter to 00:00:00, and sets arrow preceding word LAP to point up, indicating timer counts up when toggled ON.

With a number other than zero in scratchpad, toggles associated timer OFF, resets counter to number in scratchpad, and sets arrow preceding word LAP to point down, indicating timer counts down when toggled ON.

LS5 thru 7 While associated timer is running, halts timer display, but timer keeps running internally. When pressed again, display returns to show active timer count. An arrow (←) is displayed following LAP while timer is actively counting. An asterisk is displayed following LAP while display is halted, but timer is running.

While associated timer is OFF, results in no operation. Neither arrow, nor asterisk following LAP, is displayed.

Three independent timers are available for elapsed time (counting up to 23:59:59 and stopping) or counting down to 00:00:00. A √TIMER X annunciation is shown when a timer counting down reaches 00:00:00 (X represents timer that reached zero). Each timer has capability to count up or down, and also to be halted.

Figure 1-168 (Sheet 22 of 28)

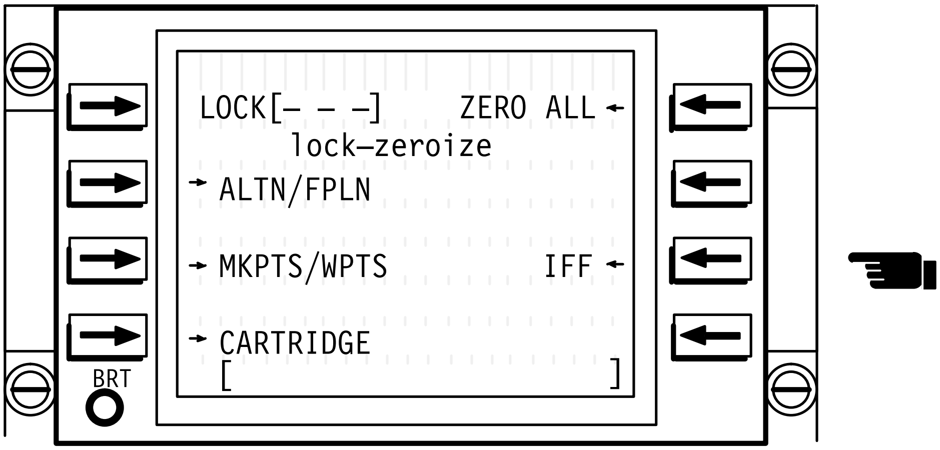
Any time a power interrupt occurs or a different CDU becomes bus controller, any timer that is running is put in OFF mode and set to 00:00:00.

Entry of time is from one to six digits. To reset timer to 00:00:00, one to six zeros are entered. This prepares timer for a count up of up to 23:59:59. Entry of any non zero digits up to a maximum entry of 235959 (representing 23:59:59, which is maximum for each of six positions) prepares timer for a countdown when timer is started. An entry of less than six numbers is assigned leading zeros (127 is 00:01:27).

Figure 1-168 (Sheet 23 of 28)

CDU Menus - Index (Continued)

(Lock/Zeroize)



D57 385 I

NOTE

Lock/Zeroize Page is accessed from Index 1 page.

Data line 1 always displays dashes within brackets at LS1.

All of above zeroize functions display asterisk instead of an arrow for 3 seconds after second line select keypress, showing that function has been selected. When system is locked, no arrows are displayed except for ZERO ALL line select.

If either GPS or data loader is failed, a √STATUS message is displayed in scratchpad, but system attempts to perform zeroize action anyway. In addition, if a zeroize action is attempted for data loader (that is, zeroize all or zeroize cartridge) when there is no cartridge present, a NO CARTRIDGE message is displayed in scratchpad. Hierarchy of these two scratchpad messages is √STATUS, then NO CARTRIDGE.

The zeroize all function zeroizes GPS SA/AS keys if receiver contains keys. If receiver is off, NO KEYS ZERO annunciation is displayed following zeroize all command, to inform operator that GPS SA/AS keys were not zeroized.

LRUs that can be zeroized are listed below. Included are data types or functions which are affected by zeroizing.

CDUs 1 through 3. CDU data can be zeroized individually or collectively, as follows:

Flight plan waypoints, including history waypoints and any holds, approaches, intercepts, or MOPs that are defined.

Alternate flight plan waypoints, including any holds, approaches, intercepts, and MOPs that are defined. Entered parameters on alternate flight plan-related pages are set to their default values.

Markpoint list.

Waypoint list.

Reversionary data base.

Figure 1-168 (Sheet 24 of 28)

In addition, system zeroizing unlocks a locked CDU (see below).

Data Loader Cartridge. All data on installed data loader cartridge is erased upon zeroizing.

GPS1 and 2 SA/AS keys are erased upon zeroizing.

Unauthorized access protection (LOCK) function is a security lock capability to inhibit accidental or intentional manipulation of stored system data, including data cartridge data. System lock is performed by means of a password entry on Lock/Zeroize Page. Locking system causes a LOCKED annunication to appear on all CDUs, sets all CDU pages to Lock/Zeroize Page, and allows only Zeroize All function to be performed. System unlocks only with correct password entry or by performing Zeroize All. After unlock, all CDUs remain at Lock/Zeroize Page; however, all operations, entries, and data access provisions are returned. An unlimited number of password entry attempts is allowed.

LS1	With a valid entry in scratchpad (any 3 characters), enters three-character password to LOCK or UNLOCK system when on ground. Only UNLOCK function is allowed when airborne. If an attempt is made to LOCK system while airborne (based on the Weight on Wheels discrete), GROUND ONLY scratchpad message is displayed.
LS2	Zeroizes flight plan and CDU-loaded alternate flight plan data in system. This function requires confirmation, indicated by a CONFIRM CLEAR FPLNS scratchpad message. In addition to flight plan and alternate flight plan, any defined holds, approaches, intercepts, or MOPs are also zeroized.
LS3	Zeroizes markpoint and waypoint lists. This function requires confirmation, indicated by a CONFIRM CLEAR PTS scratchpad message.
LS4	Zeroizes Data Loader cartridge, including navaid data base. This function requires confirmation, indicated by CONFIRM CLEAR CART scratchpad message.
LS5	Provides system zeroizing and toggles Master Zeroize. This function requires confirmation, indicated by a CONFIRM ZERO ALL scratchpad message. See NOTE.
WITH IDG **LS7**	When pressed, performs the following: a. Sets mode control for Modes 1, 2, 3/A, 4, C and S to OUT. b. Sets Mode 1 code to 00. c. Sets Mode 3/A code to 0000. d. Zeroizes Mode 4 code. e. Sets Mode 4 to code A. f. Sets TCAS sensitivity to STBY. If emergency mode is active when a zeroize is initiated, the IFF remains in emergency mode, and IFF settings such as Mode 4 (or other previous mode settings) are zeroized as above.◀

NOTE

- Zeroized data includes EGIs present position, causing both EGIs to lose alignment, and all navigation solutions to become invalid.
- When zeroizing CDU data via the lock/zeroize page, allow at least three minutes for the NVM memory in all CDUs to clear before powering down GINS. If a CDU memory is not cleared, and that CDU is powered up as bus controller on a subsequent mission, the retained data is propagated to all CDUs.

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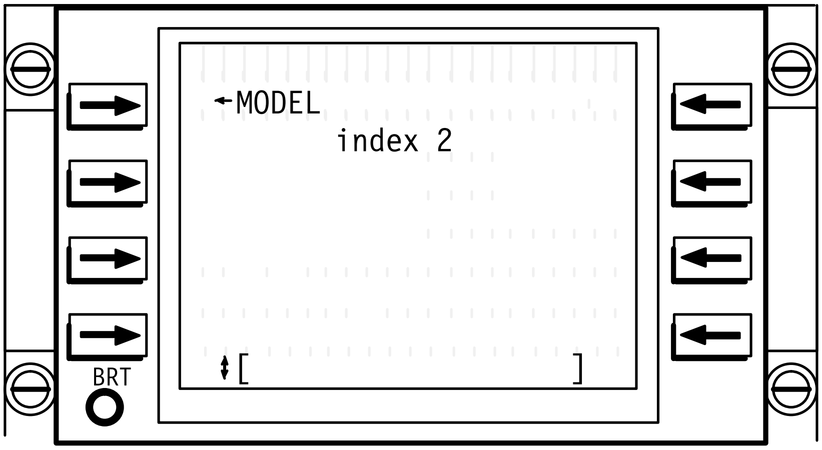
CDU Menus - Index (Continued)

(Index 2)



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NOTE

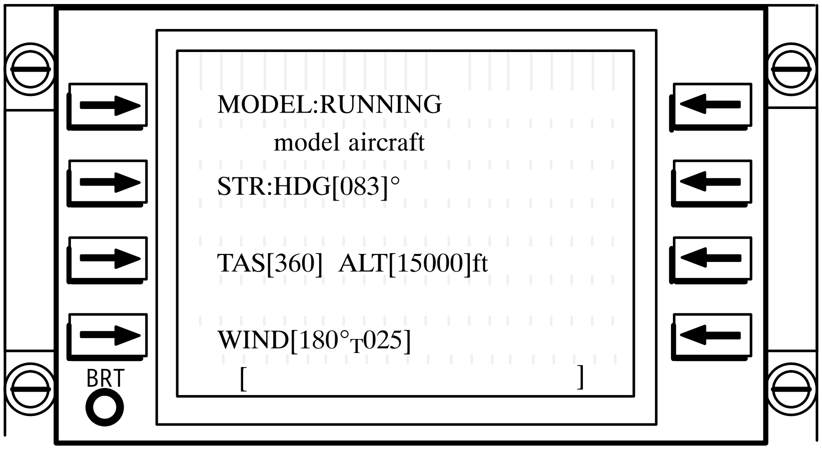
Index 2 page is accessed by vertical scrolling from Index 1 page.

Vertical scrolling accesses Index 1 page, and wraps around.

LS1	LS1 accesses Model Aircraft page if Weight on Wheels discrete indicates airplane is on ground. Otherwise, pressing LS1 displays GROUND ONLY scratchpad message.
LS5	(Ground Maintenance function only.)

Figure 1-168 (Sheet 26 of 28)

(Model Aircraft)



MODEL:RUNNING
model aircraft
STR:HDG[083]°
TAS[360] ALT[15000]ft
WIND[$180°_{T}$025]
[ ]

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NOTE

Model Aircraft page is accessed from Index 2 page.

Data line 2 displays heading in $°_{T}$ when True/Mag Select discrete is set to true or when no magnetic variation tables are available.

LS1 Toggles mode of operation between RUNNING and STOPPED if airplane is on ground. When toggled to RUNNING, speed remains constant, but heading and altitude are automatically adjusted along horizontal and vertical execution of flight plan. Model is switched automatically to STOPPED if aircraft is airborne. When aircraft is airborne, causes GROUND ONLY scratchpad message to be displayed.

LS2 When a valid entry in scratchpad, enters model aircraft heading in degrees, whether STOPPED or RUNNING. Heading is dynamic, and follows along flight plan execution. Default heading is 360°.

With a blank scratchpad, toggles heading between steer (STR) and hold (HLD). When toggled to HLD mode, heading is maintained and displayed heading does not follow horizontal flight plan execution. When toggled to STR mode, heading follows horizontal flight plan execution.

With – in scratchpad, sets heading to default value.

LS3 With a valid entry in scratchpad, enters model aircraft TAS in knots. Default is 360 knots.

With – in scratchpad, sets TAS to default value.

With an empty scratchpad, copies TAS into scratchpad.

Figure 1-168 (Sheet 27 of 28)

CDU Menus - Index (Continued)

(Model Aircraft) Continued

LS4	With a valid entry in scratchpad, enters model aircraft wind as direction/magnitude. Default wind is 360° at 0.0 knots. Model wind direction is direction from which wind is blowing. With – in scratchpad, sets model wind to default value. With an empty scratchpad, copies wind into scratchpad.
LS7	With a valid entry in scratchpad, enters model aircraft pressure altitude in feet. Model assumes baroset of 29.92 inches for determination of barometric and pressure altitude. Default altitude is 10000 feet. With – in scratchpad, sets altitude to default value. With an empty scratchpad, copies altitude into scratchpad.

The model aircraft function provides an on-airplane simulation capability that generates navigation data necessary to drive guidance function. Model aircraft function is accessible when airplane is on ground (based upon Weight on Wheels discrete).

When model aircraft is active, CDU displays model aircraft related data on Pilot and Copilot Position, Lateral Steer, and Vertical Steer pages. CDU pages displaying model aircraft data, or data derived from model aircraft inputs, display MODEL as navigation source. Navigation source selections made on Steer Select pages do not affect model aircraft operation.

CDU pages other than Position and Steer pages that display navigation data reflect status and data received from actual airplane sensors.

Model aircraft generates a simulated navigation solution based on crew entered airspeed, wind, initial heading, and initial altitude. Position used to initialize model is position entered on Start 1 Position/Time page. A simulated heading may be either entered or computed by model aircraft from designated pilot's bank angle command computed by guidance function.

Figure 1-168 (Sheet 28 of 28)

CDU Menus - Flight Plan

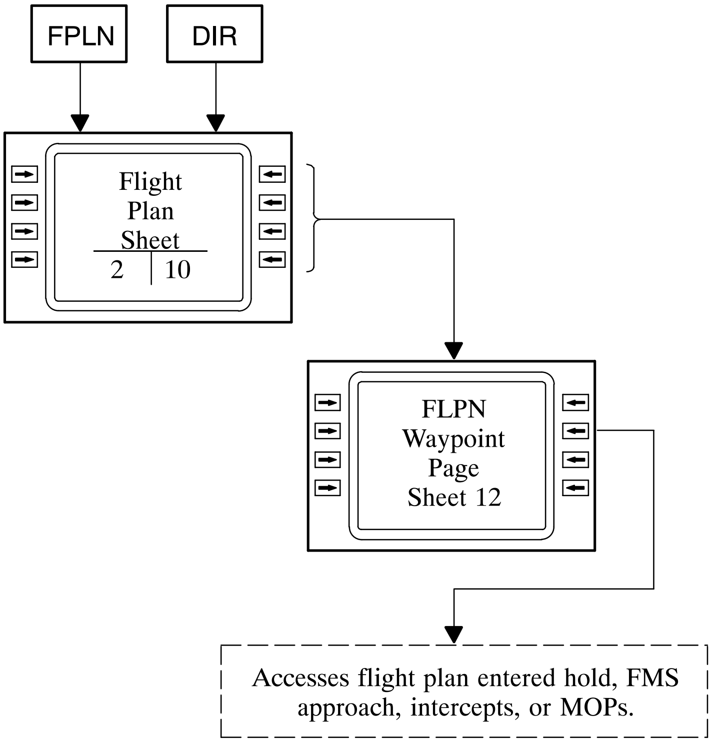

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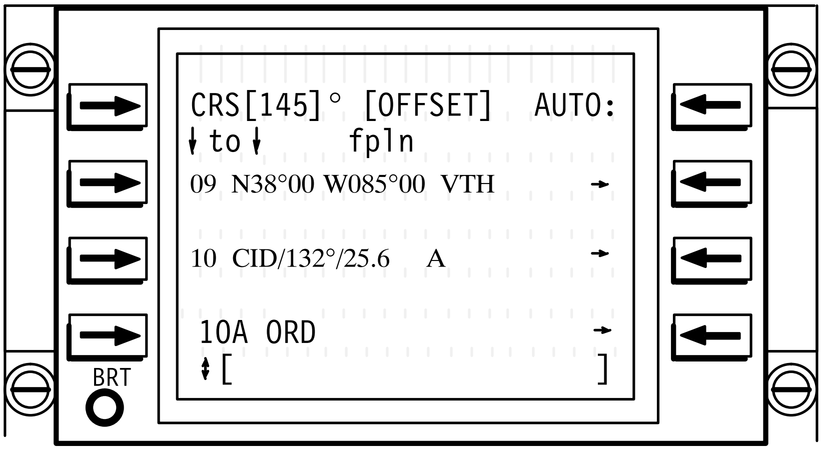
Figure 1-169 (Sheet 1 of 13)

CDU Menus - Flight Plan (Continued)

(FPLN)



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NOTE

- Flight Plan Page is accessed by pressing FPLN or Direct–To (DIR) keys on CDU or by line select from: 1) Flight Plan Waypoint page, 2) Flight Plan Edit page, 3) Alternate Flight Plan page, 4) Hold page, 5) Intercept page, 6) FMS Approach page, 7) Closed Random Pattern MOP page, 8) Circle MOP page, 9) Racetrack MOP page, 10) Figure Eight MOP page, or 11) Refuel MOP page.

- When accessed by pressing FPLN key, or by line select keys from any page listed above, except Flight Plan Waypoint page, Flight Plan page is displayed with TO waypoint in data line 2. When Flight Plan page is accessed from Flight Plan Waypoint page, waypoint that was displayed on Flight Plan Waypoint page is displayed on data line 1 of Flight Plan page, unless waypoint is TO waypoint, which is displayed on data line 2 of Flight Plan page.

Data line 1 displays inbound course to TO waypoint. Course is in $°_T$ if True/Mag Select discrete is set to true or if no magnetic variation or declination data is available for TO waypoint. Flight plan inbound course to fix point of a holding pattern or MOP is displayed during execution of hold or MOP. Data line 1 also displays parallel course offset for flight plan. If entered, parallel course offset is displayed right justified in offset field. Course offsets are displayed as R or L followed by distance from 0.1 to 99.9 nautical miles. Leading zeros in the tens digit are not displayed.

Title line displays a to/from indicator whenever TO waypoint is displayed on data line 2. When on FROM side of TO waypoint, ↓ to ↓ displayed on title line changes to ↓ from ↓ . Any course edits are applied to inbound/outbound course as appropriate, and to/from label reflects airplane position relative to a line through waypoint perpendicular to course.

When Flight Plan page is displayed during flight, data line 1 continues to display inbound course, offset, and sequence mode and title line continues to display to/from indicator as flight plan waypoints are sequenced. Upon sequencing, TO waypoint on data line 2 shifts upward off page while remaining waypoints shift upward one line.

Data lines 2, 3, 4 display waypoint number, followed by waypoint coordinates or identifier, followed by any waypoint attributes defined for waypoint.

Figure 1-169 (Sheet 2 of 13)

Waypoints in flight plan are numbered sequentially from 1 to 60 as they are entered (either as an entire flight plan or individually at end of an existing flight plan). Initial FROM waypoint is numbered 0. Waypoints inserted between existing waypoints in flight plan are numbered alphanumerically. For example, a waypoint inserted between waypoints 10 and 11 is numbered 10A. If additional waypoints are inserted after 10A, they are numbered 10B, 10C and so on. If alphanumeric level exceeds 26 waypoints, sequence wraps back to A. If a waypoint is inserted at a gap in numbering sequence, waypoint is numbered alphanumerically with respect to previous waypoint number. For example, a waypoint inserted between waypoints 10 and 12 is numbered 10A. If waypoints are inserted between alphanumerically numbered waypoints, they are given appropriate sequential alphanumeric number and subsequent alphanumeric waypoints are renumbered sequentially. For example, a new waypoint inserted between 10A and 10B is numbered 10B and subsequent alphanumeric waypoints are renumbered sequentially. If a waypoint is entered prior to TO waypoint at beginning of a flight plan (FROM waypoint is present position), then new waypoint is numbered 0A. A waypoint entered prior to 0A is numbered 0A and existing waypoint(s) prior to waypoint 1 are renumbered 0B, 0C and so on. Otherwise, inserting waypoints between FROM and TO follow normal numbering rules described above, because waypoints retain their number when they become history waypoints.

When flight plan waypoints are deleted, flight plan list closes up automatically, but does not renumber (this causes an incremental skip in flight plan number sequence). When waypoints are deleted at alphanumeric level, waypoints following deletion are renumbered (for example, if 3C is deleted 3D now becomes 3C, 3E becomes 3D and so on). Operator can renumber entire flight plan, which causes all alphanumeric level waypoints to become numbered waypoints.

If alternate flight plan is transferred into flight plan, waypoints in alternate become numbered. Entry of alternate flight plan within flight plan is identical to numbering sequence of manually entered waypoints.

Waypoint coordinates or identifiers are displayed left justified in waypoint field.

Right side of data lines 2, 3, 4 displays attributes associated with corresponding waypoints. Attributes defined are:

H	A holding pattern has been attached to this waypoint.
T	Waypoint has a desired time of arrival associated with it. This indicates that a time navigation (TNAV) function is to be performed to obtain desired arrival time.
V	Waypoint has an altitude specified which causes vertical navigation to be performed.
A	Waypoint is designated as FMS Missed Approach Point.
P	This waypoint is a fix point for an MOP which is to be executed upon arrival at point.
I	Waypoint is a valid intercept solution for a moving target.

Each waypoint can also have more than one attribute associated with it. Possible attribute combinations are:

VTH	Waypoint is fix for a holding pattern and has a TNAV and a VNAV associated with it.
VH	Waypoint is a fix for a holding pattern and has a VNAV associated with it.

Figure 1-169 (Sheet 3 of 13)

CDU Menus - Flight Plan (Continued)

(FPLN) Continued

VT	Waypoint has a TNAV and a VNAV associated with it.
TH	Waypoint is a fix for a holding pattern and has a TNAV associated with it.
VTP	Waypoint is a fix for an MOP and has a TNAV and VNAV associated with it.
TP	Waypoint is a fix for an MOP and has a TNAV associated with it.
VP	Waypoint is a fix for an MOP and has a VNAV associated with it.
IT	Waypoint is a valid intercept solution for a moving target and has a TNAV associated with it.
AT	Waypoint is the MAP and has a TNAV associated with it.

When waypoint alert is activated prior to a track change due to leg switching, TO waypoint number flashes for ten seconds and then remains steady. It also flashes for ten seconds prior to waypoint passage when flight plan is in manual mode. If TO waypoint has a VNAV attached to it, V attribute flashes for 10 seconds prior to vertical capture and when airplane is 1000 feet above BOD or 1000 feet below TOC. If TO waypoint is a MAP, A flashes for 10 seconds prior to capture and when MDA is achieved.

LS1 Inserts a crew selected inbound/outbound course for TO waypoint when a valid course is in scratchpad. Course edits are limited to ±90° from currently displayed course in AUTO: mode (LS5). If edit is greater than 90°, CRS CHANGE >90 scratchpad message is displayed. If sequencing is in manual mode, course edit is not limited. The ° symbol for inbound course is displayed as $^\circ_T$ when true/mag discrete is set to true or when no magnetic variation or declination data is available for TO waypoint. If operator attempts to enter course as magnetic and no magnetic variation or declination data is available for TO waypoint, a NO MAG VAR scratchpad message is displayed and course entry requires a true value. An attempt to change course when a pattern, intercept, or hold is active or when TO waypoint is MAP, causes xxx IS ACTIVE scratchpad message to be displayed, where xxx is CIR, CRP, FG8, RTK, RFL, INTR, HOLD, or APPROACH. An attempt to enter a course when no TO waypoint exists causes ENTER WAYPOINT scratchpad message to be displayed.

Enters a parallel course offset (entered/displayed to nearest tenth of a nautical mile) when a valid offset is in scratchpad. R or L is required as first character (for example, R1.1 or L12.0) and valid range is 0.1 to 99.9 nautical miles. Switch action is inhibited when an FAF or MAP is TO waypoint and causes APPROACH DEFINED scratchpad message to be displayed. An attempt to insert an offset when an MOP or hold fix is TO waypoint is inhibited and causes PATTERN DEFINED or HOLD DEFINED scratchpad message, respectively, to be displayed.

Deletes a parallel course offset if scratchpad contains any of the following: –, 0.0, .0, 00.0, 0., or 0, or L or R with any combination of zeros.

Copies course into scratchpad if scratchpad is blank.

Figure 1-169 (Sheet 4 of 13)

LS2,3,4 Insert a waypoint from scratchpad at point corresponding to line select key pressed. All subsequent waypoints move down in flight plan. Valid waypoint entry formats include latitude/longitude coordinates, MGRS coordinates, RPIDs, or RPID/bearing/distance. An attempt to add a waypoint when 60 waypoints already exist in the flight plan is prohibited and causes FPLN FULL scratchpad message to be displayed. An attempt to insert a waypoint at the TO when a hold, MOP, or FMS approach is active causes xxx IS ACTIVE scratchpad message, where xxx is HOLD, FG8, CRP, CIR, RTK, RFL or APPROACH, to be displayed.

When a – is entered in scratchpad, deletes waypoint adjacent to line select key. All subsequent waypoints move up flight plan to fill gap at deleted waypoint. An attempt to delete TO waypoint when a hold, MOP, intercept, or FMS approach is active is inhibited and causes xxx IS ACTIVE scratchpad message, where xxx is HOLD, FG8, CRP, CIR, RTK, RFL, INTR, or APPROACH, to be displayed. An attempt to delete last remaining history waypoint is prohibited and causes INVALID DELETION scratchpad message to be displayed.

With a valid User Defined Identifier (UDID) in scratchpad, attaches UDID to waypoint at corresponding line select key.

With a valid bearing/distance in scratchpad, amends waypoint corresponding to line select key pressed and places amended waypoint in scratchpad.

With an empty scratchpad, copies corresponding waypoint into scratchpad.

When accessed from Alternate Flight Plan page, Hold page, Intercept page, FMS Approach page, Circle MOP page, Racetrack MOP page, Figure Eight MOP page, Refuel MOP page or Closed Random Pattern MOP page, one of the following scratchpad messages is displayed:

ADD ALTN BEFORE?
ATTACH CIR AT?
ATTACH CRP AT?
ATTACH FG8 AT?
ATTACH RTK AT?
ATTACH RFL AT?
ATTACH FMS APPR AT?
ATTACH HOLD AT?
INSERT CIR BEFORE?
INSERT CRP BEFORE?
INSERT FG8 BEFORE?
INSERT RTK BEFORE?
INSERT RFL BEFORE?
INSERT INTR BEFORE?

When ADD ALTN BEFORE? is displayed, LS2, LS3, or LS4 inserts alternate flight plan waypoints into flight plan starting at line adjacent to actuated line select key. Whatever was displayed on starting line prior to insertion moves down to end of inserted waypoints. If addition of alternate flight plan causes number of waypoints in flight plan to exceed 60, FPLN FULL scratchpad message is displayed prior to adding any waypoints, to allow operator to delete waypoints not needed.

Figure 1-169 (Sheet 5 of 13)

CDU Menus - Flight Plan (Continued)

(FPLN) Continued

When an ATTACH xxx AT? message is displayed, LS2, LS3, or LS4 attaches parameters associated with scratchpad to waypoint associated with line select key pressed. This waypoint then becomes fix point or capture lobe center for specified MOP or hold, or MAP for an FMS approach. An attempt to attach a hold, FMS approach, or MOP at an intercept is inhibited, and causes INTERCEPT DEFINED scratchpad message to be displayed. An attempt to attach a hold or MOP at an FMS approach is inhibited and causes APPROACH DEFINED scratchpad message to be displayed. An attempt to attach a hold, FMS approach, or MOP at an MOP is inhibited and causes PATTERN DEFINED scratchpad message to be displayed. An attempt to attach an MOP or FMS approach at a hold is inhibited and causes HOLD DEFINED scratchpad message to be displayed. If an attempt is made to attach a holding pattern with a magnetic course to a waypoint which has no magnetic variation or declination data, NO MAG VAR scratchpad message is displayed and pattern is not attached to waypoint.

When an INSERT xxx BEFORE? message is displayed, LS2, LS3, or LS4 inserts new MOP or intercept into flight plan at location prior to waypoint associated with line select key pressed. Whatever was displayed on line prior to insertion moves down one position in flight plan. An attempt to insert an MOP or intercept when 60 waypoints already exist in flight plan is prohibited and causes FPLN FULL scratchpad message to be displayed.

If an FMS approach, intercept, or MOP is modified so that it is no longer valid (for example, approach parameters, intercept parameters, or MOP fix or capture lobe center is deleted), an attempt to attach approach or insert intercept or MOP causes ENTER PARAMETERS scratchpad message to be displayed.

An attempt to attach or insert an MOP when 20 MOPs already exist in flight plan is prohibited and causes MAX PTRNS IN FPLN scratchpad message to be displayed. An attempt to insert an intercept when 10 intercepts already exist in flight plan is prohibited and causes MAX INTRS IN FPLN scratchpad message to be displayed.

LS5 When scratchpad empty, toggles flight plan advancing mode between MAN and AUTO. When a MAP becomes TO waypoint, leg sequencing mode is set automatically to MAN mode and selection of AUTO mode is inhibited until MAP is reached. An attempt to toggle sequencing mode when airplane is on TO side of MAP, and MAP is TO waypoint, causes APPROACH IS ACTIVE scratchpad message to be displayed. Upon reaching MAP, selection of AUTO mode is again possible.

Provides capability to insert a parallel offset as described for LS1.

Deletes a parallel course offset if scratchpad contains any of following: –, 0.0, .0, 00.0, 0., or 0, or L or R with any combination of zeros.

Figure 1-169 (Sheet 6 of 13)

LS6,7,8 With any scratchpad entry other than –, accesses Flight Plan Waypoint page for waypoint corresponding to line select key pressed.

An attribute may be deleted by entering – in scratchpad and pressing line select key adjacent to attribute. If a waypoint has multiple attributes associated with it, right-most attribute is deleted first. Intercept I attribute cannot be deleted from Flight Plan page. An attempt to delete the intercept I attribute causes INVALID DELETION scratchpad message to be displayed. In order to delete intercept attribute, waypoint itself must be deleted. When MOP P attribute is deleted, MOP fix waypoint is maintained in flight plan. If an MOP or approach is active, an attempt to delete P or A attribute causes xxx IS ACTIVE scratchpad message, where xxx is RTK, CIR, FG8, RFL, CRP or APPROACH, to be displayed.

Vertical scrolling accesses additional Flight Plan pages. Scrolling up accesses additional waypoints in the order of decreasing waypoint number and scrolling down accesses waypoints in the order of increasing waypoint number. When oldest history waypoint is displayed on data line 1, the ↕ scroll indicator changes to ↓ and upward scrolling is prohibited. When *END is displayed on data line 2, the ↕ scroll indicator changes to ↑ and downward scrolling is prohibited. If vertical scroll key is held down, scrolling is continuous until end of flight plan or key is released.

Waypoints are entered via CDU as follows:

a. Manual entry of a Reference Point Identifier (RPID).

b. Manual entry of an RPID with a bearing/distance offset.

c. Manual entry of latitude/longitude coordinates.

d. Manual entry of Military Grid Reference System (MGRS) coordinates.

e. Insertion of an intercept (moving) waypoint.

f. Insertion of Mission Orbit Patterns (MOPs).

g. Transfer of alternate flight plan waypoints into flight plan.

Waypoints can be modified as follows:

a. Application of a bearing/distance offset to any fixed point.

b. Modification of inbound course to the TO waypoint.

c. Identification of a waypoint as a holding fix.

d. Identification of a waypoint as an MOP fix.

Figure 1-169 (Sheet 7 of 13)

CDU Menus - Flight Plan (Continued)

(FPLN) Continued

NOTE

- When Mag/True selector is set to MAG, offset bearings from all RPIDs are magnetic. When Mag/True selector is set to TRUE, offset bearings from NAVID RPIDs are magnetic. Offset bearings from all other RPIDs and manually entered coordinates are true.
- The magvar algorithm is not used for NAVAID RPIDs. They are assigned actual station variation. This may be different than the magnetic variation calculated by the algorithm. A bearing to a point defined off of a NAVAID RPID using the offset bearing/distance function is based on station variation. This bearing can be slightly different from the desired track to the point from the RPID, which is calculated using the magvar algorithm.

e. Application of a desired time of arrival.

f. Application of altitudes or flight levels for vertical navigation.

g. Attachment of UDID to waypoints.

h. Definition of an FMS approach at a waypoint.

Waypoints may be deleted as follows:

a. Deletion of individual waypoints.

b. Deletion of entire flight plan in startup procedure.

c. Deletion of entire flight plan with zeroize function.

d. Deletion of entire flight plan when replaced with alternate flight plan.

e. Automatic deletion of intervening points when a Direct–To function is initiated to a future flight plan waypoint.

When waypoints are inserted between existing waypoints, succeeding waypoints automatically move down-list. Similarly, when waypoints are deleted, flight plan automatically eliminates all holes by moving waypoints up-list as required. Transferring a new flight plan from alternate flight plan (replace flight plan option) overwrites flight plan currently in use. Alternate flight plan can also be inserted into current flight plan.

When no TO waypoint exists, NO FPLN is displayed. An attempt to enter a waypoint when 60 waypoints exist (not including history points) causes FPLN FULL scratchpad message to be displayed.

Each waypoint in flight plan consists of following required data:

a. Waypoint number

b. Waypoint latitude/longitude coordinates

c. Waypoint declination

Figure 1-169 (Sheet 8 of 13)

In addition, it is possible to enter and/or display following optional waypoint data:

a. Waypoint identifier

b. Waypoint altitude

c. Desired vertical angle or initial vertical speed

d. Desired time of arrival

e. Bank angle for turn

f. MOP designator

g. Fix position, time, track and ground speed for an intercept target

Following waypoint data is computed and displayed on CDU:

a. Course into each TO waypoint

b. Magnetic Variation (for all waypoints without declination)

c. Estimated Time of Arrival (ETA) and Estimated Time Enroute (ETE)

d. Estimated Time to Intercept (TTI) for an intercept target

Five most recent flight plan history waypoints are maintained by CDU as they are passed. History waypoints are modifiable and may be deleted (if more than one history waypoint exists) or copied into scratchpad. In addition, latitude/longitude solution for an intercept point is maintained in history. Points of Direct–To activation (turn points) do not appear as history waypoints. When flight plan is erased or zeroized, current present position based on designated pilot's solution is placed as newest history waypoint.

A Direct–To can be performed to a history waypoint. When this function is chosen, all waypoints existing in history after Direct–To point are reflown in order. If a Direct–To is performed to oldest history waypoint, present position is inserted as FROM.

CDU provides capability to access a library of RPID waypoints on data loader cartridge, which can be used as basis for flight planning activities. Capability exists to store a maximum of LESS GA 20,000◀ WITH GA 120,000◀ reference points on a data loader cartridge. It is not possible to load reference points into data loader cartridge from CDU.

Bus controller CDU provides capability to store a backup database of 200 RPIDs in NVM to be used in event of a data cartridge failure. Backup database is loaded into bus controller CDU automatically from data loader at powerup.

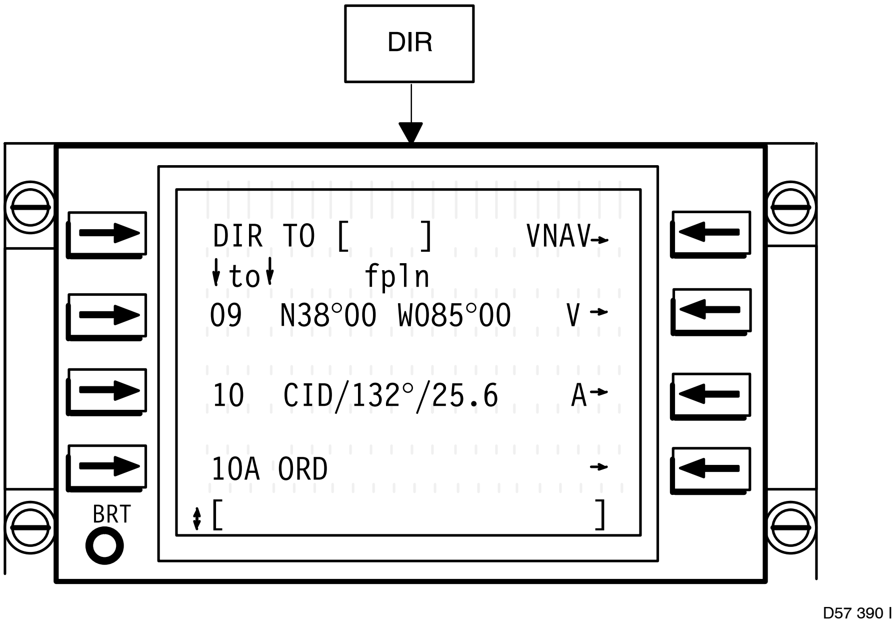
A magnetic variation data base is maintained in CDU NVM for conversion of references from True to Magnetic North. Data base (if present on data loader cartridge) is transferred automatically from data cartridge each time cartridge is inserted if date stamp associated with data base is more recent than date stamp of existing CDU data base. Once loaded, a magnetic variation data base remains in effect until it is overwritten by insertion of a new cartridge containing a more recent magnetic variation data base.

Magnetic variation data base is globally valid, based on linear interpolation of tabular values which are evenly spaced every 10 degrees of latitude and longitude. Only a single value is stored for poles, representing limit of magnetic variation as pole is approached along Prime Meridian.

Figure 1-169 (Sheet 9 of 13)

CDU Menus - Flight Plan (Continued)

(Direct)



```
DIR TO [    ]     VNAV→
↓to↓     fpln
09  N38°00 W085°00   V→

10  CID/132°/25.6    A→

10A ORD               →
↕[                    ]
```

NOTE

Selecting LS5 performs a direct descent/climb.

Title line displays ↓ to ↓ whenever current TO waypoint is displayed on data line 2.

Pressing FPLN key erases DIR TO [ ] message and Flight Plan page display returns to format shown under FPLN option. In this case, current TO waypoint is restored to data line 2 and course, offset and sequence mode are displayed on data line 1.

LS1	With a valid waypoint entry in scratchpad, initiates an immediate Direct–To course change to new waypoint and displays that waypoint as TO waypoint. If flight plan contains 60 waypoints, an attempt to perform a Direct–To to a waypoint in scratchpad is inhibited and causes FPLN FULL scratchpad message to be displayed. When pressed, Flight Plan page is displayed with current TO waypoint on data line 2. With a valid bearing/distance in the scratchpad, initiates an immediate Direct–To course change to vector waypoint located at specified bearing/distance offset from designated pilot's present position when LS1 is activated. When pressed, Flight Plan page is displayed with current TO waypoint on data line 2. With an empty scratchpad, LS1 is inoperative.

Figure 1-169 (Sheet 10 of 13)

LS2,3,4	With an empty scratchpad, each initiates an immediate Direct–To course change to waypoint corresponding to line select pressed. Direct–To waypoint selected becomes TO waypoint and all intervening waypoints (between previous TO waypoint and new Direct–To waypoint) are deleted. After selection, Flight Plan page is displayed with current TO waypoint on data line 2. With a valid waypoint entry in scratchpad, each inserts waypoint into flight plan at line select location. Existing waypoints at and following line select move down in flight plan. If flight plan contains 60 waypoints, an attempt to insert a waypoint is inhibited and causes FPLN FULL scratchpad message to be displayed. Can also assign a UDID to a waypoint, delete a waypoint, insert an MOP, attach an MOP, approach or hold, or apply a bearing/distance offset to a waypoint. If a Direct–To is performed to a future waypoint for which only an altitude (no angle or rate) is defined, a VNAV Direct–To is performed. If a VNAV path has already been captured and a Direct–To (lateral) is performed to TO waypoint, VNAV Direct–To is also performed automatically.
LS5	If a VNAV is assigned at current TO waypoint, a Direct–To climb/descent to VNAV point is available. Pressing LS5 causes an immediate climb/descent to VNAV waypoint. After pressing LS5, Flight Plan Waypoint page is accessed. If VNAV is not displayed adjacent to LS5, LS5 is inoperative.
LS6,7,8	Operate as described under FPLN option. In addition, when a CRP is active and Direct–To function is executed, Closed Random Pattern MOP page is accessed directly, bypassing Flight Plan Waypoint page, and DIRECT TO CRP? scratchpad message is displayed.

Vertical scrolling operates as described under FPLN option, except that data line 1 is unaffected by scroll operation.

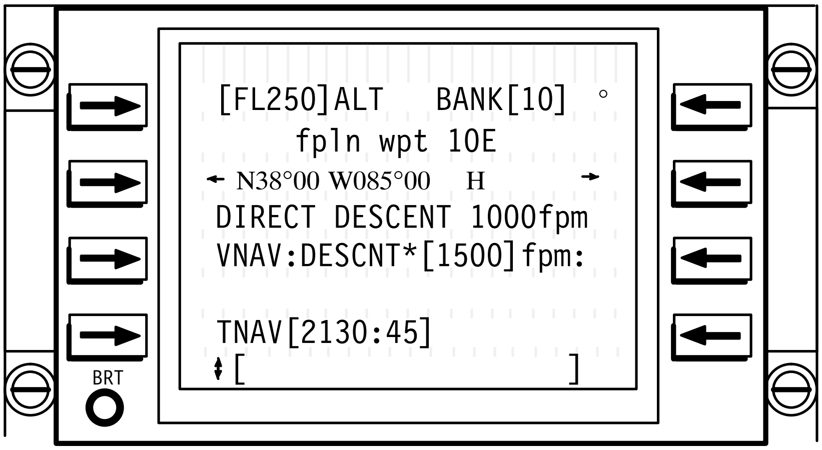
Direct–To function provides capability to modify flight plan to define, and execute immediately, a new great-circle course directly to a waypoint. Direct–To waypoint can be a future waypoint in flight plan, a history waypoint, a waypoint from scratchpad, or a waypoint generated as a vector from present position.

When DIR key is pressed, DIR TO [ ] is displayed on data line 1 of Flight Plan page, permitting entry of a Direct–To waypoint. DIR TO [ ] remains on data line 1, even as flight plan is scrolled. When Direct–To point is entered into flight plan it is assigned a waypoint number in accordance with guidelines defined under Flight Plan accessed from FPLN key. When Direct–To is selected for a future flight plan waypoint, all intervening flight plan waypoints are deleted and flight plan continues after passage of Direct–To waypoint. If a Direct–To is performed to a history waypoint, intervening waypoints retain original displayed waypoint numbers. When a history waypoint is selected as Direct–To point, flight plan repeats all subsequent history waypoints. If TO waypoint has a VNAV assigned to it when DIR key is pressed, a Direct–To climb/descent to VNAV point is available. In this case, VNAV is displayed on data line 1 adjacent to LS5. VNAV is displayed whenever original TO waypoint with VNAV attribute is displayed on data line 2.

Figure 1-169 (Sheet 11 of 13)

CDU Menus - Flight Plan (Continued)

(Waypoint)



```
[FL250]ALT   BANK[10] °
     fpln wpt 10E
← N38°00 W085°00   H     →
DIRECT DESCENT 1000fpm
VNAV:DESCNT*[1500]fpm:

TNAV[2130:45]
↕[                     ]
```

NOTE

> The Flight Plan Waypoint page is accessed via applicable line select key for associated waypoint on Flight Plan page, or after performing a VNAV Direct–To from Flight Plan page, as described under flight plan DIR option, LS5.

Title line displays waypoint number as shown on Flight Plan page.

Data line 2 displays waypoint position as shown on Flight Plan page. If a UDID was entered on waypoint (for example, /TOWER) this page displays label. This line also displays attributes, if any, associated with waypoint. Only attributes for which there are additional pages (H, I, A, P) are displayed on this page.

Information line displays direct descent/climb advisory from present position to waypoint if an altitude or flight level is defined at that point. Display toggles between °'s and fpm based on selection of desired vertical angle or desired vertical rate (see LS7). Displayed direct climb/descent rate is instantaneous vertical rate computed from direct descent angle and current airplane speed. To select direct climb/descent, Direct–To function is used and VNAV must be at TO waypoint. This line is displayed only when an altitude is entered in data line 1.

Data line 3 is displayed only when an altitude is entered in data line 1.

LS1 Enters waypoint altitude. Altitude is entered as a flight level (for example, FL050) or altitude in feet (for example, 23543). Altitude entry is limited to a 500 foot (FL005) minimum. An attempt to enter a value less than 500 feet prompts a 500 FT MINIMUM scratchpad message to be displayed. If waypoint is an intercept or MAP, entry is inhibited and causes INTERCEPT DEFINED or APPROACH DEFINED scratchpad message, respectively, to be displayed. If an FMS approach is attached to a waypoint with an altitude specified, altitude is blanked.

With a – in scratchpad, deletes altitude for waypoint and blanks data line 3.

With a blank scratchpad, copies waypoint altitude into scratchpad.

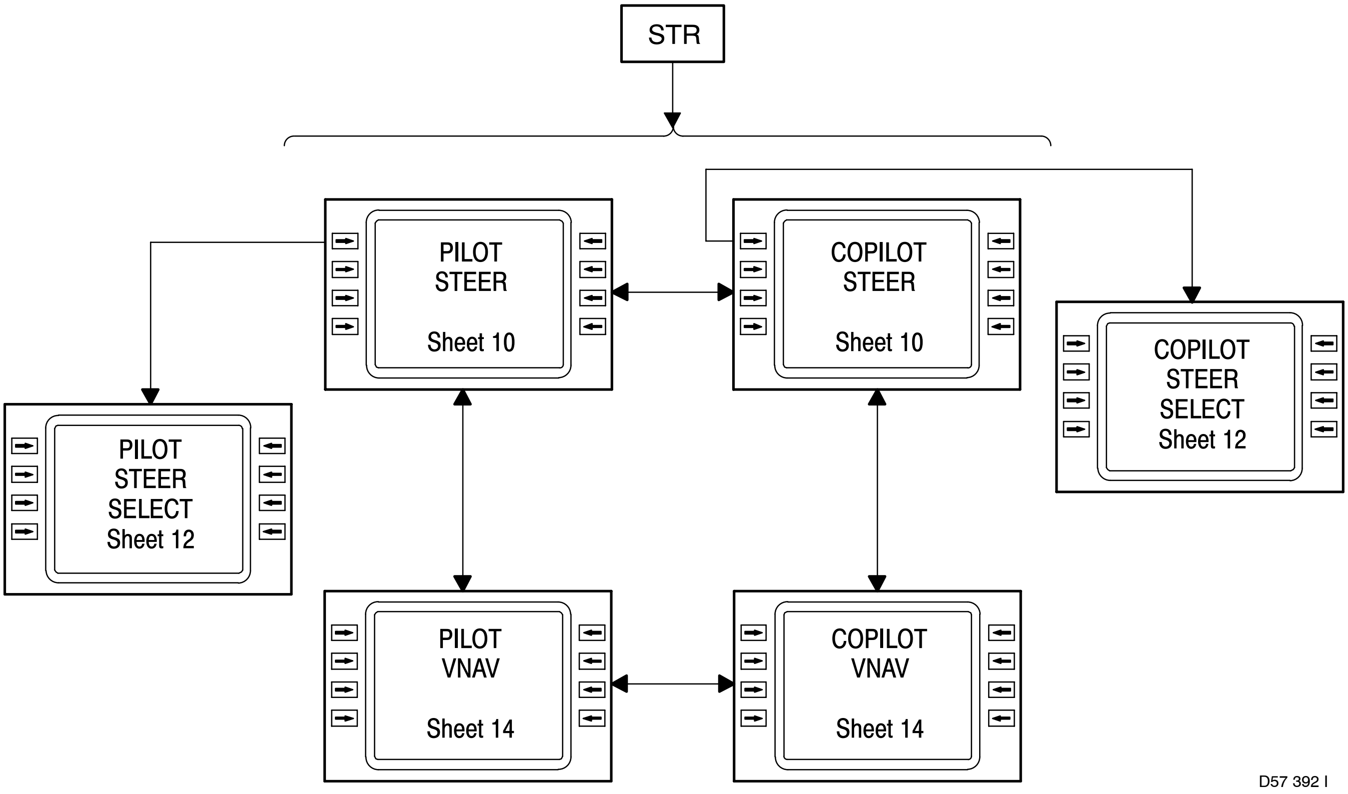
Figure 1-169 (Sheet 12 of 13)

LS2	Accesses Flight Plan page. If waypoint is TO waypoint, Flight Plan page is displayed with TO waypoint on data line 2. If waypoint is not TO waypoint, Flight Plan page displays selected waypoint on top line.
LS3	Toggles between descent (DESCNT) and climb (CLIMB) for VNAV function. If no altitude is entered at LS1, LS3 is inoperable. If a vertical angle or rate has not been entered, selection of LS3 is inhibited and causes ENTER ANGLE OR RATE scratchpad message to be displayed. If VNAV is active, selection is inhibited and causes VNAV IS ACTIVE scratchpad message to be displayed.
LS4,8	With an entry in scratchpad, enters UTC time for TNAV function. With a – in scratchpad, deletes time for TNAV function. With a blank scratchpad, copies arrival time into scratchpad.
LS5	With an entry in scratchpad, enters maximum bank angle for associated waypoint. Default is 25°. With a – in scratchpad, sets maximum bank angle to default value. With a blank scratchpad, copies maximum bank angle into scratchpad.
LS6	Allows access to Hold, Intercept, Approach or MOP Pages (Figure Eight, Circle, Closed Random, Racetrack, Refuel) based on displayed attribute (H, I, A, P).
LS7	With a blank scratchpad, toggles between vertical angle in degrees and initial vertical rate in feet per minute (fpm) for a climb or descent. Climb/descent rate is instantaneous rate at bottom of climb or top of descent. If vertical rate is entered, climb/descent angle is computed dynamically, based on entered rate. After capturing vertical path, computed vertical angle is frozen and climb/descent rate is computed dynamically, based on current conditions. An asterisk is displayed next to value which is fixed. If vertical rate is entered parameter, asterisk is displayed adjacent to it until VNAV alert is issued. Asterisk is then displayed adjacent to vertical angle. With an entry in scratchpad, enters desired climb/descent angle or vertical rate based on toggle selected by LS7. With a – in scratchpad, deletes vertical rate or angle. If deleted quantity is a computed quantity, value is recomputed. If deleted quantity was an entered parameter and an altitude exists for previous waypoint, angle and rate are recomputed based on default case. If deleted quantity was entered and an altitude does not exist at previous waypoint, a vertical Direct–To is performed and angle and rate displays are Direct VNAV quantities. If no altitude is entered at LS1, LS7 is non-operational.

Vertical scrolling accesses additional Flight Plan Waypoint pages. Down scroll accesses additional Flight Plan Waypoint pages in order of increasing waypoint number. Up scroll accesses additional Flight Plan Waypoint pages in order of decreasing waypoint number. Up scroll key is inoperative when oldest history waypoint is displayed on data line 2. Down scroll key is inoperative when last waypoint in flight plan is displayed on data line 2.

Figure 1-169 (Sheet 13 of 13)

CDU Menus - Steer



The FMS provides independently selectable solutions (for pilot and copilot positions) for guidance and steering signals to drive flight director and flight instruments. Two guidance solutions utilize independently selectable navigation solutions; however, both solutions are referenced to the same flight plan; that is, there can be only one active flight plan. Flight plan sequencing is referenced to the designated pilot navigation solution. The selectable navigation solutions are:

a. EGI1 Integrated Solution (INU1/GPS1)

b. EGI2 Integrated Solution (INU2/GPS2)

c. INU1 Only

d. INU2 Only

e. GPS1/A/H

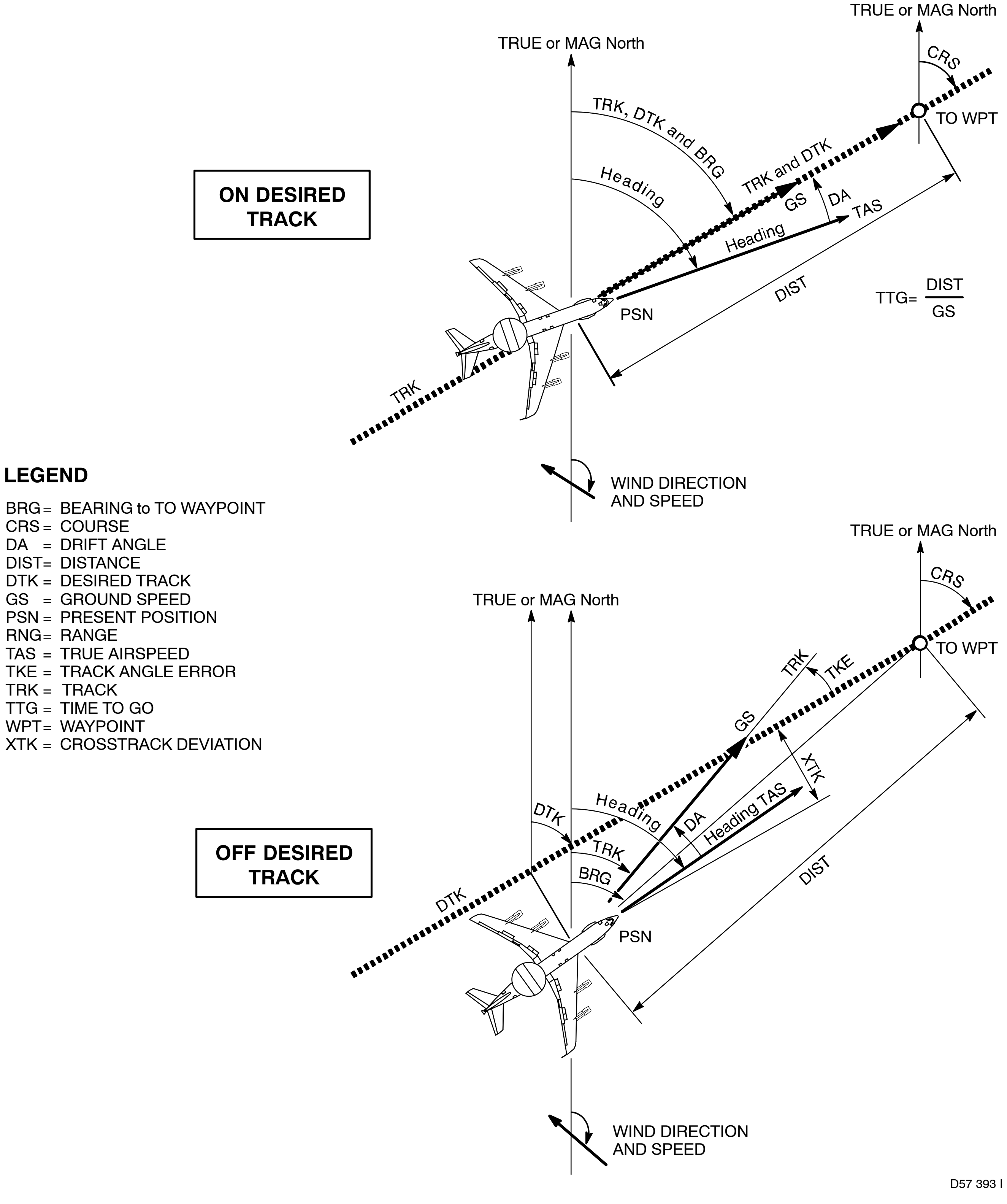
f. GPS2/A/H

The pilot and copilot select from among these solutions using Steer Select page. Also see INAV pages, *figure 1-174*.

The FMS computes and displays guidance information (for both pilot and copilot navigation solutions) for TO waypoint in active flight plan. Quantities illustrated are all displayed as true quantities when true/mag discrete (MAG/TRUE switch in pilot RNAV ANNUNCIATOR panel) is set to true or when no valid magnetic variation tables are in CDU.

See pilot/copilot str page and fpln page.

Figure 1-170 (Sheet 1 of 14)



LEGEND

BRG = BEARING to TO WAYPOINT
CRS = COURSE
DA = DRIFT ANGLE
DIST = DISTANCE
DTK = DESIRED TRACK
GS = GROUND SPEED
PSN = PRESENT POSITION
RNG = RANGE
TAS = TRUE AIRSPEED
TKE = TRACK ANGLE ERROR
TRK = TRACK
TTG = TIME TO GO
WPT = WAYPOINT
XTK = CROSSTRACK DEVIATION

Figure 1-170 (Sheet 2 of 14)

CDU Menus – Steer (Continued)

TERMINOLOGY	DEFINITION
Bearing (BRG)	Compass direction (true or magnetic) at present position of a great circle from present position to the TO waypoint.
Course (CRS)	Compass direction (true or magnetic) of the desired track at the TO waypoint.
Cross track deviation (XTK)	Shortest distance between present position and desired track. Deviation is right (R) if airplane is right of desired track as seen by an observer looking from the FROM waypoint toward the TO waypoint, else left (L).
Desired Track (no abbrev)	Great circle connecting the FROM and TO waypoints.
Desired track angle (DTK)	Compass direction (true or magnetic) of the desired track at a point on the desired track closest to present position.
Distance (DIST)	Shortest distance on the surface of ellipsoid chosen to represent earth between present position and TO waypoint.
Drift angle (DA)	Angle (right or left) from airplane heading to ground track. DA is not displayed on the HSI in GINS mode because ground track is not displayed on the HSI. DA is displayed on the CDU on the first Lateral Steering page.
Estimated time enroute (ETE)	Estimated lapse time between two waypoints, based on GS entered into flight plan before flight, and based on present computed ground speed in flight.
Fast/Slow Indication	Current ground speed is faster or slower than commanded (by FMS) ground speed.
Ground speed (GS)	Speed below present position on the geoid surface chosen to represent earth. Ground speed command is the ground speed necessary to cross the next waypoint at a planned arrival time. Shown only on CDUs at first Lateral Steering page.
Ground track angle (TRK)	Compass direction (true or magnetic) at present position of a line tangent to the airplane path over the geoid surface chosen to represent earth. TRK is not displayed on HSIs. TRK is displayed on the CDU Position page.
Heading (true or magnetic)	Compass direction (true or magnetic) of airplane centerline, looking forward. CDU does not display magnetic heading. CDU true heading is found on INAV INU Nav Data page. HSIs display true or magnetic heading as selected on pilot's RNAV ANNUNCIATORS panel.
Present position (PSN)	Latitude, longitude, and altitude of airplane at this instant.
Time to go (TTG)	DIST to TO waypoint divided by current GS. Correct only if TRK is direct to the TO waypoint and present GS does not change.

Figure 1-170 (Sheet 3 of 14)

TERMINOLOGY	DEFINITION
Track angle error (TKE)	Angle between ground track and desired ground track, or the difference between ground track angle and desired track angle. Track angle error is right (R) when the shorter direction of rotation from DTK to TRK is clockwise, else left (L). When TKE and XTK are of opposite R/L sign, airplane is converging toward desired track.
WIND	Wind direction (true) and wind speed are displayed on the CDU Position page.

Following guidance quantities are computed for display on Data page (if airplane is on ground, ground speed entered on Data page is used to compute data):

a. ETA – estimated UTC when airplane will arrive at TO waypoint. This is computed using current TAS and wind along each leg. If TAS is invalid, ground speed is used. If ground speed is invalid, ETA is also invalid.

b. ETE – estimated time airplane will be enroute to TO waypoint along selected leg or directly from present position, compensated with current wind if valid.

c. Great circle bearing and distance from present position to TO waypoint.

Above guidance quantities are based on actual or planned navigation parameters and desired time of arrival at designated waypoints or MOPs. Actual quantities are based on flight plan, while planned quantities are based on alternate flight plan.

Outputs to flight instruments are provided to direct airplane along a predefined flight plan. Guidance outputs to flight instruments include following:

a. Drift corrected lateral (bank) steering commands (Bank Command)

b. Waypoint Bearing

c. Crosstrack Deviation

d. Distance to Go

e. To/From Pointer

f. Desired Track

g. Vertical Deviation – Deviation is computed and displayed as a linear value when in en route or terminal modes of navigation and as an angular value in approach mode.

h. VNAV alert advising that VNAV capture or arrival at a desired altitude is imminent (based upon designated pilot navigation solution) or altitude is lower than MDA on an approach.

i. Fast–slow indicator advising of desired speed necessary to execute a planned time of arrival (based upon designated pilot navigation solution)

j. Ten second flight plan change advisory of an impending track change (based upon the designated pilot navigation solution)

Figure 1-170 (Sheet 4 of 14)

CDU Menus – Steer (Continued)

Validity flags and pointers for vertical deviation and fast/slow indicators are controlled by FMS as follows:

a. Vertical Deviation – If a VNAV has been defined at current TO waypoint, vertical deviation pointer is displayed when airplane is at or within 5 minutes of TOD/BOC. Otherwise, pointer is pulled out of view. If either of following conditions occurs while pointer is in view, vertical deviation (glide slope) flag is displayed: a NAV FAIL condition exists, or source of altitude data being used by selected navigation solution fails. Altitude source for navigation solutions is Barometric Inertial Altitude from INU for INUY/XXXX and INU only solutions and Pressure Altitude from CADC for GPS navigation solution (unless GPS navigation solution is GPS/—/—, in which case VNAV is invalidated regardless of whether CADC data is valid). Vertical deviation flag is always pulled out of view as long as pointer is out of view.

b. Fast/Slow Indicator – If a TNAV has been defined at a future flight plan waypoint, fast/slow pointer is displayed. If a holding pattern or MOP is inserted in flight plan prior to TNAV waypoint, pointer is pulled out of view until pattern is exited. If a TNAV has not been defined in flight plan, pointer is pulled out of view. If a NAV FAIL condition exists while pointer is in view, speed flag is displayed. Speed flag is always pulled out of view as long as pointer is out of view.

Scaling of flight instrument outputs conforms to requirements of GPS Integration Guide (GIG) for enroute, terminal and approach modes, respectively. While on an FMS approach leg, when MAP is TO waypoint, flight instrument outputs are set automatically to conform to GIG requirements for approach mode. When either an FAF or an airport is in flight plan and along–flight–plan–distance between airplane and FAF or airport is less than 50 nm, outputs are set automatically to conform to GIG requirements for terminal mode. Otherwise outputs conform to GIG requirements for enroute mode. When on FROM side of MAP, mode remains in approach mode. Crew selects enroute, terminal, or approach scaling mode at any time. Approach, terminal, and enroute flight modes are as shown below (unless crew has manually selected TERMINAL or APPROACH scaling on Steer Select page).

When flight instrument outputs associated with designated pilot navigation solution meet GIG requirements for approach mode, APPROACH annunciation is displayed. When flight instrument outputs associated with designated pilot navigation solution meet GIG requirements for terminal mode, TERMINAL annunciation displayed. When a transition is made from enroute to terminal or enroute to approach (based on designated pilot navigation solution), √BAROSET annunciation is displayed to remind crew to ensure that correct baroset entry has been made on Position page.

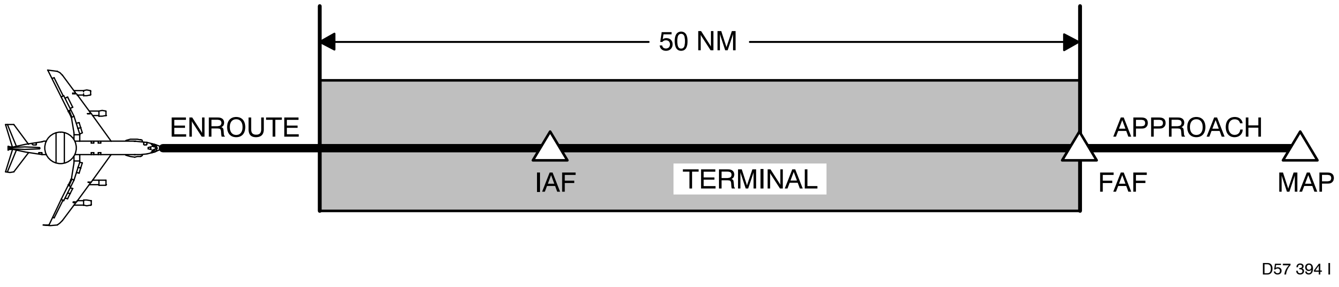


Figure 1-170 (Sheet 5 of 14)

Minimum avionics requirements (MAR) for flight instruments scaling for enroute, terminal, and approach modes are as follows (per two dots instrument deflection):

Lateral Deviation

+/– 4.0 nm for enroute mode

+/– 1.0 nm for terminal mode

+/– 0.3 nm for approach mode

Vertical Deviation

+/– 1000 feet for enroute and terminal modes

+/– 0.7° for approach mode

Navigation error limits that are used to determine when to display a √NAV ERR annunciation to flight crew and when to invalidate guidance outputs to flight director/autopilot are shown below. These limits are applied to INUY/XXXX and INUY/– – – – modes when selected as source of guidance/steering outputs for either pilot or copilot flight instruments. √NAV ERR annunciation is displayed whenever 95% error of designated pilot navigation solution exceeds navigation error warning limit specified or whenever EGI estimated nav error exceeds 1.0 nm for designated pilot solution. Guidance outputs to pilot or copilot flight directors/instruments are invalidated when 95% error of their respective navigation solutions exceeds system use limit specified for each flight mode. CDU display fields are not invalidated when error limits are exceeded.

Integrated Navigation Annunciation and Validity Limits

FLIGHT MODE	NAVIGATION ERROR WARNING LIMIT (95% PROBABLE ERROR)	NAVIGATION ERROR WARNING LIMIT (EHE)	SYSTEM USE LIMIT (95% PROBABLE ERROR)	SYSTEM USE LIMIT (EHE)
Approach	0.20 nm	151 meters	0.3 nm	227 meters
Terminal	0.47 nm	355 meters	1.7 nm	1285 meters
Enroute	0.77 nm	582 meters	2.8 nm	2117 meters

NOTE

Limits apply to INUY/XXXX and INUY/– – – – Modes.

Figure 1-170 (Sheet 6 of 14)

CDU Menus – Steer (Continued)

If position index is invalid, 95% error displayed on CDU is dashed and FMS no longer monitors error limits as described above. Guidance outputs to flight director are still available, however.

FMS also conforms to GIG for standalone GPS navigation modes. Navigation error limits (based upon GIG) that are used to determine when to display √NAV ERR annunciation and when to invalidate guidance outputs to flight director/instruments are as shown below. These limits are applied to GPS/A/H and GPS/–/– modes in same manner as described above for integrated navigation modes.

GIG Navigation Annunciation and Validity Limits

FLIGHT MODE	NAVIGATION ERROR WARNING LIMIT (95% PROBABLE ERROR)	NAVIGATION ERROR WARNING LIMIT (EHE)	SYSTEM USE LIMIT (95% PROBABLE ERROR)	SYSTEM USE LIMIT (EHE)
Approach	0.03 nm	23 meters	0.07 nm	50 meters
Terminal	0.1 nm	76 meters	0.15 nm	115 meters
Enroute	0.1 nm	76 meters	0.15 nm	115 meters
NOTE Limits apply to GPS1/A/H, GPS2/A/H, GPS1/–/– and GPS2/–/– display modes.				

INU-only navigation modes are treated in same manner as case described above where 95% error estimations are unavailable. Navigation displays and guidance outputs are available, but FMS is unable to determine navigation accuracy to compare with limit criteria.

In addition to HSI displays, INAV function provides a Bank Command signal to autopilot/flight director system for automatic lateral-directional guidance for all flight plan operations. Bank Command signals in enroute mode changes at 2.5°/second, and in terminal and approach modes, 5°/second.

Flight crew can select between pilot-side or copilot-side steering signals for autopilot via DESIGNATED PILOT switch which controls Designated Pilot Select discrete input to CDUs. Navigation/guidance solution (pilot or copilot) selected for autopilot is referred to as designated pilot solution.

Either pilot or copilot navigation solution can be selected to drive Autopilot/Flight Director system via external switching relays. The designated pilot solution is indicated on Steer Select page. However, each Bank Command output is generated independently, based on selected navigation source for that side.

Integrated navigation solution used to generate guidance and flight instrument displays is obtained from EGIs. Navigation sensor data from INUs and CADCs is obtained through a direct interface to those sensors. GPS navigation solution is provided by the BSIUs if they are available. If no BSIU is available, GPS data to generate Position, Lateral Steer, and Integrated Navigation pages is obtained from EGI.

Figure 1-170 (Sheet 7 of 14)

BSIUs navigation function generates the GPS/A/H navigation solutions that are used by BC CDU to control flight instrument displays and guidance data.

Control and configuration of BSIU navigation function are performed by BC CDU. Configuration data consists of following:

a. Sensor configuration (sensors assigned to BSIU)

b. INAV initialization commands

c. Weight on wheels

Each BSIU maintains a GPS navigation state. BSIU1 maintains a navigation solution using GPS data from EGI1 and BSIU2 maintains an independent navigation solution using GPS data from EGI2.

GPS navigation state is nominally equal to GPS receiver data. GPS navigation mode purpose is to smooth the 1.0 Hz GPS background navigation data and generate a fast rate solution necessary for guidance and flight instrument displays, using heading and CADC data. Heading source is AHRS.

Each BSIU generates a GPS navigation state, functionally divided into fast rate (10 Hz) and slow rate (0.5 Hz) functions. Fast rate function updates and outputs navigation state with current navigation sensor data. Slow rate fixed – gain filter function generates error corrections that are applied to correct fast rate navigation state.

Sensors used to generate GPS navigation state are based on a predetermined hierarchy shown below in order of highest to lowest priority, along with sensor validity conditions for each configuration. GPS function selects highest mode supportable by available navigation sensors that are assigned to BSIU. Solution reverts automatically to degraded modes of operation, depending on validity status of assigned navigation sensors.

GPS Mode Hierarchy

PRIORITY	**MODE NAME**	**NAVIGATION SENSOR VALIDITY**		
		GPS	**CADC** ①	**AHRS**
1	GPS1/A/H	valid ②	valid	valid ③
2	GPS1/–/–	valid ②	invalid	invalid
3	GPS1 NAV FAIL	invalid	N/A	N/A

① Sensor designated by bus controller CDU.

② Required to enter mode.

③ A valid heading source (AHRS) must be available to enter mode.

GPS navigation state is updated in all GPS modes except GPS NAV FAIL. If a GPS NAV FAIL condition is detected data in state vector flagged as invalid.

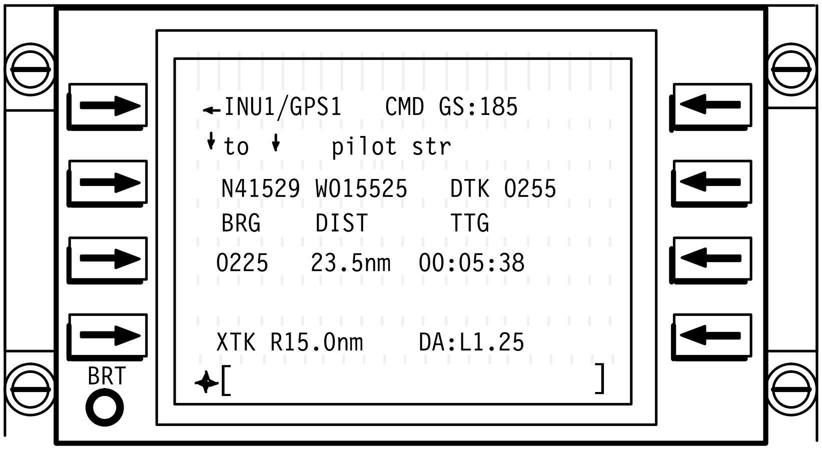
Figure 1-170 (Sheet 8 of 14)

CDU Menus - Steer (Continued)

Whenever a GPS mode is entered, position is initialized to GPS measured position (Present Position Latitude and Present Position Longitude). If mode is GPS/A/H, GPS mode position is updated with True Airspeed and True Heading, and correction data provided by a fixed-gain filter.

Fixed-gain filter computes error corrections once every two seconds and applies them incrementally to 10 Hz position. Corrections are based on updated position estimate and measured GPS position. If navigation mode is not GPS/A/H (that is, true airspeed or heading is not available), filter corrections are set to zero and not applied.

Figure 1-170 (Sheet 9 of 14)



```
←INU1/GPS1   CMD GS:185
↓to ↓     pilot str
 N41529 W015525   DTK 0255
 BRG    DIST      TTG
0225   23.5nm  00:05:38

XTK R15.0nm    DA:L1.25
✦[                    ]
```

NOTE

- Steer pages (lateral and vertical) are accessed by pressing steer (STR) key. Steer page displayed when STR key is pressed is last page accessed on that CDU; except after a cold start, Pilot Lateral Steer page is accessed.
- Copilot Lateral Steer page provides same data format and functionality as Pilot Lateral Steer page, with copilot data based on navigation mode selected for copilot displays.

Data line 1 displays source of navigation data. See *figure 1-171* for a description of possible sources and their conditions. Depending on state of LS5 toggle, data line 1 displays Ground Speed, commanded ground speed (if there is a valid TNAV point in flight plan), or a fast/slow indication. For a holding pattern, CMD IAS is displayed three minutes prior to reaching holding fix.

Title line displays page title and ↓ to ↓ label for associated active waypoint being displayed on data line 2. ↓ to ↓ label changes to ↓ from ↓ when on from side of active waypoint. ↓ to ↓ label flashes when 10 second waypoint alert is provided.

Data line 2 displays current active waypoint on left side of display (as displayed on Flight Plan page) and Desired Track at present position on right side of display (based upon course at active waypoint and navigation solution from pilot's/copilot's navigation source). Desired ground track is in $^{\circ}_{T}$ when True/Mag Select discrete is set to true or when no magnetic variation tables are available.

When a pattern is active, current destination is displayed. When a CRP is active, TO waypoint on data line 2 changes dynamically to display current destination within CRP. When a racetrack or figure 8 is active, TO waypoint on data line 2 changes dynamically to display next roll in or roll out point. When a circle is active, TO waypoint is circle reference point.

Information line displays labels associated with display information on data line 3.

Data line 3 displays Waypoint Bearing from airplane present position to active waypoint, Distance to Go from airplane present position to active waypoint, and Time to Go to active waypoint (using pilot's/copilot's navigation source). Bearing is in $^{\circ}_{T}$ when True/Mag Select discrete is set to true or when no magnetic variation tables are available. After passage of final waypoint, Time-To-Go counts up.

Figure 1-170 (Sheet 10 of 14)

CDU Menus - Steer (Continued)

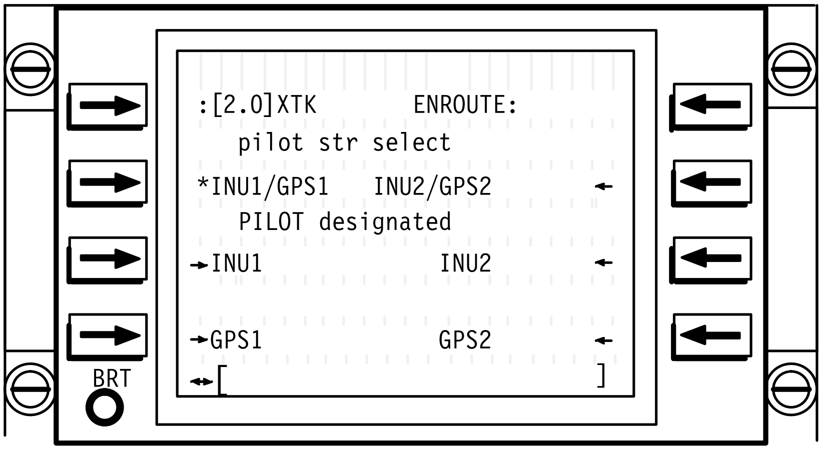
Data line 4 displays Crosstrack Deviation, current Drift Angle or track angle error, depending on state of LS8 toggle (using pilot's/copilot's navigation source). Cross track deviation displays R when present position is to right of an observer at FROM waypoint looking toward TO waypoint and L otherwise. Drift angle displays R when drift is right (nose of airplane is rotated counterclockwise from current track angle) and L otherwise. Track angle error displays L when track is rotated counterclockwise from desired track and R otherwise. Track angle error and drift angle are relative terms and always displayed with ° symbol.

LS1	Accesses Pilot Steer Select page.
LS5	Toggles display among commanded ground speed (CMD GS) or commanded indicated airspeed (CMD IAS), actual ground speed (GS), and a fast/slow indication (FAST or SLOW). SLOW is indicated when airplane current Ground Speed (or Indicated Airspeed) is slower than commanded ground speed (or CMD IAS). FAST is indicated when airplane current Ground Speed (or Indicated Airspeed) is faster than commanded ground speed (or CMD IAS).
LS8	Toggles display between DA and TKE.

Vertical scroll keys scroll to Pilot Vertical Steer page, and wrap around.

Lateral scroll keys scroll to Copilot Steer page, and wrap around.

Figure 1-170 (Sheet 11 of 14)



```
:[2.0]XTK       ENROUTE:
   pilot str select
*INU1/GPS1   INU2/GPS2      ←
   PILOT designated
→INU1            INU2       ←

→GPS1            GPS2       ←
↔[                          ]
```

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NOTE

Pilot Steer Select page is accessed from Pilot Lateral Steer page or by lateral scrolling from Copilot Steer Select page. Copilot Steer Select page provides same data format and functionality as Pilot Steer Select page. Copilot Steer Select page is accessed from Copilot Lateral Steer page or by lateral scrolling from Pilot Steer Select page.

Data line 1 displays current selected scaling mode (enroute, approach, or terminal) for lateral deviation.

Upon cold start, LS1 is cross-track alert display defaulted to dashes.

Information line displays which navigation solution has been selected as designated pilot's navigation source.

LS1 Entries for LS1 are only operational on Steer Select page that has been selected as designated pilot. (Same value is displayed without brackets for non-designated Steer Select page and display still toggles). If designated pilot selection is changed, same cross track value is utilized for new source.

With an empty scratchpad, toggles between XTK and SPD.

With a valid entry in scratchpad and with XTK displayed, enters a distance that is used to generate XTK annunciation for excessive cross track deviation.

With a valid entry in scratchpad and with SPD displayed, enters a speed that is used to generate an alert when current airplane speed deviates from commanded speed by entered amount.

With a – in scratchpad and with XTK displayed, deletes cross track distance and causes suppression of cross track alert function.

With a – in scratchpad and with SPD displayed, deletes speed and causes suppression of speed command alert function.

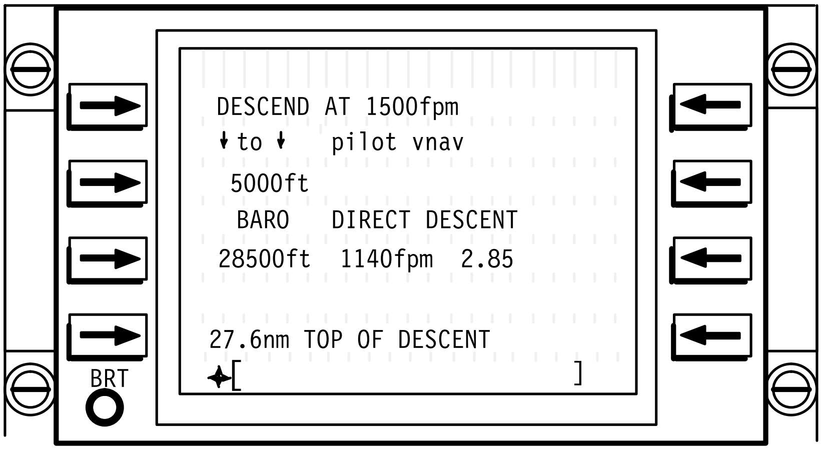
Figure 1-170 (Sheet 12 of 14)

CDU Menus - Steer (Continued)

LS2,3,4, 6,7,8	Select which navigation solution is used to compute data for pilot's/copilot's displays. An asterisk replaces arrow to indicate which source has been selected. INU1/GPS and INU2/GPS labels do not change to reflect current INAV solution.
LS5	With colon displayed, toggles scaling mode for lateral deviation between en route (ENROUTE), terminal (TERMINAL), and approach (APPROACH). Colon is only displayed on designated pilot's Steer Select page. Toggling scaling mode on designated pilot's Steer Select page changes scaling on both the pilot's and copilot's displays. On cold start, scaling mode defaults to ENROUTE mode.

Lateral scroll keys scroll to Copilot Steer Select page, and wrap around.

Figure 1-170 (Sheet 13 of 14)



```
DESCEND AT 1500fpm
↓to ↓   pilot vnav
 5000ft
  BARO   DIRECT DESCENT
28500ft  1140fpm  2.85

27.6nm TOP OF DESCENT
✦[                       ]
```

NOTE

> Pilot Vertical Steer page is accessed by pressing STR key, lateral scrolling from Copilot Vertical Steer page, or vertical scrolling from Pilot Lateral Steer page. Copilot Vertical Steer page provides same data format and functionality as Pilot Vertical Steer page.

Data line 1 displays desired descent/climb angle (DESCEND AT or CLIMB AT) or descent/climb rate as entered in flight plan for active waypoint.

Title line displays page title and to label for associated active waypoint altitude being displayed on data line 2.

Data line 2 displays desired altitude at active waypoint. TO altitude flashes for 10 seconds when 1000 foot level off alert occurs. This alert is based on designated pilot's navigation solution. When on FROM side of TO waypoint, VNAV parameters are invalidated and title line, desired TO altitude, data line 1 and current Pressure Altitude continue to be displayed while remaining displays are dashed.

Information line displays labels for parameters shown on data line 3.

Data line 3 displays current airplane Pressure Altitude (to nearest 10 feet) using pilot's/copilot's navigation source on left side of display, and direct rate and angle for descent or climb (displayed as DIRECT CLIMB for a climb) using pilot's/copilot's navigation source, on right side of display. Altitude displayed is Pressure Altitude (PRES) when active waypoint altitude is entered as a flight level and is barometric corrected altitude (BARO) otherwise. If pilot/copilot altitude is not valid, numeric altitude display is dashed. Negative altitudes are indicated by a minus (–) prefix. If no altitude exists for active waypoint, altitude displayed is BARO altitude.

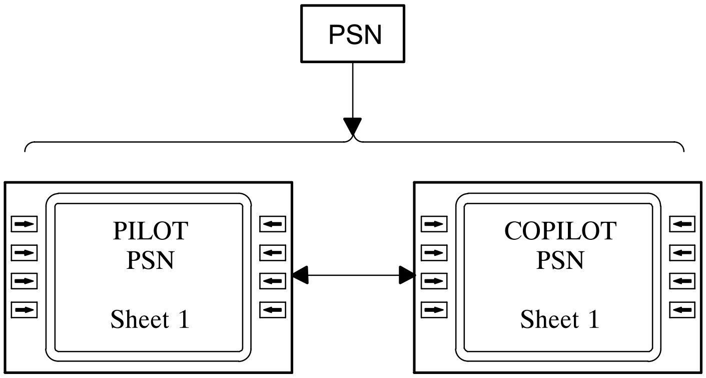
Data line 4 displays along track distance to Top Of Descent, or Bottom Of Climb, using pilot's/copilot's navigation source. Numeric values are dashed if: current Pressure Altitude is less than desired altitude for a descent, current Pressure Altitude is greater than desired altitude for a climb, or airplane has passed Top Of Descent (or Bottom Of Climb). TOP OF DESCENT or BOTTOM OF CLIMB label flashes for 10 seconds prior to capture of vertical path. Alert is based on designated pilot's navigation solution.

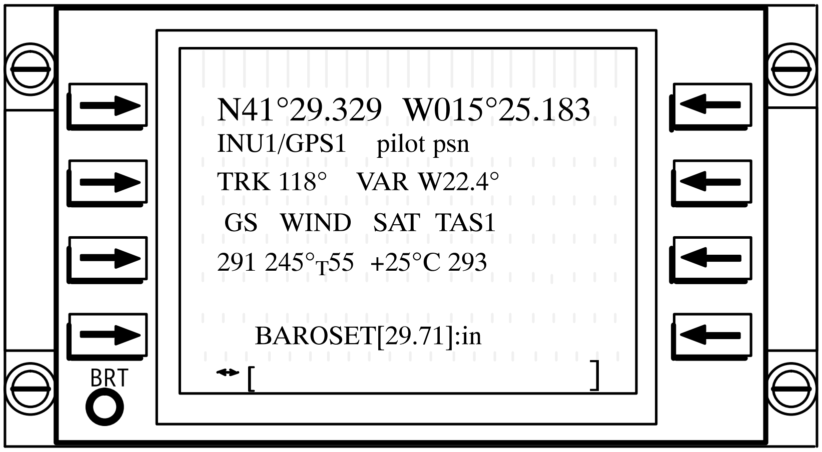
Vertical scroll keys scroll to Pilot Lateral Steer page, and wrap around.

Lateral scroll keys scroll to Copilot Vertical Steer page, and wrap around.

Figure 1-170 (Sheet 14 of 14)

CDU Menus - Position




N41°29.329 W015°25.183
INU1/GPS1   pilot psn
TRK 118°   VAR W22.4°
GS   WIND   SAT TAS1
291 245°$_T$55 +25°C 293

BAROSET[29.71]:in
[   ]

NOTE

- Psn pages are accessed from PSN key.
- Copilot Position page is identical in format and operates in an analogous manner.

Data line 1 displays Present Position Latitude and Present Position Longitude for navigation solution selected. Selected navigation solution is shown on title line. If selected navigation solution is invalid, position on data line 1 is dashed.

Title line displays source of navigation data. Dashes replace sensor name when sensor data is not available for selected mode.

Figure 1-171 (Sheet 1 of 5)

Data line 2 displays Track Angle and present position magnetic variation for navigation solution. Magnetic variation is displayed as E (variation east of true north) or W (variation west of true north) where magnetic variation is defined as true north minus magnetic north. If no magnetic variation tables are available, magnetic variation field is dashed. The ° symbol for ground track display on this page is displayed as $^{\circ}{}_{T}$ when TRUE/MAG Select discrete is set to TRUE or when no magnetic variation tables are available.

Information line displays labels for parameters displayed on data line 3. Airspeed label is TAS1 if navigation solution is using CADC1 True Airspeed, TAS2 if CADC2 True Airspeed is used, and TAS if navigation solution computed true airspeed is used.

Data line 3 displays Wind Velocity and Ground Speed for navigation solution selected and True Airspeed (TAS) and Static Air Temperature (SAT) from CADC associated with navigation solution. If True Airspeed (TAS) or Static Air Temperature (SAT) data is not valid, SAT and TAS numeric fields are dashed.

Data line 4 displays baroset for CADCs.

When designated pilot’s navigation solution is invalid, NAV FAIL annunciation is displayed.

If navigation solution selected is EGI INAV or INU, wind is computed by CDU based upon ground speed and TAS.

LS8 With a blank scratchpad, toggles baroset entry units between inches (in.) and millibars (mb). Entered baroset is sent to both CADCs.

With a valid baroset in scratchpad, enters a baroset. Value for baroset displayed on Pilot Position page is same as value displayed on Copilot’s Position page. Units display is CDU dependent, (that is, one CDU can display baroset in millibars while another can display it in inches). Default is 29.92 inches (1013.2 millibars).

With – in scratchpad, sets baroset to default value.

Lateral scrolling accesses copilot psn page, and wraps around.

Figure 1-171 (Sheet 2 of 5)

CDU Menus - Position (Continued)

Navigation sources and associated display modes are as follows:

NAVIGATION SOURCES

SELECTED MODE	DISPLAYED MODE	CONDITIONS FOR DISPLAY
EGI1 INAV	INU1/GPS1	INU1/GPS1 output is integrated navigation solution.
EGI1 INAV	INU1/GPS2	INU1/GPS2 output is integrated navigation solution (GPS1 invalid).
EGI1 INAV	INU1/JTDS	INU1/JTIDS output is integrated navigation solution (GPS1, GPS2 invalid). ①
EGI1 INAV	INU1/——	Corrected INU1 output is integrated navigation solution (GPS1, GPS2, JTIDS invalid).
EGI1 INAV	——1/——	EGI1 output is integrated navigation solution, but INU1 is not valid (not a valid mode).
INU1	INU1	INU1 navigation data is valid navigation data. ②
INU1	——1	INU1 navigation data is not valid navigation data.
EGI2 INAV	INU2/GPS2	INU2/GPS2 output is integrated navigation solution.
EGI2 INAV	INU2/GPS1	INU2/GPS1 output is integrated navigation solution (GPS2 invalid).
EGI2 INAV	INU2/JTDS	INU2/JTIDS output is integrated navigation solution (GPS1, GPS2 invalid).
EGI2 INAV	INU2/——	Corrected INU2 output is integrated navigation solution (GPS1, GPS2, JTIDS invalid). ①
EGI2 INAV	——2/——	EGI2 output is integrated navigation solution, but INU2 is not valid (not a valid mode).
INU2	INU2	INU2 navigation data is valid navigation data. ②
INU2	——2	INU2 navigation data is not valid navigation data.
GPS1	GPS1/A/H	GPS1 navigation data is being smoothed with airspeed and heading. ③
GPS1	GPS1/–/–	GPS1 navigation data is not being smoothed with airspeed and heading data.
GPS1	——1/–/–	GPS1 is invalid.
GPS2	GPS2/A/H	GPS2 navigation data is being smoothed with airspeed and heading data.
GPS2	GPS2/–/–	GPS2 navigation data is not being smoothed with airspeed and heading. ③
GPS2	——2/–/–	GPS2 is invalid.
MODEL	MODEL	Model airplane function is providing navigation solution.

① Corrections consist of whatever drift corrections were developed while INU was being aided.

② Free-running inertial solution only – no corrections are developed or applied.

③ GPS/A/H solutions are developed and sustained in BSIUs.

Figure 1-171 (Sheet 3 of 5)

Navigation display and control functions performed by CDU are as described in following paragraphs.

CDU uses navigation data that is grouped by navigation mode. Navigation solutions utilized by CDU come directly or indirectly from one of two EGIs. Navigation solutions utilized by CDU consist of EGI integrated solutions called INAV solutions, pure inertial solutions from EGI referred to as INU solutions, and GPS solutions. GPS solutions are obtained from BSIU, which smooths GPS solution using AHRS heading and TAS when BSIUs are available; or GPS solution is obtained directly from EGI if BSIUs are not available. GPS1 solution is obtained from BSIU1 and GPS2 solution is obtained from BSIU2.

CDUs use same criteria as BSIUs for determining validity of GPS navigation solutions with following exception: BSIU criteria specify state 5 satellite data for determining validity of GPS navigation solution. CDU criteria allow for either state 5 or state 3 satellite data to be used.

There are three separate INAV modes for each INU. To avoid confusion when referring to an INAV mode, INU1/XXXX and INU2/YYYY are used to signify mode. XXXX or YYYY could signify GPS1, GPS2, or JTIDS. Nominal choice for INU1 is GPS1. Nominal choice for INU2 is GPS2.

Source of data displayed on position and INAV pages is dependent on navigation mode selected.

Each navigation mode receives a unique set of source data that may vary dependent upon data validity. When airspeed and ground speed are available, wind velocity is maintained.

If navigation mode is INU1/XXXX or INU2/YYYY, following source data is used:

- Present Position Latitude
- Present Position Longitude
- Pressure Altitude
- True Heading
- True Airspeed
- Ground Speed
- Track Angle
- Vertical Velocity
- Static Air Temperature
- Indicated Airspeed

If navigation mode selected is INU1 or INU2, following source data is used:

- Present Position Latitude
- Present Position Longitude
- Pressure Altitude
- True Heading
- True Airspeed
- Ground Speed
- Track Angle
- Vertical Velocity–
- Drift Angle
- Static Air Temperature
- Indicated Airspeed

Figure 1-171 (Sheet 4 of 5)

CDU Menus - Position (Continued)

If selected navigation mode is a GPS mode and BSIU is responding, data in following table is used:

QUANTITY	SOURCE	DESTINATION
Airplane Present Position	BSIU	BC CDU
Airplane Pressure Altitude	BSIU	BC CDU
Airplane True Heading	BSIU	BC CDU
Airplane True Airspeed	BSIU	BC CDU
Current Wind	BSIU	BC CDU
Current Ground Speed	BSIU	BC CDU
Airplane Track Angle	BSIU	BC CDU

NOTE

Following CADC data is also used: vertical velocity, static air temperature, and indicated airspeed.

If a GPS mode has been selected and BSIU is not responding, following data is used:

- Present Position Latitude
- Present Position Longitude
- Ground Speed
- Static Air Temperature
- Indicated Airspeed

Based on components of Ground Speed, airplane track angle can be computed. When above situation is encountered, True Heading, Wind Velocity, True Airspeed and Pressure Altitude are invalid.

Figure 1-171 (Sheet 5 of 5)

CDU Menus - Edit

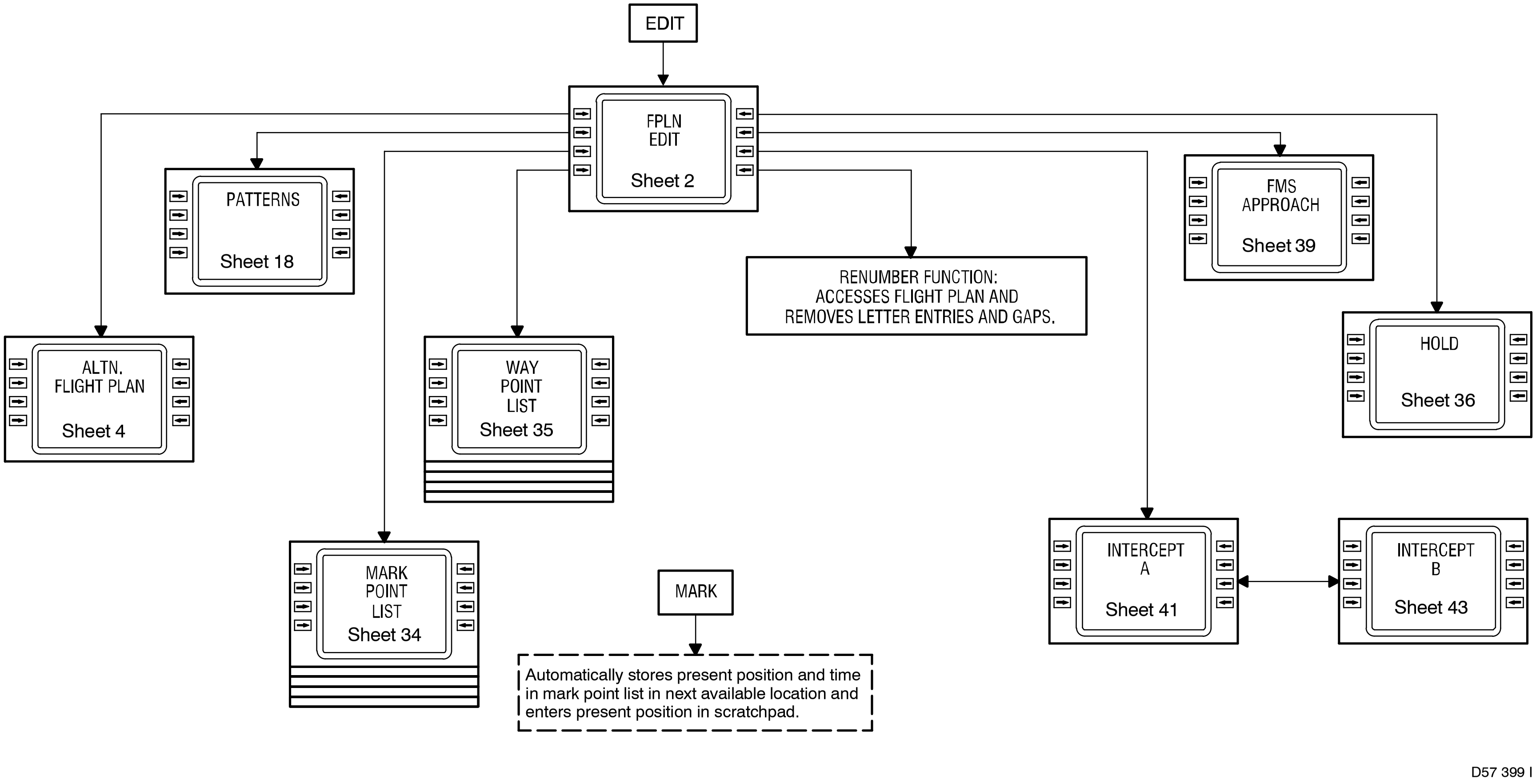
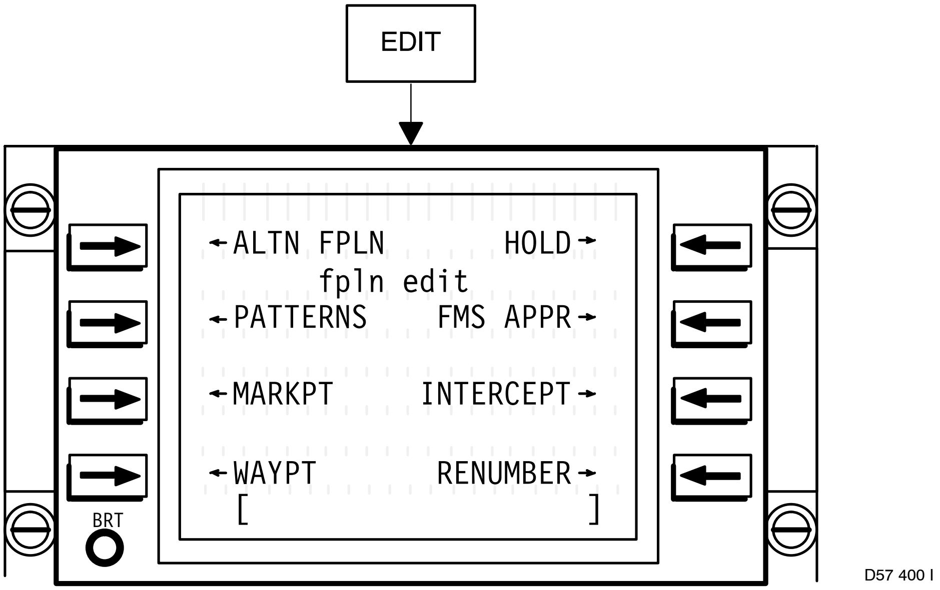


Figure 1-172 (Sheet 1 of 44)

CDU Menus - Edit (Continued)



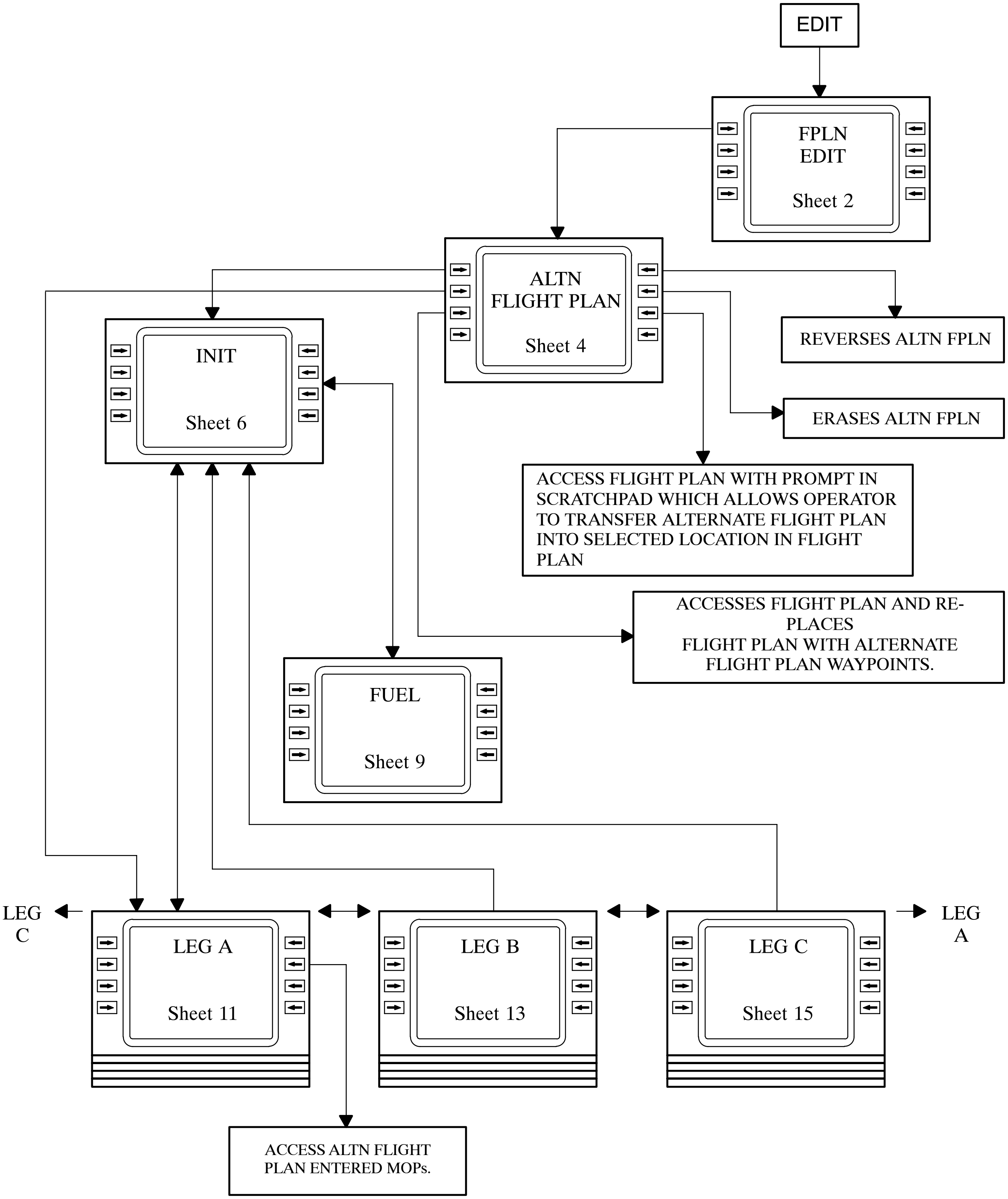
LS1	Accesses Alternate Flight Plan pages.
LS2	Accesses Patterns pages.
LS3	Accesses Mark Point List page.
LS4	Accesses Waypoint List page.
LS5	Accesses Hold page.
LS6	Accesses FMS Approach page.
LS7	Accesses Intercept pages.
LS8	Renumbers flight plan (removing all alpha entries and gaps) and accesses Flight Plan page. Requires confirmation, indicated by CONFIRM RENUMB FPLN scratchpad message. Flight plan is renumbered, beginning at TO waypoint, with TO waypoint number. History waypoints are not renumbered.

Pages accessed via Flight Plan Edit page permit crew to enter and modify data associated with flight plan and alternate flight plan. Following is a summary of general requirements for defining these edits.

If an Edit page is accessed on more than one CDU, and edit has not already been entered into flight plan or alternate flight plan, then each CDU displays same data for each data type. That is, an entry on one CDU is displayed on all other CDUs that are on same Edit page. For circle, racetrack, and figure 8 patterns, one Edit page is used for all three pattern types so that entry definition parameters are preserved when changing pattern types via scrolling.

When edit has been entered into flight plan or alternate flight plan, Edit pages are also accessible from Flight Plan or Alternate Flight Plan pages. For those edits for which more than one edit can be entered (that is, there can be 10 intercepts and 20 MOPs in flight plan, and 20 MOPs in alternate flight plan), each CDU independently displays Edit pages. That is, there can be three circles independently displayed on each CDU when Edit pages are accessed from flight plan or alternate flight plan. Definition data can then be modified independently on each CDU. If pattern course or fix had not been defined when attached to flight plan or alternate flight plan, these parameters are displayed on appropriate definition page when Edit page is accessed from flight plan or alternate flight plan.

Figure 1-172 (Sheet 2 of 44)

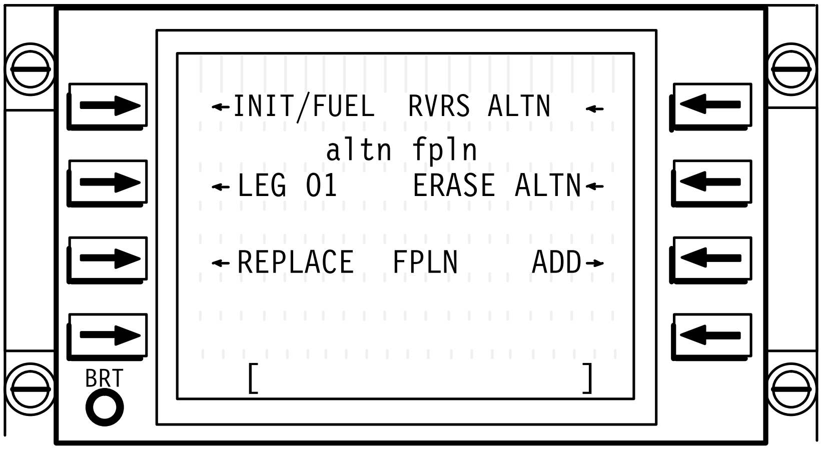


D57 401 I

Figure 1-172 (Sheet 3 of 44)

CDU Menus - Edit (Continued)

ALTERNATE FLIGHT PLAN FUNCTIONS



D57 402 I

NOTE

Alternate Flight Plan page is accessed from Flight Plan Edit page.

LS1	Accesses Alternate Flight Plan Initialization and Fuel pages.
LS2	Accesses last Alternate Flight Plan Leg A page selected from that CDU.
LS3	Replaces flight plan with alternate flight plan waypoints. This function requires a confirmation indicated by scratchpad message CONFIRM RPLACE FPLN. After confirming this function, display changes to Flight Plan page.
LS5	Reverses alternate flight plan order. This function requires a confirmation indicated by scratchpad message CONFIRM RVRSE ALTN.
LS6	Erases alternate flight plan. This function requires a confirmation indicated by scratchpad message CONFIRM ERASE ALTN.
LS7	Accesses Flight Plan page and causes ADD ALTN BEFORE? to be displayed in scratchpad. Operator can then transfer alternate flight plan into a selected location in flight plan by pressing line select next to point in flight plan before which alternate is to be added.

On initial access to an alternate flight plan, or after clearing an existing alternate flight plan, following data is required for normal computations: initial position (default is present position), zero fuel weight, and initial fuel load. This function also allows for entry of a planned departure or arrival time, and climb parameters.

Alternate flight plan legs are created as a contiguous sequence of waypoints. Data required to define a leg is: TO waypoint, average true airspeed, average wind speed and direction, and average fuel flow rate. An altitude (or flight level) and a maximum bank angle can be entered, but they do not affect alternate flight plan computations.

Figure 1-172 (Sheet 4 of 44)

Each time a new leg is defined, true airspeed, wind speed/direction, and fuel flow rate from previous leg are assumed until crew enters new values. When a new intermediate waypoint is inserted, two legs are created where there was only one, and all subsequent legs are renumbered in sequence. Airspeed, wind speed/direction, and fuel flow rate are assumed to be same for both new legs and set equal to values of original leg where new waypoint is inserted. Each time a new leg is defined or a waypoint is inserted between two waypoints, bank angle defaults to 25°.

Great Circle distance and outbound bearing to TO waypoint are computed as well as accumulated distance from initial point. This accumulated distance does not include any MOP distances. Distance from initial point to TO point and distance remaining from TO point until end of plan are computed and displayed on CDU.

Crew may also elect to reverse an alternate flight plan. When this function is performed, leg order reversed. If a climb definition exists in an alternate flight plan, it remains unchanged when plan is reversed. Any MOPs which exist in an alternate flight plan remain attached to proper waypoints.

An alternate flight plan allows for a single climb beginning at FROM waypoint. Crew may enter following: time to climb, air distance to climb, fuel to climb, and average wind aloft forecast during climb. Default values are zero.

Ground distance to top of climb is computed based on lateral flight plan course, computed average airspeed and average forecast wind aloft. Leg containing top of climb is identified on CDU. Total distance from departure point to top of climb is also computed and displayed.

Computations use climb allowances until top of climb and then standard time, distance and fuel relationships are used for remainder of leg containing top of climb. Since climb may be completed before next TO waypoint is encountered, function requires airspeed and fuel burn rate to be defined for all legs, to have a complete alternate flight plan definition.

Any one waypoint in an alternate flight plan can have a required time of arrival associated with it, or initial point may have a departure time. When this option is exercised, function computes all other times based on standard time and distance relationships. If alternate flight plan contains loiters, loiter times are used for ETA computations. If crew enters no required time of arrival at a waypoint, departure time of first leg defaults to 0000. If crew specifies a desired arrival time at more than one waypoint, function uses most recent entry. If an arrival time is specified for a leg contained within a climb, 0000 is used for initial departure time. If required time is an arrival time, time is passed to time navigation function with associated waypoint if alternate flight plan is added to, or replaces, active flight plan. If an ETD has been specified for an MOP which has been inserted into alternate flight plan, ETD does not affect alternate flight plan computations.

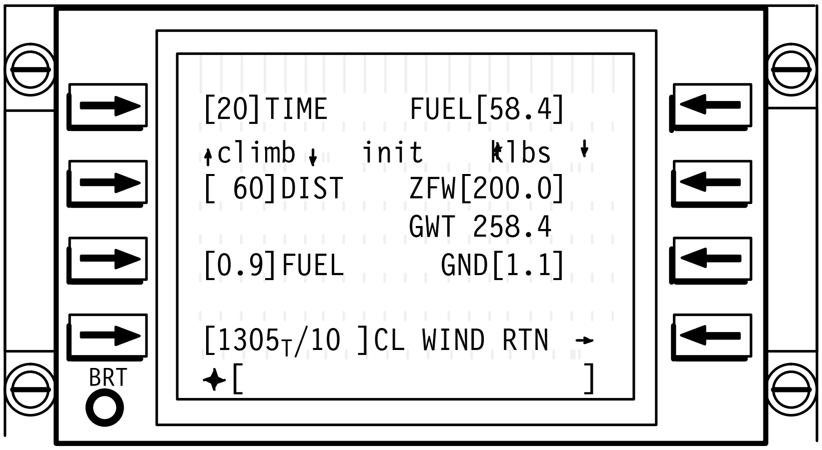
Durations of enroute legs are computed using ground speed and Great Circle distance. Time associated with burning of ground fuel (prior to takeoff) is zero. Pilot has option of entering an approach fuel allowance in kilo-pounds. If no fuel allowance is entered, zero kilo-pounds is used and no time allowance for approach is made. If pilot enters an approach fuel allowance other than zero, an approach time of 15 minutes is used. Time associated with reserve and extra fuel is based on fuel burn rate in last leg of cruise. Total endurance is a computed value that is calculated as duration of flight (including all loiter times) plus approach time, reserve time and extra time.

Alternate flight plan also allows for each leg to have a loiter associated with it. Crew can enter estimated time in pattern and average fuel flow rate for loiter. Time and fuel for that loiter are applied instantaneously at waypoint. If a waypoint having a loiter associated with it is contained within a climb, time and fuel computations for that loiter are not incorporated into alternate flight plan.

Figure 1-172 (Sheet 5 of 44)

CDU Menus - Edit (Continued)

(Initialization)



```
[20]TIME     FUEL[58.4]
↑climb↓  init    ↑klbs ↓
[ 60]DIST    ZFW[200.0]
             GWT 258.4
[0.9]FUEL      GND[1.1]

[1305T/10 ]CL WIND RTN →
✦[                     ]
```

D57 403 I

NOTE

Alternate Flight Plan Initialization page is accessed from Alternate Flight Plan page, by vertical scrolling from Leg pages, or by lateral scrolling from Fuel page.

Information line displays initial gross weight (in klbs) prior to startup.

LS1	With a valid entry in scratchpad, enters time to climb. If no time is entered, a default of 0 minutes is set. With a blank scratchpad, copies time to climb into scratchpad. With a – in scratchpad, sets time to climb to default value.
LS2	With a valid entry in scratchpad, enters air distance to climb. If no distance is entered, a default of 0 nautical miles is set. With a blank scratchpad, causes scratchpad to display distance to climb. With a – in scratchpad, sets distance to climb to default value.
LS3	With a valid entry in scratchpad, enters fuel to climb. If no fuel is entered, a default of 0 klbs is set. With a blank scratchpad, causes scratchpad to display fuel to climb. With a – in scratchpad, sets fuel to climb to default value.

Figure 1-172 (Sheet 6 of 44)

LS4	With a valid entry in scratchpad, enters average climb wind speed and direction (in degrees true/knots). If no climb wind is entered, a default of 360° and 0 knots is set. Direction entered for model wind is direction from which wind is blowing. With a blank scratchpad, copies climb wind speed and direction into scratchpad. With a – in scratchpad, sets climb wind speed to default value.
LS5	With a valid entry in scratchpad, enters total fuel prior to startup. If crew has entered an extra fuel allowance or extra endurance on Fuel page, total fuel is computed. If total fuel cannot be computed, total fuel display is blank. With a blank scratchpad, copies total fuel into scratchpad.
LS6	With a valid entry in scratchpad, enters zero fuel weight prior to startup. With a blank scratchpad, copies zero fuel weight into scratchpad. With a – in scratchpad, deletes zero fuel weight.
LS7	With a valid entry in scratchpad, enters ground fuel allowance. Default of 0 klbs is set. With a blank scratchpad, copies ground fuel into scratchpad. With a – in scratchpad, sets ground fuel to default value.
LS8	Returns to Alternate Flight Plan page.

Lateral scrolling accesses Fuel page, and wraps around.

Upward scrolling accesses last Leg A page in alternate flight plan. Downward scrolling accesses first Leg A page in alternate flight plan.

Following fuel quantities are enterable in alternate flight plan as follows:

Total Fuel – Total mission fuel

Extra Fuel – Fuel above required mission fuel and all allowances

Fuel on-load – Air refueling amount

If no fuel on-load has been specified, crew can enter either total fuel or extra fuel. When one of these parameters is specified, the other is calculated along with all corresponding intermediate fuel loadings and gross weights. If crew enters both total fuel and extra fuel, function uses most recently entered value. Crew can enter extra endurance in lieu of an extra fuel allowance. Extra fuel is computed based on this endurance and fuel burn rate of last leg in alternate flight plan.

Figure 1-172 (Sheet 7 of 44)

CDU Menus - Edit (Continued)

(Initialization) Continued

If a fuel on-load has been defined, extra fuel (or endurance) is not enterable and total fuel is only enterable on Alternate Flight Plan Initialization page. In this case, total fuel displayed on Alternate Flight Plan Fuel page is computed from entered total fuel and specified fuel on-load.

In specifying fuel on-load during flight, crew specifies leg on which this function is to be performed, as well as amount of fuel on-loaded. Function assumes that an air refueling is performed upon arriving at next TO waypoint. When an on-load of fuel is specified, weight of fuel is accounted for in gross weight and remaining fuel computations.

Crew also has capability of specifying a fuel off-load during mission. Crew must specify waypoint where this is to happen, as well as amount of off-load. Function assumes that off-load is performed upon arriving at waypoint. When an off-load has been specified, weight of fuel is accounted for in gross weight computations only (that is, off-loaded fuel does not affect remaining fuel computations).

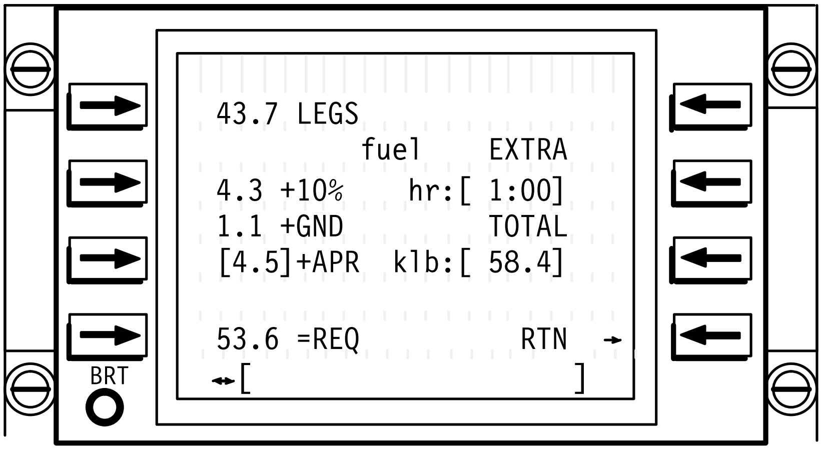
If a fuel on-load or off-load is contained within a climb, weight and fuel computations for on-load or off-load are not incorporated into alternate flight plan.

Fuel allowances other than burns during mission legs and climb include: ground fuel, approach fuel, and reserve fuel. Ground fuel allowance is applied prior to initiation of first leg. That is, fuel weight at beginning of first leg is computed as total fuel minus ground fuel. Approach fuel allowance is applied after final leg. Reserve fuel is computed as greater of 10% of leg and climb fuel or 20 minutes at last leg fuel burn rate. Total fuel is defined as sum of climb, cruise, approach, reserve, ground, and extra fuel.

Extra fuel is specified (or computed) as either kilo-pounds of fuel or as endurance time based on last leg fuel burn rate. When crew chooses to enter total fuel load, it is to be entered as kilo-pounds of fuel.

Figure 1-172 (Sheet 8 of 44)

(Fuel)



```
43.7 LEGS
       fuel    EXTRA
4.3 +10%    hr:[ 1:00]
1.1 +GND         TOTAL
[4.5]+APR  klb:[ 58.4]

53.6 =REQ         RTN →
↔[                    ]
```

D57 404 I

NOTE

> Alternate Flight Plan Fuel page is accessed by lateral scrolling from Alternate Flight Plan Initialization page.

Data line 1 displays total fuel required for defined legs, including climb fuel.

Computed reserve fuel is displayed on data line 2 as either 10% of leg and climb fuel or 20 minutes (20m) based on fuel burn rate of last entered leg. Larger value is selected and method used is displayed on data line 2.

Information line displays ground fuel (from Alternate Flight Plan Initialization page).

Data line 4 displays required (REQ) ramp fuel, which is computed by summing leg fuel, reserve, approach allowance, and ground allowance.

LS3 With a valid entry in scratchpad, enters approach fuel allowance. Default is 0.0.

With a blank scratchpad, copies approach fuel into scratchpad.

With a – in scratchpad, sets approach fuel to its default value.

LS6 With a blank scratchpad, toggles between display of extra fuel as endurance in hours (hr) and weight in thousands of pounds (klbs). Endurance is displayed in hrs:min while weight is displayed as klbs.

If extra fuel is computed to be a negative value, extra endurance display is dashed.

With display toggled to weight mode, enters desired extra fuel (with a valid entry in scratchpad). Entry of extra fuel is not permitted if an on-load of fuel has been specified in alternate flight plan. If an attempt is made to enter extra fuel while an on-load is defined, ONLOAD DEFINED scratchpad message is displayed.

Figure 1-172 (Sheet 9 of 44)

CDU Menus - Edit (Continued)

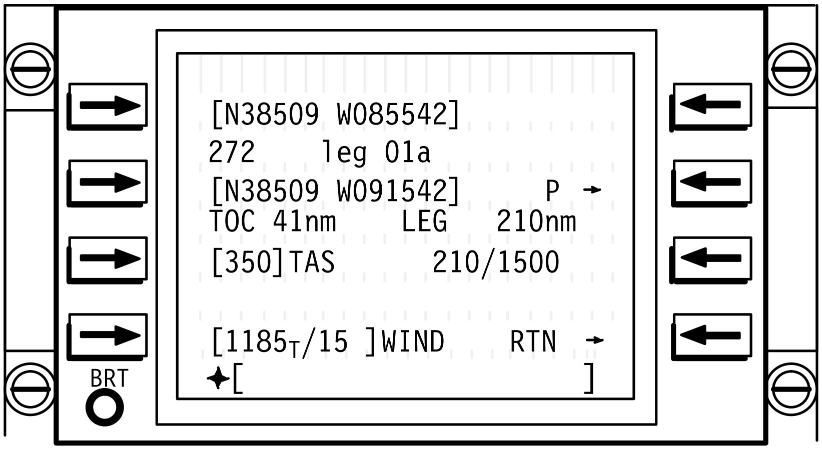
(Fuel) Continued

	With display toggled to endurance mode, enters desired extra fuel in endurance at last leg burn rate. Entry of extra endurance is not permitted if a fuel on-load has been defined in alternate flight plan. If an attempt is made to enter extra endurance while an on-load is defined, ONLOAD DEFINED scratchpad message is displayed.
LS7	With a blank scratchpad, toggles display between display of total fuel as endurance in hours (hr) and weight in thousands of pounds (klbs). Label above data field alternates between TOTAL and ENDUR.
	With a valid entry in scratchpad, enters desired total fuel when display is toggled to weight mode. Entry of total fuel is not permitted if a fuel on-load has been defined in alternate flight plan. If an attempt is made to enter total fuel while an on-load is defined, ONLOAD DEFINED scratchpad message is displayed.
	With display toggled to endurance mode, displays total endurance. Entry of total endurance is not allowed.
LS8	Returns to Alternate Flight Plan page.

Lateral scrolling accesses Alternate Flight Plan Initialization page, and wraps around.

Figure 1-172 (Sheet 10 of 44)

(Leg 01a)



```
[N38509 W085542]
272    leg 01a
[N38509 W091542]     P →
TOC 41nm    LEG   210nm
[350]TAS      210/1500

[1185T/15 ]WIND    RTN →
✦[                  ]
```

NOTE

> Alternate Flight Plan Leg A page is accessed from Alternate Flight Plan page, by vertical scrolling from Alternate Flight Plan Initialization page, or by lateral scrolling from Leg B or Leg C pages.

Title line displays outbound bearing to TO waypoint. Degree symbol for inbound course is displayed as $°_T$ when true/mag discrete is set to true or when no magnetic variation or declination data is available for that location.

Information line displays leg distance and distance to top of climb if a climb definition exists in alternate flight plan.

Data line 3 displays distance from origin to TO waypoint (left of /) and remaining distance from TO to destination (right of /) in nautical miles.

LS1,5	With a valid waypoint entry in scratchpad, enters initial point on leg 01 only. Brackets are not displayed on subsequent legs, and data line 1 contains TO waypoint from previous leg. With a blank scratchpad, copies waypoint into scratchpad.
LS2	With a valid waypoint entry in scratchpad, enters TO waypoint, which always creates a new leg. After last entered leg, *END is displayed. An attempt to enter more than 60 waypoints causes scratchpad message ALTN FPLN FULL to be displayed. When an ATTACH xxx AT? message is displayed, LS2 attaches parameters associated with scratchpad to waypoint associated with line select key pressed. This waypoint then becomes fix point for specified MOP (Circle, Racetrack, Figure Eight, Closed Random, or Refuel). When an INSERT xxx BEFORE? message is displayed, LS2 inserts new MOP into alternate flight plan at location prior to waypoint associated with line select key pressed.

Figure 1-172 (Sheet 11 of 44)

CDU Menus - Edit (Continued)

(Leg 01a) Continued

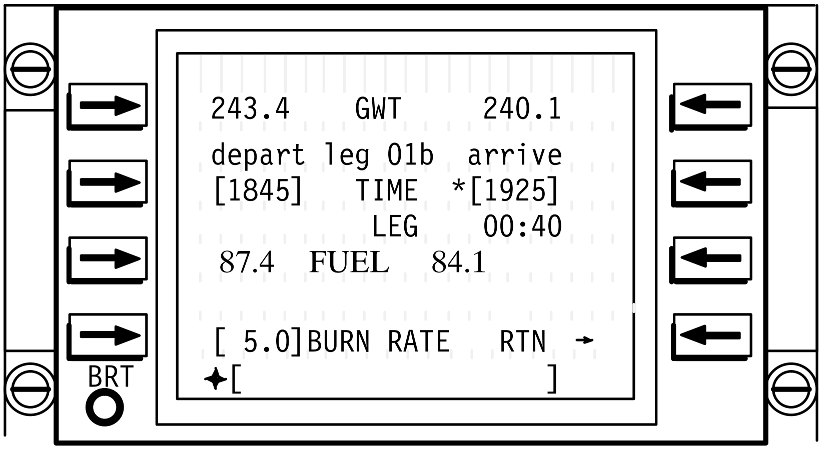
	An attempt to attach or insert an MOP when 20 MOPs already exist in alternate flight plan is prohibited and causes MAX PTRNS IN ALTN scratchpad message to be displayed. With a blank scratchpad, copies waypoint into scratchpad. With a – in scratchpad, deletes TO waypoint.
LS3	With a valid entry in scratchpad, enters leg true airspeed in knots. If leg true airspeed entry is attempted prior to entry of associated TO waypoint adjacent to LS2, scratchpad message ENTER WAYPOINT is displayed and entry is not accepted. First entry of true airspeed is applied to all legs in alternate flight plan. With a blank scratchpad, copies true airspeed into scratchpad. With a – in scratchpad, sets TAS to values for previous leg. If no previous leg exists, TAS for all legs is deleted.
LS4	With a valid entry in scratchpad, enters leg wind aloft in knots and degrees true. If wind entry is attempted prior to entry of associated TO waypoint adjacent to LS2, scratchpad message ENTER WAYPOINT is displayed and entry is not accepted. Default wind direction is 360° at 0 knots. Wind direction is direction from which it is blowing. With a blank scratchpad, copies wind into scratchpad. With a – in scratchpad, sets wind to value for previous leg. If no previous leg exists, wind for all legs is set to default value.
LS6	With a pattern (P) entered at that leg, accesses associated MOP page (Circle, Racetrack, Figure Eight, Closed Random, or Refuel).
LS8	Returns to Alternate Flight Plan page.

Upward scrolling accesses previous Leg A page in alternate flight plan. If Leg A page being displayed is first leg in alternate flight plan, upward scrolling accesses Alternate Flight Plan Initialization page. Downward scrolling accesses next Leg A page in alternate flight plan. If Leg A page being displayed is for *END leg in alternate flight plan, downward scrolling accesses Alternate Flight Plan Initialization page.

Lateral scrolling is not available from Leg A page if it is displaying *END leg in alternate flight plan, as indicated by ↕ adjacent to scratchpad. If leg being displayed is not *END leg, pressing right arrow key scrolls to Leg B page for defined leg, and pressing left arrow key scrolls to Leg C page for defined leg.

Figure 1-172 (Sheet 12 of 44)

(Leg 01b)



```
243.4    GWT     240.1
depart leg 01b  arrive
[1845]   TIME  *[1925]
           LEG    00:40
 87.4  FUEL   84.1

[ 5.0]BURN RATE   RTN →
✦[                   ]
```

D57 406 I

NOTE

> Alternate Flight Plan Leg B page is accessed by lateral scrolling from the Leg A or Leg C pages.

Data lines 1, 2, and 3 display gross weight, time and fuel loading, respectively, at beginning and end of each leg. One arrival or departure time can be entered and all other times are computed such that required arrival/departure time is met. If waypoint associated with required time is deleted, default condition (initial departure time of 0000) is used. If a climb has been defined, all arrival times for points prior to top of climb are displayed as dashes and no asterisk is displayed.

Title line displays leg number for displayed data.

Information line displays total duration of leg in hours and minutes.

LS2	With a valid entry in scratchpad, enters leg departure time in UTC on leg 01 only (that is, brackets are not displayed on subsequent legs). Entry of initial departure time allows computation of subsequent arrival and departure times. If a future arrival time is entered, departure time is computed and displayed. An asterisk (*) is displayed next to departure time if this value has been entered. With a blank scratchpad, copies departure time into scratchpad on leg 01 only.
LS4	With a valid entry in scratchpad, enters average fuel consumption rate. First entry of average fuel consumption rate is applied to all legs in alternate flight plan. With a blank scratchpad, copies burn rate into scratchpad. With a – in scratchpad, sets burn rate to value for previous leg. If no previous leg exists, burn rate for all legs is deleted.

Figure 1-172 (Sheet 13 of 44)

CDU Menus - Edit (Continued)

(Leg 01b) Continued

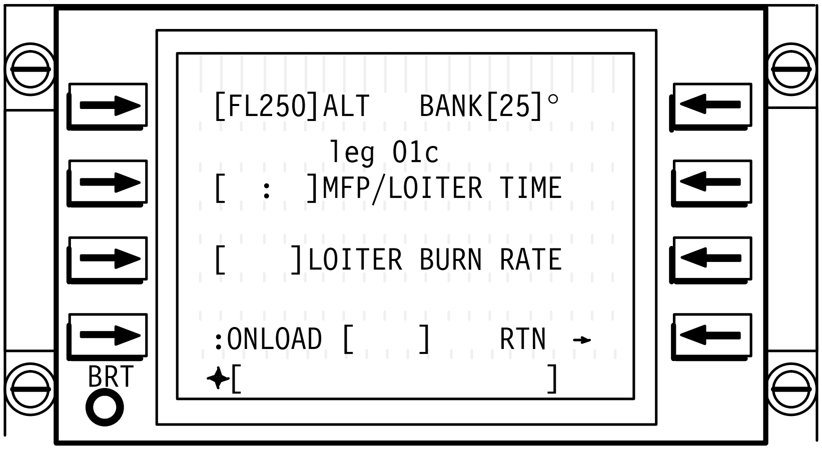
LS6	With a valid entry in scratchpad, enters arrival time at end of leg in UTC. An asterisk (*) is displayed next to entered arrival time. All arrival times are computed based on entered arrival/departure time. With a blank scratchpad, copies arrival time into scratchpad.
LS8	Returns to Alternate Flight Plan page.

Upward scrolling accesses previous Leg B page in alternate flight plan. If Leg B page being displayed is for first leg in alternate flight plan, upward scrolling accesses Alternate Flight Plan Initialization page. Downward scrolling accesses next Leg B page in alternate flight plan. If Leg B page being displayed is for last leg in alternate flight plan, downward scrolling accesses Alternate Flight Plan Initialization page.

Right arrow key scrolls to Leg C page. Left arrow key scrolls to Leg A page.

Figure 1-172 (Sheet 14 of 44)

(Leg 01c)



```
[FL250]ALT   BANK[25]°
        leg 01c
[  :  ]MFP/LOITER TIME

[    ]LOITER BURN RATE

:ONLOAD [    ]    RTN →
✦[                     ]
```

NOTE

Alternate Flight Plan Leg C page is accessed by lateral scrolling from Leg A or Leg B pages.

Title line displays leg number for which displayed data is valid.

LS1 With a valid entry in scratchpad, enters desired altitude for VNAV function (entered as flight level or altitude). An attempt to enter a value less than 500 feet causes 500 FT MINIMUM scratchpad message to be displayed. Altitude defined for a leg is associated with TO if alternate flight plan is transferred to flight plan.

With a – in scratchpad, deletes entered VNAV altitude.

With a blank scratchpad, copies VNAV altitude into scratchpad.

LS2 With a valid entry in scratchpad, enters estimated time (in hrs:min) in loiter for an MOP. Maximum entry allowed is 23:59.

With a – in scratchpad, deletes loiter time.

With a blank scratchpad, copies loiter time into scratchpad.

LS3 With a valid entry in scratchpad, enters average fuel consumption rate (in klbs per hour) for loiter.

With a – in scratchpad, deletes loiter burn rate.

With a blank scratchpad, copies loiter burn rate into scratchpad.

Figure 1-172 (Sheet 15 of 44)

CDU Menus - Edit (Continued)

(Leg 01c) Continued

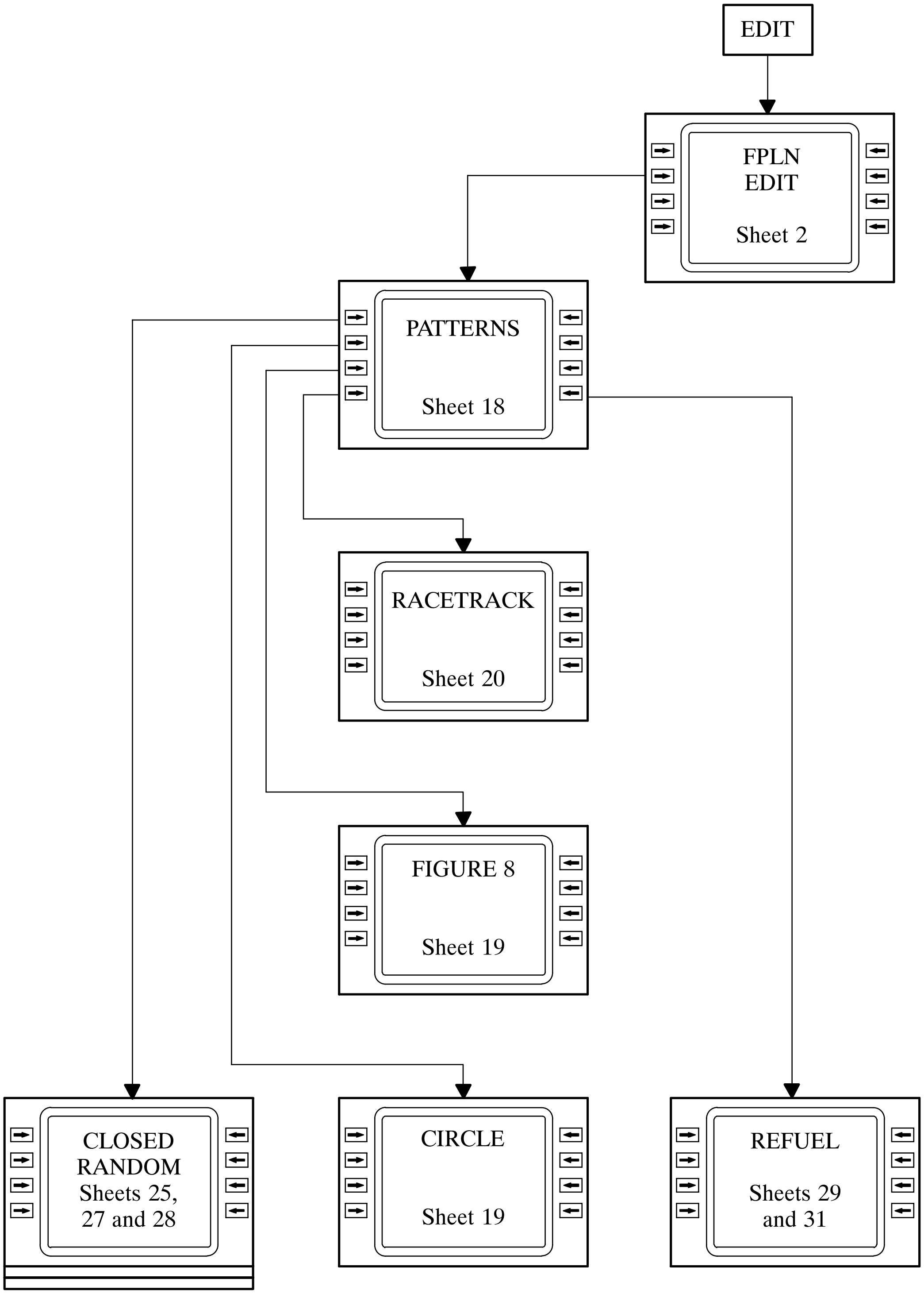
LS4	With a blank scratchpad, toggles fuel load display between ONLOAD and OFFLOAD. With a valid entry in scratchpad, enters on-load or off-load of fuel for that leg (in klbs). With a – in scratchpad, deletes ONLOAD or OFFLOAD fuel.
LS5	With a valid entry in scratchpad, enters maximum bank angle. With a – in scratchpad, defaults maximum bank angle to 25°. With a blank scratchpad, copies bank angle into scratchpad.
LS8	Returns to Alternate Flight Plan page.

Upward scrolling accesses previous Leg C page in alternate flight plan. If Leg C page being displayed is for first leg in alternate flight plan, upward scrolling accesses Alternate Flight Plan Initialization page. Downward scrolling accesses next Leg C page in alternate flight plan. If Leg C page being displayed is for last leg in alternate flight plan, downward scrolling accesses Alternate Flight Plan Initialization page.

Pressing right arrow key scrolls to Leg A page. Pressing left arrow key scrolls to Leg B page.

Figure 1-172 (Sheet 16 of 44)

(Patterns)

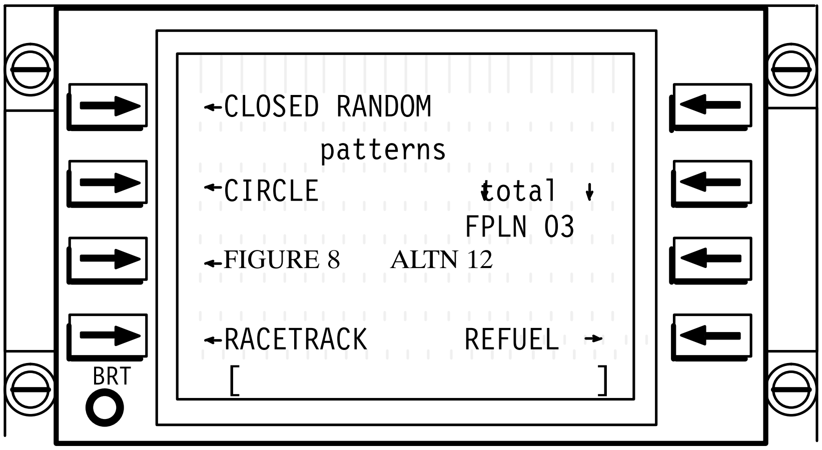


D57 408 I

Figure 1-172 (Sheet 17 of 44)

CDU Menus - Edit (Continued)

(Patterns) Continued



NOTE

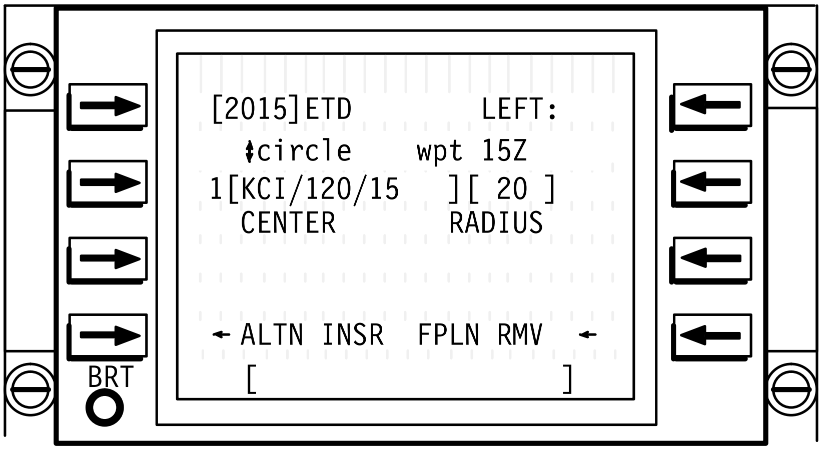
Patterns page is accessed from Flight Plan Edit page.

Information line displays total number of MOPs entered in flight plan. Twenty MOPs are allowed in flight plan.

Data line 3 displays total number of MOPs entered in alternate flight plan. Twenty MOPs are allowed in alternate flight plan.

LS1	Accesses Closed Random Pattern MOP page.
LS2	Accesses Circle MOP page.
LS3	Accesses Figure Eight MOP page.
LS4	Accesses Racetrack MOP page.
LS8	Accesses Refuel MOP page.

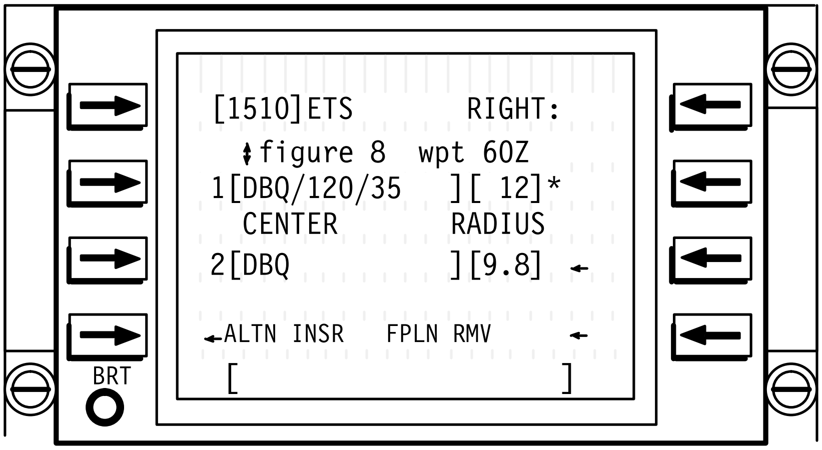
Figure 1-172 (Sheet 18 of 44)



```
[2015]ETD         LEFT:
  ↕circle     wpt 15Z
1[KCI/120/15    ][ 20 ]
  CENTER        RADIUS


 ← ALTN INSR  FPLN RMV  ←
  [                    ]
```

NOTE

- Circle, Racetrack, and Figure 8 MOP pages are accessed from Patterns, Flight Plan Waypoint, or Alternate Flight Plan Leg A page.
- See scrolling description for additional accesses.



```
[1510]ETS        RIGHT:
  ↕figure 8   wpt 60Z
1[DBQ/120/35    ][ 12]*
  CENTER        RADIUS
2[DBQ           ][9.8] ←

←ALTN INSR   FPLN RMV    ←
 [                     ]
```

NOTE

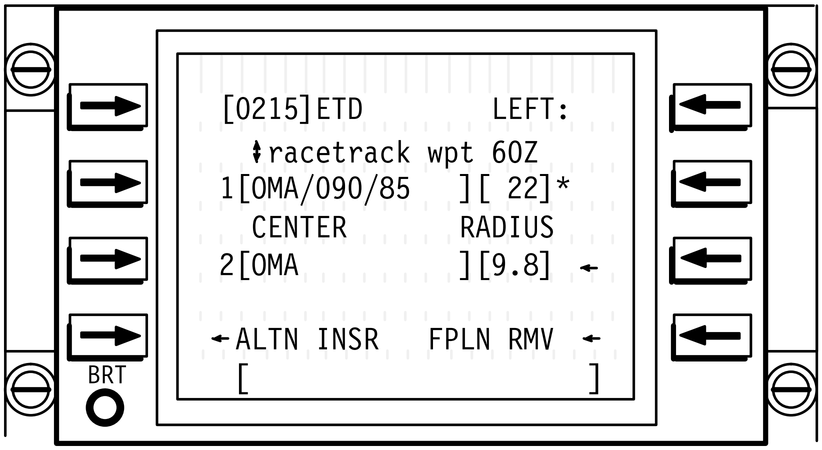
Figure 8 page shown as accessed from Alternate Flight Leg A page.

D57 410 I

Figure 1-172 (Sheet 19 of 44)

CDU Menus - Edit (Continued)

(Patterns) Continued



```
[0215]ETD        LEFT:
 ↕racetrack wpt 60Z
1[OMA/090/85   ][ 22]*
  CENTER       RADIUS
2[OMA          ][9.8] ←

←ALTN INSR   FPLN RMV ←
 [                    ]
```

D57 411 I

NOTE

Racetrack page shown as accessed from FPLN page.

Information line displays maximum bank angle computed from entered pattern width and airplane speed if airborne. If on ground, Data page ground speed is used. If pattern is inserted into alternate flight plan, no bank angle computations are made, and display is dashed.

Title line and data lines 3 and 4 reflect page access as follows:

If Circle, Racetrack, or Figure 8 MOP page was accessed from Flight Plan Edit page (for definition), or removed from flight plan or alternate flight plan, title line is displayed as ↕ circle, ↕ racetrack, or ↕ figure 8.

If Circle, Racetrack, or Figure 8 MOP page was accessed from Flight Plan page (defined MOP), title line is displayed as ↕ circle (↕ racetrack or ↕ figure 8) wpt xxx (where xxx is waypoint number to which that MOP is assigned). LS8 is displayed as FPLN RMV← and LS4 is displayed as ALTN INSR.

If Circle, Racetrack, or Figure 8 MOP page was accessed from Alternate Flight Plan Leg A page (defined MOP), title line is displayed as ↕ circle (↕ racetrack or ↕ figure 8) leg xx (where xx is leg number to which that MOP is assigned). LS8 is displayed as FPLN INSR and LS4 is displayed as ALTN RMV←.

LS1 With a valid entry in scratchpad, enters ETD.

With a – in scratchpad, deletes ETD.

With an empty scratchpad, copies ETD into scratchpad.

Figure 1-172 (Sheet 20 of 44)

LS2 With a valid waypoint entry in scratchpad, enters location as center point of circle, or lobe 1 for FG8/RTK. Also for FG8/RTK, center location must be a point located so distance between lobe centers is at least 3 nm greater than sum of radii of lobes. An entry for FG8/RTK that fails to meet this distance check is prohibited and prompts INVALID ENTRY scratchpad message. If CIR/FG8/RTK pattern has been inserted in flight plan or alternate flight plan, selection causes FPLN RMV label, FPLN* label, or ALTN RMV label to change to PTRN CHNG, and CONFIRM PAT CHANGE is written in scratchpad. Change is not implemented until confirmed by selecting appropriate line select (LS8 for flight plan change or LS4 for alternate flight plan change).

With a – in scratchpad, deletes point. If pattern has been inserted in flight plan or alternate flight plan, deletion is prohibited, and causes INVALID DELETION scratchpad message to be displayed.

With an empty scratchpad, copies center location to scratchpad.

LS3 LS3 applies to FG8/RTK only. With a valid waypoint entry in scratchpad, enters location as center point of lobe 2. Center location must be a point located so distance between lobe centers is at least 3 nm greater than sum of radii of lobes. An entry that fails to meet this distance check is prohibited, and causes INVALID ENTRY scratchpad message to be displayed. If pattern has been inserted in flight plan or alternate flight plan, selection causes FPLN RMV label, FPLN* label, or ALTN RMV label to change PTRN CHNG, and CONFIRM PAT CHANGE is written in scratchpad. Change is not implemented until confirmed by selecting appropriate line select (LS8 for flight plan change or LS4 for alternate flight plan change).

With a – in scratchpad, deletes point. If pattern has been inserted in flight plan or alternate flight plan, deletion is prohibited and causes INVALID DELETION scratchpad message to be displayed.

With an empty scratchpad, copies center location to scratchpad.

LS4 Without at least one center location entered (for FG8/RTK only), causes ENTER PARAMETERS scratchpad message to be displayed. With ←ALTN INSR written adjacent to it, accesses Alternate Flight Plan Leg A page. If circle center or, for FG8/RTK, both center locations have been defined on this page, INSERT CIR/FG8/RTK BEFORE? is written in scratchpad. If only one center location (or no circle center) has been defined on this page, ATTACH CIR/FG8/RTK AT? is written in scratchpad.

With →ALTN RMV written adjacent to it, removes pattern from alternate flight plan after confirmation indicated by CONFIRM ALTN RMV scratchpad message.

With →PTRN CHNG written adjacent to it, replaces pattern as previously defined in alternate flight plan with pattern as displayed after confirmation indicated by CONFIRM PAT CHANGE or CONFIRM CHNG TO CIR/FG8/RTK scratchpad message.

Figure 1-172 (Sheet 21 of 44)

CDU Menus - Edit (Continued)

(Patterns) Continued

LS5	Toggles between right and left initial turn into pattern where right is clockwise and left is counter-clockwise. Left turn is default direction. If pattern has been inserted in flight plan or alternate flight plan, selection causes FPLN RMV label, FPLN* label, or ALTN RMV label to change to PTRN CHNG, and CONFIRM PAT CHANGE is written in scratchpad. Change is not implemented until confirmed by selecting appropriate line select (LS8 for flight plan change or LS4 for alternate flight plan change).
LS6	With a valid entry in scratchpad, enters radius of circle or lobe 1 in nautical miles. Radius must be at least 5 nautical miles in length and, for FG8/RTK, distance between lobe centers must be at least 3 nm larger than sum of radii of lobes. An entry that fails to meet either of these criteria is prohibited and causes INVALID ENTRY scratchpad message to be displayed. If pattern has been inserted in flight plan or alternate flight plan, selection causes FPLN RMV label, FPLN* label, or ALTN RMV label to change to PTRN CHNG, and CONFIRM PAT CHANGE is written in scratchpad. Change is not implemented until confirmed by selecting appropriate line select (LS8 for flight plan change or LS4 for alternate flight plan change). With a – in scratchpad, sets radius to default value of 5 nm. If pattern has been inserted in flight plan or alternate flight plan, selection causes FPLN RMV label, FPLN* label, or ALTN RMV label to change to PTRN CHNG, and CONFIRM PAT CHANGE is written in scratchpad. Change is not implemented until confirmed by selecting appropriate line select (LS8 for flight plan change or LS4 for alternate flight plan change). For FG8/RTK only, with an ← displayed adjacent to line select, an empty scratchpad causes ← to change to asterisk adjacent to LS6, and asterisk to change to ← adjacent to LS7, thereby designating lobe 1 as capture lobe for pattern and lobe 2 as secondary lobe. When pattern is attached to a flight plan waypoint or an alternate flight plan waypoint, flight plan or alternate flight plan waypoint becomes capture lobe for pattern, regardless of selection on this page. When pattern is inserted into flight plan or alternate flight plan, designated lobe is capture lobe and waypoint in flight plan. Default capture lobe is lobe 1. If pattern has been inserted in flight plan or alternate flight plan, selection causes FPLN RMV label, FPLN* label, or ALTN RMV label to change to PTRN CHNG, and CONFIRM PAT CHANGE is written in scratchpad. Change is not implemented until confirmed by selecting appropriate line select (LS8 for flight plan change or LS4 for alternate flight plan change).
LS7	LS7 applies to FG8/RTK only. With a valid entry in scratchpad, enters radius of lobe 2 in nautical miles. Radius must be at least 5 nautical miles in length, and distance between lobe centers must be at least 3 nm larger than sum of radii of lobes. An entry that fails to meet either of these criteria is prohibited and causes INVALID ENTRY scratchpad message to be displayed. If pattern has been inserted in flight plan or alternate flight plan, selection causes FPLN RMV label, FPLN* label, or ALTN RMV label to change to PTRN CHNG, and CONFIRM PAT CHANGE is written in scratchpad. Change is not implemented until confirmed by selecting appropriate line select (LS8 for flight plan change or LS4 for alternate flight plan change).

Figure 1-172 (Sheet 22 of 44)

With a – in scratchpad, sets radius to default value of 5 nm. If pattern has been inserted in flight plan or alternate flight plan, selection causes FPLN RMV label, FPLN* label, or ALTN RMV label to change to PTRN CHNG, and CONFIRM PAT CHANGE is written in scratchpad. Change is not implemented until confirmed by selecting appropriate line select (LS8 for flight plan change or LS4 for alternate flight plan change).

With an ← displayed adjacent to line select, an empty scratchpad causes ← to change to an asterisk adjacent to LS7, and asterisk to change to ← adjacent to LS6, thereby designating lobe 2 as capture lobe for pattern and lobe 1 as secondary lobe. When pattern is attached to a flight plan waypoint or an alternate flight plan waypoint, flight plan or alternate flight plan waypoint becomes capture lobe for pattern regardless of selection on this page. When pattern is inserted into flight plan or alternate flight plan, designated lobe is capture lobe and waypoint in flight plan. Default capture lobe is lobe 1. If pattern has been inserted in flight plan or alternate flight plan, selection causes FPLN RMV label, FPLN* label, or ALTN RMV label to change to PTRN CHNG, and CONFIRM PAT CHANGE is written in scratchpad. Change is not implemented until confirmed by selecting appropriate line select (LS8 for flight plan change or LS4 for alternate flight plan change).

LS8 Without at least one center location entered (for FG8/RTK only), causes ENTER PARAMETERS scratchpad message to be displayed. With FPLN INSR→ written adjacent to it, accesses Flight Plan page. If circle center or, for FG8/RTK, both center locations have been defined on this page, INSERT CIR/FG8/RTK BEFORE? is written in scratchpad. If only one center location (or no circle center) has been defined on this page, ATTACH CIR/FG8/RTK AT? is written in scratchpad.

With FPLN RMV← written adjacent to it, removes pattern from flight plan after confirmation indicated by CONFIRM FPLN RMV scratchpad message. If pattern defined on this page is active, FPLN RMV← is replaced by FPLN* and selection results in no response.

With PTRN CHNG← written adjacent to it, replaces pattern as previously defined in flight plan with pattern as displayed after confirmation indicated by CONFIRM PAT CHANGE or CONFIRM CHNG TO CIR/FG8/RTK scratchpad message. If pattern is active, a Direct–To to capture lobe is also performed.

Figure 1-172 (Sheet 23 of 44)

CDU Menus - Edit (Continued)

(Patterns) Continued

NOTE

When vertical scrolling to circle pattern from FG8 or RTK, center and radius of capture lobe are displayed as center and radius of circle.

Vertical scrolling cycles through selectable pattern types, allowing pattern type selection under following conditions:

Definition entry via Flight Plan Edit page: Allows operator to enter pattern parameters on any MOP page and select or change type of pattern to be flown prior to entry of MOP into flight plan or alternate flight plan. Scrolling down changes title line to reflect new pattern selected as follows (wraparound scrolling):

- ↕ figure 8
- ↕ racetrack
- ↕ circle

MOP page access from flight plan: Allows operator to change flight plan defined MOP parameters or type prior to or during execution. Scrolling down changes label adjacent to LS8 to PTRN CHNG and causes scratchpad message indicating which pattern has been requested, as follows:

- CONFIRM CHNG TO (FG8 or RTK)
- CONFIRM CHNG TO (RTK or CIR)

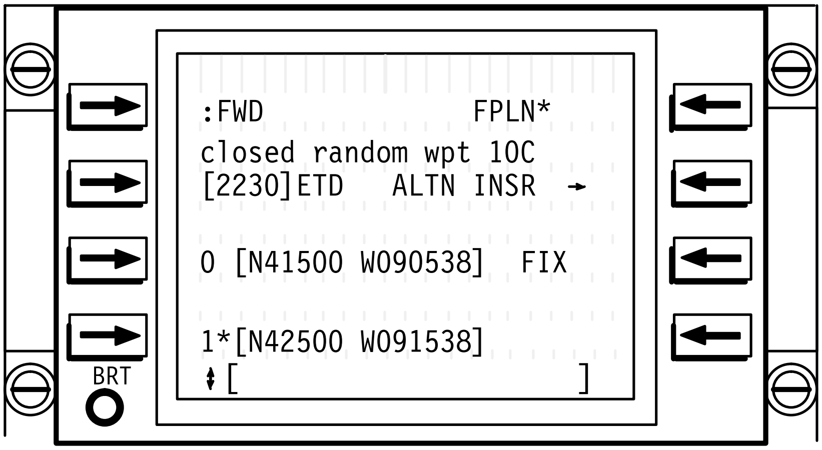
If vertical scroll key is pressed a third time, scratchpad is blanked and label adjacent to LS8 is displayed as FPLN RMV←. Changing flight plan entered MOP type requires operator to scroll vertically to desired pattern type and press LS8, labeled PTRN CHNG←, to confirm pattern change. Upon confirmation, page display changes to MOP page for selected pattern and LS8 is displayed as FPLN RMV← (if future flight plan point) or FPLN* (if active). If a change to a center location or radius fails to meet distance check, pattern change is prohibited and causes INVALID ENTRY message to alternate in scratchpad.

MOP page access from alternate flight plan: Allows operator to change alternate flight plan defined MOP type. Scrolling down changes label adjacent to LS8 to PTRN CHNG and causes scratchpad message indicating which pattern has been requested, as follows:

- CONFIRM CHNG TO (FG8 or RTK)
- CONFIRM CHNG TO (RTK or CIR)

If vertical scroll key is pressed a third time, scratchpad is blanked and label adjacent to LS4 is displayed as ALTN RMV←. Changing alternate flight plan entered MOP type requires operator to scroll vertically to desired pattern type and press LS4, labeled PTRN CHNG, to confirm pattern change. Upon confirmation, page display changes to MOP page for selected pattern, and LS4 is displayed as ALTN RMV←.

Figure 1-172 (Sheet 24 of 44)

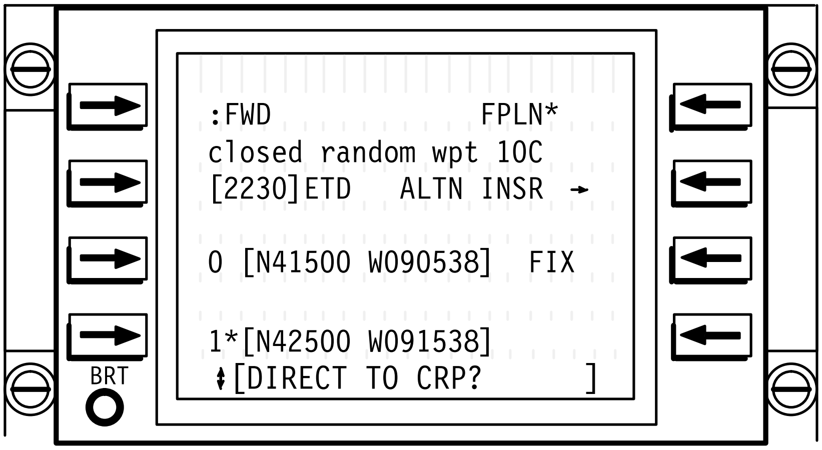


```
:FWD            FPLN*
closed random wpt 10C
[2230]ETD   ALTN INSR →

0 [N41500 W090538]  FIX

1*[N42500 W091538]
↕[                    ]
```

NOTE

- Closed Random Pattern MOP pages are accessed from Patterns page, Flight Plan page, Flight Plan Waypoint page, or Alternate Flight Plan Leg A.

- Page is shown as accessed from fpln page.



```
:FWD            FPLN*
closed random wpt 10C
[2230]ETD   ALTN INSR →

0 [N41500 W090538]  FIX

1*[N42500 W091538]
↕[DIRECT TO CRP?      ]
```

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NOTE

Page is shown as accessed from Direct–To.

If Closed Random Pattern MOP page was accessed from Flight Plan Edit page (for definition), or removed from flight plan or alternate flight plan, title line is displayed as closed random.

If Closed Random Pattern MOP page was accessed from Flight Plan page (defined CRP), title line is displayed as closed random wpt xxx (where xxx is waypoint number to which that CRP is assigned). LS5 is displayed as FPLN RMV← and LS6 is displayed as ALTN INSR.

Figure 1-172 (Sheet 25 of 44)

CDU Menus - Edit (Continued)

(Patterns) Continued

If Closed Random Pattern MOP page was accessed from Alternate Flight Plan Leg A page (defined CRP), title line is displayed as closed random leg xx (where xx is leg number to which that CRP is assigned). LS5 is displayed as FPLN INSR and LS6 is displayed as ALTN RMV←.

When a CRP is active in flight plan, an asterisk is displayed in front of waypoint that is current TO waypoint.

Direct–To a waypoint within CRP can be performed when CRP is active in flight plan. Pressing DIR key during CRP execution, and pressing LS6 on Flight Plan page accesses Closed Random Pattern MOP page (bypassing Flight Plan Waypoint page) and allowing selection of Direct–To point. Once accessed (via Direct–To), Closed Random Pattern MOP page is displayed as illustrated above, and selection of Direct–To is via left line select key (adjacent to requested Direct–To point).

After selection of Direct–To CRP point, DIRECT TO CRP? scratchpad message is cleared and associated Closed Random Pattern MOP page continues to be displayed. Unlike a Direct–To to a future flight plan waypoint, intermediate waypoints are not deleted.

LS1	Selection of LS1 toggles CRP sequencing between forward (FWD – fix, 1, 2, 3.....) and reverse (REV – fix, 9, 8, 7.....).
LS2	Enters ETD. With a – in scratchpad, deletes ETD. With an empty scratchpad, copies ETD into scratchpad.
LS3,7	With a valid waypoint entry in the scratchpad, enters CRP fix point. If pattern has been inserted in flight plan or alternate flight plan, selection results in PATTERN DEFINED scratchpad message. With a – in scratchpad, deletes fix. If pattern has been inserted in flight plan or alternate flight plan, deletion is inhibited and causes INVALID DELETION scratchpad message to be displayed. With an empty scratchpad, copies pattern fix point into scratchpad.
LS4,8	With a valid waypoint entry in scratchpad, enters first point in CRP. This point is only displayed as a latitude/longitude. With a – in scratchpad, deletes first point. With an empty scratchpad, copies point into scratchpad.

Figure 1-172 (Sheet 26 of 44)

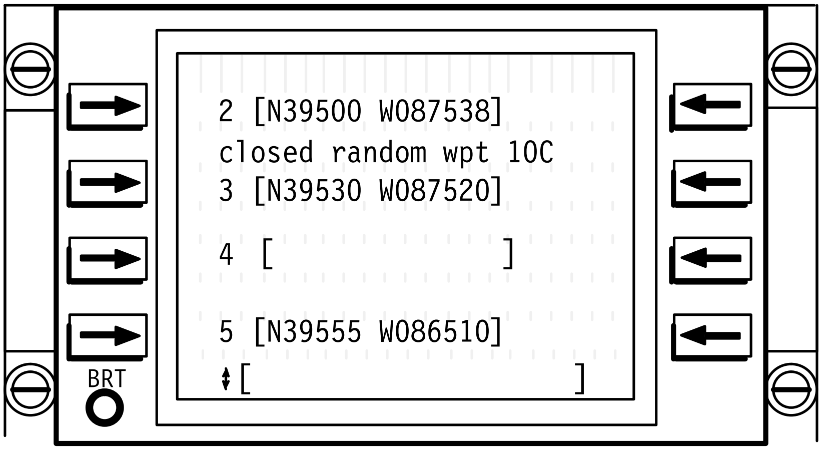
LS5 With FPLN INSR written adjacent to it, accesses Flight Plan page. If a fix has been defined on this page, INSERT CRP BEFORE? is written in scratchpad. If a fix has not been defined on this page, ATTACH CRP AT? is written in scratchpad.

With FPLN RMV← written adjacent to it, removes CRP from flight plan after confirmation indicated by the CONFIRM FPLN RMV scratchpad message. If CRP defined on this page is active, FPLN RMV← is replaced by FPLN* and pattern is not removable.

LS6 With ALTN INSR written adjacent to it, accesses Alternate Flight Plan Leg A page. If a fix has been defined on this page, INSERT CRP BEFORE? is written in scratchpad. If a fix has not been defined on this page, ATTACH CRP AT? is written in scratchpad.

With ALTN RMV← written adjacent to it, removes CRP from alternate flight plan after confirmation indicated by CONFIRM ALTN RMV scratchpad message.

Vertical scrolling accesses additional Closed Random Pattern MOP pages, and wraps around. Down scroll key accesses Closed Random Pattern MOP Page 2. Up scroll key accesses Closed Random Pattern MOP Page 3. Pages 2 and 3 are shown below.



```
2 [N39500 W087538]
closed random wpt 10C
3 [N39530 W087520]
4 [             ]
5 [N39555 W086510]
↕[                    ]
```

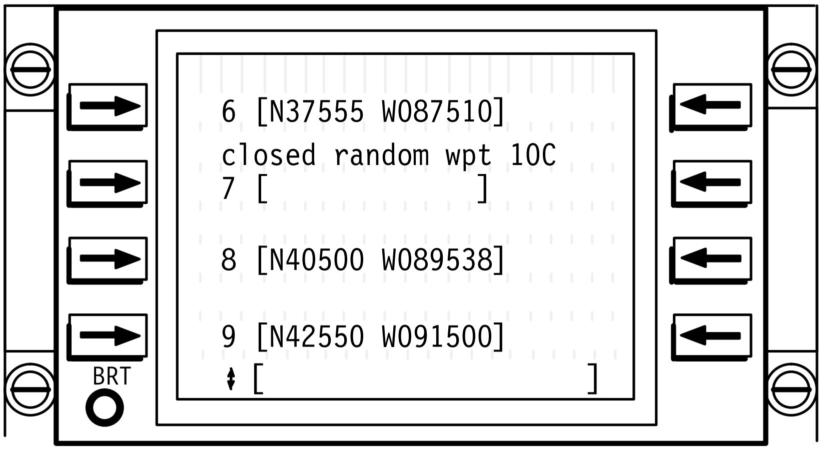
NOTE

Switch actions are described under CRP MOP page 3.

Figure 1-172 (Sheet 27 of 44)

CDU Menus - Edit (Continued)

(Patterns) Continued



```
6 [N37555 W087510]
closed random wpt 10C
7 [            ]

8 [N40500 W089538]

9 [N42550 W091500]
↕[                  ]
```

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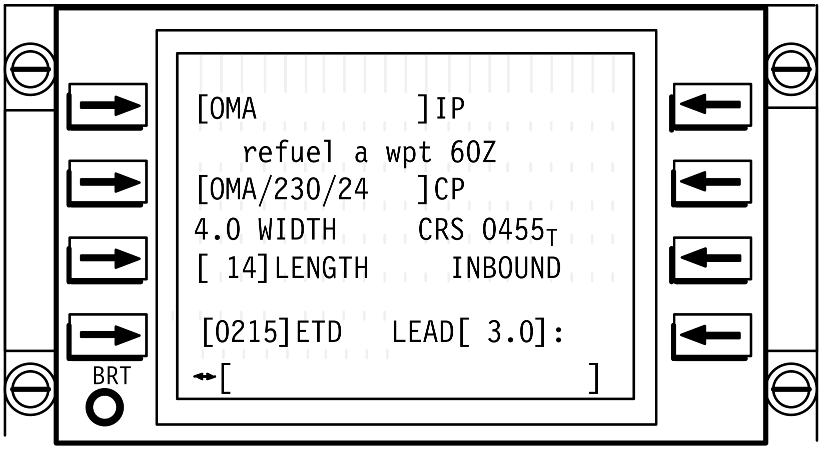
LS1 or 5	With a valid waypoint in scratchpad, enters CRP point 2 (page 2) or 6 (page 3). With a – in scratchpad, deletes point. With an empty scratchpad, copies point into scratchpad.
LS2 or 6	With a valid waypoint in scratchpad, enters CRP point 3 (page 2) or 7 (page 3). With a – in scratchpad, deletes point. With an empty scratchpad, copies point into scratchpad.
LS3 or 7	With a valid waypoint in scratchpad, enters CRP point 4 (page 2) or 8 (page 3). With a – in scratchpad, deletes point. With an empty scratchpad, copies point into scratchpad.
LS4 or 8	With a valid waypoint in scratchpad, enters CRP point 5 (page 2) or 9 (page 3). With a – in scratchpad, deletes point. With an empty scratchpad, copies point into scratchpad.

Scrolling is described under CRP MOP page 1.

Figure 1-172 (Sheet 28 of 44)

(Refuel a Waypoint)



```
[OMA          ]IP
   refuel a wpt 60Z
[OMA/230/24   ]CP
4.0 WIDTH     CRS 0455T
[ 14]LENGTH     INBOUND

[0215]ETD   LEAD[ 3.0]:
↔[                       ]
```

NOTE

Refuel A MOP page is accessed from Patterns page or by vertical scrolling from Refuel B MOP page.

Title line reflects page access as follows:

If Refuel A MOP page was accessed from Patterns page (for definition) or if Refuel A MOP page was removed from flight plan or alternate flight plan, title line is displayed as refuel a.

If Refuel B MOP page was accessed from Flight Plan Waypoint page (defined refuel pattern), title line of Refuel A MOP page is displayed as refuel a wpt xxx (where xxx is waypoint number to which refuel pattern is assigned).

If Refuel B MOP page was accessed from Alternate Flight Plan Leg A page (defined refuel pattern), title line of Refuel A MOP page is displayed as refuel a leg xx (where xx is leg number to which refuel pattern is assigned).

Left side of information line on Refuel A MOP page displays pattern width when pattern is active. Width is determined with true airspeed, wind, and 25° bank angle turn, all referenced to turn from outbound leg to inbound leg. Width is recomputed each time airplane overflies control point. A bank angle is computed for inbound to outbound turn to allow a smooth capture of outbound leg. Right side of information line on Refuel A MOP page displays course between initial point and control point in degrees true. This course is pattern orientation.

Right side of data line 3 displays which leg is to be captured when pattern becomes enabled. Display is blanked when leg is captured.

To modify IP or CP of a refuel pattern inserted in flight plan, refuel pattern must be removed from flight plan via Refuel B MOP page. Following modification, refuel pattern can then be reinserted in flight plan. Length, ETD and roll-out range are modifiable at any time.

Figure 1-172 (Sheet 29 of 44)

CDU Menus - Edit (Continued)

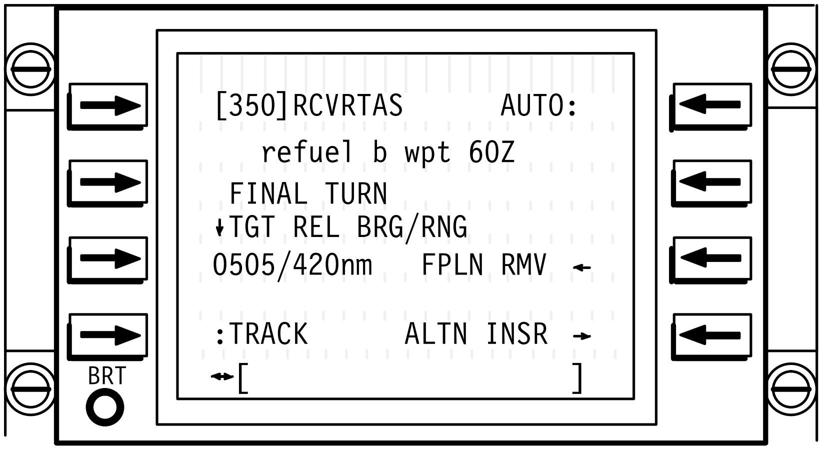
(Refuel a Waypoint) Continued

LS1	With a valid waypoint entry in scratchpad, enters Air Refuel Initial Point (IP). If pattern has been inserted in flight plan or alternate flight plan, causes PATTERN DEFINED scratchpad message to be displayed. With a – in scratchpad, deletes Initial Point. If pattern has been inserted in flight plan or alternate flight plan, deletion is prohibited and causes INVALID DELETION scratchpad message to be displayed. With an empty scratchpad, copies Initial Point into scratchpad.
LS2	With a valid waypoint entry in scratchpad, enters Air Refuel Control Point (CP). If pattern has been inserted in flight plan or alternate flight plan, selection causes PATTERN DEFINED scratchpad message to be displayed. With a – in scratchpad, deletes Control Point. If pattern has been inserted in flight plan or alternate flight plan, deletion is prohibited and causes INVALID DELETION scratchpad message to be displayed. With an empty scratchpad, copies Control Point into scratchpad.
LS3	With a valid entry in scratchpad, enters pattern length in nautical miles. Default length is 14 nautical miles. With a – in scratchpad, sets length to default. With an empty scratchpad, copies length into scratchpad.
LS4	With a valid entry in scratchpad, enters ETD. With a – in scratchpad, deletes ETD. With an empty scratchpad, copies ETD into scratchpad.
LS8	With a blank scratchpad, toggles between LEAD and TRAIL for roll-out range. If LEAD is displayed, airplane leads receiver by specified distance upon roll-out onto inbound leg, and if TRAIL is displayed, airplane trails receiver by specified distance upon roll-out onto inbound leg. With a valid entry in scratchpad, enters roll-out range in nautical miles. Roll out range default is LEAD 3.0 nautical miles. With a – in scratchpad, sets roll-out range to default.

Lateral scrolling accesses Refuel B MOP page, and wraps around.

Figure 1-172 (Sheet 30 of 44)

(Refuel b Waypoint)



```
[350]RCVRTAS      AUTO:
   refuel b wpt 60Z
 FINAL TURN
↓TGT REL BRG/RNG
0505/420nm   FPLN RMV ←

:TRACK      ALTN INSR →
↔[                    ]
```

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NOTE

> Refuel B MOP page is accessed from Refuel A MOP page, Flight Plan Waypoint page, or Alternate Flight Plan Leg A page.

Data line 3 displays desired final turn target relative bearing and final turn range between airplane and receiver, as calculated with desired roll-out range, pattern width, and receiver true airspeed, when mode is rendezvous. This allows comparison with actual values from radar, TACAN, or other sources.

Title line reflects page access as follows:

> If Refuel A MOP page was accessed from Patterns page (for definition), or Refuel A MOP page was removed from flight plan or alternate flight plan, then title line of Refuel B MOP page is displayed as refuel b.
>
> If Refuel B MOP page was accessed from Flight Plan Waypoint page (defined refuel pattern), title line is displayed as refuel b wpt xxx (where xxx is waypoint number to which refuel pattern is assigned). Line 7 is displayed as FPLN RMV← and Line 8 is displayed as ALTN INSR.
>
> If Refuel B MOP page was accessed from Alternate Flight Plan Leg A page (defined refuel pattern), title line is displayed as refuel b leg xx (where xx is leg number to which refuel pattern is assigned). Line 7 is displayed as FPLN INSR and Line 8 is displayed as ALTN RMV←.

Modification to receiver true airspeed entry can be performed regardless of whether refuel pattern has been inserted into flight plan.

Figure 1-172 (Sheet 31 of 44)

CDU Menus - Edit (Continued)

(Refuel b Waypoint) Continued

LS1 With a valid entry in scratchpad, enters receiver true airspeed (RCVRTAS). If no receiver true airspeed is entered, final turn relative bearing and range on data line 3 is dashed.

With a – in scratchpad, deletes true airspeed. If receiver true airspeed is deleted, final turn relative bearing and range on data line 3 is dashed.

With an empty scratchpad, copies receiver true airspeed into scratchpad.

LS4 Toggles among DISABLED, ORBIT, RDVZ, and TRACK. Default is DISABLED. When toggled to DISABLED, airplane follows flight plan and disregards pattern.

Can be toggled from DISABLED to ORBIT, RDVZ, or TRACK at any time. Pattern, however, can only become active when CP is TO waypoint. When pattern becomes active, airplane captures, by means of a direct entry, inbound or outbound leg.

With DISABLED displayed, toggles display to ORBIT and initiates orbit mode. When toggled to ORBIT, DISABLED option is no longer available until pattern is terminated.

With ORBIT displayed, toggles display to RDVZ and initiates rendezvous mode. If on inbound leg, airplane immediately turns to capture outbound course and holds this course until final turn is made. If airplane is on outbound leg when this selection is made, airplane holds outbound course until final turn is made.

With RDVZ displayed, toggles display to TRACK and initiates final turn. Airplane turns to capture inbound course and holds this course until pilot re-enters orbit mode by pressing toggle again or terminates pattern by performing a Direct–To.

LS5 Toggles among AUTO, OUTBOUND, and INBOUND. Default is AUTO. When pattern becomes active with key toggled to AUTO, airplane captures inbound or outbound leg of pattern as determined by FMS. Leg to be captured is displayed on data line 3 of Refuel A MOP page.

With AUTO displayed, toggles display to OUTBOUND. When toggled to OUTBOUND, airplane captures outbound leg.

With OUTBOUND displayed, toggles display to INBOUND. When toggled to INBOUND, airplane captures inbound leg.

Figure 1-172 (Sheet 32 of 44)

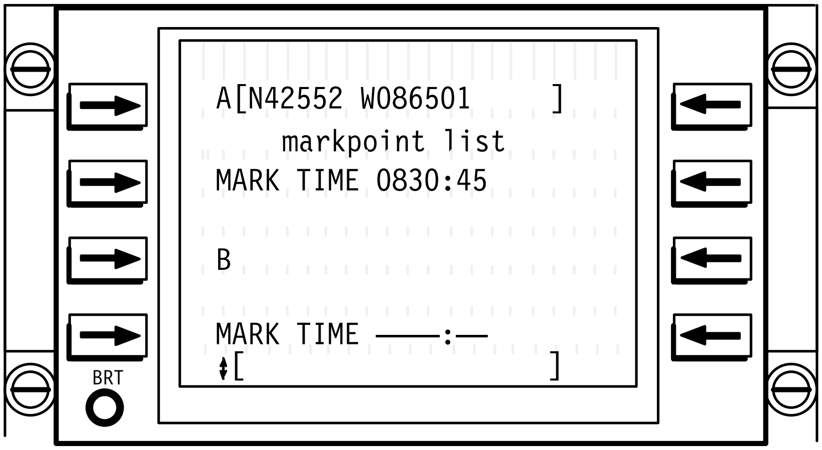
LS7	With FPLN INSR displayed adjacent to it, accesses Flight Plan page. If a control point has been defined on Refuel A MOP page, INSERT RFL BEFORE? is displayed in scratchpad. If a control point has not been defined on Refuel A MOP page, ATTACH RFL AT? is displayed in scratchpad. Note that IP is not inserted as a flight plan waypoint. With FPLN RMV← written adjacent to it, removes refuel pattern from flight plan after confirmation indicated by CONFIRM FPLN RMV scratchpad message. If refuel pattern defined on Refuel A MOP page is active, FPLN RMV← is replaced by FPLN* and pattern is not removable. With no initial point entered on Refuel A MOP page, causes ENTER PARAMETERS scratchpad message to be displayed.
LS8	With ALTN INSR written adjacent to it, accesses Alternate Flight Plan Leg A page. If a control point has been defined on Refuel A MOP page, INSERT RFL BEFORE? is written in scratchpad. If a control point has not been defined on Refuel A MOP page, ATTACH RFL AT? is written in scratchpad. With ALTN RMV← written adjacent to it, removes refuel pattern from alternate flight plan after confirmation indicated by CONFIRM ALTN RMV scratchpad message. With no initial point entered on Refuel A MOP page, causes ENTER PARAMETERS scratchpad message to be displayed.

Lateral scrolling accesses Refuel A MOP page, and wraps around.

Figure 1-172 (Sheet 33 of 44)

CDU Menus - Edit (Continued)

(Markpoint List)



```
A[N42552 W086501     ]
    markpoint list
MARK TIME 0830:45

B

MARK TIME ——:—
⇕[                   ]
```

NOTE

- Markpoint List page is accessed from Flight Plan Edit page. Last scrolled position is accessed.
- Markpoint list defines up to ten markpoints and stores them in a single list.

Data lines 1 and 3 display latitude/longitude of markpoints entered via MARK key. When crew initiates a MARK, position of airplane based upon designated pilot's navigation solution is displayed in scratchpad and is stored automatically (with mark time) in next available markpoint location (A thru J, sequentially). Brackets are displayed only for those locations which contain markpoints. Up to 10 markpoints can be defined on markpoint list, and additional entries overwrite first mark (that is, eleventh mark overwrites first, twelfth mark overwrites second, and so forth).

Data lines 2 and 4 display time of mark for markpoint displayed immediately above it. Display is dashed if a markpoint is not entered in above location.

Data For operation is available for markpoint list points (see Data Page description).

UDIDs are allowed.

LS1,3,5, or 7 With a blank scratchpad, copies associated waypoint into scratchpad.

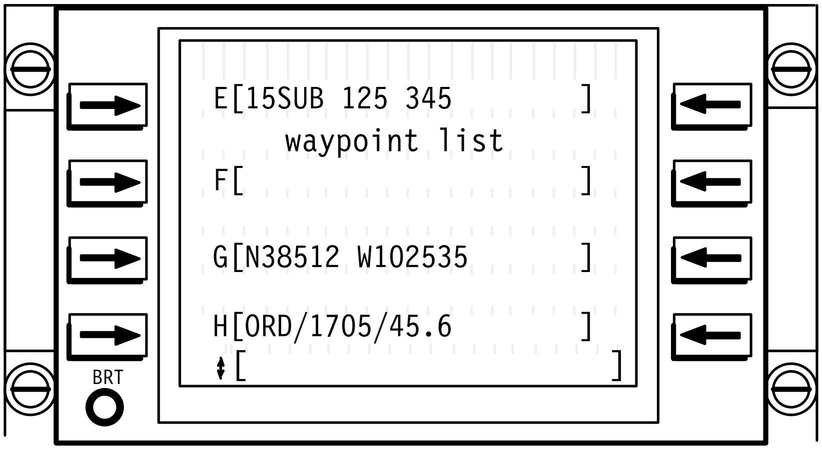
With a – in scratchpad, deletes markpoint associated with line select. If a markpoint deletion is performed on a point other than last markpoint, list contracts to remove gap.

With a manually entered waypoint in scratchpad, causes INVALID ENTRY scratchpad message to be displayed.

Vertical scrolling accesses additional Markpoint List pages, and wraps around. Down scroll key accesses additional markpoints, two at a time, in increasing alphabetic order. Up scroll key accesses additional markpoints, two at a time, in decreasing alphabetic order.

Figure 1-172 (Sheet 34 of 44)

(Waypoint List)



```
E[15SUB 125 345        ]
    waypoint list
F[                     ]

G[N38512 W102535       ]

H[ORD/1705/45.6        ]
↕[                       ]
```

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NOTE

Waypoint List page is accessed from Flight Plan Edit page. Last scrolled position is accessed.

LS1 thru 8	With a valid waypoint entry in scratchpad, each key enters position (up to 20, A thru T) adjacent to line select pressed. If this line already contains a waypoint, it is overwritten when new position is entered. With a – in scratchpad, deletes waypoint associated with that line select. With a blank scratchpad, copies associated waypoint into scratchpad.

UDIDs are allowed.

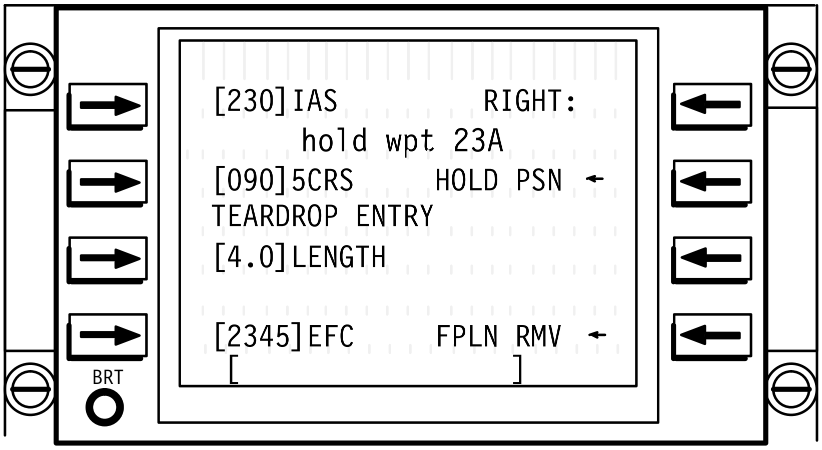
Vertical scrolling accesses additional Waypoint List pages, and wraps around. Down scroll key accesses waypoints, four at a time, in increasing alphabetic order. Up scroll key accesses waypoints, four at a time, in decreasing alphabetic order.

Data For operation is available for waypoint list points. See Data Page description.

Figure 1-172 (Sheet 35 of 44)

CDU Menus - Edit (Continued)

(Hold)



```
[230]IAS         RIGHT:
     hold wpt 23A
[090]5CRS     HOLD PSN ←
TEARDROP ENTRY
[4.0]LENGTH

[2345]EFC     FPLN RMV ←
 [                 ]
```

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NOTE

Hold page is accessed from Flight Plan Edit page or Flight Plan Waypoint page.

Information line displays following information:

Prior to entry into hold, information line displays type of entry as either DIRECT ENTRY, TEARDROP ENTRY, or PARALLEL ENTRY. When hold becomes active, type of entry is removed and HOLD ACTIVE is displayed on annunciation line.

Title line displays hold if a hold is not inserted into flight plan, and hold wpt xxx (where xxx is number of waypoint to which hold definition is attached) if hold is inserted into flight plan.

LS1 With an entry in scratchpad, enters Indicated Airspeed (IAS), for holding, in knots. Entered airspeed is displayed on Pilot and Copilot Lateral Steer pages as CMD IAS, and is applied three minutes prior to holding waypoint. Default airspeed is 230 knots.

With a – in scratchpad, sets IAS to its default value.

With an empty scratchpad, copies IAS into scratchpad.

Figure 1-172 (Sheet 36 of 44)

LS2	With a valid course in scratchpad, enters course inbound to holding fix in degrees. Default course is inbound course from flight plan for waypoint to which hold is attached. This is displayed as [INB]°CRS prior to inserting holding pattern into flight plan. If hold definition has not been attached to a waypoint, and no course has been entered, degrees (°) symbol for inbound course is displayed as $^{\circ}_{\mathrm{T}}$ when true/mag discrete is set to true. If true/mag discrete is set to magnetic and no course entry has been made, course is displayed with ° symbol. When a course is entered, format of ° symbol for course display is dependent on how course was entered. If course was entered as magnetic and hold definition has not been attached to a waypoint, ° is displayed regardless of state of true/mag discrete. If holding pattern has been attached to a waypoint, and operator attempts to enter course as magnetic, and no magnetic variation or declination data is available for holding fix, a NO MAG VAR scratchpad message is displayed and course entry requires a true value (for example, entry of 360T). If course was entered as true, $^{\circ}_{\mathrm{T}}$ symbol is displayed regardless of state of true/mag discrete. With a – in scratchpad, returns display to value for inbound course from flight plan, if hold has been inserted into flight plan, or [INB] if hold has not been inserted into flight plan. With an empty scratchpad, copies course into scratchpad.
LS3	With an entry in scratchpad, enters pattern length in nautical miles. Default length is 4.0 nautical miles. With a – in scratchpad, sets length to its default value. With an empty scratchpad, copies length into scratchpad.
LS4	With a valid entry in scratchpad, enters Expected Further Clearance (EFC) time. With a – in scratchpad, deletes EFC. With an empty scratchpad, copies EFC into scratchpad.
LS5	Toggles between right and left turns in pattern. A default right turn direction is used.
LS6	Allows for immediate execution of a holding pattern with designated pilot's present position as fix point. This operation requires a confirmation indicated by scratchpad message CONFIRM HOLD PSN. If course has been altered prior to activation of this function, it is overwritten by current airplane track. If hold at present position is selected when flight plan is full, FPLN FULL scratchpad message is displayed. If a future hold is entered in flight plan, and hold at present position is executed, future hold is not removed from flight plan. Hold at present position function is not available while an MFP or hold is active. An attempt to hold at present position while an MFP or hold is active causes xxx IS ACTIVE scratchpad message to be displayed, where xxx is CIR, CRP, FG8, RTK, RFL or HOLD.

Figure 1-172 (Sheet 37 of 44)

CDU Menus - Edit (Continued)

(Hold) Continued

Upon confirmation of hold-at-present-position function, following events occur:

- LS8 displays FPLN*.
- HOLD ACTIVE is displayed on annunciation line
- Title line on HOLD page changes to hold wpt xxx
- Holding fix (airplane position in Lat/Long when HOLD PSN was confirmed) is inserted as TO with H attribute attached. Point takes on number prior to previous TO waypoint in flight plan.

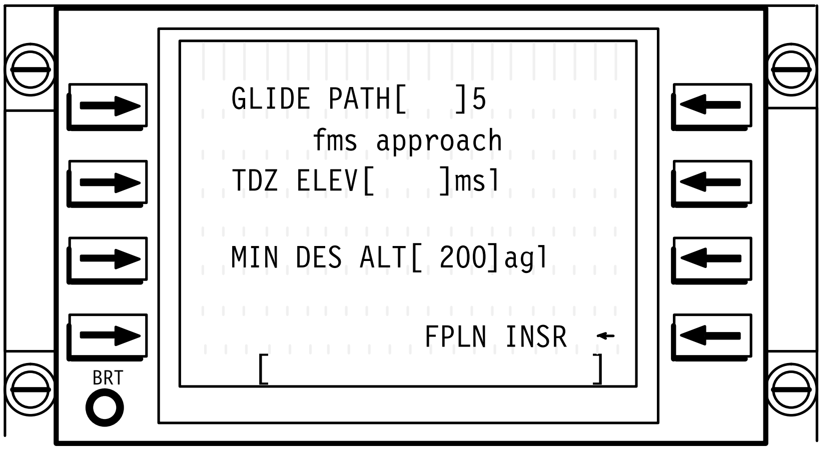
LS8 If hold definition displayed on this page has not been inserted into flight plan, FPLN INSR is written adjacent to LS8. If hold definition displayed on this page has been inserted into flight plan, FPLN RMV← is displayed adjacent to LS8.

With FPLN INSR written adjacent to it, accesses Flight Plan page and ATTACH HOLD AT? is written in scratchpad.

With FPLN RMV← written adjacent to it, removes hold from flight plan after confirmation indicated by CONFIRM FPLN RMV scratchpad message. If hold is active, FPLN RMV← is replaced by FPLN* and hold is not removable from Hold page.

Figure 1-172 (Sheet 38 of 44)

(Approach)



GLIDE PATH[   ]5
fms approach
TDZ ELEV[   ]msl

MIN DES ALT[200]agl

FPLN INSR ←
[   ]

NOTE

FMS Approach page is accessed from Flight Plan Edit Page or from Flight Plan Waypoint page.

Title line displays fms approach if an FMS approach is not inserted into flight plan, and displays fms approach wpt xxx (where xxx is waypoint number) if FMS approach is inserted into flight plan.

During execution of an FMS approach, FAF and MAP are used to define inbound course for approach. When MAP becomes TO waypoint, flight plan switches to MAN mode.

LS1,5 With a valid scratchpad entry, enters a glide path angle for approach, which represents desired vertical descent angle. If MAP is TO waypoint, APPROACH IS ACTIVE scratchpad message is displayed and insertion is prohibited.

With a – in scratchpad, deletes glide path entry if FMS approach has not been inserted in flight plan. If FMS approach has been inserted, causes INVALID DELETION scratchpad message to be displayed and deletion is prohibited.

With an empty scratchpad, copies glide path into scratchpad.

LS2,6 With a valid scratchpad entry, enters Touchdown Zone (TDZ) elevation Mean Sea Level (MSL). If MAP is TO waypoint, APPROACH IS ACTIVE scratchpad message is displayed and insertion is prohibited.

With a – in scratchpad, deletes TDZ elevation if FMS approach has not been inserted in flight plan. If FMS approach has been inserted, causes INVALID DELETION scratchpad message to be displayed and deletion is prohibited.

With an empty scratchpad, copies TDZ into scratchpad.

Figure 1-172 (Sheet 39 of 44)

CDU Menus - Edit (Continued)

(Approach) Continued

LS3,7 With a valid scratchpad entry, enters Minimum Descent Altitude (MDA) Above Ground Level (AGL). MDA default is 200 feet. If MAP is TO waypoint, APPROACH IS ACTIVE scratchpad message is displayed and insertion is prohibited.

With a – in scratchpad, sets MDA to its default value, whether on ground or airborne, if MAP is not TO waypoint. If MAP is TO waypoint, causes APPROACH IS ACTIVE scratchpad message to be displayed and function is prohibited.

With an empty scratchpad, copies MDA into scratchpad.

LS8 If approach definition displayed on this page has not been inserted into flight plan, FPLN INSR is written adjacent to LS8. If approach definition displayed on this page has been inserted into flight plan, FPLN RMV← is displayed adjacent to LS8.

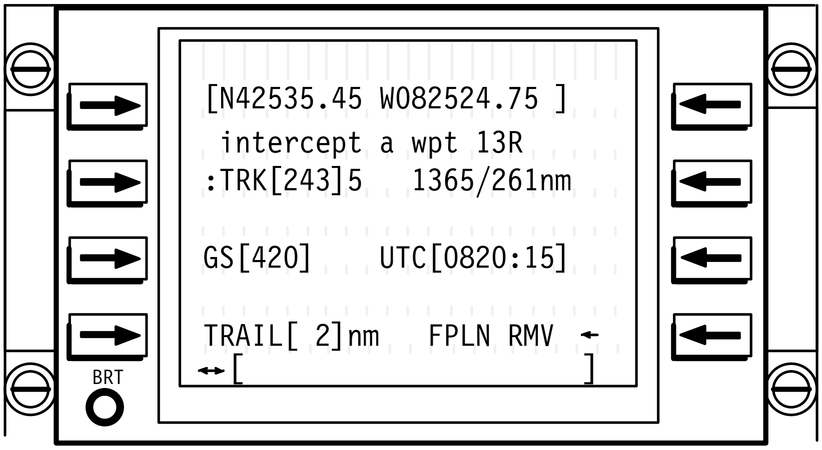
With FPLN INSR adjacent, LS8 accesses Flight Plan page and displays ATTACH FMS APPR AT? in scratchpad.

With FPLN RMV← adjacent, LS8 removes FMS approach from flight plan after confirmation indicated by CONFIRM FPLN RMV scratchpad message. If FMS approach is current TO, FPLN RMV← is replaced by FPLN* and it cannot be removed from FMS Approach page.

If an attempt is made to insert approach definition into flight plan without defining glide path angle and TDZ elevation, ENTER PARAMETERS scratchpad message is displayed and Flight Plan page is not accessed.

Figure 1-172 (Sheet 40 of 44)

(Intercept a)



```
[N42535.45 W082524.75 ]
 intercept a wpt 13R
:TRK[243]5   1365/261nm

GS[420]    UTC[0820:15]

TRAIL[ 2]nm   FPLN RMV ←
↔[                      ]
```

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NOTE

Intercept A page is accessed from Flight Plan Edit page, Flight Plan Waypoint page, or by lateral scrolling from Intercept B page.

Data line 2 displays bearing/distance to current target location. Bearing is in $°_T$ if true/mag discrete is set to true or no magnetic variation tables are available.

If an intercept is not inserted into flight plan, title line displays intercept a. If intercept is inserted into flight plan, title line displays intercept a wpt xxx (where xxx is number of waypoint in flight plan).

LS1,5 With a valid waypoint entry in scratchpad. Enters position of moving target at time of report.

With a – in scratchpad, deletes waypoint. If intercept has been inserted in flight plan, deletion is prohibited and causes INVALID DELETION scratchpad message to be displayed.

Selection with an empty scratchpad copies waypoint into scratchpad.

LS2 With a blank scratchpad, toggles target ground track entry between degrees true and degrees magnetic. Symbol following entry displays $°_T$ for true and ° for magnetic. Default condition of toggle is true. If a target fix has not been entered, selection of LS2 causes ENTER FIX scratchpad message to be displayed. If entered target fix has no associated magnetic variation, selection of LS2 causes NO MAG VAR scratchpad message to be displayed. True/mag discrete does not affect state of this toggle.

With a valid entry in scratchpad, enters target ground track. If an attempt is made to enter a magnetic ground track when target fix has no associated magnetic variation, causes NO MAG VAR scratchpad message to be displayed.

With a – in scratchpad, deletes ground track. If intercept has been inserted in flight plan, deletion is prohibited and causes INVALID DELETION scratchpad message to be displayed.

Figure 1-172 (Sheet 41 of 44)

CDU Menus - Edit (Continued)

(Intercept a) Continued

LS3 With an entry in scratchpad, enters target ground speed in knots.

With a – in scratchpad, deletes ground speed. If intercept has been inserted in flight plan, deletion is prohibited and causes INVALID DELETION scratchpad message to be displayed.

With an empty scratchpad, copies ground speed into scratchpad.

LS4 With an entry in scratchpad, enters along-track-trail-distance in nautical miles. Default is 0 nm.

With a – in scratchpad, sets trail distance to its default value.

With an empty scratchpad, copies trail distance into scratchpad.

LS7 With a valid UTC entry in scratchpad, enters time of target report. This display defaults to current time when position is entered in data line 1.

With a – in scratchpad, deletes time. If intercept has been inserted in flight plan, deletion is prohibited and causes INVALID DELETION scratchpad message to be displayed.

With an empty scratchpad, copies time into scratchpad.

LS8 If intercept definition displayed on this page has not been inserted into flight plan, FPLN INSR is written adjacent to LS8. If intercept definition displayed on this page has been inserted into flight plan, FPLN RMV← is displayed adjacent to LS8.

If there are less than ten intercepts in flight plan, selection of LS8 with FPLN INSR written adjacent to it accesses Flight Plan page, and INSERT INTR BEFORE? is written in scratchpad.

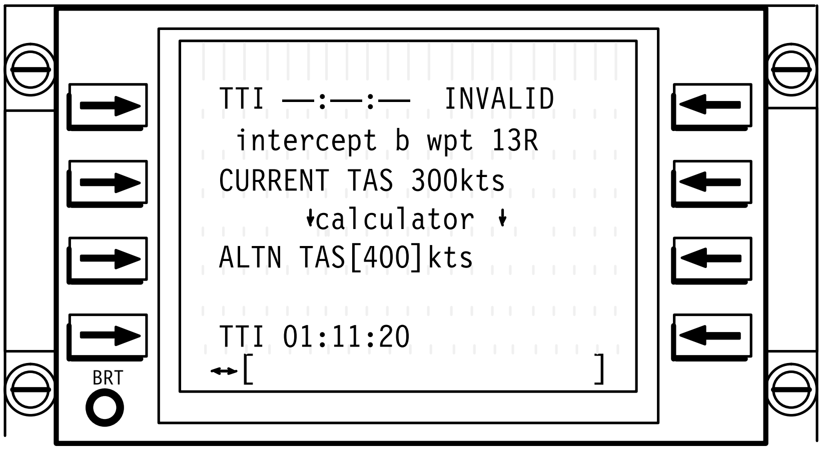
With FPLN RMV← written adjacent to it, removes intercept from flight plan after confirmation indicated by CONFIRM FPLN RMV scratchpad message. If intercept is active, FPLN RMV← is replaced by FPLN* and intercept is not removeable from Intercept page.

If an attempt is made to insert an intercept into flight plan without defining target location, ground track, and ground speed, ENTER PARAMETERS scratchpad message is displayed.

Lateral scrolling accesses Intercept B page, and wraps around.

Figure 1-172 (Sheet 42 of 44)

(Intercept b)



```
TTI —:—:—  INVALID
 intercept b wpt 13R
CURRENT TAS 300kts
     ↓calculator ↓
ALTN TAS[400]kts

TTI 01:11:20
↔[                    ]
```

NOTE

Intercept B page is accessed by lateral scrolling from Intercept A page.

Data line 1 displays time to intercept (hr:min:sec). If an intercept is not possible, an intercept point is generated 1000 nautical miles down track from fix position. In this case, time to intercept on left side of data line 1 is dashed while right side of data line 1 displays INVALID.

Data line 2 displays current airplane true airspeed in knots.

Data line 4 displays an alternate solution corresponding to alternate true airspeed entered on data line 3. Display format is identical to data line 1 (that is, INVALID is displayed on right side of line when an intercept is not possible).

If an intercept is not inserted into flight plan, title line displays intercept b. If intercept is inserted into flight plan, title line displays intercept b wpt xxx (where xxx is number of waypoint in flight plan).

Calculator function is only available, and only displayed, for first intercept in flight plan or for an intercept not entered in flight plan. Data lines 3 and 4 are replaced with INTERVENING INTERCEPT and NO CALCULATOR SOLUTION, respectively, when selected intercept is in flight plan, but a different intercept has been inserted between present position and subject intercept.

LS3 Enters airplane true airspeed for an alternate intercept solution. Default airspeed is 360 knots. This entry is applied only to calculator function and does not affect intercept definition itself.

With a – in scratchpad, sets alternate true airspeed to its default value.

With an empty scratchpad, copies alternate true airspeed into scratchpad.

Lateral scrolling accesses Intercept A page, and wraps around.

Figure 1-172 (Sheet 43 of 44)

CDU Menus - Edit (Continued)

(Intercept b) Continued

A desired time of arrival can be specified at intercept point. This time is enterable on Flight Plan Waypoint page associated with intercept waypoint in flight plan. Commanded ground speed to achieve intercept is computed and is displayed on Pilot and Copilot Lateral Steer pages.

For intercepts entered in flight plan, solution is based on along-flight-plan parameters, while for intercepts not entered in flight plan, solution is based on Direct–To execution of intercept.

When intercept solution for active waypoint is invalid, NO INTERCEPT annunciation is displayed.

Ground speed entry on Data page is used to calculate intercepts while airplane is on ground. This ground speed is displayed on data line 2.

Figure 1-172 (Sheet 44 of 44)

CDU Menus - Data

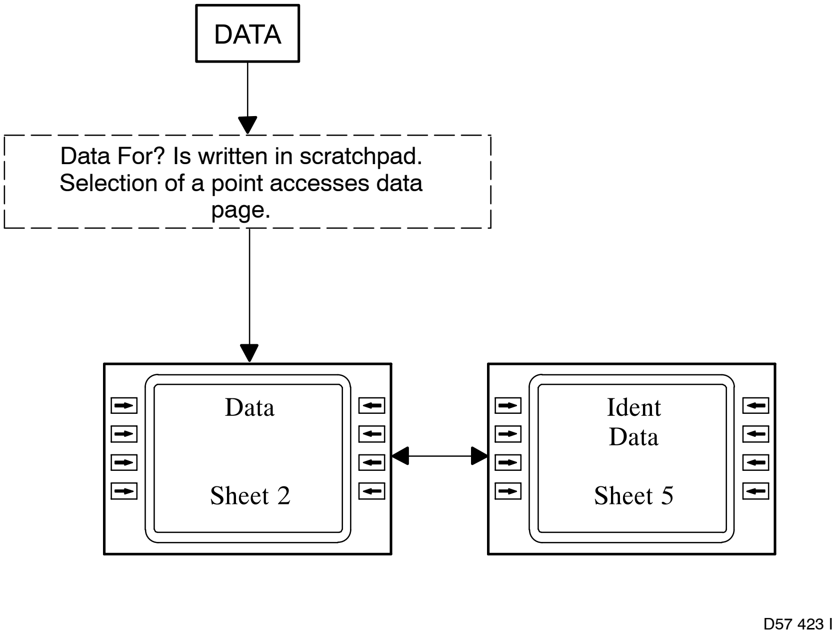
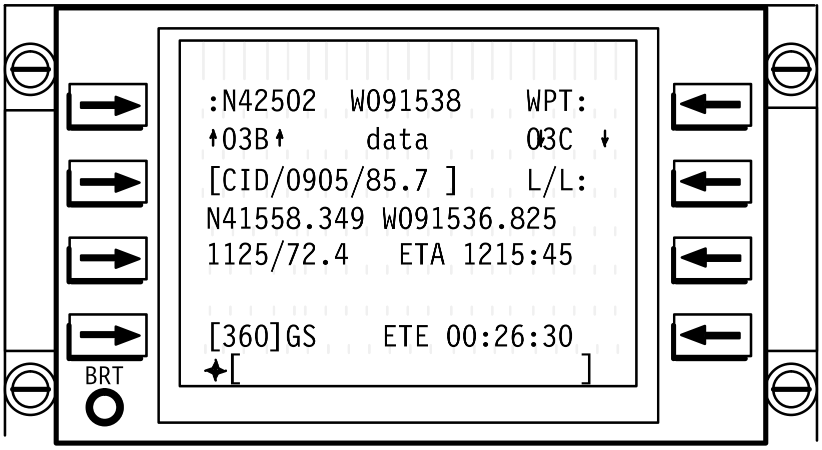


Figure 1-173 (Sheet 1 of 5)

CDU Menus - Data (Continued)



```
:N42502  W091538    WPT:
↑03B↑     data      03C ↓
[CID/0905/85.7 ]    L/L:
N41558.349 W091536.825
1125/72.4   ETA 1215:45

[360]GS    ETE 00:26:30
✦[                       ]
```

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NOTE

> Data page is accessed by pressing DATA key, which causes scratchpad message DATA FOR?, and pressing a line select key adjacent to an operator enterable waypoint.

Information line displays position of selected Data For point. Display format is dependent on state of LS6.

Data line 3 displays bearing/distance from position in data line 1 to selected Data For point or entered point displayed on data line 2. Bearing is true referenced if true/mag discrete is set to true or no magnetic variation or declination data is available. Data line 3 also displays ETA to TO based on current airplane true airspeed, wind, and current time if in flight, or on entered ground speed and current time if on ground. If TO and FROM waypoints displayed on page are same point, bearing displays 360°, distance displays 0 and ETA is dashed. If ETA of selected TO waypoint is more than 24 hours in future, ETA displays **:**:**.

Data line 4 displays Estimated Time Enroute (ETE) between FROM and TO based on current airplane true airspeed and wind when airborne or on entered ground speed if on ground. If TO and FROM waypoints displayed on page are same point, ETE displays 00:00:00. If ETE is greater than 23:59:59, asterisks are displayed.

LS1 Flight Plan Points: Toggles between FROM waypoint (displayed as on Flight Plan page) for Data For point on data line 2 and airplane present position based on designated pilot's solution (Nddmm Wdddmm). When LS1 is toggled from present position to FROM waypoint, TO waypoint displayed on data line 2 remains fixed, FROM waypoint displayed on data line 1 is flight plan waypoint prior to TO and title line displays ↑xxx↑ (left justified) where xxx is associated waypoint number. When LS1 is toggled to present position, title line displays ↑PSN↑. When page is initially accessed for a flight plan waypoint, flight plan point prior to TO is displayed.

If FROM waypoint displayed on Data page is deleted from flight plan, FROM waypoint changes to present position as described above.

Non-Flight Plan Points: Key is inoperative and displays airplane present position (Nddmm Wdddmm) based on designated pilot's solution, and title line displays ↑PSN↑. The colon adjacent to LS1 is not displayed.

Figure 1-173 (Sheet 2 of 5)

Flight Plan FROM and Non-Flight Plan TO: Toggles to present position as described for flight plan waypoints. Once toggled to present position, the colon adjacent to LS1 is removed and no further toggle action is allowed.

Flight Plan Points: This data line displays, as TO, selected Data For waypoint (displayed as on Flight Plan page). When selected Data For point is a flight plan waypoint, title line (right justified) displays ↓xxx↓ where xxx is associated waypoint number. Key allows entry of a waypoint. When an operator entered waypoint is displayed, title line will display ↓DIR↓, display adjacent to LS5 is blanked, and vertical scrolling is inhibited. User defined labels cannot be defined for these waypoints.

If TO waypoint displayed on Data page is deleted from flight plan, FROM remains fixed, vertical scrolling mode of LS5 is blanked, TO waypoint is blanked, scrolling is inhibited, title line displays ↓DIR↓, information is blanked, and ETA, ETE, bearing, and distance displays are dashed.

Non-Flight Plan Points: This data line displays, as TO, selected Data For waypoint (displayed as entered). Title line displays ↓DIR↓ (right justified). LS2 allows operator to enter other waypoints. User defined labels cannot be defined for these waypoints.

With a blank scratchpad, copies TO waypoint into scratchpad.

LS4 With an entry in scratchpad, enters ground speed to be used while on ground (during flight, or while model airplane is toggled to RUNNING, ground speed display is removed and key is inoperative). Default ground speed is 360 knots.

When display is present, with a blank scratchpad, copies ground speed into scratchpad.

Entering a – in scratchpad and pressing LS4 sets ground speed to default value.

Ground speed displayed is used for ETA and ETE computations as well as for intercept and MFP bank angle computations when on ground.

LS5 Flight Plan Points: Toggles vertical scrolling for flight plan waypoints between waypoint (WPT) and leg (LEG). When toggled to WPT, vertical scrolling scrolls only TO. When toggled to LEG, vertical scrolling scrolls TO and FROM waypoints. Mode is LEG upon initial access to this page.

When scrolling mode is toggled from WPT to LEG, TO waypoint is fixed and FROM waypoint associated with it is displayed in data line 1. If no FROM exists in flight plan, present position is used as FROM waypoint.

If a waypoint is entered via LS2, label adjacent to LS5 is not displayed, line select is inoperative, and vertical scrolling is inhibited.

Present Position: Label adjacent to LS5 is not displayed, line select is inoperative, and vertical scrolling is inhibited.

LS6 Toggles TO waypoint position display on information line between latitude/longitude (L/L) and Military Grid Reference System (MGRS). Display is L/L upon initial access to page.

Figure 1-173 (Sheet 3 of 5)

CDU Menus - Data (Continued)

Lateral scrolling accesses Ident Data page, and wraps around.

Vertical scrolling operates in accordance with selected scrolling mode as described for LS5 above. Vertical scrolling is not allowed prior to oldest history waypoint or after last flight plan waypoint. When oldest flight plan history point is displayed, symbol adjacent to scratchpad indicates lateral or down scrolling only. When last flight plan waypoint is displayed, symbol adjacent to scratchpad indicates lateral or up scrolling only. Vertical scrolling is not allowed for non-flight plan waypoints, in which case symbol adjacent to scratchpad indicates lateral scrolling only.

Data function is used to generate what if? scenarios for computations between two flight plan waypoints or between present position and a selected TO waypoint. Data function computes bearing and distance between a FROM waypoint and a TO waypoint as well as ETE between FROM and TO waypoints. An ETA is also computed based on FROM/TO pair. All times computed by data function are computed based on a constant true airspeed assumption.

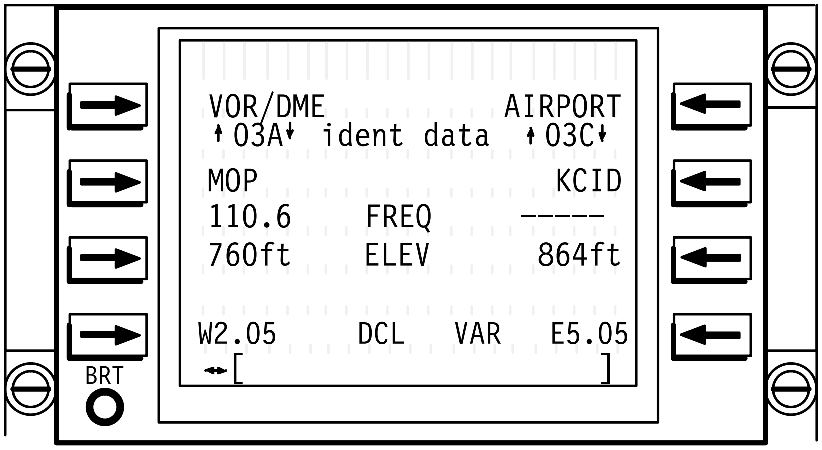
Data page displays a FROM waypoint and a TO waypoint. TO waypoint can be a manually entered point, a non-flight plan waypoint or a flight plan waypoint. When Data page is accessed with a manually entered point, FROM displays present position and all displays on Data page are based on direct computations between FROM and TO. If data function is performed for a flight plan waypoint, FROM waypoint is point prior to waypoint selected. If FROM waypoint is a future flight plan waypoint, ETA displayed is computed along flight plan to FROM and then to TO. If FROM is a history waypoint, ETA is computed direct from present position to TO.

If data function is performed for a flight plan waypoint and an inactive pattern is defined at an intervening waypoint, function utilizes ETD or EFC to compute a loiter time for pattern. If an ETD/EFC does not exist, zero loiter time is assumed in computations. If an ETD or EFC exists, an ETA is computed to fix point. This ETA is then compared to ETD/EFC of pattern to determine if ETD/EFC has already elapsed. If ETD/EFC has already elapsed, ETA display on Data Page is dashed. If ETD/EFC has not elapsed, data function computes a delta time by subtracting ETA of fix point from ETD/EFC. This computation results in an estimated loiter time remaining. This time is then used in conjunction with normal data computations to determine ETA of selected waypoint, which is computed along the flight plan.

If a pattern is active and data function is performed to a flight plan waypoint outside of pattern, data function first checks for a valid ETD or EFC if FROM is not a history waypoint. If an ETD or EFC has not been entered, ETA display on Data page is dashed. If an ETD/EFC exists, it is checked against current time to determine if ETD/EFC has already elapsed. If ETD/EFC has already elapsed, ETA on Data page is dashed. If ETD/EFC has not elapsed, a loiter time is computed as described above (using current time and ETD/EFC) and used in conjunction with normal time computations to determine ETA for selected point. If a pattern is active and data function is performed to a flight plan waypoint outside of pattern and FROM is a history point, ETA display is computed direct from present position to TO waypoint.

When data function is performed for a CRP pattern point (not fix), whether in flight plan or not, present position is used as FROM. In this instance, function computes parameters direct to selected point.

Figure 1-173 (Sheet 4 of 5)



D57 425 I

NOTE

Ident Data page is accessed by lateral scrolling from Data page.

Data line 1 displays waypoint types for both FROM and TO waypoints. Possible types are FIX (waypoint fix), AIRPORT, NDB, NDB/DME, DME, VOR, VORTAC, TACAN, and VOR/DME. If no identifier exists (for example, for a latitude/longitude), display is blank.

Title line displays associated waypoint number if point is an identifier in flight plan, PSN if point is present position, or DIR if point is not in flight plan, similarly to Data page. TO waypoint (or DIR point) is right justified and FROM waypoint is left justified.

Data line 2 displays identifier for associated FROM or TO waypoints if one exists. If no identifier exists (for example, for a latitude/longitude), display is blank.

Information line displays frequency.

Data line 3 displays station elevation.

Data line 4 displays either station declination (DCL) or magnetic variation (VAR) of FROM and TO waypoints. If point is a waypoint, airport, NDB, NDB/DME, latitude/longitude, UTM, RPID/bearing/distance, or DME, magnetic variation is displayed if valid. Dashes are displayed if no magnetic variation is available for that location. If point is a VOR, VORTAC, TACAN, or VOR/DME, station declination is displayed. For values greater than 99°, display is rounded to nearest degree.

Lateral scrolling returns to Data page from which Ident Data page was originally accessed, and wraps around.

Figure 1-173 (Sheet 5 of 5)

CDU Menus - INAV

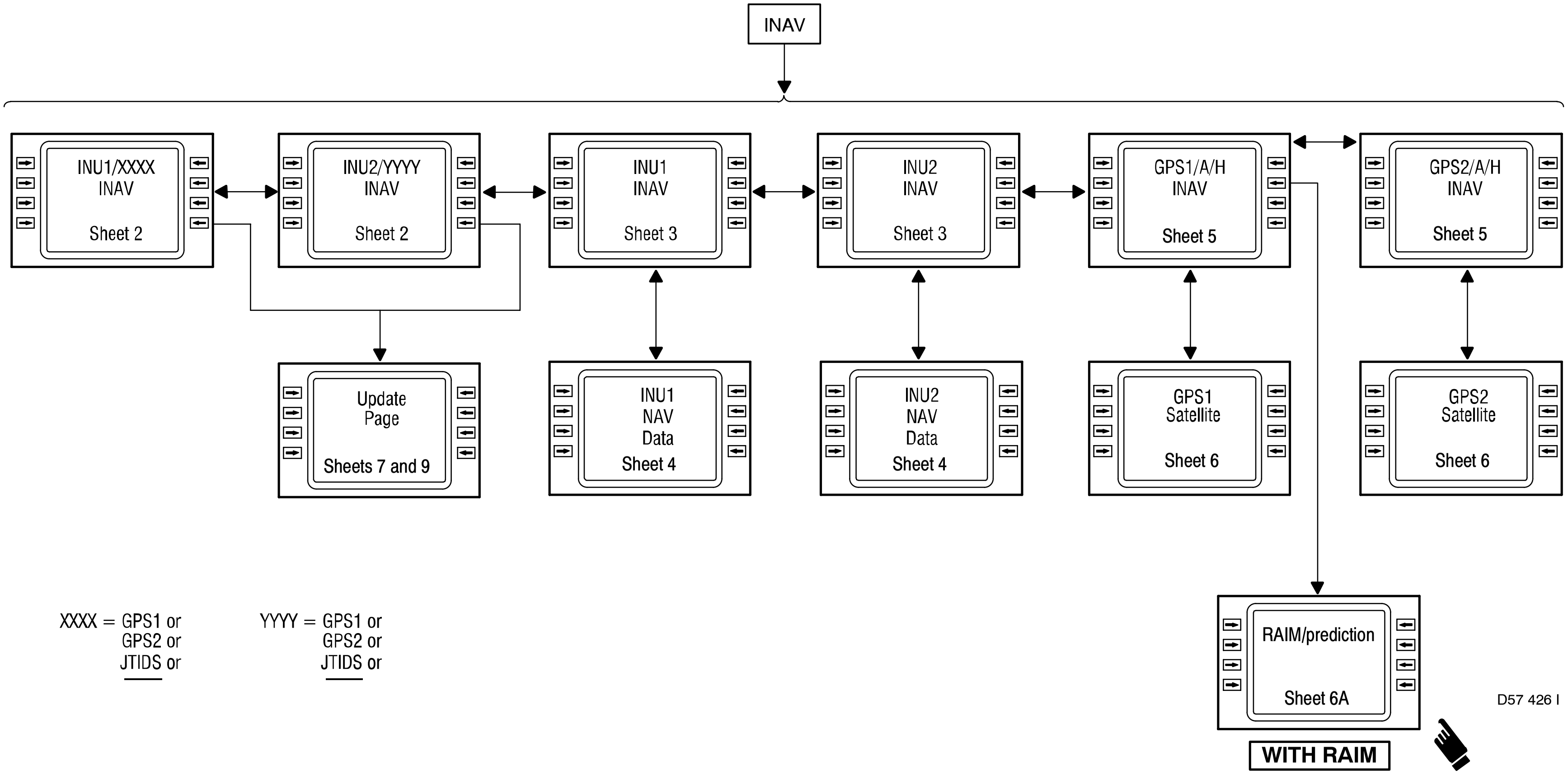
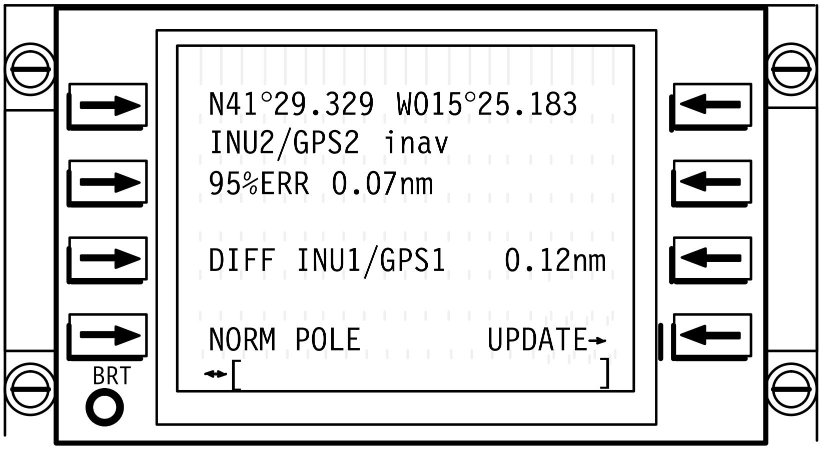


Figure 1-174 (Sheet 1 of 11)



NOTE

- There are separate INAV pages for each of six navigation solutions: INU1/XXXX, INU2/YYYY, INU1, INU2, GPS1/A/H, and GPS2/A/H. Page displayed when INAV key is pressed is last page that was accessed on that CDU, except after a cold start when INU1/XXXX INAV page is displayed.

- INU1/GPS1 is EGI1 default solution. If GPS1 fails, EGI1 automatically reverts to INU1/GPS2. If GPS1 and GPS2 both fail, EGI1 automatically reverts to INU1/JTDS. If GPS1, GPS2, and JTDS all fail, EGI1 automatically reverts to INU1/——. EGI2 operates in an analogous manner.

Data line 1 displays Present Position Latitude and Present Position Longitude for navigation solution shown on title line. Navigation solution position is displayed regardless of its validity.

WITH GA INU1/XXXX and INU2/YYYY solutions are continuously monitored by GINS. If any of the following conditions exist for more than 30 consecutive seconds, the VFY BLENDED (1,2) annunciation is displayed:

a. INU1/XXXX or INU2/YYYY 95%ERR is > 0.3 nm (APPROACH), 1.7 nm (TERMINAL), or 2.8 nm (ENROUTE).

b. (VFY BLENDED1) Difference between INU1/GPS1 and INU2/GPS2 > [1.224(INU1/GPS1 95%ERR + INU2/GPS2 95%ERR)] AND difference between INU1/GPS1 and GPS1 > [1.224(INU1/GPS1 95%ERR + GPS1 95%ERR)].

c. (VFY BLENDED2) Difference between INU2/GPS2 and INU1/GPS1 > [1.224(INU2/GPS2 95%ERR + INU1/GPS1 95%ERR)] AND difference between INU2/GPS2 and GPS2 > [1.224(INU2/GPS2 95%ERR + GPS2 95%ERR)]. ◀

Title line displays source of navigation data being displayed. See *figure 1-171*.

Data line 2 displays position index or 95% probable error for navigation solution shown on title line, in nautical miles. Position index computation is based upon EGI EHE. EGI EHE is multiplied by 2.45 to convert EHE to 95% CEP value which represents radius of circle such that probability of being within circle centered at EGI estimate of position is 0.95.

Figure 1-174 (Sheet 2 of 11)

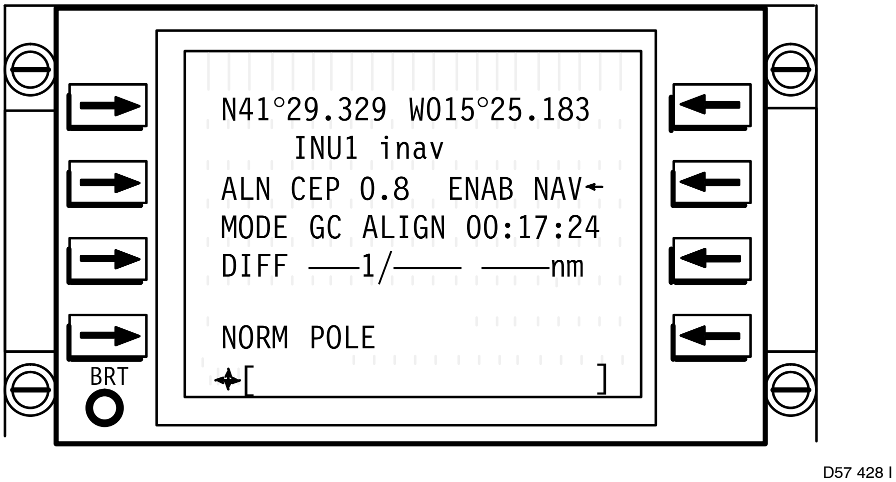
CDU Menus - INAV (Continued)

Data line 3 displays difference in nautical miles between the designated pilot's navigation solution (displayed after DIFF) and source of navigation data on this page.

Data line 4 displays pole type currently being used by INU associated with navigation data source displayed on title line. Two Pole Selection states are possible: NORM – for normal reference, DISP – for displaced reference.

LS8 Accesses Update page.

Lateral scrolling scrolls to other INAV pages in sequence: INU2/YYYY, INU1, INU2, GPS1/A/H, GPS2/A/H, INU1/XXXX, and wrap around.



```
N41°29.329 W015°25.183
     INU1 inav
ALN CEP 0.8  ENAB NAV←
MODE GC ALIGN 00:17:24
DIFF ——1/——— ———nm

NORM POLE
←[                         ]
```

NOTE

> There are separate INAV pages for each of six navigation solutions: INU1/XXXX, INU2/YYYY, INU1, INU2, GPS1/A/H, and GPS2/A/H. Page displayed when INAV key is pressed is last page that was accessed on that CDU, except after a cold start when INU1/XXXX INAV page is displayed.

Data line 1 displays Present Position Latitude and Present Position Longitude for navigation solution selected and displayed on title line. INU navigation solution position is displayed regardless of its validity, and regardless of alignment status.

Title line displays source of navigation data.

Data line 2 displays alignment circular error probable for INU in nautical miles. Value represents EGI Alignment Quality. WITH GA When INU enters MODE NAV, ALN CEP changes to 95%ERR value. The value on the ground is initially the same as the blended solution value for the 95%ERR. After takeoff, the value grows at a rate of 1.7 nm/hr, to reflect the actual value of the free inertial 95% error. The maximum value possible from this display is 21.6 nm, which is reached approximately 13 hrs after takeoff. After reaching this value, "***" is displayed for the 95%ERR. If the EGI mode changes to GC, IFA, or TEST, the display returns to the ALIGN CEP indication.◀

Information line displays sensor mode. Valid modes for INU are GC ALIGN, DG ALIGN, NAV, IFA, or TEST. During DG and GC alignments (including INU IBIT), time of alignment is displayed in hours, minutes, and seconds. Value represents EGI Alignment Time. When EGI is in TEST, enabling NAV mode is prohibited, and scratchpad message EGI IN TEST is displayed.

Figure 1-174 (Sheet 3 of 11)

Data line 3 displays difference in nautical miles between designated pilot's navigation solution (displayed after DIFF) and source of navigation data on this page.

Data line 4 displays pole type currently being used by INU. Two Pole Selection states are possible: NORM – for normal reference, DISP – for displaced reference.

Lateral scrolling scrolls to other Integrated Navigation pages in sequence: INU1, INU2, GPS1/A/H, GPS2/A/H, INU1/XXXX, INU2/YYYY, and wrap around.

WITH GA INU solutions are continuously monitored by GINS. If INU1 (INU2) is in NAV mode and any of the following conditinos exist for more than 30 consecutive seconds, the VFY INU (1,2) annunciation is displayed:

a. The horizontal speed difference between INU1 and GPS1 OR INS2 and GPS2 is greater than 5 knots.

b. The position difference between INU1 and GPS1 > [1.224(INU1 95%ERR + GPS1 95%ERR) + 0.5 nm] OR difference between INU2 and GPS2 > [1.224(INU2 95%ERR + GPS2 95%ERR) + 0.5 nm].

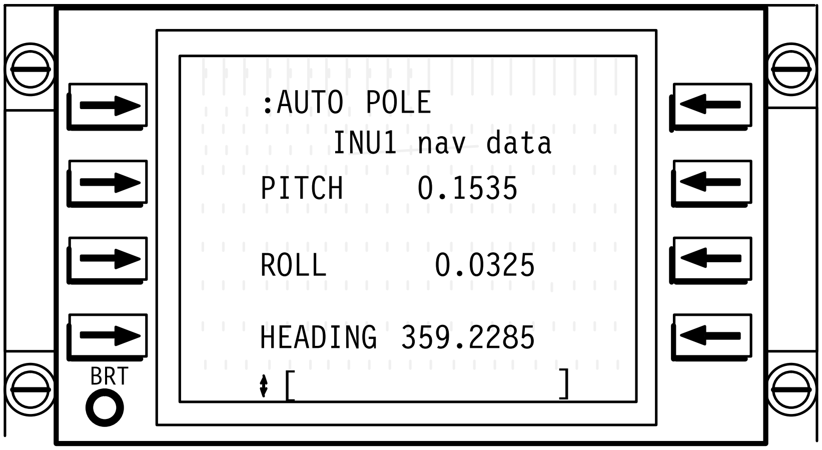
The COMPARE INU annunciation is displayed if both INUs are in NAV mode and either of the following conditions exist for more than 30 consecutive seconds:

a. The horizontal speed difference between INU1 and INU2 is > 7 knots.

b. The position difference between INU1 and INU2 [1.224(INU1 95%ERR + INU2 95%ERR) + 1.0 nm]. ◀

LS6 With an arrow displayed, commands associated INU to NAV mode.

Vertical scrolling, either upward or downward, scrolls to INU Navigation Data page.



```
:AUTO POLE
    INU1 nav data
PITCH    0.1535

ROLL      0.0325

HEADING 359.2285
↕[                ]
```

D57 429 I

NOTE

INU1 Navigation Data page is accessed by scrolling vertically from INU1 Integrated Navigation page. INU2 Navigation Data page is identical in format and operates in an analogous manner.

Figure 1-174 (Sheet 4 of 11)

CDU Menus - INAV (Continued)

Title line displays source of navigation data displayed on this page, either INU1 or INU2.

Data line 2 displays Pitch Angle; + = up, – = down.

Data line 3 displays Roll Angle; + = right, – = left.

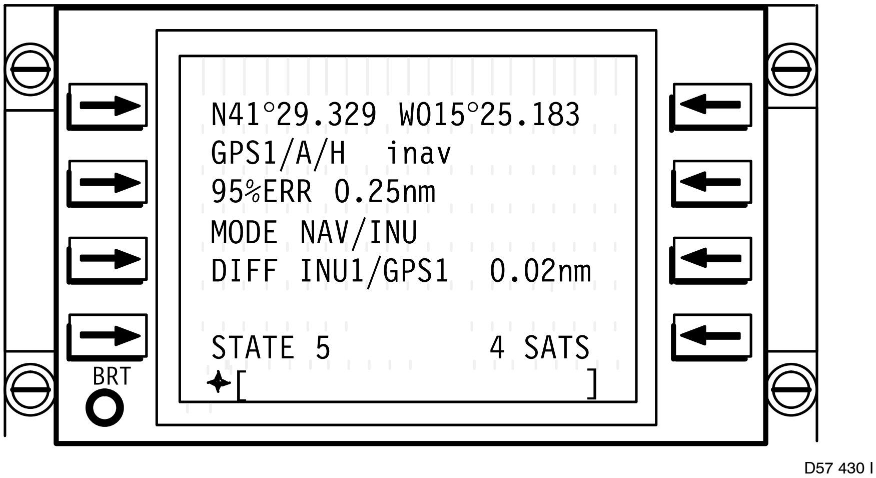
Data line 4 displays True Heading.

LS1	Toggles pole type function between automatic (AUTO), normal (NORM), and displaced (DISP) for both EGIs. Default setting is automatic. In automatic mode, EGIs select which pole type, either normal or displaced. When toggled to normal, EGIs are commanded to use normal pole type, and when toggled to displaced, EGI is commanded to use displaced pole type.

Vertical scrolling, either upward or downward, scrolls to INU Integrated Navigation page.

Figure 1-174 (Sheet 4A of 11)

LESS RAIM



```
N41°29.329 W015°25.183
GPS1/A/H  inav
95%ERR 0.25nm
MODE NAV/INU
DIFF INU1/GPS1  0.02nm

STATE 5       4 SATS
✦[                    ]
```

NOTE

- There are separate INAV pages for each of six navigation solutions: INU1/XXXX, INU2/YYYY, INU1, INU2, GPS1/A/H, and GPS2/A/H. Page displayed when INAV key is pressed is last page that was accessed on that CDU, except after a cold start when INU1/XXXX INAV page is displayed.
- The GPS2 Integrated Navigation page is identical in format and operate in an analogous manner.

Data line 1 displays GPS Present Position Latitude and Present Position Longitude. GPS1 navigation solution position is displayed regardless of its validity.

Title line displays source of navigation data displayed on this page.

Data line 2 displays 95% probable error in nautical miles derived from GPS1 Estimated Horizontal Error (EHE).

Information line displays a combination of GPS Mode and GPS Filter Mode. Valid modes for GPS are NAV, INIT, or TEST. Valid filter modes are INU or Position, Velocity, and Acceleration (PVA). When filter mode is INU, GPS is accepting aiding data from INU.

Data line 3 displays difference in nautical miles between designated pilot's navigation solution (displayed after DIFF) and GPS.

Data line 4 displays receiver state (5, 3 or –) and total number of satellites being tracked (sum of the number of satellites in state 3 operation and in state 5 operation) as defined by GPS Satellite Summary. Receiver state (defined by GPS State) is 5 if four satellites in state 5 operation are currently being tracked. Receiver state is 3 if any number of satellites are being tracked in state 3. Receiver state is dashed if three or fewer satellites are tracked in state 5 and no satellites are tracked in state 3.

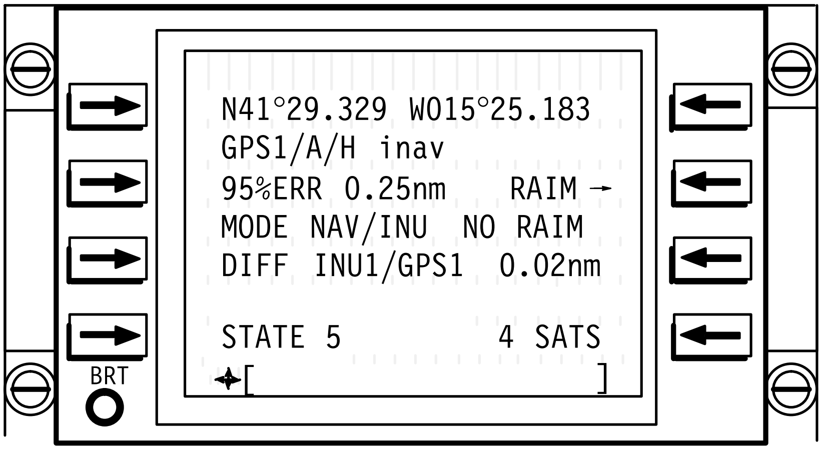
Lateral scrolling scrolls to other Integrated Navigation pages in sequence: GPS1/A/H, GPS2/A/H, INU1/XXXX, INU2/YYYY, INU1, INU2, and wraps around.

Vertical scrolling either upward or downward accesses GPS Satellite Data page. ◀

Figure 1-174 (Sheet 5 of 11)

CDU Menus - INAV (Continued)

WITH RAIM



```
N41°29.329 W015°25.183
GPS1/A/H inav
95%ERR 0.25nm    RAIM →
MODE NAV/INU  NO RAIM
DIFF INU1/GPS1  0.02nm

STATE 5          4 SATS
✦[                    ]
```

NOTE

- There are separate INAV pages for each of six navigation solutions: INU1/XXXX, INU2/YYYY, INU1, INU2, GPS1/A/H, and GPS2/A/H. Page displayed when INAV key is pressed is last page that was accessed on that CDU, except after a cold start when INU1/XXXX INAV page is displayed.
- The GPS2 Integrated Navigation page is identical in format and operates in an analogous manner.

Data line 1 displays GPS Present Position Latitude and Present Position Longitude. GPS1 navigation solution position is displayed regardless of its validity.

Title line displays source of navigation data displayed on this page.

Data line 2 displays 95% probable error in nautical miles derived from GPS1 Estimated Horizontal Error (EHE).

The left side of the information line displays a combination of GPS Mode and GPS Filter Mode. Valid modes for GPS are NAV, INIT, or TEST. Valid filter modes are INU or Position, Velocity, and Acceleration (PVA). When filter mode is INU, GPS is accepting aiding data from INU.

The right side of the information line displays RAIM state, as follows with the following meanings:

RAIM OFF	RAIM has been selected OFF. ON/OFF selection is done via the RAIM/prediction page, LS3. Following GINS power up the default state is RAIM ON. If RAIM is ON, one of the following three displays is shown.
NO RAIM	RAIM must be ON to get a NO RAIM annunciation. If RAIM was OFF and is now selected ON, the NO RAIM status (but not the annunciation on L6) is displayed momentarily until RAIM processing takes effect. During RAIM processing the current status can alternate between RAIM ACT, NO RAIM and RAIM WRN. The status changes from RAIM ACT to NO RAIM under two possible conditions: 1) If fewer than five satellites are visible a continuous NO RAIM annunciation occurs, or 2) If a satellite fault is detected, resulting in an exclusion, a NO RAIM annunciation occurs unless a new navigation solution is obtained within 30 seconds. A NO RAIM status overrides a RAIM WRN status. The NO RAIM status does not cause the RAIM ALERT light to illuminate, and the ALERT light goes out if a RAIM WRN is replaced by NO RAIM. With altitude aiding, a complete navigation solution is available with only three or four satellites in view, however a continuous NO RAIM is annunciated.

Figure 1-174 (Sheet 5A of 11)

RAIM ACT RAIM is ON and active. There are at least five satellites visible and the navigation solution integrity is being monitored by a check of the GPS navigation solution against the alert limits applicable to the scaling mode indicated on the RNAV annunciator panels, and the limits are not exceeded.

RAIM WRN RAIM Warning. RAIM is ON. A complete navigation solution exists with at least five satellites in view. The size of the 95% probable position envelope, which is a part of the complete navigation solution, has exceeded the specified limits for an alarm condition, as applicable to the the scaling mode indicated on the RNAV annunciator panels, for a certain amount of time, therefore the navigation solution accuracy is suspect. This status also illuminates the RAIM ALERT light. Unless more than one faulty satellite is in view, a RAIM WRN should not persist continuously when FDE is possible. FDE is possible when at least six satellites are in view.

The scaling mode versus time criteria at the alarm condition that trigger the RAIM WRN status and the RAIM ALERT light are as follows:

SCALING MODE	TIME AT ALARM CONDITION TO TRIGGER ALERT
Enroute	10 seconds
Terminal	2 seconds
Approach	2 seconds

Data line 3 displays difference in nautical miles between designated pilot's navigation solution (displayed after DIFF) and GPS.

Data line 4 displays receiver state (5, 3 or –) and total number of satellites being tracked (sum of the number of satellites in state 3 operation and in state 5 operation) as defined by GPS Satellite Summary. Receiver state (defined by GPS State) is 5 if four satellites in state 5 operation are currently being tracked. Receiver state is 3 if any number of satellites are being tracked in state 3. Receiver state is dashed if three or fewer satellites are tracked in state 5 and no satellites are tracked in state 3. ◀

Figure 1-174 (Sheet 5B of 11)

CDU Menus - INAV (Continued)

LS6 Accesses RAIM/prediction page.

Lateral scrolling scrolls to other Integrated Navigation pages in sequence: GPS1/A/H, GPS2/A/H, INU1/XXXX, INU2/YYYY, INU1, INU2, and wrap around.

Vertical scrolling, either upward or downward, accesses GPS Satellite Data page.

All RAIM processing is activated or deactivated based on the state of the RAIM/prediction page RAIM processing toggle. The current RAIM processing state (ON or OFF) is sent to both GPS receivers via 1553B bus following receiver initialization, and whenever the RAIM processing state changes.

All RAIM processing is performed by the selected GPS receiver. Selection of any EGI1 navigation solution (INU1/GPS1, INU1, or GPS1) designates GPS1 for RAIM processing. Similarly, selection of any EGI2 navigation solution designates GPS2 for RAIM processing. If a selected GPS receiver fails, all GPS processing reverts to the alternate GPS receiver, including RAIM.

When the controlling CDU transitions between ENROUTE, TERMINAL, and APPROACH scaling modes, the scaling mode for RAIM processing for each GPS receiver is also set.

The CDU-generated COMPARE GPS annunciation can only occur with RAIM ON, but is otherwise independent of RAIM processing. The COMPARE GPS annunciation is generated by the CDU when the distance between the two EGI GPS-only navigation solutions for present position is greater than the limit for current scaling mode (see following table). The COMPARE GPS annunciation does not of itself illuminate the RAIM ALERT light.

CRITERIA FOR THE COMPARE GPS ANNUNCIATION

SCALING MODE	DISTANCE BETWEEN THE TWO GPS RECEIVER GPS-ONLY POSITIONS
Enroute	2.0 nm
Terminal	1.0 nm
Approach	0.3 nm

If the COMPARE GPS annunciation occurs, the operator should then compare the GPS-only and INU-only solutions of EGI 1 and EGI 2, or some other NAV solution, to ascertain which one is causing the problem; then select the EGI with the better navigation solution. The COMPARE GPS annunciation is suppressed if a GPS receiver fails or cannot generate a GPS solution.

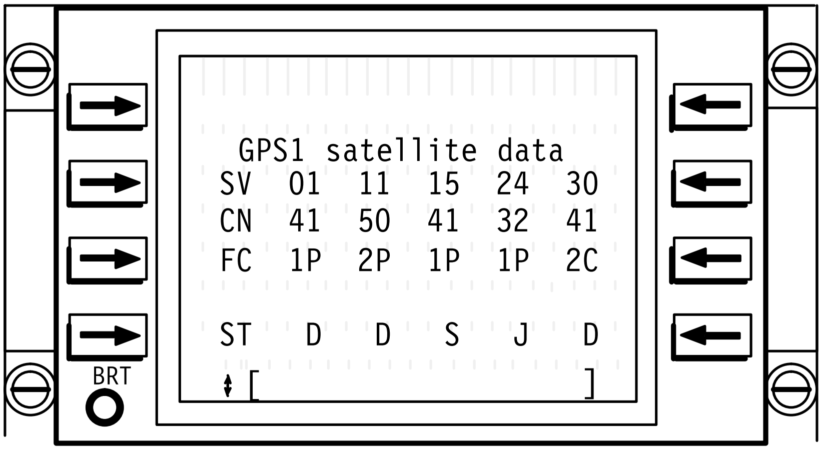
WITH GA GPS solutions are continuously monitored by GINS. If any of the following conditions exist for more than 30 consectutive seconds, the VFY GPS1 (2) annunciation is displayed:

a. GPS(1,2) 95%ERR is > 0.07 nm (APPROACH), 0.15 nm (TERMINAL), or 0.15 nm (ENROUTE).

b. (VFY GPS1) Difference between GPS1 and GPS2 > [1.224(GPS1 95%ERR + GPS2 95%ERR)]
AND difference between GPS1 and INU1/GPS1 > [1.224(GPS1 95%ERR + INU1/GPS1 95%ERR)].

c. (VFY GPS2) Difference between GPS2 and GPS1 > [1.224(GPS2 95%ERR + GPS1 95%ERR)]
AND difference between GPS2 and INU2/GPS2 > [1.224(GPS2 95%ERR + INU2/GPS2 95%ERR)]. ◀

Figure 1-174 (Sheet 5C of 11)



NOTE

GPS Satellite Data page is accessed by scrolling vertically from GPS Integrated Navigation page. GPS2 Satellite Data page is identical in format and operates in an analogous manner.

Title line displays source of navigation data displayed on this page.

Data line 2 displays satellite numbers of satellite vehicles being tracked as defined by GPS Satellite Summary.

Information line displays carrier/noise ratio for satellites being tracked.

Data line 3 displays frequency (1 or 2) and code type (P or C) for satellite being tracked as defined by GPS Satellite Summary.

Data line 4 displays tracking state for satellites being tracked as defined by GPS Satellite Summary. The possible tracking states include:

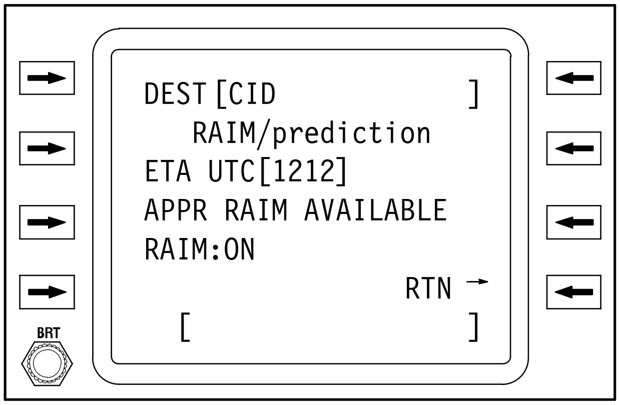
S – Search for satellite signal – States 1 and 2
T – Satellite signal is being tracked – States 4 and 6
J – Satellite signal track is degraded due to jamming or partial obscuration – State 3
D – Satellite signal is being tracked and data is being collected from it – State 5
R – Satellite signal has been lost and recovery operations are being attempted – State 7

Vertical scrolling either upward or downward accesses GPS Integrated Navigation page.

Figure 1-174 (Sheet 6 of 11)

CDU Menus - INAV (Continued)

WITH RAIM



```
DEST [CID            ]
   RAIM/prediction
ETA UTC[1212]
APPR RAIM AVAILABLE
RAIM:ON
                RTN →
  [                  ]
```

NOTE

RAIM prediction page is accessed from GPS Integrated Navigation page.

Data line 1 displays destination as RPID or geographic position.

Data line 2 displays destination ETA in UTC.

Information line displays status of RAIM prediction:

RAIM REQUESTED is displayed when an operator initiated RAIM request has been made but the results have not yet been reported by the receiver.

APPR RAIM AVAILABLE is displayed if the receiver indicates RAIM availability at the entered location and ETA.

APPR RAIM UNAVAILABLE is displayed if the receiver indicates RAIM predicted not available at the entered location and time.

RAIM CHECK UNAVAILABLE is displayed when GPS receiver is in initialization mode, or if a RAIM prediction cannot be computed.

RAIM CHECK CANCELLED is displayed when receiver transitions to navigation mode if a RAIM request was in progress when receiver entered initialization mode.

Information line is otherwise blank when no waypoint is entered on data line 1 or when no ETA is entered on data line 2.

Data line 3 displays ON/OFF status of RAIM processing.

Data line 4 shows return function via LS8, to GPS INAV page from which RAIM/prediction page was accessed.

LS1,5	With a valid waypoint entry in scratchpad, enters position for operator initiated RAIM request. It also deletes ETA at LS2 if one is displayed. With – in scratchpad, deletes waypoint at LS1. It also deletes ETA at LS2 if one is displayed.

Figure 1-174 (Sheet 6A of 11)

	When an empty scratchpad, copies waypoint into scratchpad.
LS2	With a valid time in scratchpad, enters UTC time of operator initiated RAIM request in hours and minutes (no space) and initiates request. With a – in the scratchpad, deletes the ETA. With an empty scratchpad, copies ETA into scratchpad.
LS3	Toggles RAIM processing state between ON and OFF. Upon cold start, RAIM processing state defaults to ON.
LS8	Access GPS inav page for corresponding primary or alternate receiver from which RAIM/prediction page was accessed.

The prediction function is used to predict integrity monitor availability at a waypoint or other destination at a time entered by the operator. For a manual RAIM prediction, Predicted Latitude, Predicted Longitude, Predicted Time, Predicted Altitude, Predictive RAIM Interval Size (five minutes) and Predictive RAIM Number of Intervals (three) are sent to each GPS receiver. When the results of receiver RAIM prediction calculations are returned from selected GPS receiver, these values are compared with Initial Latitude, Initial Longitude, Initial Time, Initial Altitude, Current Predictive RAIM Interval Size and Current Predictive RAIM Number of Intervals received from the receiver. If any of the values do not match, the results of the prediction are considered unable to be computed.

RAIM prediction requests are initiated from the RAIM/prediction page. Data sent to the GPS receiver is as follows: position and time are as entered on RAIM/prediction page; altitude is the height associated with the position if it is an identifier, or zero otherwise. Predictive RAIM interval size is 5 minutes and predictive RAIM number of intervals is 3 (checks integrity monitor availability every 5 minutes, ±15 minutes from the specified time).

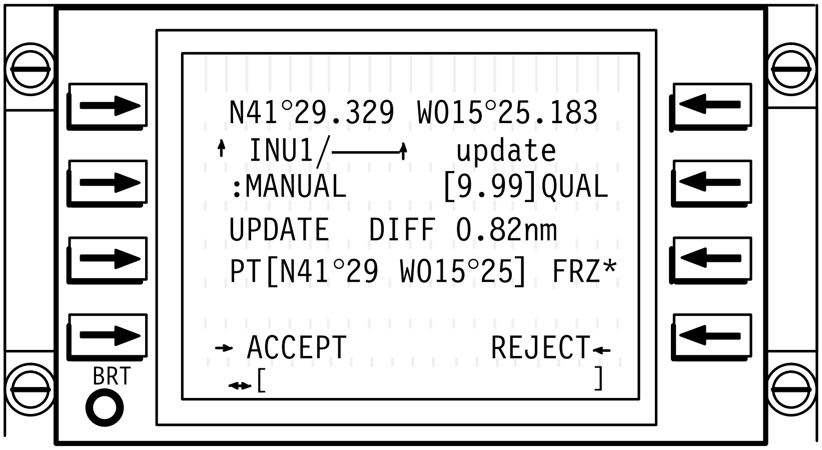
If valid position and valid time have been entered, an operator initiated RAIM request is attempted each time the RAIM/prediction page is accessed.

Entry of a new position or time before a RAIM request result is reported cancels the original prediction request and causes a changed request using the new values. ◀

Figure 1-174 (Sheet 6B of 11)

CDU Menus - INAV (Continued)

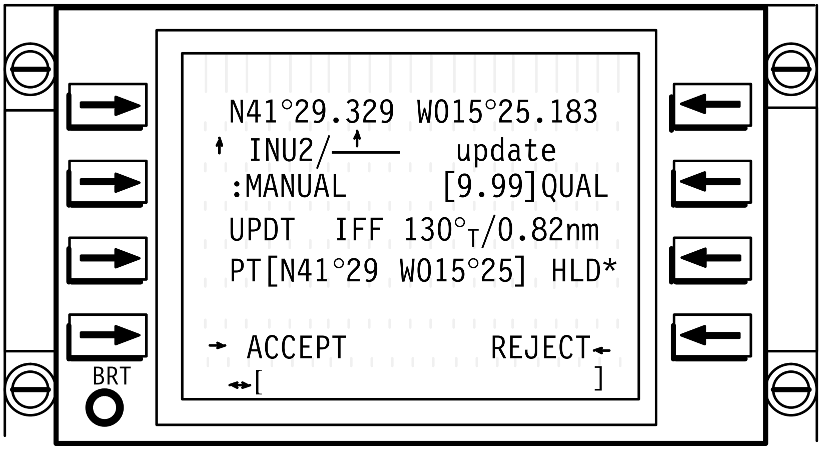
LESS GA



```
 N41°29.329 W015°25.183
↑ INU1/———↑  update
 :MANUAL     [9.99]QUAL
 UPDATE  DIFF 0.82nm
 PT[N41°29 W015°25] FRZ*

→ ACCEPT        REJECT←
↔[                    ]
```

WITH GA



```
 N41°29.329 W015°25.183
↑ INU2/—↑—   update
 :MANUAL     [9.99]QUAL
 UPDT  IFF 130°T/0.82nm
 PT[N41°29 W015°25] HLD*

→ ACCEPT        REJECT←
↔[                    ]
```

NOTE

> Update pages are accessed from INAV pages. INU2/—— update page is identical in format and operates in an analogous manner.

Position updates are performed for EGI integrated navigation solutions. Source of check point position used for updates is one of following:

- Designated pilot's solution
- Manually entered position

When update source is selected, a difference between navigation source and check point position is computed and displayed. Crew may then accept or reject computed error.

Updates to integrated navigation solution are allowed only if GPS or JTIDS data is not being incorporated; that is, displayed modes are INU1/—— or INU2/——. If accepted, update is sent to appropriate EGI.

Data line 1 displays current or frozen position of navigation source displayed on title line that is being updated.

Title line displays navigation solution that is being updated.

Figure 1-174 (Sheet 7 of 11)

The information line displays LESS GA difference between navigation solution being updated (displayed on title line) and navigation source used for update (displayed adjacent to LS2). ◀ WITH GA difference and bearing from the navigation solution being updated (displayed on title line) to the navigation source solution userd for the update (displayed adjacent to LS2). ◀ Display is dashed if either source is invalid. Difference is displayed to hundredths of nautical miles for differences less than 10 nm. For differences greater than 10 nm, difference display follows display convention for distances. WITH GA Magnetic bearing is dispayed when MAG is selected on the MAG/TRUE switch, and true bearing when TRUE is selected. ◀

Data line 2 displays quality of position update value in nautical miles.

Data line 3 displays location of source being used for update.

If navigation source is INUX/GPSY or INUX/JTIDS, or if navigation source is INU1/—— or INU2/——, and GPS or JTIDS become valid, display on Data Line 4 is blanked and both LS4 and LS8 are non operative.

Note that if INU/XXXX rejects update (Reject Update), NO UPDATE message is displayed.

LS2 Toggles between navigation sources that can be used for performing an update to integrated solution and blanks display on data line 4. Sources are: designated pilot's solution (which is displayed using mode associated with designated pilot's solution), and MANUAL. An arrow is displayed adjacent to LS7 when a valid source is displayed on this data line. If selected source is not valid, arrow is blanked. This selection causes any frozen display to become active.

LS3 LESS GA Toggling navigation source on data line 2 to MANUAL allows for entry of a check point position, as follows:

TO waypoint is inserted when first toggled to MANUAL. If this point is overwritten by an entry, entered location is retained until MANUAL is toggled again.

When a check point position is entered while in MANUAL mode, an arrow is displayed adjacent to LS7 and display on data line 4 is blanked. Difference between check point position and navigation source displayed on title line is computed and displayed on information line.

With a blank scratchpad, copies point location displayed into scratchpad.

With a – in scratchpad, sets check point position to TO waypoint. ◀

WITH GA When MANUAL is selected at LS2:

Dashes are initially displayed and the brackets removed around the entry on data line 3. Upon selection of LS7, asterisk replaces arrow at LS7, brackets are displayed around the entry on data line 3, and a check point position can be entered. After a check point position is entered, the bearing/difference from the navigation source displayed on data line 1 to the check point position displayed on data line 3 is computed and displayed on the information line. The update can be accepted or rejected as desired, using LS4 or LS8, respectively.

With a blank scratchpad, copies point location displayed into scratchpad.

When the designated pilot's solution is selected at LS2:

The designated pilot's solution is displayed. Upon selection of LS7, positions on data line 1 and data line 3 are frozen, and asterisk replaces arrow at LS7. The bearing/difference from the navigation source displayed on data line 1 to the position displayed on data line 3 is computed and displayed on the information line. The update can be accepted or rejected as desired, using LS4 or LS8, respectively. ◀

Figure 1-174 (Sheet 8 of 11)

CDU Menus - INAV (Continued)

LS4 **LESS GA** When an arrow is displayed, pressing LS4 accepts correction. If accepted, arrow at LS4 changes to an asterisk and arrow adjacent to LS8 is blanked. After accepting update, INU/XXXX is updated by amount displayed on information line (including quality of position update value), navigation solution present position on data line 1 becomes active, quality of position update value is reset to 9.99, asterisk is replaced with an arrow adjacent to LS7, and difference between two navigation sources is displayed on information line. LS4 is inoperative when an arrow is not being displayed (either blank or with an asterisk). The asterisk associated with LS4 is displayed for three seconds, at which time entire display on data line 4 is blanked. ◀

WITH GA When either MANUAL or the designated pilot's solution is selected at LS2, if the INU has valid aiding (INUX/GPSY or INUX/JTDS), updating is not possible. Pressing LS4 in this case displays GPSY IS VALID or JTIDS IS VALID annunciations as appropriate.

When MANUAL is selected at LS2:

When an arrow is displayed, pressing LS4 accepts correction, when position quality at LS6 is greater than 0.5 and the calculated difference between held position and entered position is less than or equal to 10.0nm. If position quality is less than or equal to 0.5, the √ QUALITY annunciation is displayed and the update is not made. If position quality is greater than 0.5 and the calculated difference between held position and entered position is greater than 10.0 nm, CONFIRM UPDATE annunciation is displayed, and acceptance occurs upon reselection of LS4. If accepted, arrow at LS4 changes to an asterisk and arrow adjacent to LS8 is blanked. After accepting update, INU/XXXX is updated by amount displayed on information line (including quality of position update value), navigation solution present position on data line 1 becomes active, quality of position update value is reset to 9.99, asterisk is replaced with an arrow adjacent to LS7, and difference between two navigation sources is displayed on information line. LS4 is inoperative when an arrow is not being displayed (either blank or with an asterisk). The asterisk associated with LS4 is displayed for three seconds, at which time entire display on data line 4 is blanked.

When the designated pilot's solution is selected at LS2:

When an arrow is displayed, pressing LS4 accepts correction. Arrow at LS4 changes to asterisk, and arrow adjacent to LS8 is blanked. After accepting the update, the INUX/—— solution is updated by the amount displayed on the information line (including the quality of position update value), the quality of position update value is reset to 9.99, asterisk is replaced with an arrow adjacent to LS7, and the difference between the two navigation sources is dashed. LS4 is not operational when arrow is not displayed. The asterisk associated with LS4 is displayed for three seconds at which time the entire display on data line 4 is blanked. ◀

LS6 With a valid quality of position update value in scratchpad, enters value into data field. Value is in nautical miles, and accepted range is from 0.5 nm to 9.99 nm. This value is determined by operator confidence in the update fix position quality: 0.5 nm (high confidence), 9.99 nm (extremely low confidence).

With a –, sets quality of position update to default of 9.99.

With an empty scratchpad, copies quality of position update to scratchpad.

Figure 1-174 (Sheet 9 of 11)

LS7 LESS GA When an arrow is displayed, changes arrow to an asterisk, freezes position displayed on data line 1, freezes difference displayed on information line, and freezes display on data line 3. Additionally, data line 4 display is as shown above, allowing for an accept or reject selection. A blank replaces arrow adjacent to LS7 when solution displayed on data line 1 is invalid. When an asterisk or blank is displayed, LS7 is inoperative. ◀

WITH GA When MANUAL is selected at LS2:

When an arrow is displayed, changes arrow to an asterisk, holds position displayed on data line 1, and displays brackets around the position entry at data line 3 (indicating a position can now be entered). Upon reselection of LS7, position on data line 1 becomes dynamic and brackets around the entered position on data line 3 are removed. When the brackets are displayed, after entry of a position, ACCEPT (LS4) and REJECT (LS8) appear, allowing a decision on the update. A blank replaces arrow adjacent to LS7 when solution displayed on data line 1 is invalid. When an asterisk or blank is displayed, LS7 is inoperative.

When the designated pilot's solution is selected at LS2:

When an arrow is displayed, changes arrow to an asterisk, freezes position displayed on data line 1, freezes bearing/difference displayed on information line, and freezes display on data line 3. Additionally, data line 4 display is as shown above, allowing for an accept or reject selection. A blank replaces arrow adjacent to LS7 when solution displayed on data line 1 is invalid. When an asterisk or blank is displayed, LS7 is inoperative. ◀

LS8 LESS GA When an arrow is displayed, rejects update, arrow changes to an asterisk, arrow adjacent to LS4 is blanked, position on data line 1 becomes active, Designated Pilot's solution on data line 3 becomes active, asterisk is replaced with an arrow adjacent to LS7, and dynamic difference between two navigation sources is displayed on information line. This line select is inoperative when an arrow is not being displayed (either blank or with an asterisk). The asterisk associated with LS8 is displayed for three seconds, at which time entire display on data line 4 is blanked. ◀

WITH GA When MANUAL is selected at LS2:

When an arrow is displayed, rejects update, arrow changes to an asterisk, arrow adjacent to LS4 is blanked, position on data line 1 becomes active, dashes are displayed on data line 3, asterisk is replaced with an arrow adjacent to LS7 , and dashes are displayed on the information line. LS8 is inoperative when an arrow is not being displayed. The asterisk associated with LS8 is displayed for three seconds, at which time entire display on data line 4 is blanked.

When the designated pilot's solution is selected at LS2:

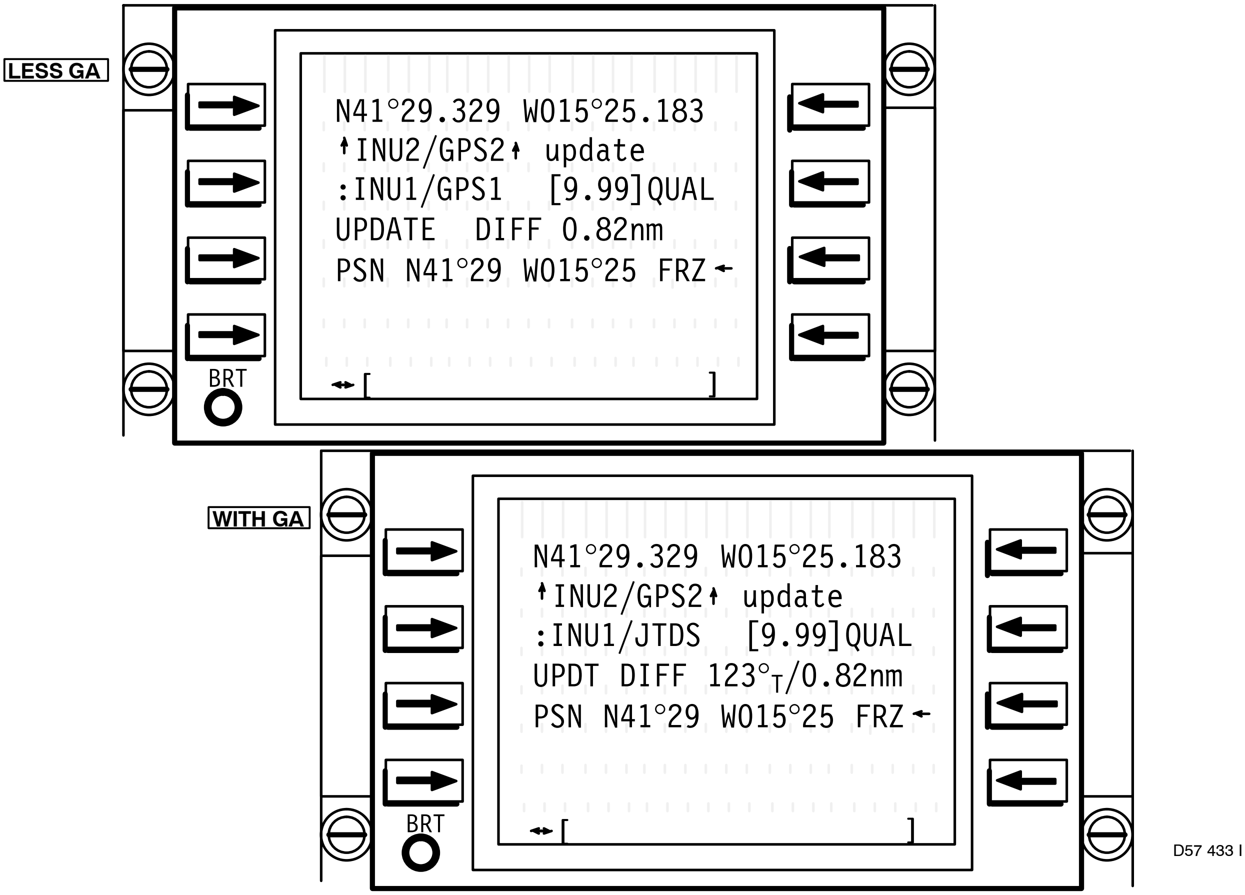
When an arrow is displayed, rejects update, arrow changes to an asterisk, arrow adjacent to LS4 is blanked, position on data line 1 becomes active, Designated Pilot's solution on data line 3 becomes active, asterisk is replaced with an arrow adjacent to LS7, and dynamic difference between two navigation sources is displayed on information line. This line select is inoperative when an arrow is not being displayed (either blank or with an asterisk). The asterisk associated with LS8 is displayed for three seconds, at which time entire display on data line 4 is blanked. ◀

Lateral scrolling scrolls to INU2/—— navigation solution Update page.

Figure 1-174 (Sheet 10 of 11)

CDU Menus - INAV (Continued)

INU2/GPS2 Update page with Designated Pilot's solution selected as update source is shown below. Line selects and data lines operate same as described for INU1/—— Update page.



```
N41°29.329 W015°25.183
↑INU2/GPS2↑ update
:INU1/GPS1   [9.99]QUAL
UPDATE  DIFF 0.82nm
PSN N41°29 W015°25 FRZ←

↔[                       ]
```

```
N41°29.329 W015°25.183
↑INU2/GPS2↑ update
:INU1/JTDS   [9.99]QUAL
UPDT DIFF 123°T/0.82nm
PSN N41°29 W015°25 FRZ←

↔[                       ]
```

NOTE

- All sensor and integrated navigation data received by bus controller CDU is referenced to a WGS-84 datum. If a datum other than WGS-84 is selected, navigation information received by FMS guidance function (that is, INU1/XXXX, INU2/YYYY, INU1, INU2, GPS1/A/H and GPS2/A/H) is converted to selected datum. Converted position is used to generate guidance and flight instrument displays.
- Selection of datum does not affect navigation sensors, integrated navigation solution, or waypoints in system.
- Bus controller CDU sends sensor configuration information to each BSIU via FMB. Configuration data includes following information:
  a. GPS configuration – GPS1 is assigned to BSIU1 and GPS2 is assigned to BSIU2.
  b. CADC configuration – BSIU1 is assigned CADC that has been selected to aid EGI1 and BSIU2 is assigned CADC that has been selected to aid EGI2, as shown on Aiding Page menu.

Figure 1-174 (Sheet 11 of 11)

CDU Menus - Status

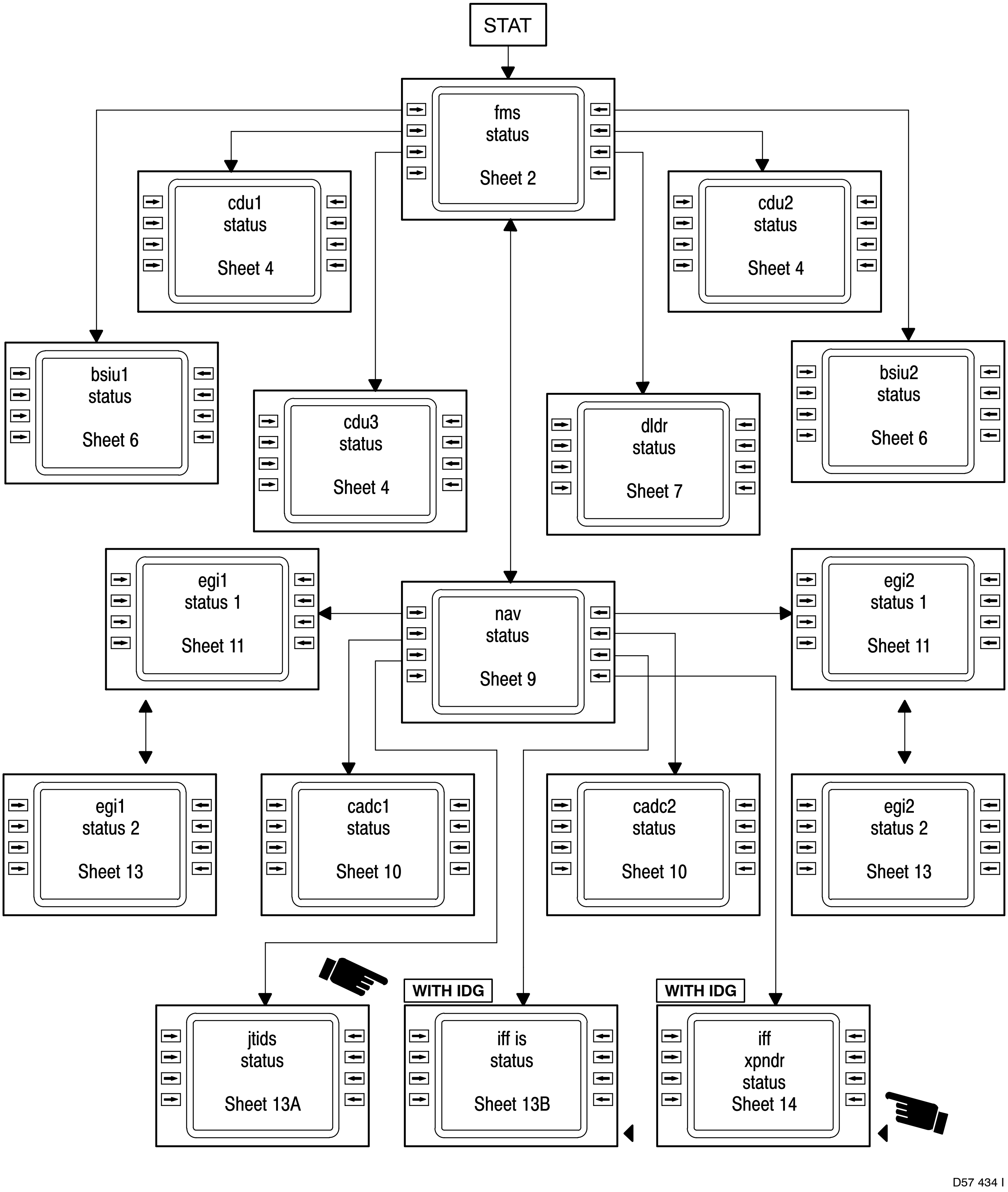
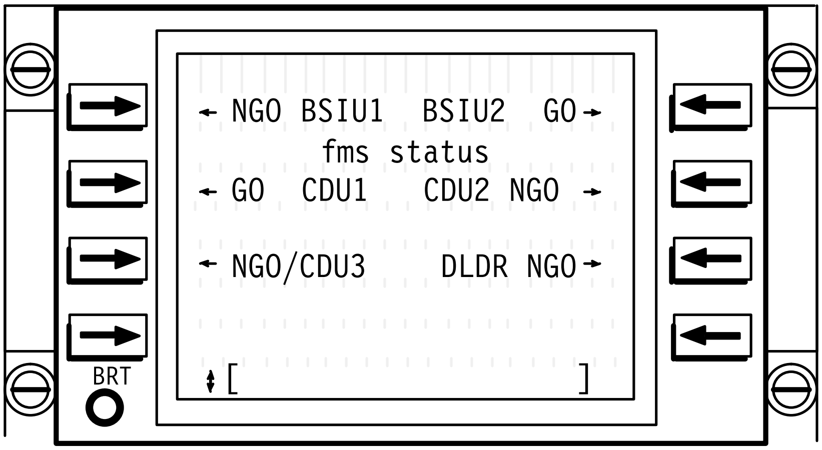


Figure 1-175 (Sheet 1 of 14)

CDU Menus - Status (Continued)

(FMS Status)



NOTE

- FMS Status page is accessed by pressing STAT key or by vertical scrolling from Navigation page.
- Continuous built-in test (CBIT) and initiated built-in test (IBIT) are operable in GINS. CBIT is available in air or on ground. IBIT is available only on ground.

Data line 1 displays overall status of BSIUs 1 and 2.

Data line 2 displays overall status of CDUs 1 and 2.

Data line 3 displays overall status of CDU 3 and data loader.

Vertical scrolling accesses Navigation Status page.

LS1	Accesses BSIU1 Status page.
LS2	Accesses CDU1 Status page.
LS3	Accesses CDU3 Status page.
LS5	Accesses BSIU2 Status page.
LS6	Accesses CDU2 Status page.
LS7	Accesses Data Loader Status page.

Figure 1-175 (Sheet 2 of 14)

The Bus controller CDU monitors status of LRUs and displays a status summary. CBIT results of all LRUs that have CBIT capability are integrated into status reporting function.

When subsystem changes status from GO to NGO, a √STATUS annunciation appears on annunciation line of all CDUs, regardless of current page displayed on each CDU. In addition, a CDU ALERT illuminates in each RNAV ANNUNCIATOR panel. Conditions for alerting crew include:

Bus controller failures
Failure of data path to any bus controller or remote terminal
Irrecoverable status error conditions
Subsystem current operating condition disagrees with operator-commanded input.

Bus status is displayed as GO, NGO–A (bus A failed), NGO–B (bus B failed), or NGO–T (buses A and B failed, or terminal failed). A single bus failure does not result in an annunciation or an alert, but increments failure counter. If power is commanded off to an LRU, NGO–T is displayed as bus status.

CDU annunciation and CDU ALERT indicator are cleared by pressing either CLR or STAT function keys on CDU. Pressing STAT key accesses Status pages. Current, top-level status information of all LRUs reporting CBIT is displayed on FMS Status page and Navigation Status page. Overall status is displayed in following order of hierarchy: TST (unit in test), NGO, dashes (status unknown or data path failure), or GO and is based upon same criteria as for alerting crew. A check mark (√) appears on these pages between LRU label and status display of failed LRU. The √ is cleared by accessing detailed status page of failed LRU. For those LRUs that have detailed status pages, overall status is also displayed on title line of respective page. More detailed status information is available on individual LRU Status pages. If a failure has occurred in an LRU, LRU Status pages identify which internal component(s) caused failure. If detailed status for a specific subsystem is unknown for any reason (that is, unit is in test or has a data path failure), dashes are displayed for that subsystem.

If an EGI or CADC fails, all flight crew attempted inputs for CBIT are inhibited and result in a √STATUS scratchpad message, with two exceptions:

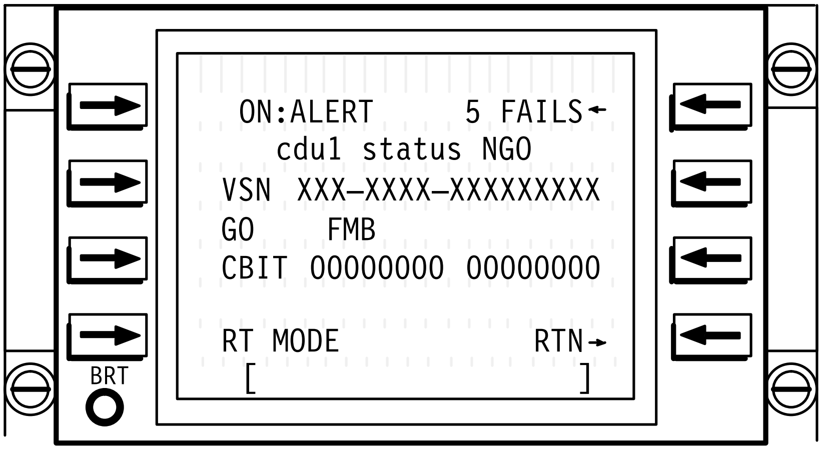
> Altitude Loop Bit Status causes a √STATUS annunciation and causes INU overall status to be NGO. However, subsequent control inputs to failed INU are not prohibited and do not cause a √STATUS scratchpad message. Altitude Loop Bit status is shown on EGI Status 1 page.
>
> Battery Status causes a √STATUS annunciation and causes GPS overall status to be NGO as normal. However, subsequent control inputs to GPS are not prohibited and do not cause a √STATUS scratchpad message. Battery status is shown on EGI Status 2 page.

CBIT status data can be stored on data cartridge as described in data loader functions. Start and end dates for status data on data cartridge are also stored. Status data is retained in NVM until it is cleared by an operator command to send it to data loader. Each time flight crew initiates a transfer of status data to data cartridge, this data overwrites any previously stored status data, starting a new failure record.

Figure 1-175 (Sheet 3 of 14)

CDU Menus - Status (Continued)

(CDU Status)



```
 ON:ALERT     5 FAILS←
   cdu1 status NGO
VSN  XXX–XXXX–XXXXXXXXX
GO    FMB
CBIT 00000000 00000000

RT MODE             RTN→
 [                     ]
```

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NOTE

> CDU Status pages are accessed from FMS Status page. All CDU Status pages have same structure and perform identical functions.

Title line displays top level LRU status.

Information line displays bus status for FMB as GO, NGO–A, NGO–B, or NGO–T.

Data line 1 displays failure counter.

Failure counter increments when title line toggles between GO and NGO or upon CDU bus failure.

When ALERT is set to ON, a failure in associated CDU causes √STATUS annunciation and illuminates CDU ALERT indicator. When ALERT is set to OFF, failures in associated CDU do not cause √STATUS annunciation and do not illuminate CDU ALERT indicator. State of this toggle is ON upon cold start. When toggled OFF, failure history continues to be recorded.

Data line 2 displays CDU software version number. If system determines configuration of software in CDUs is not compatible, a √VERSION annunciation is displayed on annunciation line and transfer of NVM data to remote terminal CDUs is prohibited.

Figure 1-175 (Sheet 4 of 14)

Data line 3 displays CBIT results in a sixteen bit data word where a 1 indicates a failure. Bit 1 is leftmost bit in display:

Bit	Description
1-7	Unused (zeros)
8	Subsystem Fail
9	Terminal Fail
10	IOC 1553 No. 2
11	Discrete I/O A7
12	Graphics Generator
13	IOC 1553 No. 1
14	Memory Card A5
15	Memory Card A3
16	CPU Card

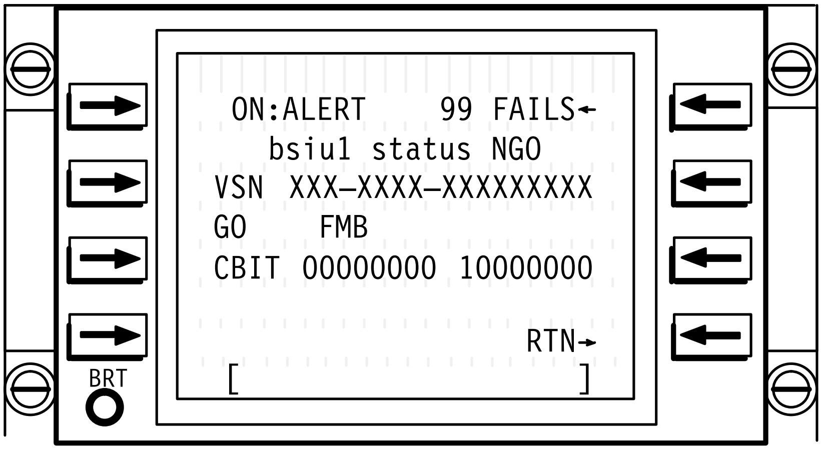
Data line 4 displays CDU mode (on FMB) as either BC (bus controller) or RT (remote terminal).

LS1	Toggles √STATUS annunciation ALERT ON and OFF.
LS5	Resets failure counter to 0.
LS8	Returns to FMS Status page.

Figure 1-175 (Sheet 5 of 14)

CDU Menus - Status (Continued)

(BSIU Status)



```
 ON:ALERT    99 FAILS←
   bsiu1 status NGO
VSN XXX–XXXX–XXXXXXXXX
GO    FMB
CBIT 00000000 10000000

                  RTN←
[                    ]
```

NOTE

BSIU Status pages are accessed from FMS Status page. Both BSIU Status pages have same structure and perform identical functions.

Title line displays top level LRU status.

Information line displays bus status for FMB. Bus status is displayed as GO, NGO–A, NGO–B, or NGO–T.

Data line 1 displays an ALERT Function (same as for CDU), and a failure counter, which increments when title line toggles between GO and NGO, or upon BSIU bus failure.

Data line 2 displays BSIU software version number.

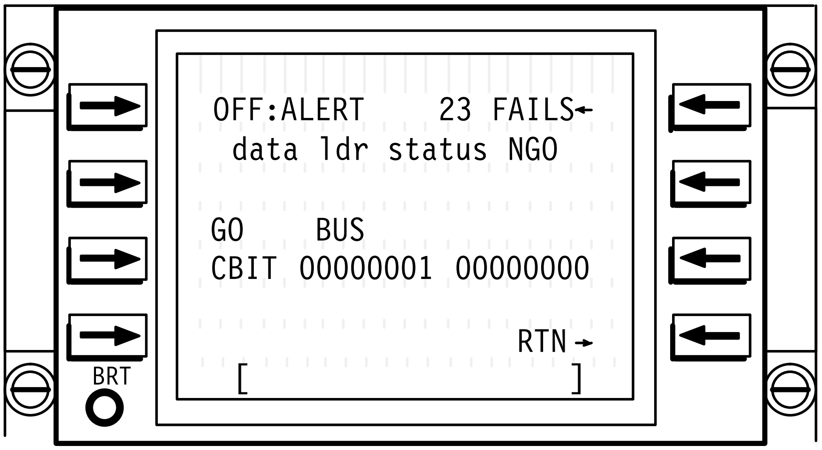
Data line 3 displays CBIT results in a sixteen bit data word, where a 1 indicates a failure. Bit 1 is leftmost bit in display:

Bit	Description	Bit	Description
1-4	Unused (set to 0)	11	Power Supply
5	Subsystem Fail	12	SIM 5 – J10
6	Terminal Fail	13	SIM 4 – J9
7	CPU SRU	14	SIM 3 – J8
8	Memory SRU	15	SIM 2 – J7
9	1553 No. 2 SRU	16	SIM 1 – J6
10	1553 No. 1 SRU		

LS1	Toggles √STATUS annunciation ALERT ON and OFF.
LS5	Resets failure counter to 0.
LS8	Returns to FMS Status page.

Figure 1-175 (Sheet 6 of 14)

(Data Loader Status)



```
OFF:ALERT    23 FAILS←
 data ldr status NGO

GO    BUS
CBIT 00000001 00000000

                 RTN→
[                    ]
```

NOTE

Data Loader Status page is accessed from FMS Status page.

Title line displays top level LRU status.

Information line displays bus status as GO, NGO–A, NGO–B, or NGO–T.

Data line 1 displays an alert function (same as for CDUs and BSIUs), and a failure counter, which increments when title line toggles between GO and NGO, or upon data loader bus failure.

Data line 3 displays CBIT results in a sixteen bit data word, where a 1 indicates a failure. Bit 1 is leftmost bit on display:

Bit	Description
1	0 Reserved
2	0 Reserved
3	0 Reserved
4	Terminal Address, Illegal Parity Used
5	Fail-Safe Timer Fail
6	Checksum (PROM Checksum Fail)
7	0 Reserved
8	RAM Fault
9	0 Reserved
10	LSI Fault
11	Xmtr B Bus (does not turn on)
12	Xmtr A Bus (does not turn on)
13	Fault B Bus (Transmitter Data Fault)
14	Fault A Bus (Transmitter Data Fault)
15	Subsystem Fail
16	Terminal Fail

Figure 1-175 (Sheet 7 of 14)

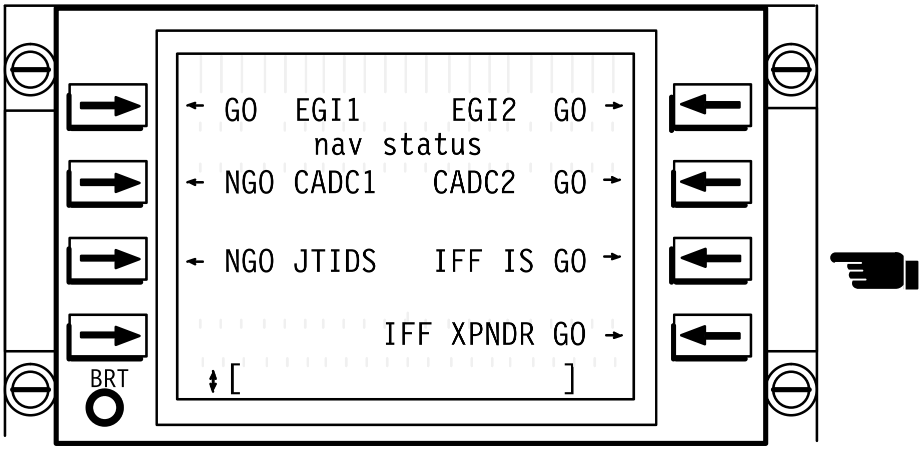
CDU Menus - Status (Continued)

(Data Loader Status) Continued

LS1	Toggles √STATUS annunciation ALERT ON and OFF.
LS5	Resets failure counter to 0.
LS8	Returns to FMS Status page.

Figure 1-175 (Sheet 8 of 14)

(NAV Status)



NOTE

Navigation Status page is accessed by vertical scrolling from FMS Status page.

Data line 1 displays overall status of EGIs 1 and 2 (if either GPS or INU fails).

Data line 2 displays overall status of CADCs 1 and 2.

Data line 3 displays overall status of JTIDS bus interface.

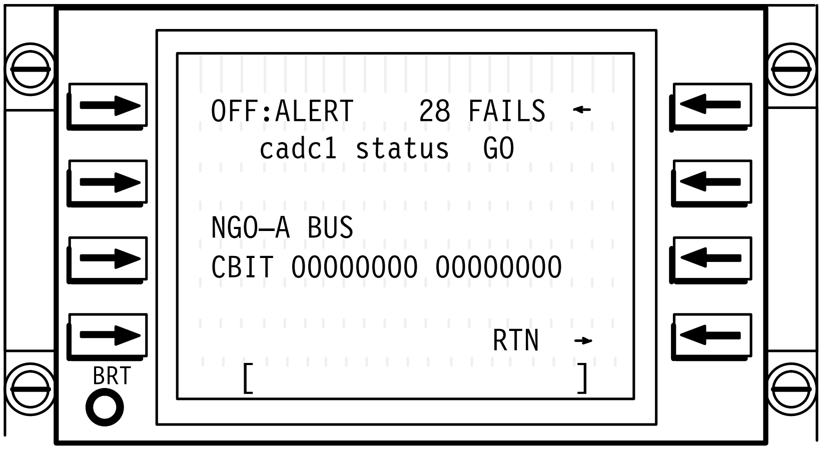
LS1	Accesses EGI1 Status 1 page.
LS2	Accesses CADC1 Status page.
LS3	Accesses JTIDS Status page.
LS5	Accesses EGI2 Status page.
LS6	Accesses CADC2 Status page.
LS7	**WITH IDG** Accesses iff is status (mission interrogator set) page.
LS8	**WITH IDG** Accesses iff xpndr status (IFF transponder Mode S) page.

Vertical scrolling accesses FMS Status page.

Figure 1-175 (Sheet 9 of 14)

CDU Menus - Status (Continued)

(CADC Status)



```
OFF:ALERT    28 FAILS ←
   cadc1 status  GO

NGO–A BUS
CBIT 00000000 00000000

                  RTN →
 [                     ]
```

NOTE

CADC Status pages are accessed from the Navigation Status page. Both CADC Status pages have same structure and perform identical functions.

Title line displays top level LRU status.

Information line displays bus status as GO, NGO–A, NGO–B, or NGO–T.

Data line 1 displays an ALERT function (same as for FMS LRUs), and a failure counter, which increments when title line toggles between GO and NGO or upon CADC bus failure.

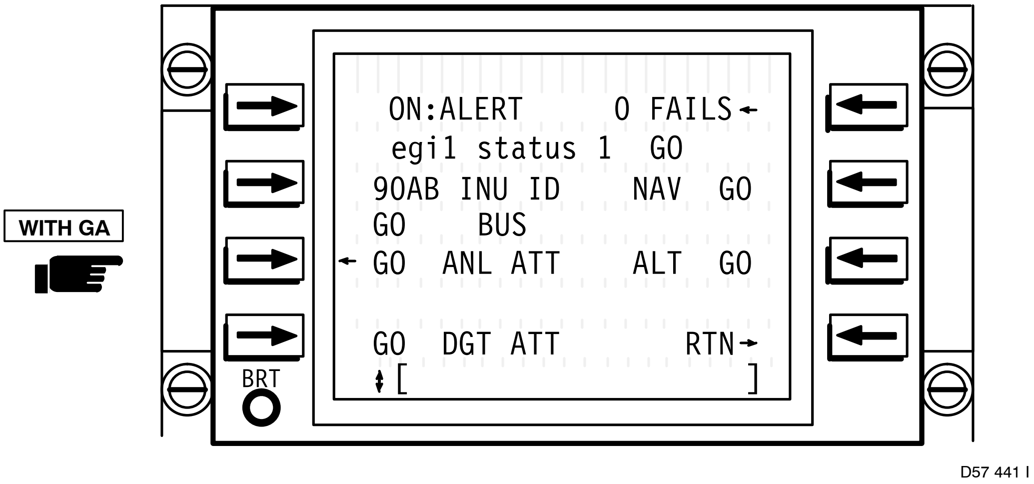
Data line 3 displays results from bus status word in a sixteen bit data word, where a 1 indicates a failure. Bit 1 is leftmost bit in display:

Bit	Description
1-14	Unused set to 0
15	Subsystem Fail
16	Terminal Fail

LS1	Toggles √STATUS annunciation ALERT ON and OFF.
LS5	Resets failure counter to 0.
LS8	Returns to Navigation Status page.

Figure 1-175 (Sheet 10 of 14)

(EGI Status)



```
 ON:ALERT     0 FAILS←
  egi1 status 1  GO
90AB INU ID    NAV  GO
GO    BUS
← GO  ANL ATT    ALT  GO

GO  DGT ATT       RTN→
↕[                    ]
```

NOTE

- EGI Status 1 pages are accessed from Navigation Status page. Both EGI Status 1 pages have same structure and perform identical functions.
- When ALERT is set to ON, an Invalid INU or Invalid GPS causes √STATUS annunciation. When ALERT is set to OFF, an Invalid INU or Invalid GPS does not cause √STATUS annunciation. State of this toggle is ON upon cold start. When toggled OFF, failure history continues to be recorded.

Data line 1 displays an ALERT function (second NOTE below screen), and a failure counter which increments when title line toggles between GO and NGO or upon INU bus failure.

Title line displays EGI Status.

Left hand side of data line 2 displays INU CPCI Identification (any 4 Hex characters). Right hand side of data line 2 displays INU Navigation Data status. It also reflects current terminal and subsystem status reported in bus status word.

Information line displays bus status as GO, NGO–A, NGO–B, or NGO–T.

Data line 3 displays Analog Attitude Status (ANL ATT) and Altitude Loop Bit Status (ALT). An Altitude Loop Bit failure causes Altitude Loop Bit Status to be set to NGO, causing a √STATUS annunciation and causing INU overall status to be NGO. However, system does not prohibit user from performing control inputs to INUs in this case.

Data line 4 displays Digital Attitude Status (DGT ATT).

Figure 1-175 (Sheet 11 of 14)

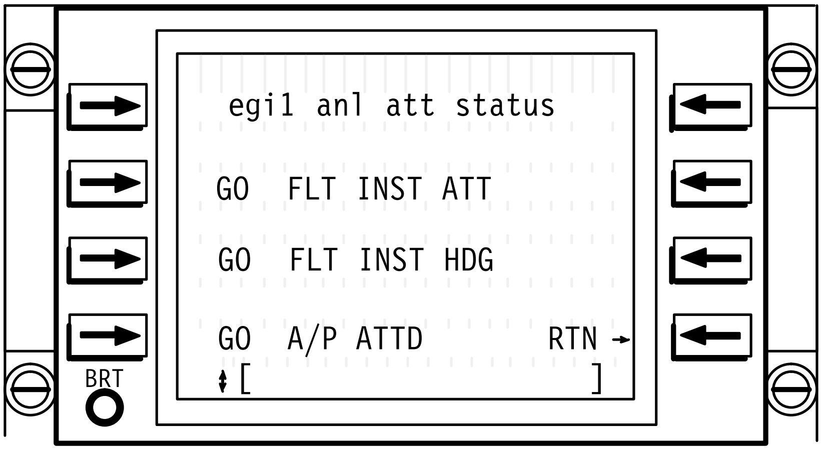
CDU Menus - Status (Continued)

(EGI Status) Continued

LS1	Toggles √STATUS annunciation ALERT ON and OFF.
LS3	WITH GA Accesses the EGI Analog Attitude Status page. ◀
LS5	Resets failure counter to 0.
LS8	Returns to Navigation Status page.

Vertical scrolling accesses associated EGIX Status 2 page (X being either 1 or 2).

WITH GA (EGI Analog Attitude Status)



NOTE

EGI1 Analog Attitude Status page is accessed from the EGI1 Status 1 page. Both EGI Analog Attitude Status pages have same structure and perform identical functions.

Title line displays EGI analog attitude status.

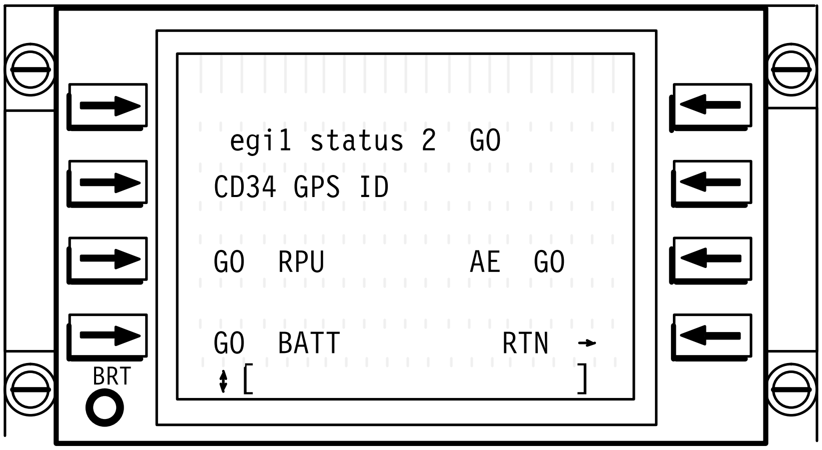
Data line 2 displays the flight instruments analog attitude output status. A GO status indicates the EGI check of the voltages provided for pitch and roll to the ADI and flight director are in the proper range.

Data line 3 displays the flight instruments analog heading output status. A GO status indicates the EGI check of the voltages provided for heading to the HSI are in the proper range.

Data line 4 displays the autopilot analog attitude output status. A GO status indicates the EGI check of the voltages provided to the autopilot for pitch, roll, and versine are in the proper range.

LS8	Returns to Navigation Status page. ◀

Figure 1-175 (Sheet 12 of 14)



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NOTE

> EGI Status 2 pages are accessed from Navigation Status page. Both EGI Status 2 pages have same structure and perform identical functions.

Title line displays EGI Status.

Data line 2 displays GPS CPCI Identification (any 4 Hex characters).

Data line 3 displays RPU Status (Receiver Processor Unit) and AE Status (Antenna Electronics). RPU is also set to NGO upon terminal or subsystem failure as reported in bus status word.

Data line 4 displays Battery Status (BATT). If battery power is low, Battery Status is set to LOW, causing a √STATUS annunciation, and causing GPS overall status to be NGO. If battery power is dead, Battery Status is set to NGO, causing a √STATUS annunciation and causing GPS overall status to be NGO. However, system does not prohibit user from performing control inputs to GPS due to a battery failure.

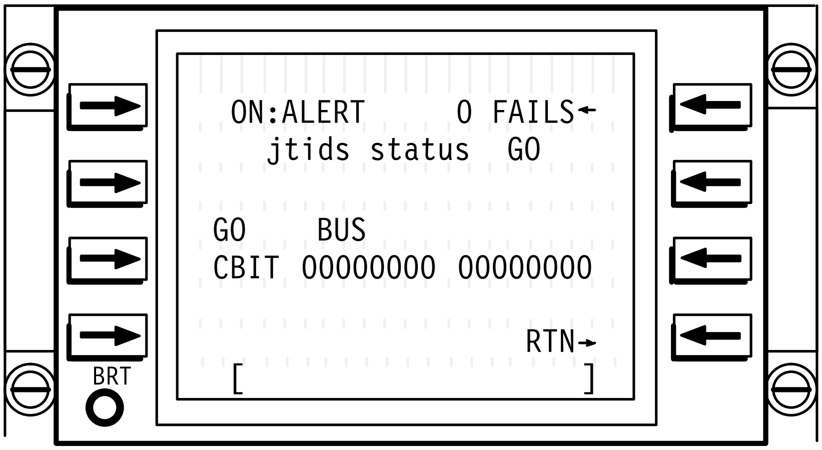
LS8	Return to Navigation Status page.

Vertical scrolling accesses associated EGIX Status 1 page (X being either 1 or 2).

Figure 1-175 (Sheet 13 of 14)

CDU Menus - Status (Continued)

(JTIDS-CDU Bus Status)



```
 ON:ALERT     0 FAILS←
    jtids status  GO

GO    BUS
CBIT 00000000 00000000

                  RTN→
 [                   ]
```

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NOTE

- JTIDS status page is accessed from nav status page.
- Status displayed is status of bus traffic between CDU and JTIDS.

Title line displays top level LRU status.

Information line displays CDU-JTIDS bus traffic status as GO, NGO–A, NGO–B, or NGO–T.

Data line 1 displays an ALERT function (same as for EGIs), and a failure counter, which increments when title line selects between GO and NGO, or upon JTIDS bus failure.

Data line 3 displays results from bus status word in a sixteen bit data word, where a 1 indicates a failure. Bit 1 is leftmost bit in display:

Bit	Description
1-14	Unused set to 0
15	Subsystem Fail
16	Terminal Fail

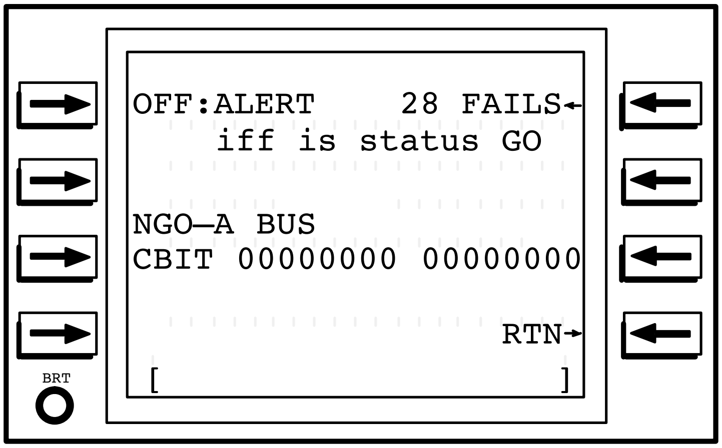
LS1 Selects √STATUS annunciation ALERT, ON or OFF.

LS5 Resets failure counter to 0.

LS8 Returns to nav status page.

Figure 1–175 (Sheet 13A of 14)

WITH IDG (IFF Interrogator Set Status)



```
OFF:ALERT    28 FAILS←
   iff is status GO

NGO—A BUS
CBIT 00000000 00000000

                  RTN→
[                     ]
```

NOTE

IFF interrogator set status page is accessed from nav status page.

LS1 Selects ON : ALERT, or OFF : ALERT. When ALERT is selected ON a failure in the IFF interrogator set causes a ✓STATUS annunciation and illuminates the CDU ALERT caution light. When selected ON, neither the annunciation nor the light illumination occur, however failure history continues to be recorded. Display at poweron is ON:ALERT.

Title line displays top level LRU status: GO or NGO.

Information line displays 1553 bus status: GO, NGO–A, NGO–B, or NGO–T.

Data line 3 displays a sixteen bit 1553 bus status word, where 1 indicates a fail state. The bits are defined as follows (bit 1 is the leftmost bit displayed):

Bit	Description
1-14	Unused – set to 0
15	Subsystem Fail
16	Terminal Fail

Data line 1 displays a failure which increments when the title line changes between GO and NGO, or upon IFF interrogator bus failure.

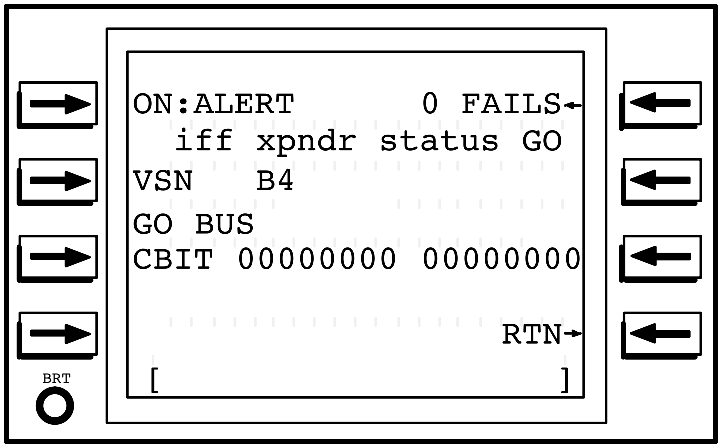
LS5 Resets failure counter to zero.

LS8 Returns to nav status page.

Figure 1–175 (Sheet 13B of 14)

CDU Menus - Status (Continued)

WITH IDG IFF Status Page



```
ON:ALERT       0 FAILS←
  iff xpndr status GO
VSN   B4
GO BUS
CBIT 00000000 00000000

                  RTN→
[                     ]
```

Title line displays top level LRU status.

Data line 1 displays an ALERT function and failure counter. When ALERT is set to ON, a failure causes the ✓STATUS annunciation and illuminates CDU ALERT caution light. When ALERT is set to OFF, failures do not cause ✓STATUS annunciation and do not illuminate CDU ALERT caution light. ALERT defaults to ON when EDC power is removed for longer than 30 seconds. When selected OFF, failure history continues to be recorded. The failure counter increments when the title line changes between GO and NGO or upon IFF bus failure.

Data line 3 displays CBIT results. Only bits 15 and 16 are used. A “1” in bit 15 indicates a terminal failure; in bit 16 indicates a subsystem failure.

LS1 Selects the ✓STATUS annunciation ALERT, ON or OFF. When ALERT is set to ON, a failure causes ✓STATUS annunciation and illuminates CDU ALERT caution light on RNAV ANNUNCIATOR panel. When ALERT is set to OFF, failures do not cause the ✓STATUS annunciation and do not illuminate CDU ALERT caution light. Display at poweron is ON:ALERT.

LS2 Displays IFF transponder software version number.

Info Displays 1553 bus status:

(1) GO	
(2) NGO–A	(1553 bus A channel)
(3) NGO–B	(1553 bus B channel)
(4) NGO–T	(1553 bus terminal)

LS5 Resets failure counter to 0. Occurs within the CDU only – does not reset the IFF’s internal failure counter.

LS8 Returns to nav status page.

Figure 1–175 (Sheet 14 of 14) ◀

CDU Alerts

TYPE OF ALERT	INITIATING CONDITION
TRACK CHANGE indicator; flash TO Waypoint Number on Flight Plan page, and flash ↓ to ↓ label on Pilot and Copilot Steer pages.	Ten seconds prior to waypoint sequence.
VERT NAV CHANGE indicator; flash V on Flight Plan page, and flash TOD/BOC on Pilot and Copilot Vertical Steer pages.	Ten seconds prior to vertical capture.
VERT NAV CHANGE indicator; flash V on Flight Plan page, and flash Pressure Altitude on Flight Plan Waypoint page.	One thousand feet above Bottom of Descent (BOD) or 1000 ft below Top Of Climb (TOC).
VERT NAV CHANGE indicator; flash A on Flight Plan page, flash TOD on Pilot and Copilot Steer pages.	Ten seconds prior to capture when a MAP is the next TO.
VERT NAV CHANGE indicator; flash A on Flight Plan page, flash altitude on Pilot and Copilot Vertical Steer pages.	MDA is attained.
SPEED ALERT Caution Light	Exceed entered speed threshold.
CDU ALERT Caution Light	Master alert – check CDU.
RAIM ALERT Caution Light	RAIM integrity function alert (RAIM WRN status) exists.
ENROUTE Indicator	FMS in Enroute Mode
TERMINAL Indicator	FMS in Terminal Mode
APPROACH Indicator	FMS in Approach Mode

NOTE

Alerts flash 600 milliseconds on, 400 milliseconds off.

Figure 1-176

CDU Annunciations and Scratchpad Messages

ANNUNCIATION SCRATCHPAD MESSAGE	INITIATING CONDITION	RESET MECHANISM	ANNUNCIATION CHARACTERISTICS S – scratchpad L – left side L6 R – right side L6 B – blinks A – alternates with other data N – non-clearable M – master alert
ADD ALTN BEFORE?	An alternate flight plan has been selected to be added to flight plan	CLR key or insertion of alternate flight plan into flight plan	SN
ALTN FPLN FULL	Attempt to insert more than 60 legs into alternate flight plan	CLR key	SA
APPROACH	HSI deviations are set for Approach Mode scaling	HSI deviations change to Terminal Mode or Enroute Mode scaling	ALN
APPROACH DEFINED	Attempt to enter VNAV parameters for or attach a Hold or pattern to a waypoint with an FMS approach attached, or an attempt to insert an offset or modify flight plan course when a MAP or FAF is the TO waypoint	CLR key	SA
APPROACH IS ACTIVE	Attempt to delete approach from flight plan during execution; attempt to modify flight plan course or sequencing mode or MDA when a MAP is TO waypoint	CLR key	SA
ATTACH CIR AT?	A circle pattern without defined center location has been selected for insertion into flight plan or alternate flight plan	CLR key or valid insert	S
ATTACH CRP AT?	A closed random pattern without a defined fix has been selected for insertion into flight plan or alternate flight plan	CLR key or valid insert	S
ATTACH FG8 AT	A figure 8 pattern with only one defined lobe center has been selected for insertion into flight plan or alternate flight plan	CLR key or valid insert	S

Figure 1-177 (Sheet 1 of 16)

ANNUNCIATION SCRATCHPAD MESSAGE	INITIATING CONDITION	RESET MECHANISM	**ANNUNCIATION CHARACTERISTICS** S – scratchpad L – left side L6 R – right side L6 B – blinks A – alternates with other data N – non-clearable M – master alert
ATTACH FMS APPR AT?	An FMS approach has been selected for insertion into flight plan	CLR key or valid insert	S
ATTACH HOLD AT?	A hold has been selected for insertion into flight plan	CLR key or valid insert	S
ATTACH RFL AT?	A refuel pattern without a defined fix has been selected for insertion into flight plan or alternate flight plan	CLR key or valid insert	S
ATTACH RTK AT?	A racetrack pattern with only one defined lobe center has been selected for insertion into flight plan or alternate flight plan	CLR key or valid insert	S
ATTD RDY 1	INU 1 indicates that attitude mode can be achieved with current alignment	CLR key, or improved alignment status or enabling nav mode	AL
ATTD RDY 2	INU 2 indicates that attitude mode can be achieved with current alignment	CLR key, or improved alignment status or enabling nav mode	AL
√BAROSET	Terminal mode or approach mode has been automatically engaged from en route mode	CLR key, or entering a baroset on a Position page	ARB
√GPS	Loss of GPS in Designated Pilot's solution due to loss of validity of GPS	CLR key, or reobtaining GPS or selecting a solution without GPS	ARB
WITH GA √INU1 ALN	When the EGI1 CEP or the rate of change of EHE is > 0.9	EGI1 CEP or rate of change of EHE is < 0.9	ARBNM
√INU2 ALN	When the EGI2 CEP or the rate of change of EHE is > 0.9	EGI2 CEP or rate of change of EHE is < 0.9	ARBNM ◀

Figure 1-177 (Sheet 2 of 16)

CDU Annunciations and Scratchpad Messages (Continued)

ANNUNCIATION SCRATCHPAD MESSAGE	INITIATING CONDITION	RESET MECHANISM	**ANNUNCIATION CHARACTERISTICS** S – scratchpad L – left side L6 R – right side L6 B – blinks A – alternates with other data N – non-clearable M – master alert
√INU1 MDE	The commanded INU1 mode and the actual INU1 mode are different	CLR key, or commanded and actual INU1 modes coming into agreement	ARB
√INU2 MDE	The commanded INU2 mode and the actual INU2 mode are different	CLR key, or commanded and actual INU2 modes coming into agreement	ARB
√NAV ERR	Downgrade in Designated Pilot's 95% probable error or EGI Estimated Nav Error >1 nm	CLR key, or acceptable error or EGI Estimated Nav Error bit not set	ARBM
WITH IDG √POWER	Power mode prohibits the attempted command.	CLR key	SA ◀
√STATUS	Detected failure of an LRU or interface signal	CLR key, or pressing STAT key	ARBM
√STATUS	A request for display or operation that cannot be provided due to failure, or LRU is under test	CLR key	SA
√TIMER 1	Down-count to zero	CLR key	ARB
√TIMER 2	Down-count to zero	CLR key	ARB
√TIMER 3	Down-count to zero	CLR key	ARB
√VERSION	CDU has incorrect software version	Replace or power down unit with incorrect version	RBNM
CARTRIDGE IN USE	Attempt to access data cartridge while data is currently being up/down-loaded	CLR key	SA
CIR ACTIVE	Circle pattern is currently being executed	Circle pattern cancelled	L

Figure 1-177 (Sheet 3 of 16)

ANNUNCIATION SCRATCHPAD MESSAGE	INITIATING CONDITION	RESET MECHANISM	ANNUNCIATION CHARACTERISTICS S – scratchpad L – left side L6 R – right side L6 B – blinks A – alternates with other data N – non-clearable M – master alert
CIR IS ACTIVE	Attempt to delete or modify circle fix or modify flight plan course during pattern execution	CLR key	SA
COMPARE GPS	GPS solution is suspect	CLR key ①	L
WITH GA COMPARE INU	Both INUs are in NAV mode and the position difference between INU1 and INU2 is > [1.224 (INU1 95%ERR + INU2 95%ERR) + 1.0nm] for more than 30 seconds OR Both INUs are in NAV mode and the horizontal speed difference between INU1 and UNU2 is > 7 knots for more than 30 seconds.	CLR key or initiating condition is corrected	L ◄
CONFIRM ALTN RMV	Request to remove a pattern from alternate flight plan	CLR key or reselect ALTN FPLN	S
CONFIRM CHNG TO CIR	Request to change MOP type to circle	CLR key or selection of PTRN CHNG	S
CONFIRM CHNG TO FG8	Request to change MOP type to figure 8	CLR key or selection of PTRN CHNG	S
CONFIRM CHNG TO RTK	Request to change MOP type to racetrack	CLR key or selection of PTRN CHNG	S
CONFIRM CLEAR CART	Request to clear data cartridge	CLR key or reselect CARTRIDGE	S
CONFIRM CLEAR FPLNS	Request to clear flight plan and alternate flight plans	CLR key or reselect FPLN/ALTN	S
WITH IDG CONFIRM CLEAR IFF	Request to zeroize IFF M1, M3A and M4 codes (zeroize page)	CLR key or reselect IFF	S
CONFIRM CLEAR M4	Request to zeroize IFF M4 codes only (IFF mode 4 page)	CLR key or reselect M4 zero	S ◄
CONFIRM CLEAR PTS	Request to clear markpoint and waypoint lists	CLR key or reselect MKPTS/WPTS	S

① Operator should manually compare navigation solutions of the 2 EGIs and other NAV System to determine which EGI has erroneous data and possibly switch preferred EGIs.

Figure 1-177 (Sheet 4 of 16)

CDU Annunciations and Scratchpad Messages (Continued)

ANNUNCIATION SCRATCHPAD MESSAGE	INITIATING CONDITION	RESET MECHANISM	ANNUNCIATION CHARACTERISTICS S – scratchpad L – left side L6 R – right side L6 B – blinks A – alternates with other data N – non-clearable M – master alert
WITH IDG CONFIRM CODE HOLD	Request to hold M4 IFF codes (IFF mode 4 page)	CLR key or reselect HOLD	S ◀
CONFIRM EGI1 TEST	Request to perform EGI IBIT Test on EGI1	CLR key or reselect INITIATE TEST	S
CONFIRM EGI2 TEST	Request to perform EGI IBIT Test on EGI2	CLR key or reselect INITIATE TEST	S
WITH IDG CONFIRM EMER IFF	Request to initiate IFF emergency mode (tcas/iff control page)	CLR key or reselect EMER	S ◀
CONFIRM ERASE DATA	Request to erase flight data (start 3 page)	CLR key or reselect ERASE FLT/DATA	S
CONFIRM ERASE ALTN	Request to erase alternate flight plan (altn fpln page)	CLR key or reselect ERASE ALTN	S
CONFIRM ERASE FPLN	Request to erase flight plan (start 3 page)	CLR key or reselect ERASE FPLN	S
CONFIRM FPLN RMV	Request to remove a hold, FMS approach, pattern or intercept from flight plan	CLR key or reselect FPLN RMV	S
CONFIRM HOLD PSN	Request to hold at present position	CLR key or reselect HOLD PSN	S
CONFIRM LOAD ALL	Request to load all flight data into CDU from data cartridge	CLR key or reselect LOAD MASTER	S
CONFIRM LOAD ALMNAC	Request to load GPS almanac data	CLR key or reselect LOAD ALMANAC	S
CONFIRM LOAD ALTN	Request to load alternate flight plan into CDU from data cartridge	CLR key or reselect LOAD ALTN	S
CONFIRM LOAD DATA	Request to load flight data (start 3 page)	CLR key or reselect LOAD FLT/DATA	S
CONFIRM LOAD PTS	Request to load markpoint and waypoint lists into CDU from data cartridge	CLR key or reselect LOAD MKPT/WPT	S
CONFIRM PAT CHANGE	Request to change a parameter of an MOP.	CLR key or reselect PTRN CHNG	S
CONFIRM RENUMB FPLN	Request to renumber flight plan	CLR key or reselect RENUMBER	S

Figure 1-177 (Sheet 5 of 16)

ANNUNCIATION SCRATCHPAD MESSAGE	INITIATING CONDITION	RESET MECHANISM	ANNUNCIATION CHARACTERISTICS S – scratchpad L – left side L6 R – right side L6 B – blinks A – alternates with other data N – non-clearable M – master alert
CONFIRM RPLACE FPLN	Request to replace flight plan with alternate (start 3 and altn fpln pages)	CLR key or reselect REPLACE FPLN	S
CONFIRM RVRSE ALTN	Request to reverse alternate flight plan	CLR key or reselect RVRS ALTN	S
CONFIRM SAVE ALL	Request to save all flight data to data cartridge	CLR key or reselect SAVE MASTER	S
CONFIRM SAVE ALMANAC	Request to save GPS almanac data	CLR key or reselect SAVE ALMANAC	S
CONFIRM SAVE ALTN	Request to save alternate flight plan to data cartridge	CLR key or reselect SAVE ALTN	S
CONFIRM SAVE PTS	Request to save markpoint and waypoint lists to data cartridge	CLR key or reselect SAVE MKPT/WPT	S
CONFIRM SAVE STATUS	Request to save system status to data cartridge	CLR key or reselect SAVE STAT	S
CONFIRM SYSTEM TEST	Request to initiate test on all LRUs controlled by FMS	CLR key or reselect SYSTEM	S
CONFIRM ZERO ALL	Request to zeroize system	CLR key or reselect ZERO ALL	S
CRP ACTIVE	Closed random pattern is currently being executed	Closed random pattern cancelled	ALN
CRP IS ACTIVE	Attempt to delete or modify closed random pattern fix or modify flight plan course during pattern execution	CLR key	SA
CRS CHANGE >90	Attempt to apply course edit greater than 90° from current inbound course while in automatic leg sequence mode	CLR key	SA

Figure 1-177 (Sheet 6 of 16)

CDU Annunciations and Scratchpad Messages (Continued)

ANNUNCIATION SCRATCHPAD MESSAGE	INITIATING CONDITION	RESET MECHANISM	**ANNUNCIATION CHARACTERISTICS** S – scratchpad L – left side L6 R – right side L6 B – blinks A – alternates with other data N – non-clearable M – master alert
DATA FOR?	Prompt for access to data page	CLR key or valid waypoint selection	S
WITH GA DB TRUNCATED	Upon auto transfer of the cartridge contents, if the RPID list is greater than the RPID limit of 120,000 points	Loss of data loader due to cold start or data loader failure transient of more than 3 seconds, removal of the cartridge or the CLR key	L ◀
DIRECT TO CRP?	Access of CRP page from Direct–To Flight Plan page	CLR key or selection of CRP point for Direct–To	S
EGI IN TEST	Attempt to put INU in Nav mode on INU INAV page after EGI has been placed into test	CLR key	S
WITH IDG EMERGENCY ENGAGED	Attempt to change IFF modes or codes when set to emergency configuration	CLR key	SA ◀
ENTER ANGLE OR RATE	Attempt to toggle between CLIMB and DESCNT when no vertical angle or rate has been entered	CLR key	SA
ENTER FIX	Attempt to enter a magnetic track or toggle to a magnetic track when a target fix has not been entered on Intercept A page	CLR key	SA
ENTER PARAMETERS	Attempt to insert an intercept, MOP, or approach into flight plan when defining parameters have not been entered	CLR key	SA
ENTER WAYPOINT	Attempt to enter an alternate flight plan parameter prior to entering waypoint or attempt to enter a flight plan course when no TO exists	CLR key	SA

Figure 1-177 (Sheet 7 of 16)

ANNUNCIATION SCRATCHPAD MESSAGE	**INITIATING CONDITION**	**RESET MECHANISM**	**ANNUNCIATION CHARACTERISTICS** **S – scratchpad** **L – left side L6** **R – right side L6** **B – blinks** **A – alternates with other data** **N – non-clearable** **M – master alert**
ENTER UTC	On power up if time is not available and crew has not entered time or if bus control is switched with time not valid	CLR key or entry of time or return of valid time	AL
ENTER UTC/DATE	Attempt to start the timer without a valid UTC and date available in the system	CLR key	SA
500 FT MINIMUM	Alternate to enter a VNAV or alternate flight plan altitude less than 500 ft or FL005	CLR key	SA
FG8 ACTIVE	Figure 8 pattern is currently being executed	Figure 8 pattern cancelled	ALN
FG8 IS ACTIVE	Attempt to delete or modify figure 8 fix or modify flight plan course during pattern execution	CLR key	SA
FPLN FULL	Attempt to insert more than 60 waypoints into flight plan	CLR key	SA
GPS1 IS VALID	Attempt to accept an update to integrated navigation solution when GPS1 is valid	CLR key	SA
GPS2 IS VALID	Attempt to accept an update to integrated navigation solution when GPS2 is valid	CLR key	SA
GROUND ONLY	Attempt to perform a ground operation during flight	CLR key	SA
HOLD ACTIVE	Hold is currently being executed	Hold cancelled	ALN
HOLD DEFINED	Attempt to insert a pattern, or FMS approach on a waypoint with a Hold attached or an attempt to insert an offset when a holding fix is TO waypoint	CLR key	SA

Figure 1-177 (Sheet 8 of 16)

CDU Annunciations and Scratchpad Messages (Continued)

ANNUNCIATION SCRATCHPAD MESSAGE	INITIATING CONDITION	RESET MECHANISM	ANNUNCIATION CHARACTERISTICS S – scratchpad L – left side L6 R – right side L6 B – blinks A – alternates with other data N – non-clearable M – master alert
HOLD IS ACTIVE	Attempt to delete or modify holding fix or modify flight plan course during hold execution	CLR key	SA
WITH IDG HOLD/ ZERO IN PROG	Attempt to change Mode 4 code while M4 code hold is enabled or M4 zeroize is in progress and Mode 4 enable is ON	CLR key	SA
IDENT	IFF M3 ident has been selected	Displayed for only 3 seconds	ARN
IFF IN TEST	Attempt to initiate IFF test when performing IFF test	Displayed for only 3 seconds	SA ◄
INSERT CIR BEFORE?	A circle pattern with a defined fix has been selected for insertion into flight plan or alternate flight plan	CLR key or valid insert	S
INSERT CRP BEFORE?	A closed random pattern with a defined fix has been selected for insertion into flight plan or alternate flight plan	CLR key or valid insert	
INSERT FG8 BEFORE?	A figure 8 pattern with a defined fix has been selected for insertion into flight plan or alternate flight plan	CLR key or valid insert	S
INSERT INTR BEFORE?	An intercept has been selected for insertion into flight plan	CLR key or valid insert	S
INSERT RFL BEFORE?	A refuel pattern with a defined fix has been selected for insertion into fpln or alternate flight plan	CLR key or valid insert	S
INSERT RTK BEFORE?	A racetrack pattern with a defined fix has been selected for insertion into flight plan or alternate flight plan	CLR key or valid insert	S

Figure 1-177 (Sheet 9 of 16)

CDU Annunciations and Scratchpad Messages (Continued)

ANNUNCIATION SCRATCHPAD MESSAGE	INITIATING CONDITION	RESET MECHANISM	ANNUNCIATION CHARACTERISTICS S – scratchpad L – left side L6 R – right side L6 B – blinks A – alternates with other data N – non-clearable M – master alert
INTERCEPT DEFINED	Attempt to enter VNAV parameters for or attach a HOLD, FMS approach, or pattern to a point defined as an intercept	CLR key	SA
INTR ACTIVE	An intercept is currently flight plan TO waypoint	Deletion to intercept point via direct–TO	ALN
INTR IS ACTIVE	Attempt to delete intercept from flight plan during execution (current TO) or attempt to modify flight plan course when an intercept is TO waypoint	CLR key	SA
INU1 IFA	INU1 has initiated an In Flight Alignment and INU1 is in Designated Pilot's solution	CLR key or inflight alignment has completed	ARA
INU2 IFA	INU2 has initiated an In Flight Alignment and INU2 is in Designated Pilot's solution	CLR key or inflight alignment has completed	ARA
INVALID DELETION	Attempt to delete intercept attribute, history waypoint (if only one exists), or intercept, MOP, or FMS approach parameters when in flight plan or alternate flight plan	CLR key	SA
INVALID ENTRY	Attempt to insert scratchpad data which does not pass format or range tests, or attempt to select a function when insufficient data has been entered	CLR key or selecting a line key for which entry is allowed	SA
INVLD BRST1	EGI1 has indicated Invalid Boresight Angles	CLR key or EGI1 has indicated valid boresight angles	ALN
INVLD BRST2	EGI2 has indicated Invalid Boresight Angles	CLR key or EGI2 has indicated valid boresight angles	ALN

Figure 1-177 (Sheet 10 of 16)

ANNUNCIATION SCRATCHPAD MESSAGE	INITIATING CONDITION	RESET MECHANISM	ANNUNCIATION CHARACTERISTICS S – scratchpad L – left side L6 R – right side L6 B – blinks A – alternates with other data N – non-clearable M – master alert
JTDS IS VALID	Attempt to accept an update to integrated navigation solution when JTIDS is valid	CLR key	SA
WITH GA JTDS RELNAV	JTIDS cannot be used for navigation or JTIDS position upgrade quality is poor	CLR key or JTIDS quality corrected	L ◀
KEY1 ALRT	GPS1 SA/AS keys will expire in two hours	CLR key or entry of new keys passing time test	ARB
KEY2 ALRT	GPS2 SA/AS keys will expire in two hours	CLR key or entry of new keys passing time test	ARB
KEY1 ERR	Incorrect SA/AS key received	CLR key or entry of correct key	ARB
KEY2 ERR	Incorrect SA/AS key received	CLR key or entry of correct key	ARB
LOAD FAIL	Failure passing data to/from data cartridge	CLR key	AR
LOAD IN PROGRESS	Attempt to use or modify data that is being transferred via the data loader	CLR key	SA
LOCKED	Password has been entered, locking system	Entry of correct password or zeroizing system	ALN
WITH IDG M4 REPLY	When the IFF replies to a mode 4 interrogation and annunciation (ANN or AUD) is enabled on the IFF mode 4 page	Automatically reset by the IFF when the condition no longer exists or annunciation is not enabled (OUT) on the IFF mode 4 page	ARB ◀

Figure 1-177 (Sheet 11 of 16)

ANNUNCIATION SCRATCHPAD MESSAGE	INITIATING CONDITION	RESET MECHANISM	ANNUNCIATION CHARACTERISTICS S – scratchpad L – left side L6 R – right side L6 B – blinks A – alternates with other data N – non-clearable M – master alert
WITH IDG M4 WARN	IFF is configured for mode 4 operation (M4 ON, NORM selected) but codes are not loaded. (This annunciation does not occur in STBY.)	Reload codes	ARB
	The mode 4 applique determines that an interrogation is valid and commands a response, but the transponder fails to feed back a ‘response sent’ status to the applique. This is not the same condition as a refusal to reply; the M4 WARN annunciation does not occur with a legitimate refusal to reply resulting from a code mis–match. Also, this is not caused by suppression.	Automatically reset by the IFF when the condition no longer exists	
	The mode 4 applique fails IBIT or continuous self test, in NORM.	Check M4 status on iff test page. Repeat IBIT. Have maintenance replace LRUs, as required.	
MAX INTRS IN FPLN	Attempt to insert more than 10 intercepts into flight plan	CLR key	SA
MAX PTRNS IN ALTN	Attempt to insert more than 20 patterns into alternate flight plan	CLR key	SA
MAX PTRNS IN FPLN	Attempt to insert more than 20 patterns into flight plan	CLR key	SA
MDA	When minimum descent altitude is reached during execution of an FMS approach, Altitude alert is illuminated	CLR key or passage of missed approach point	ALB
WITH IDG MODE S ON	Attempt to change the IFF antenna selection when MS is ON.	CLR key	SA ◀

NOTE

The conditions for an M4 WARN annunciation and an IFF caution light illumination are exactly the same. The only condition that can give one without the other is if the M4 CAUT/ZERO circuit breaker is open; then it is possible to get an M4 WARN when the light is out. ◀

Figure 1-177 (Sheet 11 of 16)

CDU Annunciations and Scratchpad Messages (Continued)

ANNUNCIATION SCRATCHPAD MESSAGE	INITIATING CONDITION	RESET MECHANISM	ANNUNCIATION CHARACTERISTICS S – scratchpad L – left side L6 R – right side L6 B – blinks A – alternates with other data N – non-clearable M – master alert
NAV FAIL	No valid navigation mode. Designated pilot nav solution invalid	Upgrade to valid navigation mode	ALNM
NAV READY 1	INU 1 indicates that ENAB NAV can be selected to put INU in navigation mode	CLR key or enabling nav mode	AL
NAV READY 2	INU 2 indicates that ENAB NAV can be selected to put INU in navigation mode	CLR key or enabling nav mode	AL
NO CARTRIDGE	Attempt to access Data Loader Data when no cartridge is installed	CLR key	SA
NO FPLN	No TO waypoint exists	Entry of a flight plan or TO waypoint	ALN
NO INTERCEPT	Intercept solution for active waypoint is invalid	CLR key or intercept solution becomes valid	AL
NO KEY1 ZERO	Failure to zeroize GPS1 SA/AS keys	CLR key or subsequent successful clear of keys	ALB
NO KEY2 ZERO	Failure to zeroize GPS2 SA/AS keys	CLR key or subsequent successful clear of keys	ALB
NO MAG VAR	Attempt to enter Magnetic Variation (Course, Bearing, or Track) without Magnetic Variation tables	CLR key	SA
NOT STORED	Entry not found in data base	CLR key	SA
NO UPDATE	EGI has rejected an attempted update	CLR key	LB
NO RAIM	RAIM unavailable for more than 30 seconds	CLR key	R
OFFSET	Parallel offset is applied	Offset cancelled	LN

Figure 1-177 (Sheet 12 of 16)

ANNUNCIATION SCRATCHPAD MESSAGE	**INITIATING CONDITION**	**RESET MECHANISM**	**ANNUNCIATION CHARACTERISTICS** **S – scratchpad** **L – left side L6** **R – right side L6** **B – blinks** **A – alternates with other data** **N – non-clearable** **M – master alert**
OFFSET CNCLD	Parallel offset automatically cancelled	CLR key	LBM
ONLOAD DEFINED	Attempt to enter extra fuel or total fuel on Fuel page when an onload is defined in alternate flight plan	CLR key	SA
PATTERN DEFINED	Attempt to attach a hold, FMS approach or CRP at a point defined to be a pattern, attempt to insert an offset when a pattern fix is TO waypoint.	CLR key	SA
PATTERN NOT IN FPLN	Attempt to enable refuel pattern when pattern is not in active flight plan	CLR key	SA
PCA INTERCEPT	Intercept solution for active waypoints is to Point of Closest Approach		
RFL ACTIVE	Refuel pattern is currently being executed	Refuel pattern cancelled	LN
RFL IS ACTIVE	Attempt to delete or modify refuel fix or modify flight plan course during pattern execution	CLR key	SA
RTK ACTIVE	Racetrack pattern is currently being executed	Racetrack pattern cancelled	ALN
RTK IS ACTIVE	Attempt to delete or modify racetrack fix or modify flight plan course during pattern execution	CLR key	SA
SAFE KEYS 1	GPS1 SA/AS keys are zeroized	CLR key	AL
SAFE KEYS 2	GPS2 SA/AS keys are zeroized	CLR key	AL
WITH IDG SET M3A ON	Attempt to select mode C ON when mode 3/A is OUT	CLR key	SA
SET MODE S ON	Attempt to change the TCAS sensitivity when MS is OUT	CLR key	SA ◀

Figure 1-177 (Sheet 13 of 16)

CDU Annunciations and Scratchpad Messages (Continued)

ANNUNCIATION SCRATCHPAD MESSAGE	INITIATING CONDITION	RESET MECHANISM	ANNUNCIATION CHARACTERISTICS S – scratchpad L – left side L6 R – right side L6 B – blinks A – alternates with other data N – non-clearable M – master alert
TERMINAL	HSI deviations are set for terminal scaling	HSI deviations change to approach or enroute scaling	ALN
UNUSED FUNCTION	Selection of LESS IDG IFF, M3, ◀ NAV, COM, or MSN function keys	CLR key	SB
WITH GA VFY AHRS HDG	When one AHRS heading disagrees with both headings from the blended solutions by more than 10 degees	CLR key or AHRS heading corrected	L ◀
WITH GA VFY AHRS1	When AHRS1 heading disagrees with the heading from AHRS2 and the heading from the blended solution from EGI1 by more than 10 degrees	CLR key or AHRS1 heading corrected	L ◀
WITH GA VFY AHRS2	When AHRS2 heading disagrees with the heading from AHRS1 and the heading from the blended solution from EGI2 by more than 10 degrees	CLR key or AHRS2 heading corrected	L ◀
WITH GA VFY BLENDED1	INU1/GPS1 95%ERR is > 0.3 nm (APPROACH), 1.7 nm (TERMINAL), or 2.8 nm (ENROUTE) for more than 30 seconds OR The position difference between INU1/GPS1 and INU2/GPS2 is > [1.224(INU1/GPS1 95%ERR + INU2/GPS2 95%ERR)] AND the position difference between INU1/GPS1 and GPS1 is > [1.224(INU1/GPS1 95%ERR + GPS1 95%ERR)] for more than 30 seconds	CLR key or initiating condition no longer exists	L ◀

Figure 1-177 (Sheet 14 of 16)

ANNUNCIATION SCRATCHPAD MESSAGE	**INITIATING CONDITION**	**RESET MECHANISM**	**ANNUNCIATION CHARACTERISTICS** **S – scratchpad** **L – left side L6** **R – right side L6** **B – blinks** **A – alternates with other data** **N – non-clearable** **M – master alert**
WITH GA VFY BLENDED2	INU2/GPS2 95%ERR is > 0.3nm (APPROACH), 1.7nm (TERMINAL), or 2.8nm (ENROUTE) for more than 30 seconds OR The position difference between INU2/GPS2 and INU1/GPS1 is > [1.224(INU2/GPS2 95%ERR + INU1/GPS1 95%ERR)] AND the position difference between INU2/GPS2 and GPS2 is > [1.224(INU2/GPS2 95%ERR + GPS2 95%ERR)] for more than 30 seconds	CLR key or initiating condition no longer exists	L ◀
WITH GA VFY GPS1	GPS1 95%ERR is > 0.07nm (APPROACH), 0.15nm (TERMINAL), or 0.15nm (ENROUTE) for more than 30 seconds OR The position difference between GPS1 and GPS2 is > [1.224(GPS1 95%ERR + GPS2 95%ERR)] AND the position difference between GPS1 and INU1/GPS1 is > [1.224(GPS1 95%ERR + INU1/GPS1 95%ERR) for more than 30 seconds	CLR key or initiating condition no longer exists	L ◀
WITH GA VFY GPS2	GPS2 95%ERR is > 0.07nm (APPROACH), 0.15nm (TERMINAL), or 0.15nm (ENROUTE) for more than 30 seconds OR The position difference between GPS2 and GPS1 is > [1.224(GPS2 95%ERR + GPS1 95%ERR)] AND the position difference between GPS2 and INU2/GPS2 is > [1.224(GPS2 95%ERR + INU2/GPS2 95%ERR) for more than 30 seconds	CLR key or initiating condition no longer exists	L ◀

Figure 1-177 (Sheet 15 of 16)

CDU Annunciations and Scratchpad Messages (Continued)

ANNUNCIATION SCRATCHPAD MESSAGE	INITIATING CONDITION	RESET MECHANISM	ANNUNCIATION CHARACTERISTICS S – scratchpad L – left side L6 R – right side L6 B – blinks A – alternates with other data N – non-clearable M – master alert
WITH GA VFY INU1	INU1 is in NAV mode and the horizontal speed difference between INU1 and GPS1 is > 5 knots for more than 30 seconds OR INU1 is in NAV mode and the position difference between INU1 and GPS1 is > [1.224(INU1 95%ERR + GPS1 95%ERR)] + 0.5nm for more than 30 seconds	CLR key or initiating condition no longer exists	L ◀
WITH GA VFY INU2	INU1 is in NAV mode and the horizontal speed difference between INU1 and GPS1 is > 5 knots for more than 30 seconds OR INU1 is in NAV mode and the position difference between INU1 and GPS1 is > [1.224(INU1 95%ERR + GPS1 95%ERR)] + 0.5nm for more than 30 seconds	CLR key or initiating condition no longer exists	L ◀
WITH GA VFY TAS	CADC true airspeed disagrees with the other CADC true airspeed by more than 6 knots	CLR key or CADC true airspeed difference is less than 6 knots	L ◀
VNAV IS ACTIVE	Attempt to toggle between CLIMB and DESCNT when a VNAV is active	CLR key	SA
XTK ALERT	Airplane cross track deviation exceeds crew entered specified threshold	Airplane is maneuvered to bring cross track deviation within threshold or deviation threshold is expanded	ARBN
XXXX:XX	UTC DISPLAY enabled on start 1 page	Disable UTC DISPLAY on start 1 page	ARN

Figure 1-177 (Sheet 16 of 16)

CDU Annunciation Line Priorities

LEFT HALF	RIGHT HALF
LOCKED	WITH IDG IDENT
MDA	M4 REPLY
OFFSET–CNCLD	M4 WARN ◀
ENTER UTC	XTK ALERT
NAV READY X ①	√GPS
ATTD READY X ①	√NAV ERR
INVLD BRSTX ①	√STATUS
NO KEYX ZERO ①	NO RAIM
SAFE KEYS X ①	INUX IFA ①
NO UPDATE	√INUX MDE ①
NAV FAIL	INIT DATA
COMPARE GPS	√BAROSET
WITH GA VFY BLENDEDX ◀ ①	KEYX ALRT ①
WITH GA VFY GPSX ◀ ①	LOAD FAIL
WITH GA VFY INUX ◀ ①	KEYX ERR ①
WITH GA COMPARE INU ◀	XXXX:XX ②
WITH GA VFY AHRSX ◀ ①	
WITH GA VFY AHRS HDG ◀	
WITH GA VFY TAS ◀	
WITH GA JTDS RELNAV ◀	
NO INTERCEPT	
OFFSET	
APPROACH	
TERMINAL	
HOLD ACTIVE	
INTR ACTIVE	
CRP ACTIVE	
RFL ACTIVE	
FG8 ACTIVE	
RTK ACTIVE	
CIR ACTIVE	
NO FPLN	

① X represents associated LRU (1 or 2).
② XXXX:XX represents UTC time.

Figure 1-178

NAVIGATION EQUIPMENT ELECTRIC POWER SOURCES

Electric power sources are listed in *figure 1-179*.

Navigation Equipment Electric Power Sources

EQUIPMENT/SYSTEM	TYPE OF POWER	POWER SOURCE	CIRCUIT BREAKER LOCATION/LABEL
CDU 1	28V DC	FAVDC 1	P6, GINS NAVIGATION – CDU – PILOT RNAV 1 RNAV 3
CDU 2	28V DC	FAVDC 2	P6, GINS NAVIGATION – CDU – COPILOT BSIU 2 RNAV 2
CDU 3	28V DC	HOT BAT	P6, GINS NAVIGATION – CDU – NVGTR BSIU 1 CTRL PNL & MDL
RNAV Panel 1	28V DC	FAVDC 1	P6, GINS NAVIGATION – CDU – PILOT RNAV 1 RNAV 3
RNAV Panel 2	28V DC	FAVDC 2	P6, GINS NAVIGATION – CDU – COPILOT BSIU 2 RNAV 2
RNAV Panel 3	28V DC	FAVDC 1	P6, GINS NAVIGATION – CDU – PILOT RNAV 1 RNAV 3
AE 1	115V AC	EAC	P6, GINS NAVIGATION – AE – 1
AE 2	115V AC	FAAC 2	P6, GINS NAVIGATION – AE – 2
EGI 1 and Battery	28V DC	FAVDC 1	P6, GINS NAVIGATION – EGI – 1; P6, GINS NAVIGATION – EGI – BATT 1
EGI 2 and Battery	28V DC	FAVDC 2	P6, GINS NAVIGATION – EGI – 2; P6, GINS NAVIGATION – EGI – BATT 2
BSIU 1	28V DC	HOT BAT	P6, GINS NAVIGATION – CDU – NVGTR BSIU 1 CTRL PNL & MDL
BSIU 2	28V DC	FAVDC 2	P6, GINS NAVIGATION – CDU – COPILOT BSIU 2 RNAV 2
CADC 1	115V AC	FAAC 1	P5, AIR DATA – ØA ①
CADC 2	115V AC	FAAC 2	P5, AIR DATA – ØA ①
1553 BUS CONTROL Switch	28V DC	HOT BAT	P6, GINS NAVIGATION – CDU – PILOT RNAV 1 RNAV 3
DESIGNATED PILOT Selector Switch	28V DC	EDC	P5, AUTOPILOT WARN
ADC SOURCE SELECT Switch	28V DC	EDC	P5, AUTOPILOT WARN
GINS CONTROL PANEL Illumination	28V DC	HOT BAT	P6, GINS NAVIGATION – CDU – NVGTR BSIU 1 CTRL PNL & MDL

① CADC 1 CB is on left side below AIR DATA – ALTM VIB NO. 1;
CADC 2 CB is on right side below AIR DATA – ALTM VIB NO. 2.

Figure 1-179

GINS ABNORMAL OPERATION

GINS may be operated in certain degraded modes permitting missions to be continued in a jamming or degraded GPS environment and with certain system failures. The NAVIGATION 1553 BUS SPLITTING PROCEDURE in Section IV allows the navigator to either split the bus in response to certain malfunctions or to respond to an inadvertent split bus condition. The GINS ABNORMAL OPERATION PROCEDURES Table, *figure 1-179A*, lists certain malfunction indications along with probable and possible causes and initial corrective actions that may be taken. The GINS TROUBLESHOOTING (CBIT) FAULT CODES Table, *figure 1-179B*, lists particular bits of the fault code messages obtained from the status pages and, where appropriate, lists operator actions that can be taken in response to specific faults.

NAVIGATION 1553 BUS SPLITTING PROCEDURE

In the remote event that the dual 1553 bus becomes incapacitated, a 1553 BUS CONTROL selector switch is provided to enable the crew to separate the system into two parts, so that half will continue operating. This condition is identifiable either as one where all CDUs display the words NO INPUT on a blank screen (indicating that no CDU is BC and no CDU can communicate with other units on the bus e.g. JTIDS has assumed BC duties), or as described in *figure 1-179A,* GINS ABNORMAL OPERATIONS PROCEDURE.

By splitting the system in this manner, the LRU causing the 1553 bus problems can be isolated to one subsystem. The subsystem containing the bad LRU will still be unusable, but the other subsystem should provide either the pilot or copilot/nav with enough navigation functionality to continue a mission or provide for a safe return. If all three CDUs were displaying NO INPUT, the subsystem which is operating correctly will be immediately apparent after the bus is split, as the words NO INPUT will disappear from the CDU screen(s). The following table displays what the operator will see displayed for each LRUs status once the 1553 BUS CONTROL selector switch is set to ISOLATE.

LRU	Bus Status on Pilot's CDU	Bus Status on Copilot's and Navigator's CDUs
CDU 1	GO	NGO
CDU 2	NGO	GO
CDU 3	NGO	GO
BSIU 1	GO	NGO
BSIU 2	NGO	GO
EGI 1	GO	NGO
EGI 2	NGO	GO
Data Loader	NGO	GO
JTIDS	NGO	GO
IFF	NGO	GO
IFF IS	NGO	GO
IFF XPNDR	GO	NGO
CADC 1	GO	NGO
CADC 2	NGO	GO

In the event that one side of the bus still shows NO INPUT on the associated CDUs, the crew should isolate the specific LRU causing the problem. To accomplish this, the crew should begin powering off the LRUs in the non–operating subsystem sequentially, with those that are the least operationally important and/or easiest to re–initialize done first. It will be immediately apparent to the operator when the faulty LRU has been powered off, as the words NO INPUT will disappear from the CDU screen(s) associated with that side of the bus. Trustworthy LRUs should be powered back to on before proceeding to the next LRU. When the status of a faulty LRU is determined via the CDUs on that side of the bus, attempt to correct the problem by cycling power to the LRU and/or verifying that the bus coupler cable is firmly attached to the LRU. If the specific bad LRU is isolated by the crew and can not be corrected, that LRU should remain powered off and the bus split switch should be set back to NORMAL. This action should return the system to full capability except for the functions provided by the faulty LRU. It is not recommended that the aircraft be flown for a long period of time with the 1553 BUS CONTROL selector switch set to ISOLATE, due to the overall impact on system operation.

GINS Abnormal Operation Procedures

SYMPTOM	FAULT	ACTION
NOTE • Ensure safe aviation and navigation by all means available before taking ACTIONS. • If applicable, accomplish emergency checklist procedures before taking ACTIONS to regain enough system functionality to continue the flight and recover safely. • √ STATUS annunciations appear on CDU for most abnormal conditions, check status pages for details. When feasible, record data for maintenance action. • SYMPTOMS are initial indications of a situation or problem, listed alphabetically. Also check other systems or categories for possible symptoms. • FAULTS are possible causes of a situation or problem. • ACTIONS are considerations intended to restore system functionality. When taking ACTIONS, consider impact on mission and other systems as well. Use best judgment for course of action if taking ACTIONS fails. • Communicate ACTIONS status to crew for mission considerations. • Even though many possibilities have been taken into consideration, this is not an exhaustive list of conditions. • Because of GINS interdependencies on other systems, more than one system can be affected. • While other systems are included, these procedures deal primarily with GINS-related issues. Consult the appropriate section of the flight manual for other system information. • In conjunction with these procedures, refer to the Navigation 1553 Bus Splitting Procedure, CDU Annunciations and Scratchpad Messages, and the appropriate section of the flight manual.		
1553 DATA BUS		
BC switches to CDU 3	AC power switched from ground to aircraft	a. None. Power interruption causes bus control to revert to battery powered CDU 3. b. If another CDU is desired as BC, switch off CDU 3, confirm BC transfer, then switch CDU 3 back on.
NGO-A on any LRU status page	1553 bus A failure	None. Bus B operative.
NGO-B on any LRU status page	1553 bus B failure	None. Bus A operative.

Figure 1-179A (Sheet 1 of 38)

GINS Abnormal Operation Procedures (Continued)

SYMPTOM	FAULT	ACTION
NGO-A or NGO-B for two or more LRUs	Partial 1553 bus malfunction	None, faults have no operational impact. Data available on redundant bus.
NGO-T on any LRU status page	Both 1553 bus A and B failures for that LRU	a. Look up CBIT status on GINS CBIT table (*figure 1-179B*). Take appropriate action as indicated. b. If action unsuccessful, attempt to restore LRU by cycling power and/or CB.
NGO-T status for two or more LRUs	1. Failure of 1553 bus splitting relay 2. Relay power loss, causing 1553 bus to split	a. Verify bus split on CDU 1: NGO-T for DLDR EGI 2, CADC 2, BSIU 2, JTIDS, and IFF. b. Verify bus split on CDU 2 or CDU 3: NGO-T for EGI 1, CADC 1 and BSIU 1. c. Verify all GINS CBs are closed on P6 CB panel. d. Attempt to restore by performing Navigation 1553 Bus Splitting Procedure. e. If 1553 bus cannot be restored, operate GINS in split mode remainder of flight.
	Partial 1553 bus malfunction	a. Verify indications are not consistent with a split bus (see ACTIONs a and b above). b. Perform Navigation 1553 Bus Splitting Procedure and operate in split mode remainder of flight.
AHRS		
AHRS 1 and/or 2 mag heading differs from GINS mag heading displayed on CDU by large amount (>4°)	Incorrect or missing MAGVAR in BC CDU	a. Perform a heading check to determine discrepancy. b. Check PSN page for MAGVAR value. c. Load MAGVAR table with PCMCIA card. d. If not successful, with GINS NAV MODE selected, HSI displays TRUE heading even with switch in MAG.

Figure 1-179A (Sheet 2 of 38)

SYMPTOM	FAULT	ACTION
VFY AHRS 1 (2) annunciation	AHRS 1 (2) heading disagrees with AHRS 2 (1) and the EGI 1 (2) blended solution heading by >10°	a. Perform a heading check to determine discrepancy. b. Use TACAN/VOR NAV modes on opposite side from AHRS setting. Avoid use of TACAN or VOR/LOC NAV modes on same side as faulty AHRS heading. c. Avoid use of GPSn/A/H mode on the side with the AHRS error. Winds will be incorrect on error side.
VFY AHRS HDG annunciation	One AHRS heading disagrees with both blended solution headings by >10°	a. Perform a heading check to determine accurate AHRS. b. Set ADI Source Select Switch to GINS on side with faulty AHRS. Use caution if side with faulty AHRS requires use of TACAN or VOR/LOC NAV MODE as display will be inaccurate. Use caution for cross-side RMI, as display will be inaccurate.
AUTOPILOT		
Autopilot disengages and does not re-engage on same EGI	EGI loss of alignment, missing or invalid attitude signal to autopilot	a. Check AUTOPILOT CB closed on P5 CB panel. b. Check EGI status. c. Attempt to correct by inflight aligning EGI.

Figure 1-179A (Sheet 3 of 38)

GINS Abnormal Operation Procedures (Continued)

SYMPTOM	FAULT	ACTION
Autopilot disengages suddenly	EGI failure, loss of attitude or heading input, loss of alignment	a. Set DESIGNATED PILOT selector switch to other position. b. Switch pilot/copilot steering solution as required and reengage autopilot. c. Attempt to restore by inflight aligning failed EGI.
	CADC malfunction or failure, loss of altitude input	a. If CADC 2 has failed, notify ATC that Mode C altitude reporting is unreliable. b. Set ADC SOURCE SELECT switch to good CADC and reengage autopilot. c. Switch CADC aiding to EGIs on aiding page to good CADC.
	BSIU malfunction or failure, loss of steering signal	a. Check status of BSIU associated with DESIGNATED PILOT selector switch position. b. Attempt to restore faulty BSIU by cycling power. If BSIU still shows a NGO on its status page, power off BSIU, pull and reset CB, and power on BSIU again. When CB is pulled and reset, power to other equipment on the same CB will be interrupted – consider impact to other equipment prior to pulling CB. c. If BSIU returns to GO status, reengage autopilot. If BSIU does not return to GO status, set DESIGNATED PILOT selector switch to other position and reengage autopilot.

Figure 1-179A (Sheet 4 of 38)

SYMPTOM	FAULT	ACTION
Autopilot does not engage	1. EGI malfunction 2. EGI failure	a. Select alternate EGI for all sources. b. If time allows on ground, power EGI off, cycle CB, then power on affected EGI to attempt to clear fault. c. If airborne, inflight align affected EGI.
	BSIU failure, no steering signals available	a. Set DESIGNATED PILOT selector switch to other position and reengage autopilot. b. Attempt to restore faulty BSIU by cycling power. If BSIU still shows a NGO on its status page, power off BSIU, pull and reset CB, and power on BSIU again. When CB is pulled and reset, power to other equipment on the same CB will be interrupted – consider impact to other equipment prior to pulling CB. c. If BSIU fault is corrected and DESIGNATED PILOT selector switch is set to COPILOT, disengage autopilot, set switch to PILOT, and reengage autopilot.

Figure 1-179A (Sheet 5 of 38)

GINS Abnormal Operation Procedures (Continued)

SYMPTOM	FAULT	ACTION
Autopilot remains engaged but does not steer to flight plan	JTIDS has assumed control of 1553 bus	a. If JTIDS is needed for mission and must have GINS input, perform Navigation 1553 Bus Splitting Procedure. b. If JTIDS is not needed, turn JTIDS off (N, MCC, CT).
	Total 1553 bus malfunction	a. Perform Navigation 1553 Bus Splitting Procedure, and operate in split mode remainder of flight. b. Force another CDU to assume bus control by turning BC CDU off. c. Verify transfer of BC to another CDU, then turn CDU back on.
	Partial 1553 bus malfunction	a. Verify indications are not consistent with a split bus (see ACTIONs a and b below). b. Perform Navigation 1553 Bus Splitting Procedure and operate in split mode remainder of flight.
	1. Failure of 1553 bus splitting relay 2. Loss of power to this relay, causing 1553 bus to split	a. Verify bus split on CDU 1: NGO-T for DLDR, EGI 2, CADC 2, BSIU 2, JTIDS, and IFF. b. Verify bus split on CDU 2 or CDU 3: NGO-T for EGI 1, CADC 1, and BSIU 1. c. Verify all GINS CBs are closed on P6 CB panel. d. Attempt to restore by performing Navigation 1553 Bus Splitting Procedure. e. If 1553 bus cannot be restored, operate in split mode remainder of flight.

Figure 1-179A (Sheet 6 of 38)

SYMPTOM	FAULT	ACTION
Autopilot steering erratic	Improper alignment of EGI	Conduct INFLIGHT ALIGNMENT procedure for designated pilot EGI.
BSIU		
BSIUx status NGO-A	1553 bus A failure	None. Bus B operative.
BSIUx status NGO-B	1553 bus B failure	None. Bus A operative.
BSIUx status NGO-T	1. BSIU malfunction 2. Split 1553 bus 3. 1553 bus failure	a. Disengage autopilot, set DESIGNATED PILOT selector switch to other position, and reengage autopilot. b. Attempt to restore faulty BSIU by cycling power. If BSIU still shows a NGO on its status page, power off BSIU, pull and reset CB, and power on BSIU again. When CB is pulled and reset, power to other equipment on the same CB will be interrupted – consider impact to other equipment prior to pulling CB. c. Check BSIU status page for NGO and CBIT indications.
Copilot HSI HEADING and/or NAV flags (GINS NAV MODE)	BSIU 2 malfunction or failure	
HSI MILES display flag (GINS NAV MODE)	Corresponding BSIU malfunction or failure	
Pilot HSI HEADING and/or NAV flags (GINS NAV MODE)	BSIU 1 malfunction or failure	
Pilot HSI HEADING and/or NAV flags (GINS NAV MODE) AND Copilot HSI HEADING and/or NAV flags (GINS NAV MODE)	Both BSIUs malfunctioning or failed	

Figure 1-179A (Sheet 7 of 38)

GINS Abnormal Operation Procedures (Continued)

SYMPTOM	FAULT	ACTION
CADC		
Airspeed, altitude, or temperature erroneous	CADC malfunction or failure	a. Check CADC status. Select functioning CADC on aiding page for both EGIs. b. Ensure ADC SOURCE SELECT switch is set to functioning CADC. If required, disengage autopilot, set switch to other position, and reengage autopilot. c. Attempt recovery of faulty CADC by cycling CB on P5 CB panel. d. If CADC 2 is suspect, notify ATC that Mode C may be unreliable.
CADCx status NGO-A	CADC unable to send or receive data via 1553 data bus A	None, Bus B operative.
CADCx status NGO-B	CADC unable to send or receive data via 1553 data bus B	None, Bus A operative.
CADCx status NGO-T	CADC unable to send or receive data via 1553 data bus A or B	a. Check CADC status. Select functioning CADC on aiding page for both EGIs. b. Ensure ADC SOURCE SELECT switch is set to functioning CADC. If required, disengage autopilot, set switch to other position, and reengage autopilot. c. Attempt recovery of faulty CADC by cycling CB on P5 CB panel. d. If CADC 2 is suspect, notify ATC that Mode C may be unreliable.
CDU display of barometric altitude, true airspeed, and static air temperature invalid	1. CADC CBIT 15 (1553 communications) 2. CADC CBIT 16 (1553 communications)	a. Cross check with other air data instruments. b. If CADC 2 is suspect, notify ATC that Mode C may be unreliable. c. Check CADC status. Select functioning CADC on aiding page for both EGIs.

Figure 1-179A (Sheet 8 of 38)

GINS Abnormal Operation Procedures (Continued)

SYMPTOM	FAULT	ACTION
Copilot altimeter goes to STBY, Mach/airspeed indicator flag, TAT flag, SAT flag	CADC 2 malfunction or failure	a. Autopilot can disengage if ADC SOURCE SELECT switch is in ADC 2 ALTERNATE position. Switch to ADC 1 and reengage autopilot. b. Notify ATC that Mode C can be unreliable. c. On aiding page, switch EGI 2 to CADC 1, to display valid wind, TAS, and SAT when EGI 2 information is chosen as a steering source. d. Check CADC 2 status page for CBIT codes. e. Check AIR DATA – ØA CB on copilot side of P5 panel.
Pilot altimeter goes to STBY, Mach/airspeed indicator flag	CADC 1 malfunction or failure	a. Autopilot may disengage if ADC SOURCE SELECT switch is set to ADC 1. Set switch to ADC 2 ALTERNATE and reengage autopilot. b. On aiding page, switch EGI 1 to CADC 2, to display valid wind, TAS, and SAT when EGI 1 information is chosen as a steering source. c. Check CADC 1 status page for CBIT codes. d. Check nav status page for CBIT codes. e. Check AIR DATA – ØA CB on pilot side of P5 CB panel.

Figure 1-179A (Sheet 9 of 38)

SYMPTOM	FAULT	ACTION
Pilot altimeter goes to STBY, Mach/airspeed indicator flag, AND Copilot altimeter goes to STBY, Mach/airspeed indicator flag, TAT flag, SAT flag, AND Navigator TAS and SAT flags, CADC 1 and 2 NGO status, GPSx/–/H on gps inav pages	Both CADCs malfunctioned or failed.	a. Autopilot disengages due to loss of altitude data. It can be reengaged, but without altitude hold capability. b. Notify ATC that Mode C may be unreliable. c. Advise MCC that mission system altitude data may not be reliable. ASO may need to manually update altitude in the system. d. Air data is not available to GINS, wind and altitude information may be erroneous. e. Altimeters operating on uncorrected pitot-static sources. Also, displayed temperatures (SAT & TAT) are uncorrected. f. Airspeeds (IAS & TAS) may be unreliable. IAS and/or SAT may be approximated from ICE-T calculations (use briefed temperature deviation). GS should be available from GINS, use last known winds to determine TAS. g. Recycle both AIR DATA – ØA CBs on P5 CB panel. h. As time permits, check CADC status pages for CBIT codes.
VFY TAS annunciation	One CADC true airspeed disagrees with the other CADC true airspeed by >6 knots	a. Verify airspeed discrepancy by cross-checking other airspeeds. If required, accomplish an ICE-T check to determine accurate airspeed. b. Check CADC status. Select functioning CADC on aiding page for both EGIs. c. GINS wind computation may be in error. Also, other CADC-fed instruments may be in error.

Figure 1-179A (Sheet 10 of 38)

GINS Abnormal Operation Procedures (Continued)

SYMPTOM	FAULT	ACTION
CDU		
One CDU displays: NO INPUT	CDU malfunction	a. Cycle power to CDU. b. If NO INPUT is still displayed, power off CDU and cycle CB on P6 CB panel. When CB is pulled and reset, power to other equipment on the same CB will be interrupted – consider impact to other equipment prior to pulling CB. c. Turn on CDU. If NO INPUT is still displayed, turn off CDU (leave CB in to enable use of other equipment on that CB) and complete flight with CDU off.
Two CDUs display: NO INPUT	Bus controller failure	a. Turn off CDU that does not display NO INPUT. Other two displays should recover. b. Attempt to recover faulty CDU by cycling its power and CB on P6 CB panel. When CB is pulled and reset, power to other equipment on the same CB will be interrupted – consider impact to other equipment prior to pulling CB. c. If fault persists, power off CDU and complete flight with that CDU off.
Three CDUs display: NO INPUT	JTIDS has assumed control of 1553 bus	a. If JTIDS is needed for mission and must have GINS input, perform Navigation 1553 Bus Splitting Procedure. b. If JTIDS is not needed, turn JTIDS off (N, MCC, CT).
No database available, or NO FPLN	1. Active flight plan has been erased 2. Active flight plan has been zeroized	a. Load flight plan into alternate, then active flight plans with PCMCIA card. b. Manually load flight plan directly into active flight plan.
√ VERSION annunciation	CDU has different software version from BC CDU	Notify maintenance; requires loading new CDU software.

Figure 1-179A (Sheet 11 of 38)

SYMPTOM	FAULT	ACTION
CDU 3, data loader, GINS CONTROL PANEL, and BSIU 1 loss momentarily on ground	Hot Battery Bus has failed (possibly occurring during switch from ground to aircraft power)	a. Even though these units can operate normally on AC power, pilot should decide if maintenance should replace aircraft batteries before flight. b. FE can reduce load on bus, and some unit functionality can be restored.
CDU erroneous data	1. CDU CBIT 8 (1553 bus data component failure) 2. CDU CBIT 9 (1553 bus data terminal failure) 3. CDU CBIT 13 (1553 bus #1 failure) 4. CDU CBIT 16 (CDU communications)	a. Power off CDU. If CDU was BC, BC will transfer to another CDU automatically. b. Attempt to recover faulty CDU by resetting CB on P6 CB panel. When CB is pulled and reset, power to other equipment on the same CB will be interrupted – consider impact to other equipment prior to pulling CB. c. Power on CDU. If CDU erroneous data persists, power off CDU and complete flight with that CDU off.
CDU input/output failures	CDU CBIT 11 (MAG/TRUE, WOW, MASTER ZEROIZE, DESIGNATED PILOT inputs, and CDU ALERT, RAIM, ALT ALERT outputs loss)	None. Recognize that only one pilot might be receiving alerts and react accordingly.
CDU is blank	1. CDU malfunction 2. CDU failure 3. CDU unseated from cannon plug (power connection in rear of CDU)	a. Verify brightness knob is turned up. b. Verify AC battery indicates a minimum of 26 volts. c. Attempt to recover faulty CDU by cycling its power and CB on P6 CB panel. When CB is pulled and reset, power to other equipment on the same CB will be interrupted – consider impact to other equipment prior to pulling CB. d. If unable to restore, use another CDU to look up CBIT code for maintenance. e. If unseated and fault is detected while on the ground, contact maintenance.
CDUx status NGO-A	CDU unable to send or receive data via 1553 data bus A	None. Data bus B operable.

Figure 1-179A (Sheet 12 of 38)

GINS Abnormal Operation Procedures (Continued)

SYMPTOM	FAULT	ACTION
CDUx status NGO-B	CDU unable to send or receive data via 1553 data bus B	None. Data bus A operable.
CDUx status NGO-T	CDU unable to send or receive data via 1553 data bus A or B	Attempt to restore by performing Navigation 1553 Bus Splitting Procedure.
Corrupt or missing data	CDU CBIT 15 (NVM data)	Attempt to recover faulty CDU by cycling its power and CB on P6 CB panel. When CB is pulled and reset, power to other equipment on the same CB will be interrupted – consider impact to other equipment prior to pulling CB. If fault persists, power off CDU and complete flight with that CDU off.
CRT flickers or goes blank	CDU CBIT 12	None. If CRT is unusable, power off CDU and complete flight with that CDU off.
NO MAGVAR annunciation	Attempt to enter magnetic variation is a field without MAGVAR table present in CDU	a. Check pilot or copilot psn page for MAGVAR value. b. If MAGVAR value is not shown but PCMCIA card is in data loader, insert PCMCIA card into other slot or load a different PCMCIA card into data loader.

Figure 1-179A (Sheet 13 of 38)

SYMPTOM	FAULT	ACTION
CRYPTO		
GPS SA/AS displays NONE after load attempt	Invalid crypto codes loaded	a. NONE displayed on GPS SA/AS page, or LOADED displayed (without changing to VERIFIED) on GPS SA/AS page for over 12 1/2 minutes since GPS signals have been received. Ask CT to check cold validity. If fault persists, press ZEROIZE – GPS CRYPTO switch. b. If on the ground, power off EGIs and cycle the EGI CBs on P6 CB panel. After codes are reloaded by CT, reinitialize EGIs. c. If airborne, and there is no reason to believe access to GPS signal coverage will not be assured, power off EGIs and cycle the EGI CBs on P6 CB panel. After codes are reloaded by CT, power on EGIs and conduct an inflight alignment. If flight or mission conditions dictate requirement for one EGI to be operational at all times, complete action on one EGI at a time.
	CDU has not validated codes because at least one GPS satellite signal not yet received	LOADED display should be replaced with VERIFIED shortly after GPS satellite signal has been received, but can take up to 12 1/2 minutes.
NO KEY1 (2) ZERO annunciation	Failure to zeroize GPS SA/AS (crypto) keys	Zeroize keys at key loader on E14 cabinet.
NAV FAIL annunciation, SAFE KEYS 1 and SAFE KEYS 2 annunciations	Crypto codes zeroized when operating GINS in keyed mode	None. EGIs will display a NAV FAIL message when the crypto is zeroized and the receiver transitions from P-code to C/A code, but will continue to operate.
DATA LOADER		
Data loader status NGO-A	Data loader unable to send or receive data via 1553 data bus A	None. Data bus B operable.
Data loader status NGO-B	Data loader unable to send or receive data via 1553 data bus B	None. Data bus A operable.

Figure 1-179A (Sheet 14 of 38)

GINS Abnormal Operation Procedures (Continued)

SYMPTOM	FAULT	ACTION
Data loader status NGO-T	Data loader unable to send or receive data via 1553 data bus A or B	Attempt to recover data loader by cycling CB on P6 CB panel. When CB is pulled and reset, power to CDU 3, BSIU 1, and GINS control panel will be interrupted – consider impact to other equipment prior to pulling CB.
Data loader not reading or writing data from/to PCMCIA card (LEDs do not illuminate)	1. Data loader failure 2. Data loader power failure	a. Possibly simultaneous with CDU 3, BSIU 1, and GINS CONTROL PANEL failures: check GINS NAVIGATION – CDU – NVGTR BSIU1 CTRL PNL & MDL CB on P6 CB panel. b. If data loader still inoperative, manual data loading is required. c. Check data loader status page for CBIT codes for maintenance.
LOAD FAIL annunciation	Failure reading from or writing to PCMCIA card	a. Try PCMCIA card in other slot. b. Try another PCMCIA card. c. Recycle power to data loader and try PCMCIA card again.

Figure 1-179A (Sheet 15 of 38)

SYMPTOM	FAULT	ACTION
EGI		
Autopilot disengages HDG and NAV flags on pilot and copilot HSIs when GINS mode selected GYRO flag on either ADI when GINS selected for ADI source ----/GPSx, ---- (on any inu inav page), NAV FAIL	1. EGI loss of alignment 2. EGI power loss	If either EGI was navigating aircraft, multiple events occur; ensure safety of flight: a. Give pilots heading to fly, as pilots will have to hand-fly, and flight instruments can be temporarily unusable until reset. b. Place both ADI switches into AHRS for attitude source. c. Switch both pilots' NAV MODE selectors to either TACAN or VOR/LOC. d. Clear or investigate any annunciations or instrument flags. e. As time permits, advise MCC of situation. Mission system is inoperative until GINS is restored. f. Check/reset GINS NAVIGATION – EGI – 1 and EGI – 2 CBs on P6 CB panel. g. Attempt to restore both EGIs by inflight alignment. h. Advise pilots and MCC of status.
√ NAV ERR annunciation	1. Downgrade in designated pilot's 95%ERR 2. Designated pilot's EGI estimated nav error > 1 nm	a. Cross-check position and heading to determine accurate sources. b. Switch pilot and copilot steering solutions to accurate sources as required. c. Switch CPS NAV SOURCE to functioning EGI; advise MCC and CDMT. d. Inflight align faulty EGI, or manually update if GPS satellite signal and JTIDS REL NAV are not available.

Figure 1-179A (Sheet 16 of 38)

GINS Abnormal Operation Procedures (Continued)

SYMPTOM	FAULT	ACTION
COMPARE INU annunciation	1. Both INUs are in NAV mode and position difference between INU 1 and INU 2 is > [1.224(INU1 95%ERR + INU2 95%ERR) + 1.0 nm] for > 30 seconds 2. Both INUs are in NAV mode and horizontal speed difference between INU 1 and INU 2 is >7 knots for > 30 seconds	a. Compare blended solutions positions and 95%ERR to determine accurate position. b. Compare INU positions to determine which is most accurate. c. If corresponding blended solution 95%ERR is 0.05 or greater, inflight align EGI.
Autopilot disengages DESIGNATED PILOT selector switch in PILOT Pilot ADI GYRO flag Pilot HSI NAV flag (when pilot NAV MODE select switch is set to GINS)	EGI 1 failure	If EGI 1 was navigating aircraft, multiple events occur; ensure safety of flight: a. Switch DESIGNATED PILOT selector switch to COPILOT and both pilots steering source to INU2/GPS2. (Clear √ NAV SOURCE annunciation.) Autopilot can be re-engaged when switched. b. Set pilot ADI source select switch to AHRS. c. Clear or investigate any annunciations or instrument flags. d. As time permits, advise MCC of situation, and switch CPS NAV SOURCE switch to EGI 2. e. Check GINS NAVIGATION – EGI – 1 CB on P6 CB panel. Attempt one reset if CB was open. f. Check EGI 1 status pages. g. Check aiding page and make changes as necessary. h. If conditions permit, attempt to restore EGI 1 by inflight alignment.

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GINS Abnormal Operation Procedures (Continued)

SYMPTOM	FAULT	ACTION
Autopilot disengages if DESIGNATED PILOT selector switch in COPILOT GYRO flag appears on copilot ADI Copilot HSI NAV flag (when copilot NAV MODE selector set to GINS)	EGI 2 failure	If EGI 2 was navigating aircraft, multiple events occur; ensure safety of flight: a. Switch DESIGNATED PILOT selector switch to PILOT and pilot steering source to INU1/GPS1. Autopilot can be re-engaged when switched. b. Place copilot NAV MODE selector in TACAN or VOR/LOC for navigation cross-checks. c. Set copilot ADI/WXR source select switch to AHRS. d. Clear or investigate any annunciations or instrument flags. e. As time permits, advise MCC of situation, and switch CPS NAV SOURCE to EGI 1. f. Check GINS NAVIGATION – EGI – 2 CB on P6 CB panel. Attempt one reset if CB was open. g. Check aiding page and make changes as necessary. h. If conditions permit, attempt to restore EGI 2 by inflight alignment.
EGI BATTERIES FAULT x light illuminated	1. Battery charger malfunction 2. Battery pack malfunction	a. On ground, if mission requirements and time permits, contact maintenance to replace EGI battery. EGI battery charger is unreliable and EGI battery status is unknown. b. If airborne, set DESIGNATED PILOT selector switch, ADC source selector switch, CPS source select switch, and pilot/copilot steering sources to functioning EGI. In case of primary power loss, EGIs should run a minimum of 30 minutes on battery.

Figure 1-179A (Sheet 18 of 38)

SYMPTOM	FAULT	ACTION
EGI BATTERIES EGI x caution light illuminated	AC power has failed, and EGI is operating on its own battery power	a. Note time light illuminated. EGIs should run a minimum of 30 minutes on battery. b. If only one EGI is operating on battery power, set DESIGNATED PILOT selector switch, ADC source select switch, CPS source select switch, and pilot/copilot steering sources to functioning EGI.
EGI does not complete alignment in 5 minutes on ground	Possible aircraft movement	a. Check inu inav page for alignment quality and timing. If quality is not improving, and/or timing not indicated, then restart alignment. b. Check pilot or copilot psn page for any GS indication. If >0 when parked, cycle power and CB to EGI and restart alignment. c. If aircraft begins to move before INU is in MODE NAV, the alignment counter will suspend. Once aircraft stops moving, the alignment counter will resume following a short delay. d. If AUTONAV was not selected at startup, select ENAB NAV after stopping.
EGI does not inflight align	GPS not available	a. Check GPS inav and satellite data pages for constellation status. b. Check EGI status 2 page for RPU status. c. Check GINS NAVIGATION – AE CBs closed on P6 CB panel.
	WOW switch failure	a. Power off EGI to be inflight aligned. b. Coordinate with P/FE to cycle LANDING GEAR – SAFETY – RIGHT RLY & LEVER LATCH CB on P5 CB panel. c. Reattempt EGI inflight alignment.
EGI heading, pitch, and/or roll do not match AHRS heading, pitch, and/or roll	Incorrect or missing boresight values	a. Switch to other EGI for all sources. b. No operator actions possible, maintenance must load values.

Figure 1-179A (Sheet 19 of 38)

GINS Abnormal Operation Procedures (Continued)

SYMPTOM	FAULT	ACTION
EGI inflight alignment, frozen time of alignment displayed	EGI does not complete inflight alignment in 10 minutes	a. Check satellite tracking and valid GPS solution. Look for reasonable 95% errors. b. Perform 90° or 180° heading change, holding heading for at least 2 minutes. c. Attempt another inflight alignment.
EGIx status: AE NGO	Malfunction of GPS antenna or AE	a. Check GINS NAVIGATION – AE CB on P6 CB panel. b. If on ground, power off system, cycle GINS CBs on P6 CB panel, and power on EGI 1, then EGI 2. If GPS is receiving satellites and position is accurate, this anomaly may possibly clear itself. c. If airborne and associated GPS is not receiving satellites or displaying an accurate position, functioning GPS should automatically be substituted into EGI solution by the GINS, If the EGI displaying the AE NGO retains the faulty GPS in its solution, select the other EGI for both steering sources and set the DESIGNATED PILOT selector switch to the side with the functioning EGI. d. Cycle CB on P6 CB panel to affected AE to attempt to clear fault.
EGIx status: ANL ATT NGO; NGO FLT INST ATT	Pitch and roll input voltages to corresponding ADI and flight director are out of proper range	a. Check/reset corresponding flight instrument and flight director CBs on P5 CB panel. b. If reset was unsuccessful, switch DESIGNATED PILOT selector switch to other position. c. Change steering solution to same side as designated pilot.

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SYMPTOM	FAULT	ACTION
EGIx status: ANL ATT NGO; NGO FLT INST HDG	Heading input voltages to corresponding ADI and flight director are out of proper range	a. Check/reset corresponding flight instrument and flight director CBs on P5 CB panel. b. If reset was unsuccessful, switch DESIGNATED PILOT selector switch to other position. c. Change steering solution to same side as designated pilot.
EGIx status: ANL ATT NGO; NGO A/P ATTD	Pitch, roll, and versine voltages to autopilot are out of proper range	a. Check/reset AUTOPILOT CB on P5 CB panel. b. If reset was unsuccessful, switch DESIGNATED PILOT selector switch to other position. c. Change steering solution to same side as designated pilot.
	No loopback signal from autopilot	a. Check AUTOPILOT CB is closed on P5 CB panel. b. Place DESIGNATED PILOT selector switch to other position. c. Change steering solution to same side as designated pilot.
	Loss of pitch or roll from EGI to autopilot	
EGIx status: NGO-A BUS	Failure of 1553 A bus	None. Data Bus B operable.
EGIx status: NGO-B BUS	Failure of 1553 B bus	None. Data Bus A operable.
EGIx status: NGO-T BUS	1. EGI malfunction 2. EGI failure 3. 1553 bus connection failure	a. Switch DESIGNATED PILOT selector switch to other position. b. Change steering solution to designated pilot side. c. If time allows on ground, power EGI off, cycle CB on P6 CB panel, then power on affected EGI to attempt to clear fault. d. If airborne, inflight align affected EGI.

Figure 1-179A (Sheet 21 of 38)

GINS Abnormal Operation Procedures (Continued)

SYMPTOM	FAULT	ACTION
EGIx status: RPU NGO	Malfunction of GPS receiver	a. Press GPSx INIT on start 2 nav/init page for the appropriate EGI. b. If time allows on ground, power EGI off, cycle CB on P6 CB panel, then power on affected EGI to attempt to clear fault. c. If airborne, switch DESIGNATED PILOT selector switch to other position, and change steering solution to that side. d. Cycle power to affected EGI to attempt to clear fault.
GS > 0 when parked	Improper alignment of EGI	a. If time permits, cycle power and CB on P6 CB panel to the EGI and realign. b. If unable to perform ground alignment, inflight align when able.
INUx/---- on blended inav page	1. Loss of both GPS aiding in both EGIs 2. JTIDS not available for aiding	a. Cycle GINS NAVIGATION – AE CBs on P6 CB panel. b. If available, load current almanac from PCMCIA card. c. Press GPS INIT (both) on start 2 page to reinitiate GPS tracking.
INU drifting excessively, but blended solution acceptable	Possible incomplete or bad initial INU alignment	a. If on ground, realign EGI. b. If airborne, monitor blended solution. If time or mission permits, consider switching to accurate EGI and performing inflight alignment.
INU heading inaccurate	1. Possible bad or incomplete alignment 2. Loss of alignment	a. Perform heading check to determine accurate heading. b. If on ground, cycle power to EGI and realign. c. If airborne, perform inflight alignment.

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SYMPTOM	FAULT	ACTION
KEYx ERR annunciation	Incorrect SA/AS key received	a. Ask CT to reload crypto keys at E14 cabinet. b. If message reappears, ask CT to verify correct codes, then reload. c. EGI power must be recycled and EGI realigned to utilize Y-code processing.
VFY BLENDED 1 (2) annunciation	1. INU1/GPS1 (INU2/GPS2) 95%ERR is > 0.3 nm (APPROACH), 1.7 nm (TERMINAL), or 2.8 nm (ENROUTE) for > 30 seconds 2. Position difference between INU1/GPS1 and INU2/GPS2 is > [1.224 (INU1/GPS1 95%ERR + INU2/GPS2 95%ERR)] AND position difference between INU1/GPS1 (INU2/GPS2) and GPS1 (2) is > [1.224 (INU1 (2)/GPS1 (2) 95%ERR + GPS1 (2) 95%ERR)] for > 30 seconds	a. Confirm blended solution is incorrect by cross-checking against all other solutions. b. If warranted, select different designated pilot's steering solution, and switch CPS source. c. If possible, manually update the blended solution to correct the position discrepancy (GPS and/or JTIDS not available; or d. Inflight align inaccurate EGI.

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GINS Abnormal Operation Procedures (Continued)

SYMPTOM	FAULT	ACTION
VFY INU 1 (2) annunciation	1. INU1 (2) is in NAV mode and the horizontal speed difference between INU1 (2) and GPS1 (2) is > 5 knots for > 30 seconds 2. INU1 (2) is in NAV mode and position difference between INU1 (2) and GPS1 (2) is > [1.224(INU1 (2) 95%ERR + GPS1 (2) 95%ERR) + 0.5 nm] for > 30 seconds	a. Confirm INU solution is incorrect by cross-checking against other solutions. b. Switch to other EGI for designated pilot solution and CPS source. c. Inflight align inaccurate EGI.
Wind information inaccurate	Improper alignment of EGI	a. Switch to other EGI for attitude and navigation. b. Attempt to correct by inflight alignment.
GPS time unavailable	EGI internal clock has not been set with date, and EGI is unable to receive time form GPS	a. If airborne, switch DESIGNATED PILOT selector switch to other position, and change steering solution to designated pilot side. b. Switch CPS SOURCE SELECT to other EGI. c. To reset, press IDX, start 2 page, GPS INIT for the affected EGI. May take several minutes to restore GPS.
FLIGHT INSTRUMENTS		
ADI GYRO flag (ADI switch in GINS)	1. EGI malfunction 2. EGI failure 3. 1553 bus connection failure	a. Set ADI source select switch to AHRS. b. Select alternate EGI for all sources. c. If time allows on ground, power EGI off, cycle CB on P6 CB panel, then repower affected EGI to attempt to clear fault. d. If airborne, inflight align affected EGI.

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SYMPTOM	FAULT	ACTION
HSI/ADI loss of on-side nav solution and display	1. BSIU CBIT 5 (general 1553) 2. BSIU CBIT 6 (general 1553 terminal failure) 3. BSIU CBIT 7 (1553 bus data CPU) 4. BSIU CBIT 10 (1553 bus #1 communication)	a. Set ADI source select switch to AHRS. b. Set DESIGNATED PILOT selector switch and steering sources to functioning EGI. c. Attempt recovery of BSIU by cycling power at GINS CONTROL PANEL. d. If fault persists, attempt to recover BSIU by cycling CB on P6 CB panel. When CB is pulled and reset, power to other equipment on the same CB will be interrupted – consider impact to other equipment prior to pulling CB.
HSI and ADI loss of on-side nav solution and displays; loss of flight phase annunciations (RNAV ANNUNCIATORS panel)	BSIU CBIT 11 (output discretes)	a. Set ADI source select switch to AHRS. b. Set DESIGNATED PILOT selector switch and steering sources to functioning EGI. c. Attempt recovery of BSIU by cycling power at GINS CONTROL PANEL. d. If fault persists, attempt to recover BSIU by cycling CB on P6 CB panel. When CB is pulled and reset, power to other equipment on the same CB will be interrupted – consider impact to other equipment prior to pulling CB.
HSI course and bearing displays invalid or inoperative; waypoint, vertical navigation, and speed alerts (RNAV ANNUNCIATORS panel) invalid or inoperative	BSIU CBIT 16 (SIM #1 discrete outputs)	a. Set DESIGNATED PILOT selector switch and steering sources to functioning EGI. b. Attempt recovery of BSIU by cycling power at GINS CONTROL PANEL. c. If fault persists, attempt to recover BSIU by cycling CB on P6 CB panel. When CB is pulled and reset, power to other equipment on the same CB will be interrupted – consider impact to other equipment prior to pulling CB.
HSI distance display inoperative (GINS nav mode)	BSIU CBIT 12 (SIM #5)	Use cross-side HSI distance or CDU distance to go display.

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GINS Abnormal Operation Procedures (Continued)

SYMPTOM	FAULT	ACTION
HSI HDG flag (GINS nav mode)	Incorrect or missing MAGVAR in EGI	No operator action possible. Maintenance must reload EGI software.
HSI heading discrepancies between TACAN/VOR and GINS nav modes	Improper alignment of EGI	a. Set DESIGNATED PILOT selector switch and steering sources to functioning EGI. b. Inflight align errant EGI.
HSI invalid navigation indications (from-to, course deviation, flight phase annunciation) and ADI invalid fast/slow indication	BSIU CBIT 15 (SIM #2 discrete outputs)	a. Set DESIGNATED PILOT selector switch and steering sources to functioning EGI. b. Attempt recovery of BSIU by cycling power at GINS CONTROL PANEL. c. If fault persists, attempt to recover BSIU by cycling CB on P6 panel. When CB is pulled and reset, power to other equipment on the same CB will be interrupted – consider impact to other equipment prior to pulling CB.
HSI NAV flag (GINS nav mode)	JTIDS has assumed control of 1553 bus	a. If JTIDS is needed for mission and must have GINS input, perform Navigation 1553 Bus Splitting Procedure. b. If JTIDS is not needed, turn JTIDS off (N, MCC, CT).
HSI NAV & HDG flags (GINS nav mode)	1. EGI malfunction 2. EGI failure 3. 1553 bus connection failure	a. Set DESIGNATED PILOT selector switch and steering sources to functioning EGI. b. If time allows on ground, power EGI off, cycle CB on P6 CB panel, then repower affected EGI to attempt to clear fault. c. If airborne, inflight align affected EGI.

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GINS Abnormal Operation Procedures (Continued)

SYMPTOM	FAULT	ACTION
HSI vertical deviation, ADI AHRS heading, and bank commands to flight director and autopilot invalid or inoperative	BSIU CBIT 14 (SIM #3)	a. Set DESIGNATED PILOT selector switch and steering sources to functioning EGI. b. Attempt recovery of BSIU by cycling power at GINS CONTROL PANEL. c. If fault persists, attempt to recover BSIU by cycling CB on P6 CB panel. When CB is pulled and reset, power to other equipment on the same CB will be interrupted – consider impact to other equipment prior to pulling CB.
GINS CONTROL PANEL		
EGI BATTERIES EGI x caution light illuminated	AC power has failed, and EGI is operating on its own battery power	a. Note time light illuminated. EGIs should run 30 minutes on battery. b. If only one EGI is operating on battery power, set DESIGNATED PILOT selector switch, ADC source select switch, CPS source slect switch, and pilot/copilot steering sources to functioning EGI.
EGI BATTERIES FAULT x light illuminated	1. Battery charger malfunction 2. Battery pack malfunction	a. On ground, if mission requirements and time permits, contact maintenance to replace EGI battery. EGI battery charger is unreliable and EGI battery status is unknown. b. If airborne, set DESIGNATED PILOT selector switch, ADC source select switch, CPS source select switch, and pilot/copilot steering sources to functioning EGI.
GINS CONTROL PANEL and CDU 3 blanks Pilot HSI NAV flag (GINS NAV mode)	Control panel power failure	Check/reset GINS NAVIGATION – CDU – NVGTR BSIU 1 CTRL PNL & MDL CB on P6 CB panel.

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SYMPTOM	FAULT	ACTION
Zeroization of crypto codes, flight plans, alternate flight plans, waypoints, markpoints, almanac, PCMCIA card contents Loss of EGI alignment	MASTER ZEROIZE pressed	a. None, if intentional. Otherwise, notify pilot and MCC of navigation system degradation. b. If GINS operation is desired, power down EGIs and conduct entire initialization process again. Expect longer GPS constellation acquisition due to no almanac present in system. If available, load another PCMCIA card that has a recent almanac in order to expedite initialization procedure.
GPS		
Blended solution drifting excessively	GPS is suspect	If blended solution 95%ERR = 0.05 for > 5 minutes, consider inflight alignment
√ GPS annunciation	GPS in designated pilot's solution is invalid	a. Possible momentary condition. b. If persistent, cross-check both GPS solutions, to determine best solution. c. Select best solution for designated pilot. d. If warranted, select GPS INIT on start 2 page for affected GPS.
COMPARE GPS annunciation	The two GPS-only solutions differ by > 0.3 nm (APPROACH), 1.0 nm (TERMINAL), or 4.0 nm (ENROUTE)	a. If JTIDS REL NAV is available, EGI selected by operator on aiding page will switch to JTIDS aiding, as indicated by INUx/JTDS. b. Compare GPS-only and INU-only solutions of both EGIs, and other sources if available to determine best EGI for navigation. c. If both EGIs have RAIM WRN status, see RAIM WRN procedures.

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GINS Abnormal Operation Procedures (Continued)

SYMPTOM	FAULT	ACTION
Dual GPS loss (----/A/H, ----/-/H, or ----/-/- on both gps inav pages, √ GPS	1. AE 1 or AE 2 failure 2. GEM card (RPU) failure in the EGI	a. If JTIDS relnav is available, preferred EGI will switch to JTIDS aiding, as indicated by INU1/JTDS (for example) b. Check nav status pages for cause. **NOTE** If airborne, regardless of whether either GPS is restored, do not turn EGI off. The EGI cannot be inflight aligned without GPS. c. Attempt restoration of both GPS by recycling AE CBs and selecting GPS INIT for both on start 2 page. If needed, reload almanac from PCMCIA card. d. Blended solutions can be manually updated using radial/DME fix or other EGI solution.
GPS signal loss	Aircraft maneuvering	a. Wait until maneuvering is complete, and look for satellite signals to return after wings level. b. If GPS does not recover on its own, attempt to reacquire by using GPS INIT.
GPSx/-/H (inav page)	GPSx is not receiving airspeed information from the CADC selected on the aiding page	a. Check for other CADC failures. b. If CADC has failed, attempt to restore by cycling CB on P5 CB panel. c. On Aiding page, switch EGI aiding to operable CADC.
GPSx/A/- (inav page)	GPSx is not receiving heading information from the corresponding AHRS	a. Check AHRS CB on P5 CB panel. b. Perform heading check to confirm accurate heading.
GPSx/-/- (inav page)	GPSx is not receiving airspeed information from the CADC selected on the aiding page AND not receiving heading information from the corresponding AHRS	a. On aiding page, switch EGI aiding to functioning CADC. b. Check corresponding AHRS CB on P5 CB panel.

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SYMPTOM	FAULT	ACTION
GPS solution invalid or no satellites tracked	Malfunction of GPS antenna or AE	a. Check GINS NAVIGATION – AE CB on P6 CB panel. b. Select functioning EGI for all sources. c. Attempt to clear fault by cycling CB on P6 CB panel to affected AE.
No RAIM annunciation	1. RAIM is on, and < 5 satellites are visible 2. RAIM unavailable for > 30 seconds 3. GPS navigation unavailable for > 30 seconds	a. Check that both GPS are displaying tracking problems. Select alternate EGI, as appropriate. b. Check for jamming condition. If jamming is indicated on gps satellite page, deselect RAIM in order to avoid dropping satellites that can be difficult to acquire. Also, ensure crypto codes are loaded, in order to utilize Y-code (jam resistant). c. Verify loss of GPS is not due to maneuver. d. If either GPS solution is invalid, and jamming is not present, attempt to re-acquire satellites by pressing appropriate GPS INIT on start 2 page. e. If coverage remains poor, wait as long as 10 minutes. More satellites possibly will come into view. The blended solution maintains accuracy based on inertial-only data and Kalman filter predictions of the free-running INU performance (based on calculations made while blended solution had GPS coverage) for short GPS outages.

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GINS Abnormal Operation Procedures (Continued)

SYMPTOM	FAULT	ACTION
RAIM WRN/RAIM ALERT annunciation	1. One or more satellites have become unstable, and ephemeris data is unusable 2. Position data is suspect or unusable due to larger probable position envelope	a. If RAIM WRN and COMPARE GPS occur together, select alternate EGI. b. Assure Y-codes are received by both EGIs. Reload crypto codes as required. c. Verify position using alternate sources (TACAN/VOR, etc.). d. Select most accurate steering source. e. RAIM WRN may disappear if satellite constellation changes, or aircraft is flown to different geographic location.
SV low C/N ratio (GPS inav page)	Selective Availability implemented	a. Coordinate with CT to load or reload crypto codes at E14 cabinet.
Fewer than 4 SV received	Crypto codes are not loaded, or encryption is not working	b. EGI power must be recycled and EGI realigned to utilize Y-code processing.
Satellite state: J	Active GPS jamming	a. Notify pilot and MCC. b. Eliminate source of noise. AE will automatically attempt to reduce effect of jamming source by creating an antenna null towards the source of the jamming. Up to six antenna nulls can be created. c. Avoid interrupting satellite reception. Do not press GPS INIT if any satellites at all are being tracked. d. Select RAIM OFF. e. If jamming is persistent and GPS is required, if not done previously, ask CT to load GPS crypto codes at E14 cabinet.

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SYMPTOM	FAULT	ACTION
Single GPS loss (----/A/H, ----/-/H, or ----/-/- on either gps inav page), √ GPS	1. AE 1 or AE 2 failure 2. GEM card (RPU) failure in the EGI	a. If one GPS fails, the EGI uses the GPS solution from the other EGI (INU1/GPS2 or INU2/GPS1). b. If satellites are still not being received after reloading codes, select GPS INIT on start 2 nav/init page to restart GPS satellite acquisition. c. Attempt restoration of GPS by recycling GINS NAVIGATION – AE CB on P6 CB panel and selecting GPS INIT on start 2 page. If needed, reload almanac from PCMCIA card.
VFY GPS 1 (2) annunciation	1. GPS 1 (2) 95%ERR is > 0.07 nm (APPROACH), 0.15 nm (TERMINAL), or 0.15 nm (ENROUTE) for > 30 seconds 2. Position difference between GPS 1 and GPS 2 is > [1.224(GPS1 95%ERR + GPS2 95%ERR)] AND position difference between GPS1 (2) and INU1/GPS1 (INU2/GPS2) is > [1.224(GPS1 (2) 95%ERR + INU1/GPS1 (INU2/GPS2) 95%ERR)] for > 30 seconds	a. Confirm GPS solution is incorrect by cross-checking against all solutions. b. Ensure another solution is selected as the designated pilot's solution. c. Attempt to correct the GPS solution by using the applicable GPS INIT key on the start 2 page. d. If GPS solution remains incorrect, disable satellite tracking by pulling the applicable GINS NAVIGATION – AE CB on P6 CB panel. e. If desired, reset the GINS NAVIGATION – AE CB on P6 CB panel, and attempt to regain that GPS. f. Compare constellation and solution against other GPS and solutions.

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GINS Abnormal Operation Procedures (Continued)

SYMPTOM	FAULT	ACTION
No GPS signals	Both AEs non-functional	a. Attempt restoration of both GPSs by cycling GINS NAVIGATION – AE CBs on P6 CB panel and selecting GPS INIT for both on start 2 page. If needed, reload almanac from PCMCIA card. b. If JTIDS REL NAV is available, the EGI designated on aiding page will revert to JTIDS aiding (e.g. INUx/JTDS). c. If JTIDS REL NAV is unavailable, blended solution reverts to INUx/---. At the moment GPS signal coverage is lost, the INUx/--- solution will normally be the most accurate position source available due to the Kalman filter predictions of the free-running INU performance. If there was a difference between the INUx/GPS and INUx positions prior to the loss of GPS signal coverage, the INUx/--- position does not revert automatically to the INUx position. Instead, the INUx/--- position will closely resemble the INUx/GPS position (prior to GPS signal loss) initially, and then begin to decay over time. This solution can be manually updated, as required.
JTIDS		
JTIDS low position quality	JTIDS has assumed control of 1553 bus and GINS input unavailable	a. If JTIDS is needed for mission and must have GINS input, perform Navigation 1553 Bus Splitting Procedure. b. If JTIDS is not needed, turn JTIDS off (N, MCC, CT).
	Total 1553 bus malfunction; GINS input unavailable	a. Force another CDU to assume bus control by turning BC CDU off. b. If problem persists, perform Navigation 1553 Bus Splitting Procedure, and operate rest of mission split.
JTIDS navigation data from GINS invalid or unavailable	1. JTIDS CBIT 15 (1553 communications) 2. JTIDS CBIT 16 (1553 communications)	a. Coordinate with CT to determine problem. b. Coordinate with CT to cycle power and JTIDS CBs on P66-2 CB panel

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SYMPTOM	FAULT	ACTION
JTIDS NGO annunciation	1. JTIDS malfunction 2. 1553 bus malfunction 3. JTIDS loss of power	a. Coordinate with CT to determine problem. b. Note JTIDS status page indications.
JTDS RELNAV annunciation	JTIDS cannot be used for navigation or JTIDS position quality is poor	a. Coordinate with CT to determine if JTIDS is functional and/or if enough stations are in the link. b. Manually update blended solution if necessary (no GPS or JTIDS updating available).
JTIDS status NGO-A	JTIDS unable to send or receive data via 1553 data bus A	None. Data bus B operable.
JTIDS status NGO-B	JTIDS unable to send or receive data via 1553 data bus B	None. Data bus A operable.
JTIDS status NGO-T	JTIDS unable to send or receive data via 1553 data bus A or B	a. Coordinate with CT to determine problem. b. If situation persists, JTIDS can still function, but GINS is unable to use JTIDS aiding.

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GINS Abnormal Operation Procedures (Continued)

SYMPTOM	FAULT	ACTION
MISSION SYSTEMS		
CPS nav source automatically changes to other EGI (CDMT)	GPS receiver malfunction	a. Look for other GPS failure indications. b. Switch to other EGI for all sources, then cycle power to affected EGI to attempt to clear fault (IFA).
	1. EGI malfunction 2. EGI failure 3. 1553 bus connection failure	a. Select alternate EGI for all sources. b. Inflight align affected EGI.
	GPS antenna or AE malfunction	a. Check GINS NAVIGATION – AE CB on P6 CB panel. b. Select other EGI for all sources. c. Cycle power to affected AE to attempt to clear fault.
Mission crew reports discrepancies between E-3 reported information and ATC correlated information	Mission system/CPS getting inputs from errant EGI	a. Check navigation validity of preferred EGI. b. Place CPS NAV SOURCE switch in accurate EGI position, and notify MCC/CDMT. c. If switching sources does not correct problem, consider switching errant EGI off and inflight aligning.
Mission IFF loss of GINS information	1. IFF CBIT 15 (1553 communications) 2. IFF CBIT 16 (1553 communications)	Attempt to recover data bus by performing Navigation 1553 Bus Splitting Procedure.
Mission system poor tracking performance	Incorrect or missing boresight values	a. Switch to other EGI for all sources. b. No operator actions possible, maintenance must load values.

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GINS Abnormal Operation Procedures (Continued)

SYMPTOM	FAULT	ACTION
POWER		
Aircraft power switched	1. FE switches power from ground to aircraft sources 2. Loss of AC power while airborne	Verify CDU 3 is still BC CDU.
All generators lost	Source investigated by FE	a. Accomplish LOSS OF ALL GENERATORS emergency procedure checklist. b. Assist copilot with navigation and communication. c. Units operating on Hot Battery Bus: IFF, marker beacon, VHF NAV 1 (ILS and voice receive only), VHF 1 and UHF radios, interphone and PA, CDU 3, BSIU 1, data loader, 1553 bus control switch, and GINS CONTROL PANEL. d. EGIs operate on battery power for a minimum of 30 minutes up to a maximum of 2 hours.
Any generator loss	Source investigated by FE	No action necessary if generator sync bus picks up load.

Figure 1-179A (Sheet 36 of 38)

SYMPTOM	FAULT	ACTION
CDU 1, pilot and navigator RNAV ANNUNCIATOR panel, and CADC 1 non-functional EGI 1 caution light illuminated	Loss of GEN 2 with bus isolated	Multiple events occur; ensure safety of flight. Accomplish the following if FE cannot immediately restore GEN 2 by sync bus: a. If ADC 1 is selected at ADAB panel, autopilot disengages due to loss of CADC altitude input. Set ADC SOURCE SELECT switch to ADC 2 ALTERNATE, DESIGNATED PILOT selector switch to COPILOT, and reengage autopilot. b. If GINS navigation is desired, copilot's instruments should be made primary navigation until generator 2 is restored, because pilot CDU and RNAV ANNUNCIATOR panel are off, pilot's altimeter is in STBY, and CADC 2 (copilot's side) is operational to all instruments. c. Verify/select copilot steer solution to INU2/GPS2, and copilot NAV MODE selector to GINS. d. Copilot's altimeter should stay in RESET and be made primary altitude reference. e. TACAN/VOR navigation cross-checks will have to be made off RMIs, since pilot NAV MODE selector must remain in GINS for autopilot operation. f. Clear or investigate any annunciations or instrument flags. g. As time permits, advise MCC of situation, and if necessary, switch CPS NAV SOURCE switch to EGI 2. h. Check/reset GINS NAVIGATION – CDU – PILOT RNAV 1 RNAV 3 CB on P6 CB panel. i. Check aiding page and make changes as necessary.

Figure 1-179A (Sheet 37 of 38)

GINS Abnormal Operation Procedures (Continued)

SYMPTOM	FAULT	ACTION
CDU 2 CP RNAV ANNUNCIATOR panel, AE 2, BSIU 2, and CADC 2 are non-functional EGI 2 caution light illuminated	Loss of GEN 8 with bus isolated	Multiple events occur; ensure safety of flight. Accomplish the following if FE cannot immediately restore GEN 8 by sync bus: a. If ADC 2 is selected at ADAB panel, autopilot disengages due to loss of CADC altitude input. Set ADC SOURCE SELECT switch to ADC 1, DESIGNATED PILOT selector switch to PILOT, and reengage autopilot. b. Copilot altimeter is in STBY. Set IFF Mode C enabling switch to OUT and advise ATC. c. Verify/select copilot steer solution is set to INU1/GPS1. d. Check/reset GINS NAVIGATION – CDU – PILOT RNAV 1 RNAV 3 CB on P6 CB panel. e. Check aiding page and make changes as necessary.
NAV FAIL after switching aircraft power	1. Battery charger malfunction 2. Battery pack malfunction 3. Battery pack will not hold charge 4. CB open on battery pack	a. On ground, contact maintenance to check EGI battery CB or replace battery. b. If time does not permit changing battery, cycle EGI power and CB, and ground or inflight align. c. If battery is not strong enough to maintain alignment, AC power should maintain alignment.
RNAV ANNUNCIATORS PANEL		
MAG/TRUE switch on pilot RNAV ANNUNCIATORS panel does not change headings on HSI	1. No MAGVAR loaded in CDU 2. MAGVAR is near zero, where MH = TH	a. Check psn page to see MAGVAR value. If none displayed, load MAGVAR into CDU with PCMCIA card. b. Check CBIT status and take corrective action from GINS CBIT table.

Figure 1-179A (Sheet 38 of 38)

GINS Troubleshooting (CBIT) Fault Codes

STATUS BIT	LOST SIGNALS	SYSTEM INDICATIONS	CORRECTIVE ACTION
NOTE - Bits numbered left to right. - Unless specified otherwise, all information applies only to the on-side system.			
CDU Bits 1-7	Not used		
CDU Bit 8	1553 Bus Data (component failure)	Erroneous Data	Shut down CDU
CDU Bit 9	1553 Bus Data (terminal failure)	Erroneous Data	Shut down CDU
CDU Bit 10	None	None	None (bus 2 not used on this platform)
CDU Bit 11	Discrete I/O	①	None: Recognize that only one pilot may be receiving alerts and react accordingly
CDU Bit 12	None	CRT Flickers or goes blank	None. If CRT goes blank or is useless, use alternative procedures for use of two CDUs for remainder of mission.
CDU Bit 13	1553 Bus Data (Bus #1 failure)	Erroneous Data	Shut down CDU
CDU Bit 14	N/A		
CDU Bit 15	NVM Data	Corrupt or missing data	Cycle power on CDU and use the cross-side CDU
CDU Bit 16	CDU Communications	Erroneous Data	Shut down CDU
BSIU Bits 1-4	Not used		
BSIU Bit 5	None (general 1553)	Loss of on-side Nav solution and display	None
BSIU Bit 6	None (general 1553 terminal failure)	Loss of on-side Nav solution and display	None

Figure 1-179B (Sheet 1 of 3)

GINS Troubleshooting (CBIT) Fault Codes (Continued)

STATUS BIT	LOST SIGNALS	SYSTEM INDICATIONS	CORRECTIVE ACTION
BSIU Bit 7	1553 Bus Data (CPU)	Loss of on-side Nav solution and display	None
BSIU Bit 8	NVM Data	None	Cycle power on GINS CONTROL PANEL. Check that designated pilot's solution is being generated out of the good BSIU, cross-side CDU.
BSIU Bit 9	None	None	None (bus 2 not used on this platform)
BSIU Bit 10	1553 Bus Communication (Bus #1)	Loss of on-side Nav solution and display	None
BSIU Bit 11	Output Discretes	Annunciations of FMS flight phase, Inability to drive HSI, ADI, FDC	Make sure designated pilots solution is generated by other BSIU
BSIU Bit 12	SIM #5	Loss of distance display on on-side HSI	Use cross-side HSI distance or CDU distance to go display
BSIU Bit 13	Not used		
BSIU Bit 14	SIM #3	Vertical deviation display on on-side HSI and ADI AHRS heading input to on-side system; Bank command to FDC & AP	Use cross-side BSIU as the designated pilot's solution
BSIU Bit 15	Discrete Outputs (SIM #2)	Annunciation of phase of flight; Navigation validity; From/to indicator; Course deviation indication to HSI; Fast/Slow indicator on ADI	Use cross-side BSIU as the designated pilot's solution
BSIU Bit 16	Discrete Outputs (SIM #1)	Waypoint alert; Vertical Navigation alert; Speed alert; Bearing display to HSI; course Display to HSI	Use cross-side BSIU as the designated pilot's solution
CADC Bits 1-14	Not used		

Figure 1-179B (Sheet 2 of 3)

STATUS BIT	LOST SIGNALS	SYSTEM INDICATIONS	CORRECTIVE ACTION
CADC Bit 15	CADC 1553 communications	Display and use in navigational computations of pressure altitude, barometric altitude, true airspeed, static air temperature	Select still functioning CADC as the aid to both EGIs
CADC Bit 16	CADC 1553 communications	Display and use in navigational computations of pressure altitude, barometric altitude, true airspeed, static air temperature	Select still functioning CADC as the aid to both EGIs
JTIDS Bits 1-14	Not used		
JTIDS Bit 15	JTIDS 1553 communications	Loss of information from the FMS to JTIDS	None
JTIDS Bit 16	JTIDS 1553 communications	Loss of information from the FMS to JTIDS	None
IFF Bits 1-14	Not used		
IFF Bit 15	IFF 1553 communications	Loss of EGI aiding information to IFF	None
IFF Bit 16	IFF 1553 communications	Loss of EGI aiding information to IFF	None

① Dependent on type of failure. Can cause loss of the following inputs and outputs to the on-side CDU:

- True/Mag select input
- Weight-on-wheels input
- CDU alert output
- Master zeroize input
- RAIM alert output
- Altitude alert output
- Designated pilot select input

Figure 1-179B (Sheet 3 of 3)

SUBSECTION I–P
COMMUNICATION SYSTEM

Table of Contents

SUMMARY

The communications system provides all the intra–airplane and external communications required by the flight crew and mission crew. The intra-airplane communications, provided by the audio distribution system (ADS), consists of six intercom systems, a public address system and central switching equipment. The external communications equipment, consisting of UHF, VHF and HF radios, provides clear voice (and secure voice, if programmed) operation for the flight crew. The system also provides clear voice, secure voice, digital data and relaying operations for the mission crew. The communication equipment is located as shown in *figure 1-180*.

FLIGHT CREW COMMUNICATIONS

The flight crew communications, consisting of six intercom systems, a public address system, and three radio systems, provide all the internal and external airplane communications required by the flight crew. All inputs and outputs of these systems go through the ADS. The major units of the flight crew communication equipment are listed in *figure 1-181*.

AUDIO DISTRIBUTION SYSTEM

The audio distribution system (ADS) provides communication between flight crew members, between flight crew and mission crew, and between flight crew and maintenance personnel. This system also allows selection of audio inputs and outputs for air-to-air and air-to-ground communication. The flight crew ADS functions are controlled by the ADS panels at each crew station (*figure 1-182*). *Figure 1-183* illustrates the signal flow between the ADS panels and the rest of the communication system.

Central Switching Units (CSU)

The central switching units (CSU) connect all intercom and radio audio signals to the individual ADS panels. For additional information, refer to T.O. 1E-3A-43-1-1.

NOTE

- The audio distribution panel can fail when central switching unit CSU 1 or CSU 2 overheats. If these units both fail, all radio and interphone communication is lost.
- CSU 2 controls pilot’s and flight engineer’s communications and CSU 1 controls copilot’s and navigator’s communications.
- To extend communication operating time after complete loss of draw-through cooling, pilot may direct shutting down one CSU (by opening CSU 1 or CSU 2 circuit breaker on P5 panel).
- To aid cooling of the operating CSU after draw-through failure, pilot may direct opening the E11 equipment rack door.

ADS Panel

The flight crew audio distribution panel provides transmission and reception on the UHF, UHF guard, VHF, and HF radio systems, the interphone systems and the public address system. Reception capability is provided for audio outputs from VHF NAV, TACAN, ADF, UHF ADF, marker beacon, IFF (AIMS) and VHF guard receiver. Hot microphone intercom is also provided.

NOTE

- The MASTER VOL control must be set to a position clockwise from the OFF position in order to receive any usable communication or navigation radio audio output.
- Audio output from all sources except PA is received only on flight crew headsets. PA output from other than flight deck is received on speakers.
- The MAINT INTPH selector (13, *figure 1-13* or 40, *figure 1-180*) must be set to AIRCRAFT or BOTH in order to communicate with personnel in the lower compartments.

Refer to subsection I-M for individual radio navigation aid operating instructions.

ADS Panel Locations

Flight crew ADS panels are located on the aisle stand (*figure 1-9*) on the flight engineer's panel (*figure 1-13*) and on the navigator's panel (*figure 1-14*). The observer's interphone connector (*figure 1-10*) is wired in parallel with the pilot's interphone connector. The observer has transmission and reception capability as selected by the pilot.

ADS Panel Operation

To receive on any system, rotate the MASTER VOL knob clockwise from the stop and rotate the knob for the selected system to set desired volume level. To transmit on a system, pull up the knob, rotate clockwise from off position, and press microphone switch.

NOTE

If a secure channel (mission interphone or secure voice radio) is selected at a flight crew station, no clear voice transmission is possible from that station (including flight interphone).

The HOT MIC switch allows a hot mike interphone capability so that the crew can talk in an emergency situation without having to press microphone switches. The interphone is constantly keyed in this condition. Pressing the microphone switch with the HOT MIC switch set allows radio transmission on the selected radios only.

NOTE

With HOT MIC selected and transmission selected on flight interphone, mission interphone is not received if selected.

Microphone Switches

A three-position, MIC-OFF-INPH, control wheel microphone switch is located on the outboard horn of each pilot's control wheel. Pressing the MIC (lower) position of the switch allows use of the communication system selected by the ADS panel (*figure 1-182*). Pressing the INPH (upper) position of the switch allows use of the interphone system selected by the ADS panel.

The other flight crew positions have press-to-talk foot switches and a lapel press-to-talk switch.

Headset Adapter Cords

The INTERPHONE connectors at all crew stations are equipped with multi-pin screw-type connectors which mate with an adapter cord. The adapter cords are approximately five feet long and have standard headset connectors on one end.

NOTE

Crew station headset cords do not fit external interphone stations.

INTERNAL COMMUNICATIONS (INTERCOM)

Through the ADS panels, the flight crew has access to the flight crew intercom, mission intercom, four-channel selective intercom, mission maintenance intercom, airplane maintenance intercom, air refueling receptacle interphone and public address system. These systems provide the flight crew with all the required intra-airplane communications.

The maintenance interphone systems are connected to the flight crew interphone by the MAIN INPH maintenance interphone switch on the flight engineer's auxiliary panel (*figure 1–180*).

Flight Crew Intercom

The flight crew intercom provides communication between flight crew stations and between flight crew and maintenance personnel (if airplane or mission maintenance interphone is connected). Operate the flight crew intercom as follows:

NOTE

> Power must be available on the emergency dc bus (BATTERY switch ON, EMERGENCY POWER switch MANUAL ON or NORMAL) to operate the flight crew intercom.

1. Rotate ADS panel FLT INPH knob clockwise one quarter turn.

   Monitoring of flight crew intercom is now available at flight crew headsets.

2. Adjust MASTER VOL knob as required.

3. Pull FLT INPH knob out.

   Flight crew intercom is now fully operable. To talk on intercom press press–to–talk switch.

NOTE

> If mission interphone or a secure voice radio is selected at a flight crew station, flight interphone is disabled at the station. Crew coordination must be performed on mission interphone.

– – – When Transmission Is No Longer Required – – –

4. Push FLT INPH knob in.

   Flight crew intercom transmission is not available. Monitoring capability remains. If it is desired to turn intercom off, rotate FLT INTPH knob fully counterclockwise.

Receptacle Interphone

The air refueling receptacle interphone is accessed by an unlabeled alternate action switch just to the right of the flight engineer's interphone jack on the flight engineer's lower auxiliary panel (*figure 1-180*). Receptacle interphone, if used, should be switched ON prior to contact. Pressing the switch to ON connects the flight crew interphone to the tanker interphone through the boom/receptacle signal coils as soon as contact is made (provided that the tanker is configured). This permits radio silent interphone communications with the tanker as long as boom contact is maintained.

The receptacle interphone amplifier is powered when the MASTER REFUEL switch is ON. Communication with the amplifier is enabled with the flight engineer's receptacle interphone switch/indicator (*figure 1-180*). Adjust sidetone volume with the FLT INPH knob on each flight crew ADS panel before contact. Readjust FLT INPH volume, as required, when contact is made. At pilot's discretion, selection of MISSION or BOTH on MAINT INTPH (*figure 1-180*) enables mission crew to monitor conversations or talk with tanker.

When pilot not flying desires to speak to tanker, HOT MIC switch on ADS panel may be used momentarily to avoid interference with control wheel movements of pilot flying. Also, headset cord PTT switch may be used if radios are deselected.

Power for the receptacle interphone audio amplifier comes from 28V DC bus 8 through the REFUELING – SLY DR & TOG LCH – NORMAL circuit breaker on the P61–1 panel and through the MASTER REFUEL switch. Power for the ON light in the receptacle interphone (unlabeled) switch/indicator comes from the emergency DC bus through the EMERGENCY COMMUNICATIONS – ADS – CSU 2 A/V MAINT circuit breaker on the P5 panel. The ON light is tested with the auxiliary panel LT IND test switch. The ON light is an indication of switch position only.

Selective Intercom

A four–channel clear–selective intercom is available to the flight crew through the ADS panel. This intercom provides the flight crew with direct access to the radio operator, the senior director, the surveillance officer and the mission crew commander. Any of the four stations can connect the flight crew with any other flight or mission crew station. Perform steps 1 through 3 to place a call.

1. Press ADS panel CALL pushbutton.

   If a network is available, CALL indicator illuminates. If a network is not available, BUSY indicator flashes. Continue with procedure if a network is available; otherwise terminate call by pressing CALL pushbutton again.

2. Check CALL indicator illuminated.

– – – When Dial Tone Is Heard – – –

3. Press selected station pushbutton.

   Selected station: (COMM, WPN, SURVL, or CMDR) is called and CALL indicator flashes.

   If called station is not in use, selective intercom CALL indicator flashes at both the station being called and at the station placing the call. If called station is in use, selective intercom BUSY indicator flashes. To terminate call, press CALL pushbutton again.

Perform steps 4 and 5 to answer a call.

4. Press CALL pushbutton.

   CALL indicator illuminates steady.

5. Adjust MASTER VOL knob as required.

   Both calling and called stations adjust volume for desired listening level.

NOTE

- Calls to more than one selective intercom station from the flight deck must be made through the communications console.
- If flight or mission interphone button is pulled out, transmissions from this position can be heard by any position on the flight or mission net. Push all other transmit buttons in to prevent interference with other flight or mission crew positions while on selective intercom.

Perform step 6 to terminate a call.

6. Press CALL pushbutton.

   Both called and calling station press CALL pushbutton to terminate call.

Mission Intercom

The mission intercom provides the flight crew with a single intercom net for classified interphone conferences. Stations are assigned to a net at the communications console. Operate the intercom as follows:

1. Rotate ADS panel MSN INPH knob clockwise one–quarter turn.

   Monitoring of mission intercom is available. Adjust volume as required.

NOTE

With HOT MIC selected and transmission selected on flight interphone, mission interphone is not received if selected.

2. Adjust MASTER VOL knob as required.

3. Pull MSN INPH knob out.

   Mission intercom is now fully operable. To talk on intercom, press press–to–talk switch.

NOTE

Flight interphone and radio transmission is disabled from an ADS panel with mission interphone knob pulled out. If the pilot or copilot presses the control column microphone switch, the mission intercom is overridden.

– – – When Transmission Is No Longer Required – – –

4. Push MSN INPH knob in.

   Mission intercom transmission is not available. Monitor capability remains. To turn intercom off, rotate MSN INPH knob fully counterclockwise. Flight interphone is disabled until knob is in.

Public Address System

Flight deck ADS panels provide flight crew with access to the airplane Public Address (PA) system.

NOTE

- PA messages from the flight deck are broadcast over all headsets and speakers, with a burst alert on speakers. PA transmission interferes with all audio reception at other stations. Do not use PA in flight, except in emergencies, or as directed by normal procedures.
- Flight deck speakers receive PA only and are muted when PA is from flight deck station.
- All radio transmission by person selecting PA is inhibited (except those initiated by pilot or copilot) with MIC switch.

To talk on the PA system, set ADS panel PA switch to ON and press the press–to–talk switch or set HOT MIC switch to up position. When press–to–talk switch is pressed, flight deck speakers are muted.

Maintenance Intercom

Intercommunication for maintenance is provided by 6 airplane maintenance stations and 19 mission maintenance stations that are distributed throughout the airplane (*figure 1-180*). These stations are connected to the flight crew intercom (*figure 1-183*) through the MAINT INPH panel (*figure 1-180*) located on the flight engineer's auxiliary panel.

Airplane Maintenance Intercom

The airplane maintenance stations are those primarily associated with airplane maintenance and servicing. All airplane maintenance stations are located in pressurized areas, except the cord set remote connectors near the nose and main wheel wells and at the external power receptacle. *Figure 1-184* illustrates and describes the airplane maintenance intercom panel.

Mission Maintenance Intercom

The 19 mission maintenance stations are used for mission equipment maintenance and inflight emergency coordination between flight and mission crewmembers. One station is located in the crew rest area. This station provides communication to and from the crew rest area when a headset or handset is installed. Like the airplane maintenance intercom panels, each of the mission maintenance intercom panels provides a connector for microphone/headsets and a screwdriver adjusted volume control. In addition, they also provide a CALL pushbutton to signal the communication operator and HOT MIC switch to provide continuous microphone operation. *Figure 1-184* also illustrates and describes this panel.

NOTE

- Mission maintenance intercom can be used during ground refueling by closing the MSN MAINT circuit breaker (P66-2). Obtain 50–foot cord from ART position. Connect cord to mission maintenance interphone panel. Set MAINT INPH selector (*figure 1-180*) to MISSION or BOTH.
- At pilot's discretion, maintenance intercom can be used during air refueling to enable mission crew communication with tanker intercom by setting the MAINT INPH selector to either MISSION or BOTH when receptacle interphone is in use.
- Personnel in lower compartments in flight will not use hot mic on mission maintenance intercom to prevent interference with other users on maintenance net.

EXTERNAL COMMUNICATIONS

The flight crew external communications equipment consists of one UHF transceiver available only to the flight crew, and one each VHF and HF transceiver that are shared with the mission crew. These radios provide all the clear voice air–to–air and air–to–ground communication required by the flight crew. In addition, the flight crew has access to a UHF guard transceiver and a VHF guard receiver for emergency use.

UHF Communications

The flight crew UHF communications equipment consists of a UHF transceiver and a UHF guard transceiver. The UHF transceiver is used and controlled exclusively by the flight crew if properly selected on the communications console ADS Programming and Display Panel (*figure 1-180*). The UHF guard transceiver (tuned at the communications console) can be operated from all flight crew positions. The UHF guard radio can be retuned to other than guard frequencies if an additional communications channel is needed.

NOTE

Normally, both the UHF guard radio and the UHF–ADF will be tuned to guard channel, 243.00 MHz. One of these receivers must be tuned to guard channel at all times. The other receiver may be tuned to another frequency.

UHF Transceiver

The UHF transceiver operates in the 225 to 399.975 MHz band, with 0.025 MHz channel separation for a total of approximately 7,000 channels. The power output of this transmitter is 30 watts.

UHF Flight Deck Digital Radio Control

The Flight Deck Digital Radio Control (FDDRC) displays startup, operating, and BIT status for information or modification via four main menus:

a. Frequency

b. Preset – View

c. Preset – Store

d. Built–In Test

Access to these menus, and modification of the menu parameters, is controlled by six pushbutton switches (keys) and one rotary switch. Each menu has the following three display modes:

e. Parameter Display

f. Parameter Select

g. Parameter Modify

See *figure 1-185*.

NOTE

- It is recommended that pilot not flying aircraft operate FDDRC in flight. If it is necessary to reach across forward electronic panel, ensure no inadvertent movement of control column, control wheel, stabilizer trim, throttles, flap lever or speed brake lever.

- For air traffic control (ATC) communications, use VHF radio whenever feasible. For UHF radio, use of FDDRC preset frequencies is recommended.

Active/Stby Frequency Exchange

This procedure interchanges the active and standby frequencies.

1. Set PRESET/MAN switch to MAN.
2. Select frequency menu via MENU key.
3. With ↑ and ↓ keys, exchange STBY and ACTIVE frequencies.
4. When exchange is complete, TUNING is displayed on third line, indicating transceiver is tuning to new ACTIVE frequency. After a maximum of 8 seconds, TUNING goes out and third menu line display is blank.

Preset Frequency Recall

Frequency change is accomplished by selecting a preset frequency with front panel PRESET/MAN switch and selecting a preset bank, A, B, or C, with the ← and → keys while in the Parameter Display Mode. The current standby frequency is saved for later use and replaced by the active frequency, and the preset frequency replaces the active frequency.

1. Select frequency menu via MENU key.
2. Set PRESET/MAN switch to any preset channel (1 through 8).
3. Note selected switch position is displayed on right side of third line.
4. With ← and → keys, select desired preset channel bank, A, B, or C, as displayed on right side of third line.

NOTE

Immediately after each change, active and standby frequencies are updated with contents of preset and previous active frequency, respectively. This allows operator to verify correct preset has been selected. Three seconds after last change, or upon pressing ENT key, whichever occurs first, a tune command with new frequency is sent to Digital Decoder Module (DDM). This feature applies to Preset Mode only.

5. After three seconds, or upon pressing ENT, note that TUNING is displayed on third line, indicating new frequency is being loaded. After a maximum of 8 seconds, TUNING goes out and third menu line display contains selected preset channel.

Manual Stby Frequency Editing

Only the standby frequency can be edited.

1. Select frequency menu via MENU key.
2. Set PRESET/MAN switch to MAN.
3. Press ENT key and select digit for editing (digit is flashing).

NOTE

- Enter new frequency from left to right.
- Perform steps 4 and/or 5 as necessary to set desired frequency.

4. To change selected digit, press → or ← key.
5. To change flashing digit, press ↑ key, or ↓ key.

6. After STBY frequency has been changed, press ENT to complete entry.

Preset Frequency Storage

1. Select preset – view menu via MENU key.
2. Press ↑ or ↓ key to select desired frequency preset number and memory bank, 1–A through 8–C.
3. Press MENU key to select STORE in second line of display. Note that STORE frequency is bracketed.
4. Press ENT key and select digit for editing (digit is flashing). Observe STORE frequency first digit (2 or 3) is flashing.

NOTE

- Enter new frequency from left to right.
- Perform steps 5 and/or 6 as necessary to set desired frequency.

5. To change selected digit, press → key or ← key.
6. To change flashing digit, press ↑ key or ↓ key.
7. Press ENT to enter selected digital value.
8. Press ← key to select STORE.
9. Press ENT key twice to store selected digital value.
10. Repeat steps 1 through 9 as necessary to set up and store other preset frequencies.

Preset Frequency Review

1. Select preset – view menu via MENU key.
2. With ↑ and ↓ keys, cycle through preset frequencies.

NOTE

Frequency preset number and memory bank are in top line of display. Second line shows actual frequency.

Display Intensity Correction

The FDDRC display intensity is a result of the lamp supply voltage and the FDDRC intensity correction (INTENS CORR) factor. The FDDRC display intensity can be offset from 100% to 13% of maximum intensity. Depending on the setting of the lamp supply, the intensity offset can be varied up or down by seven levels to match display intensity to that of other equipment. Depending on the lamp supply setting, a full range of offsets may not be available.

1. Select preset – view or preset – store menu via MENU key.
2. With → key, select correction offset in INTENS CORR line.
3. Press ENT to enter parameter modify mode.
4. Use ↑ and ↓ keys to select desired correction offset between –7 and +7.
5. Press ENT to enter new lamp intensity correction offset.

NOTE

Radio panels rheostat cannot be used to control digital display illumination intensity effectively. FDDRC must be used to control intensity.

UHF Guard Transceiver Operation

Normally, both UHF guard and UHF/ADF radios are used to monitor the 243.000 MHz guard channel. However, either radio may be tuned to another frequency as long as one radio remains tuned to 243.000 MHz. Refer to MISSION CREW COMMUNICATIONS.

CAUTION

Set COMM – FWD switch on AVIONICS POWER DISCONNECT panel to DISC when cooling air is not available to rack E19 (forward forced air system not operating).

NOTE

UHF guard transceiver must be retuned at the communications console when power is restored to the unit.

1. Rotate ADS PANEL UHF–G knob clockwise.

   Guard receiver is activated.

2. Adjust MASTER VOL knob.

– – – To Enable Transmitter (step 3) – – –

3. Pull out UHF G knob.

– – – To Disable Transmitter (step 4) – – –

4. Push UHF G knob in.

– – – To Disable Audio Output (step 5) – – –

5. Rotate UHF G knob fully counterclockwise.

LESS IDG VHF Communications

The flight deck VHF communications consist of a VHF communication transceiver and a VHF guard receiver.

VHF Transceiver

The VHF transceiver is used to provide ground–to–ground, ground–to–air, air–to–air and air–to–ground communication. The flight crew has primary control of this transceiver, but the radio can be used by the mission crew. This transceiver operates in the frequency range of 116.000 MHz to 149.950 MHz at 25 KHz intervals and with a power output of 25 watts. Although the VHF radio can be tuned to frequencies up to 151.975 MHz, transmissions above 149.950 MHz are degraded due to antenna and bandpass filter limitations.

VHF Control Panel

The VHF control panel is located in the overhead panel (*figure 1-7*). *Figure 1-186* identifies and describes the VHF panel indicators and controls.

VHF Transceiver Operation

The VHF transceiver is operated as follows:

1. Rotate ADS panel VHF knob clockwise.

   Audio output from VHF receiver is available. VHF transceiver is now controlled by flight crew.

   NOTE

   If mission crew is using VHF radio, notify communications operator (if time permits) when flight crew takes control of VHF radio so that required mission radio can be reassigned and so that operator can verify radio is still programmed to flight crew.

2. Set VHF control panel power/test switch to TEST.

   Squelch should now be disabled and receiver noise is heard. Side tone is heard when the transmitter is keyed.

3. Set FREQUENCY selector knobs to desired frequency.

   If desired frequency is not displayed in FREQUENCY display windows, select frequency with appropriate selector knobs.

4. Set VHF control panel power/test switch to ON.

5. Pull ADS panel VHF knob out.

6. Set SELECT switch to desired frequency.

7. Set ADS panel VHF and MASTER VOL knobs as required.

– – – To Shut Down VHF Radios (Steps 8 and 9) – – –

8. Push ADS panel VHF knob in and rotate counterclockwise to stop.

   If VHF knob is not in and rotated to off, mission crew cannot use the VHF radio.

9. Set VHF control panel power/test switch to OFF.

VHF Guard Receiver Operation

The VHF guard receiver, although interchangeable with the VHF transceiver, does not have the capability to transmit. This receiver is wired so as to be pretuned to the guard channel frequency of 121.500 MHz. Operate the VHF guard receive as follows:

CAUTION

Set COMM – FWD switch on AVIONICS POWER DISCONNECT panel to DISC when cooling air is not available to rack E12 (forward forced air system not operating).

1. Rotate ADS panel VHF G knob clockwise.

2. Set VHF control panel power/test switch to ON.

3. Set ADS panel VHF G and MASTER VOL knobs as required.

NOTE

MASTER VOL knob must be clockwise from off position to receive any audio output from ADS.

– – – To Test VHF Guard Receiver (Step 4) – – –

4. Set VHF control panel power/test switch to GUARD TEST.

   Squelch is disabled allowing receiver noise to be heard. This indicates receiver is operating.

– – – To Receive On VHF Guard Receiver (Step 5) – – –

5. Set VHF control panel power/test switch to ON.

– – – To Disable VHF Guard Receiver Audio Output (Step 6) – – –

6. Rotate ADS panel VHF G Knob fully counterclockwise.

– – – To Turn VHF Guard (And VHF) Radio OFF (Step 7) – – –

7. Set VHF control panel power/test switch to OFF. ◀

WITH IDG VHF Communications

The flight deck VHF communications consist of two VHF communication transceivers and a VHF guard receiver.

VHF Transceivers

VHF 1 and 2, ARC 210, transceivers provide half–duplex AM communications in all phases of ground and flight operations. When required, either radio can also be used by the mission crew. The radios operate in the frequency range of 118.000 to 149.950 MHz at either 8.33 or 25 KHz channel spacing. ATC uses 8.33 KHz channel spacing from 118.000 to 137.000 MHz.

NOTE

- The VHF radios can be tuned to frequencies up to 155.975 MHz, however above 149.950 MHz operation is degraded due to antenna and bandpass filter limitations.
- VHF 2 antenna is located between the main gear doors. With gear doors open, line of sight is blocked in the lateral directions.
- VHF 1 radio transmission between 120.300 – 122.700 MHz results in bleedover interference on guard frequency. Non–voice, static interference occurs in the headsets of anyone monitoring guard frequency on VHF 3.
- VHF 2 radio transmission between 118.000 – 130.000 MHz results in bleedover interference on guard frequency. Non–voice, static interference occurs in the headsets of anyone monitoring guard frequency on VHF 3.
- The interference radius can be as great as 2,000 feet. Aircraft or ground stations within this radius and monitoring VHF guard frequency might experience interference.

VHF Control Panels (RCUs)

Two remote control units (RCUs) are provided in the overhead P13 panel (23, *figure 1–7A)* for flight deck control of the VHF radios. Controls and indicators are shown in *figure 1–186A*. Visual annunciations displayed by the RCUs are listed in *figure 1–186B*.

Both pilots have equal access to both RCUs. Whichever radio is primary, the use of that RCU will be coordinated between the pilots. For purposes of description, the left hand RCU is referred to as the pilot’s RCU, only to give it a name and because it is closer to the pilot, not because it is designated for the pilot’s exclusive use. Likewise, the right hand RCU is referred to as the copilot’s RCU. This terminology is to avoid confusion with numbers since the pilot’s RCU controls VHF 2 and the copilot’s RCU controls VHF 1. It is set up this way because VHF 1 should usually be the primary VHF radio, and the copilot is expected to use the VHF radio more frequently.

The pilot's RCU either controls or monitors VHF 2, as enabled at the P73 console. The copilot's RCU either controls or monitors VHF 1, depending upon whether the radio is seized at any of the flight deck ADS panels.

Power and Cooling

VHF 1 and 2 are both cooled by cabin ambient air. Neither radio requires use of the baseband distribution panel nor the avionics power disconnect panel.

VHF 1 should be available for ground emergency communications as soon as airplane battery switch is ON. VHF 1 radio and copilot's RCU are powered through P5 EMERGENCY COMMUNICATIONS – VHF 1 circuit breaker.

VHF 2 should be available as soon as AC power is available to TRU 6, or DC tie bus is powered. Power for VHF 2 and pilot's RCU passes through P66–2 VHF – AM2 breaker.

P73 Console Setup for VHF 1 and 2

The P73 console should be left in a configuration that permits flight deck operation of VHF 1 at the beginning of preflight as soon as airplane battery is switched on.

Assure VHF 1 is programmed to flight deck ADS panel VHF knob by checking that ADS Programming and Display Panel thumbwheels for VHF–AM 1 are set to DIRECT ACCESS 27. The panel should normally be found in this configuration.

VHF 2 will be assigned to the flight deck for ground and airborn operations except as needed by the mission crew. The flight crew is responsible for the preflight checks of VHF 2. When flight crew operations of VHF 2 are planned, program VHF 2 under the HF push on the flight crew's ADS panels. Set up P73 as follows:

1. Program VHF 2 to the flight deck ADS panels HF knobs by setting ADS Programming and Display Panel thumbwheels for VHF–AM 2 to DIRECT ACCESS 15.
2. Assure that P66–2 circuit breaker VHF – AM2 is closed.
3. Rotate VHF ACCESS CONTROL – VHF 2 SELECT switch to FLIGHT DECK.

Flight Deck RCU Operation

Manual Frequency Setup

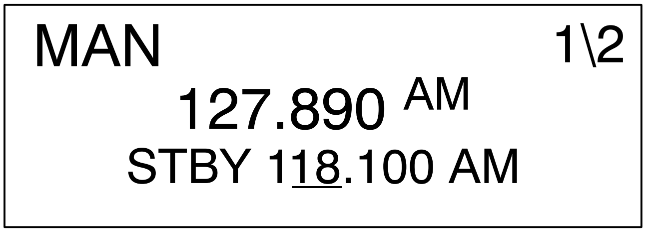
The following steps will be performed on both RCUs if both VHF 1 and 2 will be used by the flight crew.

1. RCU BRT/SQ OFF (PULL) Switch – Pushed In
2. RCU Operational Mode Selector – TR or TR+G

NOTE

> The RCU might momentarily display a searching for radio message. After 10 seconds, proceed to the next step. In the illustrations that follow, the 1 and 2 shown in the 1\2 designation are receiver–transmitter numbers. The pilot's RCU will show a 2 and the copilot's RCU will show a 1 on the screen.

3. Frequency Mode Selector – MAN
4. Set frequency mode selector to MAN (see the following).



MAN 1\2
127.890 AM
STBY 118.100 AM

The upper frequency displayed is the (active) receiver–transmitter frequency. The lower frequency is the previous (standby) frequency used. The LOAD/OFST pushbutton switches the frequencies from one display location to the other.

5. Use CHAN/FREQ CRSR (PUSH) switch to select an operating frequency.
    a. Push CHAN/FREQ CRSR (PUSH) switch to select the lower frequency display digit(s) to change.
    b. Rotate CHAN/FREQ CRSR (PUSH) switch to select desired digit(s).

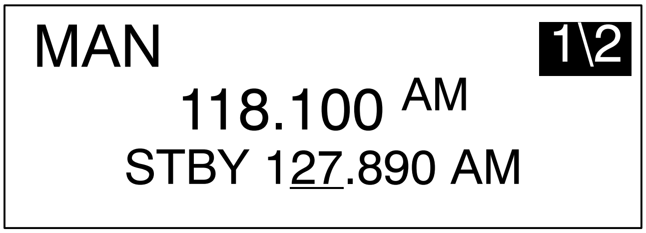
c. Repeat steps a and b as necessary, until desired frequency is displayed in the lower frequency display location.

6. Push LOAD/OFST pushbutton to set operating frequency.

NOTE

Flight deck RCUs allow tuning above 149.950 MHz, but operation is restricted by filters and antenna performance. Controls cannot be dialed in below 118.000 MHz.

7. Key radio to establish two–way communications with another station. Sidetone should be present in headset audio while transmitting. Radio keyed indication is when the 1\2 goes inverse video.



MAN 1\2

118.100 AM

STBY 127.890 AM

WARNING

Do not transmit on VHF–AM radio on ground unless personnel are a minimum of ten feet from radiating antennas.

8. To monitor guard channel, set operational mode selector to TR+G.

Loading Preset Channels

The receiver–transmitter can store up to 25 preset channel frequencies. Perform the following checks prior to loading the preset channels, if necessary:

1. Set frequency mode selector to PRST.
2. Set operational mode selector to TR.
3. Rotate CHAN/FREQ CRSR (PUSH) switch to obtain desired channel indication on CHAN FREQ/NET/TIME display.
4. Set operational mode selector to CHNG PRST.
5. Observe frequency indication on CHAN FREQ/NET/TIME display. To change frequency, refer to the following illustration and perform the following:

a. Alternately push, then release, CHAN/FREQ CRSR (PUSH) switch until cursor is under frequency digit(s) to be changed in lower frequency location.

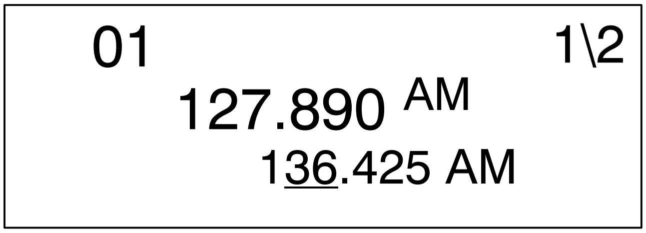
b. Rotate CHAN/FREQ CRSR (PUSH) switch to select digits(s) desired.

c. Repeat steps a and b, as necessary, until desired frequency is displayed.

d. Push LOAD/OFST pushbutton to select desired frequency.

NOTE

Flight deck RCUs allow tuning above 149.950 MHz, but operation is restricted by filters and antenna performance. Controls cannot be dialed in below 118.000 MHz.



01 1\2

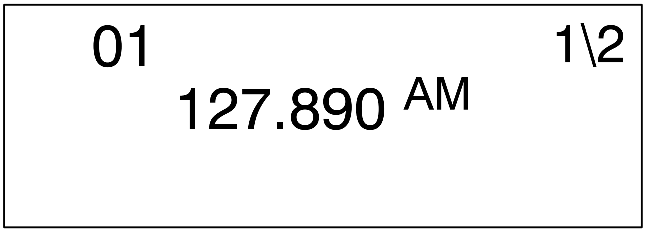
127.890 AM

136.425 AM

6. Repeat steps 2 through 5d, as necessary, until all channels have been loaded with the desired frequencies.
7. Rotate CHAN/FREQ CRSR (PUSH) switch to each channel, then observe CHAN FREQ/NET/TIME display. Desired frequency should be displayed for each channel.

Preset Channel Operation

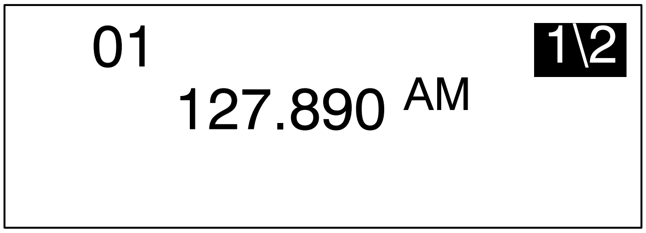
1. Set operational mode selector to TR or TR+G.
2. Set frequency mode selector to PRST.
3. Rotate CHAN/FREQ CRSR (PUSH) switch to obtain desired channel indication on CHAN FREQ/NET/TIME display (see the following for a typical screen).



01 1\2

127.890 AM

4. Key radio to establish two–way communications with another station. Sidetone should be present in headset audio while transmitting. Radio keyed indication is when the 1\2 goes inverse video, as shown in the following:


01 1\2
127.890 AM

WARNING

Do not transmit on VHF–AM radio on ground unless personnel are a minimum of ten feet from radiating antennas.

VHF Guard Receiver Operation

The VHF guard receiver (VHF 3) does not have the capability to transmit. This receiver is wired so as to be pretuned to the guard channel frequency of 121.500 MHz. Operate the VHF guard receiver as follows:

CAUTION

Set COMM – FWD switch on AVIONICS POWER DISCONNECT panel to DISC when cooling air is not available to rack E12 (forward forced air system not operating).

1. Rotate ADS panel VHF G knob clockwise.
2. Set VHF ACCESS CONTROL panel VHF GUARD switch to ON.
3. Set ADS panel VHF G and MASTER VOL knobs as required.

NOTE

MASTER VOL knob must be clockwise from off position to receive any audio output from ADS.

– – – To Test VHF Guard Receiver (Step 4) – – –

4. Set VHF ACCESS CONTROL panel VHF GUARD switch to TEST.

   Squelch is disabled allowing receiver noise to be heard. This indicates receiver is operating.

– – – To Receive On VHF Guard Receiver (Step 5) – – –

5. Set VHF ACCESS CONTROL panel VHF GUARD switch to ON.

– – – To Disable VHF Guard Receiver Audio Output (Step 6) – – –

6. Rotate ADS panel VHF G Knob fully counterclockwise.

– – – To Turn VHF Guard Receiver OFF (Step 7) – – –

7. Set VHF ACCESS CONTROL panel VHF GUARD switch to OFF.

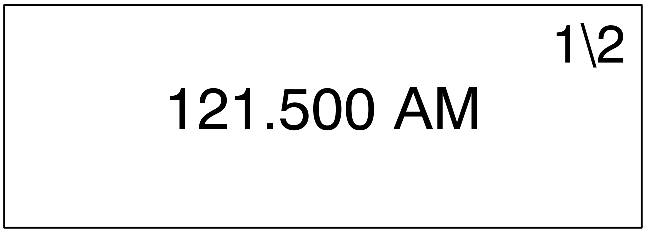
Emergency Guard Operation (RCU Control)

Use this procedure if guard radio transmit and receive capability is desired from the RCUs on the P13 panel.

1. Set operational mode selector to TR.
2. Pull and rotate frequency mode selector and set to 121 (PULL) to select the emergency (guard) channel. CHAN FREQ/NET/TIME display indicates 121.500 AM and the receiver–transmitter tunes to 121.500 MHz, as shown in the following screen. The receiver–transmitter is then ready to communicate on the selected frequency.

NOTE

All other RCU front panel control settings, except OFF, TEST, and BRT/SQ OFF (PULL), are disabled.


1\2
121.500 AM

Air Traffic Control (ATC) 8.33 KHz Channel Spacing

The International Civil Aviation Organization (ICAO) developed a channel naming scheme that is compliant with either 25 KHz channel spacing or 8.33 KHz channel spacing. The radio provides an 8.33 KHz channel spacing feature for operation under normal operational conditions.

The air traffic controller selects a channel name just as is done with 25 KHz channel spacing. The radio operator sets the channel on the RCU, if used. The receiver–transmitter receives the channel command from the RCU and performs all necessary conversions to translate from an ATC channel to an ATC frequency, with the appropriate receiver bandwidth. The operation is completely transparent to the RCU operator. A listing of ICAO channel names and corresponding frequency translation information is provided in *figure 1–186C*. The steps in the following checklist provide procedures for selection of channels with 8.33 KHz channel spacing.

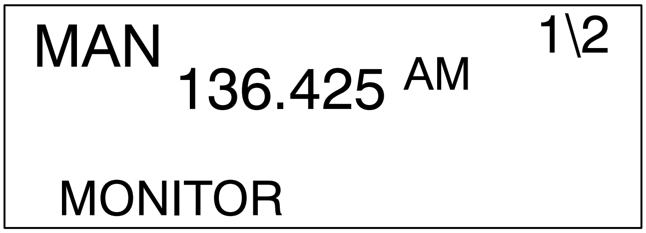
1. Set operational mode selector to TR or TR+G.
2. Set frequency mode selector to MAN or PRST.
3. Select desired channel name having 8.33 KHz bandwidth (refer to *figure 1–186C*, ICAO Channel Name and Frequency Translation).

Monitor Mode

Operation of either VHF 1 or 2 can be monitored from the corresponding pilot's RCU display screen while the radio is under the control of the communications operator. Perform the following steps:

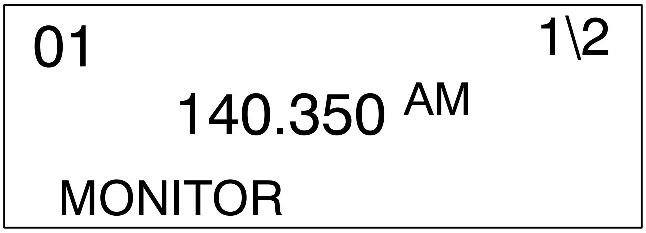
1. For VHF 2, set P73 VHF ACCESS CONTROL – VHF 2 SELECT switch to COMM CONSOLE.
2. For VHF 1, set all four flight deck ADS panel VHF knobs to zero volume detent and push down.

   The following screens illustrate a few of the possible RCU displays in monitor mode.



MAN 136.425 AM 1\2

MONITOR



01 1\2

140.350 AM

MONITOR

NOTE

- When VHF 2 SELECT switch is rotated from FLIGHT DECK to COMM CONSOLE, radio retains RCU–selected frequency until reset at P73. When VHF 2 SELECT switch is rotated from COMM CONSOLE to FLIGHT DECK, last RCU–selected frequency returns to radio. The same functionality also exists for VHF 1 when control is transferred.
- For mission crew to use VHF 1 without flight deck having the ability to seize control of the radio, accomplish the following: ensure all four flight deck ADS panel VHF knobs are full counter–clockwise and pushed down. On the ADS Programming and Display panel (P73) move the VHF–AM 1 thumbwheel to any setting except DIRECT ACCESS 27. Comm now has control of VH 1and the flight deck cannot take control intentionally or by accident. If VHF–AM 1 remains in DIRECT ACCESS 27, and the flight deck moves one of the ADS panel VHF knobs out of the OFF position, VHF 1 will be seized, and the prviously selected frequency (as set by the flight deck), will be tuned.

RCU Switch Test

An RCU switch test can be performed to verify that the RCU is operating within acceptable performance limits. Perform the following verifications prior to performance of the RCU switch test.

- Ensure that circuit breakers for the receiver–transmitter are closed.
- For VHF 2, ensure that VHF seize control switch is set for RCU operation of the radio.
- For VHF 1, ensure VHF knobs on all flight deck audio panels are in and full counterclockwise.
- For VHF 2, ensure RCU operational mode selector is set to OFF.
- Ensure RCU frequency mode selector is set to PRST.
- Ensure RCU BRT/SQ OFF (PULL) push–pull switch is pushed in.

1. Set operational mode selector to TR+G, then (without delay) simultaneously push the Menu Cursor and Menu Pointer pushbuttons for approximately two seconds. RCU displays a screen similar to that shown in the following illustration.

SWITCH TEST
RCU:XXX–XXXX–XXX
SQ ON\OFF CHAN FREQ[1]
MODE [2] FUNCTION [3]

The XXX–XXXX–XXX is the RCU software part number. The ON/OFF shown after SQ indicates the position of the BRT/SQ OFF (PULL) switch (in or out).

2. Set each RCU control shown in the following table as indicated. Verify associated CHAN FREQ/NET/TIME display indication is displayed in appropriate display field.

NOTE

Contact maintenance personnel if display indication is abnormal.

CONTROL SETTING	DISPLAY INDICATION
CHAN/FREQ CRSR (PUSH) pushed	CHANNEL KNOB
CHAN/FREQ CRSR (PUSH) rotated clockwise	CHANNEL UP
CHAN/FREQ CRSR (PUSH) rotated counterclockwise	CHANNEL DOWN
LOAD/OFST pushed	LOAD/OFST
Menu Cursor pushed	MENU CURSOR
Menu Pointer pushed	MENU POINTER
AJ/M (PULL)	AJ/M
AJ	AJ
MAR	MAR
PRST	PRST
MAN	MAN
243	243
121 (PULL)	121
CHNG PRST	CHNG PRST
ADF	ADF
TR	TR
TR+G	TR+G
TEST	TEST

Operational Performance Test

An operational performance test can be performed to verify that the radio is operating within acceptable performance limits. Perform the following verifications prior to performance of the operational performance test:

- Ensure P73 VHF 2 SELECT is set to FLIGHT DECK for VHF 2.
- Ensure at least one flight deck audio panel VHF knob is pulled out and rotated clockwise, for test of VHF 1.
- Ensure at least one flight deck audio panel HF knob is pulled out and rotated clockwise for test of VHF 2.
- Ensure RCU operational mode selector is set to OFF.
- Ensure RCU frequency mode selector is set to MAN.
- Ensure RCU BRT/SQ OFF (PULL) push–pull switch is pushed in.

1. Set operational mode selector to TR. RCU may momentarily display the screen shown. After 10 seconds, proceed to next step.

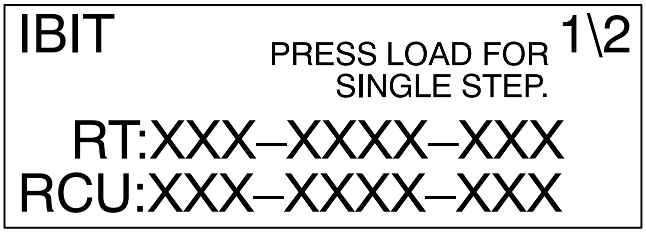
NOTE

Contact maintenance personnel if radio operation is abnormal during the performance of this checklist.

SEARCHING FOR RADIO R1\R2

R1\R2 indicates that either receiver–transmitter R1 (VHF1) or receiver–transmitter R2 (VHF2) is displayed in the message.

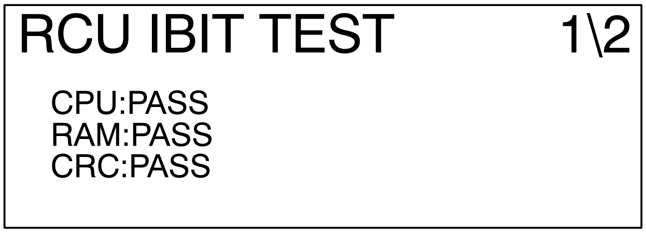
2. Set operational mode selector to TEST. RCU IBIT TEST, then IBIT IN PROGRESS, is displayed while operator–initiated BIT (IBIT) is in progress. IBIT isolates system faults. The following screens should appear:



IBIT 1\2

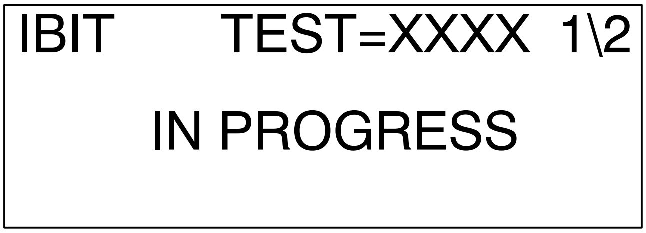
PRESS LOAD FOR
SINGLE STEP.

RT:XXX–XXXX–XXX
RCU:XXX–XXXX–XXX



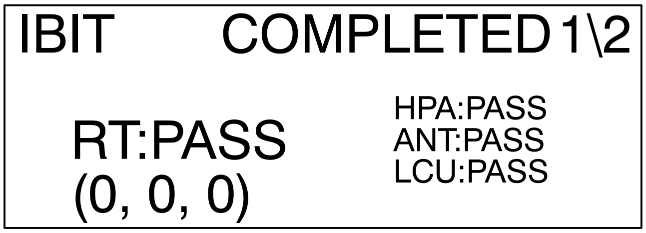
RCU IBIT TEST 1\2

CPU:PASS
RAM:PASS
CRC:PASS



IBIT TEST=XXXX 1\2

IN PROGRESS



IBIT COMPLETED 1\2

RT:PASS
(0, 0, 0)

HPA:PASS
ANT:PASS
LCU:PASS

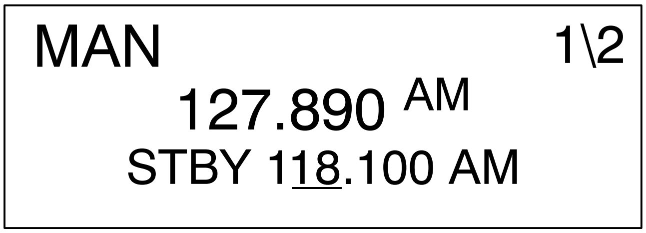
3. Set operational mode selector to TR.

4. Use CHAN/FREQ CRSR (PUSH) switch to tune receiver–transmitter to 118.100 MHz.

   a. Push CHAN/FREQ CRSR (PUSH) switch to select the lower frequency display digit(s) to change.

   b. Rotate CHAN/FREQ CRSR (PUSH) switch to select desired digit(s).

   c. Repeat steps a and b, as necessary, until desired frequency is displayed in the lower frequency display location.



MAN 1\2

127.890 AM

STBY 118.100 AM

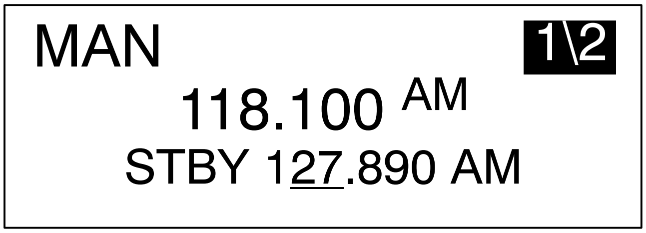
5. Push LOAD/OFST switch to tune radio to 118.100 MHz. The upper frequency display location displays 118.100 AM.

6. Operate CHAN/FREQ CRSR (PUSH) and LOAD/OFST switches to obtain frequency indications in the range of 118.000 through 149.950 MHz.

NOTE

Selection of frequencies outside the allowable ranges is unauthorized and results in automatic rejection of the selection as indicated by INVALID being momentarily displayed when LOAD/OFST is pushed. The receiver–transmitter remains tuned to the last valid frequency displayed before entering of the invalid frequency.

7. Key the transmitter to establish two–way communications with another station. Undistorted audio should be heard in the headset. Sidetone audio should be heard when transmitting. The push–to–talk (PTT) indicator is displayed while transmitting, as shown in the following screen.



MAN 1\2

118.100 AM

STBY 127.890 AM

WARNING

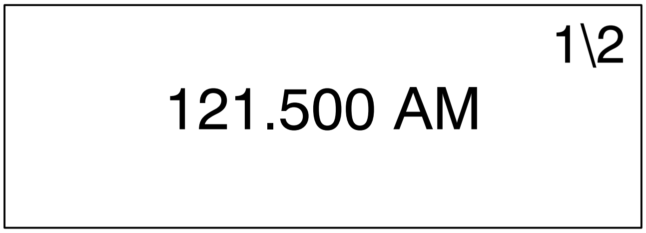
Do not transmit on VHF–AM radio on ground unless personnel are a minimum of ten feet from radiating antennas.

8. Set operational mode selector to TR+G.

9. Request that another station transmit on guard frequency of the selected operating band. Guard receiver audio should be heard clearly through the headset. Monitor guard audio while switching the operational mode selector to TR. Guard audio should no longer be heard.

10. If transmitting on guard is desired, set frequency mode selector to 121 (PULL). CHAN FREQ/NET/TIME display indicates 121.500 AM.

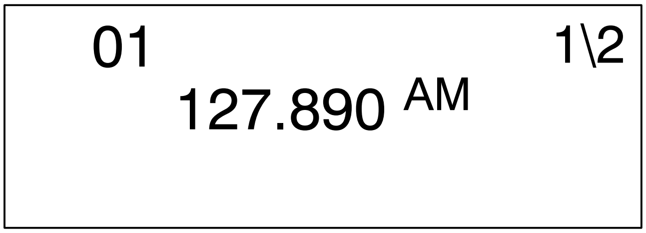
Front panel control settings, except TEST and BRT/SQ OFF (PULL), should be disabled.



```
1\2
121.500 AM
```

11. Set frequency mode selector to PRST.

12. Rotate CHAN/FREQ CRSR (PUSH) switch to obtain channel 1 indication on CHAN FREQ/NET/TIME display (see the following for a typical screen). CHAN FREQ/NET/TIME display shows correct preset frequency for channel 1 (refer to Loading Preset Channels procedure, if required).



```
01                1\2
127.890 AM
```

13. Rotate CHAN/FREQ CRSR (PUSH) switch clockwise for progressive channel indications of channels 2 through 25. The correct preset frequency should be displayed for each channel selected.

14. Set frequency mode selector to MAN.

15. Set operational mode selector to TR, then tune receiver–transmitter to an unused channel.

16. Monitor headset audio, then pull BRT/SQ OFF (PULL) switch out to disable squelch. Noise is heard in headset. Push BRT/SQ OFF (PULL) switch in. Noise stops.

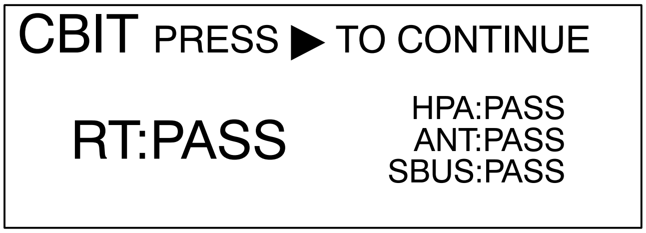
17. Reset frequency mode and frequency as desired.

CBIT Status

Continuous built–in test (CBIT) runs automatically while the radio is operating. CBIT status indications can be viewed by the operator to verify that the system is operating within acceptable performance limits or to view fault indications. Perform the following verifications prior to checking the CBIT status indications of the radio, if necessary:

- Ensure that VHF seize control switch is set for RCU operation of the radio.
- Ensure RCU BRT/SQ OFF (PULL) push–pull switch is pushed in.
- Ensure that the radio is in an operational mode.

1. Push Menu Pointer pushbutton to access the CBIT status indication. See the following for a typical screen.



```
CBIT PRESS ▶ TO CONTINUE
                   HPA:PASS
RT:PASS            ANT:PASS
                   SBUS:PASS
```

2. Follow instructions displayed on each CBIT screen to view CBIT status indications. ◀

HF Communications

The flight crew HF communications consist of an HF transmitter and HF receiver that are combined to form a single radio set. This radio set is used for long range air-to-air and air-to-ground communication.

HF Radio Set

The HF radio set operates within the 2.0-MHz to 30 MHz frequency range at 0.1 KHz increments. It is capable of operating at either 100, 200 or 400 watts. Control of this radio, like the VHF transceiver, is shared with the mission crew, with the flight crew capable of taking control of the radio set (if programmed) at any time. When controlled by the flight crew, the HF radio only operates in the upper side band. (AM reception and transmission receivable by AM stations are available.)

HF Control Panel

The HF control panel is located in the navigator's upper panel (*figure 1-14*). *Figure 1-187* identifies and describes the panel controls and indicators.

NOTE

Do not transmit on time or frequency standard broadcasting frequencies.

HF Radio Operation

System Initialization

WARNING

- HF radio subsystem contains a radio frequency power amplifier/power supply (PA/PS). When operated into an antenna, power amplifier can produce electromagnetic fields near antenna that exceed maximum limits. Direct contact with antenna can produce severe RF burns.
- Do not transmit on HF radio on the ground if ground personnel can touch exterior of airplane or are using headsets connected to airplane. Transmission causes electrical voltages on exterior of airplane which are not dangerous, but could shock personnel causing sudden movement, thus causing injury.
- To prevent possible ignition of fuel vapor, do not transmit on HF within 200 feet of equipment being refueled or defueled.
- Do not transmit HF radio on the ground unless personnel are a minimum of ten feet from radiating antenna.
- In Automatic Link Establishment (ALE) mode, HF radio subsystem sounds (transmits short tone bursts) and replies to ALE calls automatically without operator action. Any time local flight directives forbid HF emissions, such as during ordnance loading or refueling, or when personnel are working near airplane, ensure radio set control function switch is set to STBY. Failure to comply can cause ignition of ordnance or fuel, with consequent injury to personnel and damage to equipment.

CAUTION

Do not close HF radio circuit breakers unless cooling air is available. Applying power to HF sets without cooling damages receiver/transmitter.

1. Check each 115 VAC 10 AMP and +28 VDC 5 AMP circuit breaker (exterior) is closed.
2. Ensure cabinet door is secured and (E13 during preflight) cooling air is applied to cabinet.
3. When cooling air is available, apply power to HF radios via AVIONICS POWER DISCONNECT COMM FWD switch and COMM DISCONNECT PANEL switch 4.
4. On auxiliary control, rotate HF SELECT switch to select desired radio, then lift ENTER switch momentarily.
5. See *figure 1-188*. Set function switch to STBY. SYSTEM – – – – – – – is displayed while power-on BIT (P-BIT) is in process. If communications cannot be established between receiver-transmitter and radio set control, SYSTEM-NO GO COMM FAIL is displayed. If SYSTEM-NO GO COMM FAIL is not displayed, proceed to step 6.
6. Top-level standby screen displays SYSTEM-GO or SYSTEM-NO GO after P-BIT. If SYSTEM-GO is displayed, proceed to step 7. If SYSTEM-NO GO is displayed, it is not usable until repaired.
7. Press FILL line select switch. Display indicates fill status of operational modes.

NOTE

ALE mode is inoperative until a self address is selected. Self address is selected in SETUP OPTIONS.

8. Press RTN line select switch to return to standby screen.

NOTE

If an inoperative mode is displayed, a decision must be made to call maintenance personnel immediately or to continue operation with limited capability. For example, if ALE operation is not required and radio set control is reporting ALE inoperative, operation can continue in manual or preset modes.

Setup Options

See *figure 1-189*. To set up HF radio subsystem options, perform the following procedure.

1. After power up is complete, press SETUP line select switch. SETUP 1/2 (setup page 1 of 2) is displayed at top of SETUP screen.

2. Use down or up CURSOR switch to view page 2 of SETUP screen pages. Entire screen scrolls to page 2 when cursor is moved past first or last field on screen. Entire screen scrolls back to page 1 when cursor is moved up past first field on screen or down past last field on screen. Setup parameters are described in step 3.

3. Use CURSOR switches to position cursor under character(s) to be edited. Use VALUE switches to edit characters as required.

   a. SELF: – Displays own ALE self address and allows selection of a self address. Self address is normally assigned by network manager and included in datafill file.

   b. hh:mm:ss (hours : minutes : seconds) – Displays current system time. Clock starts running after exiting time and date edit fields or pressing RTN.

   c. dd MMM yy (day – month – year) – Displays current date. Clock starts running after exiting time and date edit fields or pressing RTN.

   d. PWR: – Selects transmitter output power and can be set to HI (400 W), MED (200 W), or LOW (100 W). Default setting is HI. Power level can also be changed during normal operation using EDIT line select switch in each operational mode (function switch set to SILENT or T/R).

   e. SOUND: – Used to turn sounding on or off. Default setting is OFF.

   f. SND INTRVL: – Used to override channel record automatic sounding intervals loaded in an ALE datafill. When this parameter has a value of 0, channel record sounding intervals are used. When this parameter has a nonzero value, that value is used as sounding interval for all channels. Range of values for this setting is 0 to 180 minutes. Zero is default value.

   g. LBT: (listen before talk) – Used for manual or preset operation and turns listen-before-talk function ON or OFF. When enabled, transmissions are inhibited if modem signals are detected. Default setting is OFF.

   h. LBC: (listen before call) – Used for ALE operation and turns listen-before-call function ON or OFF. When turned OFF, transmission is accomplished without any regard to traffic. This can cause HF radio subsystem to transmit on top of other signals that may be on frequency, causing interference to other stations. Default setting is OFF. Set to ON.

   i. ALERT TONES: – When set to ON, enables alert tone to notify operator an advisory is displayed on screen. When set to OFF, disables alert tone. Default setting is ON.

4. Press RTN line select when setup edit is complete to save all edited data and return to top-level standby screen.

Manual Mode

Operations that can be performed in manual mode include configuration editing and manual radio operation.

Configuration Editing. See *figure 1-190*. This figure and the related procedures describe how to edit the equipment operation configuration during manual mode.

To edit equipment operating configuration (select a different title, frequency, emission mode, power level, or audio mode) for the selected channel, perform the following procedure.

1. Set mode selector switch to MAN.

2. Set function switch to T/R.

3. Set channel/net selector switch to desired channel (1 through 6) or select + and use VALUE switches to select channels 7 through 20.

NOTE

Screen displays CHANNEL INOP if a selected channel contains no data, corrupted data, or hardware cannot support this mode.

4. Press EDIT line select switch.

5. Use CURSOR switches to position cursor under character position or data field to be edited. Editable fields include title, receive frequency and emission mode, transmit frequency and emission mode, submode (SMODE), audio mode, and power level.

6. Use VALUE switches to change character or data field to desired value.

7. Repeat steps 3 through 6 as necessary. Press RTN.

8. To erase all preprogrammed information, including datafill data, pull and turn function switch to ZERO (PULL). ZEROIZED advisory is displayed until switch is returned to R/T or SILENT. Manual mode data defaults to default database.

Manual Radio Operation. To operate in manual mode, perform the following procedure.

1. Set function switch to T/R.

2. Set mode selector switch to MAN. Screen displays manual mode title followed by selected channel number, RCV frequency, and emission mode.

3. Set squelch.

4. Set channel/net selector switch to desired channel (1 through 6) or select + and use VALUE switches to select channels 7 through 20.

NOTE

Screen displays CHANNEL INOP if a selected channel contains no data, corrupted data, or hardware cannot support this mode.

5. Press microphone PTT switch. Observe EDIT disappears from screen and XMT frequency and mode are displayed while PTT switch is pressed. If a tone is heard, wait until tone stops, then begin communication.

Preset Operation

To operate in preset mode, see *figure 1-191* while performing following procedure.

1. Set function switch to T/R.

2. Set mode selector switch to PRE. Screen displays preset mode title followed by selected preset channel number, RCV frequency, and emission mode.

3. Set squelch.

4. Set channel/net selector switch to desired preset channel (1 through 6) or select + and use VALUE switches to select channels 7 through 20.

NOTE

Screen displays CHANNEL INOP if a selected channel contains no data, corrupted data, or hardware cannot support this mode.

5. To edit name of preset channel in line 1 of display, change SMODE, select a different power level, or change audio mode, press EDIT line select switch.

6. Use CURSOR switches to position cursor under character position or data field to be edited.

7. Use VALUE switches to change character or data field to desired value.

8. After edit is complete, press RTN line select switch.

9. Press microphone PTT switch. If a tune tone is heard, wait until tone stops, then begin communication. When microphone PTT switch is pressed, XMT frequency is displayed.

10. To erase all preprogrammed information, including datafill data, pull and turn function switch to ZERO (PULL). ZEROIZED advisory is displayed until switch is returned to T/R or SILENT. Zeroizing results in loading of a default mission database. If default mission database contains an operable set of data, CHANNEL INOP advisory is not displayed.

Pages 1–865 and 1–866 deleted.

MISSION CREW COMMUNICATIONS

For detailed information on mission crew communications equipment, refer to T.O. 1E-3A-43-1-1.

FLIGHT WITHOUT MISSION CREW

Communications Console

The communications console (*figure 1-180*) controls mission crew communication equipment and selects which radios are available to the flight crew. Normally, this console is controlled by the airborne communications operator and the communications technician. When a mission crew is not onboard, the ADS programming and display panel (*figure 1-180*) must be powered and programmed in order to use flight crew radios and interphones. The following procedures are performed at the airborne communications operator's station, at the communication console, next to the aisle.

ADS Programming and Display Panel Preparation

1. COMM DISCONNECT Panel Switch 1 – ON

CAUTION

To avoid equipment damage due to overheating, see *figure 1-54* to determine cooling air required for non-ADS equipment affected by COMM DISCONNECT switchlight 1. Apply cooling air or open circuit breakers to non-ADS equipment, as required, before proceeding. Then, if the COOLING ALERT – FAULT and switchlight CAUTION lamp segment on COMM DISCONNECT panel illuminates, press COOLING ALERT switchlight and verify that OVRD lamp segment illuminates. Switchlight CAUTION lamp segment will remain illuminated indicating that those circuits are powered without one or more required cooling air systems.

2. Close EMERGENCY COMMUNICATIONS circuit breakers (8) (P5).
3. Set ADS PROGRAMMING AND DISPLAY panel POWER switch to ON.

   When power is applied to the ADS, an automatic test starts. If a fault is detected, an audible signal is heard in the operator's headset and the FAILURE LOCATION indicators show the number of the failed unit. To continue the test, press the CONTINUE TEST pushbutton. The test cycle continues unless another fault is detected. To bypass a failed unit, open the test panel door, set the failed unit switch to NO TEST, close the door, and press the CONTINUE TEST pushbutton.

4. Set FLIGHT DECK HF thumbwheels to 26.
5. Set FLIGHT DECK VHF thumbwheels to 27.
6. Set FLIGHT DECK UHF thumbwheels to 30.
7. Set FLIGHT DECK MISSION INTERCOM thumbwheels (4 places) as required.
8. Set COMM OPR/COMM TECH MISSION INTERCOM 1 switch to ON (up).

UHF Guard Transceiver or UHF-ADF Receiver Tuning

These radios must be tuned at the communications console (*figures 1-120* and *1-180*. To tune the UHF guard transceiver or UHF-ADF receiver, perform the following steps:

NOTE

Either the UHF guard transceiver or the UHF-ADF receiver should be tuned to guard (243.0 MHz) channel. One of these radios may be tuned to another frequency as long as guard channel is monitored and guard channel transmitting capability is available (243.0 on UHF transceiver preset tuning).

1. For UHF guard only, set Avionics Power Disconnect Switch COMM FWD – NORM

CAUTION

Do not set Avionics Power Switch COMM FWD to NORM unless forward forced air system is operating.

2. For UHF-ADF Guard only, set Avionics Power Disconnect Switch COMM AFT – NORM.

CAUTION

Do not set Avionics Power Disconnect Switch to NORM unless aft forced air system is operating.

3. Close EMERGENCY COMMUNICATIONS circuit breakers (8) (P5).
4. COMM DISCONNECT Panel Switch No 1 – ON.

CAUTION

To avoid equipment damage due to overheating, see *figure 1-54* to determine cooling air required for equipment affected by COMM DISCONNECT switchlight 1. Apply cooling air or open circuit breakers to unused equipment, as required, before proceeding. Then, if the COOLING ALERT – FAULT and switchlight CAUTION lamp segment on COMM DISCONNECT panel illuminates, press COOLING ALERT switchlight and verify that OVRD lamp segment illuminates. Switchlight CAUTION lamp segment will remain illuminated, indicating that systems are powered without one or more required cooling air systems.

NOTE

Steps 5 through 9 are performed at the communications console radio operator position.

5. Set UHF communications control panel frequency selector knobs as required.

   Set to desired frequency.
6. Set ADDRESS MAIN selector to 12 (Guard Transceiver) or 13 (UHF-ADF).
7. Set ADDRESS SUB selector to 0 (zero).
8. Set MODE selector to AM or ADF.
9. Press ENTER pushbutton.
10. Press INTERROGATE button, verify that desired frequency did not load or radio is not powered. Check circuit breakers.

Alternate UHF Transceiver Operation

If the assigned flight deck UHF transceiver fails, an alternate UHF transceiver can be assigned to the flight deck. This alternate radio must be tuned at the communications console (*figures 1-120* and *1-180*).

1. Close EMERGENCY COMMUNICATIONS ADS circuit breakers (4) (P5).
2. COMM DISCONNECT Panel Switch 1 and 4 – ON.

CAUTION

To avoid equipment damage due to overheating, see *figure 1-54* to determine cooling air required for equipment affected by COMM DISCONNECT switchlight 1 and 4. Apply cooling air or open circuit breakers to unused equipment, as required, before proceeding. Then, if the COOLING ALERT – FAULT and switchlight CAUTION lamp segment on COMM DISCONNECT panel illuminates, press COOLING ALERT switchlight and verify that OVRD lamp segment illuminates. Switchlight CAUTION lamp segment will remain illuminated indicating that systems are powered without one or more required cooling air systems.

3. Set UHF COMMUNICATIONS radio control panel at position 7 of communications console ADDRESS MAIN selector to 08.
4. Set ADDRESS SUB selector to zero (0).
5. Set MODE selector to AM.
6. Set frequency selector to desired frequency.

7. Press ENTER pushbutton. Verify MALF warning light does not illuminate continuously.

8. Press INTERROGATE pushbutton. Verify desired frequency is displayed in FREQUENCY window and desired mode indicator illuminates.

9. Set ADS PROGRAMMING AND DISPLAY panel FLIGHT DECK UHF thumbwheels to 22.

10. To receive audio signal in flight deck, turn flight deck ADS panel UHF knob and MASTER VOL knobs to desired level.

11. To transmit on UHF from flight deck, pull up ADS panel UHF knob. Transmitter is now enabled on frequency tuned at communications console.

Alternate UHF – Guard Reception

During ground operation and in flight when the forward forced air system is not operating, the UHF-ADF is tuned to 243.000/MHz and monitored to provide guard reception. Three alternate procedures are provided, two of which may be used on the ground or in flight, and once in flight only.

To use either UHF receiver R2 or R4 (refer to T.O. 1E-3A-43-1-1) for guard reception:

1. Press Switchlight 1 and 3 on COMM DISCONNECT panel and verify that ON lamp is illuminated.

CAUTION

To avoid equipment damage due to overheating, see *figure 1-54* to determine cooling air required for equipment affected by COMM DISCONNECT switchlight 1 and 3. Apply cooling air or open circuit breakers to unused equipment, as required, before proceeding. Then, if COOLING ALERT – FAULT and switchlights 1 and/or 3 CAUTION lamp segments on COMM DISCONNECT panel illuminate, press COOLING ALERT switchlight and verify that OVRD lamp segment illuminates. Switchlight CAUTION lamp segment(s) will remain illuminated indicating that those systems are powered without one or more cooling air systems.

2. Press switchlights 1, 4 and 5 on COMM DISCONNECT panel and verify that ON lamp segments illuminate.

CAUTION

To avoid equipment damage due to overheating, see *figure 1-54* to determine cooling air required for equipment affected by COMM DISCONNECT switchlights 1, 4 and 5. Apply cooling air or open circuit breakers to unused equipment, as required, before proceeding. Then, if COOLING ALERT – FAULT and switchlights 1, 4 and/or 5 CAUTION lamp segments on COMM DISCONNECT panel illuminate, press COOLING ALERT switchlight and verify that OVRD lamp segment illuminates. Switchlight CAUTION lamp segment(s) will remain illuminated indicating that those systems are powered without one or more required cooling air systems.

3. Tune UHF R2 (or R4) to 243.000 MHz as described under ALTERNATE UHF TRANSCEIVER OPERATION (set ADDRESS MAIN to 02 for R2 or 04 for R4 in step 6). Set ADDRESS SUB to zero.

4. Set R2 (or R4) thumbwheels on BDP to 01.

5. Set R2 (or R4) ACTV DISC switch on BDP to ACTV.

6. Set FLT DECK HF thumbwheels on communications console to 16 for R2 or R4.

   Flight crew can now use R2 (or R4) by operating flight deck HF knob. (No flight deck HF reception/transmission is possible.)

   The two remaining options are: to use the flight deck UHF for guard (prevents UHF use for other communications), or to use VHF guard (notify tower/ATC that you have no UHF guard reception).

CAUTION

Allowable operation time for VHF guard radio without cooling air in a warm cabin has not been determined. Use VHF guard only when cabin cooling is available.

LESS IDG VHF-AM 2 Transceiver Tuning

If VHF-AM 1, the normal flight deck VHF-AM transceiver fails, VHF 2 may be assigned to the flight deck. However, all tuning of VHF 2 must be accomplished at the communications console.

1. Close EMERGENCY COMMUNICATIONS ADS circuit breakers (4) (P5).
2. Press switchlights 1, 4 and 5 on COMM DISCONNECT panel and verify that ON lamp segments illuminated.

CAUTION

To avoid equipment damage due to overheating, see *figure 1-54* to determine cooling air required for equipment affected by COMM DISCONNECT switchlights 1, 4, and 5. Apply cooling air or open circuit breakers to unused equipment, as required, before proceeding. Then, if COOLING ALERT – FAULT and switchlights 1, 4 and 5 CAUTION lamp segments on COMM DISCONNECT panel illuminates, press COOLING ALERT switchlights and verify that OVRD lamp segment illuminates. Switchlight CAUTION lamp segment(s) will remain illuminated indicating that those systems are powered without one or more required cooling air systems.

NOTE

Steps 3 through 12 are performed at communications console and baseband distribution panel.

3. Close AC POWER and DC POWER circuit breakers on HF/VHF BASEBAND DISTRIBUTION PANEL.
4. Set HF/VHF BASEBAND DISTRIBUTION panel VHF AM2 ACTVT/DISC switch to DISC.
5. Set VHF AM2 FUNCTION SELECT thumbwheel to 9.
6. Set VHF AM2 ACTVT/DISC switch to ACTVT.
7. Set communications console ADS PROGRAMMING AND DISPLAY panel FLIGHT DECK VHF thumbwheels to 15.
8. Set COMM OPR/COMM TECH DIRECT ACCESS A thumbwheels to 15.
9. Pull MISSION ADS PANEL DIRECT ACCESS A control knob out and adjust volume.
10. Set VHF-AM mission radio control panel VHF-AM 1 MODE selector to ON.

NOTE

This allows VHF guard radio to remain on if flight deck VHF control panel is turned off. VHF guard can be monitored.

11. Set VHF-2 MODE selector to ON.
12. Set VHF-2 frequency control knobs to desired frequency.
13. Verify VHF-AM 2 operation at communications console by transmitting and receiving.

NOTE

The following procedures apply to operation of VHF-2 from the flight deck.

– – – To Operate VHF-2 From the Flight Deck (Steps 14 and 15) – – –

14. Pull ADS panel VHF knob out.
15. Adjust volume using VHF and MASTER VOL knobs.

VHF-2 is fully operable on frequency set up at communications console.◀

WITH IDG VHF-AM 2 Transceiver Tuning

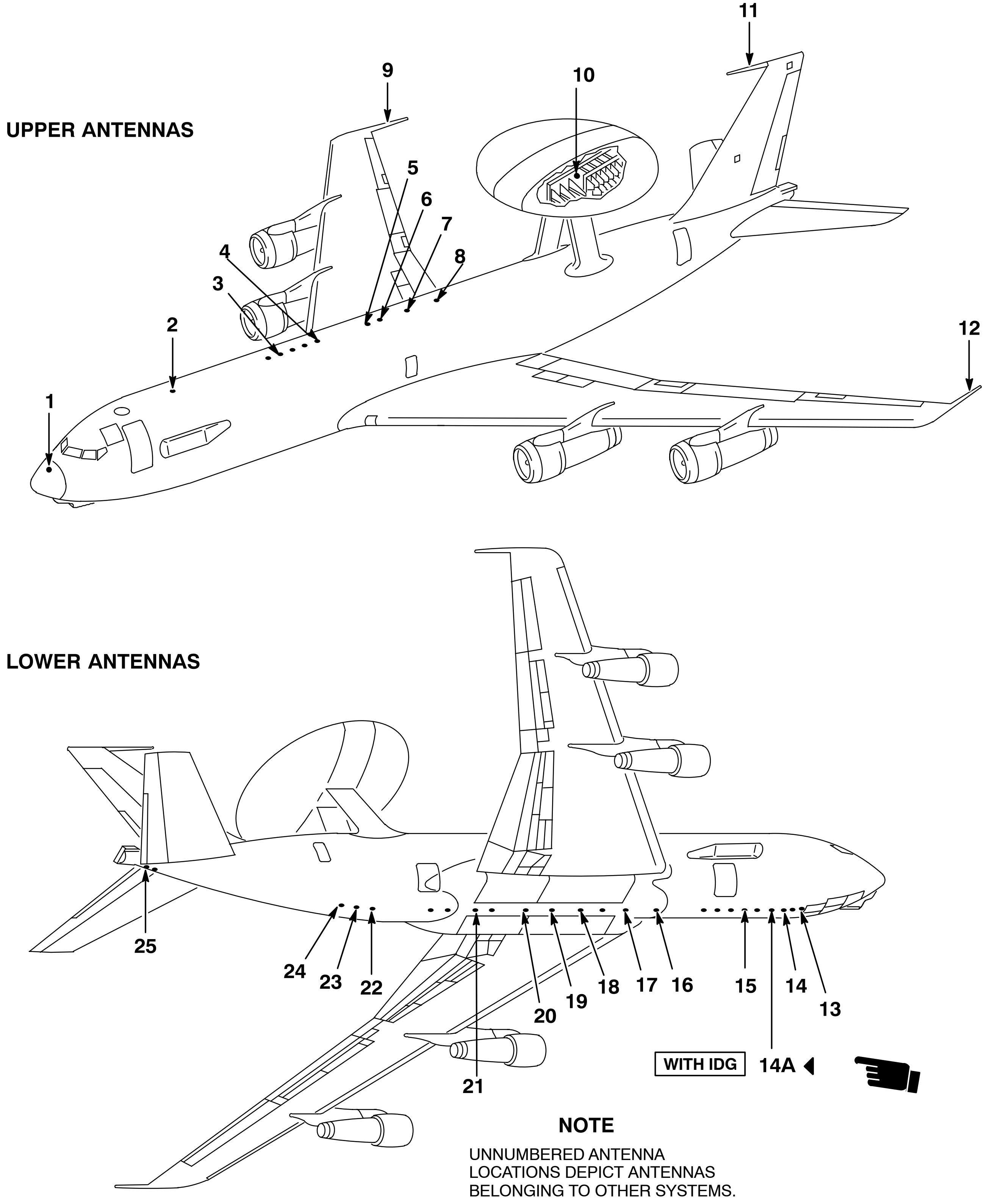
Refer to VHF Transceiver operating procedures, this subsection.◀

COMMUNICATION SYSTEMS ELECTRIC POWER SOURCES

Electric power sources for the communications equipment are listed in *figure 1-192*.

Pages 1–871 and 1–872 deleted.

Communications Equipment Locations



NOTE

UNNUMBERED ANTENNA LOCATIONS DEPICT ANTENNAS BELONGING TO OTHER SYSTEMS.

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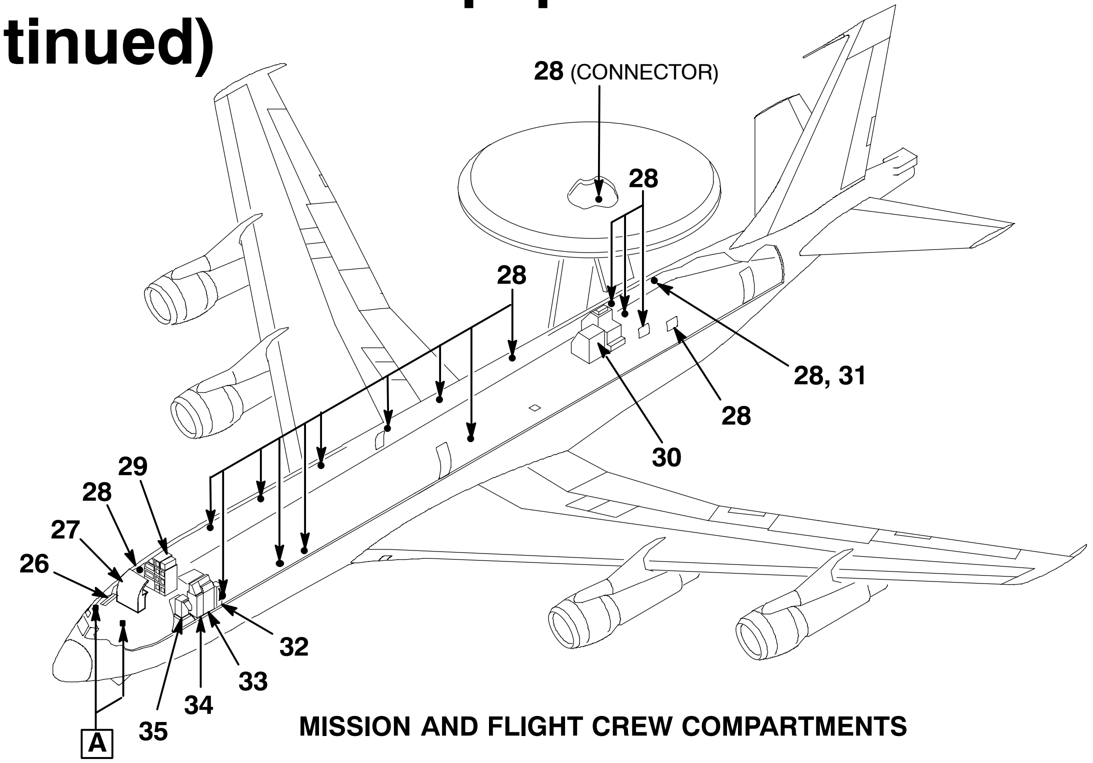
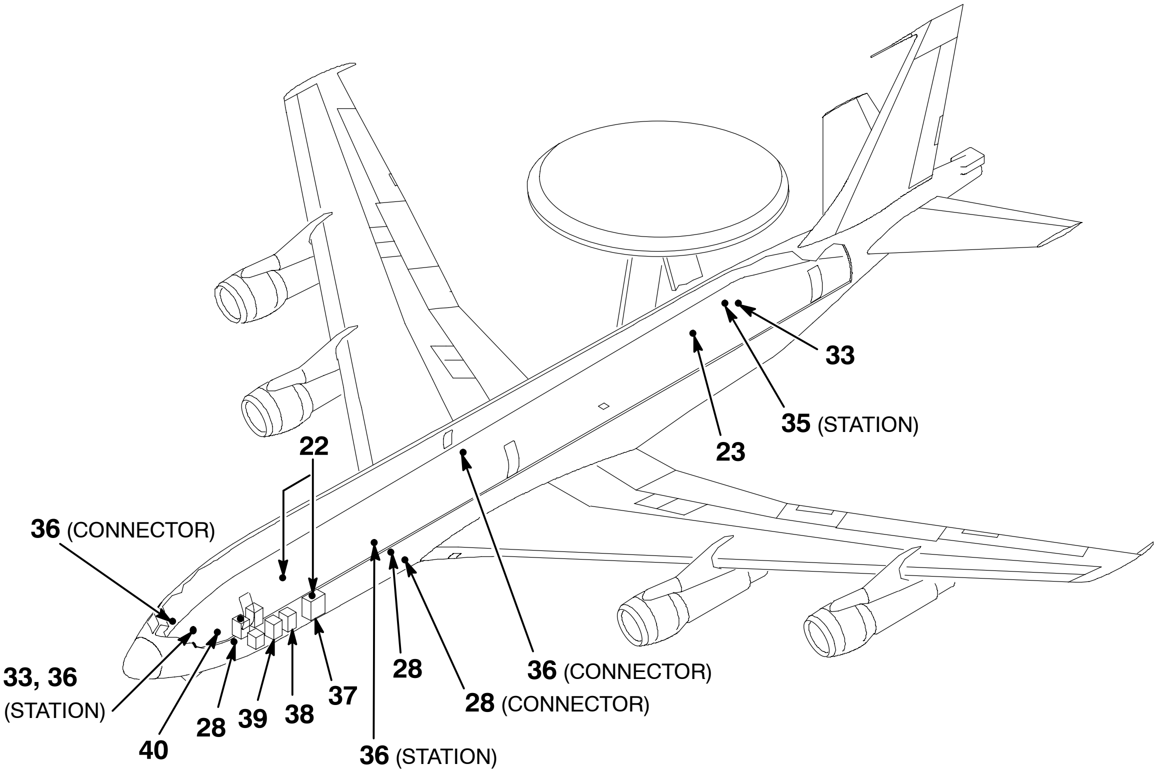
Figure 1-180 (Sheet 1 of 9)

Communications Equipment Locations (Continued)



MISSION AND FLIGHT CREW COMPARTMENTS



FORWARD AND AFT LOWER COMPARTMENTS

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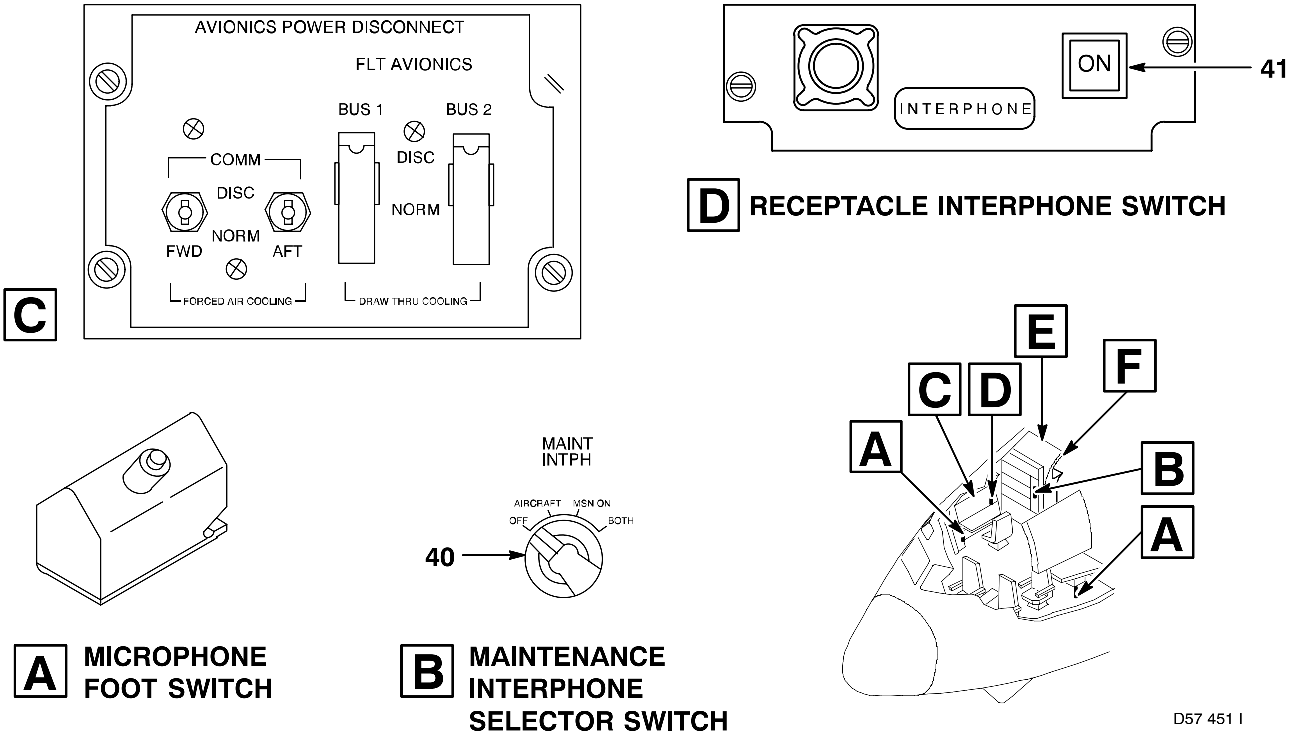
Figure 1-180 (Sheet 2 of 9)



NO.	ITEM	TYPE
1	JTIDS ANTENNA, NOSE	RECTANGULAR HORN
2	UHF HIGH POWER TRANSMIT ANTENNA	BLADE
3	UHF LOW POWER TRANSMIT ANTENNA	BLADE
4	UHF SATCOM/LOS TRANSMIT/RECEIVE ANTENNA	SATCOM/LOS
5	FLIGHT CREW VHF AM TRANSMIT/RECEIVE ANTENNA	BLADE
6	UHF SATCOM/LOS TRANSMIT/RECEIVE ANTENNA	SATCOM/LOS
7	UHF RECEIVE ANTENNA	BLADE
8	**WITH AP** BI RECEIVE ANTENNA ◀	SATCOM/LOS
9	HF TRANSMIT/RECEIVE ANTENNA	PROBE
10	UHF TRANSMIT TADIL C DIRECTIONAL ANTENNA	LOG PERIODIC
11	FLIGHT CREW HF TRANSMIT/RECEIVE ANTENNA	PROBE

Figure1-180 (Sheet 3 of 9)

Communications Equipment Locations (Continued)

NO.	ITEM	TYPE
12	HF HIGH POWER TRANSMIT/RECEIVE ANTENNA	PROBE
13	**LESS IDG** UHF HIGH POWER TRANSMIT ANTENNA **WITH IDG** TCAS LOWER	BLADE ◀ PLANAR ARRAY ◀
14	**LESS IDG** FLIGHT CREW UHF LOW POWER TRANSMIT ANTENNA **WITH IDG** UHF HIGH POWER TRANSMIT ANTENNA	BLADE ◀ BLADE ◀
14A	**LESS IDG** IFF **WITH IDG** UHF LOW POWER TRANSMIT ANTENNA/IFF	BLADE ◀ BLADE ◀
15	UHF LOW POWER TRANSMIT ANTENNA	BLADE
16	FLIGHT CREW UHF GUARD TRANSMIT ANTENNA	BLADE
17	VHF-FM TRANSMIT/RECEIVE ANTENNA	BLADE
18	VHF-AM TRANSMIT/RECEIVE ANTENNA	BLADE
19	UHF ADF ANTENNA	FLUSH MOUNTED LOOP
20	VHF-AM GUARD RECEIVE ANTENNA	BLADE
21	UHF RECEIVE ANTENNA	BLADE
22	FLIGHT CREW UHF GUARD RECEIVE ANTENNA	BLADE
23	UHF RECEIVE ANTENNA	BLADE
24	FLIGHT CREW UHF RECEIVE ANTENNA	BLADE
25	JTIDS ANTENNA	RECTANGULAR HORN
26	AIR REFUELING RECEPTACLE INTERPHONE	
27	COMMUNICATIONS CONSOLE	
28	MISSION MAINTENANCE INTERCOM STATION (19)	
29	RACK E19 (BASEBAND DISTRIBUTION SYSTEM, TADIL-A, HF, AND UHF EQUIPMENT)	
30	RACK E13 (UHF AND HF COMMUNICATIONS EQUIPMENT)	

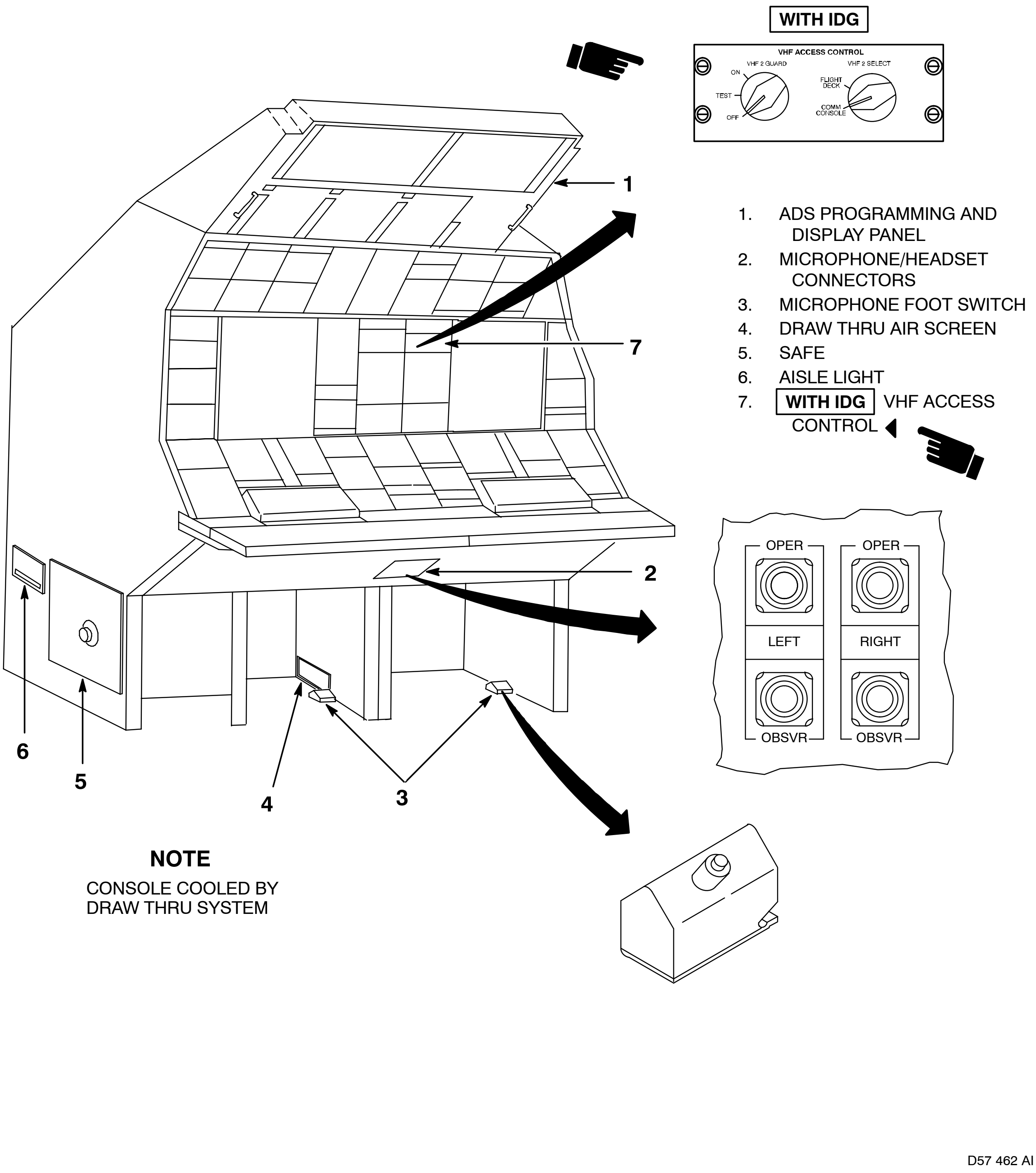
Figure 1-180 (Sheet 4 of 9)

NO.	ITEM	TYPE
31	REST AREA HANDSET ASSEMBLY	
32	RACK E12 (VHF-AM COMMUNICATIONS EQUIPMENT)	
33	RACK E11 (ADS AND VHF-AM BANDPASS FILTERS)	
34	RACK E10 (CRYPTOGRAPHIC EQUIPMENT)	
35	RACK E8 (HF COMMUNICATIONS EQUIPMENT)	
36	AIRPLANE MAINTENANCE INTERCOM STATION WITH REMOTE EXTERNAL CONNECTOR (3)	
37	RACK E4 (UHF COMMUNICATIONS EQUIPMENT)	
38	RACK E3 (UHF COMMUNICATIONS EQUIPMENT)	
39	RACK E2 (UHF COMMUNICATIONS EQUIPMENT)	
40	MAINTENANCE INTERPHONE SELECTOR SWITCH	
41	AIR REFUELING RECEPTACLE INTERPHONE SWITCH (GREEN)	

Figure 1-180 (Sheet 5 of 9)

Communications Equipment Locations (Continued)

E **COMMUNICATIONS CONSOLE (TYPICAL)**



1. ADS PROGRAMMING AND DISPLAY PANEL
2. MICROPHONE/HEADSET CONNECTORS
3. MICROPHONE FOOT SWITCH
4. DRAW THRU AIR SCREEN
5. SAFE
6. AISLE LIGHT
7. WITH IDG VHF ACCESS CONTROL ◀

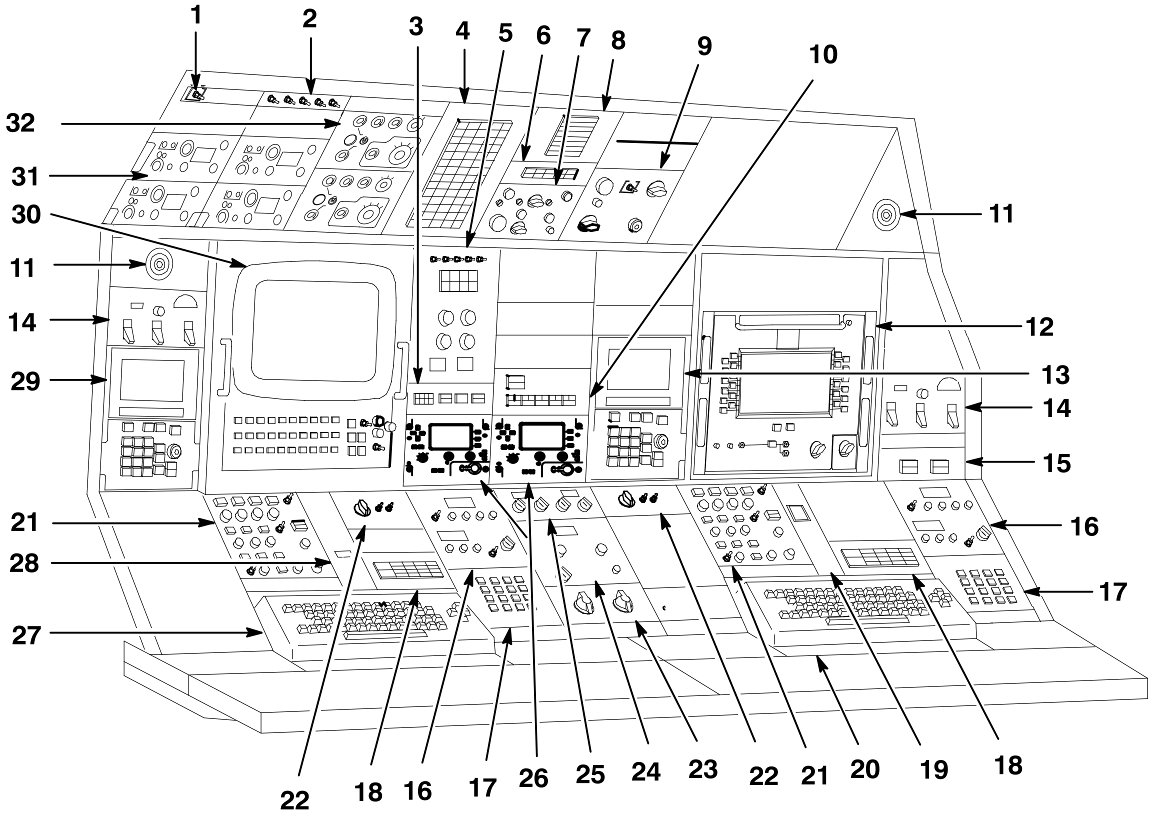
NOTE

CONSOLE COOLED BY DRAW THRU SYSTEM

Figure 1–180 (Sheet 6 of 9)

E COMMUNICATIONS CONSOLE (TYPICAL) (CONT.)

LESS IDG ☛



1. WBSV ZEROIZE CONTROL
2. WBSV DELAY CONTROL KY–58
3. FLIGHT DECK INTERFACE CONTROL PANEL
4. UHF BITE INDICATOR PANEL
5. LINK 11 DS CONTROL PANEL
6. COOLING AIR MONITOR PANEL
7. KGX–40/TSEC CONTROL PANEL
8. VISUAL WARNING DISPLAY UNIT
9. SDU LOAD AND CONTROL UNIT (JTIDS)
10. COMM DISCONNECT PANEL
11. GASPER AIR
12. CONTROL DISPLAY UNIT (JTIDS)
13. HAVE QUICK CONTROLS AND INDICATORS NO. 2
14. OXYGEN REGULATOR
15. AUDIO/TOD SWITCH CONTROL
16. UHF COMMUNICATION RADIO CONTROL PANEL
17. KEYER PANEL
18. SATCOM CONTROL PANEL
19. E41 RACK COOLING MONITOR PANEL
20. TELETYPEWRITER KEYBOARD TRANSMITTER (JTIDS)
21. MISSION ADS PANEL
22. HF AUX CONTROL PANEL
23. LIGHT CONTROL PANEL
24. VHF–FM CONTROLS AND INDICATORS
25. VHF–AM CONTROLS AND INDICATORS
26. HF RADIO SET CONTROL PANELS (2)
27. TELETYPEWRITER KEYBOARD TRANSMITTER (DDS)
28. LAMP TEST PANEL
29. HAVE QUICK A–NET CONTROLS AND INDICATORS NO. 1
30. DIGITAL DISPLAY INDICATOR
31. KYV–5 REMOTE CONTROL UNIT (4)
32. KY–75 CONTROL PANEL (2)

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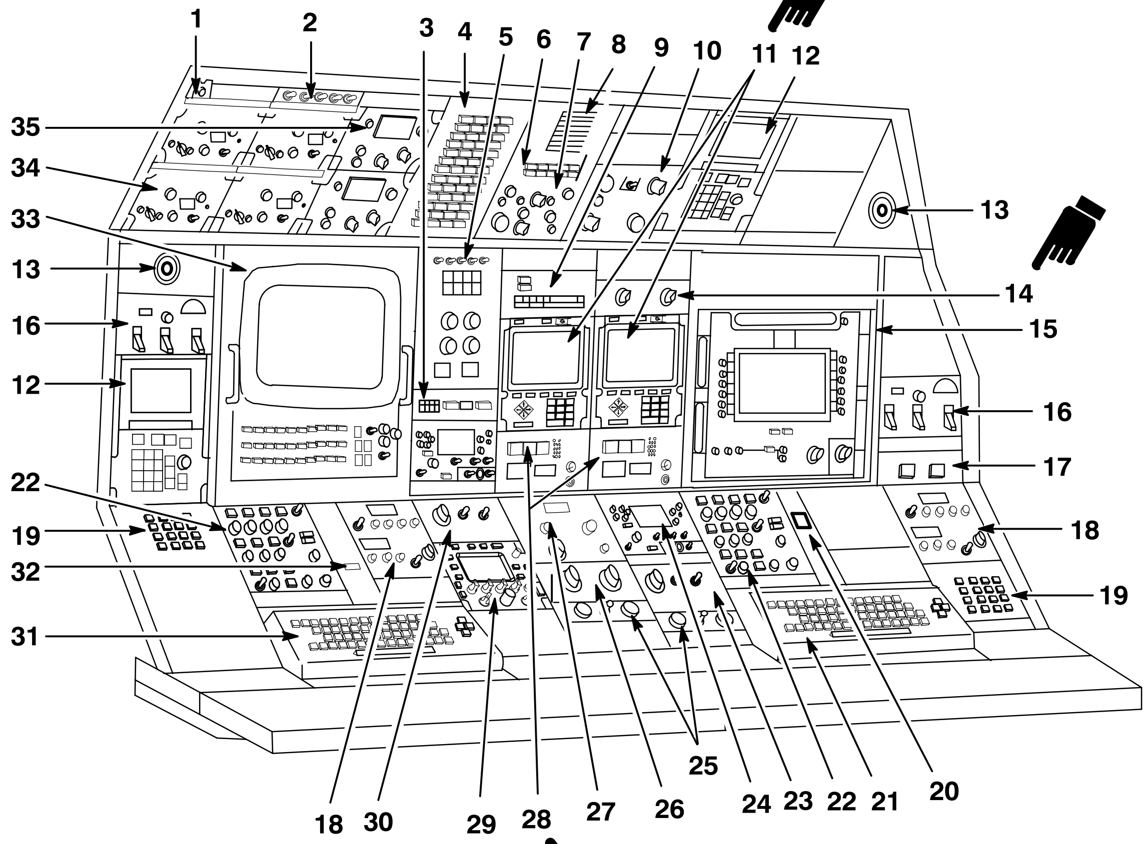
Figure 1–180 (Sheet 7 of 9) ◀

E COMMUNICATIONS CONSOLE (TYPICAL) (CONT.)

WITH IDG



1. WBSV ZEROIZE CONTROL
2. WBSV DELAY CONTROL KY–58
3. FLIGHT DECK INTERFACE CONTROL PANEL
4. UHF BITE INDICATOR PANEL
5. LINK 11 DS CONTROL PANEL
6. COOLING AIR MONITOR PANEL
7. KGX–40/TSEC CONTROL PANEL
8. VISUAL WARNING DISPLAY UNIT
9. COMM DISCONNECT PANEL
10. SDU LOAD AND CONTROL UNIT (JTIDS)
11. RCU FRONT PANEL (2)
12. HAVE QUICK CONTROL INDICATOR, A–NET
13. GASPER AIR
14. VHF ACCESS CONTROL
15. CONTROL DISPLAY UNIT (JTIDS)
16. OXYGEN REGULATOR
17. AUDIO/TOD SWITCH CONTROL
18. UHF COMMUNICATION RADIO CONTROL PANEL
19. KEYER PANEL
20. E41 RACK COOLING MONITOR PANEL
21. TELETYPEWRITER KEYBOARD TRANSMITTER (JTIDS)
22. MISSION ADS PANEL
23. HF AUX CONTROL PANEL
24. HF RADIO SET CONTROL PANEL
25. SATCOM KEY FILL PANEL (2)
26. LIGHT CONTROL PANEL
27. VHF–AM CONTROLS AND INDICATORS
28. SATCOM CONTROL PANEL (2)
29. RADIO SET CONTROL PANEL
30. HF AUXILIARY CONTROL PANEL
31. TELETYPEWRITER KEYBOARD TRANSMITTER (DDS)
32. LAMP TEST PANEL
33. DIGITAL DISPLAY INDICATOR
34. KYV–5 REMOTE CONTROL UNIT (4)
35. KY–75 CONTROL PANEL (2)

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Figure 1–180 (Sheet 7A of 9)

Communications Equipment Locations (Continued)

F ADS PROGRAMMING AND DISPLAY PANEL

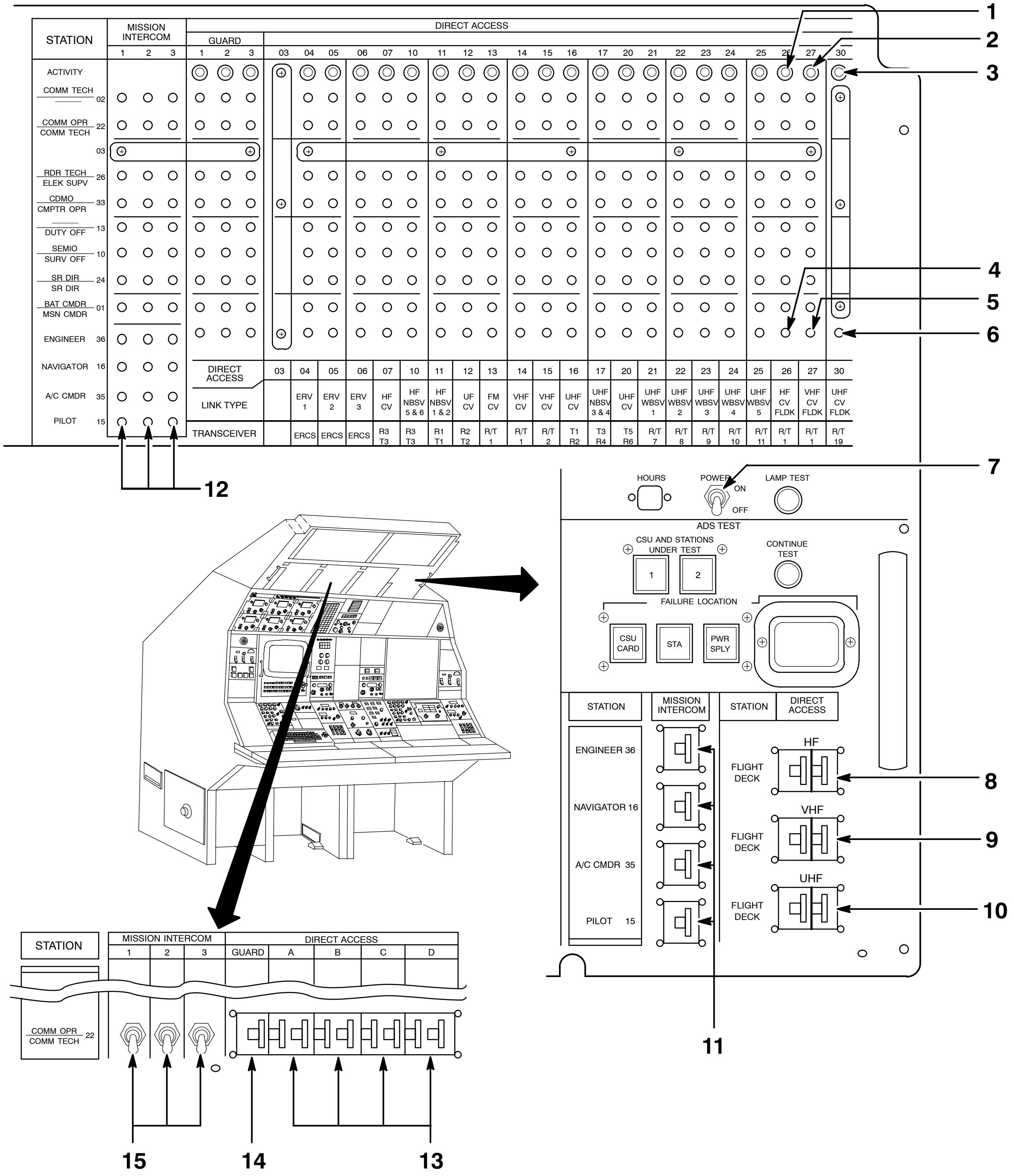

Figure 1-180 (Sheet 8 of 9)

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Pages 1–881 through 1–884 deleted.

Communications Equipment Locations (Continued)

NO.	CONTROL/INDICATOR	FUNCTION
1	DIRECT ACCESS 26 ACTIVITY Warning Light (Red)	When on, indicates receive, transmitter key activity on DIRECT ACCESS channel 26 (flight crew HF radio).
2	DIRECT ACCESS 27 ACTIVITY Warning Light (Red)	When on, indicates receive, transmit or key activity on DIRECT ACCESS channel 27 (flight crew VHF radio).
3	DIRECT ACCESS 30 ACTIVITY Warning Light (Red)	When on, indicates receive, transmit or key activity on DIRECT ACCESS channel 30 (flight crew UHF radio).
4	Flight Crew DIRECT ACCESS 26 Warning Light (Red)	When on, indicates flight crew is assigned DIRECT ACCESS channel 26 (flight crew HF radio).
5	Flight Crew DIRECT ACCESS 27 Warning Light (Red)	When on, indicates flight crew is assigned DIRECT ACCESS channel 27 (flight crew VHF radio).
6	Flight Crew DIRECT ACCESS 30 Warning Light (Red)	When on, indicates flight crew is assigned DIRECT ACCESS channel 30 (flight crew UHF radio).
7	POWER Switch	
	ON	Applies airplane 115 volt power to ADS PROGRAMMING AND DISPLAY panel.
	OFF	Power is removed from panel.
8	FLIGHT DECK HF Thumbwheels	Programs flight crew to HF DIRECT ACCESS channel. Normally set to 26.
9	FLIGHT DECK VHF Thumbwheels	Programs flight crew to VHF-AM DIRECT ACCESS channel. Normally set to 27.
10	FLIGHT DECK UHF Thumbwheels	Programs flight crew to UHF direct access channel. Normally set to 30.
11	FLIGHT DECK MISSION INTERCOM Thumbwheels	Programs flight crew to mission intercom net. Normally all four set to 1.
12	STATION/MISSION INTERCOM Warning Lights	When ON, indicate mission intercom net or nets assigned to stations.
13	COMM OPR/COMM TECH DIRECT ACCESS Thumbwheels	Programs radio/communications operator station to direct access channels.
14	COMM OPR/COMM TECH GUARD Thumbwheel	Programs radio/communications operator station to guard channel.
15	COMM OPR/COMM TECH MISSION INTERCOM 1, 2, 3, switches	Programs radio/communications operator station to mission intercom nets. Far left switch (1) normally in up position. Allow intercommunications with flight crew.

Figure1–180 (Sheet 9 of 9)

Flight Crew Communications Equipment

TYPE	DESIGNATION	FUNCTION	PRIMARY OPERATOR	RANGE	TYPE
UHF Comm	AN/ARC-169 (R/T 19)	1. Provides air-to-air and air-to-ground, two-way voice communications.	Flight Crew	Line of sight.	UHF control panel – forward electronics panel. ADS panels – in aisle stand. ③
UHF Guard	AN/ARC-169 (R/T 12)	2. Provides UHF guard communications.	Flight Crew and Communication Systems Operator	Line of sight.	ADS panels – aisle stand. Tuned by communication systems operator. ③
VHF Comm	**LESS IDG** AN/ARC-166 (R/T 1) ◀ **WITH IDG** AN/ARC–210 (R/T 1 and R/T 2) ◀	1. Provides ground-to-ground, ground-to-air, air-to-air and air-to-ground, two-way voice communications.	Flight Crew and Communication Systems Operator.	Line of sight.	VHF control panels – pilot's overhead panel. ADS panels – ③ aisle stand. ④

Figure 1-181 (Sheet 1 of 2)

TYPE	DESIGNATION	FUNCTION	PRIMARY OPERATOR	RANGE	TYPE
VHF Guard	AN/ARC-166 (R/T 3)	2. Provides VHF guard reception.	Flight Crew and Communication Systems Operator	Line of sight.	ADS panels – aisle stand. Fixed tuning. ③
HF Comm	AN/ARC-229 (HF 1) ① ②	Provides air-to-air and air-to-ground, two-way voice communications.	Flight Crew and Communication Systems Operator. Flight crew can take control at any time (if programmed).	World wide depending on frequency and atmospheric conditions.	HF control panel – Navigator's upper panel. ADS panels – aisle stand. ③
Interphones (Flight crew, Mission, Selective, Airplane Maint., Air Refueling Receptacle and Mission Maint.)	AN/AIC-28(V)1	Multiple nets provide intercommunications for flight crew, mission crew and maintenance personnel.	All personnel		ADS panels – aisle stands navigator and flight engineers consoles. Airplane and mission maintenance stations. ③

① HF2 may be programmed by communication systems operator for flight crew use.

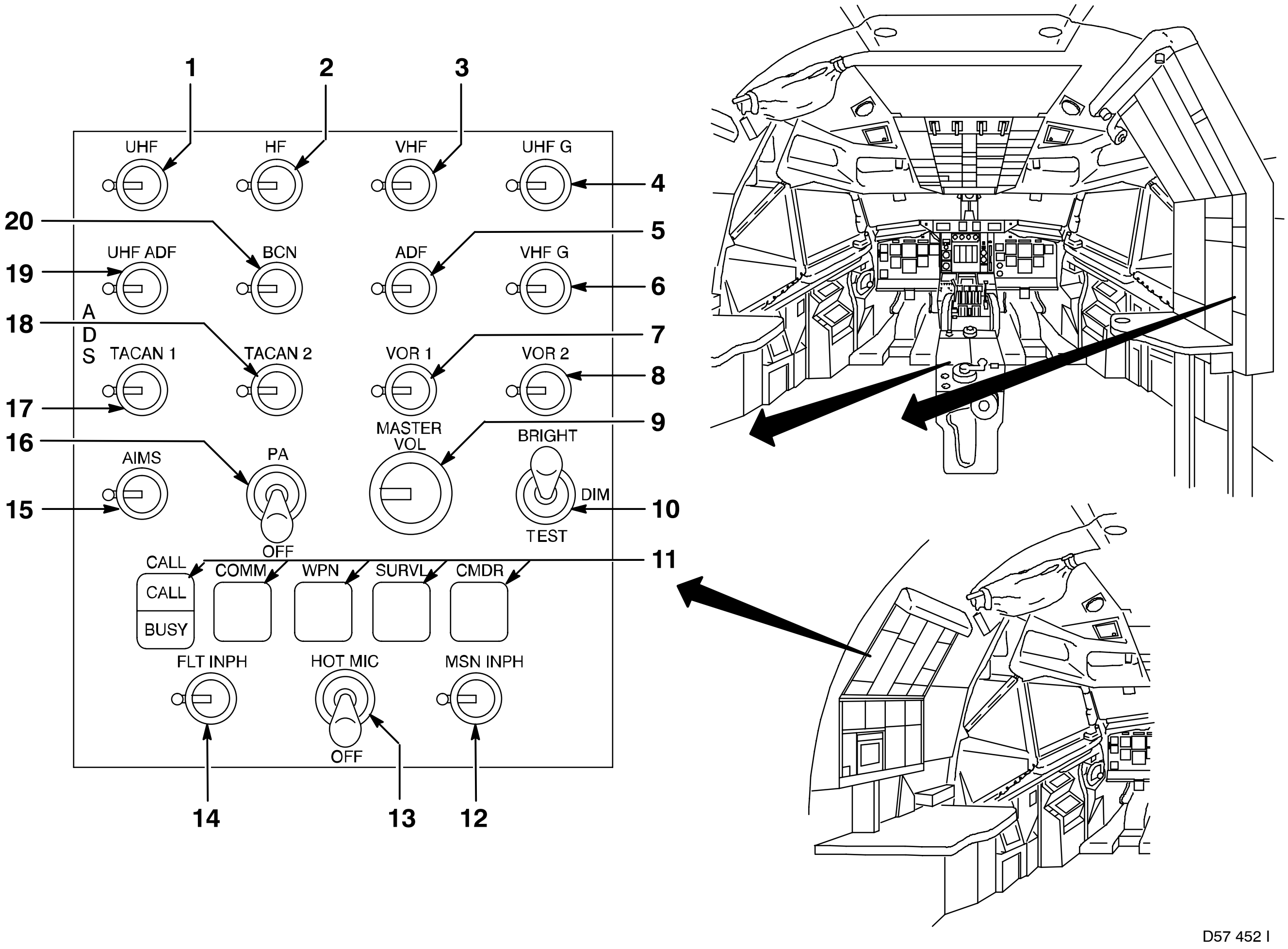
② HF3 may be programmed by communication systems operator for flight crew use.

③ Observer receives/transmits on same radios as pilot.

④ VHF 2 may be programmed by communication systems operator for flight crew use.

Figure 1-181 (Sheet 2 of 2)

Flight Crew ADS Panel



NO.	CONTROL/INDICATOR	FUNCTION

NOTE

- Small knob-type controls, UHF through AIMS, FLT INPH and MSN INPH, operate as follows:
- All knobs, when pushed in and rotated clockwise, permit monitor/receive only. When pulled out and rotated clockwise, knobs in top and bottom rows permit transmit/receive access to labeled items (UHF, VHF, HF, UHF G, FLT INPH and MSN INPH).
- ADS audio outputs are heard on headset only, except for PA announcements and audible warnings.
- When knob is rotated counterclockwise from maximum position, each step decreases volume to approximately 1/3 of previous step.

Figure 1-182 (Sheet 1 of 4)

NO.	CONTROL/INDICATOR	FUNCTION
1	UHF Knob	Permits receive only or transmit/receive on flight deck UHF transceiver.
2	HF Knob	Permits receive only or transmit/receive on HF radio set selected and programmed by communications operator. Flight crew takes control of HF 1 as soon as knob is rotated out of full counterclockwise position.
3	VHF Knob	Permits receive only or transmit/receive on VHF-AM transceiver selected and programmed by communications operator. Flight crew takes control of VHF 1 transceiver as soon as knob is rotated out of full counterclockwise position.
4	UHF G Knob	Permits receive only or transmit/receive on separate UHF Guard transceiver tuned by communications operator.
5	ADF Knob	Permits monitor of low frequency automatic direction finding receiver.
6	VHF G Knob	Permits monitor of VHF guard receiver.
7	VOR 1 Knob	Permits monitor of VOR receiver 1.
8	VOR 2 Knob	Permits monitor of VOR receiver 2.
9	MASTER VOL Knob	When rotated clockwise, increases volume of all signals accessed by entire panel.

NOTE

MASTER VOL knob must be rotated clockwise from the off position (fully counterclockwise, approximately the 9 o’clock position) to receive any usable communication or navigation radio audio output.

NO.	CONTROL/INDICATOR	FUNCTION
10	BRIGHT DIM TEST Switch	When set to BRIGHT, causes bright illumination of CALL switch/indicator pushbutton. When set to DIM, causes dim illumination of CALL switch/indicator pushbutton. When set to TEST, causes CALL switch/indicator pushbutton to light for condition test.

Figure 1-182 (Sheet 2 of 4)

Flight Crew ADS Panel (Continued)

NO.	CONTROL/INDICATOR	FUNCTION
11	Direct Dial Switches	When pressed, initiate call to station indicated, if a selected intercom line is available.

NOTE

More than one selective intercom (direct dial) station can be called at one time.

NO.	CONTROL/INDICATOR	FUNCTION
	CALL Switch/Indicator	When pressed, CALL indicator illuminates and dial tone is heard if selective intercom network is available. If no network is available, CALL indicator does not illuminate and BUSY indicator blinks. BUSY indicator blinks at caller's station when called station is on another intercom net. When pressed again, CALL indicator goes out. If station is called when intercom off, CALL indicator will blink.
	COMM Pushbutton	When pressed, calls seat 7, CSO, if selective intercom net is available.
	WPN Pushbutton	When pressed, calls seat 14, senior director, if selective intercom net is available.
	SURVL Pushbutton	When pressed, calls seat 11, surveillance officer, if selective intercom net is available.
	CMDR Pushbutton	When pressed, calls seat 13, mission crew commander, if selective intercom net is available.
12	MSN INPH Knob	Permits monitor, or talk and listen on mission interphone channel assigned by communication systems operator. When pulled up, cuts off radio and flight crew interphone transmission from that ADS panel, except pilot and copilot may make external radio transmissions.
13	HOT MIC/OFF Switch	When set to HOT MIC, provides hot microphone capability on all intercom functions and public address system. When in HOT MIC position and press-to-talk switch or foot switch is pressed, only direct access transmission is permitted.

Figure 1-182 (Sheet 3 of 4)

NO.	CONTROL/INDICATOR	FUNCTION
14	FLT INPH	Permits monitor, or talk and listen, to other flight crew stations which are monitoring flight interphone line. The MAINT INPH selector on the flight engineer's auxiliary panel must be set to connect to airplane maintenance intercom, mission maintenance intercom or both. The receptacle interphone switch on the flight engineer's auxiliary panel must be pressed ON to enable interphone with tanker. If MSN INPH button is pulled up, or secure voice radio is programmed to that station, flight crew interphone transmission from that panel is shut off.
15	AIMS Knob	**LESS IDG** Permits monitor of audio signal from AN/APX-101 (AIMS) (IFF) transponder, when AUDIO–LIGHT switch on IFF is set AUDIO. ◀ **WITH IDG** Permits monitor of audio signal from AN/APX–119 (IFF Mode S) transponder that occurs when transponder is configured for Mode 4 operation (codes loaded, M4 ON and REPLY selected to AUD) and refuses to reply to a Mode 4 interrogation.◀

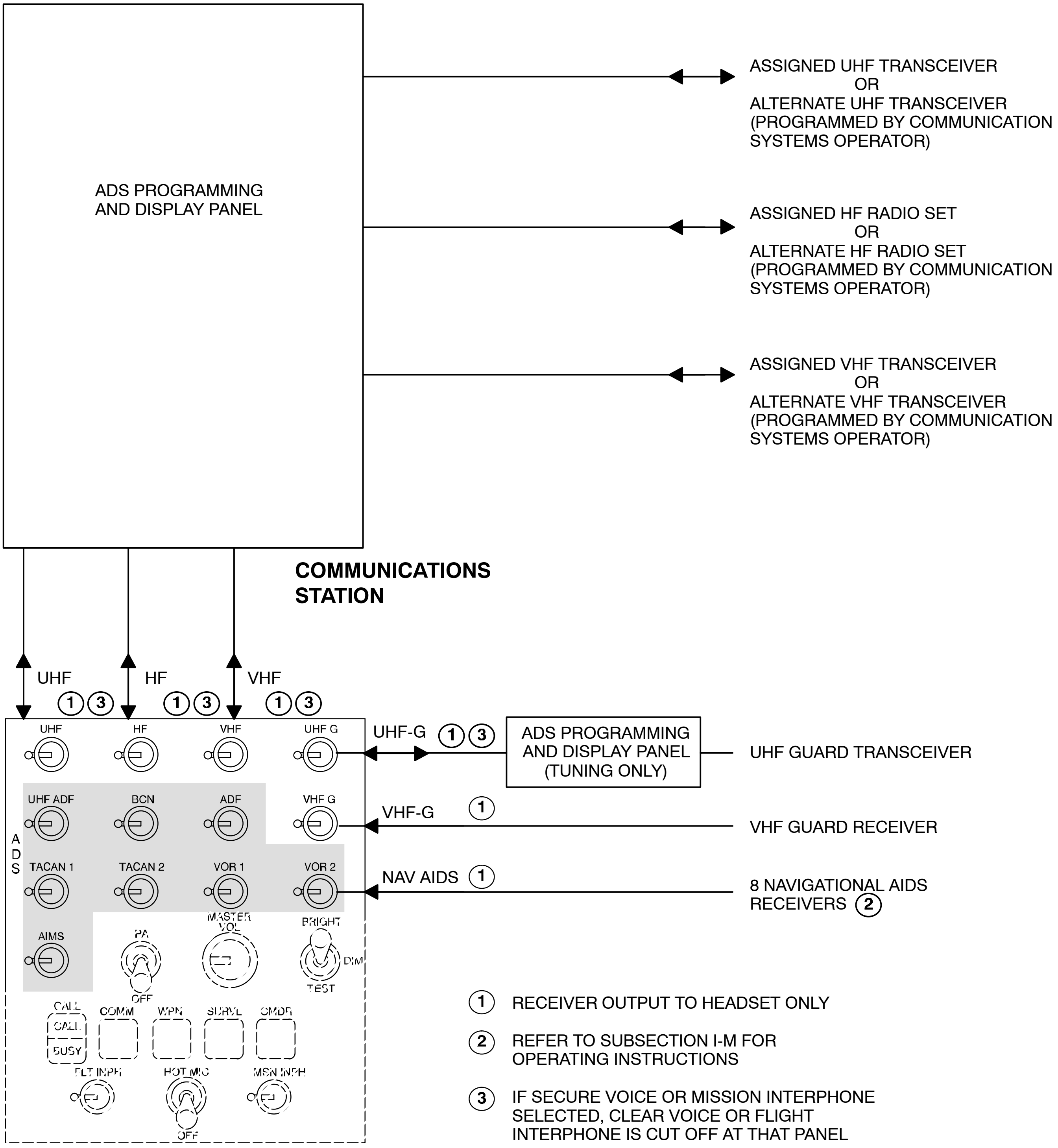
WARNING

WITH IDG The ADS tone is quite loud and should be initially monitored with a single detent of volume on the AIMS knob. ◀

NO.	CONTROL/INDICATOR	FUNCTION
16	PA Switch	When set to PA position, permits speech access to public address system. Two-position pull-to-move latching toggle switch. PA broadcast has priority over any other transmissions except for the pilots' ADS panels where the MIC position of the control wheel switch can be used to make direct access radio transmissions.
17	TACAN 1 Knob	Permits monitor of TACAN receiver 1.
18	TACAN 2 Knob	Permits monitor of TACAN receiver 2.
19	UHF ADF Knob	Permits monitor of ARA-50 UHF Automatic Direction Finding (UHF ADF) receiver. Direction finding output is on pilot's RMI. Receiver must be tuned by CSO.
20	BCN Knob	Permits monitor of marker beacon receiver.

Figure 1-182 (Sheet 4 of 4)

ADS Functional Flow Diagram

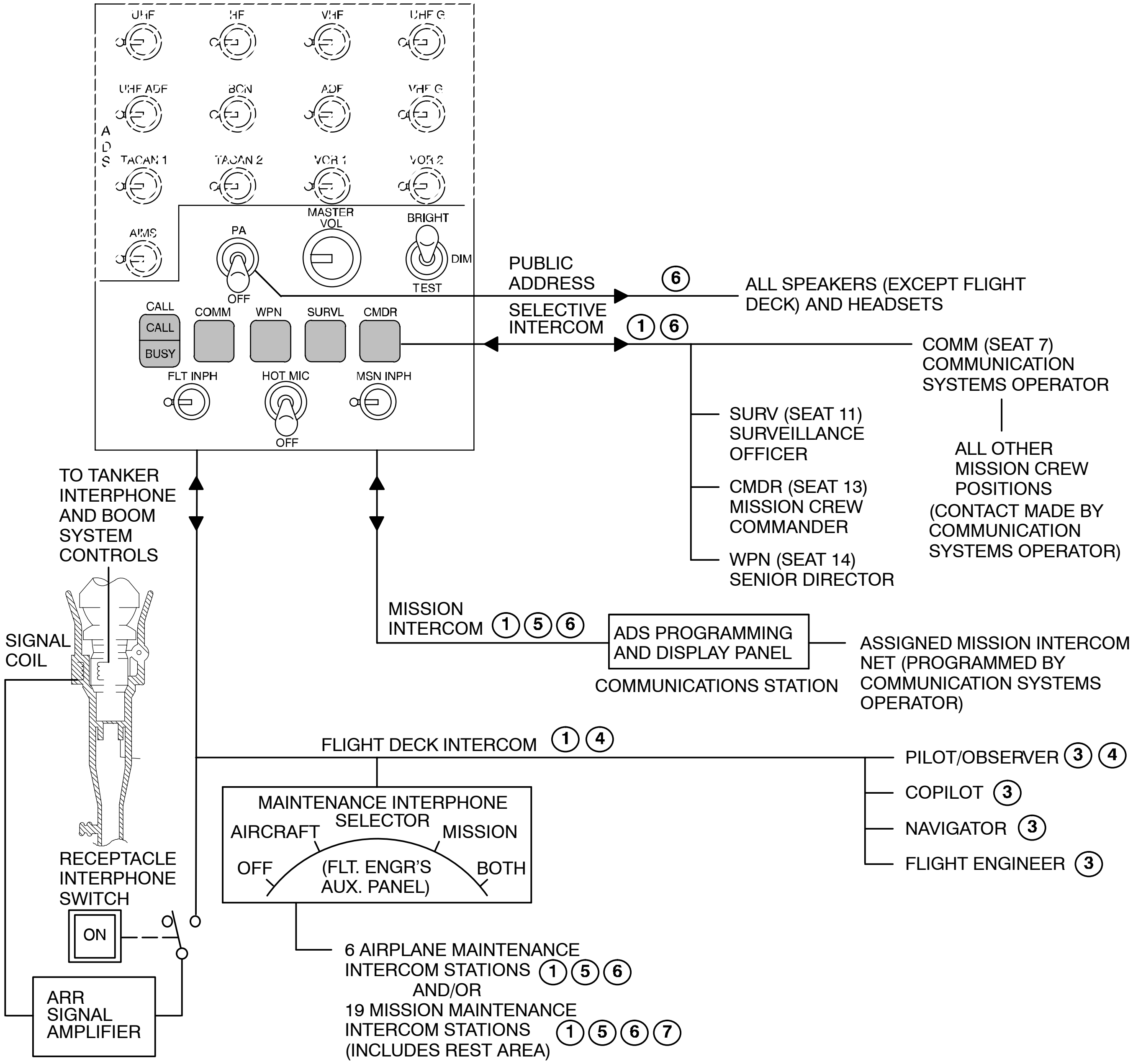


① RECEIVER OUTPUT TO HEADSET ONLY

② REFER TO SUBSECTION I-M FOR OPERATING INSTRUCTIONS

③ IF SECURE VOICE OR MISSION INTERPHONE SELECTED, CLEAR VOICE OR FLIGHT INTERPHONE IS CUT OFF AT THAT PANEL

Figure 1-183 (Sheet 1 of 2)



① RECEIVED ON HEADSET ONLY.

③ IF MISSION INTERPHONE OR SECURE VOICE RADIO IS SELECTED, CLEAR VOICE OR FLIGHT INTERPHONE IS CUT OFF AT THAT PANEL.

④ OBSERVER'S HEADSET IS CONTROLLED BY PILOT'S ADS PANEL.

⑤ MAINTENANCE INTPH SELECTOR MUST BE SET TO BOTH OR TO DESIRED SYSTEM TO CONNECT FLIGHT CREW AND MAINTENANCE INTERPHONES. SELECTOR WILL BE SET TO BOTH IF PERSONNEL ARE IN LOWER DECK IN FLIGHT OR DURING EMERGENCIES.

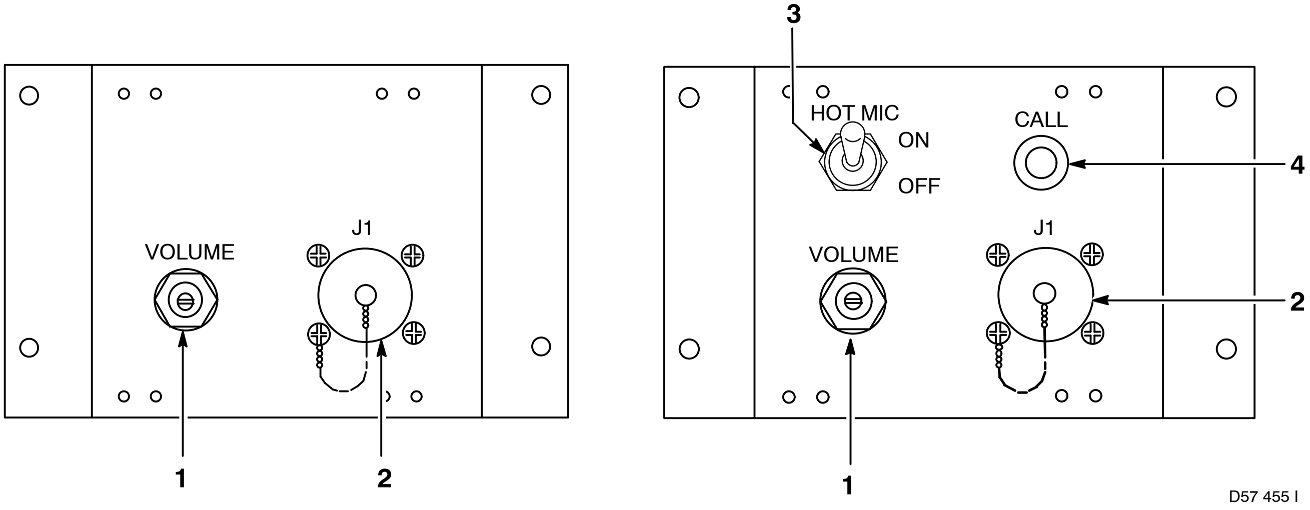
⑥ ALARM SIGNALS ARE HEARD ON ALL SPEAKERS (EXCEPT FLIGHT DECK) AND ALL HEADSETS.

⑦ AT PILOT'S DISCRETION, MAINTENANCE INTERCOM CAN BE USED DURING AIR REFUELING TO ENABLE MISSION CREW COMMUNICATION WITH TANKER INTERCOM BY SETTING MAINT INTPH SELECTOR TO EITHER MISSION OR BOTH WHEN RECEPTACLE INTERPHONE IS IN USE.

D57 454 I

Figure 1-183 (Sheet 2 of 2)

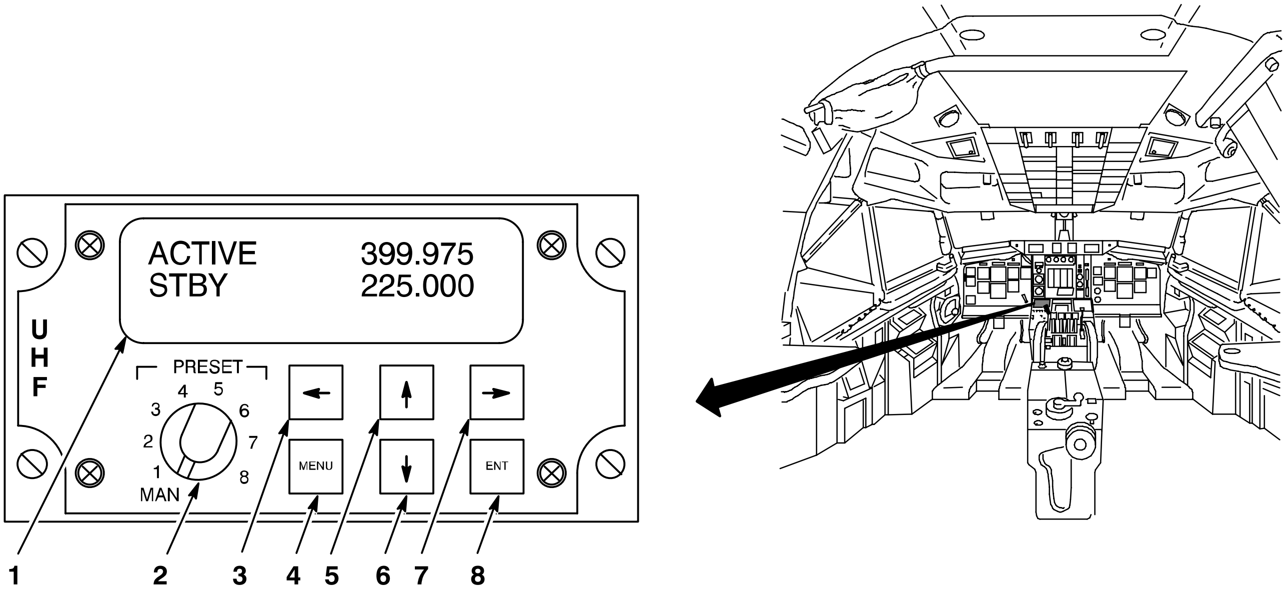
Maintenance Interphone Station Panels



NO.	CONTROL/INDICATOR	FUNCTION
		ALL STATIONS
1	Volume Control	Provides screwdriver adjustment of headset volume.
2	J1 Headset Connector	Provides connection point for headset/microphone cord.
		MISSION MAINTENANCE STATIONS ONLY
3	HOT MIC Switch	Allows hands-off operation of microphone. When set to ON, microphone is energized continuously.
4	CALL Pushbutton	When pressed, blinks MAIN SIG indicators on communication console ADS panels if ADS MAINT controls are off.

Figure 1-184

Flight Crew UHF Communications Controls



FLIGHT DECK DIGITAL RADIO CONTROL (FDDRC)

D57 457 I

NO.	CONTROL/INDICATOR	FUNCTION
1	Display	Displays power up results, input and display menus, and BIT menus.

NOTE

- It is recommended that pilot not flying aircraft operate FDDRC in flight. If it is necessary to reach across forward electronic panel, ensure no inadvertent movement of control column, control wheel, stabilizer trim, throttles, flap lever or speed brake lever.
- For air traffic control (ATC) communications, use VHF radio whenever feasible. For UHF radio, use of FDDRC preset frequencies is recommended.

NO.	CONTROL/INDICATOR	FUNCTION
2	PRESET/MAN Switch	Selects manual operating mode or one of eight preset frequencies within one of three memory banks.
3, 7	→ ← Arrow Keys	
	Parameter Display Mode	Select next present memory bank A, B, or C.
	Parameter Select Mode	Select parameter to right (or left) of current parameter. If already at far right (or left), then left-most (or right-most) parameter of next line is selected.
	Parameter Modify Mode	If parameter being modified is numeric, then digit to right (or left) of current one is selected. If already at right-most (or left-most) digit, then left-most (or right-most) digit is selected. If parameter is non-numeric, then key is inoperative.

Figure 1-185 (Sheet 1 of 8)

Flight Crew UHF Communications Controls (Continued)

NO.	CONTROL/INDICATOR	FUNCTION
4	MENU Key	
	Parameter Display Mode	Selects next user menu.
	Parameter Select Mode	Brings up next menu. Parameter most likely to be changed is bracketed.
	Parameter Modify Mode	Restores value of current parameter before modification of that parameter was started.
5, 6	↑ ↓ Arrow Keys	
	Parameter Display Mode	Exchange STBY frequency with ACTIVE frequency.
	Parameter Select Mode	Select parameter above (or below) current parameter. If already at top (or bottom) of menu, then bottom (or top) parameter of previous menu is selected when in STORE or BIT menu.
	Parameter Modify Mode	Select parameter previous allowed value.
8	ENT Key	
	Parameter Display Mode	Allows operator to jump back to Parameter Select Mode if an error was made.
	Parameter Select Mode	Selects Parameter Modify Mode to modify value of currently selected parameter.
	Parameter Modify Mode	Terminates entry of current parameter and commands FDDRC to place in new value of parameter in STBY register.

NOTE

- The display grid consists of 3 lines, each 16 characters in length. A display menu set, containing powerup displays and four basic menus, is as follows:

a. Power Up Display

b. Frequency Menu

c. Preset – View Menu

d. Preset – Store Menu

e. Built–In Test Menu

Figure 1-185 (Sheet 2 of 8)

Pages 1–897 and 1–898, including
Figure 1–185 (Sheets 3 of 8 and 4 of 8), Deleted

- Power Up Displays and Sequence. Three displays show power up sequence. See below. The first occurs for approximately four seconds every time power is applied to FDDRC. This display cannot be edited. Display top line is FDDRC assigned nomenclature. Second line is abbreviated name. Bottom line is installed firmware version (V), designated by year (YY), month (MM), day (DD), and revision level (R). Second power up display indicates active and standby frequencies, and that transceiver and filter circuits are being tuned. Third display is similar to frequency menu. When tuning sequence is complete, third line of display can be blank, indicate a fault, and/or indicate a selected preset. TUNING is not displayed. Powerup displays occur automatically. When third display occurs, FDDRC can be operated.

FIRST POWERUP DISPLAY

```
      C-12415/A
        FDDRC
     vYY.MMDD.R
```

- Frequency menu (below) is top of menu series and contains parameters of probable greatest interest to operator. This menu appears automatically at end of powerup sequence.

TYPICAL FREQUENCY MENU

```
ACTIVE   99.975
  STBY(294.600)
 FAULT      1-A
```

Line 1 displays active frequency to right of word ACTIVE. Valid range of active frequency is 225.000 to 399.975 MHz. This frequency cannot be edited. Upon initial entry in menu, standby frequency is bracketed.

Line 2 displays standby frequency to right of word STBY. Standby frequency is only frequency that can be edited. Editing standby frequency does not change active operating frequency. Valid range of standby frequency is 225.000 to 399.975 MHz; it is changed in 25 kHz steps.

Line 3 left-most parameter display is BIT status. This parameter is shown only if DDM FDDRC or DDM(s) have a fault detected by BIT. If no faults are detected, this field is blank. If one or more faults are detected, the display shows FAULT.

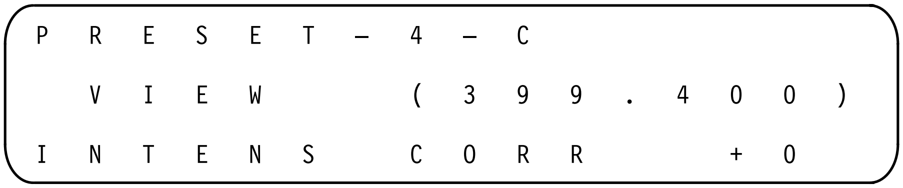
Figure 1-185 (Sheet 5 of 8)

Flight Crew UHF Communications Controls (Continued)

The Line 3 right–most field shows preset and bank selection. This field is occupied only if a preset is selected by front panel PRESET/MAN switch and is blank if switch is in MAN position. Numeric character is PRESET/MAN switch position and alpha character identifies preset bank A, B, or C. FDDRC holds 24 preset channels (3 banks, 8 positions per bank).

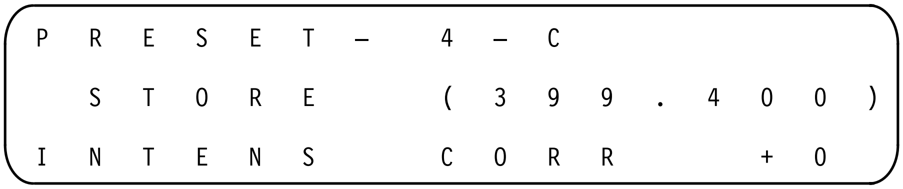
- Preset menu contains preset manipulation and display intensity correction parameters. This menu enables operator to inspect and modify preset frequencies without interrupting any system operation. This menu also allows changing display intensity offset correction factor.

TYPICAL PRESET – VIEW MENU



```
PRESET–4–C
 VIEW  (399.400)
INTENS CORR  +0
```

TYPICAL PRESET – STORE MENU



```
PRESET– 4–C
 STORE  (399.400)
INTENS  CORR  +0
```

Line 1 contains PRESET number and memory bank currently being displayed as VIEW frequency.

Line 2 contains preset VIEW or STORE display on left side and a frequency on right side.

This display is frequency that has been stored in selected preset. In VIEW mode, this frequency cannot be edited by operator.

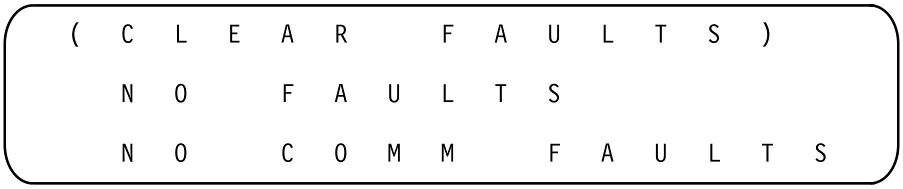
This display is frequency that is to be stored in selected preset. In STORE mode, this frequency can be edited by operator.

Line 3 shows parameter that allows operator to select an offset to display intensity (brightness) by changing offset factor to automatic display intensity tracking. This entry can be changed by operator independently of VIEW or STORE mode.

Figure 1-185 (Sheet 6 of 8)

- Built–In Test Menu contains fault summary. Upon initial showing in menu, parameter most likely to be changed is bracketed (CLEAR FAULTS) in display.

NO–FAULT BIT MENU



```
(CLEAR FAULTS)
 NO FAULTS
 NO COMM FAULTS
```

Line 1 allows operator to clear current faults (faults are latched). Operator can also initiate FDDRC self–test, transmitter test, and receiver test using this display line. (Press ENT, note line 1 flashes, scroll to item to be tested, press ENT, note BIT TEST IN PROGRESS for about four seconds, tone in pilot seat headset, test results displayed. Do not test transmitter on active frequency, to avoid jamming ongoing communications.)

Line 2 is a list of current module faults scrolled, if more than one fault is listed.

Line 3 is a list of communications faults that can occur between FDDRC and DDM. It can be scrolled if more than one fault is listed.

- FDDRC uses three display modes of operation, as follows:

a. Parameter Display

b. Parameter Select

c. Parameter Modify.

Parameter Display Mode is first display that occurs when any menu is entered. Parameter most likely to be changed is bracketed.

Parameter Select Mode displays parameters for modification. Press applicable arrow keys to select parameter to be modified. Direction of next parameter selected is determined by direction of arrow. Left (←) and right (→) keys scroll around current menu; up (↑) and down (↓) keys roll selection to previous and next menus, respectively. In this mode, pressing MENU key causes next menu in sequence to be displayed. Press ENT to bring up Parameter Modify Mode.

Figure 1-185 (Sheet 7 of 8)

Flight Crew UHF Communications Controls (Continued)

In Parameter Modify Mode, parameter to be changed is bracketed and flashes. If parameter is numeric, only digit to be modified flashes. Pressing ← and → keys select digit to be changed. Pressing ↑ and ↓ keys modify digit value. All numeric parameters have a range of valid values. FDDRC prevents operator from changing parameter to an invalid value. If parameter is non–numeric, then entire parameter flashes. Pressing ↑ and ↓ keys modify parameter value to previous and next allowed values, respectively. Left and right arrow keys are inoperative.

Upon entry into Parameter Modify Mode, parameter value is saved.

Pressing MENU key any time prior to pressing ENT key restores parameter to its previous value.

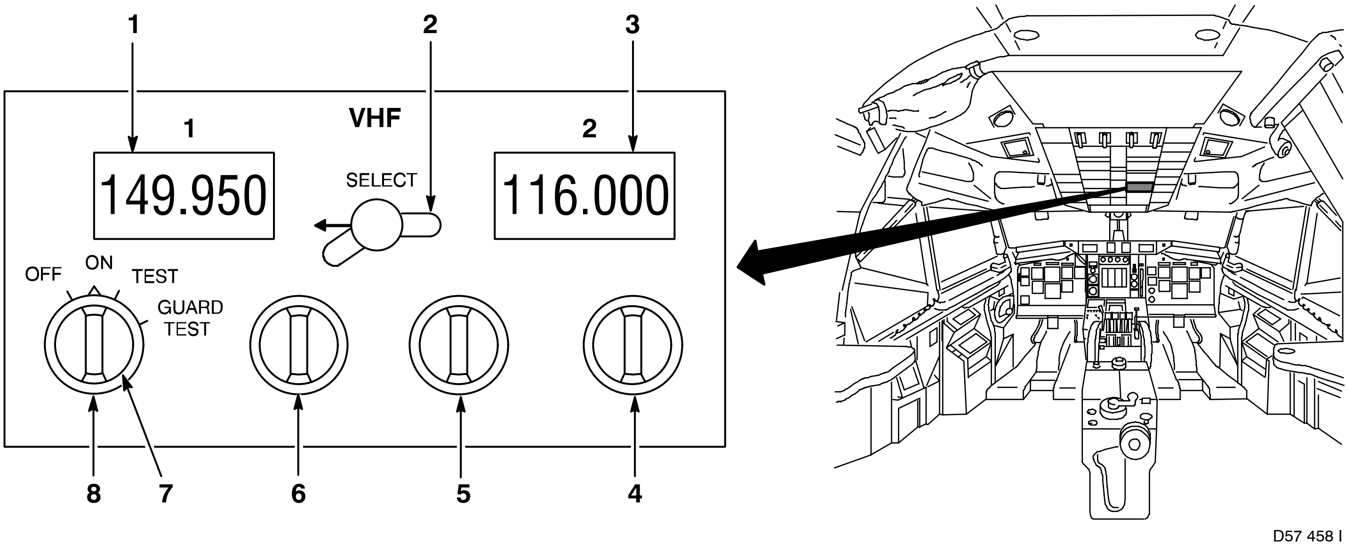
Pressing ENT key causes new parameter to be saved (or original parameter if MENU key has been pressed). Display then switches back to Parameter Display Mode. Parameter flashing stops and brackets disappear.

Parameter just modified is still selected and can be changed again by pressing ENT key.

Display intensity correction functions are not affected by frequency or present programming of FDDRC.

Figure 1-185 (Sheet 8 of 8)

LESS IDG Flight Deck VHF Communications Controls



NO.	CONTROL/INDICATOR	FUNCTION
1	Frequency Display Window 1	Displays the frequency set by controls 6 and 7.
2	SELECT Switch	When turned to expose arrow, tunes transceiver to frequency selected on control indicated by arrow.
3	Frequency Display Window 2	Displays the frequency set by controls 4 and 5.
4	Frequency Selector Control	Selects fractional MHz of window 2 frequency.
5	Frequency Selector Control (Inner knob only, outer ring ineffective)	Selects whole MHz of window 2 frequency.
6	Frequency Selector Control	Selects fractional MHz of window 1 frequency.
7	Frequency Selector Control (Inner knob)	Selects whole MHz of window 1 frequency.

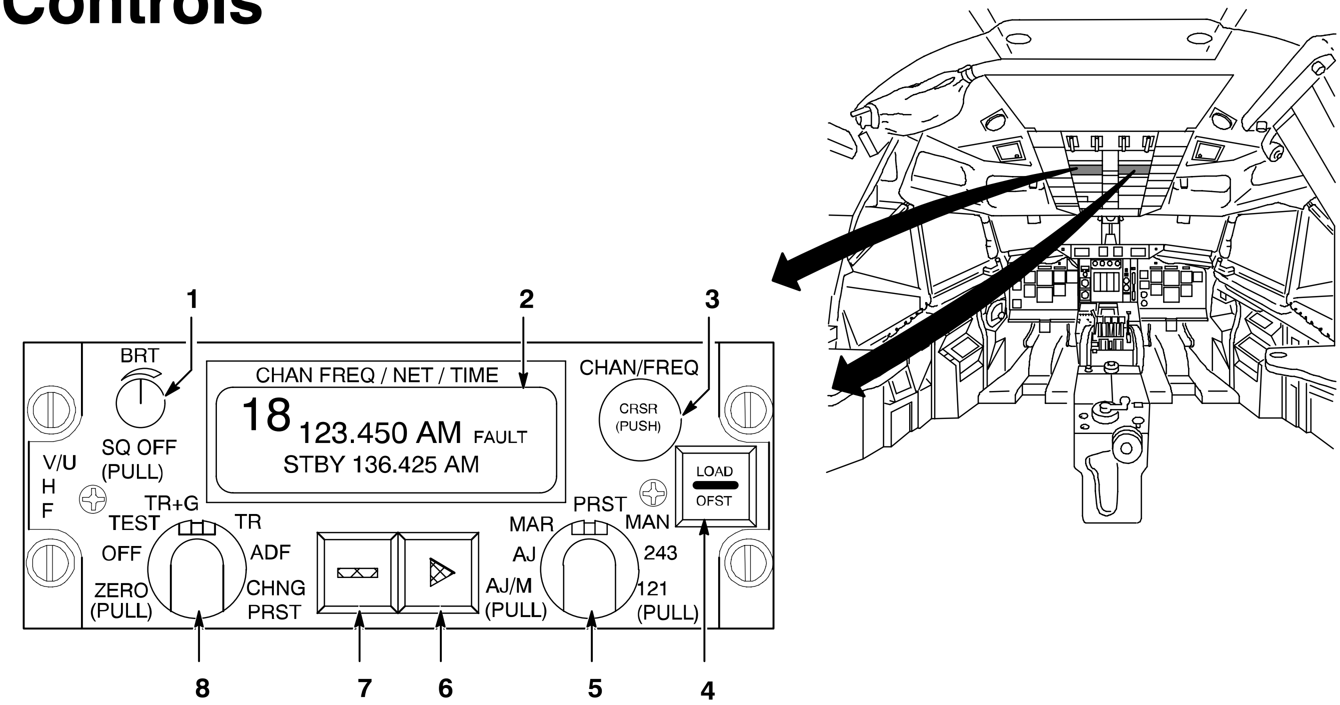
Figure 1-186 (Sheet 1 of 2)

LESS IDG Flight Deck VHF Communications Controls (Continued)

NO.	CONTROL/INDICATOR	FUNCTION
8	Power/Test Switch (Outer Ring)	When set to OFF, removes power from VHF transceivers. When set to ON, applies power to VHF and VHF guard transceivers. When set to TEST, disables VHF transceiver squelch so that receiver noise is heard. When set to GUARD/TEST, and ADS panel VHF G Knob is turned on, disables VHF G transceiver squelch so that receiver noise is heard.

Figure 1-186 (Sheet 2 of 2)

WITH IDG Flight Deck VHF Communications Controls



NO.	CONTROL/INDICATOR	FUNCTION
1	Panel Lighting and Squelch Control	Rotation controls brightness of backlight. Disables squelch when pulled out.
2	CHAN FREQ/NET/TIME (Liquid crystal display)	Displays radio channel, frequency, net (monitor mode only), time (monitor mode only), mode, receiver–transmitter number, push–to–talk (PTT) indicator (inverse video), and built–in test (BIT) results.
3	CHAN/FREQ CRSR (PUSH) (Pushbutton rotary switch)	Each time switch is pushed, cursor position changes. Rotating switch changes channel (CHAN) or frequency (FREQ) value, depending on mode selected and cursor position.
4	LOAD/OFST (Pushbutton switch)	When pushed, enables the loading of various data and operating frequencies, depending upon the mode selected.
5	Frequency mode selector (Rotary switch)	Selects the following frequency modes:
	AJ/M (PULL)	Not used. INVALID MODE is displayed if AJ/M (PULL) position is selected.

Figure 1-186A (Sheet 1 of 4)

WITH IDG Flight Deck VHF Communications Controls (Continued)

NO.	CONTROL/INDICATOR	FUNCTION
	AJ	Not used. INVALID MODE is displayed if AJ position is selected.
	MAR	Not used. INVALID MODE is displayed if MAR position is selected.
	PRST	Preset (PRST) mode. Operator can select 25 simplex channels. The selected channel, frequency, and modulation type (AM) is displayed.
	MAN	Manual (MAN) frequency select mode. Operator can manually select any of the operating frequencies available to the system.
	243	Not used. INVALID MODE is displayed if 243 position is selected.
	121 (PULL) (Pull–to–turn)	VHF guard mode. The transmitter and main receiver are tuned to 121.500 MHz (AM). All control settings, except OFF, TEST, and VOL/SQ OFF (PULL), are inoperative.
6	Menu Pointer (Pushbutton switch)	Displays continuous built–in test (CBIT) status from operational mode screens.
7	Menu Cursor (Pushbutton switch)	Used only during switch test procedure to observe display indications.
8	Operational mode selector (Rotary switch)	Selects the following operational modes:
	ZRO (PULL)	Zeroize (ZRO) mode. Data is erased from memory by the zeroize function. ZEROIZE IN PROGRESS is displayed during the zeroize function, then ZEROIZE COMPLETED. Rotary switch must remain in ZRO (PULL) position for several seconds for a proper zeroize.
	OFF	If P73 VHF ACCESS CONTROL – VHF 2 SELECT rotary switch is set to FLIGHT DECK, then setting Pilot's RCU to OFF position removes power from pilot's RCU and also removes power from VHF 2 transceiver. If P73 VHF ACCESS CONTROL – VHF 2 SELECT rotary switch is set to COMM CONSOLE, then pilot's RCU, if not OFF, is in monitor mode. In monitor mode, switching pilot's RCU OFF only removes power from pilot's RCU. VHF 2 radio, being controlled from P73 console, can remain available for transmit/receive under HF (or another) ADS push regardless of whether or not VHF 2 radio is monitored via pilot's RCU. P73 ADS programming and display panel determines where radio is assigned.

Figure 1-186A (Sheet 2 of 4)

NO.	CONTROL/INDICATOR	FUNCTION
		Switching copilot’s RCU to OFF position removes power from copilot’s RCU and also removes power from VHF 1 transceiver provided that at least one of the flight deck ADS panels has seized the VHF 1 radio by having a VHF knob out of the zero volume detent or pulled up. If the VHF 1 radio is not seized by any flight deck ADS panel, then VHF 1 can be controlled at the P73 console, and copilot’s RCU, if on, monitors VHF 1 radio frequencies and settings. Switching copilot’s RCU OFF when it is monitoring VHF 1 does not remove power from VHF 1 transceiver; settings at P73 console determine what happens to VHF 1 transceiver. If P73 console has VHF 1 powered on and VHF 1 is still programmed to the flight deck via the ADS programming and display panel, then VHF 1 remains available to flight deck under the ADS VHF push and frequencies are selected at P73 console. If VHF 1 is being used by the mission crew, care should be taken that no flight deck ADS panel seize the radio by moving a VHF knob because this disrupts mission crew use of the radio even though the RCU might be OFF. **NOTE** For mission crew to use VHF 1 without the flight deck having the ability to seize control of the radio, accomplish the following: ensure all four flight deck ADS panel VHF knobs are full counter–clockwise and pushed down. On the ADS Programming and Display Panel (P73) move the VHF–AM 1 thumbwheel to any setting except DIRECT ACCESS 27. Comm now has control of VHF 1, and the flight deck cannot take control intentionally or by accident. If VHF–AM 1 remains in DIRECT ACCESS 27, and the flight deck moves one of the ADS panel VHF knobs out of the OFF position, VHF 1 will be seized, and the previously selected frequency (as set by the flight deck) will be tuned.
	TEST	Test mode. Initiates built–in–test function of the RCU and receiver–transmitter. RCU IBIT TEST, then IBIT IN PROGRESS, is displayed while operator–initiated built–in test (IBIT) is in progress. Faults detected are displayed. With no RCU faults detected, CPU : PASS, RAM : PASS and CRC:PASS are displayed. With no receiver–transmitter faults detected, RT : PASS, HPA : PASS, ANT : PASS, and LCU : PASS are displayed. **NOTE** Test mode takes precedence over all operations.

Figure 1-186A (Sheet 3 of 4)

NO.	CONTROL/INDICATOR	FUNCTION
	TR+G	Main receiver–transmitter plus guard (TR+G) mode. The main receiver, transmitter, and guard receiver are on, and able to perform all functions.
	TR	Main receiver–transmitter mode. The main communications receiver and transmitter are on. Guard receiver is off. **NOTE** During radio transmission guard reception is muted.
	ADF	Not used. INVALID MODE is displayed if ADF position is selected.
	CHNG PRST	Change preset mode. Preset channels, and corresponding operating frequencies, can be loaded into receiver–transmitter memory.

Figure 1-186A (Sheet 4 of 4) ◀

WITH IDG Flight Deck RCU Visual Annunciations

MESSAGE	MEANING	ACTION
CPU FAIL	RCU fault detected by initiated built–in test (IBIT).	Contact maintenance personnel. Limited operation of the RCU may be possible.
CPU PASS	RCU passed IBIT central processing unit (CPU) test with no faults detected.	No response required.
CRC FAIL	RCU fault detected by IBIT.	Contact maintenance personnel. Limited operation of the RCU may be possible.
CRC PASS	RCU passed IBIT cyclic redundancy checksum (CRC) test with no faults detected.	No response required.
FAULT	A fault condition is detected.	Perform indicated action using controlling device.
IN PROGRESS	IBIT is in progress.	No response required.
INVALID	A frequency outside of the allowable frequency range has been entered by the operator. The radio has automatically rejected the frequency.	Enter frequency within allowable range.
INVALID MODE	A non–operational mode selection has been made by the operator. The radio has automatically rejected the selection.	Select a valid operational mode.
MONITOR	The RCU is in monitor mode and not in control of the radio.	No response required.
RAM FAIL	RCU fault detected by IBIT.	Contact maintenance personnel. Limited operation of the RCU may be possible.
RAM PASS	RCU passed IBIT random access memory (RAM) test with no faults detected.	No response required.
RT FAIL	Receiver–transmitter fault detected by built–in test (BIT).	Contact maintenance personnel. Limited operation of the receiver–transmitter (RT) may be possible.
RT PASS	Receiver–transmitter passed BIT with no faults detected.	No response required.
SEARCHING FOR RADIO R1\R2	System communication between the RCU and receiver–transmitter R1 or receiver–transmitter R2 is not established.	Contact maintenance personnel if message does not clear automatically after 10 seconds.

Figure 1-186B ◀

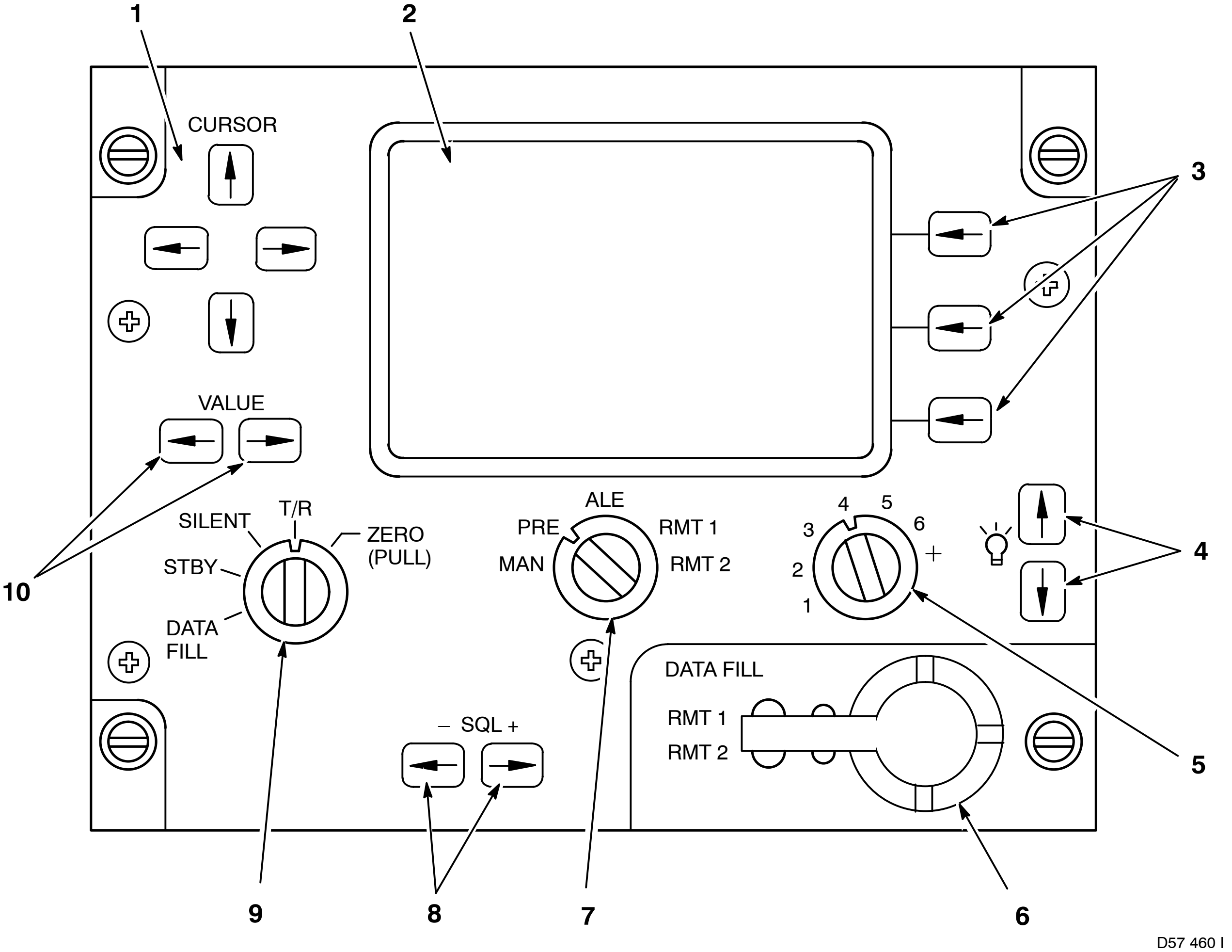
WITH IDG ICAO Channel Name and Frequency Translation

CHANNEL NAME (MHz) (USER ENTERED)	BANDWIDTH (KHz)	RECEIVER–TRANSMITTER INTERPRETED FREQUENCY (MHz)
118.000	25.0	118.0000
118.005	8.33	118.0000
118.010	8.33	118.0083
118.015	8.33	118.0167
118.020 ①	25.0	118.0250
118.025	25.0	118.0250
118.030	8.33	118.0250
118.035	8.33	118.0333
118.040	8.33	118.0417
118.045 ①	25.0	118.0450
118.050	25.0	118.0500
118.055	8.33	118.0500
118.060	8.33	118.0583
118.065	8.33	118.0667
118.070 ①	25.0	118.0750
118.075	25.0	118.0750
118.080	8.33	118.0750
118.085	8.33	118.0833
118.090	8.33	118.0917
118.095 ①	25.0	118.0950
Sequence repeats		

① Channel name is not listed in the actual ICAO table, but is shown to illustrate how the receiver–transmitter performs while tuned to the indicated channel name.

Figure 1-186C ◀

Flight Crew HF Communications Controls



NO.	CONTROL/INDICATOR	FUNCTION
1	CURSOR Switches (Pushbuttons)	When depressed, position display screen (No. 2) cursor (underline) vertically or horizontally. In edit mode, advance to next consecutive character position or data field.
2	Display Screen	Liquid crystal display contains six display lines. Each line displays up to 21 alphanumeric characters and provides specific information depending on operation being performed. Fifteen characters are left justified for communications, advisory and status information. Five characters are right justified for control selection using line–select switches.
3	Line Select Switches (Pushbuttons)	When pressed, select control function or process options displayed immediately to left of each switch. Function of each varies depending on operation being performed.

Figure 1-187 (Sheet 1 of 7)

Flight Crew HF Communications Controls (Continued)

NO.	CONTROL/INDICATOR	FUNCTION
4	Brightness Switches (Pushbuttons)	When pressed, change brightness of display screen according to pushbutton markings; ↑ = increase, ↓ = decrease.
5	Channel/Net Selector Switch (Rotary)	When rotated, select programmed operating channels or nets, depending on operating mode. The + position allows channel or net selection 7 through 20 using VALUE switches.
6	Data Fill Connector	Provides access to low speed binary interface (LSBI) of receiver–transmitter. Used during data fill (preset and ALE parameters) operations.
7	Mode Selector Switch (Rotary)	When rotated, selects operational modes:
	MAN	Selects basic HF communications. In MAN mode, operating frequency and emission mode can be selected manually. When selected, information is stored for future recall using channel selector. ALE can be used by changing submode (SMODE) to ALE.
	PRE	Selects basic HF communications. Channel selector is used to select a programmed preset frequency. Frequency and emission mode cannot be changed during preset operation. ALE can be used by changing submode (SMODE) to ALE.
	ALE	Selects automatic link establishment scanning mode of operation.
	RMT1	Provides access to LSBI of receiver–transmitter using DATA FILL connector on front panel. It is used during datafill (preset and ALE parameters) operations.
	RMT2	Not used.
8	– SQL + (Squelch Switches) (Pushbuttons)	Control radio squelch and audio muting. When SQL switch is pressed, squelch status is displayed at bottom of display for 5 seconds. Displayed settings are OFF and 0 through 7. OFF and 0 position provide no squelch. Positions 1 through 7 provide muting and increasing levels of squelch.

Figure 1-187 (Sheet 2 of 7)

Pages 1–907 and 1–908, including
Figure 1–187 (Sheets 3 of 7 and 4 of 7), Deleted.

NO.	CONTROL/INDICATOR	FUNCTION
9	Function Switch (Rotary)	When rotated, selects operating function of radio set.
	DATA FILL	For data fill operations using data fill device.
	STBY	Selects standby function. In STBY position, BIT, setup or fill operations can be performed prior to operating radio.
	SILENT	Used in ALE mode to prevent radio from sounding or responding to incoming calls automatically. PTT is still active in silent mode.
	T/R	Allows system to transmit and receive in selected mode.
	ZERO	Position has pull–to–turn feature and is used to erase all data loaded into radio set.
10	VALUE Switches (Pushbuttons)	When pressed, increase or decrease a field value or a single character value, depending on cursor position.

Figure 1-187 (Sheet 5 of 7)

Flight Crew HF Communications Controls (Continued)

DISPLAY LINE	ITEM	DISPLAY TYPE	VALID RANGE	DISPLAY FORMAT	DEFAULT VALUES
1	Channel/net title (call sign)	Alpha-numeric	1 to 15 characters	Free text	Mode: channel/net no. ①
2	ALE address: – CALL TO – SELF Address	Alpha-numeric	1 to 15 characters	ADRS: xxx SELF: xxx	②
	Automatic sounding (ALE)	Character	ON, OFF	SOUND: xxx	None
3	Sounding interval (ALE)	Numeric	0 to 180	SND INTRVL: xxx	0 ③
3, 4	Receive frequency	Numeric	2.0 to 29.9999 MHz	RCV xx.xxxx	None
	Emission mode	Character	USB, LSB, ISB, AME	One space to right of frequency	USB
4	Transmit frequency	Numeric	2.0 to 29.9999 MHz	XMT xx.xxxx	None
	Time	Numeric	00:00:00 to 23:59:59	HH:MM:SS	None
	Listen before call (ALE)	Character	ON, OFF	LBC: xxx	OFF
	Listen before talk	Character	ON, OFF	LBT: xxx	OFF
5	Date	Alpha-numeric	01 JAN XX to 31 DEC XX	dd MMM yy	None
	Alert tones (ALE call)	Character	ON, OFF	ALERT TONES: xxx	ON
	Submode	Character	BASIC, ALE	SMODE: xxxxx	BASIC
6	Power level	Character	LOW, MED, HI	PWR: xxx	HI
	Audio mode	Character	Voice, Link–11, Data	One space right of power (7 characters)	VOICE
	Squelch	Alpha-numeric	OFF, 0 to 7	SQL: xxxx	OFF

① Titles determined by data fill. Manual channel titles can be edited.

② Only first 10 characters of address displayed. To see all 15 characters of call address, press left or right cursor keys on EDIT page.

③ If sounding interval value is 0, programmed channel sounding intervals are used. Values of 1 to 180 minutes are used as sounding interval for all channels.

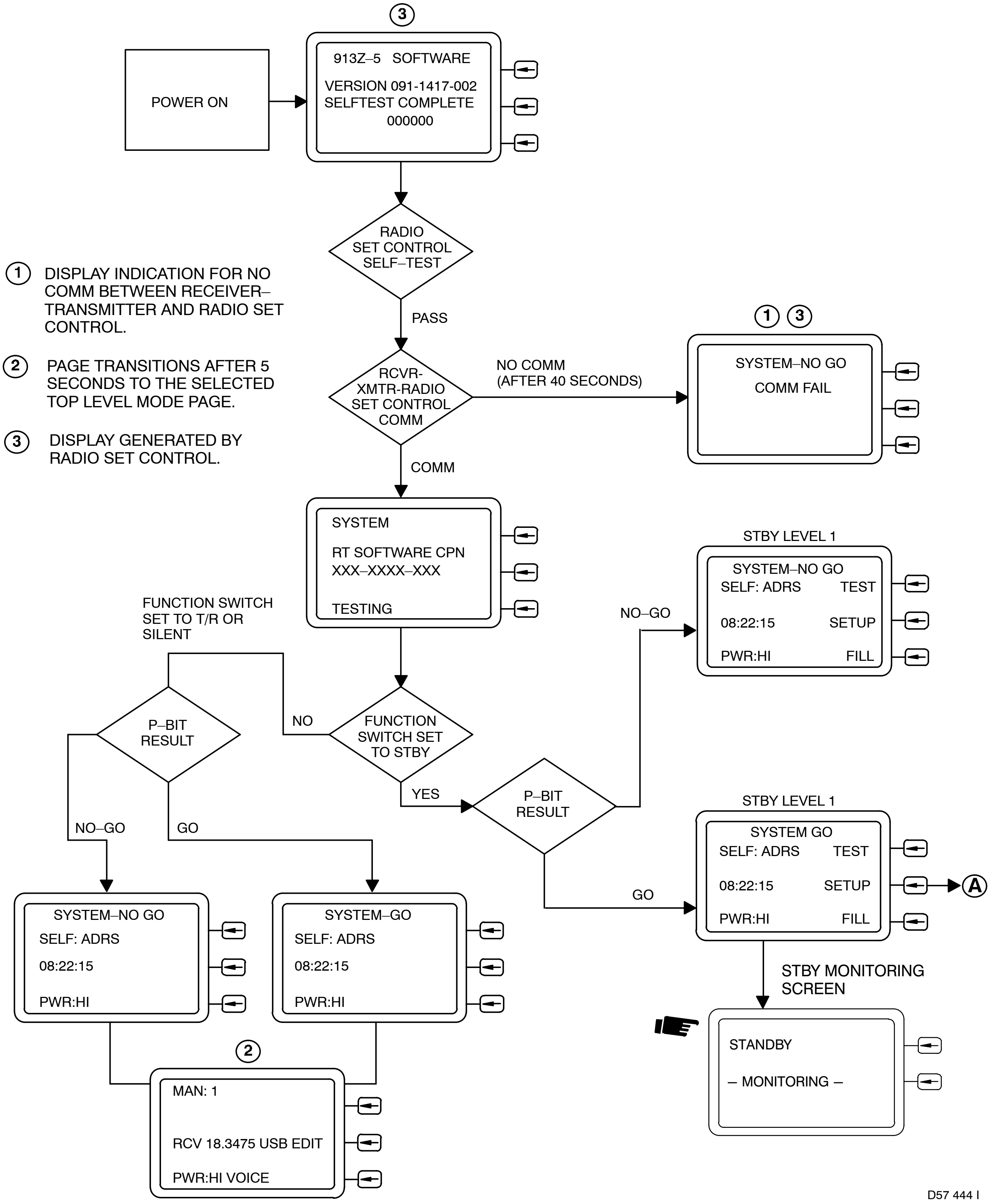
Figure 1-187 (Sheet 6 of 7)

ADVISORY	DEFINITION
CALL FAIL	HF radio subsystem failed to complete an outgoing ALE call. ①
CALLING	HF radio subsystem is currently placing an ALE call to another address. ②
CHANNEL BUSY	Selected ALE net is in use. Wait or try another net. ②
CHANNEL INOP	ALE data not loaded, a data inconsistency exists or hardware cannot support selected mode of operation. ②
CHECK MSG	Message has been received. ③
HOLD	An ALE call is being held on a specific frequency by operator. ①
INCOMING CALL	Another radio is establishing an ALE link. ①
INOP MODES EXST	Warning to expect inoperative modes. ①
LINKED	An ALE link is established. ①
LOAD FAIL	Data loading process was incomplete, inaccurate, or otherwise not successful. ①
MSG ABORT	HF radio subsystem is discontinuing sending of current message. ②
NO AUTO XMT	HF radio subsystem has been instructed to emit no automatic transmissions or communications. ①
NO DATA	Data base is not filled with necessary data to perform requested operations. ③
NO RCVD MSGS	No messages have been received. ①
RSC FAIL	Radio set control is inoperative. ①
RT FAIL	Receiver–transmitter failed. ①
COMM FAIL	Receiver–transmitter is failing to communicate with radio set control.
SOUND	HF radio subsystem is sending an ALE sound. ②
TESTING	BIT is being performed. ①
ZEROIZED	All mission data fill information has been erased. ①

① Cleared when a change of mode, function, net, or page if advisory or condition does not apply to selected change.
② Cleared upon process completion.
③ Cleared after requested action is performed.

Figure 1-187 (Sheet 7 of 7) ◀

HF Radio Power Up Sequence

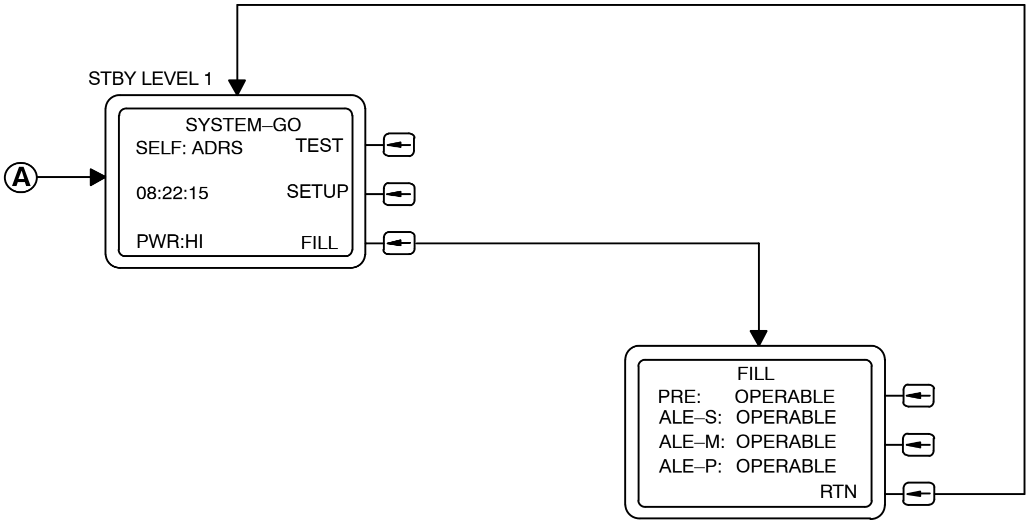


① DISPLAY INDICATION FOR NO COMM BETWEEN RECEIVER–TRANSMITTER AND RADIO SET CONTROL.

② PAGE TRANSITIONS AFTER 5 SECONDS TO THE SELECTED TOP LEVEL MODE PAGE.

③ DISPLAY GENERATED BY RADIO SET CONTROL.

Figure 1-188 (Sheet 1 of 2)



POSSIBLE INOP INDICATIONS ARE AS FOLLOWS:
(IN ORDER OF PRIORITY, TOP TO BOTTOM)

PRE:
- PRE: NO DATA
- PRE: OPERABLE

ALE–S:
- ALE–S: NO DATA
- ALE–S: OPERABLE

ALE–M:
- ALE–M: NO DATA
- ALE–M: OPERABLE

ALE–P:
- ALE–P: NO DATA
- ALE–P: OPERABLE

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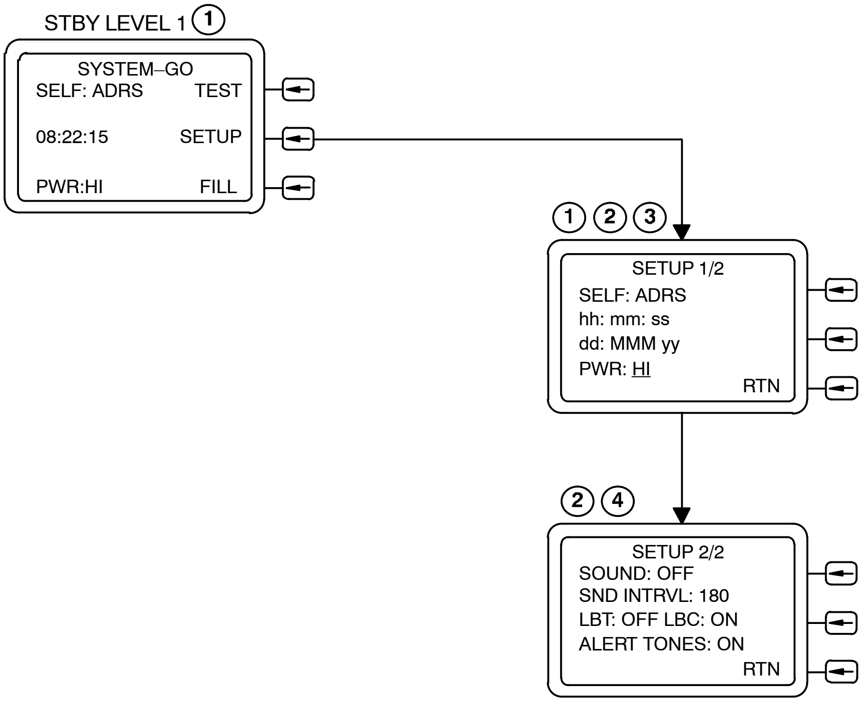
Figure 1-188 (Sheet 2 of 2)

Setup Operation



① TIME DOES NOT UPDATE WHILE CURSOR IS LOCATED WITHIN TIME OR DATE DISPLAY FIELDS. TIME RESUMES UPDATING AFTER CURSOR IS MOVED TO ANOTHER FIELD. IF VALUE SWITCHES ARE USED TO CHANGE TIME OR DATE, TIME UPDATES WHEN CURSOR IS MOVED OFF TIME OR DATE FIELDS OR WHEN RTN IS PRESSED.

② PRESS RTN SWITCH TO RETURN TO STANDBY SYSTEM–GO DISPLAY PAGE.

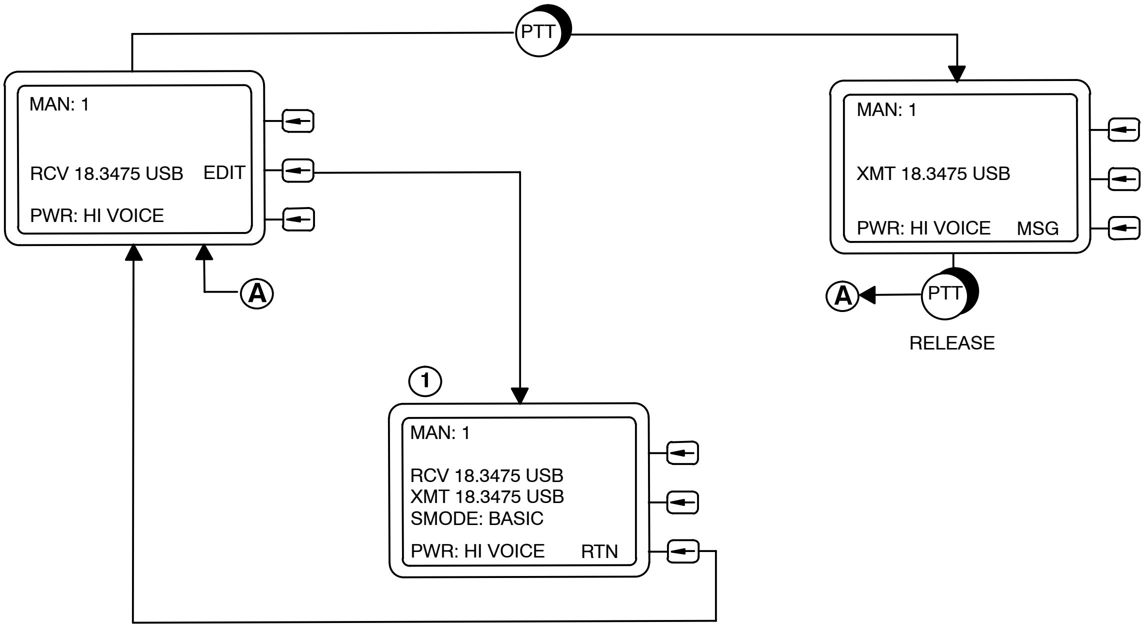
③ SETUP PAGE 2 OF 2 IS ACCESSED WHEN CURSOR IS SCROLLED PAST FIRST OR LAST FIELD ON PAGE.

④ SETUP PAGE 1 OF 2 IS ACCESSED WHEN CURSOR IS SCROLLED PAST FIRST OR LAST FIELD ON PAGE.

D57 446 I

Figure 1-189

Manual Operation



CURSOR DEFAULTS TO RCV FREQUENCY FIELD. USE CURSOR SWITCHES TO POSITION CURSOR TO EDIT:

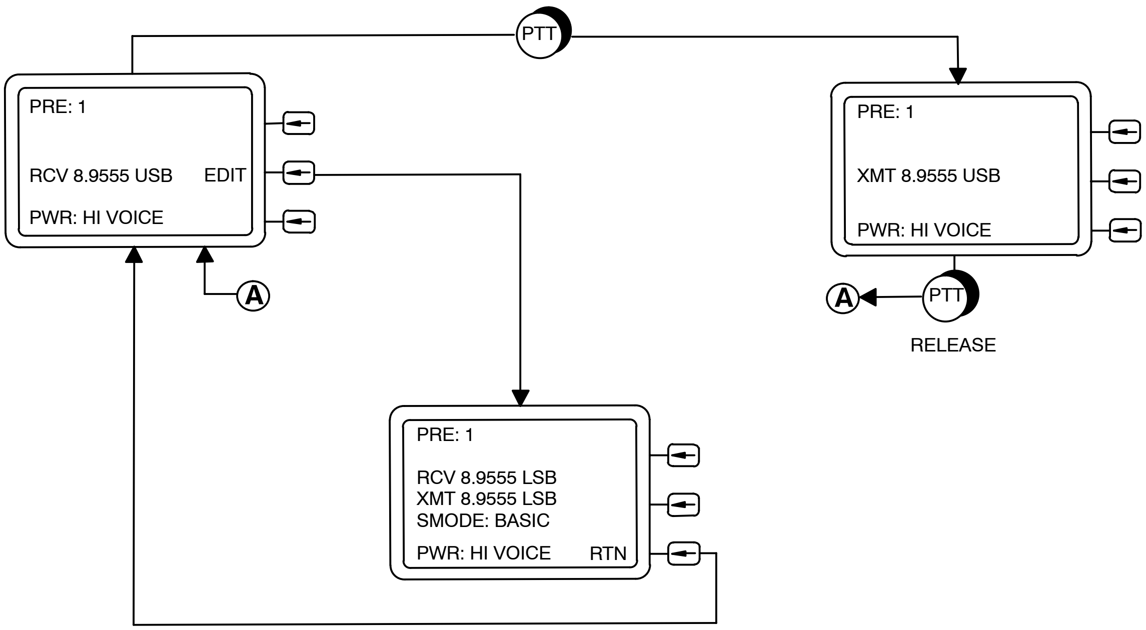
TITLE
RCV FREQ – EMISSION MODE
XMT FREQ – EMISSION MODE
SMODE
POWER LEVEL – AUDIO MODE

① XMT AND RCV FREQUENCIES ARE LINKED. EDITING EITHER XMT OR RCV FREQUENCY OR EMISSION MODE CHANGES BOTH.

D57 447 I

Figure 1-190

Preset Operation



CURSOR DEFAULTS TO PWR FIELD. USE CURSOR SWITCHES TO POSITION CURSOR TO EDIT:

TITLE
SMODE
POWER LEVEL – AUDIO MODE

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Figure 1-191

Communications Electric Power Sources (Flight Crew)

EQUIPMENT/SYSTEM	TYPE OF POWER	POWER SOURCE	CIRCUIT BREAKER LOCATION/LABEL
UHF Transceiver	28 vdc	EDC	P5, UHF XCVR
UHF Coupler	115 vac	EAC	P5, UHF XCVR CPLR
UHF Control Panel	28 vdc	EDC	P5, UHF CONTR
ADS, CSU 1	28 vdc	EDC	P5, ADS–CSU 1
ADS, CSU 2	28 vdc	EDC	P5, ADS–CSU 2 A/V MAINT
PA Amplifier	28 vdc	EDC	P5, ADS–PA AMPL
PA Speakers	28 vdc	EDC	P5, ADS–PA SPKR
VHF 1	28 vdc	EDC	P5, LESS IDG VHF◀ WITH IDG VHF 1 ◀
LESS IDG VHF 2	28 vdc	MADC 3/DIST 1	P66–2 VHF–AM2 ◀
WITH IDG VHF 2	28 vdc	MADC 6/DIST 2	P66–2 VHF–AM2 ◀
HF NO 1 ①	115 vac 28 vdc	FAAC 1 FAVDC 2	P5, HF AC P5, HF DC
HF NO 1 Coupler ①	115 vac	FAAC 1	P5, HF COUPLER
UHF/ADF ①	115 vac 28 vdc	FAAC 1 FAVDC 2	P5, UHF ADF AC P5, UHF ADF DC
UHF Guard Transceiver ①	115 vac 28 vdc	FAAC 1 TRU 8	P5, UHF G DC P5, UHF G AD
Transceiver ①	28 vdc	TRU 8	P5, UHF G DC
VHF Guard Receiver ①	28 vdc	FAVDC 2	P5, VHF G
HF/VHF Interface Control ①	28 vdc	FAVDC 2	P5, HF/VHF INTFC DC
ADS Controls ①	115 vac	MAAC 1/DIST 2	P66, ADS AUDIO CONTR
Baseband Distribution Panel (HF and VHF) ①	115 vac	MAAC 1/DIST 2	P66, BDP–HF/VHF AC
UHF Radio Control Panel, Seat 6 ①	115 vac	MAAC 1/DIST 2	P66, RADIO CONTR POSN 6
UHF Radio Control Panel, Seat 7 ①	115 vac	MAAC 2	P66, RADIO CONTR POSN 7
Mission Maintenance Interphone ①	28 vdc	MADC 3/DIST 1	P66, ADS–MSN MAINT
Receptacle Interphone	28 vdc	DC BUS 8	P66–1, REFUELING – SLWY DR & TOG LCH – NORMAL

① FLT AVIONICS BUS 1 and/or BUS 2 switches on AVIONICS POWER DISCONNECT panel control power to EQUIPMENT/SYSTEM circuit breakers referenced by this note.

Figure 1-192

SUBSECTION I-Q
BLEED AIR, AIR CONDITIONING, AND PRESSURIZATION SYSTEMS

Table of Contents

Title ***Page***

SUMMARY

The bleed air system supplies pressure regulated, precooled bleed air from the engines or the APU or a ground cart for air conditioning, cabin pressurization, engine starting, and rotodome purging. Bleed air system components are shown in *figure 1-193*, schematic in *figure 1-194*, and system controls in *figure 1-195*. Engine anti-icing is not supplied by the bleed air system. Refer to ICE AND RAIN PROTECTION SYSTEMS, subsection I-S.

The air conditioning and pressurization systems provide ventilation, control temperature, and regulate air pressure for the flight deck, mission compartment, and the forward and aft lower compartments. The lower compartments are pressurized to the same pressure as the main deck. The air conditioning and pressurization systems are supplied with compressed air by the bleed air system. An external connection is provided for a ground cooling unit.

ENGINE BLEED AIR SYSTEM

The engine bleed air system supplies air precooled to approximately 325° to 410°F and pressure regulated to between 45 and 60 psig from the engines to the wing manifold (*figure 1-194*). High pressure air, from the 16th stage of the high-pressure (N_2) compressor, passes through a pressure regulating/shutoff valve, a precooler (cooled by engine fan discharge air), then through the firewall shutoff valve, check valve, and strut duct to the wing manifold. The wing manifold is divided into three sections by the bleed air isolation valves. Bleed air from the APU or ground air source is also ducted to the wing manifold.

BLEED AIR (PRESSURE REGULATING/ SHUTOFF) VALVE

The engine bleed air (pressure regulating/shutoff) valve (18, *figure 1-193*) regulates 16th stage bleed air between 45 and 60 psig. The bleed air valve is commanded open or closed by the corresponding bleed air switch (9, *figure 1-195*) on the engineer's panel and also closes when the corresponding engine fire switch is pulled. The valve is pneumatically operated so the engine must be running in order to open or close the valve. If the engine stops (or bleed air pressure is low), the valve closes, but does not always close far enough to illuminate the OFF light.

The flow control topping circuit in bleed air valve protects against overtemperature. At 450°F, the flow control topping circuit drives the regulating valve toward a minimum flow condition. At 490°F, the flow control has no further effect. If the precooler discharge temperature reaches 505 ± 10°F, the OVERHEAT caution light illuminates. When the OVERHEAT caution light illuminates, close the affected engine bleed air valve. Refer to BLEED AIR OVERHEAT, section IIIA.

BLEED AIR PRECOOLER

The engine bleed air precooler (heat exchanger) (19, *figure 1-193*) cools the bleed air from its associated engine before the air passes the firewall shutoff valve. The precooler is cooled by engine fan stage discharge air. The amount of fan discharge air used for cooling the precooler is regulated by the precooler control valve. The precooler control valve is closed when the air leaving the precooler has a temperature of 325°F and is fully open when the air temperature is 410°F, or greater. The precooler control valve is designed to fail in the full open position.

FIREWALL SHUTOFF VALVE

Each engine bleed system has a pneumatically operated firewall shutoff valve located in the strut downstream from the precooler. This valve protects the bleed air (wing) manifold from overpressures if a pressure regulating/shutoff valve fails. If the engine bleed duct pressure increases to between 70 and 85 psig, the firewall shutoff valve closes and the FIREWALL CLOSED indicator illuminates. The OVERPRESS caution light illuminates when the pressure increases to between 80 and 85 psig. The OVERPRESS caution light goes out when the pressure decreases to between 78 and 74 psig. The firewall shutoff valve opens and the FIREWALL CLOSED indicator goes out when the pressure decreases to between 74 and 72 psig. When bleed air pressure is available from the engine, the firewall shutoff valve is opened and closed by the BLEED AIR switch. The firewall shutoff valve also closes if the fire switch for that engine is pulled (*figure 1-23*). If the engine stops (or bleed air pressure is low), the valve closes, but does not always close far enough to illuminate the FIREWALL CLOSED light.

BLEED AIR ISOLATION VALVE

Three bleed air isolation valves are installed in the wing manifold. These valves isolate various sections of the wing manifold if a leak occurs. They also allow maintaining a bleed air source to the air conditioning system if a flow control valve fails open. Each isolation valve has a separate control located on the flight engineer's bleed air control panel (2, 3, and 4, *figure 1-195*). The isolation valves take a maximum of six seconds to close or open.

ENGINE STARTER DUCT

The engine starter duct is connected between the firewall shutoff valve and the wing manifold. This duct allows bleed air from the APU, a ground cart, or another engine to power the starter during the start sequence.

ROTODOME PURGE VALVE

The rotodome purge valve, located in a branch of the APU duct downstream of the APU check valve, controls the flow of air to the rotodome. Purge valve operation is controlled by the air refueling SLIPWAY DOORS switch on the flight engineer's panel. The purge valve is a motor operated valve which receives power through the PURGE VALVE circuit breaker on the P67-3 panel. The purge valve is opened electrically when slipway doors open. When slipway doors close, a timer delays purge valve closure for 5 minutes. The purge valve can also be opened manually.

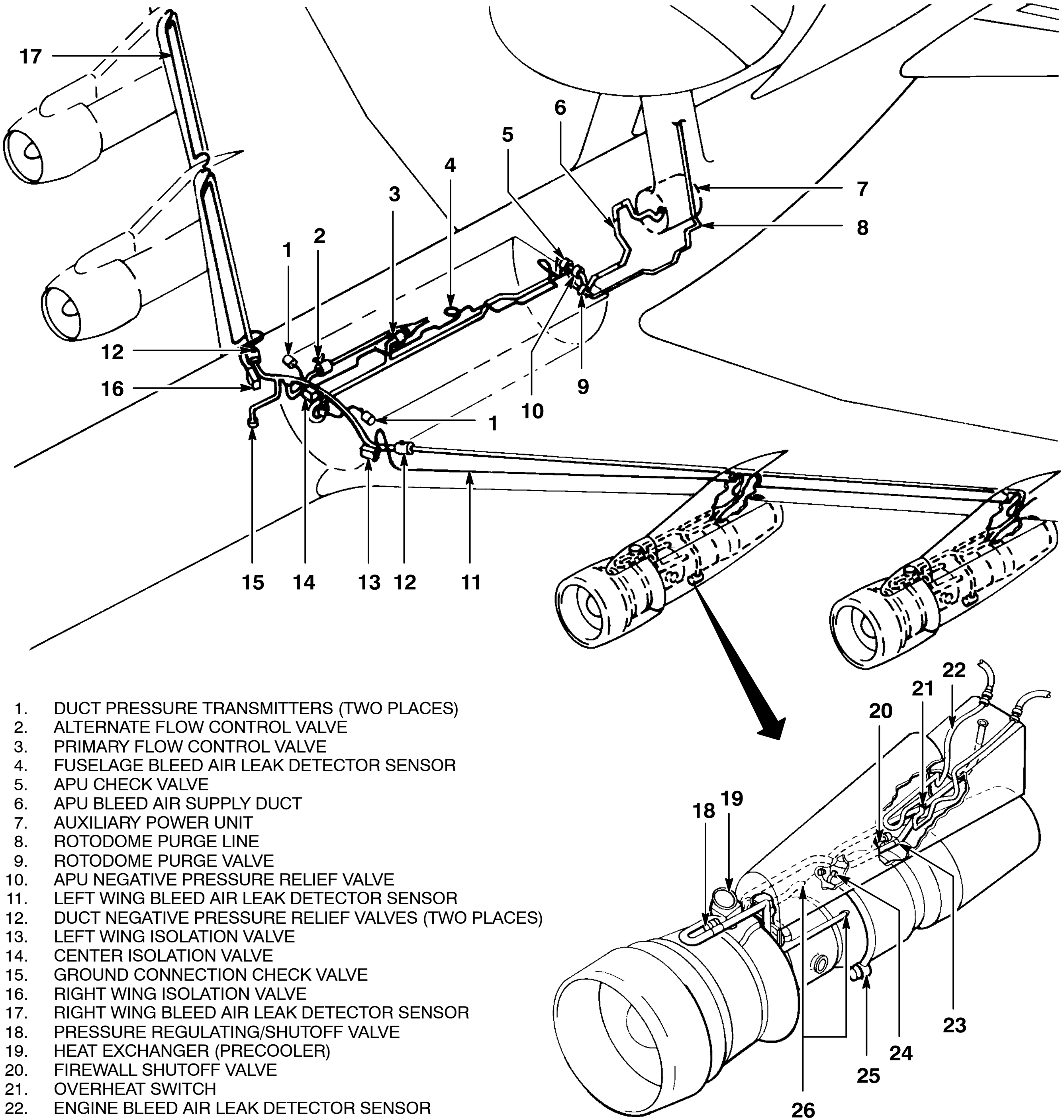
LEAK DETECTION

Leak detector loops are located near the wing manifold including engine struts down to firewall shutoff valve, and APU (fuselage) duct to warn of cracks and ruptures in the bleed air system (see *figure 1-193*). The wing manifold detectors are divided into two zones, left wing and right wing, and include the associated engine struts. The APU duct (fuselage) detector loop extends forward from the APU check valve near the forward pressure bulkhead in the aft lower compartment, through the pressure bulkhead, then inside the keel beam past the wheel wells, then through the air conditioning pack bay, ending at the pressure bulkhead between the air conditioning pack bay and the lower forward compartment. The detector loops are similar to the engine and wheel well fire detector loops. If a temperature of 310°F is reached (outside of the duct), in any engine strut above the firewall shutoff valve, the LEAK caution light on the bleed air control panel (*figure 1-195*) for the appropriate wing zone (left or right) illuminates. If a temperature of 225°F is reached anywhere along the wing or APU detector, the appropriate wing zone or APU duct (center) LEAK caution light illuminates and remains illuminated until the detector cools. The leak detector system can be tested by pressing the LEAK TEST switch caution light on the air conditioning control panel. When pressed, the LEAK TEST switch tests the detector loops, the controller, and the indicator lights. When the LEAK TEST switch is released, the leak detection loops and controller are reset. LEAK caution lights go out when detector cools.

NOTE

If a LEAK light remains illuminated or illuminates intermittently after a leak is corrected and detector has cooled, or remains illuminated after LEAK TEST switch is released, the detection system has malfunctioned.

Bleed Air System Component Locations



1. DUCT PRESSURE TRANSMITTERS (TWO PLACES)
2. ALTERNATE FLOW CONTROL VALVE
3. PRIMARY FLOW CONTROL VALVE
4. FUSELAGE BLEED AIR LEAK DETECTOR SENSOR
5. APU CHECK VALVE
6. APU BLEED AIR SUPPLY DUCT
7. AUXILIARY POWER UNIT
8. ROTODOME PURGE LINE
9. ROTODOME PURGE VALVE
10. APU NEGATIVE PRESSURE RELIEF VALVE
11. LEFT WING BLEED AIR LEAK DETECTOR SENSOR
12. DUCT NEGATIVE PRESSURE RELIEF VALVES (TWO PLACES)
13. LEFT WING ISOLATION VALVE
14. CENTER ISOLATION VALVE
15. GROUND CONNECTION CHECK VALVE
16. RIGHT WING ISOLATION VALVE
17. RIGHT WING BLEED AIR LEAK DETECTOR SENSOR
18. PRESSURE REGULATING/SHUTOFF VALVE
19. HEAT EXCHANGER (PRECOOLER)
20. FIREWALL SHUTOFF VALVE
21. OVERHEAT SWITCH
22. ENGINE BLEED AIR LEAK DETECTOR SENSOR
23. CHECK VALVE
24. STARTER CONTROL VALVE
25. STARTER
26. SIXTEENTH STAGE BLEED PORTS

D57 465 SI

Figure 1-193

Bleed Air System Schematic

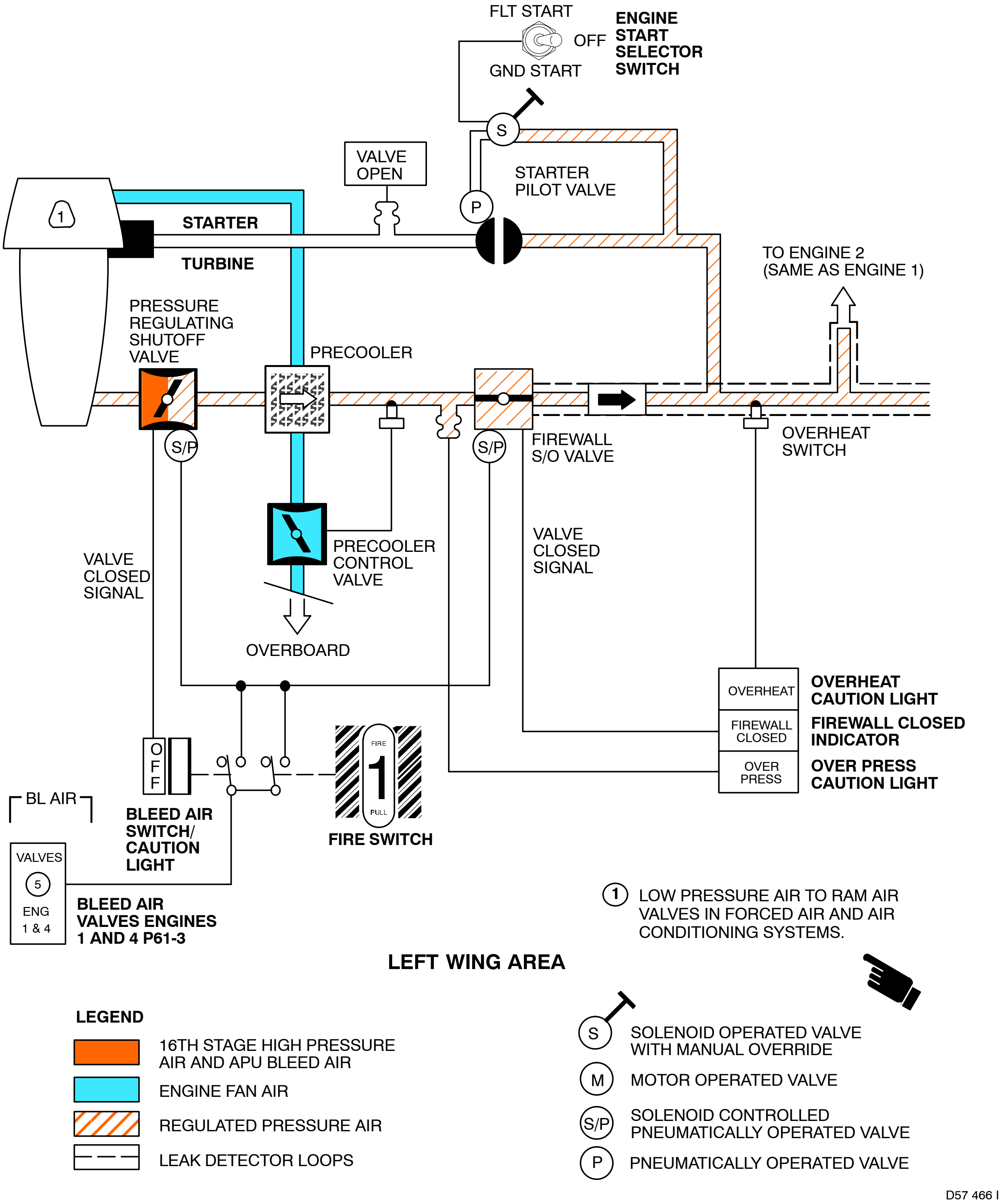


Figure 1-194 (Sheet 1 of 2)

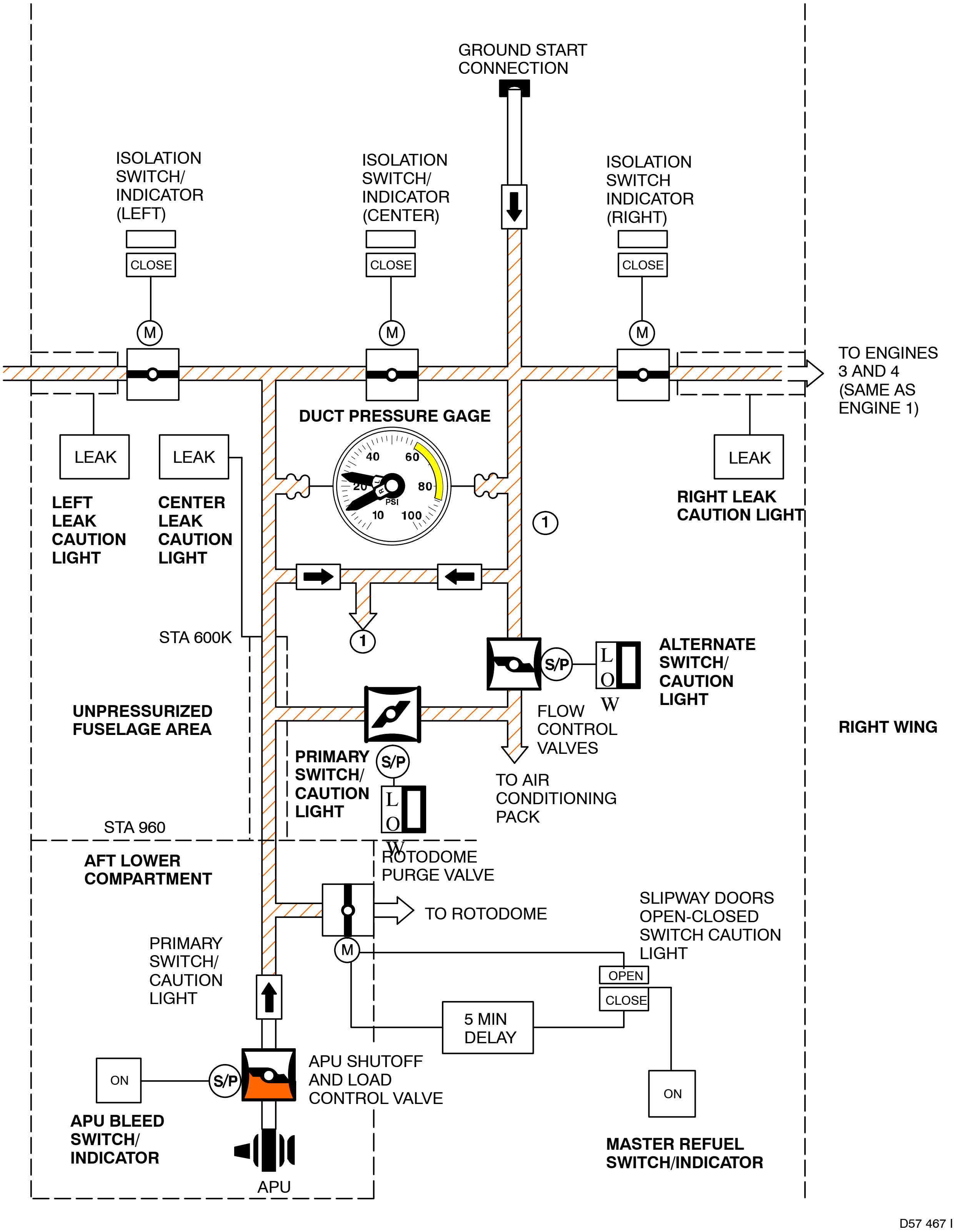


Figure 1-194 (Sheet 2 of 2)

Bleed Air System Controls and Indicators

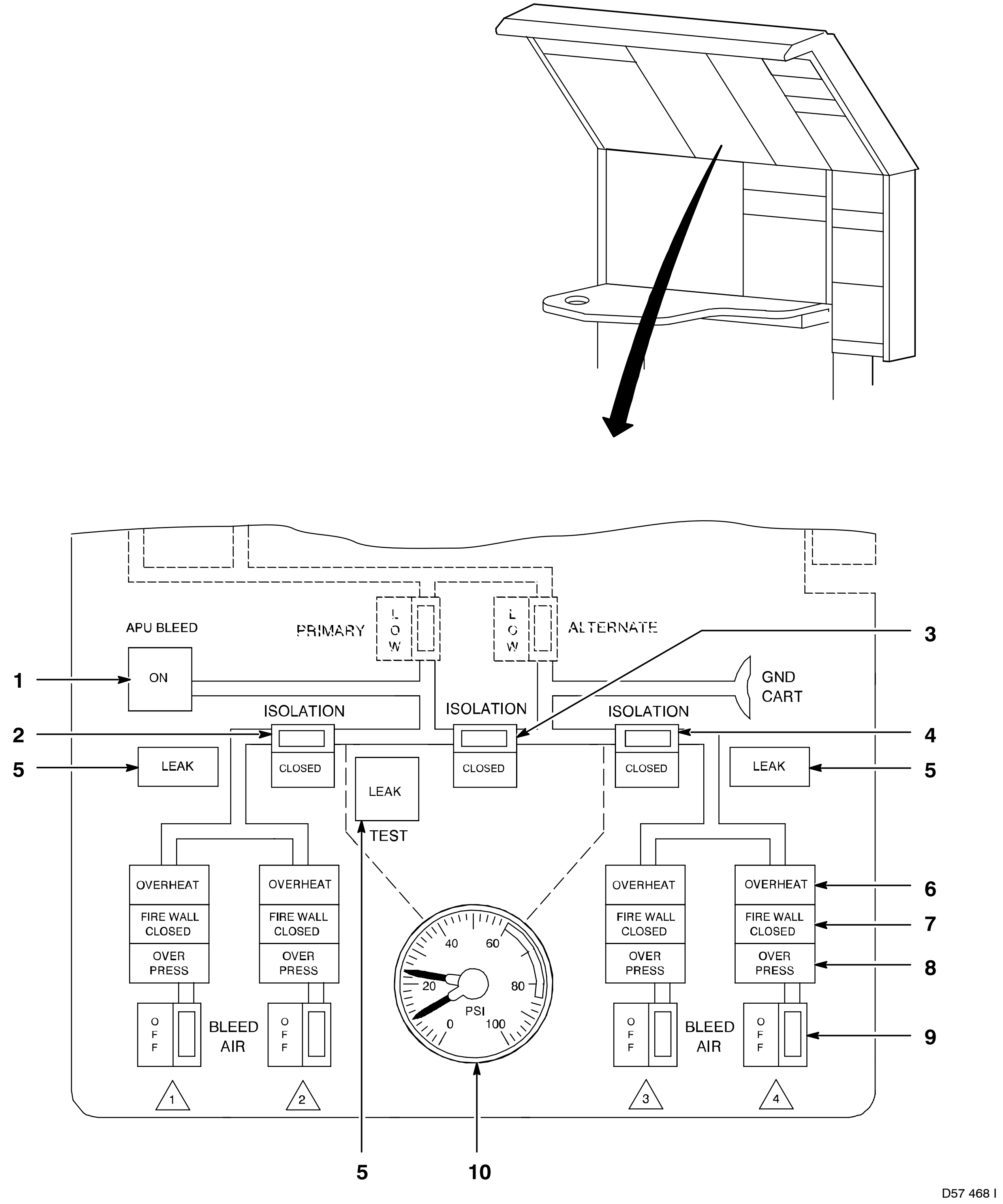


Figure 1-195 (Sheet 1 of 3)

NO.	CONTROL/INDICATOR	FUNCTION
1	APU BLEED Switch/Indicator (Green)	When depressed, the ON indicator illuminates and the APU bleed air valve control solenoid commands the APU bleed air valve to operate if the APU is running. The APU bleed air valve is a solenoid controlled pneumatically operated valve. When released, the ON indicator goes out and the APU bleed air valve control solenoid commands the APU bleed air valve to close.
2	Left ISOLATION Switch/ Indicator (Green/White) (Left)	When the switch is in the depressed position, the isolation valve is commanded to open. When the switch is in the released position, isolation valve is commanded closed to stop flow between left wing and fuselage. White line light illuminates when valve is commanded open. Green CLOSED indicator illuminates when valve is closed.
3	Center ISOLATION Switch/ Indicator (Green/White) (Center)	When the switch is in the depressed position, the isolation valve is commanded to open. When the switch is in the released position, isolation valve is commanded closed to shut off flow from left to right side of fuselage. White line light illuminates when valve is commanded open. Green CLOSED indicator illuminates when valve is closed.
4	Right ISOLATION Switch/ Indicator (Green/White) (Center)	When the switch is in the depressed position, the isolation valve is commanded to open. When the switch is in the released position, isolation valve is commanded closed to shut off flow between right wing and fuselage. White line light illuminates when valve is commanded open. Green CLOSED indicator illuminates when valve is closed.
5	LEAK Caution Lights (Left, Right) (Amber) and LEAK TEST Switch/Caution Light (Center) (Amber)	When illuminated, indicates a bleed air leak (or shorted detector) in left wing duct from left wing isolation valve down struts to left engines firewall shutoff valves (left light), from APU check valve through wheel well and air conditioning bay (center light, combined with TEST switch) or right wing duct from right wing isolation valve down struts to right engines firewall shutoff valves (right light). LEAK TEST switch, when pressed, tests all three leak detector loops, causing leak lights to illuminate. When released, detectors are reset.

NOTE

If a LEAK light remains illuminated or illuminates intermittently after a leak is corrected and detector has cooled, or remains illuminated after LEAK TEST switch is released, the detection system has malfunctioned.

Figure 1-195 (Sheet 2 of 3)

Bleed Air System Controls and Indicators (Continued)

NO.	CONTROL/INDICATOR	FUNCTION
6	OVERHEAT Caution Light (4 Places) (Amber)	When illuminated, indicates precooler discharge air temperature reached 505 ± 10°F.
7	FIREWALL CLOSED Indicator (Green) (4 Places)	When illuminated, indicates firewall shutoff valve is fully closed.
8	OVER PRESS Caution Light (Amber) (4 Places)	Illuminates when engine bleed duct pressure increases above 80 to 85 psig. Goes out when engine bleed duct pressure goes below 78 to 74 psig.
9	BLEED AIR Switch/Caution Light (Amber/White) (4 Places)	When depressed, with engine running, commands engine bleed air pressure regulating/shutoff valve at engine and firewall shutoff valve to open. White line light illuminates when valves commanded open. In released position, the bleed air valve is commanded closed, and line light goes out. The amber OFF caution light illuminates when bleed air valve is fully closed. Also in released position, firewall shutoff valve is commanded closed. If engine is not running or bleed air pressure is low, valves do not always move far enough to illuminate OFF and FIREWALL CLOSED indicators.
10	Duct Pressure Gage (Dual gage)	Dual pointers indicate air pressure in left (L) and right (R) wing ducts in psig.

Figure 1-195 (Sheet 3 of 3)

APU BLEED AIR SYSTEM

Bleed air from the APU is ducted through a check valve to the left half of the wing manifold. APU bleed air pressure is not regulated. Flow of APU bleed air is modulated by the APU shutoff and load control valve which is solenoid controlled and pneumatically operated.

This valve is opened by pressing the APU BLEED switch. Once the valve is open, it modulates the flow of APU bleed air according to APU speed and EGT. If the APU speed begins to drop off or the EGT approaches 650°C, the APU shutoff and load control valve reduces the amount of bleed air so the APU speed or EGT can return within limits. If, by eliminating bleed air, the APU cannot maintain the EGT within limits, the APU generator must be manually tripped off the line and the APU must be shut down. The APU shutoff and load control valve automatically closes when the APU is shut down. The valve also closes when the APU fire switch is pulled.

EXTERNAL AIR SOURCE

A ground connection for an external air source is provided under the right wing root. The ground connection is used to connect ground gas turbine compressors for engine starting or to provide high pressure hot air for air conditioning on the ground. If used for air conditioning and smoke and smell are detected, switch to a ground cooling cart or APU.

BLEED AIR SYSTEM OPERATION

The bleed air manifold can be supplied with air from the engines, the APU, or a ground source.

BLEED AIR SUPPLY FROM AN OPERATING ENGINE

1. Set appropriate ISOLATION switch/indicator to open. For normal operation, all isolation valves are open.
2. Set BLEED AIR switches to on as appropriate.
3. Observe that FIREWALL CLOSED indicator and OVERPRESS caution light are out.

BLEED AIR SUPPLY FROM APU

1. Set appropriate ISOLATION switch/indicator to open. For normal operation, all isolation valves are open.
2. Set APU BLEED switch to ON.

BLEED AIR SUPPLY FROM GROUND AIR SOURCE

1. Attach hose to ground connector (15, *figure 1-193*).
2. Set ISOLATION switch/indicators as required. For normal operation, all isolation valves open.
3. Turn on ground air source.

BLEED AIR SHUTDOWN

To shut off bleed air, close engine or APU source valve, or turn off ground air source as required:

WARNING

Reduce engine power to idle on operating engines before disconnecting ground air. High-pressure bleed air can cause hose to whip and injure ground crew if check valve fails to close.

NOTE

Bleed air valve must be closed before engine stops in order for valve to close completely. If engine stops or bleed air pressure is low, valve does not always close far enough to illuminate OFF light.

BLEED AIR LEAKS

Bleed air leaks can be controlled by closing engine bleed air valves and the appropriate isolation valves. (Refer to BLEED AIR LEAK, section IIIA.)

CAUTION

The only indication of a bleed air leak upsteam of the PRSOV is a decrease in EPR and N_1 rpm. At TRT, 16th stage bleed air may exceed 800°F and 200 psia. Immediately retarding the throttle to idle will minimize further damage to engine and pylon components.

All bleed air ducts (except the APU bleed duct and duct section between the left and right isolation valves) are in unpressurized areas, vented to outside air. Bleed air is reduced in pressure and temperature before entering the manifold. Blow out panels in the struts and inboard wing allow air to vent overboard if a leak occurs in those areas. A bleed air leak in the vicinity of leading edge flaps or slats will escape through openings around the leading edge devices without causing overpressure of the wing structure. The greatest hazard is from the temperature of the escaping bleed air. After the bleed air precooler, the temperature is not great enough to cause immediate damage or fire. A bleed air leak downstream from the PRSOV is not a critical emergency in this airplane, although it should not be allowed to persist. Takeoff should not be aborted for a bleed air leak light unless there are other engine indications.

NOTE

- Since bleed air shutoff valves have a small hole in the valve to prevent surging, duct pressure does not decrease immediately to zero when bleed air valves are closed and no leak is present. Pressure does decrease rapidly to zero if a duct is leaking. If valve indicators show closed, leak is controlled.
- If a LEAK light remains illuminated or illuminates intermittently after a leak is corrected and detector has cooled, or remains illuminated after LEAK TEST switch is released, the detection system has malfunctioned.

AIR CONDITIONING SYSTEM

The air conditioning system, which includes the air conditioning pack, associated valves and controls, and the zone temperature control system, provides temperature regulated air to the flight deck, mission crew compartment, and lower compartments. Hot, compressed air from the bleed air system is supplied to the air conditioning pack through either the primary or alternate flow control valve located in the air conditioning bay. After the hot bleed air passes through either flow control valve, it enters the air conditioning pack where the air pressure and temperature are reduced to the levels necessary for airplane cooling. Cold air from the air conditioning pack is mixed with hot bleed air by the zone temperature control system to maintain the desired temperatures throughout the airplane. Air conditioning system component locations are shown in *figure 1-196*. Air conditioning system controls and indicators are described in *figure 1-197*. Under normal operating conditions, the system supplies a complete change of cabin air in 5 to 6 minutes.

AIR CONDITIONING DISTRIBUTION

Conditioned air (*figure 1-198*) inside the airplane is distributed into four zones; forward, mid and aft mission crew compartment zones and the flight deck zone. Air is supplied to the mission crew compartment zones through ducts in the right sidewall to overhead outlets. The air circulates and flows out through the sidewall vents to the lower compartments, then overboard through the outflow valves. Air also flows through the electronic consoles and certain other equipment, then overboard via the drawthrough cooling system. Conditioned air is supplied to the flight deck zone through outlets along the side windows, under the windshield, near the pilots' feet, and above the navigator's seat. Temperatures in these zones are adjusted by the zone temperature control system.

Additional gasper air outlets are provided at each crew station and in crew rest areas (*figure 1-198*). Gasper air has the same temperature as the air leaving the air conditioning pack. Ventilation is provided by exhausting air overboard through the pressurization outflow valves, the galley and lavatory vents, and the draw-through cooling system.

FOOT AND SHOULDER HEATERS

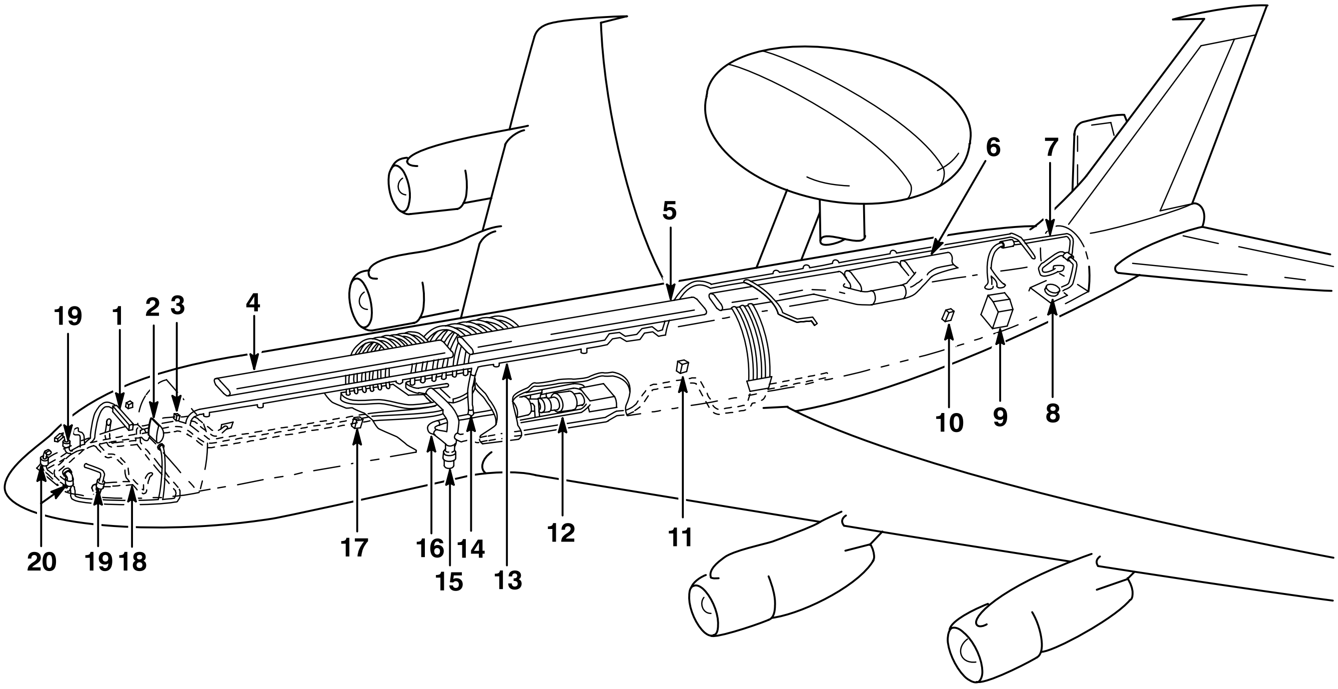
Additional hot air can be supplied to the pilots by the electric shoulder and foot heaters located in the flight deck zone distribution ducts supplying air to the side window outlets and the outlets near the pilots feet. These heaters provide additional heat to relieve the cold soak effect of long flights at high altitude. The switches controlling these heaters are located on the pilots side panels (*figure 1-10*). Power is provided from AVAC bus 4 through CREW HTR ØB and CREW HTR ØC circuit breakers on panel P61-3. ØB powers the LOW position of all heaters; both ØB and ØC power HIGH positions. Power is removed from the HIGH switch position by the left squat switch so that only LOW heat is available on the ground. Overheat protection is internal to each heater. Switches should be OFF unless air conditioning pack is on.

FLOW CONTROL VALVES

The flow control valves modulate the amount of air that enters the air conditioning pack. They also provide the means to shut off airflow into the pack. The primary flow control valve is normally selected during all operations.

The primary flow control valve is opened by pressing the PRIMARY switch caution light. If this valve fails to move from the closed position within five seconds of pressing the PRIMARY switch, the alternate flow control valve opens automatically. When the primary flow control valve is open, pressing the ALTERNATE switch caution light does not open the alternate flow control valve. If the ALTERNATE switch caution light is pressed first and the alternate flow control valve fails to open, the primary flow control valve does not open automatically. Unless a malfunction exists, any time the PRIMARY switch caution light is pressed (regardless of the alternate flow control valve position) the primary flow control valve is commanded open and the alternate flow control valve is commanded to close. If an automatic transfer from the primary to alternate flow control valve occurs, the PRIMARY switch caution light must be pressed upon system shutdown to reset the automatic transfer function. The pack bypass valve and ram air door cannot be operated manually and the trim air shutoff valve is inoperative until either the PRIMARY or ALTERNATE switch caution light is pressed and line light illuminates. If a flow control valve fails open, the other flow control valve can be used to control the air flow by closing the center bleed air isolation valve and the appropriate left or right bleed air isolation valve. When ac electrical power is lost and the airplane operates on emergency battery power, both flow control valves are open but they only operate on the low flow schedule (approximately 2/3 normal flow each). In this case, the line light and the LOW indicator of the PRIMARY and ALTERNATE switch/caution lights are illuminated. Also, when either switch/caution light is pressed, both flow control valves close.

Air Conditioning System Component Locations



1.	FLIGHT DECK ZONE DISTRIBUTION SYSTEM	12.	AIR CONDITIONING PACK
2.	URINAL VENTILATION SYSTEM	13.	GASPER AIR SYSTEM
3.	FLIGHT DECK ZONE TEMPERATURE SENSOR	14.	PACK EXHAUST DUCT
4.	FORWARD ZONE DISTRIBUTION SYSTEM	15.	GROUND CONNECTION
5.	MID ZONE DISTRIBUTION SYSTEM	16.	MAIN DISTRIBUTION MANIFOLD
6.	AFT ZONE DISTRIBUTION SYSTEM	17.	FORWARD ZONE TEMPERATURE SENSOR
7.	GALLEY AND LAVATORY VENTILATION SYSTEM	18.	FLIGHT DECK GASPER AIR DISTRIBUTION DUCTING
8.	LAVATORY	19.	SHOULDER HEATERS
9.	GALLEY	20.	FOOT HEATERS
10.	AFT ZONE TEMPERATURE SENSOR		
11.	MID ZONE TEMPERATURE SENSOR		

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Figure 1-196

Air Conditioning System Controls and Indicators

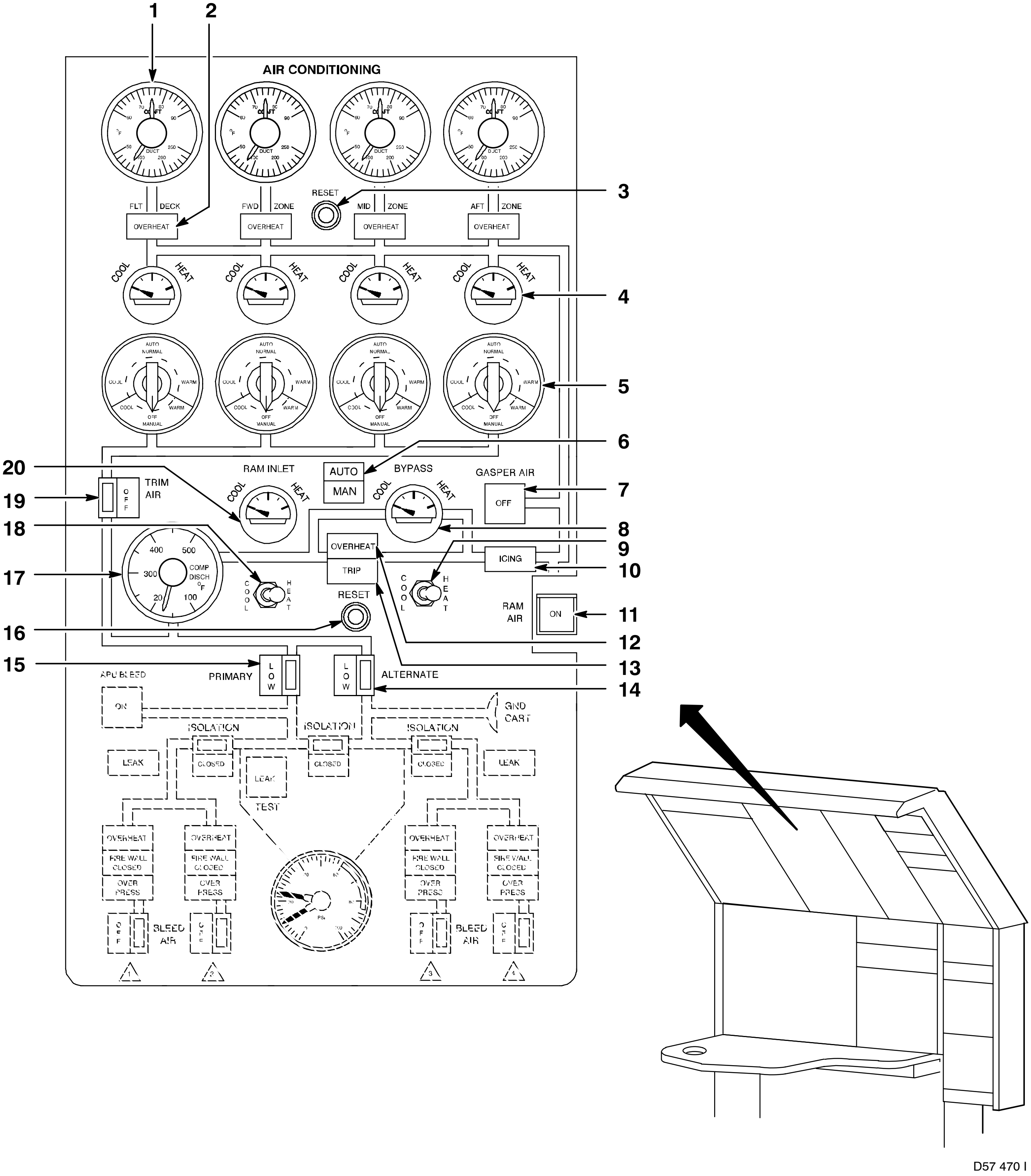


Figure 1-197 (Sheet 1 of 4)

NO.	CONTROL/INDICATOR	FUNCTION
1	COMPT – DUCT Temperature Gages (4 Places)	Indicate temperature in compartment (COMPT) and supply duct (DUCT), in degrees F, for flight deck, forward, mid, and aft zones.
2	Zone OVERHEAT Caution Lights (4 Places) (Amber)	When illuminated, indicate duct temperature above 205 ± 5°F. Caution light remains on until system is reset. One caution light for each duct.
3	Zone Overheat RESET Button	When pressed after overheat condition is past, resets zone temperature controller. Zone OVERHEAT caution lights go out when zone temperature controller is reset.
4	COOL – HEAT Valve Position Gages (4 Places)	Indicate relative position of zone trim air valve. One gage for each zone trim air valve.
5	AUTO NORMAL – MANUAL Zone Temperature Selector Knobs (4 Places)	Set desired zone temperature, either automatically (AUTO NORMAL) or manually (MANUAL) maintained, depending on position of selector knobs. Turning knob to MANUAL WARM or MANUAL COOL causes zone temperature to raise or lower.
6	Pack AUTO–MAN Switch/ Indicator (Green)	When depressed, selects automatic mode of operation for air conditioning pack. When released, selects manual mode. AUTO indicator illuminates when in automatic operation. MAN indicator illuminates when manual mode is selected. AUTO–MAN indicator illuminates only if air is flowing through either the primary or alternate flow control valve.
7	GASPER AIR Switch/Indicator (Green)	When depressed, turns gasper air fan on. When released, turns fan off. OFF indicator illuminates when fan is off.
8	BYPASS Position Gage	Indicates relative position of pack bypass valve.
9	BYPASS COOL–HEAT Switch (BYPASS Switch) (Momentary)	Operates pack bypass valve when AUTO–MAN switch set to MAN. When held to HEAT, moves valve toward full open position. When held to COOL, moves valve toward full closed position. Spring loaded to off.
10	ICING Caution Light (Amber)	ICING caution light illuminates to indicate the pressure drop across water separator is too high. Ice or dirt in the water separator causes the pressure drop to increase. Caution light goes out when pressure drop decreases to within limits.

Figure 1-197 (Sheet 2 of 4)

Air Conditioning System Controls and Indicators (Continued)

NO.	CONTROL/INDICATOR	FUNCTION
11	RAM AIR Switch/Indicator (Green) (Guarded)	When depressed, opens ram air valve and closes both flow control valves. ON indicator illuminates when the ram air valve is not fully closed. The airplane depressurizes when the RAM AIR switch is depressed (because both flow control valves close). When in released position, closes ram air valve and allows flow control valves to operate.
12	Pack OVERHEAT – Caution Light (Amber)	OVERHEAT caution light illuminates when either the compressor discharge 425°F overtemperature switch or the pack discharge 205°F overtemperature switch has closed. The caution light goes out when the system is reset using the pack overheat RESET button.
13	TRIP Caution Light (Amber)	TRIP caution light illuminates to indicate pack tripoff, due to zone duct temperature above 250 ± 10°F.
14	ALTERNATE Switch/Caution Light (Amber)	When depressed, commands alternate flow control valve to operate. Line light illuminates when valve is operating. When in released position, valve is commanded closed and line light goes out when valve is closed. LOW caution light illuminates when ACM compressor 450°F overtemperature switch actuates or when operating on battery only.
15	PRIMARY Switch/Caution Light (Amber)	When depressed, commands primary flow control valve to operate. Line light illuminates when valve is operating. When in released position, valve is commanded closed and line light goes out when valve is closed. LOW caution light illuminates when ACM compressor 450°F overtemperature switch actuates or when operating on battery only.
16	Pack Overheat RESET Button	When pressed after overheat condition passed, resets pack temperature controller to normal operation and allows a flow control valve to operate. If reset is accomplished, the pack TRIP caution light goes out and/or pack OVERHEAT caution light goes out.
17	COMP DISCH (Compressor Discharge) Temperature Gage	Indicates temperature of air leaving ACM compressor in degrees F.
18	RAM INLET COOL – HEAT Switch (RAM INLET Switch) (Momentary Switch)	Manual control for ram air door. Operates when AUTO–MAN switch set to MAN. When held to HEAT, moves door toward closed. When held to COOL, moves door toward open. Spring loaded to OFF.

Figure 1-197 (Sheet 3 of 4)

NO.	CONTROL/INDICATOR	FUNCTION
19	TRIM AIR Switch/Indicator (Green/White)	When depressed, the white line light is illuminated and the trim air valve solenoid commands the trim air valve to operate. The trim air valve is a solenoid controlled pneumatically operated valve. When the trim air valve is commanded to operate and at least one zone trim air valve is open, the trim air valve opens and regulates air pressure to the zone trim air valves. When the downstream air pressure cannot be maintained at approximately 3 1/2 psig, the trim air valve closes and the green OFF indicator is illuminated. When released, the white line light is out and the valve solenoid is spring loaded to command the trim air valve closed. When the trim air valve is closed, the OFF indicator is illuminated.
20	Ram Inlet Door Position Gage	Indicates relative position of ram air inlet door.

Figure 1-197 (Sheet 4 of 4)

Air Conditioning Distribution

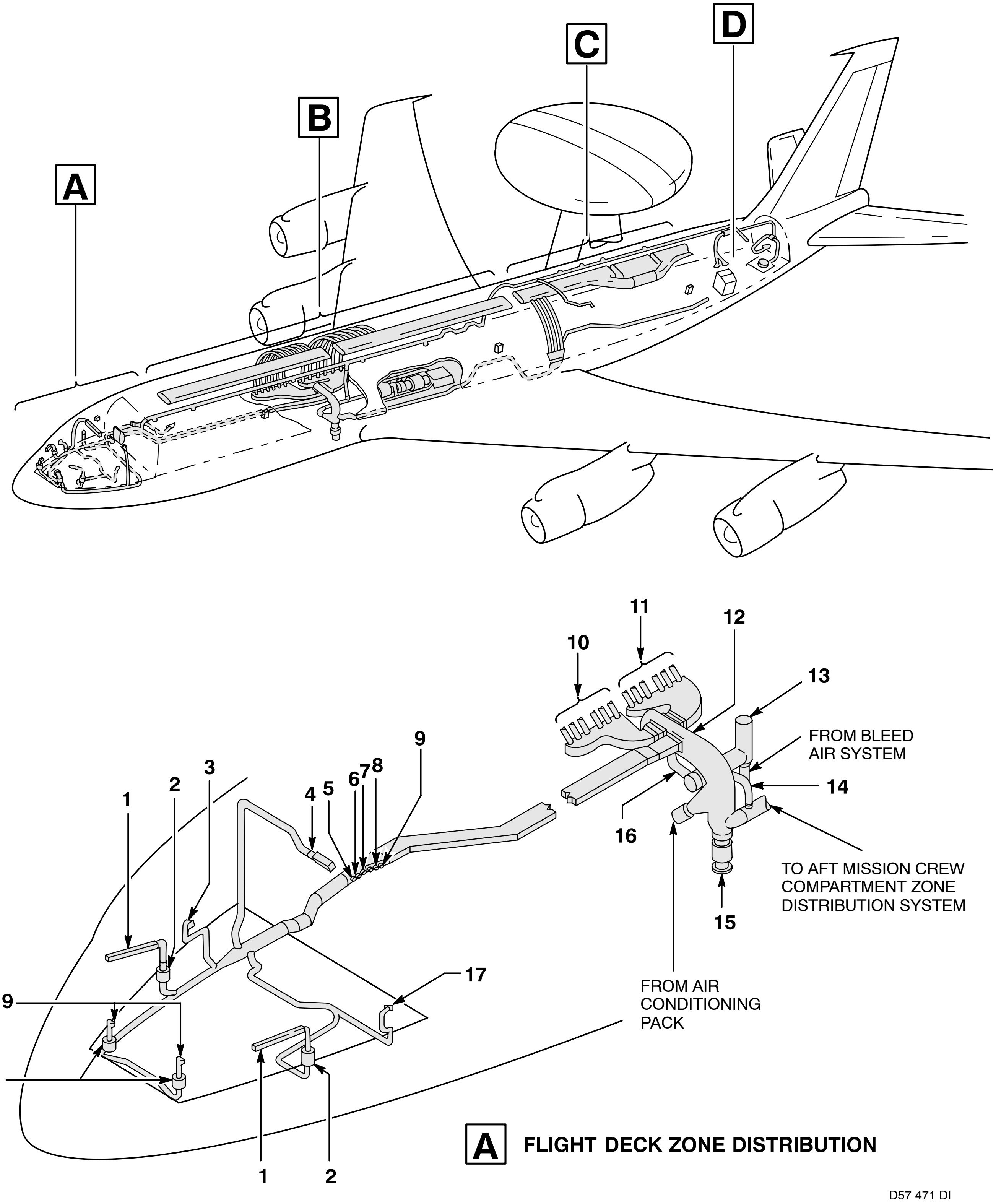
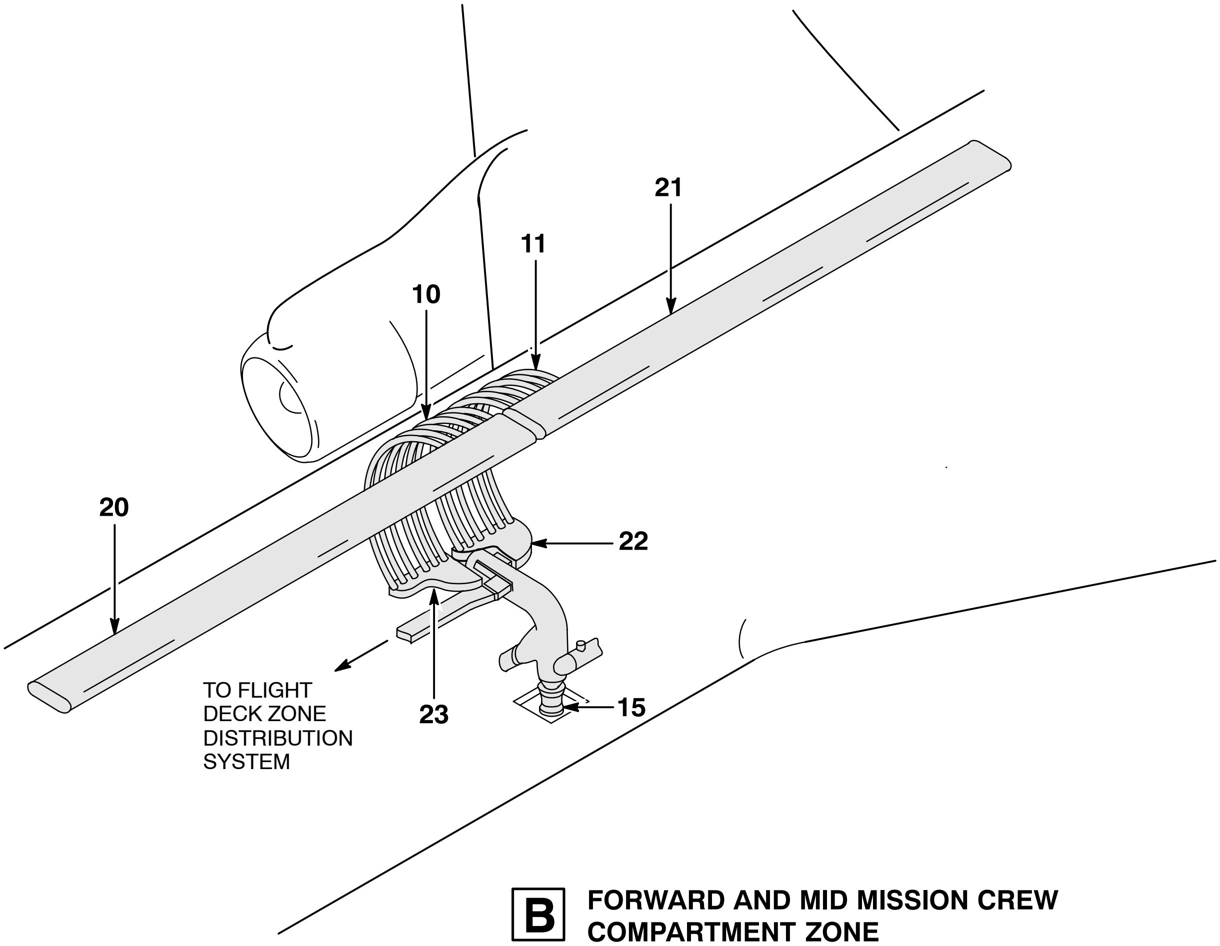


Figure 1-198 (Sheet 1 of 4)



B **FORWARD AND MID MISSION CREW COMPARTMENT ZONE DISTRIBUTION SYSTEMS**

1. SHOULDER HEATER OUTLET
2. SHOULDER HEATER
3. FLIGHT ENGINEER OUTLET
4. OVERHEAD OUTLET
5. PRIMARY ZONE DUCT LIMIT SWITCH
6. ALTERNATE ZONE DUCT LIMIT SWITCH
7. ZONE DUCT OVERTEMPERATURE SWITCH
8. ZONE DUCT TEMPERATURE SENSOR
9. ZONE DUCT TEMPERATURE BULB
10. FORWARD CABIN ZONE RISER DUCT (6 PLACES)
11. MID CABIN ZONE RISER DUCT (6 PLACES)
12. MAIN DISTRIBUTION MANIFOLD
13. TRIM AIR SURGE TANK
14. AFT CABIN TRIM AIR SUPPLY DUCT
15. GROUND CART CONNECTION
16. FLIGHT DECK TRIM AIR SUPPLY DUCT
17. NAVIGATOR OUTLET
18. FOOT HEATERS
19. FOOT HEATER OUTLET
20. FORWARD CABIN ZONE OVERHEAD PLENUM
21. MID CABIN ZONE OVERHEAD PLENUM
22. MID CABIN ZONE SUPPLY DUCT
23. FORWARD CABIN ZONE SUPPLY DUCT

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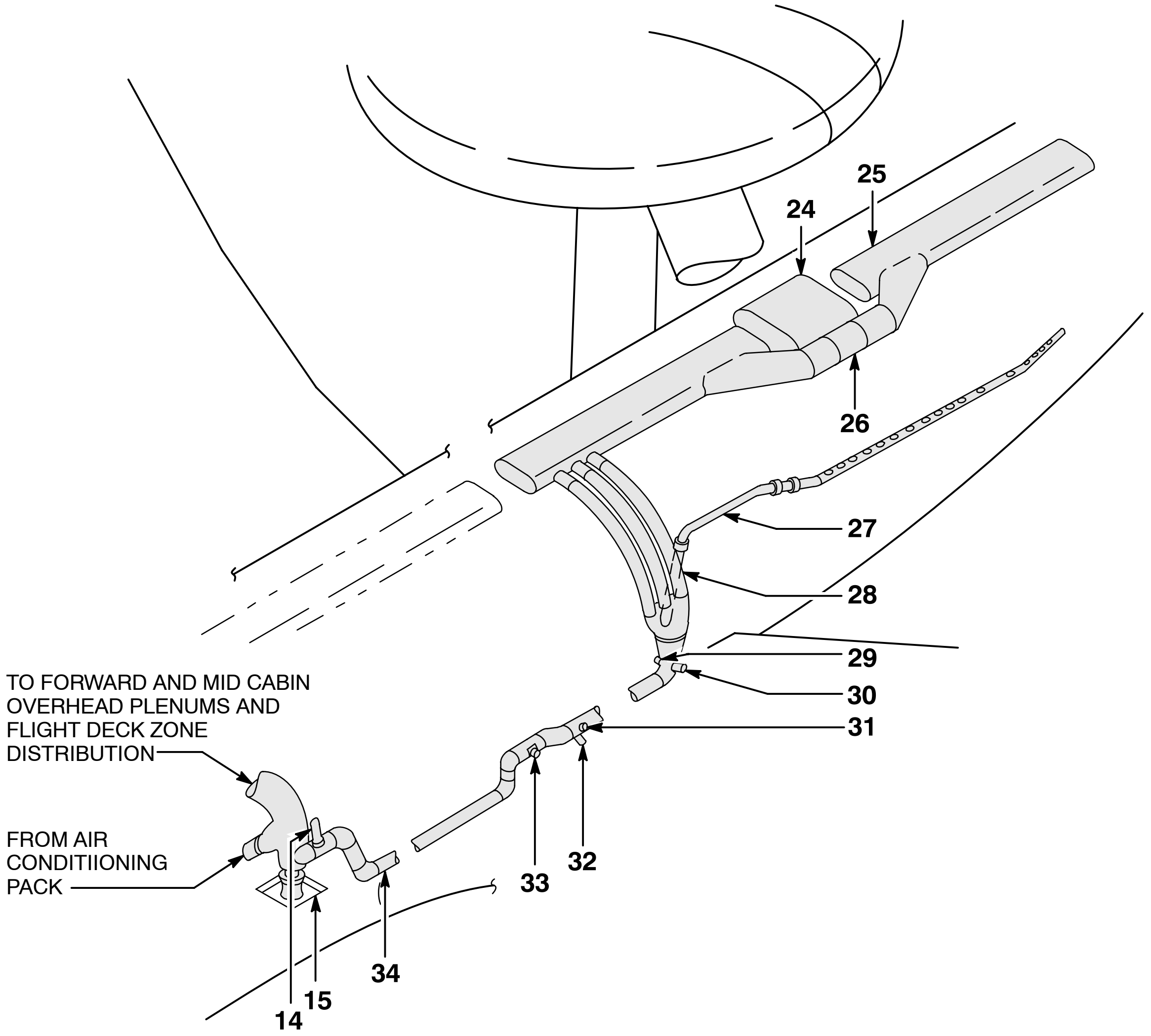
Figure 1-198 (Sheet 2 of 4)

Air Conditioning Distribution (Continued)



C **AFT MISSION CREW COMPARTMENT ZONE DISTRIBUTION SYSTEM**

24. WATER TANK
25. AFT CABIN OVERHEAD PLENUM
26. WATER TANK BYPASS DUCT
27. WAVE GUIDE COOLING DUCT
28. RISERS
29. PRIMARY ZONE DUCT LIMIT SWITCH
30. ALTERNATE ZONE DUCT LIMIT SWITCH
31. ZONE DUCT OVERTEMPERATURE SWITCH
32. ZONE DUCT TEMPERATURE BULB
33. ZONE DUCT TEMPERATURE SENSOR
34. AFT CABIN ZONE SUPPLY DUCT

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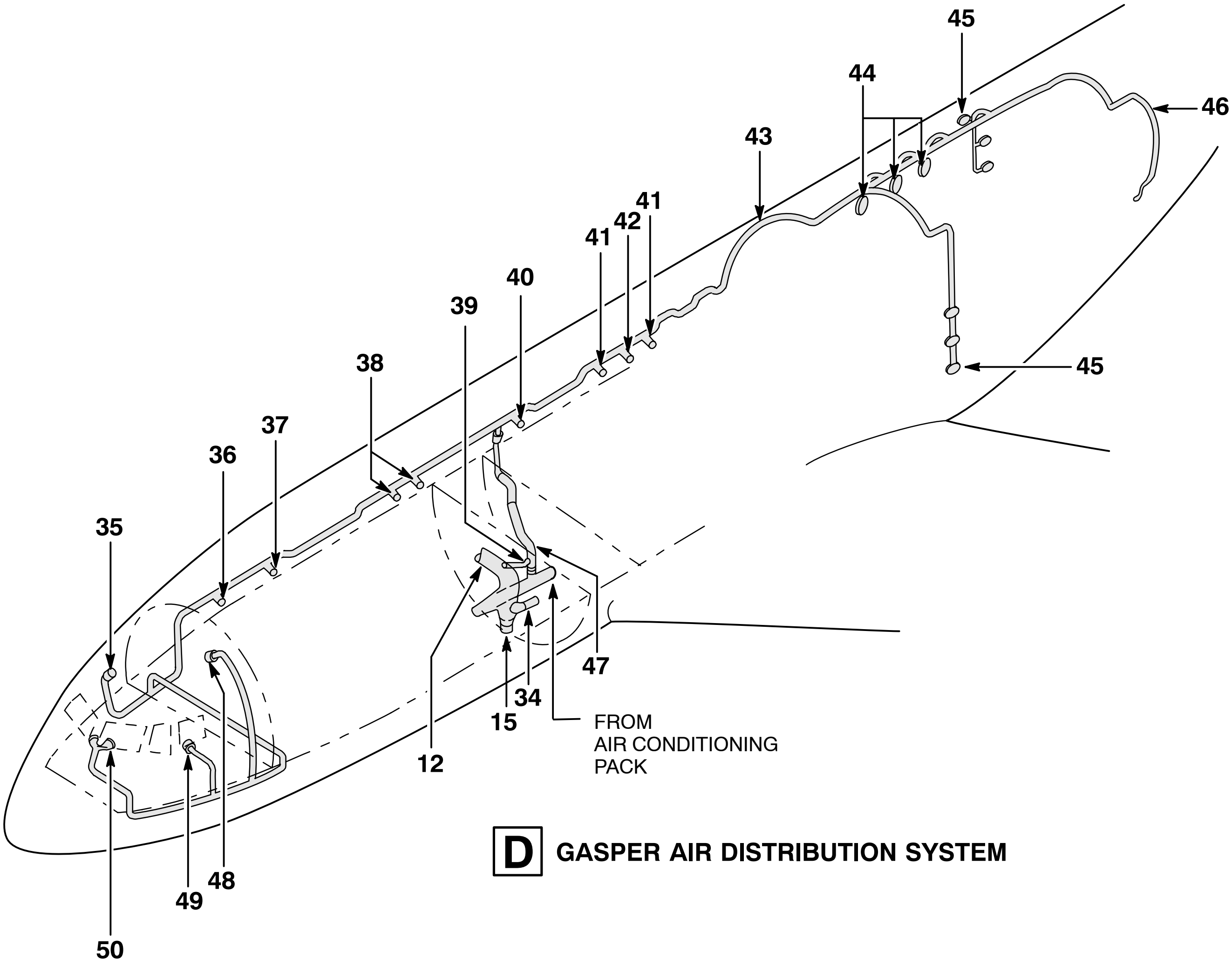
Figure 1-198 (Sheet 3 of 4)



35.	FLIGHT ENGINEER AIR OUTLET	43.	GASPER AIR DISTRIBUTION MANIFOLD
36.	COMMUNICATIONS CONSOLE AIR OUTLET	44.	REST SEATS CREW SERVICE UNIT
37.	DATA DISPLAY CONSOLE AIR OUTLET	45.	CREW BERTHS SERVICE UNITS (3 PLACES)
38.	MULTIPURPOSE CONSOLES AIR OUTLET	46.	LAVATORY AIR OUTLET
39.	SURGE DUCT	47.	GASPER FAN
40.	MULTIPURPOSE CONSOLES AND SPECIAL PURPOSE CONSOLE AIR OUTLET	48.	NAVIGATOR AIR OUTLET
41.	OUTLET NOT IN USE	49.	OBSERVER AIR OUTLET
42.	RADAR MAINTENANCE TECHNICIAN CONSOLE AIR OUTLET	50.	PILOT AND COPILOT AIR OUTLETS

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Figure 1-198 (Sheet 4 of 4)

NOTE

If EMERGENCY DEPRESS switch on pressurization control panel is set to EMERGENCY DEPRESS, or UNPRESS switch on forced air system control panel is pressed, altitude limiters in the cabin outflow valves are overridden and the valves move towards the open position so that the valve position indicator needles reach the mid range position mark and both flow control valves close. When EMERGENCY DEPRESS switch is reset to off, alternate flow control valve opens. Press PRIMARY switch/caution light twice to open primary valve, close alternate valve and reset automatic transfer function.

AIR CONDITIONING PACK

The air conditioning pack (*figure 1-199*), includes the Air Cycle Machine (ACM), heat exchangers, water separator, and controls. The pack reduces the pressure and temperature of engine bleed air to the level desired for cabin air conditioning and pressurization. Air from the bleed manifold passes through a flow control valve and is cooled in the primary heat exchanger by ram (outside) air.

In flight, the amount of ram air available is controlled by the pack temperature controller (automatic mode) or manually by the flight engineer (manual mode). On the ground, the squat switch causes the ram air door to open completely (and prevents manual closing of the ram air door).

Air leaving the primary heat exchanger flows into the ACM compressor which adds heat energy to the air. Air then expands through the secondary heat exchanger (giving up the heat added by the compressor) and continues to expand through the turbine, giving up more energy. Any water vapor present condenses and is trapped in the water separator. Liquid water is piped from the separator and sprayed into the ram air side of the heat exchangers for better cooling.

When operated in the automatic mode, the pack temperature controller (in response to the zone temperature control system settings) modulates the ram air door and pack bypass valve, automatically mixing warm turbine bypass air with the turbine exhaust air to maintain a 35°F minimum temperature in the water separator. If the pressure drop across the water separator becomes too great, usually due to the formation of ice, the ICING caution light on the air conditioning control panel illuminates. If the air conditioning pack is operating in automatic mode when the ICING caution light illuminates, either the pack temperature controller is malfunctioning or the water separator is clogged with dirt, so operate the pack in manual mode. When operating in the manual mode, constant attention must be given to the system to ensure water separator does not accumulate ice.

If the ICING caution light illuminates when the pack is in manual mode, the pack bypass valve automatically opens to melt the ice out of the water separator. In this case (after the ICING caution light goes out), manually adjust the pack bypass valve to prevent further water separator icing. Air flowing from the water separator is ducted to the zone temperature control system and the gasper outlets. To cool the aircraft cabin down quickly, leave the ACM in the automatic mode, close the main TRIM AIR valve, and adjust zone temperature selectors to maximum MANUAL COOL. Operating the ACM in manual mode full cold will not cool the aircraft down quickly.

CAUTION

Operating air conditioning system in manual mode with max cooling (pack bypass valve closed) may cause ice to form in the water separator. If any cabin altitude or pressure fluctuations are detected in the system, open bypass valve or switch air conditioning system to AUTO.

During flight, to avoid overheat conditions, monitor the air conditioning system temperatures periodically. If the compressor discharge temperature approaches the overheat limits, select manual pack operation and open the ram inlet door to the full cool position. If this action does not cool down the pack, open the pack bypass valve.

AIR CONDITIONING PACK OVERHEAT

Air conditioning pack overheat detection is provided at two points, the ACM compressor and the water separator. When the ACM compressor discharge air reaches 425 ±10°F, the compressor discharge 425°F overtemperature switch removes power from the pack temperature controller, the pack OVERHEAT caution light illuminates, the pack bypass valve does not move, and (in flight) the ram air door is commanded to open. On the ground, the ram door is already full open due to a signal from the landing gear squat switch. When the compressor discharge temperature decreases to 385±10°F the pack can be reset.

If the temperature continues to rise and reaches 450 ±10°F maximum, the compressor discharge 450°F overtemperature switch causes the operating flow control valve to switch to the low flow mode. This mode limits the air flow to approximately 2/3 normal flow. In this case, both the LOW caution light and line light, of the operating flow control valve switch (PRIMARY or ALTERNATE) are illuminated.

Air Conditioning Pack Schematic

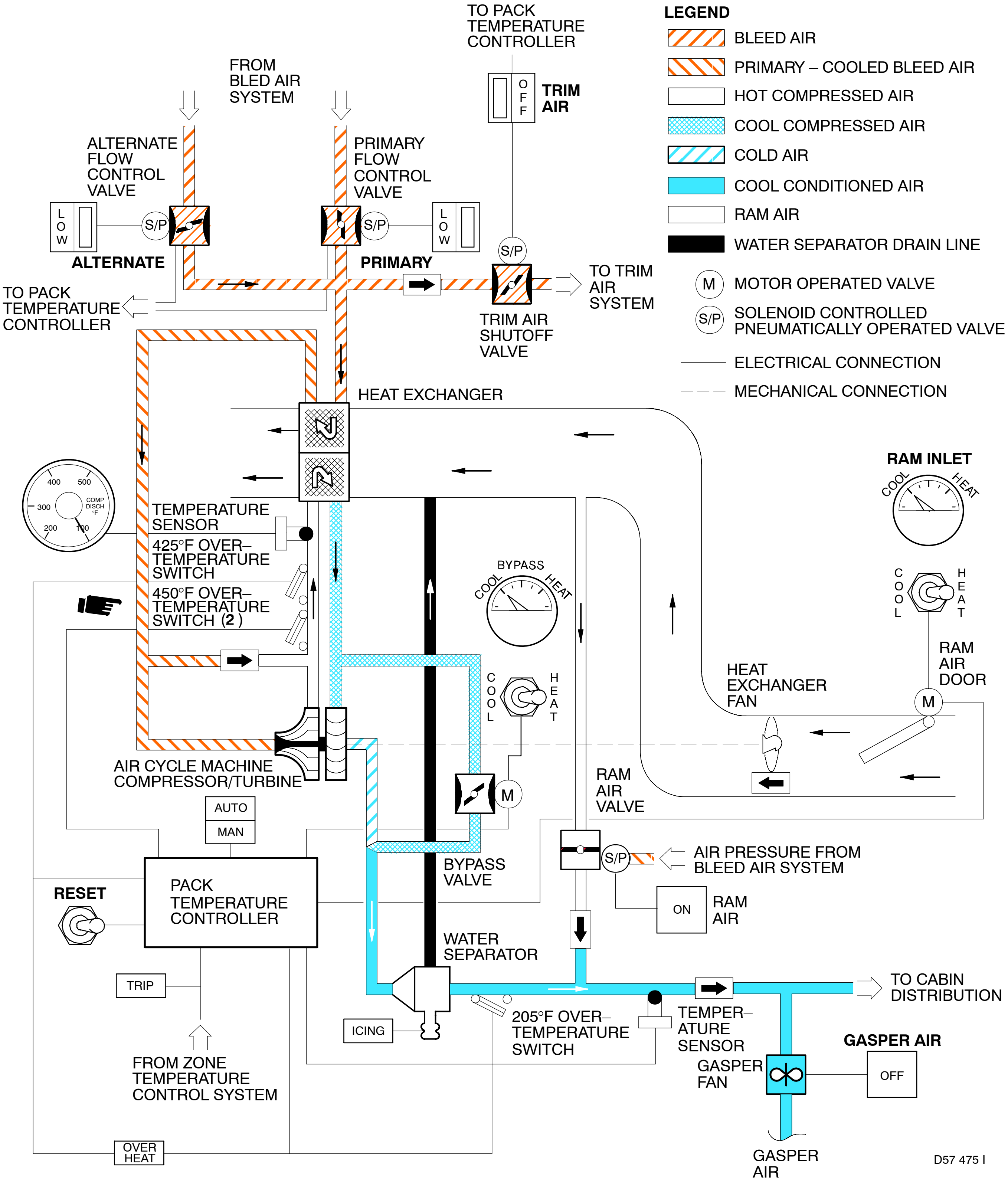


Figure 1-199

The LOW caution light of the other flow control valve also illuminates with the 450° overheat condition but the valve remains closed. The 450° overheat can be reset when the pack cools to 410 ± 10°F.

NOTE

> If, after an air conditioning pack overheat is reset, the compressor discharge temperature does not stabilize at or below 360°, operate the pack manually.

If the temperature at the water separator outlet reaches 205 ± 5°F, the pack discharge 205°F overtemperature limit switch causes the air conditioning pack to switch to the full cool mode (ram air door open, pack bypass valve closed). Until any air conditioning pack overheat is reset, manual control of the ram air door and pack bypass valve is not possible. If the compressor discharge 425°F overtemperature switch or pack discharge 205°F overtemperature switch is activated, the pack OVERHEAT caution light illuminates. Using the ram air door position, pack bypass valve position, configuration of the flow control valves, and the compressor outlet temperature indicator readings as clues, the location of the overheat can be determined.

If the following indications appear, an ACM compressor overheat to a temperature greater than 450 ± 10°F occurred. This type of overheat can be partially reset when the compressor discharge temperature decreases below 410 ± 10°F for approximately 15 seconds, and completely reset when discharge temperature is below 385 ± 10°F.

a. Compressor discharge temperature gage reads 440°F or greater.

b. Pack OVERHEAT caution light is illuminated.

c. Operating flow control valve switches to low flow mode (LOW caution light illuminated in both flow control valve switches and line light illuminated in operating flow control valve switch.) Indicates compressor discharge 450°F overtemperature switch has also actuated.

d. Pack bypass valve remains in previous position. (BYPASS position gage not moving.)

e. Ram air door full open. (RAM INLET door position gage shows full COOL.)

If the following indications appear, the temperature at the water separator outlet reaches 205 ± 5°F. This type of overheat can be reset when the temperature decreases to 174 ± 10°F.

a. Pack OVERHEAT caution light is illuminated

b. Ram air door is full open. (RAM INLET door position gage shows full COOL.)

c. Pack bypass valve is full closed. (BYPASS position gage indicates full COOL.)

d. Zone duct temperatures are high.

After the overheat is located and the temperature decreases to the point where the system can be completely reset, press the pack overheat RESET button. The pack RESET button must be pressed repeatedly or held in the reset position until the pack OVERHEAT caution light goes out, indicating the air conditioning system has reset. The pack RESET button returns both the air conditioning pack and the flow control valves to the configuration they were in prior to the overheat. This action also resets the overheat protection circuits.

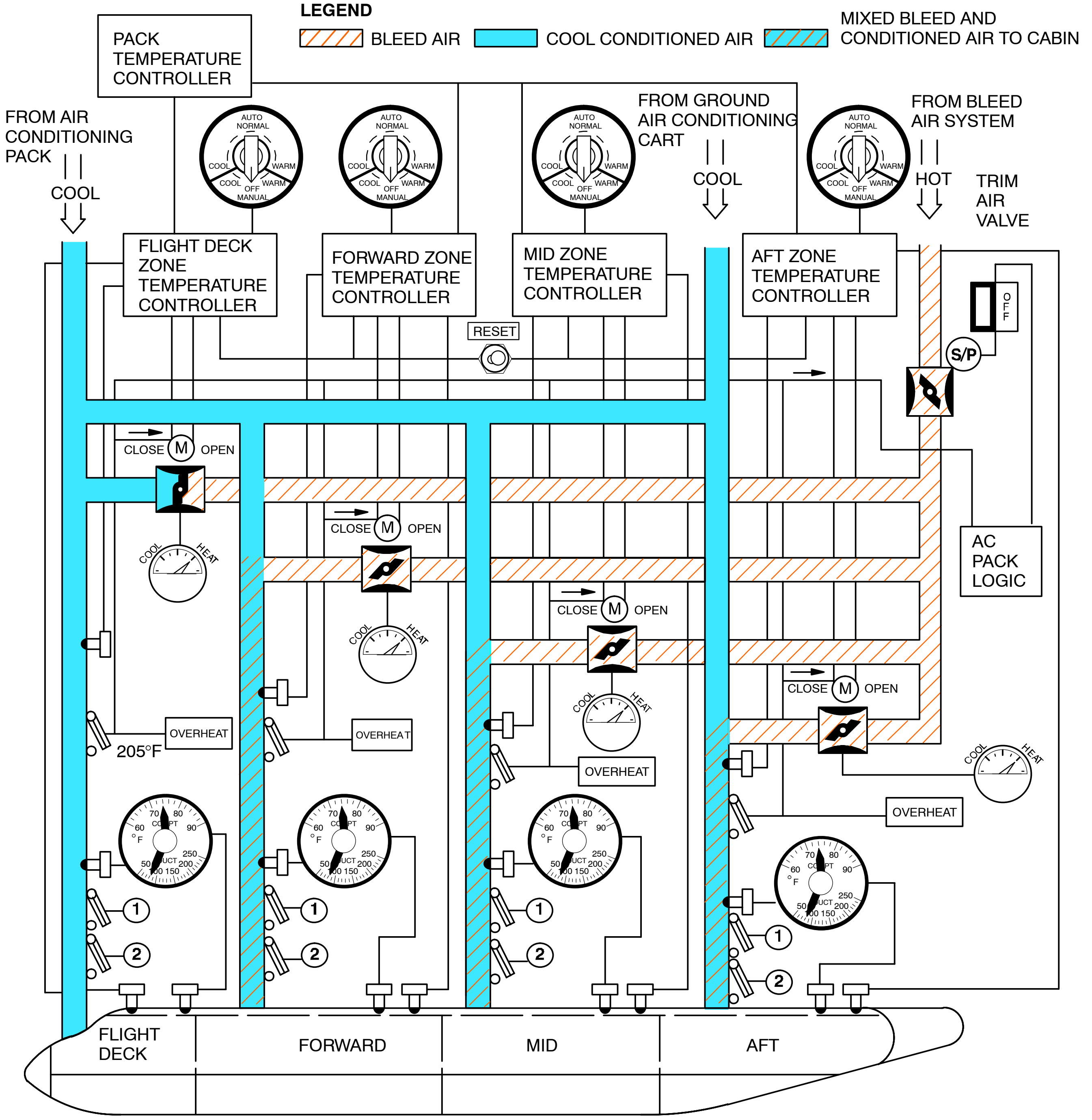
TEMPERATURE CONTROL

The airplane interior is divided into four zones for temperature control: Flight deck zone and forward, middle, and aft mission crew compartment zones. The zone temperature control system consists of four zone temperature selectors, four zone temperature controllers, and four motor-operated zone trim valves. The zone temperature controllers have two modes of operation: Automatic and manual. The zone temperature controllers use inputs from flight engineer panel switch settings, duct temperature sensors, and zone compartment temperature sensors and also incorporate temperature topping circuits to limit the zone duct temperatures. The zone temperature controllers mix hot bleed air and air conditioned air.

ZONE TEMPERATURE CONTROL SYSTEM

This system (*figure 1-200*) controls the temperature throughout the airplane interior. Control of airplane interior temperature by zones is necessary due to variations in equipment operation and crew seating. With all four zone temperature selectors and the air conditioning pack in automatic mode, the zone that requires the coolest air controls the temperature of the air coming from the ACM, down to a minimum of 35°F. Pack output temperature is controlled by the pack temperature controller which modulates the pack bypass valve and the ram air door to maintain the air temperature as required by the zone temperature selector with the minimum setting.

Air Conditioning Zone Temperature Control Schematic



① OVER 250°F CLOSES PRIMARY FLOW CONTROL VALVE

② OVER 250°F CLOSES ALTERNATE FLOW CONTROL VALVE

Ⓢ/Ⓟ SOLENOID CONTROLLED PNEUMATICALLY OPERATED VALVE

① ② OVER 250°F FOR ANY COMBINATION OF 1 AND 2 SHUTS DOWN AIR CONDITIONING PACK AND ILLUMINATES PACK TRIP CAUTION LIGHT

Ⓢ MOTOR OPERATED VALVE

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Figure 1-200

The zone trim air valve for the zone requiring the coolest air supply is closed. The temperature of the other three zones is maintained by mixing varying amounts of hot bleed air with the air coming from the ACM. This mixing is controlled by each zone temperature controller according to the position of the respective zone temperature selector and is accomplished by modulating each zone trim valve.

Zone Temperature Control System Automatic Operation

During automatic operation, the temperature of each zone can be increased or decreased by rotating the desired zone temperature selector toward AUTO WARM or AUTO COOL, as appropriate (selectors remain in set position). When a zone temperature selector (other than selector controlling temperature of air leaving the pack) is rotated toward AUTO WARM, the associated zone trim valve opens (indicated by COOL–HEAT valve position gage pointer moving toward HEAT), increasing the air temperature to the selected zone. When a zone temperature selector (other than selector controlling temperature of air leaving the pack) is rotated toward AUTO COOL, the associated zone trim valve closes (indicated by COOL–HEAT valve position gage pointer moving toward COOL), decreasing the air temperature to the selected zone. If the zone temperature selector controlling the temperature of the air conditioning pack is rotated toward AUTO WARM, the pack temperature controller increases the temperature of the air leaving the pack. If this zone temperature selector is rotated toward AUTO COOL, the pack temperature controller decreases (to a minimum of 35°F) the temperature of the air leaving the pack. Any time the zone temperature selector controlling the air conditioning pack is adjusted, the other zone temperature controllers readjust their associated zone trim valves to maintain the temperatures set by the associated zone temperature selectors.

The temperature of each zone duct and compartment is monitored by the corresponding COMPT DUCT temperature gage. During automatic operation, the zone temperature control system maintains the zone temperatures between 65°F and 85°F as selected by each zone temperature selector. As the temperature in a particular zone drops below the selected temperature, the affected zone temperature controller drives the associated zone trim valve further open (toward HEAT). As the temperature within a particular zone rises above the selected temperature, the affected zone temperature controller drives the associated zone trim valve toward closed (COOL).

Zone Temperature Control System Manual Operation

Manual operation of the zone temperature control system is accomplished by setting the zone temperature selector knobs to MANUAL, allowing manual control of the zone trim valves. Manual temperature control within each zone is accomplished by incremental movement of the affected zone trim valve (zone temperature selector knob to MANUAL COOL or MANUAL WARM), until compartment and zone duct temperatures are as desired. When the zone temperature selector knob is released, it returns to the center OFF position. The zone trim valve stays as positioned by the manual command. Further manual adjustments of trim valve position may be made until zone temperature is as desired. As long as the air conditioning pack is operating in the automatic mode, the coolest air that can be delivered to any zone has a temperature of 35°F. When a zone temperature selector is in manual mode, the temperature controller for the affected zone is inoperative. The compartment temperature can be adjusted manually to temperatures outside the 65°F to 85°F range. Any number of zones can be operated in manual mode without affecting automatic control of the remaining zones or zone.

If the zone temperature selector that is controlling the temperature of the air conditioning pack output air is rotated to MANUAL, the zone temperature controller demanding the next lowest temperature air (if in automatic mode) assumes control of the pack temperature controller. If all zone temperature selectors are set to manual mode, the air conditioning pack (if in automatic mode) switches to full cool and provides air at 35°F.

During flight, the zone temperature indicators should be periodically monitored. If a zone duct approaches the overheat limits, set the affected zone temperature selector to MANUAL COOL and hold until the associated zone trim air valve is indicated closed, allowing the duct to cool. Refer to section IIIA for all emergency procedures.

AIR CONDITIONING OPERATION

The air conditioning system can be operated in any of the following modes: Automatic, manual, and heat exchanger only. These modes are used for either pressurized or unpressurized operation. Usually, the automatic mode is selected for normal operations. In addition, a ram air mode can be used but the airplane cannot be pressurized and there is little control of cooling or heating.

CAUTION

The draw-through cooling system must be operating in order to operate the air conditioning system. Pack controller and zone temperature controllers are cooled by drawthrough system. (Refer to ELECTRONICS COOLING SYSTEM.)

AIR CONDITIONING SYSTEM AUTOMATIC OPERATION

To operate the air conditioning system in automatic mode, proceed as follows:

1. Ensure power is available and all necessary circuit breakers are closed.

2. Select appropriate bleed air source (engine, APU, or ground cart).

   Refer to BLEED AIR OPERATION.

   NOTE

   Air conditioned air can be supplied from a ground cart, directly to the distribution manifold. To do this, connect the air conditioning ground cart to the connector (15, *figure 1-198*) located on the bottom of the fuselage at the air conditioning bay. Use of an air conditioning ground cart bypasses the air conditioning pack and the zone temperature controllers. The temperature is maintained by the ground cart. If air is supplied from an air conditioning ground cart, disregard the following procedures.

3. Check that pack AUTO–MAN switch/indicator displays AUTO.

4. Set all zone temperature selectors to AUTO NORMAL.

5. Press PRIMARY switch/caution light. Check line light illuminated and LOW caution light out.

6. Check that TRIM AIR switch/indicator line light is illuminated. OFF indicator is out if air is flowing (a zone trim valve is open), illuminated if no air is flowing (trim valves closed).

7. Press GASPER AIR switch/indicator and check OFF indicator out.

8. Adjust zone temperature selectors as required.

AIR CONDITIONING SYSTEM MANUAL OPERATION

To operate the air conditioning system manually, proceed as follows:

1. Ensure power is available and all necessary circuit breakers are closed.

2. Select appropriate bleed air source (engine, APU, or ground cart).

   Refer to BLEED AIR OPERATION.

3. Check that pack AUTO–MAN switch/indicator displays MAN.

4. Set all zone temperature selectors to AUTO NORMAL.

5. Press PRIMARY switch/caution light. Check line light illuminated and LOW caution light out.

6. Ensure TRIM AIR switch indicator line light is illuminated. OFF indicator is out if air is flowing (a zone trim valve is open), illuminated if no air is flowing (trim valves closed).

7. Press GASPER AIR switch/indicator and check OFF indicator out.

Air Conditioning System Operating Modes

OPERATING MODES	PRIMARY		ALTERNATE		COMP DISCH GAGE	RAM INLET DOOR POSITION GAGE	AUTO MAN SWITCH INDICATOR	BYPASS POSITION GAGE	PACK OVER HEAT CAUTION LIGHT
	LOW CAUTION LIGHT	LINE LIGHT	LOW CAUTION LIGHT	LINE LIGHT					
GROUND									
Air Conditioning Ground Cart	Out	Out	Out	Out	Low	Full COOL	Out	As Is	Out
APU or High Press Ground Cart	Out	Illum.	Out	Out	Normal	Full COOL	AUTO	Modulating	Out
Engines	Out	Illum.	Out	Out	Normal	Full COOL	AUTO	Modulating	Out
FLIGHT									
Takeoff	Out	Illum.	Out	Out	Normal	Modulating	AUTO	Modulating	Out
Cruise	Out	Illum.	Out	Out	Normal	Modulating	AUTO	Modulating	Out
Descent	Out	Illum.	Out	Out	Normal	Modulating	AUTO	Modulating	Out
Unpressurized Pack Operation	Out	Illum.	Out	Out	Normal	Modulating	AUTO	Modulating	Out
Unpressurized RAM AIR Valve Open	Out	Out	Out	Out	Low	As Is	AUTO	As Is	Out
Operating on Emergency DC Power	LOW	Illum.	LOW	Illum.	Not Functional	Not Functional	Out	Not Functional	Out

Figure 1-201 (Sheet 1 of 4)

TRIP CAUTION LIGHT	PACK OVERHEAT RESET BUTTON	GASPER AIR SWITCH INDICATOR	ICING CAUTION LIGHT	RAM AIR SWITCH INDICATOR	TRIM AIR		ZONE COOL HEAT VALVE	ZONE OVERHEAT	DUCT TEMP GAGES	COMPT TEMP GAGES	ZONE RESET BUTTON
					LINE SIGHT	OFF INDICATOR					
Out	Not Functional	On or OFF	Out	Out	Out	Out	As Is	Out	Functional	Normal	Not Functional
Out	Functional	On or OFF	Out	Out	Illum.	Out OFF	Modulating	Out	Normal	Normal	Functional
Out	Functional	On or OFF	Out	Out	Illum.	Out OFF	Modulating	Out	Normal	Normal	Functional
Out	Functional	On or OFF	Out	Out	Illum.	Out OFF	Modulating	Out	Normal	Normal	Functional
Out	Functional	On or OFF	Out	Out	Illum.	Out OFF	Modulating	Out	Normal	Normal	Functional
Out	Functional	On or OFF	Out	Out	Illum.	Out OFF	Modulating	Out	Normal	Normal	Functional
Out	Functional	On or OFF	Out	Out	Illum.	Out OFF	Modulating	Out	Normal	Normal	Functional
Out	Functional	On or OFF	Out	ON	Out	Out	HEAT	Out	LOW	LOW	Functional
Out	Not Functional	Not Functional	Out	Out Not Functional	Out	Not Functional, valve closed	Not Functional	Out	Not Functional	Not Functional	Not Functional

Figure 1-201 (Sheet 2 of 4)

Air Conditioning System Operating Modes (Continued)

OPERATING MODES	PRIMARY		ALTERNATE		COMP DISCH GAGE	RAM INLET DOOR POSITION GAGE	AUTO MAN SWITCH INDI-CATOR	BYPASS POSITION GAGE	PACK OVER HEAT CAUTION LIGHT
	LOW CAUTION LIGHT	LINE LIGHT	LOW CAUTION LIGHT	LINE LIGHT					
GROUND OR FLIGHT									
Pack 450° Overheat	LOW	Illum.	LOW	Out	Over 450°F	Full COOL	AUTO	As Is	OVER HEAT
Pack 425° Overheat	Out	Illum.	Out	Out	Over 415°F	Full COOL	AUTO	As Is	OVER HEAT
Pack 205° Overheat	Out	Illum.	Out	Out	Normal	Full COOL	AUTO	Full COOL	OVER HEAT
Zone 205° Overheat (Duct Temp 200° to 230°)	Out	Illum.	Out	Out	Normal to High	Modulating	AUTO	Modulating	Out
Zone 250° Overheat	Out	Out	Out	Out	Normal to High	As Is	AUTO	As Is	Out

Figure 1-201 (Sheet 3 of 4)

TRIP CAUTION LIGHT	PACK OVERHEAT RESET BUTTON	GASPER AIR SWITCH INDICATOR	ICING CAUTION LIGHT	RAM AIR SWITCH INDICATOR	TRIM AIR		ZONE COOL HEAT VALVE	ZONE OVERHEAT	DUCT TEMP GAGES	COMPT TEMP GAGES	ZONE RESET BUTTON
					LINE LIGHT	OFF INDICATOR					
Out	410 ± 10°F COMP DISCH	On or OFF	Out	Out	Illum.	Out OFF	Modulating	Out	Normal	Normal	Functional
Out	385 ± 10°F COMP DISCH	On or OFF	Out	Out	Illum.	Out OFF	Modulating	Out	Normal	Normal	Functional
Out	Less than 174 ± 10°F DUCT Temp.	On or OFF	Out	Out	Illum.	Out OFF	Modulating	Out	High	Normal	Functional
Out	Not Functional	On or OFF	Out	Out	Illum.	OFF	Full COOL	OVER HEAT Affected duct	High	Normal	120°F DUCT Temp
TRIP	230°F DUCT Temp.	On or OFF	Out	Out	Illum.	OFF	Full COOL	OVER HEAT Affected duct	High	Normal	120°F DUCT Temp

Figure 1-201 (Sheet 4 of 4)

8. Set pack output temperature by adjusting the RAM INLET COOL–HEAT switch and BYPASS COOL–HEAT switch.

NOTE

To prevent overheat, do not allow the compressor discharge temperature to exceed 400°F.

AIR CONDITIONING SYSTEM HEAT-EXCHANGER-ONLY OPERATION (PACK BYPASS)

If an air cycle machine fails in flight, select heat-exchanger-only (pack bypass) operation as follows:

NOTE

Heat-exchanger-only operation does not provide cooling on the ground.

1. Ensure power is available and all necessary circuit breakers are closed.
2. Open bleed air valves.

   Refer to BLEED AIR OPERATION.
3. Check that pack AUTO–MAN switch/indicator displays MAN.
4. Set all zone temperature selectors to AUTO NORMAL.
5. Press PRIMARY switch/caution light. Check line light illuminated and LOW caution light out.
6. Ensure TRIM AIR switch/indicator line light is illuminated. OFF indicator is out if air is flowing, illuminated if no air is flowing.
7. Hold BYPASS COOL–HEAT switch to HEAT until BYPASS position gage indicates full HEAT.
8. Hold RAM INLET COOL–HEAT switch to COOL until RAM INLET door position gage indicates full COOL or until air temperature is as desired.
9. Set cabin zone temperatures by adjusting zone temperature selectors.
10. If desired, press GASPER AIR switch/indicator and check OFF indicator out.

AIR CONDITIONING SYSTEM RAM AIR OPERATION

To operate the air conditioning system in the ram air mode, press the RAM AIR switch/indicator. Pressing this switch opens the ram air valve and closes both flow control valves. This causes the airplane to depressurize, and once depressurized, allows ram air to ventilate and cool the airplane interior. When the ram air valve is not fully closed, the RAM AIR switch/indicator ON light illuminates. The ram air door does not have to be manually positioned when operating on ram air since, in flight, the ram air door is always open far enough to provide all the air required. When the RAM AIR switch/indicator is pressed again, to close the ram air valve, the operating flow control valve reopens and the RAM AIR switch indicator ON light goes out. Refer to section II for normal procedures. Ram air ventilation provides a change of cabin air every 12 to 15 minutes.

CABIN PRESSURIZATION SYSTEM

High pressure air is supplied by the bleed air system, through the air conditioning distribution system, to the pressurized compartments. Cabin pressurization system components are shown in *figure 1-202*. The cabin is pressurized by controlling the rate at which this air exhausts through two cabin pressure outflow valves. The outflow valves are controlled by the electronically operated pressure controller which regulates cabin pressure to maintain low cabin altitude during high altitude flight, within the differential pressure limit of 8.6 psi. A plot of cabin altitude for various pressure levels is in *figure 5-13*. Pressurization system controls and indicators are described in *figure 1-203*, a schematic of the cabin pressurization system is shown in *figure 1-204*.

The cabin pressure controller operates in either automatic or manual mode, as selected on the cabin pressurization panel. During automatic operation, four selections are made on the cabin pressurization panel: Flight altitude, takeoff or landing mode of pressure control, barometric pressure correction, and cabin rate of pressure change. During automatic operation, the cabin RATE knob sets the maximum rate of change the cabin pressure controller can command. Normally the RATE knob is set to the dark band which commands the cabin pressure controller to limit the maximum cabin rate of change to between 300 and 500 feet per minute.

In the manual mode, the cabin altitude and rate of pressure change are adjusted by the manual control knob on the cabin pressurization panel while monitoring the cabin altitude, cabin differential pressure gage, and the cabin rate of climb indicator. Manual control permits the selection of any differential. Pressure relief devices within the two outflow valves protect the airplane from over pressurization and negative pressures.

In the automatic mode, the control system operates on 115vac. In the manual mode, the control system operates on 28vdc. If ac and/or dc power are lost, the aircraft then operates in the isobaric range. The outflow valves maintain the existing cabin altitude until power is restored, regardless of changes in aircraft altitude. While ascending in the isobaric mode, cabin altitude can be maintained until the aircraft reaches the designed maximum differential pressure of 9.42. During descent in the isobaric mode, cabin altitude remains constant until cabin and aircraft altitudes are equal. At this time, cabin and aircraft altitude rates of descent are equal.

The two cabin pressure outflow valves provide cabin pressure regulation, vacuum relief and positive pressure relief. They are located near the bottom centerline of the airplane, one in the rear of the forward lower compartment, and one in the rear of the aft lower compartment. These valves pass air from the cabin as determined by settings on the cabin pressurization panel. The outflow valves also function as safety valves to relieve at approximately 9.4 psi positive pressure differential or approximately 0.3 psi negative pressure differential. These two conditions override the automatic or manual control signals. Cabin altitude limit control is in each outflow valve to limit cabin altitude to approximately 14,000 feet, maximum, if other components fail, provided the bleed air system supplies sufficient airflow and leakage is not excessive. An electric vacuum pump at each outflow valve provides faster operation action at low differentials and keeps each outflow valve open on the ground. The pumps are automatically turned off on a rising 2.5 psi cabin differential.

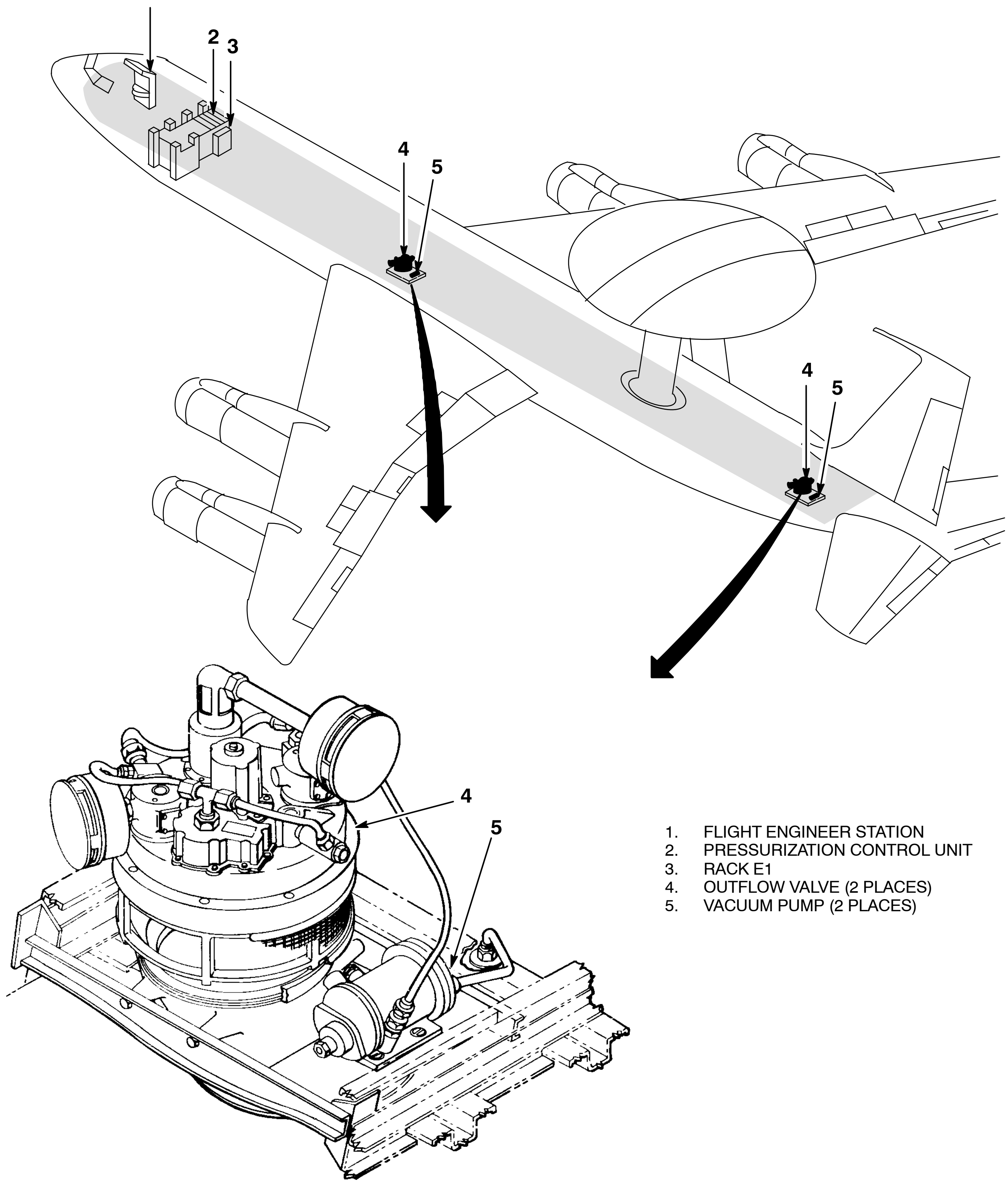
When set to EMERGENCY DEPRESS, the EMERGENCY DEPRESS switch (*figure 1-203*) opens both outflow valves, overrides the 14,000-foot cabin altitude limit control and closes both flow control valves to depressurize the airplane.

NOTE

> Setting the UNPRESS/OB VALVE switch on the flight engineer's FAC UNPRESS & OVERRIDE panel to UNPRESS overrides the cabin altitude limit control so the cabin altitude can be manually raised above 14,000 feet. For a complete description of the UNPRESS function, refer to FORCED AIR COOLING SYSTEM.

The cabin altitude warning horn provides a warning any time the cabin altitude exceeds 10,000 feet. This horn, located under the flight engineer's table, is operated by a pressure switch located behind the flight engineer's panel. This switch also operates the loss of pressure visual displays and the loss of pressure audio alarm. (Refer to CREW WARNING AND ALERTING SYSTEM.) The horn and aural warning can be shut off by pressing the ALTITUDE HORN CUTOUT pushbutton on the pressurization control panels. The entire cabin altitude warning system resets when the cabin altitude descends below 10,000 feet.

Cabin Pressurization System Component Locations



1. FLIGHT ENGINEER STATION
2. PRESSURIZATION CONTROL UNIT
3. RACK E1
4. OUTFLOW VALVE (2 PLACES)
5. VACUUM PUMP (2 PLACES)

D57 477 SI

Figure 1-202

Pressurization System Controls and Indicators

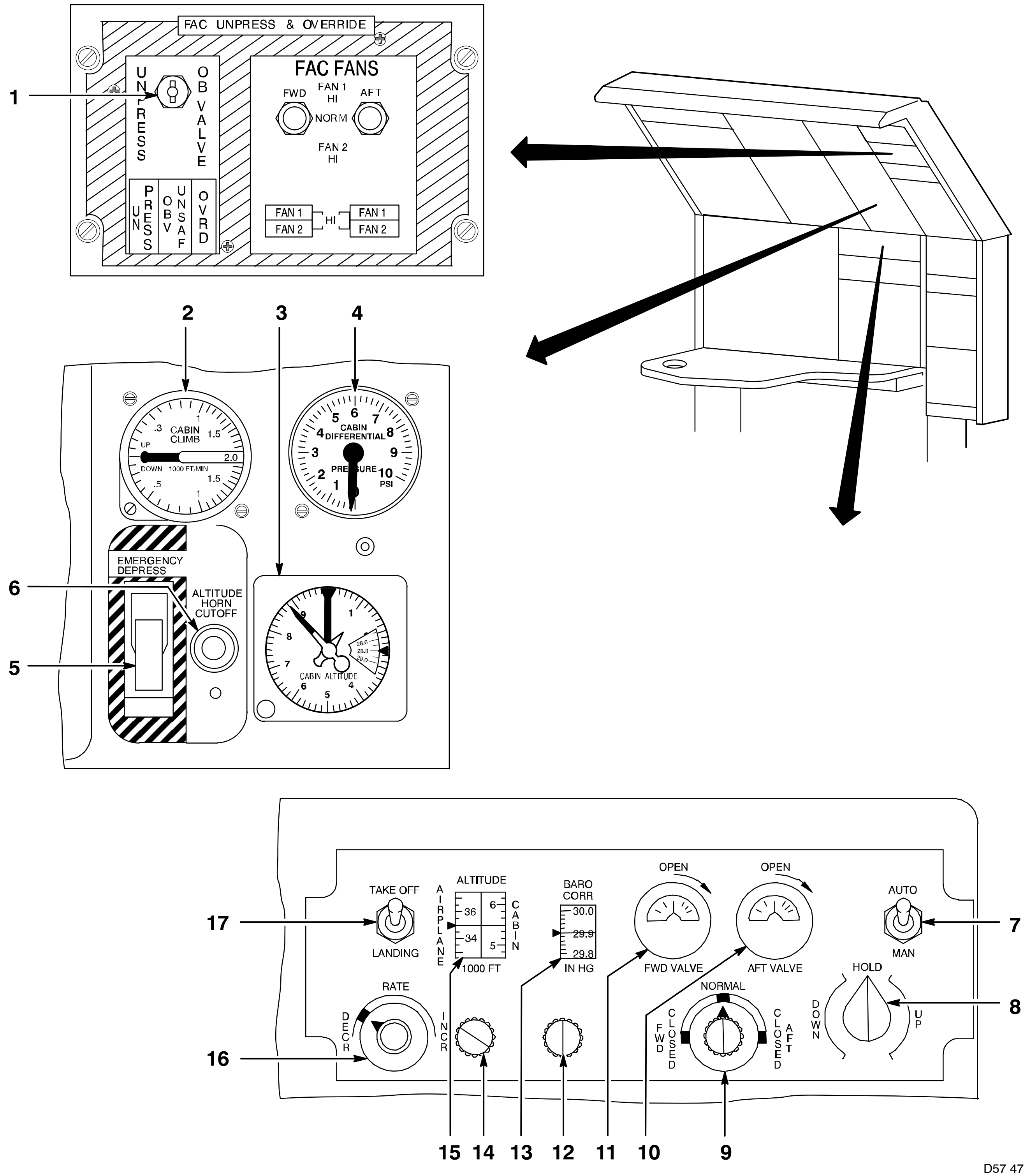


Figure 1-203 (Sheet 1 of 4)

Pressurization System Controls and Indicators (Continued)

NO.	CONTROL/INDICATOR	FUNCTION
1	UNPRESS/OB VALVE Switch	Three-position lever-lock toggle switch UNPRESS: Enables forward and aft systems to operate in unpressurized mode. Opens overboard valves, ram valves, closes heat exchanger valves, operates both fans speed, and inhibits altitude limit control on cabin pressure control system outflow valves. Operation in unpressurized mode will not occur unless the cabin altitude exceeds 15,000 feet and cabin-to-ambient pressure differential is less than 2 psi. OFF (Center): Switch position for normal operation. OB VALVE: Drives overboard valve closed using auxiliary power circuits.

NOTE

Operating cabin altitude rate knob when UNPRESS/OB VALVE switch is set to UNPRESS and cabin altitude is between 10,000 and 14,000 feet could result in depressurizing airplane.

2	CABIN CLIMB Gage (CABIN Rate of Climb Indicator)	Indicates rate of change of cabin altitude in thousands of feet per minute (tolerance is 50 ft/min).

NOTE

If gage is out of tolerance, wait until gage is at normal operating temperature before adjusting.

3	CABIN ALTITUDE (Cabin Altimeter)	Indicates cabin altitude in feet. Setting knob allows setting barometric scale. Three pointers indicate cabin altitude in feet as follows: Longest pointer (black with white bug at scale) indicates tens of thousands of feet, short white hand indicates thousands of feet, long white hand indicates hundreds of feet and 20-foot subdivisions.
4	CABIN DIFFERENTIAL PRESSURE Gage	Indicates differential pressure from cabin to outside (ambient) air in psi (0.2 psi).
5	EMERGENCY DEPRESS Switch (Guarded)	Guarded in center off position. When set to EMERGENCY DEPRESS, opens outflow valves to depressurize airplane, overrides 14,000 foot cabin altitude limiter, and closes both flow control valves. When set to TEST (momentary), tests operation of cabin altitude warning system.

Figure 1-203 (Sheet 2 of 4)

NO.	CONTROL/INDICATOR	FUNCTION
6	ALTITUDE HORN CUTOUT Pushbutton	When pressed, stops operation of cabin attitude warning horn and resets warning system.
7	AUTO – MAN Switch (Rate Control Switch)	When set to AUTO, pressurization altitude rate control is automatic. When set to MAN, manual control knob controls cabin altitude rate.
8	DOWN – HOLD – UP Knob (Manual Control Knob)	Rotating knob out of HOLD position changes cabin altitude when controller is in manual mode (AUTO–MAN switch set to MAN). Rotation clockwise from HOLD (toward UP) raises cabin altitude. Rotation counterclockwise from HOLD (toward DOWN) lowers cabin altitude. Cabin rate of change is proportional to knob movement.
9	FWD – AFT (Outflow Valve Balance Knob)	When set to NORMAL, allows automatic operation of outflow valves by controller. When rotated clockwise from NORMAL (toward AFT CLOSED) causes aft outflow valve to move toward closed. Forward valve will open to compensate for reduced flow. When turned counterclockwise (toward FWD CLOSED) from NORMAL, forward valve runs toward closed position and aft valve opens to compensate. Position of valves is shown on FWD VALVE and AFT VALVE gages above knob.
10	AFT VALVE Gage	Gage displays position of aft outflow valve.
11	FWD VALVE Gage	Gage displays position of forward outflow valve.
12	BARRO CORR Knob	Turn knob right to increase setting of BARRO CORR scale; turn to left to decrease setting.
13	BARRO CORR Scale (Barometer correction)	Indicates barometer correction (altimeter setting) value in inches of mercury set for use in cabin pressure controller. Scale is set by knob (12) below scale.
14	Cabin Altitude Set Knob	Turn knob clockwise to increase AIRPLANE CABIN ALTITUDE scale setting; turn counterclockwise to reduce setting.
15	AIRPLANE CABIN ALTITUDE Scale	Indicates cabin altitude in thousands of feet and corresponding airplane cruise altitude for maximum (8.6 psi) differential. Scale is set by knob below scale.

Figure 1-203 (Sheet 3 of 4)

Pressurization System Controls and Indicators (Continued)

NO.	CONTROL/INDICATOR	FUNCTION
16	RATE Knob	Adjusts cabin rate of change from 50 to 2,000 ft/min. When set to dark band, commands electronic pressure controller to limit cabin rate of change to 300 to 500 ft/min. When AUTO–MAN switch is in MAN, RATE knob is inoperative.
17	TAKE OFF – LANDING Switch (Pressurization Mode Switch)	When set to TAKE OFF, allows pressurization of cabin to 250 feet below field pressure altitude. When set to LANDING, opens outflow valves on ground, dumping cabin pressure.

NOTE

Switch must be in LANDING position, except where specifically directed by operating procedures.

Figure 1-203 (Sheet 4 of 4)

Pressurization System Schematic

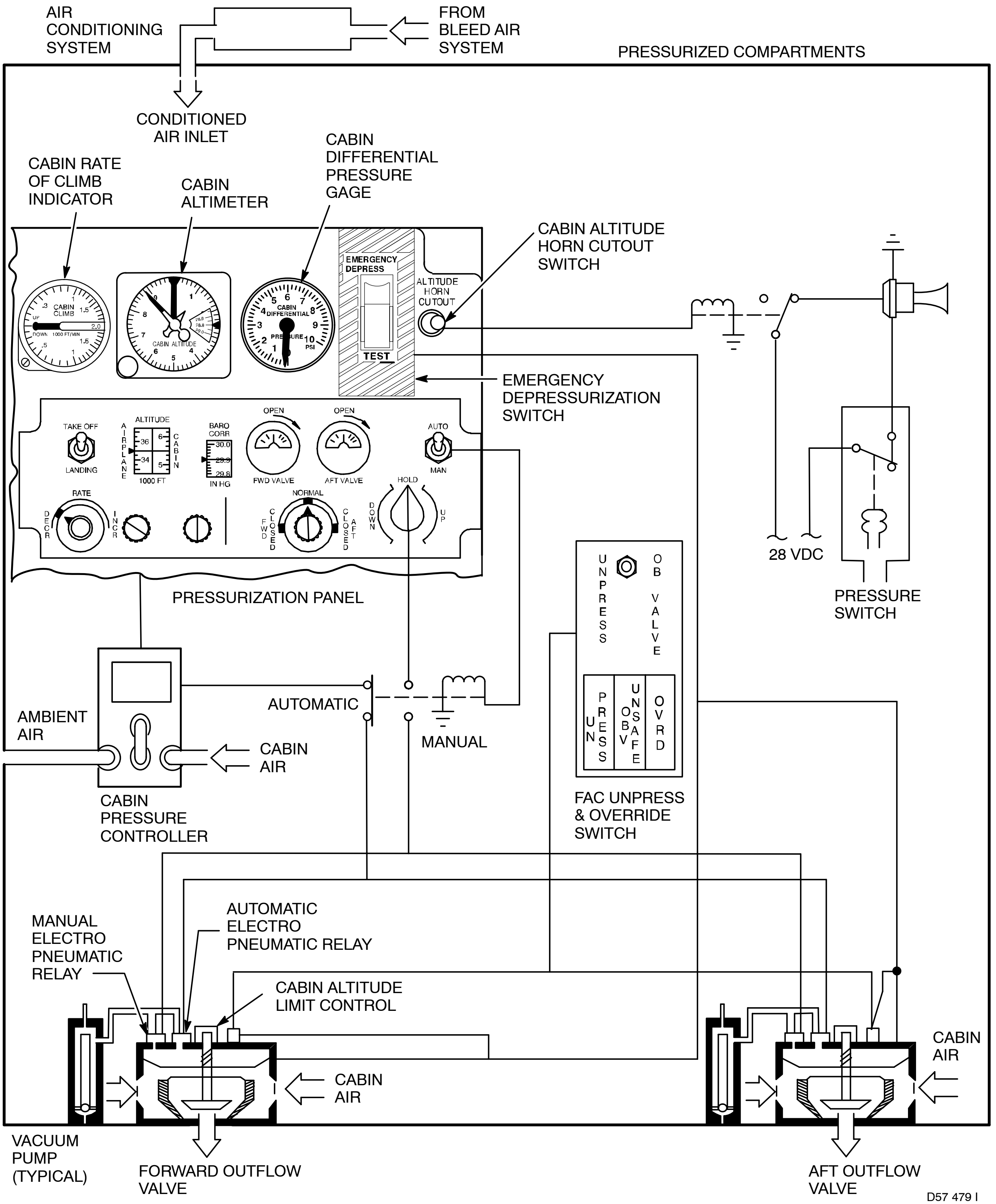


Figure 1-204

CABIN PRESSURIZATION SYSTEM OPERATION

The pressurization system has two modes of operation, automatic and manual. To set the pressurization system for automatic operation, follow the procedures in section II.

MANUAL OPERATION

WARNING

Oxygen is required for personnel entering the aft lower compartment when pressurization is in manual operation.

To operate the pressurization system manually, proceed as follows:

1. Takeoff
   a. Pressurization Mode Switch – Landing
   b. Outflow Valve Balance Knob – NORMAL
   c. AUTO–MAN Switch – MAN
   d. Cabin Altimeter – Current Altimeter Setting
   e. DOWN–HOLD–UP (Manual Control) Knob – Adjust to UP side as required to keep outflow valve open.
   f. During climb, adjust DOWN–HOLD–UP (manual control) knob to the UP side to maintain cabin pressure differential within limits of 8.6 psi and a rate of climb less than 500 fpm. Set the DOWN–HOLD–UP (manual control) knob to HOLD once the desired cabin altitude is obtained between 5,000 and 8,000 feet. Refer to section V for cabin altitude at various airplane altitudes and cabin pressures.
2. Descent
   a. Prior to descent, adjust DOWN–HOLD–UP (manual control) knob to the DOWN side to start cabin altitude down towards landing station field elevation (remain within limits of 8.6 psi cabin differential) so as the airplane descends cabin rate of descent can be maintained at 300 fpm. Set cabin altitude to current altimeter setting.
   b. During descent, adjust DOWN–HOLD–UP (manual control) knob on the DOWN side to maintain cabin differential, cabin altitude and cabin rate of descent as desired.
   c. Prior to landing, set cabin altitude to field elevation.
   d. After landing, set DOWN–HOLD–UP (manual control) knob to the full UP position.

DEPRESSURIZATION AND REPRESSURIZATION

To depressurize the airplane, proceed as follows:

1. If required – don oxygen mask

   If required, the pilot will notify crew to use oxygen until further notified and to remain seated as long as seat belt sign is illuminated.

   WARNING

   Personnel in seats 28, 31, and 34 through 41 are provided with portable oxygen bottles having a limited duration available. Refer to subsection I-V for duration at various altitudes.

2. If required, set SEAT BELTS and NO SMOKING switches to ON.

   If use of oxygen is required, the flight crew will report on interphone when requested by pilot. The mission crew will report to the Mission Crew Commander who will then report to the pilot.

3. Set cabin altitude selector to airplane altitude or 15,000 feet, whichever is higher.

   CAUTION

   Weather radar will not be operated at cabin pressure altitudes above 20,000 feet.

4. Set pressurization RATE knob to maximum INCR.

5. Check draw through cooling.

   Ensure NO FLOW Caution Light is out and fan is operating if cabin differential pressure less than 1 psi.

6. Set FAC UNPRESS & OVERRIDE panel UNPRESS/OB VALVE switch to UNPRESS, if above 13,000 feet cabin pressure altitude.

7. Set AUTO–MAN switch to MAN.

8. Set manual control knob to UP.

   Proper planning allows cabin rate of climb to be maintained at 500 ft/min.

9. When cabin altitude reaches limit, set EMERGENCY DEPRESS switch to EMERGENCY DEPRESS.

   Overrides cabin altitude limiter to open outflow valves. Closes air conditioning flow control valves.

CAUTION

When operating unpressurized and the aft forced air cooling system RAM VALVE OPEN indicator is illuminated, control the temperature of the aft system manually at 45 ± 5°F. The aft forced air cooling system must be operated in the manual mode to maintain proper temperature control when operating unpressurized with the ram valve open.

10. Set air conditioning ram valve as required.

    Perform steps 11 through 20 to repressurize the airplane.

11. Close three bleed air valves.

    Only one bleed air valve should be used for initial repressurization.

12. Set throttle on engine with open bleed air valve to idle.

    This allows control of pressurization rate.

13. Close air conditioning ram air valve.

14. SET FAC UNPRESS & OVERRIDE panel UNPRESS/OB VALVE switch to OFF (center).

15. Set EMERGENCY DEPRESS switch to OFF.

16. Set manual control knob to full DOWN.

17. Use throttle of engine with open bleed air valve as required to set cabin rate of descent. Rate can be maintained at 300 ft/min or set as desired.

– – – When Cabin Altitude is 13,000 Feet or Less – – –

18. Set cabin altitude scale at desired altitude.

19. Set RATE knob to full decrease.

20. Set AUTO – MAN switch to AUTO.

21. Open all bleed air valves. Throttle of engine used to repressurize can be returned to normal thrust setting.

– – – Return to Normal Operation – – –

BLEED AIR, AIR CONDITIONING, AND PRESSURIZATION SYSTEMS ELECTRIC POWER SOURCES

See *figure 1-205* for bleed air, air conditioning, and pressurization electric power sources.

Bleed Air, Air Conditioning and Pressurization Electric Power Sources

EQUIPMENT/SYSTEM	TYPE OF POWER	POWER SOURCE	CIRCUIT BREAKER LOCATION/LABEL
Aft Outflow Valve Vacuum Pump	115V AC	AVAC Bus 4	P61-3, VAC PUMP – AFT
Alternate Flow Control/Shutoff Valve	28V DC	BAT BUS	P61-3, FLOW CONTROL VALVES ALTER SHUT OFF
Alternate Flow Control/Shutoff Valve	28V DC	AVDC Bus 4	P61-3, FLOW CONTROL VALVES LOW FLOW & ALTER TEMP
Automatic Depress On Landing	28V DC	AVDC Bus 8	P61-3, PRESS CONTR DC
Compressor Temperature Indicator	28V DC	AVDC Bus 8	P61-3, INDICATORS – TEMP & VALVE POS
Emergency Depress Switch	28V DC	BAT BUS	P61-3, DEPRESS CONTR
Flight Deck and Forward Zone Automatic Temperature Control Valve	115V AC	AVAC Bus 4	P61-3, TEMP CONTROL VALVE AUTO – FLT DK & FWD ZONE
Flight Deck and Forward Zone Manual Temperature Control Valve	115V AC	AVAC Bus 6	P61-3, TEMP CONTROL VALVE MANUAL – FLT DK & FWD ZONE
Flight Deck and Forward Zone Temperature Controllers	28V DC	AVDC Bus 8	P61-3, TEMP CONTROLLERS – FLT DK & FWD
Flight Deck and Forward Zone Temperature Indicators	28V DC	AVDC Bus 8	P61-3, INDICATORS – FLT DK FWD ZONE TEMP
Forward Outflow Valve Vacuum Pump	115V AC	AVAC Bus 4	P61-3, VAC PUMP – FWD
Gasper Fan	115V AC	AVAC Bus 4	P61-3, GASPER FAN CONTR
Gasper Fan	28V DC	AVDC Bus 4	P61-3, GASPER FAN CONTR
Loss of Pressure Warning Lights	28V DC	BAT BUS	P6, VIS WARN – LOSS OF PRESS LIGHTS
Loss of Pressure Warning Lights Relay ①	28V DC	BAT BUS	P6, VIS WARN – LOSS OF PRESS WARN RELAY
Cabin Altitude Warning Horn Cutoff Switch	28V DC	AVDC 8	P5, WARN HORN CUTOUT RELAY

Figure 1-205 (Sheet 1 of 2)

EQUIPMENT/SYSTEM	TYPE OF POWER	POWER SOURCE	CIRCUIT BREAKER LOCATION/LABEL
Cabin Altitude Warning Horn ②	28V DC	AVDC 8	P5, LANDING GEAR – WARN HORN
Mid and Aft Zone Automatic Temperature Control Valve	115V AC	AVAC Bus 4	P61-3, TEMP CONTROL VALVE AUTO – MID & AFT ZONE
Mid and Aft Zone Manual Temperature Control Valve	115V AC	AVAC Bus 6	P61-3, TEMP CONTROL VALVE MANUAL – MID & AFT ZONE
Mid and Aft Zone Temperature Controllers	28V DC	AVDC Bus 8	P61-3, TEMP CONTROLLERS – MID & AFT
Mid and Aft Zone Temperature Indicators	28V DC	AVDC Bus 4	P61-3, INDICATORS – MID & AFT ZONE TEMP
Pack Automatic Temperature Control Valve	115V AC	AVAC Bus 4	P61-3, TEMP CONTROL VALVE AUTO – PACK
Pack Manual Temperature Control Valve	115V AC	AVAC Bus 6	P61-3, TEMP CONTROL VALVE MANUAL – PACK
Pack Temperature Controller	28V DC	AVDC Bus 8	P61-3, TEMP CONTROLLERS – PACK
Pressurization Controller and Outflow Valves	115V AC	AVAC Bus 4	P61-3, PRESS CONTR AC
Pressurization Controller and Outflow Valves	28V DC	AVDC Bus 8	P61-3, PRESS CONTR DC
Primary Flow Control/Shutoff Valve	28V DC	BAT BUS	P61-3, FLOW CONTROL VALVES – PRI SHUT OFF & PRI TEMP
Temperature Sensor Fan	115V AC	AVAC Bus 6	P61-3, TEMP SENSOR FAN

① Also provides power to cabin altitude warning switch and EMERGENCY DEPRESS switch.

② This horn also acts as landing gear warning horn.

Figure 1-205 (Sheet 2 of 2)

SUBSECTION I-R
ELECTRONICS COOLING SYSTEMS

Table of Contents

Title ***Page***

SUMMARY

There are six systems for cooling airplane and mission electronic equipment. Two forced air cooling systems (forward and aft) cool mission electronic racks, communications racks, ESM electronics rack, and the navigation equipment rack. A draw through cooling system cools mission consoles and communications equipment. A liquid cooling system cools the mission radar transmitter using fuel in the main fuel tanks as a heat sink. Fans cool the electric power feeder duct containing the radar feeder cables and APU generator three phase, 400 Hz power output cable to the sync bus. Fans cool the ESM antennas and associated RF processors.

DRAW THROUGH COOLING SYSTEM

The draw through cooling system (*figure 1-206*) cools certain airplane electronic equipment, mission consoles, and mission radar EMI filters by moving cabin air through the units and exhausting it overboard. The air movement is caused by a system fan at low cabin differential pressure, and by the pressure differential alone when it is sufficient. The system operates automatically. Indicators are provided on the flight engineer’s panel to indicate the status and operating mode of the system (*figure 1-207*). Indicators are also provided on the communications console and computer console.

NORMAL OPERATION

Air flow through the system at low (0 to 3 psi) cabin differential pressure is controlled by a modulating flow control valve; which at low (approximately 1.0 psi) cabin differential pressure causes the system fan to operate to increase the airflow. Air flow through the system at higher cabin differential pressure is controlled by the draw through system venturi. There is overlap in the air flow through the flow control valve and the venturi to assure smooth transition. The flow control valve is completely closed above 3 psi cabin differential pressure. (See *figure 1-208*.)

In normal operation, the fan operates on low speed (LOW SPEED, VALVE OPEN, and AUTO indicators illuminated) until cabin differential pressure rises above approximately 1.0 psi when the fan stops operating (LOW SPEED and AUTO indicators go out). When cabin differential pressure rises above approximately 2.0 psi, the VALVE OPEN indicator goes out and the panel indicators are all out.

When cabin altitude is above 15,000 ± 1,000 feet, the 15,000-foot cabin pressure altitude switches actuate and cause the draw through system logic to command the fan to operate on high speed when the cabin differential pressure drops below approximately 1.0 psi. If only one of the 15,000-foot cabin altitude switches actuates, the MAN indicator illuminates. When the MAN indicator illuminates, pressing the AUTO–MAN switch causes the fan to be commanded to operate on high speed.

CAUTION

To prevent fan burnout, do not press the AUTO–MAN switch when the MAN indicator is illuminated, unless the LOW SPEED indicator is illuminated, or the cabin differential pressure is below 1.0 psi, and the VALVE OPEN indicator is illuminated.

NOTE

The draw-through cooling system is very sensitive to air flow changes at low cabin differential pressure (such as during climbout and approach to landing). During such conditions, the AUTO and LOW SPEED indicators illuminate and go out often as the system turns the draw-through fan on and off to maintain the flow of cooling air.

System M Cooling

The SEU is cooled by draw-through cooling; all other equipment is cooled by natural convection. The system may be powered up any time draw-through cooling is available, however, if the flight engineer receives a NO FLOW indication on the DRAW THROUGH COOLING panel, the CDMT receives a DAPG COOLING AIR OFF, or the CT receives a DRAW THROUGH indication, System M should be powered down. It is preferred the system be kept powered down during ground operations.

CAUTION

Do not operate System M SEU for more than five minutes without draw-through cooling in operation.

ABNORMAL OPERATION

The flight deck UHF transceiver can fail after approximately five seconds while transmitting or five minutes on receive if cooling air is lost. The Audio Distribution System (rack E11) can fail after approximately 20 minutes if cooling air is lost. The SDCs and DDIs have an overheat warning light and an overheat warning code is also displayed. The CPS has built in overheat warning and protection. The autopilot can fail approximately 30 minutes after loss of cooling air. The remaining equipment cooled by the draw-through system can be expected to function but can be damaged by long operation without cooling air.

Draw Through Fan Inoperative

CAUTION

- If the airplane is operated with the draw through cooling system fan inoperative, the following equipment must not be operated while the AUTO or LOW SPEED indicators are illuminated (cabin differential pressure less than approximately 1.0 psi): Mission avionics cooled by the draw through cooling system, and the flight deck UHF radio. This effectively restricts communications transmissions on the ground, and immediately after takeoff, to the VHF transceiver and the HF transceiver in the E13 rack. Limit ground operations to the minimum time possible. Open the parallel yaw damper power circuit breaker (YAW DAMPERS PRL ØA on panel P5) if lack of adequate cooling air flow exceeds two consecutive hours.

- Deploying the bailout chute or opening over wing hatch in flight causes the cabin pressure to be lower than ambient. If an abandon airplane emergency does not exist, open the DRAW THRU CLG FAN circuit breaker (panel P61-3) to prevent burning out the draw through cooling system fan.

Draw Through Cooling System Schematic

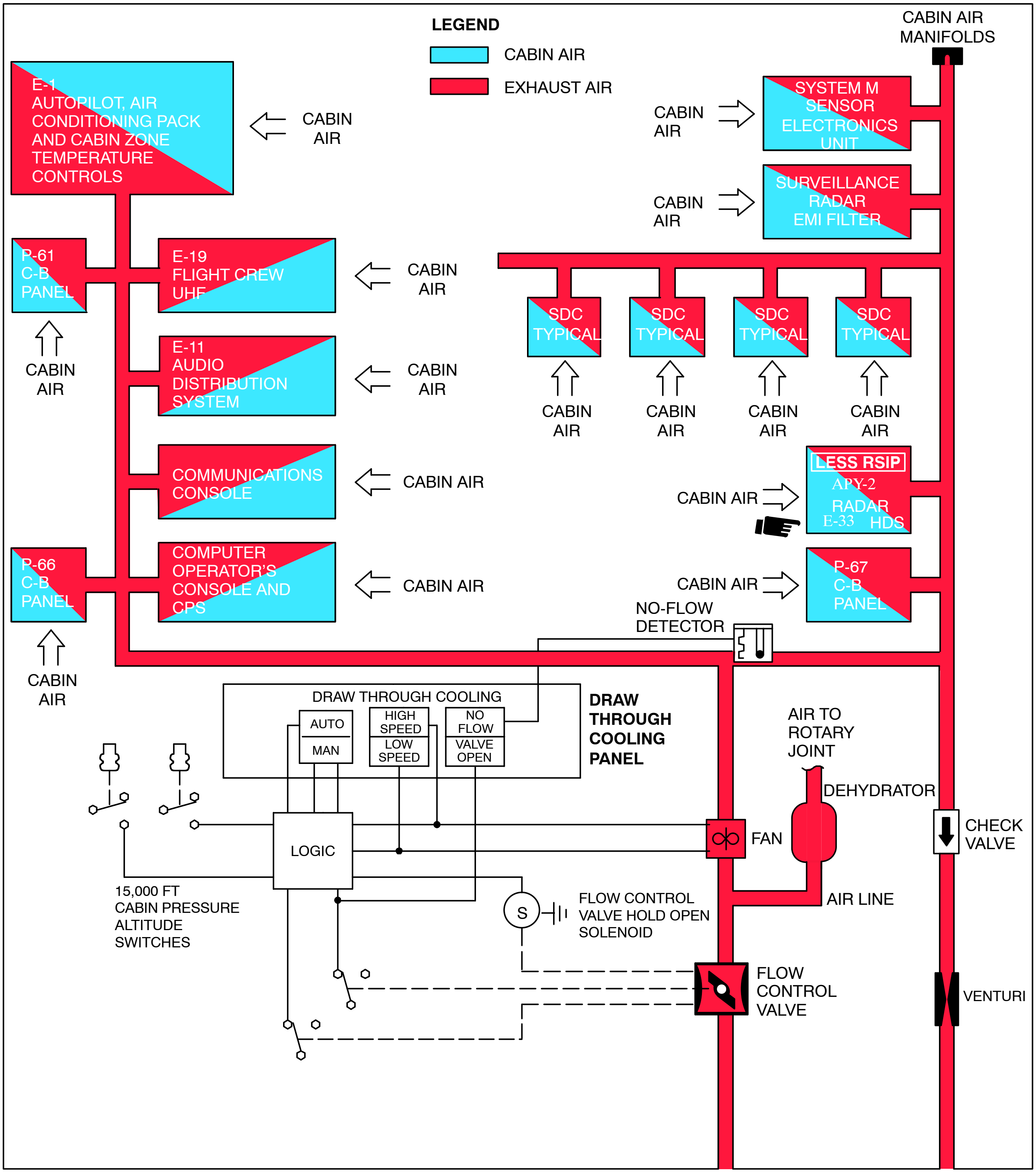


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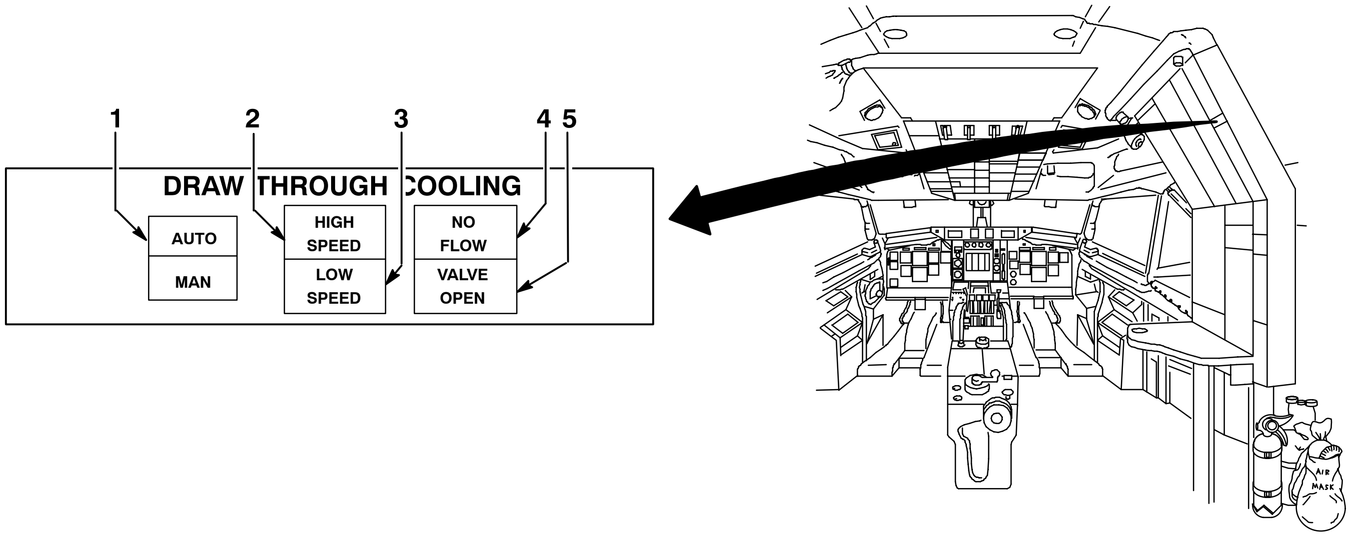
Figure 1-206

Draw Through Cooling System Controls and Indicators



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NO.	CONTROL/INDICATOR	FUNCTION
1	AUTO MAN Switch/Indicator (Green)	AUTO indicator is illuminated when power is on the airplane and the cabin differential pressure is less than approximately 1.0 psi. The same signal that causes the draw through system logic to command the fan to operate on low speed also causes the AUTO light to illuminate. The signal comes from a switch actuated by the position of the draw through system flow control valve. AUTO indicator is also illuminated when both 15,000 foot cabin pressure altitude switches have actuated regardless of the cabin differential pressure. If only one 15,000 foot cabin pressure altitude switch actuates, the AUTO indicator will not illuminate regardless of the cabin differential pressure. Pressing the AUTO–MAN switch when the AUTO indicator is illuminated does nothing.

Figure 1-207 (Sheet 1 of 2)

NO.	CONTROL/INDICATOR	FUNCTION
		MAN indicator is illuminated when only one 15,000 foot cabin pressure altitude switch has actuated and the draw through fan is not commanded to operate on high cabin differential pressure. Pressing the AUTO–MAN switch when the MAN indicator is illuminated causes the logic to command the draw through system fan to operate on high speed, the HIGH SPEED indicator to illuminate, the MAN indicator to go out, the LOW SPEED indicator to go out (if the fan had been operating on low speed), and the solenoid on the flow control valve to hold the flow control valve full open if the VALVE OPEN light is illuminated.

CAUTION

To prevent fan burnout, do not press the AUTO–MAN switch when the MAN indicator is illuminated unless the LOW SPEED indicator is illuminated, or the cabin differential pressure is below 1.0 psi, and the VALVE OPEN indicator is illuminated.

NO.	CONTROL/INDICATOR	FUNCTION
		Pressing the AUTO–MAN switch when neither the AUTO or MAN indicator is illuminated does not affect the system.
2	HIGH SPEED Indicator (Green)	The HIGH SPEED indicator is illuminated when the draw through system fan is commanded to operate on high speed. Conditions for high speed operation are: Cabin altitude above 15,000 ± 1,000 feet; cabin differential pressure below approximately 1.0 psi.
3	LOW SPEED Indicator (Green)	The LOW SPEED indicator is illuminated when the draw through system fan is commanded to operate on low speed. Conditions for low speed operation are: Cabin differential pressure below approximately 1.0 psi and the fan has not been commanded to operate on high speed. The signal to command low speed operation comes from the same switch which causes the AUTO indicator to illuminate.
4	NO FLOW Caution Light (Amber)	The NO FLOW caution light is illuminated when the cooling air flow in the draw through system is too low to cool the avionics. Refer to ABNORMAL OPERATIONS.
5	VALVE OPEN Indicator (Green)	The VALVE OPEN indicator is illuminated when the cabin differential pressure is below approximately 2.0 psi. The signal comes from a switch actuated by the position of the draw through system flow control valve. Valve can be manually opened or closed.

Figure 1-207 (Sheet 2 of 2)

Draw Through Cooling System Operating Modes

OPERATING MODE	CABIN ALTITUDE (FEET)	CABIN DIFFERENTIAL PRESSURE (APPROXIMATE)	AUTO INDI- CATOR	MAN INDI- CATOR	HIGH SPEED INDI- CATOR	LOW SPEED INDI- CATOR	NO FLOW INDI- CATOR	VALVE OPEN INDI- CATOR
GROUND ①	– – –	< 1 PSI	Illum	Out	Out	Illum	Out	Illum
CLIMB	– – –	< 1 PSI	Illum ② Out	Out	Out	Illum ② Out	Out	Illum
	– – –	1 to 2 PSI	Out	Out	Out	Out	Out	Illum
CRUISE	– – –	> 2 PSI	Out	Out	Out	Out	Out	Out
DESCENT	– – –	1 to 2 PSI	Out	Out	Out	Out	Out	Illum
		< 1 PSI	Illum ② Out	Out	Out	Illum ② Out	Out	Illum
UNPRESSUR- IZED	< 15,000 ± 1,000	< 1 PSI	Illum	Out	Out	Illum	Out	Illum
	> 15,000 ± 1,000 Both pressure altitude switches	> 2 PSI	Out	Out	Out	Out	Out	Out
		1 to 2 PSI	Illum	Out	Out	Illum	Out	Illum
		< 1 PSI	Illum	Out	Illum	Out	Out	Illum
	> 15,000 ± 1,000 One pressure altitude switch	> 2 PSI	Out	Illum	Out	Out	Out	Out
		1 to 2 PSI	Out	Illum	Out	Out	Out	Illum

CAUTION

To prevent fan burnout, do not press the AUTO–MAN switch when MAN indicator is illuminated unless the LOW SPEED indicator is illuminated, or the cabin differential pressure is below 1.0 psi, and the VALVE OPEN indicator is illuminated.

OPERATING MODE	CABIN ALTITUDE (FEET)	CABIN DIFFERENTIAL PRESSURE (APPROXIMATE)	AUTO INDI- CATOR	MAN INDI- CATOR	HIGH SPEED INDI- CATOR	LOW SPEED INDI- CATOR	NO FLOW INDI- CATOR	VALVE OPEN INDI- CATOR
		< 1 PSI	Out	Illum	Out	Illum	Out	Illum
		PRESS AUTO–MAN SWITCH						
			Out	Out	Illum	Out	Out	Illum

① The draw through cooling system operates the same on the ground as airborne.

② At low cabin differential pressure, system may turn fan on and off many times.

< Indicates Less Than. > Indicates More Than.

Figure 1-208

No Flow Caution Light Illuminated

When the NO FLOW caution light illuminates and cabin differential pressure is less than 1.0 psi, perform these steps:

a. Check that four DRAW THRU CLG circuit breakers on P61-3 are closed.

b. Verify that draw through flow control valve in forward lower compartment is open. Valve can be opened manually.

CAUTION

> If NO FLOW caution light remains illuminated, open three flight deck UHF circuit breakers on P5 panel and notify MCC to shut down mission equipment cooled by draw through system.

The ADS can fail when central switching unit CSU 1 or CSU 2 overheats. If these units fail, all radio and interphone communication is lost.

NOTE

- To extend communication operating time after complete loss of draw-through cooling, pilot may direct shutting down one CSU (by opening CSU 1 or CSU 2 circuit breaker on P5 panel).
- To aid cooling of the operating CSU after draw-through failure, pilot may direct opening the E11 equipment rack door.
- CSU 2 controls pilot's and flight engineer's communications and CSU 1 controls copilot's and navigator's communications.

FORCED AIR COOLING SYSTEMS

Two forced air cooling systems, designated the forward and aft systems, remove heat from mission electronic racks and the navigation equipment rack, and transfer the heat overboard through a heat exchanger (in flight), or by exhausting cabin air overboard (on the ground), or by taking ram air through the system and exhausting it overboard (unpressurized flight above 15,000 feet). System schematics are shown in *figures 1-209* and *1-210*. The forward system fans and heat exchanger are located in the left equipment bay, forward of the wheel well. The aft system fans and heat exchanger are located in the aft lower compartment.

FORCED AIR COOLING CONTROLS

System controls (*figure 1-211*) are located on the flight engineer's panel, the communications console and two ground maintenance control panels, located in the mission crew compartment.

The Forward AFAC Ground Maintenance Control Panel was modified by the addition of a relay, and indicator lamp. The indicator light provides a status of the E41 rack valve.

NOTE

> If the cannon plug connector is removed from the rack shutoff valve at the E41 rack, a VALVE CLOSED indication will be given.

Flight Engineer's Forced Air Cooling Controls

The forced air cooling control panel on the flight engineer's auxiliary panel (*figure 1-211*) provides power controls, system indicator and caution lights, and valve position indicators. The controls start and stop automatic operation and control limited manual operation. The FAC UNPRESS & OVERRIDE panel (*figure 1-211*) provides visual warning and override control of the FACS overboard valves and includes manual control switches to select high speed operation of system fans if required.

Forced Air Cooling Ground Maintenance Control Panels

Two ground maintenance control panels, *figure 1-211,* provide control of cooling air shutoff valves to direct cooling air to various portions of the system for ground operation. Caution lights on each panel indicate the condition of the shutoff valves in that system. The forward AFAC ground maintenance control panel is located above forward lower compartment access hatch. The aft AFAC maintenance control panel is located above the ART's console.

CAUTION

> Operation of the ground maintenance control panels is locked out by the landing gear safety (squat) switch and switches automatically to the takeoff valve configuration at liftoff. Flight engineer must verify that both ground maintenance control panel switches are set to TAKEOFF on preflight interior inspection to ensure proper cooling air flow before takeoff.

GROUND MAINTENANCE FORCED AIR COOLING INTERFACE PANEL

The Ground Maintenance Forced Air Cooling Interface Panel (*figure 1-211*), provides forced air cooling pressure and temperature sensing monitor points for the SDU-34 Forced Air Monitor and Alarm Test Set.

NOTE

> If the SDU-34 switch is left in the ON position, the Supply Air Temperature gage on the flight engineer's Forced Air Cooling Panel will not read correctly. Automatic temperature protection and warning circuits will be fully operative.

Forced Air Cooling Monitor Panels

Monitor panels, *figure 1-211*, are located on the computer operator's panel and on the communications operator's console. Caution lights on these panels are illuminated if no cooling air is flowing through the equipment racks or if the associated valves are not fully open. The panels operate any time the system is powered.

FORCED AIR COOLING SYSTEM OPERATION

The forced air cooling systems normally operate automatically. Manual operation is limited to control of supply air temperature, ground testing of automatic fan switching circuits, initiation of unpressurized operation (above 15,000 feet cabin altitude), initiation of overboard valve operation (due to uncommanded opening of valves), selection of high-speed operation for either fan NO 1 or fan NO 2 when required on both or either system and selection of air source on the ground. When operating automatically, the systems attempt to maintain the supply air temperature at 40°F. See *figure 1-212*.

CAUTION

> Interruption of electric power when changing from airplane generators to external power (or APU) or when changing to airplane generators from external power (or APU) can cause the forced air fan ELCU to trip. If this happens, the fan speed light goes out. Restart the fan immediately by pressing the POWER switch for that system twice (OFF, then on) and then pressing the appropriate fan switch for that system. The LOW SPD light should illuminate. Failure to restart fan can cause failure of equipment cooled by the forced air system.

In flight, capacity of the forced air cooling to cool the avionics depends on the temperature differential between the outside air and the air circulating in the forced air cooling systems. When the Total Air Temperature (TAT) indicator reads 15°C (59°F) or less (and is not rising) full cooling capacity can be expected. When the TAT exceeds approximately 0°C (32°F) and the mission equipment is operating, the temperature of the cooling air in the forced air systems is approximately 10°F higher than the TAT. This varies due to heat load on the system and instrument tolerances.

Automatic Operation

On the ground, with air supplied from a ground source (cart), electric power supplied to the system, and mode switch indicator on CART, the fans cannot be operated and the automatic and manual temperature controls are inoperative. All cooling air shutoff valves are open. The cabin valve is closed. The diverter valve is closed. All indicators on the forward and aft ground maintenance control panels are out, except the DVRTR VALVE CLOSED light, which is illuminated. The overboard valve is in COOL (open) position. The heat exchanger valve is in HEAT (closed) position. The bypass valve is in COOL (closed) position.

On the ground, with power applied to the system, MODE switch set to ENG APU, and fan NO 1 operating; the POWER OFF indicator is out, the FAN 1 LOW SPD, SYSTEM CONTR AUTO, and MODE ENG APU indicators are illuminated. Cooling air shutoff valves are set as controlled by the switch settings on the ground maintenance panels. The CABIN VALVE OPEN and DVRTR VALVE CLOSED lights on the ground maintenance control panels are illuminated.

CAUTION

Operating both forward and aft forced air cooling system fans on the ground simultaneously can damage the draw through system fan unless a cabin door is open.

NOTE

Fan NO 1 and NO 2 are alternated as primary and alternate units. The description given is for NO 1 as the primary unit and NO 2 as the alternate. Change the numbers in the description as necessary if NO 2 is chosen as primary and NO 1 is chosen as alternate.

Cabin air is taken in through the open cabin air valve, circulated through the equipment racks, and exhausted overboard through the overboard valve. The heat exchanger valve is fully closed. The HEAT EXCH gage shows full HEAT. The system automatically controls supply air temperature by modulating the bypass and overboard valves. The fan changeover circuit may be tested.

At liftoff, extension of the landing gear struts operates the safety relay (squat switch), automatically switching the logic to the takeoff configuration. The cabin valves close and the CABIN VALVE OPEN caution lights on the ground maintenance panels go out. The overboard valves close (OVBD gage shows full HEAT). The system automatically controls supply air temperature by modulating the bypass and heat exchanger valves.

When the temperature in the forced air system(s) is within the temperature zone which opens the shutoff valves (below 74 ± 5°F or below 64 ± 5°F if it had been above 74 ± 5°F) the valves open. However, if the TAT is not below 15°C, the shutoff valves can reclose, putting the system(s) back into the TAKEOFF configuration.

During climbout, fan NO 1 is on low speed and fan NO 2 is also on low speed below approximately 5,000 feet cabin altitude. Fan 1 and fan 2 both remain on low speed regardless of cabin pressure altitude until the supply air temperature has decreased below 64 ± 5°F. When supply air temperature decreases to 64 ± 5°F, independent of altitude, the cooling air shutoff valves to all remaining racks are opened and the diverter valve opens. When fan NO 2 shuts down, a six second time delay circuit switches fan NO 1 to high speed.

At cruising altitude, with cabin altitude above approximately 5,000 feet, fan NO 1 operates at high speed. Fan NO 2 does not operate unless fan NO 1 fails.

On descent below 4,200 feet cabin pressure altitude, fan NO 1 switches to low speed and fan NO 2 is commanded to operate on low speed.

Select a cabin pressure altitude between 5,000 and 8,000 feet for continuous operation.

When supply air temperature rises above 74 ± 5°F, independent of altitude, fan NO 1 changes to low speed and fan NO 2 is commanded to operate on low speed until the temperature has decreased below 64 ± 5°F. The cooling air shutoff valves change to TAKEOFF configuration. The diverter valves close.

Abnormal Operation

CAUTION

Interruption of electric power when changing from airplane generators to external power (or APU) or when changing to airplane generators from external power (or APU) can cause the forced air fan ELCU to trip. If this happens, the fan speed light goes out. Restart the fan immediately by pressing the POWER switch for that system twice (OFF, then on) and then pressing the primary fan switch for that system. The LOW SPD light should illuminate. Failure to restart fan can cause failure of equipment cooled by the forced air system.

NOTE

Fans NO 1 and NO 2 are alternated as primary and alternate units. The description given is for NO 1 as the primary unit and NO 2 as the alternate. Change the numbers in the description as necessary if NO 2 is chosen as primary and NO 1 is chosen as alternate. Alternate unit will operate only if primary fails.

Forward System

Abnormal operation of the equipment cooled by the forward forced air system can indicate lack of cooling air. Each high power UHF amplifier (in racks E2 and E3) has a vane actuated switch which shuts it down immediately when cooling air flow is lost. A code on the communications console UHF BITE (built-in test equipment) panel tells the CSO that the UHF high power amplifier shut down. When cooling air is lost the mission UHF transceivers in racks E2, E4, and E19 can fail after approximately five seconds if transmitting and after approximately five minutes on receive. Without cooling air, the HF transmitter in rack E8 can fail in approximately three seconds if transmitting, and after approximately one minute if not transmitting. The HF receiver can fail after approximately five minutes without cooling air. The Data Processing System (DPS) in racks E20, and E21, gives indication of overheat by intermittent errors after about 15 minutes without cooling air. The display data controller (DDC), in rack E23, has an overheat light and an advisory message on the computer operator's scope.

Aft System

The UHF receivers in rack E13 can fail after approximately five minutes without cooling air. Without cooling air, the HF transmitter can fail in approximately three seconds if transmitting and after approximately one minute if not transmitting. The HF receiver can fail after approximately five minutes without cooling air. The mission radar, if overheated, can have abnormal output without displaying an overheat warning. The IFF has interlocked overheat protection which shuts it down. If certain ESM equipment in the E51 rack overheats, the OVERHEAT caution light on the ESMG CONTROL panel illuminates and if the equipment becomes too hot, it is shut down and the SHUT DOWN caution light on the ESMG CONTROL panel illuminates. The ESMG CONTROL panel is located at the computer console.

Fan Number One Fails on High Speed

The sequence of indications is: The fan number one HIGH SPD indicator goes out when fan number one quits. Then the NO FLOW caution light illuminates when the air flow has stopped long enough for the heating element in the flow sensor to heat up the heat sensitive switch in the sensor. When the flow sensor near the fans sends a no flow signal (in addition to the signal from the no flow sensor which caused the NO FLOW caution light to illuminate) the system logic then commands fan number two to start. Fan number two starts on low speed (LOW SPEED light illuminated) for about six seconds and then switches to high speed (HIGH SPEED light illuminated, LOW SPEED light out). When the air flow has cooled the system flow sensor, the NO FLOW caution light goes out. The supply air temperature starts to recover to normal. As soon as the NO FLOW caution light goes out or the supply air temperature gage shows recovery, the avionics on the affected system can be powered up. There is no way to hasten the sequence.

CAUTION

After fan number two has switched to high speed, open FAN NO 1 circuit breaker on the P61-3 panel to ensure that no power can be applied to fan number one.

NOTE

If fan number one overheats and causes smoke, the smoke can enter the airplane cabin when fan number two starts. The smoke should gradually disperse, since fan number one is not operating and can cool off.

1. FAN 1 HIGH SPD Indicator Light Out or NO FLOW Caution Light Illuminated – Inform MCC and CSO, (and N if Aft System)

2. FAN 2 HIGH SPEED Indicator Light Illuminated – Inform MCC and CSO (and N if Aft System)

3. NO FLOW Caution Light Out and/or Supply Air Temperature Starts to Recover – Inform MCC and CSO (and N if Aft System)

Fan Number Two Fails on High Speed

The sequence of indications is: the fan number two HIGH SPEED indicator goes out when fan number two quits, the

NO FLOW caution light illuminates when the air flow has stopped long enough for the heating element in the flow sensor to heat up the heat sensitive switch in the sensor. Pressing FAN 1 switch indicator causes the system to start fan number one. Since it failed before, it will probably fail again very soon, causing the system to start fan number two again, which will also probably fail very soon. If the fans are smoking, some smoke and smell can enter the main cabin.

CAUTION

Open circuit breaker on P61-3 panel to insure no power is going to the fan.

1. FAN 2 HIGH SPEED Indicator Light Out – Inform MCC, CSO and also N for Aft System

2. NO FLOW Caution Light Illuminated – Inform MCC and CSO, and also N for Aft System

Two Fans on Low Speed, One Fan Fails

The only immediate indication of fan failure is that the LOW SPD (fan 1) or LOW SPEED (fan 2) indicator goes out. If the system is in the TAKEOFF configuration, the cooling is sufficient for the equipment on the TAKEOFF cooling loop. If the full system is being cooled, the loss of one fan on low speed reduces the cooling capacity. Raising the cabin pressure altitude above 5000 feet changes the fan operation to one fan on high speed, which restores full cooling capacity. Until full cooling capacity is restored, monitor the SUPPLY AIR temperature gage and do not transmit on the HF radio in the affected system. If full cooling capacity cannot be restored, shut down the equipment cooled by that system. If the failure is in the aft forced air cooling system, monitor the INS. If the failed fan is fan number 1: at the change over to operation with one fan on high speed, the system shuts down fan number two (FAN 2 LOW SPEED indicator out). Fan number one does not start (HI SPD indicator does not illuminate). The sequence from this point is the same as for the failure of fan number one on high speed.

CAUTION

Open circuit breaker on P61-3 panel to ensure no power is going to the fan.

Supply Air Gage Above 70°F

SUPPLY AIR Temperature Gage above 70°F and rising when TAT is below 15°C and not rising indicates system is not regulating temperature properly.

1. Inform MCC that system temperature is near the temperature at which the shutoff valves close to put the system in TAKEOFF configuration.

2. SYSTEM CONTR switch to MAN, HEAT–COOL switch held in COOL until system HEAT EXCH and BYPASS gages show FULL COOL.

3. Check other forced air cooling system to see if it is regulating properly.

Supply Air Gage Below 35°F

SUPPLY AIR temperature gage below 35°F and not rising when system is operating. Check supply air temperature of other forced air cooling system between 35°F and 45°F. If that system is operating within limits, it is further indication that the control system of the system that is cold is not operating properly.

1. SYSTEM CONTR switch to MAN, HEAT–COOL switch hold in HEAT until system HEAT EXCH and BYPASS gages show FULL HEAT.

2. When SUPPLY AIR temperature gage shows air temperature is between 35°F and 45°F, HEAT–COOL switch hold in COOL for a few seconds to get the valves off the full heat positions, then SYSTEM CONTR switch to AUTO. Monitor system temperature. If system temperature stays between 35°F and 45°F, regulation has probably been restored. If system temperature does not stay between 35°F and 45°F maintain manual control of the system temperature.

OVBD Valve Not Closed

OVBD gage does not go to FULL HEAT (full closed) after takeoff. The OVBD valve normally takes approximately 40 seconds to go from FULL COOL (full open) to FULL HEAT (full closed) and does not start closed until liftoff. Another indication or check of the problem is that when the cabin begins to pressurize, the pressure relief valves on the racks open, allowing cabin air into the forced air cooling system and then overboard. Consequences of operating with this condition can be insufficient cooling for some or all avionics on that system, and if fan number one fails, the transfer to fan number two can be very slow or not happen at all (depending on how far open the OVBD valve is). When the UNPRESS/OB VALVE switch is set to OVERRIDE, auxiliary power circuits in the forward and aft systems overboard valves close the valves.

1. SYSTEM CONTR switch to MAN, HEAT–COOL switch hold in HEAT until OVBD gage shows FULL HEAT (OVBD valve closed). BYPASS gage must read FULL HEAT (open) before OVBD valve will move to FULL HEAT (closed).

2. If OVBD gage goes to FULL HEAT, set SYSTEM CONTR switch to AUTO and monitor supply air temperature and the BYPASS and HEAT EXCH gages (to check that system is controlling valves). Check rack pressure relief valves when cabin begins to pressurize to assure normal operation.

3. If OVBD gage does not go to FULL HEAT, and when the cabin begins to pressurize, the rack pressure relief valves appear to be allowing more air out of the cabin than normal, the OVBD valve is not shut. Set UNPRESS/OB VALVE switch to OB VALVE and verify the OVBD lamp illuminates. If condition persists, inform the MCC.

Unpress Switch On

UNPRESS indicator illuminated when unpressurized operation is not intended. Set UNPRESS/OB VALVE switch to OFF (center).

Ram Valve Open Indicator Illuminated

When unpressurized operation not intended, check the UNPRESS/OB VALVE switch is set to OFF (center). Check rack pressure relief valves for abnormal amounts of cabin air going into forced air system if cabin pressurized.

Ram Valve Indicator Not Illuminated (Unpressurized 15,000 Ft or Above)

When unpressurized operation is intended but the RAM VALVE OPEN indicator does not illuminate:

1. Inform the CSO and MCC of possible loss of cooling air.

CAUTION

> Without cooling air, the HF transmitters can fail in approximately three seconds if transmitting, the UHF transmitters can fail in approximately five seconds if transmitting, and the UHF transceivers can fail in approximately one minute if only receiving. (Other critical failure times are noted elsewhere but are longer than these.)

2. Test the panel lights.

3. If the RAM VALVE OPEN light illuminates on test, the valve did not open. Setting the affected forced air cooling POWER switch to OFF for 5 to 10 seconds then on, several times, can possibly free the valve and the affected forced air cooling fans can then be turned on again, restoring cooling.

4. If the RAM VALVE OPEN light does not illuminate on test, it is still possible the ram valve did not open. To check if the aft forced air system ram valve has opened, try to open the doors on the E17 (Interrogator Set) rack; if it is difficult to open the door, the ram valve has not opened. If the ram valve has not opened, proceed as in item c above.

5. If the ram valve does not open, inform the RO and MCC that cooling air is lost for that forced air system.

Manual Operation

Manual operation of the forced air cooling systems is limited to testing the automatic fan switching circuits on the ground, manual regulation of heat exchanger, bypass and overboard valves, overboard valve override operation, selection of high-speed operation for either fan NO 1 or fan NO 2 on both or either system and initiation of unpressurized operation (above 15,000 feet cabin altitude).

CAUTION

> Manual operation of FAC FANS in HIGH SPEED will be limited to one minute or less below 5,000 feet MSL to prevent fan motor burnout.

To start the system manually, with ac electric power available to the system (POWER OFF indicator illuminated), press the POWER switch/indicator (POWER OFF indicator goes out). To stop the system, press the POWER switch/indicator again (POWER OFF indicator illuminates).

To test the fan switching circuit, with fan NO 1 operating, press the FWD or AFT SYSTEM SELECT switch to select system to be tested. Press the TEST switch. The FAN 1 LOW SPD indicator goes out, indicating that the fan is off. In less than 2 minutes, the AIR NO FLOW caution light illuminates, and the FAN 2 LOW SPEED indicator illuminates. Pressing the FAN 1 LOW SPD switch/indicator de-energizes fan NO 2 and returns fan NO 1 to normal operation and resets the switching circuits.

NOTE

Fan NO 1 and NO 2 are alternated as primary and alternate units. The description given is for Fan NO 1 as the primary unit and Fan NO 2 as the alternate. Change the numbers in the description as necessary if NO 2 is chosen as primary and NO 1 is chosen as alternate.

To control the supply air temperature manually when operating in the ENG APU mode; set the SYSTEM SELECT switch to the desired system (FWD or AFT) and monitor the supply air temperature gage. To lower the supply air temperature, refer to SUPPLY AIR GAGE ABOVE 70°F. To raise the supply air temperature, refer to SUPPLY AIR GAGE BELOW 35°F.

To initiate unpressurized operation of both forced air cooling systems, set the UNPRESS/OB VALVE switch to UNPRESS and verify that the UNPRESS light illuminates. When the UNPRESS light is illuminated, the altitude limit control device on the cabin pressure control system outflow valves is overridden, allowing the cabin altitude to rise above the nominal 14,000 foot limit and also sets up the forced air cooling system logic circuits for unpressurized operation.

When cabin altitude is above approximately 15,000 feet, both fans in each forced air cooling system operate at high speed. When cabin altitude is above 15,000 feet and cabin differential pressure is less than 2 psi, the ram valves open (RAM VALVE OPEN indicators illuminate) and modulate to limit maximum duct pressure differential at less than 1/2 psi. The overboard valves open and modulate. (OVBD gage needle moves toward COOL.) The heat exchanger valves close (HEAT EXCH gage shows full HEAT). The system automatically regulates temperature by modulating the bypass and overboard valves. Manual control of the bypass and overboard valves with the HEAT–COOL switch is possible in the manual mode.

CAUTION

When operating unpressurized and the aft forced air cooling system RAM VALVE OPEN indicator is illuminated, control the temperature of the aft system manually at 45 ± 5°F. The aft forced air cooling system must be operated in the manual mode to maintain proper temperature control when operating unpressurized with the ram valve open.

When the airplane descends below approximately 15,000 feet, or the cabin differential pressure exceeds 2 psi, or the UNPRESS/OB VALVE switch is set to OFF (center) (UNPRESS light extinguished), the NO 2 fans stop, the ram valves close, the overboard valves close, and the forced air and cabin pressurization system returns to normal (closed loop) operation.

Auxiliary power control circuits in the forward and aft FACS overboard valves provide redundant, manual capability to close the valves. In the event one of the overboard valves begins to open in flight, placing the UNPRESS/OB VALVE switch to OB VALVE (OVRD light illuminates) will electrically drive both override valves closed.

NOTE

The DESCENT switchlight is used to prevent automatic closing of cooling air valves for equipment racks E2, E3, E4, E8, E10, and E12 during descent. This allows the temperature of the racks to rise, preventing accumulation of moisture due to condensation.

Forward Forced Air Cooling System Schematic

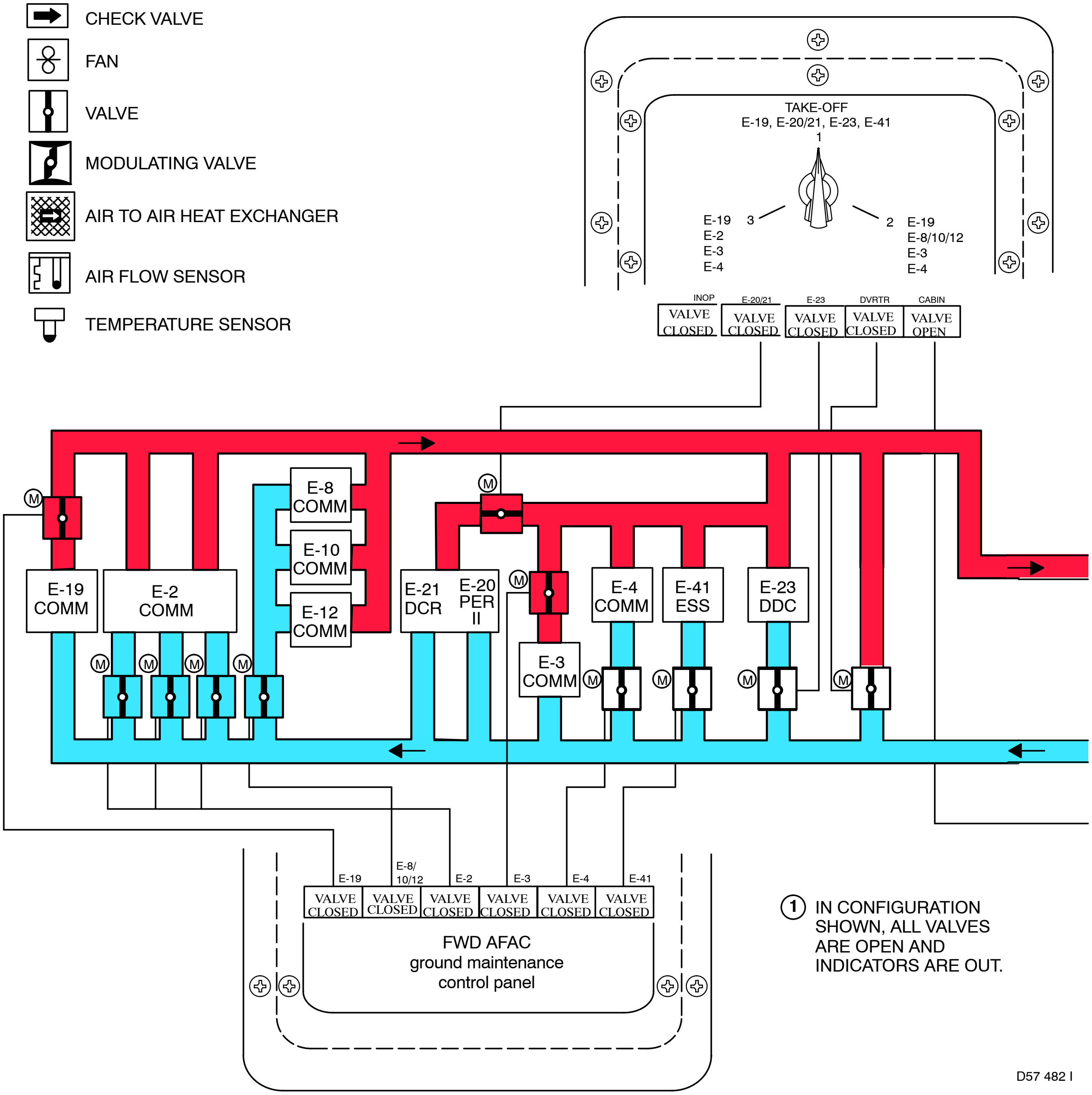
CONDITIONS: INFLIGHT, ABOVE 5000 FT CABIN ALTITUDE, PRESSURIZED, SUPPLY AIR TEMP LESS THAN 74 ±5° F OR 64 ±5° F. ①

LEGEND

▨ RAM AIR
🟥 RETURN AIR
🟦 SUPPLY AIR
Ⓜ MOTOR OPERATED VALVE
(S/P) SOLENOID CONTROLLED PNEUMATICALLY OPERATED VALVE

SYMBOLS

PRESSURE RELIEF VALVE
CHECK VALVE
FAN
VALVE
MODULATING VALVE
AIR TO AIR HEAT EXCHANGER
AIR FLOW SENSOR
TEMPERATURE SENSOR



① IN CONFIGURATION SHOWN, ALL VALVES ARE OPEN AND INDICATORS ARE OUT.

Figure 1-209 (Sheet 1 of 2)

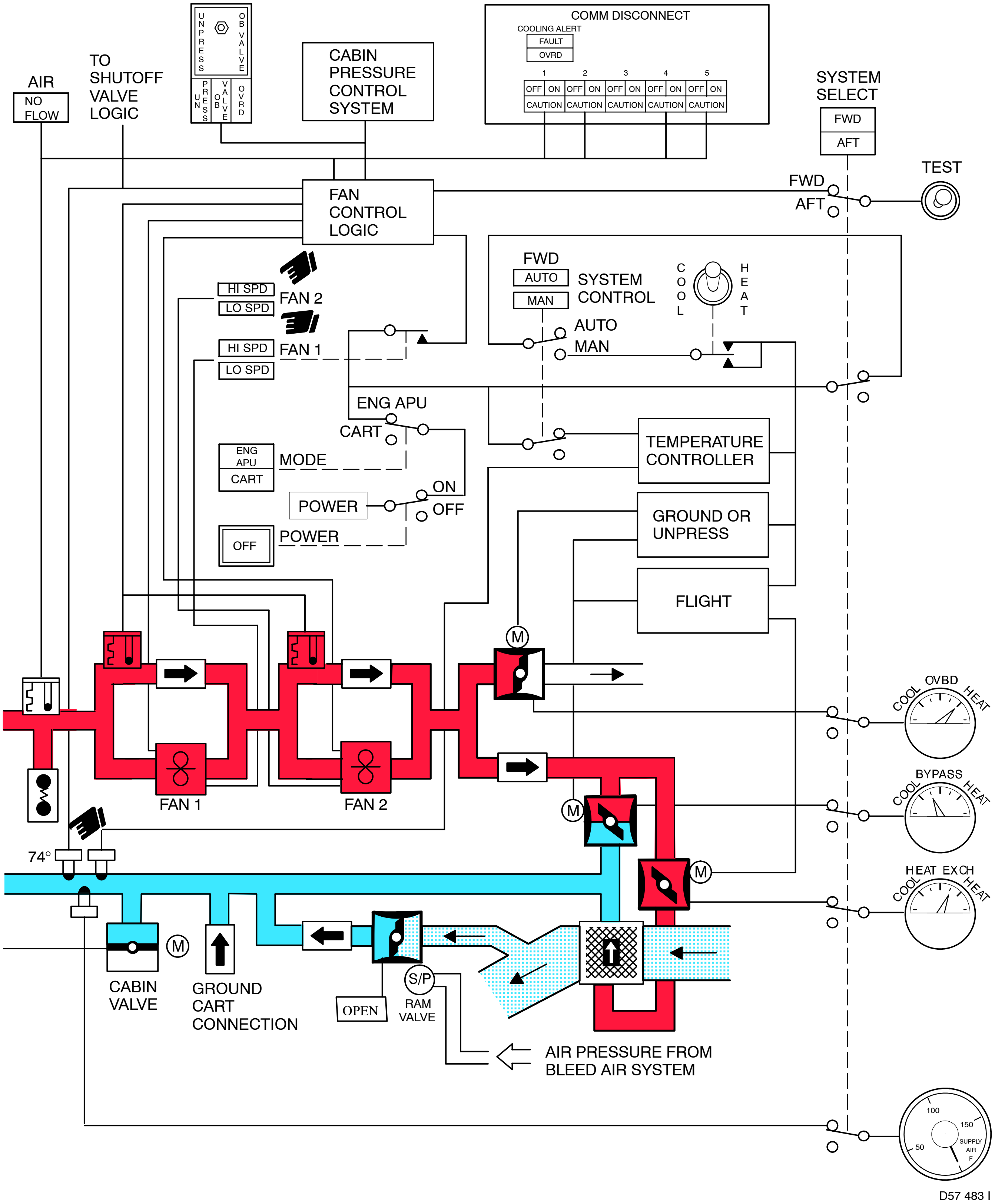


Figure 1-209 (Sheet 2 of 2)

Aft Forced Air Cooling System Schematic

LESS RSIP

CONDITION: INFLIGHT, ABOVE 5,000 FT CABIN ALTITUDE, PRESSURIZED

LEGEND

▨ RAM AIR

🟥 RETURN AIR

🟦 SUPPLY AIR

SYMBOLS

CHECK VALVE

AIR FLOW SENSOR

TEMPERATURE SENSOR

Ⓜ MOTOR OPERATED VALVE

(S/P) SOLENOID CONTROLLED PNEUMATICALLY OPERATED VALVE

AIR TO AIR HEAT EXCHANGER

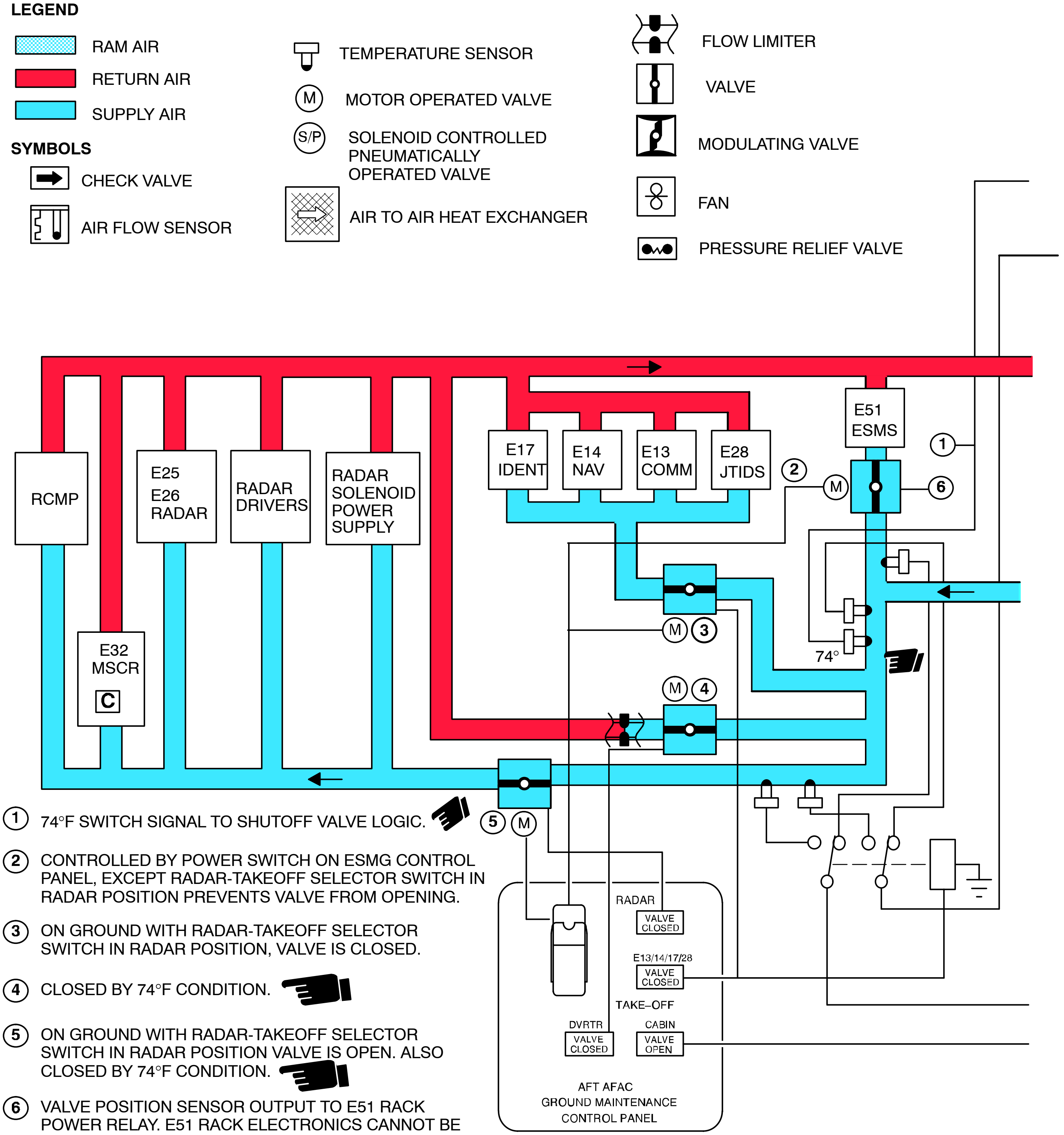
FLOW LIMITER

VALVE

MODULATING VALVE

FAN

PRESSURE RELIEF VALVE



① 74°F SWITCH SIGNAL TO SHUTOFF VALVE LOGIC.

② CONTROLLED BY POWER SWITCH ON ESMG CONTROL PANEL, EXCEPT RADAR-TAKEOFF SELECTOR SWITCH IN RADAR POSITION PREVENTS VALVE FROM OPENING.

③ ON GROUND WITH RADAR-TAKEOFF SELECTOR SWITCH IN RADAR POSITION, VALVE IS CLOSED.

④ CLOSED BY 74°F CONDITION.

⑤ ON GROUND WITH RADAR-TAKEOFF SELECTOR SWITCH IN RADAR POSITION VALVE IS OPEN. ALSO CLOSED BY 74°F CONDITION.

⑥ VALVE POSITION SENSOR OUTPUT TO E51 RACK POWER RELAY. E51 RACK ELECTRONICS CANNOT BE POWERED UNLESS VALVE IS FULLY OPEN.

Figure 1-210 (Sheet 1 of 3)

WITH RSIP

CONDITION: INFLIGHT, ABOVE 5,000 FT CABIN ALTITUDE, PRESSURIZED

LEGEND

▨ RAM AIR

🟥 RETURN AIR

🟦 SUPPLY AIR

SYMBOLS

CHECK VALVE

AIR FLOW SENSOR

TEMPERATURE SENSOR

Ⓜ MOTOR OPERATED VALVE

S/P SOLENOID CONTROLLED PNEUMATICALLY OPERATED VALVE

AIR TO AIR HEAT EXCHANGER

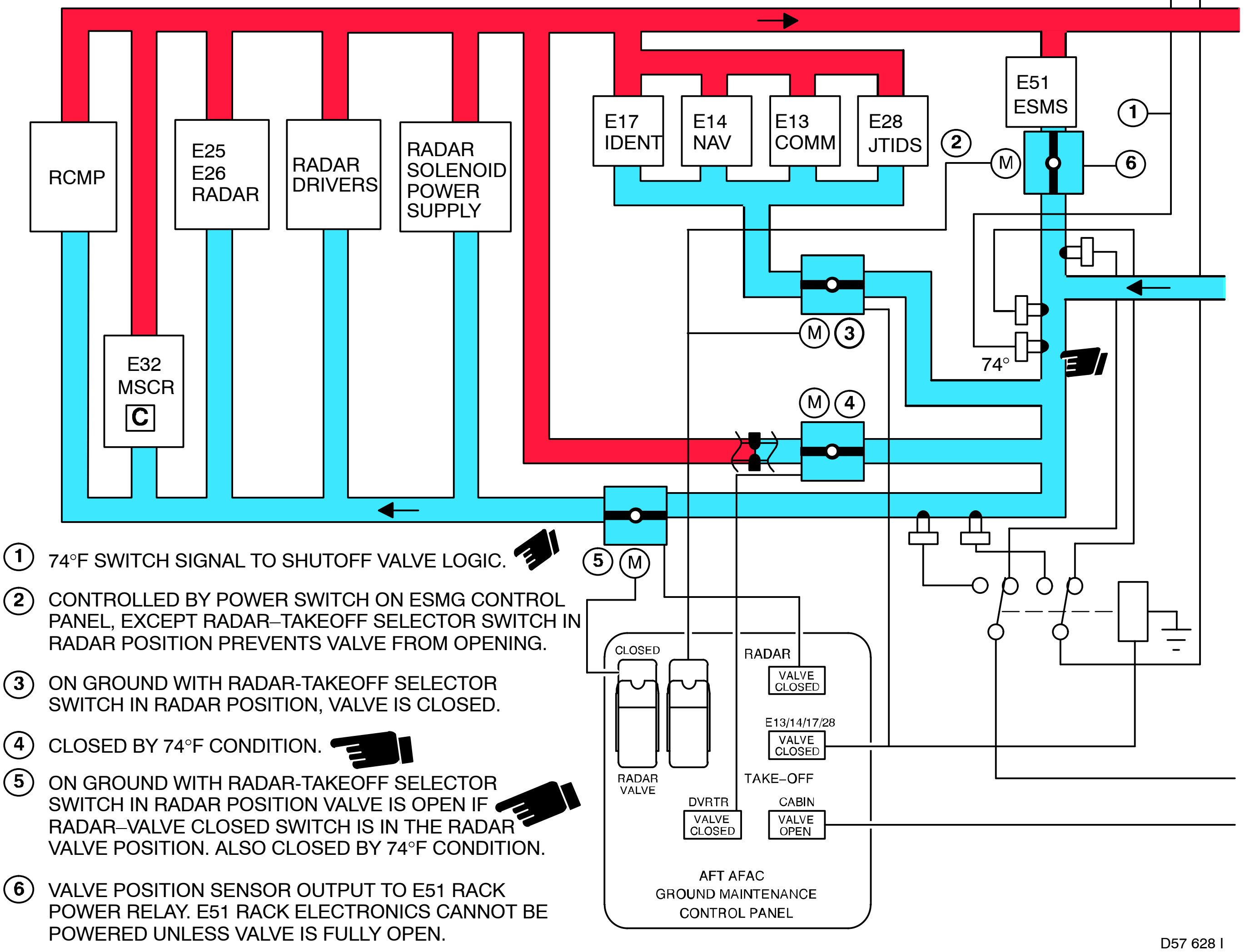
FLOW LIMITER

VALVE

MODULATING VALVE

FAN

PRESSURE RELIEF VALVE



① 74°F SWITCH SIGNAL TO SHUTOFF VALVE LOGIC.

② CONTROLLED BY POWER SWITCH ON ESMG CONTROL PANEL, EXCEPT RADAR–TAKEOFF SELECTOR SWITCH IN RADAR POSITION PREVENTS VALVE FROM OPENING.

③ ON GROUND WITH RADAR-TAKEOFF SELECTOR SWITCH IN RADAR POSITION, VALVE IS CLOSED.

④ CLOSED BY 74°F CONDITION.

⑤ ON GROUND WITH RADAR-TAKEOFF SELECTOR SWITCH IN RADAR POSITION VALVE IS OPEN IF RADAR–VALVE CLOSED SWITCH IS IN THE RADAR VALVE POSITION. ALSO CLOSED BY 74°F CONDITION.

⑥ VALVE POSITION SENSOR OUTPUT TO E51 RACK POWER RELAY. E51 RACK ELECTRONICS CANNOT BE POWERED UNLESS VALVE IS FULLY OPEN.

D57 628 I

Figure 1-210 (Sheet 2 of 3)

Aft Forced Air Cooling System Schematic (Continued)

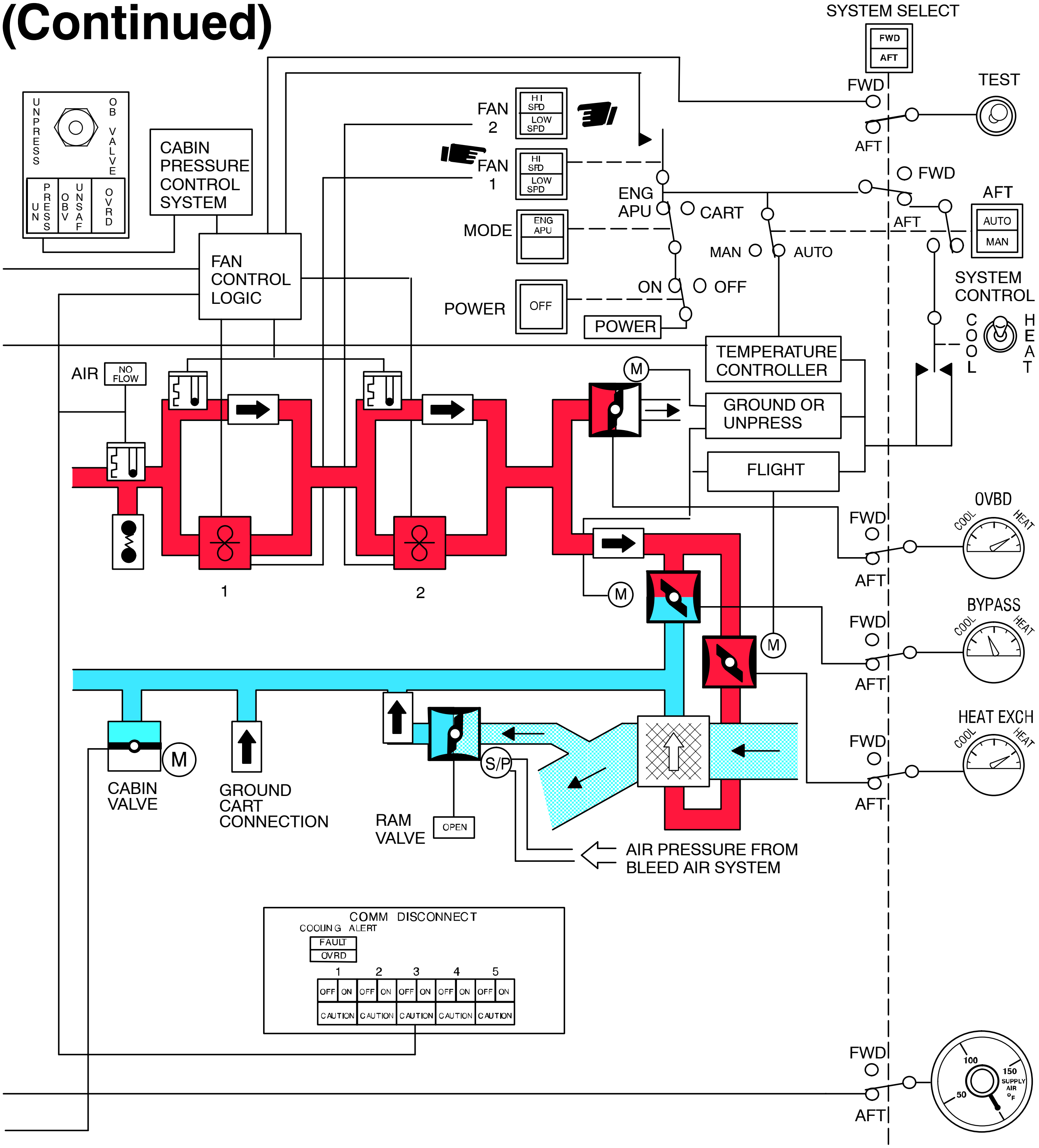


Figure 1-210 (Sheet 3 of 3)

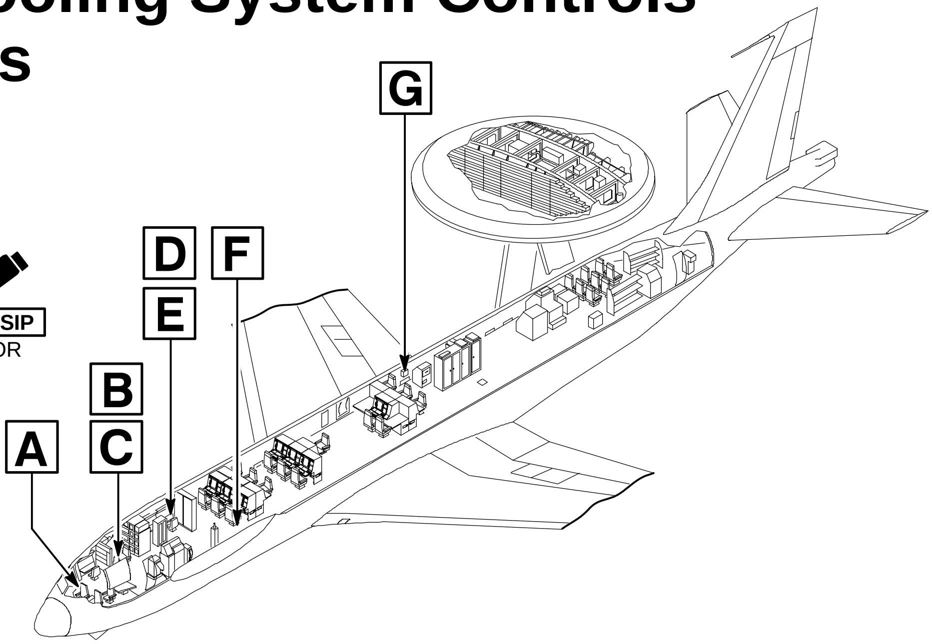
D57 486 I

Pages 1–979 and 1–980 deleted.

Forced Air Cooling System Controls and Indicators

NOTE

LOCATOR SHOWN IN **WITH RSIP** CONFIGURATION; SUFFICES FOR OTHER CONFIGURATIONS.



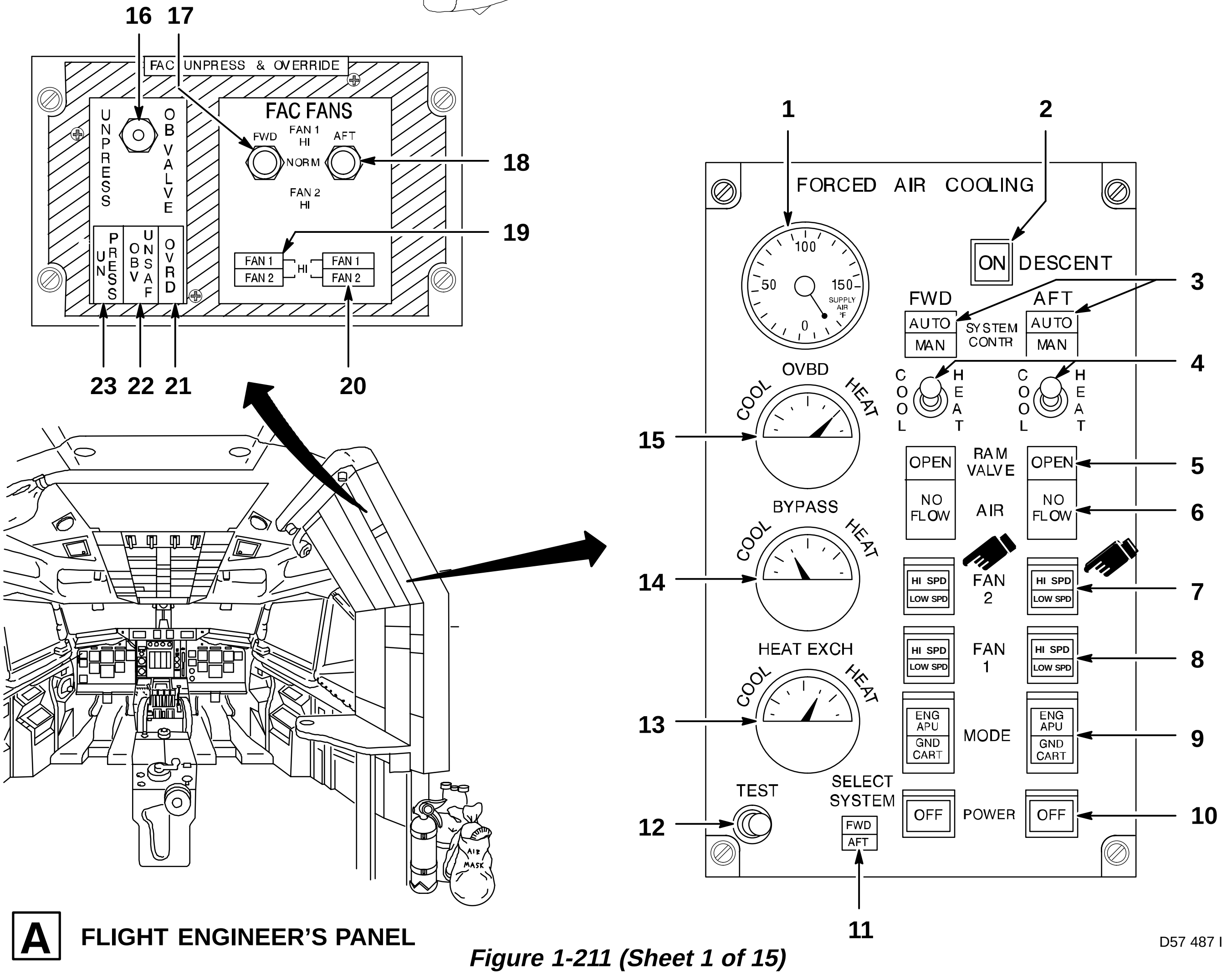


Figure 1-211 (Sheet 1 of 15)

Forced Air Cooling System Controls and Indicators (Continued)

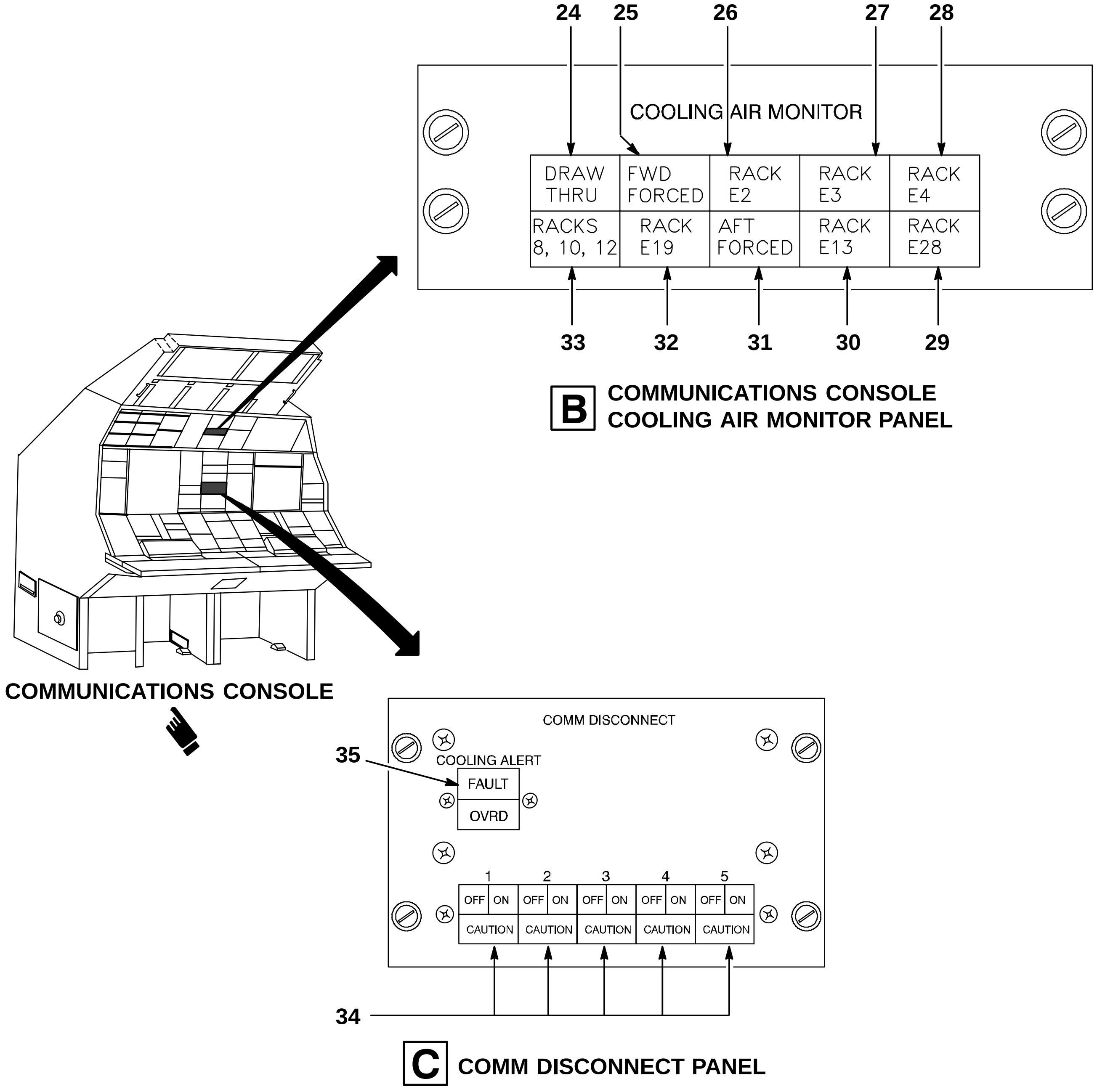
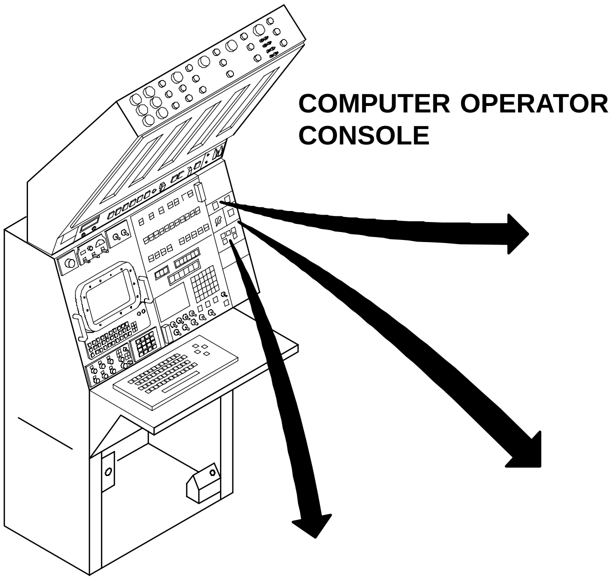
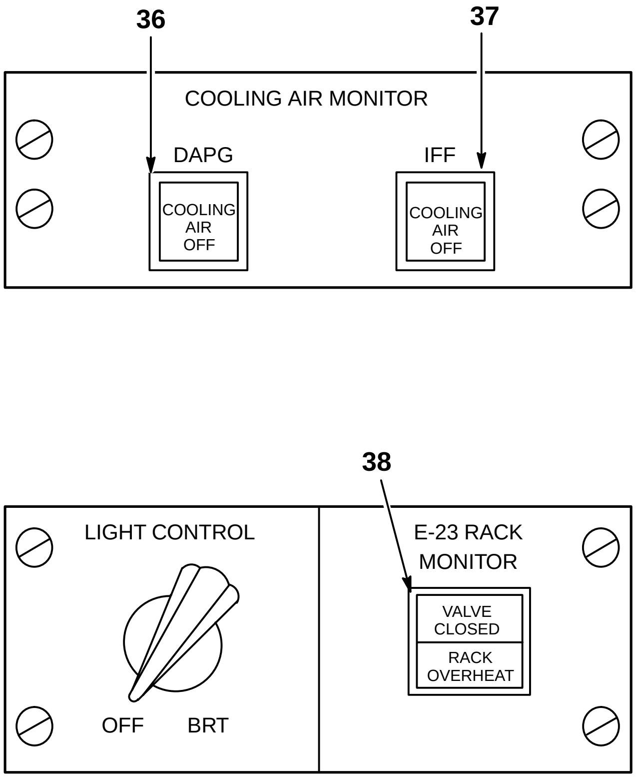
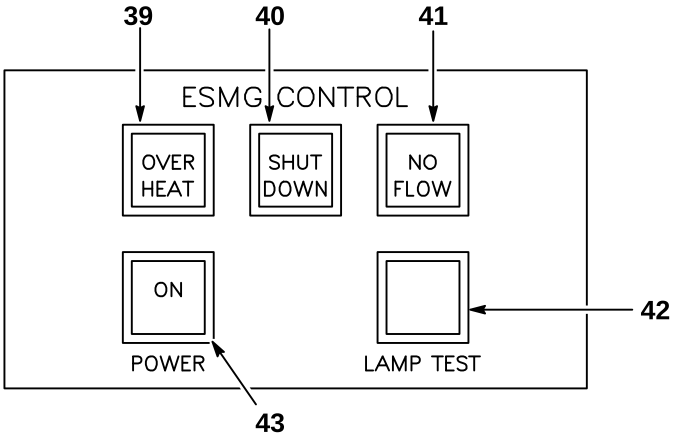


Figure 1-211 (Sheet 2 of 15)





D **COMPUTER OPERATOR CONSOLE COOLING AIR MONITOR PANELS (2)**

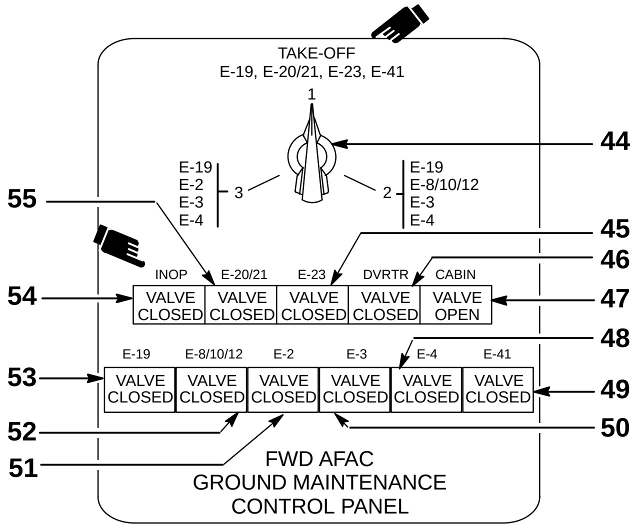


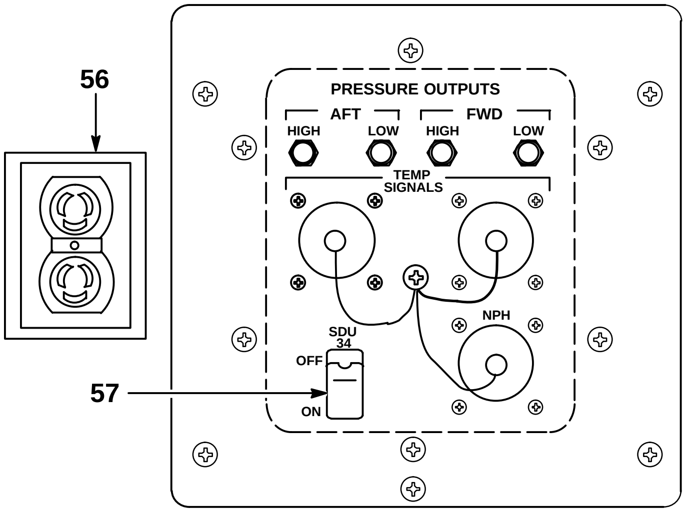
E **ESMG CONTROL (COOLING AIR) PANEL**

D57 489 I

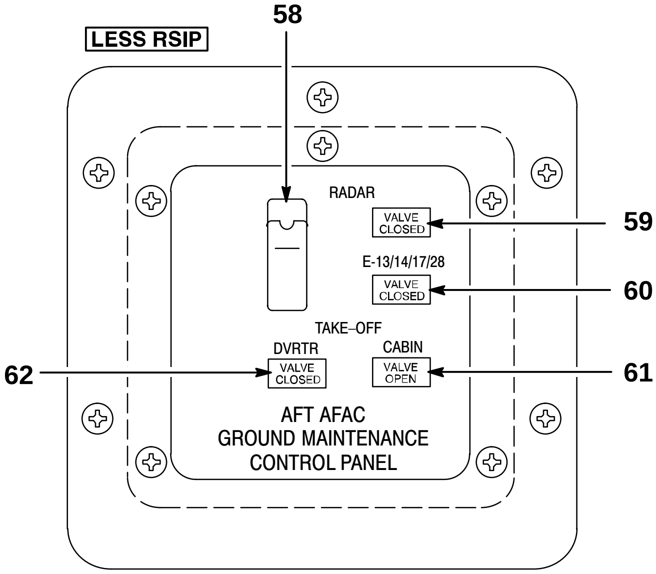
Figure 1-211 (Sheet 3 of 15)

Forced Air Cooling System Controls and Indicators (Continued)

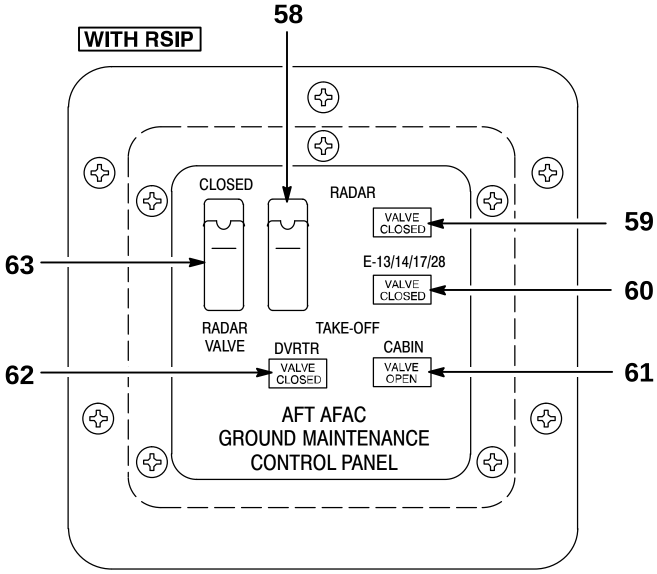




F **FORWARD AFAC GROUND MAINTENANCE CONTROL PANEL**



G **AFT AFAC GROUND MAINTENANCE CONTROL PANEL**



G **AFT AFAC GROUND MAINTENANCE CONTROL PANEL**

D57 490 I

Figure 1-211 (Sheet 4 of 15)

NO.	CONTROL/INDICATOR	FUNCTION
		A FLIGHT ENGINEER'S PANEL
1	SUPPLY AIR °F (Supply Air Temperature) Gage	Indicates temperature of supply air in degrees F in system selected by SYSTEM SELECT switch. When power is removed from aft system (or both) gage indicates temperature in forward system duct. When aft system is selected, displays temperature in E-13/14/17/28 and E51 rack branches, unless valves to those branches are not full open, in which case gage displays temperature in radar duct.
2	DESCENT Switchlight (Green, Guarded)	When in depressed position, ON indicator is illuminated. Prevents automatic closing of the cooling air valves for equipment racks E2, E3, E4, E8, E10, E12 and E41. This allows the temperature of the racks to rise, preventing accumulation of moisture due to condensation.
3	SYSTEM CONTR (System Control) Switch Indicator (Green) (One for each system)	Selects operating mode of system control logic. When in released position, MAN indicator is illuminated and HEAT–COOL switch operates valves in that system. When in depressed position, AUTO indicator is illuminated and system valves are controlled only by logic circuits.
		NOTE SYSTEM SELECT switch must be set to system to be controlled manually, or HEAT–COOL switch is inoperative.
4	HEAT COOL Switch (Momentary) (One for each system)	The switch is armed when SYSTEM CONTR switch is set to MAN, and SYSTEM SELECT switch is set to that system. Switch controls temperature of system supply air by regulating bypass and overboard valves on the ground or in unpressurized flight above 15,000 feet when cabin differential pressure is less than 2 psi. In normal flight, the switch controls the bypass and heat exchanger valves. Valve position gages show position of valves in selected system. When on the ground, or unpressurized above 15,000 feet, setting the switch to HEAT opens the bypass valve first, then closes the overboard valve. Setting the switch to COOL opens the overboard valve first and then closes the bypass valve. In flight, setting the switch to HEAT opens the bypass valve and then closes the heat exchanger valve. Setting the switch to COOL opens the heat exchanger valve and then closes the bypass valve.

Figure 1-211 (Sheet 5 of 15)

Forced Air Cooling System Controls and Indicators (Continued)

NO.	CONTROL/INDICATOR	FUNCTION
5	RAM VALVE OPEN Indicators (Green) (One for each system)	Illuminated when power is applied to the system and ram valve is not closed. Ram valve is normally closed except during unpressurized operation above 15,000 feet.
6	AIR NO FLOW Caution Lights (Amber) (One for each system)	Illuminated when power is applied to the system and the airflow detector does not sense sufficient cooling airflow in the system. If just FAN 1 HI SPD or LOW SPD indicator is illuminated, the control logic unpowers fan 1 and commands fan 2 to operate. If just FAN 2 HIGH SPEED or LOW SPEED indicator is illuminated, the control logic only unpowers fan NO 2. If both fans are commanded to operate, and the caution light is illuminated, no control action occurs.

CAUTION

It can take up to two minutes after airflow stops for a NO FLOW caution light to illuminate. Refer to ABNORMAL OPERATION.

NO.	CONTROL/INDICATOR	FUNCTION
7	FAN 2 HIGH SPD–LOW SPD Switch Indicator (Green) (One for each system)	When pressed (with power available to system and system in ENG APU mode), enables control logic to start fan 2. LOW SPD indicator illuminates when fan is commanded to operate at low speed. HI SPD indicator illuminates when fan is commanded to operate at high speed. Indicator goes out when fan motor overheats and shuts down. Switch does not shut down fan 2. When pressed with FAN 1 HIGH SPD or LOW SPD indicator illuminated and FAN 2 HIGH SPD–LOW SPD indicator out, causes changeover circuit to unpower fan 1, commands fan 2 to operate, and resets automatic switchover circuitry. FAC FANS switches on the FACS UNPRESS & OVERRIDE panel permit manual selection of high-speed operation on forward and/or aft FACS fan 1 or 2.
8	FAN 1 HIGH SPD–LOW SPD Switch Indicator (Green) (One for each system)	When pressed (with power available to system and system in ENG APU mode) enables control logic to start fan 1. LOW SPD indicator illuminates when fan is commanded to operate at low speed. HI SPD indicator illuminates when fan is commanded to operate at high speed. The indicator goes out when fan motor overheats and shuts down. Switch does not shut down fan 1. When pressed with FAN 2 HIGH SPD or LOW SPD indicator illuminated and FAN 1 HI SPD–LOW SPD indicator out, causes changeover circuit to turn off fan 2, commands fan 1 to operate, and resets automatic switchover circuitry. FAC FANS switches on the FACS UNPRESS & OVERRIDE panel permit manual selection of high-speed operation on forward and/or aft FACS fans 1 or 2.

Figure 1-211 (Sheet 6 of 15)

NO.	CONTROL/INDICATOR	FUNCTION
9	MODE ENG APU – GND CART Switch Indicator (Mode Switch) (Green, Guarded) (One for each system)	Controls operating mode of system. When in released position, CART indicator is illuminated, control panel switches and system fans are inoperative. Valve position and supply air temperature gages operate. Temperature is controlled by ground air source (ground cart) connected to each system. The NO FLOW caution lights operate, providing indication only. Cooling air is supplied to entire system. CART mode operates only on ground. When in depressed position, ENG APU indicator is illuminated and the system operates normally.
10	POWER OFF Switch Indicator (Green, Guarded) (One for each system)	When in released position and power is available to the system, OFF indicator is illuminated and power is removed from all of system except SUPPLY AIR temperature gage and UNPRESS switch. When in depressed position, switch applies power through control logic to system and OFF indicator goes out.
11	SYSTEM SELECT FWD–AFT Switch Indicator (Green)	Selects system to be monitored by valve position gages and supply air temperature gage. When pressed, selects either forward or aft system. When forward is selected, FWD indicator is illuminated and forward system valve position and supply air temperature are displayed. When aft system is selected, AFT indicator is illuminated and aft system valve positions and duct temperature are displayed. Selects system for control by HEAT–COOL switch when SYSTEM CONTR switch is set to MAN. Also selects system for TEST pushbutton test.
12	TEST Pushbutton (Momentary)	When pressed, allows testing of automatic fan changeover circuit from fan 1 to fan 2. Tests only the system selected on SYSTEM SELECT switch. When pressed, unpowers fan 1, causing airflow detector to illuminate NO FLOW caution light and then system logic to command fan 2 to operate. When fan 2 is operating, TEST pushbutton is inoperative. Pressing FAN 1 switch resets system. TEST pushbutton operable only on the ground.
13	HEAT EXCH Gage	Indicates relative position of heat exchanger valve in system selected by SYSTEM SELECT switch. When valve is open, gage indicates full COOL. When valve is closed, gage indicates full HEAT.
14	BYPASS Gage	Indicates relative position of bypass valve in system selected by SYSTEM SELECT switch. When valve is closed, gage indicates full COOL. When valve is open, gage indicates full HEAT.

Figure 1-211 (Sheet 7 of 15)

Forced Air Cooling System Controls and Indicators (Continued)

NO.	CONTROL/INDICATOR	FUNCTION
15	OVBD Gage	Indicates relative position of overboard valve in system selected by SYSTEM SELECT switch. When valve is closed, gage indicates full HEAT. When valve is open, gage indicates full COOL.
16	UNPRESS/OB VALVE Switch	Three-position lever-lock toggle switch. UNPRESS: Enables forward and aft systems to operate in unpressurized mode. Opens overboard valves, ram valves, closes heat exchanger valves, operates both fans at high speed, and inhibits altitude limit control on cabin pressure control system outflow valves. Operation in unpressurized mode cannot occur unless the cabin altitude exceeds 15,000 feet and cabin-to-ambient pressure differential is less than 2 psi. OFF (Center): Switch position for normal operation. OB VALVE: Drives overboard valve closed using auxiliary power circuits.

NOTE

Operating cabin altitude rate knob when UNPRESS/OB VALVE switch is set to UNPRESS and cabin altitude is between 10,000 and 14,000 feet could result in depressurizing airplane.

17	FACS FAN FWD Switch	Three-position lever-lock toggle switch. FAN 1 HI: Used to manually set forward forced air cooling system fan 1 manually to high-speed operation. NORMAL: Switch position for normal fan operation. FAN 2 HI: Used to set forward forced air cooling system fan 2 manually to high-speed operation.

CAUTION

Use of FAN 1 HI or FAN 2 HI will be limited to one minute at or below 5,000 feet MSL to prevent damage to fan motors.

18	FACS FANS AFT Switch	Three-position lever-lock toggle switch. FAN 1 HI: Used to set forward forced air cooling system fan 1 manually to high-speed operation.

Figure 1-211 (Sheet 8 of 15)

NO.	CONTROL/INDICATOR	FUNCTION
		NORMAL: Switch position for normal fan operation. FAN 2 HI: Used to set aft forced air cooling system fan 2 manually to high-speed operation.

CAUTION

Use of FAN 1 HI or FAN 2 HI will be limited to one minute at or below 5,000 feet MSL, to prevent damage to fan motors.

NO.	CONTROL/INDICATOR	FUNCTION
19	FWD FAN 1/FAN 2 Indicator (Green)	FAN 1 Illuminated: High-speed override for forward forced air cooling system fan 1 is on. FAN 2 Illuminated: High-speed override for forward forced air cooling system fan 2 is on.
20	AFT FAN 1/FAN 2 Indicator (Green)	FAN 1 Illuminated: High-speed override for aft forced air cooling system fan 1 is on. FAN 2 Illuminated: High-speed override for aft forced air cooling system fan 2 is on.
21	OVRD Indicator (Green)	Illuminated when UNPRESS/OB VALVE switch is set to OB VALVE.
22	OBV UNSAF Caution Light (Amber)	Illuminated when overboard valve is open. Flickering during takeoff is normal.
23	UNPRESS Indicator (Green)	Illuminated when UNPRESS/OB VALVE switch set to UNPRESS.

B COMMUNICATIONS CONSOLE COOLING AIR MONITOR PANEL

NOTE

Signal sources for no cooling air flow are the same as for the flight engineer's panel. Signal sources for cooling air shutoff valve position are the same as for the ground maintenance panels.

NO.	CONTROL/INDICATOR	FUNCTION
24	DRAW THRU Caution Light (Amber)	When illuminated, indicates power is applied to the draw through cooling system, but no airflow is detected.
25	FWD FORCED Caution Light (Amber)	When illuminated, indicates power is applied to forward forced air system but no airflow is detected.

Figure 1-211 (Sheet 9 of 15)

Forced Air Cooling System Controls and Indicators (Continued)

NO.	CONTROL/INDICATOR	FUNCTION
26	RACK E2 Caution Light (Amber)	When illuminated, indicates power is applied to forward forced air system and at least one of the three cooling air shutoff valves to rack E2 is not fully open.
27	RACK E3 Caution Light (Amber)	When illuminated, indicates power is applied to forward forced air system and the cooling air shutoff valve to rack E3 is not fully open.
28	RACK E4 Caution Light (Amber)	When illuminated, indicates power is applied to forward forced air system and the cooling air shutoff valve to rack E4 is not fully open.
29	Rack E28 Caution Light (Amber)	When illuminated, indicates power is applied to aft forced air system and shutoff valve to racks E13, E14, E17 and E28 is not fully open.
30	RACK E13 Caution Light (Amber)	When illuminated, indicates power is applied to aft forced air system and shutoff valve to racks E13, E14, E17 and E28 is not fully open.
31	AFT FORCED Caution Light (Amber)	When illuminated, indicates power is applied to aft forced air system, but no airflow is detected.
32	RACK E19 Caution Light (Amber)	When illuminated, indicates power is applied to forward forced air system and valve to rack E19 is not fully open.
33	RACKS 8, 10, 12 Caution Light (Amber)	When illuminated, indicates power is applied to forward forced air system and the cooling air shutoff valve to racks E8, E10 and E12 is not fully open.

C COMMUNICATIONS CONSOLE COMM DISCONNECT PANEL

NOTE

Signal sources for no cooling air flow are the same as for the flight engineer’s panel.

34	1 through 5 Switchlights:	See *figure 1-54* for communications equipment affected by and cooling air monitored by switchlight.
	OFF Caution Light (Amber)	Removes power. When illuminated, indicates that power is not being supplied to associated communications equipment.
	ON Indicator (Green)	Provides power. When illuminated, indicates that power is being supplied to associated communications equipment.

Figure 1-211 (Sheet 10 of 15)

NO.	CONTROL/INDICATOR	FUNCTION
	CAUTION Light (Amber)	When illuminated, indicates that required cooling air to associated communications equipment has been lost. Pressing switchlight removes power to associated communications equipment.
35	COOLING ALERT FAULT/ OVRD Switchlight FAULT Caution Light (Amber-Flashing)	Illuminates when communications equipment powered through a disconnect switchlight experiences loss of cooling air. Goes out when cooling air is restored; or power is removed from the associated equipment; or COOLING ALERT switchlight is pressed, activating the override function. In override mode, OVRD warning light segment is illuminated and fault circuits are reset to detect any additional cooling air loss.
	OVRD Warning Light (Red)	Illuminates after COOLING ALERT switchlight is pressed when FAULT caution light segment is illuminated. Indicates that fault detection circuitry is reset and associated communications equipment is operating without cooling air.

D COMPUTER OPERATOR'S CONSOLE COOLING AIR MONITOR PANELS

NOTE

Signal sources for no cooling air flow are the same as for the flight engineer's panel. Signal sources for cooling air shutoff valve position are the same as for the ground maintenance panels.

NO.	CONTROL/INDICATOR	FUNCTION
36	DAPG COOLING AIR OFF Warning Light (Red)	When illuminated, indicates power applied to forward forced air cooling system and no air flow is present; or the cooling air shutoff valve to the E20 and E21 racks is not fully open; or draw through cooling system air flow is not detected.
37	IFF COOLING AIR OFF Warning Light (Red)	When illuminated, indicates power is applied to aft forced air system and no air flow is present; or cooling air shutoff valve to racks E13, E14, E17, and E28 is not fully open.
38	E-23 RACK MONITOR Switchlight	Tests both lamps when pressed.
	VALVE CLOSED Indicator (Green)	When illuminated, indicates that cooling air valve to equipment rack E23 is closed.

NOTE

Signal source for cooling air shutoff valve position is the same as for the ground maintenance panels.

Figure 1-211 (Sheet 11 of 15)

Forced Air Cooling System Controls and Indicators (Continued)

NO.	CONTROL/INDICATOR	FUNCTION
	RACK OVERHEAT Warning Light (Red)	When illuminated, indicates overheat condition in equipment rack E23.

NOTE

Signal source for rack overheat is directly from the rack.

E ESMG CONTROL PANEL

NO.	CONTROL/INDICATOR	FUNCTION
39	OVER HEAT Caution Light (Amber)	Illuminates when certain equipment in the E51 rack overheats.
40	SHUT DOWN Caution Light (Amber)	Illuminates when power switch is ON and power is removed from certain equipment in the E51 rack because of overheat condition.
41	NO FLOW Caution Light (Amber)	Operated by the aft forced air system no flow logic. When illuminated, indicates power is applied to the aft forced air system and no air flow is present. Signal source is same as for flight engineer's panel.
42	LAMP Test Switch	When depressed, causes all lamps in the ESMG CONTROL panel to illuminate.
43	POWER Switch/Indicator (Green)	When set to the depressed position, causes fans which supply cooling air to each ESM antenna to operate and also commands the aft forced air system valve for E51 rack to open. When the valve supplying cooling air from the aft forced air cooling system is fully open, the ON indicator is illuminated and power is available to the ESM system. In order for the valve supplying cooling to the E51 rack to open, the POWER INTERLOCK switch on the E51 rack must be set to ON and the aft forced air system RADAR–TAKEOFF selector switch on the aft AFAC ground maintenance control panel must also be set to TAKEOFF.

Figure 1-211 (Sheet 12 of 15)

NO.	CONTROL/INDICATOR	FUNCTION
	F **FORWARD AFAC GROUND MAINTENANCE CONTROL PANEL**	
44	Selector Switch	Rotary switch with three positions. Switch controls only on ground, when ENG APU mode has been selected on system MODE switch (flight engineer's panel). When set to position, supplies air only to racks shown on panel for that position. The three positions are: 1. TAKE–OFF E-19, E-20/21, E-23 2. E-19, E-8/10/12, E-3, E-4 3. E-19, E-2, E-3, E-4
	VALVE Caution Lights (Amber)	There are ten caution lights, one for each valve (except item 51, which monitors three valves with one light). Lights operate as long as power is applied to system.
45	E-23 VALVE CLOSED	When illuminated, indicates that cooling air shutoff valve to data display rack is not fully open.
46	DVRTR VALVE CLOSED (Diverter Valve Closed)	When illuminated, indicates that diverter valve is not fully open. If illuminated in flight, no action is required.

CAUTION

If not illuminated when airplane is on the ground with system in ENG–APU mode, diverter valve must be closed manually to assure adequate cooling airflow in selected racks.

NO.	CONTROL/INDICATOR	FUNCTION
47	CABIN VALVE OPEN	When illuminated, indicates the cabin valve is not fully closed.

CAUTION

The cabin valve must be closed in all operating modes except ground operation in ENG–APU mode.

NO.	CONTROL/INDICATOR	FUNCTION
48	E-4 VALVE CLOSED	When illuminated, indicates cooling air shutoff valve to rack E4 is not fully open.
49	E-41 VALVE CLOSED	When illuminated, indicates cooling air shutoff valve to rack E41 is not fully open.

Figure 1-211 (Sheet 13 of 15)

Forced Air Cooling System Controls and Indicators (Continued)

NO.	CONTROL/INDICATOR	FUNCTION
50	E-3 VALVE CLOSED	When illuminated, indicates cooling air shutoff valve to rack E3 is not fully open.
51	E-2 VALVE CLOSED	When illuminated, indicates at least one of the three cooling air shutoff valves to rack E2 is not fully open.
52	E-8/10/12 VALVE CLOSED	When illuminated, indicates cooling air shutoff valve to racks E8, E10, and E12 is not fully open.
53	E-19 VALVE CLOSED	When illuminated, indicates cooling air shutoff valve to rack E19 is not fully open.
54	INOP VALVE CLOSED	Not used.
55	E-20/21 VALVE CLOSED	When illuminated, indicates that cooling air shutoff valve to racks E20 and E21 is not fully open.
56	Convenience Outlet	115 VAC, 400 Hz for use with SDU-34 Test Set. Controlled by circuit breakers on P66-3.
57	SDU-34 Switch (Guarded)	Used to interface SDU-34 Test Set to airplane public address system.

NOTE

If the SDU-34 switch is left in the ON position, the SUPPLY AIR temperature gage on the flight engineer's FORCED AIR COOLING panel does not read correctly. Automatic temperature protection and warning circuits are fully operative.

G AFT AFAC GROUND MAINTENANCE CONTROL PANEL

NO.	CONTROL/INDICATOR	FUNCTION
58	RADAR–TAKEOFF Selector Switch (Guarded)	Guarded to TAKEOFF. With guard closed or when set to TAKEOFF (with system in ENG–APU mode) closes cooling air shutoff valve to radar and opens cooling air shutoff valve to racks E13, E14, E17 and E28. When set to RADAR, opens cooling air shutoff valve to radar **WITH RSIP** if CLOSED – RADAR VALVE switch is in RADAR VALVE position ◀ and closes cooling air shutoff valve to racks E13, E14, E17 and E28. Switch controls only on ground with MODE switch in ENG–APU mode. When set to RADAR, commands valve to rack E51 closed which removes power from ESM, either on ground or airborne. When set to TAKEOFF, enables normal ESM operation. Not affected by RSIP.

Figure 1-211 (Sheet 14 of 15)

NO.	CONTROL/INDICATOR	FUNCTION
59	RADAR VALVE CLOSED Caution Light (Amber)	When illuminated, indicates cooling air shutoff valve to radar is not fully open. Light operates any time power is applied to system.
60	E13/14/17/28 VALVE CLOSED Caution light (Amber)	When illuminated, indicates valve to racks, E13/14/17 and 28 is not fully open. Light operates any time power is applied to system.
61	CABIN VALVE OPEN Caution Light (Amber)	When illuminated, indicates cabin valve is not fully closed.

CAUTION

The cabin valve must be closed in all operating modes except ground operation in ENG–APU mode.

62	DVRTR VALVE CLOSED Caution Light (Amber)	When illuminated, indicates diverter valve is not fully open. If illuminated in flight, no action is required.

CAUTION

If not illuminated when airplane is on the ground with system in ENG–APU mode, diverter valve must be closed manually to assure adequate cooling airflow to selected racks.

63	**LESS RSIP** (Not Installed) ◀ **WITH RSIP** CLOSED – RADAR VALVE Switch (Guarded) ◀	When set to CLOSED (up, unguarded) position (with system in ENG–APU or CART mode), closes radar cooling air valve, shutting off cooling air supply to radar equipment racks. Used to shut off cooling air supply to radar equipment whenever radar set is turned off to reduce buildup of condensation in equipment areas. Switch must be in RADAR VALVE (down, guarded) position during normal radar set operation.

Figure 1-211 (Sheet 15 of 15)

Forced Air Cooling System Operating Modes

OPERATING MODES	POWER OFF SWITCH INDI-CATOR	MODE SWITCH INDICATOR		FAN 1 SWITCH INDICATOR		FAN 2	
		ENG APU	CART	HI SPD	LOW SPD	HI SPD	LOW SPD
GROUND Power Off Airplane	Out	Out	Out	Out	Out	Out	Out
Power Off System	OFF	Out	Out	Out	Out	Out	Out
Power On System CART	Out	Out	CART	Out	Out	Out	Out
Power On System ENG APU	Out	ENG APU	Out	Out	LOW SPD AFT or FWD	Out	Out
FLIGHT Takeoff	Out	ENG APU	Out	Out	Out Fwd LOW SPD Aft	Out	Out
Liftoff (Fwd Fan On)	Out	ENG APU	Out	Out	LOW SPD	Out	LOW SPD
Below 4200 ft (descending) Below 5000 ft (ascending) Cabin Pressure Altitude	Out	ENG APU	Out	Out	LOW SPD	Out	LOW SPD
Supply Air Temp over 74 ± 5°F	Out	ENG APU	Out	Out	LOW SPD	Out	LOW SPD
Supply Air Temp over 64 ± 5°F if had been over 74 ± 5°F	Out	ENG APU	Out	Out	LOW SPD	Out	LOW SPD
Above 4200 ft (descending) Above 5000 ft (ascending) Cabin Pressure Altitude Cabin Supply Air Temp below 74 ± 5°F or 64 ± 5°F	Out	ENG APU	Out	HI SPD	Out	Out	Out
UNPRESSURIZED Above 15,000 ft Cabin Alt and Cabin Diff. Press more than 2 psi	Out	ENG APU	Out	HI SPD	Out	HIGH SPD	Out
Above 15,000 ft Cabin Alt and Cabin Diff. Press less than 2 psi	Out	ENG APU	Out	HI SPD	Out	HIGH SPD	Out

NOTE: Fan No. 1 and Fan No. 2 are alternated as primary and alternate units. The description given is for fan No. 1 as the primary unit and fan No. 2 as the alternate. Change the numbers in the description as necessary if fan No. 2 is chosen as primary and fan No. 1 is chosen as alternate.

Figure 1-212 (Sheet 1 of 4)

AIR NO FLOW CAUTION LIGHT	RAM VALVE OPEN INDI- CATOR	SYSTEM CONTR SWITCH INDICATOR		UNPRESS ON SWITCH INDICATOR	SUPPLY AIR TEMPERA- TURE GAGE	OVBD VALVE GAGE	BYPASS VALVE GAGE	HEAT EXCH VALVE GAGE
		AUTO	MAN					
Out (Not Functional)	Out	Out	Out	Out (Not Functional)	Not Functional	Full COOL	Full COOL	Full COOL
Out (Not Functional)	Out	Out	Out	Out	Fwd Syst Temp	Full COOL	Full COOL	Full COOL
Out	Out	Out	Out	Out	Fwd or Aft	Full COOL (Open)	Full COOL (Closed)	Full HEAT (Closed)
NO FLOW (Fwd) Out (Aft)	Out	AUTO	Out	Out	Fwd or Aft	Modulating	Modulating	Full HEAT
NO FLOW (Fwd) Out (Aft)	Out	AUTO	Out	Out	Fwd or Aft	Modulating	Modulating	Full HEAT
Out	Out	AUTO	Out	Out	Fwd or Aft	Full HEAT	Modulating	Modulating
Out	Out	AUTO	Out	Out	Fwd or Aft	Full HEAT	Modulating	Modulating
Out	Out	AUTO	Out	Out	Fwd or Aft	Full HEAT	Modulating	Modulating
Out	Out	AUTO	Out	Out	Fwd or Aft	Full HEAT	Modulating	Modulating
Out	Out	AUTO	Out	Out	Fwd or Aft	Full HEAT	Modulating	Modulating
Out	Out	AUTO	Out	ON	Fwd or Aft	Full HEAT	Modulating	Modulating
Out	OPEN	AUTO	Out	ON	Fwd or Aft	COOL and Modulating	Modulating	Full Heat

Figure 1-212 (Sheet 2 of 4)

Forced Air Cooling System Operating Modes (Continued)

OPERATING MODES	FORWARD AFAC GROUND MAINTENANCE CONTROL PANEL				AFT AFAC GROUND MAINTENANCE CONTROL PANEL			
	CABIN VALVE OPEN CAUTION LIGHT	DVRTR VALVE CLOSED CAUTION LIGHT	E-19, E-20/21, E23, E-41	E-2 E-3 E-4 E-8/10/12	CABIN VALVE OPEN CAUTION LIGHT	DVRTR VALVE CLOSED CAUTION LIGHT	E-13/14, 17, 28 VALVE CLOSED CAUTION LIGHT	RADAR VALVE CLOSED CAUTION LIGHT
GROUND Power Off Airplane	Out	Out	Out	Out	Out	Out	Out	Out
Power Off System	VALVE OPEN	VALVE CLOSED	Out or VALVE CLOSED	Out or ④ VALVE CLOSED	VALVE OPEN	VALVE CLOSED	Out or VALVE CLOSED	Out or VALVE CLOSED
Power on System CART	Out	VALVE CLOSED	Out	Out ④	Out	VALVE CLOSED	Out	Out
Power on System ENG APU	VALVE OPEN	VALVE CLOSED	Out or VALVE CLOSED	Out or ④ VALVE CLOSED	VALVE OPEN	VALVE CLOSED	Out or VALVE CLOSED	Out or VALVE CLOSED
FLIGHT Takeoff	VALVE OPEN	VALVE CLOSED	Out	VALVE ④ CLOSED	VALVE OPEN	VALVE CLOSED	Out	VALVE CLOSED
Liftoff (Fwd Fan On)	Out	Out 64±5°F VALVE 74 ± 5°F CLOSED	Out	Out 64±5°F VALVE ④ 74 ± 5°F CLOSED	Out	Out 64±5°F VALVE 74 ± 5°F CLOSED	Out	Out 64±5°F VALVE 74 ± 5°F CLOSED
Below 4200 ft (descending) Below 5000 ft (ascending) Cabin Pressure Altitude	Out	Out or VALVE CLOSED	Out	Out or ④ VALVE CLOSED	Out	Out or VALVE CLOSED	Out	Out or VALVE CLOSED
Supply Air Temp over 74 ± 5°F	Out	VALVE CLOSED	Out	VALVE ④ CLOSED	Out	VALVE CLOSED	Out	VALVE CLOSED
Supply Air Temp over 64 ± 5°F if had been over 74 ± 5°F	Out	VALVE CLOSED	Out	VALVE ④ CLOSED	Out	VALVE CLOSED	Out	VALVE CLOSED
Above 4200 ft (descending) Above 5000 ft (ascending) Cabin Pressure Altitude Cabin Supply Air Test Temp below 74 ± 5°F or 64 ± 5°F	Out	Out	Out	Out ④	Out	Out	Out	Out
UNPRESSURIZED Above 15,000 ft cabin Alt and Cabin Diff. Press more than 2 psi	Out	Out	Out	Out ③ ④	Out	Out	Out	Out ③
Above 15,000 ft cabin Alt and Cabin Diff. Press less than 2 psi	Out	Out	Out	Out ③ ④	Out	Out	Out	Out ③

Figure 1-212 (Sheet 3 of 4)

COMMUNICATIONS CONSOLE COOLING AIR MONITOR PANEL				COMPUTER OPERATOR COOLING AIR MONITOR PANEL	
RACK E2; E3; E4 8, 10, 12; E19, E41 CAUTION LIGHTS	**RACK E13 CAUTION LIGHT**	**FWD FORCED CAUTION LIGHT**	**AFT FORCED CAUTION LIGHT**	**DAPG COOLING WARN LIGHT**	**IFF COOLING WARN LIGHT**
Out	Out	Out (Not Functional)	Out (Not Functional)	Out ②	Out
Out or Illuminated ① ④	Out or Illuminated	Illuminated	Illuminated	Illuminated	Illuminated
Out ④	Out	Out	Out	Out	Out
Out or Illuminated ① ④	Out or Illuminated	Illuminated	Out	Out or Illuminated	Out or Illuminated
Illuminated ① ④	Out	Illuminated	Out	Illuminated	Out
Out or Illuminated ① ④	Out	Out	Out	Out	Out
Out or Illuminated ① ④	Out	Out	Out	Out	Out
Illuminated ① ④	Out	Out	Out	Out	Out
Illuminated ① ④	Out	Out	Out	Out	Out
Out ④	Out	Out	Out	Out	Out
Out ③ ④	Out	Out	Out	Out	Out
Out ③ ④	Out	Out	Out	Out	Out

① RACK E19 caution light out.

② DAPG caution light is also illuminated by draw through cooling system flow switch.

③ Unless supply air above 74 ± 5°F

④ E2, E3, E4, E8, E10 and E12 illuminated when the FORCED AIR COOLING panel DESCENT switchlight is pressed ON.

Figure 1-212 (Sheet 4 of 4)

LIQUID COOLING SYSTEM

The Liquid Cooling System (LCS) removes heat from the mission radar system and transfers heat to the fuel in the four main wing tanks. Heat is transferred to the fuel by circulating fuel through the liquid cooling system heat exchangers in inboard main wing tanks 2 and 3. The fuel in wing tanks NO 1, 2, 3, and 4 warms and the heat is transferred to the colder wing structure around the fuel tanks and then to the colder outside air. The liquid cooling system is pressurized so fuel cannot leak into the liquid cooling system. The liquid used is an Ethylene Glycol (62%) and Water (38%) (EGW) mixture . The main components of the system are located in the aft inboard corner of the left wheel well. This includes the expansion tank, two pumps, control module, drains, ground cooling connections, particulate filter, demineralizer, nitrogen bottle, and nitrogen regulator. See *figure 1-213* for a schematic of the liquid cooling system.

LCS OPERATION

The temperature of the fuel in wing tanks NO 1, 2, 3, and 4 can be read at the flight engineer's station (*figure 1-33*) and the mission radar console. A pressure altitude signal from the air data computer is used to modify the temperature limit signal (above 27,000 feet). When fuel temperature exceeds the limit, the OHEAT caution light for that tank illuminates. See section V for maximum fuel temperature versus altitude. On the liquid cooling system panel on the mission radar console, the cooler valves FUEL OFF caution lights illuminate when the fuel valve for the corresponding liquid coolant heat exchanger is closed (or closing) or when fuel pressure from both fuel boost pumps supplying fuel to the heat exchanger becomes too low to provide good heat transfer. When less than 5,000 pounds of fuel is contained in a main fuel tank with LCS heat exchanger circuit operating, monitor tank temperature and coordinate with ART to monitor LCS coolant temperature. See *figure 1-214* for system controls and indicators.

CAUTION

If OHEAT caution light illuminates, verify boost pumps are on, HEAT EXCH switch is on, and notify ART if temperature is above limit shown in section V.

NOTE

Two boost pumps in each main tank should be on when the radar liquid cooling system is operating. If one boost pump fails in a tank with heat exchanger operating, normal liquid cooling system performance is still available unless engine is at thrust greater than MRT above 12,000 feet. Notify ART, and monitor remaining boost pump. Monitor fuel temperatures in tanks with operating LCS heat exchangers during radar operation.

LCS COOLANT (EGW) LEAKS

If EGW solution leaks from the LCS and comes in contact with silver wire, silver coated wire, or silver alloy solder connections carrying a dc voltage more than 1.5 volts, the EGW can ignite. If a leak occurs, refer to EGW LEAK, section III.

NOTE

If EGW leak or spill is found on preflight, do not accept airplane for flight until maintenance has determined whether the problem is a leak or a spill and has removed as much of the liquid as possible. If leak is in pressurized portion of LCS, it should be repaired before flight unless maintenance determines that leak is not a hazard to electrical components and that LCS pressure and quantity are likely to remain adequate for planned radar operating time. In this case, mission may be flown as planned.

POWER FEEDER DUCT COOLING

The power feeder duct cooling system cools the electrical power cables from the E16 rack to the mission radar and the APU power feeder cable. The feeder duct is on the right side of the airplane (approximately body stations 820 to 960), just above the mission compartment floor. Cooling air is drawn from the main deck, through intake ducts, and exhausts into the aft lower compartment.

The primary cooling fan is on if the APU generator is on the bus or if the mission radar logic calls for high power.

When the APU is not on line (and radar switch is closed), a duct air temperature of 180 ± 10°F causes the OVERHEAT caution light on the duct overheat warning panel on the radar console to illuminate and the duct cooling secondary fan to start. The OVERHEAT caution light and duct cooling secondary fan remain on until the duct air cools below 175 ± 10°F and the DUCT COOLING FAN CONTR & OVHT IND circuit breaker on the P67-3 circuit breaker panel has been opened and closed. There is no way to tell if the circuit can be reset other than to try to reset it. The SHUTDOWN warning light on the duct overheat warning panel on the radar console illuminates when duct air temperature rises above 210 ± 10°F. The SHUTDOWN warning light goes out when duct air temperature drops to 205 ± 10°F.

When the APU generator is on the bus and the power feeder duct air temperature exceeds 180 ± 10°F the APU generator power contactor opens, removing all AC power, except the emergency AC bus. The GINS, if operating, switches to battery (EGIs) and EAC (AE1). The OVERHEAT caution light is unpowered, so there is no indication of the cause of shutdown. The system cannot be reset except by cooling the duct until the thermal switch closes. Refer to T.O. 1E-3A-43-1-1 for illustration of the radar console.

ESM SYSTEM COOLING

The ESM antennas and associated RF processors are cooled by air circulated by a fan at each antenna installation. The ESM equipment located in the E51 rack is cooled by the aft forced air system. The fans at each antenna installation and the cooling air shutoff valve for the E51 rack are controlled by the POWER switchlight on the ESMG CONTROL panel at the computer operator console *(figure 1-211)*.

While the cooling air shutoff valve for the E51 rack is full open, interlocks allow the ESM system to be powered. A NO FLOW caution light on the ESMG CONTROL panel operates in parallel with the aft forced air system AIR NO FLOW caution light on the FORCED AIR COOLING panel at the flight engineer’s station. The ESMG CONTROL panel NO FLOW caution light also illuminates, via a valve position switch, when the E51 rack cooling air shutoff valve is in the full closed position. An OVERHEAT caution light on the ESMG CONTROL panel illuminates if certain equipment within the E51 rack overheats.

ELECTRONICS COOLING SYSTEMS ELECTRIC POWER SOURCES

Electric power sources for electronics cooling systems are shown in *figure 1-215.*

Liquid Cooling System Schematic

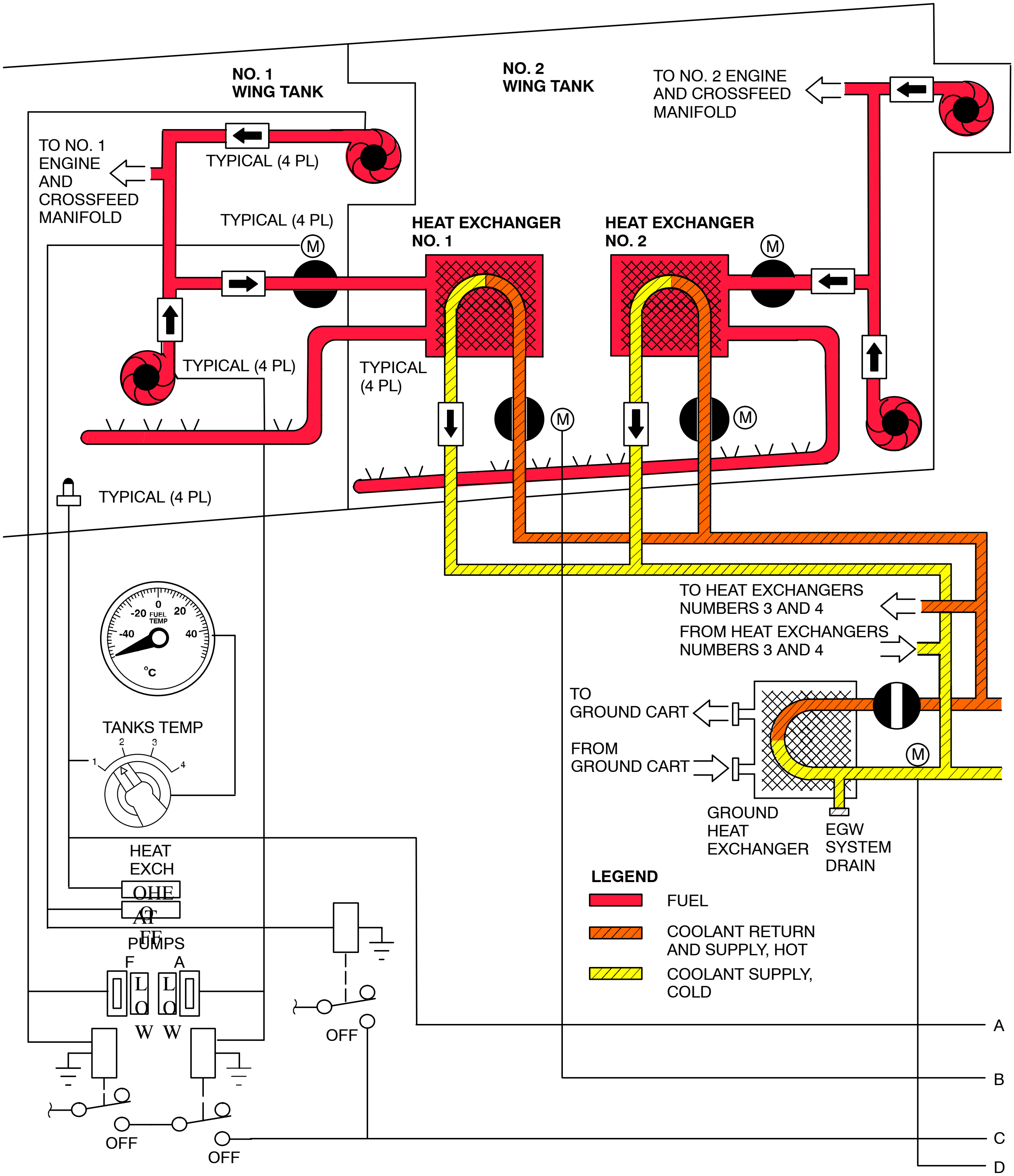


Figure 1-213 (Sheet 1 of 2)

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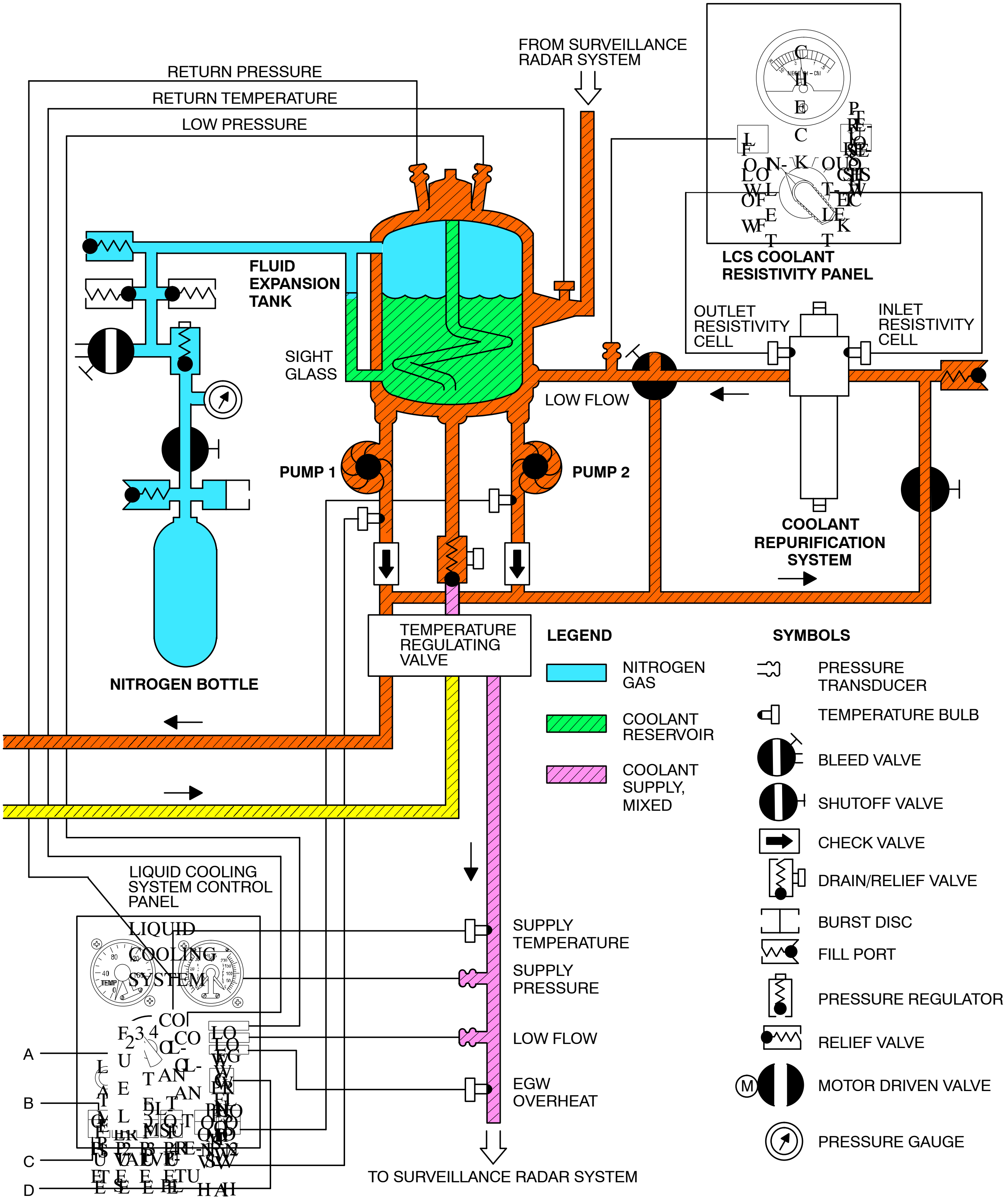

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Liquid Cooling System Controls and Indicators

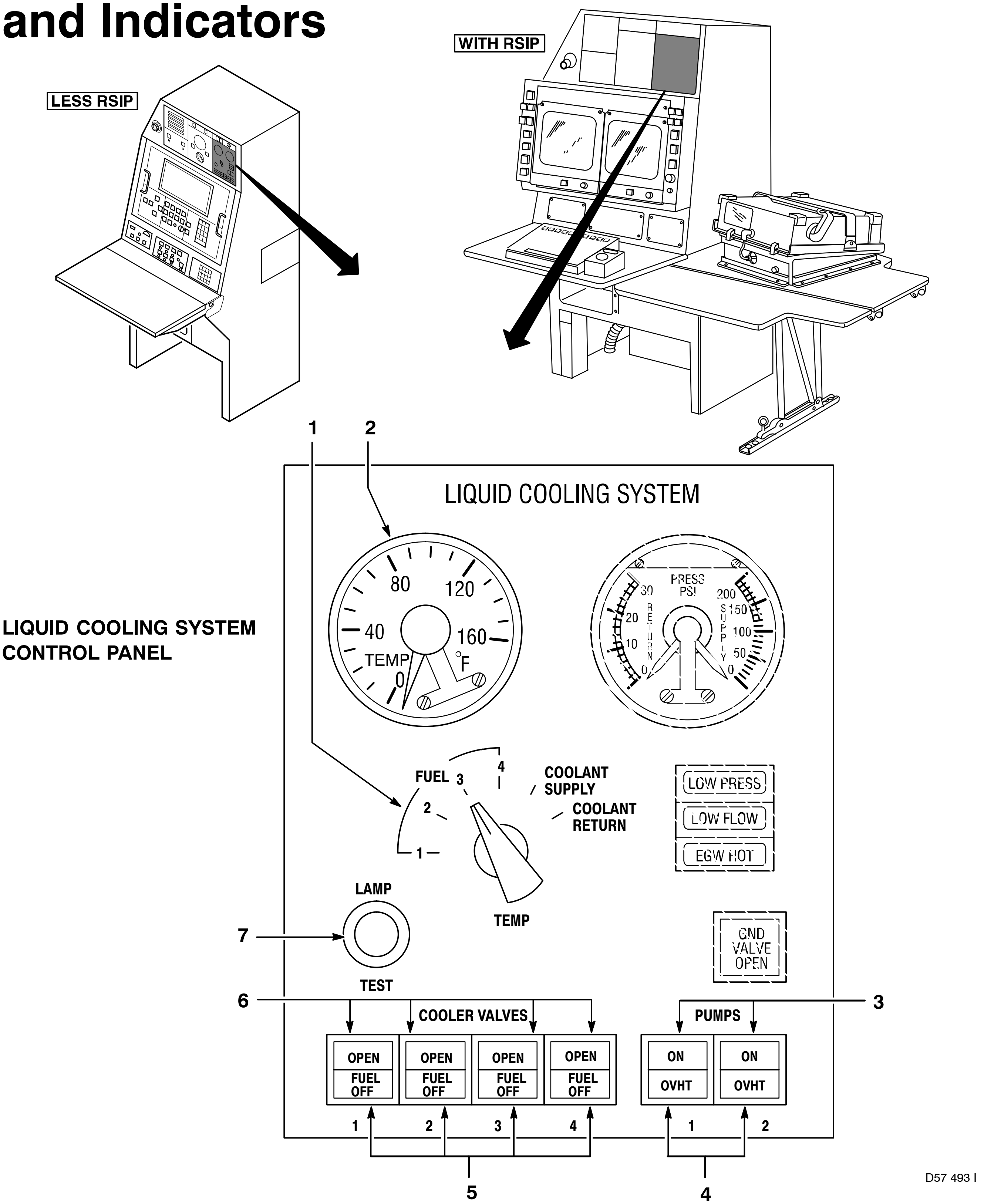

Figure 1-214 (Sheet 1 of 2)

NO.	CONTROL/INDICATOR	FUNCTION
LIQUID COOLING SYSTEM CONTROL PANEL		
1	TEMP Switch	Selects a temperature sensor in numbered main wing fuel tank and temperature sensor for Ethylene Glycol Water (EGW) coolant supply line or return line.
2	TEMP Gage	Indicates temperature in degrees Fahrenheit at sensor selected at TEMP switch.
NOTE FUEL TEMP gage on flight engineer's panel indicates in degrees C.		
3	PUMPS ON Switch/Indicators (White)	Alternate action switches – when pressed, each turns light on (or off) corresponding coolant circulation pump. ON illuminates when switch is in on position.
4	PUMPS OVHT Caution Lights (Amber)	OVHT light illuminates when corresponding pump motor windings are overheated. Illuminates at 350°F increasing and goes out at 320°F decreasing.
5	COOLER VALVES FUEL OFF Caution Lights (Amber)	FUEL OFF light illuminates when corresponding fuel input gate valve to heat exchanger is closed and/or corresponding main wing tank fuel boost pumps are off.
6	COOLER VALVES OPEN Switch/Indicators (White)	Alternate action switches – when pressed, each opens (or closes) the coolant gate valve to the heat exchanger in the same numbered main wing tank cooling circuit. OPEN light illuminates when switch is in valve open position. Fuel flow through the heat exchangers is controlled at the flight engineer station.
7	LAMP TEST Pushbutton	When pressed and held, causes test illumination of all lamps on LIQUID COOLING SYSTEM panel.

Figure 1-214 (Sheet 2 of 2)

Electronics Cooling Systems Electric Power Sources

EQUIPMENT/SYSTEM	TYPE OF POWER	POWER SOURCE	CIRCUIT BREAKER LOCATION/LABEL
DRAW THRU COOLING			
Fan – Low Speed Operation	115V AC	AVAC Bus 4	P61-3 DRAW THRU CLG – FAN
Fan – High Speed Operation	115V AC	GEN 4	RACK E-15 ELCU M1113
Fan Low Speed Logic and Control	28V DC	AVDC Bus 4	P61-3 DRAW THRU CLG – ALT SWITCH NO 1
Fan High Speed Logic and Control	28V DC	AVDC Bus 8	P61-3 DRAW THRU CLG – ALT SWITCH NO 2
No Flow Indicator and Flow Control Valve Limit Switches	28V DC	AVDC Bus 8	P61-3 DRAW THRU CLG – FLOW CONTR VALVE
15,000 Ft Pressure Switches			
No 1	28V DC	AVDC Bus 4	P61-3 DRAW THRU CLG – ALT SWITCH NO 1
No 2	28V DC	AVDC Bus 8	P61-3 DRAW THRU CLG – ALT SWITCH NO 2
FORCED AIR COOLING			
FORWARD FORCED AIR SYSTEM			
Temp Controller and Heat Exch, Ovbd, and Bypass Valves	115V AC	AVAC Bus 4	P61-3 FORCED AIR COOLING – VALVES – FWD TEMP C HE/OB/ BYPASS
Logic and Control Power and Fwd/Aft Temp Sensor Power	28V DC	AVDC Bus 8	P61-3 FORCED AIR COOLING – SYS CONTR – LOGIC FWD
Fan No 1			
Indicator Lights and Control Power	28V DC	AVDC Bus 8	P61-3 FORCED AIR COOLING – FAN – NO 1 FWD

Figure 1-215 (Sheet 1 of 5)

EQUIPMENT/SYSTEM	TYPE OF POWER	POWER SOURCE	CIRCUIT BREAKER LOCATION/LABEL
Power			
Low Speed	115V AC	GEN 3	E-15 ELCU M1009
High Speed	115V AC	GEN 3	E-15 ELCU M1007
Fan No 2			
Indicator Lights and Control Power	28V DC	AVDC Bus 4	P61-3 FORCED AIR COOLING – FAN – NO 2 FWD
Power			
Low Speed	115V AC	GEN 5	E-15 ELCU M1011
High Speed	115V AC	GEN 5	E-15 ELCU M1013
Shutoff Valve Relays and Indicators Power	28V DC	AVDC Bus 4	P61-3 FORCED AIR COOLING – SYS CONTR – VALVE RELAYS FWD
Rack E20, 21 Shutoff Valves, Fwd Diverter and Cabin Valves Power	28V AC	AVAC Bus 4	P61-3 FORCED AIR COOLING – VALVES – E20-E21 CAB/DIV
Rack E2, 6-Inch Shutoff Valve Power	28V AC	AVAC Bus 4	P61-3 FORCED AIR COOLING – VALVES – FWD E2
Rack E2, 2-Inch and 4-Inch Shutoff Valves and Rack E19, E23 and E41 Shutoff Valves	28V AC	AVAC Bus 4	P61-3 FORCED AIR COOLING – VALVES FWD E19/23
Rack E3, E4 and E8-10-12 Shutoff Valves	28V AC	AVAC Bus 4	P61-3 FORCED AIR COOLING – VALVES E3/4/8 E10/12
AFT FORCED AIR SYSTEM			
Temp Controller and Heat Exch, Ovbd and Bypass Valves	115V AC	AVAC Bus 4	P61-3 FORCED AIR COOLING – VALVES – AFT TEMP C HE/OB/BYPASS
Logic and Control Power	28V DC	AVAC Bus 8	P61-3 FORCED AIR COOLING – SYS CONTR – LOGIC AFT

Figure 1-215 (Sheet 2 of 5)

Electronics Cooling Systems Electric Power Sources (Continued)

EQUIPMENT/SYSTEM	TYPE OF POWER	POWER SOURCE	CIRCUIT BREAKER LOCATION/LABEL
Fan No 1			
Indicator Lights and Power	28V DC	AVDC Bus 8	P61-3 FORCED AIR COOLING – FAN – NO 1 AFT
Power			
Low Speed	115V AC	GEN 7	E-15 ELCU M1008
High Speed	115V AC	GEN 7	E-15 ELCU M1010
Fan No 2			
Indicator Lights and Control Power	28V DC	AVDC Bus 4	P61-3 FORCED AIR COOLING – FAN – NO 2 AFT
Power			
Low Speed	115V AC	GEN 8	E-15 ELCU M1012
High Speed	115V AC	GEN 8	E-15 ELCU M1014
Shutoff Valve Relays and Indicators Power and Temp Sensor Selector	28V DC	AVDC Bus 4	P61-3 FORCED AIR COOLING – SYS CONTR – VALVE RELAYS AFT
Shutoff Valves Power: Racks E13, E14, E17, E28; CABIN Valve; DIVERTER Valve; RADAR Valve	115V AC	AVAC Bus 4	P61-3 FORCED AIR COOLING – VALVES – AFT E13/14/17/28 CAB/DIV RADAR
Shutoff Valve Power: Rack E51 Valve	115V AC	AVAC Bus 4	P61-3 FORCED AIR COOLING – VALVES – AFT E51
15,000 Ft Pressure Switches			
NO. 1	28V DC	AVDC Bus 4	P61-3 DRAW THRU CLG – ALT SWITCH NO 1
NO. 2	28V DC	AVDC Bus 8	P61-3 DRAW THRU CLG – ALT SWITCH NO 2

Figure 1-215 (Sheet 3 of 5)

EQUIPMENT/SYSTEM	TYPE OF POWER	POWER SOURCE	CIRCUIT BREAKER LOCATION/LABEL
Comm Console Air Cooling Monitor Indicators Power			
Forward Forced Air System Indicators	28V DC	MADC Bus 5 DIST 2	P67-3, COOLING AIR – COMM – FWD
Aft Forced Air System Indicators	28V DC	MADC Bus 5 DIST 2	P67-3, COOLING AIR – COMM – AFT
Computer Console Air Cooling Monitor Indicators Power			
DAPG	28V DC	MADC Bus 5 DIST 2	P67-3, COOLING AIR – DPFG/IFF – FWD
IFF	28V DC	MADC Bus 5 DIST 2	P67-3, COOLING AIR – DPFG/IFF – AFT
LIQUID COOLING			
Liquid Pump No. 1 Control	28V DC	MADC 6	P67-3, LIQUID COOLING SYSTEM – LIQUID PUMP CONTR 1
Power	115V AC	GEN 8	E16, ELCU M1052
Liquid Pump No 2 Control	28V DC	MADC Bus 5 DIST 2	P67-3, LIQUID COOLING SYSTEM – LIQUID PUMP CONTR 2
Power	115V AC	GEN 6	E16, ELCU M1053
Indicator lights Low Press, Low Flow, EGW Hot, Low Flow, Low Resist. Lamp Test and Temp Sensor	28V DC	MAAC Bus 3 DIST 3	P67-3, LIQUID COOLING SYSTEM – INDS
Resistivity Indicator	115V AC	MAAC Bus *7*	P67-3, LIQUID COOLING SYSTEM – RESIST IND
Open Indicator and Fuel Off Caution Light and Valve Power			
Cooler 1	28V DC	MADC Bus 5 DIST 2	P67-3, LIQUID COOLING SYSTEM – VALVE – COOLER 1

Figure 1-215 (Sheet 4 of 5)

Electronics Cooling Systems Electric Power Sources (Continued)

EQUIPMENT/SYSTEM	TYPE OF POWER	POWER SOURCE	CIRCUIT BREAKER LOCATION/LABEL
Cooler 2	28V DC	MADC Bus 3 DIST 3	P67-3 LIQUID COOLING SYSTEM – VALVE – COOLER 2
Cooler 3	28V DC	MADC Bus 3 DIST 3	P67-3 LIQUID COOLING SYSTEM – VALVE – COOLER 3
Cooler 4	28V DC	MADC Bus 5 DIST 2	P67-3 LIQUID COOLING SYSTEM – VALVE – COOLER 4
Ground Valve Open Indicator and Valve	28V DC	MADC Bus 3 DIST 3	P67-3 LIQUID COOLING SYSTEM – VALVE – GND
POWER FEEDING DUCT COOLING			
Fan Control and Overheat Caution Light	28V DC	MADC Bus 5 DIST 2	P67-3 DUCT COOLING – FAN CONTR & OVHT IND
Shut Down Caution Light	28V DC	MADC Bus 3 DIST 3	P67-3 DUCT COOLING – WARN IND
Primary Fan Power	115V AC	MAAC Bus 6	P67-3 DUCT COOLING – PRI FAN
Secondary Fan Power	115V AC	MAAC Bus 7	P67-3 DUCT COOLING – SEC FAN
ESM SYSTEM COOLING			
Antennas and Associated Equipment Cooling Fans	115V AC	MAAC Bus 3 DIST 1	P67-3 ESMG – FANS
Control for Antenna Cooling Fans and Command of Forced Air Cooling Valve for Rack E51	28V DC	MADC Bus 3 DIST 3	P67-3 ESMG–CTL LOGIC ◀

Figure 1-215 (Sheet 5 of 5)

SUBSECTION I-S
ICE AND RAIN PROTECTION SYSTEMS

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SUMMARY

Engine bleed air is used to anti-ice portions of the engine nose cowl, nose dome and inlet guide vanes, and EPR system (P_{t2}) probes. Electric power is used to heat the pitot probes, total air temperature probe, Q-inlet probe, flight deck windows, attitude warning vanes and angle of attack probes. The water service waste drain mast, and some water lines are also heated electrically.

WINDSHIELD WIPERS

Forward visibility during heavy rain is improved by using electrically-driven windshield wipers.

ENGINE AND NACELLE ANTI-ICE SYSTEM

The engine inlet guide vanes and nose dome are thermally anti-iced by 16th stage bleed air which is ducted through the guide vanes to the nose dome and is then vented into the engine intake. The nose cowl is anti-iced by 16th stage bleed air that is heat regulated by being mixed with ambient air in an injector. 16th stage bleed air is used to anti-ice the EPR (P_{t2}) probe. The nose cowl anti-ice valve closes if the corresponding engine fire switch is pulled or when either electrical power or bleed air is removed. The engine inlet anti-ice valve remains in the position it was in when electrical power was removed. The temperature of anti-icing air is regulated by thermostatically controlled valves which limit temperature by limiting airflow. The system is shown in *figure 1-216*.

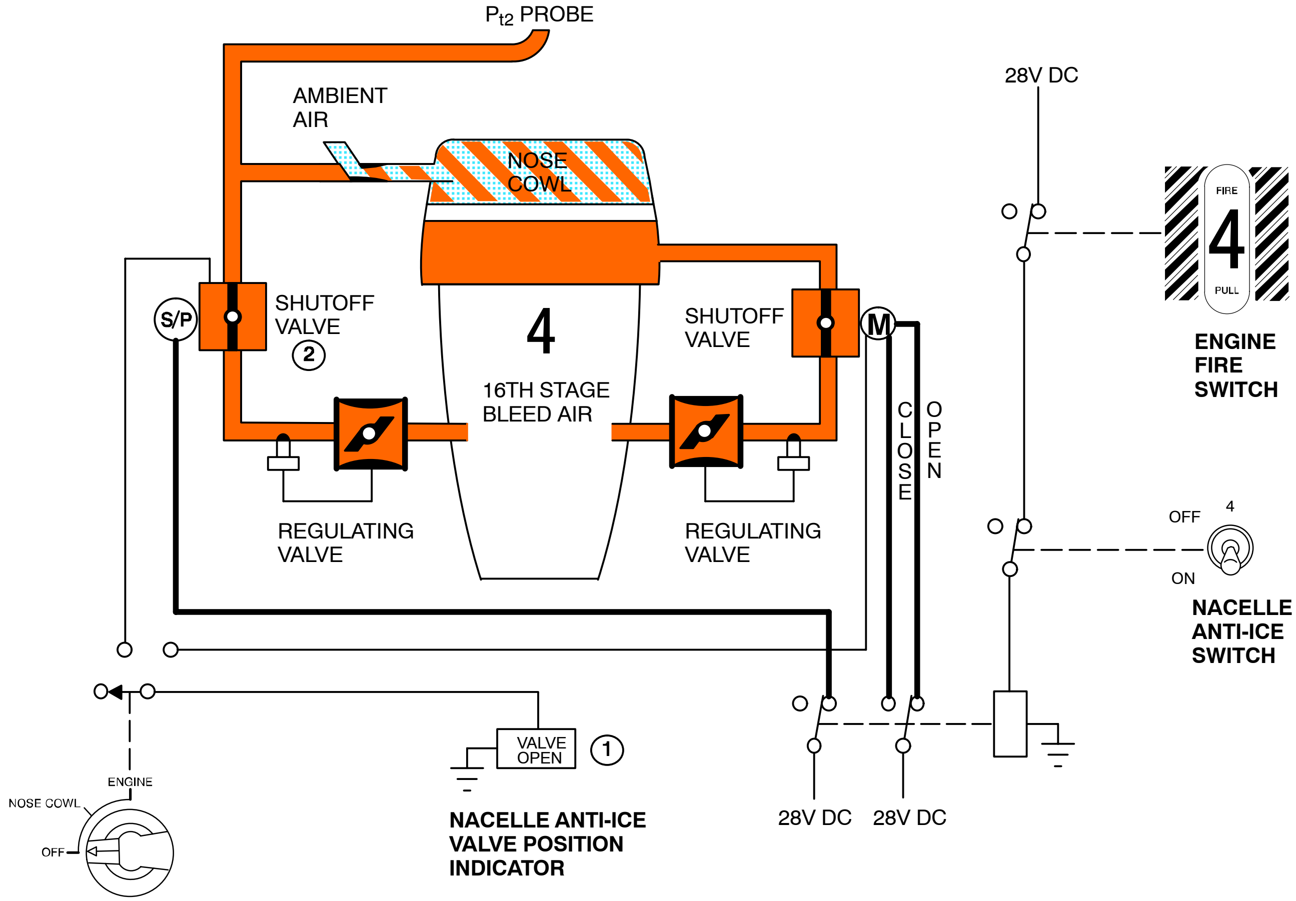
CAUTION

Operation of the anti-ice systems in dry air at total air temperatures in excess of 10°C (50°F) at engine power settings above 70% N_1 can cause damage to the engine.

NOTE

- Erratic EPR indications or abnormal EPR indication relative to N_1 can indicate engine icing.
- Nose cowl shutoff valves are air operated and cannot be operated until engine bleed air is available. Nacelle anti-ice valves are motor operated and can be operated before engine is started. Valve position can be checked at any time.

Engine and Nacelle Anti-Ice System



① WHEN ENGINE IS SELECTED, VALVE OPEN INDICATOR ILLUMINATES WHEN VALVE IS FULLY OPEN AND GOES OUT WHEN VALVE IS FULLY CLOSED. WHEN NOSE COWL IS SELECTED, VALVE OPEN INDICATOR ILLUMINATES AT ANY TIME VALVE IS NOT FULLY CLOSED.

② VALVE IS OPERATED BY AIR PRESSURE. ENGINE MUST BE OPERATING OR VALVE DOES NOT MOVE.

LEGEND

🟧	HIGH PRESSURE ENGINE BLEED AIR
▨	HEATED AMBIENT AIR
━	ACTUATION POWER
─	VALVE POSITION SIGNAL
─	MECHANICAL CONNECTION
S/P	SOLENOID CONTROLLED PNEUMATICALLY ACTUATED VALVE
M	MOTOR OPERATED VALVE

SYMBOL

⊥	TEMPERATURE SENSOR

D57 494 I

Figure 1-216

WINDOW HEAT SYSTEM

The flight deck windows are laminated glass and plastic, electrically heated for anti-icing or defogging, and to insure maximum impact strength. Each NO 1 (forward) window has a built in temperature sensor and an electronic controller for that window and the opposite NO 2 (side) window. Control switches determine the rate at which these windows are heated (*figures 1-217* and *1-218*). Power to heat the other windows is the same for both switch positions and is applied directly to the windows through thermal switches clamped on the NO 3 and 5 windows. Thus each switch powers all windows on its side of the control cabin (except NO 2) and the opposite NO 2 window. If the controller unit fails to limit the temperature of either NO 1 window, an overheat circuit in the controller shuts off power through that circuit and the corresponding overheat caution light comes on. A shorted window sensor also prevents heat from being applied to the NO 1 window, and opposite NO 2 window.

CAUTION

- Do not operate window heat for more than 10 minutes with sliding windows open if outside temperature is below 10°C (50°F).
- Operate window heat in LOW for 10 minutes (unless mission accomplishment procedures dictate otherwise) before setting to HIGH to avoid possible damage to windows.

PROBE HEATERS

There are three pitot probes mounted on the airplane nose section, one for the pilot's instruments and air data computer, one for the copilot's instruments, and one for other pressure instruments and equipment. Each of these is heated by integral electric wiring. The total air temperature probe, also on the nose section, and the Q-inlet pitot probe (for the rudder feel system), located at the base of the vertical fins are electrically heated. The shield around the Q-inlet probe is not heated. Stall warning vanes, under each wing leading edge, and angle of attack probes, near the pitot probes, have electrical heating.

These electric probe heaters are controlled by two switches on the overhead panel (*figure 1-218*). The stall warning vanes are heated when either or both of the switches are ON; there is no direct indication of operation. However, a HEAT OFF caution light for each of the other heaters comes on if that probe is not heated.

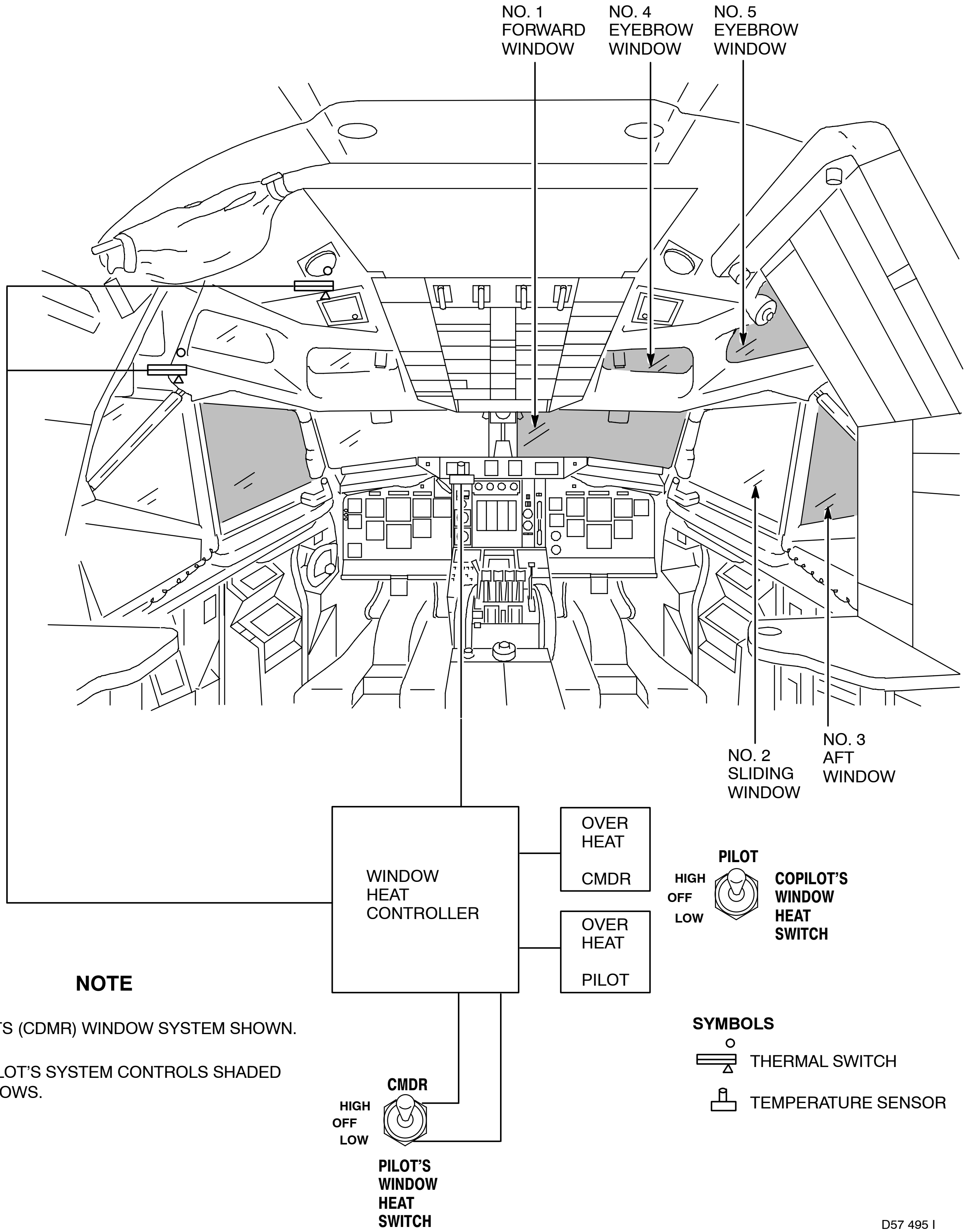
Power to the stall warning vane heaters is 115vac in the air, and reduced to 28vdc on the ground, controlled by the landing gear safety switches. When the NO 3 throttle is advanced for takeoff, the stall warning vane heaters receive 115vac power. Power sources for the system are listed in *figure 1-219*.

For information on effects of probe heat failures, refer to FLIGHT WITH UNRELIABLE AIR SPEED/MACH INDICATIONS in section IIIA and EFFECTS OF PITOT STATIC ICING in section VII.

ICE AND RAIN PROTECTION SYSTEMS ELECTRIC POWER SOURCES

Electrical power sources for ice and rain protection systems are listed in *figure 1-219*.

Window Heat System



NOTE

- PILOTS (CDMR) WINDOW SYSTEM SHOWN.
- COPILOT'S SYSTEM CONTROLS SHADED WINDOWS.

Figure 1-217

Ice and Rain Protection Controls and Indicators

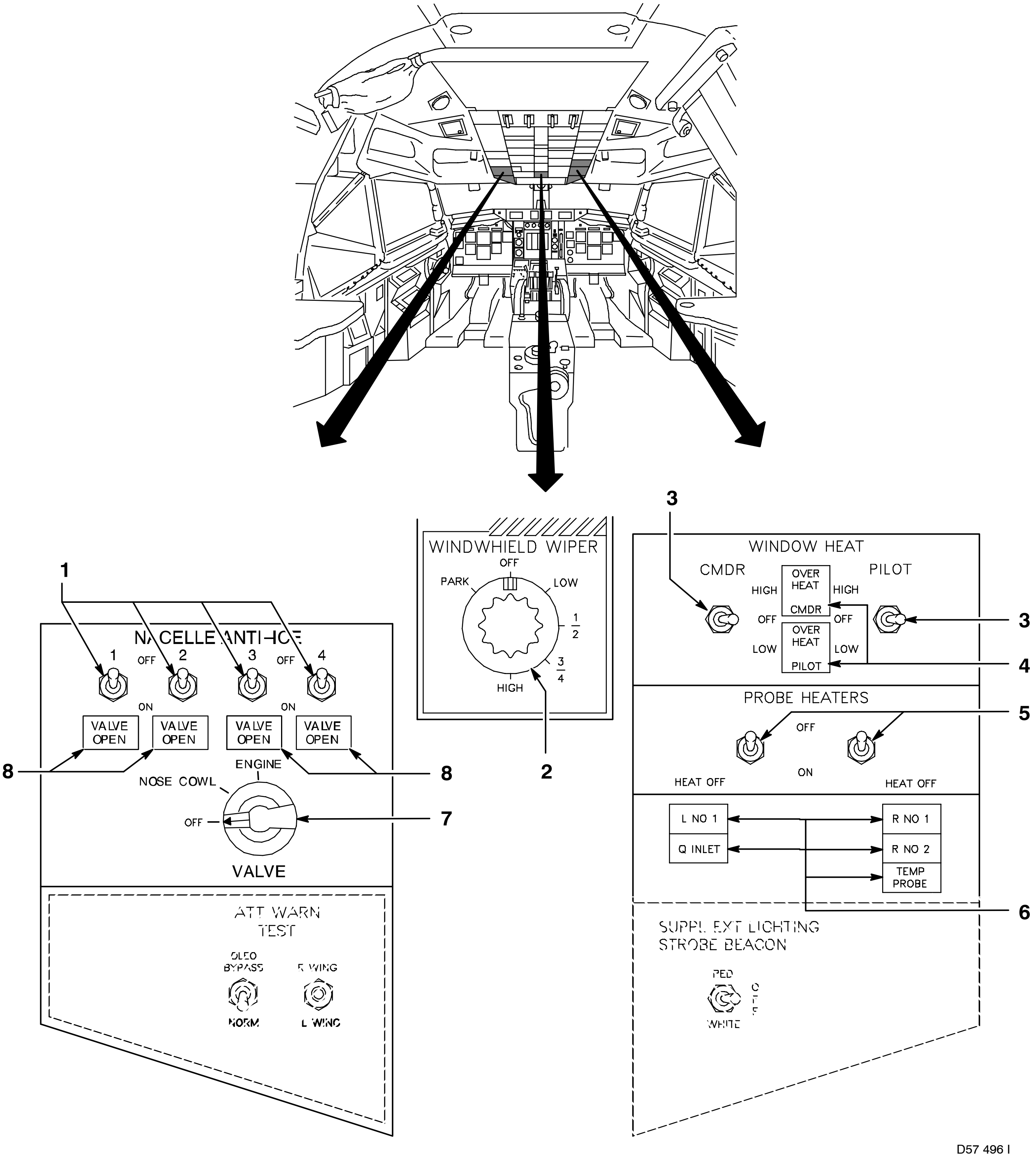


Figure 1-218 (Sheet 1 of 3)

Ice and Rain Protection Controls and Indicators (Continued)

NO.	CONTROL/INDICATOR	FUNCTION
1	NACELLE anti-ice (Engine Anti-Ice) Switches (4)	When set to ON, opens motor operated anti-ice valve to engine inlet, and actuates solenoid to allow air pressure to open nose cowl valve. Arm associated nacelle VALVE OPEN indicator. When set to OFF, closes valves. Engine fire switch overrides switch to close valves.
2	WINDSHIELD WIPER Switch	When rotated from OFF, starts electrically operated windshield wipers. Speed is controlled by switch position. When set to OFF, stops wipers. When set to PARK, stows wipers. Spring-loaded to OFF from PARK.

CAUTION

Do not operate windshield wipers on dry windshields.

NO.	CONTROL/INDICATOR	FUNCTION
3	WINDOW HEAT Switches (2) (CMDR – PILOT)	Supply power to electrically heated windows. Left (CMDR) supplies all of pilot's windows except NO 2 which is supplied by right (PILOT) switch. Right (PILOT) switch supplies all of the copilot's windows except NO 2 which is supplied by the left (CMDR) switch. When either switch is set to HIGH, system will heat NO 1 and NO 2 windows at a fast rate. When set to OFF, removes power from window heat system. Resets overheat protection. When set to LOW, system will heat NO 1 and NO 2 windows at a slower rate.

NOTE

NO 3, 4 and 5 windows are heated at the same, slower rate in HIGH or LOW.

NO.	CONTROL/INDICATOR	FUNCTION
4	WINDOW HEAT OVER HEAT Caution Lights/Press to Test Switches (2) (Amber)	When OVER HEAT is illuminated, indicates left (CMDR) or right (PILOT) NO 1 (forward) window has overheated and electric power has automatically been removed from that window and opposite sliding window. When pressed, OVER HEAT illuminates to indicate window overheat protection is operative. Associated window heat switch must be set to HIGH or LOW for test, and to OFF to turn out light and reset system.

Figure 1-218 (Sheet 2 of 3)

NO.	CONTROL/INDICATOR	FUNCTION
5	PROBE HEATERS Switches (2) (Left, Right)	When set to ON, supply 115 vac power in the air and on the ground, to probe heaters. When set to OFF, deactivate probe heaters. Left side switch supplies power to: pilot's pitot, Q-inlet, both attitude warning vanes, and left angle of attack probe. Right side switch supplies power to: copilot's pitot, third pitot, total air temperature (TAT) probe, right angle of attack probe, and both attitude warning vanes.

WARNING

Do not touch heated surface of probes when airplane is on the ground. Hot probe surface could cause injury if touched.

6	HEAT OFF Caution Lights (5) (Amber)	Illuminate to indicate when heater is not being powered.
	L NO 1	Indicates pilot's pitot probe or left angle of attack probe.
	R NO 1	Indicates copilot's pitot probe.
	R NO 2	Indicates auxiliary pitot probe.
	Q INLET	Indicates rudder Q-spring probe.
	TEMP PROBE	Indicates TAT probe or right angle of attack probe.
7	VALVE Selector Switch	Selects valves to be monitored by VALVE OPEN indicators. Switches all four VALVE OPEN indicators at once.
8	VALVE OPEN Indicators (4) (Green)	Armed only when associated NACELLE anti-ice switch is set to ON. When VALVE selector switch is set to ENGINE, VALVE OPEN indicator illuminates when valve is fully open and goes out when valve is fully closed. When VALVE selector switch is set to NOSE COWL, VALVE OPEN indicator illuminates any time valve is not fully closed.

Figure 1-218 (Sheet 3 of 3)

Ice and Rain Protection Electric Power Sources

EQUIPMENT/SYSTEM	TYPE OF POWER	POWER SOURCE	CIRCUIT BREAKER LOCATION/LABEL
WINDOW HEAT			
Pilot's NO 1 and Copilot's NO 2 Windows	115V AC	AVAC Bus 2	P61-2, L NO 1 & R NO 2
Pilot's NO 3, 4 and 5 Windows	115V AC	AVAC Bus 2	P61-2, LEFT WINDOW NO 3, 4 & 5
Control, Pilot's Windows	115V AC 28V DC	AVAC Bus 2 AVDC Bus 2	P61-2, LEFT WINDOW CONTR P61-2, L DC CONTR
Pilot's NO 2 and Copilot's NO 1 Windows	115V AC	AVAC Bus 6	P61-2, L NO 2 & R NO 1
Copilot's NO 3, 4, and 5 Windows	115V AC	AVAC Bus 6	P61-2, RIGHT WINDOW NO 3, 4 & 5
Control, Copilot's Windows	115V AC 28V DC	AVAC Bus 6 AVDC Bus 8	P61-2, RIGHT WINDOW CONTR P61-2, R DC CONTR
PROBE HEAT			
Q-Spring Heater	115V AC	AVAC Bus 4	P61-2, Q SPR HTR
Pilot's Pitot and Left Angle of Attack Probe	115V AC	AVAC Bus 6	P61-2, CMDR PITOT & ANGLE ATTACK 1
Copilot's Pitot and Auxiliary Pitot	115V AC	AVAC Bus 4	P61-2, RIGHT PITOT & AUX
TAT Probe and Right Angle of Attack Probe	115V AC	AVAC Bus 4	P61-2, RIGHT TAT & ANGLE ATTACK 2
Stall Warning Vanes ③			
Left Side and Shaker (Ground)	28V DC	FAVDC Bus 1	P5, ATTD WARN–SHAKER DC 1
Right Side and Shaker (Ground)	28V DC	FAVDC Bus 2	P5, ATTD WARN–SHAKER DC 2
Left Side Flight	115V AC	FAAC Bus 1	P5, ATTD WARN–LEFT WING ØB
Right Side Flight	115V AC	FAAC Bus 2	P5, ATTD WARN–RIGHT WING ØB

Figure 1-219 (Sheet 1 of 2)

EQUIPMENT/SYSTEM	TYPE OF POWER	POWER SOURCE	CIRCUIT BREAKER LOCATION/LABEL
HEAT OFF Caution Lights	28V AC	28V AC Bus 2	P61-2, PROBE HTR IND
Engine Nose Cowl Valve, Engine 1 ①	28V DC	AVDC Bus 2 Main	P61-2, ENG NOSE COWL AI VAL NO 1
Nacelle Valve, Engine 1 ②	28V DC	AVDC Bus 2	P61-2, NACELLE ANTI ICE VAL NO 1
Engine Nose Cowl Valve, ① Engine 2	28V DC	BAT BUS	P61-2, ENG NOSE COWL AI VAL NO 2
Nacelle Valve, Engine 2 ②	28V DC	BAT BUS	P61-2, NACELLE ANTI ICE VAL NO 2
Engine Nose Cowl Valve, ① Engine 3	28V DC	BAT BUS	P61-2, ENG NOSE COWL AI VAL NO 3
Nacelle Valve, Engine 3 ②	28V DC	BAT BUS	P61-2, NACELLE ANTI ICE VAL NO 3
Engine Nose Cowl Valve, Engine 4 ①	28V DC	AVDC Bus 8	P61-2, ENG NOSE COWL AI VAL NO 4
Nacelle Valve, Engine 4 ②	28V DC	AVDC Bus 8	P61-2, NACELLE ANTI ICE VAL NO 4
WINDSHIELD WIPERS			
Left Windshield Wiper	28V DC	AVDC Bus 4	P61-2, WSHLD WPR LEFT
Right Windshield Wiper	28V DC	AVDC Bus 8	P61-2, WSHLD WPR RIGHT

① Valve closes with loss or removal of dc power, or with loss or removal of bleed air pressure. Both bleed air pressure and dc power are required to open the valve.

② Valve remains in position at time of dc power failure. Valve does not require bleed air pressure to open or close.

③ FLT AVIONICS BUS 1 and/or BUS 2 switches on AVIONICS POWER DISCONNECT panel controls power to equipment/system circuit breakers referenced by this note.

Figure 1-219 (Sheet 2 of 2)

SUBSECTION I-T
LIGHTING EQUIPMENT

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SUMMARY

The airplane lighting system includes exterior and interior lights. Exterior lighting includes landing lights, wing lights, wheel well lights, beacon lights, navigation lights, and emergency escape lights. Refueling slipway lights are described with the fuel system controls and indicators (*figure 1-33*). Interior lights include flight deck, mission crew compartment, lower compartments, and miscellaneous lights. Mission equipment console lighting is described in T.O. 1E-3A-43-1-1.

NOTE

All warning, caution and indicating lights are described under their respective systems.

EXTERIOR LIGHTING

Exterior lighting, *figure 1-220*, includes fixed and retractable landing lights, runway turnoff, wing illumination, and beacon (anticollision) lights, navigation lights, wheel well lights, exterior emergency lights and two strobe lights. The tailcone compartment light, located near the stabilizer jackscrew, is controlled by a switch on the aft side of the pressure bulkhead just inside the tail compartment access hatch. All other exterior lighting controls are located on the pilots overhead panel.

CAUTION

- Do not operate the landing lights or the runway turnoff lights unless airplane is in motion, except for momentary checks to verify operation.
- Do not extend retractable landing lights above 223 KIAS.

NOTE

- Do not use retractable landing lights for daylight touch and go landings.
- Navigation lights require AC power for operation.

One fixed landing light (*figure 1-220*) is located in the inboard leading edge of each wing. A retractable landing light (*figure 1-220*) is located on the lower surface of each wing near the tip. Each retractable light has separate switches for extension/retraction and for illumination. The extend/retract switches do not need to be held in position once set to EXTEND or RETRACT, since motor operation is stopped by a limit switch for each direction. The switch should be returned to off when convenient. Extension or retraction can take up to 20 seconds at higher speeds. Both the fixed and retractable landing lights are used to provide illumination for takeoff and landing.

Runway turnoff lights, located beside each fixed landing light, provide illumination of the runway edges during taxi, takeoff, and landing. One wing illumination light, installed on each side of the fuselage forward of the wing, provides illumination of the leading edge, upper surface and nacelle area of each wing. The navigation and anticollision lights are standard installations with a navigation light located at each wingtip and the tailcone and an anticollision light (beacon light) located at the top of the vertical stabilizer and one located on the bottom of the fuselage just forward of the wing. Red and white strobe lights are mounted on the top and bottom of the airplane, as shown in *figure 1-220*.

The nose wheel well light is mounted on the aft bulkhead of the nose gear well. This light provides illumination for checking the nose wheel, nose wheel well, and the nose gear downlock. Besides the WHEEL WELL switch on the pilot's overhead panel, the nose wheel well light can be turned on by a switch located on the nose wheel well interphone panel.

The main gear wheel well lights are mounted inside the wheel well and provide light for checking the main gear. On the ground, the main wheel well lights can be individually controlled by switches located inside the wheel wells. In flight, setting the WHEEL WELL switch to ON applies power to the main and nose gear wheel well lights. With the WHEEL WELL switch set to NORM, the lights are controlled by the individual switches.

Emergency exterior lights, which are flush-mounted along the fuselage sides to illuminate the emergency exit paths, include the overwing illumination lights, the overwing emergency exit lights, and the emergency escape slide lights. See *figure 1-220* for light locations. The nine exterior emergency lights have four remotely mounted power packs which provide emergency power. These lights are controlled by the EMER EXIT LIGHTS switch located on the pilot's overhead panel.

The EMER EXIT LIGHTS switch is normally guarded to the ARMED position. If, while armed, power from AVAC bus 4 or AVDC bus 2 is lost, the exterior emergency lights come on, powered by their power packs. With the EMER EXIT LIGHTS switch set to ARMED and power available from AVAC bus 4, the emergency lights battery packs receive a trickle charge from AVDC bus 2 and the emergency lights remain off. When set to ON, EMER EXIT LIGHTS switch removes the battery charging power and the emergency exterior lights illuminate, powered by their remote power packs. When set to OFF, EMER EXIT LIGHTS switch applies a trickle charge to the battery packs and keeps the emergency exterior lights off when power is removed from the airplane. See *figure 1-221* for exterior lighting controls, power sources, and circuit protection.

NOTE

> Assure that EMER EXIT LIGHTS switch is OFF before power is removed. If switch is ARMED (or ON) when power is removed from AVAC bus 4 or AVDC bus 2, exterior emergency lights illuminate on their remote power packs.

The following truth table summarizes operation of exterior emergency exit lights:

EMER EXIT LIGHTS Switch	**OFF***				**ARMED***				**ON***			
AVAC bus 4 power	on		off		on		off		on		off	
AVDC bus 2 power	on	off	on	off	on	off	on	off	on	off	on	off
Exterior Emergency Exit Lights	off	**	off	**	off	**	on	**	on	**	on	**

* The off/arm/on state is not changed by moving this switch unless AVDC bus 2 is powered.

** Lights are off if they were unarmed, on if they were armed.

INTERIOR LIGHTING

Interior lighting includes flight deck lighting, forward, mid and aft mission crew compartment lighting, forward and aft lower compartment lights, and mission crew compartment emergency lighting. *Figure 1-222* shows all flight deck lighting locations and controls. *Figures 1-223* through *1-226* show all mission crew and lower compartment lighting locations and controls. Operation of the portable emergency exit lights is described in the discussion of the forward mission crew compartment lighting. Operation of all other mission crew compartment emergency lighting is described in the discussion of the mid mission crew compartment lighting.

NOTE

> Fluorescent lights do not operate properly at temperatures below +45°F (+7°C) and can fail to operate at all at cabin temperatures below 40°F.

FLIGHT DECK LIGHTING

Flight deck lighting consists of two types; white fluorescent for the pilot, copilot and engineer panel lighting and the navigators table lighting and incandescent lamps for table, background, circuit breaker panel, navigators panel, radio panel, map, flight kit, panel flood, dome and lower cab lights. All flight deck lighting controls (B, E, F, 16, 17, 18, 21 through 24 and 27 through 30, *figure 1-222*) operate as follows: When rotated clockwise, controls increase intensity of associated lights; and when rotated full counterclockwise, controls turn off associated lights. Other lighting controls (19, 20, 25 and 26) are two-position (ON–OFF) toggle switches which operate the pilot and copilot flight kit and map lights. The following lights are available on battery power: Main instrument panel background lights, map lights, compass light, flight kit lights, and emergency flood lights.

Miscellaneous lighting controls include the LIGHT OVERRIDE switch, the flight engineer's indicator light test (IND LT) switch, the instrument panels indicator light test (IND LIGHTS) switch, and the lower cab light switch. The LIGHT OVERRIDE switch (A, *figure 1-222*) allows turning on panel and table lights full bright by actuating one switch. When set to NORM, all lights are controlled by their respective control. When set to OVERRIDE, turns on the control stand flood lights, pilots' and engineers' fluorescent panel lights, navigation station flood and table lights, and the dome lights full bright, regardless of individual light control settings.

The IND LIGHTS switch on the center instrument panel, when set to TEST, turns on bright all switch lights, annunciators, and indicators (except MARKER BEACON) located on the pilots' forward panels. When set to BRT, all lights indicated above are controlled by their individual dimmer switches and can be adjusted over their entire intensity range. When set to DIM, the lights indicated above are still controlled by their individual dimmer switches but the range of available light intensity is reduced. The IND LT switch located on the flight engineer's panel controls all indicator, annunciator, and switch light illumination of the flight engineer's panels. The IND LT switch operates in the same manner as the pilots' IND LIGHTS switch.

CAUTION

When replacing lights in instruments or switches, make sure proper replacement lamp is installed. If wrong part number lamp is used, overheating of switch and/or wire can result.

The LOWER CAB LIGHT switch, located on the observers panel, operates in conjunction with three other switches located under the main deck next to various forward lower compartment access hatches. These four switches act together as four-way switches to control all the forward lower compartment dome lights.

FORWARD MISSION CREW COMPARTMENT LIGHTING

Forward mission crew compartment lights include dimmable incandescent forward ceiling lights, dimmable fluorescent special and main overhead lights, cold weather and emergency incandescent lights, low level emergency lights, aisle lights, entryway lights, and portable emergency exit lights. Controls for the forward ceiling, fluorescent main overhead and cold weather lights are located on the P66-3 panel. Controls for the emergency incandescent and low level emergency lights are located on the P67-2 panel. The entryway lights have a single switch located just inside the forward entry door that controls both the overhead and threshold entryway lights. The aisle lights have no controls other than circuit breakers, while the portable emergency exit lights are controlled by the EMER EXIT LIGHTS switch located on the pilots' overhead panel.

The PRIMARY NO 1 and PRIMARY NO 2 controls (*figure 1-223*) operate in the same manner. When rotated full counterclockwise, the associated lights are off. As the controls are rotated clockwise the associated lights increase in brightness. The PRIMARY NO 1 switch controls the forward ceiling lights while the PRIMARY NO 2 switch controls the first four main overhead light assemblies. The SECONDARY NO 2 switch (*figure 1-223*) is a two position (ON–OFF) toggle switch that controls the first five cold weather light assemblies. (See *figure 1-223* for light locations.)

The portable emergency exit lights are self contained units, powered by conventional (flashlight-type) dry cell. There are a total of six lights of which one is located above each emergency exit aft of the cockpit and one above the bailout chute.

They can be operated in four ways:

a. by a sliding switch on each unit which operates each light whenever it is mounted in its holder or handcarried.

b. by an inertia switch in each mount which turns the light on with impact of approximately two g's or greater.

c. by setting the pilot's EMER EXIT LIGHTS switch to ON.

d. by removal of power from AVAC bus 4 while the EMER EXIT LIGHTS switch is ARMED.

If a unit is turned on by an inertia switch, it can be turned off by its sliding switch (ON, then back to OFF) or by removing the light from its mount and reinstalling it. If all six units are turned on by the EMER EXIT LIGHTS switch (ARMED or ON), they can be turned off by setting the EMER EXIT LIGHTS switch to OFF regardless of the condition of any airplane power bus.

Unlike the exterior emergency exit lights, the interior lights have no memory of a previously armed state. If the EMER EXIT LIGHTS switch is OFF when all power is lost, setting the switch to either ARMED or ON illuminates the interior lights, but not the exterior lights. Conversely, if the EMER EXIT LIGHTS switch is ON or ARMED when all power is lost, setting the switch to OFF switches the interior lights off, but not the exterior lights.

Two special fluorescent lighting units, one located over the communication operator's station and the other over the computer operator's station (*figure 1-223*), are individually operated by controls at each console. Both these controls operate in the same manner as the PRIMARY NO 1 and PRIMARY NO 2 switches. For a detailed description of the special fluorescent lighting controls, refer to T.O. 1E-3A-43-1-1.

The cold weather/emergency light assemblies contain four incandescent bulbs. Three bulbs act as cold weather lights which are used when it is too cold for fluorescent light operation (below +45°F). The cold weather lights are controlled by the SECONDARY NO 2 switch. The fourth bulb acts as an emergency light which is controlled by the EMERGENCY LIGHTS switches on the P67-2 panel.

MID MISSION CREW COMPARTMENT LIGHTING

Mid mission crew compartment lighting includes dimmable fluorescent main overhead lights, cold weather lights, aisle lights, low level emergency lights, emergency incandescent lights, and portable overwing emergency exit lights. Controls for the main overhead, cold weather, low level emergency and emergency incandescent lights are located on the P67-2 panel. The aisle lights have no controls other than circuit breakers while the portable overwing emergency exit lights are controlled by the EMER EXIT LIGHTS switch on the pilot's overhead panel. The portable overwing emergency exit lights operate in the same manner as the portable emergency exit lights in the forward cabin.

The PRIMARY NO 3 switch (*figure 1-224*) controls both rows of main overhead fluorescent lights from those just behind rack E23 to those just in front of the overwing emergency exit door (12 total). The PRIMARY NO 2 switch (*figure 1-223*) controls both rows of main overhead fluorescent lights from those above the overwing emergency exit door to those in front of rack E13 (12 total). Both the PRIMARY NO 3 and PRIMARY NO 4 switches operate in the same manner as do the PRIMARY NO 1 and PRIMARY NO 2 switches.

The SECONDARY NO 3 & 4 switch (*figure 1-224*) is a two position (ON–OFF) toggle switch that controls the cold weather incandescent lights (26 total). The lights controlled by the SECONDARY NO 3 & 4 switch include those in the right row from just behind rack E23 to those in front of rack E13 and those in the left row from just behind crew position 11 to in front of rack E13.

The low level emergency lights and emergency incandescent lights in all three zones (forward, mid and aft mission crew compartments) are controlled by the two EMERGENCY LIGHTS switches (*figure 1-224*) located on the P67-2 panel. With the arming switch set to OFF, all emergency lighting, other than the portable type, is off regardless of the intensity switch position. Also, any time the EMERGENCY LIGHTS arming switch is set to OFF or ON, power is removed from the emergency lighting battery charger. If the arming switch is set to ARMED and power is available from 28 VAC bus 7, all associated emergency lights remain off. If power is lost on 28 VAC bus 7 with the arming and intensity switches set to ARMED and LOW, respectively, all low level emergency lights illuminate, powered by the lighting batteries. The lighting batteries can power the low level emergency lights for approximately two hours. If power is removed from 28 VAC bus 7 with the arming and intensity switches set to ARMED and HIGH, respectively, all the following emergency lights, powered by the lighting batteries, illuminate bright; all (14) low level emergency lights, three aft and four forward lower compartment dome lights; the aft and forward lower compartment dome lights illuminate only if the switches that normally control the lower compartment lights are also set to ON: the forward overhead entry and forward threshold lights, the forward ceiling light above crew position seven, all (31) emergency incandescent lights, four aft ceiling lights (E, *figure 1-225*), aft overhead entry and aft threshold lights, lavatory compartment light, and the aisle light located next to the aft emergency exit (galley) door. The lighting batteries provide approximately 30 minutes of power when the intensity switch is set to HIGH. If the arming switch is set to ON and the intensity switch is set to LOW, all low level emergency lights come on, powered by lighting batteries. The lights come on even if 28 VAC bus 7 is powered. If the arming switch is set to ON and the intensity switch is set to HIGH, all emergency lights as previously described come on, powered by the lighting batteries.

During normal taxi and flight operations, the arming switch will be set to ARMED and the intensity switch will be set to HIGH. To conserve battery power during prolonged emergency conditions, the intensity switch should be set to LOW.

AFT MISSION CREW COMPARTMENT LIGHTING

Aft mission crew compartment lighting includes aft area lights, aft entryway overhead and entryway threshold lights, galley lights, aisle lights, low level emergency lights, portable emergency exit lights, crew rest seat and bunk oxygen panel lights, crew rest seat lights, bunk reading lights, and lavatory lights. The aft area lights are divided into three groups, NAV–IFF, crew rest, and galley lights.

Each of these groups has an individual control located on the P36 panel (*figure 1-225*). All three controls operate in the same manner. The full counterclockwise control position turns off the associated lights. As the control is rotated clockwise, the associated lights increase in brightness. The low level emergency lights and certain other lights (E, *figure 1-225*) are controlled by the EMERGENCY LIGHTS switches on the P67-2 panel. Operation of these lights is as described under the mid cabin lighting system. All lights other than aft area, emergency and aisle lights are controlled by switches located near the associated light as in the case of the oxygen panel lights. The crew rest and oxygen panel lighting controls are shown in subsection I-U.

LOWER COMPARTMENT LIGHTS

Each lower compartment (forward and aft) has its own incandescent dome lighting system. The forward lower compartment has 18 dome lights located (*figure 1-226*) to provide the necessary illumination. There are three switches located in the under deck area that control the dome lights; one switch just to the right of the radio access door, one slightly forward of the forward cargo door, and another between rack E15 and the forward lower compartment access hatch. All lights can be turned on by any one switch. A fourth switch located on the observers panel (described under cockpit lighting) acts as a fourway switch with the other switches to turn on the forward lower compartment lights. Certain dome lights (E, *figure 1-226*) also act as emergency lights. The lights illuminate if the emergency lights illuminate, and one of the dome light switches is set to ON.

The aft lower compartment has 10 lights located to provide illumination of critical components. There are two switches that control the dome lights. One switch is located slightly forward of the aft cargo door and the other is just aft of the aft lower compartment access hatch. These controls act as two way switches to turn on all the dome lights. Certain dome lights (E, *figure 1-226*), also act as emergency lights. The lights illuminate if the emergency lights illuminate, and either of the dome light switches is set to ON.

Exterior Lighting Locations

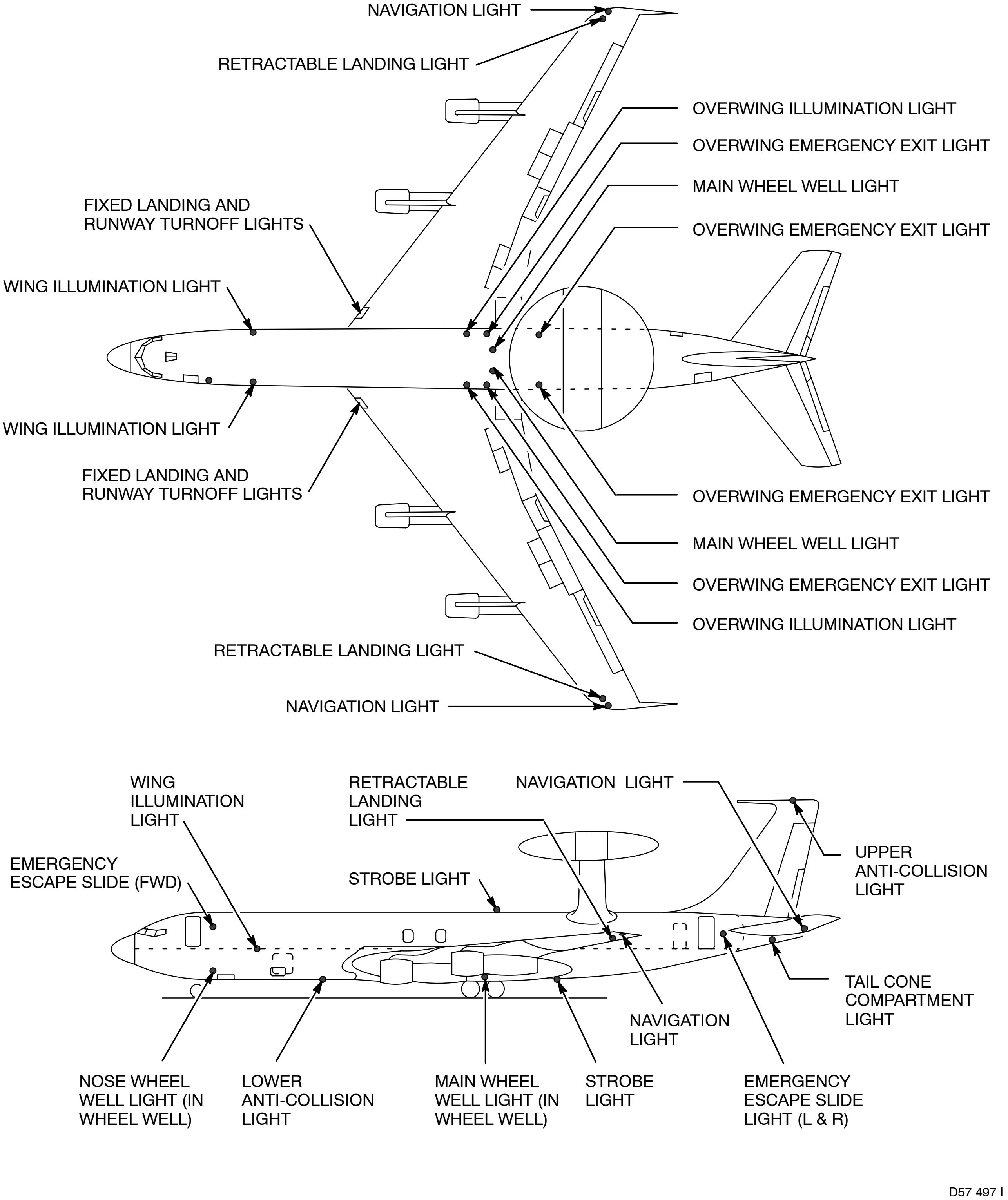
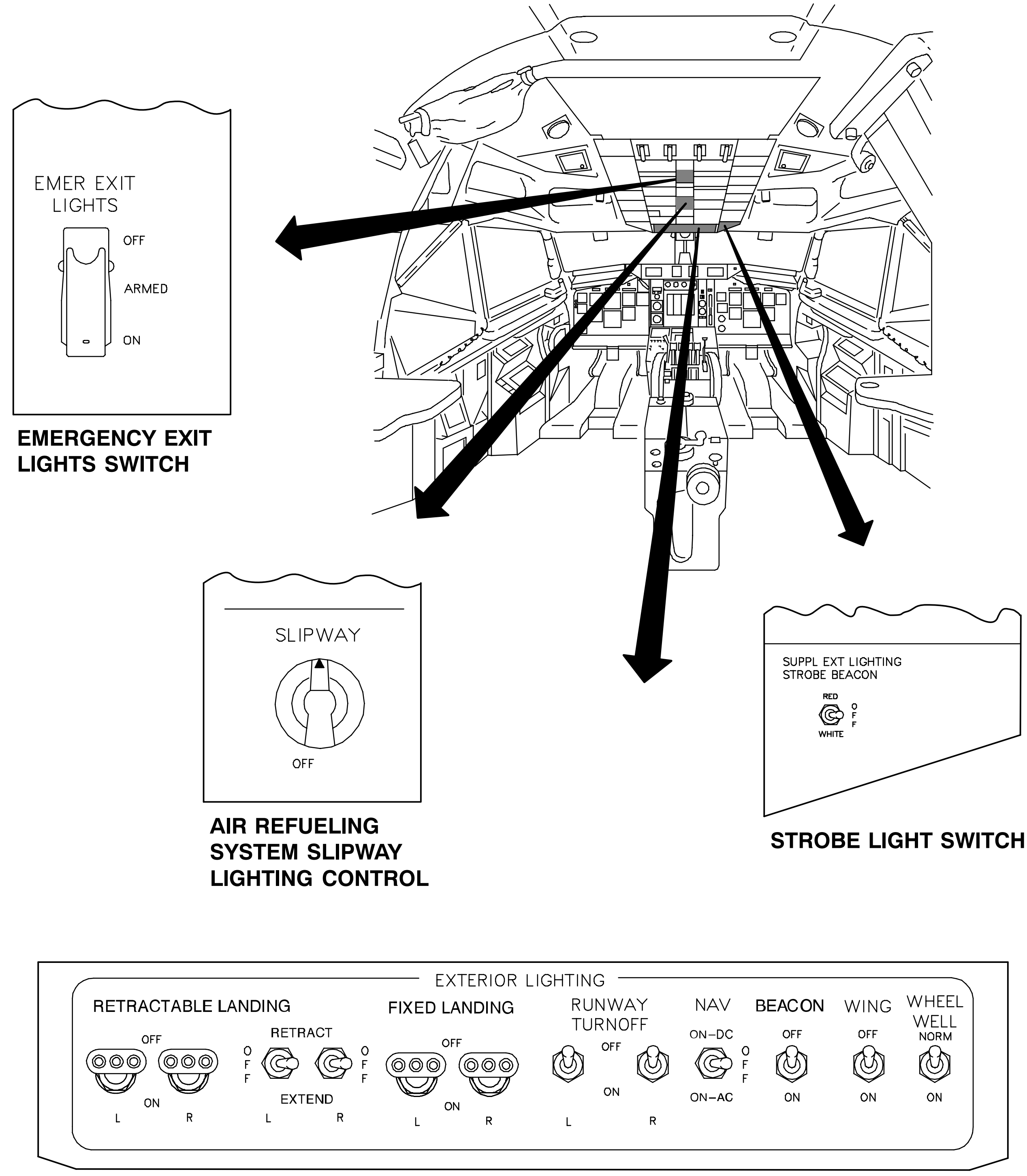


Figure 1-220

Exterior Lighting Controls and Power Sources



EMERGENCY EXIT LIGHTS SWITCH

AIR REFUELING SYSTEM SLIPWAY LIGHTING CONTROL

STROBE LIGHT SWITCH

EXTERNAL LIGHTING CONTROLS

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Figure 1-221 (Sheet 1 of 3)

Exterior Lighting Controls and Power Sources (Continued)

LIGHTS	SWITCH AND LOCATION	POWER SOURCE	CIRCUIT BREAKER LOCATION/LABEL
Aft Service Door Escape Slide Light, Aft Entry Door Escape Slide Light, Overwing Exit Light	EMER EXIT LIGHTS Switch Pilots Overhead Panel	AVDC MAIN Bus 2	P6, ESSENTIAL LIGHTING – EXTERIOR – AFT
Overwing Emergency Exit Lights, Overwing Exterior Illumination Lights, Forward Escape Slide Light	EMER EXIT LIGHTS Switch Pilots Overhead Panel	AVDC MAIN Bus 2	P6, ESSENTIAL LIGHTING – EXTERIOR – FWD
Emergency Exit Lights Arming Power	EMER EXIT LIGHTS Switch Pilots Overhead Panel	AVDC MAIN Bus 2	P6, ESSENTIAL LIGHTING – EXTERIOR – ARM
Emergency Exit Lights Arming Relay Power	(None)	AVAC Bus 4	P6, EXTERIOR LIGHTS – EMER EXIT
Right Retractable Landing Light Motor	RETRACTABLE LANDING RETRACT–OFF–EXTEND R Switch, 6 Pilots Overhead Panel ①	AVDC MAIN Bus 2	P6, LANDING LIGHTS – MOTOR RIGHT HAND
Right Retractable Landing Light	RETRACTABLE LANDING OFF–ON, R Switch, Pilots Overhead Panel	AVAC Bus 4	P6, LANDING LIGHTS – RETRACT RIGHT HAND
Left Retractable Landing Light Motor	RETRACTABLE LANDING RETRACT–OFF–EXTEND L Switch, Pilots Overhead Panel ①	AVDC MAIN Bus 2	P6, LANDING LIGHTS – MOTOR LEFT HAND
Left Retractable Landing Light	RETRACTABLE LANDING OFF–ON, L Switch, Pilots Overhead Panel	AVAC Bus 4	P6, LANDING LIGHTS – RETRACT LEFT HAND
Left Fixed Landing Light	FIXED LANDING OFF–ON, L Switch, Pilots Overhead Panel	AVAC Bus 4	P6, LANDING LIGHTS – FIXED LEFT HAND
Right Fixed Landing Light	FIXED LANDING OFF–ON R Switch, Pilots Overhead Panel	AVAC Bus 4	P6, LANDING LIGHTS – FIXED RIGHT HAND

Figure 1-221 (Sheet 2 of 3)

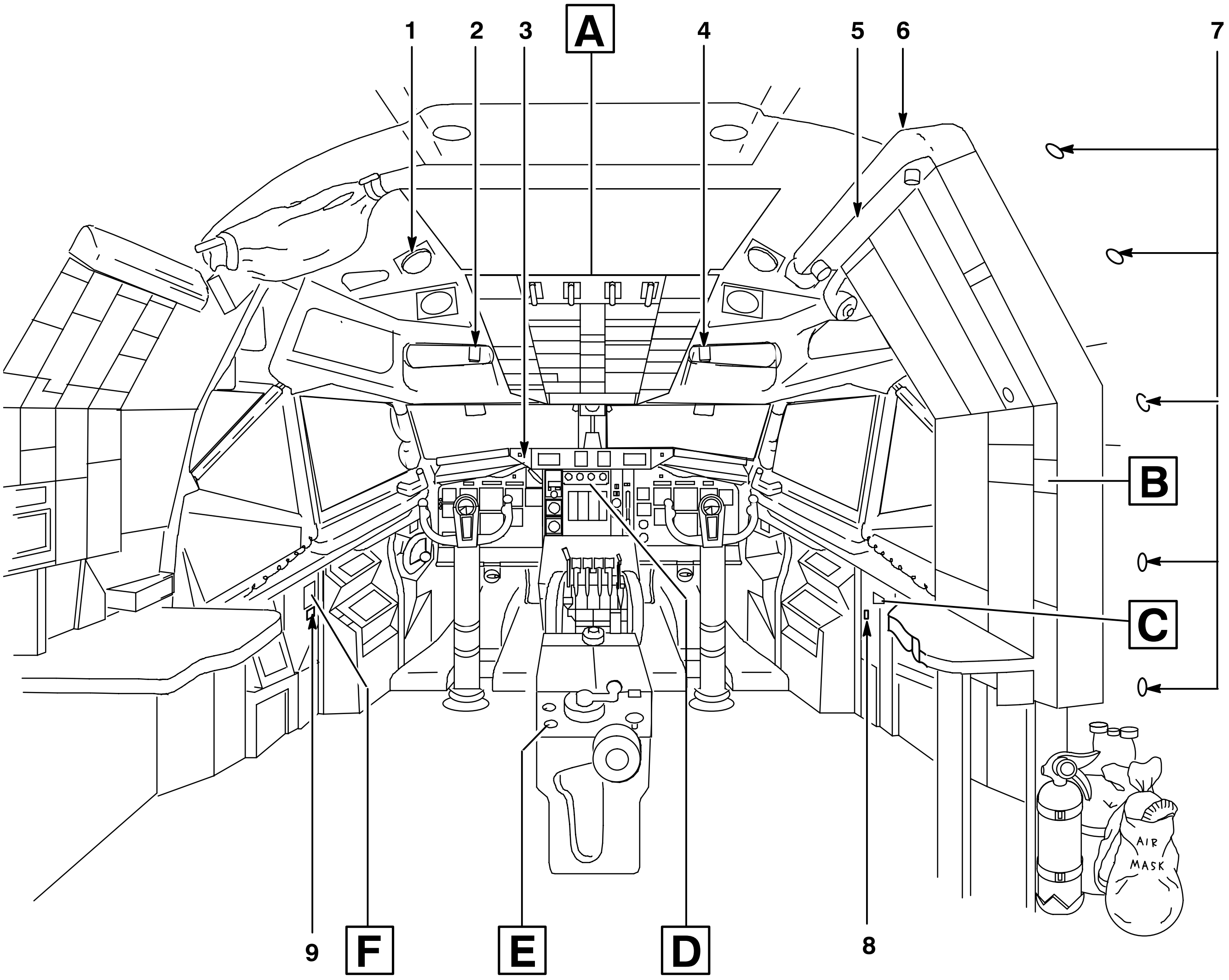
LIGHTS	SWITCH AND LOCATION	POWER SOURCE	CIRCUIT BREAKER LOCATION/LABEL
Left Runway Turnoff Light	RUNWAY TURNOFF OFF–ON, L Switch, Pilots Overhead Panel	28V AC Bus 8 DIST 1	P6, RWY TURNOFF – LEFT HAND
Right Runway Turnoff Light	RUNWAY TURNOFF OFF–ON, R Switch, Pilots Overhead Panel	28V AC Bus 8 DIST 1	P6, RWY TURNOFF – RIGHT HAND
Navigation Lights – Wing Tip and Tail	NAVIGATION Switch, Pilots Overhead Panel (ON)	28V AC Bus 8 DIST 1	P6, NAV – AC
	NAVIGATION Switch, Pilots Overhead Panel ON DC	AVDC MAIN Bus 2 ②	P6, NAV – DC
Beacon Lights – Upper	BEACON Switch, Pilots Overhead Panel	AVAC Bus 4	P6, BCN – UPPER
Beacon Lights – Lower	BEACON Switch, Pilots Overhead Panel	AVAC Bus 6	P6, BCN – LOWER
Wing Lights	WING Switch, Pilots Overhead Panel	28V AC Bus 8 DIST 1	P6, WING ILLUM
Wheel Well Lights	WHEEL WELL Lights Switch Pilots Overhead Panel and Individual Switches in Each Wheel Well	28V AC Bus 8 DIST 1	P6, WHEEL WELL
Air Refueling System Slipway Lights	SLIPWAY Switch, Pilots Overhead Panel	28V AC Bus 8 DIST 1	P6, REFUEL SLIPWAY
Strobe Lights	SUPPL EXT LIGHTING – STROBE BEACON, Pilots Overhead Panel	AVDC2 MAIN AVDC2 MAIN	P6, BCN–STROBE – UPPER P6, BCN–STROBE – LOWER

① Extension or retraction cycle is stopped by limit switch.

② The switch position marked ON–DC, receives dc power from TRU 2, not from the battery. Navigation lights are inoperative if all ac power is lost.

Figure 1-221 (Sheet 3 of 3)

Flight Deck Lighting Locations and Controls



1. DOME LIGHT
2. PILOT’S MAP LIGHT
3. PILOT’S LIGHT SHIELD
4. COPILOT’S MAP LIGHT
5. FLIGHT ENGINEER’S LIGHT SHIELD
6. AC CIRCUIT BREAKER PANEL LIGHT
7. CIRCUIT BREAKER PANEL FLOOD LIGHTS
8. COPILOT’S FLIGHT KIT LIGHT
9. PILOT’S FLIGHT KIT LIGHT
10. OVERHEAD PANEL LIGHTING CONTROL
11. DOME LIGHTING CONTROL
12. LIGHT OVERRIDE SWITCH
13. COMPASS LIGHTING CONTROL
14. COPILOT’S FLIGHT KIT LIGHT SWITCH
15. COPILOT’S MAP LIGHT SWITCH
16. FLIGHT ENGINEER’S BACKGROUND LIGHTING CONTROL
17. FLIGHT ENGINEER’S TABLE LIGHTING CONTROL
18. FLIGHT ENGINEER’S PANEL LIGHTING CONTROL
19. FLIGHT ENGINEER’S IND LT SWITCH
20. CIRCUIT BREAKER PANEL LIGHTING CONTROL
21. COPILOT’S PANEL LIGHTING CONTROL
22. PANEL BACKGROUND LIGHTING CONTROL
23. PILOT’S PANELS IND LIGHTS SWITCH
24. CENTER INSTRUMENT PANEL LIGHTING CONTROL
25. PILOT’S PANEL LIGHTING CONTROL
26. RADIO PANEL LIGHTING CONTROL
27. RADIO PANEL LIGHTING CONTROL

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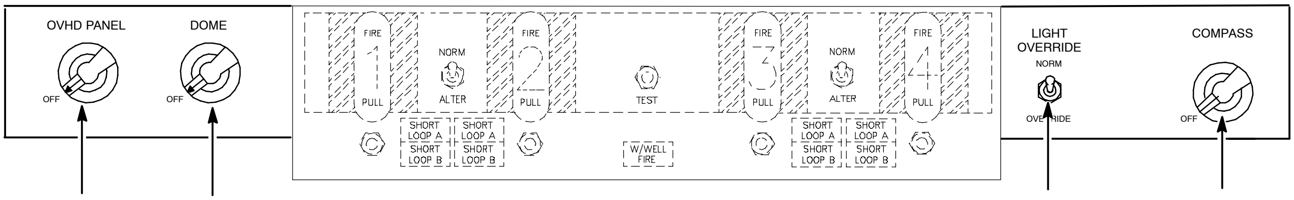
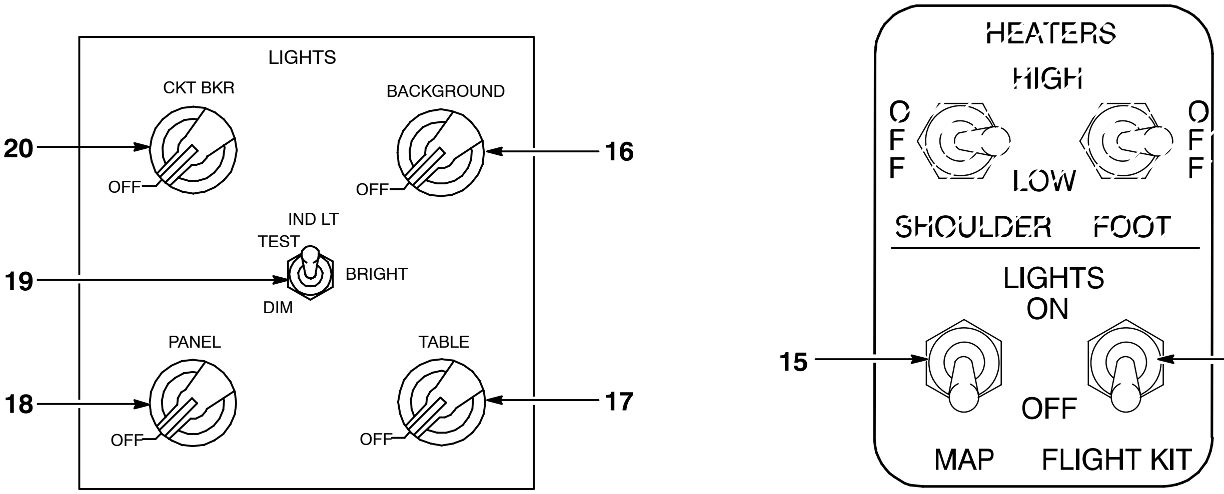
Figure 1-222 (Sheet 1 of 4)

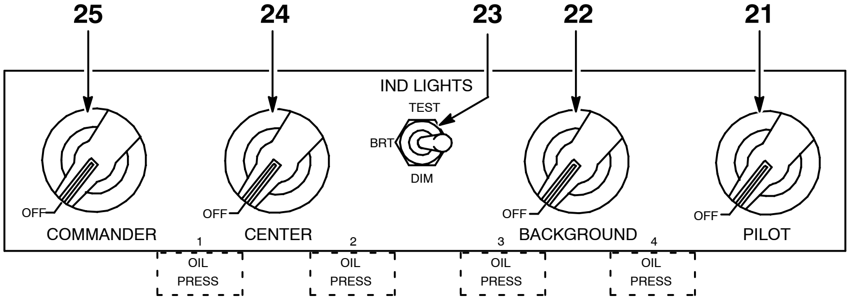


A OVERHEAD INSTRUMENT PANEL LIGHTING CONTROLS



B FLIGHT ENGINEER'S LIGHTING CONTROL'S

C COPILOT'S FLIGHT KIT AND MAP LIGHT SWITCHES



D INSTRUMENT PANELS LIGHTING CONTROLS

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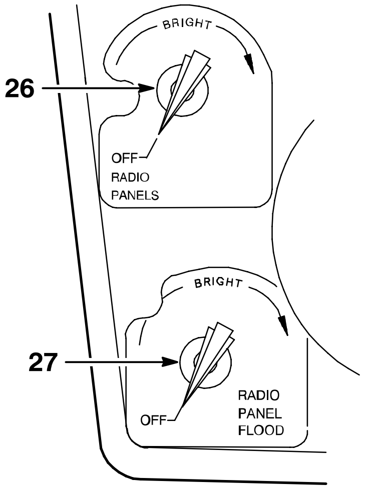
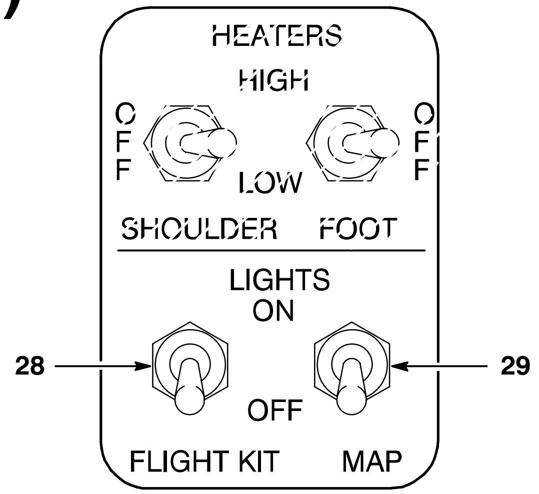
Figure 1-222 (Sheet 2 of 4)

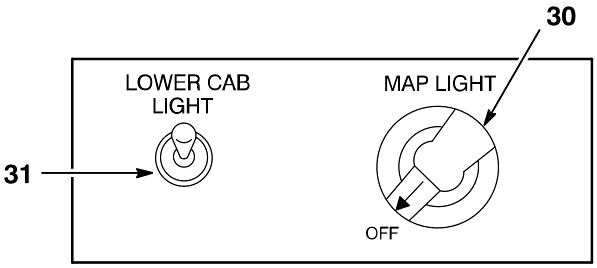
Flight Deck Lighting Locations and Controls (Continued)



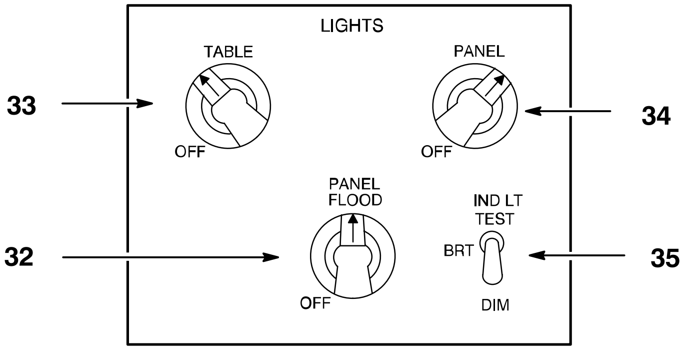
E RADIO PANEL LIGHTING CONTROLS



F PILOT'S FLIGHT KIT AND MAP LIGHT SWITCHES



H OBSERVER'S LIGHTING CONTROL PANEL



G NAVIGATOR'S LIGHTING CONTROL

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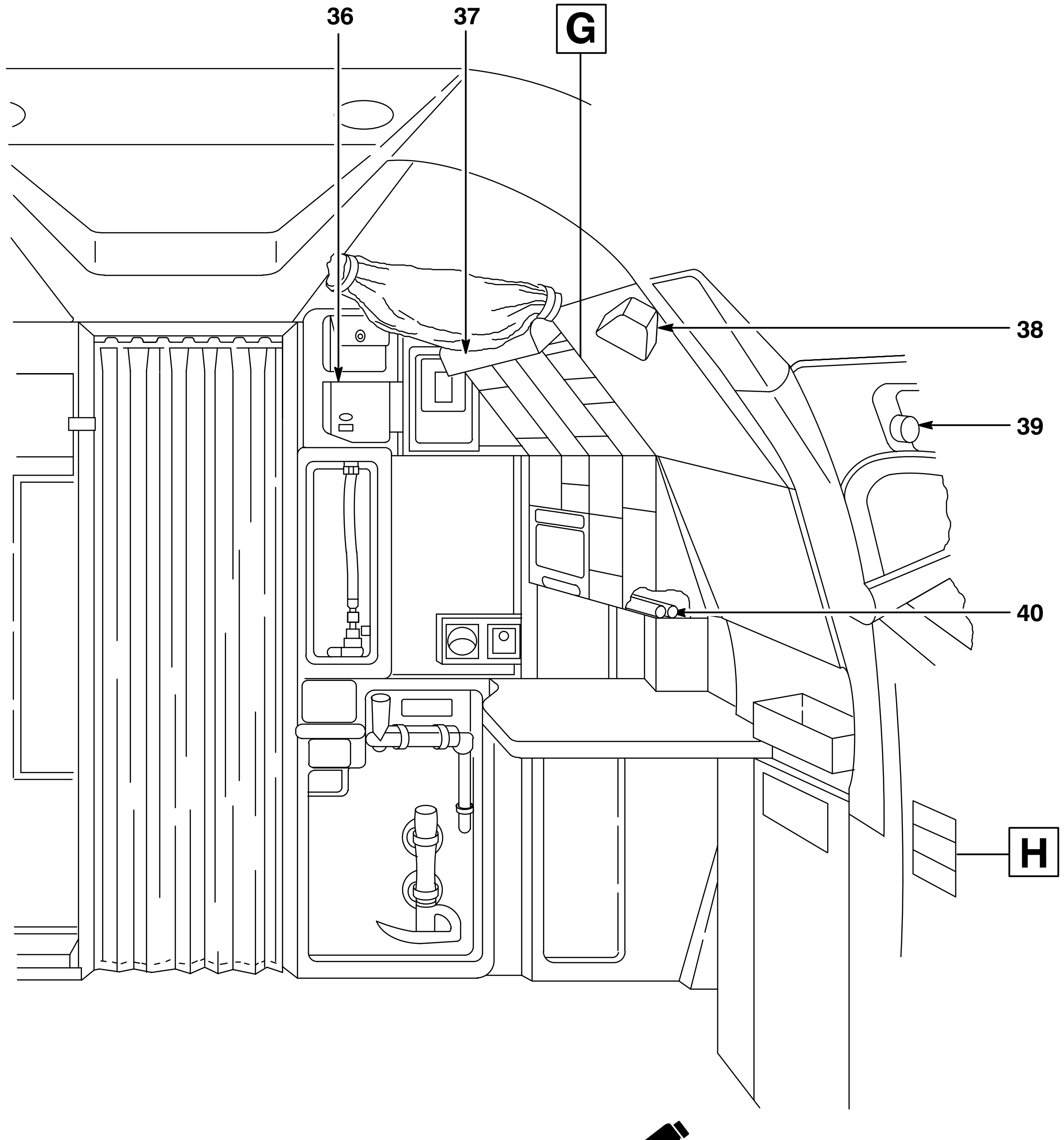
Figure 1-222 (Sheet 3 of 4)



28. PILOT'S FLIGHT KIT LIGHT SWITCH
29. PILOT'S MAP LIGHT SWITCH
30. OBSERVER'S MAP LIGHTING CONTROL
31. LOWER CAB LIGHT SWITCH
32. NAVIGATOR'S PANEL FLOOD LIGHTING CONTROL
33. NAVIGATOR'S TABLE LIGHTING CONTROL
34. NAVIGATOR'S PANEL LIGHTING CONTROL
35. NAVIGATOR'S PANEL LIGHT TEST SWITCH
36. SPARE BULB STOWAGE
37. PANEL INCANDESCENT TUBULAR WHITE LIGHT
38. CIRCUIT BREAKER PANEL LIGHT
39. OBSERVER'S MAP LIGHT
40. WHITE FLUORESCENT TABLE LIGHTS

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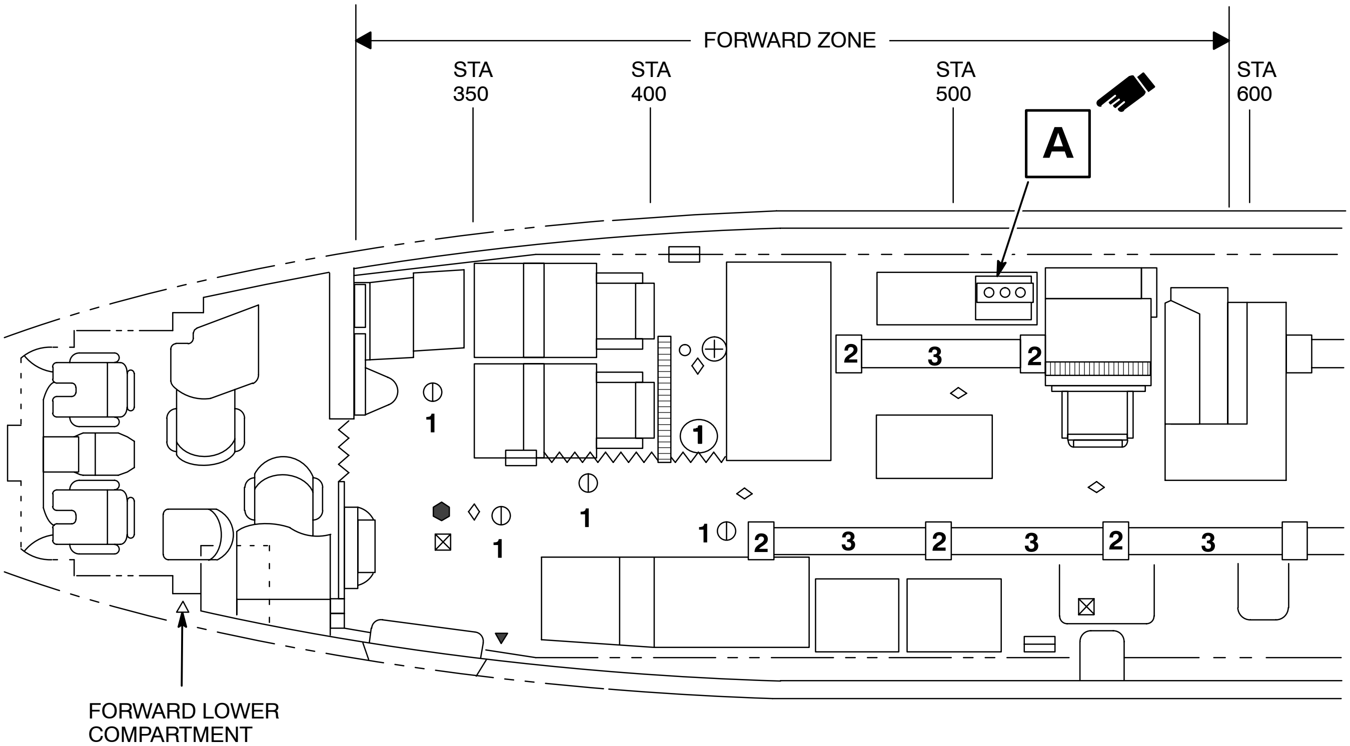
Figure 1-222 (Sheet 4 of 4)

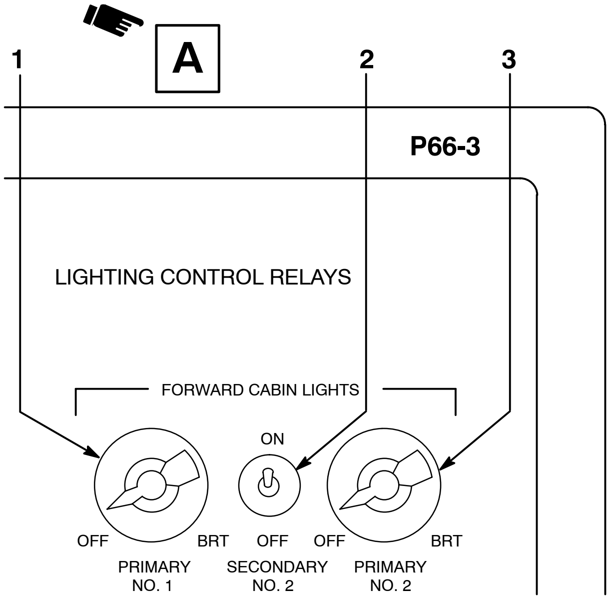
Forward Mission Crew Compartment Lighting Locations and Controls



FORWARD LOWER COMPARTMENT LIGHT SWITCH (ON OBSERVERS PANEL)

LEGEND

▭	DIMMABLE MAIN OVERHEAD FLUORESCENT LIGHT (4)
▯	COLD WEATHER/EMERGENCY LIGHT (5)
⦶	FORWARD AREA LIGHT (4)
◇	LOW LEVEL EMERGENCY LIGHT (5)
⊟	AISLE LIGHT (2)
⬢	ENTRYWAY OVERHEAD LIGHT (1)
▼	ENTRYWAY LIGHT SWITCH (1)
◫	ENTRYWAY THRESHOLD LIGHT (1)
▥	SPECIAL FLUORESCENT LIGHT (2)
⊠	PORTABLE EMERGENCY EXIT LIGHT (2)
⊕	COMMUNICATIONS COMPARTMENT LIGHT (1)
○	COMMUNICATIONS COMPARTMENT LIGHT/EMERGENCY LIGHT (1)
①	CONTROLLED FROM COMM CONSOLE



NOTE

NUMBERS USED TO LABEL CONTROLS CORRESPOND TO NUMBERS USED TO LABEL LIGHTS.

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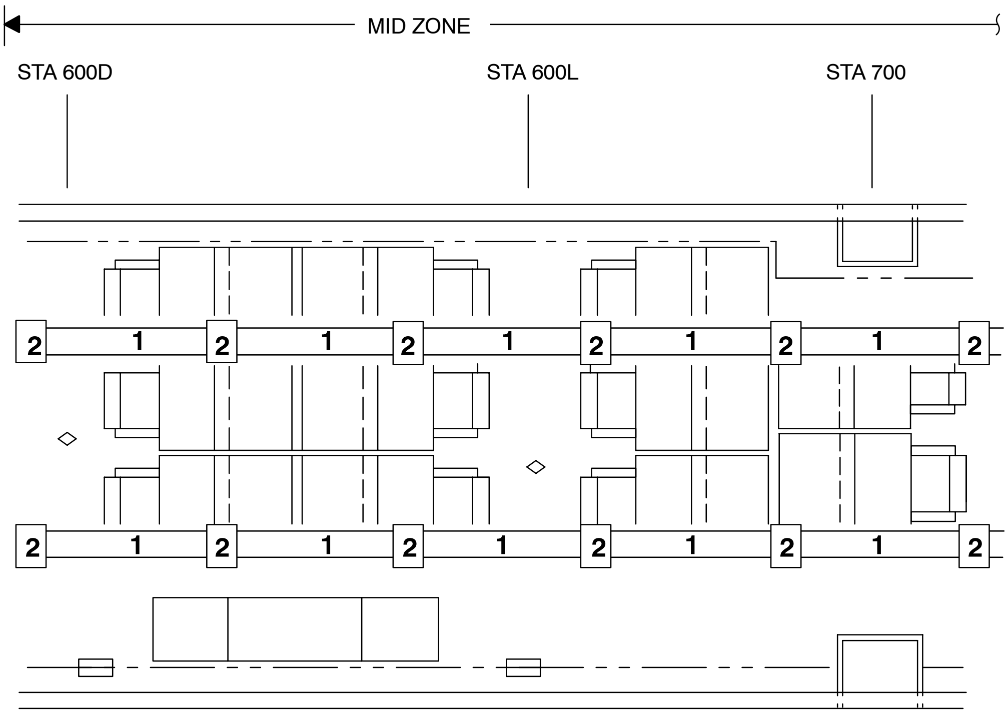
Figure 1-223

Mid Mission Crew Compartment Lighting Locations and Controls



LEGEND

◇ LOW LEVEL EMERGENCY LIGHT (5)

▭ DIMMABLE MAIN OVERHEAD FLUORESCENT LIGHT (24)

▯ COLD WEATHER/EMERGENCY LIGHT (25)

⊠ PORTABLE EMERGENCY EXIT LIGHT (2)

⊟ AISLE LIGHT (5)

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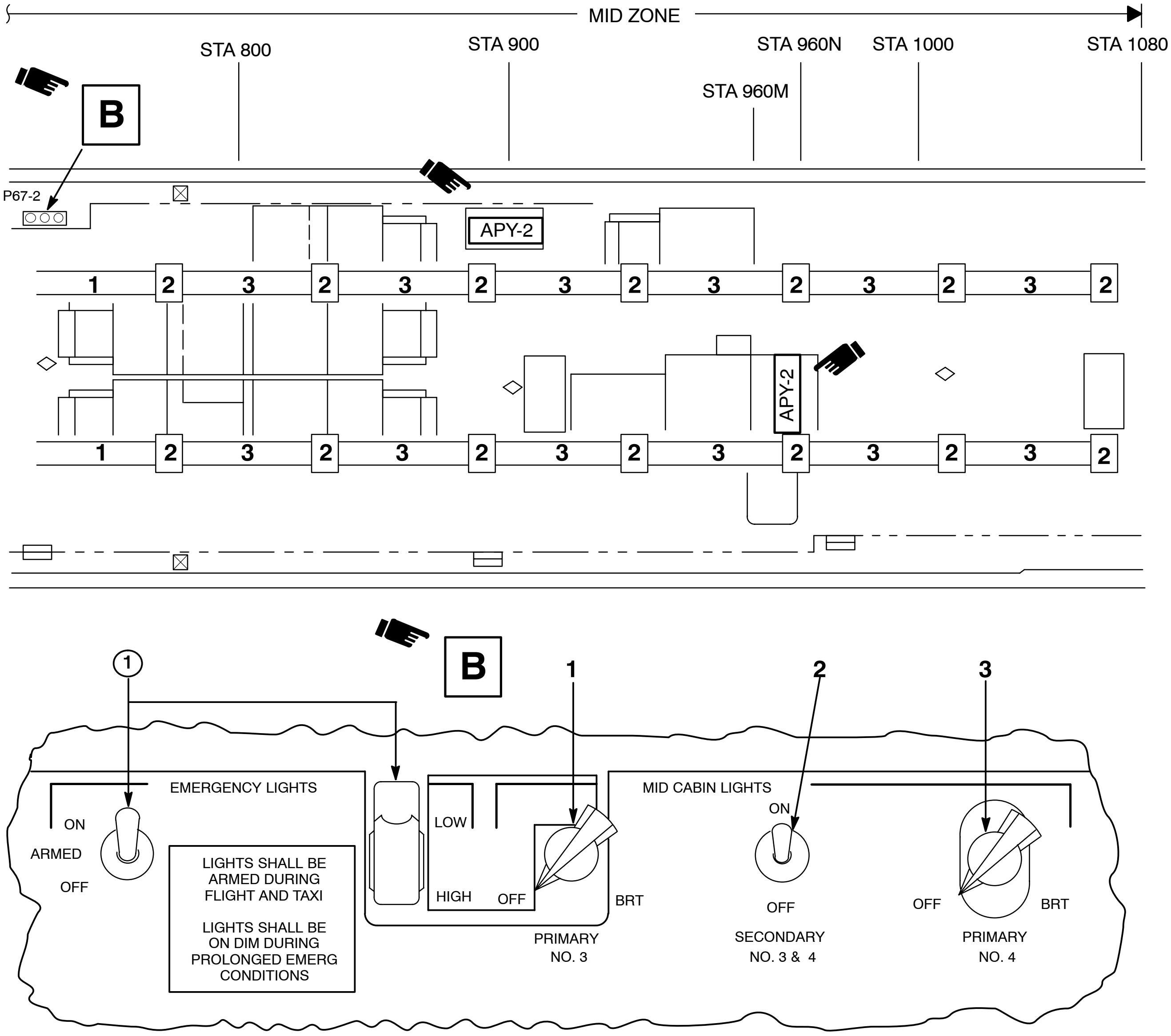
Figure 1-224 (Sheet 1 of 2)

Mid Mission Crew Compartment Lighting Locations and Controls (Continued)



NOTE

NUMBERS USED TO LABEL CONTROLS CORRESPOND TO NUMBERS USED TO LABEL LIGHTS.

① EMERGENCY LIGHTS SWITCHES CONTROL EMERGENCY LIGHTS IN ALL THREE ZONES.

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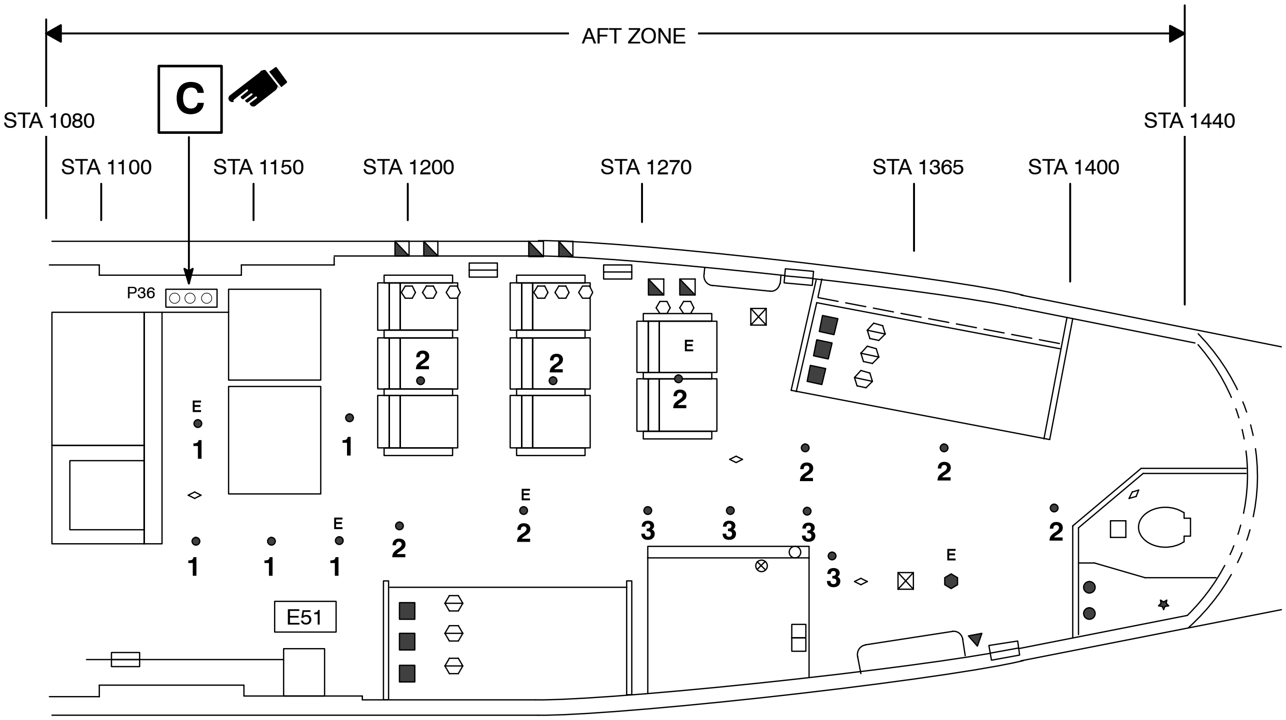
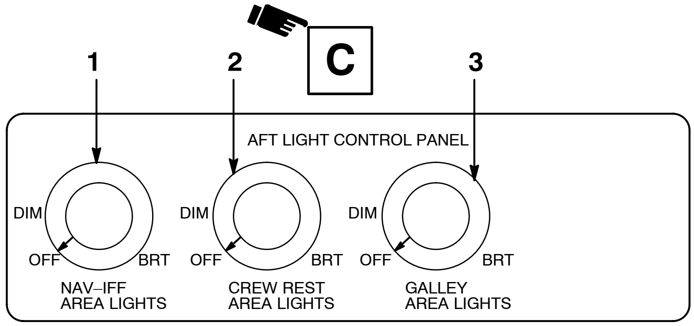
Figure 1-224 (Sheet 2 of 2)

Aft Mission Crew Compartment Lighting Locations and Controls



LEGEND

E	EMERGENCY LIGHT (5)
▼	ENTRY LIGHT SWITCH (1)
⬡	CREW REST SEAT LIGHT AND SWITCH (8)
⊗	GALLEY LIGHT (1)
○	GALLEY SWITCH (1)
□	LAVATORY CEILING LIGHT (1)
●	LAVATORY MIRROR LIGHT (2)
✶	LAVATORY MIRROR LIGHT SWITCH (1)
◇	LOW LEVEL EMERGENCY LIGHT (4)
⊠	PORTABLE EMERGENCY EXIT LIGHT (2)
■	BUNK READING LIGHT AND SWITCH (6)
⊟	AISLE LIGHT (5)
◪	CREW REST SEAT OXYGEN REGULATOR PANEL LIGHT (6)
⊖	BUNK UNIT OXYGEN REGULATOR PANEL LIGHT (6)
⊟	ENTRYWAY THRESHOLD LIGHT (1)
•	AFT AREA LIGHT (17)



NOTE

NUMBERS USED TO LABEL CONTROLS CORRESPOND TO NUMBERS USED TO LABEL LIGHTS.

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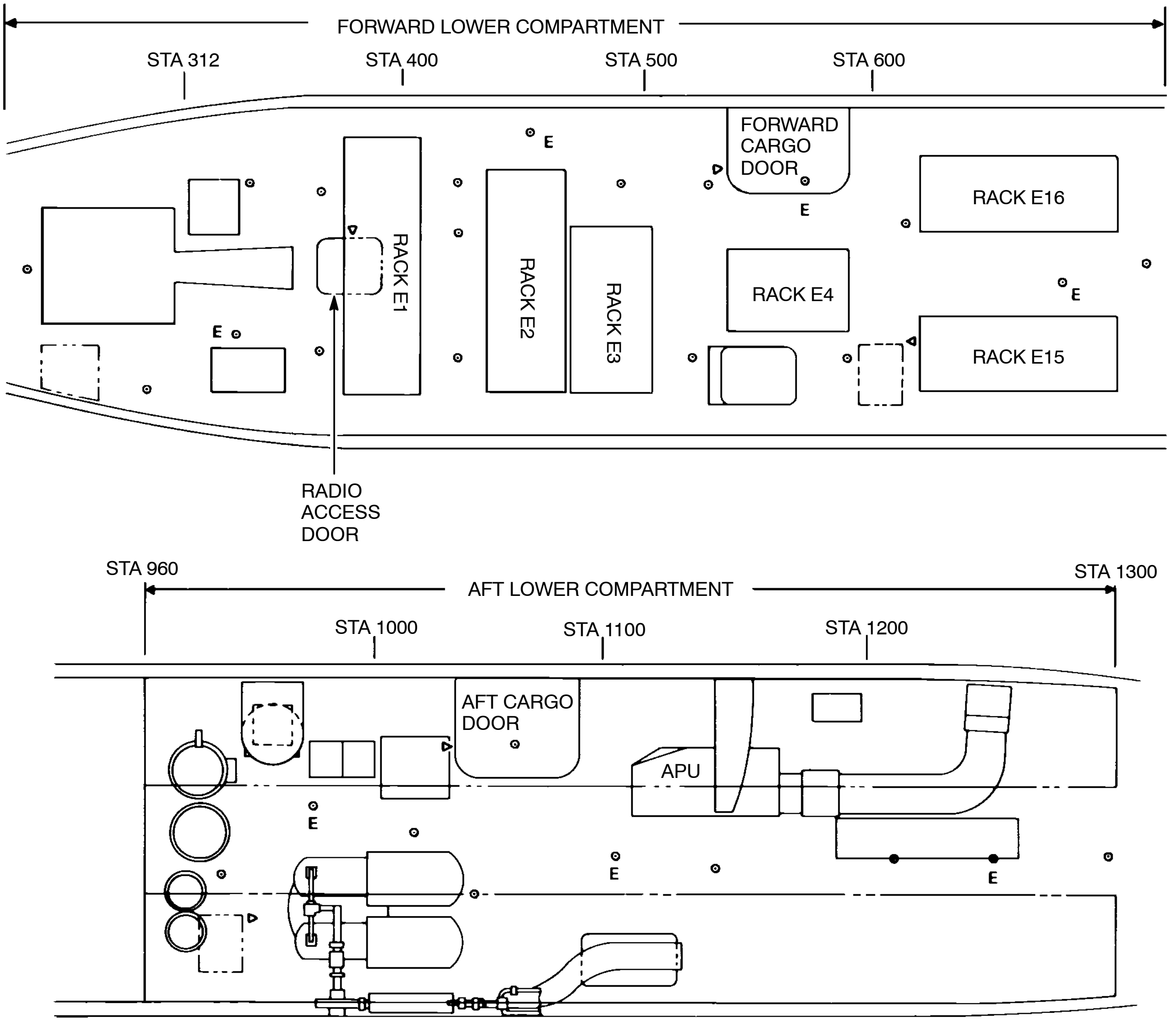
Figure 1-225

Forward and Aft Lower Compartment Lighting Locations



LEGEND

⊙ LOWER EQUIPMENT BAY DOME LIGHT (28)

△ LOWER EQUIPMENT BAY LIGHT SWITCH (5)

E EMERGENCY LIGHT (7)

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Figure 1-226

SUBSECTION I-U
CREW ACCOMMODATIONS

Table of Contents

Title ***Page***

SUMMARY

Crew accommodations include all equipment provided for crew comfort and convenience such as doors, windows, seats, bunks, galley, and lavatory.

DOORS

There are three doors on the upper deck, one door in each lower compartment, and a door for access to the forward lower compartment. The upper deck doors include the two entry doors and the galley door (*figure 1-3*). These doors are plug-type, manually operated doors which can be opened from inside or outside the airplane. Door opening procedure is shown in *figure 1-227*. Each main deck door is equipped with an emergency escape slide. (See EMERGENCY EQUIPMENT.) A door caution light panel (*figure 1-228*) provides an indication to the flight crew if any door is unlocked or open. Refer to appropriate DOOR CAUTION LIGHT ILLUMINATED procedure in section III.

WARNING

- To avoid possible injury to personnel on boarding stands, make sure escape slides are disconnected from floor before opening personnel doors.
- To avoid possible injury to personnel opening door, if airplane is pressurized, or if a negative pressure differential exists from operation of the forced air cooling systems, turn door handle 1/4 turn to vertical position, check that no air is flowing through top of door opening, then complete door opening sequence.
- When opening entry or galley doors after emergency landing or ditching, stop when door handle is in vertical position and check for possible entry of fire, smoke or water. If fire, smoke or water enters airplane at top or bottom of door, return handle to locked position and use another exit if possible.
- Both entry doors and the galley door are equipped with safety straps (*figure 1-227*). These straps will be fastened across door opening if door is open and no stairs are in place. Make sure straps are fastened clear of doorway when closing door.
- To avoid possible injury to ground crew or jamming of emergency exits, do not place any object under the seals of entry or galley doors.

CAUTION

The door control handle must be fully rotated to the open position when opening and closing the door. This causes the door to pivot thus allowing it to clear the entry without causing damage to the door or frame. Also, doors must not be left in a partially open position that would cause undue stress on hinges. Always open doors fully and latch them to prevent misalignment.

The lower deck doors are on the right side of the airplane (*figures 1-3* and *3-1*) and on the bottom centerline, aft of the nosewheel well. These doors are opened from inside or outside, as follows:

1. Pull handle out (outside handle only).

2. Turn handle 1/8 turn counterclockwise (outside) or clockwise (inside).

3. Move door in about six inches. (Slide side doors open after moving in. Electronics access door is hinged at forward edge.)

CAUTION

- Door can be closed with outside handle in locked position, but does not latch. Handle must be in unlocked (horizontal) position to close door.

- Inside handle of electronics access (bottom) door must be in closed position when closing door or door latch does not lock.

WINDOWS

All windows in the airplane are fixed in place and cannot be opened, except for the pilot's NO 2 (sliding) windows (*figure 1-229*).

WINDOW OPENING

1. Squeeze trigger on handle (1, *figure 1-229*).

2. Pull handle in and aft (2).

CAUTION

Do not operate window heat for more than 10 minutes with sliding window open if outside temperature is below 10°C (50°F) to avoid damage to windows.

WINDOW CLOSING

1. Pull latch release rod (3, *figure 1-229*).

2. Push handle forward until window is closed.

3. Rotate handle outward to lock.

NOTEPAD CLIPBOARDS

A notepad clipboard is mounted on the bottom sile cover of each pilot's NO 2 window.

SEATS

There are six types of seats in the airplane: Pilot's, flight engineer's, navigator's, observer's, mission crew , and crew rest.

PILOTS' SEATS

The pilot's and copilot's seats (*figure 1-230*) are identical, except that controls are on the inboard side of both seats (right side of pilot's seat, left side of copilot's seat).

The seats are adjustable for height, seat tilt, back tilt (recline), and fore and aft position. Operation of the vertical control handle allows adjustment of seat height in half inch increments, over a two-inch range. The seat is locked by releasing the handle. Operation of the backrest tilt control allows adjustment over a range of approximately 20 degrees. The seat is locked in position when the control is released. The seat tilt adjustment handle allows movement of the seat cushion and thigh support over the range from three degrees up to seven degrees down from neutral.

Operation of the fore and aft control allows adjustment two inches forward and five inches aft from the neutral position.

The inboard arm rests fold up for entry to the seat. To raise the arm rest, push forward on the arm rest release (2, *figure 1-230*). Each seat has a seat belt, and inertia reel shoulder harness, with a single rotary release buckle. The black shoulder harness release tab (3) allows the shoulder harness to be released without releasing the seat belt. To release shoulder harness, press forward on the tab. The back cushion is removable, and can be used for flotation. The back cushion can be removed to allow wearing a parachute while seated.

FLIGHT ENGINEER'S SEAT

The flight engineer's seat (*figure 1-231*) is adjustable vertically, in two horizontal directions (directly toward or away from the engineer's panel and diagonally) and can be rotated. The seat is equipped with a seat belt and shoulder harness with a rotary buckle lock. The black shoulder harness release tab (3) allows the shoulder harness to be released without releasing the seat belt. To release shoulder harness, press forward on the tab. The back cushion can be used for flotation and can be removed to allow wearing a parachute.

The vertical motion control allows movement in half inch increments. The rotary control has stops at 30 degree intervals.

WARNING

The seat does not provide maximum crash restraint, unless it is facing forward or 30 degrees (first stop) outboard.

The inboard, outboard and diagonal motions can be adjusted in one inch increments. The arm rests are adjusted in the same way as on the pilot's seats.

NAVIGATOR'S SEAT

The navigator's seat (*figure 1-232*) is similar to the engineer's seat (including arm rest and shoulder harness release), except that it does not have the diagonal motion feature.

Controls are on the left side of the seat and on the aft side of the base. The swivel adjustment allows 360 degrees of rotation, with locking stops every 30 degrees.

WARNING

The seat does not provide maximum crash restraint, unless it is facing forward or 30 degrees (first stop) outboard.

The vertical adjustment allows adjustment in half inch increments. The inboard/outboard adjustment allows movement in one inch increments.

OBSERVER'S SEAT

The observer's seat (*figure 1-233*) is located behind the pilot's seat. The seat can be removed if not needed for flight. The tilt latch allows the seat to be tilted forward for access to the lower forward compartment. The shoulder harness can be released (by a black tab (2) on the rotary buckle) by pressing forward on the tab.

MISSION CREW SEATS

Mission crew member's seats are similar to the navigator's seat. The seats are adjustable for height, leg room, and rotation and are equipped with seat belts and shoulder harness.

WARNING

For maximum crash restraint, mission crew member's seats shall be positioned facing forward or aft (away from consoles) for takeoff and landing.

CREW REST SEATS

Eight crew rest seats (*figure 1-234*) are located on the right side of the airplane. Each seat back is adjustable. Crew service units above the seats (*figure 1-235*) contain three ventilating (gasper) air outlets, three reading lights, and two oxygen masks for the outer two seats. The aisle seats of triple seats have a portable oxygen bottle and mask stowed under the seat. Crew rest seats may be occupied for takeoff and landing.

WARNING

The masks in the crew service units do not deploy automatically. To use masks, open door, don mask, and make sure regulator is set to ON and 100%.

ADDITIONAL MISSION CREW SEATS

Some airplanes are equipped with up to eight airline type seats for additional mission crew members (*figure 1-3* and section III, LANDING EMERGENCY PROCEDURES, ditching, for seat diagram). A portable oxygen bottle is located under each seat.

WARNING

Seats 43, 44, 45 and 46 will not be occupied when baggage/cargo is restrained on the J compartment baggage plate using the approved cargo net. Cargo net may flex due to some crash and/or flight loads causing baggage/cargo to impact personnel.

CREW REST AREA

The crew rest area (*figure 1-3*) contains the crew rest seats, crew bunks, the galley, a coat closet, and the lavatory.

CREW SERVICE UNITS

Three crew service units are located above the crew rest seats (see *figure 1-235*, item A). Each unit contains ventilating (gasper) air outlets, reading lights and two oxygen regulators for the two outboard crew rest seats. The masks in these units do not fall out of the compartment automatically. The door must be opened and the mask pulled out before use.

A crew service unit is located in the bunk unit (see *figure 1-235*, item B). Each unit has a ventilating (gasper) air outlet, reading light and one oxygen regulator. The mask must be pulled out for use.

CREW BUNKS

Six bunks in groups of three (*figure 1-236*) are provided for crew rest on the ground or in flight. Each bunk has a mattress, a reading light and a safety belt.

WARNING

- Bunks will not be occupied during takeoff, landing, or inflight refueling.
- Bunks will not be used for cargo tiedown at any time.
- Bunk oxygen masks do not deploy automatically. Remove plastic cover, don mask and set regulator to ON and 100% to use mask.

GALLEY

The galley (*figure 1-237*) is located on the left side of the crew rest area, between the aft entry door and the crew bunks. Galley equipment includes a work surface, two ovens, a coffee brewer, two hot jugs for liquid storage, a hot cup for heating liquids, electrical outlets (115 volts, 400 Hz) and a dual temperature freezer-refrigerator.

Galley Electrical Power

Electric power to the galley is supplied from generator bus NO 8 through the GALLEY circuit breaker on the P67-3 panel. The galley electrical panel (1, *figure 1-237*) contains the MAIN POWER switch, and individual switches for each galley component, the pilot lights which illuminate when power is supplied to each component.

Galley Lights

The lights over the galley work surface are controlled by the LIGHTS switch on the galley electrical panel. Overhead lights are controlled from the aft lighting panel (*figure 1-225*). Refer to AFT MISSION CREW COMPARTMENT LIGHTING.

Refrigerator

The dual temperature refrigerator-freezer (9, *figure 1-237*) contains two freezer compartments (upper doors) and two cooling compartments (lower doors).

NOTE

If the refrigerator has been inoperative, allow refrigerator to cool for 90 minutes before storing frozen meals.

Refrigerator operation is automatic, once electric power is available. To operate the refrigerator, the GALLEY circuit breaker (P67-3) must be closed and power panel and the MAIN POWER and REFRIGERATOR switches on the galley power panel must be on.

Coffee Brewer

The automatic coffee brewer and water dispenser (15, *figure 1-237*) is a self contained unit which supplies hot and cold water and measures hot water for brewing coffee. The three water outlets are separate. Hot or cold water can be obtained while coffee is being brewed, but use of the hot water outlet while brewing coffee delays the coffee brewing cycle. Hot water is available at a flow rate of approximately one half gallon per minute. The coffee brewer contains a holder for prepackaged coffee grounds, a coffee pot holder, and an electric hot plate for keeping brewed coffee hot.

Coffee Brewer Operation

To operate the coffee brewer:

1. Close GALLEY circuit breaker (P67-3).
2. Set galley MAIN POWER and COFFEE BREWER switches (on galley electrical panel) to ON.
3. Open coffee bag holder clamp (37, *figure 1-237*) and move bag holder handle (36) to open bag holder (38).
4. Place coffee bag in holder, raise handle (36) and fasten clamp (37).
5. Place coffee pot in holder (39), with liquid level sensor (40) in pot. Set HOT PLATE switch to ON.

NOTE

- If liquid sensor is not placed in pot, water does not shut off automatically.
- Coffeemaker should be attended during coffee brewing cycle.
- Make sure liquid level sensor (40) and hot plate surface under coffee pot (15) are clean or liquid level sensor can fail to operate.

6. Press hot water pushbutton (32) to purge air from coffee maker.
7. Press BREW button (31), when amber light (30) illuminates. Hot water should flow until level sensor shuts off water. If water does not stop, press PUSH TO STOP button (34). Coffee brewing cycle takes approximately three minutes. If coffee is to be kept warm, place coffee pot on hot plate.
8. Open clamp (37) and remove bag from holder.

CAUTION

- If airplane is to be depressurized, set HOT PLATE, COFFEE BREWER, and HOT JUG switches to OFF to prevent boiling of liquids and possible damage to galley components.
- Set COFFEE BREWER switch (on galley power panel) to OFF when coffee maker is not in use or if coffee pot is removed from hot plate for long periods of time.

Ovens

The galley contains two electric ovens (6, *figure 1-237*). The oven controls are contained on individual control panels above the ovens and on the galley electrical panel.

Each oven is equipped with a timer control (20, *figure 1-237*), a temperature selector (19), an ON–OFF switch (22) and two indicator lights. The amber pilot light (23) is illuminated only when the temperature controller is applying power to the heating element.

The thermostat in the temperature controller maintains the oven temperature at the setting desired.

To provide better air circulation in the oven and reduce preparation time, each oven has a circulating fan (24, *figure 1-237*) and a baffle plate (25) to control air flow in the oven.

Oven Operation

To operate the oven:

1. Close GALLEY circuit breaker (P67-3).
2. Set OVEN 1 or OVEN 2 switch (on galley electrical panel) to ON.
3. Set oven ON–OFF switch to ON. (Red light illuminates.)
4. Set timer as desired.
5. Set temperature controller as desired. Amber light should illuminate, unless oven is hot from previous use.

NOTE

- Turn timer knob past 15 minutes to wind spring, then reset to desired time.

- Preheat oven for five minutes (set to desired cooking temperature) before heating food. If amber light does not illuminate (and oven is cold) heating element is not receiving power: check circuit breaker and switches.

6. After preheating oven, load oven, reset timer for cooking cycle.

NOTE

- When oven reaches desired temperature, amber light goes out. Temperature controller cycles power to heating element as required to maintain temperature.
- If oven is still warm from previous use and a lower temperature is selected, amber light does not come on until oven cools.
- Oven should be cleaned at end of each cooking cycle, if possible. Allow oven to cool, remove baffle by unlocking quarter turn fasteners at top and bottom of baffle (26, *figure 1-237*), clean oven, and wipe dry.

Hot Cup

The hot cup (17, *figure 1-237*) plugs into an electrical receptacle on the galley. The receptacle is controlled by a timer and a circuit breaker on the galley power panel.

WARNING

The hot cup heating element can explode if operated dry. Do not attempt to operate the hot cup without at least one cup liquid or semisolid food in hot cup.

LAVATORY

A lavatory (*figure 1-238*) is located in the aft end of the mission crew compartment, on the left side. An OCCUPIED indicator is on the outside of the lavatory and, when visible, indicates that it is in use. The indicator is actuated by the door lock. It is possible to unlock the lavatory door from outside the lavatory compartment without using special tools, by manually sliding the latch. The washbasin has a faucet supplying hot and cold running water from the water system. The hot water is heated by a water heater located under the washbasin. The heater is powered by 115vac power through the LAV ELEC SYS circuit breaker on P67-3 panel. The water heater has a manual switch, an amber indicator lamp, and a thermal switch. If the heater overheats, the thermal switch opens and the lamp goes out. The thermal switch can be reset by unscrewing the wing nut on top of the heater and pressing the button on the thermal switch. Lavatory lights include a dome light and a fluorescent mirror light.

An outlet (7, *figure 1-238*) supplies 115vdc power for electric shaver operation. Power is supplied through the LAV ELEC SYS circuit breaker on panel P67-3 and a rectifier.

CAUTION

- The rectifier output is limited. Do not attempt to power any electrical equipment, except shavers, from this outlet.
- Shavers intended for AC ONLY operation can be damaged by attempted operation on dc power. Use only dc or ac/dc shavers.

The toilet is flushed by turning the toilet flush handle. This begins an automatic flushing cycle which lasts for approximately 10 seconds. A separator between the bowl and the waste tank prevents splash and avoids sight of the tank contents. If mechanical or power failure occurs, the hinged separator can be forced out of the way to permit the toilet to be used as a static (nonflush) unit until normal operation is restored.

The toilet waste tank accumulates the waste from the toilet, to be subsequently removed on the ground through the toilet service panel. The toilet service panel is located on the lower aft body of the airplane. The panel includes the toilet drain outlet, flush port, and drain valve handle. Servicing of the toilet service panel requires special ground servicing equipment and is normally performed by maintenance personnel.

WATER SUPPLY SYSTEM

The water supply system (*figure 1-239*) supplies water to the lavatory and the galley. The system consists of a 40-gallon tank and connecting lines. The drain mast and some of the lines are electrically heated to prevent freezing.

CAUTION

When water tank is empty, set water heater switch to OFF to prevent overheating of lavatory water heater.

URINAL

A urinal (*figure 1-246*) is located opposite the front entry door. A curtain is provided for privacy.

CREW BAGGAGE/CARGO TIEDOWN

Three methods for securing baggage/cargo on the J compartment baggage plate are provided. Method one utilizes the approved cargo net to secure the load. Method two utilizes approved cargo straps to secure the load. Method three utilizes the alternate cargo net (P/N 229882–11; Manufacturer: Brueggemann) and CGU–1B tiedown devices to secure the load. Refer to T.O. 1E-3A-5-2 for complete tiedown instructions.

Method One

Refer to T.O. 1E-3A-5-2 for tiedown instructions when using approved cargo net.

Method Two

Refer to T.O. 1E-3A-5-2 for tiedown instructions when using approved cargo straps without approved cargo net.

Method Three

To load baggage/cargo on the J compartment baggage plate utilizing the alternate cargo net (Brueggemann):

WARNING

Serious injury to personnel can occur if cargo is not properly secured.

1. Attach eight outboard fittings (attached to black line), six aft fittings and six forward fittings from cargo net to baggage plate track, spaced equally along tracks.

NOTE

Ensure forward fittings are connected to baggage plate track aft of Static Frequency Converter box.

2. Attach two inboard fittings from cargo net to baggage plate track next to E28 Cabinet.
3. Attach three D–rings to the outboard baggage plate track and one end of each of three CGU–1B tiedown devices to the D–rings.

NOTE

- Equally space the D–rings along track between forward fittings and E28 cabinet to provide additional lateral support adjacent to additional mission crew seats.
- Ensure CGU–1B tiedown devices are outside the cargo net.

4. Gather cargo net and three CGU–1B tiedown devices and place baggage in tiedown area, with heaviest (most dense) objects on the bottom.

WARNING

- Do not stack load more than 40 inches above tiedown area. Light weight items may protrude above the 40 inch level if they are secured below the 40 inch level.
- Maximum load is 2,598 pounds, not to exceed 90 pounds per square foot.
- Personnel may not occupy additional mission crew seats 43, 44, 45 and 46 when baggage/cargo loaded on the baggage plate exceeds 30 inches above tiedown area.

5. Pull cargo net over the stack.
6. Attach six remaining inboard fittings of cargo net to baggage plate track, spaced equally along the track.
7. Attach J–rings and evenly tension four circumferential straps.
8. Pull three CGU–1B tiedown devices over stack.
9. Attach three D–rings to inboard baggage plate track aligned with outboard track D–rings, attach each CGU–1B tiedown device to a D–ring, and tighten.

CREW ACCOMMODATIONS ELECTRIC POWER SOURCES

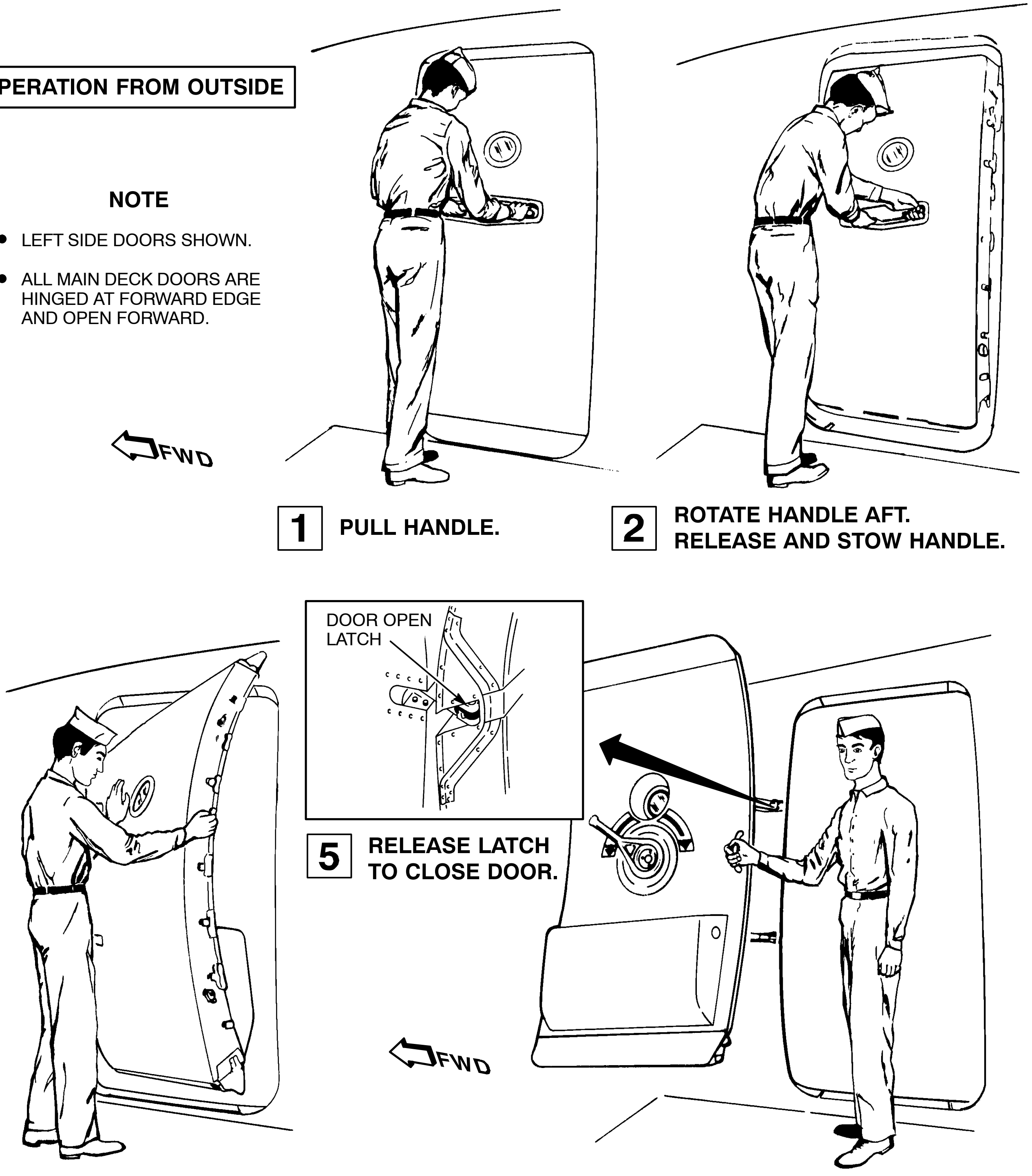
Electric power sources for crew accommodations are listed in *figure 1-240*.

Entry Door Operation

OPERATION FROM OUTSIDE

NOTE

- LEFT SIDE DOORS SHOWN.
- ALL MAIN DECK DOORS ARE HINGED AT FORWARD EDGE AND OPEN FORWARD.



1 PULL HANDLE.

2 ROTATE HANDLE AFT. RELEASE AND STOW HANDLE.

3 PULL AFT SIDE OUTWARD WHILE PUSHING FORWARD SIDE INWARD.

4 SWING DOOR PARALLEL TO AIRPLANE UNTIL DOOR OPEN LATCH HAS CAUGHT.

5 RELEASE LATCH TO CLOSE DOOR.

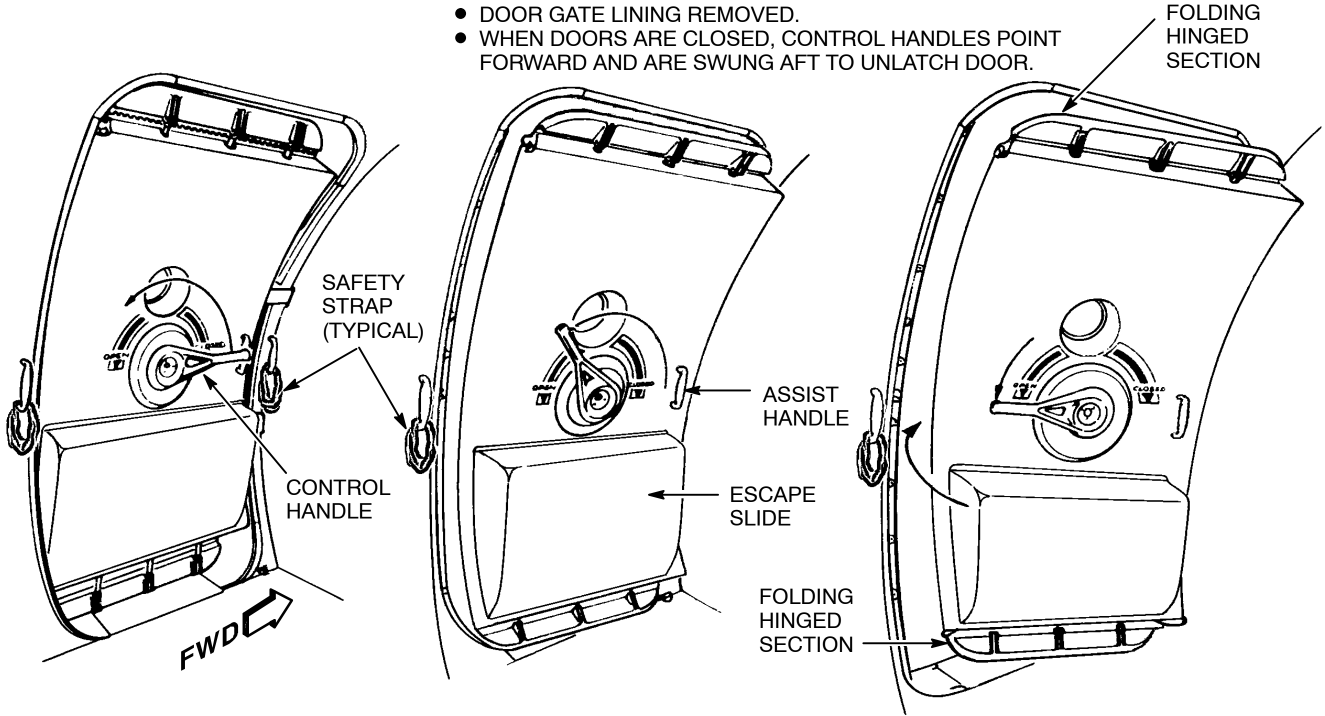
D57 508 SI

Figure 1-227 (Sheet 1 of 2)

OPERATION FROM INSIDE

NOTE

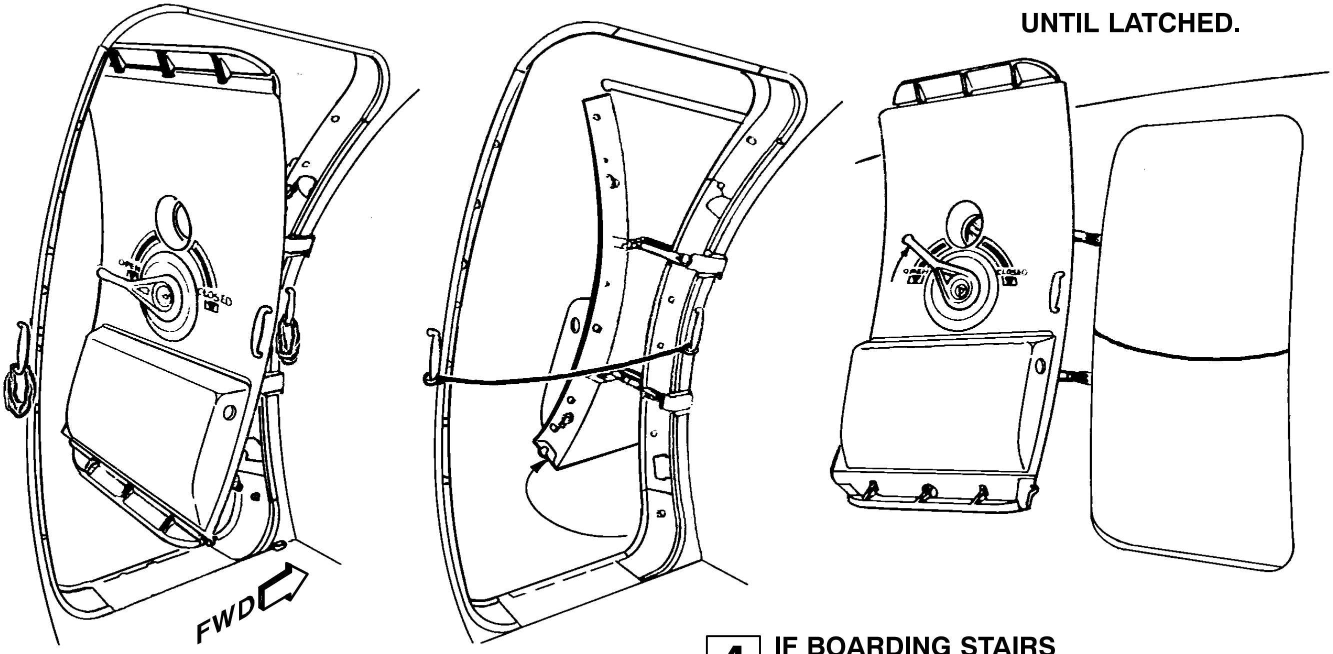
- LEFT SIDE DOORS SHOWN.
- DOOR GATE LINING REMOVED.
- WHEN DOORS ARE CLOSED, CONTROL HANDLES POINT FORWARD AND ARE SWUNG AFT TO UNLATCH DOOR.



1 ROTATE HANDLE AFT IN DIRECTION OF ARROW.

2 PULL IN ON ASSIST HANDLE.

3 PUSH OUT ON AFT EDGE OF DOOR. CONTINUE PUSHING UNTIL LATCHED.



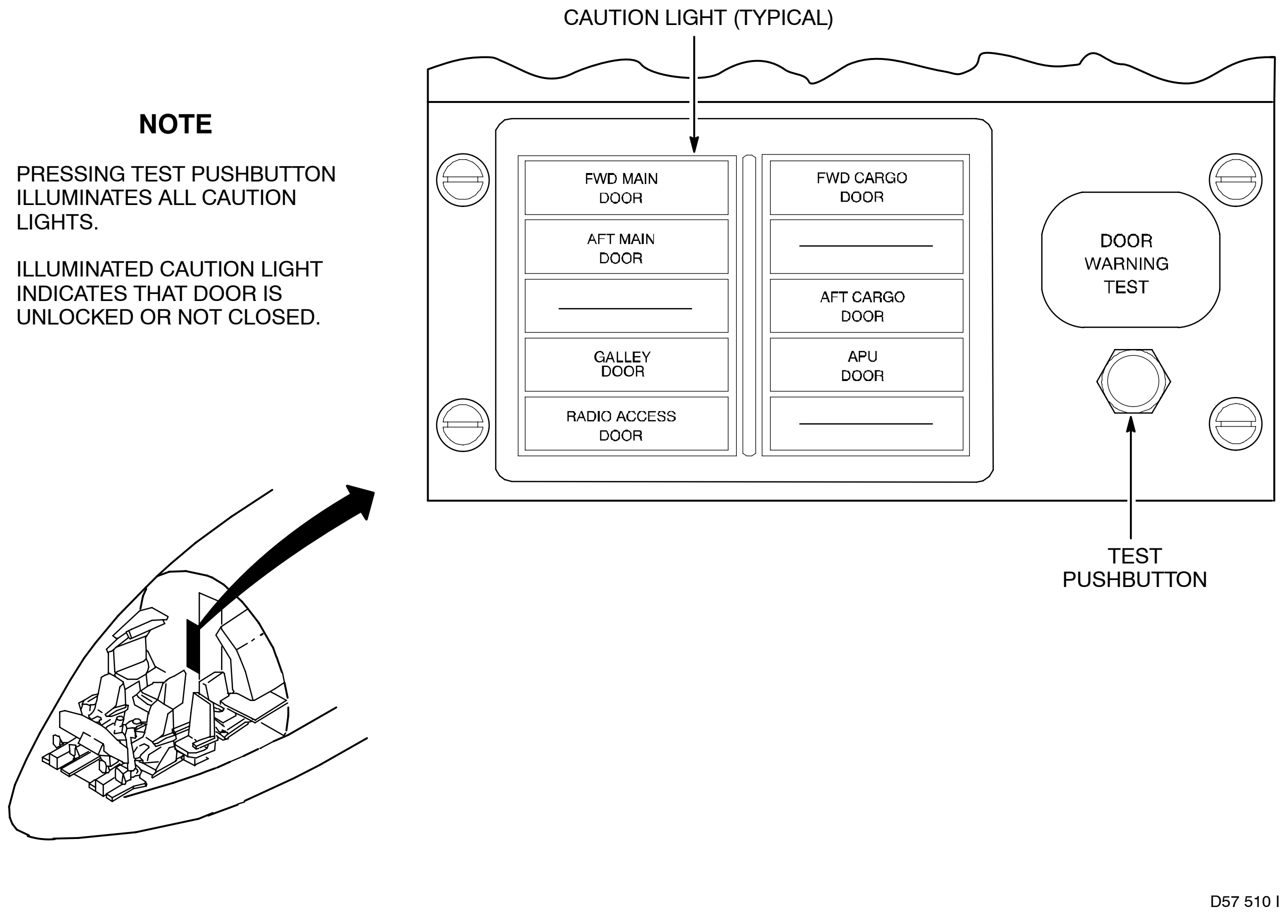
3 CONTINUED

4 IF BOARDING STAIRS NOT IN PLACE, FASTEN STRAP ACROSS DOOR.

D57 509 SI

Figure 1-227 (Sheet 2 of 2)

Door Caution Light Panel

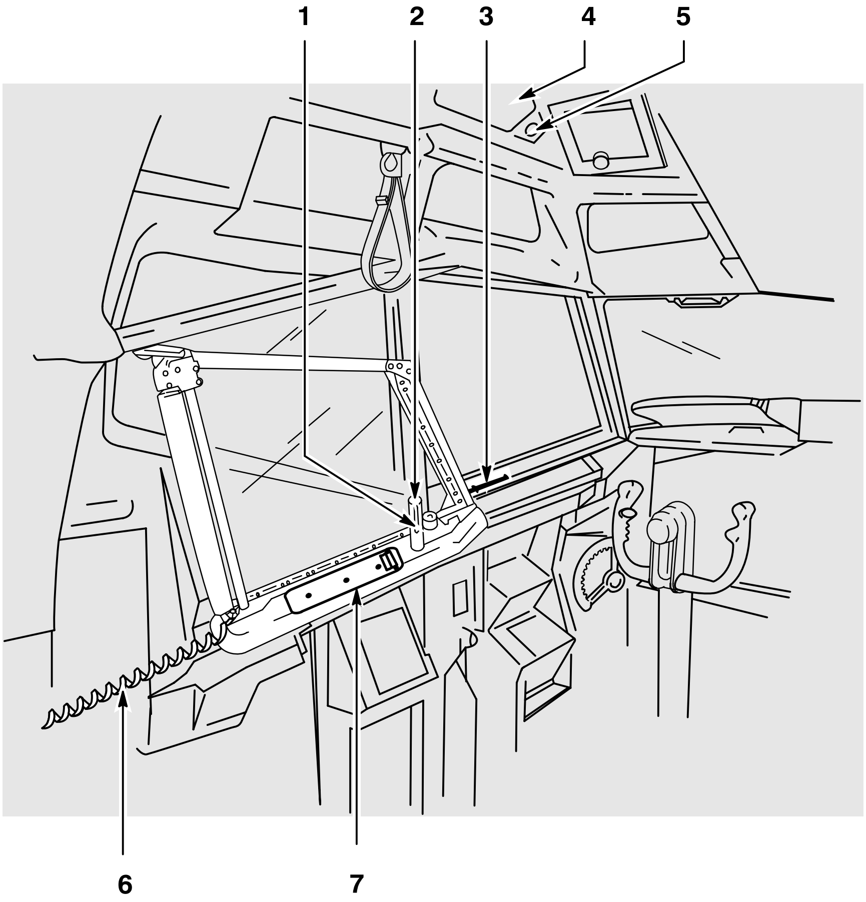


NOTE

- PRESSING TEST PUSHBUTTON ILLUMINATES ALL CAUTION LIGHTS.
- ILLUMINATED CAUTION LIGHT INDICATES THAT DOOR IS UNLOCKED OR NOT CLOSED.

Figure 1-228

Pilot’s Sliding Window and Escape Strap



NOTE

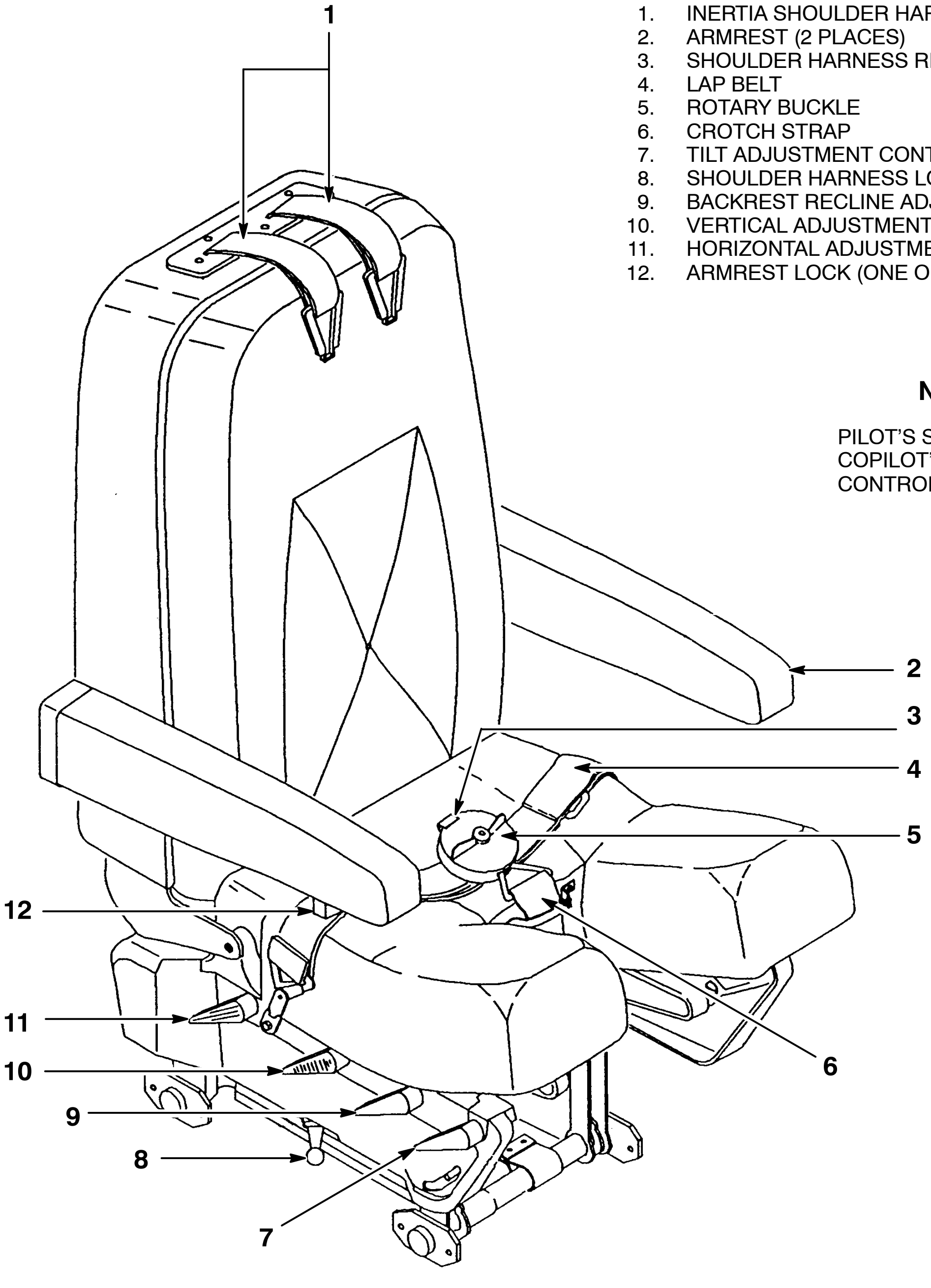
COPILOT’S SLIDING WINDOW SIMILAR.

1. TRIGGER
2. HANDLE
3. LATCH RELEASE ROD
4. ESCAPE STRAP STORAGE COVER
5. ESCAPE STRAP COVER RELEASE
6. WINDOW HEAT POWER CORD
7. NOTEPAD CLIPBOARD

D57 511 DI

Figure 1-229

Pilots' Seats



1. INERTIA SHOULDER HARNESS
2. ARMREST (2 PLACES)
3. SHOULDER HARNESS RELEASE TAB
4. LAP BELT
5. ROTARY BUCKLE
6. CROTCH STRAP
7. TILT ADJUSTMENT CONTROL HANDLE
8. SHOULDER HARNESS LOCK
9. BACKREST RECLINE ADJUSTMENT CONTROL HANDLE
10. VERTICAL ADJUSTMENT CONTROL HANDLE
11. HORIZONTAL ADJUSTMENT CONTROL HANDLE
12. ARMREST LOCK (ONE ON EACH ARMREST)

NOTE

PILOT'S SEAT SHOWN.
COPILOT'S SEAT HAS
CONTROLS ON LEFT SIDE.

D57 512 SI

Figure 1-230

Flight Engineer’s Seat

1. SHOULDER HARNESS
2. ARMREST LOCK (BOTH ARMS)
3. SHOULDER HARNESS RELEASE TAB
4. VERTICAL ADJUSTMENT LEVER
5. DIAGONAL ADJUSTMENT LEVER
6. HORIZONTAL ADJUSTMENT LEVER
7. SWIVEL ADJUSTMENT LEVER
8. CROTCH STRAP
9. SHOULDER HARNESS LOCK
10. SEAT BELT

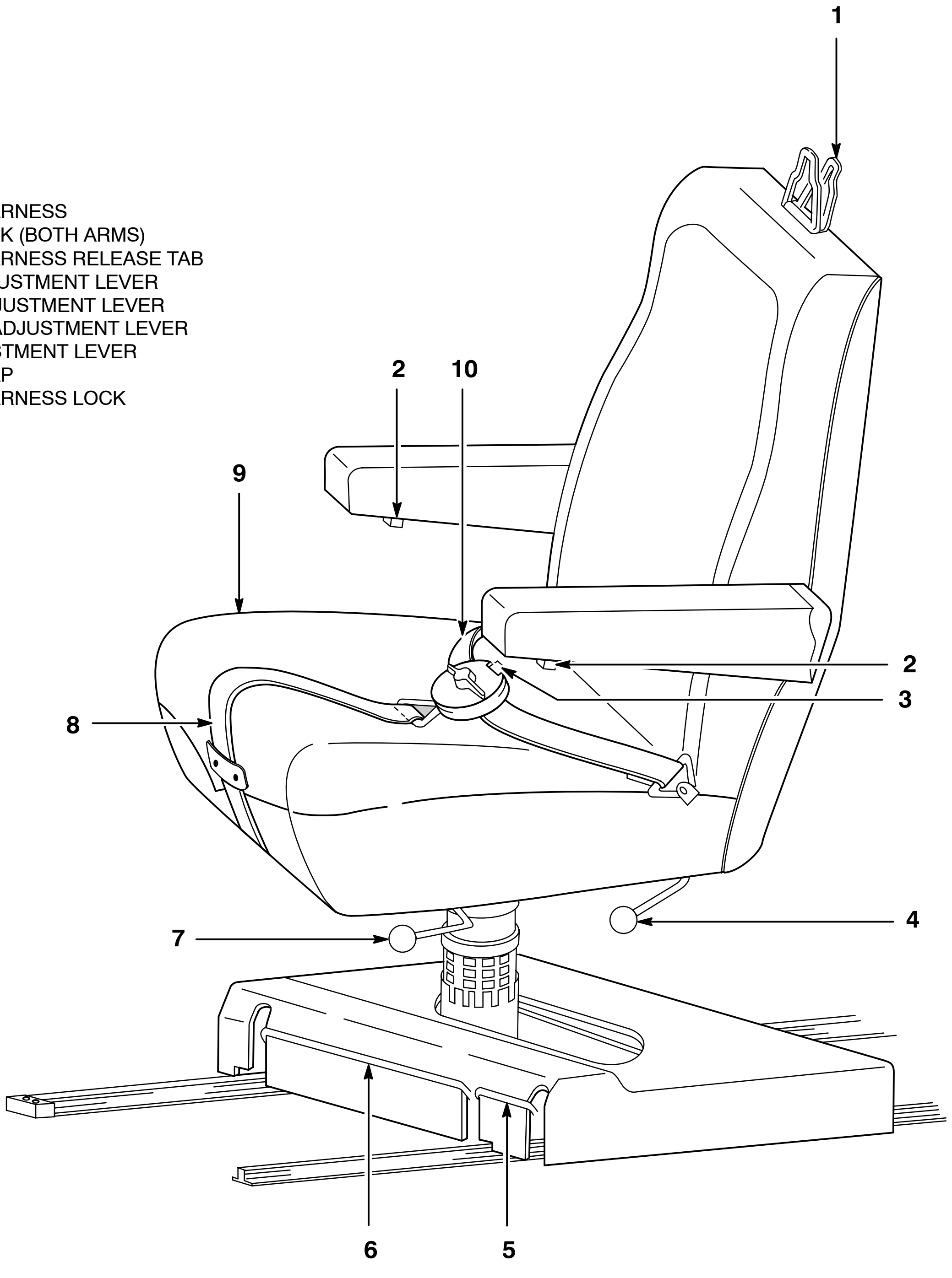


Figure 1-231

Navigator’s Seat

1. SHOULDER HARNESS
2. SEAT BELT
3. CROTCH STRAP
4. SHOULDER HARNESS LOCK
5. SWIVEL ADJUSTMENT LEVER
6. HORIZONTAL ADJUSTMENT LEVER
7. VERTICAL ADJUSTMENT LEVER
8. SHOULDER HARNESS RELEASE TAB

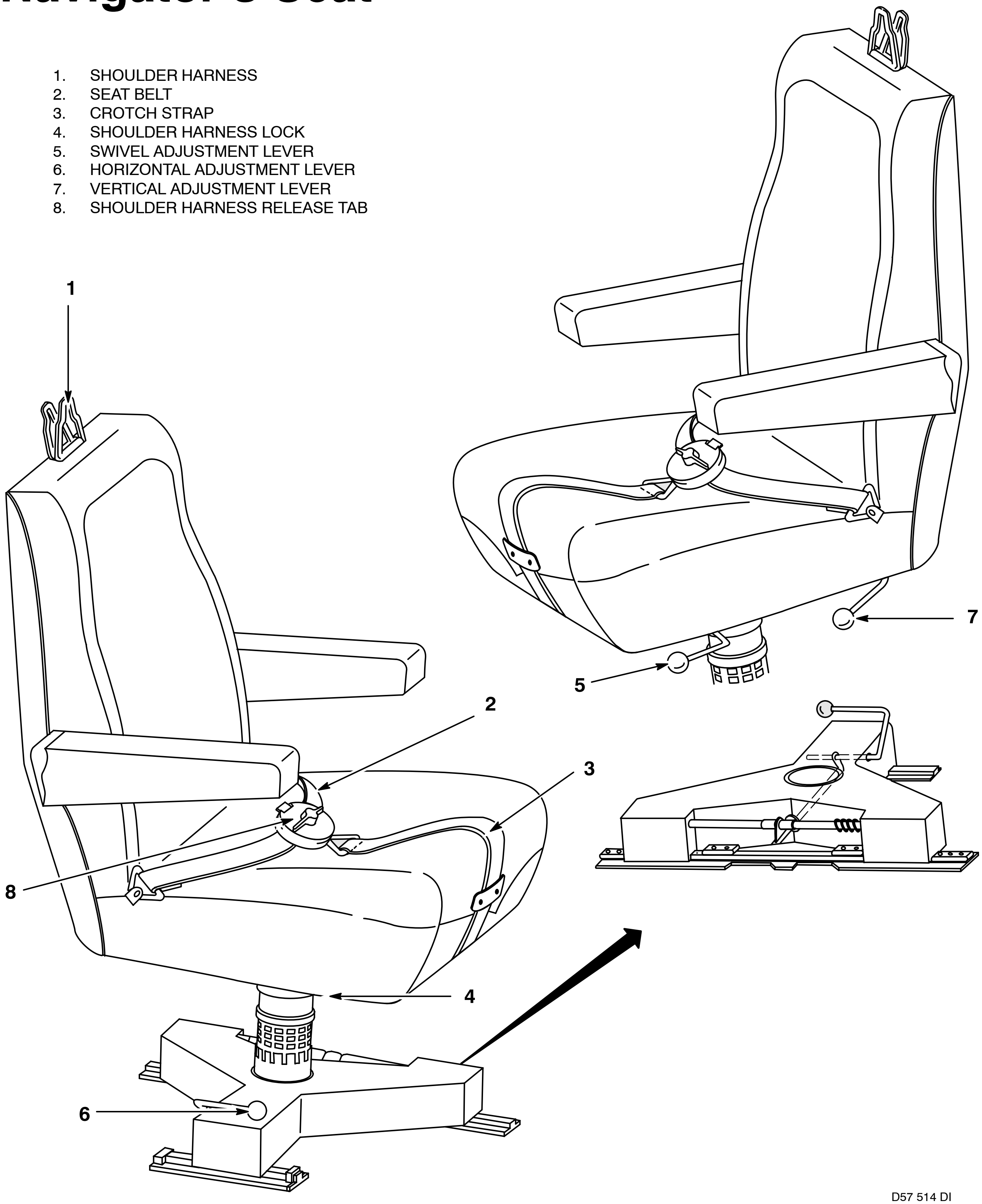
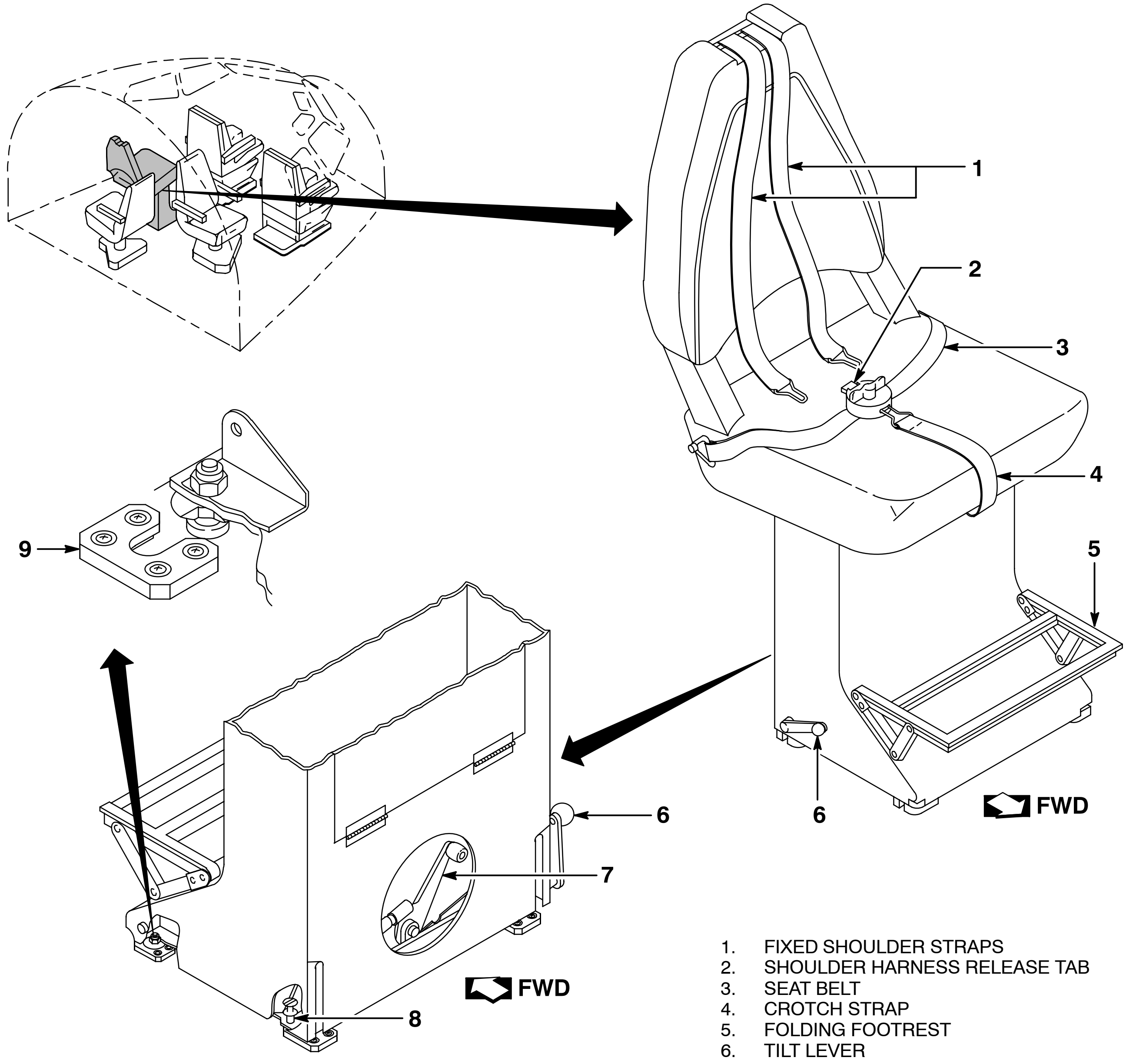


Figure 1-232

Observer's Seat

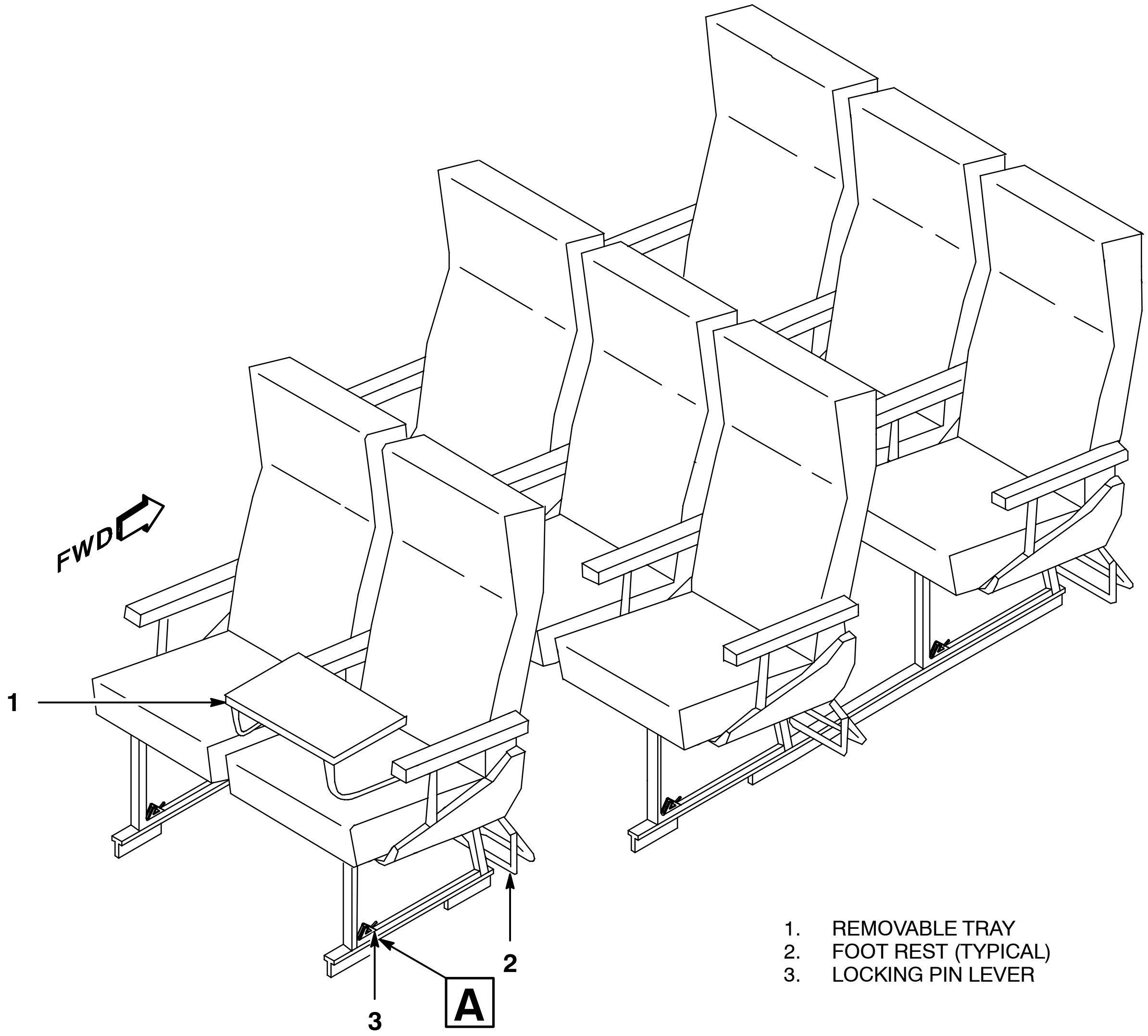


1. FIXED SHOULDER STRAPS
2. SHOULDER HARNESS RELEASE TAB
3. SEAT BELT
4. CROTCH STRAP
5. FOLDING FOOTREST
6. TILT LEVER
7. BASE RELEASE LEVER
8. LOCK PINS
9. ANCHOR PLATES

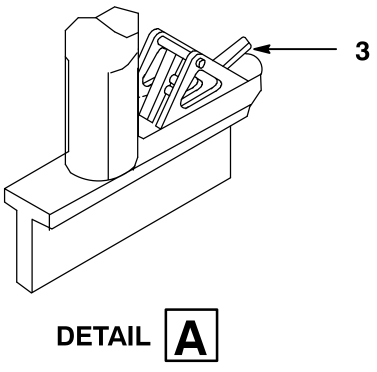
D57 515 DI

Figure 1-233

Crew Rest Seats



1. REMOVABLE TRAY
2. FOOT REST (TYPICAL)
3. LOCKING PIN LEVER



DETAIL **A**

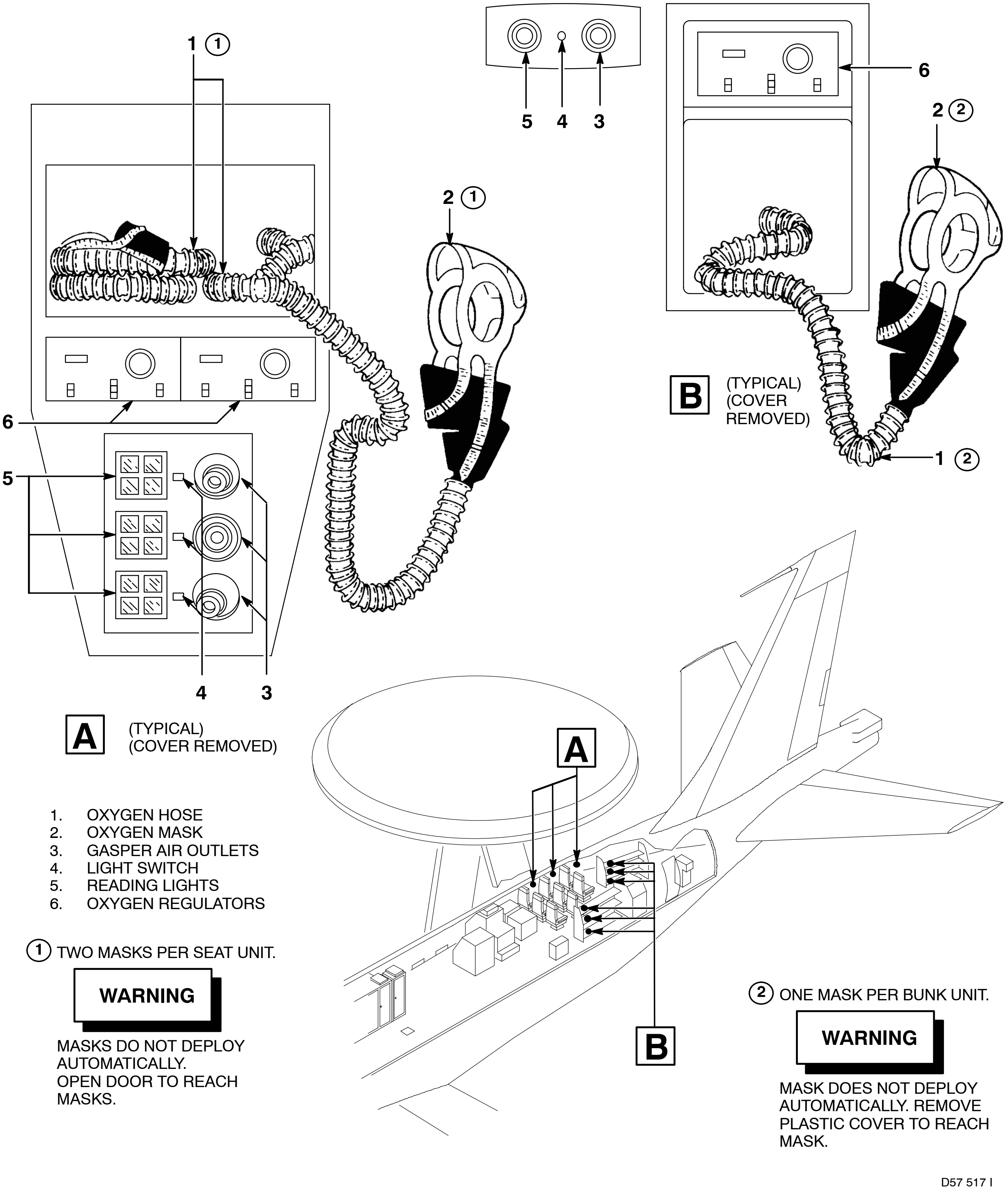
NOTE

- ADDITIONAL MISSION CREW SEATS ARE SIMILAR.
- TRAYS CAN BE ATTACHED TO ALL SEATS.
- PORTABLE OXYGEN BOTTLES ARE LOCATED UNDER AISLE SEAT OF TRIPLE CREW REST SEATS AND UNDER ALL ADDITIONAL MISSION CREW SEATS.
- TO REMOVE SEAT, LIFT LEVER (3) ON BOTH SIDES. TO LOCK IN NEW LOCATION, RELEASE LEVER (3).

D57 516 I

Figure 1-234

Crew Service Units



1. OXYGEN HOSE
2. OXYGEN MASK
3. GASPER AIR OUTLETS
4. LIGHT SWITCH
5. READING LIGHTS
6. OXYGEN REGULATORS

① TWO MASKS PER SEAT UNIT.

WARNING

MASKS DO NOT DEPLOY AUTOMATICALLY.
OPEN DOOR TO REACH MASKS.

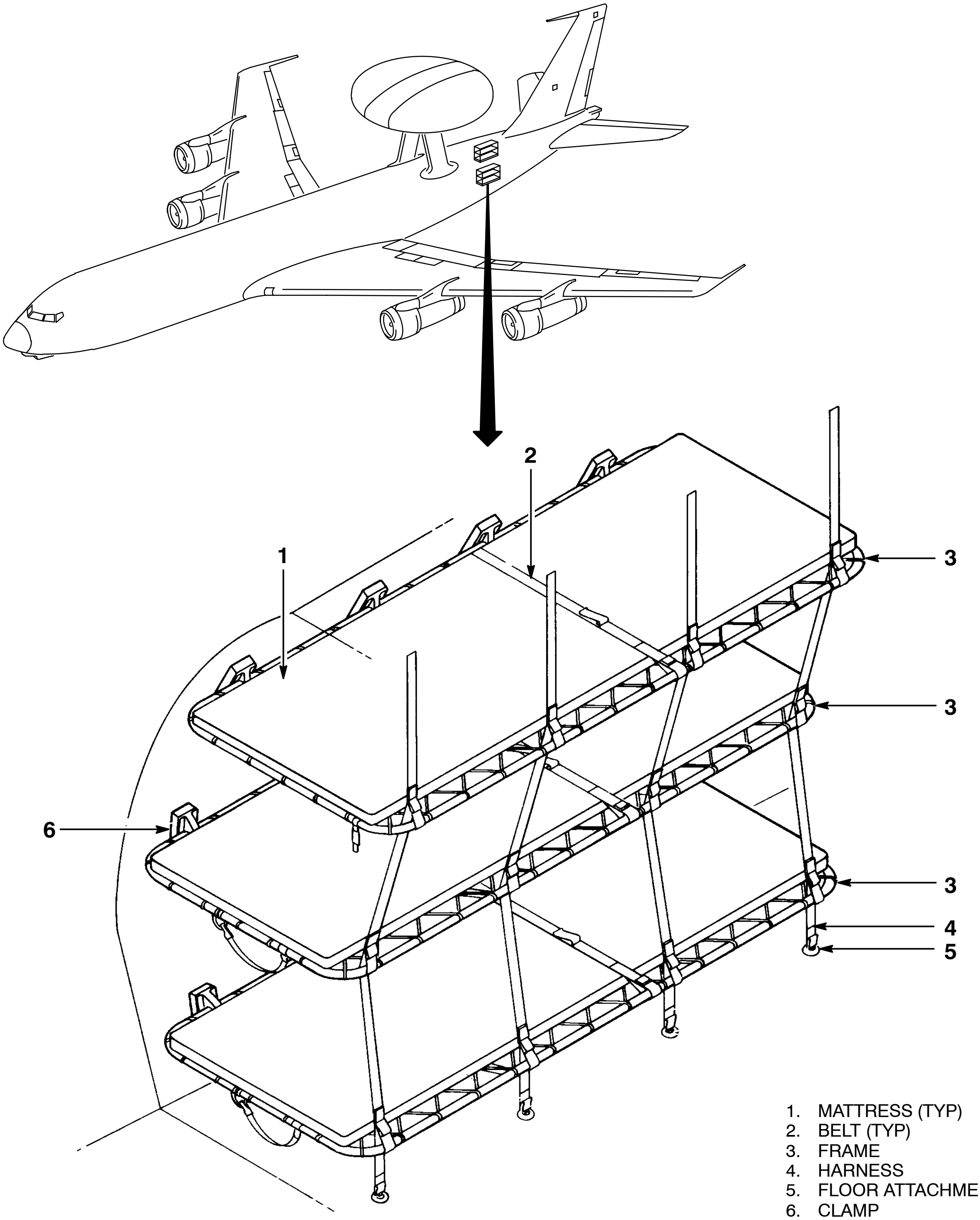
② ONE MASK PER BUNK UNIT.

WARNING

MASK DOES NOT DEPLOY AUTOMATICALLY. REMOVE PLASTIC COVER TO REACH MASK.

Figure 1-235

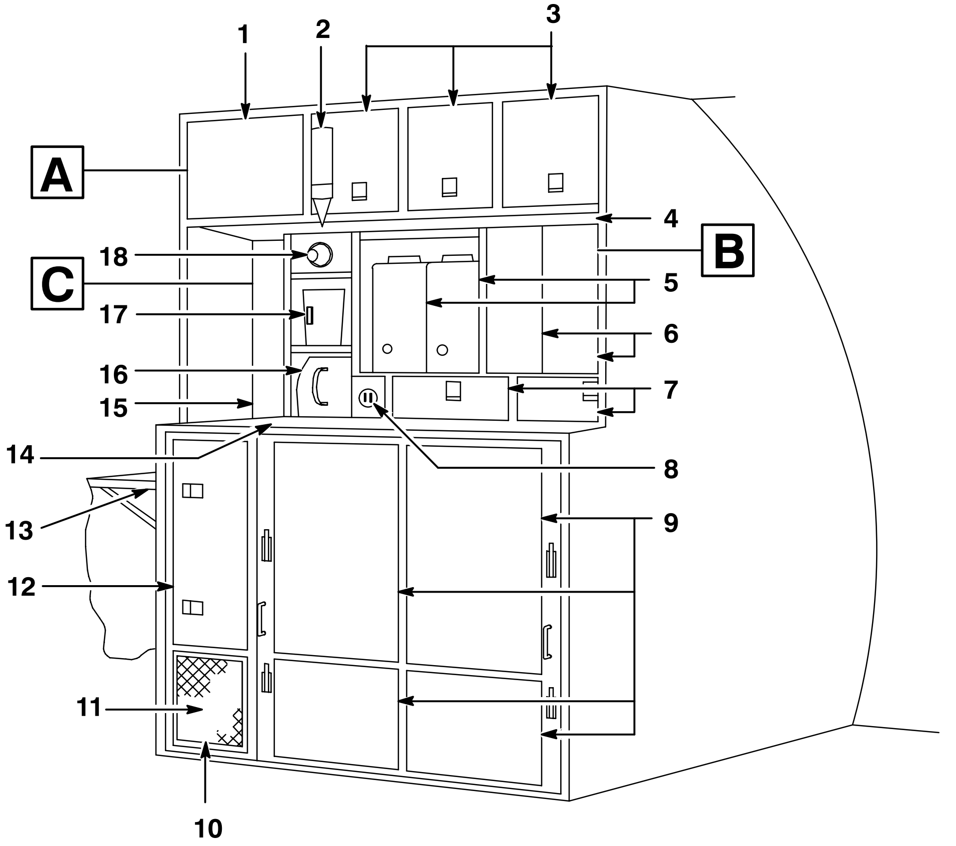
Crew Rest Bunks

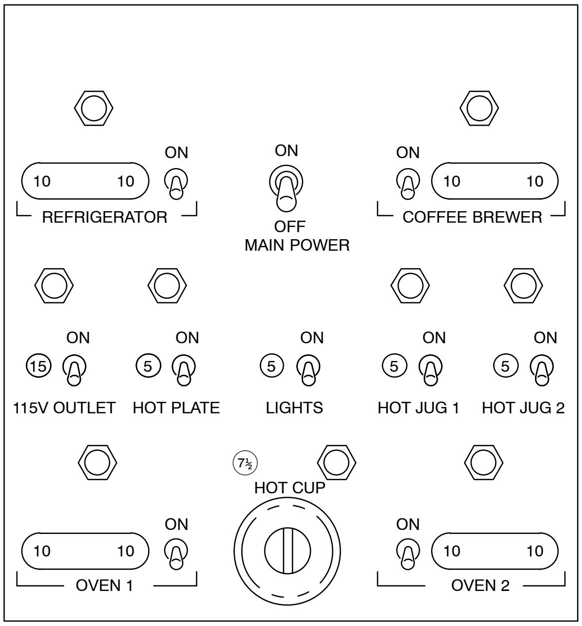


1. MATTRESS (TYP)
2. BELT (TYP)
3. FRAME
4. HARNESS
5. FLOOR ATTACHMENT
6. CLAMP

Figure 1-236

Galley





A **ELECTRICAL PANEL**

1. ELECTRICAL PANEL
2. DRINKING CUP DISPENSER
3. STORAGE (3 PLACES)
4. COUNTER TOP LIGHTS
5. HOT JUGS (TWO PLACES)
6. OVEN (TWO PLACES)
7. STORAGE DRAWERS (TWO PLACES)
8. ELECTRICAL OUTLET
9. ELECTROMECHANICAL DUAL TEMP REFRIGERATOR FREEZER
10. CONDENSER/FILTER COVER ASSEMBLY
11. REFRIGERATOR CONDENSING UNIT
12. WASTE COMPARTMENT
13. AUX TRASH BAG HOLDER AND COVER
14. SINK
15. COFFEE BREWER/HOT AND COLD WATER DISPENSER
16. COFFEE SERVER AND HOT PLATE
17. HOT CUP
18. CUP DISPENSER

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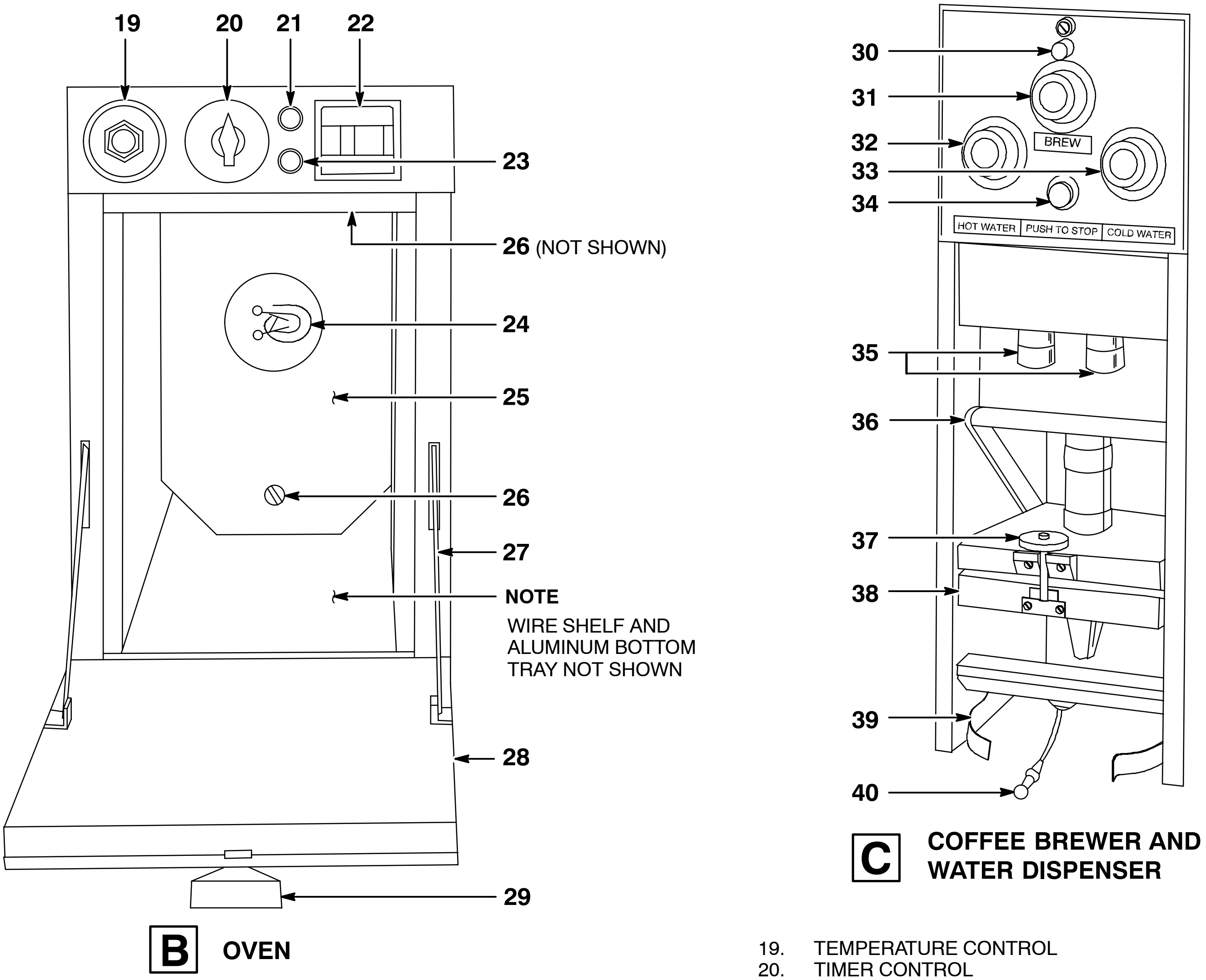
Figure 1-237 (Sheet 1 of 2)

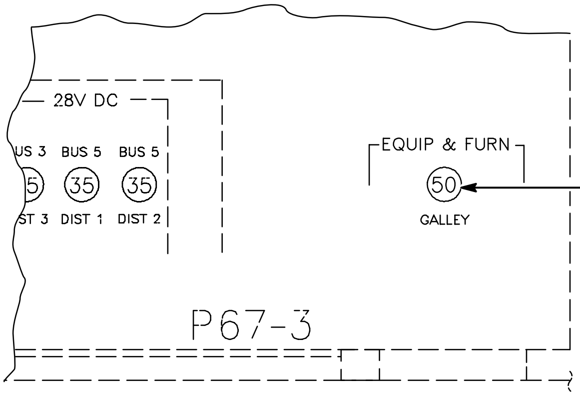
Galley (Continued)



NOTE
WIRE SHELF AND
ALUMINUM BOTTOM
TRAY NOT SHOWN

B **OVEN**

C **COFFEE BREWER AND WATER DISPENSER**



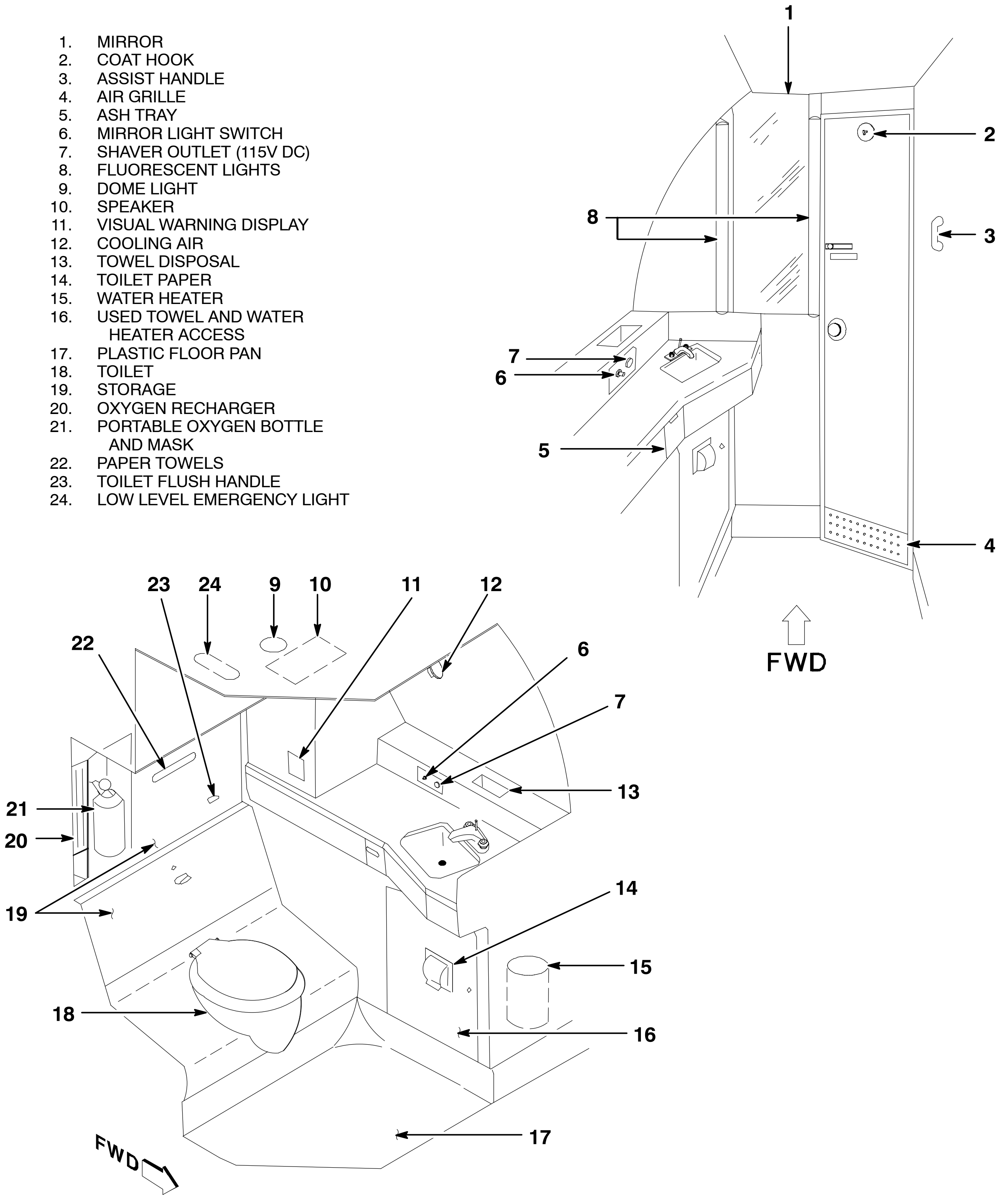
GALLEY
CIRCUIT
BREAKER

19. TEMPERATURE CONTROL
20. TIMER CONTROL
21. RED POWER ON LIGHT
22. ON–OFF SWITCH
23. AMBER PILOT LIGHT
24. FAN MOTOR
25. FAN BAFFLE
26. BAFFLE FASTENERS (TOP AND BOTTOM)
27. DOOR STOP
28. DOOR
29. DOOR LATCH
30. AMBER PILOT LIGHT
31. BREW PUSHBUTTON
32. HOT WATER PUSHBUTTON
33. COLD WATER PUSHBUTTON
34. PUSH TO STOP PUSHBUTTON
35. HOT AND COLD WATER NOZZLES
36. COFFEE BAG RETENTION HANDLE
37. CLAMP
38. COFFEE BAG HOLDER
39. COFFEE POT HOLDER
40. LIQUID LEVEL SENSOR

D57 520 I

Figure 1-237 (Sheet 2 of 2)

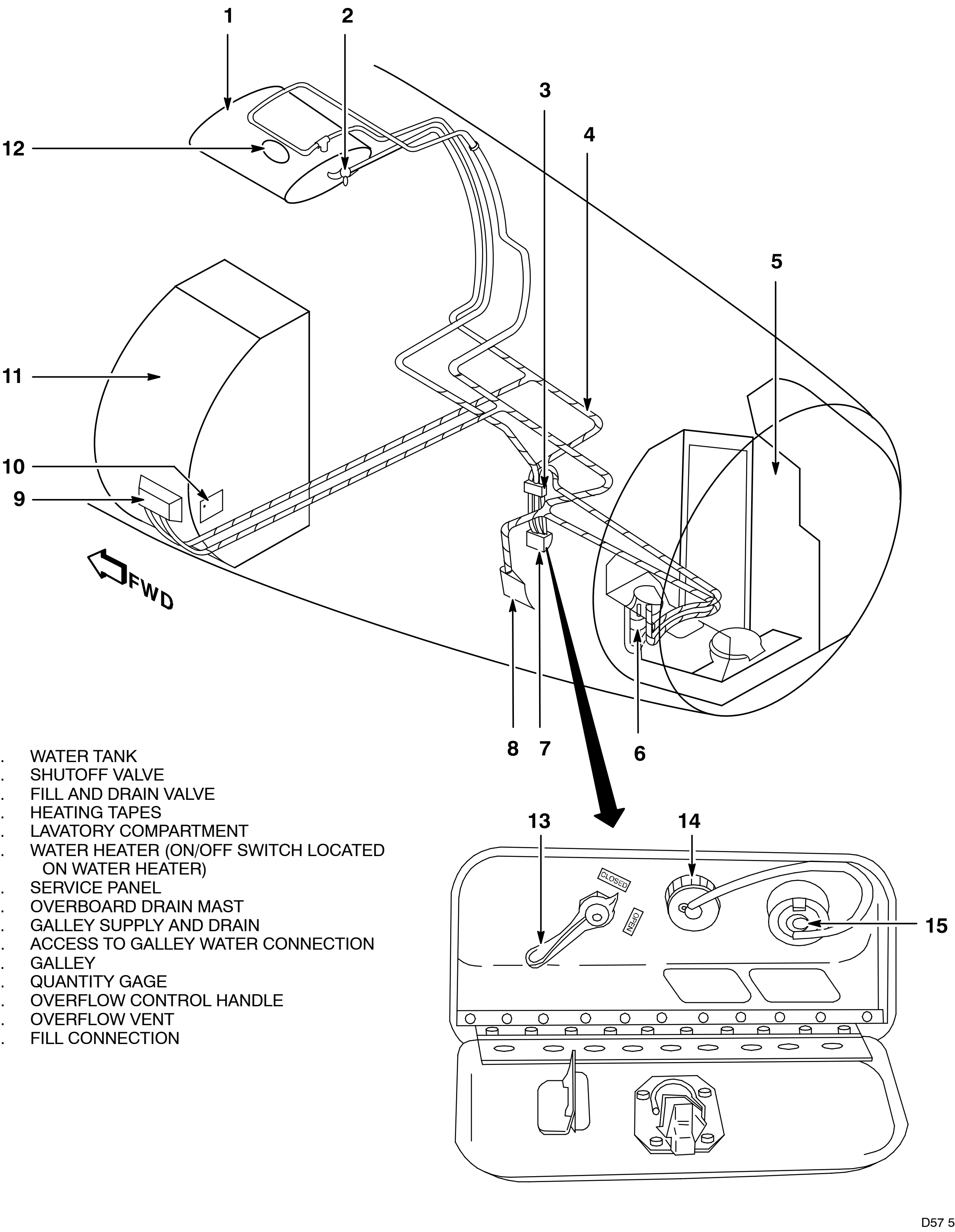
Lavatory



1. MIRROR
2. COAT HOOK
3. ASSIST HANDLE
4. AIR GRILLE
5. ASH TRAY
6. MIRROR LIGHT SWITCH
7. SHAVER OUTLET (115V DC)
8. FLUORESCENT LIGHTS
9. DOME LIGHT
10. SPEAKER
11. VISUAL WARNING DISPLAY
12. COOLING AIR
13. TOWEL DISPOSAL
14. TOILET PAPER
15. WATER HEATER
16. USED TOWEL AND WATER HEATER ACCESS
17. PLASTIC FLOOR PAN
18. TOILET
19. STORAGE
20. OXYGEN RECHARGER
21. PORTABLE OXYGEN BOTTLE AND MASK
22. PAPER TOWELS
23. TOILET FLUSH HANDLE
24. LOW LEVEL EMERGENCY LIGHT

Figure 1-238

Water Supply System



1. WATER TANK
2. SHUTOFF VALVE
3. FILL AND DRAIN VALVE
4. HEATING TAPES
5. LAVATORY COMPARTMENT
6. WATER HEATER (ON/OFF SWITCH LOCATED ON WATER HEATER)
7. SERVICE PANEL
8. OVERBOARD DRAIN MAST
9. GALLEY SUPPLY AND DRAIN
10. ACCESS TO GALLEY WATER CONNECTION
11. GALLEY
12. QUANTITY GAGE
13. OVERFLOW CONTROL HANDLE
14. OVERFLOW VENT
15. FILL CONNECTION

Figure 1-239

Crew Accommodations Electric Power Sources

EQUIPMENT/SYSTEM	TYPE OF POWER	POWER SOURCE	CIRCUIT BREAKER LOCATION/LABEL
Galley	115V AC	MAAC Bus 8	P67-3, GALLEY
Pilot’s Foot and Shoulder Heaters	115V AC	AVAC Bus 4	P61-3, CREW HTR ØB
Copilot’s Foot and Shoulder Heaters	115V AC	AVAC Bus 4	P61-3, CREW HTR ØC
Water Drain Mast Heater	115V AC	MAAC Bus 6	P67-3, WATER DRAIN MAST
28V Water Drain Mast Heater	28V AC	28V AC Bus 5	P67-3, 28V WATER DRAIN MAST
Drain and Water Line Heaters	115V AC	MAAC Bus 7	P67-3, TOILET DRAIN & WL
Lavatory Electric System	115V AC	MAAC Bus 7	P67-3, LAV ELEC SYS
Toilet Flush Motor and Timer	115V AC	MAAC Bus 7	P67-3, TOILET FLUSH MOTOR & TIMER

Figure 1-240

SUBSECTION I-V
OXYGEN, EMERGENCY AND WARNING SYSTEMS

Table of Contents

Title ***Page***

OXYGEN SYSTEM

This airplane is equipped with a single oxygen system for flight crew and mission crew (*figure 1-241*). Liquid oxygen is stored in a 75 liter capacity storage container and evaporator (converter). A diluter-demand regulator is located at each crew station. Portable oxygen bottles and recharging units are located in all compartments of the airplane. The liquid oxygen converter is located in the lower aft compartment (*figure 1-3*). System controls and indicators are shown in *figure 1-241*. A quantity gage and a caution light which indicate either low quantity or low pressure are located on the flight engineer's auxiliary panel (*figure 1-13*). Oxygen hose connection procedure is shown in *figure 1-242*. Duration of system use available is shown in *figure 1-243*. The quick donning oxygen mask is shown in *figure 1-244*. Electric power sources for the system are listed in *figure 1-252*.

REGULATORS

Each crew position has a diluter-demand regulator (*figure 1-241*) which provides a mixture of oxygen and ambient air, or 100% oxygen, depending on the setting of the regulator. The percentage of oxygen in the mixture increases as cabin pressure altitude increases, becoming 100% oxygen at approximately 30,000 feet. Above approximately 34,000 feet, oxygen is delivered under pressure to the mask. The EMERGENCY position of the emergency lever (6, *figure 1-241*) provides positive pressure at any altitude, to ensure flow of oxygen to the user or to clear a mask of smoke or fumes.

WARNING

On regulators with no test connector or a test connector and a placard on the front panel, it is possible to breathe through the mask when the SUPPLY lever is set to OFF and the diluter lever is set to NORMAL OXYGEN. With the regulator having one test port on the panel, it is not possible to breathe at all with SUPPLY lever set to OFF and diluter lever set to NORMAL OXYGEN.

The flow indicator (1) changes from black to white as oxygen is inhaled, showing a blinking action during normal breathing. A pressure gage (2) shows the pressure in the oxygen line to the regulator.

OXYGEN SYSTEM NORMAL OPERATION

Preflight

The preflight procedure below applies to all crewmembers, except those on walkaround bottles.

1. Flight engineer will check liquid oxygen quantity gage. Check that quantity is sufficient to comply with local directives.
2. Check mask and regulator.
    a. Set oxygen supply lever to ON.
    b. Connect and don mask, and if available, anti-smoke goggles.

c. Check normal and 100% settings. Set emergency lever to NORMAL and diluter lever to 100%. Check flow indicator shows white during inhalation and black during exhalation. Pressure should be 290 to 430 psi.

d. Check emergency and 100% settings. Set emergency lever to EMERGENCY. Check for proper mask fit and for serviceable hoses and connectors. Hold breath and check for no flow around edges of mask (blinker remains black). White blinker indicates a leak. If antismoke goggles are available, pull vent valve knob out and verify airflow through anti-smoke goggles. Push vent valve knob in and verify airflow through antismoke goggles stops.

e. Breathe normally for two or three cycles. Blinker shows white during inhalation, black during exhalation.

f. Check normal and normal settings. Set emergency and diluter levers to NORMAL. Blinker should show white during inhalation, black during exhalation.

g. Check normal, 100% and OFF setting. Set emergency lever to NORMAL, set supply lever to OFF. (Regulator with test connector and no placard on front should move automatically to 100%). Set diluter lever to 100% if required. Attempt to breathe through mask. Ability to breathe indicates faulty regulator.

WARNING

Some regulators with test connector on front panel (*figure 1-241*) do not move diluter lever to 100% when supply lever is set to OFF. These regulators are usually placarded NO OFF PROTECTION. Always verify diluter lever is set to 100% when setting supply lever to OFF.

h. Set supply lever as required.

i. Check oxygen microphone assembly.

j. If crew station has a quick-don mask, stow as shown in *figure 1-244*. With the flight crew quick-don mask and antismoke goggles, stow as shown in *figure 1-245*.

NOTE

At flight crew positions, the mask will be stowed with the vent valve in the closed position.

3. Check portable oxygen bottle.

Ensure that portable oxygen bottle at crewmember's station is serviced and properly secured and that altitude selector knob is set to NORM position. Portable oxygen bottle may be checked any time prior to Before Start crew report.

WARNING

If portable bottles are not properly secured, bottles can vibrate out of holder in flight, possibly causing injury to crewmembers.

NOTE

If the portable system is depleted to 10 psi or less for over two hours, or if the time it has been depleted cannot be determined, the portable unit must be purged. If inflight purging is required, purge it by recharging, then discharging (by setting the regulator to EMER) to approximately 50 psi. Repeat two more cycles, then recharge to system pressure.

Oxygen Use

The following procedure should be used when going on oxygen.

1. Set SUPPLY lever to ON. Check that oxygen pressure is between 290 and 430 psi.
2. Set diluter lever as required.

3. Check FLOW indicator frequently for normal operation.

WARNING

When oxygen equipment is used, check to ensure that hose is connected, pressure is up, regulator settings as desired, and flow indicator is operating. This is important, as it is possible to breathe through some masks when the hose is disconnected or when diluter lever is on NORMAL OXYGEN and SUPPLY lever OFF. With some regulators having one test port on front panel, it is not possible to breathe at all with SUPPLY lever set to OFF and diluter lever set to NORMAL OXYGEN.

NOTE

- Normal position should be used for long duration unpressurized flight. Regulator is normally set for 100% for emergencies. Change to normal at pilot's command.
- Approximate oxygen duration can be determined from *figure 1-243*.

OXYGEN SYSTEM EMERGENCY OPERATION

With symptoms of hypoxia or if smoke or fumes are present, immediately set SUPPLY lever to ON, and diluter lever to 100% OXYGEN. Set EMERGENCY lever to EMERGENCY position if required.

WARNING

- The oxygen regulator is suitable for routine use up to 43,000 feet and for emergency use up to 50,000 feet. In case of loss of cabin pressurization during flights above 43,000 feet, descend to an altitude of 43,000 feet or below within 5 minutes.
- In case of failure of the oxygen system, switch immediately to the portable oxygen bottles. If failure is prolonged, descend to a safe altitude to operate without oxygen before the supply is depleted in the portable oxygen bottles.
- Personnel in seats 28, 31 and 34 through 41 are provided with portable oxygen bottles having a limited duration. Refer to *figure 1-243* for oxygen duration at various cabin altitudes.

PORTABLE OXYGEN UNITS

There are two types of portable units on the airplane, bottles for use with the crewmember's regular oxygen mask (walkaround bottles) and bottles with attached full face smoke masks (firefighters masks or smoke masks). Locations of these units are shown in *figure 1-246*. Oxygen bottle rechargers (9, *figure 1-246*) are located throughout the airplane.

An MA-1 portable oxygen bottle (*figure 1-241*) consists of a low pressure oxygen cylinder and a pressure regulator. The regulator includes a pressure gage (12), altitude selector knob (10), and a strap for carrying the bottle. The pressure gage is calibrated from zero to 500 psi, with a red line at 450 psi. The altitude selector has NORM – 30M – 42M and EMER positions. The NORM position is used from sea level to 30,000 feet cabin altitude.

NOTE

- When using individual crewmember's mask, set regulator to NORM unless clearing mask of smoke or when using 30M or 42M setting for pressure breathing.
- When using new type firefighter's masks (with compensating tube) regulator may be set to 30M or 42M as needed to keep mask free of smoke.

The 30M position is used from 30,000 feet to 42,000 feet cabin altitude, and provides slight positive pressure to aid breathing. The 42M position is used at cabin altitudes from

42,000 to 45,000 feet, providing a slightly higher pressure at the mask. EMER is used when a still higher pressure is required, at altitudes above 45,000 feet, or if pressure is required to prevent smoke or fumes from entering the mask. The oxygen cylinder provides enough oxygen for about 10 minutes of moderate activity at 25,000 feet, if originally charged to 300 psi. Duration is decreased by lower altitude, lower pressure and increasing activity (*figure 1-243*).

NOTE

> With the airplane at normal operating gross weights, it is unlikely that cabin altitude can exceed 42,000 feet.

When performing a preflight inspection of portable oxygen bottles, check that bottle is charged to at least 290 psi. Check hose for cleanliness, check mounting bracket and straps for security.

Personnel in crew rest seats 28 and 31 or supplementary mission crew seats 34 through 41 will perform oxygen mask preflight check below.

a. Don mask, adjust straps for proper fit.

b. Set regulator to 42M, hold breath, mask should not leak.

c. Set regulator to NORM, flow should stop except when inhaling.

d. Stow mask and bottle. Secure straps.

Charging Portable Oxygen Bottles

Portable bottles can be charged by any of 13 recharger locations (9, *figure 1-246*). To use the recharger:

a. Remove dust cap (17, *figure 1-241*) from recharger (15) by rotating release lever (16).

WARNING

- Prior to servicing or purging portable oxygen bottles, ensure filler port and oxygen recharger outlet are free of oil or grease.
- Crewmember filling or purging portable oxygen bottles will refrain from smoking.

b. Insert filler port (7) into recharger (15). Oxygen flows into bottle until pressure in bottle equals oxygen system pressure. Bottle can be filled while mask is in use. Rotate release lever (16) to remove bottle.

Purging Portable Oxygen Bottles

If the portable system is depleted to 10 psi or less for over two hours, or if the time it has been depleted cannot be determined, the portable unit must be purged. If inflight purging is required, purge it by recharging, then discharging (by setting the regulator to EMER) to approximately 50 psi. Repeat two more cycles, then recharge to system pressure.

QUICK DONNING OXYGEN MASKS

There are two types of quick don oxygen masks on the aircraft. The standard aircrew quick don mask is used throughout the mission crew compartment and at the observer's seat on the night deck. See *figure 1-244*. The flight crew quick don mask with anti-smoke goggles is used only at the pilot, copilot, navigator, and flight engineer stations. See *figure 1-245*.

The standard quick don oxygen mask consists of a quick don suspension device and an oxygen mask. It contains an integral microphone assembly which connects to the crewmember's headset and the ADS system. Microphone switching from the headset to the oxygen mask is automatic and is completed as the suspension device is donned.

The flight crew quick don oxygen mask with anti-smoke goggles has the same features as the standard quick don oxygen mask. It is also equipped with a vent valve, which vents oxygen from the mask to keep the goggles clear of any smoke.

Quick Donning Mask Use

To use quick donning mask:

1. On oxygen regulator panel set SUPPLY lever to ON and diluter lever to 100% OXYGEN.
2. Don mask. Pull mask down out of hanger strap. Allow suspension assembly to unfold.
3. Pull mask forward over head until nape strap contacts base of head.

NOTE

> Mask microphone automatically switches on when mask right suspension assembly unfolds. This unfolding action also disables the headset microphone.

4. Don anti-smoke goggles (at flight crew positions) if required, due to smoke or fumes. The goggles should fit over the top of the hardshell. Open the vent valve by pulling on the vent valve knob. Set emergency lever to emergency position (as required) to clear anti-smoke goggles.

Quick Donning Mask Postflight

When leaving airplane, perform the following steps:

1. Stow mask. Stow mask as directed in preflight procedure above.
2. Disconnect headset cord.
3. Place dust cover on mask.

EMERGENCY EQUIPMENT

Emergency equipment on this airplane includes emergency exits, escape slides, bailout chute, parachutes, life rafts, survival kits, fire extinguishers, and first aid kits. Emergency equipment is located as shown in *figures 1-3* and *1-246*.

EMERGENCY EXITS

There are seven emergency exits on the main deck: 2 entry doors and the galley door (equipped with escape slide/rafts), two overwing hatches (with escape straps, see *figure 3-5*), and the pilots' sliding windows. Since exit through the doors is fastest, they are primary ground exits.

The overwing hatches are primary ditching exits and secondary ground exits (since exit through the hatches is slower). The escape straps from the overwing hatches can be attached to clips on the inboard nacelles to make a handrail for ditching evacuation. In a successful ditching, all main deck doors should be above water level, but the overwing hatches should be used if available. Refer to GROUND EVACUATION and DITCHING, section III.

ESCAPE SLIDES

Escape slides (*figure 1-247*) are installed on each main entry door and the service door. The slides deploy automatically when the door is opened, if the slide fitting has been attached to the floor. The manual inflation handle must be pulled to inflate the slide. A pressure gage is provided to check the pressure in the air bottle.

WARNING

- Attempting to inflate escape slides inside the airplane could cause injury to crewmembers and damage to slides. Follow procedure in *figure 3-3*.
- Slide is unusable unless retaining bar passes through slide harness and through loop on retaining hook assembly. Retaining bar must be secured by nylon lanyard passing through the retaining bar.

NOTE

- Escape slides can be detached from door and used as life rafts if life rafts fail to inflate. To use as raft, remove slide from door (if possible, pass deflated slide out of overwing hatch, then inflate and launch as raft). If door is above water, slide may be deployed by opening door. When slide has inflated, pull ditching release strap to separate slide from airplane. Slide is then tied to airplane by lanyard. Cut lanyard to release slide after boarding.
- The hook shall be placed in the floor fitting as soon as entry stand is removed in preparation for towing/taxiing and remain there until airplane is parked.

BAILOUT CHUTE

The bailout chute (*figure 1-248*) allows crewmembers to leave the airplane at any speed in the airplane flight envelope. The chute is equipped with a pneumatically operated spoiler which extends to protect the crewmember from the air flow as he leaves the airplane. (Refer to BAILOUT, section III for bailout procedure).

A pressure gage, showing the pressure in the spoiler compressed air bottle, and a cabin differential pressure gage are mounted above the bailout chute. To operate the chute:

1. Remove safety lock pin from chinning bar by pressing button, then pulling pin.

2. Wait until cabin differential pressure is one psi or less (green zone on gage).
3. Pull down on chinning bar until it is in a horizontal position. (Chute door is released and spoiler extends.)
4. Raise and latch floor grill.
5. Facing aft, grasp chinning bar with both hands and drop into chute with feet together.
6. Release bar, fold arms across chest to reduce possibility of injury from air blast or from striking sides of chute.
7. Deploy parachute when clear of airplane.

NOTE

When the bailout chute spoiler is deployed, the copilot's pitot-static system is unreliable.

PARACHUTE STATIC LINE

The static line (*figure 1-248*) is used to pull the parachute ripcord when a crewmember is injured or unconscious. To use the static line, open the storage container, attach the clip to the ripcord release (T handle), then lower the crewmember into the bailout chute, and release.

NOTE

The static line connector will not fit the automatic release knob. If an unconscious or injured crewmember must be evacuated at high altitude, pull the automatic release, then lower crewmember into bailout chute, and release.

LIFE RAFTS

The airplane is equipped with two automatically deployed life rafts (*figure 1-249*). The capacity of each raft is 20 people. The rafts may be released manually by pulling the manual release handle at the overwing exit hatch. The automatic release system operates by action of water on a water activated battery in the wheel well, causing an explosive squib to release gas from the gas cylinder and unlatch the raft compartment door. The raft and the compartment door separate as the door falls away from the airplane. The survival kit container separates from the door and is tied to the raft by a lanyard.

The raft can be used with either side up. Equalizer tubes are provided to ensure inflation of both chambers. A hand pump is provided to maintain pressure, or for manual inflation if the automatic system fails. When the raft is fully inflated, the equalizer tubes should be clamped off to prevent deflation of both chambers in case of a puncture.

To inflate the raft manually, attach the pump to the valve, open the valve (1 1/2 turns for flush valves, 2 turns for all others), pump chamber until firm to the touch, close valve and stow pump.

When boarding a raft, remember these points:

a. Rig escape strap from hatch to fitting on upper surface of wing at inboard engine strut (*figure 3-5*).

b. Be sure no sharp objects such as rings, pencils, buckles, and similar objects contact raft. Remain seated on floor of raft, without sliding. In heavy seas, move more people to upwind side of raft.

c. Keep rafts away from airplane structure which might damage rafts.

WARNING

- If raft has been cold-soaked at temperatures below –20°C, it can take 20 to 30 minutes for raft to inflate. Place raft package in water to warm raft and inflation cylinder. Individual rafts from survival kits and escape slides can be used for flotation until rafts can be inflated. Detach slide hook from floor fitting before inflating slide.
- If possible, launch rafts over leading edge of wing to avoid damage from flaps. Do not allow raft to contact vortex generators.

d. Use most suitable exit for embarking into raft. This can vary with airplane damage, wave and wind action, and airplane attitude in the water.

e. Do not jump into rafts.

f. Inflate life vest immediately after leaving airplane.

g. Load rafts equally. Account for all personnel at this time.

h. Pull survival kit aboard raft.

WARNING

Make sure raft compartment door has separated from kit before pulling kit into raft.

i. Distribute salvaged supplies between rafts. Stow survival kit, and tie kit to raft. Tie individual survival kits/rafts to large raft.

j. Move raft away from airplane as soon as it is loaded.

k. Rope rafts together with enough line to prevent pulling a raft under or breaking line if one raft is in a trough.

l. Stay near the airplane, if possible, as long as the airplane is afloat. Rig raft sea anchor to minimize drift. Search starts at reported ditching position and will be aided by staying as near airplane as possible.

m. Rig raft canopy and secure. Minimize exposure to elements. Keep interior of raft as dry as possible. All crewmembers must be alert for symptoms of shock.

FIRE EXTINGUISHERS

There are ten hand-held fire extinguishers on the airplane, located as shown in *figure 1-246*. The extinguishers hold five pounds of extinguishing agent, are suitable for any class of fire and the agent is non-toxic. The agent does not present a hazard from absorption through the skin.

WARNING

- The portable fire extinguishers are charged with bromochlorodifluoromethane (Halon 1211). Although Halon 1211 is non-toxic, care should be taken, as the agent can form toxic byproducts when exposed to fire or high temperature. Crewmembers using extinguishers will use oxygen.
- During and after discharge of a Halon fire extinguisher, the area should be ventilated thoroughly. Do not attempt any other cleanup after a fire as Halon 1211 byproducts become corrosive if exposed to moisture.
- Crewmembers not engaged in fighting fire should not look toward extinguisher or fire to prevent extinguisher discharge stream from splashing into eyes.
- If an extinguisher leaks, turn it upside down, cover the nozzle with a cloth (or aim it into a can) to catch any liquid discharge. Then press trigger to release pressurizing gas with minimum release of agent. Stow extinguisher in the bracket and record in form 781 so extinguisher can be replaced.

To use extinguisher, position it vertically about eight feet from fire. Remove pull ring pin. Aim nozzle at base of fire. Squeeze trigger and sweep agent across the base of the fire with a side-to-side motion.

NOTE

There is little or no cooling effect when the extinguishing agent evaporates. The primary action is to smother the fire by keeping oxygen away from the burning material. Do not use the extinguisher on smoking electrical equipment unless flames are actually visible. Refer to ELECTRICAL FIRE, section III.

SMOKE MASKS

Six portable oxygen bottles, equipped with full-face type masks (firefighter's oxygen masks) are located in the airplane (*figures 1-246* and *1-250*). The oxygen bottles are the same as the portable (walkaround) bottles (*figure 1-241*).

WARNING

- The smoke mask cannot be fitted over eyeglasses and obtain a perfect seal, however, these masks can be used by firefighters. Personnel will obtain best possible seal with eyeglasses.
- Personnel must adjust headstraps to obtain proper fit with the smoke masks.
- The smoke mask should not be used at cabin altitudes above 43,000 feet.

NOTE

If eye protection from smoke or fumes is required, use helmet visor if smoke mask is not available.

FIRST AID KITS

Ten first aid kits are provided in all areas of the airplane, as shown in *figure 1-246*. Each kit contains two compartments. The smaller compartment is empty.

NOTE

The kit must be removed from the airplane, inspected by medical personnel, and resealed if the seal is broken.

CRASH AXE

Crash axes are provided in the flight deck and in the mission compartment (*figures 1-3* and *1-246*).

CREW WARNING AND ALERTING SYSTEM

The crew warning and alerting system, consisting of signs in the mission compartment, lavatory, and lower deck, provides visual warning of critical inflight emergencies and alert signals for safety instructions (*figure 1-251*). There are two sizes of display signs. Large displays (*figure 1-251*) are located overhead in the mission compartment and lower deck. Small console displays are located on the communications console, duty officer's console, computer console, radar console, and in the lavatory.

WARNING SIGNALS

The following warning signals are shown on all display units:

BAILOUT and CRASH LANDING, manually controlled by the WARNING LIGHTS switch (26, *figure 1-7*) on the pilot's overhead panel.

LOSS OF PRESSURE, automatically controlled by the cabin pressurization system. The LOSS OF PRESSURE signs can be tested by using the TEST position of the EMERGENCY DEPRESS switch (5, *figure 1-203*).

Aural warning signals are used to supplement the warning signs. The BAILOUT and CRASH LANDING warning is an electronically generated bell tone, repeated 5 times per second, on interphone and PA speakers.

WARNING

The bell signal is loud enough to prevent hearing any other signal on radio, interphone, or PA. The bell signal shall be used only as specified in EMERGENCY SIGNALS section and then turned off. The bell may be tested on the ground for up to ten seconds as directed in section II, if crewmembers are notified before testing.

The LOSS OF PRESSURE aural signal sounds automatically when the signs illuminate. The warning is a tone which sweeps from 700 Hz to 1,700 Hz in 0.8 second, repeating once per second. The signal can be silenced by pressing the ALTITUDE HORN CUTOUT pushbutton (6, *figure 1-203*) on the flight engineer's panel.

WARNING

When the LOSS OF PRESSURE signs are illuminated in flight, all crewmembers will immediately don oxygen masks and set oxygen regulators to ON and 100%. Refer to section III for emergency procedures.

ALERT SIGNALS

Two additional signals are used to alert crewmembers when (for safety) seat belts should be fastened or when smoking is prohibited. These signs are controlled by the SEAT BELTS and NO SMOKING switches (28, *figure 1-7*) on the pilot's overhead panel. There is no aural signal with these signs.

WARNING

- When illuminating FASTEN SEAT BELT signs in flight, pilot or flight engineer will notify MCC by interphone. MCC will verify that all personnel in mission compartment and bunks have fastened belts and that all personnel in lower compartments and lavatory have returned to seats. Crewmembers whose crew duties specifically require may leave their seats as required in performance of those duties.
- When the NO SMOKING signs are illuminated, all crewmembers will extinguish smoking material and refrain from smoking until the signs are turned off.

WITH F SMOKE AND FUME DETECTION SYSTEM

The smoke and fume detection system detects smoke or fumes originating from a combustion source. Detectors are installed in both lower compartments, the draw through cooling system, and both forced air systems. Normal system power is from FAAC bus 1. Standby power is from AVAC bus 8. Power for the fault indicators (on the box in the lower forward compartment) is from the battery bus.

This system has been deactivated by TCTO 1E-3-697. P-5 circuit breakers are banded open, system controls have been removed from flight engineers panel and smoke detection control unit has been removed from the lower forward compartment. The remaining detectors, breakers and wiring will be removed by TCTO 1E-3-723. ◀

NOTE

If a smoke detector caution light illuminates, perform Fire, Smoke or Fumes in Airplane Interior procedures, section III.

OXYGEN, EMERGENCY AND WARNING SYSTEMS ELECTRIC POWER SOURCES

Electric power sources for the oxygen, emergency, and warning systems are listed in *figure 1-252*.

Oxygen System Controls and Indicators

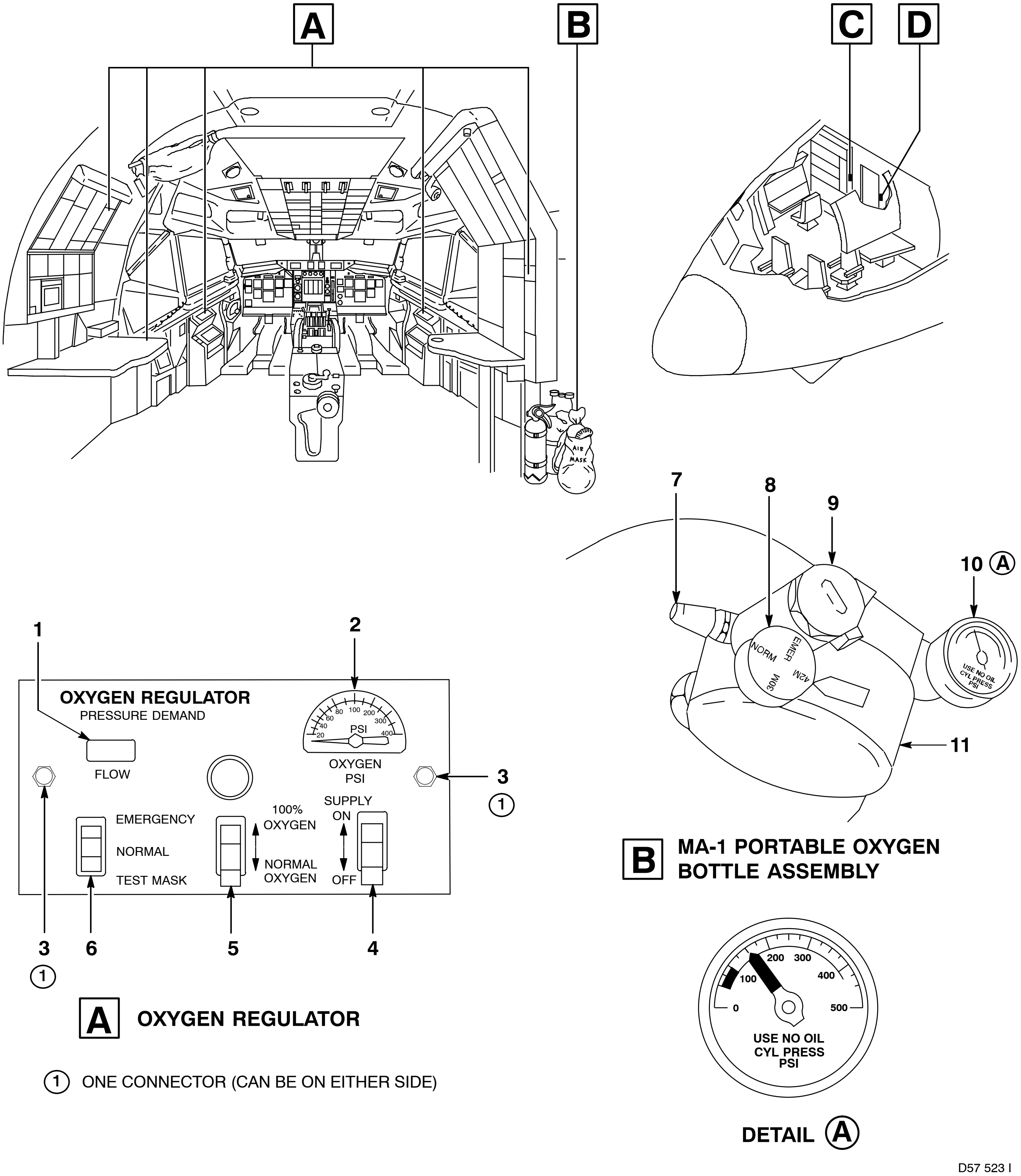
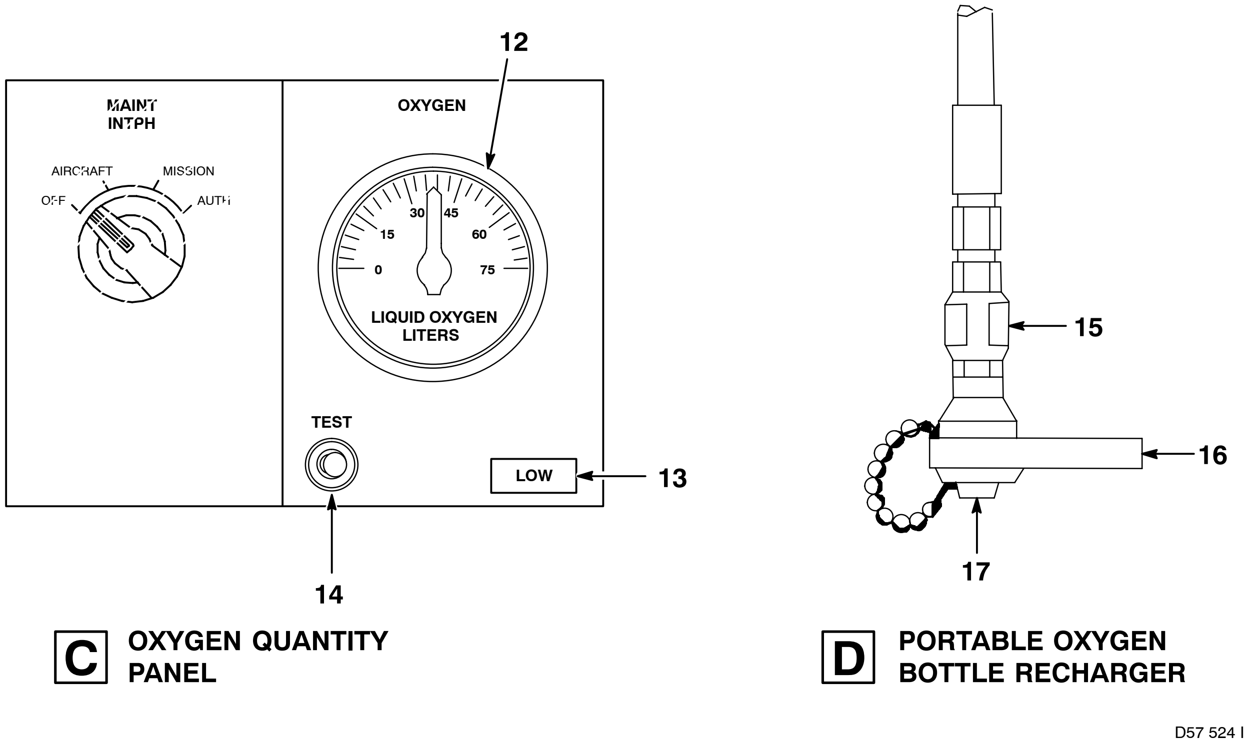


Figure 1-241 (Sheet 1 of 5)



C OXYGEN QUANTITY PANEL

D PORTABLE OXYGEN BOTTLE RECHARGER

NO.	CONTROL/INDICATOR	FUNCTION
	A OXYGEN REGULATOR (TYPICAL)	
1	FLOW/Indicator (Black/White)	Movement and color change of indicator shows relative amount of oxygen flow to mask. When normal flow passes through regulator, indicator is white. When no flow passes through regulator, indicator is black. Normal breathing produces a blinking effect as indicator changes from black to white.
2	OXYGEN PSI (Oxygen Pressure) Gage	Indicates pressure on high pressure side of regulator.
3	Test Fitting	For maintenance use. Allows testing of regulator without removal from airplane.
4	SUPPLY Lever	Controls shutoff valve to regulator. When set to ON, admits oxygen to regulator. Quantity and pressure delivered to mask depends on setting of EMERGENCY and diluter lever and on cabin altitude. When set to OFF, shuts off flow to regulator and mask. Normally ON for flight.

Figure 1-241 (Sheet 2 of 5)

Oxygen System Controls and Indicators (Continued)

NO.	CONTROL/INDICATOR	FUNCTION
5	Diluter Lever	Controls percentage of oxygen and air actually delivered to mask. When set to NORMAL, delivers a varying mixture of air and oxygen (100% air at sea level increasing to 100% oxygen at approximately 30,000 feet). When set to 100%, supplies 100% oxygen to mask.

WARNING

When oxygen equipment is used, check to ensure that hose is connected, pressure is up, regulator settings as desired and flow indicator is operating. This is important as it is possible to breathe through some masks when the hose is disconnected or when diluter lever is on NORMAL OXYGEN and supply lever OFF. With some regulators with test port on panel, it is not possible to breathe at all with SUPPLY lever set to OFF and diluter lever set to NORMAL OXYGEN.

NOTE

Normal position should be used for long-duration unpressurized flight. Regulator is normally set for 100% for emergencies. Change to normal at pilot's command.

6	EMERGENCY Lever	Controls pressure of oxygen supplied to mask. When set to EMERGENCY, supplies continuous flow of oxygen at slight positive pressure, ensuring flow of oxygen to user in event of poorly fitting mask or smoke/fumes in airplane. When set to NORMAL, pressure is controlled by regulator and varies with cabin altitude. Regulator delivers oxygen at positive pressure above approximately 34,000 feet cabin altitude. When momentarily held to TEST MASK, delivers higher positive pressure flow to check mask and hose for leaks. SUPPLY lever must be ON to receive oxygen from mask.

NOTE

Use of EMERGENCY or TEST MASK position overrides diluter control.

Figure 1-241 (Sheet 3 of 5)

NO.	CONTROL/INDICATOR	FUNCTION
		B MA-1 PORTABLE OXYGEN BOTTLE ASSEMBLY
7	Filler Port	Provides connection for filling bottle.
8	Altitude Selector Knob	Controls pressure of oxygen in mixture supplied to mask. When set to NORM, regulator operates in demand mode, supplying oxygen only on demand. Regulator supplies 100% oxygen at all times. When set to 30M, regulator supplies 100% oxygen under slight pressure to mask. When set to 42M, regulator supplies higher positive pressure to mask. When set to EMER, regulator provides a still higher positive pressure to mask.

WARNING

- Oxygen duration is extremely limited when using the bottle. If the firefighter's mask is equipped with the compensating tube on the exhalation valve, use the lowest pressure setting (30M, 42M or EMER) which keeps the mask free of smoke. If using the mask only for eye protection from fire extinguisher, use NORM, unless clearing mask of smoke. Refer to oxygen duration chart.
- Do not use firefighter's smoke mask with portable oxygen bottle above 43,000 feet cabin (pressure) altitude.
- A positive lock is not provided on the MA-1 portable oxygen bottle altitude selector knob. The knob can be unintentionally moved from the desired position, possibly causing a depletion of the oxygen supply.

NO.	CONTROL/INDICATOR	FUNCTION
9	Oxygen Mask Hose	Attachment point for mask hose.
10	Pressure Gage	Indicates pressure in bottle in psi.

NOTE

If the portable system is depleted to 10 psi or less for over two hours, or if the times it has been depleted cannot be determined, the portable unit must be purged. If inflight purging is required, purge it by recharging, then discharging (by setting the regulator to EMER) to approximately 50 psi. Repeat two more cycles, then recharge to system pressure.

NO.	CONTROL/INDICATOR	FUNCTION
11	Pressure Regulator	Regulates pressure of oxygen delivered to mask according to setting of altitude selector knob.

Figure 1-241 (Sheet 4 of 5)

Oxygen System Controls and Indicators (Continued)

NO.	CONTROL/INDICATOR	FUNCTION
		C OXYGEN QUANTITY PANEL
12	OXYGEN Gage (Liquid Oxygen Quantity Gage)	Indicates volume of liquid oxygen in converter in liters. System capacity is 75 liters.
13	LOW Caution Light (Amber)	When on, indicates liquid oxygen quantity is below 7.5 liters or system pressure is below 42 psig. System should be refilled before flight.
14	TEST Button	When pressed, causes quantity gage reading to go toward zero and causes LOW caution light to come on at 7.5 liter indication. Gage and caution light return to normal when button is released.
		D PORTABLE OXYGEN BOTTLE RECHARGER
15	Recharger Hose	Provides oxygen source for recharging portable bottles. Located thirteen places throughout the airplane as shown in *figure 1-238*.
16	Release Lever	Rotating lever releases dust cap (17).
17	Dust Cap	Prevents dust and grease from contaminating recharger. Cap must be removed from recharger by rotating release lever (16) to fill bottle.

WARNING

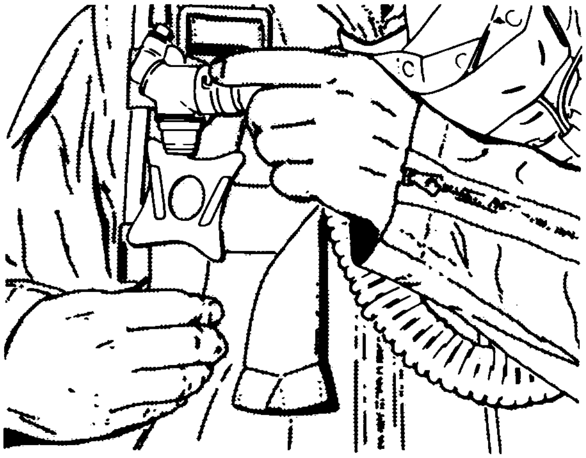
Prior to servicing or purging portable oxygen bottles, insure that oxygen bottle filler port and oxygen recharger outlet are free of oil or grease.

Figure 1-241 (Sheet 5 of 5)

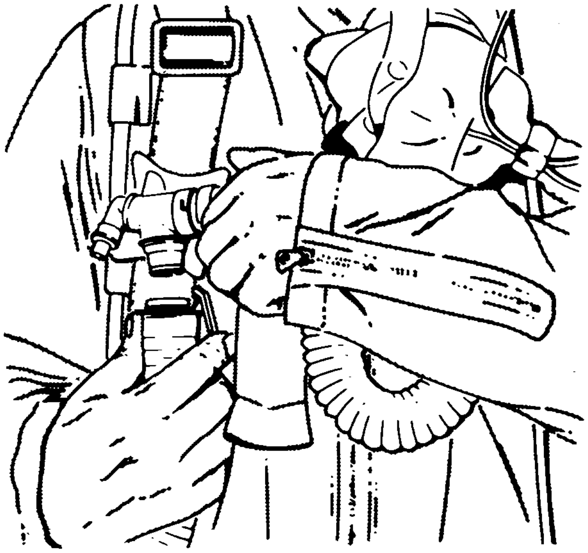
Oxygen Hose Connection
(With Type CRU-8/P or CRU-60/P Connector)

NOTE

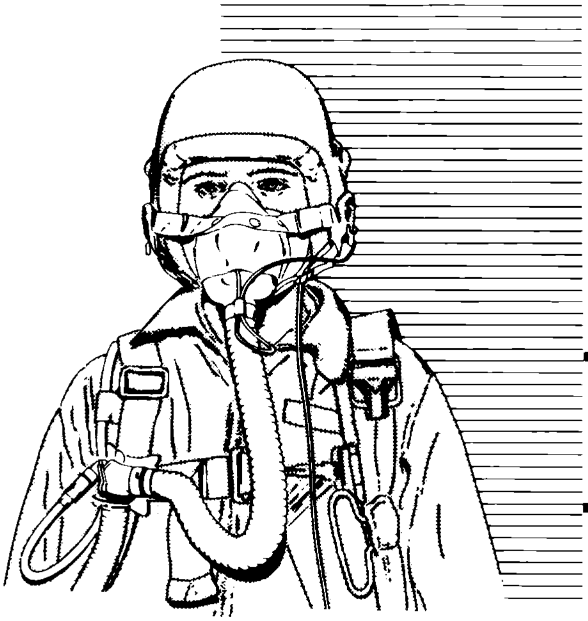
THIS ILLUSTRATION SHOWS THE PROCEDURE FOR CONNECTING THE OXYGEN HOSE AND DOES NOT NECESSARILY REFLECT THE TYPE OF HEAD GEAR, OXYGEN MASK AND OXYGEN MASK STRAPS TO BE USED.



1 ATTACH CRU-8/P OR CRU-60/P CONNECTOR INTO PARACHUTE HARNESS PLATE BY ENGAGING MALE DOVE-TAILED PLATE ON CONNECTOR INTO FEMALE RECEIVING TRACK UNTIL SPRING-LOADED PIN DROPS IN PLACE.



2 CONNECT AIRPLANE OXYGEN SUPPLY HOSE TO THE QUICK DISCONNECT FITTING ON THE CONNECTOR AND CHECK THAT SEALING GASKET IS ONLY HALF EXPOSED.



3 ATTACH MD-1 BAIL-OUT BOTTLE HOSE TO MALE BAYONET CONNECTOR ON CRU-8/P OR CRU-60/P CONNECTOR. PUT ON OXYGEN MASK AND CHECK OXYGEN FLOW INDICATOR.

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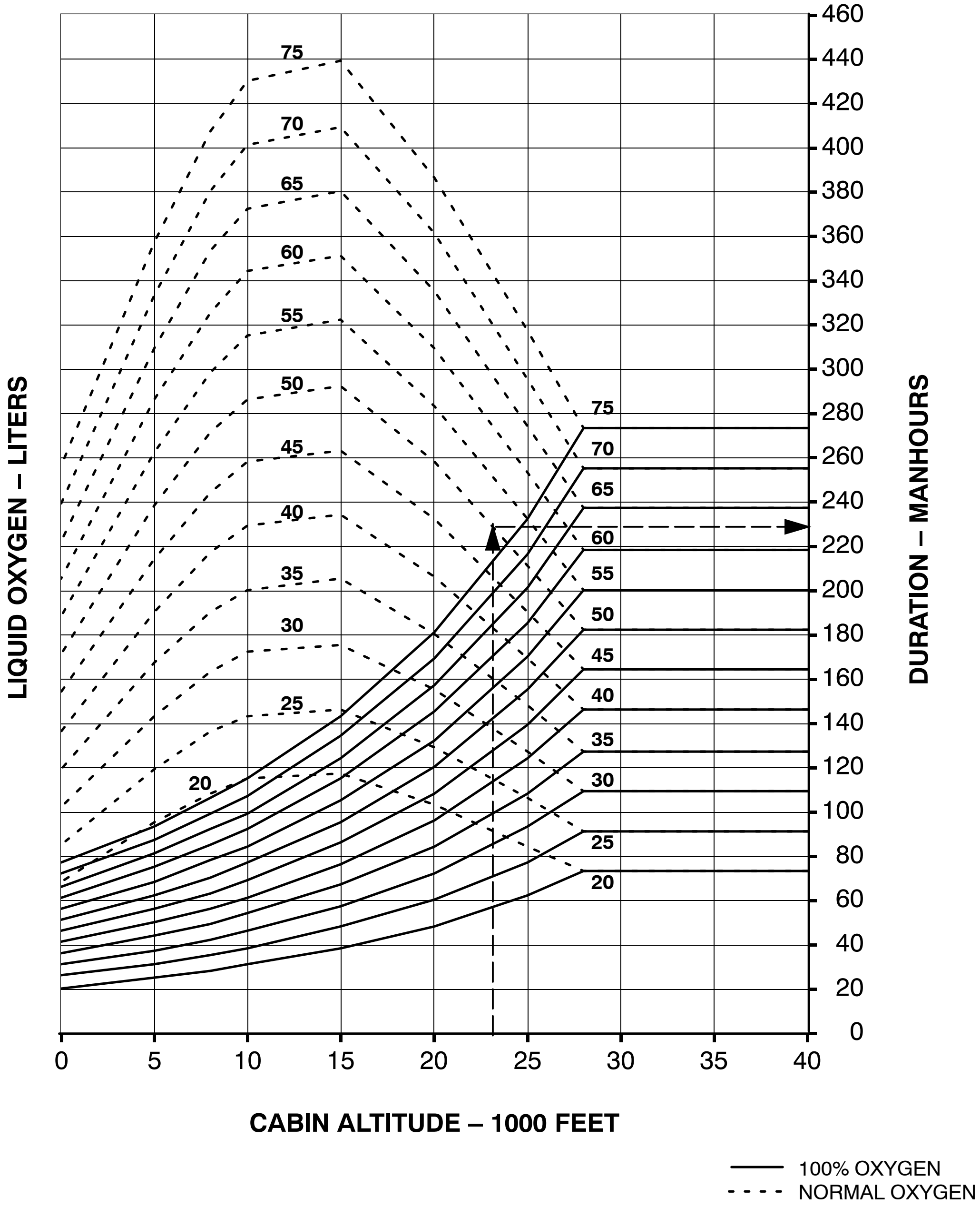
Figure 1-242

Oxygen Duration



EXAMPLE PROBLEM:

GIVEN: CABIN PRESSURIZATION IS LOST WHILE ON STATION. AN IMMEDIATE DESCENT IS MADE TO 23,000 FEET. THERE ARE 20 CREWMEMBERS ABOARD. THE MISSION HAS 8 HOURS TO CONTINUE. FLIGHT ENGINEER'S GAGE INDICATES 50 LITERS OXYGEN REMAINING. ☛

FIND: DETERMINE IF SUFFICIENT OXYGEN REMAINS TO COMPLETE THE MISSION.

SOLUTION: ENTER THE CABIN ALTITUDE SCALE OF THE CHART AT 23,000 FEET AND PROJECT VERTICALLY TO THE 50 LITER NORMAL OXYGEN (DASHED) LINE, THEN PROJECT RIGHT TO DURATION – MAN-HOURS. READ 230 MAN-HOURS. DIVIDE THE MAN-HOURS BY THE NUMBER OF PERSONS ABOARD TO DETERMINE DURATION IN HOURS. 230/20 = 11.5 HOURS. THEREFORE, THE MISSION CAN BE COMPLETED WITH THE REMAINING OXYGEN SUPPLY.

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Figure 1-243 (Sheet 1 of 2)

MA-1 PORTABLE OXYGEN SYSTEM
OR FIREFIGHTERS’ OXYGEN ASSEMBLY ①
(PRESSURIZED TO 300 PSI, USED TO 50 PSI) ②

REGULATOR SETTING	CABIN ALTITUDE (FT)	OXYGEN DURATION	
		MODERATE ACTIVITY	PASSIVE (SEATED)
NORM	Below 12,000	4 Minutes	10 Minutes
	12,000 to 20,000	7 Minutes	16 Minutes
	20,000 to 30,000	10 Minutes	23 Minutes
30M	30,000 to 40,000	14 Minutes ③	30 Minutes ③
	40,000 to 42,000	17 Minutes ③	28 Minutes ③ ④
42M	42,000 to 45,000 ⑥	19 Minutes ③ ④ ⑤	23 Minutes ③ ④
EMER	Above 45,000 ⑥	20 Minutes ③ ④ ⑤	

① MA-1 consists of A-6 Bottle, A-21 Regulator, and either aircrew mask MBU/5P or /12P, quick don mask MBU/10, or firefighters (smoke) mask.

② If the oxygen pressure in MA-1 portable oxygen bottle drops below 10 psi, recharge bottle immediately, or purging is required.

③ No allowance for mask leakage.

④ Time shown is limit for persons not conditioned to pressure breathing.

⑤

WARNING

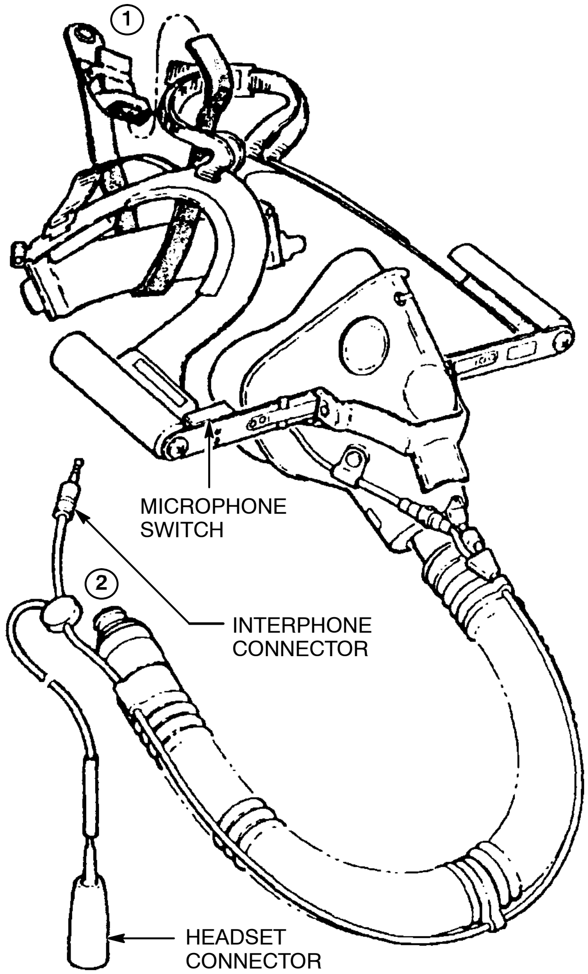
Do not use firefighter’s smoke mask with portable oxygen bottle above 43,000 feet cabin (pressure) altitude.

⑥ Altitude above normal operating range of this airplane.

Figure 1-243 (Sheet 2 of 2)

Standard Quick Donning Oxygen Mask

1 WHEN READY TO DON MASK, TAKE A FIRM GRASP AROUND VALVE AND HOSE ASSEMBLY, WITH EITHER RIGHT OR LEFT HAND. A SHARP DOWNWARD PULL RELEASES MASK FROM QUICK-RELEASE HANGER.



① WHEN STOWED, STRAP MUST PASS AROUND STRAPS, AS SHOWN.

② HOSE CONNECTOR MATES WITH AIRPLANE FITTING, NOT WITH CRU/60P.

2 HOOK MASK OVER BACK OF HEAD LIKE A CAP. PULL FORWARD ON THE MASK, EXTENDING SLIDERS ON EACH SIDE TO THEIR MAXIMUM DISTANCE. PULL MASK DOWN, OVER GLASSES WHICH MAY BE WORN, AND BRING INTO PROPER POSITION OVER NOSE AND MOUTH, MOVING HEADSET MICROPHONE OUT OF WAY WHILE DONNING MASK.

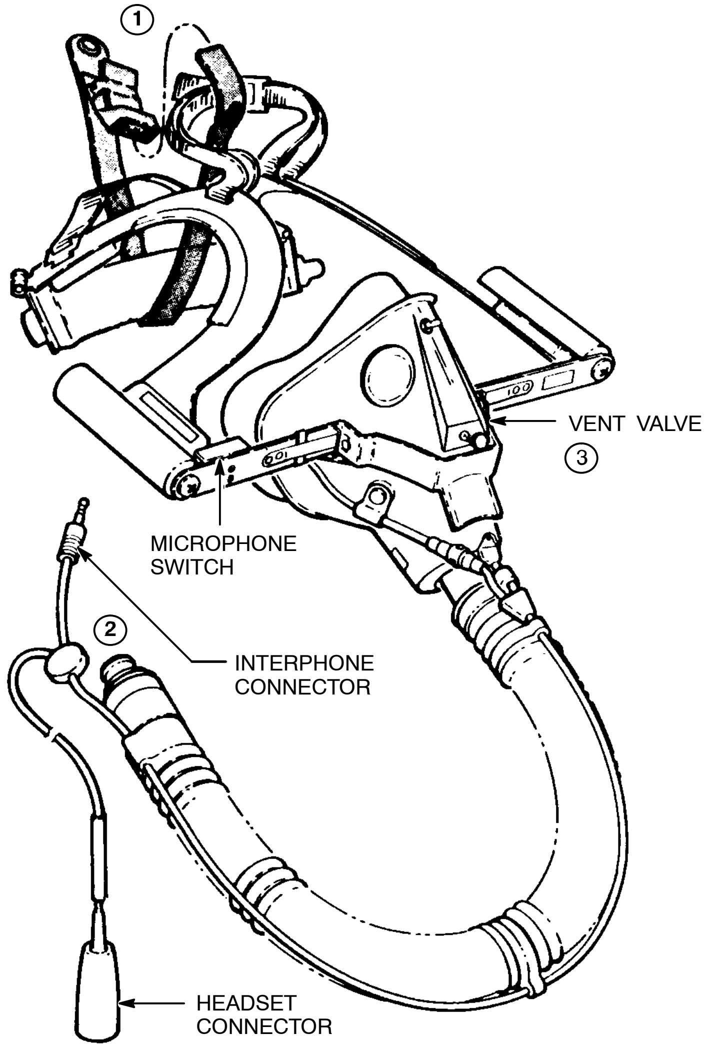
3 MASK IS NOW IN PROPER POSITION ON FACE AND READY TO USE.

D57 527 SI

Figure 1-244

Flight Crew Quick Donning Oxygen Mask

1 WHEN READY TO DON MASK, TAKE A FIRM GRASP AROUND VALVE AND HOSE ASSEMBLY, WITH EITHER RIGHT OR LEFT HAND. A SHARP DOWNWARD PULL RELEASES MASK FROM QUICK-RELEASE HANGER.



① WHEN STOWED, STRAP MUST PASS AROUND STRAPS, AS SHOWN.

② HOSE CONNECTOR MATES WITH AIRPLANE FITTING, NOT WITH CRU/60P.

③ VENT VALVE ONLY ON FLIGHT CREW MASK, USED WITH ANTI-SMOKE GOGGLES.

2 HOOK MASK OVER BACK OF HEAD LIKE A CAP. PULL FORWARD ON THE MASK, EXTENDING SLIDERS ON EACH SIDE TO THEIR MAXIMUM DISTANCE. PULL MASK DOWN, OVER GLASSES WHICH MAY BE WORN, AND BRING INTO PROPER POSITION OVER NOSE AND MOUTH, MOVING HEADSET MICROPHONE OUT OF WAY WHILE DONNING MASK.

3 MASK IS NOW IN PROPER POSITION ON FACE AND READY TO USE.

D57 528 SI

Figure 1-245 (Sheet 1 of 2)

Flight Crew Quick Donning Oxygen Mask (Continued)

4 WHEN WORN, ANTI-SMOKE GOGGLES SHOULD BE PLACED OVER FLIGHT CREW TYPE QUICK DON OXYGEN MASK TO ENSURE BEST POSSIBLE SEAL. GOGGLES SHOULD FIT OVER HARDSHELL, AND VENT VALVE SHOULD BE OPENED BY PULLING ON VENT VALVE KNOB.

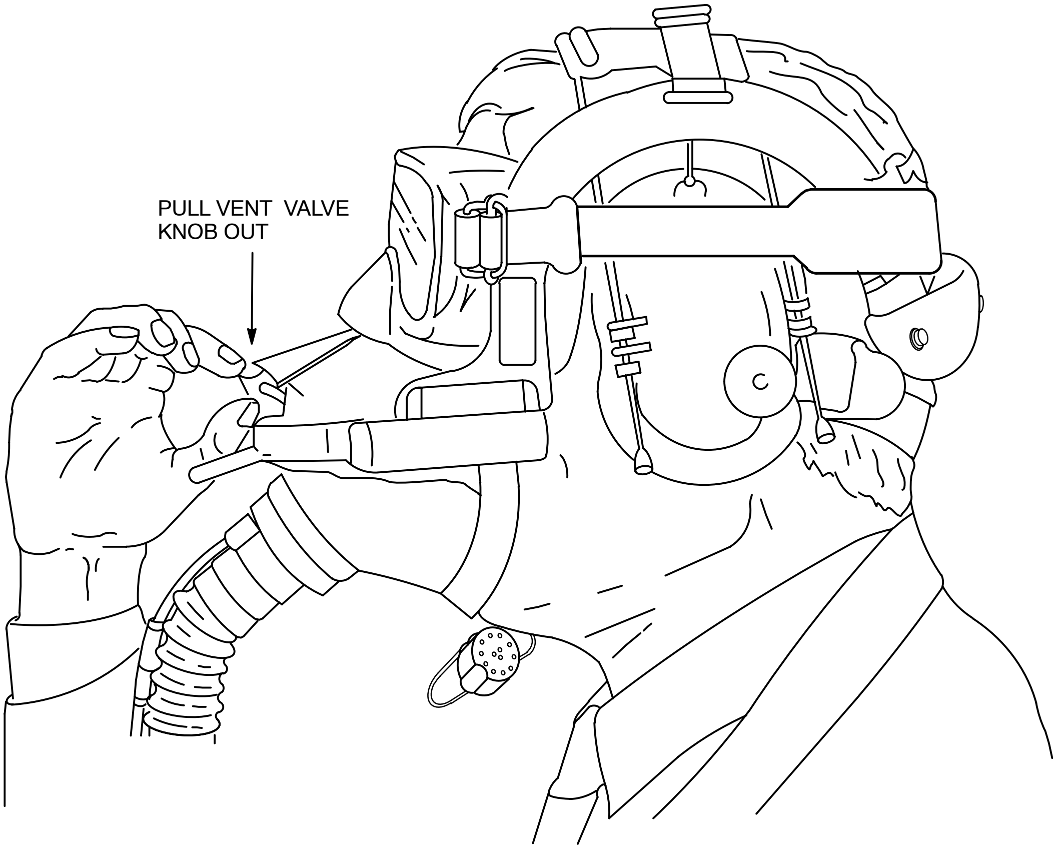
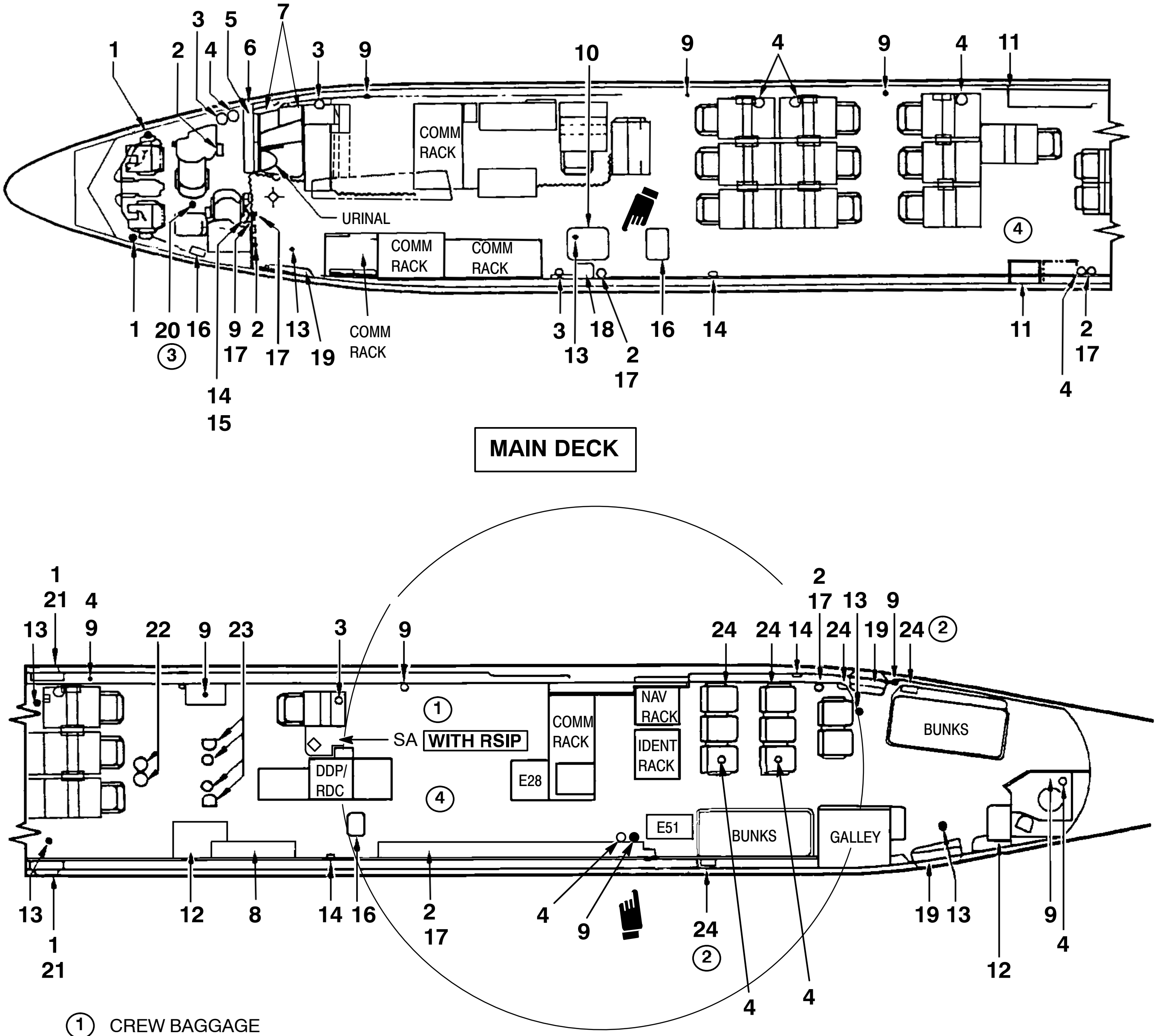


Figure 1-245 (Sheet 2 of 2)

Emergency Equipment Locations



① CREW BAGGAGE TIEDOWN AREA (SOME AIRPLANES) (T.O. 1E-3A-1 SUBSECTION I-U)

② ONE CSU PER BUNK

③ IN POCKET ON SEAT BACK

④ 4 EXTRA SEATS WITH OXYGEN BOTTLES CAN BE INSTALLED HERE

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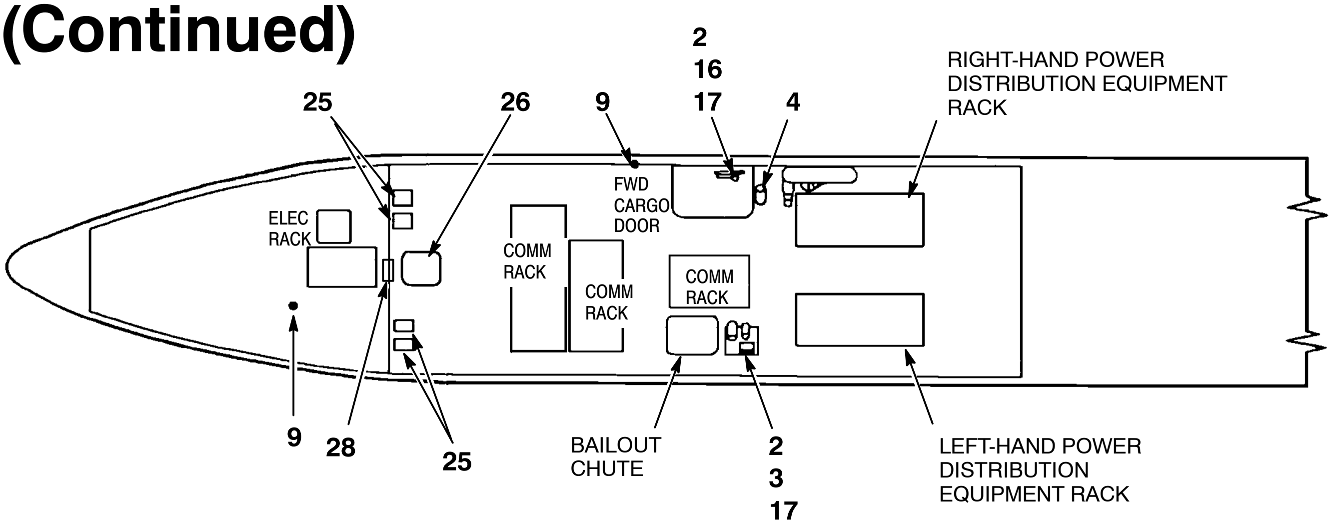
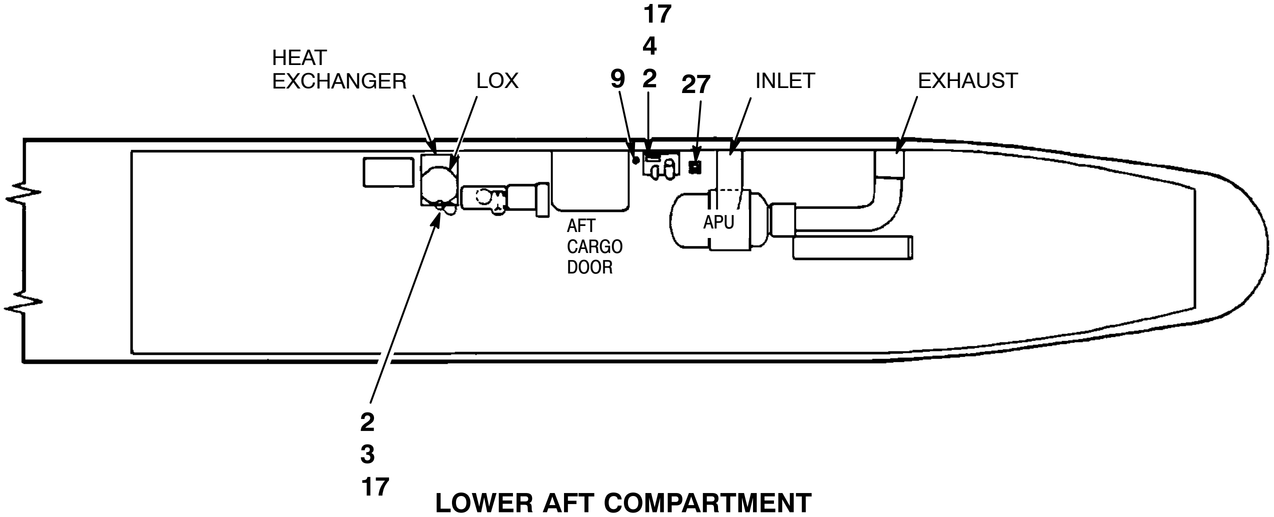
Figure 1-246 (Sheet 1 of 2)

Emergency Equipment Locations (Continued)



LOWER FORWARD COMPARTMENT



LOWER AFT COMPARTMENT

1. ESCAPE STRAP (4)
2. FIRE EXTINGUISHER (10)
3. FIRE FIGHTERS PORTABLE 0$_2$ ASSEMBLY (SMOKE MASK) (6)
4. PORTABLE O$_2$ (20)
5. ELECTRO MAGNETIC PULSE (EMP) SHIELDS (STOWED) (1)
6. FLIGHT ENGINEER AUX. PANEL AND CIRCUIT BREAKER PANEL (1)
7. FLIGHT CREW SURVIVAL EQUIPMENT AND SEXTANT STOWAGE (2)
8. RESTRAINT HARNESS
9. PORTABLE OXYGEN BOTTLE RECHARGER (13)
10. BAILOUT CHUTE FLOOR GRILL (1)
11. AUTOMATIC LIFE RAFT (BOTH SIDES) (2)
12. SPARE EQUIPMENT STOWAGE AREA (2)
13. PORTABLE EMERGENCY LIGHTS (6)
14. AXE (4)
15. LANDING GEAR HAND CRANK
16. LOWER DECK ACCESS HATCH (3)
17. FIRST AID KIT (10)
18. BAILOUT JETTISON MECHANISM AND ENCLOSURE (1)
19. ESCAPE SLIDE (3)
20. FIREFIGHTER’S GLOVES (1)
21. EMERGENCY EXIT (BOTH SIDES) (2)
22. EMERGENCY WHEEL WELL DOOR RELEASE (2)
23. MAIN GEAR INSPECTION DOOR (4)
24. CREW SERVICE UNIT (CSU) (9)
25. BATTERY (4)
26. RADIO ACCESS DOOR (1)
27. APU FIRE DETECTION AND EXTINGUISHING EQUIP. (1)
28. EMERGENCY GEAR EXTENSION LEVER

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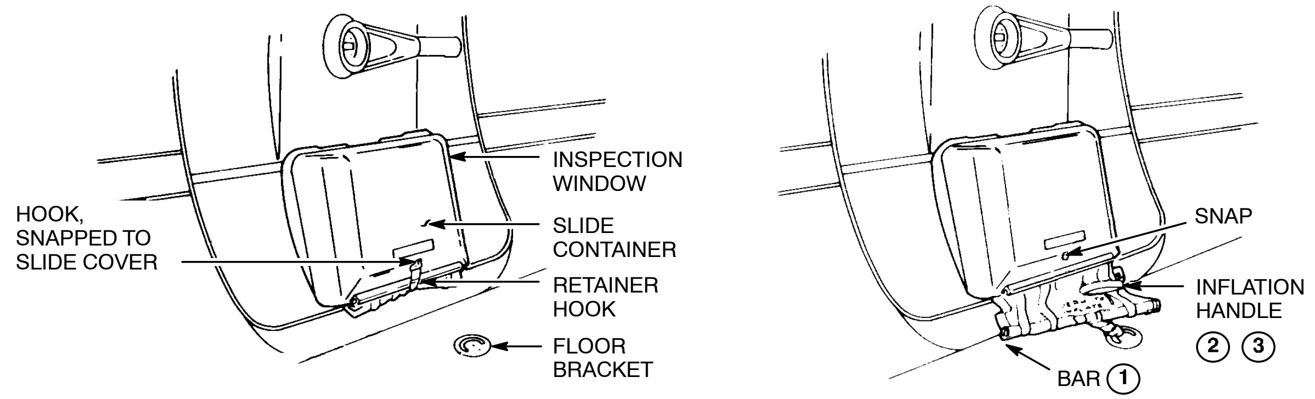
Figure 1-246 (Sheet 2 of 2)

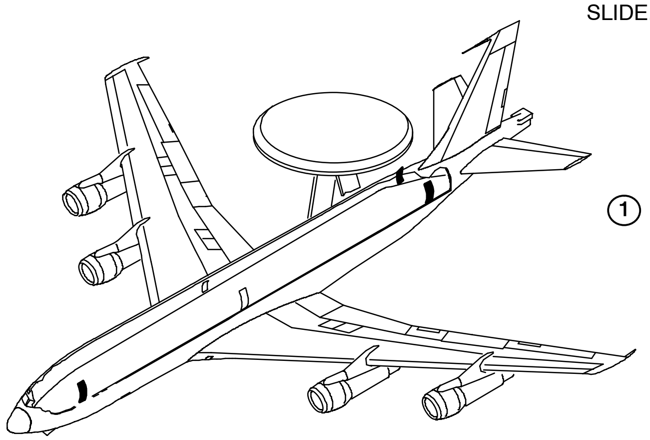
Escape Slides



1 ESCAPE SLIDE STOWED IN CONTAINER WITH DOOR CLOSED

2 SLIDE ARMED

OPENING DOOR DEPLOYS SLIDE. PULL INFLATION HANDLE TO INFLATE SLIDE.



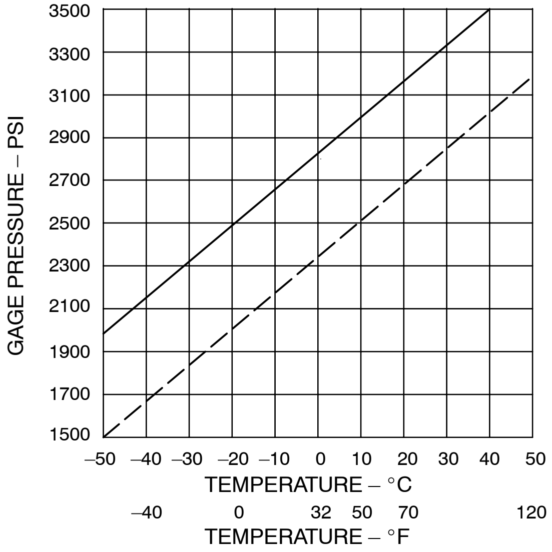
WARNING

① SLIDE IS UNUSABLE UNLESS RETAINING BAR PASSES THROUGH SLIDE HARNESS AND THROUGH LOOP ON RETAINING HOOK ASSEMBLY. RETAINING BAR MUST BE SECURED BY NYLON LANYARD PASSING THROUGH THE RETAINING BAR.

NOTE

② THIS HANDLE MUST BE PULLED TO INFLATE SLIDE.

③ DO NOT PULL THIS HANDLE TO LIFT SLIDE.



ESCAPE SLIDE CHARGE PRESSURE

——— MAX. — — — MIN.

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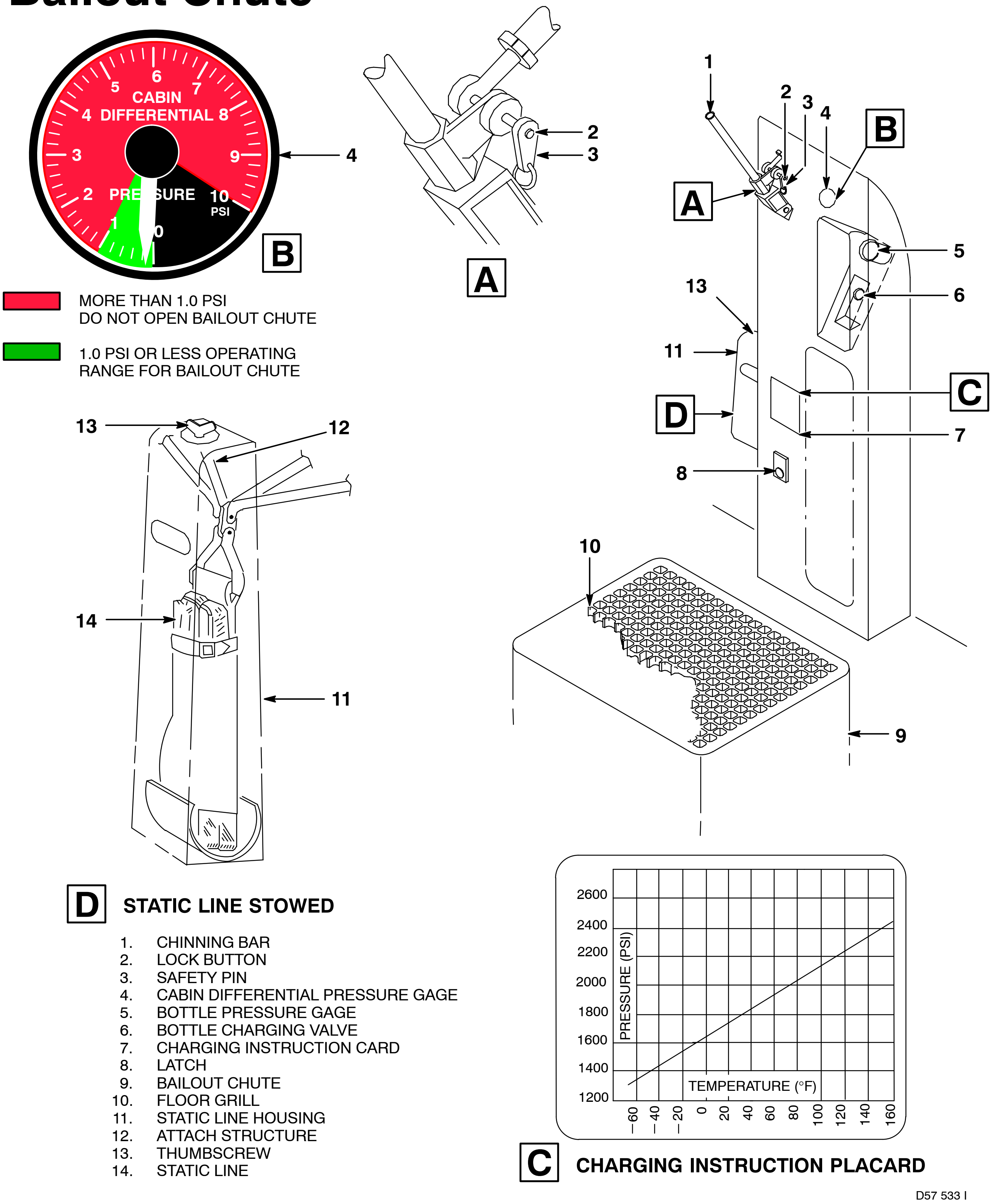
Figure 1-247

Bailout Chute



🟥 MORE THAN 1.0 PSI
DO NOT OPEN BAILOUT CHUTE

🟩 1.0 PSI OR LESS OPERATING
RANGE FOR BAILOUT CHUTE

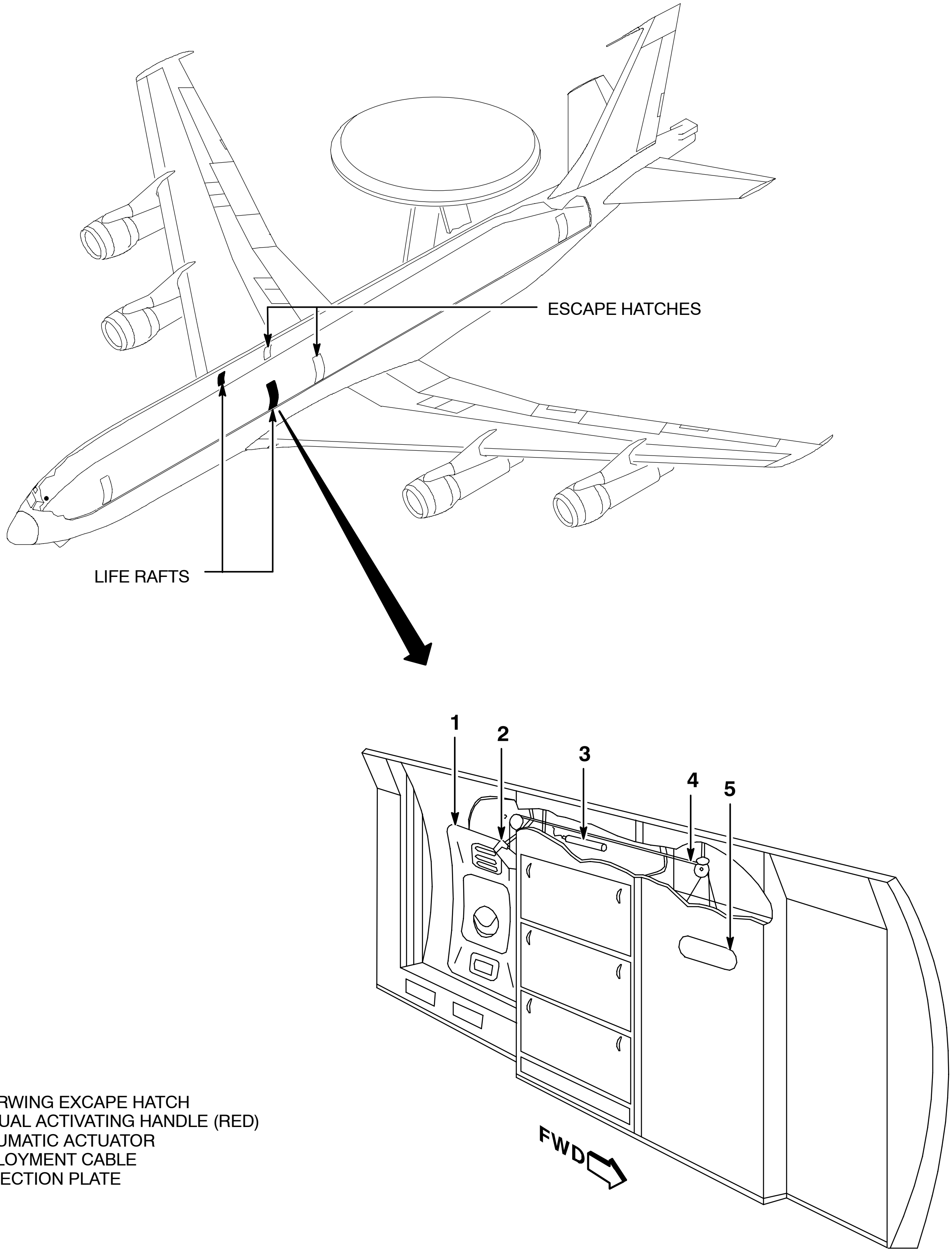
D STATIC LINE STOWED

C CHARGING INSTRUCTION PLACARD

1. CHINNING BAR
2. LOCK BUTTON
3. SAFETY PIN
4. CABIN DIFFERENTIAL PRESSURE GAGE
5. BOTTLE PRESSURE GAGE
6. BOTTLE CHARGING VALVE
7. CHARGING INSTRUCTION CARD
8. LATCH
9. BAILOUT CHUTE
10. FLOOR GRILL
11. STATIC LINE HOUSING
12. ATTACH STRUCTURE
13. THUMBSCREW
14. STATIC LINE

Figure 1-248

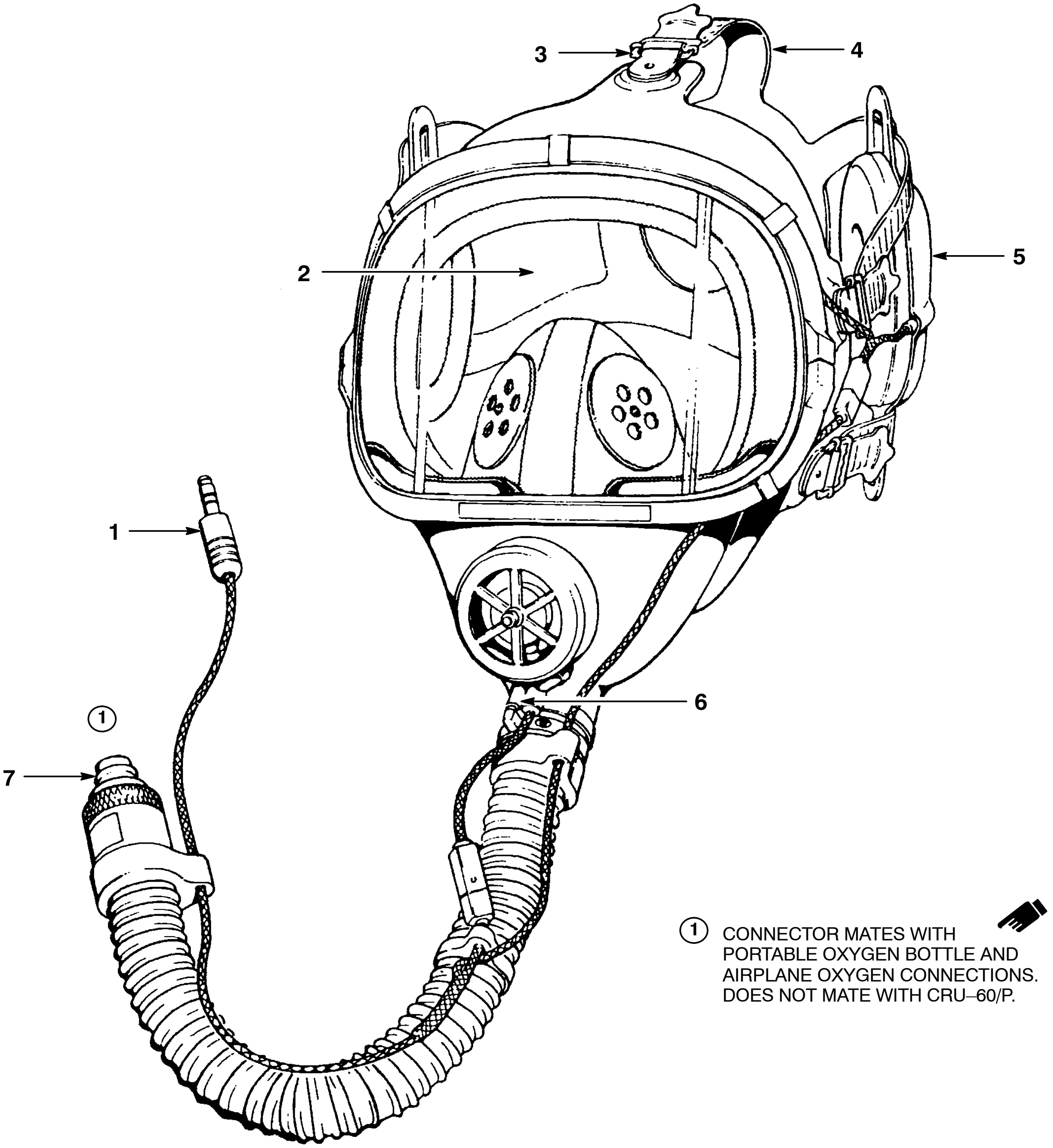
Life Rafts



1. OVERWING EXCAPE HATCH
2. MANUAL ACTIVATING HANDLE (RED)
3. PNEUMATIC ACTUATOR
4. DEPLOYMENT CABLE
5. INSPECTION PLATE

Figure 1-249

Fire Fighter’s Smoke Mask



① CONNECTOR MATES WITH PORTABLE OXYGEN BOTTLE AND AIRPLANE OXYGEN CONNECTIONS. DOES NOT MATE WITH CRU–60/P.

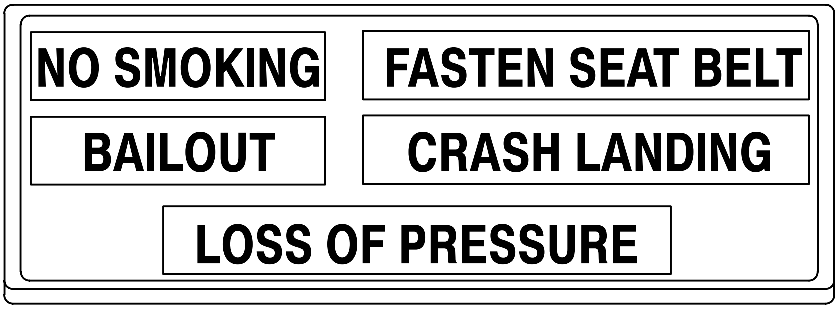
Figure 1-250 (Sheet 1 of 2)

NO.	CONTROL/INDICATOR	FUNCTION
1	Microphone and Earphone Plug	Fits standard interphone cord. There is no interphone switch, so cord lapel switch must be used. ①
2	Lens	
3	Buckles (5 places)	Provide adjustment for head strap (4) to allow individual fitting.
4	Head strap (5 places)	Five straps with five adjustment buckles (3) allow individual fitting.
5	Ear cup (2 places)	Contains earphone. ①
6	Compensating Tube	Regulates flow rate through mask. ①
7	Connector	Provides connection to portable oxygen bottle or airplane oxygen fittings. Does not mate with CRU/60P.

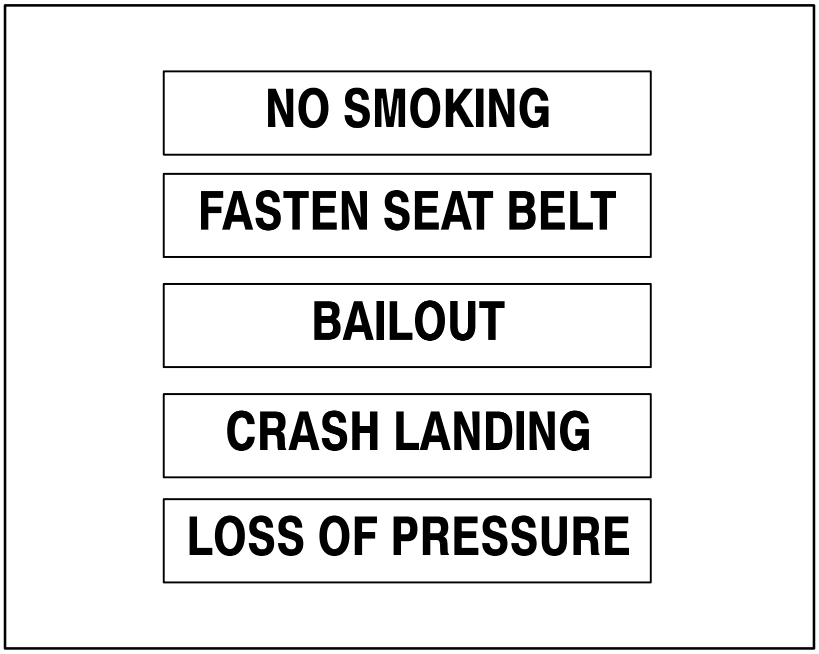
① Some older masks do not have a compensating tube or interphone.

Figure 1-250 (Sheet 2 of 2)

Visual Warning Display Units



LARGE DISPLAY



CONSOLE DISPLAY

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Figure 1-251

Oxygen and Warning Equipment Electric Power Sources

EQUIPMENT/SYSTEM	TYPE OF POWER	POWER SOURCE	CIRCUIT BREAKER LOCATION/LABEL
Liquid Oxygen Quantity Gage	115V AC	AVAC BUS 4	P61-4, OXYGEN – QTY IND
Liquid Oxygen and Door Warning Lights	28V DC	AVDC BUS 4 MAIN	P61-4, OXYGEN – & DOOR WARN IND LT
No Smoking Signs	28V DC	AVDC BUS 2 MAIN	P6, NO SMOKING
Seat Belt Signs	28V DC	AVDC BUS 2 MAIN	P6, SEAT BELTS
Bailout and Crash Landing Signs	28V DC	BAT BUS	P6, BAILOUT CRASH LANDING
Smoke Detector Normal Power	115V AC	FAAC Bus 1	P5, SMOKE DETECTION NORMAL AC POWER ①
Smoke Detector Standby Power	115V AC	AVAC Bus 8	P5, SMOKE DETECTION STANDBY PWR ①
Smoke Detector Failure Warning	28V DC	BAT BUS	P5, SMOKE DETECTION FAULT IND PWR ①

① Banded open by TCTO 1E-3-697

Figure 1-252

SUBSECTION I-W
MISCELLANEOUS EQUIPMENT AND SERVICING

Table of Contents

MISCELLANEOUS EQUIPMENT

FLIGHT LOADS RECORDER 3, 5 ▶ 9, 24

A flight loads recorder, *figure 1-255*, is installed in some airplanes to determine stresses on structural parts of the airplane, and to collect data in support of the fatigue tracking program. The system includes a signal data recorder and a signal converter multiplexer. Data is obtained from accelerometers, transducers, and strain gages in various locations on the airplane.

These data are used to update the load factors in the Individual Aircraft Tracking Program. This program uses the load factors with the IATP Flight Log (AFTO Form 117) to calculate data which is used by the system manager to schedule inspections or modifications to insure flight safety. The IATP Flight Logs are used to collect usage data from 100% of the airplane force per AFI 63-1001.

SIGNAL DATA RECORDER

The signal data recorder is installed in the E-1 rack in the forward lower compartment. Power to the recorder is 115 vac from flight avionics AC bus 2 through the FLT LOADS RCDR ØC circuit breaker and 28 vdc from flight avionics DC bus 2 through the FLT LOADS – RCDR DC circuit breaker (both located on the P5 panel).

SIGNAL DATA RECORDER OPERATION

The recorder requires a minimum of attention by the flight crew. The tape remaining indicator (2, *figure 1-255*) and the documentary data switches (3) are the primary controls of interest to the flight crew.

The recorder uses a magnetic tape cassette, with a capacity of 15 hours recording time. The tape cassette will normally be replaced by flight crew or maintenance personnel when the tape remaining is not sufficient for the next scheduled flight or at the completion of one flight following maintenance on the flight loads recorder system. Changing the cassette one flight following maintenance on the system reduces the time required for OC-ALC/PSWR to confirm that the system is operating properly. The number of hours of tape remaining can be calculated by multiplying the percent of tape remaining obtained from indicator (2) times 15 hours.

One spare tape cassette should be carried on the airplane at all times. Some missions can be longer than 15 hours, requiring replacement of a tape cassette during flight (at approximately 14 hours). The documentary data switches will remain the same as at the beginning of the flight.

NOTE

- The spare cassette will be carried in the avionic spares cabinet.
- If a cassette is removed in flight, send cassette to Oklahoma City Air Logistics Center, OC-ALC/ENFOC, Tinker AFB, OK 73145-3042.

Before each flight, enter the appropriate data on the documentary data switches by rotating the thumbwheels (4). To reach the switches, open the door (9) by turning the latches 1/4 turn clockwise and pull the door down.

Enter data as shown by the labels over the thumbwheels (*figure 1-255*). Note that airplane gross weight and fuel load are entered in 100 pound units. For example, a gross weight of 306,400 pounds would be entered as 3064. The date is entered as the last digit of the year, then the month (01 through 12), and the day, June 15, 2002, would be entered as 20615. Enter the last four digits of the airplane serial number.

The following code will be used for mission types:

01	Contingency/Exercise/Training Deployment
02	RCC Deployment
03	Contingency/Exercise/Training Station Manning – Unrefueled
04	Contingency/Exercise/Training Station Manning – Refueled
05	Pilot Transition
06	High Speed, Low Altitude Dash
07	Functional Check Flight
00	Other

The following codes will be used for bases:

10	Tinker AFB	60	Elemendorf AFB
20	March AFB	70	Kadena AB
30	McChord AFB	80	Mildenhall AB
40	Griffiss AFB	90	Keflavik AB
50	Tyndall AFB	00	Other

The recorder has a self-test feature. Pressing the TEST switch (9, *figure 1-255*) causes the test light (8) to illuminate indicating that a self-test is in progress (light should stay on approximately 23 to 45 seconds). If maintenance is required one of three failure lights (6) illuminates. A flight will not be delayed for recorder maintenance.

The recorder operates automatically when power is switched from APU or external power to the airplane generators.

NOTE

> The recorder does not operate unless the tape cover is closed and the left hand latch (1, *figure 1-255*) is fastened. If the airplane is powered by airplane generators for ground maintenance, open the tape cover to disable the recorder.

LOAD ADJUSTER

A load adjuster holder is installed on the forward leg of the flight engineer's table. Instructions for use of the load adjuster are in T.O. 1-1B-50.

G FILE STORAGE

Storage cabinets for the onboard reference technical order file (G-File) are provided on the left side of the airplane between the liferaft compartment and the overwing hatch (*figure 1-3*). The file contains airplane and mission equipment maintenance and servicing manuals.

THERMAL AND ELECTROMAGNETIC PULSE (EMP) SHIELDS

All windows in the airplane are provided with shielding against the thermal radiation and electromagnetic pulse (EMP) of a nuclear detonation. Metal shields are included in the window shades on door and overwing hatch windows. Flight deck windows are provided with removable shields (*figure 1-256*). Shields for the flight deck windows are stowed in a rack opposite the main entry door, below the rack for the sextant sighting stool (*figures 1-3* and *1-144*).

NOTE

> EMP shields must be left in the container plastic storage bags until installed in windows.

Flight deck EMP shields are one piece shields, except for the side (NO 2) window shields which are split into two pieces for ease of installation. Shields for the forward (NO 1) and side (NO 2) windows are equipped with view ports to allow limited forward vision with shields installed. EMP shielding with viewports open is provided by wires embedded in the viewport. Thermal protection in the viewport area is provided by a metal cover hinged to the main section of the shield.

To install the shields (*figure 1-256*) tilt the shield so that the velcro fasteners on one edge engage the velcro fasteners on the frame, then rotate the shield into position, and fasten the turn button fasteners.

WARNING

- When installing shields, make certain that pressure is applied around the edges of shields and turn buttons are fastened.
- If light is visible around edge of viewport cover (when closed), shield should be replaced.

HAVE SIREN SYSTEM

The HAVE SIREN system consists of four transmitter units, mounted as shown in *figure 1-257*, and operator controls (*figure 1-258*). Circuit breakers for the system are on P61-5 panel. electrical load control units (ELCU) are in the E15 and E16 electrical racks in the forward lower compartment.

The operator control unit (OCU) is on the navigator's upper panel (*figure 1-258*). The OCU is installed when the transmitter units are installed. A closure (blank) panel is installed if the OCU is removed.

The transmitter unit includes an electronic control unit (ECU), a transmitter unit, and a connecting cable. If the transmitter is not installed, a closure panel replaces the ECU and the aft fairing is installed to reduce airplane drag. When the transmitter is installed but is not operated, a protective closure plate covers the transmitter. The fairings and closure plates are stowed on the airplane when not in use.

System control power is supplied through the SDS PWR circuit breakers on P61-5. There are five circuit breakers, one for the OCU and one for each ELCU.

System operation is limited to turning the system on and off. Observe the following limitations.

SYSTEM OPERATION

HAVE SIREN operation consists of turning the system on and off, monitoring the system for fault indications and taking corrective action when a fault is detected.

To operate the HAVE SIREN, perform the following steps:

1. SDS PWR Circuit Breakers – Set

   Ensure the circuit breakers, located on the P61-5 panel, are set. If any (or all) have tripped, check with maintenance or the FE before resetting them.

2. ELCU POWER Switches – ON (1, 2, 3, 4)

   When each switch is set to ON, power (via the SDS PWR circuit breakers) is supplied through each ELCU to its associated ECU and associated XMTR cooling fan.

3. OCU ON–OPR Switch – Pressed

   When the OCU ON–OPR switch is pressed, the ON light (white) illuminates immediately. Power distribution and control circuits activate, the XMTR begins to warm up and the BIT/fault inhibit initiates. During the inhibits, no faults are detected.

After a 60 ± 5 second override/warmup period, during which the fault inhibit allows all Transmitter Set operations to stabilize, the inhibit is removed and the fault monitor circuits are energized. If the Set is functioning normally, the green OPR light illuminates.

WARNING

> Do not view operating transmitter for more than one minute from less than three feet away.

a. Hold the number of on-off cycles to a minimum to increase transmitter life.

b. Desirable cycle (on-off) time is 15 minutes. However, if mission requirements dictate, transmitter may be shut down.

c. Turn system on three minutes before takeoff, if possible. Minimum warmup time is one minute.

FAULT INDICATIONS AND CORRECTIVE ACTIONS

The fault monitor circuits detect a number of out-of-tolerance parameters to include XMTR overtemp and low source load current.

If a fault is detected in one or more of the Sets during system operation, the fault relay trips, causing the affected Set to shut down automatically (the remaining Sets continue to operate). The respective FAULT light (amber) on the OCU OFF indicator illuminates and the OPR light goes out, but the ON light remains illuminated. See *figure 1-258*.

When a fault occurs, the operator may restart the faulty Set by pressing the OCU ON switch (this does not affect those Sets still in operation). This resets the fault relay and the Set returns to normal operation if a fault condition is not detected at the end of the 60-second override.

NOTE

> A number displayed on the OCU OFF indicator, along with an illuminated OPR lamp, shows that the operation of that respective set has degraded to a marginal level (*figure 1-258*). The Set is not shut down, but continues operation. Therefore, the operator does not need to try to restart the Set.

The marginal indication warns the operator that corrective action should be taken by maintenance personnel at the first opportunity.

All fault indications and marginal operational level indications should be recorded on the Form 781 and debriefed to maintenance.

TURNING SYSTEM OFF

To turn the system off, perform the following steps:

1. OCU OFF Switch – Pressed

   When the OCU OFF switch is pressed, it causes the power distribution and control circuits to de-energize the XMTR sources. A 60-second cooldown cycle begins. During this cycle, the cooling fan continues operating. **WITH U** Also, the OCU ON indicator remains illuminated during the entire 60-second cool-down cycle.◀ At the end of the cooldown cycle, the power distribution and control circuits are de-energized and the Sets turn off. **WITH U** Also, the OCU ON indicator goes out at turnoff. However, if the OCU ON indicator remains illuminated after the normal 60 ± 5 second cool-down cycle, one or more ECUs have malfunctioned and their respective transmitter units can still be in operate mode, resulting in a potential infrared radiation hazard to maintenance personnel. If this is the case, turn off HAVE SIREN power and write up the ECUs on Form 781.◀

2. ELCU Switches – As Required

   CAUTION

   All ELCU switches will remain ON for at least one minute after shutdown of HAVE SIREN system to allow automatic one minute cooldown cycle. NO 1 and NO 3 throttles will not be set to CUTOFF until one minute after HAVE SIREN system is shut down.

NUCLEAR HARDNESS CRITICALITY

The term hardness critical refers to those components of airplane and mission equipment in which sensitivity to nuclear weapons effects could reduce system survivability. It is essential that hardness of these components is preserved during operations and maintenance so that airplane nuclear survivability is not degraded. Nuclear weapons effects, which the airplane must survive, include nuclear radiation, Electromagnetic Pulse (EMP), thermal radiation and air blast.

Many of the airplane systems contain parts, circuits, and design features that are hardness critical. To ensure that the designed level of hardness is maintained, special care must be taken in operation and maintenance to avoid degrading system hardness inadvertently.

CAUTION

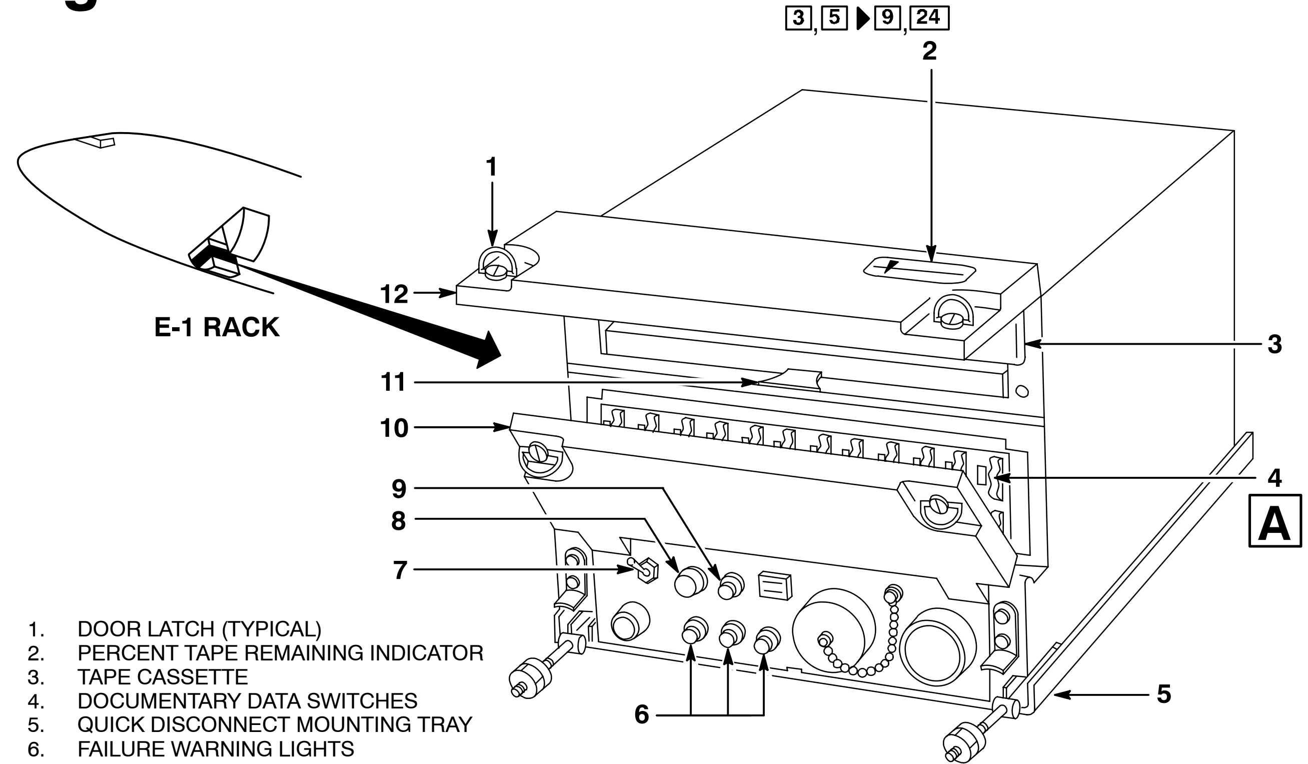
- Do not alter or destroy EMP shielding and electrical continuity by contaminating, damaging, or omitting EMP gaskets and shields. EMP gaskets always interface with conductive (non-painted) surfaces.
- Do not apply excessive bending or pulling forces to electrical cables, shields, or pigtails.
- Use only specified fasteners and related hardware. Apply only specified torque values.
- Electrical isolators are installed in some systems to prevent EMP induced currents from flowing into the pressurized compartments. Systems inside the pressurized area could be damaged by these currents if isolators are dirty or are not present. Special attention should be given to these isolators during preflight inspections to ensure that the isolators are clean, and that no contact or connection has been made which would shortcircuit the isolators.

Certain procedures, which must be followed after a nuclear transient, are listed in section IIIA under NUCLEAR EVENT RECOVERY. These procedures enable resetting and restarting mission equipment to resume normal operation.

SERVICING

Servicing points are located as shown in *figure 1-259*. All exterior servicing points are located on the lower portion of the airplane, except for overwing fuel filler ports. The placard, shown in *figure 1-259*, located in the nosewheel well, shows the location of servicing points. All exterior servicing points are marked with the NATO standard symbols shown on the placard. A list of ground power units suitable for airline preflight operation is included in *figure 1-259*.

Flight Loads Recorder



1. DOOR LATCH (TYPICAL)
2. PERCENT TAPE REMAINING INDICATOR
3. TAPE CASSETTE
4. DOCUMENTARY DATA SWITCHES
5. QUICK DISCONNECT MOUNTING TRAY
6. FAILURE WARNING LIGHTS
7. CAL/DEACTIVATE SWITCH
8. TEST LIGHT
9. TEST SWITCH
10. DOCUMENTARY DATA ACCESS DOOR
11. CASSETTE LATCH
12. CASSETTE ACCESS DOOR

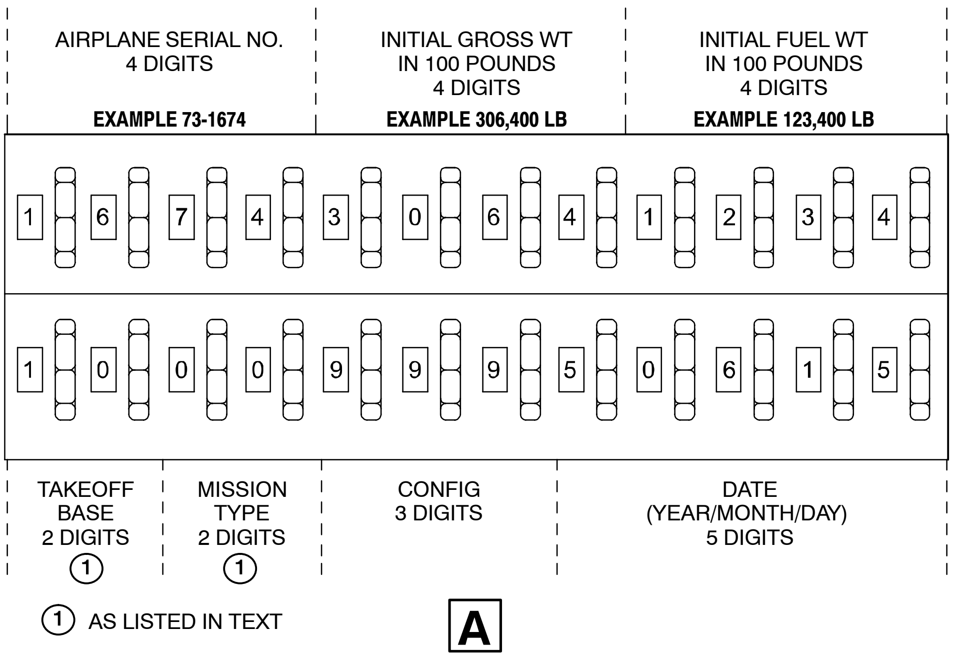


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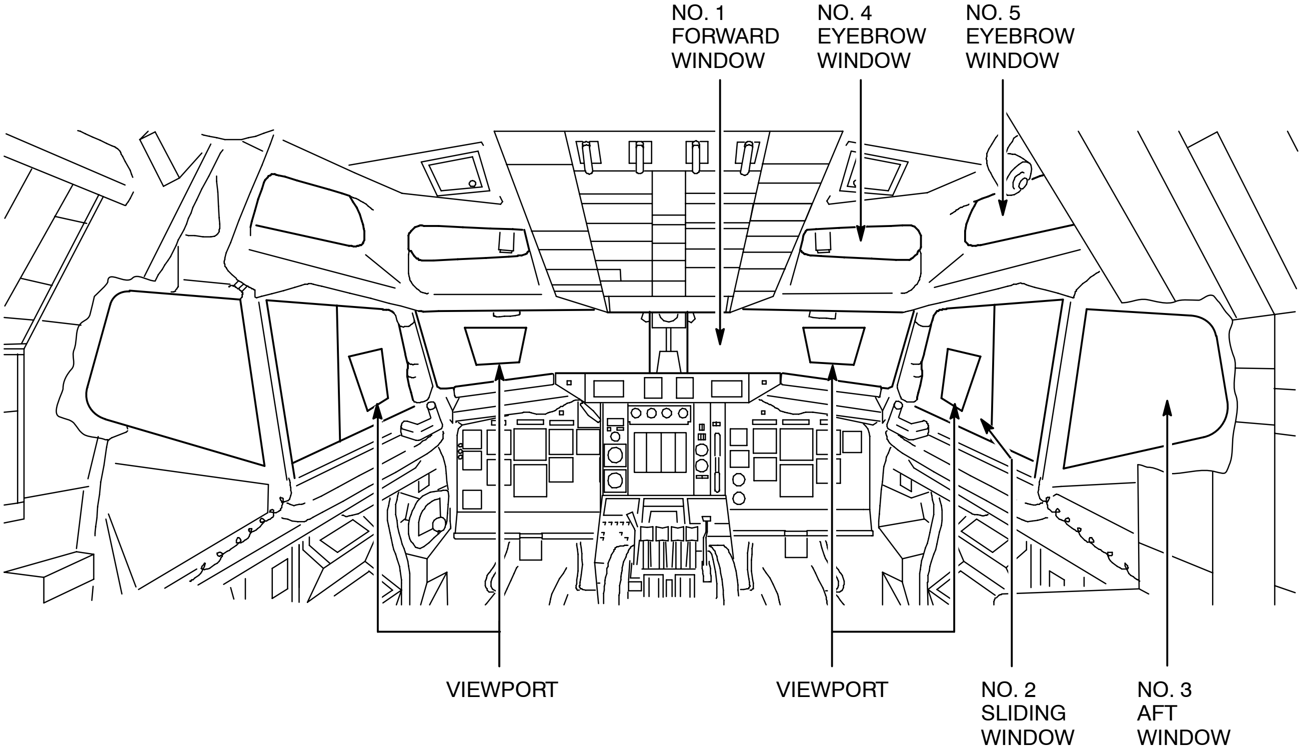
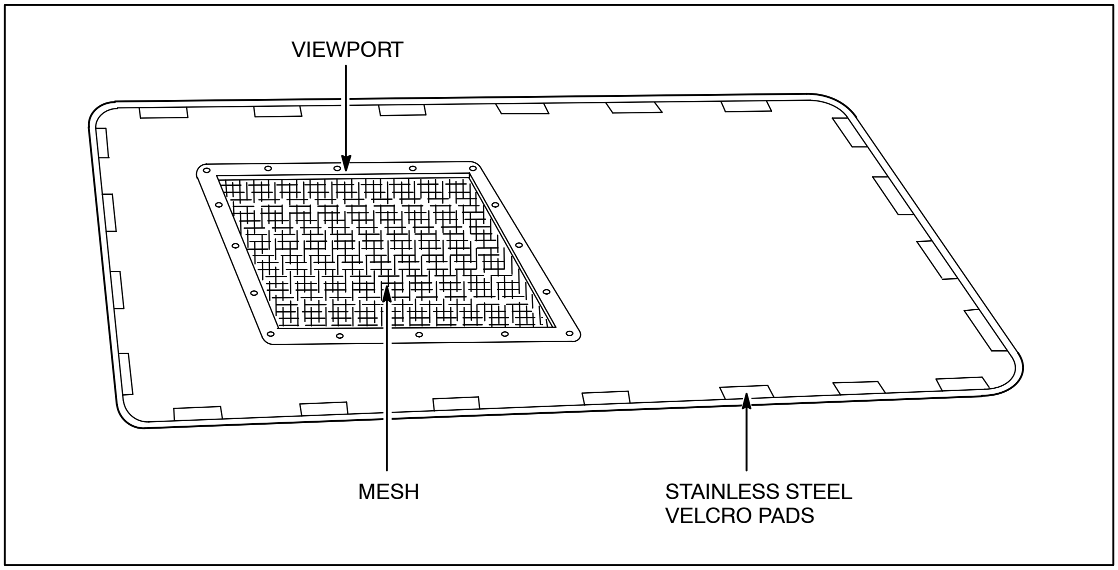
Figure 1-255

Thermal and Electromagnetic Pulse (EMP) Shields

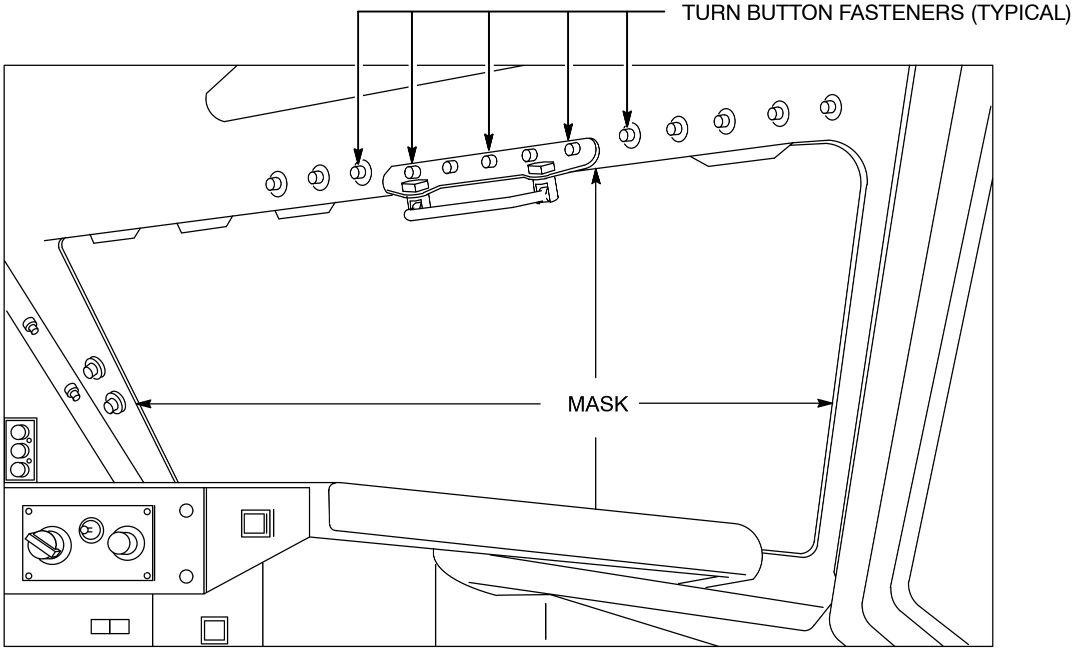




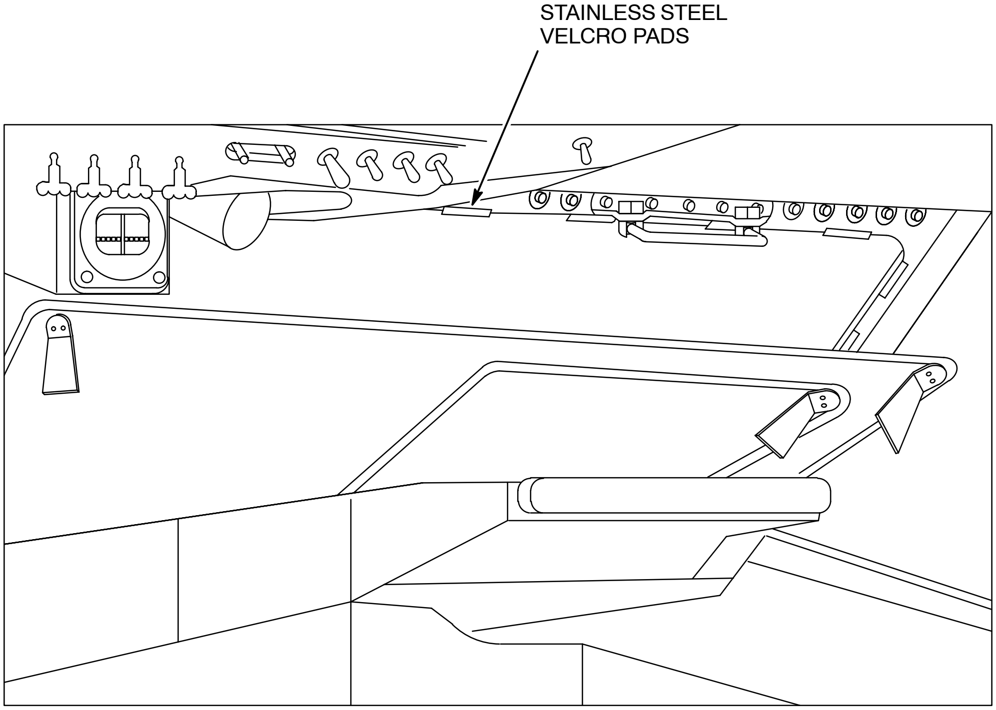
A **SHIELD FOR NO. 1 WINDOW**

D57 540 I

Figure 1-256 (Sheet 1 of 3)



B **WINDOW WITH MASK INSTALLED**
COPILOT'S NO. 1 WINDOW (PILOT'S WINDOW SIMILAR)

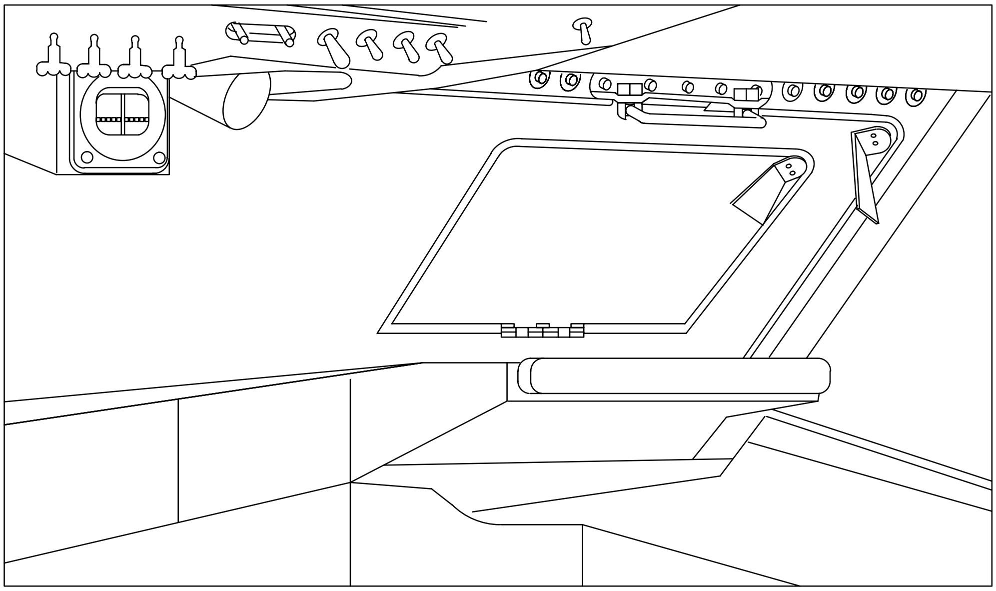


C **SHIELD INSTALLATION**

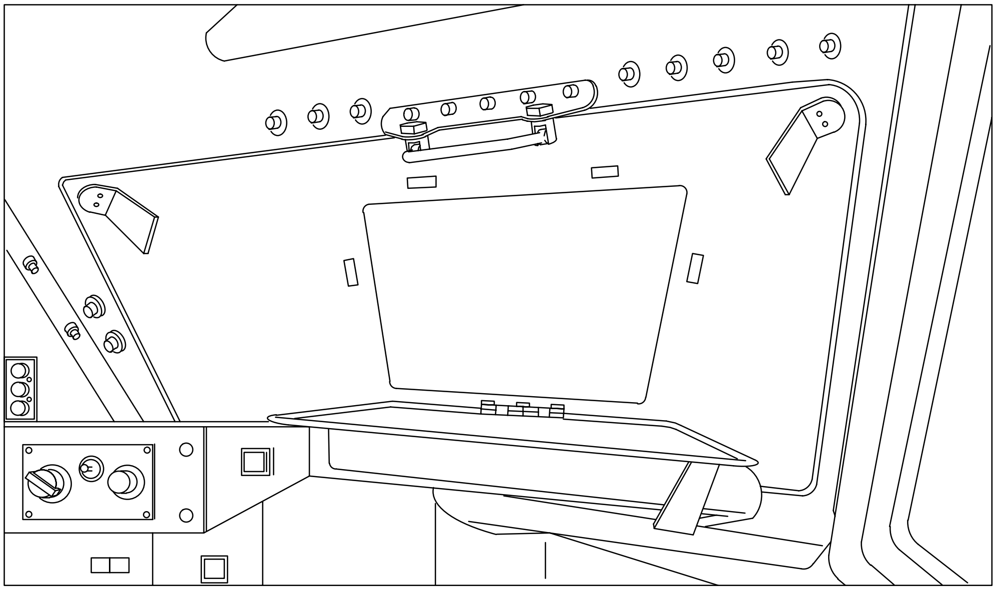
D57 541 I

Figure 1-256 (Sheet 2 of 3)

Thermal and Electromagnetic Pulse (EMP) Shields (Continued)



D **SHIELD INSTALLED** (VIEWING PORT CLOSED)

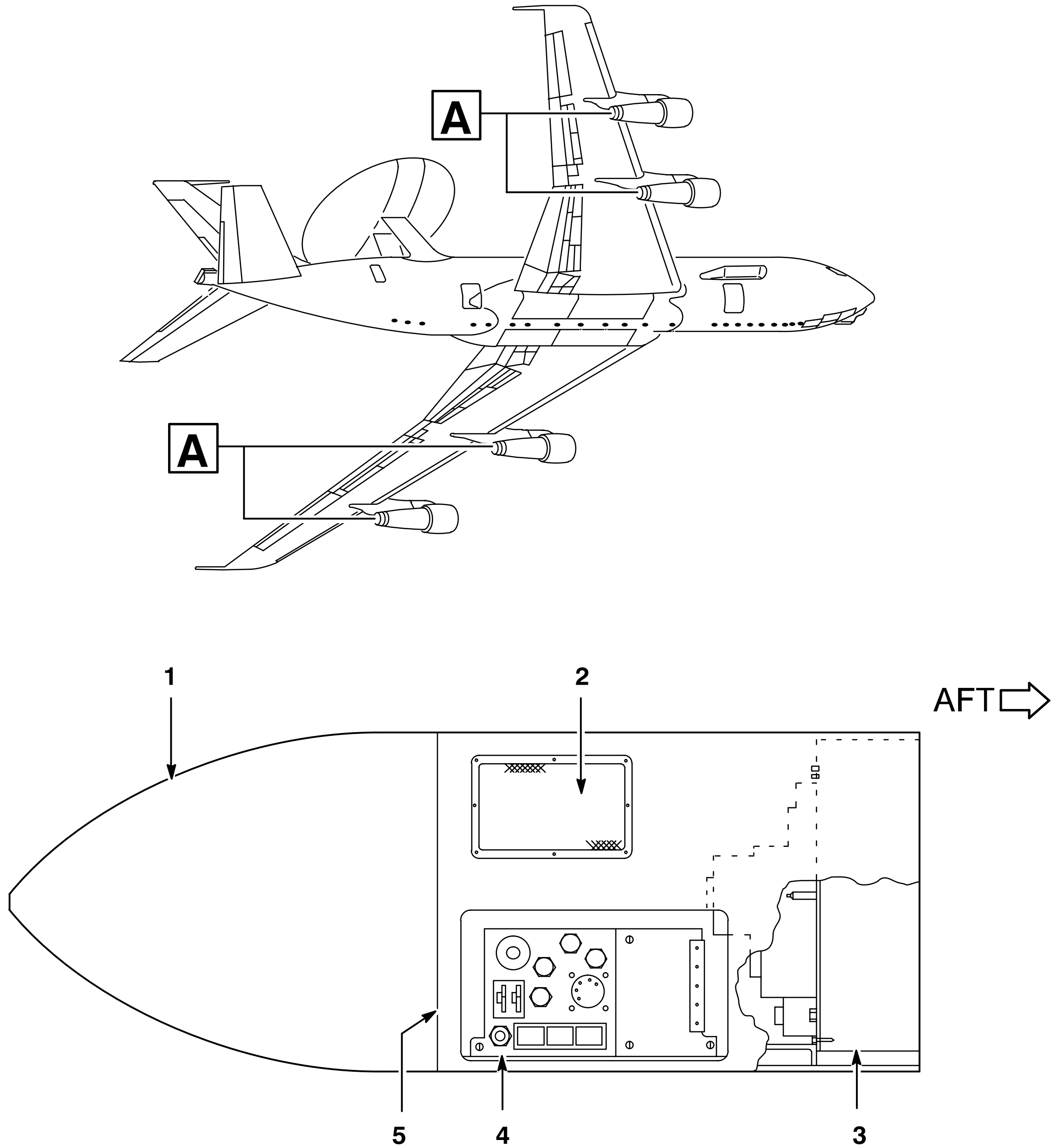


E **SHIELD INSTALLED** (VIEWING PORT OPEN)

D57 542 I

Figure 1-256 (Sheet 3 of 3)

HAVE SIREN Equipment



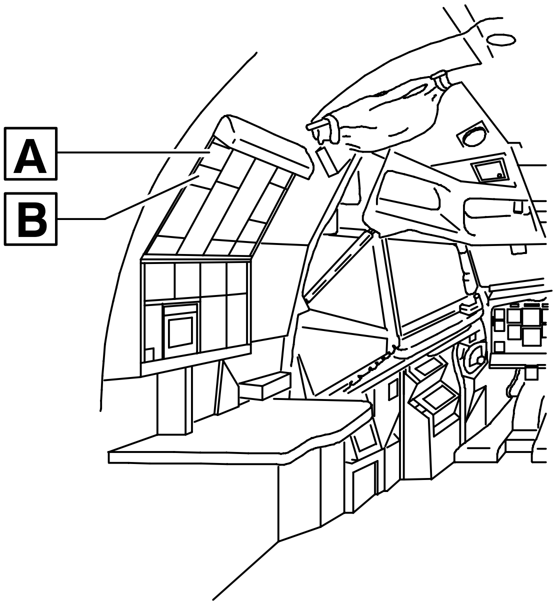
A TRANSMITTER UNIT (4 PLACES)

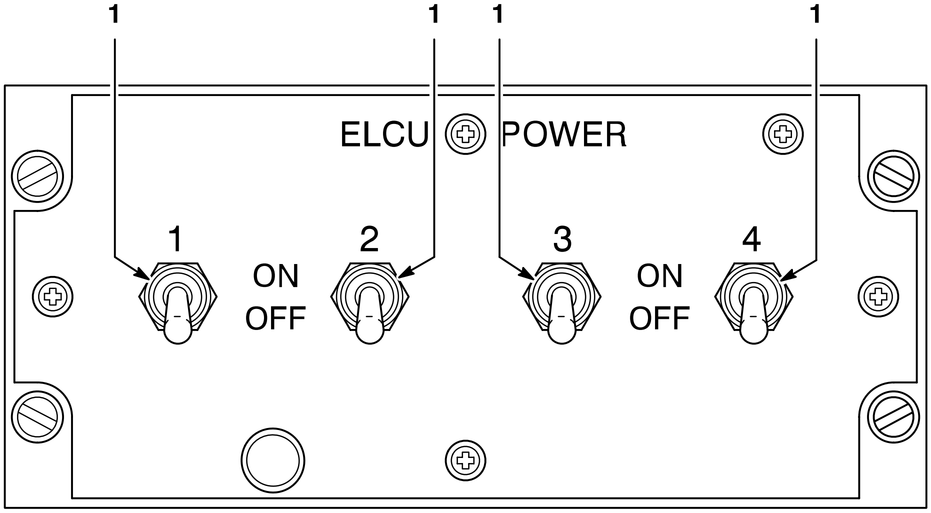
1. CONTAINER
2. COOLING AIR INLETS (COVER REMOVED)
3. TRANSMITTER UNIT
4. ECU
5. ACCESS OPENING (COVER REMOVED)

D57 543 I

Figure 1-257

HAVE SIREN Controls and Indicators

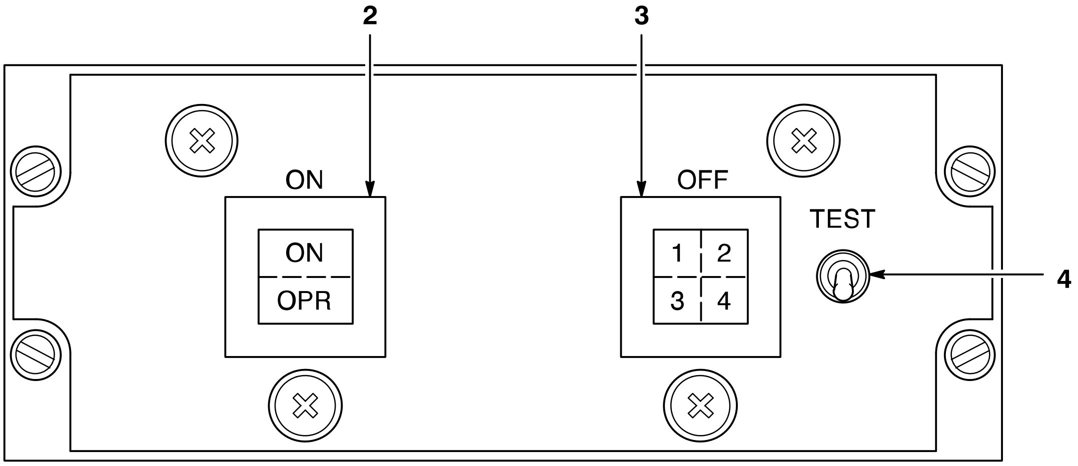




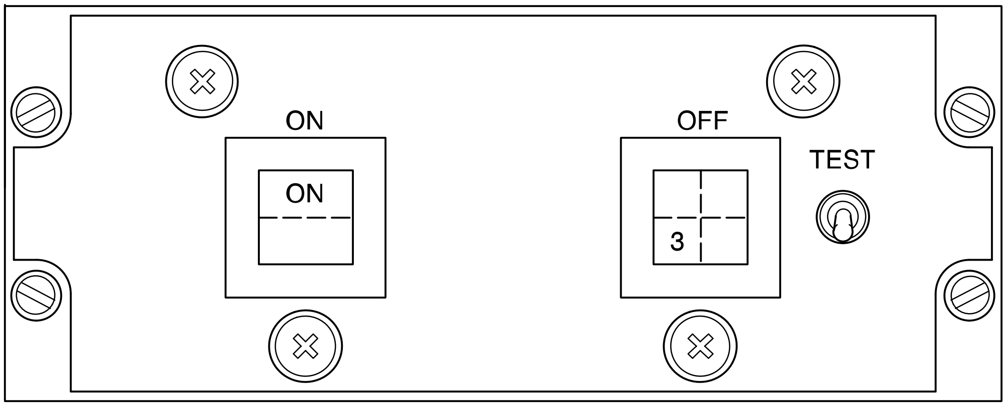
A **ELCU POWER SWITCHES**

D57 544 I

Figure 1-258 (Sheet 1 of 3)

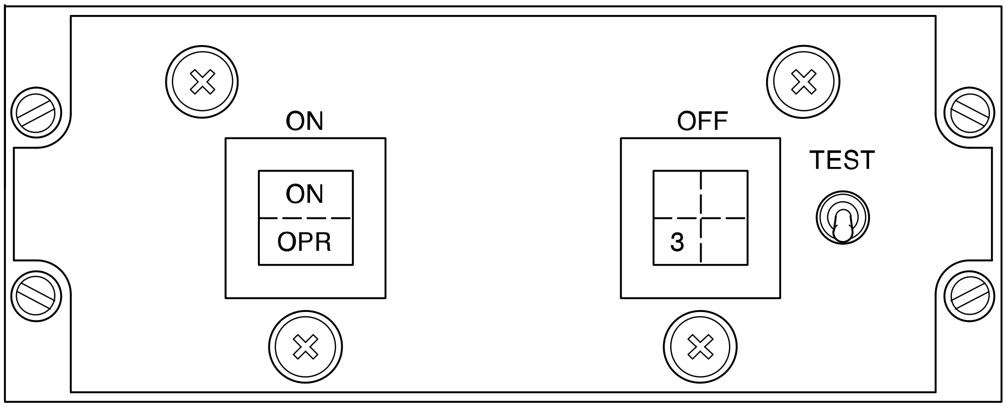


B OPERATOR CONTROL UNIT (OCU)



OPERATOR CONTROL UNIT (OCU)

INDICATES FAULT DETECTED IN TRANSMITTER SET #3 AND THAT SET #3 HAS AUTOMATICALLY SHUT DOWN. OTHER SETS ARE OPERATING NORMALLY.



OPERATOR CONTROL UNIT (OCU)

INDICATES TRANSMITTER SET #3 IS OPERATING AT A MARGINAL LEVEL. OTHER SETS ARE OPERATING NORMALLY.

D57 545 I

Figure 1-258 (Sheet 2 of 3)

HAVE SIREN Controls and Indicators (Continued)

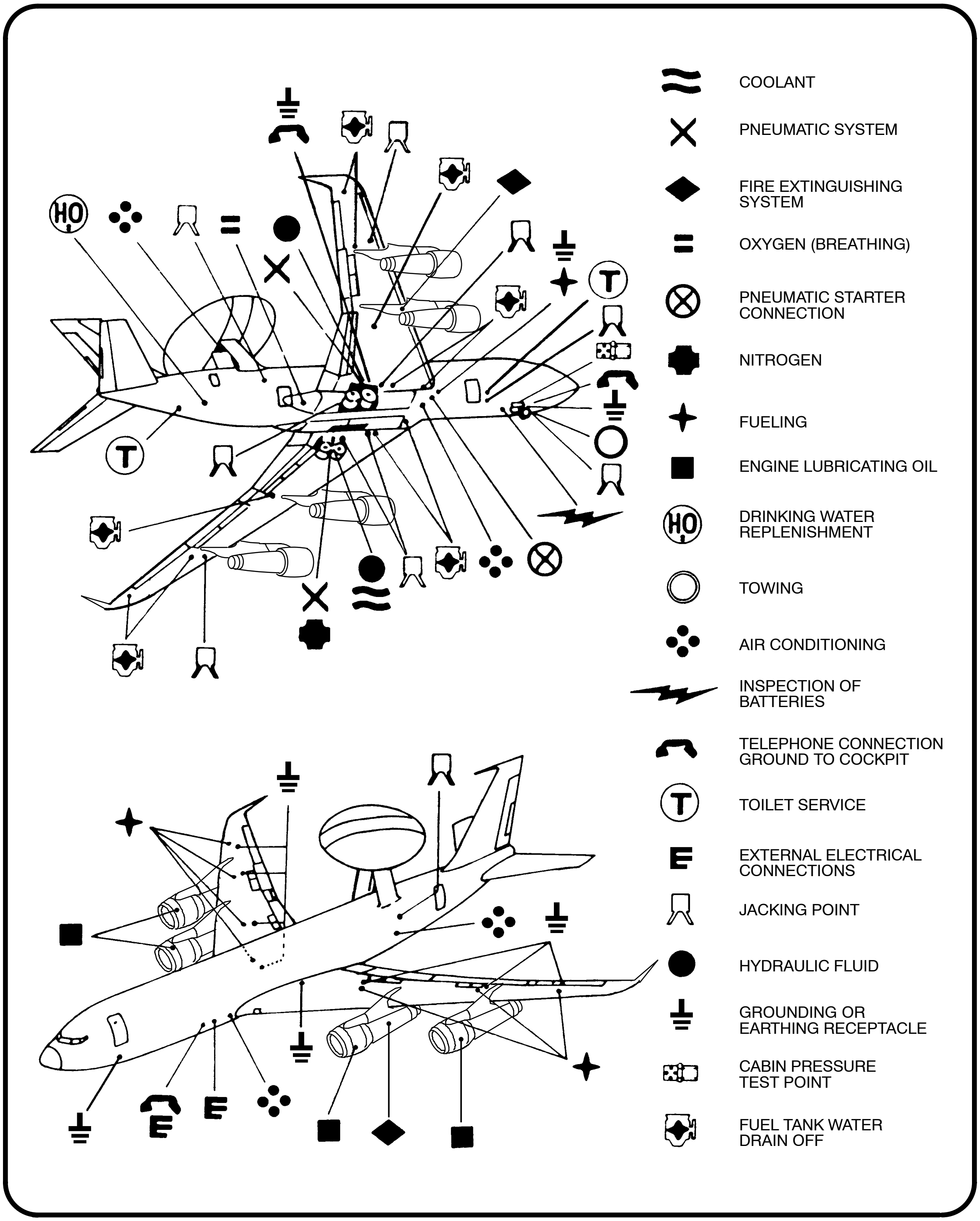
NO.	CONTROL/INDICATOR	FUNCTION
A ELCU PWR SWITCH PANEL		
1	ELCU PWR Switches, NO 1, 2, 3 and 4	When set to ON, supply 28 vdc power (from SDS PWR circuit breakers on P61-5) to close ELCU and apply 115 vac power to cooling fan and transmitter unit. When set to OFF, removes power from ELCU and transmitter.
CAUTION All ELCU switches will remain ON for at least one minute after shutdown of HAVE SIREN system to allow automatic one minute cool down cycle. NO 1 and NO 3 throttles will not be set to CUTOFF for at least one minute after HAVE SIREN system is shut down.		
B OPERATOR CONTROL UNIT (OCU)		
2	ON – OPR Switch	Momentary pushbutton switch. Turns on system when pressed.
	ON (White)	When illuminated, indicates system has been turned on. Illuminates immediately when ON switch is pressed. Normally goes out when OFF switch is pressed. If a fault caution light is illuminated when OFF is pressed, ON indicator and fault caution light remain illuminated for approximately 60 seconds (cool down period).
	OPR (Green)	When illuminated, indicates all monitored operating conditions are within normal limits on all ECUs and transmitters. Illuminates approximately 60 seconds after ON switch is pressed. Goes out when OFF switch is pressed or when a monitored condition is out of normal and allowed marginal tolerance.
3	OFF Switch	Momentary pushbutton. Removes power from system when pressed.
	1, 2, 3, 4 Caution Lights (Amber)	Illuminates if a monitored condition is out of limits in the same number system as the caution light. Systems are numbered from left to right. If OPR light is still illuminated, system is still operating, but is marginal. If OPR light is out, that unit has shut down. Units with caution lights out are still operating.
4	TEST Switch	Momentary lamp test. When set to TEST (up), illuminates all lamps in ON and OFF switches.

Figure 1-258 (Sheet 3 of 3)

Servicing

Service Point Markings

NATO STANDARD
SERVICE POINT MARKINGS



NOTE: THE SYMBOLS SHOWN ARE USED TO IDENTIFY SERVICING POINTS ON THE AIRPLANE. A COPY OF THIS PLACARD IS INSTALLED IN THE NOSE WHEEL WELL.

D57 546 SI

Figure 1-259 (Sheet 1 of 3)

Servicing (Continued)

Servicing Specifications

ITEM	MATERIAL	USAF SPEC
Fuel System	JP-8 Fuel (See section V for other fuels)	MIL-T-83133
Engine Oil System	Lubricating Oil	MIL-L-7808
Hydraulic System	Hydraulic Fluid	MIL-H-5606
Generator Drives (IDG)	Lubricating Oil	MIL-L-7808
Starter	Lubricating Oil	MIL-L-7808
Air-Conditioning Pack	Lubricating Oil	MIL-L-7808
APU Oil System	Lubricating Oil	MIL-L-7808
Oxygen System	Liquid Oxygen	None
Fire Extinguishing System, Engine and APU	Halon 1301, Bromotrifluoromethane, Install replacement bottle	None
Fire Extinguishers, Portable	Bromochlorodifluoromethane (Halon 1211)	None
Landing Gear Struts	Hydraulic Fluid	MIL-H-5606
Emergency Brakes	Air or Dry Nitrogen	None
Bailout System	Air or Dry Nitrogen	None
Water System	(Use Water Service Cart)	None
Toilet and Urinal	(Use Toilet Service Cart)	None

NOTE

Automotive antifreeze may be added to toilet and urinal in cold weather if required.

ITEM	MATERIAL	USAF SPEC
Starting Air Source ①	MA/1A	None
	A/M 32A-60A ②	None

Figure 1-259 (Sheet 2 of 3)

ITEM	MATERIAL	USAF SPEC
External Power Unit ①	A/M 32A-60A ②	60KW (200 Amp)
	EMU-G/E	60KW (200 Amp)
	MD-3A	45KW (150 Amp)
	EMU-21/U	30KW (104 Amp)
	EMU-22/U	60KW (200 Amp)
	EMU-23/U ③	100KW (350 Amp)
	EMU-24/U ③	150KW (500 Amp)
	MD-4	52.5KW (175 Amp)
	NC-10/10B (USN)	90KVA (360 Amp)
	MEP116A/ADS J	100KW (278 Amp)

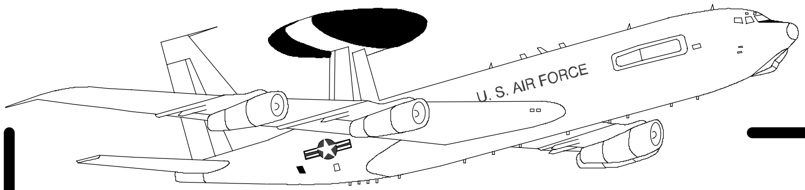
① Any commercial unit which is normally used for starting air or power for 4-engine transports may be used.

② Combined Air/Electric power source.

③ Limited to 90 KVA/360 Amp if only one external power plug is used.

Figure 1-259 (Sheet 3 of 3)

Section II



NORMAL PROCEDURES

Table of Contents

Title *Page*

Table of Contents (Continued)

INTRODUCTION TO PROCEDURES

This section contains the normal procedures for use by the pilot, copilot, and flight engineer. Steps requiring coordination with the navigator, mission crew, or ground crew are also indicated. The steps are the same as in the crewmember's abbreviated checklists, but are amplified with additional explanation and detail where required. When required by adverse weather, these procedures shall be modified by the procedures in Section VII.

WARNING

Due to the extensive modification required to equip the airplane for its mission, certain operating procedures are different from those used on other four-engine jet airplanes. Failure to follow these procedures can lead to loss of the airplane and crew in case of engine or control system failures under some conditions. Refer to Sections III and VI.

CAUTION

Because of the large amount of electronic equipment installed, procedures involving operation of equipment cooling systems shall be carefully followed. Refer to individual system instructions in Section I.

PREPARATION FOR FLIGHT

WEIGHT AND BALANCE

The flight engineer will compute the weight and balance. Refer to the Handbook of Weight and Balance, T.O. 1-1B-50. Make certain that the weight and balance clearance is satisfactory before each flight. Verify that the fuel loading is the same as that shown on the DD Form 365-4 weight and balance clearance. Refer to Section V for weight limitations and check the takeoff and anticipated landing gross weight.

TAKEOFF AND LANDING DATA (TOLD) CARDS

Before takeoff, the flight engineer will complete a Takeoff and Landing Data Worksheet. Quick reference data will be entered on the pilot's TOLD card. Refer to T.O. 1E-3A-1-1. Section VII, for instructions to fill out TOLD cards.

WARNING

Recompute applicable takeoff data if any weather or configuration change occurs greater than as follows:

Runway Temp.	5°C
Press. Alt.	500 feet
Gross Wt.	5,000 pounds
CG	0.5%

Obstacle clearance calculation must also be recomputed.

NOTE

Critical field length is increased or decreased approximately 100 feet by increases or decreases of ±1°C runway temperature, ±100 feet pressure altitude, or ±1,000 pounds gross weight.

CHECKLISTS

The flight crew is responsible for performing the checklist procedures as listed in this section, with modifications required by weather, Section VII. Performance of each item will be indicated by the appropriate response. The flight engineer normally reads all checklists. The person reading the checklist will verify that the proper action was taken by checking the actual control or indicator, where practical. If no response is given, the person reading the checklist will repeat the item and request the proper response. Crewmembers are identified by the symbols P, CP, E, N, OBS, MCC, CSO, CT, CDMT, ART and GC for pilot, copilot, flight engineer, navigator, observer, mission crew commander, airborne communications system operator, airborne communications technician, airborne computer display maintenance technician, airborne radar technician, and ground crew, respectively. The pilot will initiate all checklists requiring crew coordination. For a "through-flight" type of operation a crewmember will perform, as a minimum, those steps indicated with an asterisk (*). Where action is affected by darkness, weather, or other condition, the response AS REQUIRED/AS DESIRED is printed. Where action is affected by the desires of the user and no specific requirement exists, the response AS REQUIRED/AS DESIRED is printed. The actual setting of the control will be used as a response, for example: ANTI–ICE – On.

Steps requiring coordination between flight crew and ground crew or mission crew are indicated by a circle around the number, as ⑦ Flight engineer will report each checklist completed, on interphone.

Some checklists have alternate actions, depending on airplane conditions. These are indicated by a statement beginning and ending with three dashes, such as:

– – – If Electrical Power Is Not Applied to Airplane, Omit Step 4 – – –

If the condition is as stated, follow the directions in the statement. If the opposite condition exists, ignore the statement, and perform the step.

ALERT PROCEDURES

Alert procedures include cocking, takeoff, rapid launch (scramble), re-cocking, and alert preflight. The normal procedures in this section are used, except for certain modified steps, as noted below.

COCKING

There are three alert configurations.

Condition I (CC1) prepares the airplane and mission equipment for a survivability launch in minimum time. INU alignment must be initiated and have either entered NAV mode or displayed ATTD RDY1 (or 2) for the flight director and autopilot preflight checks to be completed, after which the GINS may be powered down. The flight crew (P, N, E) perform all normal preflight checks and mission crew (CSO, CT, CDMT, ART) performs preflight checks per T.O. 1E-3A-43-1-1. After completing normal preflight checks, the BEFORE START checklist is completed as noted for CC1. The airplane is cocked with power off.

Condition II (CC2) prepares the airplane and mission equipment for rapid launch. The airplane is cocked with power on, GINS aligned, and air conditioning as required. All normal preflight inspections are completed, as for CC1. The BEFORE START checklist is complete as noted for CC2.

Condition III (CC3) is a survivability launch, similar to CC1; however, only the airplane is prepared for launch. INU alignment must be initiated and have either entered NAV mode or displayed ATTD RDY1 (or 2) for the flight director and autopilot preflight checks to be completed, after which the GINS may be powered down. Preflight and cocking are performed by the pilot and flight engineer, using the normal preflight inspections and the BEFORE START checklist as noted for CC3. This checklist may also be used as a Buddy Preflight to minimize ground crew duty (preflight) delays.

Checklist responses for alert are shown in underscored capitals, followed by (CC1) for Condition I, (CC2) for Condition II, or (CC3) for Condition III.

ENGINE START, TAXI, AND TAKEOFF (SCRAMBLE)

Perform the normal procedures in this section, beginning with the STARTING ENGINES checklist. If GINS operation is required after scramble from CC1 or CC3 alert, navigator will perform INFLIGHT ALIGNMENT checklist.

RECOCKING

If a takeoff is not made from alert launch, perform the AFTER LANDING, ENGINE SHUTDOWN, and BEFORE START checklists, to restore the airplane to the cocked configuration. In addition, the navigator must perform the navigator's RECOCKING checklist given in Section IV, to return to alert Condition II.

ALERT PREFLIGHT (WHEN REQUIRED)

Perform BEFORE ENTERING AIRPLANE, BEFORE INTERIOR INSPECTION, and BEFORE START checklists. A pilot or flight engineer should also perform a brief visual inspection of airplane exterior to check for obvious leaks or damage and to verify that area is still clear.

Flight engineer will also perform the flight engineer's station items marked with an asterisk (*) in the INTERIOR INSPECTION checklist. On airplanes 3, 5, ▶ 9, 24, update flight loads recorder data.

UNCOCKING

Perform normal ENGINE SHUTDOWN and BEFORE LEAVING AIRPLANE checklists.

PREFLIGHT INSPECTIONS

Applicable preflight inspections are performed before the first flight of the day, after a crew change, or after maintenance of any kind (except routine servicing). The applicable maintenance preflight will be completed before the flight crew preflight procedures listed below. Duplicate inspections or operational checks of some systems by flight crewmembers are required in the interest of flying safety. If the airplane is located at a station where maintenance inspections cannot be performed, or where maintenance personnel are not familiar with the airplane, the pilot is responsible for the condition of the airplane including mission equipment.

It is the pilot's responsibility to ensure that the visual inspections of airplane interior and exterior are carried out by flight crew and mission personnel (if carried). Give particular attention to items requiring coordination with mission crew personnel.

BEFORE ENTERING AIRPLANE

This inspection is performed before any flight, to verify that no obviously unsafe items exist. All plugs and covers should be removed at this time. (This check is normally performed by flight engineer.)

*1. AFTO Form 781 – Checked, Complete (P, E)

Check AFTO Form 781 before starting preflight inspection. Verify that all required maintenance is complete and signed off.

Note GINS crypto status – keyed or unkeyed. Also note CDU software version (VSN).

*2. Hydraulic Quantity Gage – Checked (E, GC)

Ensure hydraulic quantity is 5.6 ± 0.25 gallons with flaps up, landing gear extended, right landing gear door closed, left landing gear door open, spoilers down, leading edge flaps retracted, air refueling receiver doors closed, hydraulic pumps not running and system pressure zero, and hydraulic accumulators charged. Ensure brake hydraulic system is depressurized by pumping the brakes until brake pressure gage shows no further decrease in pressure. This indicates the accumulator is at precharge.

*3. Nose Gear – Checked

a. Gear Pins – Installed

b. Gear Doors – Open, Handle in Down Detent

c. Door Actuators – Disconnected

WARNING

If gear door is open, check that door ground lock handle is in down detent to prevent door closing rapidly when hydraulic system is pressurized. Door closing can cause injury to personnel in path of door. A binding handle indicates possible binding linkage, which could interfere with emergency operation.

– – – If Electric Power Is Not Applied To Airplane, Omit Step 4 – – –

4. Airflow from Draw-Through Cooling Fan – Checked

CAUTION

If power is applied to airplane and draw through cooling flow control valve is not open, open valve manually and close fan circuit breakers. Equipment cooled by draw-through system can be damaged if airflow stops.

*5. Fuel Identiplate (DD Form 1896) – Checked, Aboard

*6. Static Ground Wires – Connected

At least one ground is required. If more than one is used, connect each to a separate ground point on the ramp.

*7. Right Main Wheel Well – Checked

a. Gear Door – Open, Handle in Down Detent

WARNING

If gear door is open, check that door ground lock handle is in down detent to prevent door closing rapidly when hydraulic system is pressurized. Door closing could cause injury to personnel in path of door. A binding handle indicates possible binding linkage which could interfere with emergency operation.

b. Chocks, Gear Pin, and Door Actuator Lock – Installed

c. Rudder Manual Shutoff Valve – Open, Safetied

d. APU Ground Fire Panel – Set

  (1) APU FIRE CONTROL Handle – Up

  (2) APU FIRE DISCHARGE Switch – OFF

NOTE

If APU fire handle is pulled down with discharge switch set to ON, APU fire extinguisher discharges.

e. Hydraulic Bypass Valve – CLOSED, Safetied

*8. Right Wing, Engines, and Control Surfaces – Clear

Verify engines and flight controls are clear of obstructions and ground equipment. Note flap position.

*9. Aft Lower Compartment General Condition – Checked

Check aft lower compartment for general condition and security of equipment and for EGW leaks.

WARNING

Sulfur hexafluoride (SF_6) gas in the mission equipment is a colorless odorless gas which is heavier than air. To prevent inhaling SF_6, open aft cargo door, move away from door and allow compartment to ventilate for one minute before entering the airplane. Refer to SULFUR HEXAFLUORIDE (SF_6) LEAK, Section III.

NOTE

If EGW leak or spill is found on preflight, do not accept airplane for flight until maintenance has determined whether the problem is a leak or spill and has removed as much of the liquid as possible. If leak is in pressurized portion of LCS, it should be repaired before flight unless maintenance determines that leak is not a hazard to electrical components and that LCS pressure and quantity are likely to remain adequate for planned radar operating time. In this case, mission may be flown as planned.

a. Oxygen Manual Shutoff Valve – Open, Safetied

b. Power Feeder Duct Fan Exhaust – Checked

APU generator must be on to perform inspection.

c. APU – Checked

  (1) APU Fire Bottle Pressure – Checked

  For correct fire bottle pressure, see *figure 1-27*.

  (2) Accumulator Pressure – As Required for Start

  2,500 psi if temperature is above-18°C (0°F). 3,000 psi if temperature is between -18°C and -40°C (0°F and -40°F), 3,500 psi if temperature is below -40°C (-40°F). Use both accumulators for starts at temperatures below -29°C (-20°F).

  (3) APU MANUAL START Switch – NORM, If Battery In Airplane

  Switch is visible through view port in start box cover. Switch must be set to NORM unless manual start is intended.

WARNING

If battery power is not available, interphone, lower compartment lights, and APU fire detector and extinguisher are inoperative. With these systems inoperative, any APU malfunction can develop into a serious condition before adequate countermeasures can be taken or personnel be warned. Therefore, APU operation without battery is prohibited except as stated under EMERGENCY TAXI.

(4) APU Access Door Assemblies – CLOSED

Ensure front and aft cover access door assemblies are closed. Door bosses may be adjusted as necessary to ensure a tight fit.

*10. APU Exterior Area – Checked

a. Inlet and Exhaust Doors – Clear

b. APU Shroud Drains – Clear, No Leakage

*11. Left Main Wheel Well – Checked

a. Gear Door – Open, Handle in Down Detent

WARNING

If gear door is open, check that door ground lock handle is in down detent to prevent door closing rapidly when hydraulic system is pressurized. Door closing could cause injury to personnel in path of door. A binding handle indicates possible binding linkage which could interfere with emergency operation.

b. Chocks, Gear Pin, and Door Actuator Lock – Installed

c. Hydraulic Filter Differential Pressure Indicators – Checked

If filter indicator is extended, reset. If the indicator extends again, the filter element shall be replaced.

d. Hydraulic Quantity – Checked

Reservoir sight gage should indicate full.

e. Utility Reservoir Air Pressure Gage – Checked

Reservoir pressure should be 20 to 50 psi.

CAUTION

Verify air pressure gage shows at least 20 psi. If not, have maintenance pressurize reservoir to at least 20 psi. Do not start auxiliary pumps until reservoir is pressurized. Pumps can be damaged by cavitation if fluid supply is not pressurized.

*12. Left Wing, Engines, and Control Surfaces – Clear

Verify engines and flight controls are clear of obstructions and ground equipment. Note flap position.

*13. Ground Crew and Equipment – Positioned

Verify that required fire equipment is in position for APU start. Verify ground crew, interphone, ground air source and external power (if required) are in position for preflight checks.

BEFORE INTERIOR INSPECTION

This safety check is performed, with power on or off, before any preflight or through flight inspection to prevent possibility of damage to airplane or injury to personnel if a system is operated inadvertently. Flight engineer performs this inspection.

*1. AFT AFAC Ground Maintenance Panel Switch – TAKEOFF

Insures cooling air is provided to rack E14 if operating in the ENG/APU mode.

Check diverter valve closed if in ENG/APU mode.

CAUTION

If diverter valve is not closed, close valve manually for adequate cooling in selected racks.

*2. Ground Maintenance Forced Air Cooling Interface Panel – Checked (E)
SDU-34 Switch-OFF

NOTE

If the SDU-34 switch is left in the ON position, the SUPPLY AIR temperature gage on the flight engineer's FORCED AIR COOLING panel does not read correctly. Automatic temperature protection and warning circuits are fully operative.

*3. Computer Operator Station – Checked (E or CDMT)

a. Data Display POWER Switch – OFF, Guard Closed

Located on E23 rack.

CAUTION

This switch is guarded, but the guard does not move the switch to OFF when closed. Open the guard, check that switch is OFF, then close guard.

b. System Power Switch – OFF

Located on computer control panel.

c. DDI Power Switch – OFF

Located on DDI panel.

d. CPS Power Input ON/OFF Switch – OFF

Located on bottom of CSP panel.

e. OBTM&M Power Panel IFF and DD&C Switches – OFF

Located above DDI panel.

f. ESMG POWER Switch – Off

Switch extended; lights not illuminated.

*4. Communications Console – Checked/SET (E or CT)
LESS IDG Ensure UHF and VHF are set up for radio checks ◀
WITH IDG Ensure UHF, VHF 1 and VHF 2 are set up for radio checks ◀
COMM DISCONNECT panel switchlights 1 through 5 OFF (if AC power is applied).

NOTE

When battery power is applied, all lights on the COMM DISCONNECT panel illuminate. This is normal.

*5. Flight Engineer’s Station – Checked (E)

a. FLT AVX DISC CONT Circuit Breaker Closed (in) (P61–6)

b. COMM DISC CONT Circuit Breaker Closed (in) (P61–6)

CAUTION

Applying power to the airplane without ensuring that the FLT AVX DISC CONT and COMM DISC CONT circuit breakers are closed bypasses the AVIONICS POWER DISCONNECT and COMM DISCONNECT panels and applies uncontrolled power directly to all equipment normally controlled by these two panels. This could result in equipment damage if required cooling is not available.

*6. AVIONICS POWER DISCONNECT Panel – Check/Set (E)

– – – If No Electrical Power is Applied to Airplane – – –

a. COMM FWD and COMM AFT Switches – DISC

b. FLT AVIONICS BUS 1 and BUS 2 – DISC

– – – If Electrical Power is Applied to Airplane – – –

c. COMM FWD and COMM AFT Switches – DISC

d. FLT AVIONICS BUS 1 and BUS 2 – NORM

*7. EMERGENCY POWER Switch – As Required

NORMAL if airplane is powered; OFF if not powered.

WARNING

Whenever external electrical power is applied to the airplane, one of the access doors must be open, or air conditioning must be on, to supply air to the main cabin for the draw through-cooling system. Failure to do so causes a pressurization effect within the airplane, causing damage to equipment and/or injury to personnel.

*8. BATTERY Switch – ON

Applies power to battery bus.

*9. Fuel PUMPS Switches – OFF

*10. Auxiliary Hydraulic Pumps Switches – OFF

*11. EMERGENCY FLAP Switches (3) – OFF

  a. Arming Switch – OFF, Guard Closed

  b. INBD, OUTBD Switches – OFF

  Prevents electrical operation of flaps.

*12. WINDSHIELD WIPER Switch – OFF

*13. Navigation Lights – ON

*14. Gear Lever – Down, In (Three Green Lights if Sync Bus Powered)

Gear lights and lever latch are off if no AC electrical power on airplane.

WARNING

Do not set landing gear lever to OFF when airplane is on ground. This depressurizes nose gear actuators and could collapse nose gear.

*15. Flap Lever – With Flaps ±3°

Set flap lever to actual flap position. Since flap gages operate electrically, gage indication may not match flap position until power is applied to airplane. Gage tolerance is ±3° with power on.

*16. Weather Radar – OFF (E, N)

*17. Fuel Dump Panel – Cover Closed

INTERIOR INSPECTION

Airplane controls and systems are checked and set in proper configuration for engine start. This inspection is normally performed by the flight engineer. If either navigator or pilots are on board, they may perform inspection steps at their stations. A typical inspection route is shown in the inspection procedure for Mission Crew Compartment.

Flight Deck Inspection

Flight Engineer's Station

*1. Circuit Breakers – Checked (E)

  a. All breakers closed (in) or banded/tagged open.

  b. SDS PWR (P61-5) Closed, if system to be used.

*2. AVIONICS POWER DISCONNECT Panel – Checked/Set (E)

  a. COMM FWD and COMM AFT Switches – DISC

  b. FLT AVIONICS BUS 1 and BUS 2 – NORM

*3. **LESS IDG** VHF ◀ **WITH IDG** VHF 1 ◀ – ON (E)

*4. EMERGENCY POWER Switch – OFF, MANUAL ON, NORMAL

  a. When set to OFF, ensure APU accumulator pressure gages indicate zero and UHF radio lights are not illuminated. Ensure **LESS IDG** VHF ◀ **WITH IDG** VHF 1 ◀ radio is unpowered.

  b. When set to MANUAL ON, ensure UHF radio and emergency power ON caution lights are illuminated. Ensure APU accumulator pressure gages show the pressure indicated prior to turning the switch to OFF. Ensure **LESS IDG** VHF◀ **WITH IDG** VHF 1◀ radio is powered.

  c. When set to NORMAL and SYNC bus is not powered, indications are same as when set to MANUAL ON. If SYNC bus is powered, there are no indications. Ensure **LESS IDG** VHF◀ **WITH IDG** VHF 1 ◀ radio is powered.

*5. Batteries – ON and Checked

BATTERY switch set to ON. DC meters switch set to AV BATT, LTG BATT and voltage 26 or above on each battery. DC ammeter indicates load. If SYNC bus is powered, there is no indicated DC load.

*6. BUS TIE OPEN Switches – Closed

*7. APU BLEED Switch – OFF

⑧ Communications – Checked (E, GC)

a. MAINT INTPH Selector Switch – As Desired

b. Interphone – Checked

For alert preflight, check all ADS panels.

c. UHF and **LESS IDG** VHF RADIO◀ **WITH IDG** VHF Radio #1 ◀ – Checked

Contact ground stations as required for fire protection.

WARNING

Do not transmit on VHF–AM radio on ground unless personnel are a minimum of ten feet from radiating antennas.

CAUTION

- Do not operate UHF radio until draw through cooling is operating.
- Do not operate radios until cabin temperature is below 100°F. Refer to HOT DAY CABIN COOLING, Section VII.

⑨ Electric Power and APU – Checked and As Required

a. APU FIRE Warning – Test (E, GC)

Coordinate with ground crew for APU fire warning test.

b. APU – Started, If Required

(1) Set ACCUM switch to No 1 or No 2 if temperature is above -29°C (-20°F) or BOTH if temperature is below -29°C (–20°F).

(2) Set (and hold) APU CONTR switch to START. APU accumulator pressure drops. The EGT rises.

CAUTION

- Monitor EGT. If EGT is above 650°C (except between 650°C and 720°C for no more than 10 seconds during start or load application) or if EGT exceeds 720°C at any time, shut down APU.
- Set APU CONTR switch to STOP if EGT does not start to rise within two seconds of APU accumulator pressure stabilizing after drop for APU starter. Wait five minutes, then switch to other accumulator for second attempt.

NOTE

- An automatic five minute time delay must expire before a second start can be attempted.
- If the airplane is fueled with JP-5 or JP-8 and fuel temperature is below -30°C (-22°F), it can be difficult or impossible to start the APU.

(3) When ON SPEED indicator illuminates (30 seconds at 0°F and above, 60 seconds below 0°F measured from time EGT starts to rise), set APU CONTR switch to run.

– – – If External Power Is In Use and Total Load Is Above 170 Amperes, Reduce Load Below 170 Amperes Before Connecting APU Generator – – –

c. Set APU GENERATOR or EXTERNAL POWER Switch – ON

CAUTION

- If external power unit is connected to airplane and AVAIL indicator is not illuminated, verify plug is in connector 1A, then set EXTERNAL POWER switch to OFF before setting APU GENERATOR switch to ON.
- When connecting external power, wait seven seconds after external power source is connected to external receptacles or BATTERY switch is set to ON, whichever occurs last, before pressing EXTERNAL POWER switch to ON. This allows BPCU to complete its power quality checks. If external power is switched ON sooner, a power source out of tolerance in voltage or frequency can damage both airplane systems and the external power cart.
- If APU shuts down during power transfer, or shuts down for no apparent cause, have condition of APU accessory drive shaft checked prior to any restart attempt.

d. AC and DC Meters – Checked

(1) Check AC voltage and frequency; verify frequency is steady.

(2) Check DC voltage and amperage on all TRUs.

e. APU BLEED Switch – ON, Unless Using External Air

*10. Flight Engineer Panel Lights – Checked and Set

Set IND LT switch to TEST. Verify all lamps in switches and indicators are illuminated. Adjust TABLE, CKT BKR, PANEL, and BACK-GROUND light controls as required. RADAR OFF indicator does not illuminate if radar CONTACTOR POWER circuit breaker on P67-2 is open.

*11. Forced Air Cooling – Checked and On

a. POWER Switches – On

b. SYSTEM SELECT Switch – AFT

c. MODE Switches – ENG/APU, Unless on External Air

d. FAN 1 or FAN 2 switches – AFT FAN 1 or AFT FAN 2 on LOW SPD unless on external air.

NOTE

Alternate AFT FAN 1 and AFT FAN 2 between flights. Record fan used.

e. AFT NO FLOW Caution Light – Out

f. RAM VALVE OPEN Indicators – Out

g. System Control Switches – AUTO

h. DESCENT Switch – Off

i. FACS FAN FWD/AFT Switches – Normal

j. UNPRESS/OB VALVE Switches – Off (Center)

*12. Draw Through Cooling – Checked and On

a. AUTO Indicator – Illuminated

b. LOW SPEED Indicator – Illuminated

c. VALVE OPEN Indicator – Illuminated

d. NO FLOW Indicator – Out

*13. AVIONICS POWER DISCONNECT Panel – Checked/Set (E, CSO)

a. COMM FWD Switch – DISC

b. COMM AFT Switch – NORM

Applies power to UHF-ADF and HF-1.

*14. ROTODOME DRIVE – Set and OFF

a. System Select Switch – As Required

Alternate utility and auxiliary drive between flights. Record drive used.

b. SPEED Switch – OFF

c. UTIL LUB or AUX LUB LOW PRESS Caution Light – Illuminated

Light for selected system illuminates.

*15. Hydraulic System – Checked and Set

a. ENGINES 2 and 3 FLUID SHUTOFF Switches – On

b. ENGINES 2 AND 3 PUMP Switches – On, PRESS Caution Lights Illuminated

c. UTILITY HEAT EXCH Switch – Depressed

ORIDE and OHEAT lights out.

d. Utility Hydraulic Pressure Gages – Zero (±100 psi)

e. Auxiliary and Utility Rotodome Shutoff Valve Switches – On

Lights out.

f. INTCON VALVE Switch – SYS

g. AUXILIARY HEAT EXCH Switch – Depressed

ORIDE and OHEAT lights out.

h. Auxiliary Pump No 2 Switch – On, Pressure Checked

Auxiliary hydraulic pressure gage indicates at least 2,800 psi. RUDDER BOOST low pressure warning light (center instrument panel) out. Rudder mode indicator shows 3,000 psi.

i. BRAKE PRESS Gage – 2,500 psi or Less

Depress brake pedals to deplete brake system to 2,500 psi.

j. Auxiliary Pump No 1 Switch – On

k. BRAKE PRESS Gage – 2800 psi MINIMUM.

l. Utility Hydraulic Pressure Gages – Zero (±100)

*16. Fuel System – Checked, Set

a. Heat Exchanger Overheat Caution Lights – Test

Observe that the four OHEAT caution lights illuminate.

b. Fuel Quantity Gages – Test

FUEL QUANTITY gages run toward zero. If fuel quantity is low, QUANTITY LOW caution light illuminates when gage total reaches 9,000 pounds.

c. MASTER REFUEL Switch – ON

d. REFUEL VALVES Switches (7) – OFF

If line light remains illuminated after pressing switch, check ground refueling panel for proper setting.

e. MAIN VALVE Switch – CLOSE

f. SLIPWAY DOORS OPEN-CLOSE Switch – CLOSE

g. SLIPWAY DOORS NORM–ALTER Switch – NORM

h. SIGNAL AMPL Switch – NORM

i. MASTER REFUEL Switch – Off

j. Air Refueling Accumulator Pressure Gage – Checked

Pressure at least as shown on placard.

k. Reserve Tank Transfer Switches – OFF

l. Fuel Pumps – On

To pressurize fuel lines.

NOTE

Boost pump low pressure caution light should illuminate momentarily when pump switch is pressed. Maintenance will be performed if any tank boost pump low pressure caution light does not illuminate momentarily when switch is pressed.

m. Heat Exchanger Switches – As Required

Set heat exchanger switches to ON if radar to be operated.

n. Fuel Temperature – Checked

Set temperature selector switch to 1, 2, 3, 4 and check temperature in each main tank.

o. CROSSFEED Switches – As Required

At least one open. Check all crossfeed valves for proper operation.

Refer to FUEL MANAGEMENT, subsection I-D.

p. FUEL HEAT Switches – Off

q. TOTAL FUEL REMAINING Gage – Set

Set to gage or dripstick total.

*17. Electrical System – Checked

a. IDG LOW RPM Lights – Illuminated

b. IDG Overheat Lights – Out

c. IDG Disconnect Switches – Guard Closed, Safetied

d. AC Ammeters – Checked, Zero

e. Generator OFF Lights – OFF Illuminated

Line lights out.

f. BUS TIE OPEN Lights – Out

Line light illuminated.

g. RADAR Switch – Depressed, Guard Closed

OFF light out.

*18. Engine Instruments – Checked

N_2 RPM and oil pressure, approximately zero. Oil temperature ambient or above. Oil quantity gage is malfunctioning if quantity indication is less than 0.25 gallon.

*19. IDG Oil Temperature Indicators – Checked

a. IDG WARN DISC Switch – Up (Normal Position)

b. IDG TEMP TEST Switch – Down, Hold

c. All IDG Temperature Indicator Channel Pointer – Above 190°C

d. OHEAT Segment of ALL IDG DISC Switchlights – Illuminated

e. Copilot's IDG OHEAT Annunciator – Illuminated

f. IDG TEMP TEST Switch – Release

g. Copilot and IDG DISC Switchlight OHEAT Lights – Out

h. IDG Temperature Indicator Channels – Ambient

*20. Pressurization – Checked and Set

a. RATE Knob – On Index Mark

b. Pressurization Mode Switch – LANDING

c. CABIN ALTITUDE Scale – Set

Select cruise settings between 5,000 feet and 8,000 feet cabin altitude. For local flights, set field elevation.

d. Barometer Correction Scale – Set

Set to current altimeter setting.

e. Outflow Valve Balance Knob – NORMAL

f. Manual Control Knob – Set to HOLD

g. Rate Control Switch – AUTO

h. Cabin Rate of Climb Gage – Zero ± 50 Ft/min

NOTE

If OAT less than 15°C (59°F) do not adjust gage to zero until after flight engineer's panel lights have been on for 10 minutes.

i. Cabin Altimeter Barometer – Set to 29.92

j. CABIN DIFFERENTIAL PRESSURE Gage – Zero

21. Clock – Wound, Set

*22. Bleed Air and Air Conditioning – Checked and Set

a. Engine BLEED AIR Switches – OFF

b. OVERPRESSURE Caution Light – Out

c. FIREWALL CLOSED Indicators – Illuminated

d. OVERHEAT Caution Lights – Out

e. LEAK Caution Lights – Test and Off

(1) LEAK TEST Switch/Caution Light – Press and Hold

(2) All Three LEAK Caution Lights – Illuminated

(3) LEAK TEST Switch/Caution Light – Release

f. ISOLATION Valve Switches – Checked Off, then On

g. ALTERNATE Switch – Checked On, Then Off

h. PRIMARY Switch – Checked

On if air conditioning needed.

i. RAM AIR Switch – Off

j. TRIM AIR Switch – On

k. RAM INLET Gage – Full COOL

l. Pack AUTO–MAN Switch – AUTO

m. Pack OVERHEAT and TRIP Caution Lights – Out

n. ICING Caution Light – Out

o. GASPER AIR Switch – As Required

p. Zone Temperature Selector Knobs – AUTO Range

Set as required within AUTO range.

q. Zone OVERHEAT Caution Lights – Out

r. COMPT–DUCT Temperature Gages – Check

*23. Oxygen, Interphone – Checked, ON, 100%

The oxygen preflight may be completed before this checklist if desired.

a. Set oxygen SUPPLY lever to ON.

b. Connect and don mask, and if available, anti-smoke goggles.

c. Check NORMAL and 100% settings.

Set EMERGENCY lever to NORMAL and diluter lever to 100%. Check flow indicator shows white during inhalation and black during exhalation. Pressure should be 290 to 430 psi.

d. Check EMERGENCY and 100% settings.

Set EMERGENCY lever to EMERGENCY. Check mask for proper fit and serviceability of hoses and connectors. Hold breath and check for no flow around edges of mask (blinker remains black). White blinker indicates a leak. If anti-smoke goggles are available, pull vent valve knob out and verify airflow through anti-smoke goggles. Push vent valve knob in and verify airflow through anti-smoke goggles stops.

e. Breathe normally for two to three cycles.

Blinker shows white during inhalation, black during exhalation.

f. Check NORMAL and NORMAL settings.

Set EMERGENCY and diluter levers to NORMAL. Blinker should show white during inhalation, black during exhalation.

g. Check NORMAL, 100% and OFF setting.

Set EMERGENCY lever to NORMAL, set SUPPLY lever to OFF. (Regulator with test connector and no placard on front should move automatically to 100%.) Set diluter lever to 100% if required. Attempt to breathe through mask. Ability to breathe indicates faulty regulator.

WARNING

Some regulators with test connector on front panel (subsection I-V) do not move diluter lever to 100% when SUPPLY lever is set to OFF. These regulators are usually placarded NO OFF PROTECTION. Always verify diluter lever is set to 100% when setting SUPPLY lever to OFF.

h. Set SUPPLY lever to ON.

i. Check oxygen mask microphone assembly.

j. Check anti-smoke goggles for serviceability.

k. Ensure the vent valve on the quick don oxygen mask is pushed in.

l. Stow mask.

*24. Fire Extinguisher – Checked, Stowed

*25. Portable Oxygen Bottles – Checked, Stowed

Charged to between 290 and 430 psi.

NOTE

If the portable oxygen bottle is depleted to 10 psi or less for over two hours or if the time it has been depleted cannot be determined, the portable oxygen bottle must be purged. If inflight purging is required, purge it by recharging, then discharging (by setting the regulator to EMRG) to approximately 50 psi. Repeat two more cycles, then recharge to system pressure.

*26. Fuel Dump Panel – Checked

Press to test dump chute caution lights and dump valve indicators. Check lights are out, switches set to OFF or (CLOSE), cover closed. Cover should not close unless switches are set to OFF.

*27. Liquid Oxygen Quantity – Checked, Light Off

a. TEST Button – Press, Release

Gage pointer moves toward zero. Low warning light illuminates at 7.5 liter indication.

b. Quantity – Checked

*28. Door Warning Panel – Checked

a. DOOR WARNING TEST Button – Press

Verify all warning lights on.

b. DOOR WARNING TEST Button – Release

Verify all lights off, except for doors left open.

*29. Crash Axe – Stowed

*30. Manual Gear Handle – Checked, Stowed

Verify pin is attached and installed.

*31. First Aid Kit – Checked, Stowed

Verify red seal is not broken.

*32. Navigator's ELCU PWR Switches – As Required

ON if HAVE SIREN system to be used.

*33. Navigator's and Observer's Oxygen – OFF, 100%

Unless seats are occupied.

*34. Firefighter's Gloves – Stowed (Flight Engineer's Seat Pocket)

Pilot's Station

1. Overhead Panel and Dome Lights – As Required

2. Standby Compass – Extended

3. COMPASS Light Switch – As Required

*4. Fire Warning – Checked

  a. FIRE Switches – In

  Push switches in to verify. Full switch travel is approximately 1/2 inch.

  b. Bottle Transfer Switches – NORM

  c. Fire TEST Button – Press and Hold

  Hold until all four engine fire warning lights, WHEEL WELL FIRE warning light, and LOOP SHORT caution lights are illuminated. There is a short time delay before the WHEEL WELL FIRE warning light illuminates.

  d. Master FIRE Warning Light – Press

  Silence fire bell by pressing master FIRE warning light each time bell rings. FIRE warning lights and LOOP SHORT caution lights remain illuminated.

  e. Fire TEST Button – Release

  All fire warning lights out.

5. Compasses – Set and Checked

Set controller to latitude. Set N or S. Set to SLAVED.

Check heading indicated on HSIs and RMIs agree within 2.5 degrees of each other.

6. Antiskid – TEST and ON

  a. ANTI SKID Switch – ON, Guard Closed

  b. TEST Switch – OUTBD, INBD, OFF

  INBD REL indicators illuminate when test switch is set to OUTBD. OUTBD REL indicators illuminate when test switch is set to INBD.

7. NACELLE ANTI–ICE Switches and Indicators – OFF and Tested

Press to test VALVE OPEN indicators and verify indicators remain out after test.

*8. CONTINUOUS IGNITION Switch – OFF

*9. Engines 1 and 2 Start Selector Switches and VALVE OPEN Indicators – OFF and Tested

Press to test VALVE OPEN indicators and verify indicators remain out after test.

*10. TACAN 1 and 2 Function Selectors – T/R

*11. RUDDER, Rudder Override, and SPOILERS Switches – Checked

  a. RUDDER Switch – ON, Guard Closed, Safetied

  b. Rudder Override Switch – NORMAL, Guard Closed, No Safety Wire

  c. SPOILERS Switches – ON, Guards Closed, No Safety Wire

NOTE

If rudder override or SPOILERS switches are safety wired, remove safety wire.

12. Yaw Dampers – Checked, Series ON

  a. SERIES Switch – OFF

  b. PARALLEL Switch – ON

  c. PARALLEL TEST Switch – L, R, Then OFF

  Rudder pedals, rudder, and parallel damper indicator move left then neutral when left position selected; rudder pedals, rudder, and parallel damper indicator move right then neutral when right position selected.

d. SERIES Switch – ON

Check parallel yaw damper disengages.

e. SERIES TEST Switch – L, Then OFF

Rudder (RUD) indicator moves left, then neutral. When switch is released, indicator moves right, then neutral.

f. Parallel Disengage Caution Light – Press to Reset

*13. Emergency Exit Lights Switch – ARMED, Guard Closed

*14. NO SMOKING Sign Switch – ON

15. SLIPWAY Lights Switch – OFF

16. FUEL ENRICHMENT Switch – OFF

*17. Engines 3 and 4 Start Selector Switches and VALVE OPEN Indicators – OFF and Tested

Press to test VALVE OPEN indicators and verify indicators remain out after test.

*18. ADF Function Selector – ADF

*19. **LESS IDG** VHF Communications Radio – ON ◀
WITH IDG VHF Communications Radios – TR+G

VHF 1 is available through copilot's RCU. VHF 2 is either available or can be monitored through pilot's RCU. VHF 2 is controllable from the flight deck if selected at P73 console; otherwise it is controlled from the P73 console and may be monitored via pilot's RCU. Whether controlled or monitored (or even not monitored, by the pilot's RCU being switched OFF), it may still be made available for transmit/receive under a flight deck ADS push if selected at P73 programming and display panel. ◀

*20. **LESS IDG** IFF MASTER Switch – STBY ◀

*21. **LESS IDG** IFF MODE 4 ON/OUT Switch – ON ◀

*22. **LESS IDG** IFF CODE Switch – Not Zero ◀

23. LIGHT OVERRIDE Switch – OVERRIDE, NORMAL

Appropriate flight deck lights full bright, then normal (subsection I–T).

*24. CVR/DFDR/CPL – Checked

NOTE

This check is normally performed on APU or airplane power. When performing this check using external generator power, the GNDPWR switch must be placed in the ON position. The GNDPWR switch is located behind the DFDR/CVR access panel in the aft cabin area (FS1440).

a. CVR/TEST Pushbutton – Press to Test

Verify FDAU, DFDR, and CVR indicators illuminate.

b. UHF – Tuned to 243.00 MHz

c. Communications – Established

Notify ground control/tower of a CPL test and to monitor signal for verification.

WARNING

Do not transmit on VHF–AM radio on ground unless personnel are a minimum of ten feet from radiating antennas.

d. CPL Switch – ON, for 3 Tone Cycles

e. CPL Switch – RESET, No Tone

f. CPL Switch – AUTO, No Tone, Guard Closed

g. CVR TEST Switch – TEST, CVR Indicator Illuminated, Guard Closed

h. DFDR/FDAU Switch – DFDR, Hold

DFDR indicator illuminated within 5 seconds.

i. DFDR/FDAU Switch – NORM

DFDR indicator out within 12 seconds.

j. DFDR/FDAU Switch – FDAU

FDAU indicator illuminated within one second. If DFDR indicator illuminates, disregard.

k. DFDR/FDAU Switch – NORM, Guard Closed

DFDR indicator out within 20 seconds. FDAU indicator out within 5 seconds.

l. UHF Radio – As Required

m. If the check was performed using external power, place the GNDPWR switch in the OFF position and replace the access panel.

25. MARKER BEACON – TEST and ON

a. Power Switch – ON

b. Sensitivity Switch – TEST

All marker beacon lights (pilot's panels) illuminated. Verify appropriate tones over headset.

c. Sensitivity Switch – LOW

*26. RADIO ALTIMETER Switch – ON

27. EMERGENCY FLAP Switches – OFF, Guard Closed

INBD and OUTBD switches off and arming switch guard closed.

28. IFF TRANSPONDER Switch – ON

At power on, IFF is in STBY until PBIT completes. No IFF transmissions occur during PBIT. PBIT requires 11 seconds. Following PBIT, the IFF assumes the configuration commanded by the controlling CDU.

If PBIT fails, VSI shows TCAS flag and the RT or ANT fault latching indicator on the front of the IFF unit in the E1 rack turns white. Determine and correct cause of failure.

29. Mach Warning Test Switch – Press

Press switch to test. Verify Mach warning sounds.

30. WINDOW HEAT – Test and OFF

a. WINDOW HEAT CMDR and PILOT Switches – LOW

b. OVERHEAT Lights – Press to Test

Verify lights illuminate.

c. WINDOW HEAT CMDR and PILOT Switches – OFF

Verify lights out.

31. PROBE HEATERS – Checked and OFF

Press to test HEAT OFF indicators. Verify all five indicators illuminate. Set PROBE HEATERS switches to ON. Confirm HEAT OFF indicators out, then set PROBE HEATERS switches to OFF.

32. Overhead Panel Latches – Closed and Secured

33. Pilot's Escape Straps – Checked

a. Strap Attachment – Secure

b. Strap – Stowed, Cover Closed

34. Pilot's SHOULDER and FOOT HEATERS Switches – OFF

35. Pilot's FLIGHT KIT and MAP LIGHTS Switches – Checked

*36. Pilot's Oxygen Regulator – OFF, 100%

37. PNEUMATIC BRAKE Handle – OFF, Safetied

*38. Pilot's Panel Lights – Checked and On (IND LIGHTS Switch TEST, BRT)

Verify all lights except IDG OHEAT warning annunciator illuminate when switch set to TEST.

39. Yaw Damper Disengage Light – Out

*40. VHF NAV 1 and 2 Radios – On

*41. Engine Instruments – Checked, No Flags

Four OIL PRESS caution lights illuminated. EPR gages indicate approximately 1.06. EPR bugs free to move. Set takeoff EPR setting. N_1 RPM and fuel flow gages indicate zero. EGT gages indicate ambient or above. Warning flags retracted in all instruments.

*42. Landing Gear DOOR Warning Light – Checked

Light illuminated if any gear door open.

*43. GEAR Warning Light – Out

*44. Gear Lever and Lights – Down, In, Three Green Lights

45. Stabilizer Trim Wheel Handles – Stowed

*46. Flaps – 14

*47. No. 3 Throttle – Vertical

*48. Takeoff Warning Horn and Stick Shaker – Checked

Horn sounds intermittently if flaps are not at 14, stabilizer trim not in the green band, and/or speed brake lever out of detent. Stick shaker operates if flaps are not at 14.

   a. Flap Lever – UP

   Move flap lever to approximately 7 degrees.

   b. Warning Horn and Stick Shaker – Horn sounds intermittently and stick shaker operates

   c. Flap Lever – 14

   Takeoff warning horn sounds and stick shaker operates until flaps reach approximately 14. INBD and OUTBD flap gages both indicate 14 ± 3. Both LE FLAP indicators illuminated.

   d. Warning Horn and Stick Shaker – Off

   e. SPEED BRAKE Lever – Out of Detent

   Move lever to approximately 8 degrees on scale.

   f. Warning Horn – Sounds intermittently

   g. SPEED BRAKE Lever – Full Forward, In Detent

   h. Warning Horn – Off

   Horn should stop when lever reaches approximately 2 degrees on scale.

   i. Stabilizer Trim – Greater than 3 1/2 Units Nose Up

   j. Warning Horn – Sounds intermittently

NOTE

On airplanes with stabilizer trim limit switches at the allowable extreme positions, horn can sound at 3 1/2, ±1/2 unit of nose up trim. If warning horn sounds at any trim setting other than 3 1/2 units, note amount and direction of difference and compare with difference noted when zero setting is checked in exterior inspection.

   k. Stabilizer Trim – Set to Zero

   l. Warning Horn – Off

*49. Throttles – Checked and Cutoff

Operate each throttle throughout entire range to check for binding and throttle cushion, then set to cutoff. Check fuel shutoff VALVE light when moving throttle out of cutoff and back to cutoff.

*50. PARKING BRAKE – Set, Light Illuminated

*51. Stall Warning – Checked

   a. OLEO BYPASS Switch – OLEO BYPASS (Hold)

   b. Stall Warning Test Selector Switch – L WING and R WING, Off

   Stick shaker operates in both L WING and R WING positions.

52. RUDDER BOOST Warning Light – Out

53. TOTAL AIR TEMP Indicator – Checked, No Flag

*54. Emergency (PNEUMATIC) BRAKE Pressure Gage – Checked

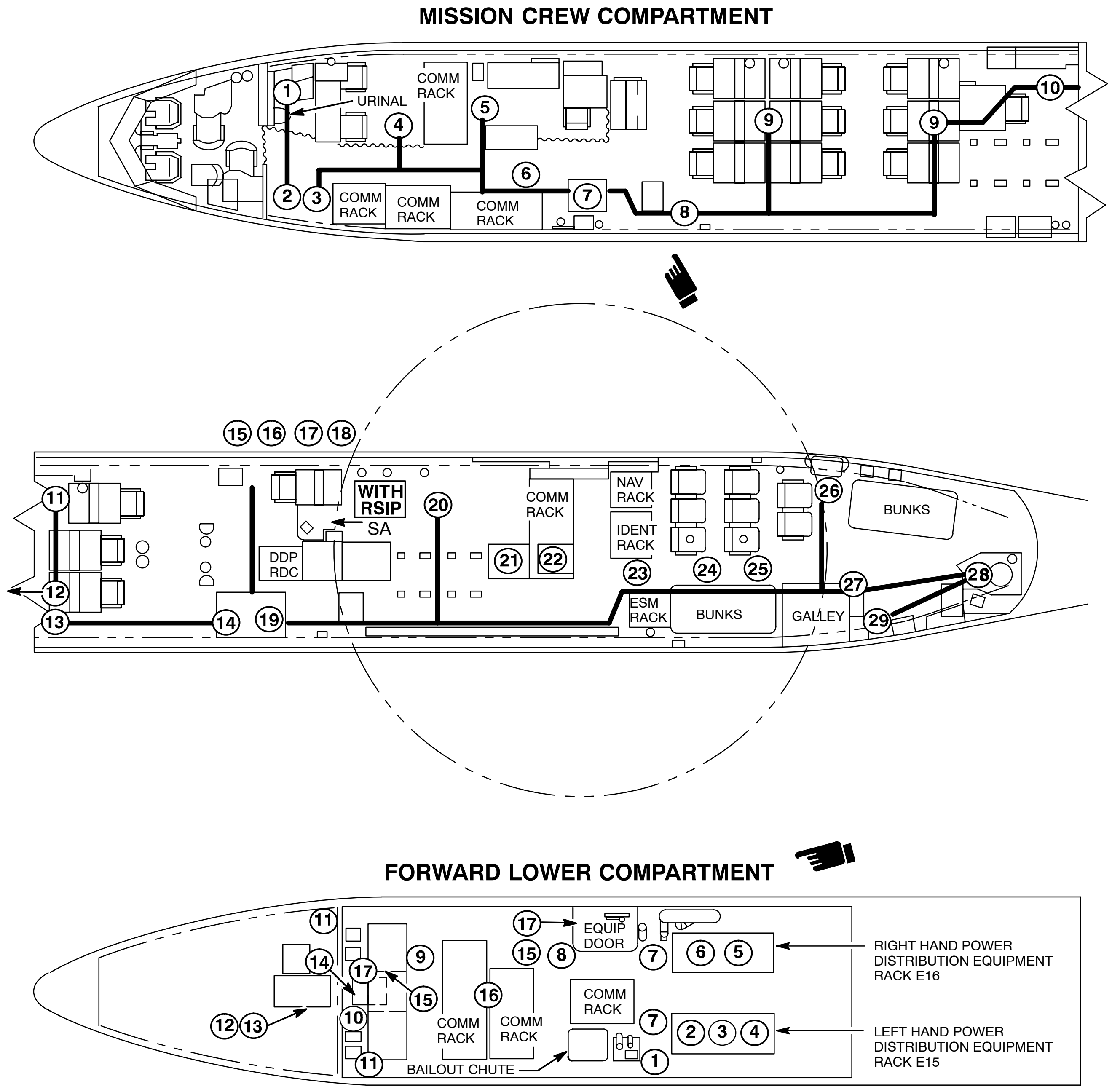
Refer to subsection I-G for correct pressure.

*55. Copilot's Oxygen Regulator – OFF, 100%

56. Copilot's SHOULDER and FOOT HEATERS Switches – OFF

57. Copilot's FLIGHT KIT and MAP LIGHTS Switches – Checked

Interior Inspection Route (Typical)



NOTE

NUMBERS REFER TO STEPS IN INTERIOR INSPECTION CHECKLISTS FOR COMPARTMENT.

D57 547 I

Figure 2-1

Mission Crew Compartment

Check compartment for security of all equipment and panels. All oxygen bottles properly secured and serviced and loose equipment stowed. All rack panels secure. All oxygen regulators set to 100% and OFF. Observe all NO SMOKING signs illuminated. Fire extinguishers and first aid kits checked. Survival equipment (as required for planned mission) stowed. Perform steps preceded by an x when a mission crew is not on board. A typical route is shown in *figure 2-1*. Flight engineer normally performs this check.

1. Forward Storage Area – Checked

   a. LPUs (5) – Stowed

   b. EMP Shields – Stowed

   c. Urinal – Clean and Serviced

*2. Forward Entry Door – Checked

Slide pressure gage normal per subsection I-V. Outer handle stowed. Safety strap clear. Slide hook attached to retaining bar.

WARNING

Slide is unusable unless retaining bar passes through slide harness and through the loop on the retaining hook assembly. Retaining bar must be secured by the nylon lanyard passing through the retaining bar.

*x3. E8 Rack, 115 VAC 10 AMP and 28 VDC 5 AMP Circuit Breakers – OPEN

*x4. Communications Console – Checked and ON

   a. ADS Programming Thumbwheel Switches – Set

      (1) **LESS IDG** FLIGHT DECK HF – 26 ◀ **WITH IDG** FLIGHT DECK HF/VHF #2 – 15 (VHF #2) or 26 (HF #1)

      If VHF #2 is required by flight deck, set FLIGHT DECK HF – 15 ◀

      (2) FLIGHT DECK **LESS IDG** VHF ◀ **WITH IDG** VHF 1 ◀ – 27

      (3) FLIGHT DECK UHF – 30

      (4) MISSION INTERCOM – (1)

      Set ENGINEER, NAVIGATOR, A/C CMDR and PILOT switches to 1.

      (5) **WITH IDG** VHF ACCESS CONTROL – VHF 2 SELECT – Set

      If VHF 2 is required by flight deck, as is the standard ground configuration, set VHF ACCESS CONTROL – VHF 2 SELECT – FLIGHT DECK. ◀

   b. COMM OPR/COMM TECH and COMM TECH MISSION INTERCOM 1 Switches – ON

   c. DDI Power Switch – OFF

   Located on DDI DISPLAY CONTROL panel at CSO station.

   d. COMM DISCONNECT Panel – Checked and OFF (E or CT)

WARNING

Applying power to the airplane without ensuring that the COMM DISCONNECT switches are set to OFF could damage equipment if required cooling is not available.

NOTE

- When battery power is applied, all lights on the COMM DISCONNECT panel illuminate. This is normal.
- Power must be applied to verify that COMM DISCONNECT panel switches are OFF.

*x5. P66 Circuit Breakers – Checked and Set

Close only the circuit breakers listed below. These circuit breakers are identified on *figure 1-47* with a shaded line around the circuit breaker. All other circuit breakers are closed by mission crew.

   a. Panel P66-1

   UHF RADIO CONTR POS 6

UHF RADIO CONTR POS 7

MISSION POWER DISTRIBUTION AC DIST (All Breakers)

MISSION POWER DISTRIBUTION DC DIST (All Breakers Except WBSV ZERO)

b. Panel P66-2

ADS MSN MAINT

c. Panel P66-3

All LIGHTING circuit breakers

*x6. E12 Rack, 115 VAC 10 AMP and 28 VDC 5 AMP Circuit Breakers – OPEN

*7. Bailout Chute – Checked

a. Safety Lock Pin – Installed

b. Pressure Gage – Per Placard

Refer to subsection I-V. Bailout chute charge is mission dependent.

c. Escape Chute – Free of Water

d. Floor Grill – Latched Down

e. Static Line – Secured

*8. FWD AFAC Ground Maintenance Panel Switch – TAKEOFF

Check indicators for proper valve position. If in ENG/APU mode, E20/21 indicator should be out, DVRTR and CABIN indicators should be illuminated. If in CART mode, only DVRTR indicator should be illuminated.

If the cannon plug connector is removed from the rack shutoff valve in E41 rack, VALVE CLOSED indication will be given on the FORWARD AFAC GROUND MAINTENANCE CONTROL PANEL regardless of the valve position.

*x9. Situation Display Console PWR Switches – OFF

10. Mission Crew Seats – Checked

Check seats 34 - 41 for secure fastening, a seat belt attached to each seat, oxygen mask and charged walkaround bottle under each seat. Survival equipment (as required for planned mission) stowed.

*x11. P67 Circuit Breakers – Checked and Set

Close only the circuit breakers listed below. These circuit breakers are identified on *figure 1-47* with a shaded line around the breakers. All other breakers are closed by the mission crew.

a. Panel P67-1

(1) All LIGHTING POWER DISTRIBUTION Circuit Breakers – Close

(2) All LIGHTING Circuit Breakers – Close

b. Panel P67-2

(1) EMERGENCY LIGHTS Arming Switch – Checked, ARMED

Set EMERGENCY LIGHTS arming switch to ON to observe lights, then return to ARMED.

(2) EMERGENCY LIGHTS Intensity Switch – HIGH, Guard Closed

(3) MID CABIN LIGHTS – As Needed for Flight

Adjust lights as required.

(4) RADAR ELCU Switch – OFF

c. Panel P67-3

(1) All MISSION POWER DISTRIBUTION Circuit Breakers – Close

Located on left and right side panels and bottom panel.

(2) FAN ELCU CONTR Circuit Breaker – Close

(3) RELAY CONTR CIRCUIT Circuit Breaker – Open

(4) DOORS Circuit Breaker – Close

(5) PURGE VALVE Ciruit Breaker – Close

Located in upper row of breakers.

(6) All DUCT COOLING Circuit Breakers – Close

Located in middle row of breakers.

(7) All EQUIPMENT AND FURNISHINGS Circuit Breakers – Close

(8) EQUIP & FURN GALLEY Circuit Breaker – Close, If Galley to be Operated

*12. Right Overwing Hatch – Closed and Secure

*13. Left Overwing Hatch – Closed and Secure

*14. Safety Harness – Checked

Stowed in forward spares cabinet, left side.

*x15. C Radar HDS (E33) Power Switch – OFF ◀

*x16. SRC CONTROL Panel Switch Positions and CIRCUIT BREAKERS – Checked

a. POWER SRC – ON (Recessed)

b. POWER ASP/R ON/OFF – ON (Recessed)

c. INIT FIT – Off (Extended)

d. EEPROM WRITE ENABLE ON/OFF – OFF (Down)

e. LOAD SOURCE – DISK

f. MAIN POWER CIRCUIT BREAKER – Closed

17. AFT AFAC GROUND MAINTENANCE CONTROL PANEL – Checked

a. CLOSED – RADAR VALVE Switch – As Required

Guarded (down) with mission crew on board

Unguarded (up) without mission crew on board

b. RADAR – TAKEOFF Switch – TAKEOFF

c. Indicator lights – Checked for proper valve positions.

If in ENG/APU mode, RADAR indicator should be illuminated, E13/14/17/28 indicator should be out. DVRTR and CABIN indicators should be illuminated. If in CART mode, all indicators except DVRTR and CABIN should be illuminated.

*x18. RCMP Switch Positions – Checked

a. RADAR ON/OFF – OFF (Extended)

b. RCDU ON/OVHT (2) – ON (Recessed)

c. RCMP P/S ON/SHTDN (2) – ON (Recessed)

d. CONSOLE MODE – Off (Extended)

e. LCS COOLANT RESISTIVITY – OFF

f. LCS PUMPS (2) – OFF (Extended)

g. Spectrum Analyzer Power – Off (Extended)

*19. 3, 5 ▶ 9, 24 Flight Loads Recorder Tape Cassette – Stowed

Check spare tape cassette for flight loads recorder stowed in left side electronic spares cabinet, top shelf, center cabinet. ◀

*20. Crew Baggage Tiedown – Checked

Check for proper loading, check fittings for security. If no baggage loading, check that straps and fittings are stowed properly.

*x21. JTIDS (E28) Rack – Closed

*x22. E13 Rack, 115 VAC 10 AMP and 28 VDC 5 AMP Circuit Breakers – Open *x23. IFF Rack (E17) POWER Switch – OFF

24. Water Quantity – Checked

Check quantity gage overhead.

25. Crew Rest Area – Checked

Check seats to verify cushions and seat belt secured on each seat. Oxygen regulators in crew service units set to 100% and OFF. Check bunks to verify mattress and belt on each bunk and attachment straps secure. Set aft lighting panel controls as required for flight.

*26. Galley Door – Checked

Door closed unless required for maintenance or loading. Slide pressure gage normal per subsection I-V. Slide and hook attached to retaining bar.

WARNING

Slide is unusable unless retaining bar passes through slide harness and through the loop on the retaining hook assembly. Retaining bar must be secured by nylon lanyard passing through the retaining bar.

27. Lavatory – Checked

a. Lavatory – Serviced

b. Water – Available

c. Hot Water Heater – On, if Water Available

CAUTION

If water tank is empty, set water heater switch to OFF to prevent overheating of lavatory water heater.

d. Toilet – Flushes

*28. Aft Entry Door – Checked

Closed unless required for loading. Slide pressure gage normal per subsection I-V. Slide and hook attached to retaining bar.

WARNING

Slide is unusable unless retaining bar passes through slide harness and through the loop on the retaining hook assembly. Retaining bar must be secured by nylon lanyard passing through the retaining bar.

29. Galley – Checked

a. MAIN POWER Switch – ON, If Galley to be Used

b. Circuit Breakers and Switches – As Required

If no water available, do not close coffee brewer circuit breakers. Refrigerator on if food to be carried.

c. Galley – Clean

d. Hot Cup, Jugs, Coffee Maker – Secured

e. Doors and Drawer Latches – Latched

Forward Lower Compartment

This compartment may be checked during interior inspection or during exterior inspection. The inspection should be delayed until all maintenance in the compartment is complete. The inspection may be performed in any convenient order.

1. Lights – As Required

2. Electrical System Maintenance Annunciator – Checked

   Lights checked. Record any indications and reset panel.

3. E15 Equipment Rack – Checked, Circuit Breakers Closed

4. P37 Circuit Breaker Panel – Checked, Circuit Breakers Closed

5. E16 Equipment Rack – Checked, Circuit Breakers Closed

6. P38 Circuit Breaker Panel – Checked, Circuit Breakers Closed

7. Emergency Equipment – Stowed

   Check walkaround bottle, smoke mask and first aid kit in place.

8. Lights – As Required

*9. 3, 5 ▶ 9, 24 Flight Loads Recorder – Checked and Set

   Sufficient tape for flight, data set, CAL DEACTIVATE switch set to up. ◀

10. Manual Start Valve Tool – Stowed

11. Airplane and Emergency Light Batteries – Checked, Circuit Breakers Closed

12. Nose Gear Lock Viewing Window – Clean

13. Nose Gear Emergency Lock Pin – Retracted (45°)

   Check pin area for obstruction.

WARNING

If pin is found engaged, do not attempt to reset. Inform maintenance and discontinue Preflight Inspection.

14. Nose Gear Manual Extension Handle – Stowed

15. Lights – As Required

*16. Forward Lower Compartment General Condition – Checked

   Check forward lower compartment for general condition and security of equipment.

*17. Doors – Closed and Latched

EXTERIOR INSPECTION

This inspection will be performed after the maintenance preflight inspection (per T.O. 1E-3A-6) is completed.

An exterior inspection is performed before first flight of each day, after servicing, as a part of all through flights, and as part of cocking and daily preflight during alert. A sample route is shown in *figure 2-2*; however, the inspection may be started at any convenient point. The flight engineer performs this inspection.

Observe exterior skin for damage, evidence of loose rivets, bolts, fluid leaks, access panels and hatches/doors secured. Components for damage, obstructions, security of mounting, deterioration, cleanliness, wear as well as any other problem indications.

Nose Section

*1. Steering Disconnect Link – Connected, Pin Secured

   Check link connect pin installed, safety pin in place.

*2. Airflow Deflector – Checked

*3. Tires and Wheels – Checked

   Hub caps secure.

*4. Left Pitot Probes – Clear

*5. Left Angle of Attack Probe – Clear

*6. Radome – Checked

   Check for cracks and missing conductor strips, vent slot clear.

*7. SHROUD DRAIN Outlet – Clear

*8. ESM Chin Pod – Checked Secure

*9. Nose Wheel Well – Checked

   Pneumatic brake pressure within limits.

WARNING

If gear door is open, check that door ground lock handle is in down detent to prevent door closing rapidly when hydraulic system is pressurized. Door closing could cause injury to personnel in path of door. A binding handle indicates possible binding linkage which could interfere with emergency operation.

Exterior Inspection Route (Typical)

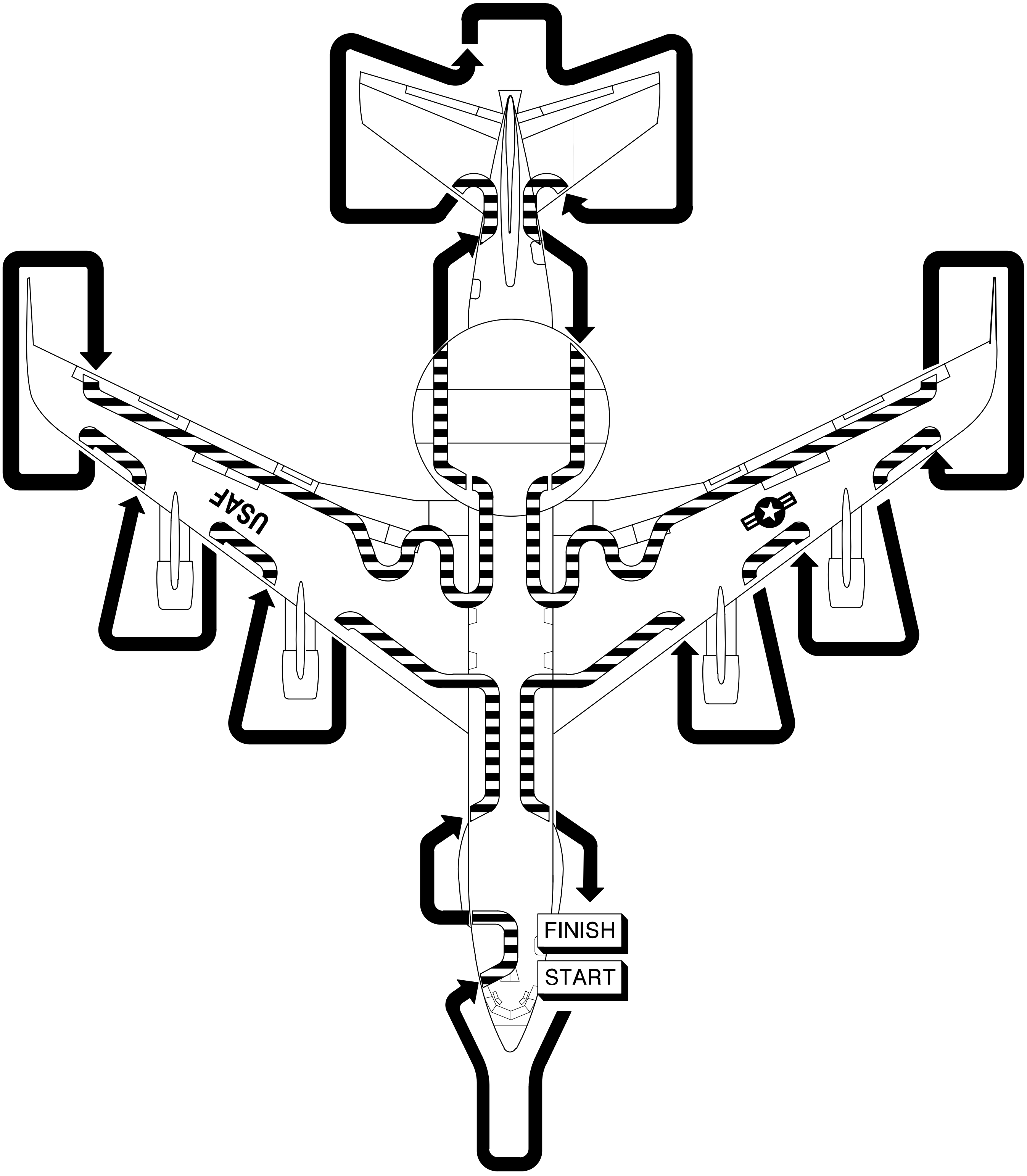


Figure 2-2

*10. Nose Gear Lock Stripe Shield – In Place

*11. Maintenance Ground Lock – Removed

*12. Steering Cylinders, Cables, and Fairing – Checked Secure

*13. Strut – Checked

*14. Nose Gear Doors – Connected, Pins Checked Secure, Doors Closed

After installing door actuator pins, check pins are secure by attempting to pull pins out.

*15. Right Pitot Probes – Clear

*16. Right Angle of Attack Probe – Clear

*17. Urinal Service Door – Closed, Secure

*18. Right ESM Pod – Checked Secure

Forward Fuselage, Right Side and Bottom

*1. **LESS IDG** Instrument Static Ports – Clear ◀
WITH IDG Instrument Static Ports and Surrounding Area – Inspected ◀

Ports must be clear (not taped or painted over). **WITH IDG** Visually inspect flush static ports and surrounding skin. Verify that flush static ports are clear and clean, and show no signs of blockage or corrosion. Also verify that surrounding skin is free from any defects. Defects (paint, skin waviness, dents, scratches, broken or loose fasteners, and patched areas) can affect static pressure system accuracy, with resulting adverse effects on accuracy of air data system. ◀

*2. Airflow From Draw Through Cooling Exhaust – Checked

CAUTION

If air is not flowing from fan outlet, open flow control valve manually and check fan circuit breakers. Equipment cooled by draw through system can be damaged if cooling air is lost.

*3. Draw Through Cooling Venturi Exhaust – Clear

*4. Single Point Refueling Caps – Secured

*5. Refueling Panel – Closed, Latched

*6. Ground Air Conditioning Access Panel – As Required

*7. Forward Outflow Valve Exhaust – Clear

*8. Ground Starting Air Access Panel – As Required

*9. Air Conditioning Ram Air Inlet – Clear

*10. Right Keel Beam Bay Door – Closed, Latched

Right Wing, Engines 3 and 4

*1. Inboard Wing Surface – Checked

Check for unlocked drip sticks.

*2. Stall Warning Airflow Vane – Checked

Check that vane is free to move.

*3. Inboard Leading Edge Flaps – Checked

*4. Engine No 3 Nacelle and Strut – Checked

Check surge bleed valves (LH closed, RH open). Check fire bottle pressure gages normal and discharge discs intact. Check droop stripes for alignment. HAVE SIREN system ready for flight. Fairing cone and cover plate off if system to be used. Cone or cover plate on if system not to be used.

*5. Mid Wing – Checked

Check for unlocked drip sticks.

*6. Leading Edge Slats – Checked

*7. Engine No 4 Nacelle and Strut – Checked

Check surge bleed valves (LH closed, RH open). Check droop stripes for alignment. HAVE SIREN system ready for flight. Fairing cone and cover plate off if system to be used. Cone or cover plate on if system not to be used.

*8. Right Outboard Wing – Checked

Check for unlocked drip sticks.

*9. Leading Edge Slats – Checked

*10. Navigation Light – Illuminated

*11. Static Dischargers – Secure, Intact

One may be missing from tip or outer two locations on trailing edge. Not more than two missing from trailing edge.

*12. Control Surfaces and Flaps – Checked

*13. Cove Lip Doors – Closed, Latched

*14. Dump Chute – Retracted, No Fuel Leaks

Right Gear and Wheel Well

*1. Truck Leveling Cylinder – Checked

*2. Tires, Wheels, Brakes, Doors – Checked

Fuse plugs intact, anti–skid covers in place, brake wear indicators.

*3. Truck Leveling and Safety (Squat) Switches – Checked

*4. Strut – Checked

Ensure uplock roller is free.

*5. Right Wheel Well – Checked

WARNING

If any gear door is open, check that door handle is in down detent to prevent the door closing rapidly when hydraulic system is pressurized. Door closing could cause injury to personnel. A binding handle indicates possible binding linkage which could interfere with emergency operation.

*6. Lockout-Deboost Valves – Checked

WARNING

- With parking brakes applied, handles must be in green range. If reset handle is in inner red range, pull handle out to replenish brake lines. If handle is in outer red or yellow (silver) range, valve must be replaced. Airplane will not be taxied.
- For lockout-deboost valves with yellow (silver) band, with the brakes released and utility system pressurized, the lockout-deboost valve reset handle should be in the yellow (silver) range. If the lockout-deboost valve reset handle is in the outer red range, the brake system must be bled.

*7. Truck Leveling Lockout–Deboost Valve – Checked

Handle must be in green range. If reset handle is in inner red range, pull handle out to replenish lines downstream of valve. If handle is in outer red range, valve must be replaced.

*8. Main Gear Inspection Window – Clean, Lens Intact

*9. Ground Locks – Removed

*10. Wheel Well Door – Closed

CAUTION

Raise ground lock handle slowly. Allowing the ground lock handle to raise quickly could cause cable damage.

Aft Fuselage, Right Side and Bottom

*1. Oxygen Service Panel – Closed, Secure

*2. Aft Lower Compartment Exterior Door – As Required

*3. Life Raft Door and Overwing Exit – Closed, Flush

4. Aft Outflow Valve Exhaust – Clear

*5. Water Service Panel – Closed, Latched

6. Overboard Drain – Checked

WARNING

Drain is normally warm. Failure of heating system could cause heater to be in airborne mode. Serious burn could result.

*7. Toilet Service Panel – Closed, Latched

*8. Right Rotodome Strut and Rotodome – Checked

Check vent and outflow valve, and ECS inlet and exhaust openings clear.

9. Rotodome Ground Safety Lock – Removed

*10. Galley Door – Closed, Latched

Empennage

*1. Static Dischargers – Secure, Intact

Not more than one missing from tip or outer two locations on trailing edge. Not more than two missing from trailing edge on one side (or fin).

*2. ESM Tail Pod – Checked Secure

*3. Navigation Light – Illuminated

*4. Stabilizer Leading Edge – On Zero Mark

Check stabilizer leading edge is on black zero mark. If stabilizer is not on mark, note direction and amount.

NOTE

The flight deck trim indicator can indicate up to ±1/2 unit off of correct position. If indicator is 1/2 unit out of position, the stabilizer leading edge is about one inch off the center of the reference mark. Moving stabilizer leading edge up trims airplane nose down. If stabilizer is not on reference mark, correct trim setting for takeoff by amount noted. (If stabilizer is one inch above mark, trim scale reads one half unit low.)

*5. Q-Spring Inlet – Clear

Aft Fuselage, Left Side and Bottom

*1. Overwing Exit and Life Raft Door – Closed, Flush

*2. Aft Entry Door – Closed, Latched

3. Aft Forced Air Cooling System – Checked

Check ram inlet, heat exchanger exhaust cleared and overboard valve clear. Ground cart connection panel closed if not required.

*4. SF_6 Access Panel – As Required

*5. Rotodome Lubrication Oil Drain Port – Clear

*6. SF_6 Static Port – Clear

*7. Left Rotodome Strut and Rotodome – Checked

Check vent and outflow valve, and ECS inlet and exhaust openings clear.

8. Rotodome Ground Safety Lock – Removed

Left Gear and Wheel Well

*1. Truck Leveling Cylinder – Checked

*2. Tires, Wheels, Brakes, Doors – Checked

Fuse plugs intact; anti-skid cover in place, and brake wear indicators.

*3. Truck Leveling and Safety (Squat) Switches – Checked

*4. Strut – Checked

Ensure uplock roller is free.

*5. Left Wheel Well – Checked

WARNING

If any gear door is open, check that door handle is in down detent to prevent gear door from closing rapidly when hydraulic system is pressurized. Rapid gear door closing could cause injury to personnel. A binding handle indicates possible binding linkage which could interfere with emergency operation.

*6. Lockout-Deboost Valves – Checked

WARNING

- With parking brakes applied, handles must be in green range. If reset handle is in inner red range, pull handle out to replenish brake lines. If handle is in outer red or yellow (silver) range, valve must be replaced. Airplane will not be taxied.
- For lockout-deboost valves with yellow (silver) band, with the brakes released and utility system pressurized, the lockout-deboost valve reset handle should be in the yellow (silver) range. If the lockout-deboost valve reset handle is in the outer red range, the brake system must be bled.

*7. Truck Leveling Lockout-Deboost Valve – Checked

Handle must be in green range. If reset handle is in inner red range, pull handle out to replenish lines downstream of valve. If handle is in outer red range, valve must be replaced.

*8. Hydraulic Reservoir – Checked

*9. Hydraulic Filter Differential Pressure Indicators – Checked

Red differential pressure indicators should not be extended after pressure is applied. If found extended, maintenance action is required prior to flight.

*10. Liquid Cooling System – Checked

Ground coolant caps are in place.

*11. Main Gear Inspection Window – Clean, Lens Intact

*12. Ground Locks – Removed

*13. Wheel Well Door – Closed

CAUTION

Raise ground lock handle slowly. Allowing the ground handle to raise quickly could cause cable damage.

Left Wing, Engines 1 and 2

*1. Dump Chute – Retracted, No Fuel Leaks

*2. Cove Lip Doors – Closed, Latched

*3. Control Surfaces and Flaps – Checked

*4. Navigation Light – Illuminated

*5. Left Outboard Wing – Checked

Check for unlocked dripsticks.

*6. Static Dischargers – Secure, Intact

One may be missing from tip or outer two locations on trailing edge. Not more than two missing on trailing edge.

*7. Leading Edge Slats – Checked

*8. Engine No 1 Nacelle and Strut – Checked

Check surge bleed valves (LH closed, RH open). Check droop stripes for alignment. HAVE SIREN system ready for flight. Fairing cone and cover plate off if system to be used. Fairing cone or cover plate on if system not to be used.

*9. Mid-Wing – Checked

Check for unlocked dripsticks.

*10. Leading Edge Slats – Checked

*11. Engine No 2 Nacelle and Strut – Checked

Check surge bleed valves (LH closed, RH open). Check fire bottle pressure gages normal and discharge discs intact. Check droop stripes for alignment. HAVE SIREN system ready for flight. Fairing cone and cover plate off if system to be used. Fairing cone or cover plate on if system not to be used.

*12. Inboard Leading Edge Flaps – Checked

*13. Stall Warning Airflow Vane – Checked

Check that vane is free to move.

*14. Inboard Wing Surface – Checked

Check for unlocked dripsticks.

*15. Left Keel Beam Bay Door – Closed, Latched

*16. Forward Forced Air Cooling System – Clear

Check ram inlet, heat exchanger exhaust cleared and overboard valve clear. Ground cart connection panel closed if not required.

Forward Fuselage Left Side

*1. Cavity Vent – Clear

*2. External Electrical Power Receptacle Covers – As Required

*3. Bailout Hatch – Closed, Flush

*4. **LESS IDG** Instrument Static Ports – Clear ◀
WITH IDG Instrument Static Ports and Surrounding Area – Inspected ◀

Ports must be clear (not taped or painted over). **WITH IDG** Visually inspect flush static ports and surrounding skin. Verify that flush static ports are clear and clean, and show no signs of blockage or corrosion. Also verify that surrounding skin is free from any defects. Defects (paint, skin waviness, dents, scratches, broken or loose fasteners, and patched areas) can affect static pressure system accuracy, with resulting adverse effects on accuracy of air data system. ◀

*5. Left ESM Pod – Checked Secure

*6. Nose Gear Lock Handle – As Required

CAUTION

Handle will remain installed if utility system will not remain pressurized until start.

AFTER PREFLIGHT

1. Release parking brake to reduce pressure in brake system.

2. **WITH IDG** VHF #2 Radio – Checked (E, GC)

   Confirm with ground crew/ground controlling agency VHF #2 radio is operating normally.

BEFORE START

Perform the following BEFORE START checklist to configure the airplane for engine start. Each crewmember will check survival equipment, as required, prior to initiating this checklist. This check may be read by the copilot through step 15 (Flight Controls) if flight engineer is performing other duties. Flight engineer or qualified observer must be on ground interphone for steps 14 and 15.

1. Oxygen, Interphone – Checked, ON, 100% (P, CP, N, OBS)

   a. Set oxygen SUPPLY lever to ON.

   b. Connect and don mask.

   c. Check NORMAL and 100% settings.

   Set EMERGENCY lever to NORMAL and diluter lever to 100%. Check FLOW indicator shows white during inhalation and black during exhalation. Pressure should be 290 to 430 psi.

   d. Check EMERGENCY and 100% settings.

   Set EMERGENCY lever to EMERGENCY. Check mask for proper fit and serviceability of hoses and connectors. Hold breath and check for no flow around edges of mask (blinker remains black). White blinker indicates a leak.

   e. Breathe normally for two to three cycles.

   Blinker shows white during inhalation, black during exhalation.

   f. Check NORMAL and NORMAL settings.

   Set EMERGENCY and diluter levers to NORMAL. Blinker should show white during inhalation, black during exhalation.

   g. Check NORMAL, 100% and OFF setting.

   Set EMERGENCY lever to NORMAL, set SUPPLY lever to OFF. (Regulator with test connector and no placard on front should move 100%.) Set diluter lever to 100% if required. Attempt to breathe through mask. Ability to breathe indicates faulty regulator.

WARNING

Some regulators with test connector on front panel (*figure 1-241*) do not move diluter lever to 100% when SUPPLY lever is set to OFF. These regulators are usually placarded NO OFF PROTECTION. Always verify diluter lever is set to 100% when setting SUPPLY lever to OFF.

   h. Set SUPPLY lever to ON.

   i. Check oxygen mask microphone assembly.

   j. Check anti-smoke goggles for serviceability.

   k. Ensure the vent valve on the quick don oxygen mask is pushed in.

l. Stow mask.

NOTE

Pilot will brief observer on panel operation to prevent observer from broadcasting inadvertently on radios.

2. **LESS IDG** IFF – Checked, Standby (CP)

a. Check MASTER Switch set to STBY.

Allow system to warm up in STBY mode for one minute in standard temperature conditions, five minutes in extreme low temperature conditions, before selecting an operating mode.

b. Set AIMS ANTENNA Switch to BOTH.

c. Set RAD TEST–MON Switch to OUT.

d. Set Mode 1 and 3/A code selectors to zero.

e. Set MASTER Switch to NORM.

f. Hold desired TEST switch (M-1, M-2, M-3/A or M-C) to TEST until TEST indicator illuminates, indicating proper operation of that mode. Release and switch returns to ON.

NOTE

Inflight checking of IFF can be accomplished in conjunction with ground radar sites. Modes 1, 2, 3/A and C can be checked on LOW and NORMAL sensitivity in addition to checking IDENT operation. Altitude input for Mode C can be read out on Time/Altitude display the pilot or copilot Vnav Steer page.

g. Set MASTER Switch to STBY.

h. Set Mode 4 switch to ON.

i. Check IFF caution light out after Mode 4 code is loaded.

NOTE

If IFF appears to be inoperative, check the 3-ampere fuse located on the R/T unit in the E1 rack. A spare fuse is provided.◀

3. Communications and Navigation Radios – Checked and Set (P, CP)

Make an operational check of communications radios, obtain the current altimeter setting and advise the flight crew of altimeter setting and primary communications radio.

Where reception is possible, pilot and copilot tune and identify appropriate ILS, VOR and TACAN frequencies and check respective ADI, HSI, RMI and range indicators for proper operation. Check ADF if required. Prior to performing navigation radio checks, ensure that all electrical buses are powered, appropriate circuit breakers are closed and the AHRS is on and operating. Set HSI heading and course knobs as required for departure.

WARNING

Do not transmit on VHF–AM radio on ground unless personnel are a minimum of ten feet from radiating antennas.

NOTE

The VHF–NAV and TACAN self-tests may be used if the test is within tolerance and a station identifier is heard. Refer to subsection I-M.

a. ILS LOCALIZER/GLIDE SLOPE Preflight:

(1) Ensure VHF NAV 1 and 2 on, receivable localizer frequency tuned and identified.

(2) Set NAV MODE selector to VOR/LOC.

(3) Set published front course.

(4) Check navigation and glide slope warning flags out of view.

(5) Check ADI and HSI warning flags out of view and HSI bearing pointers stow at three o'clock position.

(6) Check ADI and HSI for proper indication and relationship to localizer and glide slope.

NOTE

If warning flags disappear, glide slope pointers should move up or down depending upon relationship between aircraft and glide slope beam. CDI moves left or right if a valid localizer signal is received.

b. VOR Preflight:

(1) Tune and identify receivable VOR frequency.

(2) Set NAV MODE selectors to VOR/LOC and RMI mode selectors to TACAN/VOR.

(3) Check and compare HSI/RMI indications.

Check navigation warning flags on pilot's and copilot's HSIs out of view.

Check pilot's and copilot's HSI and navigation station RMI bearing pointers indicate approximately same bearing. (The navigator's RMI source selector panel TACAN 1/VOR 1 and TACAN 2/VOR 2 switches must be set to VOR 1 and VOR 2 respectively to preflight navigation station RMI.)

NOTE

- To check RMI indications, NAV MODE selectors must be set to TACAN.
- When a new VOR station is selected, navigation warning flag comes into view until bearing pointer is within two degrees of correct bearing and course deviation signal is usable. When a change is made from an ILS station to a VOR station, the navigation flag remains in view until bearing pointer has rotated from the three o'clock position to within two degrees of correct bearing.

(4) Center the CDI and check course counters read the same, or 180° from the bearing pointer. Rotate COURSE knob and check for proper CDI displacement and TO–FROM indication changes when selected course is approximately 90° to bearing pointer.

(5) Perform self-test if VOR signal is unreliable or not available.

NOTE

The VOR self test feature tests the entire system, except the antenna. If the self-test is within tolerance and a station identifier can be received (the antenna is checked), the system is satisfactory.

c. TACAN Preflight:

(1) Ensure TACAN 1 and 2 set to T/R, receivable TACAN frequency tuned and identified.

NOTE

- The TACAN ground station transmits an identifier each 36 seconds. Signal from selected station is considered unreliable when station identifier fails.
- Equipment requires approximately two minute warmup to reach operating temperature.

(2) Set NAV MODE selectors to TACAN and RMI mode selectors to TACAN/VOR.

(3) Check and compare HSI and RMI indications.

Check navigation warning flags on pilot's and copilot's HSI out of view.

NOTE

To check RMI indications, NAV MODE selectors must be set to VOR/LOC.

(4) Center CDI and check course counters read the same as, or 180° from, the bearing pointer. Rotate COURSE knob and check for proper CDI displacement and TO–FROM indication changes when selected course is approximately 90° to bearing pointer.

NOTE

If a VOR/TACAN ground check point is available, ensure that bearing pointers point to the station. Allowable error for CDI or bearing pointers is ±4° from correct bearing or 4 degrees between No 1 and No 2 pointers. Distance must be within 1/2 mile or 3% of the distance to the facility, whichever is greater.

(5) Perform self-test if TACAN signal is unreliable or not available.

NOTE

The TACAN self test feature tests the entire system, except the antenna. If the self-test is within tolerance and a station identifier can be received (the antenna is checked), the system is satisfactory.

d. ADF Preflight:

(1) Ensure ADF GAIN control set to ADF, tune and identify receivable ADF frequency.

(2) Set pilot's and copilot's RMI MODE selectors to ADF.

(3) Check that the bearing pointers on the pilot's RMIs display magnetic bearing to the station selected.

4. NAV MODE Selectors, Flight Directors – Checked and Set (P, CP)

At the pilot's discretion, perform as a minimum only the asterisked steps for either flight director. If preflighting only the heading and pitch command portion of the flight director perform only the asterisked items. For a complete preflight perform all steps. Prior to performing the check, ensure that all electrical buses are powered, appropriate circuit breakers are closed, and AHRS and systems are ON and operating.

NOTE

Applicable INU must be in NAV mode or have displayed ATTD RDY (1 or 2).

*a. Set flight director mode selector to OFF.

Check steering bars are out of view.

*b. Set flight director mode selector to HDG.

Check steering bars are in view and ADI warning flags are out of view.

*c. Using HSI heading control, set heading marker under lubber line.

Check roll steering bar is centered.

*d. Using HSI heading control, set heading marker either side of lubber line.

Check roll steering bars directs bank toward heading marker.

e. Set NAV MODE selector to VOR/LOC or TACAN and flight director mode selector to NAV/LOC.

Ensure receivable VOR or TACAN station is tuned and check HSI navigation warning flag out of view. Note appropriate flight director annunciator on.

f. Set flight director mode selector to NAV/LOC.

Check F/D VL annunciator is amber (CDI display greater than one dot deviation).

g. Slowly rotate HSI course knob to center CDI (within one dot deviation).

Check flight director roll steering bar directs bank toward course arrow.

h. Using HSI course knob, set course arrow on bearing to station.

Check CDI is centered, F/D VL annunciation changes to green, roll steering bar is centered and TO–FROM indicator indicates TO.

*i. Rotate flight director PITCH CMD control through full range.

Check pitch steering bar commands a pitchup attitude when PITCH CMD control is rotated clockwise and a pitchdown attitude when PITCH CMD control is rotated counterclockwise.

j. Set ALT HOLD switch to ON.

Check pitch steering bar directs zero pitch command.

k. Rotate ADI PITCH TRIM control to move ADI attitude tape.

Check attitude tape moves in appropriate direction when PITCH TRIM control is rotated.

l. Set flight director mode selector to MAN GS.

Check ALT HOLD switch returns to OFF.

m. Press autopilot disconnect switch.

Flight director mode returns to GA position.

NOTE

Roll steering bar centers but pitch steering bar directs a pitch altitude of approximately eight degrees which allows minimum altitude loss during go-around.

*n. Set flight director for takeoff.

If flight director system is to be used for initial climb after takeoff, set the mode selector in the desired position. Preset heading and course controls as required for departure and set the NAV MODE selector to VOR/LOC or TACAN, as required.

For a takeoff in HDG mode, set flight director mode selector to HDG, HSI heading bug to runway heading and pitch command control to maximum.

NOTE

- After moving onto the runway, heading marker may be reset to exact runway heading to center roll steering bar.
- Do not fly pitch steering bar command after takeoff. Perform normal climbout procedures and fly airplane at required performance attitude.

If flight director is not used for takeoff, set flight director mode selector to OFF.

5. Instruments – Checked and Set (P, CP)

Wind and set the clock. Check all instruments for normal readings. Set airspeed bugs. Press to test ADI test button. Check for approximately 10° pitchup, 20 ° right roll and GYRO flag in view. Rotate ADI PITCH TRIM control to move ADI attitude tape. Check radio altimeters. Crosscheck heading indications within 2.5°.

NOTE

Standby compass may show up to 10° error on the ground due to magnetic effects of landing gear lever lock solenoid.

a. Low Range Radio Altimeter Preflight:

    (1) Set low altitude marker (bug) to 20 feet.

    (2) Check all low altitude caution lights and DH lights illuminated and altitude pointers indicate approximately minus two feet.

    (3) Press and hold TEST pushbutton on either radio altimeter indicator.

    (4) Check all low altitude caution lights and DH lights go out, warning flags in both radio altimeter indicators appear, warning flags cover both ADI RUNWAY symbols (if runway symbols in view) and radio altimeter pointer drives to 40 ± 4 feet.

    (5) Release test pushbutton and set low altitude marker (bug) for departure.

6. Altimeters – Checked and RESET (P), Checked and RESET (CP) Set _____, Reading _____ Ft (N)

Set proper altimeter setting. Check that all altimeters are within 75 feet of a known elevation. Check pilot's and copilot's altimeters in both modes. Pilot will call out altimeter setting, known elevation, pilot's altimeter reading in RESET and STBY. Copilot and navigator will respond as indicated above if altimeters are within tolerance. Check STBY flag out of view on pilot's and copilot's altimeter when check complete.

NOTE

If the difference between any two altimeters exceeds 75 feet, refer to allowable differences in *figure 5-14*.

7. ADI Switches – As Required (P, CP)

Select GINS if ATTD RDY (1 and/or 2) has been displayed.

8. Standby Attitude Indicator – Checked and Set (P)

Indicator uncaged and erected. Flag out of view.

9. Flaps – 14, 14, Green Lights (CP)

Flap lever set to 14. INBD and OUTBD gages indicate 14 ± 3°. Both LE FLAP indicators illuminated.

10. GINS – Checked and Set (P, CP, N)

    a. Start 1 Page – Displayed and Checked, As Required

       Check for correct initial position, date time and datum.

    b. Start 2 Page – Displayed and Checked, As Required

       Check GC (Gyro Compass) selected, not DG.

    c. Start 3 Page – Displayed and Checked, As Required

       Check for correct data base date.

    d. FPLN Page(s) – Displayed and Checked

       Verify flight plan correct.

    e. Pilot/Copilot Str Select Pages – Displayed, As Required

       Select navigation solution for pilot and copilot. Pilot Steering–Pilot Copilot Steering–Copilot Enroute Mode–Illuminated.

    f. Pilot/Copilot Str Pages – Displayed

    g. DESIGNATED PILOT Switch – As Required

    h. ADC SOURCE SELECT Switch – As Required

    i. 1553 BUS CONTROL Switch – NORMAL

11. **WITH IDG** Altitude Alerters – Checked, Set (P, CP)

    Run self test by holding mode select switch for 5 ±1 seconds. Set baro as required. Set first target altitude. ◀

12. Weather Radar – Checked and Set (P or CP, N)

    a. Check test pattern:

       (1) Five color bands in lower 1/3 of range scale (50 miles) green, yellow, red, yellow, green. Width of bands is not critical. Any absent band indicates a possible fault.

       (2) Noise band gradually increasing (green) from outer edge of last green test band to about 80 NM range. Fairly uniform band of green noise from 80 to 100 NM. Uniform noise level or missing 80 to 100 NM band shows R/T fault.

       (3) If random noise displayed beyond 100 NM, reduce TGT CLAR knob setting to eliminate noise.

NOTE

If radar was not in STBY, wait three minutes before checking test pattern. Indicator either stays blank or shows bands of color until three minute warmup is complete.

13. Autopilot – Checked and Set

    NAV mode or ATTD RDY 1 or 2 annunciation required for autopilot operation. If only one INU is in NAV or ATTD RDY state, that INU must be selected via DESIGNATED PILOT switch.

    a. Autopilot Engage Switch – AUTO PILOT

    b. Pilot's Autopilot and Boom Disconnect Button – Press

       A/P WARN light flashes while disconnect button is depressed.

c. Autopilot Engage Switch – AUTO PILOT

d. Autopilot Pitch and Roll – Checked

Check control wheel movement in pitch and roll and check three axis trim indicator. Also, check stabilizer trim operates at high speed only. Return to detent.

e. Copilot's Autopilot and Boom Disconnect Button – Press

A/P WARN light flashes while disconnect button is depressed.

f. Autopilot Engage Switch – AUTO PILOT

g. Autopilot Engage Switch – OFF (E, N)

Notify navigator when this step is completed.

h. A/P WARN Light – Flashes

i. A/P WARN Light – Press

Resets A/P WARN light.

14. RUDDER TRIM and AILERON TRIM – Free and Zero (P)

Check that both trim wheels move freely. To prevent unnecessary stretching of cables, move wheels only one or two turns in each direction. Set both to zero.

⑮ Stabilizer Trim System – Checked and Set (P, CP, E or GC)

This check will be coordinated with the ground crew who will call out stabilizer motion during electrical trim check.

a. STAB TRIM CUTOUT Switches – CUTOUT

Prevents operation of electric trim.

b. Pilot's Trim Switches – Nose Up, Nose Down, OFF

Trim does not move when either switch used.

c. Manual Trim – Nose Up

Continue trimming until after step d.

d. Trim Brake – Engaged

Push yoke forward. Brake engages.

e. Trim Brake – Released

Trim motion resumes.

f. Repeat steps c. through e. in opposite direction.

WARNING

Stow manual trim handles.

g. STAB TRIM CUTOUT Switches – NORMAL

h. Pilot's Trim Switches – Nose Up, Nose Down, OFF.

NOTE

Stabilizer leading edge moves up for nose down trim and down for nose up trim.

i. Stabilizer Trim – Set for Takeoff

Set to value on TOLD card.

⑯ Flight Controls – Checked (P, E or GC)

This step will be coordinated with ground crew who will call out movement of flight controls.

NOTE

- Initial movement requires light forces. Further travel requires higher forces.
- Strong tailwinds or crosswinds can make this check difficult to perform. If elevator or aileron operation is difficult, head airplane into wind and repeat check. This check may be delayed until ready for the BEFORE TAKEOFF check, if wind direction requires.

a. Control Column – Full Forward

Elevators move down. Tabs move up.

b. Control Column – Full Aft

Elevators move up. Tabs move down.

c. Left Rudder Pedal – Push to Stop and Hold

Rudder and tab move left. Move rudder to stop in about one second. Use only enough pedal force to hold rudder against stop. Hold rudder against stop until after step d.

d. Rudder Test Switch – 3,000, 2,290, 1,450

Check rudder test gage and rudder mode indicator show same numbers as switch setting. Pressure on auxiliary hydraulic system gage can be up to 250 pounds below normal pressure when rudder is in 2,290 or 1,450 mode.

e. Right Rudder Pedal – Push to Stop and Hold

Rudder and tab move right. Move pedal to stop in about one second. Use only enough force to hold rudder against stop. Hold rudder against stop until after step f.

f. Rudder Test Switch – 3,000, 2,290, 1,450

Check rudder test gage and rudder mode indicator show same numbers as switch setting. Pressure on auxiliary hydraulic system gage can be up to 250 pounds below normal pressure when rudder is in 2,290 or 1,450 mode.

g. Rudder Pedals – Center

Rudder and tabs neutral.

h. SPEED BRAKE Lever – Full Forward

All spoilers down.

i. Control Wheel – Full Left (Hold)

Left ailerons up, tabs down. Left spoilers up. Right ailerons down, tabs up. Right spoilers down.

j. Control Wheel – Full Right (Hold)

Left ailerons down, tabs up. Left spoilers down. Right ailerons up, tabs down. Right spoilers up.

k. Control Wheel – Center

All spoilers down. Ailerons and tabs neutral.

l. SPOILERS Switches – OFF

Spoilers remain down.

m. SPEED BRAKE Lever – 60°

Spoilers remain down.

n. INBD SPOILERS Switch – ON

Inboard spoilers up. Leave switch on.

o. OUTBD SPOILERS Switch – ON

All spoilers up.

p. SPEED BRAKE Lever – Full Forward

All spoilers down.

– – – When Control Check is Complete, Clear Flight Engineer/Ground Crew to Take Position For Engine Start – – –

– – – For Normal Start, Proceed to STARTING ENGINES Checklist. For Cocking, Perform Steps 17 Through 34 – – –

17. Flaps – Up (CP)

18. Oxygen – OFF, 100% (All)

⑲ Emergency Lights – As Required (E, MCC)

(OFF, CC1, CC3) (ARMED, CC2)

20. Avionics Power Disconnect, COMM AFT Switch – As Required (E)

(DISC, CC1, CC3; NORM, CC2)

21. INU Align Status – As Required (E, N)

(OFF, CC1, CC3) (ALIGN, CC2)

22. Weather Radar – OFF (P, N)

Set range knob to OFF.

㉓ Forced Air Systems – As Required (E, N, MCC)

(OFF, CC1, CC3) (Aft System – On, AUTO, CC2)

24. PRIMARY and ALTERNATE Valve Switches – As Required (E)

(Off, CC1, CC3) (PRIMARY Valve Switch – ON, CC2)

25. DC Meter Selector Switch – As Required (E)

(Any XFMR Rectifier Position, CC1, CC3)
(As Required, CC2)

26. Fuel Boost Pumps – As Required (E)

(Off, CC1, CC3) (ON, CC2)

27. Standby Attitude Indicator – As Required (P)

(Caged, CC1, CC3) (Uncaged, CC2)

28. Parking Brake – Off (P)

29. AUXILIARY PUMPS Switches – OFF (E)

30. 3, 5, ▶ 9, 24 Flight Loads Recorder – Set (E)

Set current data. ◀

31. EMERGENCY POWER Switch – As Required (E)

(Off, CC1, CC3) (NORMAL, CC2)

32. APU and External Power – As Required (E, N)

(Off, CC1, CC3) (External Power or APU Generator – ON, CC2)

33. BATTERY Switch – As Required (E)

(Off, CC1, CC3) (ON, CC2)

㉞ Plugs and Covers – Installed, If Required (E, GC)

– – – Airplane is Now Cocked for Alert – – –

– – – Upon Notification for Launch, Proceed Directly to STARTING ENGINES Checklist – – –

ROTODOME WARMUP

This procedure is used on the GROUND or while AIRBORNE to decrease surveillance radar warmup time if requested by the airborne radar technician.

CAUTION

- Do not perform this procedure when cocking airplane.
- Purge valve must be closed when leaving the airplane.

1. Rotodome – Rotating (E)

Rotodome must be rotating for even heat distribution.

2. APU or ENGINE Bleed Air – ON (E)

3. MASTER REFUEL Switch – ON (E)

4. Slipway Doors – Open (E)

5. READY Indicator – Illuminated (E)

– – – Contact ART When Ready to Open Circuit Breaker – – –

⑥ Purge Valve Circuit Breaker – Open (E, ART)

Circuit breaker must be open for operation of more than 5 minutes, due to the 5 minute timer.

7. Slipway Doors – Closed (E)

8. MASTER REFUEL Switch – OFF (E)

– – – Complete Step 9 When Warmup is Complete – – –

⑨ Purge Valve Circuit Breaker – Closed (ART, E)

STARTING ENGINES

Engine starts will be made with interphone communication between flight crew and ground crew, except when unusual conditions prevent the use of interphone and then hand signals will be used. The pilot will insure that the flight and ground crew have a complete understanding of signals to be used. The ground crew will verify that the area ahead and behind the engines is clear of ground equipment and debris. Ground crewmen will report at once any sign of fire or malfunction during a start.

CAUTION

- The BATTERY switch must be on for all engine starts. High energy ignition, fire detection, and fire extinguisher receive power from the battery.
- Do not attempt to start engine with continuous ignition.
- Do not attempt engine starts without all electrical power. All engine instruments, except N_2 tachometers, require AC power for operation.

NORMAL START

For normal starts: the pilot operates the engine throttles; the copilot monitors engine instruments; and the flight engineer operates start selector switches, monitors start pressure, N_2 RPM and observes flight engineer's panel for malfunctions. Since the pilots cannot see the N_2 tachometers, the flight engineer will call out 15% and 35% N_2 for each engine. The flight engineer will announce and receive clearance from the ground crew prior to starting each engine. The ground crew will report "rotation".

CAUTION

- A definite indication of N_1 RPM, either visually or on engine instruments, must be observed before moving throttles to idle (from cutoff).
- If ground crew has not called "rotation", and N_1 RPM is not indicated by 25% N_2, release start switch and investigate cause before attempting another start.

The pilot will announce the starting sequence to be used over interphone. A short pause will be required between starting engine 4 and starting engine 2 to allow the ground crewmen to change position.

The flight engineer will monitor oil pressure, IDG LOW RPM lights, IDG oil temperature indicators, and start pressure, and will call out only items required (such as 15% and 35% N_2 for coordination with the pilots) or a failure, such as "OIL PRESSURE ZERO, No 3."

The pilots should monitor engine instruments until the N_1 RPM, EGT and fuel flow have stabilized. See *figure 2-3* for inlet and exhaust danger areas and *figure 2-4* for engine starting procedure.

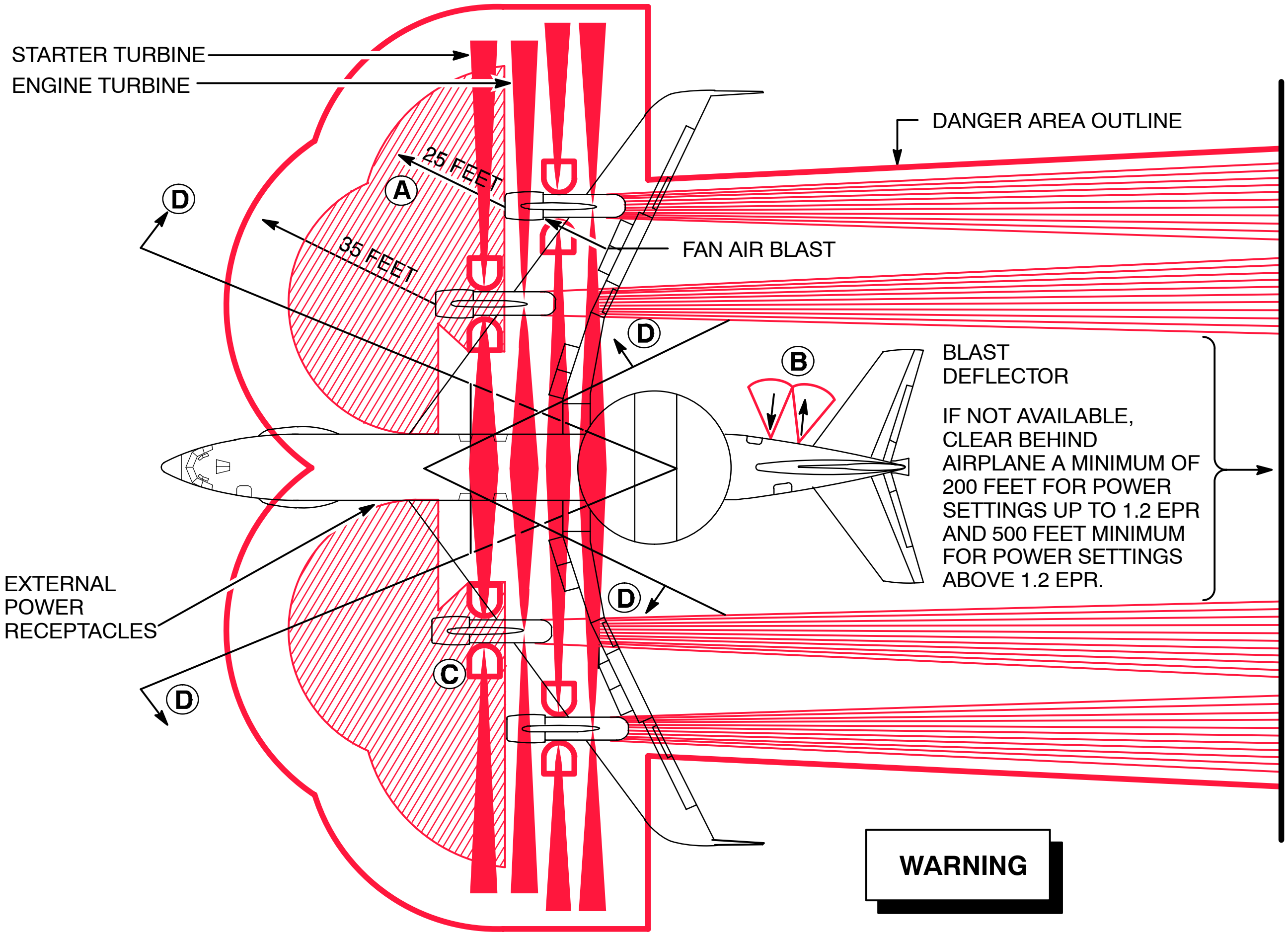
When the throttle is advanced to idle, fuel and ignition are turned on. The first sign of combustion (light off) is a rise in EGT which should occur within 20 seconds after throttle is advanced. Fuel flow at lightoff is normally less than 1,000 PPH. Fuel flow peaks at 1,600-1,800 PPH during engine acceleration and stabilizes at 1,100 PPH at idle. A sustained fuel flow of 1,400 PPH or higher at lightoff indicates a possible hot start. (Refer to STARTING MALFUNCTIONS.) Monitor EGT and RPM after lightoff to ascertain that limits are not exceeded.

CAUTION

When engine RPM and EGT have stabilized after starter cutout N_2 RPM should be between 54 and 60% and EGT below 340°C. N_1 RPM below 25% at this time is a sign of possible internal engine malfunction.

Danger Areas

DISTANCE FROM EXHAUST	20 FT	45 FT	100 FT	200 FT	300 FT
IDLE THRUST VELOCITY	135 MPH	40 MPH			
TAKEOFF THRUST VELOCITY	1000 MPH	500 MPH	200 MPH	100 MPH	50 MPH
IDLE THRUST TEMPERATURE	420 °F	195 °F			
TAKEOFF THRUST TEMPERATURE	920 °F	400 °F	200 °F	150 °F	



IF NOT AVAILABLE, CLEAR BEHIND AIRPLANE A MINIMUM OF 200 FEET FOR POWER SETTINGS UP TO 1.2 EPR AND 500 FEET MINIMUM FOR POWER SETTINGS ABOVE 1.2 EPR.

WARNING

LEGEND

▨ VERY HIGH FREQUENCY FAN NOISES VIBRATION AND INGESTION

▤ VELOCITY

🟥 ENGINE TURBINE WHEEL DANGER AREAS

Ⓐ ENGINE INTAKE DANGER AREA - (8M) 25 FT MIN WITH ENGINES AT MAXIMUM THRUST

Ⓑ APU INTAKE/EXHAUST DANGER AREA (25 FEET)

Ⓒ BLEED VALVE EXHAUST DANGER AREA

Ⓓ TIRE/WHEEL BURST DANGER AREA

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Figure 2-3

Engine Starting Procedure

PILOTS	ENGINEER	GROUND CREW
1. ANNOUNCE START SEQUENCE (P) Notify flight crew and ground crew of start sequence. Normal sequence is 3, 4, 2, 1.	1. ANNOUNCE STARTING NO.__	1. ANNOUNCE READY ON __
	2. SET AND HOLD START SELECTOR TO GND START Monitor VALVE OPEN indicator (For manual start, call “Valve Open”).	2. ANNOUNCE ROTATION
	3. MONITOR AIR PRESSURE, N_2, OIL PRESSURE, CAUTION LIGHTS. CALL OUT FAILURES (For cross start, adjust operating engine RPM to obtain required air pressure of 20 to 60 psig.)	3. MONITOR START Notify flight crew if fire or malfunction is observed.
2. SET THROTTLE TO IDLE (P) At 15% N_2 Monitor forward engine CAUTION instruments for abnormal indications. Verify OIL PRESS caution light out. **CAUTION** • A definite indication of N_1 RPM, either visually or on engine instruments, must be observed before moving throttles from cutoff to idle. • If pilots or engineer call NO CUTOUT or if VALVE OPEN indicator does not go out when start selector is released, set throttle to CUTOFF, to prevent starter damage.	4. ANNOUNCE 15% N_2 **CAUTION** Terminate start if no oil pressure is observed within 30 seconds of start initiation. 5. RELEASE START SELECTOR AND ANNOUNCE 35% N_2 **CAUTION** If start valve fails to close when start selector is released (indicated by VALVE OPEN indicator illuminated, or no rise in duct pressure), call “no cutout” and terminate start by setting throttle to CUTOFF, closing wing ISOLATION valve(s), and shut OFF starter air source to avoid damage to the starter. 6. MONITOR ENGINEER’S PANEL FOR ABNORMAL INDICATIONS ON ENGINE, HYDRAULICS.	
3. REPEAT STEP 2 FOR OTHER THREE ENGINES.	7. REPEAT STEPS 1 TO 6 FOR OTHER THREE ENGINES.	4. REPEAT FOR OTHER THREE ENGINES.

Figure 2-4

ALTERNATE START

For alternate starting methods refer to ENGINE OPERATION in subsection I-B. Flight crew will review applicable precautions and procedures with ground crew prior to start.

EXTERNAL AIR START

To start with external air, follow normal checklist procedure for APU start, except substitute external air for APU air. External electric power will be required if APU generator is inoperative.

WARNING

Reduce engine power to idle on operating engines before disconnecting ground air. High-pressure bleed air can cause hose to whip and injure ground crew if check valve fails to close.

CROSS START

After one engine is started, ground air or APU can be disconnected and engine bleed air used for cross starting other engines. Under some conditions, up to 80 to 90% N_1 RPM on the engine supplying air can be required to obtain required duct pressure.

NOTE

- For normal operations, APU start is preferred to cross start. Cross start is noisier, uses more fuel, and is more dangerous to personnel and equipment behind the airplane.
- In order to save time for scramble starts, the APU bleed valve can be closed, electrical power transferred to engine generators after the first engine is started. This allows the APU to begin cooldown while engines are being started.

MANUAL START

If an engine cannot be started because the starter pilot valve does not operate electrically, the starter valve can be operated manually. The manual start tool is stowed on the side of the left-hand flight avionics rack in the forward lower compartment. If interphone communication is available, the starting sequence is the same as a normal start (including use of start switches), except that the flight engineer must also call for “start valve open” or “start valve closed” on interphone. If interphone is not available, a signal man must be positioned where he/she can see the pilots and the valve operator. Pilot will brief ground crew on signals to be used.

To open the start valve manually, insert the point of the tool in the start valve release lug (3, *figure 1-17*) from above and push up on the handle. Maintain pressure on the valve until the engineer calls for valve closing. When pressure is released, the start valve should close by air pressure.

WARNING

- When operating a manual start, ground crew should use caution when in vicinity of fan duct exit nozzle. Air blast from operating engine could cause injury to personnel in fan discharge air path and in danger areas shown in *figure 2-3*.
- Leave throttle at idle after manual start until ground crewmen are clear of fan discharge air stream.

CAUTION

If start valve does not close when released, notify pilot to shut down engine to prevent starter damage.

STARTING MALFUNCTIONS

The following are indications of possible malfunctions.

CAUTION

If any of following malfunctions occur, discontinue start immediately by setting throttle to cutoff. Investigate cause before attempting another start.

a. EGT does not increase within 20 seconds after throttle is moved to idle. (Wet start.)

b. Sustained fuel flow at lightoff above 1,400 PPH. (Indicates impending hot start.)

c. EGT rapidly increasing or above 405°C. (Indicates impending hot start.)

d. N_1 or N_2 not increasing, or increasing slowly, while EGT is rapidly increasing. (Hung start.)

e. No indication of oil pressure 30 seconds after start initiation.

f. N_2 rpm below 54% two minutes after fuel on (throttle advanced).

CAUTION

- If start valve fails to close when start selector is released (indicated by VALVE OPEN indicator illuminated, or no rise in duct pressure), call “no cutout” and terminate start by setting throttle to CUT–OFF, closing wing ISOLATION valve(s), and shut off starter air source to avoid damage to the starter.
- If start selector switch is released from GND START below 35% N_2, set throttle to cutoff and allow engine to stop rotation before re-engaging starter. Motor engine with starter for 15 seconds to clear fuel from engine before attempting another start.
- If START CONTROL & IGNITION circuit breaker has tripped, do not reset until throttle is in cutoff and start selector switch is OFF. Tailpipe fire or torching can result if circuit breaker is reset with throttle advanced or if start selector is not set to OFF.
- Do not attempt to re-engage starter until N_2 rotation has stopped. Starter drive shaft can shear if starter is engaged while engine is rotating.

Failure to Start (Start Valve Not Open or Sheared Starter Shaft)

A failed start valve is indicated by no drop in duct pressure and failure of VALVE OPEN indicator to illuminate when start selector switch is moved to GND START. Engineer will check start air pressure, ISOLATION valve switches, and START CONTROL & IGNITION circuit breaker. If circuit breaker is open, it may be reset once. If second starting attempt is not successful, use manual start valve procedure in ALTERNATE STARTING PROCEDURES, subsection I-B, for further attempts.

CAUTION

If starter shaft is sheared, indications are same as a normal start, except that N_2 and oil pressure do not increase. Release start selector switch immediately to prevent additional damage to starter.

NOTE

If start control circuit breaker remains open after an attempt to reset, engine cannot be started, since ignition is not available.

Wet or Hot Start

If a wet start or hot start occurs when N_2 is below 35%, set throttle to cutoff and hold start selector switch to GND START for 15 seconds to clear unburned fuel from engine. Allow engine to stop rotating and investigate to determine cause before attempting another start.

If hot start occurs above 35% N_2, set throttle to cutoff. Allow engine to stop rotating and determine cause before attempting another start.

Fire During Start

If ground crew reports a tailpipe fire, proceed as for wet or hot start.

If a fire warning light illuminates, use ENGINE FAILURE OR FIRE procedure.

Hung Start

If N_1 or N_2 does not increase, or increases very slowly while EGT rapidly increases, set throttle to cutoff and hold start selector switch to GND START for 15 seconds to clear fuel from engine. Do not attempt to restart until N_2 rpm decreases to zero and cause has been determined.

CAUTION

If N_1 rpm is not indicated by 25% N_2 or ground crew calling rotation, release start switch and investigate cause before attempting another start.

STARTING ENGINES CHECKLIST

This checklist is used for all engine starts (NORMAL, ALERT, and SCRAMBLE).

– – – For Normal Starts, Omit Steps 1 Through 11 – – –

① All Plugs and Covers – Removed (E, GC)

2. AFTO Forms 781H and 781A – Checked (P, CP, E)
3. BATTERY Switch – ON (E)
4. EMERGENCY POWER Switch – NORMAL (E)
5. Standby Attitude Indicator – Uncaged (P, CP)
6. APU/External Power – On (E, N)
7. Aft Forced Air Cooling – On (E, N)
8. INU Mode – ALIGN or Nav (N)
9. Weather Radar – ON (P, N)

   Set range knob as required.

10. EMER EXIT LIGHTS Switch – ARMED, Guard Closed (CP)
11. OXYGEN – ON, 100% (P, CP, E, N, OBS)
12. AVIONICS POWER DISCONNECT, COMM AFT Switch – NORM (E)
13. SEAT BELTS Sign Switch – ON (CP or E)

⑭ APU or Ground Air – ON (E, GC)

   a. APU or Ground Air Cart – Started

   b. APU BLEED Switch – ON if APU used for Start

   c. APU GENERATOR Switch – ON

⑮ Hydraulic System – Set (E, GC)

   Flight engineer verifies ground crew and equipment are clear before starting pumps.

   a. AUXILIARY PUMPS Switches – On

   b. INTCON VALVE Switch – SYS

   Ground crew verify that wheel well doors close.

   c. ROTODOME DRIVE System Select Switch – As Required

CAUTION

If changing drives with rotodome rotating, set SPEED switch to OFF and wait 10 seconds before selecting other system.

NOTE

Alternate systems, one flight on utility drive, one flight on auxiliary drive. Record drive used.

16. PARKING BRAKE – Set (P)

⑰ Gear Pins – Remove, Directed (E, GC)

   Flight engineer directs ground crew to remove any installed ground locks.

⑱ Doors, Slides, Emergency Lights – Clear to Close and Arm (E, CSO, ART)

   Notify CSO and ART to close doors and arm emergency slides and lights.

19. WINDOW HEAT Switches – LOW (CP)

    Verify OVERHEAT caution light is out.

CAUTION

- Operate window heat in LOW for 10 minutes (unless mission accomplishment procedures dictate otherwise) before setting to HIGH to avoid damage to windows.
- Do not operate window heat for more than 10 minutes with sliding windows open if outside temperature is below 50°F (10°C).

20. FUEL ENRICHMENT Switch – As Required (E)

    ON for JP-5 or JP-8 and outside air temperature at or below 32°F (0°C), otherwise OFF.

NOTE

- Fuel enrichment above 32°F (0°C) is not recommended.
- If airplane is fueled with fuel other than JP-4 or AVGAS, fuel enrichment may be used for starting below 32°F (0°C).
- If airplane is fueled with fuel other than JP-4 or AVGAS, fuel enrichment must be used for starting below 0°F (–18°C).
- Engine starts can be difficult or impossible if fuel temperature is below –22°F (–30°C).

21. ROTODOME DRIVE SPEED Switch – As Required (E)

    Set at IDLE unless low temperature requires use of XMIT.

WARNING

Do not operate auxiliary rotodome drive at 6 RPM (XMIT) for takeoff, landing or go-around.

CAUTION

If the low pressure light does not go out within 2 minutes at 70°F (4 minutes at –54°C) move speed switch to OFF to prevent damage to hydraulic drive unit.

22. Fuel Panel – Set for Start (E)

    Refer to FUEL MANAGEMENT, subsection I-D.

㉓ Doors, Slides, Emergency Lights – Closed, Armed (CSO, ART, E)

24. Takeoff Briefing – Reviewed (P, CP, N, E)

    Pilots will review TOLD card data and set altimeters, airspeed bugs, and EPR bugs. Briefing will include takeoff, emergency and local departure procedures. This briefing may be accomplished at any convenient time prior to this step.

25. Gear Pins – Removed and stowed (E)

㉖ Warning Alarms and Lights – Checked (P or CP, E, ART, CDMT, CSO)

Pilot announces on PA, “Crew, checking warning alarms and lights.” Pilot also announces when checking each switch position. Set the WARNING BELL and LIGHT switches to ON, CRASH, BAILOUT and OFF. LOSS OF PRESSURE alarm will also be checked at this time. In turn the ART, CDMT, and CSO will check their respective compartments for illumination of the visual displays and warning alarm and will report to engineer only warning alarm and light malfunctions.

27. GINS – Ready for taxi (N)

    INUs aligned and in NAV mode
    or
    ATTD RDY (1 and/or 2) displayed; up to five minutes required to complete alignment in flight
    or
    ATTD RDY (1 and/or 2) not displayed; up to ten minutes required to complete alignment in flight.

㉘ Mission Crew – Ready for start and taxi (E, MCC)

MCC reports when mission crewmembers are seated, seat belts on, and oxygen ON, 100%. MCC will also check that personnel in crew rest or spare mission crew seats are seated with seat belts fastened.

29. PRIMARY and ALTERNATE Valve Switches – Off (E)

30. Start Clearance – Received (P, CP)

Obtain start clearance from tower and ground crew.

NOTE

- If starting engines at high altitude airport on hot day, advance throttle about one inch ahead of idle to reduce time required to accelerate to idle RPM. Retard throttle after starting.
- If starting engines in conditions conducive to engine inlet icing, turn on engine anti–ice after each engine is started. Confirm both valves opened before starting next engine.

31. BEACON Switch – ON (CP)

– – – When Engines Are Started (*figure 2-4*) – – –

32. NACELLE ANTI-ICE Switches – Checked and Set (P or E)

NOTE

Nacelle anti-ice will be used if OAT is 10°C or below and visible moisture is present. Anti-ice should be turned on and checked for proper operation immediately after each individual engine start in these conditions.

a. VALVE SELECTOR Switch – NOSE COWL

VALVE OPEN indicators (4) do not illuminate. Leave switch at NOSE COWL until step c.

b. NACELLE ANTI-ICE Switches – ON

VALVE OPEN indicators (4) illuminated

NOTE

Perform this check at idle power when possible. If a nose cowl anti-icing valve does not open in 1 second at idle thrust, increase thrust to 37 to 40% N_1. Do not exceed 40% N_1 when checking valve. If a valve does not open within 1 second at 37 to 40% N_1, record in AFTO Form 781. (Failure to open within 1 second at 37 to 40% indicates valve is sticking because of corrosion and can fail). If sticking anti-icing valve does not open when engine is stabilized at 1.2 EPR, valve has failed.

c. VALVE SELECTOR Switch – ENGINE

VALVE OPEN indicators should illuminate for all four engines.

d. NACELLE ANTI-ICE Switches – OFF

VALVE OPEN indicators (4) go out.

e. VALVE SELECTOR Switch – NOSE COWL

Verify VALVE OPEN indicators out for all four engines.

f. NACELLE ANTI-ICE Switches – ON if OAT at or below 10°C and visible moisture present.

CAUTION

- Do not operate nacelle anti-ice at power settings above 70% N_1 when outside air temperature is above 10°C unless visible moisture is present. Operation of nacelle anti-ice under these conditions for more than 10 seconds can cause damage to the engine. Anti-ice may be tested for up to one minute at power settings below 70% N_1 at temperatures above 10°C.
- In severe icing conditions (heavy super-cooled fog, freezing rain or wet snow) ice buildup can form on engine inlet guide vanes and early stages of the compressors during extended ground idle operations with nacelle anti-ice ON. Periodic engine runups to as high a thrust setting as practical (at least 55% N_1) dependent on parking area and taxiway conditions, can minimize these ice buildups. Such runups should be for about 10 seconds every 10 minutes. Subsequent takeoff under these conditions will be immediately preceded by a static engine runup for observation of EPR, N_1, and EGT to insure normal engine operation and that engine inlets are free of ice. If surface conditions preclude advancing power enough to dissipate inlet icing or icing remains visible on the inlet cowl or guide vanes, do not attempt takeoff.

33. PRIMARY Valve Switch – On (E)

34. FUEL ENRICHMENT Switch – OFF (P or E)

35. Electrical System – Set (E)

CAUTION

If LOW RPM light fails to go out when starting engine and generator breaker does not close, shut down the engine and have maintenance make a visual check for structural integrity and verify the IDG is reconnected before attempting restart. If LOW RPM stays illuminated after restart, disconnect IDG and resume operation with generator inoperative.

NOTE

- If LOW RPM light fails to go out after generator breaker is closed and the generator comes on line, the cause is probably a fault in the speed sensing circuit.
- Notify navigator and CSO prior to changing power.
- Any generator with a low RPM light caused by a faulty speed sensing circuit will experience its own bus tie opening when the load on that generator exceeds 80 amps.

a. IDG LOW RPM Light(s) – Out

b. Generator On Switches – On, Line Lights Illuminated

CAUTION

When transferring from external power or APU to the airplane generators, close only one generator breaker. When bus tie breaker recloses, the other generator breakers may be closed as rapidly as desired. Attempting to close the first two generator breakers at once on power transfer can damage generator drive.

c. BUS TIE OPEN Switches – Closed, Line Lights Illuminated

d. External Power and APU Generator – Off

CAUTION

- If APU shuts down during power transfer, or shuts down for no apparent cause, have condition of APU accessory drive shaft checked prior to any restart attempt.
- If auxiliary hydraulic pump number one and/or aft forced air cooling fan number one is/are operating during electrical power transfers, the corresponding ELCUs can trip causing system(s) to shut down. If this occurs, restart the system(s) immediately to prevent damage to airplane equipment.

e. Generators – Isolated

Check that the indicated frequency is 400 ± 8 Hz with oscillations less than 4 Hz in that range.

CAUTION

If any generator is outside these limits, check IDG oil temperature indicator and LOW RPM light. If indications are normal, shut down generator and disconnect IDG. If indications are abnormal, shut down generator but do not disconnect IDG. Shut down engine and call maintenance to do physical check of IDG.

f. Generators – Paralleled

36. Draw Through Cooling System – Checked (E)

a. AUTO Indicator – Illuminated

b. LOW SPEED Indicator – Illuminated

c. VALVE OPEN Indicator – Illuminated

37. Forced Air Cooling System – Set (E)

a. POWER Switches – On

b. MODE Switches – ENG APU

c. Aft Fan – On

d. Aft Fan Indicator – LOW SPD

e. Forward Fan – Off

f. System Control Switches – AUTO

g. System Select Switch – As Desired

38. Engine BLEED AIR Switches – As Required (E)

    If APU is used for heating or cooling, engine bleeds can be left off.

39. APU BLEED Switch – As Required (E)

40. Doors – Closed (E)

    APU DOOR caution light remains illuminated until after APU is shut down.

㊶ Chocks and Ground Equipment – Remove, Directed (P, GC)

Pilot directs ground crew to remove all chocks and ground equipment, then report back on interphone. For alert starts, verify SF_6 cart is removed and panel secured.

WARNING

Reduce power to idle on operating engines before disconnecting ground air hose. High pressure bleed air can cause hose to whip and injure ground crew if check valve fails to close.

42. Hydraulic System – Checked (E)
    a. Utility Pumps – OFF, Checked, ON
    b. Auxiliary Pumps – OFF, Checked, ON
    c. Interconnect Valve Switch – OFF

WARNING

If interconnect valve does not close, airplane will not be accepted for flight.

㊸ Taxi Report – Received (P, GC)

At pilot's command ground crew reports all external power, chocks, ground wires and pitot covers removed. All hatches and panels checked secure. Aircraft in taxi configuration – clearing interphone.

44. HAVE SIREN System – As Required (N)

    On if system to be used.

TAXI

Use the minimum thrust required to start the airplane forward. If a turn is required in a congested ramp area, start the turn at a speed just high enough to allow the airplane to coast around the turn at idle thrust, so that power is not needed in the turn while the jet exhaust is pointed at adjacent parking areas.

Nose wheel steering is used for directional control, aided by differential thrust if needed.

CAUTION

- Avoid using differential braking with nose gear steering. This causes excessive side loads on the nose strut.
- Do not ride brakes. Let the airplane accelerate, apply brakes to slow down, then release brakes so they can cool. Riding brakes can melt fuse plugs and deflate tires.

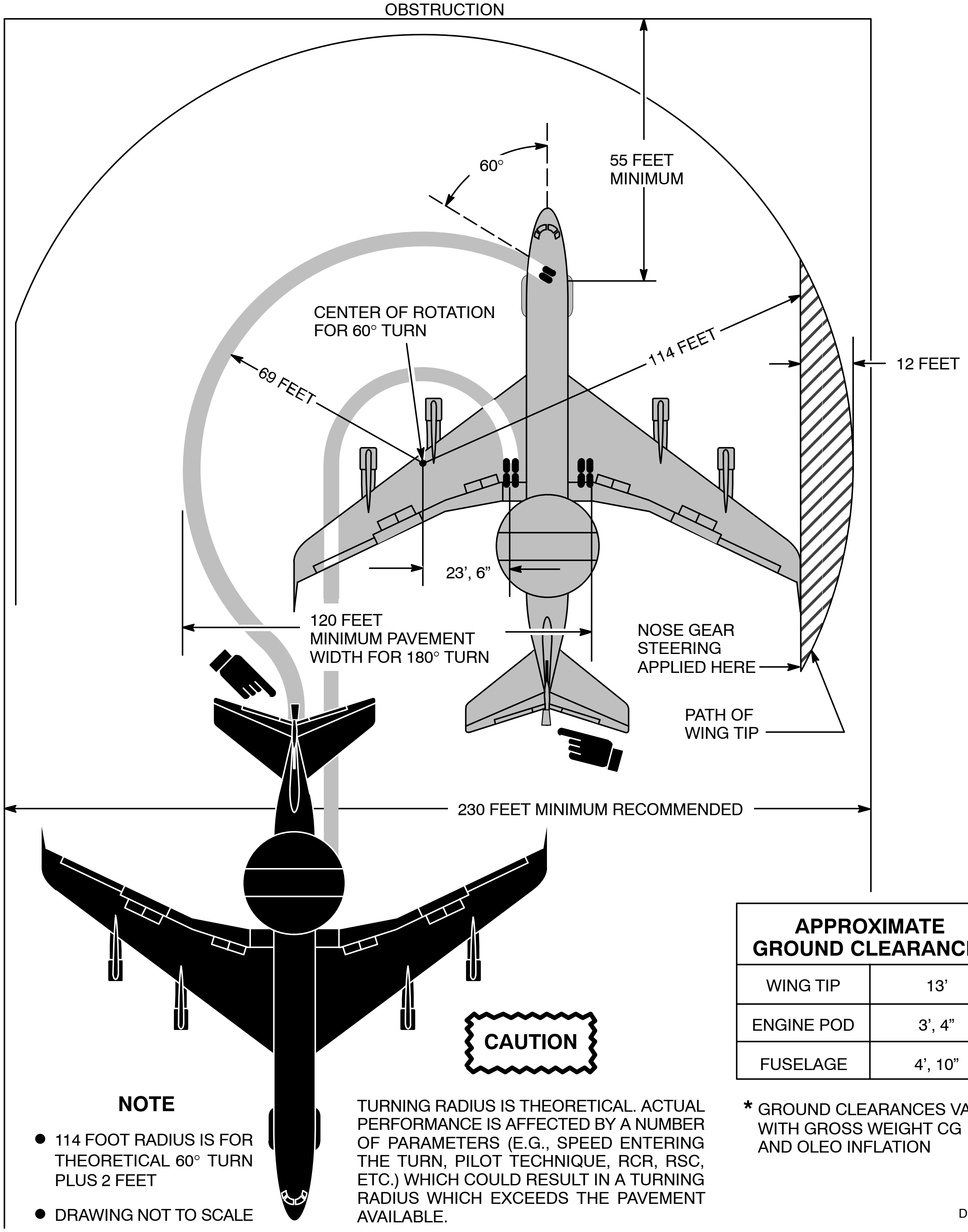
Visibility from the cockpit is good, but the pilot cannot see the wing tip from the normal seat position. The pilot is ahead of the nose wheel and the center of a turn is in a line with the main landing gear. The wing tips are aft of the center of a turn and actually move outboard up to 12 feet (*figure 2-5*). The pilot is outside of the taxiway centerline in a turn with more than 12 to 15 degrees of nosewheel steering. The pilot must overshoot the starting point before turning the nose gear steering wheel when taxiing in congested areas.

Make turns at as low a speed as possible, to reduce tire wear and side loads. After a turn, before stopping, center the nose gear steering and taxi straight ahead a few feet to relieve side loads on the landing gear.

Make a brake and nosewheel steering check after moving a few feet from the parking position.

Copilot will check turn needles, ADI, RMIs, and HSIs during a turn in either direction when not in a congested area. NAV system ground speed can be used for monitoring taxi speed. Navigator checks navigator's RMI.

Turning Radius and Ground Clearance



APPROXIMATE GROUND CLEARANCE*	
WING TIP	13'
ENGINE POD	3', 4"
FUSELAGE	4', 10"

* GROUND CLEARANCES VARY WITH GROSS WEIGHT CG AND OLEO INFLATION

CAUTION

TURNING RADIUS IS THEORETICAL. ACTUAL PERFORMANCE IS AFFECTED BY A NUMBER OF PARAMETERS (E.G., SPEED ENTERING THE TURN, PILOT TECHNIQUE, RCR, RSC, ETC.) WHICH COULD RESULT IN A TURNING RADIUS WHICH EXCEEDS THE PAVEMENT AVAILABLE.

NOTE

- 114 FOOT RADIUS IS FOR THEORETICAL 60° TURN PLUS 2 FEET
- DRAWING NOT TO SCALE

Figure 2-5

① UHF-ADF – Tuned to 243.0 MHz (E, CSO)

UHF-ADF must be retuned when power is transferred to airplane generators.

2. UHF-ADF – Monitor (P, CP, N, E)

NOTE

At least two crewmembers will monitor guard frequency at all times in flight.

3. Oil Quantity – Checked (E)

After engine has been operating at idle for at least one minute (5 minutes at –65°F) check oil quantity is no lower than two gallons below quantity noted at engine shutdown (or serviced quantity as noted in AFTO Form 781) and at least 1/4 gallon for each hour of intended flight.

NOTE

Oil quantity indicated on gage may decrease up to 2 gallons when engines start due to oil needed to fill engine oil lines, bearings, pumps, and coolers.

4. APU CONTR Switch – As Desired (E)

APU may be left on during taxi, if desired, for air conditioning or heating.

CAUTION

Prior to shutdown, operate APU for one minute without bleed air or generator load before stopping.

a. For normal APU shutdown:

(1) Press APU BLEED switch to close APU bleed valve. ON light goes out. If the primary or alternate flow control valves are not closed before closing the APU bleed air valve, the APU can surge. This can also cause the APU generator to trip off.

(2) Press APU GENERATOR switch to remove generator load. ON light goes out.

(3) Run APU for 60 seconds with no load. EGT should stabilize below 400°C.

(4) Set APU CONTR switch to STOP. APU DOOR caution light remains illuminated for approximately 90 seconds.

5. Windows – CLOSED and LOCKED (P, CP)

NOTE

Placing objects in the hole to the rear of the sliding window handle may cause difficulty in opening the window during emergency egress.

6. PROBE HEATERS Switches – ON (CP)

BEFORE TAKEOFF

The BEFORE TAKEOFF checklist is normally accomplished prior to taking active runway for takeoff. For SCRAMBLE, begin this checklist immediately after completing the TAXI checklist.

1. SPEED BRAKE Lever – Full Forward, In Detent (P)

2. Flaps – 14, 14, Green Lights (CP)

Flap lever set to 14. INBD and OUTBD gages indicate 14 (±3). Both LE FLAP indicators illuminated.

3. Stabilizer Trim – Set (P)

4. Engine BLEED AIR Switches – ON (E)

5. APU CONTR Switch – STOP (E)

CAUTION

Prior to shutdown, operate APU for one minute without bleed air or generator load before stopping.

NOTE

APU DOOR caution light remains illuminated for about 90 seconds after APU CONTR switch is set to STOP.

6. FUEL HEAT Switches – As Required (E)

   Refer to FUEL HEATER GROUND OPERATION, subsection I-B. If fuel temperature is 0°C or below, turn fuel heat on for one minute.

7. Fuel Panel – Set for Takeoff (E)

   Refer to FUEL MANAGEMENT, subsection I-D.

8. Rotodome Drive SPEED Switch – IDLE (E)

   WARNING

   Do not operate auxiliary rotodome drive at 6 rpm (XMIT) for takeoff, landing or go-around.

   NOTE

   If utility rotodome drive is operating at 6 rpm (XMIT), pump low pressure lights can illuminate when flaps are being extended or nose wheel steering is being used. Rotodome drive fluid flow requires entire output of both pumps when engines are at or near idle rpm.

9. APU DOOR Caution Light – Out (E)

   CAUTION

   - Do not attempt takeoff if either APU door is open. APU shroud can fail and airplane cannot be pressurized.
   - Tail buffeting can result if APU exhaust door is open in flight.

10. FUEL HEAT Switches – Off (E)

11. Maintenance Interphone Switch – AIRCRAFT (E)

12. CONTINUOUS IGNITION Switch – ON (E)

13. NACELLE ANTI–ICE – As Required (P, E)

    a. If Icing Conditions Anticipated During or After Takeoff – ON

    b. If Icing Conditions Not Anticipated or OAT Above 10°C – OFF

14. Altimeters, Flight Instruments, Navigation Aids, ADS Panel – Set (P, CP, N)

    a. Altimeters – Set and RESET (P), Set and RESET (CP), SET (N)

       Check that latest altimeter setting is set.

    b. ADIs, HSIs, RMIs – Set As Required for Departure; No Flags

       Flags are out of view on ADI, HSI, and RMI.

    c. Navigation Aids – As Required for Departure

    d. ADS Panel – As Required for Departure

15. **WITH IDG** Altitude Alerters – Set, As Required (CP) ◀

⑯. Mission Crew – Ready for Takeoff (E, MCC)

– – – After Cleared Onto Runway – – –

17. Takeoff Announcement – Completed (P or CP)

    Pilot or copilot makes takeoff announcement over P.A.

18. WINDOW HEAT Switches – HIGH (CP)

19. **LESS IDG** IFF MASTER Switch – NORM (CP or E) ◀ **WITH IDG** IFF – NORM (N or CP)

    Select IFF to NORM on iff control page. ◀

20. **WITH IDG** TCAS SENS – TA/RA, As Required (N or CP) ◀

21. All Exterior Lights – ON (CP or E)

    Select red or white strobe lights as desired for visibility.

    CAUTION

    Do not operate landing lights or RUNWAY TURNOFF lights unless airplane is in motion, except for momentary checks to verify operation.

TAKEOFF

TAKEOFF PLANNING

All takeoffs are planned as described in part II of T.O. 1E-3A-1-1, assuming one engine fails at V_1. If all engines are operating, takeoff performance is better than planned. Also see *figures 2-6* and *2-7*.

TAKEOFF WARNING SYSTEM

If the horn sounds before V_1 during the takeoff roll, the takeoff should be aborted.

STABILIZER TRIM SETTING

During normal pretakeoff procedures, the stabilizer trim is set according to the CG and gross weight and rechecked prior to takeoff.

NOTE

If stabilizer setting is in yellow band on decal, check c.g. and stabilizer trim setting. Pull force required at rotation with trim in yellow band is higher than normal at gross weights above 250,000 pounds.

With the stabilizer mis-set in the green or yellow band either nose down or nose up, the pilot could have no indication of mistrim prior to rotation and might not have proper amount of pressure on nose wheel.

If the airplane does not respond as anticipated at V_{ROT} with normal control column forces, assist with stabilizer trim while applying force as required.

With a forward CG and the stabilizer mistrimmed nose down but in the green or yellow band, an increased pull force is required to obtain sufficient elevator for rotation at V_{ROT} or shortly thereafter. If the takeoff is runway limited and a heavy pull force is required at rotation, use some nose up stabilizer trim to assist.

NOTE

- It is possible for pilot's stabilizer trim indicators to read ±1/2 unit from actual trim position.
- One half unit of mistrim at maximum gross weight and forward c.g. limit changes rotation pull force about 10 pounds.

If the CG is aft and the stabilizer is mistrimmed nose up but in the green band, the airplane can attempt to rotate at or before V_{ROT}. Full nose down elevator and some nose down stabilizer can be required to stop the pitch up. Pitch up with increasing speed increases a nose up out of trim condition. Use the stabilizer trim as required, hold V_{CO} to V_{CO} + 10 knots and do not retract flaps while retrimming the stabilizer. Limit bank angles to 15° at this speed until in trim.

AFT CENTER OF GRAVITY EFFECTS

At aft CG and light weights (under 230,000 pounds) observe the following CAUTIONS:

CAUTION

- At aft CG (30% or greater) and light weights (under 230,000 pounds) directional control from nose wheel steering is reduced because of little weight on the nose wheel. Slippery surfaces cause ineffective nose wheel steering. Make a rolling takeoff with slow, steady thrust application as speed increases.
- At aft CG (30% or greater) and at light gross weights (under 230,000 pounds), takeoff thrust combined with a sudden brake release tends to raise the nose wheel off the ground. If pitchup occurs, do not apply heavy brakes and/or suddenly pull the throttles to idle. This drives the nose gear back onto the runway. Instead, reduce thrust slowly, lowering the nose gently. Once the nose gear is firmly on the runway, reapply takeoff thrust slowly. If runway is limited, abort the takeoff.

Takeoff - Typical

Normal Takeoff

MANEUVERING SPEEDS

FLAPS	MANEUVERING SPEED *	MAXIMUM BANK ANGLE
0	V_{CO} + 55	30°
14	V_{CO} + 10	30°
* **WARNING**	Limit bank to 15° until this speed is reached.	

CLIMB SPEEDS

- Best angle climb
  - -- Flaps 14 – V_{CO} +10 KIAS
  - -- Flaps Up – V_{CO} +55 KIAS
- Enroute Climb
  250 KIAS to 10,000 ft then
  280 KIAS to 0.7 ± 0.01 M
- As required by ATC

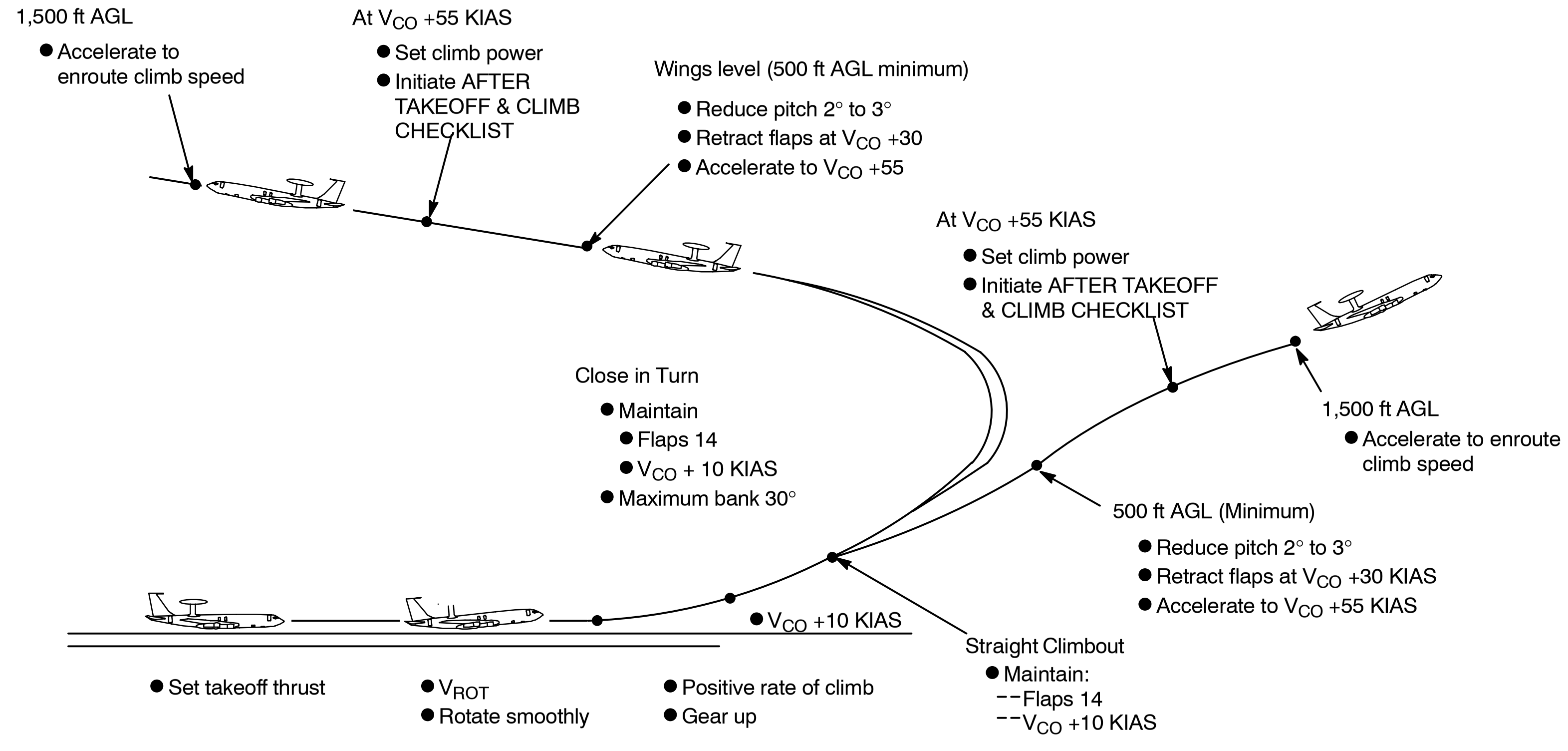


Figure 2-6

Takeoff and Departure Speeds

CONDITION	CLIMB PERFORMANCE	FLAPS	AIRSPEED KIAS
FOUR ENGINES			
After Takeoff (Max. Bank 30°)	Best Angle	14°	$V_{CO} + 10$
Departure or Obstacle Clearance, Close In (Max. Bank 30°)	Best Angle	14°	$V_{CO} + 10$
Obstacle Clearance	Best Angle	UP	$V_{CO} + 55$
Below 10,000 Feet	(Appx. Best Rate)	UP	250
Departure Acceleration	500 FPM	UP	250 to 280
Departure		UP	280 to M .70 ± .01
Turbulence		UP	280 to M .70 ± .01
THREE ENGINES			
After Takeoff (Max. Bank 15°)	Best Angle	14°	V_{CO} ①
Departure or Obstacle Clearance, Close In (Max. Bank 30°)	Best Angle	UP	$V_{CO} + 55$ then 250 to M .60 ①
TWO ENGINES			
Departure	Best Angle Best Rate	UP	$V_{CO} + 55$ then ① ② 215 to M .40

WARNING

① Maintain at least V_{MCA} (minimum control speed) as shown in T.O. 1E-3A-1-1, part VII and do not exceed corresponding EPR settings.

② With two engines out on same wing, do not exceed 250 KIAS.

Figure 2-7

ABNORMAL TAKEOFF CONFIGURATIONS

When specifically authorized, takeoff may be initiated in certain non-standard configurations. Refer to PERMISSIBLE OPERATIONS, page xiii.

WARNING

There are specific limitations on gross weight, critical field length, crosswind, and runway condition (RCR). Refer to Section V and T.O. 1E-3A-1-1.

Takeoff with 7 or 6 Brakes

If one or two brakes are inoperative, use the 7- or 6-brake takeoff data in T.O. IE-3A-1-1 and follow the procedures in section III. Observe the limitations shown in Section V.

Takeoff with Antiskid Malfunctions

If one or more antiskid valves malfunction (no REL light on preflight) observe limitations in Section V and use antiskid inoperative procedure in Section III and antiskid inoperative data in T.O. 1E-3A-1-1.

Takeoff with Partial Spoilers

If either the inboard or outboard spoilers are known to be inoperative, use the partial spoiler takeoff data in T.O. 1E-3A-1-1 and follow the procedures in Section III. Observe the limitations shown in Section V.

WARNING

Both hydraulic systems shall be operating for takeoff.

REDUCED THRUST TAKEOFF

Takeoff may be planned with less than the maximum allowable thrust for the existing outside temperature if the performance conditions in T.O. 1E-3A-1-1 can be met. Takeoff thrust may be reduced to increase engine life (by reducing the amount of time the engines are operated at high EGT and EPR) or to simulate heavy weight, hot day operation at light training gross weights and at lower temperatures.

When takeoff thrust is reduced, takeoff acceleration is reduced and the takeoff can become climb and/or runway limited where it would not be limited at takeoff rated thrust.

Reduced EPR for takeoff is calculated by finding the maximum temperature (50°C or below) which allows the airplane to meet these conditions:

a. Obstacles must be cleared with three engines operating, assuming liftoff at the end of the runway or at the end of the critical field length.

b. Minimum three engine gear up climb gradient is 3%.

For details of reduced thrust takeoff planning, refer to part II of T.O. 1E-3A-1-1.

WARNING

If windshear is suspected, use TRT for takeoff instead of reduced thrust.

NOTE

When reduced thrust is used for takeoff, the acceleration EGT limit (section V) applies.

STATIC TAKEOFF

Static takeoffs will be performed when maximum airplane performance is required. Pilot makes initial thrust setting, then engineer, at pilot's command, makes final thrust setting before brake release.

ROLLING TAKEOFF

Rolling takeoffs are permitted at all gross weights and are recommended for gross weights under 230,000 pounds.

Rolling takeoffs are made either by not stopping when taxiing onto the runway, or by advancing the throttles from 1.2 EPR to takeoff thrust after brake release. Engine performance is checked during the takeoff roll.

TAKEOFF ROLL

Release brakes slowly and smoothly for all takeoffs. If the airplane is not aligned on the runway before brake release, steer the airplane toward the centerline at the start of the takeoff roll.

The pilot advances all throttles to about 1.2 EPR. When all engines stabilize, pilot (or flight engineer at pilot's command) advances throttles slowly to takeoff thrust. This eliminates thrust asymmetry caused by differences in individual engine acceleration, aids in preventing overshooting the desired thrust setting, and minimizes engine surge caused by cross winds.

The pilot (if not already done) relinquishes throttles to the flight engineer and rests the right hand on or near the throttles. The flight engineer makes final thrust adjustments as soon as possible, but before 80 knots. Once the throttles are set for takeoff, do not readjust them unless an engine is exceeding a limit, such as N_1 or EGT. Use EPR as the primary setting. Use N_1 if EPR gage fails.

During takeoff roll, the copilot will maintain wings level and apply sufficient pressure on the yoke to maintain nosewheel contact with the runway until pilot assumes control of the yoke.

The rudder becomes effective at 60 to 80 knots. The copilot will call 80 knots.

After engine thrust stabilizes, but before reaching V_1, the flight engineer will scan the flight engineer's panel for caution lights and abnormal engine indications. Flight engineer will return scan to center instrument panel immediately.

The copilot will call V_1. The pilot then assumes control of the yoke with the right hand. The pilot's left hand will remain on nosewheel steering until approaching V_{ROT}, then shift to the yoke.

Both pilots will monitor airspeed throughout the takeoff roll.

RIGHT SEAT TAKEOFFS

If the copilot is making the takeoff, copilot will verbally confirm taking directional control at 80 knots. The pilot will then be responsible for monitoring engine instruments and calling V_1. The pilot will continue to guard the throttles until reaching V_1. In case of an abort, the pilot will assume control immediately and perform necessary actions.

ABORTED TAKEOFF

Although copilot and flight engineer both maintain a check of airspeed and engine instruments during the takeoff roll, the decision to continue the takeoff or to abort is made by the pilot alone. Prior to V_1, if the copilot or flight engineer notices a rudder boost failure, fire, or an engine malfunction which makes the airplane unsafe for flight, "REJECT," will be called. Refer to ABORTED TAKEOFF, Section III. For any other malfunction, make a short description statement to the pilot, who will make the decision to continue or abort.

If a malfunction occurs after V_1, make a short descriptive statement to the pilot. Minor malfunctions having no immediate impact on safety of flight will be reported when the airplane is safely airborne.

WARNING

- If an engine fails, the minimum control speeds shown in T.O. 1E-3A-1-1 depend on immediate application of rudder and nose gear steering pressure to maintain runway direction. Refer to ENGINE FAILURE AFTER V_1, Section III.
- For dry runway conditions, the most effective nose wheel steering occurs at about 5 to 7° of steering wheel turn. A greater angle results in skidding and scrubbing with the turning effect rapidly decreasing to near zero. Optimum steering angles are less for slippery conditions (1 to 2° for icy runway). Skidding or skipping of the nose wheel is generally recognized by heavy chatter felt through the steering wheel; if this occurs, reduce steering angle until chattering ceases.
- If either nose wheel tire fails during the takeoff run, the pilots must be alert to the possibility of failure of the remaining tire. If tire failure occurs prior to V_1 speed, abort the takeoff. If tire failure occurs after V_1 speed, and the takeoff is continued, maintain only sufficient forward pressure on the control column to insure nose wheel contact with the runway. Use the rudder as the primary means of maintaining directional control.

NOTE

The rudder is the primary means of maintaining directional control with the nose gear steering as a backup. The rudder is sufficiently effective at airspeeds above 80 knots to give adequate control in crosswinds up to the maximum allowable crosswind with four engines operating. The pilot continues to hold the nose gear steering wheel steady until rotation speed is approached to permit full directional control if an outboard engine fails.

ROTATION AND LIFTOFF

At V_{ROT}, rotate the airplane to the climbout attitude in eight to nine seconds. The movement of the column should be smooth and sustained rather than abrupt. The airplane normally lifts off at about 10° of pitch attitude. Refer to T.O. 1E-3A-1-1 for values.

The pilot not flying will call out “rotate” at V_{ROT}. The other pilot is responsible for checking his/her own airspeed and starting rotation at V_{ROT}.

WARNING

- Early rotation increases drag and also increases the ground run. Excessive early rotation could result in a high drag attitude, stick shaker actuation and an extremely long takeoff run.

- Overrotation on takeoff adversely affects takeoff performance. The nose-high attitude can result in a tail strike and causes an increase in drag, delaying acceleration to takeoff speed, and can actuate the stick shaker or cause buffet which further decreases performance. If overrotation should occur, lower the nose smoothly to 10 degrees and continue the takeoff.

GEAR RETRACTION

Retract landing gear only when a positive rate of climb is indicated on the flight instruments.

WARNING

- Because of ground effect, the vertical velocity indicator and the altimeter do not show a positive climb until the airplane is 35 to 50 feet above the runway.

- Gear retraction temporarily increases the airplane drag while the doors are open.

CAUTION

Do not actuate brake pedals during gear retraction. Sufficient braking is automatically applied to wheels when handle is up and gear is in transit. Sudden application of brake pedal force during retraction causes violent pitching of main gear truck and induces heavy loads on truck leveling system. If brake pedals are actuated inadvertently during gear retraction, record in AFTO Form 781. (Maintenance inspection must be carried out.)

CROSSWIND TAKEOFF PROCEDURE

Use normal takeoff procedures, except that pilot will preset control wheel into the wind, then copilot will use ailerons as required to keep wings level and maintain 20 pounds forward pressure on wheel to ensure sufficient nose wheel contact. After pilot releases throttles at V_1, copilot will follow through on wheel until pilot releases nose wheel steering when approaching V_{ROT}. Maintain crosswind correction as required to keep wings level. Use rudder to hold airplane on centerline.

Engine surge can occur with a strong crosswind component if takeoff thrust is set prior to brake release. With a crosswind component above 20 knots, perform a rolling takeoff.

Smooth rudder control inputs combined with small lateral control and nosewheel steering inputs result in a normal takeoff with no overcontrolling directionally or laterally.

During rotation, hold the control wheel in the displaced position to keep the wings level during liftoff. The airplane is in a sideslip with crossed controls at this point. A slow, smooth recovery from this sideslip is accomplished after liftoff.

In gust conditions, increase the rotation speed and takeoff speed by the full gust increment, not to exceed 10 knots.

Call for “GEAR UP” when a positive rate of climb is indicated on the flight instruments.

NOISE ABATEMENT TAKEOFF

In many locations a noise abatement takeoff is required. A typical procedure can require a turn to a specific heading, reduction of thrust at a specified altitude, or a maximum performance climb, followed by thrust reduction. Charts are provided in T.O. 1E-3A-1-1, Part II to determine the minimum (4-engine) EPR required for a given climb gradient.

WARNING

Noise abatement procedure will be discontinued if an engine fails, or if any malfunction occurs which requires increased climb performance.

OBSTACLE CLEARANCE TAKEOFF

Refer to the charts in T.O. 1E-3A-1-1 for climb path data for obstacle clearance. Use normal takeoff technique, except maintain takeoff thrust, flaps 14, and V_{CO} + 10 KIAS until clear of the obstacle or until reaching the height selected for flap retraction. Do not let airspeed increase above V_{CO} + 10 KIAS. If airspeed exceeds V_{CO} + 10 KIAS, raise the nose until airspeed returns to V_{CO} + 10. Do not decrease airspeed below V_{CO} + 10.

CAUTION

Observe the five minute limit on use of takeoff rated thrust, Section V.

NOTE

- Obstacle clearance performance shown in charts in T.O. 1E-3A-1-1 is based on three engines operating. Actual performance with all engines operating should be at a slightly steeper climb gradient.
- If using obstacle clearance chart based on MRT after 5 minutes of TRT, set MRT for climb (maximum 30 minutes).
- If obstacle clearance performance with rolling takeoff is marginal, use a static takeoff.

When clearing an obstacle where flaps can be retracted before reaching the obstacle, reduce climb rate to approximately 500 feet per minute then maintain takeoff thrust and accelerate to V_{CO} + 55 (best angle of climb speed) while retracting flaps. Maintain V_{CO} + 55 until the obstacle has been cleared.

FLAP OPERATING PROCEDURE

At the other pilot's command, the pilot not flying the airplane moves the flap lever and observes the flap indicators and monitors the LE FLAP lights. The flight engineer monitors hydraulic pressure and quantity during all flap operations.

AFTER TAKEOFF AND CLIMB

Under normal conditions when climb thrust is set, the flight engineer will perform the following AFTER TAKEOFF AND CLIMB checklist silently, challenging only steps not completed. Complete the following steps as mission requirements dictate. Where coordination with mission crew members is required, use mission interphone or direct access interphone as required.

CAUTION

Use of FAC FANS manual HI SPEED OVERRIDE will be limited to one minute at or below 5,000 feet MSL to prevent fan motor damage.

1. Gear Lever – OFF, In, Lights Out (CP)

   Landing Gear Up gear lever set to OFF and in detent. GEAR and DOOR warning lights out.

2. Flaps – Up (CP)

   Both gauges zero; LE flap indicator lights out.

3. RETRACTABLE LANDING Lights – As Required (CP, E)

   Do not operate retractable landing lights for daylight touch and go or daylight full stop landing.

4. Forced Air Cooling Systems – On, AUTO (E)
   a. Fan(s) – On
   b. System Control Switches – AUTO
5. NACELLE ANTI-ICE Switches – As Required (E)
6. CONTINUOUS IGNITION Switch – As Required (E)
7. Rudder Override Switch – As Required (E)

a. With 4 Engines Operating – NORMAL

b. With 3 Engines Operating, Leaving Pattern – NORMAL

c. With 2 Engines Operating Or 3 Engines, Remaining In Pattern – OVERRIDE

WARNING

When setting rudder override switch in flight, physically identify both the RUDDER (lower) and OVERRIDE (upper) switches. Operation of wrong switch could cause loss of control.

8. Rudder Mode Indicator – 2,290 PSI Above 185 KIAS With Override Switch Normal (E)

WARNING

- If rudder mode indicator does not indicate 2,290 PSI at airspeeds above 185 KIAS with override switch set to NORMAL, either limit airspeed to below 250 KIAS, or shut off rudder boost, disengage series yaw damper and engage parallel yaw damper.
- If override switch is set to OVERRIDE, do not exceed 250 KIAS.

9. Hydraulic System – Checked (E)

10. ROTODOME DRIVE SPEED Switch – As Required (E)

11. Fuel System – Checked (E)

Refer to FUEL MANAGEMENT, subsection I-D.

12. Electrical System – Checked (E)

AC ammeters should show equal load within ±30 amperes.

⑬ ART and CT – Notified, Cleared for Walkaround (E, ART, CT)

14. Air Conditioning and Pressurization – Set (E)

Set zone temperature selector knobs as required. Set GASPER AIR switch as needed for crew comfort, adjust cabin climb rate. Set auto controller BARO CORR scale to 29.92. Set cabin altitude as required.

15. Draw Through Cooling Panel – Normal (E)

All indicators and caution lights out when cabin differential above approximately 2 psi.

⑯ Mission Compartment Check – Completed (E, ART, CT)

ART and CT will notify flight engineer when compartment check is complete and if there are any abnormal items.

17. SEAT BELTS and NO SMOKING Switches – As Required (E)

⑱ Mission System – Cleared to Power Up (E, MCC)

After ensuring a minimum of six generators in parallel, rotodome at 6 RPM, forward forced air cooling system operating, and TAT is 15°C or below and not rising, the flight engineer notifies the MCC; cleared to power up mission systems.

⑲ Avionics Power Disconnect, COMM FWD Switch – NORM, When UHF G AC, UHF G DC, VHF G Requested (CT, E)

CAUTION

- Open circuit breakers for VHF guard receiver (E12) when cooling air is not available to rack E12. Indications of this condition are FORCED AIR COOLING SUPPLY AIR temperature gage indicates forward forced air cooling system air exceeds 75 ± 5°F and both forward forced air cooling system fans operate on low speed.
- If a temperature inversion exists, cooling air isolation valves in equipment racks can open and close more than once during climb. Do not close circuit breakers until after climbing above inversion layer.

⑳ UHF Guard Radio – Tuned 243.0 (CSO, E)

21. UHF Guard – Monitor (P, CP, N, E)

22. Exterior Lights – As Required (CP, E)

Landing, WING illumination, and RUNWAY TURNOFF lights OFF above 10,000 feet and illuminated below 10,000 feet. RETRACTABLE LANDING lights should be off/retracted before 223 KIAS. Strobe lights as required.

23. Rudder Mode Indicator – 1,450 PSI Above 265 KIAS (E)

WARNING

If rudder mode indicator does not indicate 1,450 PSI at airspeeds above 265 KIAS, either limit airspeed to below 250 KIAS, or shut off rudder boost, disengage series yaw damper and engage parallel yaw damper.

24. Altimeters – Set 29.92, RESET (P), Set 29.92, RESET (CP), Set 29.92 (N)

    Set altimeters to 29.92 inches when climbing through transition altitude. Pilot and copilot check altimeter modes. Pilot and copilot set radio altimeter MDA bug to 2,000 feet.

25. **WITH IDG** Altitude Alerters-29.92-Set (P or CP) ◀

26. HAVE SIREN System – OFF (N)

CLIMB

AREA DEPARTURE

A major factor in departures is airspeed control which allows a turn radius suitable for the assigned area departure. The selection of the climb speeds becomes an item of pilot judgement as to use of a speed for minimum radius turn, maximum angle of climb, maximum rate of climb, penetration of turbulence, maximum distance, or other requirement.

If a turn is required immediately after takeoff, maintain the takeoff flap setting, hold V_{C0} + 10 knots and start the turn at a safe altitude. Limit bank angle to 30°.

If a turn is not required immediately after takeoff but is desired before flap retraction, it is often better to leave the flaps extended and complete the turn using V_{CO} + 10 knots rather than to retract flaps and turn at a higher speed and consequently greater radius. Establish climb configuration on enroute heading.

The actual airspeed used when maneuvering clean varies with the situation. Generally, where considerable maneuvering is required after flaps up during an area departure, use the best angle of climb airspeed of V_{CO} + 55 knots with a normal bank limit of 30°.

WARNING

Do not exceed 0.75 Mach when gross weight is below 250,000 pounds and the CG is aft of 32% MAC. Above 0.75 Mach at these conditions, the airplane can become pitch sensitive and control inputs from either the pilot or autopilot can result in pitch oscillations which might exceed structural limitations. If oscillations occur, release the control column or disengage the autopilot. Then reduce speed to 0.75 Mach or less.

ENROUTE CLIMB

The enroute climb speed schedule is 250 KIAS to 10,000 feet, then acceleration to 280 KIAS until reaching 0.70 ± .01 Mach. Climb charts in T.O. 1E-3A-1-1, Part III, are based on accelerating to 280 KIAS with 500 ft/min. rate of climb. This speed schedule approximates the best rate of climb speed schedule as all aspects of the enroute climb profile are considered including acceleration from flaps-up speed to climb speed, rate of climb, and acceleration to cruise speed at cruise altitude.

V_{CO} + 55 knots may be used for terminal area maneuvers after takeoff.

CRUISE

On leveling off at cruise altitude, set cruise power. If a combination of gross weight and temperature requires use of limit EPR and desired Mach number cannot be maintained, either select a lower altitude, lower Mach number, or accept the speed loss until fuel burnoff permits desired Mach number.

Engine parameters should be crosschecked in flight. Normal operation is indicated by equal indications (±10%) between engines. One parameter, such as a fuel flow meter indicating abnormal flow or fluctuations, is normally reflected on other engine parameters (EGT, EPR). If no other indications are abnormal, an indicator malfunction is likely. An abnormal indication accompanied by others is checked by charts to obtain proper indications or compared to another engine.

During cruise, flight engineer will monitor operating systems. Pilots and navigator will coordinate autopilot, flight director and GINS operation as required. Pilots will maintain speed and thrust settings as required.

WITH IDG RVSM OPERATION

Following are the minimum equipment list, equipment setup requirements, and equipment failure reporting requirements for operating in RVSM airspace:

a. Pilots' altimeters will both be operating in RESET mode and must not differ by more than 200 feet. A greater altitude difference will be reported to ATC. Pilots will cross check altimeters at least once each hour.

NOTE

A difference between altimeters exceeding the allowable differences shown in *figure 5–14* is out of tolerance and shall be reported to maintenance, but not to ATC unless the difference exceeds 200 feet.

b. The altitude alerter system must be on, with at least one of the two alerters operating normally. Loss of both alerters will be reported to ATC.

c. Autopilot ALT HOLD must be operative and will be used to the maximum extent practical. Failure of the autopilot or failure of ALT HOLD, or non–temporary disengagement of altitude hold, such as for wide area turbulence, will be reported to ATC.

d. ATC transponder operation in Modes 3A and C is required. Failure of Mode 3A or C will be reported to ATC. ◀

ON-STATION

The on-station procedure is based on flying at best endurance airspeed. Primary steering control on-station is the autopilot, using pattern steering from GINS VOR or TACAN can be used for holding patterns, but bank angles should be kept below 15°. Flight engineer will monitor fuel temperature in tanks with operating LCS heat exchangers.

WARNING

Center wing fuel tank pumps must be off unless personnel are available in the flight deck to monitor LOW pressure lights. Each center wing tank fuel pump switch must be positioned to OFF without delay when the respective center wing tank fuel pump LOW pressure light illuminates.

NOTE

- Plan pattern entry (reference Mission Orbit Patterns, subsection I–L and ENTERING MOPS INTO FLIGHT PLANS, subsection I–N–3) to minimize maneuvering and bank angles to avoid interference with mission operations. When steering is engaged, the autopilot turns the airplane (in a bank up to 30°) to capture the circular segment of the steering pattern. The navigator will inform the pilot and MCC prior to selecting pattern steering. When mission operations require discontinuing the normal autopilot operation using pattern steering from the GINS (while still remaining on-station), the navigator should select waypoint steering mode in GINS. When re-entry to pattern steering is desired, normal entry procedures will be followed.
- After prolonged turns, the standby attitude indicator can tumble or precess. Pull caging knob momentarily to reset when in wings level flight.
- Verify compass SYNC indicators are centered after prolonged turns.

AIR REFUELING PROCEDURES

Air refueling procedures are contained in T.O. 1-1C-1-27, and in Air Refueling Checklists, T.O. 1-1C-1-27CL-1 and -2.

Refer to subsection I-D for details of the air refueling system. The tank filling sequence in Section I shall be followed in air refueling. Fuel feed shall be main tank to engines, regardless of gross weight.

DESCENT

ENROUTE DESCENT

Maintain cruise altitude until reaching desired distance out for planned descent and then hold selected airspeed schedule during descent. Deviations from the proper schedule can result in arriving too high at destination and require circling to descend or arriving too low and far out requiring extra time and fuel.

TURBULENCE PENETRATION - LEVEL OR DESCENT

The recommended turbulence penetration speed is: M = 0.70 (±0.01) or 280 KIAS, whichever is lower. Refer to Section VII for turbulence procedures.

OPTIONAL ENROUTE DESCENT

The pilot may perform enroute descent using only outboard speed brakes. This increases flaps-up rate of descent and reduces buffet and structural fatigue in the stabilizer.

Set inboard spoiler switch to OFF and raise outboard speed brakes. The airplane tends to pitch up; however, this characteristic is not excessive and is easily controlled by actuating speed brake lever slowly and maintaining an in-trim condition. Center the wheel before actuating speed brakes to minimize any roll tendency as roll sensitivity is increased with partially deflected speed brakes. Lower speed brakes before extending any flaps. Again, move control smoothly and trim as necessary. Make certain speed brake lever is forward and in detent before extending flaps, and both spoiler switches are ON prior to landing.

NORMAL DESCENT AND THRUST USAGE

To provide a maximum of crew comfort, the planned cabin rate of descent should be between 300 to 400 feet per minute. Inboard engine thrust is normally adjusted as needed to hold a nearly steady cabin rate of descent.

CAUTION

With mission radar on, observe limits in Section V.

NOTE

- For effective anti-ice protection, maintain a minimum of 55% N_1 on each engine if anti-ice is on.
- For low speed descents (close in and below 20,000 feet), pilot may elect to use flaps 14 and airspeed V_{REF} + 60 KIAS. This results in approximately 2,000 feet per minute rate of descent at idle power. Lowering gear increases rate of descent by approximately 400 feet per minute. Increasing flap angle also increases amount of altitude loss versus forward distance traveled.
- The minimum descent speeds for maneuvering capability and reasonable sink rates are:

  Flaps 0° – V_{REF} + 60 knots

  Flaps 14° – V_{REF} + 30 knots
- Exterior lights on at 10,000 feet.

Under normal conditions, approach briefing will be completed prior to starting descent.

DESCENT CHECKLIST

1. Approach Briefing and Landing Data – Reviewed (P, CP, E, N)

   Pilots check weather and airfield information of destination airfield. Pilot flying the approach reviews it with the other flight crewmembers with particular emphasis on minima, minimum safe altitudes, and missed approach procedures. Pilot flying the approach sets the radio altimeter bug as a backup to HAT/HAA of approach being flown. **WITH IDG** Preset MDA in Altitude Alerter. Return to altitude alert mode. ◀

   Pilot not flying sets the respective radio altimeter bug to 2,000 feet and reports passing this altitude during descent. The pilot not flying then resets the radio altimeter bug to 100 feet above HAT/HAA. Review TOLD card landing data and set EPR and airspeed bugs. Review minimum fuel and touch and go procedures, if applicable.

② Mission Crew – Coordinate for Descent (P or E, MCC)

   Notify mission crew to prepare mission equipment for descent.

3. CONTINUOUS IGNITION Switch – ON (E)

④ Surveillance Radar – Off (E, MCC)

   Verify radar is shut down.

5. Pressurization – Set (E)

   Set cabin altitude to field elevation. Set barometer correction scale to reported altimeter setting. Set RATE knob as required.

⑥ UHF-ADF – Tuned to 243.0 MHz (E, CSO)

7. UHF-ADF – Monitor (P, CP, E, N)

8. Circuit Breakers – Checked, Set (E)

   Check all circuit breakers on P5, P6, P7, P61 panels.

CAUTION

Open circuit breakers for VHF guard receiver (rack E12) when cooling air is not available to rack E12. Indications of this condition are FORCED AIR COOLING SUPPLY AIR temperature gage indicates forward forced air cooling system air exceeds 75 ± 5°F and both forward forced air cooling system fans operate on low speed.

NOTE

If a temperature inversion exists, cooling air isolation valves in equipment racks can close and open more than once during descent.

– – – After Shutdown of Mission Equipment On Forward Forced Air System, Perform Step 9 – – –

9. AVIONICS POWER DISCONNECT, COMM FWD Switch – DISC (E).

   Removes power from UHF guard transceiver, VHF guard receiver and HF/VHF INTF DC.

⑩ Forced Air Cooling – Checked and Set (E, MCC)

   Coordinate with mission crew.

   a. Aft System Fan/Control – ON/AUTO
   b. Forced Air Cooling Panel DESCENT Switchlight – Press ON (E)

      Prevents buildup of condensation in racks E2, E3, E4, E8, E10, and E12 by preventing valves from closing.
   c. System Select Switch – FWD
   d. Forward System Control Switch – MAN
   e. Forward HEAT-COOL Switch – Hold to HEAT Until OBVD, BYPASS and HEAT EXCH Gages Read Full HEAT

      Increases temperature of air in system to prevent condensation of moisture in mission equipment.
   f. System Select Switch – AFT

11. ROTODOME DRIVE SPEED Switch – IDLE (E)

WARNING

Do not operate auxiliary rotodome drive at six RPM (XMIT) for takeoff, landing, or go around.

12. HAVE SIREN System – As Required (N)

    On if system to be used.

13. Altimeters – Set ____, RESET (P), Set ____, RESET (CP), Set ____ (N)

    Pilot not flying notifies crew of current altimeter setting. Pilot flying sets current altimeter setting (QNH or QFE) when cleared below transition level. Pilot not flying and navigator will remain on 29.92 (QNE) until passing transition level, at which time all altimeters will be set to local altimeter setting (QNH or QFE).

WARNING

QFE altimeter setting (station pressure) gives altitude in feet above airport elevation, not feet above sea level.

14. **WITH IDG** Altitude Alerters – Set (P or CP)

    Set altitude alerters to next target altitude. Change baro set if target altitude is below transition level. ◀

HOLDING

Holding patterns can be flown manually or using autopilot or flight director.

NOTE

- For maximum endurance holding see T.O. 1E-3A-1-1.
- If holding with landing gear down, and doors open, increase holding fuel flow by 50% (T.O. 1E-3A-1-1).
- Autopilot and flight director turn commands and bank angles are often not equal due to differences in equipment gains.

MINIMUM FUEL PROCEDURES

This procedure establishes a fuel panel configuration permitting fuel from any and all tanks to be used by all engines. Uncovering of boost pump inlets is indicated by the associated low pressure lights illuminating. Aft boost pump lights illuminate with nose down pitch attitudes and deceleration (as in descent with low fuel), while forward boost pump lights illuminate with nose up attitudes and acceleration. Under these conditions it is neither necessary nor desirable to turn off any boost pump, because the system design precludes air pumping or pump overheat.

Prior to beginning a low fuel approach, have the flight engineer establish the go-around fuel configuration. Brief the flight engineer to report any forward boost pump low pressure lights on during any phase of the approach or go-around.

A light weight airplane nearly out of fuel accelerates and climbs rapidly if takeoff or climb thrust and the normal climb attitudes associated with these thrust settings are used. Use just enough thrust to maintain speed appropriate to the flap setting, and a pitch attitude high enough to establish a rate of climb as necessary for obstruction clearance.

If the flight engineer calls one or more forward boost pump low pressure lights on, lower the nose slightly and reduce thrust if the terrain and airspeed situation permit. This keeps all boost pump inlets covered as long as practicable. The amount of fuel available to the aft pump after the forward pump inlet has uncovered varies with tank number, pitch attitude, and fore/aft acceleration. The forward pump lights are useful as an indication of too high a pitch attitude or forward acceleration during low fuel go-around conditions.

Flap retraction to 25 and gear retraction should be handled as with a normal go-around. Lower nose attitudes may be maintained by leaving some flaps extended.

WARNING

Engine flameout can occur if airplane pitch attitude exceeds 8° nose up or 10° nose down when any outboard main tank contains less than 2,500 pounds or any inboard main tank contains less than 6,500 pounds.

If outboard main tank 1 or 4 has less than 2,500 pounds of fuel or if inboard main tank 2 or 3 has less than 6,500 pounds, perform the following procedure:

a. Main Tank Boost Pumps – All On (E)

b. Cross Feed Switches – All Open (E)

c. Heat Exchanger Switches – All Off (E)

If surveillance radar is not operating.

d. Go Around Procedures – Reviewed (P, E)

  (1) Do not exceed 8° nose up or 10° nose down body angle.

  (2) Apply thrust slowly and smoothly, avoid rapid airplane acceleration.

  (3) Maintain minimum body angle required for a positive rate of climb and safe climb gradient.

  (4) If any main tank boost pump LOW light illuminates, do not turn off boost pump.

  (5) If forward boost pump LOW light(s) illuminate, reduce nose up body attitude.

e. After go-around/transition, normal fuel management procedures may be resumed to avoid emptying a main tank.

APPROACH CHECKLIST

This checklist will be completed on initial pattern entry and all instrument approaches before starting final approach. Items marked with an x may be omitted if previously accomplished and remain unchanged.

1. Approach Briefing and Landing Data – Reviewed (P, CP, N, E)

   Pilot flying the approach reviews approach with other flight crewmembers with particular emphasis on minima, minimum safe altitudes and missed approach procedures, and sets radio altimeter bug as backup information to HAT or HAA of approach being flown. Pilot not flying sets radio altimeter bug to 100 feet above HAT or HAA. Review approach speed and set EPR and airspeed bugs. Review minimum fuel and touch and go procedures if applicable.

NOTE

Items of the approach briefing may be omitted if previously briefed and remaining unchanged.

x2. Altimeters – Set ____, RESET (P), Set ____, RESET (CP), – Set ____ (N)

Pilot, copilot and navigator check altimeter setting and respective mode.

3. **WITH IDG** Altitude Alerters – Set As Required for Approach and Missed Approach (P or CP)

Ensure baro setting is correct. Preset MDA. Return to altitude alert mode. ◀

x4. Rudder Override Switch – As Required (P, E)

a. If All Engines Operating – NORMAL

b. If One or More Engines Inoperative or at a Less Than Charted Thrust Setting – OVERRIDE below 250 KIAS

5. Forced Air Cooling – Checked (E)

a. Aft Fan – On

Both fans on low speed when below 5,000 feet cabin altitude and 75°F.

b. Forward Power Switch – OFF

c. System Select Switch – AFT

x6. Exterior Lights – As Required (CP, E)

All exterior lights on below 10,000 feet.

CAUTION

- Do not extend RETRACTABLE LANDING lights above 223 KIAS.
- Do not operate RETRACTABLE LANDING lights for daylight touch and go or daylight full stop landing.

x7. SEAT BELTS and NO SMOKING Switches – ON (CP, E)

x8. Crew Report – Ready for Landing (E, MCC)

9. Navigation Radios – Set for Approach (P, CP, N)

a. TACAN, ADF, and VOR/ILS Frequencies – Set for Approach

b. HSIs and RMIs – Set for Approach

c. Flight Director Mode Selectors – Set for Approach

INSTRUMENT APPROACHES

Typical patterns for instrument approaches are shown in *figure 2-8*. Obviously, the altitudes and distances shown are a guide and will be varied as required to conform with published approach procedures. Airspeeds may be varied if required, but flap extension speeds shown should be used, if possible, to reduce air loads on the flap structure. For additional information on approach procedures for flight director and autopilot, refer to FLIGHT DIRECTOR OPERATION, subsection I-K and AUTOPILOT OPERATION, subsection I-L.

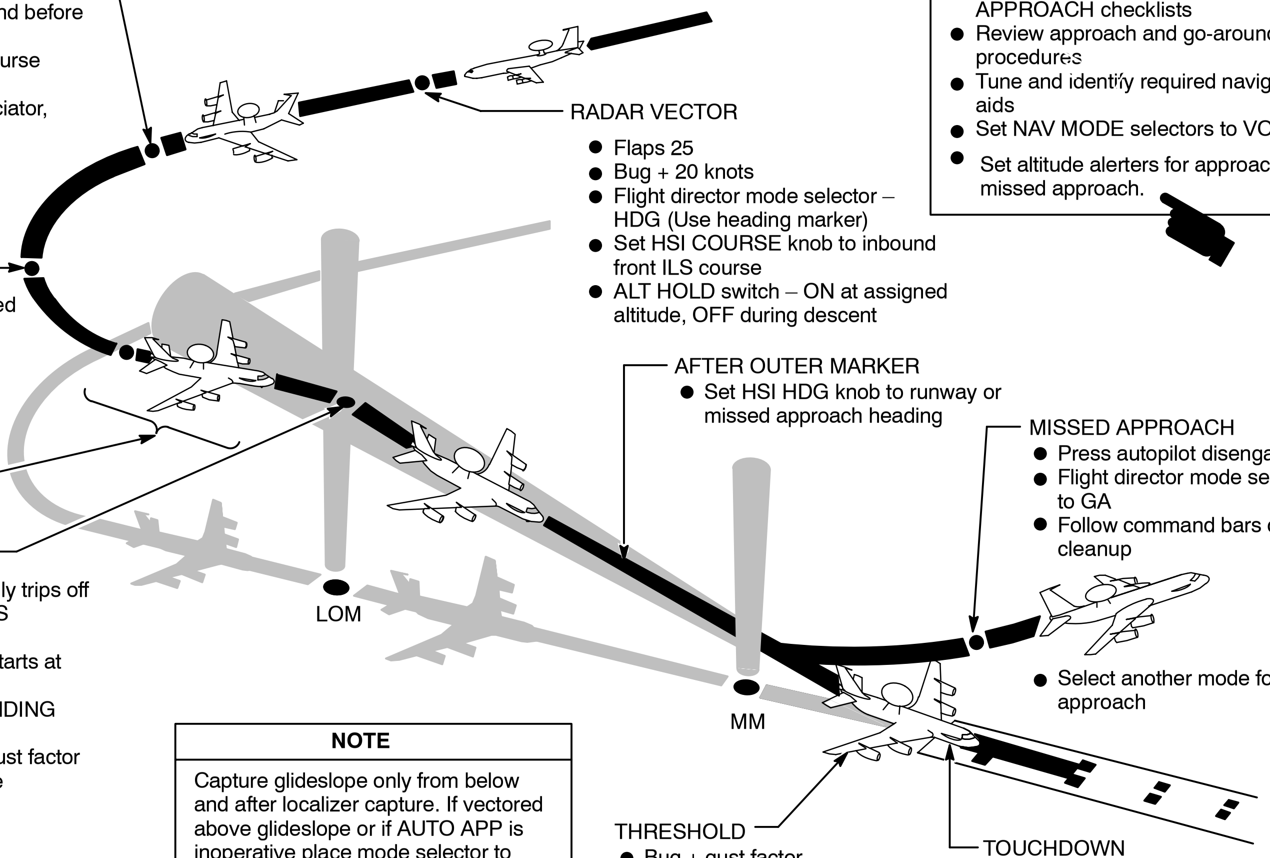
For normal (flaps 50) instrument approaches, use category D weather minimums.

Large thrust changes and resulting trim changes can be minimized by making prompt, small pitch changes of approximately 1° or less to stay on glide slope and centerline. (See *figure 2-18* for sink rate required for various glide slope angles.) Remember that the typical glide slope beam is about 1° from two dots high to two dots low. Airspeed may be allowed to vary ±5 knots from target speeds, without thrust changes.

From the pilot's normal eye position, the downward vision angle over the nose is about 15° below airplane centerline, or about 10 to 12° below the horizon at normal approach attitudes. On a normal 2 1/2 to 3° glide slope, the ground should be visible about 1,200 feet (0.2 nm) ahead of the airplane at 200 feet altitude, or about 3,000 feet (0.5 nm) before touchdown. At 100 feet altitude, the ground should be visible about 600 feet (0.1 nm) ahead of the airplane or about 1,500 feet (0.25 nm) before touchdown. It should be possible to see the runway threshold and some of the approach lights without lowering the nose of the airplane.

Instrument Approach Patterns - Typical

ILS FLIGHT DIRECTOR



APPROACH PREPARATIONS

- Set bugs to V_{ref}
- Complete DESCENT and APPROACH checklists
- Review approach and go-around procedures
- Tune and identify required navigation aids
- Set NAV MODE selectors to VOR/LOC
- Set altitude alerters for approach and missed approach.

PRIOR TO COURSE INTERCEPT

- Set mode selector to AUTO APP while below glideslope and before localizer reaches 2 dots
- Set HSI HDG knob to course intercept heading
- Flight director VL annunciator, amber

RADAR VECTOR

- Flaps 25
- Bug + 20 knots
- Flight director mode selector – HDG (Use heading marker)
- Set HSI COURSE knob to inbound front ILS course
- ALT HOLD switch – ON at assigned altitude, OFF during descent

LOCALIZER CAPTURE AT 2 DOTS

- Glideslope capture, armed
- Flight director VL annunciator – green GS annunciator – amber
- Flaps 25
- Bug + 20 knots

GEAR DOWN

AFTER OUTER MARKER

- Set HSI HDG knob to runway or missed approach heading

MISSED APPROACH

- Press autopilot disengage switch
- Flight director mode selector trips to GA
- Follow command bars during cleanup
- Select another mode for missed approach

GLIDESLOPE CAPTURE

- Altitude hold automatically trips off
- Flight director VL and GS annunciators – green
- Glideslope attenuation starts at 1500 feet radar altitude
- Complete BEFORE LANDING checklist
- Bug + 1/2 headwind + gust factor
- Establish Landing Profile

NOTE

Capture glideslope only from below and after localizer capture. If vectored above glideslope or if AUTO APP is inoperative place mode selector to MAN GS. Cross check ADI with other instruments.

THRESHOLD

- Bug + gust factor

TOUCHDOWN

- Target is 1000 to 2000 ft
- Complete AFTER LANDING checklist after rollout

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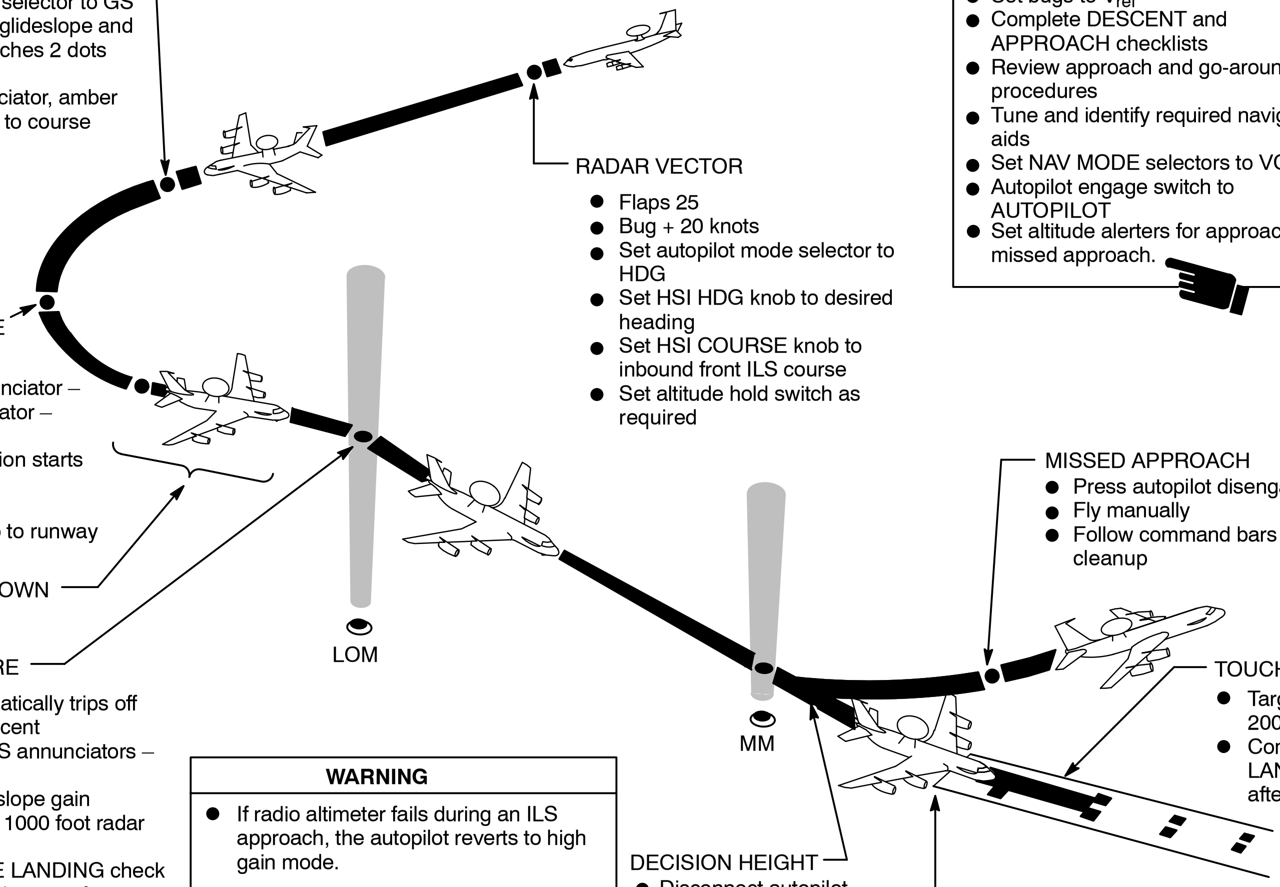
Figure 2-8 (Sheet 1 of 4)

Instrument Approach Patterns - Typical (Continued)

ILS AUTOPILOT



APPROACH PREPARATIONS

- Set bugs to V_{ref}
- Complete DESCENT and APPROACH checklists
- Review approach and go-around procedures
- Tune and identify required navigation aids
- Set NAV MODE selectors to VOR/LOC
- Autopilot engage switch to AUTOPILOT
- Set altitude alerters for approach and missed approach.

RADAR VECTOR

- Flaps 25
- Bug + 20 knots
- Set autopilot mode selector to HDG
- Set HSI HDG knob to desired heading
- Set HSI COURSE knob to inbound front ILS course
- Set altitude hold switch as required

PRIOR TO COURSE INTERCEPT

- Set autopilot mode selector to GS AUTO while below glideslope and before localizer reaches 2 dots (capture zone)
- Autopilot VL annunciator, amber
- Set HSI HDG knob to course intercept heading

LOCALIZER CAPTURE

- Glideslope armed
- Autopilot VL annnunciator – green, GS annunciator – amber
- Crosswind integration starts
- Flaps 25
- Bug + 20 knots
- Set HSI HDG knob to runway heading

GEAR DOWN

GLIDESLOPE CAPTURE

- Altitude hold automatically trips off
- Autopilot starts descent
- Autopilot VL and GS annunciators – green
- Localizer and glideslope gain reduction begins at 1000 foot radar altitude
- Complete BEFORE LANDING check
- Bug + 1/2 headwind + gust factor
- Establish Landing Profile

WARNING

- If radio altimeter fails during an ILS approach, the autopilot reverts to high gain mode.
- If the glideslope or localizer signal fails, the glideslope or localizer warning flags can appear, and the autopilot reverts to the manual mode.

MISSED APPROACH

- Press autopilot disengage switch
- Fly manually
- Follow command bars during cleanup

TOUCHDOWN

- Target is 1000 to 2000 ft
- Complete AFTER LANDING check after rollout

DECISION HEIGHT

- Disconnect autopilot for landing

THRESHOLD

- Bug + gust factor

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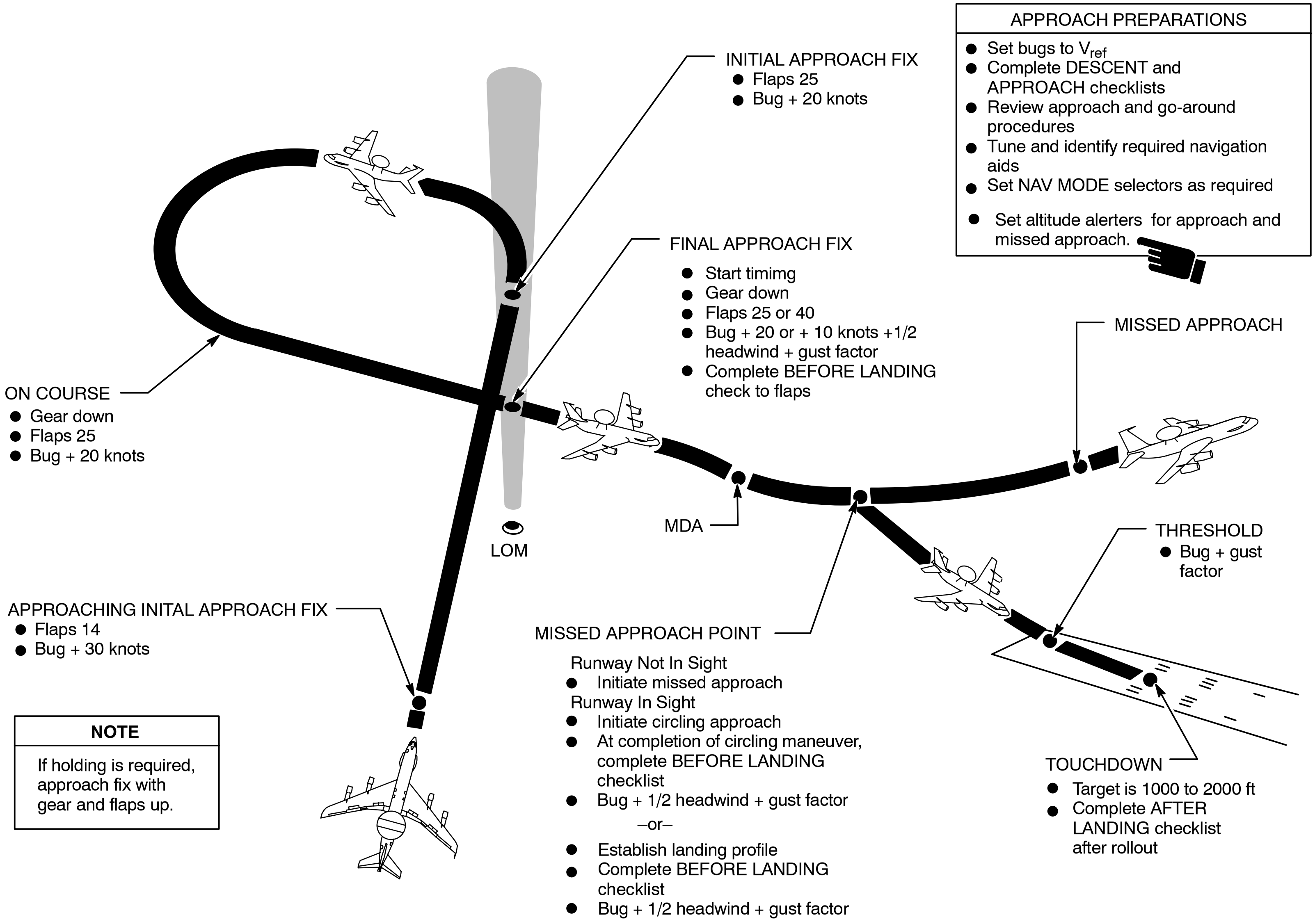
Figure 2-8 (Sheet 2 of 4)

VOR - LOC - ADF - ASR - TACAN



APPROACH PREPARATIONS

- Set bugs to V_{ref}
- Complete DESCENT and APPROACH checklists
- Review approach and go-around procedures
- Tune and identify required navigation aids
- Set NAV MODE selectors as required
- Set altitude alerters for approach and missed approach.

INITIAL APPROACH FIX

- Flaps 25
- Bug + 20 knots

FINAL APPROACH FIX

- Start timimg
- Gear down
- Flaps 25 or 40
- Bug + 20 or + 10 knots +1/2 headwind + gust factor
- Complete BEFORE LANDING check to flaps

MISSED APPROACH

ON COURSE

- Gear down
- Flaps 25
- Bug + 20 knots

THRESHOLD

- Bug + gust factor

APPROACHING INITAL APPROACH FIX

- Flaps 14
- Bug + 30 knots

MISSED APPROACH POINT

Runway Not In Sight

- Initiate missed approach

Runway In Sight

- Initiate circling approach
- At completion of circling maneuver, complete BEFORE LANDING checklist
- Bug + 1/2 headwind + gust factor

–or–

- Establish landing profile
- Complete BEFORE LANDING checklist
- Bug + 1/2 headwind + gust factor

TOUCHDOWN

- Target is 1000 to 2000 ft
- Complete AFTER LANDING checklist after rollout

NOTE

If holding is required, approach fix with gear and flaps up.

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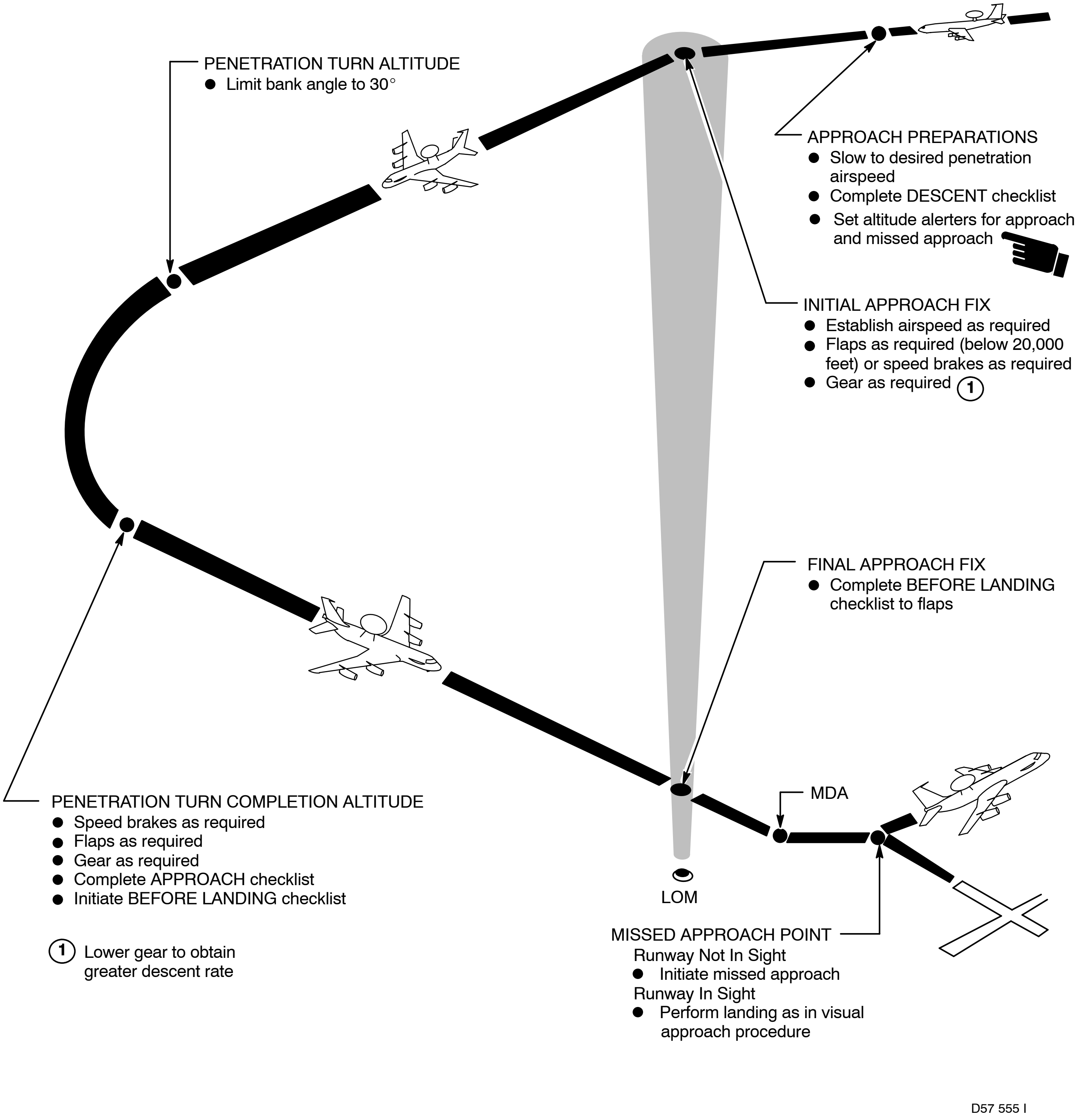
Figure 2-8 (Sheet 3 of 4)

Instrument Approach Patterns - Typical (Continued)

Typical High Altitude Penetration and Approach



PENETRATION TURN ALTITUDE

- Limit bank angle to 30°

APPROACH PREPARATIONS

- Slow to desired penetration airspeed
- Complete DESCENT checklist
- Set altitude alerters for approach and missed approach ☞

INITIAL APPROACH FIX

- Establish airspeed as required
- Flaps as required (below 20,000 feet) or speed brakes as required
- Gear as required ①

FINAL APPROACH FIX

- Complete BEFORE LANDING checklist to flaps

PENETRATION TURN COMPLETION ALTITUDE

- Speed brakes as required
- Flaps as required
- Gear as required
- Complete APPROACH checklist
- Initiate BEFORE LANDING checklist

① Lower gear to obtain greater descent rate

MISSED APPROACH POINT

Runway Not In Sight

- Initiate missed approach

Runway In Sight

- Perform landing as in visual approach procedure

Figure 2-8 (Sheet 4 of 4)

BEFORE LANDING

The following BEFORE LANDING checklist is completed on final approach to verify that all systems are ready for landing or go-around. Flight engineer will read this procedure silently and challenge only incomplete items, except for steps 1 and 2.

1. SPEED BRAKE Lever – Full Forward, In Detent (P or CP)
2. Gear – Down, In, Three Green (P, CP, E)

   Gear lever down, in detent. GEAR and DOOR warning lights out. Three green gear position lights illuminated.
3. Antiskid – ON, Four Release Lights (E)
4. SPOILERS Switches – ON (E)
5. Rudder Mode Indicator – Checked (E)
   a. If All Engines Operating – 3,000 Below 165 KIAS
   b. If One or More Engines Inoperative – 3,000 Below 250 KIAS
6. Hydraulic Brake and Systems – Pressures and Quantity Normal (E)

   Check brake pressure, utility pump pressure, auxiliary system pressure, hydraulic quantity. Low pressure lights out.
7. Fuel Panel – Set for Landing (E)

Refer to FUEL MANAGEMENT, subsection I-D.

WARNING

Engine flameout can occur if airplane pitch attitude exceeds 8° nose up or 10° nose down when any outboard main tank contains less than 2,500 pounds or any inboard main tank contains less than 6,500 pounds. Refer to MINIMUM FUEL PROCEDURES, this section.

NOTE

Fuel panel is set in proper configuration for go-around for fuel load. Both boost pumps are on in each tank being used to prevent engine flameout if forward boost pumps are uncovered during a go-around.

8. Flaps – As Required (P or CP)

   Flight engineer confirm flap lever and INBD and OUTBD gages indicate final flap setting and LE FLAP indicators are illuminated.
9. Rudder Trim – Zero (E)

– – – Continue To AFTER LANDING or TAXI BACK Checklist as Required – – –

LANDING

The normal landing approach (*figure 2-9*) is based on ILS or GCA glide path of 2.5 to 3°. Descent rates for normal glide slopes are shown in *figure 2-18*. Start approaches far enough from runway to allow airplane to be on centerline, on glide path in landing configuration, with a constant rate of descent. This allows consistent, safe approaches with touchdown at 1,000 to 2,000 foot target point. Having enough space and time on approach allows gentle turns and unhurried crew procedures.

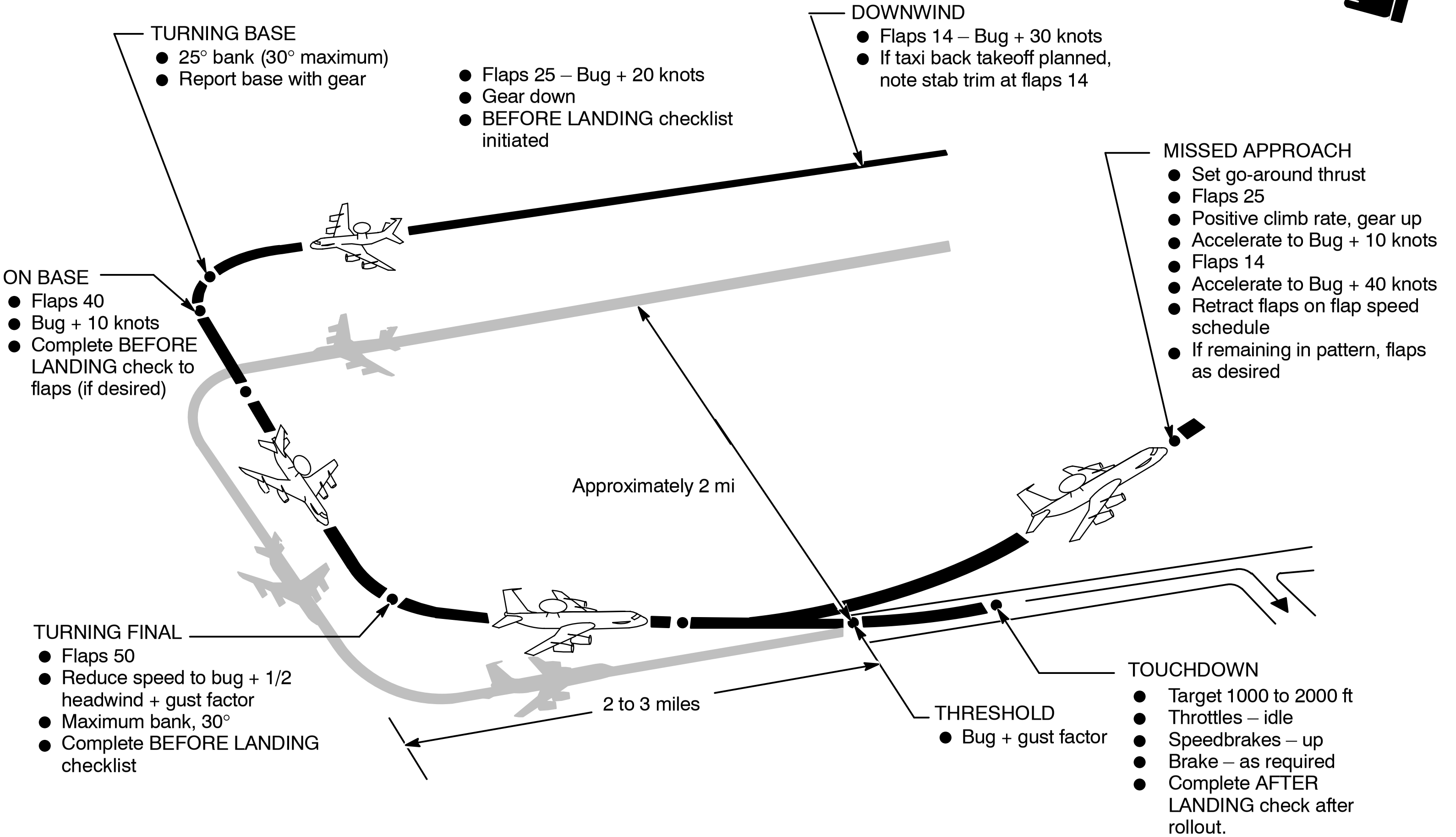
WIND GRADIENT AND GUST FACTORS

Maintain an airspeed above V_{REF} to compensate for strong wind gradient and gust effects; however, keep the airspeed reference pointer (bug) set to V_{REF} if the airplane configuration is normal.

When adding the wind gradient factor, anticipate that the airspeed decreases by this amount as the airplane nears the ground. If only the wind gradient is added, allow the airspeed to decrease to V_{REF} just prior to touchdown. Do not add thrust or drop the nose in attempting to hold the additional airspeed until touchdown. If both the wind gradient factor and gust factor are added to V_{REF}, retain only the gust factor to touchdown. The gust effect is the more important of the two conditions since a sudden change in wind does not allow sufficient time for normal pilot reaction. Refer to WIND SHEAR, Section VII.

Normal Visual Pattern and Landing

APPROACH PREPARATIONS
- Set bugs to V_{ref}
- Complete DESCENT and APPROACH checklists
- Set altitude alerters for approach and missed approach.



TURNING BASE
- 25° bank (30° maximum)
- Report base with gear

- Flaps 25 – Bug + 20 knots
- Gear down
- BEFORE LANDING checklist initiated

DOWNWIND
- Flaps 14 – Bug + 30 knots
- If taxi back takeoff planned, note stab trim at flaps 14

MISSED APPROACH
- Set go-around thrust
- Flaps 25
- Positive climb rate, gear up
- Accelerate to Bug + 10 knots
- Flaps 14
- Accelerate to Bug + 40 knots
- Retract flaps on flap speed schedule
- If remaining in pattern, flaps as desired

ON BASE
- Flaps 40
- Bug + 10 knots
- Complete BEFORE LANDING check to flaps (if desired)

TURNING FINAL
- Flaps 50
- Reduce speed to bug + 1/2 headwind + gust factor
- Maximum bank, 30°
- Complete BEFORE LANDING checklist

THRESHOLD
- Bug + gust factor

TOUCHDOWN
- Target 1000 to 2000 ft
- Throttles – idle
- Speedbrakes – up
- Brake – as required
- Complete AFTER LANDING check after rollout.

Figure 2-9

If a pilot misjudges the gradient effect, glide path and speed control will indicate the discrepancy and thrust should be applied as required to maintain rate of descent, glide path and airspeed.

Make the following adjustment to V_{REF} for wind:

Gradient effect – Add 1/2 of the headwind component.

Gust effect – Add full value of reported gust increment.

If total adjustment exceeds 20 knots, add only 20 knots to V_{REF}.

For example, assume a headwind of 18 knots, gusting to 25 knots. Add 9 knots for headwind gradient and 7 knots for gust effect, to obtain V_{REF} + 16 knots.

Approach speed is normally corrected for wind by adding 1/2 headwind plus full gust increments (not to exceed 20 knots). If there is neither wind nor gust reported, it is recommended 5 knots be added to V_{REF} (Bug) to correct for possible unreported wind on approach.

CROSSWIND LANDING

In a gusty crosswind, add the full value of the gust factor to the reference speed and 1/2 of the headwind component, up to a total of 20 knots. Establish a wings level crab angle on final approach shortly after alignment with the extended runway centerline. This drift correction is held to near the point where flare is initiated and then gradually reduced during the flare. Use of lateral control to keep wings near level during the flare and landing roll reduces the chance of hitting flaps or outboard nacelles on runway and improves braking effectiveness.

The landing gear can absorb the side loads generated by landing with a crab angle. (Refer to Maximum Crosswind for Landing Chart, part VII, T.O. 1E-3A-1-1.) If wings are level, there is no danger of touching engine pods or flaps in any reasonable landing attitude. *Figure 2-10* shows the approximate clearance angles for the wing (with spoilers up) at touchdown.

When the airplane is landed with a crab angle, the tire rolling friction and side force on the first wheel to touch down cause the airplane to turn parallel to airplane motion (zero crab angle). There is a definite tendency for the upwind wing to rise, but this can be controlled with aileron. Raising spoilers immediately helps prevent the upwind wing from rising, if done as recommended in this section. Because the upwind wing tends to rise, consider landing with a zero or near zero crab angle.

When the airplane is landed wing low, or a wing low technique is used to reduce drift during flare or rollout, ensure bank angle at touchdown does not exceed approximately 5°. Outboard engine or outboard flaps can touch ground at approximately 8° of bank in some touchdown conditions. See *figure 2-10*.

If airspeed is above V_{REF} and body attitude is level or nose down at touchdown, an inboard engine nacelle can contact the runway at relatively low bank angles. If the aircraft floats, do not unload or apply nose down control force in order to touch down on the runway. A rapidly rising upwind wing in this situation can lead to inboard engine contact with the runway.

LANDING REFERENCE SPEEDS

For all approaches, the approach (V_{APP}) and threshold (V_{TH}) speeds are calculated from the flaps 50 reference speed (V_{REF}) for the planned landing weight.

These speeds are as follows:

NOTE

> The total allowable correction for wind is 20 knots.

Flaps 50° $V_{APP} = V_{REF}$ + 1/2 Headwind + Gust

Flaps 50° $V_{TH} = V_{REF}$ + Gust

Flaps 40° $V_{APP} = V_{REF}$ + 10 KIAS + 1/2 Headwind + Gust

Flaps 40° $V_{TH} = V_{REF}$ + 10 KIAS + Gust

Flaps 25° $V_{APP} = V_{REF}$ + 20 KIAS + 1/2 Headwind + Gust

Flaps 25° $V_{TH} = V_{REF}$ + 20 KIAS + Gust

Flaps 14° $V_{APP} = V_{REF}$ + 30 KIAS + 1/2 Headwind + Gust

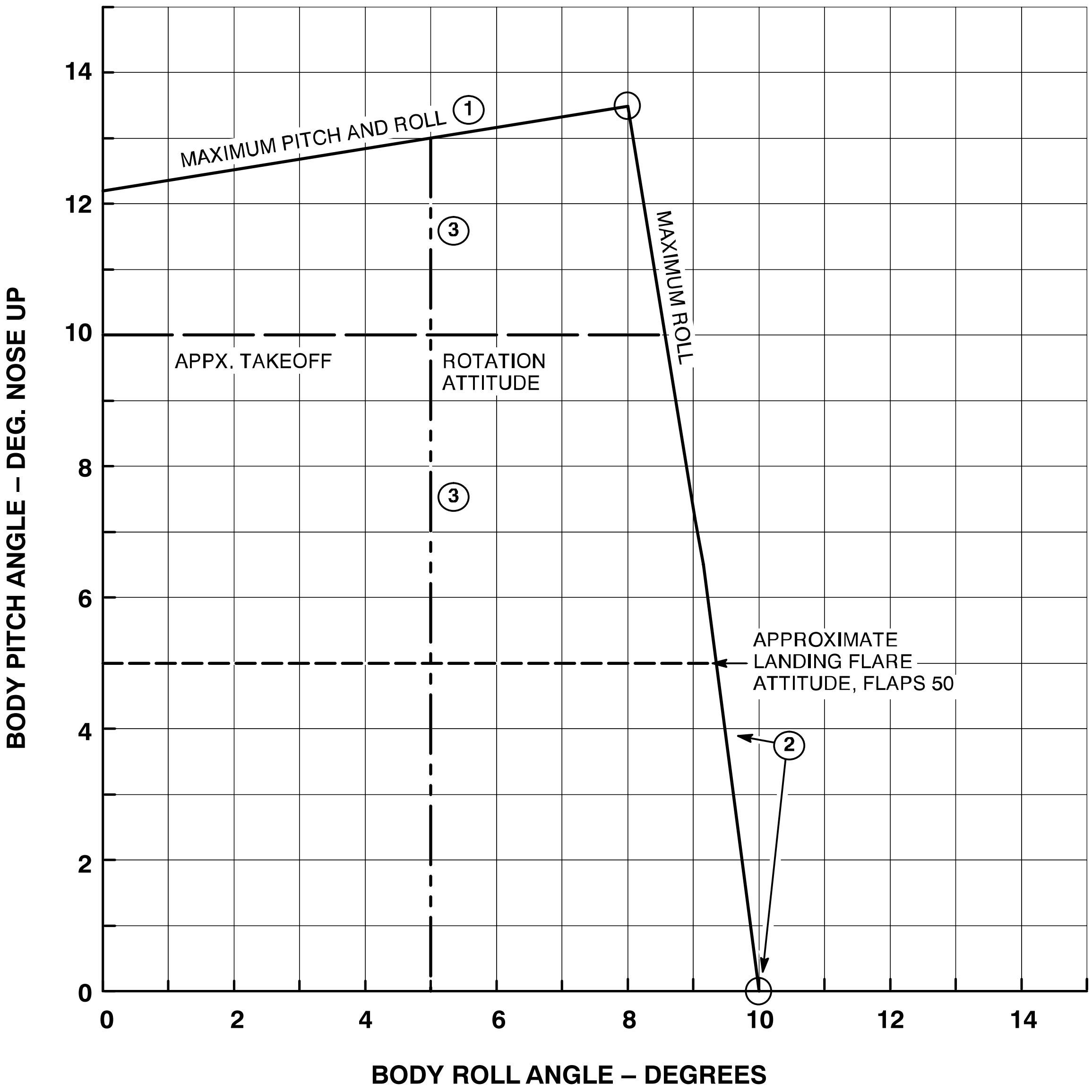
Flaps 14° $V_{TH} = V_{REF}$ + 30 KIAS + Gust

Flaps 0° $V_{APP} = V_{REF}$ + 40 KIAS + 1/2 Headwind + Gust

Flaps 0° $V_{TH} = V_{REF}$ + 40 KIAS + Gust

With one or more leading edge flap segments not extended (utility hydraulic system loss or either LE FLAP light is not on), add 15 knots to V_{REF} and make wind corrections as above: The 15 knot correction is not required for flaps 0° V_{TH}.

Wing Clearance at Touchdown



CONDITIONS:

① TAIL CONE, AFT OUTBOARD WHEEL, OUTER CORNER OF OUTBOARD FLAP AND OUTBOARD NACELLE CONTACT GROUND

② MAIN GEAR AND OUTBOARD NACELLE CONTACT GROUND

③ MAXIMUM DESIRABLE BANK ANGLE FOR WING-LOW LANDING

- GEAR DOWN
- ONE MAIN GEAR ON GROUND, NO COMPRESSION OF STRUT
- FLAPS 50
- 1-G WING LOAD
- GROUND EFFECTS CONSIDERED
- NO CROWNING OF RUNWAY CONSIDERED

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Figure 2-10

FACTORS AFFECTING LANDING DISTANCE

Avoid floating just off the runway surface before touchdown, as this uses up a large portion of the available runway. If the airplane is over the recommended speed at the point of intended touchdown, deceleration on the runway is about three times greater than in the air. The airplane should be set onto the runway as near the desired touchdown point as possible rather than being allowed to float in the air to bleed off speed.

For example: an airplane that normally approaches at 130 knots and requires a normal landing distance of 4,000 feet. With other conditions constant, flying over the threshold with 10 knots excess speed (at 140) and touching down 10 knots fast increases total landing distance 350 feet. If this 10 knots excess speed is bled off in the air (floating) before touchdown, landing distance increases by about 1,200 to 1,500 feet (*figure 2-11*).

Floating Distance

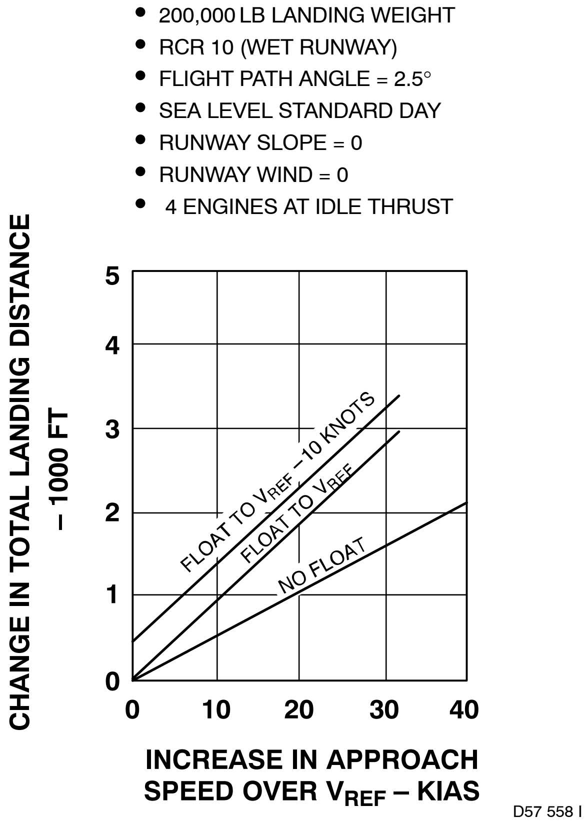


Figure 2-11

Height of the airplane over the end of the runway also has a very significant effect on total landing distance. The relatively steep trend lines (*figure 2-12*) show this effect for a range of glide path angles. This chart indicates a change in total landing distance directly. For example, flying over the end of the runway at 100 feet altitude rather than 50 feet could increase the total landing distance by 950 feet on a 3 degree glide path. This change in total landing distance results primarily because of the length of runway used up before the airplane actually touches down. Glide path angle also affects total landing distance as shown (*figure 2-12*). Even while maintaining the 50-foot height over the end of the runway, total landing distance is increased as the approach path becomes flatter. A combination of excess height over the end of the runway and a flat approach uses excessive runway. Glide path angle is a function of pilot technique and best results are obtained at a normal ILS or PAR glide slope angle.

Glide Path Effect

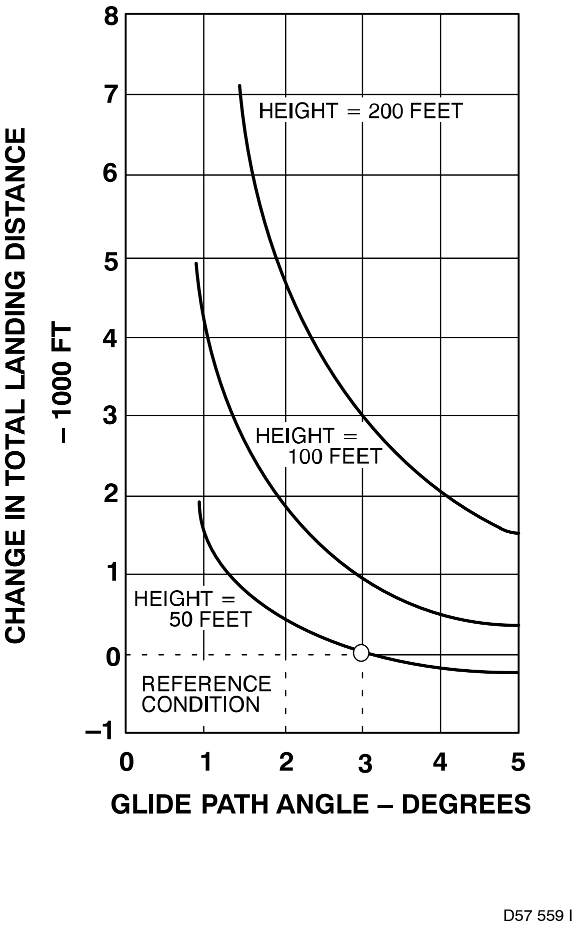


Figure 2-12

LANDING GEAR CLEARANCE OVER APPROACH END OF RUNWAY

On some airplanes, aiming at a touchdown target 1,000 feet down the runway is fairly adequate assurance that the landing gear would clear the approach end of the runway during landing approaches. Longer fuselages with landing gears located farther aft of the pilot, combined with swept wings and flaps designed for low approach speeds have resulted in higher body angles on approach. For instance, the body angle in this airplane during a normal 2.5 degree approach angle is about 3.0 degrees nose up. The main landing gear is located about 69 feet behind the pilot and the bottom of the tires is about 23 feet below the eye. Considering only the body angle and landing gear location, you can see from the diagrams (*figures 2-13* through *2-16*) that there is an additional factor equally as important as touchdown target. That other factor is the angle at which the touchdown is approached.

Descent rates vary with approach speeds (ground speed) for a constant flight path. Approach speeds vary with gross weight and wind. Wind shear can change descent rates rapidly. Once a normal approach flight path is established to the touchdown point it must not be allowed to change. Descent rates for normal glide slopes are shown in *figure 2-18*.

On a stabilized approach, the point which appears to have no relative motion is the point where the eye would contact the runway. This point should be from 1,000 to 2,000 feet down the runway. The point of main landing gear contact (with no flare) would be closer to the end of the runway. The actual distance varies with approach angle, as shown in *figures 2-13* through *2-16*. On a normal 2.5 degree approach, the main gear touchdown point (with no flare) would be about 530 feet short of the point with no apparent motion.

ILS touchdown points also vary from airport to airport; however, most touchdown points (opposite glide slope transmitter) are between 1,000 feet and 1,500 feet from the runway threshold. PAR (GCA) and VASI glide slopes and touchdown points are similar to the ILS and ideally coincide if both facilities are installed.

ILS glide slope angles vary from airport to airport; however, very few are shallower than 2 1/2° or steeper than 3-1/4° and the descent rate must be adjusted accordingly. The approach plate gives the required rate of descent for your specific ground speed. If in doubt, multiply the anticipated ground speed by 5. This is approximately your descent rate in feet per minute. For example: 130 knots x 5 = 650 feet per minute.

Once on the glide slope, maintaining the rate of descent for your ground speed keeps the airplane on the glide slope to the touchdown target. When making an ILS approach, the touchdown target and correct approach path are electronically computed for you. When making a visual approach, you have to pick your touchdown target and your approach path to the target.

In *figure 2-15*, the approach is a normal 2.5 degree approach angle aimed at a touchdown target of 500 feet down the runway.

In *figure 2-16*, the approach is a 1.5 degree approach angle to a 500-foot touchdown target. If possible, the landing gear would be 10 feet below the level of the runway at the threshold. Obviously it would strike short of the runway.

Adequate landing gear clearance is always assured if an approach angle comparable to the ILS glide slope is maintained to a touchdown target 1,000 feet down the runway.

WARNING

Check threshold crossing height (TCH) for PAR/ILS approaches to assure adequate landing gear clearance.

Pay careful attention to the angular view of the touchdown target in the windshield. If you are on the correct approach path at target speed plus 10 knots and then reduce speed to target speed, the angular view in the windshield must change. The no-motion point moves toward you as groundspeed decreases (if your eye position is constant). The table (*figure 2-17*) shows the pilot's eye height and landing gear clearance over the end of the runway for various approach and touchdown targets.

Approach Path to 1,000 Foot Target with 2.5 Degree Approach Angle

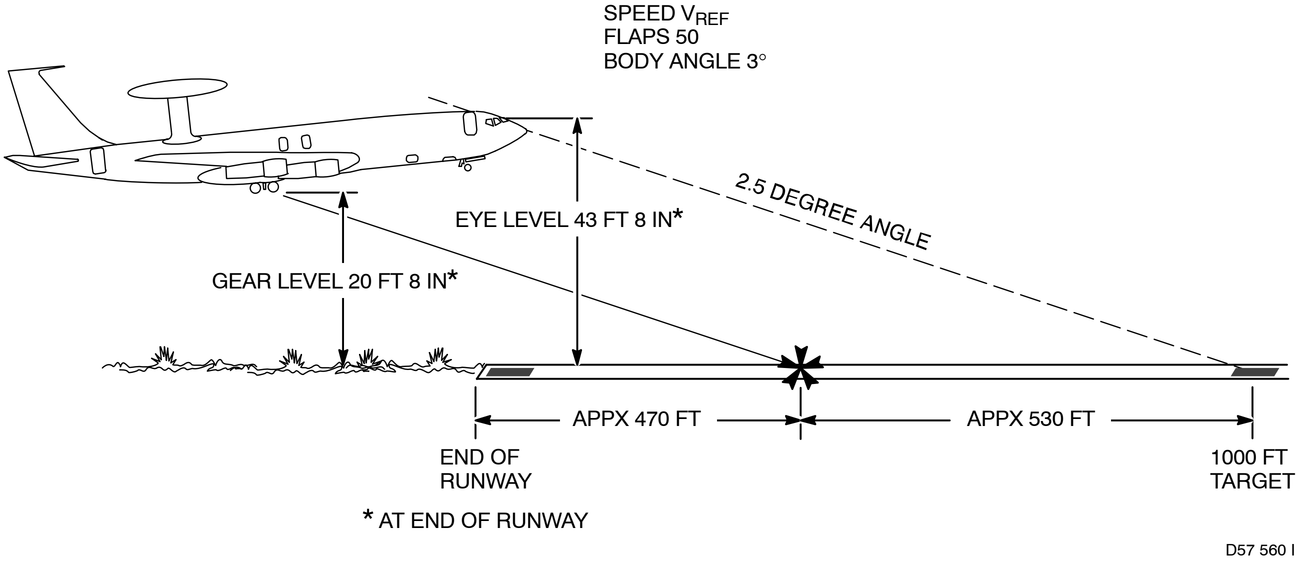


Figure 2-13

Approach Path to 1,000 Foot Target with 1.5 Degree Approach Angle

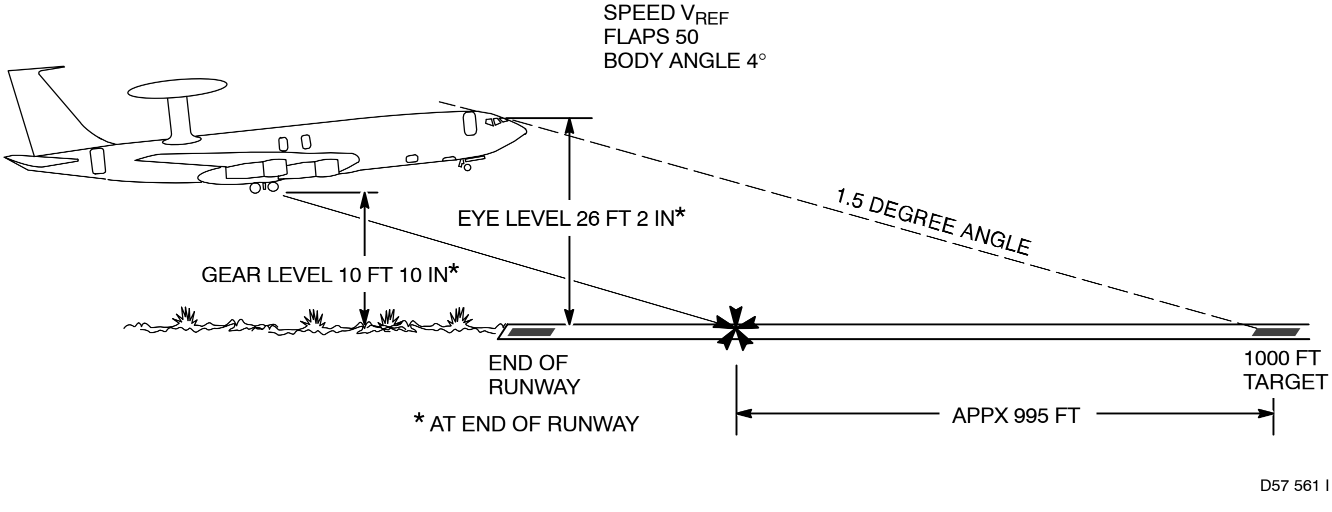


Figure 2-14

Approach Path to 500 Foot Target with 2.5 Degree Approach Angle

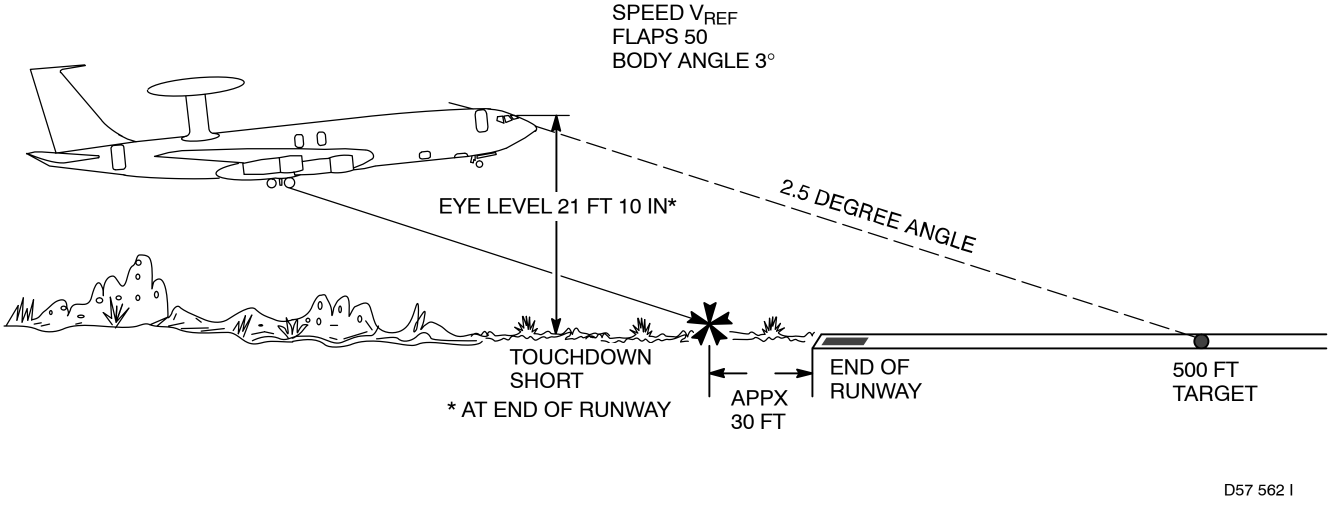


Figure 2-15

Approach Path to 500 Foot Target with 1.5 Degree Approach Angle

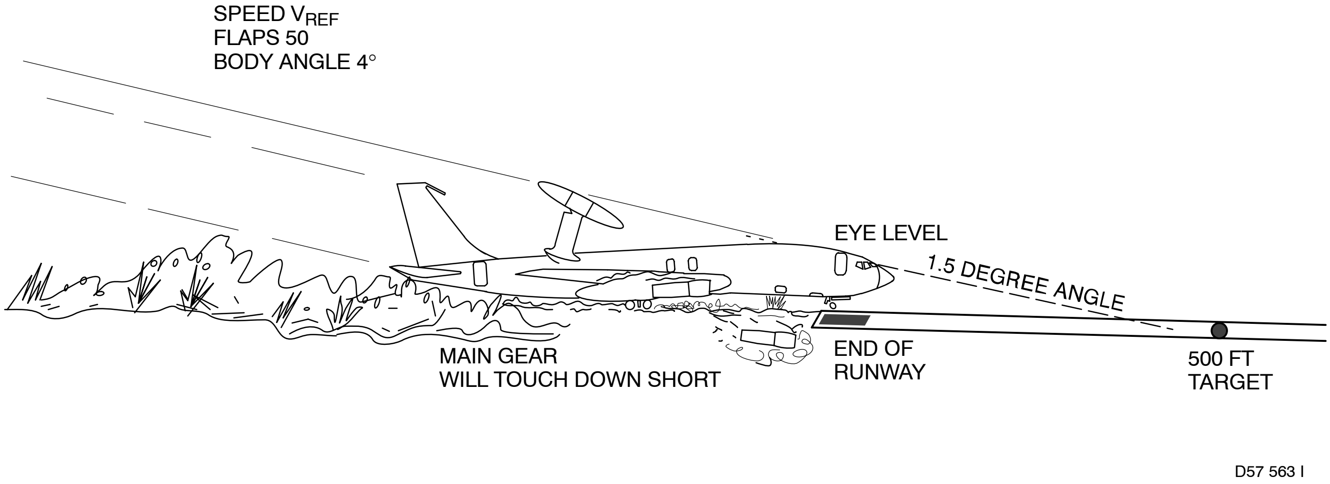


Figure 2-16

Landing Gear Clearance Over Approach End of Runway

GLIDE PATH ANGLE DEGREES	BODY ATTITUDE DEGREES NOSE UP	HEIGHT ABOVE THRESHOLD (FT, ESTIMATED)					
		500 FT TARGET		1000 FT TARGET		1500 FT TARGET	
		EYE LEVEL	MAIN GEAR	EYE LEVEL	MAIN GEAR	EYE LEVEL	MAIN GEAR
1.0	4.6	8.7	–16.5	17.5	–7.7	26.2	+1.0
1.5	4.1	13.1	–11.6	26.2	+1.8	39.3	+14.6
2.0	3.6	17.4	–6.6	34.9	+10.8	52.4	+28.3
2.5	3.1	21.8	–1.2	43.7	+ 20.7	65.5	+42.5
3.0	2.6	26.2	+3.4	52.4	+ 29.6	78.5	+55.7
3.5	2.1	30.6	+8.4	61.2	+ 39.0	91.7	+68.9
4.0	1.6	35.0	13.9	69.9	+ 48.3	104.9	+83.4

Conditions: V_{REF} ; angle of attack = 7.6° ; flap = 50° ; no flare; eye point on glide path; heights as eye and gear cross threshold. Shaded area indicates gear hits short of runway.

Figure 2-17

LANDING TECHNIQUES

Attempt to touch down 1,000 to 2,000 feet down the runway and on the centerline. Maintain V_{REF} until flare is completed; reduce thrust to idle immediately prior to touchdown. Touchdown occurs approximately 5 knots below V_{REF} at a body angle slightly above the approach body angle.

Normally, only a small aft movement of control column is necessary to check rate of descent during flare. The slight change in control column position compensates for pitch down associated with ground effect and decreasing thrust. After touchdown, raise the speed brakes rapidly to the 60 degree position, either while lowering the nose wheel to the runway or after the nose wheel is down. If they are raised while lowering the nose, care must be taken to insure a pitch up does not occur which would cause the airplane to become airborne again. Apply light to moderate braking.

WARNING

Do not attempt to take off (go-around) once the airplane is on the runway with speedbrakes deployed. Touch-and-go landings are permitted only when planned and briefed. (Refer to TOUCH AND GO LANDINGS.)

RIGHT SEAT LANDINGS

If the copilot is making the landing, the copilot will call “Speed Brakes” after touchdown. The pilot will raise the speed brakes rapidly to the 60 degree position. The copilot will apply light-to-moderate braking. During rollout, the pilot will verbally confirm taking control by stating “Pilots airplane”. The pilot assumes responsibility for directional control and braking; the copilot maintains a slight forward pressure on the yoke and keeps the wings level.

BOUNCE RECOVERY TECHNIQUE

Hold or reestablish normal landing attitude and allow the airplane to settle back to the ground. If only a shallow bounce (skip) occurs, thrust need not be increased.

Do not push over, as this only causes another bounce and possible damage to the nose gear.

Do not increase pitch attitude above normal as this only increases height of bounce and can cause entry into stall warning. This results in a second hard touchdown.

As airplane touches down second time, use normal landing procedures – speedbrakes up, brakes on.

If a hard, high bounce occurs, excessive runway is used, and a go-around is considered mandatory, apply go-around thrust and use normal go-around procedures. A second touchdown sometimes occurs during the go-around.

WARNING

- Advance throttles to approximately vertical, to ensure equal acceleration on all engines, then advance to go-around thrust. Acceleration to TRT can take as much as 10 seconds from idle.
- Do not retract the landing gear until a positive rate of climb is established.

HEAVYWEIGHT LANDINGS AND HARD LANDINGS

Landings at gross weights above 250,000 pounds (heavyweight landings) and landings at touchdown sink rates greater than the limits in section V (hard landings) require maintenance inspection before next flight.

Heavyweight Landings

The normal maximum landing weight is 250,000 pounds at a maximum sink rate of 600 feet per minute (which is structural limit). If the mission requires, the airplane may be landed at any gross weight up to the maximum ground operations weight at a sink rate decreasing to 360 feet per minute at 325,000 pounds. If emergency conditions require, the airplane may be landed at any gross weight up to the maximum inflight weight at a sink rate decreasing to 300 feet per minute at 344,000 pounds. Refer to *figure 5-7*. Touch and go landings at gross weights above 250,000 pounds are prohibited.

Since a heavyweight condition is usually known before landing, the pilot can reduce sink rate to stay within limits, preventing damage to the airplane.

CAUTION

Check brake energy limits (section V) and Brake Energy Limited Landing Weight chart in part VII of T.O. 1E-3A-1-1. Brake energy in a heavy weight landing can easily exceed 24 million foot-pounds per brake, causing fuse plugs to melt and deflating tires. If brake energy exceeds 28 million foot-pounds per brake, replacement of tires, wheels, and brakes is required.

Hard Landings

Hard landings (at any gross weight) result from exceeding sink rate limits due to high sink rate, wind shear, runway slope, or delayed excessive rotation in flare (thus forcing main landing gear into contact with ground). Landing sink rate is difficult to measure. Rate of change of radio altimeter altitude is probably the best indication, if landing over smooth terrain.

The table in *figure 2-18* shows average approach sink rates for various glide slope angles and ground speeds. Actual sink rate at touchdown is approximately one half of the approach sink rate, due to ground effect, even if the airplane is not flared. Use the observed touchdown sink rate, plus runway slope effect to determine whether or not a hard landing has occurred. Runway slope effect on sink rate is shown in *figure 2-19*.

NOTE

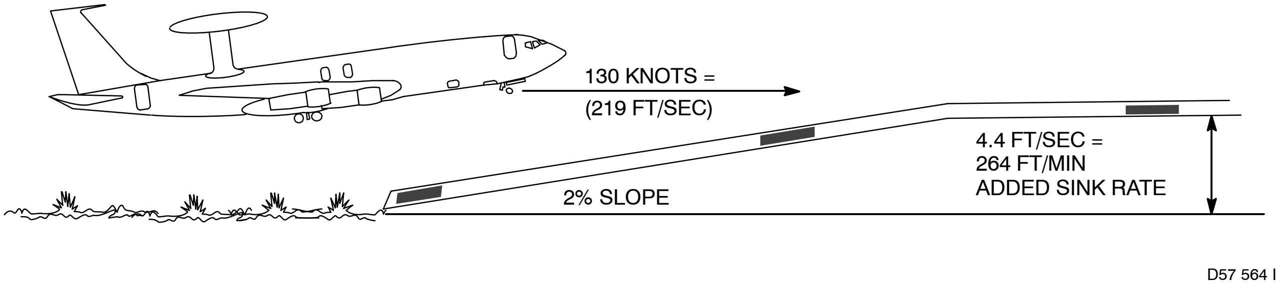
- The flight deck accelerometer cannot be used to determine whether or not a hard landing has occurred, since it measures load factor at the instrument panel, not at airplane c.g. Lowering the nose gear after main gear touches down reduces the apparent acceleration in the flight deck.
- Check nacelle droop stripes for alignment. If stripes appear out of line, strut is probably damaged. Have maintenance check before flight.

Approach Sink Rates

GLIDE SLOPE DEGREES →	NORMAL ILS						
	2.5	2.75	3.00	3.50	3.75	4.0	4.5
GROUND SPEED KNOTS	SINK RATE FEET PER MINUTE						
110	485	535	585	635	680	780	880
120	530	585	640	690	745	850	960
130	575	635	690	750	805	920	1040
140	620	680	745	805	870	990	1120
150	665	730	800	865	930	1060	1200
160	710	780	850	920	990	1130	1280
170	750	830	905	980	1050	1200	1355

Figure 2-18

Runway Slope Effects on Landing Sink Rate



GROUND SPEED – KNOTS	RUNWAY SLOPE % – 0.5	1.0	1.5	2.0
	ADDED SINK RATE – FT/MIN / FT/SEC			
110	56 0.93	111 1.86	168 2.79	222 3.72
120	61 1.01	122 2.02	183 3.03	244 4.04
130	66 1.10	132 2.2	198 3.3	264 4.4
140	71 1.18	142 2.36	213 3.54	284 4.72
150	76 1.27	152 2.53	228 3.8	304 5.06
160	81 1.35	162 2.7	243 4.05	324 5.4
170	86 1.43	172 2.87	258 4.3	344 5.74
180	91 1.52	182 3.03	273 4.55	364 6.06

Figure 2-19

BRAKES AND ANTISKID

The braking force available from the tires is proportional to the area in contact with the runway, the forces on the tires perpendicular to the runway and the coefficient of friction between the tires and runway. The contact area normally changes little during the braking cycle. The coefficient of friction depends on the tire condition and runway surface (concrete, asphalt – dry, wet or icy). As shown in *figure 2-20*, the perpendicular force on the brakes is airplane weight, plus downward force from the speed brakes, minus the lift of the wing. At touchdown, the airplane is still moving rapidly (approximately V_{REF} – 5 knots) and the wing is still supporting most of the weight of the airplane. There is little weight on the brakes at this time. Aerodynamic drag has little effect at this time. When the nose gear is on the runway, wing lift is reduced to 70 to 85 percent of airplane weight. The force on the brakes is now 15 to 30 percent of the weight and available braking is 1/3 to 1/4 of maximum.

When speedbrakes are raised, from 65 to 90 percent of airplane weight is on the wheels and braking force is now maximum. Airplane drag is increased 40 to 80 percent.

For normal rudder use, the pilot's heels are on the floor. To operate the wheel brakes properly, shift the feet up and place the heels on the instep rest. Only in this position can most pilots obtain enough pedal displacement and pedal pressure to achieve maximum braking. Always adjust the pedal and seat to obtain full rudder travel and allow maximum braking.

Immediately after the nose wheel is on the ground, apply wheel brakes. Make this first brake application with only light braking. Apply just enough brakes to feel their effectiveness and to check operation.

NOTE

> At normal landing speeds, each second of delay in brake application adds approximately 250 feet to the landing distance.

On a normal landing with the touchdown near 1,000-foot point, only moderate braking is required to stop.

If available stopping distance is restricted, maximum braking is obtained by applying and maintaining heavy pedal pressure.

DIRECTIONAL CONTROL AFTER TOUCHDOWN

Differential braking is effective for directional control when used with light to moderate braking. If all brakes are being used and one brake pedal is further displaced for directional control, excessive antiskid cycling can occur and actually reduce braking on that side. The airplane then turns opposite to desired direction. Release pedal force from both pedals and apply brakes only on side desired for directional control. Now, no matter how great or small the braking force, it causes the airplane to turn in the correct direction. When again on centerline, reapply all brakes.

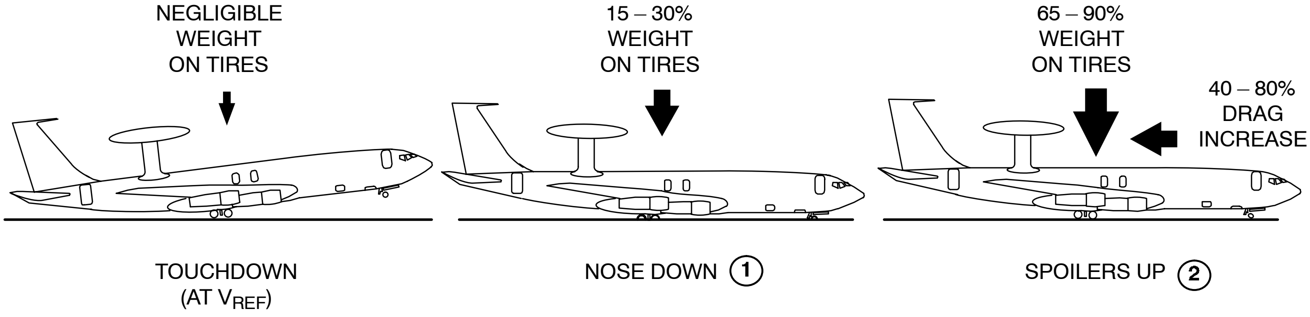
NOTE

> If one or two brakes are inoperative, refer to SEVEN- AND SIX-BRAKE OPERATION, sections III and V.

LANDING ON SLIPPERY RUNWAYS

Braking friction is greatly reduced on wet, slush covered or icy runways. On wet or slush covered runways, the wheels hydroplane during the first part of the landing roll. Use the RCR in accordance with the data in part VII, APPROACH AND LANDING, in T.O. 1E-3A-1-1, to ensure that adequate stopping distance is available after touchdown. Establish a normal approach with strict adherence to the correct approach speeds. Upon landing, apply a steadily increasing force on the brake pedals until the desired braking action is reached. As the airplane slows, more weight is placed on the wheel and braking action becomes more effective (*figure 2-20*). Sometimes, during crosswind conditions (asymmetrical wheel loading), the lighter loaded wheels remain in almost constant antiskid release. This often results in a directional control problem if runway conditions are such that nose wheel steering is ineffective. If encountered, release all pressure on both brakes, level wings to equalize wheel loads, re-apply brakes. If considerable deviation from runway centerline occurs, use other steering controls to return to runway centerline. Refer to TIRE HYDROPLANING and LANDING ON SLIPPERY RUNWAYS, section VII.

Attitude and Configuration Effects on Braking



① LOWERING THE NOSE AND RAISING THE SPOILERS PROMPTLY AFTER TOUCHDOWN TRANSFER AIRPLANE WEIGHT ONTO THE TIRES FOR DIRECTIONAL CONTROL AND BRAKING.

② RAISING THE SPOILERS ALSO INCREASES DRAG. HOLDING THE NOSE UP DOES NOT SIGNIFICANTLY INCREASE DRAG AND CAN ACTUALLY REDUCE IT.

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Figure 2-20

GO-AROUND (MISSED APPROACH)

The following GO-AROUND procedure is used when the runway is not in sight at minimum descent altitude or decision height, or when the approach is discontinued for any reason. Refer to GO-AROUND, section VI.

WARNING

- Engine flameout can occur if airplane pitch attitude exceeds 8 degrees nose up or 10 degrees nose down when any outboard main tank contains less than 2,500 pounds or any inboard main tank contains less than 6,500 pounds. Refer to MINIMUM FUEL PROCEDURES, this section.
- If an engine is inoperative, or rudder boost is inoperative, do not exceed applicable go-around EPR and do not reduce airspeed below applicable bug speed (part VII, T.O. 1E-3A-1-1). If airspeed decreases below bug speed, use symmetrical thrust until airspeed is above bug speed.

a. Immediately apply go-around power to EPR set on bug or 90% N_1, if applicable.

WARNING

Engine acceleration from idle to TRT can take up to 10 seconds.

NOTE

If gross weight is less than 250,000 pounds and all engines are operating, 90% N_1 may be set.

b. Press autopilot disengage button on control wheel. Autopilot trim rate is not sufficient to keep airplane in trim during flap retraction.

c. Raise flaps to 25 as soon as possible (minimum airspeed V_{REF}). INBD and OUTBD gages indicate 25. Both LE FLAP indicators illuminated. Flap retraction from 50 to 25 can take up to 15 seconds.

d. When positive rate of climb indicated, raise gear at pilot's command.

e. Set flap lever to 14 at V_{REF} + 10 knots. INBD and OUTBD gages indicate 14. Both LE FLAP indicators illuminated.

f. Flaps may be left at 14, if desired, or retracted at V_{REF} + 40 KIAS.

If not remaining in traffic pattern, continue to AFTER TAKEOFF AND CLIMB checklist.

TOUCH AND GO LANDINGS

A touch and go landing requires careful attention to accomplish required transition from landing to takeoff. See *figure 2-21*. At normal landing speeds, the distance required to retract flaps and accelerate engines can be as much as 3,000 feet. The pilot will brief the crew on the following procedures, including specific assignment for flaps, stabilizer trim and throttle operation.

WARNING

Do not use speedbrakes on touch and go landings.

NOTE

Do not use retractable landing lights for daylight touch and go landings.

a. Pilot making takeoff sets throttles to approximately vertical as soon as nosewheel is on the ground.

WARNING

Takeoff warning horn sounds until flaps reach about 20 degrees. Check speedbrake lever is down and stabilizer trim in green band.

b. Engineer (or pilot not making takeoff) sets flap lever to 14.

WARNING

Do not delay remainder of procedure by waiting for flaps to reach 14.

c. Pilot not making takeoff sets stabilizer trim.

CAUTION

Do not move trim switch in nose-down direction until pilot has forward pressure on control column. Attempting to trim against back pressure can cause stabilizer trim brake to engage. Attempting to trim as back pressure is relaxed can cause trim brake to chatter, possibly damaging trim brake. If trim brake chatters or engages (trim wheels stop), pull trim brake release knob.

d. When engines are stabilized (with throttles vertical) engineer (or pilot making takeoff) advances throttles, as soon as flaps are started to 14 and trim is being set.

WARNING

On dry runways, use go-around thrust (instead of 90% N_1) if above 2,000 ft pressure altitude or 50°C OAT. On wet runways, use 1.50 EPR (instead of 90% N_1).

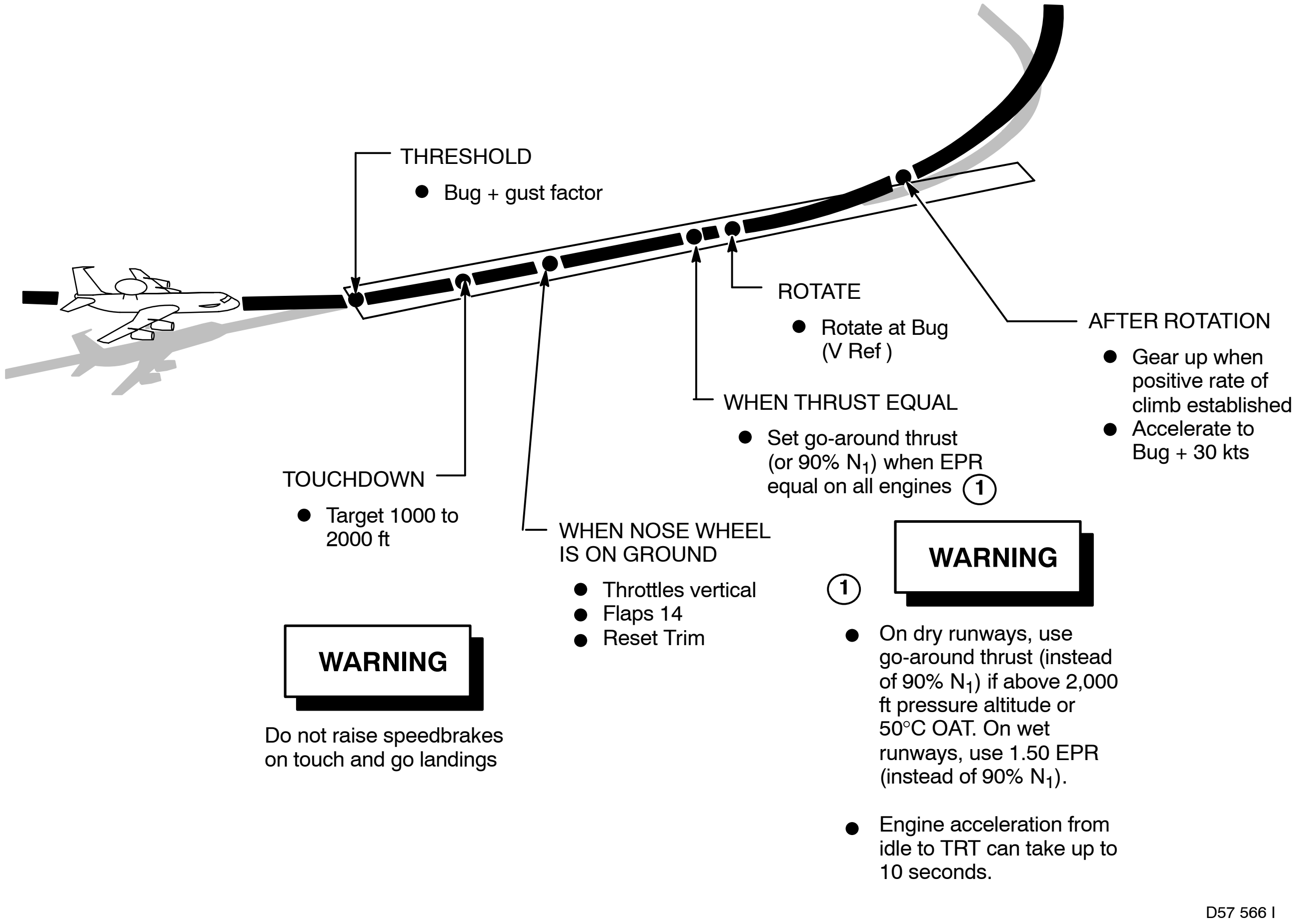
e. Rotate at V_{REF}.

f. Retract gear after positive rate of climb is observed. If remaining in pattern, refer to REPEATED LANDINGS. If leaving pattern, refer to AFTER TAKEOFF and CLIMB.

WARNING

Engine flameout can occur if airplane pitch attitude exceeds 8 degrees nose up or 10 degrees nose down when any outboard main tank contains less than 2,500 pounds or any inboard main tank contains less than 6,500 pounds. Refer to MINIMUM FUEL PROCEDURES, this section.

Touch and Go Landing



THRESHOLD

- Bug + gust factor

TOUCHDOWN

- Target 1000 to 2000 ft

WHEN NOSE WHEEL IS ON GROUND

- Throttles vertical
- Flaps 14
- Reset Trim

WHEN THRUST EQUAL

- Set go-around thrust (or 90% N_1) when EPR equal on all engines ①

ROTATE

- Rotate at Bug (V Ref)

AFTER ROTATION

- Gear up when positive rate of climb established
- Accelerate to Bug + 30 kts

WARNING

Do not raise speedbrakes on touch and go landings

WARNING

①

- On dry runways, use go-around thrust (instead of 90% N_1) if above 2,000 ft pressure altitude or 50°C OAT. On wet runways, use 1.50 EPR (instead of 90% N_1).
- Engine acceleration from idle to TRT can take up to 10 seconds.

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Figure 2-21

Touch-and-go landings may be conducted on wet runways (RCR 10 or higher) under the following conditions:

a. Gross weight between 200,000 and 250,000 pounds.

b. Pressure altitude up to 2,000 feet.

c. Ambient temperature up to 35°C.

d. Crosswind component up to 10 knots.

e. No tailwind.

Use normal touch-and-go procedures except set 1.50 EPR instead of 90% N_1.

WARNING

On a wet runway, if an engine failure is recognized at a speed below V_{REF} – 10 knots, the airplane must be stopped. The worst case stopping distance (RCR 10) is 5,450 feet from V_{REF} – 10 knots.

NOTE

In most cases, the airplane should not decelerate below V_{REF} – 10 knots if throttles are stood up as soon as the nosewheel is on the ground.

REPEATED LANDINGS

When the airplane remains in the radar pattern for a series of approaches and landings, patterns will normally be flown with gear and flaps up to conserve fuel and reduce noise. Flaps will normally be raised after reaching a safe altitude and airspeed after the takeoff or missed approach and before turning downwind. For visual patterns, flaps and landing gear should be started down before turning final. (Refer to *figure 2-9*.) Flaps may be left at 14 in the pattern to reduce speed if required to be compatible with traffic. The recommended flaps up pattern speed is 200 KIAS, which is well above stick shaker speed for all gross weights in normal traffic pattern operation.

Recompute V_{REF} and landing data for each 10,000 pound change in landing weight. Distances need not be recomputed unless conditions indicate they could have increased. (Refer to TAKEOFF AND LANDING DATA CARDS.)

Start the BEFORE LANDING checklist on downwind for VFR patterns. Start the APPROACH checklist on downwind for instrument approaches.

TAXI BACK, BOARDING/ DEPLANING

If taxiing back for another takeoff, use this checklist to return the airplane to takeoff configuration. This checklist will also be used when personnel will board and/or deplane with engines 3 and 4 running. Omit the AFTER LANDING checklist. The pilot will call for this checklist as soon as the airplane is clear of the runway.

1. SPEED BRAKE Lever – Full Forward, In Detent (P)

2. Flaps – 14, 14, Green Lights (CP)

   Flap lever set to 14. INBD and OUTBD gages indicate 14 (±3). Both LE FLAP indicators illuminated.

3. LESS IDG IFF MASTER Switch – STBY (CP or E) ◀ WITH IDG IFF – STBY (N or CP)

   Select IFF to STBY on iff control page. ◀

4. HAVE SIREN System – OFF (N)

   Shut down after clearing runway.

5. Exterior Lights – As Required (CP, E)

6. Draw Through Cooling – Checked (E)

   a. Fan – On, Low Speed

   b. NO FLOW Indicator – Out

CAUTION

If fan is not operating, check DRAW THRU CLG – FAN circuit breaker, on P61-3, and open flow control valve. Valve can be opened by momentarily opening the FAN circuit breaker. If fan does not start when breaker is closed, open valve manually.

7. Weather Radar – TEST (N, E)

8. Takeoff Data Worksheet – Computed

NOTE

- Flight engineer computes required data and checks brake cooling time. Stabilizer trim may be set to the setting noted during stabilized flight with flaps at 14. Pilot repeats takeoff briefing.
- For planning purposes pilot will determine brake energy from last landing and then, without using a headwind correction, determine brake energy for an abort at V_1 during next takeoff. Do not take off until the combined energy, reduced by 1 million ft-lb for each 7 minutes ground cooling time, is less than 28 million ft-lb. If takeoff is made with brake energy above 10 million ft-lb, follow air cooling procedures.

– – – If Taxiing Back For Immediate Takeoff, Proceed To Step 51. If Any Engines Are To Be Shut Down, Continue At Step 9 – – –

9. APU – As Required (E)

   If all engines are to be shut down for boarding/deplaning.

   a. APU Generator Switch – ON

      APU generator on bus. Monitor load before transfer (170 amperes, maximum). Notify navigator and CSO before changing power.

CAUTION

- If APU shuts down during power transfer, or shuts down for no apparent cause, have condition of APU accessory drive shaft checked prior to any restart attempt.
- If auxiliary hydraulic pump number one and/or aft forced air cooling fan number one is/are operating during electrical power transfer, the corresponding ELCUs can trip. If this occurs, restart system(s) immediately.

   b. APU BLEED Switch – ON

10. AFT Forced Air System – Checked (E)

11. Auxiliary Hydraulic Pump No 1 – Checked ON (E)

12. Engine Bleed Air Switches – OFF (E)

13. Nose Wheel, Parking Brake – Centered, Set (P)

    Taxi straight ahead a few feet to relieve side loads on tires and struts.

CAUTION

If heavy braking was used, wait 15 to 20 minutes for brakes to cool before setting parking brake. Refer to Section V for limitations.

14. Interconnect Valve Switch – SYS (E)

15. Throttles – As Required (P, CP)

CAUTION

Leave outboard engines at idle for one minute after HAVE SIREN system is shutdown.

16. Interphone – Checked (P, E, GC)

17. Chocks – Installed (E, GC)

18. Brakes – As Required (P, CP)

    If main gear chocks are installed, brakes may be released to improve brake cooling.

WARNING

With wheels chocked, brakes released and any engines running, pilot or copilot will guard the brakes.

⑲ Escape Slides, Doors – As Required (E, CSO, ART)

    Stow slides for door(s) used.

20. SEAT BELTS Sign Switch – OFF (CP or FE)

21. DESCENT Switch – Off (E)

22. Forward Forced Air Cooling System – Set (E)

    a. POWER Switch – On

    b. System Control Switch – AUTO

23. NACELLE ANTI–ICE Switches – Off (P, E)

24. CONTINUOUS IGNITION – Off (E)

– – – After Boarding/Deplaning Complete – – –

25. Parking Brake – Set (P)

26. Gear Pins – Removed (E, GC)

27. SEAT BELTS Sign Switch – ON (CP or FE)

㉘ Doors, Slides – Closed and Armed (E, CSO, ART)

29. Fuel Panel – Set for Start (E)

Refer to FUEL MANAGEMENT, subsection I–D.

30. Takeoff Briefing – Reviewed (P, CP, N, E)

31. Gear Pins – Removed and Stowed (E)

(32.) Warning Alarm and Lights – Checked (P or CP, E, ART, CDMT, CSO)

33. NAV System – Ready for Taxi (N)

Aligned and in NAV or ready for inflight alignment.

(34.) Mission Crew – Ready for Start and Taxi (E, MCC)

MCC reports when mission crewmembers are seated, seatbelts on, and oxygen ON and 100%.

35. Primary Flow Control Valve – Off (E)

36. Start Clearance – Received (P, CP)

Obtain start clearance from tower and ground crew.

– – – When Engines Started – – –

37. Primary Flow Control Valve – On (E)

38. NACELLE ANTI-ICE Switches – Checked and Set (P)

39. Electrical System – Set (E)

40. AFT Forced Air System – Checked (E)

41. Auxiliary Hydraulic Pump No 1 – Checked (E)

(42.) Chocks and Ground Equipment – Remove (P, GC)

WARNING

Reduce power to idle on operating engines before disconnecting ground air hose. High pressure bleed air can cause hose to whip and injure ground crew if check valve fails to close.

43. Engine Bleed Air Switches – On (E)

44. APU BLEED Switch – Off (E)

45. APU CONTR Switch – STOP (E)

CAUTION

Prior to shutdown, operate APU for one minute without bleed air or generator load before stopping.

46. Doors – Closed (E)

NOTE

APU DOOR caution light remains illuminated for about 90 seconds after APU CONTR switch is set to STOP.

(47.) Taxi Report – Received (P, GC)

At pilot’s command, ground crew reports external power, chocks, ground wires removed. All hatches and panels checked secure. Airplane in taxi configuration. Clearing off interphone.

48. Hydraulic System – Checked (E)

All pumps on, pressure and quantity normal.

49. Auxiliary Pumps – OFF – Checked – On (E)

If interconnect valve is closed, auxiliary system pressure should decrease. After rudder boost light illuminates, switch auxiliary pumps back on.

50. Interconnect Valve Switch – OFF (E)

WARNING

If interconnect valve does not close, airplane will not be accepted for flight.

51. Takeoff Briefing – Reviewed (P, CP, N, E)

This briefing may be accomplished at any convenient time prior to this step.

52. Stabilizer Trim – Set (P)

53. Rudder Override Switch – NORMAL (P, E)

54. FUEL HEAT Switches – As Required, OFF (E)

If fuel temperature is at or below 0°C, use fuel heat for one minute. Refer to FUEL HEATER GROUND OPERATION, subsection I-B.

55. APU Door Caution Light – Out (E)

56. Fuel Heat Switches – Off (E)

57. CONTINUOUS IGNITION – ON (E)

58. Altimeters, Flight Instruments, Navigation Aids, and ADS Panel – Checked and Set (P, CP, N)

59. **WITH IDG** Altitude Alerters – Set, As Required (P, CP) ◀

60. HAVE SIREN System – As Required (N)

    On, if system is to be used.

61. Mission Crew – Ready for Takeoff (E, MCC)

– – – After Cleared Onto Runway – – –

62. Takeoff Announcement – Completed (P, CP)

63. **LESS IDG** IFF MASTER Switch – NORM (CP or E) ◀ **WITH IDG** IFF – NORM (N, CP)

    Select IFF to NORM on iff control page. ◀

64. All Exterior Lights – On (CP, E)

AFTER LANDING

Normally complete this check as soon as the airplane is clear of runway, and another takeoff is not to be made. (Use TAXI BACK procedure if making another takeoff.)

1. SPEED BRAKE Lever – Full Forward, In Detent (P)

2. Flaps – Up (CP or E)

   Set flap lever to UP. INBD and OUTBD gages indicate zero. Both LE FLAP indicators out.

CAUTION

- If runway is covered by slush or snow and airplane is cold soaked or temperature is near or below freezing, do not retract flaps above 25 until ground crew can verify jack screws are free of ice and/or snow.
- To protect aileron control system from wind damage on the ground, flaps should be retracted to lock out outboard aileron when airplane can be subjected to wind of 35 knots or more.

NOTE

With both utility pumps operating and engines at low rpm, or with only one utility pump available, simultaneous operation of flaps, nosewheel steering, and utility rotodome drive can cause utility pump low pressure lights to illuminate.

3. Hydraulic Pressure and Quantity – Normal (E)

4. HAVE SIREN System – OFF (N)

   Shut down after clearing runway.

5. NACELLE ANTI-ICE Switches – OFF (CP or E)

6. CONTINUOUS IGNITION Switch – OFF (E)

7. **LESS IDG** IFF MASTER Switch – STBY (CP or E) ◀ **WITH IDG** IFF – STBY (N or CP)

   Select IFF to STBY on iff control page. ◀

8. **WITH IDG** M4 Codes – HOLD, As Required (N, CP, E)

   If HOLD is not activated, autozeroization might occur when power is transferred to APU due to activation of EDCR. ◀

9. WINDOW HEAT Switches – OFF (CP or E)

10. PROBE HEATERS Switches – OFF (CP or E)

11. Exterior Lights – As Required (CP or E)

    a. Strobe Lights – Off

    b. Landing Lights – As Required

CAUTION

Do not operate landing lights or RUNWAY TURNOFF lights unless the airplane is in motion, except for momentary checks to verify operation.

12. Engines – Cutoff, As Required (P, E)

Shut down outboard engines after bleed air valves are closed. Note outboard engine oil quantity immediately after shutdown.

CAUTION

Leave outboard engines at idle for one minute after HAVE SIREN system is shut down.

13. Draw Through Cooling – Checked (E)

    a. Fan – On, Low Speed

    b. NO FLOW Indicator – Out

    Fan must be operating to provide proper airflow for cooling.

CAUTION

If fan is not operating, check DRAW THRU CLG FAN circuit breaker on P61-3 and open flow control valve. Valve can be opened by momentarily opening FAN circuit breaker on P61-3. If fan does not start when breaker is closed, open valve manually.

14. APU – As Required (E)

    a. APU GENERATOR Switch – ON (E)

    APU generator on bus. Monitor load before transfer to APU (170 amperes, maximum). Notify navigator and CSO when changing power.

CAUTION

- If APU shuts down during power transfer, or shuts down for no apparent cause, have condition of APU accessory drive shaft checked prior to any restart attempt.
- If auxiliary hydraulic pump number one and/or aft forced air cooling fan number one is/are operating during electrical power transfers, the corresponding ELCUs can trip, causing system(s) to shut down. If this occurs, restart the system(s) immediately to prevent damage to airplane equipment.

    b. APU BLEED Switch – ON (E)

15. Aft Forced Air System – Checked (E)

16. Auxiliary Hydraulic Pump No 1 – Checked/ON (E)

17. Engine BLEED AIR Switches – OFF (E)

    Set remaining BLEED AIR Switches to OFF, unless needed.

18. Outflow Valves – Open (E)

    Open outflow valves if not automatically opened.

19. Weather Radar – TEST (E, N)

20. Maintenance Interphone Selector – AIRCRAFT (E)

– – – If Aircraft Is to Be Towed or Pushed Back, Proceed to TOWING AND PUSHBACK Checklist – – –

ENGINE SHUTDOWN

CAUTION

For wind of 65 knots and above, position airplane into the wind.

1. Interconnect Valve Switch – SYS (E)

2. Nose Wheel, Parking Brake – Centered, Set (P)

   Taxi straight ahead for a few feet to relieve side loads on tires and struts.

CAUTION

If heavy braking was used, wait 15 to 20 minutes for brakes to cool before setting parking brake. Refer to Section V for limitations.

3. Throttles – Cutoff (P)

NOTE

Check oil quantity within 30 minutes of engine shutdown. Quantity gages do not give a reliable indication of oil quantity if engines are shut down more than 30 minutes.

④ Emergency Lights, Escape Slides, Forward Crew Entry Door – OFF, STOWED, As Required (E, CSO, ART)

Flight engineer sets EMER EXIT LIGHTS switch to OFF. CSO and ART disconnect escape slides, turn off emergency lights and notify flight engineer when completed.

5. SEAT BELTS Switch – OFF (CP, E)
6. Fuel Boost PUMPS Switches – Off (E)
7. Weather Radar – Set, OFF (P, N)
8. Standby Attitude Indicator – CAGE (P)
9. Electric Power – As Required (E)

APU generator or external power connected. Monitor load before transferring to external power (connected load must not exceed capacity of first unit connected). When switching to external power check frequency and voltage before setting EXTERNAL POWER switch to on.

CAUTION

- If external power unit is connected to airplane and AVAIL indicator does not illuminate, verify that plug is inserted in connector 1A. If properly connected and AVAIL indicator is not illuminated, shut off airplane and APU generators before pressing EXTERNAL POWER switch. Damage to generators can result because system could attempt to parallel airplane/APU and ground power instead of changing to ground power.
- If APU shuts down during power transfer or shuts down for no apparent cause, have condition of APU accessory drive shaft checked prior to any restart attempt.
- If auxiliary hydraulic pump number one and/or aft forced air cooling fan number one is/are operating during electrical power transfers, the corresponding ELCU's can trip causing system(s) shutdown. If this occurs, restart system(s) immediately to prevent damage to airplane equipment.

10. EXTERIOR LIGHTING Switches – As Required (CP)

If recocking airplane, leave navigation lights on. Turn off fixed and retractable landing lights, runway turnoff lights and beacon lights. Strobe lights off.

CAUTION

Do not operate landing lights or RUNWAY TURNOFF lights unless airplane is in motion, except for momentary checks to verify operation.

⑪ Chocks and Nose Gear Lock Handle – In Place (E, GC)

12. ROTODOME DRIVE SPEED Switch – OFF (E)

– – – For Recocking, Perform the BEFORE START Checklist Instead of the BEFORE LEAVING AIRPLANE Checklist – – –

BEFORE LEAVING AIRPLANE

Prior to maintenance debrief, flight and mission crew will complete AFTO Form 781, listing malfunctions. For recocking, perform BEFORE START checklist.

1. GINS Classified Steering Patterns – Removed (E, N)
2. Data Cartridge – Removed
3. GINS – As Required (E, N)
4. Crypto Status Record – Checked

Ensure GINS crypto status record in AFTO Form 781 is current.

5. Avionics Power Disconnect Switches (4) – DISC (P, CP, N, E)

CAUTION

Flight crew UHF radio is available for communication as long as power is available on emergency DC bus. Limit transmission to five seconds and receiver operation to five minutes unless draw-through cooling is available.

6. IFF Codes – Removed/Zeroized (As Required) (P, CP, N, E)

NOTE

WITH IDG If required, on iff mode 1/2/3/c page set desired codes to zero by inserting a minus ("–") in each code field. On iff mode 4 page, press LS6 to zeroize Mode 4 codes. ◀

7. STBY ATT IND circuit breaker – Open (E)

8. IFF TRANSPONDER Switch – OFF (E)

9. AUXILIARY PUMPS Switches – OFF (E)

10. EMERGENCY POWER Switch – As Required (E, N)

    Off if removing all electrical power. Ensure GINS is turned off before removing emergency power.

11. Forced Air Systems – OFF (E, N)

    Coordinate with navigator.

    a. AFT System Power Switch – OFF

    b. Forced Air Cooling Panel DESCENT Switchlight – Press Off (E)

12. PRIMARY and ALTERNATE Valve Switches – As Required (E)

    Off unless required for maintenance.

13. Crew Door or Radio Access Door – Open, If Forced Air System or Ground Air Conditioning Cart In Use (E, GC)

CAUTION

- Door must be open to provide adequate airflow for air conditioning, forced air cooling system, and draw through cooling. Electronic equipment and draw through fan could be damaged if door is not open.
- If airplane electric power is lost while air conditioning ground cart is in use, airflow through airplane would stop when draw through fan stops.

14. CABIN PRESSURE VAC PUMP FWD and AFT Circuit Breakers (P61-3) – Open (E)

    Prevents excessive operating time on vacuum pump motors. Outflow valves close.

15. Parking Brake – Off (P)

    When chocks are in place.

16. Oxygen – OFF, 100% (P, CP, E, N, OBS)

17. APU and External Power – As Required (E, N)

    Off unless required for maintenance.

18. DC Meter Selector Switch – Any XFMR Rectifier Position (E)

19. BATTERY Switch – As Required (E)

    All lights go out when switch is OFF. Set BATTERY switch to OFF, unless required for maintenance.

EXTERIOR WALKAROUND

The flight engineer will make a walkaround inspection of the airplane and verify gear pins are installed before turning the airplane over to maintenance.

TOWING AND PUSHBACK

The following rules apply to all towing and pushback operations with the flight crew aboard.

a. Flight crew shall be in interphone contact with ground crew.

b. All braking is performed by tug operator except for setting parking brake.

c. Maintenance crew uses T.O. 1E-3A-2-7-2CL-1.

The flight crew uses the following procedures.

– – – If Engines Not Running, Proceed to Step 4 – – –

1. Interconnect Valve Switch – SYS (E)
2. Nose Wheel, Parking Brake – Centered, Set (P)
3. Throttles – Cutoff (P)

CAUTION

If the TOWING AND PUSHBACK checklist is being accomplished after flight with an inoperative APU, ensure that the UHF XCVR, UHF CONT, and the UHF XCVR, UHF ADF AC and UHF ADF DC, CPLR circuit breakers on the P5 panel are opened prior to all engines being shut down.

– – – Before Towing or Push Back – – –

4. Beacon Switch – OFF (CP)
5. BATTERY Switch – ON (E)
6. EMERGENCY POWER Switch – ON (E)

⑦ Interphone – Checked (P, E, GC)

⑧ APU Start, If Required (E, GC)

The APU generator will be ON to supply electrical power during towing if operable.

⑨ Hydraulic System – As Required (E, GC)

If APU operating, obtain ground clearance, start auxiliary pumps; set interconnect valve switch to SYSTEM.

⑩ Flaps – UP (P, GC)

⑪ Parking Brake – Set (P, GC)

12. Brake Pressure – 3,000 PSI (CP)

If electrical power not ON, check direct reading pressure indicator in right wheel well.

13. SEAT BELTS Switch – ON (CP or E)
14. GINS – Ready for Towing (N)

GINS may be powered up or down during ground movements.

– – – When Ready to Tow or Push Back – – –

⑮ Doors, Slides, Emergency Lights – Closed, Armed (CSO, ART, E)

NOTE

EMERGENCY LIGHTS intensity switch (P67) set to LOW (guard open) if APU not on.

⑯ Mission Crew – Ready for Towing (E, MCC)

⑰ Parking Brake – OFF (P, GC)

18. Brake Pressure – Monitor (CP)

– – – When Tow or Push Back Complete – – –

⑲ Nose Gear Scissors – Connected (E, GC)

*** * * For Starting Engines, Perform STARTING ENGINES Checklist * * ***

*** * * If Departing Airplane, Perform ENGINE SHUTDOWN and BEFORE LEAVING AIRPLANE Checklists * * ***

EMERGENCY TAXI

If emergency conditions require the airplane to be taxied when time does not permit the use of normal checklists, the following checklist may be used.

EMERGENCY TAXI CREW

The following are approved crews for emergency taxi:

a. Two pilots and one flight engineer

b. One pilot (left seat), one mechanic (qualified for engine run and taxi) in right seat, and one flight engineer

EMERGENCY TAXI CHECKLIST

① Nose Gear Chocks – Installed (E, GC)

② Static Ground Wires, and Main Wheel Chocks – Removed (E, GC)

③ Engines, APU, and Control Surfaces – Clear (E, GC)

④ Airplane Status – Checked (P, E, GC)

Check AFTO Form 781 or check with maintenance to verify airplane can be taxied.

5. BATTERY Switch – ON (E)

WARNING

If battery is not installed, normal fire protection for engine and APU are inoperative.

6. EMERGENCY POWER Switch – NORMAL (E)

7. Landing Gear Lever – Down, In (3 Green Lights if AC Power Connected) (P, CP)

– – – If Battery is Installed, Omit Step 8 – – –

– – – If Battery Removed (Or Inoperative), Perform Step 8 – – –

8. APU Fireguards – Posted

At least 2 fireguards are required when starting APU without battery. One must be inside aft lower compartment and one outside, near APU intake door.

– – – If APU Bleed Air or APU Generator Not Available, Omit Step 9, Perform Step 10 – – –

9. APU – Started, Bleed Air and Generator On (E)

If battery is not installed (or is inoperative), start APU manually.

– – – If APU Operating, Omit Step 10 – – –

⑩ External Air and/or Electric Source – Connected (E, GC)

11. Communications – Established (CP)

12. Hydraulic System – Set (E, CP)

    a. Auxiliary Pump 1 Switch – ON

    b. Interconnect Valve Switch – SYS

    c. Brake Pressure – Checked

    d. Rotodome Drive SPEED Switch – Idle

13. Parking Brakes – Set (P, CP)

14. Fuel System – Set (E)

    a. Crossfeed Valves Switches – As Required

    Crossfeed valves need not be opened if one boost pump on in each main tank.

    b. Boost Pumps – One On in Each Tank Supplying Fuel

15. Throttles – Cutoff (P, CP)

16. PRIMARY and ALTERNATE Switches – Off (E)

17. NAVIGATION and BEACON Switches – ON (CP)

18. Engines – Started (P, CP, E)

If possible, start engines 2 and 3 (for utility hydraulic pumps).

19. Electrical System – Set (E)

    If taxi distance is short, APU generator may be left on bus.

    CAUTION

    If power is transferred, check that auxiliary hydraulic pump No 1 remains on.

20. Ground Equipment, Chocks, Interphone – Removed (E, GC)

– – – Airplane is Now Ready for Taxi – – –

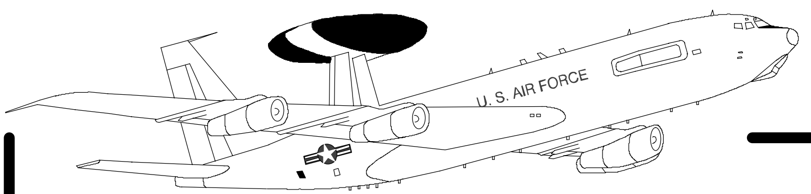
– – – When Taxi is Completed – – –

21. Nose Gear Steering – Centered (P)

22. Parking Brake – Set (P)

*** * * Perform Normal ENGINE SHUTDOWN Checklist * * ***

Section III



EMERGENCY PROCEDURES

Table of Contents

Title *Page*

Table of Contents (Continued)

Title *Page*

NOTE

Systems Emergency Procedures are in section IIIA, beginning on page 3-91.

***Not Verified by Air Force Crews**

INTRODUCTION

This section contains amplified checklists and explanatory text for most emergency situations. However, since it is impossible to provide checklists for all situations and combinations of emergencies, the pilot's sound judgement may dictate deviations from the procedures.

Procedures in this section are listed in the sequence in which they could be expected to occur on a mission. Emergency procedures involving failures of airplane systems which affect performance are listed under INFLIGHT EMERGENCY PROCEDURES. Emergency procedures which involve a single airplane system are listed by system under SYSTEMS EMERGENCY PROCEDURES (section IIIA).

WARNING

Because of the combined effects of loss of thrust and control system malfunctions, some emergency procedures require flight technique which is unlike that used on other four-engine jet airplanes. Failure to follow these procedures carefully can lead to loss of the airplane and crew in some conditions.

GENERAL EMERGENCY PROCEDURES

These procedures apply to all emergency situations. Special instructions applying to a particular situation are included with that procedure/checklist.

1. **FLY THE AIRPLANE**

   In any emergency, the pilot's primary duty is to maintain control of the airplane. Establish safe attitude, airspeed, altitude, and power setting.

2. **STOP, THINK, EVALUATE THE PROBLEM**

   Evaluate each emergency carefully before starting emergency action.

3. **REMEMBER THE OTHER SYSTEMS**

   Do not concentrate on the problem to the point of failing to see other problems or neglecting operating requirements of other systems.

CHECKLISTS

The flight crew is responsible for accomplishment of all checklists in the same sequence as they are presented in this section. Items may be accomplished before, but not later than the point indicated in each checklist.

NOTE

- Certain steps in the ABORTED TAKEOFF checklist are printed in **BOLDFACE CAPITAL LETTERS**. These steps are immediate action items and will be committed to memory by the pilots and performed in proper sequence without direct reference to the checklist.

- The memory items are the first steps of the checklist in which they appear. Following completion of the memory items, the applicable checklist will be completed.

The flight engineer normally reads all checklists. All checklists performed by crewmembers other than the pilot will be initiated at the pilot's command on interphone. The pilot may designate any crewmember to perform a procedure if the emergency requires. Where a variable response (AS REQUIRED or AS DESIRED) is indicated, the actual setting of the control will be called out by crewmember responding.

NOTE

Checklist items requiring coordination between flight crewmembers and mission crew or ground crew to complete the procedure are indicated by a circled number.

Time and conditions permitting, reference should be made to the amplified checklists contained in this section.

Checklist Symbols

Flight crewmember symbols used in the checklists are:

P	Pilot
CP	Copilot
E	Engineer
N	Navigator
OBS	Observer
GC	Ground Crew

Mission crewmember symbols used in the checklists are:

MCC	Mission Crew Commander
ART	Radar Technician
CDMT	Computer Technician
CT	Communications Technician
CSO	Communication Systems Operator

Multiple Path Checklists

Some checklists contain multiple paths, which provide a choice of steps, depending on the result of a previous step. These statements are preceded and followed by three dashes. These statements are usually printed in pairs, such as:

– – – If Smoke Stops, Proceed to Step 23 – – –

– – – If Smoke Continues, Proceed to Step 25 – – –

When a checklist path completes the emergency procedure and a return to normal procedures is possible, or another emergency procedure must be initiated, the step is followed by the symbol *** and the statement “Return to Normal Operation”, “Return to Normal Operation (Equipment Inoperative)” or “Initiate (Name of Checklist) Procedure”. When this symbol is reached, do not perform the remaining steps of that checklist.

Checklist Definitions

Two terms are used when an emergency or precautionary landing is required:

“Land as soon as possible” means an emergency condition exists (emergency will be declared). Landing at the nearest suitable airfield considering the nature of the emergency, airfield facilities, weather, and airplane landing weight.

“Land as soon as practical” means the abnormal condition is not as severe, but the mission must still be aborted. A landing at the nearest airfield is not necessary. The airplane may be flown to a suitable maintenance base.

“Return to normal operation” means return to normal systems operation. This can require review of previously completed checklist steps to restore systems to as near normal operation as possible.

CREW COORDINATION

As time and conditions permit, the pilot will keep the crew informed. Any emergency requires the full, coordinated effort of all crewmembers. Emergency procedures should be practiced often so that the crew is familiar with procedures.

When an emergency situation occurs, notify pilots and mission crew commander at once, then perform emergency procedures as directed.

Crewmembers primarily involved with the emergency will coordinate on the maintenance net. All other crewmembers will be on mission nets 2 and 3.

WARNING

To improve crew coordination in emergencies, flight engineer will set MAINT INTPH selector to BOTH. This will connect both maintenance nets to flight interphone.

NOTE

Because of excessive background noise, crew members in lower compartments should avoid using hot mic.

Emergency Operation

1. IFF EMER – ON
2. TCAS – TA–only, As Required

   TA–only mode inhibits TCAS generation of RAs and coordination of RAs with other aircraft. TA–only should be selected for engine failure or other condition that limits performance capability.

NOTE

- With an engine failure or other abnormal flight condition that reduces climb capability, set TCAS to TA-only mode via the CDU tcas/iff control page. This prevents TCAS from coordinating an RA with other TCAS equipped aircraft and inhibits RAs from being issued by own TCAS. Other TCAS equipped aircraft then respond to E-3 as if E-3 were not TCAS equipped.

- Respond to TAs by attempting to establish visual contact with the intruder aircraft. For any traffic that is acquired visually, continue to maintain or attain safe separation in accordance with ATC standards and good operating practices.

NAVIGATOR'S EMERGENCY PROCEDURES

Emergency procedures performed by the navigator are listed separately after each emergency procedure if they are different from those performed by pilots and flight engineer.

NOTE

> Navigator's emergency procedures will be initiated at the pilot's command.

Steps in the navigator's emergency checklists which are also listed (for proper sequencing) in the pilots' and flight engineer's checklists are identified by a plus (+) symbol before the step number. These steps require a response by the navigator when the flight engineer reads the step.

The navigator must be familiar with the specific actions required and with the general procedures, sequence and the appropriate text material in the pilots' and flight engineer's emergency procedures.

MISSION CREW

Procedures to be followed by individual mission crewmembers are listed in mission crew checklists and in T.O. 1E-3A-43-1-1.

EMERGENCY ENTRANCE

The airplane can be entered by any of the exits shown in *figure 3-1* except the pilots' windows, which cannot be opened from the outside. Areas suitable for cutting are marked. See *figure 3-1*.

EMERGENCY SIGNALS

If time and conditions permit, notify the crew of the emergency on PA and give instructions which are acknowledged by interphone. The mission commander verifies that all mission compartment personnel are notified of the emergency. Silence flight deck warning bells and horns as soon as possible to improve crew coordination. For further information, refer to CREW WARNING AND ALERTING SYSTEM, subsection I-V.

WARNING

> Due to the type of warning signal system installed on this airplane, a different signal procedure is used to notify the crew of ground and flight emergencies, the signals used are listed below. The alarm bell is an electronic tone repeated five times per second on PA and interphone.

In The Air

Bailout

a. Illuminate BAILOUT signs and announce over PA (if time permits) – "Prepare for Bailout"

b. Alarm Bell ON Five to Ten Seconds and BAILOUT Signs Illuminated – Abandon Airplane

Crash Landing or Ditching

a. Announce Over PA (if time permits) and Illuminate CRASH LANDING Signs – "Prepare for Crash Landing (or Ditching)"

b. Alarm Bell ON Five to Ten Seconds, CRASH LANDING Signs Illuminated – Brace for Ditching or Crash Landing. Personnel in seats without shoulder harness, assume bracing position.

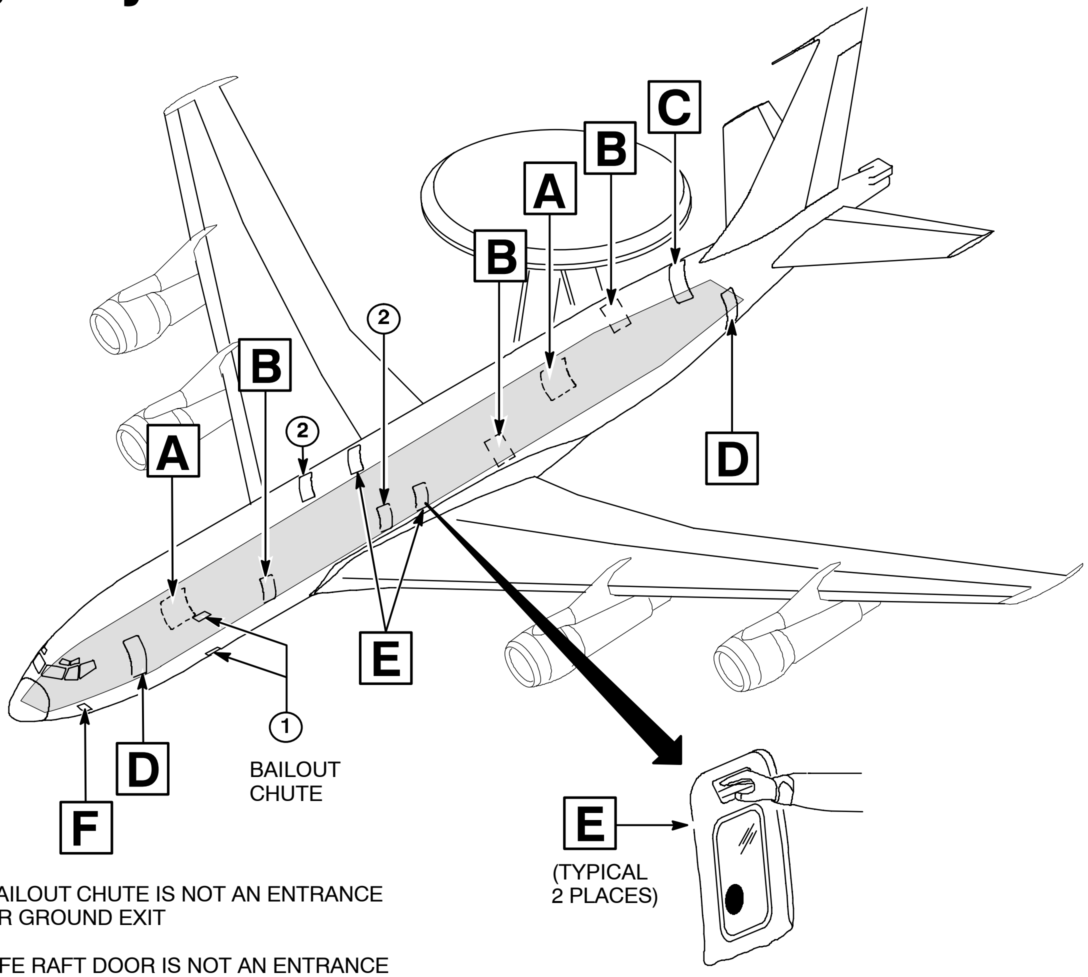
Loss of Cabin Pressure

Audible Warning and/or LOSS OF PRESSURE Signs Illuminated – Extinguish Smoking Material, Don Oxygen Mask, Set Regulator to ON and 100%. Refer to SUDDEN LOSS OF PRESSURE checklist.

On The Ground

Alarm Bell ON Five to Ten Seconds – Evacuate Airplane

Emergency Entrance/Exit

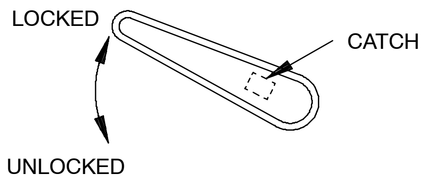


① BAILOUT CHUTE IS NOT AN ENTRANCE OR GROUND EXIT

② LIFE RAFT DOOR IS NOT AN ENTRANCE OR GROUND EXIT

CARGO DOOR HANDLE – FORWARD AND AFT

OUTSIDE

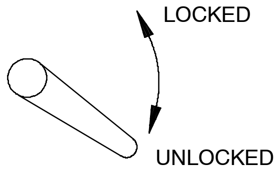


TO OPEN DOOR

1. PRESS CATCH TO RELEASE HANDLE
2. PULL HANDLE DOWN
3. PUSH DOOR IN
4. SLIDE DOOR FORWARD

A

INSIDE



TO OPEN DOOR

1. ROTATE HANDLE 1/8 TURN CLOCKWISE
2. PULL DOOR IN
3. SLIDE DOOR FORWARD

A

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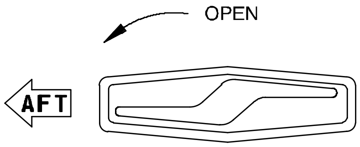
Figure 3-1 (Sheet 1 of 2)

RIGHT SIDE JUST FORWARD OF GALLEY DOOR,
LEFT SIDE JUST AFT OF OVERWING HATCH AND
FORWARD OF OVERWING HATCH

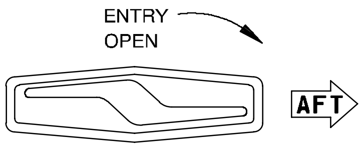
B



GALLEY DOOR EXTERNAL HANDLE

TO OPEN DOOR
1. PULL HANDLE OUTWARD AND ROTATE COUNTERCLOCKWISE
2. PULL DOOR OUTWARD

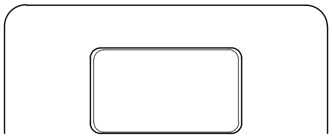
C



ENTRY DOOR EXTERNAL HANDLE

TO OPEN DOOR
1. PULL HANDLE OUTWARD AND ROTATE CLOCKWISE
2. PULL DOOR OUTWARD

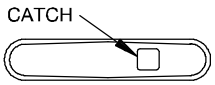
D



EMERGENCY EXIT HATCHES EXTERIOR PUSH PANEL

TO OPEN HATCH
1. PUSH IN PANEL TO UNLATCH
2. PUSH HATCH INWARD AND LIFT UPWARD
3. HATCH WEIGHS ABOUT 50 LB

E



RADIO ACCESS DOOR HANDLE

TO OPEN DOOR
1. PRESS CATCH TO RELEASE HANDLE
2. ROTATE HANDLE COUNTERCLOCKWISE
3. PUSH DOOR INWARD AND FORWARD

F

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Figure 3-1 (Sheet 2 of 2)

REPORTING MALFUNCTIONS

Log all malfunctions requiring emergency action in AFTO Form 781. If on the ground, report fire or other emergency to tower in accordance with local or major command directives while accomplishing emergency procedure.

ENGINE FAILURE OR FIRE

Fire in the engine tailpipe does not energize the fire warning system. Fire in the tailpipe is reported by the ground crew. For tailpipe fire, motor the engine to blow out the fire. For an engine fire on the ground, stop the airplane and shut down affected engine by using this procedure. Notify the field control tower to obtain fire fighting equipment. If an engine fire on the ground cannot be controlled, evacuate the airplane, using GROUND EVACUATION Checklist.

This procedure applies to all engine fires, on the ground or in flight, to engine failures, severe vibration, internal damage, or separation.

NOTE

- The following steps will be accomplished one at a time, by the pilot, or at pilot's command. If the fire warning light goes out, evaluate the situation before proceeding to the additional steps. If there is any possibility that fire still exists, complete the checklist.
- Silence fire warning bell (silencing the bell rearms the system and improves crew coordination). The master fire warning light does not remain on.

1. Throttle – Cutoff (P)
2. Fire Switch – Pulled, If Required (P, E)

   Pull fire switch for engine on fire (approximately 1/2 inch), at pilot's command (if warning light does not go out).

CAUTION

- If internal engine damage is suspected, do not pull fire switch. Pulling fire switch provides no additional protection (if engine remains on airplane) and can damage hydraulic pump and fuel control if engine is windmilling. If engine separates, close utility hydraulic shutoff valve (for that engine only) or pull fire switch.
- If no oil pressure is observed on windmilling engine, record length of time that engine windmills and N_1 and N_2 rpm.

3. Fire Bottle – Discharge, If Required (P, E)

   If fire warning light has not gone out, press fire bottle discharge button for failed engine at pilot's command.

WARNING

If generator 2, 4, 6, or 8 is inoperative, power to certain engine and flight instruments and hydraulic system components can be lost if that bus tie breaker is open. Attempt to restore power to bus as soon as practical.

NOTE

If bus tie breaker NO 6 remains open and mission radr is operating, coordinate with MCC before closing bus tie breaker NO 6.

– – – If On the Ground, Proceed to Steps 4 and 5 Without Waiting – – –

The decision to evacuate the airplane should be made after both bottles have been discharged. If the fire goes out, there is no reason to do an emergency evacuation.

– – – If Fire Switch Warning Light Goes Out Within 30 Seconds, Proceed to Step 6 – – –

– – – If Fire Switch Warning Light Remains Illuminated 30 Seconds After Step 3, Proceed to Step 4 – – –

4. Fire Extinguisher Transfer Switch – ALTER (E)

NOTE

- If fire goes out after first bottle is discharged, leave fire extinguisher transfer switch in original position for fire protection on the other engine on the same side.
- Do not move fire transfer switch unless discharging second bottle in same engine
- If first bottle is discharged in ALTER position, switch must be set to NORM position to actuate second bottle into same engine.

5. Fire Bottle Discharge Button – Press Again, If Required (P, E)

   At pilot's command.

– – – If Fire Is Not Under Control and Airplane Is On The Ground, Proceed To GROUND EVACUATION Checklist – – –

– – – If Airplane Is Airborne, Proceed to Step 6 – – –

6. Rudder Override Switch – As Required (P, E)

   OVERRIDE below 250 KIAS.

WARNING

- When operating rudder override switch in flight, physically identify both RUDDER (lower) and OVERRIDE (upper) switches to make sure correct switch is operated. Operation of wrong switch could cause loss of control.
- Do not exceed 250 KIAS with override switch set to OVERRIDE. Structural damage could result from full or rapid rudder movement with full rudder pressure.

7. Rudder Mode Indicator – As Required (E)

   Indicator should agree with flight regime/Rudder Override Switch position.

8. Electrical System – Checked (E)

   a. GEN CONTR Switches – OFF (Affected Engine)

   b. Bus Tie Switches – Closed

   c. Electrical Load – 218 Amperes per Generator, Maximum

NOTE

- Cut off non-essential load if required to maintain load within limits.
- Six generators must be operating in parallel to operate the mission radar.

9. Fuel System – Checked (E)

   a. Boost Pumps – As Required

      OFF for uncontrollable engine fire (affected engine).

   b. CROSSFEED Valves – As Required

      OFF for uncontrollable fire (affected engine).

   c. Fuel Heat Switches – OFF (affected engine)

   d. Fuel Management – As Required

10. Hydraulic System – Checked (E)

   a. Utility Pump – As Required

   b. Utility Fluid Shutoff Switch – As Required

      Close only if fire switch was pulled.

CAUTION

Operation of utility hydraulic pumps for more than five minutes with engines rotating and fire switch pulled can damage pump.

11. Bleed Air Switch – OFF (Affected Engine) (E)

WARNING

If the firewall shutoff and/or engine bleed valve fails to close, close the wing isolation valve for affected wing.

12. CONTINUOUS IGNITION Circuit Breaker – Open (Affected Engine) (E)

CAUTION

If engine and flight conditions permit, the fuel system can be cooled if windmilling N_2 rpm is at least 25%. Open CONTINUOUS IGNITION circuit breaker to prevent engine relight and set throttle to idle for 3 minutes each 30 minutes to prevent excessive temperatures in the fuel control. Do not attempt to cool the fuel system if the fire switch was pulled or there was any indication of a fire.

13. Engine Start Selector Switch – OFF (Affected Engine) (E)

14. NACELLE ANTI-ICE Switch – OFF (Affected Engine)
(P, E)

15. **WITH IDG** TCAS SENS – TA Only (CP)

VSI displays ONLY TA. This prevents TCAS from coordinating an RA with other TCAS equipped aircraft, and inhibits RAs from being issued by own TCAS. ◀

***** In Flight, Proceed to DRIFTDOWN Procedure, If Applicable *****

PRECAUTIONARY ENGINE SHUTDOWN

This procedure applies to precautionary engine shutdown. A precautionary engine shutdown is any engine shutdown to prevent engine damage or to avoid the possibility of future failure. Examples of conditions, which warrant a precautionary engine shutdown, include high oil temperature, low oil pressure, or EGT out of limits.

NOTE

The following steps will be accomplished, one at a time, by the pilot, or at pilot's command. If there is any possibility that fire exists, complete ENGINE FAILURE OR FIRE checklist in this section.

1. Throttle – Idle (P, E)

Engine remains at idle for two minutes to allow engine rpm and EGT to stabilize.

2. Rudder Override Switch – As Required (P, E)

OVERRIDE below 250 KIAS.

WARNING

- When operating rudder override switch in flight, physically identify both RUDDER (lower) and OVERRIDE (upper) switches to make sure correct switch is operating. Operation of wrong switch could cause loss of control.
- Do not exceed 250 KIAS with override switch set to OVERRIDE. Structural damage could result from full or rapid rudder movement with full rudder pressure.

3. Rudder Mode Indicator – As Required (E)

Indicator should agree with flight regime/Rudder Override Switch position.

4. Electrical System – Checked (E)
   a. GEN CONTR Switches – OFF (Affected Engine)
   b. Bus Tie Switches – Closes
   c. Electrical Load – 218 Amperes per Generator, Maximum

NOTE

- Cut off non-essential load if required to maintain load within limits.
- Six generators must be operating in parallel to operate the mission radar.

5. Fuel System – Checked (E)
   a. Boost Pumps – As Required
   b. CROSS FEED Valves – As Required
   c. FUEL HEAT Switches – OFF (Affected Engine)
   d. Fuel Management – As Required

6. Hydraulic System – Checked (E)

   a. Utility Pump – As Required

   b. Utility Fluid Shutoff Switch – As Required

7. BLEED AIR Switch – OFF (Affected Engine) (E)

WARNING

If the firewall shutoff and/or engine bleed valve fails to close, close the wing isolation valve for affected wing.

8. CONTINUOUS IGNITION Circuit Breaker – Open (Affected Engine) (E)

CAUTION

If the engine and flight conditions permit, the fuel system can be cooled if windmilling N_2 rpm is at least 25%. Open CONTINUOUS IGNITION circuit breaker to prevent engine relight and set throttle to idle for 3 minutes each 30 minutes to prevent excessive temperatures in the fuel control.

9. Throttle – Cutoff (P, E)

CAUTION

If no oil pressure is observed on windmilling engine, record length of time that engine windmills and N_1 and N_2 rpm.

10. Engine Start Selector Switch – OFF (Affected Engine) (E)

11. NACELLE ANTI-ICE Switch – OFF (Affected Engine)
    (P, E)

12. **WITH IDG** TCAS SENS – TA Only (CP)

VSI displays ONLY TA. This prevents TCAS from coordinating an RA with other TCAS equipped aircraft, and inhibits RAs from being issued by own TCAS. ◀

*** * * In Flight, Proceed to DRIFTDOWN Procedures, If Applicable* * ***

DRIFTDOWN

With one or more engines inoperative, the airplane cannot maintain altitudes greater than those shown in the performance ceiling charts in T.O. 1E-3A-1-1, Part III. If the gross weight exceeds that shown for the cruise altitude, fuel may be dumped (if altitude must be maintained) or altitude must be lost at the minimum rate possible, while consuming a minimum of fuel. This procedure is known as driftdown.

With one engine inoperative, the recommended driftdown speed for the airplane varies from 262 KIAS at a gross weight of 340,000 pounds to 213 KIAS at 220,000 pounds. When two engines are inoperative, these speeds are several knots slower.

Performance information on driftdown speed is shown in T.O. 1E-3A-1-1. While calculating driftdown performance, set the thrust to NRT on the operating engines.

SULFUR HEXAFLUORIDE (SF_6) LEAK

Some mission radar equipment in the aft lower compartment is pressurized with sulfur hexafluoride (SF_6) gas. SF_6 is colorless, odorless, and heavier than air. The radar components use SF_6 gas as a dielectric and heat transfer medium for the high voltage power supplies and high power waveguide. SF_6 is an extremely stable gas and has been described as a physiologically inert gas. If SF_6 gas escapes from an SF_6 device without it being mixed with cabin air conditioned air in an enclosed area, it collects and accumulates in lower areas due to its density. As soon as SF_6 gas is mixed with the air it diffuses and does not collect (pool) anymore.

When SF_6 is subjected to electrical discharges, such as arcing, corona or spark-over, a certain amount of decomposition of the SF_6 will take place. These discharges are normally contained within the equipment or waveguide. The decomposition products of SF_6 are poisonous in many ways and are characterized by unusual or pungent odor or, nose or throat irritation. If SF_6 is leaking in lower aft compartment, the flight engineer will open the aft outflow valve by setting outflow balance knob to FWD CLOSED and raising cabin altitude as high as practical, but not above 10,000 feet. Maintain increased cabin altitude until notified that personnel have left lower compartment.

WARNING

- Oxygen is required for personnel entering the lower aft compartment when pressurization is in manual operation.
- If SF_6 is inadvertently inhaled, place the crewmember with head lower than lungs and provide 100% oxygen. If unconscious, assist breathing by setting EMERGENCY switch on oxygen regulator (supplying unconscious crewmember) to EMERGENCY for 2 to 3 seconds, then to NORMAL for 2 to 3 seconds, repeating until crewmember is conscious.
- During ground operations, personnel gaining access to closed compartments such as cabin, aft lower compartment or rotodome should be aware of unusual or pungent odor, or nose or throat irritation. If encountered, the airplane/area should be vacated until it is properly ventilated.

GROUND EMERGENCY PROCEDURES

GROUND EVACUATION

Ground evacuation routes and exits are shown in *figures 3-1* through *3-6*. Ground evacuation is initiated at the pilot's command over PA and interphone (if possible) and by a 5 to 10 second sounding of the alarm bell. There are seven exits on the main deck. Since exit through the doors is faster, the entry and galley doors are primary ground exits. Exit through overwing hatches is slower, so these are considered secondary exits on land, but are primary ditching exits. Overwing hatches and pilots' windows are equipped with escape straps (*figures 3-4* and *3-5*). Exit through the pilots' sliding windows is possible, but the other exits should be used if available. Entry doors and galley door are equipped with escape slides (*figures 3-1* and *3-3*). If a slide fails to inflate, it can still be used for exit. Two crewmembers must exit by climbing down the escape straps (*figure 3-5*) or by another exit, and hold the slide in the extended position. To use the slide, jump into the slide so as to land in a sitting position, feet together.

WARNING

- When opening entry or galley doors after emergency landing or ditching, stop when door handle is in vertical position and check for possible entry of fire, smoke, or water. If fire, smoke, or water enters airplane at top or bottom of door, return handle to locked position and use another exit if possible.
- When jumping into a slide, jump far enough to clear the door sill. Serious injury could be caused by hitting the door sill.
- When using escape slide, clear the area at bottom of slide as quickly as possible to avoid being injured by personnel following.
- If flaps are not at 40 or 50 position and landing gear is extended, use extreme care if evacuating by overwing exits. Injury could result when jumping from flap to ground.
- To avoid injury do not exit through overwing hatches or aft doors until engines have been shut down.
- Do not pull handle until door is open and slide is clear of pack, or slide can inflate inside airplane.
- Areas around entry and galley doors will be kept clear of obstructions during ground operations, takeoffs, and landings.

1. Parking Brake – Set (P)

CAUTION

Do not set parking brake if brake energy has exceeded 24 million ft-lb. Have a crewmember or ground crew chock the nose gear.

2. SPEED BRAKE Lever – Full Forward, In Detent (P)

   Lower speedbrakes to clear wing escape route.

3. Flap Lever – 40 (or More) (P)

   Flaps 40 provide the optimum egress angle. Time permitting, ensure flap indicators read 40 or more prior to setting throttles to cutoff. If flaps were at 50 for landing, do not move flaps.

4. Throttles – Cutoff (P)

(5.) Ground Crew and Tower – Notified (P, CP)

(6.) Air Crew – Notified (P, CP)

   a. Announce intentions over the PA

   b. Alarm bell – ON 5 to 10 seconds

7. APU – STOP (E)

   Set APU CONTR switch to STOP or pull APU FIRE switch.

– – – If No Fire Indicated, Omit Steps 8 and 9 – – –

8. Affected Engine and/or APU FIRE Switches – Pull, If Fire Indicated (E)

9. Affected Engine and/or APU Fire Bottle Discharge Buttons – Press, If Fire Indicated (E)

   Discharge engine and/or APU fire bottles if fire is indicated or observed.

10. BATTERY Switch – OFF (E)

    Before leaving airplane. Intercom, PA, and flight deck lights are off when battery switch is off.

APU FIRE/EMERGENCY SHUTDOWN, NORMAL OPERATION

1. APU FIRE Switch – Pull (E, GC)

   Pull fire switch on APU control panel (approximately 1/2-inch) or APU ground control panel (to stop).

   Shuts down APU and arms fire bottle discharge switch on same panel where switch was pulled.

2. APU Fire Bottle – Discharge (E, GC)

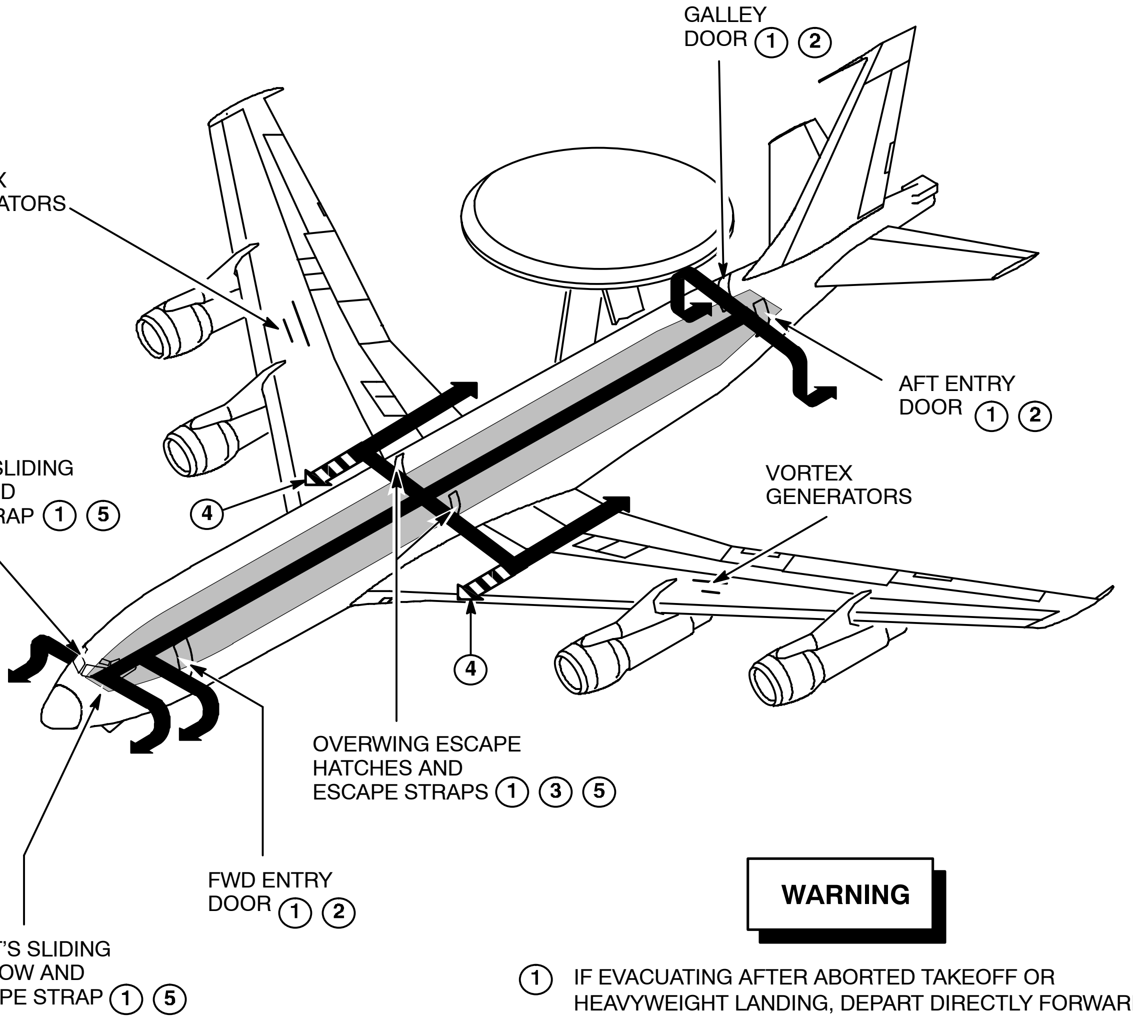
CAUTION

When APU FIRE switch (in flight deck or ground control panel) is pulled, fire extinguisher is armed only on the panel where switch was pulled.

(3.) Ground/Air Crew and Tower – Notified (P, CP, E, MCC, GC)

*** * * If Fire Persists, Proceed to GROUND EVACUATION Checklist * * ***

Ground Evacuation



WARNING

① IF EVACUATING AFTER ABORTED TAKEOFF OR HEAVYWEIGHT LANDING, DEPART DIRECTLY FORWARD OR AFT OF AIRPLANE TO AVOID POSSIBLE TIRE/WHEEL BURST AREA IF FUSE PLUGS DO NOT MELT.

② PRIMARY DOORS EQUIPPED WITH ESCAPE SLIDES. IF POSSIBLE USE THESE DOORS FOR FASTEST EVACUATION.

③ USE WHEN FLAPS DOWN AND/OR GEAR UP ON LAND OR FOR DITCHING.

④ FOR DITCHING, LAUNCH RAFTS FORWARD TO AVOID VORTEX GENERATORS.

⑤ SECONDARY EXITS. USE OTHER EXITS IF POSSIBLE. SLOWEST EVACUATION ROUTE.

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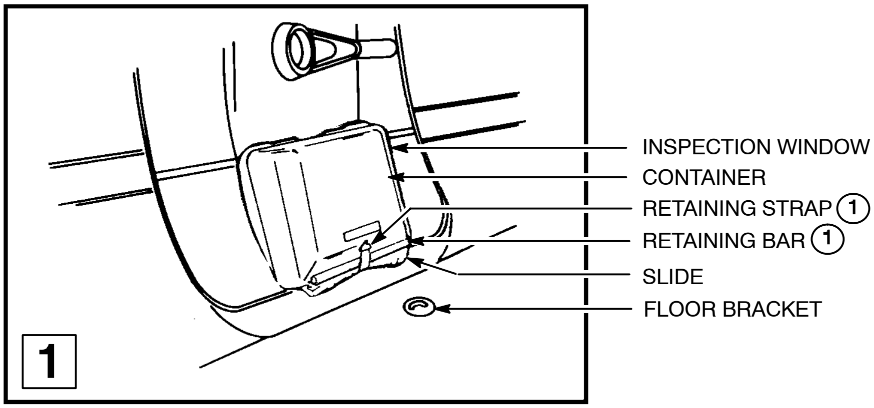
Figure 3-2

Escape Slide Inflation

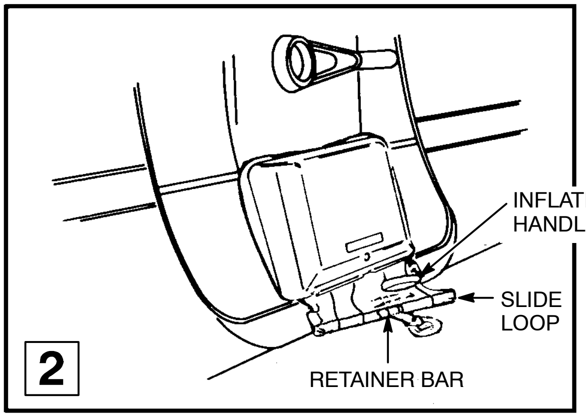
WARNING

① SLIDE IS UNUSABLE UNLESS RETAINING BAR PASSES THROUGH SLIDE HARNESS AND THROUGH LOOP ON RETAINING HOOK ASSEMBLY. RETAINING BAR MUST BE SECURED BY NYLON LANYARD PASSING THROUGH RETAINING BAR.

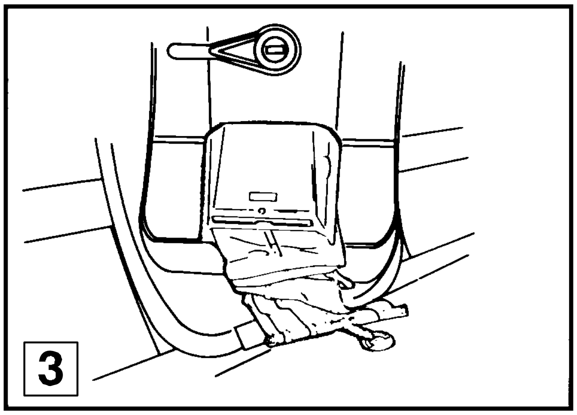
② DO NOT PULL INFLATION HANDLE UNTIL DOOR IS OPEN AND SLIDE IS CLEAR OF PACK, OR SLIDE CAN INFLATE INSIDE AIRPLANE.



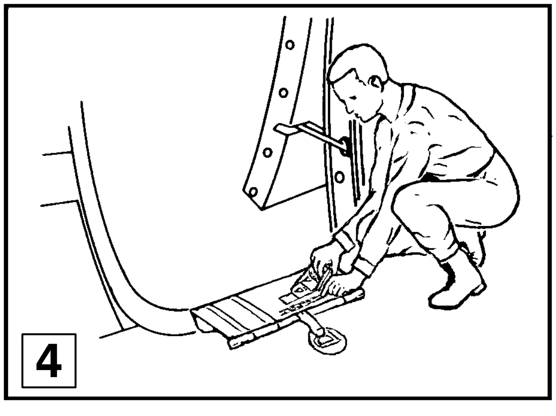
ESCAPE SLIDE IN STOWED POSITION



PLACE RETAINING STRAP IN FLOOR BRACKET ① ② ③

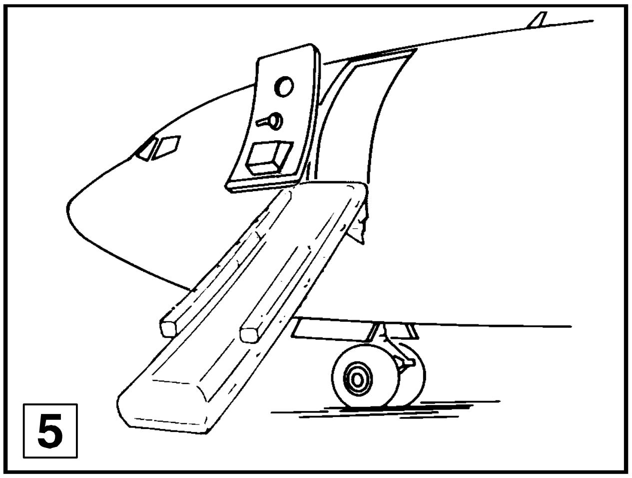


OPEN DOOR, SLIDE FALLS FREE OF CONTAINER ① ②



PULL INFLATION HANDLE TO INFLATE

③ NORMAL FLIGHT POSITION



JUMP TO CLEAR DOOR SILL. KEEP FEET RAISED

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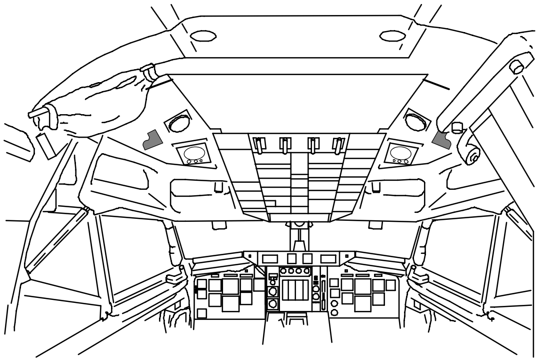
Figure 3-3

Exit Through Pilots’ Sliding Windows



NOTE: STRAPS ARE LOCATED ABOVE BOTH SLIDING WINDOWS

A **REMOVE ESCAPE STRAP FROM STOWAGE BOX ABOVE WINDOW.**

WARNING

ENSURE THE STRAP IS SECURELY FASTENED AND THE STRAP IS EXTENDED FULLY (GREEN BAND ON THE STRAP IS AT THE WINDOW SILL).

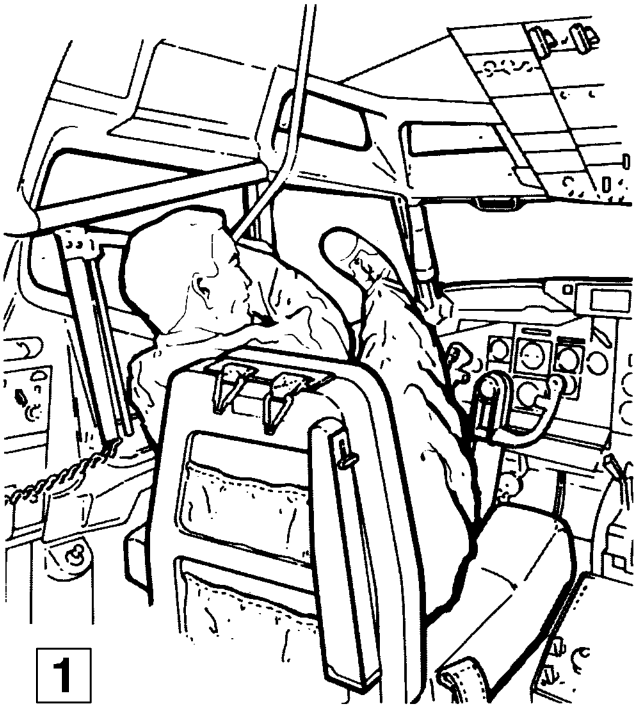
B **DROP STRAP THROUGH WINDOW.**

C **EXIT AS SHOWN (STEPS 1 TO 6).**

WARNING

USE CARE TO AVOID PROBES AND PITOT HEADS WHEN DESCENDING ALONG SIDE OF THE AIRPLANE.

D **DESCEND HAND OVER HAND RATHER THAN SLIDING DOWN STRAP.**



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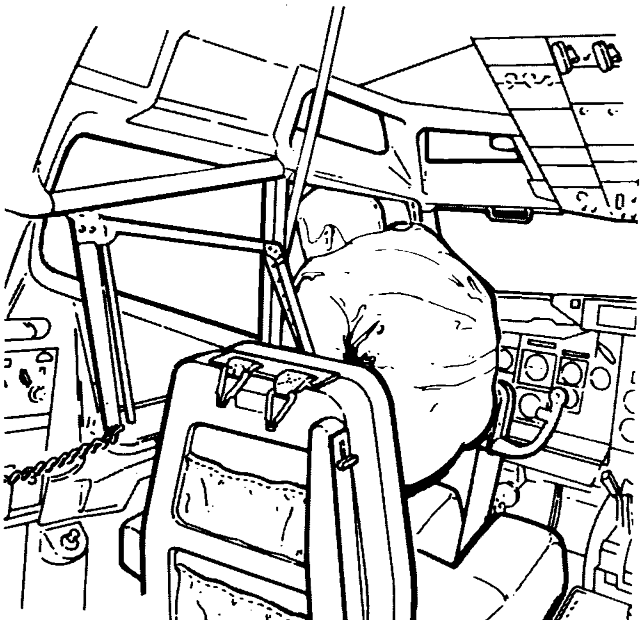

2

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Figure 3-4 (Sheet 1 of 2)

Exit Through Pilots’ Sliding Windows (Continued)

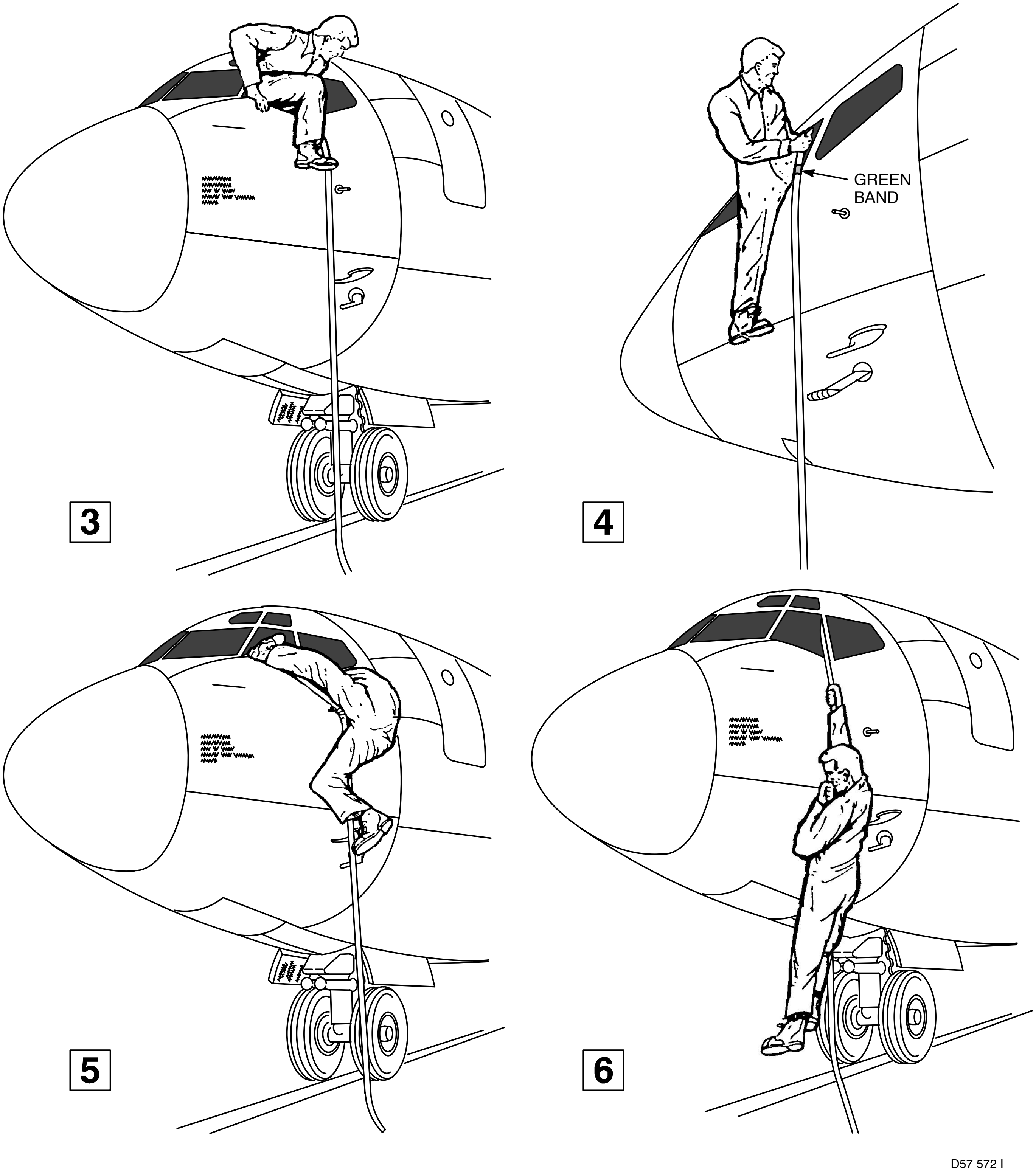


Figure 3-4 (Sheet 2 of 2)

Emergency Escape Straps - Typical

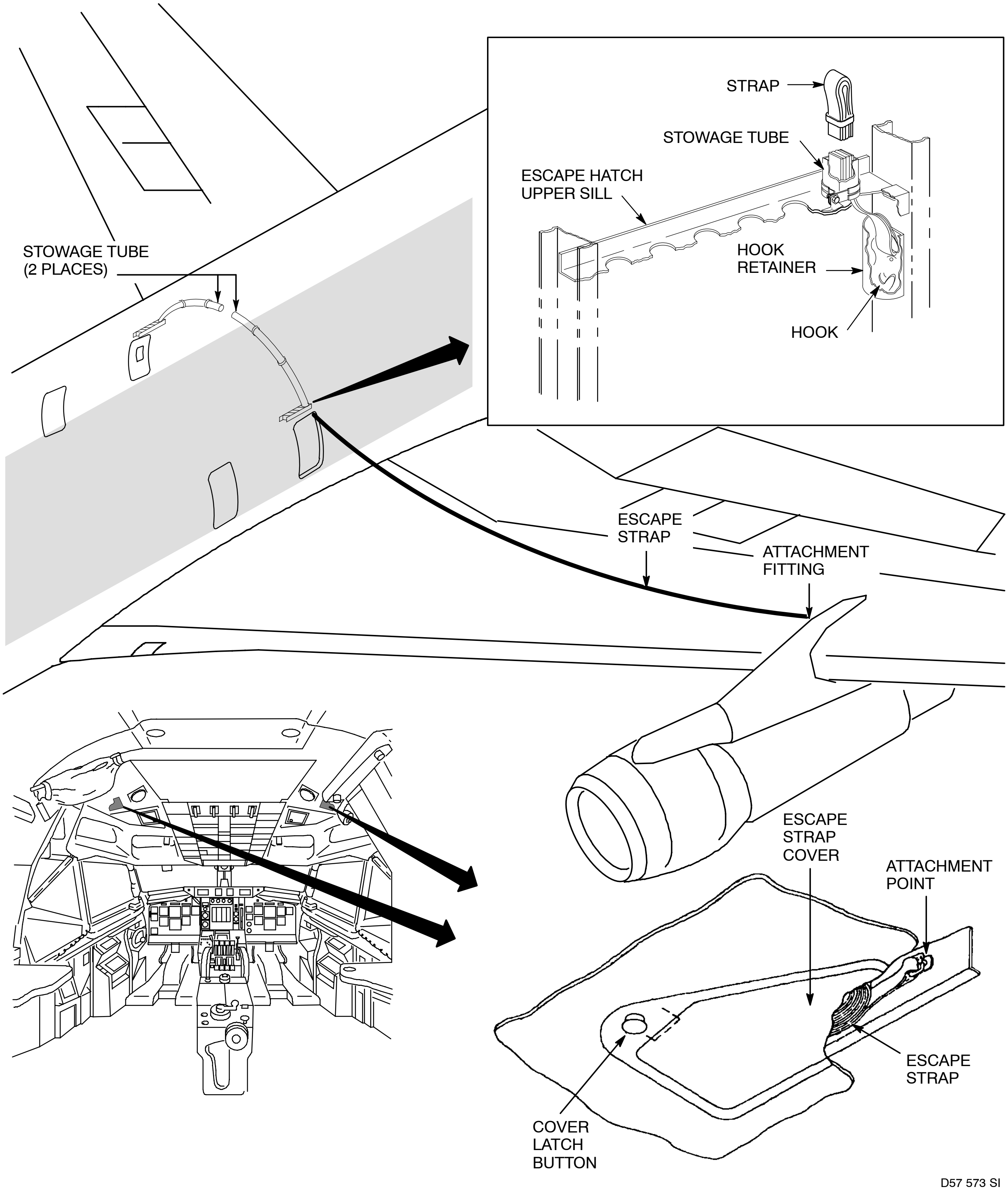
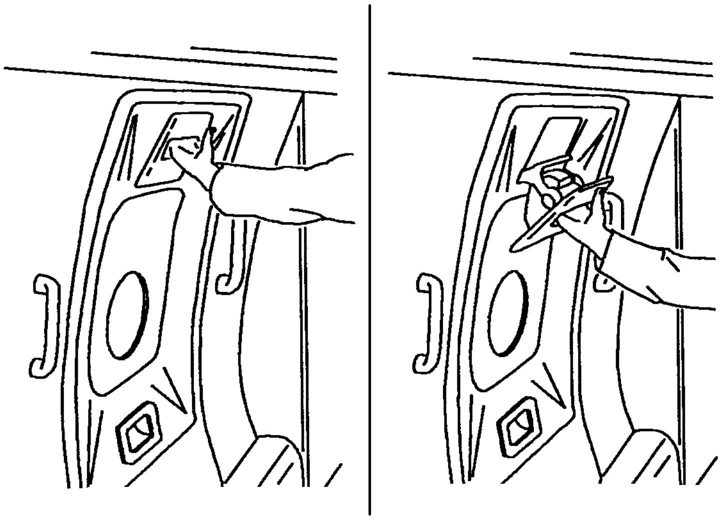
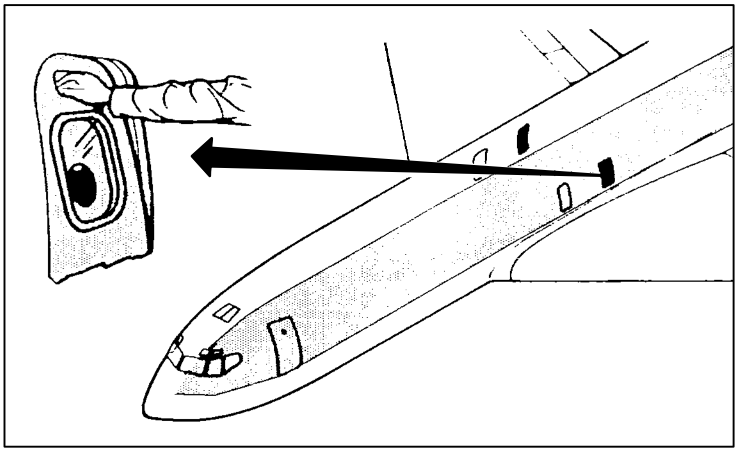


Figure 3-5

Emergency Escape Hatch Operation





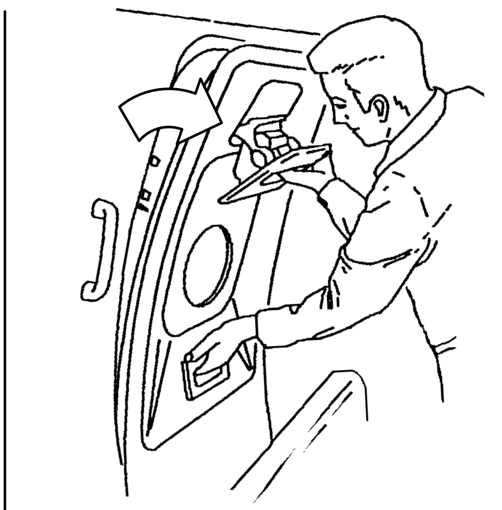
WARNING

① CREWMEMBER OPENING, REMOVING, OR INSTALLING ESCAPE HATCH IN FLIGHT MUST WEAR PARACHUTE OR WEAR RESTRAINT HARNESS. SECURE HARNESS BY SAFETY LANYARD TO BASE OF MISSION CREW SEAT. SEE FIGURE 3-7.

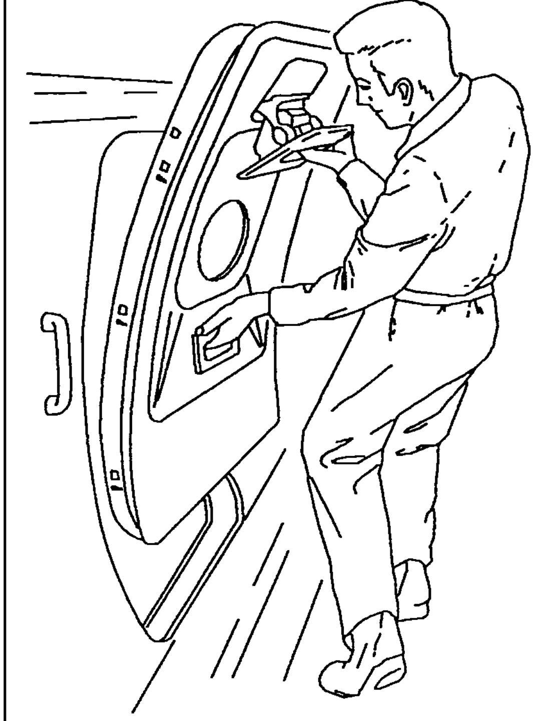
NOTE

WHEN OPENING HATCH IN FLIGHT, DECELERATE AIRPLANE BELOW 175 KIAS, DEPRESSURIZE AIRPLANE, AND SHUT OFF AIR CONDITIONING PACK.

CREWMEMBER GRASPS UPPER HANDLE OF EMERGENCY ESCAPE HATCH FROM UNDERSIDE AND GRASPS LOWER HANDLE FIRMLY.



FOR SMOKE REMOVAL, TILT HATCH IN, ABOUT ONE FOOT AT TOP. DO NOT REMOVE FROM OPENING. ①



FOR GROUND EVACUATION, PULL EMERGENCY ESCAPE HATCH UPPER HANDLE SHARPLY (WHICH OPENS PRESSURE RELIEF PLUG) AT SAME TIME PULLING STRAIGHT INWARD ON LOWER HANDLE MAINTAINING HATCH IN AS NEAR A VERTICAL POSITION AS POSSIBLE UNTIL HATCH IS WELL WITHIN AIRPLANE. HATCH WEIGHS ABOUT 50 POUNDS. TO REPLACE HATCH, REVERSE ABOVE STEPS. ENGAGE BOTTOM LATCH FIRST.

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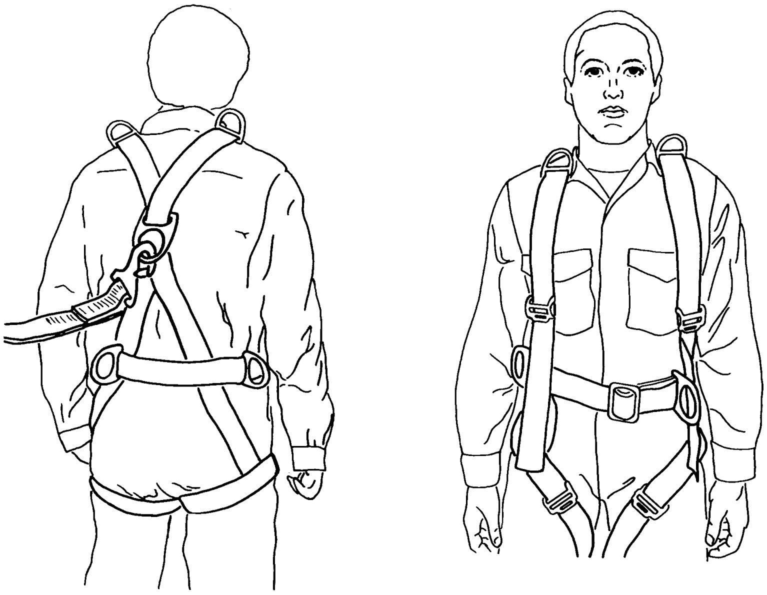
Figure 3-6

Restraint Harness



WARNING

RESTRAINT HARNESSES PREPOSITIONED ON ALL E-3 AIRPLANES WILL BE USED BY AIRCREWS ONLY, DURING EMERGENCIES. RESTRAINT HARNESSES WILL NOT BE USED BY CREW CHIEFS OR MAINTENANCE TECHNICIANS TO PERFORM MAINTENANCE ON AIRPLANE.

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Figure 3-7

APU FIRE SHUTDOWN, MANUAL OPERATION

NOTE

- If power is available to the airplane ac and dc systems (from APU or external power cart), the APU shuts down automatically if an APU fire is detected, by closing the solenoid fuel valves in the APU fuel control unit. The APU FIRE warning lights illuminate and the APU fire warning horn sounds (if the APU is providing the power, the warning is brief).

- If the battery is inoperative, the APU fire extinguishing system is inoperative and the APU airplane fuel valves and the APU inlet and exhaust doors remain open. The APU CONTR switch, APU FIRE switch, APU ground fire switch, the DISCHARGE button, and the BOTTLE DISCHARGE switch are inoperable.

1. APU BLEED Switch – Press (E)

2. ROTODOME SHUTOFF AUXILIARY Switch – OFF (E)

   Isolates hydraulic system if a hydraulic line ruptures.

   NOTE

   If electric power does not remain on airplane long enough, valve does not close.

3. MANUAL START SWITCH – NORM (GC)

   (In manual start box.) Shuts down APU by causing solenoid fuel valves in APU control unit to close if the automatic system was not powered.

4. Portable Fire Extinguishers – Discharge into APU (GC)

   Use APU fire extinguisher access (kick in door) on front of APU housing.

⑤ Ground Crew – Notify (E, GC)

   Notify other ground personnel and, if possible, fire department to aid in fighting fire.

6. APU Airplane Fuel Shutoff Valves – Close Manually (GC)

   Close valves to prevent fuel from feeding fire if a fuel line ruptures. One valve is located above and to the left of forward end of the APU, the other one is located on the aft side of the right wing spar above the right wheels.

7. Auxiliary Rotodome Shutoff Valve – Close Manually (GC)

   Located in right wheel well. Isolates hydraulic system if a hydraulic line ruptures.

NOTE

If electric power remained on airplane long enough, valve should have closed electrically (step 2).

TAKEOFF EMERGENCY PROCEDURES

Takeoff will be aborted when any malfunction which could affect safety of flight occurs before reaching V_1. The takeoff should be continued if a failure occurs after reaching V_1 except when, in the pilot's opinion, the failure makes the airplane incapable of flight. In this case, takeoff may be aborted up to refusal speed, V_R.

WARNING

If a failure occurs which, in the pilot's opinion, makes the airplane incapable of flight, the pilot should be aware that at speeds greater than V_R, the airplane probably cannot be stopped in the available runway.

ABORTED TAKEOFF

Although copilot and flight engineer both maintain a check of airspeed and engine instruments during the takeoff roll, the decision to continue the takeoff or to abort is made by the pilot alone. Prior to V_1, if the copilot or flight engineer notices a rudder boost failure, fire, or an engine malfunction which makes the airplane unsafe for flight, "REJECT" will be called. For any other malfunction, make a short descriptive statement to the pilot, who will make the decision to continue or to abort. If the malfunction occurs after V_1, make a short descriptive statement to the pilot. Minor malfunctions having no immediate impact on safety will be reported when the airplane is safely airborne. A decision to abort requires immediate braking, closing throttles to idle, and raising speedbrakes. Apply maximum braking and close throttles simultaneously if possible. Copilot maintains forward pressure on wheel for improved nosewheel steering.

– – – Perform Steps 1 and 2 simultaneously – – –

1. **BRAKES – MAXIMUM (P)**

   Apply maximum braking for runway condition and available antiskid.

2. **THROTTLES – IDLE (P)**

3. **SPEED BRAKES – UP (P) or (CP)**

   If possible, taxi clear of runway before stopping, then proceed to appropriate checklist as required.

WARNING

- Observe maximum brake energy limits in section V. Maximum energy abort causes tires to deflate when fuse plugs melt. If all tires on a truck are deflated, cool brakes with foam, fog, or dry chemical extinguisher. If any tire on a truck is not flat, do not cool wheels. Do not approach hot brakes from the side.

- If brake application causes any loss of directional control, release both brake pedals, correct heading, and re-apply brakes.

- If brakes are applied above 70 knots, brake limits will be checked and recommended procedures followed for brake cooling.

- Radar will be in TEST or STBY when personnel are within 60 feet of antenna or when ungrounded electro-explosives devices are within 100 feet of antenna.

CAUTION

Do not open wheel well doors after a high energy stop (above 24 million ft-lbs). If tires deflate, open doors could contact ground causing damage to doors.

ENGINE FAILURE AFTER V_1

If an engine failure occurs at a speed between V_1 and V_R, the takeoff should be continued, except when, in the pilot's opinion, the failure makes the airplane incapable of flight.

If takeoff is continued, use normal takeoff procedures, except immediately apply rudder and nosewheel steering as required to keep the airplane on or parallel to the runway centerline. The first indication of engine failure is yaw toward the failed engine. When an outboard engine fails near or above V_1, application of full rudder and some nosewheel steering is critical to maintaining directional control. Nosewheel steering may be required at speeds significantly above V_1 and the pilot must be prepared to apply nosewheel steering until directional control can be maintained with the rudder. Nosewheel steering can be extremely critical, especially on dry or damp runways, as its use is included in computing V_{MCG} for RCR's of 26/23 and 15. V_{MCG} values are based on failure of the upwind outboard engine, with no change in thrust of the three remaining engines, full rudder pedal travel, not more than 75% of roll control and nosewheel steering. Nosewheel steering is not assumed in computing V_{MCG} for wet or icy runways. Regardless of the RCR, nosewheel steering is required to prevent nosewheel caster, skidding or slipping. A failed inboard engine requires smaller pedal displacement and lighter forces.

WARNING

- If a stop is attempted at a speed greater than V_R, the airplane probably cannot be stopped in the available runway.
- The airplane has limited climb capability on two engines with landing gear down. Refer to THREE-ENGINE FERRY discussion in section IIIA and in T.O. 1E-3A-1-1.
- If two engines are lost on the same side, thrust must be reduced on the remaining outboard engine to maintain directional control until reaching two engine minimum control speed. Two-engine go-around thrust (part VII, T.O. 1E-3A-1-1) may be used at V_{REF} + 30 KIAS (about V_{CO} + 20 KIAS). If climb performance is satisfactory, increase bank angle beyond 5 degrees instead of reducing thrust. Refer to MINIMUM CONTROL SPEED, section VI.

NOTE

- When a copilot takeoff is made, be aware that it may be necessary for the pilot to apply nosewheel steering if an outboard engine fails at or near V_1 to ensure airplane remains on the runway because use of nosewheel steering may be essential to maintaining directional control.
- Minimum control speeds in T.O. 1E-3A-1-1 were demonstrated in flight test by applying full rudder at the first indication of outboard engine failure and immediate application of nosewheel steering.
- Air minimum control speeds were demonstrated with the airplane banked five degrees away from the inoperative engine(s). Minimum control speed is higher if wings are kept level (and climb/go-around performance is reduced).
- Maintain sufficient pressure on the nose gear steering wheel to prevent caster. Deflection angles of the nose gear steering wheel cause chattering due to skidding or skipping. If this occurs, reduce steering wheel angle until effects stop. Maintain forward pressure on control wheel until approaching V_{ROT}.
- If an engine fails after V_1 on a reduced-thrust takeoff, increasing inboard engine thrust to TRT (GO-AROUND EPR) improves takeoff and climb performance.
- On all takeoffs, increasing symmetrical thrust to TRT (GO-AROUND EPR) after safely airborne improves climb performance.

At V_{ROT}, rotate to 3 engine climbout attitude. During rotation, hold rudder pedal displacement constant and wings level. With correct rudder application, little or no lateral control input should be required after liftoff. Airplane may be banked up to 5 degrees away from dead engine after liftoff.

WARNING

- Make sure nose gear steering wheel is centered at rotation. Damage to nose gear strut could result if steering is displaced when strut extends.
- Retract landing gear when a positive rate of climb is indicated on pitot static instruments.

If an engine fails between V_1 and V_{CO}, accelerate to V_{CO} and maintain V_{CO}. If an engine fails above V_{CO} and before flap retraction, maintain the speed at engine failure and do not exceed the 3-engine climbout attitude shown on the TOLD card until reaching the altitude selected for flap retraction or obstacle clearance altitude (*figure 3-8*).

When a safe altitude for flap retraction is reached, accelerate to V_{CO} + 30 KIAS, retract flaps and accelerate to V_{CO} + 55 KIAS (allows 30 degree bank capability). If obstacle clearance is not a factor, consider reducing climb rate to increase air speed. Set climb thrust. If obstacle clearance is a factor, continue at V_{CO} + 55 KIAS to obstacle clearance altitude. Maintain airspeed below 250 KIAS with rudder override switch set to OVERRIDE, until reaching 0.6 Mach, then maintain 0.6 Mach. Observe five minute limit on use of takeoff rated thrust. Complete the ENGINE FAILURE OR FIRE checklist and proceed to normal AFTER TAKEOFF AND CLIMB checklist if leaving the pattern. If an emergency return is required, perform the APPROACH and BEFORE LANDING checklists.

EMERGENCY RETURN AFTER TAKEOFF

In case of a failure which, in the pilot's opinion, makes continued flight unsafe, the airplane can be landed at maximum takeoff weight. (See HEAVY WEIGHT LANDINGS, section II and LANDING SINK RATE LIMITS and BRAKE ENERGY LIMITS, section V.)

Be prepared for possible flat tires due to fuse plug melting. If possible, clear runway before stopping airplane. See EMERGENCY ENTRANCE/EXIT (*figure 3-1*) and GROUND EVACUATION (*figure 3-2*).

WARNING

- If possible, make a flaps 50 landing. Flap system failure (requiring a flaps 14 landing) or total ac power failure (antiskid inoperative) can cause landing field length to be in excess of runway available.
- Determine maximum crosswind allowable for landing and compare this value to that computed for takeoff planning. Landing crosswind limits can be less than takeoff limits, possibly preventing emergency return to the departure airfield.

CRASH LANDING IMMEDIATELY AFTER TAKEOFF

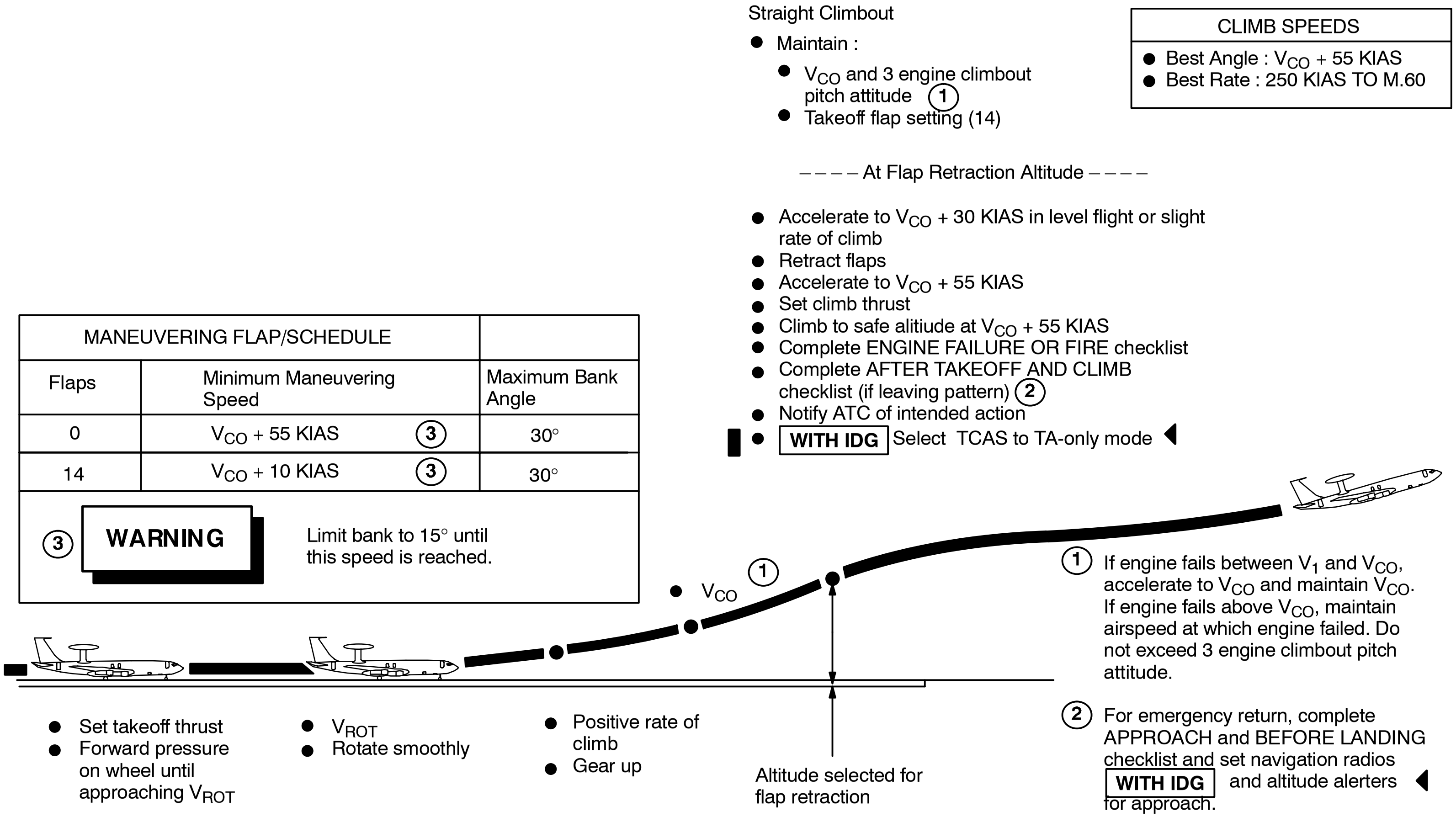
If a crash landing is necessary, make every effort to land with the landing gear down. If all of the landing gear cannot be extended, land with all available gear down. Any extended landing gear absorbs energy from the impact with the ground. Activate the CPL.

Evacuation exits for use after a crash landing (or ditching) are shown in *figures 3-1* and *3-2*. The entry doors and galley door are primary evacuation routes on land and the overwing hatches are secondary. Refer to GROUND EVACUATION.

WARNING

When opening entry or galley doors after emergency landing or ditching, stop when door handle is in vertical position and check for possible entry of fire, smoke, or water. If fire, smoke, or water enters airplane at top or bottom of door, return handle to locked position and use another exit if possible.

Engine Failure After V_1



Straight Climbout

- Maintain :
  - V_{CO} and 3 engine climbout pitch attitude ①
  - Takeoff flap setting (14)

CLIMB SPEEDS
● Best Angle : V_{CO} + 55 KIAS ● Best Rate : 250 KIAS TO M.60

– – – – At Flap Retraction Altitude – – – –

- Accelerate to V_{CO} + 30 KIAS in level flight or slight rate of climb
- Retract flaps
- Accelerate to V_{CO} + 55 KIAS
- Set climb thrust
- Climb to safe alitiude at V_{CO} + 55 KIAS
- Complete ENGINE FAILURE OR FIRE checklist
- Complete AFTER TAKEOFF AND CLIMB checklist (if leaving pattern) ②
- Notify ATC of intended action
- **WITH IDG** Select TCAS to TA-only mode ◀

MANEUVERING FLAP/SCHEDULE		
Flaps	Minimum Maneuvering Speed	Maximum Bank Angle
0	V_{CO} + 55 KIAS ③	30°
14	V_{CO} + 10 KIAS ③	30°

③ **WARNING**

Limit bank to 15° until this speed is reached.

- Set takeoff thrust
- Forward pressure on wheel until approaching V_{ROT}

- V_{ROT}
- Rotate smoothly

- Positive rate of climb
- Gear up

- V_{CO} ①

Altitude selected for flap retraction

① If engine fails between V_1 and V_{CO}, accelerate to V_{CO} and maintain V_{CO}. If engine fails above V_{CO}, maintain airspeed at which engine failed. Do not exceed 3 engine climbout pitch attitude.

② For emergency return, complete APPROACH and BEFORE LANDING checklist and set navigation radios **WITH IDG** and altitude alerters ◀ for approach.

WITH IDG **NOTE**

VSI displays ONLY TA. This prevents TCAS from coordinating an RA with other TCAS equipped aircraft and inhibits RAs from being issued by own TCAS. ◀

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Figure 3-8

a. Pilot notifies crew, on PA (if possible), of the situation and intentions and receives acknowledgement by interphone. If time does not permit use of the PA or interphone, set the WARNING BELL switch to ON for 5 to 10 seconds, then OFF, and set WARNING LIGHT switch to CRASH which illuminates the CRASH LANDING signs.

WARNING

Personnel in crew rest seats take bracing position with seat belt fastened, back against back rest, feet flat on floor and arms braced against knees.

b. Set FLAP lever to 50.

c. Landing gear down if possible on land (up if ditching).

d. After airplane stops, set SPEED BRAKE lever full forward, in detent.

e. Set throttles to cutoff.

f. Notify crew to evacuate airplane.

g. Pull all FIRE switches.

h. Press all fire bottle discharge buttons.

i. Turn BATTERY switch to OFF.

INFLIGHT EMERGENCY PROCEDURES

BAILOUT

Bailout is initiated at the pilot’s command by PA system, interphone, or alarm bell. If time permits, and bailout over water is expected, don survival suits when commanded to prepare for bailout. When a mission crew is carried, the Air Surveillance Officer acts as jumpmaster. If a mission crew is not on board, a crewmember will be designated by the pilot to act as jumpmaster. This is normally part of the crew briefing. In an uncontrolled bailout situation where there is no time to give a preparatory warning, the first crewmember reaching the bailout chute acts as jumpmaster. See *figures 1-3, 3-9* and *3-10*.

WARNING

- Do not lower the chinning bar until the differential pressure gage indicates 1.0 psi or less (green band on gage). Opening the bailout chute with higher differential pressure could cause injury to crew.
- Under level flight conditions, bail out at least 2,000 feet above the terrain whenever possible. Accident statistics show that chances for successful bailout decrease as altitude decreases below 2,000 feet above the terrain.
- Do not open parachute manually above 15,000 feet unless you are losing consciousness, you are within 5,000 feet of the ground, or it is obvious that the automatic mechanism has failed. Be prepared for high opening shocks.
- For all bailouts below 14,000 feet, pull the parachute ripcord handle as soon as clear of the bailout chute.
- For all bailouts at 14,000 feet or above, pull the automatic ripcord release immediately before exiting the airplane.

NOTE

When bailout chute spoiler is extended, pilot’s left side static port is shut off and copilot’s static system is unreliable.

Bailout

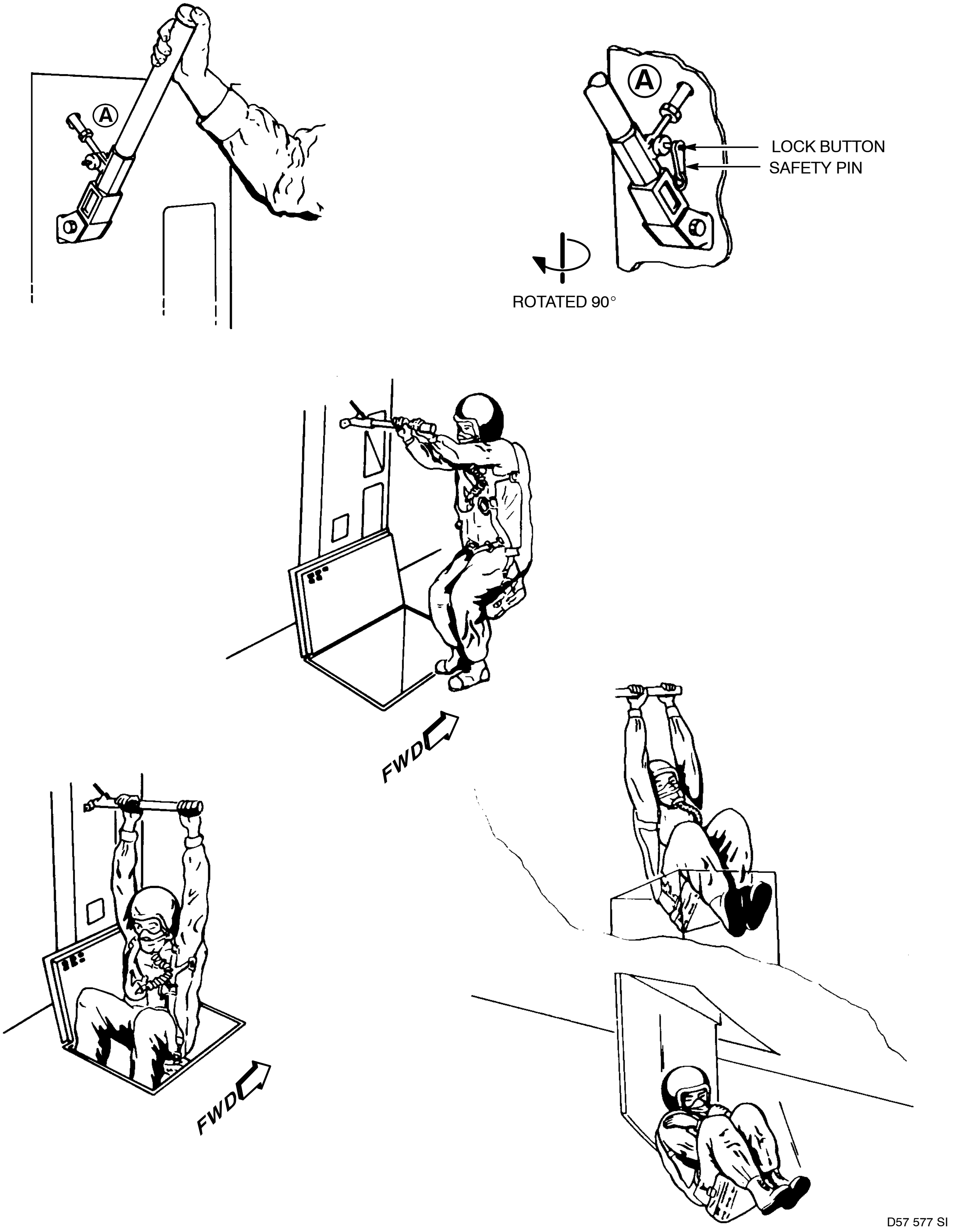
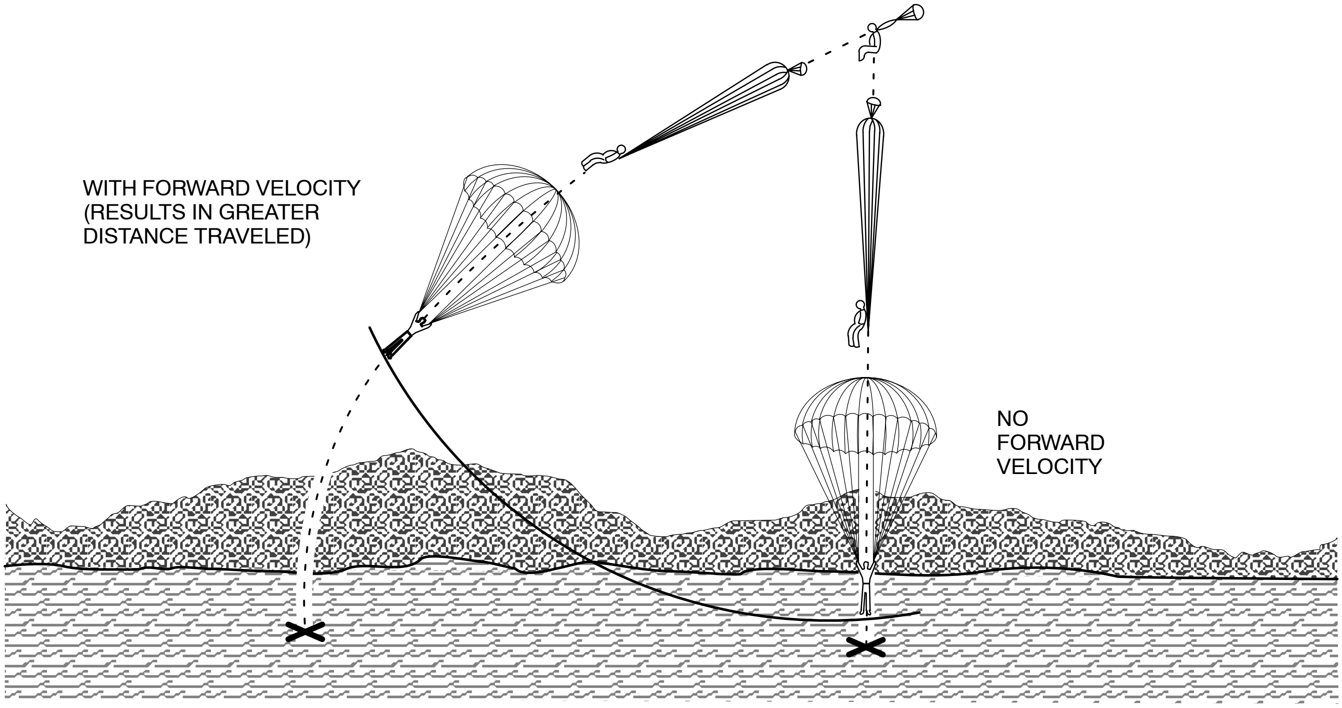


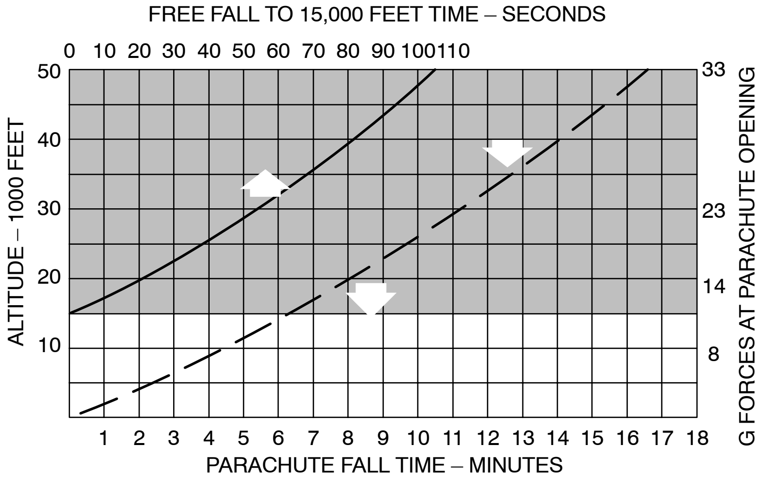
Figure 3-9

Bailout Considerations

Airspeed Effect on Bailout Descent Path



BAILOUT DESCENT TIME



LEGEND

——— FREE FALL

— — 200 LB MAN,
28 FT PARACHUTE

WARNING

DO NOT OPEN PARACHUTE MANUALLY ABOVE 15,000 FEET UNLESS YOU ARE LOSING CONSCIOUSNESS, YOU ARE WITHIN 5000 FEET OF GROUND, OR IT IS OBVIOUS THAT AUTOMATIC MECHANISM HAS FAILED.

NOTE

THE FASTER YOU FALL TO 15,000 FT THE BETTER.

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Figure 3-10

Controlled Bailout

The pilot should warn the crew as soon as possible when the decision to bail out is made.

WARNING

> Bailout through the overwing hatches is not recommended, and should only be attempted as a last resort, because of the possibility of striking the airplane.

Retract the landing gear, if possible, to avoid any possible interference. Under most circumstances, reduce airspeed to the approach speed (.6 AOA) for the maximum flap setting that can be safely obtained. This increases the clearance with the airplane, reduces the possibility of striking the fore and aft sides of the escape chute because of nose high deck angles at slower speeds and decreases the effect of tumbling. The minimum recommended altitude for controlled bailout is 2,000 feet above the terrain. If the airplane is not controllable, do not delay bailout. The appointed jumpmaster bails out after all crewmembers and passengers, except the pilot and copilot. After all personnel have bailed out, the jumpmaster notifies the pilot and then bails out followed by the copilot and pilot. The pilot engages the autopilot (if possible) just before leaving.

Immediate Bailout

An immediate bailout is one in which the emergency is such that there is no time available to plan the bailout. If an immediate bailout is required, the pilot sets the WARNING BELL switch to ON for five to ten seconds and WARNING SIGN switch to BAILOUT, and, conditions permitting, announces on PA “Bail Out, Bail Out, Bail Out”.

The engineer then depressurizes the airplane and the first crewmember reaching the bailout chute opens the chute. All personnel will leave the airplane immediately.

Low Altitude Bailout

Low altitude bailouts involve definite hazards; therefore, keep these things in mind. At low altitudes, do not delay opening the parachute once clearing the airplane is assured (a minimum delay of one second is needed to assure clearing the airplane). The actual safe minimum altitude for bailout is very difficult to determine. The number of variables involved, such as airspeed, airplane attitude, directional controllability, and even flight tests cannot determine this value. The minimum altitude varies with airplane attitude and airspeed.

During any low altitude bailout, the chances of success are improved if the airplane is in a positive climb. This gives the crewmember an initial upward component of velocity, providing more time for parachute deployment than in straight and level flight. The opposite is true of bailout from an airplane in a descent or dive. If a bailout at low altitude is necessary, the airplane should be in either level flight or a climb.

1. Don oxygen masks and bailout oxygen bottles if altitude requires and depressurize aircraft.

2. Remove chinning bar safety pin,

– – – When Cabin Differential Pressure is 1.0 psi or Less – – –

3. Pull the bar down to the horizontal position. This releases the bailout chute door and extends the chute spoiler.

4. Raise and latch floor grille.

5. Pull automatic timer release knob. Parachute opens in 5 seconds if below 14,000 feet.

WARNING

> Do not open parachute above 15,000 feet unless you are losing consciousness, you are within 5,000 feet of the ground, or it is obvious the automatic mechanism has failed.

6. Grasp chinning bar centrally over the bailout chute area facing aft and drop feet into chute.

7. When body position stabilizes, tuck knees up and let go both hands simultaneously. As soon as possible move hands down and across the chest and grasp the parachute harness; this prevents the elbows from contacting the sides of the bailout chute and the hands and arms from contacting the spoiler when the body rotates.

8. If below 14,000 feet, delay pulling ripcord until clear of the airplane.

WARNING

- Do not lower the chinning bar until the differential pressure gage indicates 1.0 psi or less (green band on gage). Opening the bailout chute with higher differential pressure could cause injury to crew or cause damage to bailout chute opening mechanism, preventing bailout chute operating.
- Wear helmet (if available) during bailout to prevent injuries if head strikes bailout chute.
- Retract the main landing gear if possible to prevent chance of being blown against an extended gear or doors.

Airspeed affects the minimum bailout altitude. From the standpoint of deployment of the parachute, extremely slow airspeed is not desirable at low altitudes. Increasing airspeed decreases the minimum altitude from which safe bailout can be expected. A parachute canopy inflates in a given distance regardless of the speed or altitude at which it is deployed. See *figure 3-10*. The trajectory of a falling body is a curve when it has an initial component of velocity in the horizontal direction. Thus, the actual distance traveled through the air is greater than the vertical distance dropped. Applying this effect to a parachute, a canopy with an initial horizontal velocity inflates in a shorter vertical distance than one without. Therefore, as airspeed increases, the minimum safe altitude for bailout becomes lower. A practical limit for this effect is when parachute opening shock becomes intolerable, or tumbling is severe enough to hinder rapid pulling of the ripcord. At very low altitudes, it is generally more desirable to bail out at a high airspeed (within airplane placard speed) than a low airspeed. Do not increase airspeed at the expense of altitude. If the airplane is controllable, at high speed and low altitude, it is usually better to trade airspeed for altitude. Although a successful bailout is possible from as low as 400 to 500 feet, the chances for survival are best when above 2,000 feet.

High Attitude Bailout

Bailout at high altitudes introduces the problems of lack of oxygen, low temperatures, and high parachute opening shock. To minimize these problems, free fall to lower altitudes. Descent time and opening shock may be determined from *figure 3-10*. The parachute is equipped with automatic opening features which are armed by pulling the automatic ripcord release. If bailout is accomplished above 14,000 feet, the parachute opens at the preset time after actuation of the automatic ripcord release.

Over Water Bailout

Successful over water bailouts require additional consideration and preparation time. When over water, bailout is not recommended unless visual contact is made with adequate surface help. If no rescue vessels are in the vicinity, consider bailout only as a last resort because of the extreme difficulty of getting the crew together in the water. In any but the warmest seas, a man can survive only a few hours if kept afloat by means of a life vest only. Wearing a survival suit increases this time but still cannot compare with the time of survival possible in a life raft. If surface help is available, head the airplane in a direction to allow the crew to drift onto the course and just ahead of the rescue vessel.

WARNING

For over water bailout, don survival suits if time permits. Put survival suits on over flying suits. A life vest is imperative and must be worn under the parachute but over the survival suit. Ensure that life vest pouches are pulled through armholes in parachute harness. Neglecting this step could cause cracked ribs and suffocation upon inflation. Mittens are located in the leg pockets of the survival suit.

Bailout Checklist

Pilot's and Flight Engineer's Checklist

Time permitting, pilot directs crew "Prepare for bailout" on PA and receives acknowledgment on interphone. Pilot directs copilot to turn on BAILOUT signs and adjusts airspeed/altitude, time permitting, to a desirable range for bailout. Ensure that crewmembers in all compartments are notified.

1. Helmet and Oxygen Mask – ON (ALL)

   Don oxygen mask and attach bailout oxygen bottle.

   WARNING

   When the "Prepare to bailout" signal is given, each crewmember will check his parachute harness for proper fit.

2. Landing Gear – UP (If Applicable) (CP)

3. Cabin Pressure – Release (E)

   Flight engineer sets EMERGENCY DEPRESS switch to EMERGENCY DEPRESS (Up).

   NOTE

   Each crewmember ensures their individual life raft pack (survival kit) is snapped onto the parachute harness. Crewmembers should check each other to see that all straps and packs are properly adjusted. When directed by the pilot, the jumpmaster actuates the chinning bar.

4. Crew – Bail Out (ALL)

   Pilot gives the bailout order and directs copilot "Alarm bell on." The copilot sets WARNING BELL switch to ON for 5 to 10 seconds, then OFF. The jumpmaster pulls the chinning bar down, lifts the bailout chute floor grille and directs the bailout as shown in *figure 3-9*.

   WARNING

   Do not lower the chinning bar until the differential pressure gage indicates 1.0 psi or less (green band on gage). Opening the bailout chute with higher differential pressure could prevent bailout chute door opening or cause injury to crew.

Navigator's Checklist

If time permits and terrain near the assumed position of the airplane is above 5,000 feet (MSL), the navigator will announce "Ground Elevation _______ Feet" on PA after pilot's PA announcement.

+1. Helmet and Oxygen Mask – ON (ALL)

Don oxygen mask and attach bailout oxygen bottle.

WARNING

When the "Prepare to bail out" signal is given, each crewmember will check parachute harness for proper fit.

+2. Crew – Bail Out (ALL)

WARNING

Do not open bailout chute until cabin differential pressure is less than 1.0 psi (green band on gage)

FIRE, SMOKE, OR FUMES IN AIRPLANE INTERIOR

When excessive smoke or a fire occurs in flight, the first requirement is to eliminate the smoke or fire. After the fire is extinguished and smoke evacuated, the decision can be made as to whether or not it is possible to continue the mission.

WARNING

- If excessive smoke or fumes become apparent during firefighting, perform applicable smoke evacuation procedure, while continuing firefighting procedure.
- Smoke (firefighter's) mask cannot be fitted over eyeglasses and obtain a perfect seal. However, these masks can be used by firefighters. Personnel will obtain best possible seal with eyeglasses.
- Remove smoke masks only after having ventilated the aircraft very well.
- The pilot will ensure crew time off oxygen is minimized while performing fume checks. Since toxicity of fumes is unknown and some fumes are odorless and colorless, exposed crewmembers should be monitored for adverse symptoms (i.e. nausea, headache, dizziness, etc.).

The procedures below provide instructions for locating an unknown source of smoke, evacuating smoke, and fighting a fire. The crewmember discovering fire, smoke, or fumes in the airplane will notify the flight crew and/or mission crew commander, then designated firefighters (N, CT, CDMT, ART) proceed with firefighting procedure as directed by pilot or flight engineer.

The source of smoke can usually be identified as electrical or air conditioning by the odor and location of the smoke.

Pilot's and Flight Engineer's Checklist

1. Oxygen – ON, 100% (ALL)

   Pilot notifies all crewmembers via PA to use oxygen until further notice. Pilots and firefighters will don smoke masks if required. Use helmet visor as smoke mask if mask is not available.

   WARNING

   Personnel in seats 33, 36, and additional crew seats 39 through 46 are provided with portable oxygen bottles having a limited duration available. Refer to subsection I-V for duration at various cabin altitudes.

2. Anti-Smoke Goggles – ON (If Required), Vent Valve Pulled (P, CP, E, N).

3. Set Oxygen EMERGENCY lever to EMERGENCY position (As Required) to clear Anti-Smoke Goggles – (ALL)

4. Flight Deck Lights – As Required (CP)

   Turn all flight deck lights to maximum to provide maximum illumination if smoke increases. Set LIGHT OVERRIDE Switch to OVERRIDE.

5. Crew Report – ON OXYGEN (P, CP, E, N, MCC)

   When directed by pilot, all crewmembers report on interphone when oxygen mask is on and checked.

6. NO SMOKING Switch – ON (E)

7. MAINT INTPH – BOTH (E)

– – – If There Is A Fire From A Known Source, Perform The FUSELAGE INTERIOR FIRE, KNOWN SOURCE Checklist – – –

– – – If The Source Of Fire, Smoke Or Fumes Is Positively Identified, Remove Power From That Equipment, And Then Perform Steps 1 Through 3 Of The ELECTRICAL FIRE, SMOKE, OR FUMES Checklist – – –

– – – If The Source Of Fire, Smoke Or Fumes Is From The Electrical System Or Is Suspected To Be The Source, Perform The ELECTRICAL FIRE, SMOKE OR FUMES Checklist – – –

– – – If The Source Of Fire, Smoke Or Fumes Is FromThe Air Conditioning System, Perform The AIR CONDITIONING SMOKE OR FUMES Checklist – – –

NOTE

- If the smoke or fumes source is in the air conditioning system, the odor and smoke are spread rapidly to all parts of the airplane interior, not just in a local area. If this condition occurs, perform the AIR CONDITIONING SMOKE OR FUMES Checklist immediately.

- The source of electrical system smoke or fumes is usually detected by visual inspection of systems or by abnormal indications such as open circuit breakers or unusual meter readings.

- If the air conditioning water separator is clogged with dirt, the smoke can smell like hot electrical insulation. This is because the pack bypass valve has opened to try to clear the separator. The smoke continues until the pack is shut off.

- If excessive smoke remains after extinguishing a fire, use the applicable smoke evacuating procedure.

- If inspection shows a fire (or smoke source) is in a definite system, remove power from that equipment, perform the initial checks, and then perform only the procedures for that system.

- Unless depressurization is required for extinguishing fire or controlling smoke source, use of normal pressurization and air conditioning eliminates smoke more rapidly than ram air flow. Normal air conditioning takes 5 to 6 minutes for a complete change of cabin air. Raising cabin altitude expedites smoke removal.

Navigator's Checklist

+1. Oxygen – ON, 100% (All)

2. Anti-Smoke Goggles – ON (If Required), Vent Valve Pulled (P, CP, E, N)

3. Set Oxygen EMERGENCY lever to EMERGENCY position (As Required) to clear Anti-Smoke Goggles.

4. Crew Report – ON OXYGEN (P, CP, N, E, MCC)

Fuselage Interior Fire, Known Source

Pilot's and Flight Engineer's Checklist

1. Fire – Extinguished (Firefighters)

   Mission crewmember and navigator extinguish fire.

2. Smoke – Evacuated, If Required (E)

   If normal ventilation does not remove smoke, use applicable smoke evacuation procedure.

Navigator's Checklist

+1. Fire – Extinguished (Firefighters)

Mission crewmember and navigator extinguish fire.

Electrical Fire, Smoke, or Fumes

This checklist will be used in any situation where the electrical system (or electrical equipment) is known or suspected to be the source of fire, smoke, or fumes. If a definite source is known, perform only steps 1 through 3. On ground, if a definite source is not located, perform steps 1 through 4. In flight, if a definite source is not located, perform steps 1 through 5 and as many of steps 6 through 30 as required to isolate the source. Steps 1 and 2 ensure that the rotodome is on utility drive and check for abnormal indications.

WARNING

- Coordination between pilots and flight engineer is required prior to activating or deactivating the auxiliary hydraulic system. Normal systems indicators may not be available due to isolation of electrical system components.

- If an engine is inoperative, maintain airspeed greater than V_{MCA} or establish symmetrical thrust until above V_{MCA} when deactivating the auxiliary hydraulic system.

NOTE

- The source of electrical fire, smoke, or fumes can usually be determined from panel indications of abnormal voltage, and current, or from visual inspection of equipment. Make this check even when the source is thought to be known and continue to do so throughout checklist.
- If visual inspection does not indicate the source, bus-by-bus isolation can be required. This is a slow process. From 10 to 15 minutes can be needed to make sure that smoke is stopped when power is removed from a bus. Insulation continues to smoke for a few minutes after power is removed, and air conditioning takes 5 to 6 minutes to remove smoke after smoke stops. Raising cabin altitude expedites smoke removal.
- There is little or no cooling effect from use of the fire extinguisher. The extinguishing agent stops a fire primarily by acting as a negative catalyst for carbon oxidation, and secondarily by displacing oxygen from reactions not involving carbon. Do not use extinguisher unless flames are visible.
- If mission conditions do not permit a landing, and in the pilot's opinion, further troubleshooting is required (once a bus has been found to be the source of smoke), refer to ELECTRICAL SMOKE SOURCE ISOLATION, this section.
- Refer to *figure 1-42* for a list of circuit breakers on each bus.
- Refer to ELECTRICAL SYSTEM ABNORMAL OPERATION, subsection I-E for list of equipment which is lost if power is removed from a particular bus.

– – – If on the Ground, Perform Only Steps 1 Through 4 – – –

1. ROTODOME DRIVE System Select Switch – UTIL (E)

   Ensure rotodome is operating on utility hydraulic system drive while electrical power is still available to operate valves.

② Electrical Meters, Circuit Breakers, Equipment – Checked (E, MCC)

Check ac voltage, load, frequency on all sources. Check dc load and voltage on all sources. Check for tripped circuit breakers. Notify MCC to have mission crew firefighters make visual check of upper and lower compartments for: tripped circuit breakers on P66, P67, and radar power panel in aft lower compartment; visual evidence of arcing, fire, or smoke; and for unusual indications at communications, computer, radar and situation display consoles.

– – – If Smoke Source Is Known, Perform Step 3 – – –

– – – If Smoke Source Is Not Known (On Ground), Perform Step 4 – – –

– – – If Smoke Source Is Not Known (in Flight), Firefighters Will Follow Directions of Pilot or Flight Engineer for Remainder of Checklist. Proceed to Step 5 – – –

③ Power – Removed From Defective Equipment (E, MCC)

Remove power from equipment causing smoke/fire. Mission crew assist flight engineer, if required.

– – – Resume Normal Operation on Remaining Systems – – –

4. Electric Power – Removed (E)

   Remove all power (external, APU, battery).

– – – Proceed to GROUND EVACUATION Checklist, If Required – – –

⑤ Surveillance Radar – Standby (E, ART)

   a. ART – Notified (E)

   b. Radar – Standby (ART)

   c. RADAR Switch (FE Panel) – OFF (E)

– – – If Smoke Stops, Perform Step 6 – – –

– – – If Smoke Continues, Perform Step 7 – – –

6. Remaining Systems – Operate Normally (E)

   Smoke source is in surveillance radar or radar feeders. Do not attempt to restart surveillance radar unless source of smoke/fumes has been isolated and corrected.

***** Resume Normal Operation (Surveillance Radar Inoperative) *****

7. All CROSSFEED Switches – OPEN (E)

   Crossfeed valves remain in position if battery power is lost.

– – – Steps 8 through 10 Isolate AC and DC Power Sources – – –

8. ALL BUS TIE OPEN Switches – OPEN (E)

   Isolate generators from ac tie bus.

9. 28V DC TIE BUS Circuit Breakers (P61-5) – Open (E)

   Open DC BUS 2, DC BUS 4, DC BUS 8 and DC BUS 3, 5, and 6 circuit breakers (*figure 1-46*).

WARNING

The rudder pressure reducer is powered by AVDC 8. If AVDC 8 loses power, rudder defaults to full system pressure (OVERRIDE) mode. Do not move the rudder rapidly or to full displacement at high indicated airspeeds.

⑩ Mission DC TIE BUS Circuit Breakers (P66-1 and P67-3) – Open (E, CT, CDMT, ART)

   a. On P66-1, CT or CDMT opens BUS 3, BUS 6 and MISSION circuit breakers (*figure 1-47*).

   b. ON P67-3, ART opens BUS 3, BUS 5, BUS 6 and MISSION circuit breakers (*figure 1-48*).

– – – If Smoke Stops, Perform Step 11 – – –

– – – If Smoke Continues, Proceed to Step 12 – – –

11. Generators and TRUs – Operate Isolated (E)

    All electrical equipment in the airplane, except AVDC bus 6, IDG 5 and 6 disconnect, and surveillance radar transmitter, can be operated. Smoke source is in tie buses.

CAUTION

Monitor operation of electrical system. Any failure of a generator or TRU while isolated causes loss of that bus.

***** Resume Normal Operation (Surveillance Radar Transmitter Inoperative) *****

NOTE

If further isolation is required, refer to ELECTRICAL SMOKE SOURCE ISOLATION.

12. Stabilizer Trim Switches – CUTOUT (P or CP)

    Set main and autopilot electric trim switches to CUTOUT and extend manual trim handles. When bus 8 loses power, electric trim is inoperative.

⑬ Navigation Rack (E-14) – Open (E, ART)

   Request ART to open navigation (E-14) rack (for additional cooling when forced air system is off).

NOTE

- Generator 2 powers CDU 1, RNAV panels 1 and 3, EGI 1 and charger, and CADC 1, via FAV1AC, TRU 2, and FAV1DC buses.
- Generator 8 powers CDU 2, RNAV Panel 2, AE 2, EGI 2 and charger, BSIU 2 and CADC 2, via FAV2AC, TRU 8, and FAV2DC buses.
- EDC bus powers DESIGNATED PILOT and ADC select switching.
- Battery bus powers AE 1, via emergency inverter and EAC bus.
- Hot battery bus powers CDU 3, BSIU 1, GINS CONTROL PANEL illumination, 1553B BUS switch, and MDL.

14. Pilot’s ADI Switch – AHRS (P)

    Insures ADI attitude source is AHRS 1.

⑮ Mission Equipment – OFF (E, ART, CDMT, CT)

16. RUDDER Switch – OFF (P, CP, E)

WARNING

Maintain airspeed greater than rudder boost off V_{MCA}.

17. DESIGNATED PILOT Switch – PILOT (P)

18. Generators 1, 3, 4, 5, 6, 7, 8 – OFF (E)

    a. Generator OFF Switches 1, 3, 4, 5, 6, 7, 8 – OFF

    b. BUS TIE OPEN Switches 1, 3, 4, 5, 6, 7, 8 – Open

    Only generator 2 is supplying power. Buses available are AVAC 2, AVDC 2, FAAC 1, MAAC 2, 28VAC 2, FAVDC 1 EAC and EDC. Pilot's electrically operated instruments are powered.

    CDU 1, RNAV panel 1, AE 1, EGI 1, EGI 2 (on battery), BSIU 1, CADC 1, CDU 3, RNAV panel 3, GINS CONTROL PANEL, 1553B BUS switch and MDL are powered. EGI 2 caution light is illuminated.

NOTE

EGI 2 is operated on battery to preserve alignment.

– – – If Smoke Stops, Perform Step 19 – – –

– – – If Smoke Continues, Proceed to Step 25 – – –

19. Generator 4 – Operate Isolated (E)

– – – If Smoke Appears, Perform Step 20 – – –

– – – If No Smoke Appears, Perform Step 22 – – –

20. Generator 4 – OFF (E)

    a. Generator Switch – OFF

    b. BUS TIE Open Switch – OPEN

    Smoke source is on AVAC 4 bus or MAAC4 bus or emergency light battery charger. Refer to *figure 1–42* for list of inoperative equipment. Refer to AC POWER SYSTEM ABNORMAL OPERATION, section I-E.

21. Remaining Systems – Restore (E)

    All busses, except No. 4 may be powered.

– – – Proceed to Step 36 – – –

22. Repeat Step 19 for Generators 6, 8, 1, 3, 5, 7 – Repeat In Order (E)

    Generator 8 provides power to copilot's instruments and stabilizer trim and enables ELCU to power auxiliary pump No. 1 if generator 2 bus is powered. See *figure 1-42* for list of equipment on each bus. Refer to AC POWER SYSTEM ABNORMAL OPERATION and DC POWER ABNORMAL OPERATION, section I-E.

– – – If No Smoke Appears, Perform Step 24 – – –

– – – If Smoke Appears, Proceed to Steps 23 and 24 – – –

23. Generator Which Caused Smoke to Appear – OFF (E)

    Leave that bus tie open.

24. Remaining Systems – Restore (E)

WARNING

Stow manual trim handles before reenergizing electric trim. Handles can cause injury if trim wheel moves electrically with handle extended.

– – – Proceed To Step 36 – – –

NOTE

If further isolation is required, refer to ELECTRICAL SMOKE SOURCE ISOLATION.

25. Copilot's ADI Switch – AHRS (CP)

    Insures AHRS 2 is attitude source for copilot's ADI.

26. Generator 8 – Operate Isolated (E)

    Provides power to copilot's instruments and stabilizer trim. EGI 2 caution light goes out when generator 8 is put on line.

WARNING

Stow manual trim handles before reenergizing electric trim. Handles can cause injury if trim wheel moves electrically with handle extended.

– – – When GYRO Flag Retracted on Copilot's ADI – – –

27. DESIGNATED PILOT Switch – COPILOT

28. Generator 2 – OFF (E)

    a. GEN CONTR OFF Switch – OFF

    b. BUS TIE OPEN Switch – OPEN

    c. FREQ REF UNIT Circuit Breaker (P61-5) – OPEN

CAUTION

Generator drives could be damaged or AC power lost if FRU is repowered. Do not restore FRU power for remainder of flight.

Pilot's instruments are inoperative. Pilot uses standby attitude indicator until bus 2 is restored. Refer to AC POWER SYSTEM ABNORMAL OPERATION, DC POWER ABNORMAL OPERATION, and *figure 1-42* subsection I-E. Pilot's CDU is off. CDU 2, RNAV panel 2, AE 2, EGI 2 and charger, CADC 2, AE 1, EGI 1, CDU 3, RNAV panel 3, GINS CONTROL PANEL, 1553 B BUS switch, and MDL are powered. EGI 1 caution light is illuminated.

– – – If Smoke Stops, Perform Step 29 – – –

– – – If Smoke Continues, Proceed to Step 30 – – –

29. Remaining Systems – Restore (E)

NOTE

- Do not reset FRU circuit breaker.
- If further isolation is required, refer to ELECTRICAL SMOKE SOURCE ISOLATION.
- EGI caution light goes out. All GINS equipment is on and powered from normal sources.

– – – Proceed to Step 36 – – –

㉚ EMERGENCY POWER Switch – OFF (E, MCC)

De-energizes EAC and EDC buses, CSU1 and CSU2, and flight deck UHF. All internal and external communication is lost. If time permits, make PA announcement before opening switch. Continue COPILOT selection on DESIGNATED PILOT panel. AE 1, DESIGNATED PILOT and ADC SOURCE SELECT switches are unpowered.

– – – If Smoke Stops, Perform Step 31 – – –

– – – If Smoke Continues, Proceed To Step 32 – – –

31. Remaining Systems – Restore Slowly (E)

    Check for smoke and monitor electrical loads.

– – – Proceed to Step 36 – – –

㉜ Battery Bus Circuit Breakers (5) – Open (E, CT)

Open the following circuit breakers:

a. Battery Circuit Breaker (on front of upper battery shelf, station 370 RH) (CT)

b. 28 VDC BUS 2 – BATT BUS (P61-5) (E)

c. HOT BATTERY BUS – BATT BUS PWR (P61-6) (E)

d. HOT BATTERY BUS – MAIN BUS DISTR (P61-6) (E)

e. EMERG BATTERY TIE – BAT TIE (P61-6) (E)

CDU 2, RNAV panel 2, AE 2, EGI 1 (on battery), EGI 2, BSIU 2, and CADC 2 are powered.

– – – If Smoke Stops, Perform Step 33 – – –

– – – If Smoke Continues, Source is in Emergency Lights System. Proceed to Step 34 – – –

33. Remaining Systems – Restore Slowly (E)

Check for smoke and monitor electrical loads.

WARNING

Land as soon as possible. Step 32 leaves engine fire detection/protection inoperative.

NOTE

- See *figure 1-42* for a list of equipment on each inoperative bus. When returning EMERGENCY POWER switch to NORMAL, EMERGENCY POWER ON caution light is inoperative. With BATT BUS C/B's open the Bus Tie and Generator Indicator lights are inoperative.
- EGI 1 caution light goes out when generator 2 is restored. CDUs 1 and 2, all RNAV panels, AE 1 and 2, EGIs 1 and 2, BSIU 2, ADC source select switch and pilot source select switch are powered.

– – – Proceed to Step 36 – – –

(34.) Battery Bus Circuit Breakers and Emergency Power – Restore (E, CT)

a. Close the following circuit breakers:

(1) Battery Circuit Breaker (On front of upper battery shelf, station 370 RH) (CT)

(2) 28 VDC BUS 2 – BATT BUS (P61-5) (E)

(3) HOT BATTERY BUS – BATT BUS PWR (P61-6) (E)

(4) HOT BATTERY BUS – MAIN BUS DISTR (P61-6) (E)

(5) EMERG BATTERY TIE – BAT TIE (P61-6) (E)

b. Set EMERGENCY POWER Switch to Normal (E)

EGI 1 caution light goes out when generator 2 is restored. All GINS equipment is on and powered from normal sources.

(35.) Emergency Lights Power – Removed (E, CT, ART)

a. Emergency Light Battery Circuit Breaker and Battery Charger Circuit Breaker – Open

On front of lower battery shelf station 370 LH (CT)

b. 115 VAC CHGR and BAT BUS Circuit Breakers (P67-1) – Open (ART)

Smoke source is in emergency light battery buses. Portable emergency lights and emergency exit lights are still available.

NOTE

Emergency lighting battery capacity, normally available via emergency battery tie, is not available.

***** Return To Normal Operation *****

36. RUDDER Switch – ON, As Required (P, CP, E)

Rudder is available if AVDC 8 MAIN is powered, with either: GEN 2 on line, or AVAC 4 and AVDC 4 MAIN powered.

WARNING

When setting RUDDER switch to ON in flight, ensure rudder and rudder trim are in neutral (centered) position. This is to prevent excessive structural loads caused by rapid increase in rudder deflection and to maintain airplane control during the transition to powered rudder.

***** Return To Normal Operation *****

Electrical Smoke Source Isolation

When the ELECTRICAL FIRE, SMOKE OR FUMES procedure has isolated the source of smoke or fumes to a generator's associated buses, further isolation can be performed if continued mission operation is necessary and sufficient time is available.

WARNING

- This procedure will only be attempted at the pilot's direction; and when, in the pilot's opinion, equipment on the bus (which was identified as the smoke source by the ELECTRICAL FIRE, SMOKE, OR FUMES checklist) is required for continued mission operation.
- This procedure will not be attempted on a bus which has been identified as the source of an electrical fire.
- This isolation procedure requires deliberately energizing electrical equipment which has been previously identified as a source of electrical smoke. Extreme care must be taken to ensure that a more serious fire/smoke condition does not occur during attempts to isolate a smoke source.

Perform the following:

a. Refer to the ac system schematic, *figure 1-40* and dc system schematic, *figure 1-41*. Determine the distribution breakers for the buses identified as smoke sources. Open those breakers. Also, open transformer rectifier unit breaker(s) (if applicable).

b. Close applicable generator breaker(s) and open the bus tie breaker(s). (Operate the generator(s) isolated.)

c. Close the ac distribution bus breakers then the dc distribution bus breakers one at a time, waiting for smoke to form (5 to 10 minutes). If smoke appears, open the last distribution breaker which was closed.

d. If equipment on the distribution bus cannot be identified by inspection as the source, open all breakers on the distribution bus (see *figure 1–42*) and close one at a time until a source is identified.

NOTE

This is a slow process. Ten to fifteen minutes per circuit is needed to build up or dissipate smoke.

Air Conditioning Smoke or Fumes (Flight)

The checklist below is for use in flight.

1. FOOT and SHOULDER HEATERS Switches – OFF (P, CP)

   Eliminates heaters as smoke source. Leave off until resuming normal operation.

NOTE

It can take 3 to 5 minutes for normal airflow to eliminate smoke after source is isolated.

– – – If Smoke Continues, Perform Step 2 – – –

***** If Smoke Stops, Leave Heaters Off and Resume Normal Operation *****

2. GASPER AIR Switch – OFF (E)

   Eliminates fan motor as smoke source.

– – – If Smoke Stops, Perform Step 3 – – –

– – – If Smoke Continues, Proceed to Step 4 – – –

3. GASPER FAN Circuit Breaker (P61-3) – Open (E)

***** Resume Normal Operation *****

4. Left ISOLATION Valve Switch – CLOSED (E)

   Isolates left wing as a smoke source. If source is engine No 1 or No 2, smoke should stop within 5 minutes. If smoke continues, source is engine No 3 or No 4 or pack.

– – – If Smoke Continues, Proceed to Step 9 – – –

– – – If Smoke Stops, Either Resume Normal Operation on 2 Bleeds or (at Pilot's Discretion) Perform Steps 5 Through 8 – – –

5. No 1 Engine BLEED AIR Valve – Closed (E)

6. Left ISOLATION Valve Switch – Open (E)

   If smoke stops, source is engine No 1.

– – – If Smoke Continues, Perform Step 7 – – –

*** **If Smoke Stops, Return to Normal Operation on 3 Bleeds** ***

7. Engine No 1 BLEED AIR Valve – OPEN (E)
8. Engine No 2 BLEED AIR Valve – Closed (E)

   Smoke source is engine No 2.

9. Left ISOLATION Valve – Open (E)
10. Right ISOLATION Valve – Closed (E)

    Isolates engines No 3 and No 4 from system. If smoke continues, source is in pack.

– – – If Smoke Continues, Proceed to Steps 15 and 16 – – –

*** **If Smoke Stops, Either Resume Normal Operation on 2 Bleeds, or (at Pilot's Discretion) Perform Steps 11 and 12** ***

11. Engine No 3 BLEED AIR Valve – Closed (E)
12. Right ISOLATION Valve – Open (E)

    If smoke stops, source is engine No 3. If smoke continues, source is engine No 4.

– – – If Smoke Continues, Perform Steps 13 and 14 – – –

*** **If Smoke Stops, Resume Normal Operation on 3 Bleeds** ***

13. Engine No 3 BLEED AIR Valve – Open (E)
14. Engine No 4 BLEED AIR Valve – Closed (E)

*** **Resume Normal Operation on 3 Bleeds** ***

15. Air Conditioning AUTO–MAN Switch – MAN (E)

    Places pack in manual operation.

16. BYPASS HEAT–COOL Switch – Full HEAT (E)

    Opens bypass (temperature control valve).

*** **If Smoke Stops, Resume Normal Operation Except Use Air Conditioning Heat-Exchanger Only Operation; Refer to Subsection I-Q** ***

– – – If Smoke Continues, Or Cabin Temperature Becomes Intolerable (At Pilot's Command) Perform Steps 17 Through 22 – – –

17. RAM INLET HEAT–COOL Switch – Full COOL (E)

    Opens ram air door for maximum airflow.

WARNING

Do not open flight deck windows except as directed by smoke evacuation procedures.

18. RAM AIR Valve Switch – ON (E)

    Airplane begins to depressurize.

19. UNPRESS/OB VALVE Switch – UNPRESS (E)

    Overrides cabin altitude limiters, and places fans 1 and 2 in both forced air systems in high speed operation.

CAUTION

- When operating unpressurized and the aft forced air cooling system RAM VALVE OPEN indicator is illuminated, control the temperature of the aft system manually at 45 ± 5°F. The aft forced air cooling system must be operated in the manual mode to maintain proper temperature control when operating unpressurized with the ram valve open.
- Refer to RAM VALVE INDICATOR NOT ILLUMINATED (UNPRESSURIZED, 15,000 FEET OR ABOVE), subsection I-R, if a RAM VALVE OPEN light does not illuminate.

20. Pressurization AUTO–MAN Switch – MAN (E)

21. Manual Control Knob – Set to UP (E)

    Opens outflow valves.

22. PRIMARY and ALTERNATE Valves – OFF (E)

    Shuts down pack, which is smoke source.

*** * * Proceed to SMOKE EVACUATION, INADEQUATE VENTILATION Checklist, If Required * * ***

Air Conditioning Smoke or Fumes (Ground)

If air conditioning smoke or fumes are noted on the ground, shut down air source, open windows and doors, and evacuate smoke. Have maintenance investigate cause. If time does not permit, or if airplane must be operated, attempt to isolate source by changing air sources as in flight procedure. Change from APU to engine or ground cart. If smoke continues, source is probably in pack. Try increasing cabin temperature to reduce compressor outlet temperature.

Smoke Evacuation, Normal Ventilation

Use this procedure only when normal pressurization and air conditioning airflow is available.

1. Draw Through Cooling – Check (E)

    a. NO FLOW Caution Light – Out

    b. Fan – Operating if Cabin Differential Pressure Less Than One psi.

       Verify system is operating.

2. Cabin Altitude Set Knob – Maximum Altitude (E)

    This increases airflow into the cabin and speeds up smoke removal.

    NOTE

    If smoke source is in aft end of airplane, open aft outflow valve with outflow valve balance knob. If smoke source is in forward cabin or flight deck open forward outflow valve with outflow valve balance knob. Open sextant port to help evacuate smoke.

3. PRIMARY or ALTERNATE Valve Switch – ON (E)

    Verify PRIMARY or ALTERNATE valve is open.

4. UNPRESS/OB VALVE Switch – UNPRESS If Above 13,000 Feet Cabin Pressure Altitude (E)

    UNPRESS/OB VALVE switch set to UNPRESS above 13,000 feet cabin pressure altitude to override cabin altitude limiters in outflow valves to increase air flow.

    CAUTION

    When operating unpressurized and the aft forced air cooling system RAM VALVE OPEN indicator is illuminated, control the temperature of the aft system manually at 45 ± 5°F. The aft forced air cooling system must be operated in the manual mode to maintain proper temperature control when operating unpressurized with the ram valve open.

*** * * If Smoke Clears, Resume Normal Operation * * ***

*** * * If Smoke Does Not Clear, or Becomes Excessive, Proceed to SMOKE EVACUATION INADEQUATE VENTILATION Checklist * * ***

Smoke Evacuation, Inadequate Ventilation

Pilot's and Flight Engineer's Checklist

NOTE

Use this procedure only when normal ventilation is inadequate or not available and airplane is unpressurized.

1. Draw Through Cooling – Check (E)

    a. NO FLOW Caution Light – Out

    b. Fan – Operating if Cabin Differential Pressure Less Than One psi.

       Verify that system is operating.

2. PRIMARY and ALTERNATE Valve Switches – OFF (E)

3. Flaps 14, 14, Green Lights (CP)

   Set flap lever to 14. INBD and OUTBD gages indicate 14. Both LE FLAP indicators illuminated.

4. Airspeed – 175 Knots Maximum (P)

   Use V_{REF} +30 KIAS but not over 175 KIAS.

5. Draw Through Cooling Fan Circuit Breakers (P61-3) – Open (E)

CAUTION

Opening overwing hatch in flight causes cabin pressure to be lower than ambient. Open DRAW THRU CLG FAN circuit breaker to prevent burning out draw through cooling system fan.

(6.) Overwing Hatch (Left Side) – Opened (P, ART or N)

Pilot directs ART (or navigator if mission crew not on board) to open hatch.

ART or navigator opens hatch as shown in *figure 3-6*.

WARNING

- Do not attempt to open, remove or replace overwing hatch in flight with flight deck window open.
- Crewmember opening, removing, or installing hatch must wear parachute or restraint harness. Secure harness by safety lanyard to base of mission crew seat.

7. Copilot's Sliding Window – Opened (CP)

– – – When Smoke Has Cleared – – –

8. Copilot's Sliding Window – Closed (CP)

   Window can be extremely hard to close.

(9.) Overwing Hatch – Closed (P, ART or N)

Pilot directs ART (or navigator if mission crew not on board) to close hatch. ART (or navigator) closes hatch as shown in *figure 3-6*.

a. If hatch is no longer in opening, move hatch to opening in horizontal position with outside surface up.

b. Engage lower latch and rotate hatch to vertical position.

c. Engage upper latch.

10. Draw Through Cooling Fan Circuit Breakers (P61-3) – Closed (E)

WARNING

If airplane was depressurized to extinguish a fire, do not repressurize until fire is definitely extinguished and cause is corrected (or power removed from defective equipment).

– – – When Ready to Pressurize, Refer to DEPRESSURIZATION AND REPRESSURIZATION, Subsection I-Q – – –

*** * * When Cabin Altitude Is Below 10,000 Feet, Resume Normal Operation (Oxygen Masks May Be Removed) * * ***

Navigator's Checklist

(+1.) Overwing Hatch (Left Side) – Opened (ART or N, P)

Pilot directs ART (or navigator if mission crew not on board) to open hatch. When directed, open hatch as shown in *figure 3-6*.

a. Grasp upper handle of hatch from underside and grasp lower handle of hatch firmly.

b. Pull upper handle firmly to open pressure relief plug. Pull hatch firmly by upper handle, tilting hatch inward until upper edge is about one foot from closed position.

c. Secure hatch with escape strap from flight deck.

WARNING

- Do not attempt to open, remove, or replace overwing hatch in flight with flight deck window open.

- Crewmember opening, removing, or installing hatch must wear parachute or restraint harness. Secure harness by safety lanyard to base of mission crew seat.

– – – When Smoke has Cleared and Copilot's Window Is Closed – – –

+2. Overwing Hatch – Closed (ART or N, P)

Pilot directs ART (or navigator if mission crew not on board) to close hatch. ART (or navigator) closes hatch as shown in *figure 3-6*.

a. If hatch is no longer in opening, move hatch to opening in horizontal position with outside surface up.

b. Engage lower latch and rotate hatch to vertical position.

c. Engage upper latch.

WHEEL WELL FIRE

Wheel well fires are usually caused by overheated brakes. Hot brakes can be caused by taxiing long distances in hot weather at light gross weights with four engines running so that brakes must be continually applied to slow the taxi speed, as might occur in a training environment on a full stop taxi back for takeoff. A single brake dragging during taxi and takeoff could also cause an unsuspected hot brake.

Hot brakes alone should not generate enough heat to trigger the fire detection system. A wheel well fire indication is likely the result of an actual secondary fire where hot brakes (or other ignition source) ignite rubber, hydraulic fluid from leaking actuators, or other flammable material. If the source of fire is on a wheel, extending the wheel into the wind steam protects the wheel well from the fire and should blow the fire out and cool the heat source. If the source of fire is inside the wheel well, lowering the gear and opening the doors minimizes wheel well damage due to heat buildup, protects the wheels from the fire, and precludes difficulty which might develop in getting the gear down.

Use the viewing ports in the mission compartment floor to inspect the gear and wheel well for evidence of fire or damage.

Brakes hot enough to ignite a fire usually melt fuse plugs, resulting in flat tires on landing. If deflated tires are suspected, refer to LANDING WITH FLAT TIRES and see Section V for taxi and towing limits with flat tires. Deflated tires do not appear flat until landing. Fuse plugs cannot be seen from the viewing ports regardless of whether the gear is up or down. If brakes are not heated internally from brake usage, a fire from an external source is not likely to heat the wheel rims enough to melt the fuse plugs.

1. Gear – DOWN (CP)

2. Gear Doors – Open (CP)

Move gear lever up, momentarily, then move lever to off as soon as door warning light illuminates. Perform a visual inspection of the gear and wheel well area.

CAUTION

Close wheel well doors before landing. If all tires are flat, doors could contact ground, causing damage to doors.

NOTE

Allow at least 20 minutes, after W/WELL FIRE light goes out, with wheels down and doors open for brake cooling.

3. **WITH IDG** TCAS SENS – TA Only (CP)

VSI displays ONLY TA. This prevents TCAS from coordinating an RA with other TCAS equipped aircraft and inhibits RAs from being issued by own TCAS. ◀

4. Hydraulic Quantity – Checked (E)

If loss of hydraulic fluid is indicated, gear should be left down and appropriate hydraulic system loss or leak isolation checklist followed. Perform a visual inspection of the gear and wheel well area.

5. Landing – Accomplished, As Soon As Practical

After evaluating the situation, the crew shall decide whether to:

Land at the nearest suitable airport; or . . .

WARNING

Do not dump fuel if there is any possibility of fire in wheel well.

. . . Retract the gear after the fire is visually confirmed to be extinguished and the brakes have cooled, if mission continuation is deemed essential.

WARNING

Do not raise the gear if wheel well damage is evident.

NOTE

Flight planning fuel reserves are calculated for a clean airplane. With landing gear extended and doors open, fuel consumption is increased by 50% (Endurance is reduced by 33%).

SUDDEN LOSS OF CABIN PRESSURE

A total loss of pressurization is relatively unusual. However, many cases of rapid, partial loss of pressure have resulted in emergency descents which could have been prevented by proper action by the crew. Due to potential adverse physiological effects above cabin altitudes of 18,000 feet, it is highly recommended, fuel and terrain permitting, to descend to an altitude where the cabin pressure can be maintained at or below 18,000 feet.

If a decrease in cabin pressure occurs (as shown by cabin climb rate, prolonged ear discomfort, the cabin altitude warning horn sounding, and LOSS OF PRESSURE signs in the mission compartment illuminating), perform the following checklist.

Silence the warning horn as soon as possible after donning oxygen mask. Check that bleed air, air-conditioning, and pressurization systems are functioning properly. Resume normal operation of the forced air cooling system as soon as possible.

WARNING

Before initiating a high speed descent, check for structural damage which could be increased by high speed descent.

Pilots' and Flight Engineer's Checklist

1. Oxygen – ON, 100% (ALL)

   Pilot notifies all crewmembers via PA to use oxygen until further notice.

   WARNING

   Personnel in seats 33, 36, and additional crew seats 39 through 46 are provided with portable oxygen bottles having a limited duration available. Refer to subsection I-V for duration at various cabin altitudes.

2. NO SMOKING Switch – ON (E)

③ Crew Report – ON Oxygen (P, CP, E, N, MCC)

   When directed by pilot, all crewmembers report on interphone when oxygen mask is on and checked.

– – – If OBV UNSAFE Caution Light On, Proceed to UNSAFE OVERBOARD VALVE INDICATION Checklist – – –

– – – If Door Caution Light Is Illuminated, Proceed to Appropriate DOOR CAUTION LIGHT ILLUMINATED Checklist – – –

4. Outflow Valves – Closed (E)

   Operate manually if required.

5. BLEED AIR Switches – ON (E)

   To ensure pressurization source.

6. ISOLATION Switches – Open (E)

7. PRIMARY or ALTERNATE Switch – ON (E)

   Turns on air conditioning pack.

8. RAM AIR Valve Switch – OFF (E)

   To restore normal ventilation.

9. EMERGENCY DEPRESS Switch – OFF (E)

10. RATE Knob – Normal (E)

11. UNPRESS/OB VALVE Switch – OFF (Center) (E)

    To restore forward and aft forced air cooling systems.

12. FWD and AFT RAM VALVE Indicators – Out (E)

13. OVBD Gage – Full HEAT (Closed) Fwd and Aft (E)

    CAUTION

    If a forced air RAM VALVE indicator illuminates, or an OVBD gage shows full COOL (open), toggle the UNPRESS/OB VALVE switch to the UNPRESS position immediately to select unpressurized mode in both forced air systems.

a. SYSTEM SELECT Switch – Press

To select other system for OVBD gage.

b. OVBD Gage – Full HEAT for Other System

14. Weather Radar – As Required (E, N)

CAUTION

Weather radar will not be operated at cabin pressure altitude above 20,000 feet.

(15.) Status Report – As Required (ART, CT, E)

*** * * If Unable to Operate Pressurized, Refer to Subsections I-Q and I-R * * ***

Navigator's Checklist

+1. Oxygen – ON, 100% (ALL)

Pilot notifies all crewmembers via PA to use oxygen until further notice.

(+2.) Crew Report – ON Oxygen (P, CP, E, N, MCC)

When directed by pilot, all crewmembers report over interphone when oxygen mask is on and checked.

3. Weather Radar – As Required

CAUTION

Weather radar will not be operated at cabin pressure altitudes above 20,000 feet.

UNSAFE OVERBOARD VALVE INDICATION

A failure of the overboard valve to close completely or remain closed is indicated on the FAC UNPRESS & OVERRIDE panel by illumination of the OB VALVE UNSAF caution light. Cabin depressurization could occur. Timely action is required as the speed of depressurization cannot be safely estimated.

1. UNPRESS/OB VALVE Switch – OB VALVE (E)

2. OB VALVE UNSAF Caution Light – Verify OFF (E)

Overboard valve has been driven closed.

3. OVBD Gage – Verify Closed (Full Heat) (E)

– – – If OB VALVE UNSAF Caution Light Remains Illuminated or OVBD Gage Does Not Go to Full Heat, Monitor Cabin Pressure and Be Prepared to Implement SUDDEN LOSS OF CABIN PRESSURE Checklist – – –

Perform normal BEFORE LANDING CHECKLIST with the following exception:

UNPRESS/OB VALVE Switch – OFF (Center)

RAPID DESCENT

This procedure (*figure 3-11*) is primarily intended to provide the highest possible sink rate, without exceeding airspeed and Mach limitations.

WARNING

- Before initiating a high speed descent, check for structural damage which could be increased by high speed descent.
- Engine flameout can occur if airplane pitch attitude exceeds 8° nose up or 10° nose down when any outboard main tank contains less than 2,500 pounds or any inboard main tank contains less than 6,500 pounds.

NOTE

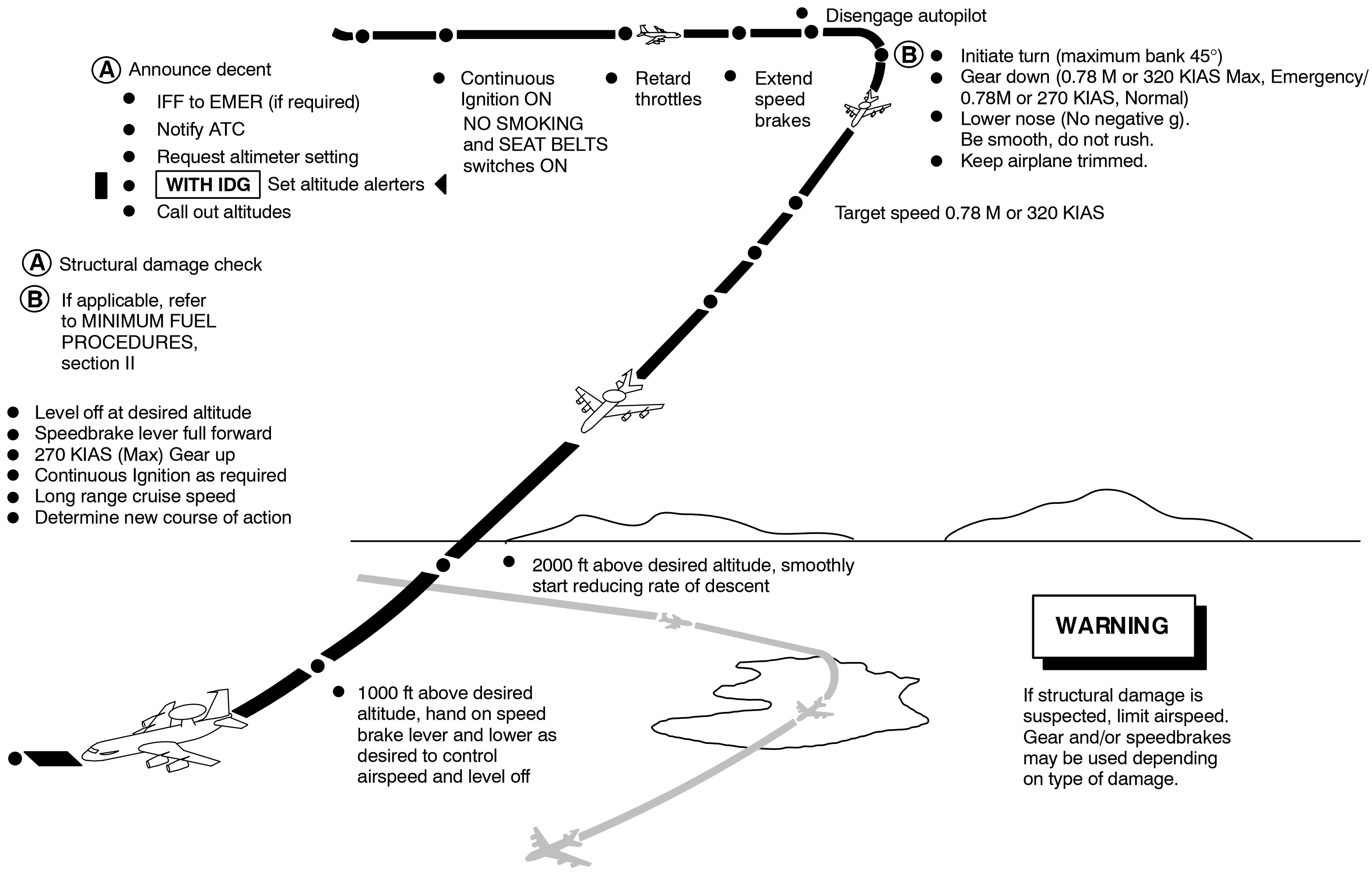
- Refer to T.O. 1E-3A-1-1 Part VI for information on descent rate, time to descend, and distance covered during descent.
- Notify ATC of descent, set IFF as required, obtain current low altitude altimeter setting. Navigator will monitor terrain clearance.

(1.) Structural Damage – Checked (P, MCC)

2. SEAT BELTS and NO SMOKING Signs – ON (E)

3. CONTINUOUS IGNITION Switch – ON (E)

Rapid Descent



WARNING

If structural damage is suspected, limit airspeed. Gear and/or speedbrakes may be used depending on type of damage.

Figure 3-11

– – – When MCC Report Crew Ready For Descent – – –

4. Throttles – Idle (P)

CAUTION

If surveillance radar is on, observe limits in Section V.

5. Speedbrakes – Up (P)

If structural integrity is in doubt, reduce speed as much as possible. Disengage autopilot, if engaged. Do not let the airplane climb while decelerating.

6. Gear Lever – DN (CP)

NOTE

- For crew comfort and to prevent possible damage due to negative g loads, initiate a turn while starting descent. Do not exceed 45° bank angle or 20° nose down pitch attitude.
- Target airspeed is 0.78M/320 KIAS. When 10 KIAS below target speed, start applying back pressure on control column. Keep airplane in trim. Reduce nose down angle as altitude decreases to maintain target speed.
- The target speed for the descent is the same as the emergency extension limit for the landing gear. The gear may be extended at any speed up to 320 KIAS or 0.78 Mach for emergency descent. Under normal conditions decrease airspeed to 270 KIAS before extending landing gear.
- If the landing gear is extended at speeds above 270 KIAS, the nose gear doors do not always close completely. The DOOR warning light remains illuminated until the doors close when speed is below 270 KIAS.
- Reduce airspeed to 270 KIAS before retracting gear.

HYDRAULIC SYSTEMS MALFUNCTION

Utility System High Pressure

If a pump output pressure is 3,500 psi or higher, shut down the affected pump. If both pumps are inoperative refer to UTILITY HYDRAULIC SYSTEM LOSS checklist.

NOTE

If only one pump is operating, do not operate flaps hydraulically when rotodome drive is in XMIT (6 RPM). High fluid demand can exceed the capacity of one pump at low engine RPM, causing slower operation of flaps and landing gear.

Utility System Low Pressure

If a single pump output pressure goes below 2,000 psi, check that the circuit breakers are closed. Shut down the affected pump. If both pumps indicate lower than normal pressure, immediately check the hydraulic quantity gage. If a leak is indicated, depressurize the utility hydraulic pumps and proceed to the HYDRAULIC SYSTEMS LEAK ISOLATION checklist. If a leak is not indicated, attempt to reduce the load on the system. If system pressure remains below normal, system may be contaminated. Depressurize the system. Refer to UTILITY HYDRAULIC SYSTEM LOSS checklist. (If system depressurization is not practical, system can be operated, but further damage can result.)

NOTE

- If only one pump is operating, do not operate flaps hydraulically when rotodome is at XMIT (6 RPM). High fluid demand can exceed the capacity of one pump at low engine RPM, causing slower operation of flaps and landing gear.
- If operation of the system is required and system pressure decreases to approximately 1300 (±50) psi, a priority valve closes, preventing hydraulic operation of trailing edge flaps.

Auxiliary System High Pressure

If auxiliary system pressure gage indicates 3,500 psi or higher, shut down the No 2 auxiliary pump. If pressure returns to normal, leave the No 2 pump off unless needed for safety of flight (switch to utility rotodome drive to reduce load on pump). If system pressure remains high after shutdown of No 2 pump, verify No 1 pump pressure by opening slipway doors and referring to the air refueling accumulator pressure gage. If pressure remains high, turn on the No 2 pump and shut down the No 1 pump (switch to utility rotodome drive). If system pressure remains high after verifying gage pressures, depressurize system if not needed for safe flight. Refer to AUXILIARY HYDRAULIC SYSTEM LOSS checklist.

NOTE

- Landing distance increases and crosswind capability is reduced with inboard spoilers inoperative. Refer to part VII of T.O. 1E-3A-1-1.
- System pressure may indicate up to 3,500 psi during speed brake operation above 200 KIAS due to spoiler blowdown.

Auxiliary System Low Pressure

If low pressure is detected, immediately check the hydraulic quantity gage. If a leak is indicated, depressurize the auxiliary system, and perform the HYDRAULIC SYSTEMS LEAK ISOLATION checklist.

If the No 1 PRESS caution light illuminates (with No 2 pump operating), check circuit breakers for that pump are closed (P61-4 panel). Check system pressure by either opening slipway doors and observing air refueling accumulator pressure gage or by turning off No 2 pump momentarily. If pressure is above 1,200 psi, the pressure switch for the light is defective. If pump No 1 pressure is below 2,000 psi and no leak is indicated, shut off No 1 pump. Refer to AUXILIARY HYDRAULIC SYSTEM LOSS checklist.

NOTE

- If No 1 pump is inoperative, only rudder boost and brake interconnect can be operated.
- Landing distance increases and crosswind capability is reduced with inboard spoilers inoperative. Refer to part VII of T.O. 1E-3A-1-1.

If the No 2 PRESS caution light illuminates (with No 1 pump operating), check circuit breakers for that pump are closed (P61-4 panel). Check system pressure by turning off No 1 pump momentarily. Coordinate with the pilot prior to turning off No 1 pump. If pressure is above 1,200 psi, the pressure switch for the light is defective. If pump No 2 pressure is below 2,000 psi and no leak is indicated, shut off No 2 pump. Switch to utility rotodome drive to reduce load on pump.

If both pumps are inoperative, proceed to AUXILIARY HYDRAULIC SYSTEM LOSS checklist.

If system pressure is low, attempt to reduce the load on the system. If reducing the load has no effect, the system should be shut down. Refer to AUXILIARY HYDRAULIC SYSTEM LOSS checklist. If system operation is required and the pressure drops below 2,200 ± 100 psi, the auxiliary rotodome drive, the normal slipway door system, and the APU accumulator recharging line are cut off from the rest of the auxiliary system by a priority valve.

Hydraulic Systems Leak Isolation

A fast leak isolates itself to either the utility or auxiliary system, because loss of only a small percentage of the total fluid quantity causes the hydraulic quantity gage to fall below the 3.2 gallon level (auxiliary replenishing level).

NOTE

- If at any time the hydraulic quantity gage is observed at the 3.2 gallon level and the PRESS caution lights for the auxiliary hydraulic pumps are illuminated, restore utility system, then proceed to the AUXILIARY HYDRAULIC SYSTEM LOSS checklist.
- If at any time the hydraulic quantity gage is observed at the zero level and the PRESS caution lights for the utility hydraulic pumps are illuminated, restore auxiliary system, then proceed to the UTILITY HYDRAULIC SYSTEM LOSS checklist.

Auxiliary hydraulic system leaks also isolate to either the No 1 or No 2 pump loops. This condition is indicated by decreasing quantity and a pump PRESS caution light illuminating. A leak in the No 2 pump loop can deplete fluid supply to the No 1 pump, causing loss of that pump.

NOTE

> A leak between the utility reservoir and utility pumps or between the utility reservoir and the No 1 auxiliary reservoir causes loss of bleed air pressure in the reservoirs. Large auxiliary system loads can cause the auxiliary No 1 PRESS caution light to illuminate because of reduced fluid supply to the pumps.

a. The following supply or return leaks are not controllable from the flight deck:

   In the utility system: A leak in the return lines to the reservoir, the reservoir, or the supply lines to the shutoff valves continues with both engine driven utility pump switches off (pumps depressurized) and both supply shutoff valves closed and depletes the utility system. With both pumps still operating, the loss continues until the utility system is depleted or until one or both utility system pump low pressure caution lights illuminate, indicating system loss. Proceed to UTILITY HYDRAULIC SYSTEM LOSS checklist.

   In the auxiliary system: A leak in the return lines to the auxiliary reservoirs, the reservoirs, or the supply lines to the auxiliary pumps cause the utility hydraulic quantity indicator to show a loss to the 3.2 gallon level. With both auxiliary pumps off, the loss continues until the system is depleted; or, with the pumps still operating, the loss continues from the auxiliary system until one or both auxiliary pump low pressure caution lights illuminate indicating system loss. Proceed to AUXILIARY HYDRAULIC SYSTEM LOSS checklist.

NOTE

> If the leak is in the return to the No 1 auxiliary reservoir or between reservoir and No 1 auxiliary pump, the No 2 auxiliary system can be used for rudder boost operation.

b. The following system leaks are controllable from the fight deck:

   A utility system leak between the supply shutoff valves and the pumps. The leak stops with both shutoff valves closed. After determining which side the leak is on, the other shutoff valve can be opened and its associated pump operated to restore utility system operation.

CAUTION

> Operation of engine driven hydraulic pumps with fluid shutoff valve OFF for more than 5 minutes can damage pumps.

   A distribution leak is sometimes controllable with one pump off. The other pump and all the subsystem components can be operated at slightly reduced capability if fluid remains in that system reservoir. A leak between the pump isolation check valve and the valves in distribution lines to the individual components is controllable only with both UTILITY PUMP switches set to OFF.

   With a leak in a subsystem downstream of its shutoff or control valve, the leaking component can be isolated and both pumps and the remainder of the systems can be operated normally.

c. Troubleshooting slow hydraulic leaks requires crew coordination along with basic system knowledge. If a system component can be identified positively as leaking, shut down that system. If the source of the leak cannot be identified, perform the entire HYDRAULIC SYSTEMS LEAK ISOLATION checklist.

WARNING

While performing the HYDRAULIC SYSTEMS LEAK ISOLATION checklist above 10,000 ft, maintain airspeed above best endurance airspeed. Below 10,000 ft, with flaps extended, maintain airspeed above rudder boost off V_{MCA} When thrust is set for straight and level flight, both best endurance airspeed above 10,000 ft and rudder boost off V_{MCA} below 10,000 ft ensure the airplane can maintain directional control with one inoperative engine.

NOTE

- The HYDRAULIC SYSTEMS LEAK ISOLATION checklist is used if the hydraulic quantity is greater than 3.2 gallons and decreasing, and the source of the leak cannot be identified. This checklist isolates the leaking component(s) of a particular system or isolates leaks in both systems caused by major component failures.
- Check the hydraulic quantity gage circuit breaker (GAGES QTY, P61-4) prior to initiating this checklist.
- If a hydraulic pump PRESS caution light illuminates, shut that pump off and check that pump's circuit breaker. If both PRESS caution lights in that system illuminate, shut off both pumps and proceed to the appropriate system LOSS checklist.

Hydraulic Systems Leak Isolation Checklist

1. Control Wheel – Neutral (P)

   Removes roll control inputs to spoilers. Complete steps 1, 2 and 3 as quickly as possible. Hold control wheel neutral until step 3 is complete.

2. SPEED BRAKE Lever – Full Forward, In Detent (P)

   With pressure still available, locks spoilers down, preventing spoiler float due to airflow.

3. SPOILERS Switches – OFF (P)

   Isolates spoilers as leak source. Prevents airflow or control action from raising spoilers.

NOTE

If the spoilers are not locked down and either or both the utility and auxiliary hydraulic systems lose pressure during a bank, the airplane may start an uncommanded roll out of the bank.

– – – If Leak Continues, Proceed To Step 4 – – –

– – – If Leak Stops, Proceed To Step 39 – – –

④ ROTODOME DRIVE System Select Switch – AUX (E, MCC)

Provides for rotodome drive operation while utility pumps are off.

CAUTION

If changing drives with rotodome rotating, set SPEED switch to OFF and wait 10 seconds before selecting other system. SPEED switch must not remain OFF. Notify MCC when changing drives.

5. ENGINE NO 2 and ENGINE NO 3 PUMP Switches – OFF (E)

   Isolates pumps as leak source. If leak stops, it is downstream of the utility pumps. If the leak continues, it is in the auxiliary system or utility reservoir or the lines to the utility system pumps. Slow leaks can take several minutes to show decreasing quantity.

6. ENGINE NO 2 and ENGINE NO 3 FLUID SHUTOFF Switches – OFF (E)

   If the leak continues, it is in either the utility hydraulic system reservoir and cannot be controlled or the auxiliary system. If the leak stops, it is between the fluid shutoff valves and the pumps or in the pumps. Slow leaks can take several minutes to show a change in quantity.

   CAUTION

   Operation of engine driven hydraulic pumps with the associated fluid shutoff valve OFF for more than 5 minutes can damage pumps.

– – – If Leak Continues, Leak is in the Auxiliary System; Or is an Uncontrollable Leak In the Utility System: Proceed to Step 7 – – –

– – – If Leak Stops, Proceed to Step 22 – – –

7. ENGINE NO 2 and ENGINE NO 3 FLUID SHUTOFF Switches – ON (E)
8. ENGINE NO 2 and ENGINE NO 3 PUMP Switches – ON (E)

   Repressurizes utility system.

(9.) ROTODOME DRIVE System Select Switch – UTIL (E, MCC)

   CAUTION

   If changing drives with rotodome rotating, set SPEED switch to OFF and wait 10 seconds before selecting other system. SPEED switch must not remain OFF. Notify MCC when changing drives.

10. OUTBOARD SPOILERS Switch – ON (E)
11. Auxiliary Rotodome Shutoff Switch – OFF (E)

    Isolates auxiliary rotodome drive and APU as leak sources.

12. Auxiliary Pump No.1 Switch – OFF (E

    Depressurizes the auxiliary system, except for rudder boost.

– – – If Leak Continues, Proceed to Step 13 – – –

– – – If #2 Auxiliary Pump is Already Inoperative, Proceed to Step 14 – – –

– – – If Leak Stops, Proceed to Step 17 – – –

13. Auxiliary Pump No 2 Switch – OFF (E)

    Depressurizes pump and rudder control system (rudder boost).

    WARNING

    - While performing the HYDRAULIC SYSTEMS LEAK ISOLATION checklist above 10,000 ft, maintain airspeed above best endurance airspeed. Below 10,000 ft, with flaps extended, maintain airspeed above rudder boost off V_{MCA}. When thrust is set for straight and level flight, both best endurance airspeed above 10,000 ft and rudder boost off V_{MCA} below 10,000 ft ensures the airplane can maintain directional control with one inoperative engine.
    - The autopilot and series yaw damper disengage. Observe yaw damper inoperative limitations or engage parallel yaw damper. Yaw damping is degraded with parallel yaw damper and manual rudder.

14. RUDDER Switch – OFF (P)

    Isolates rudder as leak source. Auxiliary system pressure gage drops to zero.

15. Series Yaw Damper Switch – OFF (P)
16. PARALLEL Yaw Damper Switch – ON (P)

    Provides yaw damping when rudder boost and series yaw damper are off and allows autopilot operation.

    CAUTION

    If parallel yaw damper does not engage or is inoperative, observe yaw damper inoperative limitations in section V.

17. Auxiliary Pump No 1 Switch – ON (E)

– – – If Leak Starts, Proceed to Step 18 – – –

– – – If No Leak Apparent, Proceed to Step 19 – –

18. Auxiliary Pump No 1 Switch – OFF (E)

NOTE

Landing distance is increased and crosswind capability is reduced with inboard spoilers inoperative. Refer to T.O. 1E-3A-1-1.

– – – Proceed to Step 43 – – –

19. Auxiliary Rotodome Shutoff Switch – ON (E)

Pressurizes lines to auxiliary rotodome drive and APU.

– – – If Leak Starts, Proceed to Step 20 – – –

– – – If No Leak Apparent, Proceed to Step 21 – –

20. Auxiliary Rotodome Shutoff Switch – OFF (E)

– – – Auxiliary Rotodome Drive and APU Accumulator Recharger Line is Isolated. Proceed to Step 41 – – –

21. Rudder Switch – ON (P)

WARNING

When setting RUDDER switch to ON in flight, ensure rudder and rudder trim are in neutral (centered) position. This is to prevent excessive structural loads caused by rapid increase in rudder deflection and to maintain airplane control during the transition to powered rudder.

– – – If Leak Starts, Set Rudder Switch to OFF. Proceed to Step 41 – – –

– – – If No Leak Apparent, Leak is in the Number Two Auxiliary Pump (Re-engage Series Yaw Damper). Proceed to Step 41 – – –

22. Utility Rotodome Shutoff Switch – OFF (E)

Isolates utility rotodome drive as leak source.

23. Interconnect Valve Switch – OFF (E)

Isolates utility and auxiliary systems.

24. EMERGENCY FLAP Arming Switch – ON (CP)

This switch only bypasses the flap motor. It does not shut off the flap control valve. A leak downstream of the flap bypass valve is not affected by this switch action.

25. Gear Lever – OFF (CP)

Isolates gear, nose gear steering, and alternate air refueling systems as leak sources.

26. ENGINE NO 3 FLUID SHUTOFF Switch – ON (E)

– – – If Leak Starts, Proceed to Step 27 – – –

– – – If No Leak Apparent, Proceed to Step 28 – – –

27. ENGINE NO 3 FLUID SHUTOFF Switch – OFF (E)

Engine No 3 pump is inoperative.

– – – Proceed to Step 30 – – –

28. ENGINE NO 3 PUMP Switch – ON (E)

– – – If Leak Starts, Proceed to Step 29 – – –

– – – If No Leak Apparent, Proceed to Step 30 – – –

29. ENGINE NO 3 PUMP Switch – OFF (E)

ENGINE NO 3 pump is inoperative.

30. ENGINE NO 2 FLUID SHUTOFF Switch – ON (E)

– – – If Leak Starts, Proceed to Step 31 – – –

– – – If No Leak Apparent, Proceed to Step 32 – – –

31. ENGINE NO 2 FLUID SHUTOFF Switch – OFF (E)

Engine No 2 pump is inoperative.

– – – If No 3 Pump is Operative, Proceed to Step 34 – – –

– – – If No 3 Pump is Inoperative, Utility Hydraulic System is Inoperative. Proceed to Step 41 – – –

32. ENGINE NO 2 PUMP Switch – ON (E)

– – – If Leak Starts, Proceed to Step 33 – – –

– – – If No Leak Apparent, Proceed to Step 34 – – –

33. ENGINE NO 2 PUMP Switch – OFF (E)

    Engine No 2 pump is inoperative.

– – – If No 3 Pump is Inoperative, Utility Hydraulic System is Inoperative. Proceed To Step 41 – – –

34. Utility Rotodome Shutoff Switch – ON (E)

    Pressurizes lines to utility rotodome drive.

– – – If Leak Starts, Proceed to Step 35 – – –

– – – If No Leak Apparent, Proceed to Step 36 – – –

35. Utility Rotodome Shutoff Switch – OFF (E)

    Utility rotodome drive inoperative.

36. EMERGENCY FLAP Arming Switch – OFF (CP)

    Pressurizes the flap motor. Restores normal flap operation.

– – – If Leak Starts, Proceed to Step 37 – – –

– – – If No Leak Apparent, Proceed to Step 38 – – –

37. EMERGENCY FLAP Arming Switch – ON (E)

    Hydraulic flap operation is inoperative. Electric flap operation is required. LE FLAPS extend normally if pressure is available.

38. GEAR Lever – As Required (CP)

NOTE

- If leak occurred with gear lever set to UP, leak is in gear-up lines or alternate air refueling system. If gear is down, leave gear down and use normal air refueling if required. Flight planning fuel reserves are calculated for a clean airplane. With landing gear extended, fuel consumption is increased by 50% (endurance is reduced by 33%) compared to values shown in part V of T.O. 1E-3A-1-1.

- If leak occurred with gear lever set to DOWN, leak is in gear lines or nose gear steering. Use MANUAL GEAR EXTENSION procedures.

- If leak occurred with gear lever set to OFF (regardless of gear position), source of leak is either upstream of landing gear valves or lines to brakes and is uncontrollable. Utility pumps must remain off to control the leak.

39. Outboard Spoiler Switch – ON (P)

    Actuate control wheel to move fluid through spoiler actuators.

– – – If Leak Starts, Proceed to Step 40 – – –

– – – If No Leak Apparent, Proceed to Step 41 – – –

40. Outboard Spoiler Switch – OFF (P)

NOTE

Landing distance is increased and crosswind capability is reduced with outboard spoilers inoperative. Refer to T.O. 1E-3A-1-1.

41. Inboard Spoiler Switch – ON (P)

    Actuate control wheel to move fluid through spoiler actuators.

– – – If Leak Starts, Proceed to Step 42 – – –

– – – If No Leak Apparent, Proceed to Step 43 – – –

42. Inboard Spoiler Switch – OFF (P)

NOTE

Landing distance is increased and crosswind capability is reduced with inboard spoilers inoperative. Refer to T.O. 1E-3A-1-1.

43. Hydraulic Systems and Quantity – Checked (P, CP, E)

    Pilots and flight engineer will review current status of hydraulic systems and check hydraulic quantity is sufficient for remainder of mission, as well as review landing requirements with inoperative equipment.

***** If Auxiliary Hydraulic System or Rudder Boost Is Inoperative, Proceed To The AUXILIARY HYDRAULIC SYSTEM LOSS Checklist *****

***** If Utility Hydraulic System Is Inoperative, Proceed To The UTILITY HYDRAULIC SYSTEM LOSS Checklist *****

***** Resume Normal Operation With Leaking Components Isolated *****

Utility Hydraulic System Loss

With the utility hydraulic system failed, leading edge flaps, outboard spoilers and nose wheel steering are inoperative. Landing gear must be extended manually and cannot be retracted in case of a go-around. Flaps must be extended and retracted electrically. Normal antiskid braking is available as long as the brake pressure gage indicates more than precharge pressure. See *figure 3-12*.

NOTE

- Hydraulic failures on the pump side of the brake isolation check valves have no effect on brake operation as long as the brake accumulator is pressurized above precharge. The auxiliary system can be used for brake operation through the interconnect valve.
- If the spoilers are not locked down and either or both the utility and auxiliary hydraulic systems lose pressure during a bank, the airplane can start an uncommanded roll out of the bank.
- If brake accumulator is pressurized to 3,000 psi, approximately 8 brake application and release cycles can be made; or one continuous application for approximately 30 seconds. If brake accumulator is pressurized to 1,200 psi, approximately four brake application and release cycles can be made; or one continuous application for approximately 10 seconds.

– – – If HYDRAULIC SYSTEMS LEAK ISOLATION Checklist Has Been Performed, Perform Only Applicable Items Of This Checklist – – –

1. Control Wheel – Neutral (P)

   Removes roll control inputs to spoilers. Complete steps 1, 2 and 3 as quickly as possible. Hold wheel neutral until step 3 is completed.

2. SPEED BRAKE Lever – Full Forward, In Detent (P)

   Lowers speed brakes, if extended, and if fluid pressure is still available, locks spoilers down, preventing spoiler float due to airflow.

3. Outboard SPOILERS Switch – OFF (P)

   Locks outboard spoilers down to prevent spoiler float during approach or go-around. Leave switch off for remainder of flight.

NOTE

If the spoilers are not locked down and either or both the utility and auxiliary hydraulic systems lose pressure during a bank, the airplane can start an uncommanded roll out of the bank.

– – – If Both Spoiler Switches Were Turned Off From Previous Checklist, Turn Inboard Switch On – – –

4. Interconnect Valve Switch – OFF (E)

   Isolates systems.

NOTE

If system interconnect valve is open, auxiliary system could be drained through a leak in utility system.

5. Rotodome Drive System Select Switch – AUX (E)

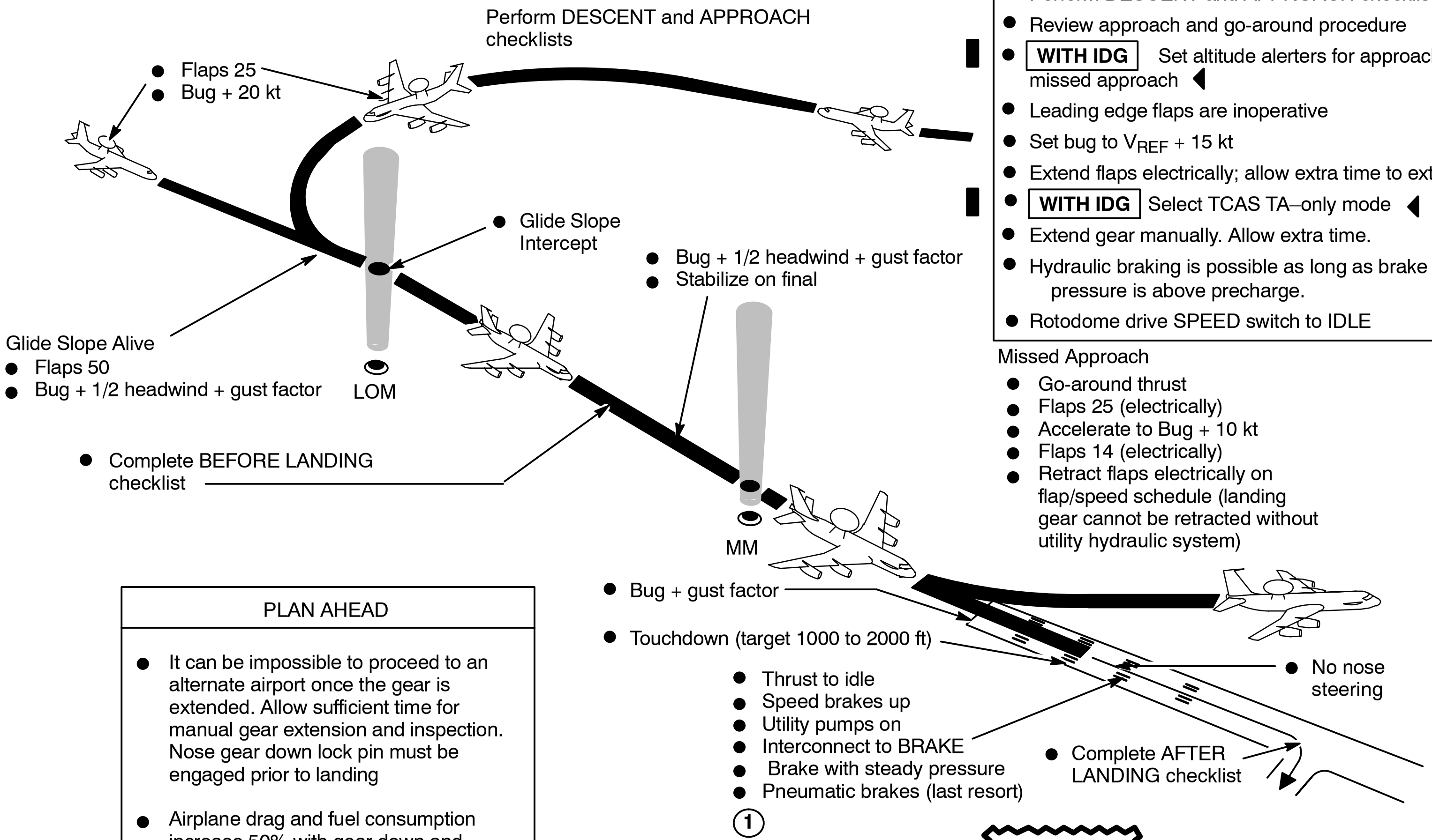
CAUTION

If changing drives with rotodome rotating, set SPEED switch to OFF and wait 10 seconds before selecting other system. Then set SPEED switch to IDLE unless radar operation is required to complete mission.

Landing With Utility Hydraulic System Loss

APPROACH PREPARATIONS

- Check weather
- Perform DESCENT and APPROACH checklists
- Review approach and go-around procedure
- **WITH IDG** Set altitude alerters for approach and missed approach ◀
- Leading edge flaps are inoperative
- Set bug to V_{REF} + 15 kt
- Extend flaps electrically; allow extra time to extend
- **WITH IDG** Select TCAS TA–only mode ◀
- Extend gear manually. Allow extra time.
- Hydraulic braking is possible as long as brake pressure is above precharge.
- Rotodome drive SPEED switch to IDLE



Perform DESCENT and APPROACH checklists

- Flaps 25
- Bug + 20 kt

Glide Slope Alive
- Flaps 50
- Bug + 1/2 headwind + gust factor

- Glide Slope Intercept

- Complete BEFORE LANDING checklist

- Bug + 1/2 headwind + gust factor
- Stabilize on final

Missed Approach
- Go-around thrust
- Flaps 25 (electrically)
- Accelerate to Bug + 10 kt
- Flaps 14 (electrically)
- Retract flaps electrically on flap/speed schedule (landing gear cannot be retracted without utility hydraulic system)

- Bug + gust factor
- Touchdown (target 1000 to 2000 ft)

- Thrust to idle
- Speed brakes up
- Utility pumps on
- Interconnect to BRAKE
- Brake with steady pressure
- Pneumatic brakes (last resort)

①

- No nose steering

- Complete AFTER LANDING checklist

PLAN AHEAD

- It can be impossible to proceed to an alternate airport once the gear is extended. Allow sufficient time for manual gear extension and inspection. Nose gear down lock pin must be engaged prior to landing
- Airplane drag and fuel consumption increase 50% with gear down and doors open. Endurance is reduced by 33%. (Part V, T.O. 1E-3A-1-1).

CAUTION

① If pneumatic brakes are used, either close gear doors with interconnect or have maintenance close doors. If tires deflate, doors can be damaged.

WITH IDG **NOTE**

VSI displays ONLY TA. This prevents TCAS from coordinating an RA with other TCAS equipped aircraft and inhibits RAs from being issued by own TCAS. ◀

Figure 3-12

6. UTILITY ENGINE NO 2 PUMP and NO 3 PUMP Switches – OFF (E)

NOTE

- Before starting descent, check destination weather. If weather is marginal, consider diverting to an alternate base before extending landing gear. Landing gear cannot be retracted if extended manually.
- Flight planning fuel reserves are calculated for a clean airplane. With landing gear extended and doors open, fuel consumption is increased by 50% (endurance is reduced by 33%) compared to values shown in T.O. 1E-3A-1-1 Part V.

Perform normal DESCENT, APPROACH, and BEFORE LANDING checklists with these exceptions:

a. Landing distance is increased and crosswind capability is reduced with outboard spoilers inoperative. Refer to T.O. 1E-3A-1-1 Part VII.

b. If normal brake pressure is available, compute landing distance using normal antiskid brakes. If normal brake pressure is lost, compute landing distance using pneumatic brakes. Refer to T.O. 1E-3A-1-1 Part VII.

c. BUG = V_{REF} + 15 knots

Add 15 knots for inoperative leading edge flaps.

WARNING

Do not use the AOA indicator with any leading edge flaps inoperative. AOA readings can be unreliable in this condition.

d. **WITH IDG** When ready to begin manual gear extension select TCAS TA–only mode. VSI displays ONLY TA. This prevents TCAS from coordinating an RA with other TCAS equipped aircraft and inhibits RAs from being issued by own TCAS. ◀

e. Allow time for manual gear extension and alternate flap operation (refer to subsection I-H).

CAUTION

If utility hydraulic system failure occurs after normal gear extension, perform nose gear, MANUAL GEAR EXTENSION procedure to install emergency lock pin.

f. Set interconnect valve switch to BRAKE after touchdown to allow auxiliary pumps to pressurize brakes.

g. If desired, utility pumps may be turned on to pressurize the system after the nose wheel is on the ground and speed brakes have been deployed. Verify fluid shutoff valves are open.

NOTE

When the utility system is repressurized, remaining fluid may partially or fully deploy leading edge flaps. Deployment of leading edge flaps can cause the aircraft to temporarily float if extended prior to nose wheel touchdown, and may increase the total landing distance. Partial deployment of leading edge flaps can also lead to uncommanded rolling. Crews should be aware of and brief this procedure thoroughly prior to the approach.

h. Hold nose gear steering wheel steady after touchdown. Nose gear shimmy damping is lost, since nosewheel steering is depressurized.

Rudder Boost OFF Landing

Perform AUXILIARY HYDRAULIC SYSTEM LOSS checklist.

Auxiliary Hydraulic System Loss

This checklist is used either in case of loss of rudder boost, failure of auxiliary pump No 1, or failure of the entire auxiliary hydraulic system. See *figure 3-13*.

– – – If Auxiliary Hydraulic System is Inoperative, Perform Entire Checklist – – –

– – – If HYDRAULIC SYSTEMS LEAK ISOLATION Checklist Has Been Performed, Perform Only Applicable Items of This Checklist – –

– – – If Only Rudder Boost is Inoperative, Proceed to Step 6 – – –

– – – If Only Auxiliary Pump No 1 is Inoperative, Perform Steps 1 through 6 Only – – –

1. Control Wheel – Neutral (P)

   Removes roll control input to spoilers. Accomplish steps 1, 2, and 3 as quickly as possible. Hold wheel neutral until step 3 is completed.

2. SPEED BRAKE Lever – Full Forward, In Detent (P)

   With pressure still available, locks spoilers down, preventing spoiler float due to airflow.

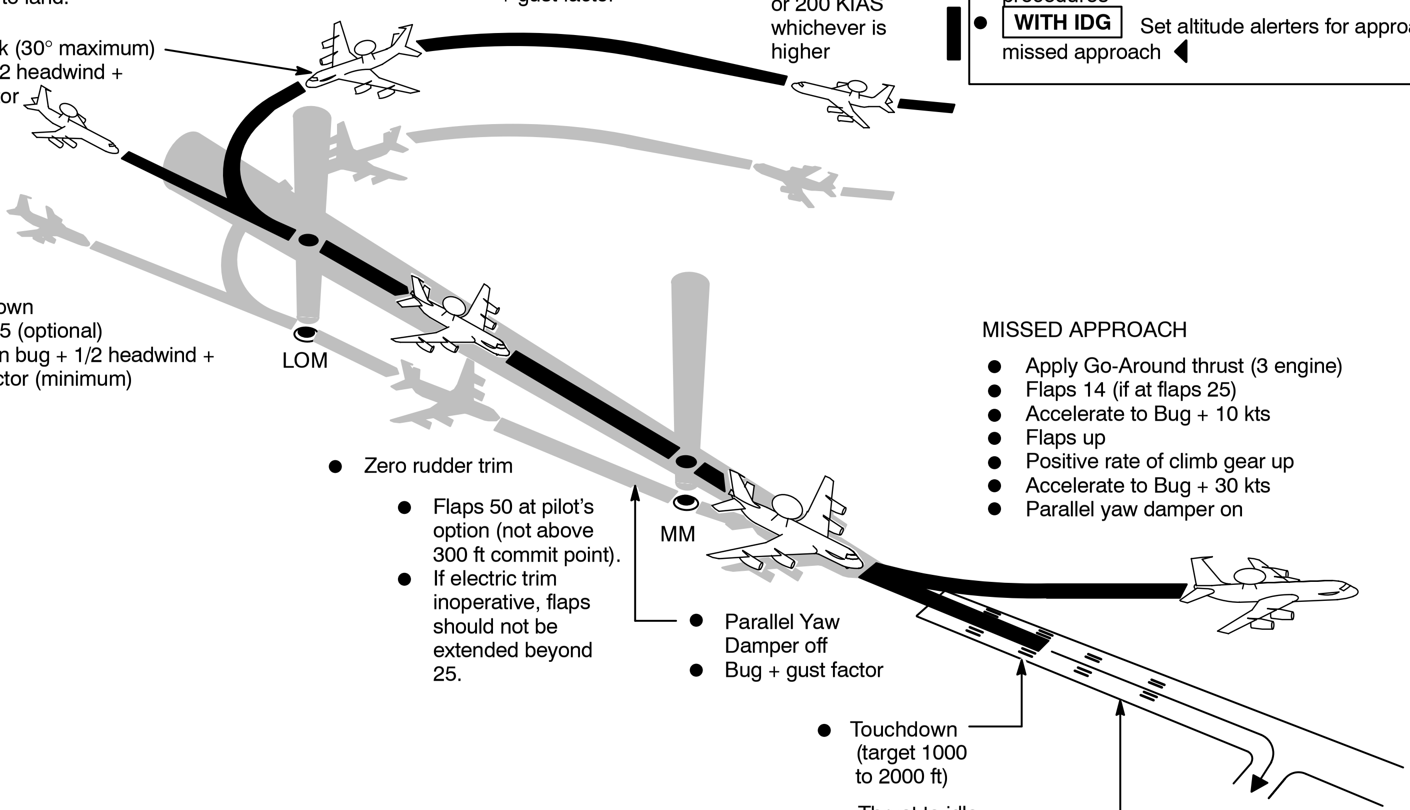
Auxiliary Hydraulic System Loss

WARNING

- With one outboard engine inoperative and rudder boost inoperative, limit outboard engine EPR per T.O. 1E-3A-1-1. Maintain airspeed of no less than V_{REF} + 30 knots until landing is assured.
- With one engine inoperative, retract flaps to 14 for go-around. Climb data for flaps 25, rudder boost off, is not available. Also, go-around is not possible when flaps are extended beyond 25. Do not attempt go-around when committed to land.

APPROACH PREPARATIONS

- Complete ENGINE FAILURE OR FIRE or PRECAUTIONARY ENGINE SHUTDOWN checklist (if required) and AUXILIARY HYDRAULIC SYSTEM LOSS checklists
- Dump fuel if required
- Complete DESCENT and APPROACH checklists
- Landing data for planned flap setting T.O. 1E-3A-1-1
- Set bug to V_{REF} + 30 kts
- Review approach, minimum fuel, and go-around procedures
- **WITH IDG** Set altitude alerters for approach and missed approach ◀



- Clean
- Bug + 30 kts or 200 KIAS whichever is higher

- Flaps 14
- Airspeed decreasing to bug + 1/2 headwind + gust factor

- 25° bank (30° maximum)
- Bug + 1/2 headwind + gust factor

- Gear down
- Flaps 25 (optional)
- Maintain bug + 1/2 headwind + gust factor (minimum)

- Zero rudder trim

- Flaps 50 at pilot's option (not above 300 ft commit point).
- If electric trim inoperative, flaps should not be extended beyond 25.

- Parallel Yaw Damper off
- Bug + gust factor

- Touchdown (target 1000 to 2000 ft)

- Thrust to idle
- Speed brakes up
- Braking as required

MISSED APPROACH

- Apply Go-Around thrust (3 engine)
- Flaps 14 (if at flaps 25)
- Accelerate to Bug + 10 kts
- Flaps up
- Positive rate of climb gear up
- Accelerate to Bug + 30 kts
- Parallel yaw damper on

Figure 3-13

3. Inboard SPOILERS Switch – OFF (P)

   Locks inboard spoilers down to prevent spoiler float during approach or go-around. Leave switch off for remainder of flight.

– – – If Both Spoiler Switches Were Turned Off From Previous Checklist, Turn Outboard Switch On – – –

NOTE

If the spoilers are not locked down and either or both the utility and auxiliary hydraulic systems lose pressure during a bank, the airplane can start an uncommanded roll out of the bank.

4. Interconnect Valve Switch – OFF (E)

   Isolates systems.

NOTE

If system interconnect valve is open, utility system could be drained through a leak in auxiliary system.

5. ROTODOME DRIVE System Select Switch – UTIL (E)

CAUTION

- If changing drives with rotodome rotating, set SPEED switch to OFF and wait 10 seconds before selecting other system. Speed switch must not remain OFF. Notify MCC when changing drives.
- If auxiliary drive inoperative, select utility drive and IDLE, unless surveillance radar operation is required.

NOTE

Steps 6, 7, 8 and 9 may be completed before completing step 5.

6. AUXILIARY PUMPS No 1 and No 2 Switches – As Required (E)

   OFF if entire auxiliary system lost. No 2 OFF if rudder boost lost.

7. SERIES Yaw Damper Switch – OFF (P)

8. PARALLEL Yaw Damper Switch – On As Required (P)

CAUTION

If parallel yaw damper is inoperative, observe yaw dampers inoperative limitation in section V.

9. RUDDER Switch – OFF (P)

NOTE

- Yaw damping is degraded with rudder boost OFF and parallel yaw damper ON. If airplane response is not satisfactory, observe yaw damper inoperative limitations in section V.
- Rudder response to pedal pressure varies during final approach, landing flare and rollout. After touchdown, as air loads decrease, rudder response increases significantly when the tab is fully deflected and additional rudder pedal movement moves the rudder directly, instead of moving the tab. Also, at low airspeeds there is an apparent lag in response to pedal movement due to the small force generated by the tab and resulting longer time for a given rudder deflection to occur. Avoid overcontrolling, especially on crosswind landing and rollout.

Perform normal DESCENT, APPROACH, BEFORE LANDING, and ENGINE SHUTDOWN checklists with the following exceptions (*figure 3-13*):

WARNING

- Pattern and approach airspeeds are based on air minimum control speed for go-around thrust. (Refer to section VI.) If a go-around is required, do not increase thrust above go-around EPR and do not allow airspeed to decrease below bug speed. If airspeed is below bug speed or thrust is above go-around EPR, directional control cannot be maintained with full rudder and five degrees of bank. To maintain directional control, either increase bank or decrease thrust. Climb performance decreases if bank is increased or thrust decreased. To increase airspeed, decrease climb angle.

- When flaps are extended beyond 25, airplane is committed to land.

- Do not decrease airspeed below V_{REF} + 30 kt until airplane is committed to land.

a. With auxiliary hydraulic system inoperative, rudder boost, series yaw damper, inboard spoilers and normal air refueling hydraulic system are lost.

b. Landing distance increases and crosswind capability is reduced with inboard spoilers inoperative. Refer to part VII of T.O. 1E-3A-1-1.

c. Check maximum allowable crosswind and the normal brake energy limited landing weight (T.O. 1E-3A-1-1). If the landing weight exceeds the chart values for flaps 14 or 25, the pilot may lower the flaps to 50 when committed (but not above 300 feet AGL) to landing or reduce landing weight by dumping fuel during descent. Airplane is committed to land when flaps are extended beyond 25.

d. Bug speed is V_{REF} + 30 knots, to maintain airspeed above V_{MCA}.

e. EPR bugs are set to the go-around EPR for rudder boost off, flaps 14 (T.O. 1E-3A-1-1, part VII).

f. If auxiliary pump No 1 is inoperative, set inboard SPOILERS switch to OFF to prevent spoiler float.

g. Flaps may be extended to 25 for approach provided airspeed is maintained at or above bug speed until landing is assured. Airspeed may be reduced to flaps 25 speed when landing is assured, but not above 300 feet AGL. Retract flaps to 14 for go-around.

NOTE

If the spoilers are not locked down and either or both the utility and auxiliary hydraulic systems lose pressure during a bank, the airplane can start an uncommanded roll out of the bank.

h. At pilot’s discretion, extend flaps to 50 when landing is assured, but not above 300 feet AGL.

NOTE

- If flaps are to be extended to 50, prepare for the combined pitch trim effects of flap extension from 14 to 50, loss of 30 knots airspeed, possible thrust reduction, and entry into ground effect during last part of final approach and landing. Control column pull forces can be high enough to cause electric trim to stall. This can be prevented by early application of nose-up trim as flaps are extended. If electric trim stalls, control column forces can exceed one pilot effort.

- If electric trim is inoperative, flaps should not be extended beyond 25 for landing.

i. Disengage parallel yaw damper, set rudder trim to zero when landing assured, prior to 200 feet AGL.

j. Go-around procedure is:

(1) Use thrust as required for climb and directional control.

WARNING

With an outboard engine failed, do not exceed go-around power as loss of directional control can occur.

NOTE

- Go-around thrust is that thrust which results in an air minimum control speed equal to the no wind approach speed. Loss of directional control can result from:

  (a) Airspeed less than bug with go-around power set.

  (b Airspeed equal to bug with thrust set above go-around power.

- In any of these situations, directional control can be restored by decreasing thrust and/or increasing airspeed by decreasing climb angle. However, if climb performance is critical, thrust should not be decreased below go-around setting.

- When climb performance is critical, set go-around thrust, increase bank angle beyond 5 degrees (no more than 15°), and decrease climb angle until reaching bug speed. After bug speed is reached, reduce bank angle to five degrees maximum and allow climb angle to increase while maintaining at least bug speed.

(2) Retract flaps to 14 (if at 25).

WARNING

If one engine and rudder boost are inoperative, do not attempt a go-around if flaps are extended beyond 25. Climb data for flaps 25 with one engine and rudder boost inoperative is not available.

(3) Retract flaps at BUG + 10 knots.

(4) Gear up (when positive rate of climb).

(5) Accelerate to bug + 30 or 200 KIAS (whichever is higher).

(6) Parallel yaw damper on when power stabilized and altitude is at least 200 feet AGL.

k. If No 1 auxiliary pump is inoperative, have maintenance install nose gear lock-handle prior to inboard engine shutdown.

Rotodome Drive Malfunctions

The rotodome must be rotating when any engine is operating. If a drive fails in flight, select other drive immediately, allowing 10 seconds for drive clutch to disengage. If idle (1/4 RPM) cannot be selected for takeoff, landing or go-around, select utility drive.

WARNING

Do not operate auxiliary rotodome drive at 6 RPM (XMIT) during takeoff, landing or go-around.

LIQUID COOLING SYSTEM (EGW) LEAK

If a leak in the liquid cooling system is discovered in flight, perform the following procedure:

a. Do not operate visual warning signs until a check shows that EGW has not leaked into signs in lower aft compartment.

b. Inspect all equipment connected to LCS for leaks, loss of pressure, and for signs of EGW contamination of electrical equipment. If LCS system is holding pressure, and no electrical equipment appears contaminated, continue normal operation. Request ART to monitor LCS pressure for rest of flight.

c. If a leak is causing EGW system pressure drop, request ART to shut down surveillance radar and LCS pumps.

d. If evidence of electrical fire is seen, follow ELECTRICAL FIRE/SMOKE/FUMES procedure. Land as soon as practical.

e. If pressure is lost and there is no evidence of electrical fire, return immediately to base where LCS maintenance can be performed.

f. If an EGW leak is suspected in any fuel tank, turn on continuous ignition to prevent engine flameout.

OIL SYSTEM MALFUNCTIONS

Any of the malfunctions below will be corrected before next flight.

CAUTION

> If internal engine damage is suspected, perform ENGINE FAILURE OR FIRE checklist.

High Oil Pressure

Oil pressure indication up to 65 psi following rapid advance of throttles to takeoff or go-around power is acceptable provided oil pressure decreases to between 40 to 60 psi during climbout.

If the oil pressure exceeds 60 psi (under conditions other than rapid acceleration), reduce thrust until oil pressure returns within limits. Continue engine operation at reduced thrust as long as pressure remains within limits. Monitor other engine instruments for remainder of flight. If pressure remains above limit after reducing thrust, shut down engine using PRECAUTIONARY ENGINE SHUTDOWN checklist unless engine is needed for safe flight.

Engine Oil Pressure Caution Light Illuminated

If oil pressure caution light illuminates, check the oil pressure gage. If oil pressure is within the normal range, reduce thrust until oil pressure caution light goes out. Continue engine operation as long as the oil pressure caution light remains out. If oil pressure caution light does not go out after reducing thrust, shut down engine using the PRECAUTIONARY ENGINE SHUTDOWN checklist if not needed for safe flight. Oil pressure can decrease to 30 psi during rapid engine deceleration. This is acceptable if oil pressure increases to above 35 psi (caution light out) within 10 minutes. If oil pressure does not increase within 10 minutes or caution light does not go out when oil pressure increases, shut down engine using PRECAUTIONARY ENGINE SHUTDOWN checklist if not needed for safe flight.

Oil Pressure In Caution Zone

If oil pressure is stable in caution zone and other engine indications are normal, operate engine at minimum thrust required until completion of flight. Malfunction must be corrected prior to next flight. If oil pressure is fluctuating in caution zone or other engine instruments indicate abnormal engine operation, shut down engine using ENGINE FAILURE OR FIRE or PRECAUTIONARY ENGINE SHUTDOWN checklist if not needed for safe flight.

Oil Temperature

If oil temperature is approaching the caution zone (132°C to 165°C), check that fuel heat switch is OFF and that thrust has not been reduced. If fuel heat was on, or thrust has just been reduced, monitor oil temperature for one minute (decrease should be observed). If temperature does not decrease, increase thrust, if desired, to power setting used before thrust reduction or reduce thrust on that engine. (Oil temperature should increase then decrease.) If temperature returns within limits, operate engine at thrust level required to maintain temperature within limits. If temperature does not return within limits within 15 minutes, or exceeds 165°C, perform PRECAUTIONARY ENGINE SHUTDOWN checklist.

Low or Fluctuating Oil Quantity

A rapid decrease or a large fluctuation in indicated oil quantity alone is not an indication of a malfunction as long as oil pressure and temperature remain in limits. Oil scavenging varies with engine thrust, oil temperature, and airplane attitude and varies from engine to engine.

A temporary decrease in indicated quantity which returns to normal when thrust is reduced to cruise settings or when thrust is increased from on-station or pattern settings to cruise is not a cause for shutting down an engine. If the oil quantity suddenly decreases and oil pressure is lost, shut the engine down using the ENGINE FAILURE OR FIRE checklist. If pressure is not lost, continue to operate the engine, but monitor oil pressure and temperature. Try to improve cooling and return oil quantity to normal by changing N_2 rpm by about 10% (reduce from TRT or climb thrust and increase from on-station or pattern thrust). If a quantity fluctuation occurs, record lowest oil quantity and indicated oil quantity in AFTO Form 781 before shutting down an engine. If the indicated quantity returns to near that recorded at start, report the problem as fluctuating oil quantity.

FUEL DUMP

Fuel can be dumped directly from all tanks except reserve tanks. The reserve tanks are dumped by transfer to the outboard main tanks. Extend and retract dump chutes with flaps up. The dump rate decreases as fuel level decreases, averaging approximately 3,600 pounds per minute for the first 100,000 pounds when dumping a full fuel load. Dump rate decreases when total fuel load is less than 80,000 pounds.

If the mission requires, the airplane may be landed at any gross weight up to the maximum in-flight weight. (Refer to Heavyweight Landings and Hard Landings, section II, and Weight Limitations, section V.)

For airplane emergencies requiring high landing speeds, time permitting, determine a target fuel and dump to that fuel. Consider airplane configuration for landing, weather conditions to ensure divert fuel requirements, and the most critical of the following to determine a target fuel: 1) Normal Brake Energy Limited Landing Weight; 2) Gross Weight Limited by Landing Distance; and 3) Go-around Capability (consider obstacle if required).

CAUTION

Do not use full and rapid aileron control while dumping fuel.

NOTE

- If emergency conditions require, fuel may be dumped with flaps at 25 degrees or less but flow rate from wing tanks will be reduced and flow rate from center wing tank will be negligible, due to blocking of the vent air inlet by the leading edge flaps.
- All except approximately 4,100 pounds of fuel in each outboard wing tank (No 1 and 4), 3,700 pounds of fuel in each inboard wing tank (No 2 and 3) and 1,600 pounds of fuel in the center wing tank can be jettisoned. For fuel grades other than JP-4, refer to *figure 1-31*.

(1.) Mission Crew – Prepare for Fuel Dump (P or E, MCC)

(2.) Mission Equipment Status – OFF (E, N, MCC)

WARNING

- Ensure HF radios are powered off during fuel dump to prevent RF radiation during HF radio tuning process.
- Ensure surveillance radar is powered down during fuel dump.

3. SPEED BRAKE Lever – Full Forward, In Detent (P)

WARNING

- Dumping fuel with inboard spoilers up can cause dumped fuel to enter horizontal stabilizer.
- Do not dump fuel if there is any possibility of fire in wheel well or inboard engines.

4. Flaps – Up (CP)

CAUTION

If emergency conditions require, retractable dump chutes can be extended or retracted with wing flaps down; however, chute actuators can be damaged and must be replaced prior to next flight.

NOTE

Dump rate is less with flaps down. Center tank cannot dump completely if flaps cover vents.

5. NO SMOKING Switch – ON (CP, E)

6. Airspeed – 240 KIAS Maximum (P)

   While extending fuel dump chutes.

7. DUMP CHUTE Switches – EXTEND (E)

   Airspeed can be increased to 275 KIAS maximum after dump chutes are extended.

   CAUTION

   If a dump chute unlatch light does not illuminate, attempting to dump fuel on that side can result in uncontrollable dumping to standpipe level for selected tanks. To control amount of fuel dumped in this condition, an individual tank may be selected (such as outboard main). Open the dump valve and check closing capability immediately. If valve does not close, all valves on that side probably cannot be closed. Center tank can be dumped through other side.

8. Dump Valve Switches – OPEN (E)

   Dump valve lights illuminate while valves are in transit.

   NOTE

   If any wing tank valve does not open, close opposite wing tank valve to maintain lateral balance.

9. FUEL QUANTITY Gages – Monitor (E)

   Fuel remaining is calculated for JP-4 at 6.5 pounds/gallon in straight and level flight. Actual fuel remaining (standpipe level) varies due to flight attitude, fuel temperature, and gage tolerances.

   a. Outboard Main Fuel Tanks – Approximately 4,100 Pounds Each

   b. Inboard Fuel Tanks – Approximately 3,700 Pounds Each

   c. Center Fuel Tank – Approximately 1,600 Pounds

   d. Total Fuel Remaining – Approximately 17,200 Pounds.

– – – At Desired Fuel Level – – –

10. Dump Valve Switches – CLOSE (E)

    NOTE

    If any valve does not close, set valve switch to OPEN, then set DUMP CHUTE switch to RETRACT for not more than 5 seconds.

11. Dump Chutes – Drain for Two Minutes (E)

12. Airspeed – 240 KIAS, Maximum (P)

13. DUMP CHUTE Switches – RETRACT (E)

    WARNING

    Do not retract fuel dump chutes until all fuel dump valves have indicated closed for 2 minutes to prevent fuel draining into wing (except as required to close valves).

    NOTE

    If dump chutes do not retract completely (dump chute lights illuminated), momentarily raise speed brakes while keeping dump chute switches at RETRACT. If speed brakes are required to obtain a locked indication for a fuel dump chute, record this as a discrepancy in AFTO Form 781.

14. DUMP CHUTE Switches – OFF (E)

15. Dump Panel Cover – Closed (E)

    Cover cannot be closed unless all switches are off.

16. NO SMOKING Switch – OFF (CP, E)

    Verify no fumes are present in the cabin before turning off the NO SMOKING switch.

17. Total Fuel Remaining Gage – Reset (E)

FUEL CONTROL FAILURE

A failure of the engine fuel control unit is indicated either by a power loss (if the high pressure stage has failed) or by an uncontrollable increase in thrust. In either case, perform ENGINE FAILURE OR FIRE checklist.

NOTE

If the N_2 rpm sensing shaft breaks, engine fuel flow stabilizes between normal rated thrust and takeoff thrust. Throttle movement does not control engine power or rpm.

THROTTLE CABLE FAILURE

A failure of the push-pull cable is indicated by a rapid increase of friction in that throttle. After two or three cycles of the throttle, binding can make it impossible to move the throttle. If the throttle binds at a high power setting, shut down the engine prior to landing using the ENGINE FAILURE OR FIRE checklist.

CAUTION

Avoid using excessive force to shut down an engine with a failed throttle cable. Torque applied to overcome friction can damage throttle linkage between throttle and push-pull cable. Shut down the engine using the corresponding fire switch.

ENGINE STALL RECOVERY

If an engine stall occurs, indicated by engine noise, erratic EPR, decreasing N_2 RPM, or increasing EGT, immediately return throttle to previous power setting, turn on continuous ignition and turn off engine anti-ice (on that engine only). If reducing power, move throttle rapidly when below approximately 80% N_2. If increasing power, move throttle slowly. Refer to ENGINE (COMPRESSOR) STALLS AND SURGES, subsection I-B.

CAUTION

Observe fuel flow limits in section V.

1. CONTINUOUS Ignition Switch – ON (E)

2. NACELLE ANTI-ICE Switch (Affected Engine) – OFF (E)

– – – If 8 Generators Operating, Omit Step 3 – – –

③ Surveillance Radar – OFF (E, MCC)

Notify MCC and set RADAR switch to OFF.

4. Generator Off Switches (Affected Engine) – OFF (E)

Removes generator drive power load from engine. Verify bus tie breakers are closed.

– – – If Engine Does Not Recover from Stall, Shut Down Engine Using ENGINE FAILURE OR FIRE Checklist Before EGT Reaches 490°C – – –

– – – If Engine Instruments on Affected Engine are Inoperative, Shut Down Engine – – –

CAUTION

OFF Flag on EGT gage can indicate EGT is above 700°C. Cross check N_1, N_2, and fuel flow before assuming EGT gage failure.

ENGINE RELIGHT

1. Engine Condition and Start Envelope – Check (P, CP, E)

Windmilling N_1, N_2; correct for altitude, airspeed.

CAUTION

- Do not attempt a relight if windmilling RPM is not at least up to the values shown in windmilling RPM table (±3%) (*figure 3-14*). Lower RPM is usually a sign of internal damage.

- Do not restart an engine which has been shut down for fire or excessive vibration, unless a more serious emergency occurs which requires the thrust of that engine.

- Airstarts with other than JP-4 fuel can be difficult to perform at fuel temperatures below –30°C. Consider descent to an altitude where warmer air temperatures exist or use fuel from a tank with operating LCS heat exchanger or from center tank.

Engine Relight Envelope

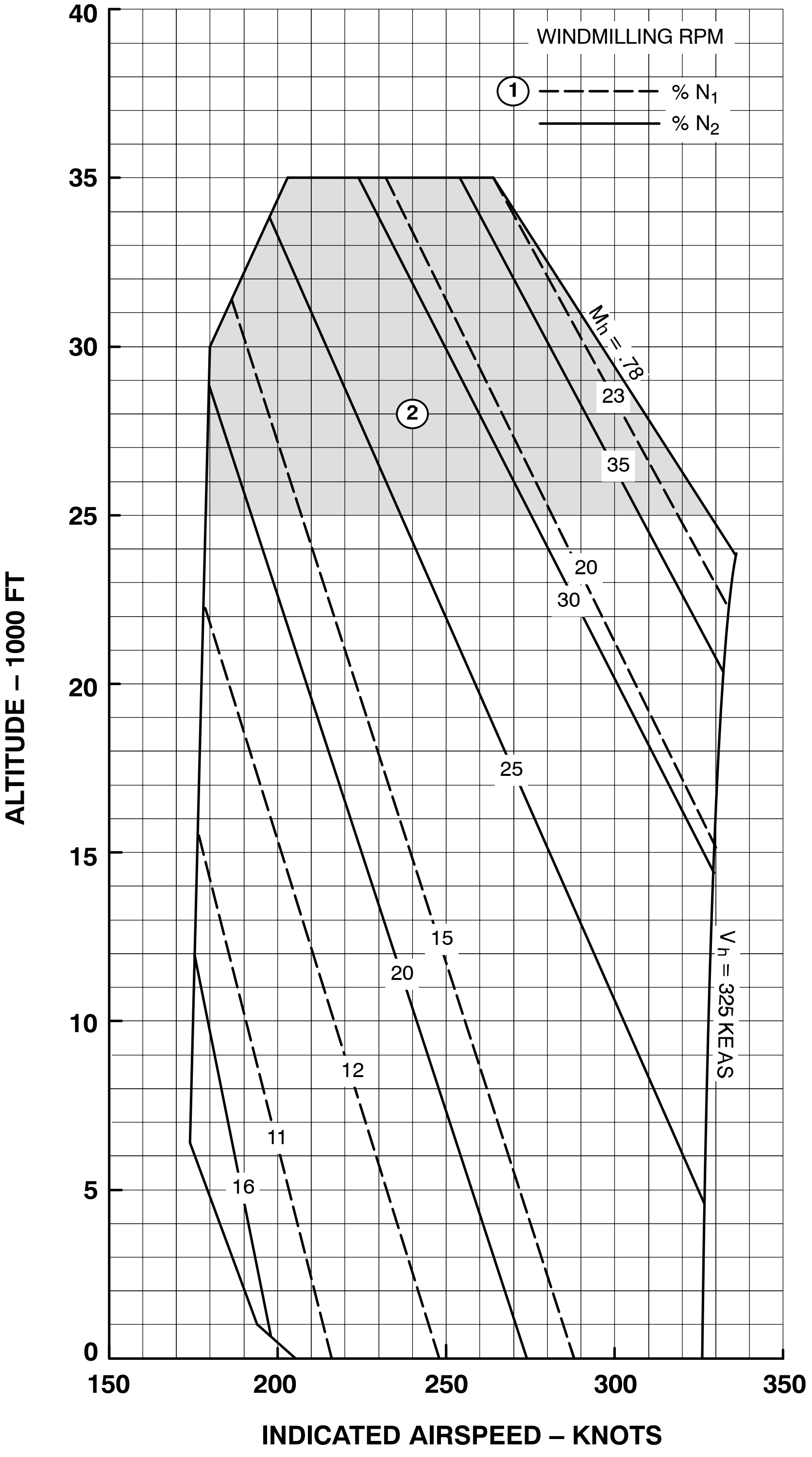
① WINDMILLING RPM CAN VARY ± 3% FROM THESE VALUES.

CAUTION

DO NOT ATTEMPT A RELIGHT IF WINDMILLING RPM IS NOT AT LEAST UP TO THE VALUES SHOWN. LOWER RPM IS USUALLY A SIGN OF INTERNAL DAMAGE.

② ENGINE STARTS MAY BE DIFFICULT/ IMPOSSIBLE ABOVE 25,000 FEET ALTITUDE (SHADED AREA) WITH JP-8 FUEL.

DATA BASIS: FLIGHT TEST WITH JP-4 FUEL



NOTE

WITH FUEL OTHER THAN JP-4, ENGINE CAN BE DIFFICULT TO START AT FUEL TEMPERATURES BELOW –30°C.

Figure 3-14

2. Affected Engine Throttle – Cutoff (P)
3. Affected Engine FIRE Switch – In (E)
4. Fuel PUMPS Switches – On, As Required (E)
5. FUEL ENRICHMENT Switch – As Required (E)

NOTE

When above 15,000 feet and operating on any fuel other than JP-4 or AVGAS, set the FUEL ENRICHMENT switch to ON.

6. Appropriate START CONTROL & IGNITION Circuit Breaker – Check Closed (E)
7. Affected Engine Start Selector Switch – FLT START (E)

CAUTION

- Do not use FLT START position for more than 10 minutes. Do not use GND START position in flight.
- Except in airplane emergencies where thrust of the inoperative engine is required for flight, do not attempt to start an engine using continuous ignition.

8. Affected Engine Throttle – Idle (P)

   EGT should increase within 30 seconds.

– – – When N_2 Is Stabilized – – –

9. Engine Start Selector Switch – OFF (E)
10. FUEL ENRICHMENT Switch – OFF (E)
11. CONTINUOUS IGN Circuit Breaker – Closed (E)
12. CONTINUOUS Ignition Switch – As Required (E)
13. Hydraulics, Electric Power, Bleeds – Restore As Required (E)
14. Rudder Override Switch – As Required (E)

DOOR CAUTION LIGHT ILLUMINATED

Illumination of a door caution light (*figure 1-228*) indicates that door is not fully locked.

APU Door Caution Light Illuminated After Takeoff, or During Initial Climbout

1. Airplane – Do Not Pressurize (E)

CAUTION

Do not pressurize airplane if APU DOOR caution light is illuminated, as damage to APU shroud can occur.

2. APU CONTR, FIRE DETECT PRIMARY SHUT DN, and AUX SHUT DN Circuit Breakers (P61-2) – Checked Closed (E)
3. APU Control Switch – STOP (E)

   If APU was not shut down prior to takeoff, it shuts down automatically on liftoff but the doors do not close automatically.

4. APU FIRE Switch – Pull (E)

– – – If APU Doors Do Not Close Within 90 Seconds, Perform Step 5 – – –

5. APU Doors – Close Manually (E)

   Attempt to close doors manually using APU DOOR lever in start box (14, *figure 1-25*).

– – – If APU Doors Do Not Close, Land as Soon as Practicable or Continue Mission Unpressurized at Pilot's Discretion – – –

*** * * If APU Doors Close, Resume Normal Operation * * ***

Door Caution Light Illuminated and Cabin Pressure Decreasing

1. Oxygen – ON, 100%, If Required (All)

   Pilot notifies all crewmembers via PA to use oxygen until further notice.

WARNING

Personnel in seats 33, 36, and additional crew seats 39 through 46 are provided with portable oxygen bottles having a limited duration available. Refer to subsection I–V for duration at various cabin altitudes.

②. Crew Report – ON Oxygen (P, CP, E, N, MCC)

When directed by pilot, all crewmembers report on interphone when oxygen mask is on and checked.

3. SEAT BELTS and NO SMOKING Switches – As Required (CP, E)

④. Door – Checked, Closed, and Locked (E, MCC)

Check that door is fully closed and inside handle is in locked position (*figures 1-228* and *3-1*).

– – – If Door Cannot Be Closed and Locked and/or If Pressurization Cannot Be Maintained; Depressurize Airplane and Land As Soon As Practicable or Continue Mission Unpressurized at Pilot's Discretion – – –

***** If Door Can Be Closed and Locked and Airplane Pressurizes Normally, Resume Normal Operation *****

Any Door Caution Light, Except APU Door, Illuminated

①. Door – Checked, Closed and Locked (E, MCC)

Check that door is fully closed and inside handle is in locked position (*figures 1-228* and *3-1*).

– – – If Door and/or Handle Not in Closed and Locked Position and Unable to Move, Depressurize Airplane and Land as Soon as Practicable or Continue Mission Unpressurized at Pilot's Discretion – – –

***** If Door and Handle Are Closed and Locked, Resume Normal Operation *****

CONTROLLABILITY CHECK

A controllability check is performed to find the minimum safe airspeed to maintain during approach and landing after inflight structural damage, fuel unbalance, or differential airspeed readings. The check should be performed at approximately 12,000 feet (but at least 8,000 feet AGL) in approach (flaps 14) and landing (flaps 50) configurations. Use care in changing to landing configuration. Before extending flaps, evaluate the possibility of landing in the existing configuration. Do not extend flaps above 20,000 feet. Checks at higher altitudes are subject to Mach number effects.

Make all speed and configuration changes slowly, noting any excessive control requirements produced. With the airplane in the desired configuration, reduce airspeed slowly, taking note of any unusual or excessive control or trim requirements. Any control problem is indicated by excessive roll, yaw, or pitch moments. Gradually decrease airspeed until either the landing bug speed is reached or an undesirable control problem is approached. If airplane gross weight is unknown (and there is no airframe icing) the check may be conducted at 0.6 AOA and the speed compared to the landing reference speed (V_{REF}) chart in T.O. 1E-3A-1-1. If airspeed indications are erratic, refer to FLIGHT WITH UNRELIABLE MACH/AIRSPEED INDICATIONS, this section.

WARNING

Do not allow airspeed to decrease to the point where more than 3/4 of available control deflection has been used in any axis. Recovery could be impossible if all control deflection is used in one direction.

If banking or fuel dumping is required for roll trim, limit bank angle to about 5 degrees (*figure 2-10*). If excessive pitch forces occur, use split flaps and split spoilers (refer to JAMMED STABILIZER). A low, flat landing approach helps reduce flare requirements. Keep airspeed and thrust at or above the levels found in this check. (Refer to section VI.)

LANDING EMERGENCY PROCEDURES

CRASH LANDING

If a crash landing is necessary, make every effort to land with the landing gear down. If all of the landing gear cannot be extended, land with all available gear down. Any extended landing gear absorbs energy from the impact with the ground. Activate the CPL.

NOTE

> If conditions require a gear-up landing, open the LANDING GEAR WARN HORN circuit breaker on panel P5.

Evacuation exits for use after a crash landing (or ditching) are shown in *figures 3-1* and *3-2*. The entry and galley doors are primary evacuation routes on land and the overwing hatches are secondary. Refer to GROUND EVACUATION.

WARNING

- Do not open overwing hatches in flight in preparation for possible crash landing or ditching (except as directed by smoke evacuation procedures). Inflight opening of hatches can be accompanied by a certain amount of hazard due to airflow around/through the hatch opening at speeds up to airplane speed. Open hatches at crash landing or ditching can expose airplane occupants to debris, fumes, or fire. Studies and crash experience indicate that impact sufficient to jam hatches closed causes fuselage breaks large enough for exit. Hatches left closed until airplane has stopped increase protection for crewmembers from fire, fuel, smoke, or water inflow.
- When opening entry or galley doors after emergency landing or ditching, stop when door handle is in vertical position and check for possible entry of fire, smoke, or water. If fire, smoke, or water enters airplane at top or bottom of door, return handle to locked position and use another exit if possible.

The entry and galley doors are larger and fitted with escape slides. Refer to *figure 3-3* for escape slide operation. If the slide fails to inflate or to remain inflated, it can still be used. Two crewmembers must deplane and hold the ground end. To use the slide, jump into the slide in a sitting position.

WARNING

> Be sure that personnel clear the edge of the doorsill when jumping into the escape slide. Hitting the sill could cause serious injury.

Each overwing escape hatch has an escape strap stowed in the ceiling above the hatch (*figure 3-5*). When the hatch is removed, the free end of the strap is accessible. Pull the strap completely out of the storage container and drape it over the wing to assist personnel in reaching the ground.

The pilots' sliding windows also have escape straps available for use (*figure 3-4*). The free end of the strap can be thrown out of the sliding window, providing an escape route for crewmembers.

WARNING

> Be certain the strap is securely fastened and the retainer is seated.

Pilot's and Flight Engineer's Checklist

① Crew – Notify (P, MCC)

Pilot notifies crew, on PA (if possible) of the situation and intentions and receives acknowledgement by interphone. If time does not permit use of the PA or interphone, set the WARNING BELL switch to ON for 5 to 10 seconds, then OFF, and set WARNING LIGHT switch to CRASH, which illuminates the CRASH LANDING signs.

2. **LESS IDG** IFF MASTER Switch – EMER (CP) ◀
   WITH IDG IFF – EMER ON (N or CP)

   On GINS CDU, press IFF, then select LS1 to ON. ◀

③ Emergency Message – Transmit (P, N, CSO)

Emergency message should contain the following information: MAYDAY, airplane call sign, position, course, speed, altitude, established time of landing or ditching and number of people on board. Transmit final position just before landing.

4. Pressurization Mode Switch – LANDING (E)

5. BLEED AIR and ISOLATION Switches – OFF (E)

6. Loose Equipment – Stowed (All)

   Navigator stows sextant and sextant stand.

7. Survival Equipment – As Required (All)

   Survival equipment as appropriate for area of landing. Anti-exposure suits and life vests for water landing (if time permits).

8. Seatbelts and Shoulder Harness – On (All)

   Pilot commands all to put on and fasten their seatbelts and shoulder harnesses.

9. Seats – Forward (E, N)

– – – When Landing Imminent – – –

10. Flaps – 50, 50, Green Lights (CP)

    Set flap lever to 50. INBD and OUTBD gages indicate 50. Both LE FLAP indicators illuminated.

11. Gear – As Required (CP)

    Down if possible on land. Up if ditching.

12. EMER EXIT LIGHTS Switch – ON (CP)

– – – Just Before Touchdown – – –

13. WARNING BELL Switch – ON, 5 to 10 seconds, then OFF (CP)

WARNING

- Personnel in aft facing seats without shoulder harness take bracing position with seat belt fastened, back against backrest, feet flat on floor and arms braced with hands on knees.

- Personnel in forward facing seats without shoulder harness take bracing position with seat belt fastened, feet flat on floor, head down and arms clasped under knees.

- For ditching, set throttles to idle at touchdown, to prevent unsymmetrical thrust if airplane bounces on touchdown.

– – – After Airplane Stops – – –

14. SPEED BRAKE Lever – Full Forward, In Detent (P, CP)

15. Throttles – Cutoff (P)

16. Evacuation – Initiate (P, MCC)

    Notify crew to evacuate airplane.

17. FIRE Switches – Pull All (P, E)

18. Fire Bottle Discharge Buttons – Press All (P, E)

19. BATTERY Switch – OFF (E)

    Last action before leaving airplane.

Navigator's Checklist

+1. Emergency Message – Transmit (P, N, CSO)

Emergency message should contain the following information; MAYDAY, airplane call sign, position, course, speed, altitude, established time of landing or ditching and number of people on board. Transmit final position just before landing.

+2. Loose Equipment – Stowed (All)

Navigator stows sextant and sextant stand.

+3. Survival Equipment – As Required (All)

Survival equipment as appropriate for area of landing. Anti-exposure suits and life vests for water landing (if time permits).

+4. Seatbelts and Shoulder Harnesses – ON (All)

+5. Seat – Forward (E, N)

DITCHING

Overwater conditions, such as multiple engine failure, fuel depletion, or uncontrollable fire which makes continuation of flight to land unlikely, are reasons for ditching. Successful ditching follows careful preparation.

The responsibilities of the crewmembers do not end with the completion of the duties specified in the individual emergency checklists. Emphasis should be placed upon a thorough knowledge of individual duties, including the care and use of emergency equipment; however, the duties of other crewmembers should be understood in the event that one or more crewmembers become incapacitated. Successful evacuation and subsequent survival differ from other emergencies in that a highly coordinated and cooperative effort is vital on the part of each crewmember.

Initial Notification

The pilot will notify the crew on PA as far as possible in advance of ditching. It will be the responsibility of the mission crew commander to ensure that all personnel in the mission compartment and crew rest area understand the nature of the emergency.

As soon as the navigator has acknowledged the pilot's original notification, the navigator will give the pilot a heading and time to the nearest land or known ocean vessel. The navigator will then prepare the emergency message for broadcast.

Ditching Procedure

The CRASH LANDING checklist will be used for ditching with the following exceptions.

a. Dump as much fuel as possible before landing (if the emergency permits) to reduce touchdown speed.

b. Turn off air-conditioning and engine bleed air. Close the pressurization outflow valves. Set CABIN ALTITUDE to minus 1,500 feet. Set BARO CORR to 31.00. Set RATE knob to mark. Set pressurization mode switch to TAKEOFF to help keep outflow valves closed on ditching.

c. Open the LANDING GEAR WARN HORN circuit breaker (P5).

d. Set EMERGENCY LIGHTS switch (P67) to HIGH before landing.

e. Determine ditching heading, usually parallel to the major swell system. Refer to SELECTING OPTIMUM HEADING FOR DITCHING, this section.

f. Establish airspeed at V_{REF} for flaps 50, and rate of descent approximately 200 to 300 feet per minute.

WARNING

- Personnel in aft facing seats without shoulder harness take bracing position with seat belt fastened, back against backrest, feet flat on floor and arms braced with hands on knees.
- Personnel in forward facing seats without shoulder harness take bracing position with seat belt fastened, feet flat on floor, head down, and arms clasped under knees.

g. Use power, if available, to minimize rate of descent at touchdown. Rotate the airplane to a body attitude of approximately 10 degrees at touchdown. Do not stall the airplane.

NOTE

When ditched with the proper nose-high attitude (10 degrees), the airplane runs smoothly without skipping. At this body attitude, flaps are lost almost immediately upon touchdown. This reduces the available lift and renders the airplane incapable of flying. The aft ends of the nacelles enter the water on contact and contribute to a smooth run. The airplane can be expected to remain afloat for some time if fuel load is low and there is no serious damage during ditching. The airplane initially floats in a near level attitude with all exits above water.

h. With complete loss of thrust on all engines, increase the approach speed by 10 to 20 knots to ensure flare and touchdown attitude without stalling.

Selecting Optimum Heading for Ditching

Except in extremely high wind conditions, the airplane should be ditched parallel to the primary swell system. A careful evaluation of the sea condition is essential to successful ditching. The surface should be analyzed from as high an altitude as the surface can be seen, 2,000 feet or more if possible. The primary or basic swell can readily be distinguished from high altitude and will be seen first. It may be hidden beneath another system plus a surface chop, but from altitude the largest and most dangerous system will be the first one recognized. Once the basic system is found, look in different directions for other systems. Perhaps the second system may not be visible until a lower altitude is reached. The wind driven sea, if any, will be recognized by the appearance of whitecaps. It is possible once a low altitude is reached that the basic system may disappear from view, hidden by the secondary system and the local chop. It is essential, therefore, to plot the direction of various systems as they are recognized.

Based on the foregoing discussion the following guidelines are offered:

a. Never land into the face of a primary swell system (or within 30 to 45 degrees of it) unless the winds are extremely high.

b. The best ditching heading is usually parallel to the major swell and down the minor swell system.

c. In strong winds it may be desirable to compromise the above by landing more into the wind and slightly across the swell system.

NOTE

Ditch parallel to and near the crest of the swell unless there is a strong crosswind of 35 knots or more. If there is a strong crosswind, ditch into the wind, making contact on the upslope of the swell near the top. Wave motion is indicative of wind direction, but swell does not necessarily move with the wind. Conditions of water surface are indicative of wind speed. If visibility is restricted, ditch heading may be determined from forecast data. *Figure 3-15* may be helpful in selecting the best ditch heading.

Night Ditching

Use of the landing lights may be required to examine the surface. If conditions are favorable, choose a ditching heading as previously recommended. If impossible to judge the surface condition, head into the wind using GINS winds or forecast prevailing winds. Make an instrument let down holding the airspeed to final approach speed (V_{REF}) with gear up and flaps 50, at the lowest possible rate of descent. The radio altimeter is a reliable method to determine altitude above the water.

WARNING

Care should be exercised when landing with lights for night ditching because the reflection from the surface makes it difficult to determine the airplane height above the water.

Ditching Exits and Assignments

All crewmembers will evacuate the airplane through one of the following exits (listed in order of preference): Overwing hatches; main deck doors, if above water level; flight deck windows. Airplane should float with all main deck doors above water long enough to board rafts. If airplane is sinking rapidly, use nearest available exit. If life rafts do not inflate due to cold soak, place raft in water to warm inflation cylinder. Detach slides from main deck doors for additional flotation.

Door/hatch opening duties and life raft assignments are shown in *figure 3-16*.

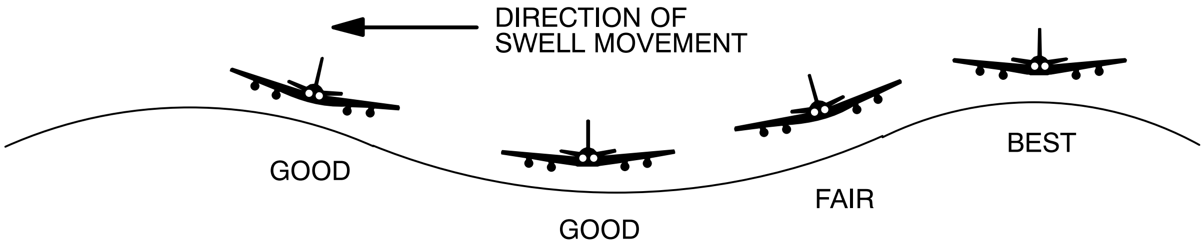
WARNING

When opening entry or galley doors after emergency landing or ditching, stop when door handle is in vertical position and check for possible entry of fire, smoke, or water. If fire, smoke, or water enters airplane at top or bottom of door, return handle to locked position and use another exit if possible.

NOTE

If mission seating arrangement requires deviation from the arrangement in *figure 3-16*, pilot and MCC shall ensure all crewmembers are thoroughly briefed on the deviations.

Selection of Ditching Heading



SURFACE CONDITION	WIND SPEED KNOTS
FEW WHITE CRESTS	10 – 15
MANY WHITE CRESTS	15 – 25
STREAKS OF FOAM FROM CRESTS	25 – 35
SPRAY BLOWN FROM TOPS OF WAVES	35 – 45

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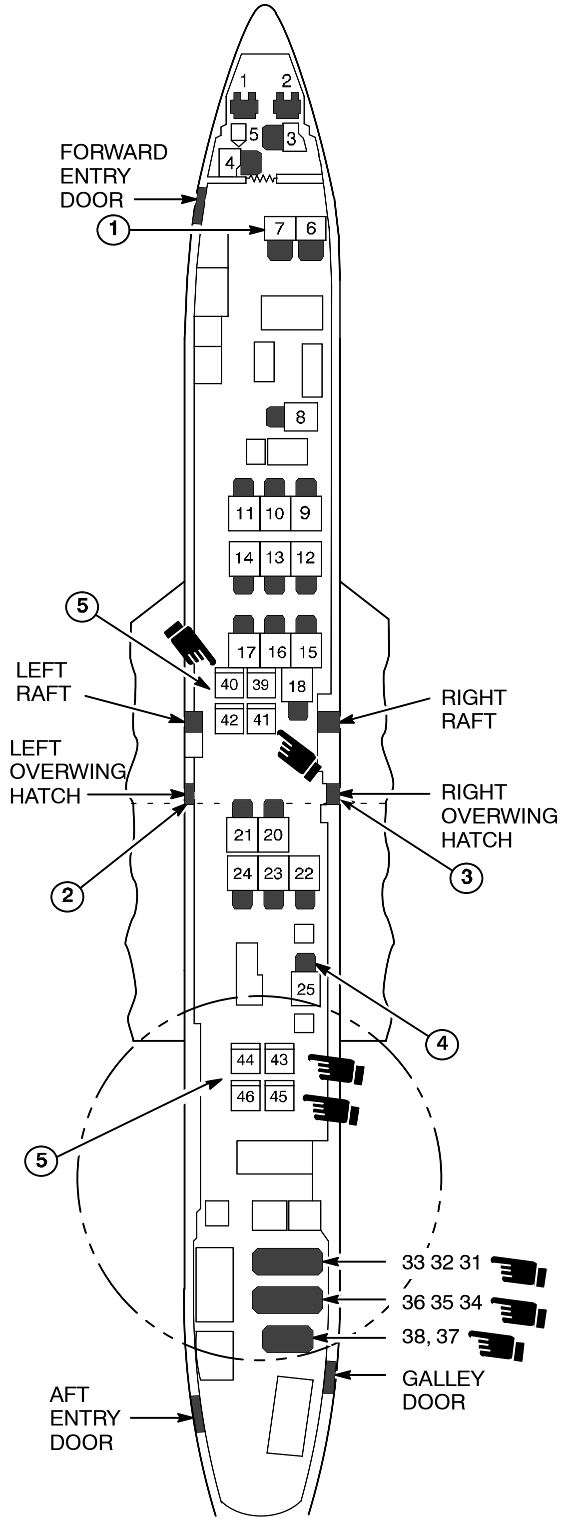
Figure 3-15

Crash Landing and Life Raft Assignments



LEFT RAFT	RIGHT RAFT
PILOT	COPILOT
FLIGHT ENGINEER	NAVIGATOR
OBSERVER (SEAT 5)	COMMUNICATIONS TECHNICIAN (SEAT 6)
COMM. OPERATOR (SEAT 7) ①	CDMT (SEAT 8)
SDC OPERATOR (SEAT 9)	SDC OPERATOR (SEAT 10)
SDC OPERATOR (SEAT 11)	SDC OPERATOR (SEAT 12)
SDC OPERATOR (SEAT 13)	SDC OPERATOR (SEAT 14)
SDC OPERATOR (SEAT 15)	SDC OPERATOR (SEAT 16)
SDC OPERATOR (SEAT 17)	SDC OPERATOR (SEAT 18)
DUTY OFFICER (SEAT 21)	SDC OPERATOR (SEAT 20)
SDC OPERATOR (SEAT 23)	SDC OPERATOR (SEAT 22)
RADAR TECH (SEAT 25) ④	SDC OPERATOR (SEAT 24)
EXTRA CREWMEMBERS FROM SEATS 31, 33, 35, 37, 39, 41, 43, 45	EXTRA CREWMEMBERS FROM SEATS 32, 34, 36, 38, 40, 42, 44, 46

NOTE

① If required, opens forward door and deploys slide.

② First crewmember assigned odd numbered seat to reach left overwing hatch will deploy raft if required, attach escape strap to wing fitting.

③ First crewmember assigned even numbered seat to reach right overwing hatch will deploy raft if required, attach escape strap to wing fitting.

④ If required, opens aft doors and deploys slides.

⑤ Four (4) seats can be installed here.

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Figure 3-16

MANUAL LANDING GEAR EXTENSION

CAUTION

- Do not attempt to insert or remove emergency nose gear lock pin on ground, with airplane weight on nose gear. This can result in collapse of nose gear.

- If the utility hydraulic system fails after a normal landing gear extension, the complete nose gear manual extension procedure must be performed to engage nose gear lock pin.

- If the airplane is landed with nose gear emergency lock pin installed (locked), flight crew will make a separate entry in AFTO Form 781 for this condition. Maintenance action is required to remove pin before next takeoff.

- Nose gear lock alignment stripes cannot be seen with gear up.

- When using hand crank, verify that nose gear is down and lock alignment stripes are in locked position (17, *figure 1–69*) before inserting lock pin. If pin is inserted with nose gear up, nose gear is locked up.

- If landing stop is in fuse plug melting range with brake energy above 24 million foot pounds per brake, attempt to close gear doors using interconnect valve after stopping. If all tires deflate, doors could be damaged.

- If nose gear is extended manually for training, remove lock pin and retract nose gear normally.

NOTE

- When main gear is extended manually, doors remain down. UHF/ADF antenna is blocked and ADF operation is unreliable. ADF can be used in manual (loop) mode. DOOR warning light remains illuminated.

- Extend nose gear first to avoid flying with mains extended in the event nose gear fails to lock down properly.

- Flight planning fuel reserves are calculated for a clean airplane. With landing gear extended and doors open, fuel consumption is increased by 50% (endurance is reduced by 33%) compared to values shown in part V of T.O. 1E-3A-1-1.

Use this procedure when the utility hydraulic system is inoperative, or when gear indicating and warning system indicates a gear is not down and locked.

When accomplishing manual gear extension, if any gear fails to extend and lock down on first attempt, repeat complete manual extension of that gear prior to extending remaining landing gear.

If any landing gear fails to indicate down and locked on flight deck indicators after second attempt, check red down lock stripes (*figure 1-69*) for indication of gear position; if indication is abnormal, consider raising the gear and perform MANUAL LANDING GEAR EXTENSION. If the gear cannot be locked, proceed to GEAR UP OR PARTIAL GEAR LANDING procedures.

Pilot's, Flight Engineer's, and Navigator's Checklist

1. Landing Gear Lever – OFF (CP)

   To assure no hydraulic pressure remains or builds up in the landing gear system, keep landing gear lever OFF until manual extension is completed.

2. Airspeed – 270 KIAS or Less (P)

– – – Nose Gear Extension – – –

3. Hand Crank – Clockwise, to Stop (Hold 5 Seconds Minimum) (E or N)

   Rotate hand crank at least 3/4 turn clockwise to unlock nose gear doors and gear. Force required on hand crank can be up to 80 pounds with crank in normal position (60 pounds with crank extended) to overcome system load and assure the stop is encountered. Hold force against stop for a full 5 seconds before reversing direction.

WARNING

Do not release hand crank after unlocking cycle has started until after step 5. Cable loads are high enough to cause crank to rotate and cause injury.

4. DOOR and GEAR Warning Lights – Illuminated (CP)

NOTE

Illumination of the GEAR and DOOR warning lights indicates opening of the nose gear doors and unlocking of the nose gear. GEAR warning light remains illuminated until nose gear is locked down. The nose gear can free fall into downlock illuminating the N GEAR (green) light and shutting off the GEAR warning light. The DOOR warning light remains illuminated.

5. Hand Crank – Counterclockwise, To Stop (E or N)

Rotate hand crank at least one turn counterclockwise to lock nose gear in down position. Apply sufficient force to hand crank to overcome system load and to assure the stop is encountered and emergency downlock pin is engaged.

NOTE

If the crank has a force tending to return it to neutral position after rotating counterclockwise to stop, nose gear lock pin is not in place. Repeat steps 3, 4 and 5 to insert lock pin.

6. N GEAR Light – Illuminated (CP)
7. GEAR Warning Light – Out (CP)

NOTE

- GEAR warning light can remain illuminated if one or more landing gear are not down and locked.
- If any gear is up and locked and any throttle is near idle or in cutoff, GEAR warning light illuminates. Pull HORN SILENCE lever to shut off GEAR warning light.

8. Nose Gear Downlock Pin – Engaged (E or N)

Check nose gear emergency downlock pin fully engaged; pin vertical and flush or extending below lower surface of pin hole.

WARNING

Keep fingers clear of pin and mechanism when engaging or removing pin.

NOTE

The nose gear cannot be retracted until the nose gear downlock pin is removed.

– – – If Pin Not Fully Engaged, Accomplish Complete Extension Using Emergency Nose Gear Lever; Follow Placard Instructions Or Nose Gear Alternate Manual Extension – – –

CAUTION

Do not attempt to insert or remove emergency nose gear lock pin on the ground with airplane weight on nose gear. This can cause collapse of nose gear.

9. Red Downlock Stripes – Aligned (E or N)

Inspect through mirror inspection window in lower nose compartment (*figure 1–69*).

Proper viewing position is level with mirror looking about 30° to 45° to right.

Stripes cannot be seen with gear up.

10. Hand Crank – Removed and Stowed (E or N)

– – – If The Nose Gear Is Down And Locked, Pin Installed, Proceed To Step 18 – – –

– – – If Only Performing The Nose Gear Portion For A Utility Hydraulic Loss After Gear Extension. Proceed To Step 32 – – –

– – – Nose Gear Alternate Manual Extension – – –

If the nose gear fails to extend using normal or manual procedures, an alternate means is provided. The nose gear manual extension lever (*figure 1–69*) is stowed on the aft side of the nose gear well.

11. Manual Extension Lever – Insert In Hole No 1 (E or N)
Verify lever is seated in both sides of drum.

12. Lever – Rotate Aft (E or N)

Rotate lever approximately 140 degrees, or until nose gear falls free. Force to open doors is about 30 pounds. Force to unlock gear is about 60 pounds.

CAUTION

It is possible to exert enough force on the lever to break cables or damage mechanism. If excessive force is required, check gear lever position. Doors cannot open unless landing gear lever is OFF.

13. Lever – Insert In Hole No 2 (E or N)

Verify lever seated in both sides of drum.

14. Lever – Rotate Forward (E or N)

Rotate forward to lock gear.

15. Downlock Stripes – Check Visually (E or N)

Turn wheel well light on and inspect downlock stripes through viewing port (*figure 1–69*). Proper viewing position is aft of mirror, looking slightly to right, with eye level at center of mirror.

16. Nose Gear Downlock Pin – Engaged (E or N)

Check nose gear downlock pin engaged (vertical).

NOTE

The nose gear cannot be retracted until the nose gear downlock pin is removed.

17. Manual Extension Lever – Stowed (E or N)

WARNING

Injury to personnel or damage to equipment could result if bar is left in drum.

– – – If Only Performing the Nose Gear Portion For a Utility Hydraulic Loss After Gear Extension. Proceed to Step 32 – – –

– – – Left Main Gear Extension – – –

18. Hand Crank – Clockwise, to Stop (E or N)

Rotate hand crank at least three turns clockwise to unlock door and gear. Force required on hand crank can be up to 80 pounds with crank in normal position (60 pounds with crank extended) to overcome system load and assure reaching the stop. Hold momentarily against stop before reversing direction.

WARNING

Do not release hand crank after unlocking cycle has started until after step 20. Cable loads are high enough to cause crank to rotate and cause injury.

19. GEAR Warning Light – Illuminated (CP)

Illumination of the GEAR warning light indicates the left main gear uplock has rotated to the unlock position. GEAR warning light remains illuminated until gear is locked down.

NOTE

If the normal manual extension system does not release the landing gear doors, proceed as follows. Open the access ports (subsection I-G) under the carpet in the mission compartment aisle at station 835. Using the heel of the shoe or the nose gear alternate extension bar, force the crank (visible through the access port) as far aft as possible. If door does not open, fit nose gear extension lever over rivet, located below crank, and rotate lever aft.

20. Hand Crank – Counterclockwise, to Stop (E or N)

Rotate hand crank at least six turns counterclockwise to lock gear in down position. Apply sufficient force to hand crank to overcome system load and assure stop is encountered.

21. L GEAR Light – Illuminated (CP)

22. GEAR Warning Light – Out (CP)

NOTE

- GEAR warning light can remain illuminated if one or more landing gear are not down and locked.

- If any gear is up and locked and any throttle is near idle or in cutoff, GEAR warning light illuminates. Pull HORN SILENCE lever to shut off GEAR warning light.

23. Hand Crank – Clockwise, Three Turns (E or N)

    Rotate hand crank approximately three turns clockwise to release mechanism spring tension.

24. Hand Crank – Removed and Stowed (E or N)

– – – Right Main Gear Extension – – –

25. Hand Crank – Counterclockwise, to Stop (E or N)

    Rotate hand crank at least three turns counterclockwise to unlock gear door and gear. Apply sufficient force to hand crank to overcome system load and assure reaching the stop. Hold momentarily against stop before reversing direction.

WARNING

Do not release hand crank once unlocking cycle has started until after step 27. Cable loads are high enough to cause crank to rotate and cause injury.

26. GEAR Warning Light – Illuminated (CP)

    Illumination of the GEAR warning light indicates the right main gear uplock has rotated to the unlock position. GEAR warning light remains illuminated until gear is locked down.

NOTE

If the normal manual extension system does not release the landing gear doors, proceed as follows. Open the access ports (subsection I-G) under the carpet in the mission compartment aisle at station 835. Using the heel of the shoe or the nose gear alternate extension bar, force the crank (visible through the access port) as far aft as possible. If door does not open, fit nose gear extension lever over rivet, located below crank, and rotate lever aft.

27. Hand Crank – Clockwise, To Stop (E or N)

    Rotate hand crank at least six turns clockwise to lock gear in down position. Apply sufficient force to hand crank to overcome system load to assure stop is encountered. Gear warning light remains illuminated until gear is locked down.

28. R GEAR Light – Illuminated (CP)

29. GEAR Warning Light – Out (CP)

NOTE

- GEAR warning light can remain illuminated if one or more landing gear are not down and locked.

- If any gear is up and locked and any throttle is near idle or in cutoff, GEAR warning light illuminates. Pull HORN SILENCE lever to shut off GEAR warning light.

30. Hand Crank – Counterclockwise, Three Turns (E or N)

    Rotate hand crank approximately three turns counterclockwise to release mechanism spring tension.

31. Hand Crank – Remove and Stow (E or N)

– – – If Gear Lever was Set to OFF to Stop Hydraulic Leak, Omit Step 32 – – –

32. Gear – Down, In, Three Green Lights (CP)

With the landing gear lever in the DOWN position, there can be enough hydraulic pressure available in the system to close the landing gear doors. Landing with the gear doors open does not cause any problems, unless all tires are flat.

CAUTION

If this step is performed after a hydraulic leak which required setting gear lever to OFF in order to stop the leak, remaining hydraulic fluid in utility system could be lost by performing this step. Check visual link indicator stripes. Nose wheel steering is not available with gear lever OFF.

NOTE

The ADF and UHF–ADF are unreliable with main gear wheel well doors open.

– – – If Any Gear Indications Are Abnormal, Perform Step 33 – – –

33. Throttle – Momentarily Idle (P)

Retard any one throttle momentarily to IDLE position. If warning horn sounds, recheck all gear indicators and red downlock stripes prior to landing.

CAUTION

If the green down light does not illuminate when either main landing gear is down, inboard or outboard antiskid may be inoperative. Verify antiskid is on by checking REL indicators. (REL indicator shows blank if antiskid is off.) If the LANDING GEAR – POS LIGHTS circuit breaker (P5) is open or AVDC MAIN bus 8 is unpowered, antiskid is inoperative.

NOTE

If the normal manual extension system does not release the landing gear doors, proceed as follows. Open the access ports (subsection I-G) under the carpet in the mission compartment aisle at station 835. Using the heel of the shoe or the nose gear alternate extension bar, force the crank (visible through the access port) as far aft as possible. If door does not open, fit nose gear extension lever over rivet, located below crank, and rotate lever aft.

– – – Perform Steps 34 and 35 If Nose Gear Was Extended for Training – – –

34. Nose Gear Lock Pin – Removed and Stowed (E or N)

WARNING

Keep fingers clear of pin and mechanism when engaging or removing pin.

35. Landing Gear – UP, Lights Out (CP)

GEAR UP OR PARTIAL GEAR LANDING

The following procedure covers all possible landing gear combinations and allows the pilot to decide the best course of action. Make every effort to land with the landing gear down. If all of the landing gear cannot be extended, landing with all available gear down absorbs energy from the impact with the ground.

The landing configuration selected should be the one most likely to remain on the runway. Past experience with similar airplanes shows that, in most cases with one main gear retracted, the airplane leaves the runway.

Consider all relevant factors: Distress messages, destination, facilities, time available, airplane configuration, landing c.g., runway length and foaming. After every means available is used to extend gear, dump fuel as required. Brief flight crew and mission crew on landing and evacuation, mission crew should prepare the mission crew compartment.

WARNING

Do not open overwing hatches in flight in preparation for possible crash landing or ditching (except as directed by smoke evacuation procedures). Inflight opening of hatches can be accompanied by a certain amount of hazard due to airflow around/ through the hatch opening, at speeds up to airplane speed. Open hatches at crash landing or ditching can expose airplane occupants to debris, fumes, or fire. Studies and crash experience indicate that impact sufficient to jam hatches closed causes fuselage breaks large enough for exit. Hatches left closed until airplane has stopped increase protection for crewmembers from fire, fuel, smoke, or water inflow.

NOTE

Flight planning fuel reserves are calculated for a clean airplane. With landing gear extended and doors open, fuel consumption is increased 50% (endurance is reduced by 33%) compared to values shown in part of T.O. 1E-3A-1-1.

Plan flaps 50 landing if possible. The flap system and engines provide stability and structural protection. Use normal landing techniques, airspeed and touchdown point. Request foaming of the landing runway if possible. Attempt to touch down and keep the airplane structure (other than landing gear) in foam throughout the landing. Land as soon as possible after foaming; foam is good up to one hour. If possible, allow time to refill foam trucks prior to landing. In addition to the following procedures, accomplish applicable portion of the CRASH LANDING checklist.

Main Gear Extended

Only if practicable, move airplane c.g. aft; reduce gross weight by selective fuel dumping. (Dumping center tank moves c.g. aft.)

If sufficient runway is available, turn inboard spoilers off before touchdown. Raise outboard spoilers as soon as main gear touches down. After touchdown, trim stabilizer to airplane NOSE UP to prevent nose from falling. Hold control column in neutral while trimming to maintain elevator control when stabilizer reaches nose up limit.

The nose normally contacts the runway at approximately 2,000 to 4,000 feet from touchdown at speeds of 40 to 70 knots.

Brake as required, consistent with stopping distance available and position relative to the foam after main gear touchdown. With nose contact, normal braking minimizes nose structure damage.

One Main Gear and Nose Gear Down

Land the airplane on the side of the runway that corresponds to the available main gear down. For example, with left main gear down, land on the left side of runway.

Nose Gear Down Only

Land airplane normally.

One Main Gear Down Only

Land on the side of the runway that corresponds to the available main gear down. At touchdown, immediately raise speed brakes to 20 degrees only for maximum lateral control. Maintain wings level as long as possible.

All Gear Up or Partially Extended

Anticipate more airplane float than normal before touchdown.

FLAP ASYMMETRY OR SPLIT FLAPS

Flap asymmetry is a difference in the amount of extension between left and right flaps of the same set. Disagreement of more than 6° between the L and R pointers on the OUTBD or INBD FLAPS gages indicates one flap (inboard or outboard) is extended farther than the other. The flap gages can indicate ±3° from actual flap position or up to 6° between L and R pointers. The asymmetry can be accompanied by a rolling tendency. All flap movement stops when the operable flaps reach the selected position. A difference between the INBD and OUTBD gages indicates split flaps. See *figure 3-17*.

WARNING

> Do not use AOA indicator with split or asymmetric flaps. AOA readings are not valid in these conditions.

Split flaps usually result from a drive motor or a follow-up failure.

– – – To Stop Flap Movement – – –

1. FLAP Lever – Set to Detent Nearest Asymmetric/Split Flap Position (P or CP)

CAUTION

> Do not attempt further movement of asymmetric flaps as airplane damage, jammed ailerons, or greater rolling tendency can result.

2. **WITH IDG** TCAS SENS – TA Only (P or CP)

   VSI displays ONLY TA. This prevents TCAS from coordinating an RA with other TCAS equipped aircraft and inhibits RAs from being issued by own TCAS. ◀

– – – To Continue Hydraulic Control of the Operable Flaps – – –

3. FLAPS BYPASS VALVE INBD or FLAPS BYPASS VALVE OUTBD Circuit Breaker (P5 Panel) – Open for Operable Flaps (E)

   Deactivates the flap bypass valve for the operable flaps in the open position. Allows the operable flaps to be operated hydraulically after the EMERGENCY FLAP arming switch is ON. For split flaps, open the breaker for the operable flaps. The other set may be operated electrically.

4. EMERGENCY FLAP Arming Switch – ON (CP)

   Closes the flap bypass valve for the other set of flaps so they cannot be moved hydraulically.

– – – To Continue Approach and Landing– – –

5. Airspeed BUGS – Set V_{REF} + 15 Knots, or V_{REF} + 30 Knots (P, CP)

   The 15 knot increase is adequate for full asymmetry or split of either inboard or outboard trailing edge flaps. When an asymmetry or split of the inboard flaps exists and the leading edge flaps are retracted, the 30-knot increase is adequate.

NOTE

- Crosswind capability is reduced (outboard aileron locked) if either outboard flap is not extended to 14. Refer to T.O. 1E-3A-1-1.
- To compute brake energy and cooling time, use the average of the two flap settings.

6. Operable Flaps – Extend On Schedule (CP)

   Extend the operable flaps normally as required for approach and landing. Observe the appropriate airspeed schedule for extension.

*** * * Complete Normal DESCENT, APPROACH, and BEFORE LANDING Checklists * * ***

FLAP FOLLOW UP FAILURE

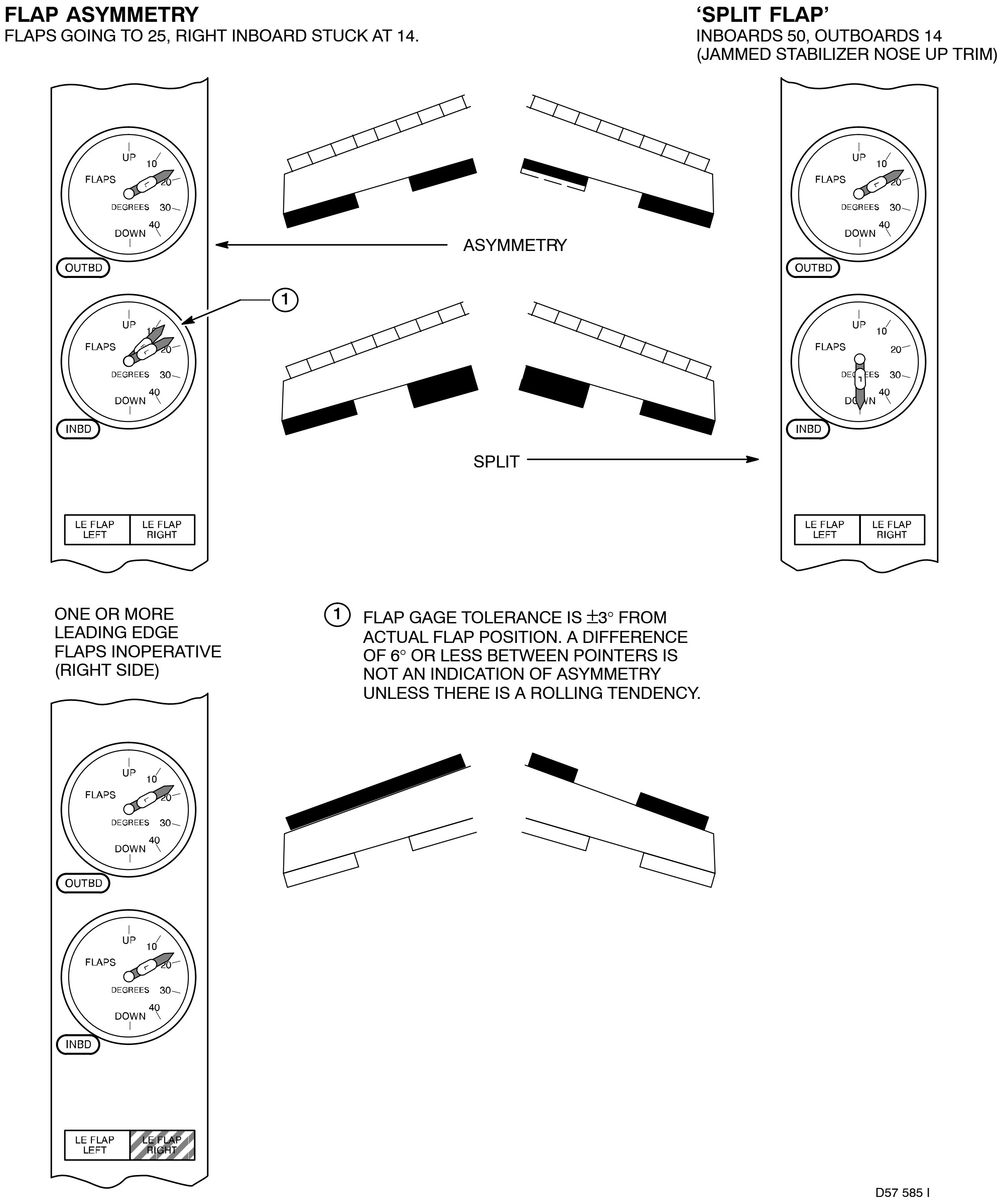
A failure of the flap follow up mechanism in one flap drive would allow that pair (inboard or outboard) to move to the maximum in the selected direction, regardless of flap lever selection. If flaps are extending, the pair moves to 50: if flaps are retracting, they move to zero. Use the following procedure:

1. EMERGENCY FLAP Arming Switch – ON (CP)

   Stops hydraulic flap operation.

2. EMERGENCY FLAP Switches – As Required

Abnormal Flap Indications



FLAP ASYMMETRY
FLAPS GOING TO 25, RIGHT INBOARD STUCK AT 14.

‘SPLIT FLAP’
INBOARDS 50, OUTBOARDS 14
(JAMMED STABILIZER NOSE UP TRIM)

ONE OR MORE
LEADING EDGE
FLAPS INOPERATIVE
(RIGHT SIDE)

① FLAP GAGE TOLERANCE IS ±3° FROM ACTUAL FLAP POSITION. A DIFFERENCE OF 6° OR LESS BETWEEN POINTERS IS NOT AN INDICATION OF ASYMMETRY UNLESS THERE IS A ROLLING TENDENCY.

Figure 3-17

ONE OR MORE LEADING EDGE FLAPS INOPERATIVE

Landing with one or more leading edge flaps inoperative requires approach at V_{REF} + 15 knots to maintain an adequate margin above the increased stall speed. This higher approach speed results in increased flare distance and landing distance. (Refer to FACTORS AFFECTING LANDING DISTANCE in section II.) Reduce landing weight and landing speed by dumping fuel, if possible. Complete normal DESCENT and BEFORE LANDING checklists.

WARNING

- Do not use angle of attack indicator with any leading edge flaps inoperative. AOA readings can be unreliable in this condition.
- Initial buffet and stall speeds can be above stick shaker speed if leading edge flaps are completely retracted.

CAUTION

- If tire placard speed is exceeded, tire failure can result. Check brake energy limited landing weight (T.O. 1E-3A-1-1).
- If one or more leading edge flaps remains extended, observe flaps 14 placard.

FLAPS UP LANDING

A well executed zero flap approach requires precise control of airspeed and glide path. The airplane is clean (except for gear) and decelerates very slowly. Excess airspeed represents kinetic energy which must be dissipated. With little drag assisting airspeed bleedoff, it is difficult to slow down, and when this is combined with ground effect, excess floating can result in wasting several thousand feet of runway.

Use normal glide slope at 700 to 900 feet per minute rate of descent. Maintain V_{REF} + 40 KIAS to near touchdown. The proper landing attitude is established by holding the approach speed to flare and touchdown. A small change in attitude is required to reduce sink rate to within desirable limits. When over the landing point let the airplane land; do not attempt to hold the airplane off as the attitude can become too nose high. Zero flap landing at heavy weight and high altitude can exceed the tire placard speed at touchdown. Reduce weight to minimum practical value consistent with operating considerations.

The probability of damaging even one tire due to the high touchdown speed is very small. Even if a tire is damaged, directional control is easily maintained. Little or no airplane damage should be experienced from a disintegrating tire with the flaps up. See section II FACTORS AFFECTING LANDING DISTANCE for effects of floating before touchdown and higher landing speeds.

Review the information below, then complete the normal DESCENT, APPROACH, and BEFORE LANDING checklists except set airspeed bug at V_{REF} + 40 KIAS. See *figure 3–18*.

CAUTION

- Tire placard speed is ground speed, not IAS. If tire placard speed is exceeded, tire failure can result.
- Outboard ailerons are inoperative with flaps up. Roll rate and cross wind capability is reduced. Refer to T.O. 1E-3A-1-1.
- Refer to T.O. 1E-3A-1-1 for Brake Energy Limited Landing Weight.

Transition to Final Approach

Bug + 20 knots is the normal maneuver speed with 0° flaps. It is recommended that a precision approach be made if available.

Final Approach

Roll out on runway centerline approximately 3 miles from end of the runway and allow airspeed to decrease to bug speed plus wind and gust correction. Get onto the glide path and proper speed early. Rate of descent should be between 700-900 feet per minute to maintain a glide path with the increased approach speed. Plan on a touchdown at the 1,000 to 2,000 foot point on the runway. Avoid any tendency to float. Use speedbrakes and brakes the same as for normal landing.

Flaps Up Landing

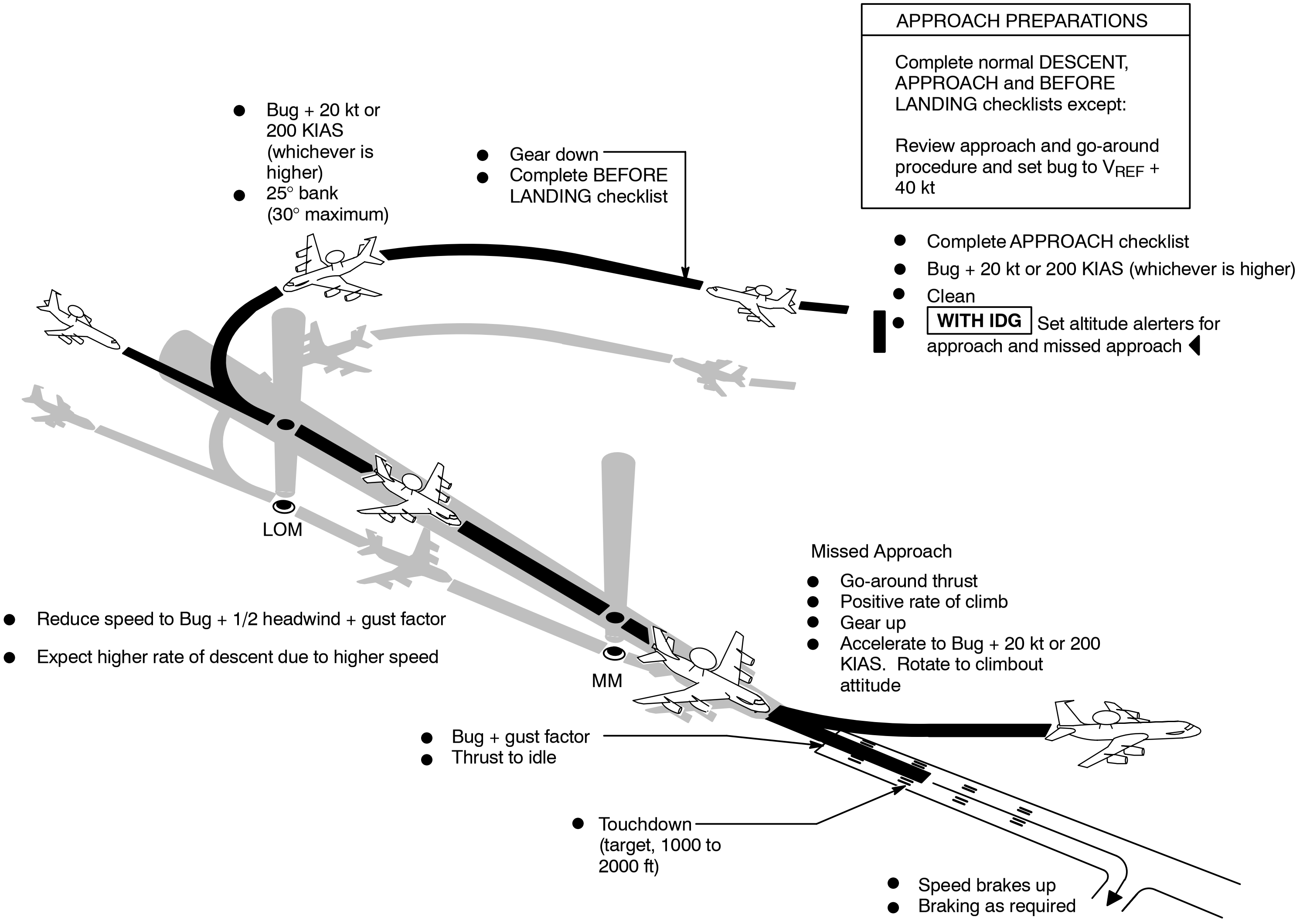


Figure 3–18

Go-Around

Apply go-around thrust and climb on runway heading at bug + 20 knots. (V_{REF} + 60 knots)

Retract landing gear after positive rate of climb is established.

ANTISKID INOPERATIVE BRAKING

If one or more antiskid units is known (or suspected) to be inoperative, leave antiskid switch ON (to protect remaining tires). Use antiskid inoperative landing data in T.O. 1E-3A-1-1 and follow procedures below:

Complete the normal BEFORE LANDING checklist, including antiskid check. Leave the antiskid switch ON. Review braking procedure before touchdown.

After speedbrakes are deployed, apply light to moderate braking using slightly less pedal pressure than used in a normal landing.

On a wet runway, apply brakes until braking action is felt. Momentarily release brake pressure, allow short time for spinup, then reapply and repeat until stopped.

CAUTION

If brakes are not released, skidding and/or blown tire can occur.

Proceed to the AFTER LANDING checklist.

WARNING

- Observe maximum brake energy limits in section V. Maximum energy stop causes tires to deflate when fuse plugs melt. If all tires on a truck are deflated, cool brakes with foam, fog, or dry chemical extinguisher. If any tire on a truck is not flat, do not cool wheels. Do not approach hot brakes from the side.
- If brake application causes any loss of directional control, release both brake pedals, correct heading, and re-apply brakes. Refer to DIRECTIONAL CONTROL AFTER TOUCHDOWN, section II, or LANDING ON SLIPPERY RUNWAY, sections II and VII.
- If brakes are applied above 70 knots, brake limits will be checked and recommended procedures followed for brake cooling.

LANDING WITH INOPERATIVE HYDRAULIC BRAKE(S) OR PNEUMATIC BRAKES

If a brake is known (or suspected) to be inoperative or if a malfunction in the utility system causes the brake gage to indicate low or zero pressure, the pilot should still try to apply hydraulic brakes before applying pneumatic brakes. Break the safety wire on the PNEUMATIC BRAKE handle before touchdown. At touchdown set interconnect valve switch to BRAKE and try normal braking. If hydraulic braking is not available, turn the PNEUMATIC BRAKE handle slowly clockwise (to approximately vertical position) until desired braking level is felt, then hold. The short delay in applying pneumatic brakes does not affect stopping distance, since more weight is on the wheels when brakes are applied. Perform normal BEFORE LANDING checklist and landing procedures to use hydraulic or pneumatic brakes. Taxi off runway if possible. Tow airplane to parking.

WARNING

When using pneumatic brakes, do not touch brake pedals. Using brake pedals can cause erratic braking.

CAUTION

- No differential brake is possible when using pneumatic brakes.
- No antiskid is available. Use pneumatic brake landing data.

A pressure gage failure or loss of accumulator precharge still allows normal braking if utility or auxiliary system can be pressurized.

If utility system has failed, set interconnect valve switch to BRAKE at touchdown. Turn on utility pumps. This allows remaining fluid to pressurize brakes. Gear doors should close. Use normal braking as long as pressure is above precharge. If no braking action is noticed, use pneumatic brakes as stated above.

If only one or two brakes are inoperative, refer to SEVEN- and SIX-BRAKE OPERATION.

SEVEN- AND SIX-BRAKE OPERATION

When landing with one or two inoperative brakes, observe the limitations in section V and use the 7- or 6-brake performance data in T.O. 1E-3A-1-1 (part VII). Use the braking technique described under DIRECTIONAL CONTROL AFTER TOUCHDOWN, section II and LANDING ON SLIPPERY RUNWAYS, sections II and VII.

CAUTION

> Observe brake energy limits if a brake is known to be inoperative. Kinetic energy of the airplane must be absorbed by remaining brakes. Refer to BRAKE LIMITATIONS, section V.

LANDING WITH FLAT TIRES

If tires are flat, the airplane can be landed on the gear. In order to taxi or tow the airplane after landing, two good tires per strut must be installed. If all tires are flat on touchdown, wheels and brakes are damaged. The landing run is extremely short. If there is no wheel well fire, reduce gross weight and landing speed by performing FUEL DUMP checklist before landing. See section V for taxi and towing limits with flat tires. Observe seven- or six-brake limitations if one or two tires are known to be flat.

If tires are known to be flat, have crew take bracing position for crash landing. Use the flight techniques described under GEAR UP OR PARTIAL GEAR LANDING, except that runway should not be foamed. Reduce gross weight as much as possible before landing.

Nose Gear Tire Flat

Keep nose gear off runway as long as possible. If sufficient runway is available, turn inboard spoilers off before touchdown. Raise outboard spoilers as soon as main gear touches down. After touchdown, trim stabilizer to airplane NOSE UP to prevent nose from falling. Hold control column in neutral while trimming to maintain elevator control when stabilizer reaches nose-up limit. Nose gear normally contacts runway at approximately 2,000 to 4,000 feet from touchdown at speeds of 40 to 70 knots.

Main Gear Tire Flat

If one or two tires on a truck are flat (see section V), the airplane can be landed and taxied normally. If both tires on one axle (condition 5) or more than two tires are flat, the airplane can be landed on the gear, but truck damage will result.

If tires are flat on only one side, land to the opposite side of the runway centerline, since the airplane tends to turn toward the flat tires. Use nosewheel steering to assist in maintaining heading.

After Landing

If possible, taxi clear of the runway before stopping. Make taxi turns with largest possible radius.

JAMMED STABILIZER

This procedure is for use any time the stabilizer trim appears to be jammed or stuck and airplane is in trim at a speed higher than approach speed, requiring airplane nose up trim for landing. Refer to *figure 3–19*. If nose down trim is needed, reverse the flap and spoiler settings.

NOTE

- Since the airplane is usually flying at airspeeds above V_{REF} and with flaps up, nose up trim is usually needed for approach with flaps down.
- For nose up trim (to reduce pull force on control column), extend inboard flaps and/or raise outboard spoilers. For nose down trim (to reduce push force on control column), extend outboard flaps and/or raise inboard spoilers.
- Do not rush to the conclusion that the stabilizer is jammed simply because manual trimming is difficult. High airloads on the jackscrew in an extreme out of trim condition can stall manual trim. Refer to FLIGHT CONTROLS ABNORMAL OPERATION, subsection I-H. Runaway electric trim does not usually cause a jammed stabilizer.
- Maintain the airspeed of the last in-trim flight condition until ready to start descent. Check for the cause of apparent loss of electric trimming. Try manual trimming. If the trim wheel appears jammed, both pilots should simultaneously apply considerable force on the manual trim handles in an attempt to break loose the jam, after reaching lower altitude and warm air. Stow the manual trim handles. Note the trim position and then call for the JAMMED STABILIZER checklist.
- If there is any doubt about trim capability, perform a controllability check.
- The procedure for nose up trim has been demonstrated in flight test at all speeds from approach to M_H.

Nose-Up Trim (Pull Force) Required

If the airplane is in trim at a speed above the normal approach speed (V_{REF} + 1/2 headwind + gust factor), perform the following steps when ready to start descent/approach (*figure 3–19*).

1. Inboard SPOILERS Switch – OFF (P)

   Sets spoiler bypass valve to lock inboard spoilers down.

2. SPEED BRAKE Lever – As Required for Trim (P)

   Use the speedbrake lever as a trim control. Move the lever slowly to check the expected airplane reaction. There is little trim effect from extending the speedbrakes above 40°. Expect higher roll rates from differential spoiler action with speedbrakes extended between 20° and 40°.

3. SPOILER VAL BYPASS INBD Circuit Breaker (P5) – Open (E)

   Locks bypass valve in position preventing accidental operation of inboard spoilers if switch is moved.

4. FLAPS BYPASS VALVE INBD Circuit Breaker (P5) – Open (E)

   Locks bypass valve in normal position, preventing operation of inboard electric flap drive.

5. Airspeed BUGS – V_{REF} + 15 Knots (P, CP)

   Set BUGS to V_{REF} + 15 knots to allow for split flap configuration.

6. **WITH IDG** TCAS SENS – TA Only (P or CP)

   Press IFF button on CDU and select LS2 to TA only. VSI displays ONLY TA. This prevents TCAS from coordinating an RA with other TCAS equipped aircraft and inhibits RAs from being issued by own TCAS. ◀

Perform normal DESCENT and APPROACH checklists, except leave circuit breakers open as listed in steps 3 and 4 and the following exceptions:

a. Dump fuel, if required.

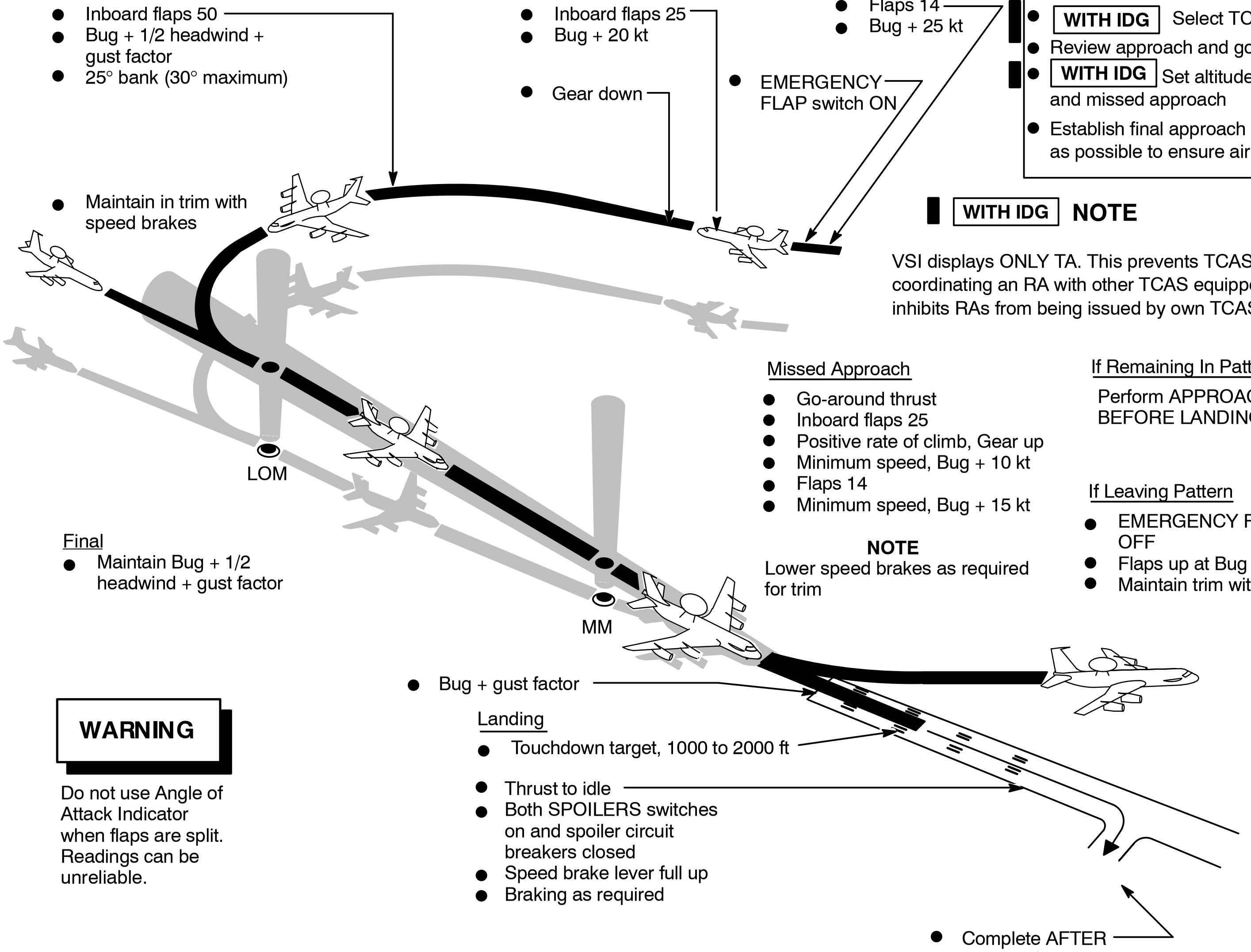
NOTE

In extreme out-of-trim conditions, airplane cg can be adjusted by selective fuel dumping. Dumping center tank fuel moves cg aft; dumping wing tank fuel moves cg forward.

Jammed Stabilizer Landing

APPROACH PREPARATIONS

- Maintain in trim speed until start of approach
- Perform JAMMED STABILIZER LANDING checklist
- Set bug to V_{REF} + 15 kt
- **WITH IDG** Select TCAS TA–only mode ◀
- Review approach and go around procedure
- **WITH IDG** Set altitude alerters for approach and missed approach ◀
- Establish final approach configuration as soon as possible to ensure airplane is in trim.



- Inboard flaps 50
- Bug + 1/2 headwind + gust factor
- 25° bank (30° maximum)

- Maintain in trim with speed brakes

- Inboard flaps 25
- Bug + 20 kt

- Gear down

- EMERGENCY FLAP switch ON

- Flaps 14
- Bug + 25 kt

WITH IDG **NOTE**

VSI displays ONLY TA. This prevents TCAS from coordinating an RA with other TCAS equipped aircraft and inhibits RAs from being issued by own TCAS. ◀

Missed Approach

- Go-around thrust
- Inboard flaps 25
- Positive rate of climb, Gear up
- Minimum speed, Bug + 10 kt
- Flaps 14
- Minimum speed, Bug + 15 kt

NOTE

Lower speed brakes as required for trim

If Remaining In Pattern

Perform APPROACH and BEFORE LANDING checklist

If Leaving Pattern

- EMERGENCY FLAP switch OFF
- Flaps up at Bug + 25 kt
- Maintain trim with speed brakes

Final

- Maintain Bug + 1/2 headwind + gust factor

- Bug + gust factor

Landing

- Touchdown target, 1000 to 2000 ft
- Thrust to idle
- Both SPOILERS switches on and spoiler circuit breakers closed
- Speed brake lever full up
- Braking as required

- Complete AFTER LANDING checklist

WARNING

Do not use Angle of Attack Indicator when flaps are split. Readings can be unreliable.

D57 587 I

Figure 3–19

b. Review go-around procedure.

(1) Set go-around thrust.

(2) Inboard flaps 25.

(3) Positive rate of climb, gear-up.

(4) Bug + 10 KIAS (V_{REF} + 25 KIAS) minimum. Flaps 14.

Pattern and approach speeds will be reviewed, paying particular attention to the higher landing speed, controllability, and missed approach problems.

(5) BUG + 15 KIAS (V_{REF} + 30 KIAS) minimum.

c. After nosewheel is on runway, close spoiler circuit breaker, set both SPOILER switches ON, then deploy spoilers to reduce landing roll.

NOTE

- Check brake energy limited landing weight (T.O. 1E-3A-1-1). If landing weight is above normal brake energy limit, consider dumping fuel to reduce gross weight and approach speed.
- Try to move stabilizer trim manually when reaching lower altitude (and warmer temperatures). Do not move stabilizer more than one unit nose down.

Perform normal APPROACH and BEFORE LANDING checklist with following exceptions:

NOTE

- Expect higher than normal rate of descent due to higher approach speed.
- Addition of thrust causes pitch up and reduction of thrust causes pitch down. Have the airplane in landing configuration and at the approach speed prior to reaching the outer marker, or if VFR, on downwind leg. The sooner approach speed bug + 1/2 headwind + gust (V_{REF} + 15 knots + 1/2 headwind + gust) is reached, the sooner the pilot knows that the airplane is properly trimmed for landing.
- If normal stick forces are required to maintain a normal approach path, reduce thrust to idle just prior to touchdown as for a normal landing. If pull force is required to maintain the approach path, leave approach thrust on until touchdown.

a. Try to move stabilizer trim manually.

NOTE

Do not move manual trim over one unit nose down. Nose-up trim available from spoilers is limited.

b. Extend all flaps to 14 hydraulically.

c. Set EMERGENCY FLAP arming switch to ON.

This locks outboard flaps at 14 unless electric operation is used. Inboard flaps can be extended as required using the flap lever. Expect nose up/down pitch change as inboard flaps extend.

In an extreme case of nose down out-of-trim, the flaps may be fully split. In this case, the outboard flaps are raised electrically with the emergency flap switches. This gives an additional nose up pitch. The outboard ailerons are inoperative.

WARNING

Do not use AOA gage with split flaps. AOA values are not valid in this condition.

d. When inboard flaps are extended to 25, minimum airspeed is BUG + 20 knots.

e. Extend landing gear and adjust trim.

Added drag of gear requires more thrust, causing nose up pitch.

f. Use speed brakes as needed for trim.

Make small movements. Wait for results.

g. Extend inboard flaps to 50.

NOTE

- Landing run is increased for split flaps and crosswind capability is reduced when any spoilers are inoperative.
- Final approach descent rate is higher than normal due to 15 knots higher speed.
- Thrust changes cause trim changes. Adding thrust causes nose up pitch. Removing thrust causes nose down pitch. Try to have final approach configuration set before final approach fix if IFR (or on downwind if VFR), to allow time for trim adjustment.
- To compute brake energy and cooling time, use the average of the two flap settings.

*** * * If Remaining In Pattern, Perform APPROACH and BEFORE LANDING Checklist * * ***

– – – If Leaving Pattern – – –

a. Set EMERGENCY FLAP arming switch to OFF.

b. Flaps up at BUG + 25 knots.

c. Speed brakes as required for trim.

Make small trim changes. Wait for effects of each change. If proceeding to alternate airport, increase airspeed to previous trim speed.

Nose-Down Trim (Push Force) Required

If the airplane is in trim at a speed below the normal approach speed (V_{REF} + 1/2 headwind + gust factor), reverse the flap and spoiler procedures in the nose up trim checklist.

THREE ENGINE LANDING

Use normal descent, approach, and landing procedures in Section II, except set RUDDER OVERRIDE switch to OVERRIDE below 250 KIAS and zero the rudder trim prior to landing.

THREE ENGINE LANDING WITH RUDDER BOOST INOPERATIVE

WITH IDG Select TCAS TA-only mode. VSI displays ONLY TA. This prevents TCAS from coordinating an RA with other TCAS equipped aircraft and inhibits RAs from being issued by own TCAS. ◀

Perform AUXILIARY HYDRAULIC SYSTEM LOSS Checklist.

TWO ENGINE LANDING

For this procedure (*figure 3–20*), use the normal DESCENT, APPROACH, and BEFORE LANDING checklists, with the following exceptions:

WARNING

- With two engines out on same wing, set rudder override switch to OVERRIDE and do not exceed 250 KIAS. Straight and level flight cannot be maintained when cruise power is set on remaining engines if rudder boost switches to 1,450 psi mode.
- When operating rudder override switch in flight, physically identify both RUDDER (lower) and override (upper, slotted guard) switches to make sure correct switch is operated. Operation of wrong switch can cause loss of control.
- Pattern and approach airspeeds are based on air minimum control speed for go-around thrust. If a go-around is required, do not increase thrust above go-around EPR and do not allow airspeed to decrease below bug speed. If airspeed is below bug speed or thrust is above go-around EPR, directional control cannot be maintained with full rudder and five degrees of bank. To maintain directional control, either increase bank or decrease thrust. Climb performance decreases if bank is increased or thrust decreased. To increase airspeed, decrease climb angle.
- Flaps can be extended to 25 for approach, but they must be retracted to 14 for go-around. Climb data for flaps 25 and two engines out is not available.
- When flaps are extended beyond 25, airplane is committed to land.
- Do not decrease airspeed below V_{REF} + 30 knots (V_{REF} + 40 for engines 2 and 3 inoperative) until airplane is committed to land.

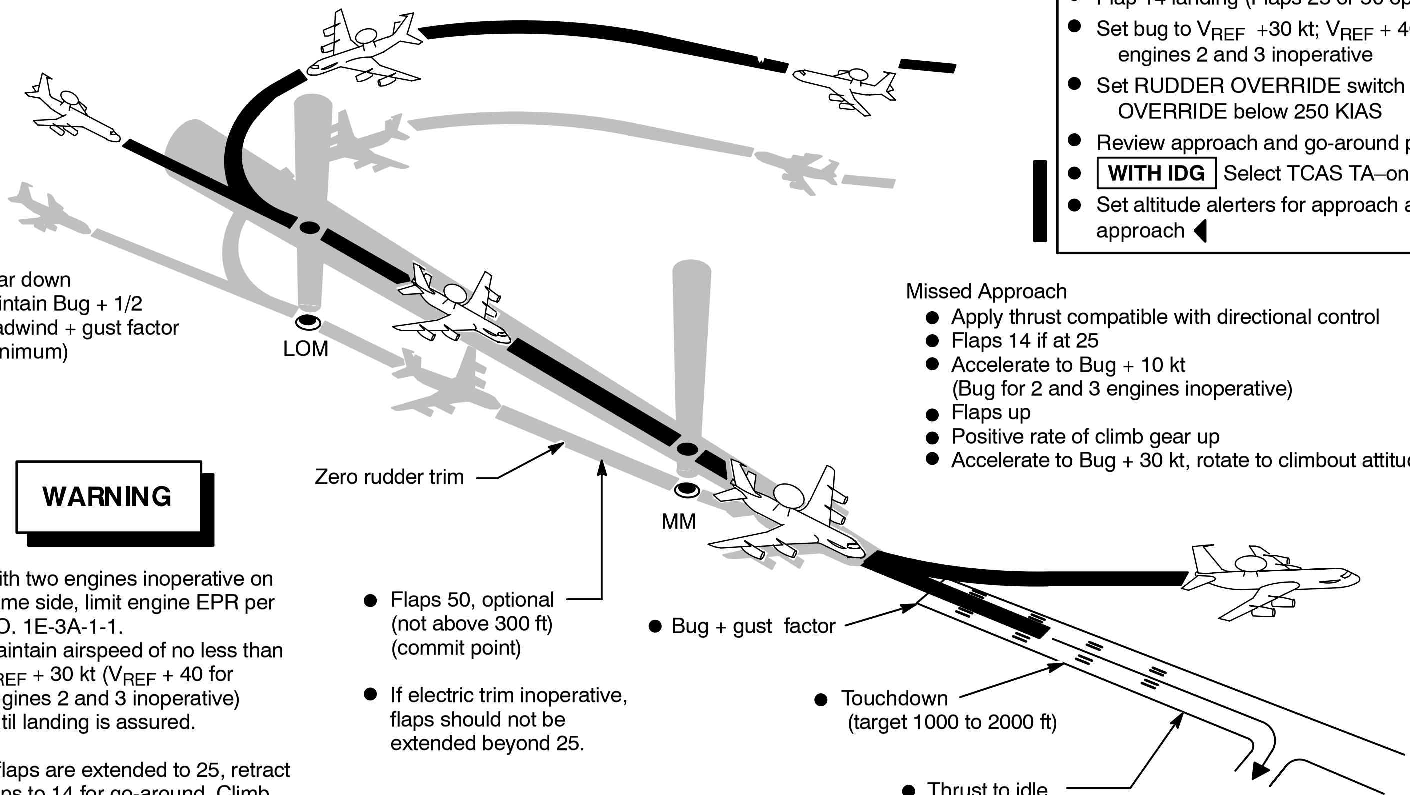
NOTE

- If two engines fail on one wing, the control techniques are the same as with one engine failed but the minimum control speed is higher. For landing with two engines failed, plan a flaps 14 approach and compute landing data for planned landing flap setting T.O. 1E-3A-1-1 Part VII. Go-around EPR settings are limited to reduce thrust so that the air minimum control speed is equal to no-wind approach speed. For a shorter landing roll, the pilot may select flaps 50 once the airplane is committed to land (but not above 300 feet AGL), and allow airspeed to decrease slowly to V_{REF}. If landing data has been computed for other than flaps 14 landing, speed must be reduced to appropriate flap speed to make landing data valid.
- If both inboard engines are inoperative, flaps must be extended by emergency system and landing gear lowered manually. Allow enough time for flap and gear extension. Set hydraulic interconnect to BRAKE after landing.
- With the utility system failed, outboard spoilers and leading edge flaps are not available, and landing gear cannot be retracted in case of a go-around. See *figure 3–20*.
- Use the flaps 14, 2-engine inoperative go-around data in T.O. 1E-3A-1-1. Outboard engine EPR could have to be reduced to maintain directional control with two engines inoperative on one side.
- Check the brake energy limited landing weight. If the landing weight exceeds the chart values for flaps 14, the pilot may either lower the flaps to 50 when committed to landing (but not above 300 feet AGL) or reduce landing weight.
- Check maximum crosswind per T.O. 1E-3A-1-1.
- **WITH IDG** Select TCAS TA-only mode. VSI displays ONLY TA. This prevents TCAS from coordinating an RA with other TCAS equipped aircraft, and inhibits RAs from being issued by own TCAS. ◀
- If both inboard engines are inoperative, manually extended gear cannot be retracted so go-around capability is reduced. If normal brake pressure is available, calculate landing distance with antiskid brakes. If normal brake pressure is lost, compute landing distance based upon pneumatic brakes. Refer to T.O. 1E-3A-1-1. Emergency extension of the flaps requires three minutes to full extension. Landing distance increases and crosswind capability is reduced when the outboard spoilers are inoperative. Refer to T.O. 1E-3A-1-1.

Two Engine Landing

APPROACH PREPARATIONS

- Complete ENGINE FAILURE OR FIRE or PRECAUTIONARY ENGINE SHUTDOWN and LANDING WITH TWO ENGINES INOPERATIVE checklists
- Check weather
- Dump fuel as required
- Flap 14 landing (Flaps 25 or 50 optional)
- Set bug to V_{REF} +30 kt; V_{REF} + 40 for engines 2 and 3 inoperative
- Set RUDDER OVERRIDE switch to OVERRIDE below 250 KIAS
- Review approach and go-around procedure
- **WITH IDG** Select TCAS TA–only mode
- Set altitude alerters for approach and missed approach ◀



- 25° bank (30° maximum)
- Bug + 1/2 headwind + gust factor

- Clean
- Bug + 30 kt or 200 KIAS (whichever is higher)

- Flaps 14 or 25
- Airspeed decreasing to bug + 1/2 headwind + gust factor

- Gear down
- Maintain Bug + 1/2 headwind + gust factor (minimum)

Zero rudder trim

- Flaps 50, optional (not above 300 ft) (commit point)
- If electric trim inoperative, flaps should not be extended beyond 25.

- Bug + gust factor

- Touchdown (target 1000 to 2000 ft)

- Thrust to idle
- Speed brakes up
- Braking as required

Missed Approach
- Apply thrust compatible with directional control
- Flaps 14 if at 25
- Accelerate to Bug + 10 kt (Bug for 2 and 3 engines inoperative)
- Flaps up
- Positive rate of climb gear up
- Accelerate to Bug + 30 kt, rotate to climbout attitude

WARNING

- With two engines inoperative on same side, limit engine EPR per T.O. 1E-3A-1-1. Maintain airspeed of no less than V_{REF} + 30 kt (V_{REF} + 40 for engines 2 and 3 inoperative) until landing is assured.
- If flaps are extended to 25, retract flaps to 14 for go-around. Climb performance with flaps 25 and gear down has not been determined.
- Airplane is committed to landing when flaps extend beyond 25. Do not attempt to go around from flap setting greater than 25.

WITH IDG **NOTE**

VSI displays ONLY TA. This prevents TCAS from coordinating an RA with other TCAS equipped aircraft and inhibits RAs from being issued by own TCAS. ◀

NOTE: Allow additional time to extend gear if engines 2 and 3 are inoperative (reduced hydraulics). If possible, intercept glide slope farther out at higher altitude. Nose gear downlock pin must be engaged prior to landing.

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Figure 3–20

a. Review go-around procedure.

   (1) Set go-around thrust. Maintain directional control.

   (2) Flaps 14 (if extended to 25).

   (3) Flaps up at BUG + 10 KIAS (V_{REF} + 40).

   (4) Positive rate of climb, gear up (if No 2 or No 3 engine operating).

b. **WITH IDG** Select TCAS TA-only mode.

VSI displays ONLY TA. This prevents TCAS from coordinating an RA with other TCAS equipped aircraft and inhibits RAs from being issued by own TCAS. ◀

c. Set rudder override switch to OVERRIDE when established below 250 KIAS.

d. Initiate fuel dump, if required.

If landing weight is above flaps 14 normal brake energy limit (T.O. 1E-3A-1-1) or does not allow a positive climb rate with flaps 14 and gear down, dump fuel to reduce landing weight and approach speed.

e. Extend landing gear manually if utility system has failed.

f. Flaps may be extended to 25 for approach provided airspeed is maintained at or above bug speed until landing is assured. Airspeed may be reduced to flaps 25 speed when landing is assured but not above 300 ft AGL. Retract flaps to 14 for go-around.

g. At pilot's discretion, extend flaps to 50 when landing assured, but not above 300 feet AGL.

NOTE

- If flaps are extended to 50, prepare for the combined pitch trim effects of flap extension from 14 to 50, loss of 30 knots airspeed, possible thrust reduction, and entry into ground effect during last part of final approach and landing. Control column pull forces can be high enough to cause electric trim to stall. This can be prevented by early application of nose-up trim as flaps are extended. If electric trim stalls, control column forces can exceed one-pilot effort.
- If electric trim is inoperative, it is recommended that flaps not be extended beyond 25 for landing.
- With engines 2 and 3 inoperative, or utility hydraulic system failed, there is not sufficient time from the commit point to fully extend trailing edge flaps electrically. Pilot may elect to take whatever electric extension is available beyond 14 or 25 commencing at or below 300 feet AGL.

h. Set BUG to V_{REF} + 30 knots (V_{REF} + 40 for engines 2 and 3 inoperative), due to flaps 14 approach and to maintain airspeed at or above V_{MCA}.

i. Check brake pressure gage.

Normal braking, including anti-skid is available if brake pressure gage indicates well above precharge (approximately 750 psi at 75°F). If utility system is inoperative, do not pump brakes, as this depletes fluid supply rapidly. If a continuous application is made, a fully charged brake accumulator contains sufficient fluid for a normal stop.

j. Check emergency brake pressure gage.

k. When landing is assured, set rudder trim to zero. If pedal force is still being applied, trim brake can cause chattering feel in trim (this is normal).

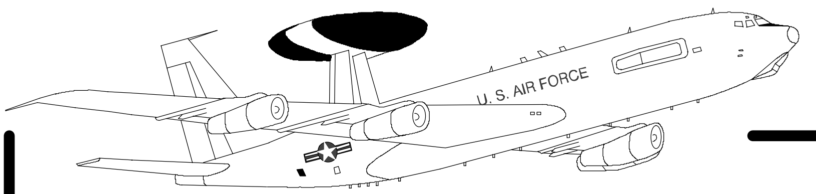
l. After landing, set interconnect valve switch to BRAKE if utility system is inoperative. If brake pressure is not indicated, use pneumatic brakes. If utility system operating, use normal braking. If utility system is inoperative, hold steering wheel centered to provide shimmy damping. Nose gear steering is inoperative.

m. Place rotodome drive in AUX to decrease load on utility pump if only one utility pump is operating.

NOTE

When preparing to land do not operate rotodome at 6 RPM.

Section IIIA



SYSTEMS EMERGENCY PROCEDURES

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***Not Verified by Air Force Crews**

ELECTRICAL POWER SYSTEM

OPERATION WITH ONE OR MORE GENERATORS INOPERATIVE

Make one attempt to reset generator control circuit breaker and/or generator. Cut off non-essential load, if required to maintain load below 218 amperes per generator. Verify bus tie breakers on inoperative bus are closed. At least six generators must be operating in parallel to operate mission radar.

WARNING

Engine fuel line damage can result from IDG case separation. Possible indications of case separation are generator failure, illumination of LOW RPM light, and abnormally high or low IDG oil temperature indication. If any of these conditions exist, check for abnormally high engine fuel flow before disconnecting IDG. If fuel leak is suspected, do not attempt IDG disconnect. Shut down engine if not needed for safety of flight.

CAUTION

- If generator failure causes all generators to trip off, refer to LOSS OF ALL GENERATORS procedure. Some control functions depend on dc power from the TRUs which could be lost if all generators are inoperative.
- If frequency of isolated generator is outside the range of 400 ± 8 Hz or fluctuates more than 4 Hz within the ±8 Hz range, check IDG oil temperature indicator and LOW RPM light. If indications are normal, shut down generator and disconnect IDG. If indications are abnormal, shut down generator and check for presence of fuel leak (abnormally high fuel flow). If fuel flow is normal, disconnect IDG.
- If any generator is outside these limits, check IDG oil temperature indicator and LOW RPM light. If indications are normal, shut down generator and disconnect IDG. If indications are abnormal, shut down engine and call maintenance to physically check IDG.

NOTE

The IDG is assumed to be disconnected if the LOW RPM light illuminates after the IDG DISC switchlight is pressed. LOW RPM light, high IDG temperature and overheat caution light indications after IDG disconnect do not affect continued operation of the engine.

If less than six generators can be paralleled, turn surveillance radar off. Turning radar off reduces electrical load approximately 400 amperes. Coordinate with mission crew commander to reduce other non-essential mission loads.

If not needed, the following items can be shut down to reduce loads:

a. Galley power

b. Reduce boost pumps to one per engine if surveillance radar is off

c. No. 2 auxiliary hydraulic pump if No 1 pump operating

d. HF radio when within VHF/UHF range

e. Mission radios (coordinate with mission crew)

f. Weather radar

LOSS OF ALL GENERATORS

Pilots' and Flight Engineer's Checklist

This condition is indicated by all GEN CONTR OFF indicators illuminated and generator ammeters indicating zero. Steps 4 through 25 restore normal ac power to the airplane and mission systems. If the attempt to restore power fails, steps 26 through 40 reduce emergency power loads to a minimum to extend battery life. Steps 29 through 32 replace the DESCENT checklist. Steps 33 through 38 replace the APPROACH checklist.

The following equipment is usable when all generators are inoperative:

All pitot-static instruments (altimeters in STBY mode), standby attitude indicator (emergency DC bus), slip indicator in ADI, clocks, standby compass.

All controls except inboard spoilers and rudder boost. (Observe yaw damper inoperative limitations, section V.) Flaps (normal operation).

Flight deck UHF and VHF communications radios. (Use VHF if possible; UHF requires about seven times as much power to operate.) To remove power from UHF radio, open UHF XCVR CPLR, UHF FDDRC and UHF XCVR circuit breakers on P5 panel. To remove power from VHF radio open VHF circuit breaker on P5 panel. Interphone and PA, pneumatic brakes, oxygen system, crash landing and bailout signs, fire warning and extinguishing.

NOTE

> Some fire switch functions (which require dc power from the TRU's) are not available when all ac power is lost. Refer to ENGINE FIRE SYSTEM, subsection I-B.

Primary and alternate flow control valves (closing). (Bleed air valves remain in position at power failure.) Emergency depressurization switch, cabin pressurization (outflow valves operate in isobaric mode). Cabin altimeter, cabin climb indicator, cabin differential pressure gages, engine controls, ignition, start control and ignition, N_2 tachometers, nacelle anti-ice (engines 2 and 3 only).

NOTE

> Inboard engine anti-ice valves operate normally. If open, the outboard engine NOSE COWL anti-ice valves close when ac power is lost. Outboard engine ENGINE inlet anti-ice valve remains in the position it was in when ac power was lost.

VHF NAV radio No. 1 (ILS and voice receiver only), IFF, marker beacon.

Fuel shutoff valves and crossfeed valves.

Flight deck DC powered lights (airplane battery) and mission compartment emergency lights (emergency lighting battery). Portable emergency exit lights (self powered) can be turned off or turned on by EMER EXIT LIGHTS switch in flight deck. After being turned off in the flight deck, each portable light can be turned on or off by a switch on the light. Exterior emergency lights (self powered) cannot be turned off.

AE number 1 (EAC bus); CDU3, BSIU1, MDL, GINS CONTROL PANEL illumination; 1553 BUS CONTROL switch (hot battery bus); both EGIs (EGI batteries: 30 minutes minimum; up to 2 hours if fully charged).

NOTE

> With CADCs not operating GINS does not receive TAS or pressure altitude inputs.

1. Pilot's ADI Attitude Source Selector Switch – AHRS (P)

2. Auxiliary Pump No. 1 Switch – OFF (E)

   Reduces starting load on AVAC bus No. 2.

3. 28 vdc TIE BUS DC BUS 3, 5, & 6 Circuit Breaker (P61-5) – Open (E)

   Isolates mission DC tie bus from AVDC tie bus and reduces starting loads on AVAC bus No. 2.

4. Generator No. 2 – Operate Isolated (E)

   a. BUS TIE OPEN Switch No. 2 – Pressed, Held

   b. Generator ON Switch No. 2 – Pressed

   c. BUS TIE OPEN Switch No. 2 – Released

      Restores power to No. 2 generator bus, associated flight avionics bus, and frequency reference unit.

– – – If Generator Breaker No. 2 Does Not Close, or Reopens, Omit Step 5 – – –

5. Auxiliary Pump No. 1 Switch – ON (E)

   Low PRESS caution light out. Restores rudder boost and series yaw damper.

WARNING

> Before turning aucxiliary pump No. 1 switch on in flight, ensure rudder is centered. Rudder movement caused by turning boost on could cause loss of directional control or structural damage.

– – – If Generator Breaker No. 2 Closes, Omit Steps 6 and 7 – – –

6. 28 vdc TIE BUS DC BUS 8 Circuit Breaker (P61-5) – Opened (E)

   Isolates DC buses 2 and 4 from DC bus 8.

7. FREQ REF UNIT Circuit Breaker (P61-5) – Opened (E)

⑧ Liquid Cooling Pumps – OFF (E, ART)

Reduces starting loads on AVAC buses 6 and 8.

9. Generator No 8 – Operated Isolated (E)

    a. BUS TIE OPEN Switch No 8 – Pressed, Held

    b. Generator ON Switch No 8 – Pressed

    c. BUS TIE OPEN Switch No 8 – Release

    Electric stabilizer trim is available.
    Copilot’s flight instruments are powered.
    Parallel yaw damper is available.

⑩ RADAR Switches – OFF (E, ART)

    a. RADAR Switch (FE Panel) – OFF (E)

    b. RADAR ELCU Switch (P67-2) – OFF (ART)

11. BUS TIE OPEN Switches – All OPEN (E)

Prevents parallel operation of generators until selected.

12. Generator ON Switch No 3 – ON (E)

Places generator No 3 on tie bus.

NOTE

- If battery is dead or disconnected, generator breakers 1, 2, 3, and 4 can be closed when generator 3 is turning. The battery bus must be powered to close generator breakers 1, 2, and 4 if generator 3 is not turning. Generator breakers 5, 6, 7, and 8 may be closed if generator 7 is turning. The battery bus must be powered to close generator breakers 5, 6 and 8 if generator 7 is not turning.

- If the battery is dead or disconnected, any bus tie breaker can be closed if the corresponding generator is turning.

13. Generator ON Switch No 7 – ON (E)

Places generator No 7 in parallel operation.

– – – If Generator No 2 is Operating, Omit Steps 14 and 15 – – –

14. Bus Tie Breaker No. 2 – Close (E)

Press generator OFF switch No. 2.

15. Auxiliary Pump No. 1 Switch – ON (E)

WARNING

Before turning auxiliary pump No. 1 switch on in flight, ensure rudder is centered. Rudder movement caused by turning boost on could cause loss of directional control or structural damage.

16. Autopilot – As Required (P)

Autopilot may be engaged, if nav system is operating.

17. Generators – Operate Isolated (E)

    a. No. 4 BUS TIE OPEN Switch – Pressed, Held

    b. No. 4 generator ON Switch – Pressed

    c. No. 4 BUS TIE OPEN Switch – Released

    d. Repeat a, b, and c For Generators 6, 1, 5, In Order – Accomplished

– – – If All Generators are Inoperative, Perform Steps 26 through 44 – – –

18. Generators 6, 5, 4, 1 – Paralleled (E)

Press generator ON switch for each generator. Parallel one generator at a time, check voltage and frequency.

19. Generator No. 8 – Paralleled (E)

Press generator No. 8 generator ON switch.

– – – If Generator No. 2 is Inoperative, Omit Step 20 – – –

20. Generator No. 2 – Paralleled (E)

Press generator No. 2 generator ON switch.

21. 28V DC TIE BUS, DC BUS 3, 5 & 6 Circuit Breaker (P61-5) – Closed (E)

    Reconnects flight avionics and mission dc tie buses.

22. 28V DC TIE BUS, DC BUS 8 Circuit Breakers (P61-5) – Closed (E)

23. Forced Air Cooling Systems – ON (E)

    a. POWER Switches – ON

    b. MODE Switches – AUTO

    c. FAN 1 Switches – Pressed

       FAN 1 indicators illuminate. LOW SPD or HI SPD.

㉔ Liquid Cooling Pumps – ON (E, ART)

Notify radar technician that pumps may be restarted.

㉕ Radar Switches – ON (E, ART)

a. RADAR Switch – On (E)

   OFF indicator out.

b. RADAR ELCU Switch (P67-2) – ON (ART)

   Radar can be operated if at least six generators are paralleled.

***** If All Generators Are Operating, Resume Normal Operations *****

26. EMER EXIT LIGHTS Switch – OFF (E)

    Saves portable emergency exit lights if AVAC bus 4 is not powered (and, if AVDC bus 2 is powered, also saves exterior emergency exit lights) until approach and landing.

– – – If All Generators Are Inoperative, Perform Steps 27 through 44 – – –

***** If One or More Generators Cannot Be Operated, Proceed to OPERATION WITH ONE OR MORE GENERATORS INOPERATIVE *****

㉗ Mission Compartment EMERGENCY LIGHTS Switch (P67-1) – LOW (E, MCC)

Reduces emergency lighting battery output to extend battery life.

NOTE

Emergency lighting battery also powers airplane hot battery bus via one-way (diode-blocked) circuit.

28. Circuit Breakers On P61-6 Panel – Opened (E)

    Open the following breakers as soon as it is determined that power is not obtainable from the main ac generators, and leave open for remainder of flight.

    a. HOT BATTERY BUS-BUS PWR CONT UNIT PROT – Opened

    b. HOT BATTERY BUS-BATT CHGR – Opened

    c. BATTERY BUS-GEN CONT UNIT No. 1 Through No. 8 – Opened

    d. BATTERY BUS-BUS PWR CONT UNIT CONT – Opened

    e. BATTERY BUS-EMERG PWR WARN IND – Opened

    f. BATTERY BUS-MAINT ANN – Opened

    g. BATTERY BUS-FLT AVX DISC CONT – Opened

    h. BATTERY BUS-COMM DISC CONT – Opened

– – – Descent Phase – – –

㉙ Mission Crew – Prepare for Descent (P, MCC)

Notify mission crew to prepare for descent.

30. Approach Briefing and Landing Data – Reviewed (P, CP, E, N)

    The pilot flying the approach will brief in accordance with published procedures. Emphasize type of crew coordination needed due to limited navigation aids. Fly the approach using rudder boost off procedures.

WARNING

For go-around, do not exceed N_2 limitations on the inboard throttles and advance the outboard throttles only as needed for a safe positive rate of climb.

NOTE

- Stabilizer must be trimmed manually.
- Rudder response to pedal pressure varies during final approach, landing flare, and rollout. After touchdown, as air loads decrease, rudder response increases significantly when the tab is fully deflected and additional rudder pedal movement moves the rudder directly, instead of moving the tab. Also, at low airspeeds there is an apparent lag in response to pedal movement due to the small force generated by the tab and resulting longer time for a given rudder deflection to occur. Take care to avoid overcontrolling, especially on crosswind landing and rollout.
- Radio altimeter is inoperative. Pilot's ILS localizer and glide slope pointers are available, but flight director and autopilot are not available. Pattern, approach speeds will be reviewed. Antiskid and inboard spoilers are inoperative. Landing distance increases without operable antiskid brakes and inboard spoilers. Crosswind limits are also reduced. Refer to T.O. 1E-3A-1-1. Landing gear extension must be checked visually.

    a. TOLD Card Data – Updated

    b. Airspeed BUGS – Set V_{REF} + 30 knots

31. CONTINUOUS IGNITION Switch – ON (E)

NOTE

Do not turn on continuous ignition until ready to descend. Total current drain of 4 engine continuous ignition is 10 amperes.

32. Altimeters – Set______ STBY (P), Set ______ STBY (CP), Set _______ (N)

– – – Approach Phase – – –

33. VHF NAV No 1 Radio – Set for Approach (P, CP)

    a. VHF NAV No 1 Radio – Tuned for Approach

    b. Pilot's NAV MODE Selector – VOR/LOC

    c. Pilot's HSI Course Knob – Set

CAUTION

- Where possible, use VHF radio for communication. VHF radio power consumption is approximately 1/3 of UHF radio power consumption.
- When airplane altitude is equal to cabin altitude, draw-through cooling is lost. Limit UHF radio transmission to minimum after airplane is depressurized to prevent damage to radios and loss of communications.

34. Circuit Breakers – Checked (E)

    Check that all circuit breakers are closed except those opened in steps above.

35. Manual Trim Handles – Extended (P, CP)

    Prepare for manual trimming. Electric trim is inoperative.

36. Crew Notified – Prepare for Landing (P)

    Use PA/interphone to notify crew to fasten seat belts for landing. (Seat belt signs are inoperative.)

(37.) MISSION EMERGENCY LIGHTS Switch (P67-2) – HIGH (E, MCC)

38. EMERGENCY EXIT LIGHTS Switch – ON (E)

Steps 37 and 38 provide additional interior lighting for landing.

– – – Before Landing Phase – – –

39. SPEED BRAKE Lever – Full Forward, In Detent (P or CP)

40. Gear – DOWN, In, Checked (P, CP, E, N)

Set gear handle to down, in detent. Check downlocks. Gear position lights are inoperative.

CAUTION

- Verify nose gear is down and locked.
- If any gear not locked, use MANUAL GEAR EXTENSION procedures to lock.

(41.) Portable Emergency Lights – ON (E, MCC)

Set all switches to ON.

42. Outboard SPOILERS Switch – ON (E)

Inboard spoilers are inoperative due to loss of auxiliary system.

43. Flaps – 14 or 25 (CP)

Flap gages and LE FLAP indicators are inoperative. Maintain 14 or 25 flaps until landing is assured (for go-around capability without rudder boost)

NOTE

- Since electric trim is inoperative, it is recommended that flaps not be extended beyond 25 for landing, if runway length permits higher landing speed.
- If flaps are extended to 50, prepare for the combined pitch trim effects of flap extension from 14 or 25 to 50, loss of 30 knots airspeed, possible thrust reduction and entry into ground effect during last part of final approach and landing. Control column pull forces can be high enough to cause difficulty in trimming. This can be prevented by early application of nose-up trim as flaps are extended. Control column forces can exceed one-pilot effort without proper nose-up trim.

– – – At Pilot’s Option, When Landing Assured – – –

44. Flaps – 50 (CP)

Flap gages and LE FLAP indicators are inoperative.

– – – Proceed to AFTER LANDING Checklist – – –

CAUTION

Have airplane wheels chocked after stopping, before releasing brake. Parking brake is inoperative.

Navigator’s Checklist

– – – Descent Phase – – –

1. Sextant Mount – Checked, If Required

Open sextant mount drain, check for water, drain if necessary, close drain.

+2. Approach Briefing and Landing Data – Reviewed (P, CP, E, N)

The pilot flying the approach will brief in accordance with published procedures. Emphasize type of crew coordination needed due to limited navigation aids. Fly the approach using rudder boost off procedures. Navigator monitors and confirms penetration and approach procedures with particular emphasis on terrain clearance.

+3. Altimeters – Set _______ STBY (P), Set_______ STBY (CP), Set _______ (N)

– – – Before Landing Phase– – –

+4. Gear – Down, In, Checked (P, CP, E, N)

Navigator checks downlocks if requested.

CAUTION

If any gear not locked, use MANUAL GEAR EXTENSION procedures to lock.

GENERATOR DRIVE OVERHEAT

– – – If IDG Temperature Indicator Channel Pointer Reaches CAUTION Range On Indicator Dial (155°C) (Orange Band) – – –

– – – If Generator OHEAT Caution Light Illuminates, Proceed to Step 4 – – –

1. Generator OFF Switch – OFF (E)
2. IDG Oil Temperature Indicator and OHEAT Segment of IDG DISC Switchlight – Monitored (E)

– – – If IDG Temperature returns to Normal range– – –

3. Generator ON Switch – Press (E)

– – – If Generator OHEAT Caution Light Illuminates – – –

4. Generator OFF Switch – OFF (E)
5. IDG DISC Switchlight – Pressed (E)

Press and hold for at least one second. This action disconnects the drive from the engine. The drive cannot be reconnected in flight.

WARNING

Engine fuel line damage can result from IDG case separation. Possible indications of case separation are generator failure, illumination of LOW RPM light, and abnormally high or low IDG oil temperature indication. If any of these conditions exist, check for abnormally high engine fuel flow before disconnecting IDG. If fuel leak is suspected, do not attempt IDG disconnect. Shut down engine if not needed for safety of flight.

CAUTION

If LOW RPM light does not illuminate, the engine may be operated normally as long as IDG oil temperature indication remains stable and within normal operating limits. If IDG oil temperature begins to fluctuate or read abnormally high (OHEAT lights illuminate), shut down engine if not needed for safety of flight.

NOTE

The IDG is assumed to be disconnected if the LOW RPM light illuminates after the IDG DISC switchlight is pressed. LOW RPM light, high IDG temperature and overheat caution light indications after IDG disconnect do not affect continued operation of the engine.

6. BUS TIE OPEN Switch – Closed (E)

Check to assure bus tie breaker is closed. If it is open, pressing the GEN CONTR OFF switch closes the bus tie.

– – – If Generator Drive is Disconnected, Continue to OPERATION WITH ONE OR MORE GENERATORS INOPERATIVE – – –

ALL BUS TIE BREAKERS OPEN

1. Electrical Panel, Circuit Breakers, Equipment – Checked (E, CT, CDMT, ART)

Check for abnormal generator indications, tripped circuit breakers both in the flight deck and the mission compartment. Have the mission crew check for any abnormal indications.

2. No 1 Bus Tie Breaker Closed – Attempted (E)

– – – If it Closes, Perform Only Step 3 – – –

– – – If it Does Not Close, This Can Indicate a Differential Fault On the Sync Bus and No Further Attempts to Restore Power to the Sync Bus Will Be Made. Perform Step 4 – – –

3. Remaining Bus Tie Breakers – Closed (E)

NOTE

- If a malfunctioning generator has been identified while operating isolated, power the affected bus from another generator and perform the appropriate procedure for the malfunctioning generator.
- If any bus is left unpowered, review the applicable bus distribution diagram to determine equipment lost.

4. Electrical System – Operate Isolated (E)

FLIGHT CONTROL SYSTEM

Aileron and elevator control cables are duplicated. Jammed controls can be freed by applying two-pilot effort to shear the controlled-shear rivets, releasing control cables from the jammed control.

RUNAWAY STABILIZER

1. Trim Brake – Engaged (P or CP)

   Move wheel opposite to trim movement to apply stabilizer trim brake.

2. STAB TRIM Switches – CUTOUT (P or CP)

   Autopilot disengages. Trim should stop.

– – – If Trim Stops, Omit Step 3 – – –

– – – If Trim Stops, Manual Trimming (Step 6) May Be Performed as Required – – –

3. Trim Wheels – Hold (P, CP)

   This can require 2 pilot effort.

4. STAB TRIM ACTR and CONTROL Circuit Breakers (P5 Panel) – Open (E)

   Removes power to STAB TRIM switches to prevent operation.

5. AUTOPILOT Circuit Breaker (P5 Panel) – Opened (E)

   Prevents autopilot engagement.

WARNING

Do not reactivate autopilot or electric trim after runaway.

NOTE

If the AUTOPILOT circuit breaker on the P5 panel trips or is opened, both EGIs will report an ANL ATT NGO. These NGOs will not affect the EGIs ability to navigate and can be corrected by closing the AUTOPILOT circuit breaker.

6. Stabilizer – Trimmed Manually (P. CP)

   This can require two pilot effort – Release STAB TRIM BRAKE.

   If manual trim is hard to move, momentarily release or reverse pitch forces and move trim wheel as rapidly as possible.

NOTE

- Split spoilers (and split flaps when below placard speed) may be used for trim if needed. Refer to JAMMED STABILIZER, Section III.
- Decreasing thrust or airspeed causes nose down pitch. Increasing thrust or airspeed causes nose up pitch.

UNUSUAL YAW IN FLIGHT

Unusual yaw in flight can be caused by:

- Series yaw damper malfunction
- Parallel yaw damper malfunction
- Rudder hardover
- Asymmetrical thrust
- Asymmetrical drag
- Structural damage
- Other flight control systems malfunction
- APU exhaust door open in flight
- Pressure vessel venting

To determine the cause of the unusual yaw:

1. Engine instruments – Checked
2. Three–axis trim indicator, RUD – Checked

   A series yaw damper malfunction can be indicated by a full and continuous deflection of the RUD three–axis trim indicator. Disengage the series yaw damper and engage the parallel yaw damper.

3. Parallel yaw damper indicator – Checked

   A parallel yaw damper malfunction is indicated by a full and continuous deflection of the rudder and parallel yaw damper trim indicator. Disengage the parallel yaw damper.

   NOTE

   Disengaging either yaw damper also disengages the autopilot.

4. Engine cowlings – Inspect visually
5. Structural damage – Inspect visually
6. Uncommanded spoilers or flap extension – Inspected visually
7. Door warning indicators – Checked
8. APU shroud – Inspected

   Listen for noise caused by open exhaust door.

   CAUTION

   - Tail buffeting can result if APU exhaust door is open in flight.
   - If either APU door is open, APU shroud can fail and airplane cannot maintain pressurization.

9. Cabin – Inspected

   Listen for noise caused by escaping air.

10. Main gear wheel wells – Inspected

    Listen for noise caused by open doors.

RUDDER HARDOVERS

In most cases, an unusual yaw is not caused by a rudder hardover.

WARNING

If the airplane is controllable, do not switch the RUDDER boost OFF until the problem is positively isolated to the rudder boost; the airplane might then become uncontrollable or damage might occur when restoring rudder boost if the pedals must be fully deflected to maintain control with rudder boost off.

A rudder hardover can be caused by:

- The rudder power control unit (PCU).
- The series yaw damper.
- The parallel yaw damper.

If rudder hardover is caused by the rudder PCU, turn RUDDER boost OFF. Refer to Section III, Rudder Boost OFF Landing.

A PCU malfunction can be indicated by one of the following effects:

- Excessive pedal force is required to move the rudder.
- Rudder response is sluggish.
- Rudder response lags behind pedal inputs.

NOTE

The preceding indications are not unique to a faulty PCU. Other mechanical malfunctions in the rudder control system could produce the same effects.

WARNING

With an outboard engine inoperative, maintain airspeed above V_{MCA} and limit outboard operating engine to go–around EPR, or set up symmetrical power before turning off rudder boost.

A series yaw damper hardover can be indicated by a full and continuous deflection of the RUD three–axis trim indicator.

Disengage the series yaw damper and engage the parallel yaw damper.

NOTE

Rudder deflection by the series yaw damper is mechanically limited to a maximum of 4 degrees from the trim position.

A parallel yaw damper hardover is indicated by a full and continuous deflection of the rudder and parallel damper trim indicator. Disengage the parallel yaw damper.

NOTE

- Disengaging either yaw damper also disengages the autopilot.
- Yaw dampning is slightly degraded with rudder boost OFF and and parallel yaw damper on. If airplane response is not satisfactory, observe Yaw Damper Inoperative Limitations in Section V.

RUDDER PRESSURE REDUCER MALFUNCTION

Failure to Decrease Pressure

If rudder mode does not change to 2,290 PSI above 185 KIAS, or to 1,450 PSI above 265 KIAS either limit airspeed to 250 KIAS or perform the following procedure.

1. RUDDER Switch – OFF (P or E)
2. SERIES Yaw Damper Switch – OFF (P)
3. PARALLEL Yaw Damper Switch – ON, If Desired (P)

WARNING

With an outboard engine inoperative, maintain airspeed above V_{MCA} and limit outboard operating engine to go-around EPR or set up symmetrical power before turning off rudder boost.

NOTE

Yaw damping is slightly degraded with rudder boost off and parallel yaw damper on. If airplane response is not satisfactory, observe yaw damper inoperative limits in section V.

– – – When Below 250 KIAS, Resume Normal Operation – – –

– – – If An Engine is Inoperative, Perform Steps 4 Through 6 When Below 250 KIAS – – –

4. RUDDER Switch – ON (P or E)

WARNING

When setting RUDDER switch to ON in flight, ensure rudder and rudder trim are in neutral (centered) position. This is to prevent excessive structural loads caused by rapid increase in rudder deflection and to maintain aircraft control during the transition to powered rudder.

5. Override Switch – OVERRIDE (E)

WARNING

When operating rudder override switch in flight, physically identify both RUDDER (lower) and OVERRIDE (upper, slotted guard) switches to make sure proper switch is operated. Operation of wrong switch can lead to loss of control.

6. SERIES Yaw Damper Switch – ON (P or E)

Failure to Increase Pressure

If rudder pressure fails to increase to 2,290 PSI at airspeeds below 235 KIAS or to 3,000 pounds at airspeeds below 165 KIAS, set override switch to OVERRIDE. If rudder mode indicator fails to switch to 3,000, use go-around power settings for 4 or 3 engines, rudder boost off, part VII, T.O. 1E-3A-1-1. Refer to Rudder Boost Out procedures.

WARNING

- When operating rudder override switch in flight, physically identify both RUDDER (lower) and OVERRIDE (upper, slotted guard) switches to make sure proper switch is operated. Operation of wrong switch can lead to loss of control.
- If an engine is inoperative and rudder mode indicator does not indicate 2,290 below 235 KIAS, 3,000 below 165 KIAS, or 3,000 when rudder override switch is set to OVERRIDE, do not slow below V_{REF} +30 KIAS and do not exceed go-around EPR setting for (4 or 3 engines, rudder boost off) shown in T.O. 1E-3A-1-1.

FUEL SYSTEM

FUEL TANK LEAK

Fuel tank leaks can be caused by an occurrence which causes structural damage or by seal failures at component connections on the spars. A leak from the bottom of a tank is improbable. Two other probable causes are improperly secured dripsticks or overwing fuel filler caps. Fuel tank leak is usually identified by high fuel consumption, continued fuel imbalance problems or illumination of boost pump LOW pressure caution light.

1. CROSSFEED Valve Switches – ON (E)
2. Boost PUMPS Switches – As Required (E)

   Feed as much fuel as practical to all engines from leaking tank.
3. FUEL QUANTITY Gages – Monitor (E)

   NOTE

   If rate of decrease in tank equals fuel flow to engines, fuel level is below leak. Operate normally.
4. Boost PUMPS Switches – As Required (E)

   Before leaking tank reaches 1,500 pounds remaining, resume fuel feed to all engines from non-leaking tanks. Shut off boost pumps in leaking tank.
5. CROSSFEED Valve Switch (For Leaking Tank) – ON (E)

   Must be on for remainder of flight to avoid flame out if tank is empty. One other crossfeed valve must be open.
6. Fuel Management – Checked (E)

   Establish fuel usage to attain symmetrical balance (if possible) and calculate cg.
7. Fuel Dump – As Required (E)

   Perform a CONTROLLABILITY CHECK, if required. If necessary, dump fuel to maintain lateral balance or to keep cg in limits.

FUEL CROSSFEED VALVE FAILURE

Failed Closed

If a crossfeed valve fails closed, that engine can be fed only from its associated tank. The affected tank can be refueled in flight. Reserve tank fuel can be transferred to the adjacent outboard main tank.

Failed Open

If any crossfeed valve fails open, use that valve to pressurize the manifold. Normal fuel management is possible from main wing tanks to engines if center wing tank boost pumps are off; and from center wing tank to all engines if center wing tank boost pumps are on.

Outboard Crossfeed Failed Open

If an outboard crossfeed fails open, normal operation is possible.

Inboard Crossfeed Failed Open

If an inboard crossfeed valve fails open, it is not possible to feed center tank to outboard engines while feeding inboard main tanks to their respective engines. During the phase of fuel management where center tank would normally feed only outboard engines, alternate between feeding center tank to all engines and feeding inboard main tanks to all engines to arrive at a burn sequence approximating the planned burn sequence. To burn from inboard mains to all engines, open all cross feed valves and use only the four inboard main tank boost pumps.

NOTE

Coordinate with the radar technician for operation of the liquid cooling system (LCS). This fuel feed configuration allows use of only one or two of the four LCS heat exchangers.

If this procedure is not usable, fuel balance can be improved by using a higher inboard thrust setting to burn more of the inboard main tank fuel. It should not be necessary to dump fuel either to restore inboard fuel balance or to maintain cg within limits. Control forces are easily neutralized by aileron and rudder trim for any amount of lateral imbalance between inboard main tanks. The cg tracks slightly forward of planned landing cg due to extra fuel in the inboard main tanks.

FUEL ICING LIGHT ILLUMINATED

If the fuel ICING caution light remains illuminated after one minute of fuel heater operation, or illuminates repeatedly, the cause is probably not fuel icing. Continued operation of the engine with the ICING light illuminated should not be attempted unless required for safety of flight. If fuel temperature in tank feeding engine is above 0°C, fuel icing is not likely. Refer to PRECAUTIONARY ENGINE SHUTDOWN checklist, section III.

FUEL HEAT VALVE FAILED OPEN

If the fuel heat valve fails open, it is not necessary to shut down the engine. However, the malfunction must be corrected before the next flight. Monitor oil temperature closely in the event of a fuel heat valve malfunction. If the oil temperature does not remain within limits, shut down the engine or land as soon as possible using the minimum thrust required to sustain safe flight. Maintain a minimum of 1,500 pounds per hour fuel flow on affected engine.

BOOST PUMP FAILURE

During descent and landing, any tank with a boost pump failed shall be manifolded to another tank with both boost pumps operating. If center wing tank boost pumps are inoperative when alternate fuel feed is needed (normally 20,000 pounds or selected switch point fuel in center tank), dump center wing tank to reduce gross weight, then burn main wing tank-to-engine. If a wing tank boost pump fails during takeoff or climb, open the crossfeed valve for that tank.

WARNING

Engine flameout can occur if airplane pitch attitude exceeds 8° nose up or 10° nose down when any outboard main tank contains less than 2,500 pounds or any inboard main tank contains less than 6,500 pounds. Refer to MINIMUM FUEL PROCEDURES, Section II.

CAUTION

If any combination of boost pump circuit breakers trip, set pump switch to OFF and open all breakers for that pump. In flight, unless required for safety of flight, leave circuit breakers open. Do not reset breakers until maintenance personnel inspect the system.

NOTE

- Failure of both boost pumps in any wing tank, while the airplane is operating tank-to-engine, can prevent obtaining takeoff rated thrust at altitudes above 12,000 feet. Advise ART to switch LCS heat exchangers, if operating, if both boost pumps in a tank fail.
- All fuel remaining in the center wing tank is unusable if both center wing tank fuel boost pumps fail. Notify pilot of fuel quantity available in wing.

EMPTY WING TANK

When a wing tank is empty during flight, observe the following limitations. Any wing tank with both fuel boost pumps operative shall not feed more than two engines at engine powers above cruise thrust. Any wing tank with only one operative fuel boost pump, when supplying fuel to two engines, shall be manifolded to a wing tank with both fuel boost pumps operative, at engine powers above cruise thrust. Perform CONTROLLABILITY CHECK, Section III, before landing.

FUEL TANK OVERHEAT

If the fuel tank OHEAT caution light illuminates, check the fuel temperature in the affected tank and the opposite tank. If the temperature in the affected tank is the same as the opposite tank and below the limit in *figure 5-9*, the warning circuit is defective. If the temperature is above the limits shown in *figure 5-9*, and LCS heat exchangers are in use, notify ART of overheat so LCS coolant flow can be switched, then shut off the heat exchangers. Check that fuel heater is off. If no other means of cooling tank is available, fly at a higher altitude for colder outside temperature.

FUEL QUANTITY INDICATOR FAILURE

Fuel quantity indicator is considered failed when PRESS TO TEST GAGES switch is pressed and fuel quantity indicator does not decrease.

Main or Reserve Tank Quantity Indicator

Use indication from corresponding opposite tank to determine fuel quantity remaining in any main or reserve tank with inoperative fuel quantity indicator. Use total fuel remaining gage to determine fuel burned and subtract from previous total. Continue normal fuel management.

WARNING

To prevent possible over-filling of tank and resulting structural damage, air refueling of wing tank with inoperative fuel gage will not be attempted except in an actual fuel emergency and only when the gage in the same tank in the opposite wing is operable.

Center Tank Quantity Indicator

Calculate fuel remaining by subtracting fuel burnoff during center tank use from initial fuel quantity in center tank.

WARNING

Do not attempt air refueling of center wing tank with inoperative fuel gage except in an actual fuel emergency. The restrictions below shall be followed.

When filling a center tank with inoperative fuel quantity indicator, determine initial quantity as in paragraph above, then calculate filling time by assuming the following fill rates and close center tank refuel valve at end of calculated filling time.

a. With center tank and wing tank refuel valves open, 3,000 pounds per minute.

b. Center tank only 4,000 pounds per minute.

c. Do not exceed estimated quantity of 62,000 pounds or airplane gross weight of 315,000 pounds, based on estimated center tank quantity.

FUEL QUANTITY INCREASE IN WING TANK

If the fuel quantity in a wing tank appears to increase during crossfeed operation, the isolation check valve or the gravity feed check valve can be open. Close the LCS heat exchanger fuel valve for that tank. If the quantity stops increasing, the isolation check valve is stuck open. If the quantity continues to increase, the gravity feed check valve is stuck open. Fuel balance may be maintained by selective control of fuel crossfeed valves and boost pumps. Monitor fuel temperature in tanks with operating LCS heat exchangers during radar operation.

AIR REFUELING MALFUNCTIONS

Refer to T.O. 1-1C-1-27.

BLEED AIR SYSTEM

BLEED AIR SYSTEM OVERHEAT

1. Affected Engine BLEED AIR Switch – OFF (E)

   Verify BLEED AIR OFF and FIREWALL CLOSED indicators illuminate. Allow a cooling period of approximately two minutes.

– – – If OVERHEAT Caution Light Goes Out, Perform Step 2 – – –

– – – If OVERHEAT Caution Light Remains Illuminated and Either the BLEED AIR Switch OFF Light or the FIREWALL CLOSED Indicator Illuminates, the OVERHEAT Detection System Has Malfunctioned, Proceed to Step 3 – – –

– – – If OVERHEAT Caution Light Remains Illuminated and Both the BLEED AIR Switch OFF Light and the FIREWALL CLOSED Do Not Illuminate. Proceed to Step 5 – – –

2. Affected Engine BLEED AIR Switch – ON (E)

– – – If OVERHEAT Caution Light Illuminates, Proceed to Step 3 – – –

– – – If OVERHEAT Caution Light Remains Out, Proceed to Step 4 – – –

3. Affected Engine BLEED AIR Switch – OFF for Remainder of Flight (E)

*** * * Return to Normal Operation Using Three Engine Bleeds * * ***

4. Bleed Air System – Monitor for Remainder of Flight (E)

*** * * Return to Normal Operation * * ***

5. Affected Engine Throttle – Cutoff, if Not Needed for Safety of Flight (P)

   Shut down engine using ENGINE FAILURE OR FIRE checklist.

NOTE

If operation of affected engine is required, operate at lowest possible thrust setting consistent with safe flight operation, until shutdown is practical.

BLEED DUCT PRESSURE IN CAUTION ZONE

When the engines are supplying bleed air and the bleed duct pressure is in the caution zone (60 to 85 PSI), one of the engine bleed air modulating/shutoff valves has malfunctioned. To correct this problem, proceed as follows:

NOTE

If a bleed air OVER PRESS caution light illuminates, accomplish the BLEED AIR SYSTEM OVER PRESSURE checklist.

– – – If Three BLEED AIR Switches Have Both the Line Light and OFF Caution Light Illuminated While One BLEED AIR Switch Has Only the Line Light Illuminated, Perform Step 1 – – –

– – – If More Than One BLEED AIR Switch Has Only the Line Light Illuminated, Perform Step 2 – – –

1. Only BLEED AIR Switch With Just Line Light Illuminated – OFF (E)

   Closing this pressure regulating valve manually should reduce system pressure and allow the rest of the pressure regulating valves to open and operate normally.

– – – If System Pressure Does Not Return to Normal, Perform Step 2 – – –

***** If System Pressure Returns to Normal, Resume Normal Operation with Failed Pressure Regulating Valve Closed. *****

2. Engine Number One BLEED AIR Switch – OFF (E)

– – – If Duct Pressure Decreases Below 60 PSI, Proceed to Step 6 – – –

– – – If Duct Pressure Remains in Caution Zone, Set Engine Number One BLEED AIR Switch to On and Proceed to Step 3 – – –

3. Engine Number Two BLEED AIR Switch – OFF (E)

– – – If Duct Pressure Decreases Below 60 PSI, Proceed to Step 6 – – –

– – – If Duct Pressure Remains in Caution Zone, Set Engine Number Two BLEED AIR Switch to On and Proceed to Step 4 – – –

4. Engine Number Three BLEED AIR Switch – OFF (E)

– – – It Duct Pressure Decreases Below 60 PSI, Proceed to Step 6 – – –

– – – If Duct Pressure Remains in Caution Zone, Set Engine Number Three BLEED AIR Switch to On and Proceed to Steps 5 and 6 – – –

5. Engine Number Four BLEED AIR Switch – OFF (E)

6. Bleed Air System – Monitor for Remainder of Flight (E)

BLEED AIR SYSTEM OVERPRESSURE

If a bleed air system OVERPRESS caution light illuminates, ensure associated FIREWALL CLOSED indicator illuminates and proceed as follows:

1. BL AIR, VALVES, ENG 1 & 4 and ENG 2 & 3 Circuit Breakers (P61-3) – Checked (E)

2. Affected Engine BLEED AIR Switch – OFF (E)

   Verify BLEED AIR switch OFF indicator and FIREWALL CLOSED indicator illuminate.

LOW BLEED AIR PRESSURE

The usual cause of low bleed air pressure is one or more bleed air valves closing. This is caused by clogged pressure sensing lines (or filters) or a leaking sensing line. The only inflight remedy is to isolate the defective valve by closing one valve at a time until the system operates normally. If all engines are operating at low thrust settings, such as descent or on-station, satisfactory bleed air operation can be obtained by setting two engines to a higher thrust level and two to a lower thrust level, so that the total fuel flow is the same.

BLEED AIR LEAKS

This checklist is intended for inflight use. If LEAK caution light illuminates on ground before start of takeoff roll, shut off bleed air and have maintenance check detector.

CAUTION

The only indication of a bleed air leak upstream from the PRSOV is a decrease in EPR and N_1. At TRT, 16th stage bleed air may exceed 800 °F and 200 psia. Immediately retarding the throttle to idle will minimize further damage to engine and pylon components. Refer to ENGINE FAILURE OR FIRE Checklist.

– – – If Left or Right LEAK Caution Light Illuminated in Flight – – –

1. ISOLATION Switch – CLOSED (E)

   Close isolation valve on leaking side.

2. BLEED AIR Switches – OFF (E)

   Close both bleeds on leaking side.

– – – If Center LEAK Caution Light Does Not Illuminate, Proceed to Step 5 – – –

– – – If Center LEAK Caution Light Illuminated, Perform Steps 3 Through 5 – – –

3. Left and Center ISOLATION Switches – CLOSED (E)

4. ALTERNATE Flow Control Valve – Opened (E)

   Open valve manually if it failed to open automatically.

5. LEAK TEST Switch – Pressed (E)

   Reset leak detector. If light blinks or does not go out, detector is defective.

– – – If Unable to Pressurize Cabin, Perform Step 6 – – –

*** * * If Able to Pressurize Cabin, Resume Normal Operation Leaving Affected ISOLATION Switches CLOSED (and PRIMARY Valve Closed, If Required) * * ***

6. RAM AIR Valve Switch – ON (E)

   Operate unpressurized if unable to pressurize on two bleeds.

AIR CONDITIONING SYSTEM

Emergency operation of the air conditioning system includes Air Conditioning Pack (ACM) overheat and zone duct overheat.

AIR CONDITIONING PACK OVERHEAT

– – – If OVERHEAT Caution Light Illuminates, RAM INLET Door and BYPASS Valve Position Gages Show Full COOL, COMP DISCH Gage Below 400°F, and Flow Control Valves Operating Normally, Perform Step 1 – – –

The temperature at the water separator outlet exceeded 205°F. The ram inlet door has been driven open and the bypass valve has been driven closed. Manual control of the ram air door and the pack bypass valve is not possible until the pack is reset. The pack can be reset when the temperature at the water separator outlet is below 174±10°F. There is no gage to indicate this.

– – – If OVERHEAT Caution Light Illuminates and COMP DISCH Temperature Gage Reads Over 415°F, Proceed to Steps 3 and 4 – – –

Pack bypass valve remains in previous position. System commands ram air door full open. If the operating flow control valve switches to low flow mode (LOW caution light and line light both illuminated), the compressor discharge temperature has exceeded 450°F.

1. Pack Overheat RESET Button – Pressed (E)

Press repeatedly or continuously until OVERHEAT caution light is out. The system cannot reset until the temperature of the water separator outlet is below 174±10°F. On automatic operation, the valves do not move until the OHEAT caution light has been out for 15 seconds.

– – – If OVERHEAT Caution Light Illuminates Again, RAM INLET Door and BYPASS Position Gages Show Full COOL, COMP DISCH Gage Below 400°F, and Flow Control Valves Operating Normally; Repeat Step 1, Then Proceed to Step 2 – – –

*** * * If OVERHEAT Caution Light is Out, Resume Normal Operation, Lowering the Temperature Setting If Required * * ***

When the pack is reset, the system returns to the control mode (automatic or manual) it was in prior to the overheat condition. The most probable cause of this overheat is operation with the pack bypass valve open and/or the ram inlet door closed.

2. Air Conditioning System – Operated Manually (E)

During manual operation, if the ICING caution light illuminates, the bypass valve is driven open until the ICING caution light is out. When the ICING caution light is out the bypass valve can be operated manually. If the water separator is clogged with dirt, not ice, the system drives the bypass valve full open on manual operation.

3. Pack Overheat RESET Button – Pressed (E)

System cannot be reset until compressor discharge temperature is below 385±10°F. Monitor COMP DISCH temperature gage. The RESET button can be pressed repeatedly or continuously.

The most probable causes: the ram air door is closed, the ram air heat exchanger is clogged, the pack bypass valve is closed, or the pack temperature controller has failed.

4. Air Conditioning System – Operated Manually (E)

More torque is available to operate the system valves on MAN than on AUTO.

AIR CONDITIONING ZONE DUCT OVERHEAT (205°F)

Zone cooling system overheat protection is provided by a zone duct over temperature switch and two limit switches installed in each of the four zones. If a zone duct reaches 200°F to 230°F, the over temperature switch in that duct causes all four zone trim valves and the trim air shutoff valve to close. The zone OVERHEAT caution light illuminates for the affected duct. The TRIM AIR switch OFF indicator also illuminates and the line light remains illuminated. When the affected zone duct over temperature switch reaches approximately 120°F, the system can be reset to its previous condition. To reset the system, press the zone overheat RESET button. When the system is reset, the illuminated zone OVERHEAT caution light and TRIM AIR switch OFF indicator go out.

1. COMP-DUCT Temperature Gages – Monitored (E)

Monitor zone duct temperature until below 165°F.

– – – If Zone Trim Valve for Zone With Illuminated Zone OVERHEAT Caution Light Closes (Valve Position Gage Full COOL), Perform Step 3 – – –

– – – If Zone Trim Valve for Zone With Illuminated Zone OVERHEAT Caution Light Does Not Close (Valve Position Gage Not Full COOL), Perform Steps 2, 3 and 4 – – –

2. Zone Temperature Selector Knob for Zone With Zone OVERHEAT Caution Light Illuminated – MANUAL OFF (E)

3. Zone Overheat RESET Button – Pressed, Until Reset (E)

When DUCT temperature gage indicates approximately 120°F, pressing the zone overheat RESET button resets the zone temperature controllers and allows the trim air valve to reopen.

4. Zone Temperature Selector Knob for Zone With Zone OVERHEAT Caution Light Illuminated – MANUAL COOL Until Zone Trim Valve Closed (E)

– – – If Zone Trim Valve Which Had OVERHEAT Caution Light Illuminated Does Not Close Manually, Proceed to Step 5 – – –

*** * * If Zone Trim Valve Which Had OVERHEAT Caution Light Illuminated is Closed, Continue Normal Operation and Operate that Zone Trim Valve Manually * * ***

5. TRIM AIR Switch – OFF, Line Light Out (E)

   The operating zone with the coldest setting controls the temperature to all four zones. (The zone trim valves on automatic control can go full open.)

***** Resume Operation, Lowering the Temperature Setting If Required *****

AIR CONDITIONING ZONE DUCT OVERHEAT (250°F)

In each zone duct are two 250 ± 10°F overtemperature switches, one of which causes the primary flow control valve to close, the other causes the alternate flow control valve to close, and either causes the pack TRIP caution light to illuminate. If only one 250 ± 10°F over temperature switch closes, the air conditioning pack continues to operate (the other flow control valve opens if the operating flow control valve closes); however, the other 250 ± 10°F over temperature switches soon close, causing the operating flow control valve to close, shutting off all air conditioning and pressurization air. When the flow control valves are closed, the PRIMARY and ALTERNATE switch line lights go out. The over temperature condition also causes the zone duct OVERHEAT caution light to illuminate, and the TRIM AIR switch indicator line light and OFF light to illuminate. The air conditioning pack can be reset when all zone duct temperature gages indicate the ducts have cooled to approximately 230°F. To reset the air conditioning pack, press the pack RESET button.

When the pack is reset, the TRIP caution light goes out and the PRIMARY or ALTERNATE flow control valve line light illuminates.

An air conditioning zone duct overheat is indicated by DUCT gage indication over 250°F, associated OVERHEAT caution lights illuminated and the air conditioning pack TRIP caution light illuminated.

NOTE

> This overheat condition causes the PRIMARY and ALTERNATE flow control valves to close and the air conditioning pack to be shut off, which causes the airplane to depressurize.

Correct an air conditioning zone duct overheat with the following procedure:

1. Pack Overheat RESET Button – Press, Until Reset (E)

   When DUCT temperature gage indicates approximately 230°F, pressing the pack overheat RESET button resets the air conditioning pack repressurizing the airplane.

2. Zone Overheat RESET Button – Press, Until Reset (E)

   When DUCT temperature gage indicates approximately 120°F, pressing the zone overheat RESET button resets the zone temperature controllers, and allows the trim air valve to reopen.

***** If Overheat Condition Repeats, Assume Manual Control of the System *****

***** Resume Normal Operation, Lowering the Temperature Setting if Required *****

NUCLEAR EVENT

This procedure will be performed when the flight crew is aware of a nuclear event (either from obvious signs, or on notification by the CDMT). The crew will perform the checklists below.

WARNING

> Due to potential severe shockwave, all crewmembers will fasten seatbelts upon notification of a nuclear event.

NUCLEAR EVENT NOTIFICATION

Pilot’s and Flight Engineer’s Checklist

(1.) Notification – Received (CDMT, P, MCC)

2. Nuclear Event Announcement – PA Announcement (P)

3. Thermal and Electromagnetic Pulse (EMP) Shields – Installed as Required (E)

NUCLEAR EVENT RECOVERY

1. Crew Notification – PA Announcement (P)

– – – If Mission Crew is Controlling HF Radio, Proceed to Step 4 – – –

2. ADS Panel HF Knob – Pull, Rotate Clockwise (CP)

3. Microphone Switch – Key, Momentarily (CP)

   Initiates retuning cycle for HF Radio.

4. UHF Radio – As Required (CP)

5. Circuit Breakers – Checked (E)

WINDOW OVERHEAT LIGHT ILLUMINATE

NOTE

When on the ground or in the air at low altitude, high ambient temperatures (above 33°C or 91.5°F) and/or heat soaking can cause the OVERHEAT light to illuminate.

1. Affected WINDOW HEAT Switch – OFF (CP)

2. Airspeed – 250 KIAS Max Below 10,000 Feet (P, CP)

– – – If Cracks or Arcing is Observed, Refer to WINDOW CRACKS OR ARCING – – –

3. After 3 to 5 Minutes, Affected WINDOW HEAT Switch – LOW (P)

– – – If OVERHEAT Light Remains Off, Wait 10 Minutes and Until Ambient Temperature is Below 33°C, Then Proceed to Step 4. If this is the Second Attempt At This Checklist, Leave Window Heat on Low for Remainder of the Flight. If the Window Overheat Light Illuminates After Low is Selected, Proceed to Step 5 – – –

– – – If OVERHEAT Light Illuminates, Proceed to Step 5 – – –

4. Affected WINDOW HEAT Switch – HIGH (CP)

– – – If OVERHEAT Light Remains Off, Resume Normal Operations – – –

– – – If OVERHEAT Light Illuminates, Steps 1 Through 4 May Be Repeated One Time Before Proceeding to Step 5 – – –

5. Affected WINDOW HEAT Switch – OFF (CP)

– – – Observe Airspeed Limitations. Maintenance Action is Required Prior to Next Flight – – –

WINDOW CRACKS OR ARCING

1. Affected WINDOW HEAT Switch – OFF (P)

NOTE

- Low window heat can be used for defogging if no arcing is present.
- Window can bulge several inches under pressure.

2. Airspeed – 250 KIAS Max Below 10,000 Feet (P, CP)
3. Crack Location – Determined (P, CP)

   Hold pencil or other pointed object at crack, move head from side to side. If crack appears to move relative to pencil, crack is in outer pane. If crack does not appear to move, crack is in inner panel.

4. Pressurization – As Required (E)

   See *figure 5-13*. If crack is in:

   a. Outer Pane Only – No Change

   b. Inner Pane Only – 5 PSI Maximum

   c. Both Panes – 2 PSI Maximum

WARNING

Flight crew will use smoke masks or helmet visors, if available, in case of further cracking.

THREE ENGINE FERRY TAKEOFF

A three engine ferry flight is an unusual operation. Refer to PERMISSIBLE OPERATIONS in the introduction, page xiii. A three engine ferry takeoff can become necessary in an emergency situation when the airplane must be evacuated from a forecast hazardous weather area or from a combat area to a base where adequate maintenance facilities are available. Three engine ferry flights should be made with a minimum flight crew and with only sufficient fuel for the mission including an adequate reserve.

WARNING

This procedure will not be performed if an RSC exists or the crosswind component from the inoperative engine side exceeds 5 knots.

FLIGHT CREW PROCEDURES

Maintenance personnel will prepare the inoperative engine for the ferry flight in accordance with T.O. 1E-3A-2-71-1 before the flight crew begins the preflight inspections. The following checklist items will be performed in addition to those specified in section II.

NOTE

To obtain maximum nosewheel steering, the airplane should be loaded to as close to the forward cg limit, 22% MAC, as practical. Center wing tank fuel can be used to obtain forward cg. Refer to subsection I–D, FUEL SYSTEM.

BEFORE ENTERING AIRPLANE

Check the AFTO Form 781 for inoperative engine status. Ensure work reported in maintenance briefing is recorded in the form. Maintenance personnel will make an entry stating either that the engine is immobilized or free to rotate. If engine is free to rotate, determine if it can be started when airborne.

INTERIOR INSPECTION

Open the inoperative engine CONTINUOUS IGN and START CONTROL & IGNITION circuit breakers on P61-2 panel. If an inboard engine is inoperative, select auxiliary rotodome drive and set the affected utility PUMP switch to OFF.

CAUTION

If inoperative engine is an inboard engine and is free to rotate, do not close the hydraulic FLUID SHUTOFF switch or pull the FIRE switch. Operating a hydraulic pump for more than five minutes with the fluid shutoff closed damages pump.

WITH IDG Select TCAS TA-only mode. VSI displays ONLY TA. This prevents TCAS from coordinating an RA with other TCAS equipped aircraft and inhibits RAs from being issued by own TCAS. ◀

STARTING ENGINES

Set inoperative engine BLEED AIR switch and the GEN CONTR switch to OFF and close BUS TIE OPEN switch. At the pilot's discretion, the other engine BLEED AIR switches and the PRIMARY and ALTERNATE flow control valve switches can be left off for the takeoff. This results in slightly better takeoff performance since the performance data was computed on the basis of engine bleeds and air-conditioning on. Set RUDDER OVERRIDE switch to OVERRIDE. Ensure rudder trim is neutral.

TAKEOFF

Line up on the side of the runway corresponding to the two good engines. Start the takeoff roll from a static position as close as possible to the end of the runway. While holding brakes, set available takeoff rated thrust on the two symmetric operating engines and approximately 1.1 EPR on the asymmetric engine. If number three engine is the inoperative or asymmetric engine, quickly move the number three throttle to vertical for at least one second to check the takeoff warning horn and retard to its original position (1.1 EPR when asymmetric engine and CUTOFF when inoperative engine).

The pilot releases brakes and then increases thrust on the asymmetric engine as rapidly as can be controlled using rudder and nose wheel steering. If thrust is increased too slowly, the airplane will not meet the performance shown in T.O. 1E-3A-1-1. If thrust is added too rapidly, the airplane will yaw toward the inoperative engine and cannot be controlled. Add thrust slowly at the beginning of takeoff roll and then more rapidly as airspeed builds. Let the airplane drift slowly toward the runway centerline.

The copilot holds 20 to 25 pounds forward pressure on the control wheel and maintains wings level until the pilot takes the control wheel upon reaching rotation speed. The flight engineer monitors the engines to ensure the symmetric engines remain set at TRT and the asymmetric engine EPR does not exceed the EPR of the symmetric engines.

Rudder is the primary means of directional control. At brake release apply full rudder, then reduce rudder slightly to allow steering corrections in either direction. Nose wheel steering is used initially for directional control when the rudder is ineffective at low airspeed. Use small amounts of nose wheel steering as too much causes nose wheel scrubbing which reduces nose wheel steering effectiveness. After the rudder becomes effective hold nose wheel steering essentially centered with only a slight amount to aid the rudder.

When approaching rotation speed reduce nose wheel steering input to zero. If nose wheel steering is used to help control the yawing effect of the asymmetric engine, at rotation speed the rudder contribution to directional control will be inadequate when the nose wheel lifts from the runway. This can be due to insufficient rudder input by the pilot or too much asymmetric thrust for even full rudder input to control.

The pilot takes control of the control wheel at rotation speed and smoothly rotates to the climbout pitch attitude. An additional pull force of up to 10 pounds can be required at rotation compared to a normal takeoff. Also, as the nose wheel lifts from the runway, large amounts of control wheel deflection can be required to keep wings level.

NOTE

- Wet or icy runways and aft center of gravity reduce nose wheel steering effectiveness and therefore require a slower thrust application for the asymmetric engine.
- This procedure assumes an outboard engine is inoperative. If an inboard engine is inoperative, takeoff performance is increased because inboard engine thrust can be increased more rapidly than outboard engine thrust.
- If it is difficult to maintain directional control on the ground or in the air, reduce the asymmetric engine thrust in small increments until satisfactory directional control is regained through use of the rudder. Do not wait for increasing airspeed to increase rudder effectiveness since rudder blow down slows the rate of increasing rudder effectiveness.

When a positive rate of climb is established, retract the landing gear. Climb straight ahead at V_{CO} and increase the asymmetric engine thrust until either equal to the TRT EPR setting on the other engines, or as limited by directional control requirements, whichever is the lesser thrust. At height selected for flap retraction lower nose slightly and accelerate to V_{CO} + 30 knots. Retract flaps, set climb thrust and accelerate to V_{CO} + 55 knots or enroute climb speed (250 KIAS/0.60M) as required.

NOTE

With an inboard engine inoperative, flap retraction time is 50% to 75% longer than normal.

If a course reversal is required immediately after takeoff, maintain flaps 14 and V_{CO} while turning.

WARNING

Do not exceed 15° bank angle with flaps 14 and airspeed V_{CO}.

When wings are level, accelerate to V_{CO} + 30 knots, retract flaps, set climb thrust and accelerate to selected climb speed. Complete the normal AFTER TAKEOFF AND CLIMB checklist plus the following additional items.

Set the RUDDER override switch to NORMAL. Open the engine bleed air valves and the primary flow control valve, if closed, to restore air conditioning and pressurization. If the engine can be started, perform the ENGINE RELIGHT checklist after completing the AFTER TAKEOFF AND CLIMB checklist.

ENGINE FAILURE DURING TAKEOFF, TAKEOFF ABORTED

The amount of runway required for a three engine ferry takeoff is based on initiating the abort at takeoff speed. If failure of an operating engine or system emergency occurs prior to reaching takeoff speed, abort the takeoff. Immediately lower nose if required, apply maximum braking, retard throttles to idle, and raise speedbrakes. The engineer will check the hydraulic brake pressure gage. As long as brake pressure (above precharge) is indicated on this gage, normal hydraulic brakes are available even if the utility hydraulic system failed.

NOTE

If brake pressure is down to precharge, do not open brake interconnect. Use pneumatic brakes.

ENGINE FAILURE - TAKEOFF CONTINUED

If an operating engine fails after liftoff but before reaching climbout speed, delay climb until reaching V_{CO}. If two engines are out on the same wing, the operating outboard engine thrust must be reduced to maintain directional control. The airplane cannot maintain level flight out of ground effect at takeoff speed (V_{TO}) with the thrust reduction required. As airspeed increases and rudder becomes more effective, increase thrust on the operating outboard engine. Bank toward the operating engines to assist directional control but limit bank angle to 7° until clear of runway and obstacles then limit bank angle to 15°.

If utility hydraulic system is available, retract landing gear when a positive rate of climb is established and can be maintained. If the second engine failure causes loss of the utility hydraulic system during takeoff with landing gear down, hydraulic pressure from the windmilling inboard engines is not sufficient to retract the landing gear. Leave the gear down and land as soon as possible.

CAUTION

- Two engine gear down performance data for enroute climb and cruise flight is not included in T.O. 1E-3A-1-1.
- If utility system failed prior to gear retraction, perform nose gear manual extension procedure to prevent collapse of nose gear upon landing. If main gear is extended manually, main landing gear doors remain open and increase drag.

As soon as possible, accelerate to V_{CO} + 30 knots. Increase altitude during acceleration to V_{CO} + 30 knots only as required for terrain avoidance. Upon reaching V_{CO} + 30 knots, retract flaps. If necessary, use the emergency flap drive. After flaps are retracted, accelerate to V_{CO} + 55 knots. Maintain V_{CO} + 55 knots until clear of obstacles. Set climb power, then accelerate to 215 KIAS. Maintain 215 KIAS until reaching 0.40 Mach. Perform the ENGINE FAILURE OR FIRE checklist as soon as possible, then perform the AFTER TAKEOFF AND CLIMB checklist. Perform the following items in addition to the normal AFTER TAKEOFF AND CLIMB checklist.

Restore engine bleed air and air conditioning if they were off for takeoff. Insure rudder override switch remains set to OVERRIDE. If airspeed exceeds 250 KIAS during cruise, avoid large and rapid rudder movements. If initially inoperative engine can be started, perform the ENGINE RELIGHT procedure.

ENGINE FAILURE DURING CLIMB

If failure of a second engine occurs during climb, land as soon as practical using the TWO ENGINE LANDING checklist. If an immediate landing is not possible, continue as described under ENGINE FAILURE – TAKEOFF CONTINUED (this section).

NOTE

> If the second engine fails during climbout, maintain the airspeed at which the engine failed, but not lower than V_{CO}, and continue the climb to cleanup height.

CRUISE

When the inoperative engine is windmilling at 25% N_2 or higher, set the throttle to idle and close the FIRE switch for 3 out of every 30 minutes to allow cooling and lubrication of the fuel control unit. Maintain fuel balance within limits.

CAUTION

> To prevent relight of inoperative engine if continuous ignition is in use, open affected engine continuous ignition circuit breaker prior to cooling the fuel control unit.

ANTISKID INOPERATIVE TAKEOFF

An antiskid inoperative takeoff is an unusual operation. Refer to PERMISSIBLE OPERATIONS in the introduction (page xiii). The airplane can take off safely with one or more antiskid valves inoperative (one or more REL lights not illuminated on preflight) if the limitations in section V are met as well as the performance restrictions contained in T.O. 1E-3A-1-1.

WARNING

> If an abort is necessary when antiskid is off on one or more brakes, raise speedbrakes completely before applying brakes. If brakes are applied before speedbrakes are deployed, brakes can lock and tires can blow.

TAKEOFF WITH SEVEN- OR SIX-BRAKES

A takeoff with seven- or six- brakes operating is an unusual operation. Refer to PERMISSIBLE OPERATIONS in the introduction (page xiii). The airplane can take off safely with one or two brakes inoperative if the limitations in section V are met as well as the performance restrictions contained in T.O. 1E-3A-1-1.

TAKEOFF WITH PARTIAL SPOILERS

A takeoff with partial spoilers is an unusual operation. Refer to PERMISSIBLE OPERATIONS in the introduction (page xiii). The airplane can take off safely with either the inboard or outboard spoilers inoperative if the performance restrictions in T.O. 1E-3A-1-1 are observed.

FLIGHT WITH UNRELIABLE AIRSPEED/MACH INDICATIONS

Flight without valid airspeed information (resulting from a blocked or frozen pitot system, or loss of radome) can be conducted safely and should present little difficulty for the experienced pilot if he is aware of the problem. Early recognition of erroneous airspeed indications you must be familiar with are the relation between attitude, thrust setting and airspeed. A delay in recognition could result in loss of control.

For each flight maneuver there is a specific body attitude, and the flight crew must know the approximate value of that attitude. For example, climb performance is based on maintaining a particular airspeed or Mach number which results in a specific body attitude varying slightly with gross weight and altitude. Any significant change from this body attitude required to maintain a desired airspeed should alert the flight crew to an impending problem.

NOTE

> The power settings and attitude data in *figure 3-21* can also be used when the bailout chute spoiler is extended and pitot-static instruments can be unreliable.

Flight With Unreliable Airspeed/Mach Indications

DATA BASIS: ESTIMATED

FLIGHT CONDITION			GROSS WEIGHT – 1,000 LB	FLAPS	BODY ATTITUDE – DEGREES NOSE UP	APPROX N_1 RPM REQ'D	APPROX SPEED – KIAS	APPROX CLIMB OR DESCENT – FT/MIN
CLIMB		10,000 Ft	340	0	7.5	Normal Rated Thrust	280	1,900
			300		7.5			2,300
			250		8.0			2,900
			200		9.0			3,800
		20,000 Ft	340	0	6.0		280	1,200
			300		6.0			1,500
			250		6.0			2,000
			200		6.5			2,800
		30,000 Ft	340	0	6.0		260	500
			300		6.0			900
			250		6.0			1,500
			200		6.0			2,300
LONG RANGE CRUISE – (Level Flight)	Constant Altitude	25,000 Ft	340	0	4.0	Adjust Power to Maintain Body Attitude in Level Flight	295	0
			300		3.5		290	
			250		3.0		285	
			200		2.5		270	
	Optimum Altitude	29,000 Ft	340	0	4.5		280	0
		32,000 Ft	300		4.5		265	
		36,000 Ft	250		4.5		245	
		41,000 Ft	200		4.5		215	
DESCENT	• Spoilers – Down • Fly to Body Attitude		340	0	2.5	Outboard at Idle. Inboard per Part VI of T.O. 1E-3A-1-1	250	–1,500
			300		1.5		250	–1,500
			250		1.0		250	–1,500
			200		–0.5		250	–1,700

Figure 3-21 (Sheet 1 of 2)

Flight With Unreliable Airspeed/Mach Indications (Continued)

DATA BASIS: ESTIMATED

FLIGHT CONDITION	GROSS WEIGHT – 1,000 LB	FLAPS	BODY ATTITUDE – DEGREES NOSE UP	APPROX N_1 RPM REQ'D	APPROX SPEED – KIAS	APPROX CLIMB OR DESCENT – FT/MIN
HOLDING – (Best Endurance, Level Flight) 10,000 Ft	340	0	6.5	74	230	0
	300		6.5	71	215	
	250		6.5	66	200	
	200		6.5	61	180	
TERMINAL AREA or TRAFFIC PATTERN – (Level Flight) • Adjust Power to Maintain Body Attitude	340	0	7.0	67	V_{REF} + 60	0
	300		7.0	64		0
	250		6.5	59		0
	200		6.0	54		0
	340	14	6.5	75	V_{REF} + 30	0
	300		6.5	71		0
	250		6.0	66		0
	200		5.5	60		0
	340	25	5.5	79	V_{REF} + 20	0
	300		5.5	75		0
	250		5.5	70		0
	200		5.0	64		0
FINAL APPROACH – (Based on 3° Glide Slope) • Adjust Power to Maintain Body Attitude • Fly to Glide Slope, or, if not available, Fly to Rate of Descent	340	50	1.0	79	V_{REF} + 10	–910
	300	50	1.0	76		–860
	250	50	1.0	70		–780
	200	50	1.0	64		–710

Figure 3-21 (Sheet 2 of 2)

When the abnormal airspeed condition is recognized, immediately return the airplane to the target attitude and thrust setting for the flight regime. After control is assured, begin troubleshooting by cross-checking related instruments and verify PROBE HEAT switches are ON and circuit breakers are closed (in). Verify that heaters are operative by checking HEAT OFF caution lights.

If continued flight without valid airspeed indications is necessary, see *figure 3-21* for the correct attitude and thrust settings for airplane gross weight and altitude.

Avoid icing conditions if possible and land at a suitable VFR airport. The ground speed can be used as a backup system at low altitude in the pattern. Conditions permitting, use a pace airplane, but do not fly under or in the downwash of the pacer airplane.

Use of the autopilot is recommended. Do not use altitude hold. Heading can be erratic in light turbulence.

Idle descents can be made to 10,000 feet by flying body attitude and checking rate of descent from *figure 3-21*. At 2,000 feet above selected altitude, reduce rate of descent to 1,000 FPM. On reaching selected altitude, establish attitude and thrust for the desired configuration. If possible, allow airplane to stabilize before changing configuration and altitude.

If ILS or GCA is available, use it for approach. Establish landing configuration early on final approach. At glide slope intercept or beginning descent, set thrust and attitude from *figure 3–21* and control rate of descent with throttle.

1. Autopilot ALT Hold Switch – OFF (P)

   Manual mode or HDG can be used for attitude hold.

2. ADI PITCH TRIM Knob – Zero (P, CP)

3. Flight Director ALT HOLD Switch – OFF (P, CP)

4. Pitch Attitude – Set and Hold (P)

WARNING AND CAUTION LIGHT INITIAL ACTIONS

Indicator lights are color coded to assist the crew in determining the action to be taken when a light illuminates. The colors and the actions are summarized below:

Red: Warning, immediate action required to protect the crew or airplane.

Amber: Caution, an abnormal situation can exist or a corrective action is required to protect a system.

Green: Normal operating condition. Refer to section I.

White: Usually indicates switch position. Refer to section I.

Blue: Used in fuel dump panel to indicate a valve is not in position called for by switch position.

Figure 3-22 lists warning (red) and caution (amber) lights and the initial actions to be taken for each light. Initial actions for other indicators are described in section I.

AUDIBLE AND TACTILE WARNINGS

Figure 3–23 lists audible (sound) and tactile (feel) warnings available to the flight crew. All of these signals require immediate corrective action. If a warning can be silenced, the silencing action is listed.

LOSS OF NOSE RADOME

Extensive radome damage or a missing radome can affect airspeed, altitude, angle of attack and stall warning systems. Indications from these systems can be in error when the pitot-static sources, angle of attack probes and stall warning vane are in the blunt nose wake. Loss of a radome results in an increase in noise level, a relatively small loss in airplane performance and no significant change in airplane handling characteristics, buffet or stall speeds.

One indication of a missing radome is the noise and low frequency buffeting resulting from a disrupted airflow around the blunt nose. Once the problem is detected by the noise and buffeting, the affected equipment should not cause any control difficulties as long as attitude rather than airspeed is used as the primary reference. Refer to FLIGHT WITH UNRELIABLE AIRSPEED/MACH INDICATION, this section, for procedures.

Comments on the various affected systems presented below are based on available data.

STALL WARNING SYSTEM

The stall warning vane can be affected by the turbulent wake at high airspeeds (low angles of attack) and cause false stall warnings. Nuisance activation of the stick shaker can occur at high speed. The stall warning vane can emerge from the blunt nose wake at higher angles of attack (low speed), so it can provide normal stall warning protection in the low speed flight regime.

ANGLE OF ATTACK SYSTEM

The angle of attack system is unreliable in these conditions.

MACH/AIRSPEED WARNING

Mach airspeed warning is unreliable in these conditions.

RUDDER PRESSURE REDUCER

A loss in pitot pressure at a given flight condition can result in a rudder pressure limit higher than normal. Follow the existing flight procedures for RUDDER PRESSURE REDUCER MALFUNCTION, this section, disengage yaw dampers, observe yaw damper inoperative limits and avoid large rudder inputs.

Warning and Caution Light Initial Actions

LIGHT	ACTION AND PROCEDURE REFERENCE
RED WARNING LIGHTS	
AUTOPILOT:	

WARNING

If autopilot warning light illuminates continuously after flap retraction, at least one flap limit switch has malfunctioned. Autopilot pitch servo is in high torque mode and pitch trim is in high speed. Avoid large, rapid pitch knob motions.

LIGHT	ACTION AND PROCEDURE REFERENCE
A/P WARN (Steady)	When below 20,000 feet and 223 KIAS, move flap lever out of detent momentarily and return. If light continues, avoid large pitch knob movements or disengage autopilot.
(Flashing)	Press light to reset. Autopilot has disengaged. Reengage autopilot if desired. Reset flight director to desired mode.
FIRE DETECTION:	
FIRE P/RST (Master Fire Warning)	Press to silence fire warning bell. Check engine, APU, and wheel well fire detector indicators. Then refer to ENGINE FAILURE OR FIRE, APU FIRE/ EMERGENCY SHUTDOWN or WHEEL WELL FIRE procedure, section III, as indicated by fire warning lights on overhead or APU panel.
FLIGHT CONTROLS:	
RUD BOOST	RUDDER switch ON. Both auxiliary hydraulic pumps on. Check auxiliary pump pressure. Change to utility rotodome drive if possible. If unable to select utility drive, use IDLE speed. Refer to AUXILIARY HYDRAULIC SYSTEM LOW PRESSURE, section III.
LANDING GEAR	
DOOR	(Light remains illuminated after manual extension.) If above 270 KIAS, slow to 270 KIAS, or below. If light does not go out, repeat retraction or extension cycle to lock doors, when below 270 KIAS. If on ground, check manual door release handles.

Figure 3-22 (Sheet 1 of 9)

Warning and Caution Light Initial Actions (Continued)

LIGHT	ACTION AND PROCEDURE REFERENCE
GEAR	When retracting the gear, if the gear warning light remains on with no other indications, recycle the gear. If the gear warning light is accompanied by a gear indicator (down and locked), a gear door light or airplane vibration indicating gear is not retracted, do not recycle gear. Put gear down and land as soon as practical. When extending gear, if the gear warning light remains on repeat extension cycle to lock gear down. If any landing gear fails to indicate down and locked on flight deck indicators, after second attempt, check alignment stripes for indication of gear position. If red gear alignment stripes are aligned, the gear is assumed locked, land as soon as practical. If alignment stripe is abnormal, refer to MANUAL LANDING GEAR EXTENSION or GEAR UP OR PARTIAL GEAR LANDING, section III, as required.
PARKING BRAKE	Release parking brake if not required.
GINS CONTROL PANEL	
FAULT 1, FAULT 2	Check CBIT status of applicable EGI via CDU. Refer to subsection I-N-3, GINS CONTROL PANEL CONTROLS AND INDICATORS.
COMM DISCONNECT PANEL COOLING ALERT: OVRD	When illuminated, indicates that CAUTION has been overridden and systems are operating without proper cooling air.
AMBER CAUTION LIGHTS	
AIR CONDITIONING SYSTEM:	
OVERHEAT (Zone)	Reset. Refer to AIR CONDITIONING ZONE DUCT OVERHEAT (205°F), this section.

Figure 3-22 (Sheet 2 of 9)

LIGHT	ACTION AND PROCEDURE REFERENCE
OHEAT (Pack)	Reset. Refer to AIR CONDITIONING PACK OVERHEAT, this section.
TRIP (Pack)	Reset. Refer to AIR CONDITIONING ZONE DUCT OVERHEAT (250°F), this section.
ALTERNATE LOW	Normal condition if air conditioning system operating on battery (all ac electric power lost).
and/or	
PRIMARY LOW	For ACM compressor 450°F overtemperature condition; refer to AIR CONDITIONING PACK OVERHEAT (subsection I-Q).
ICING (Pack)	Reduce load on pack. Refer to AIR CONDITIONING OPERATION, (subsection I-Q).
LOW (flow)	Check pressurization and power to valves. Refer to AIR CONDITIONING OPERATION, subsection I-Q.
BLEED AIR SYSTEM:	
LEAK	Close engine bleed air valves and isolation valve on leak side. press leak test switch to reset detector. Refer to BLEED AIR LEAK procedure, this section.
OVERHEAT	Refer to BLEED AIR SYSTEM OVERHEAT procedure, this section.
OVER PRESS	Refer to BLEED AIR SYSTEM OVER PRESSURE procedure, this section.
COMM DISCONNECT PANEL:	
SWITCHLIGHTS 1 THROUGH 5 CAUTION Lamp (Amber)	Press the CAUTION switchlight to shut down all equipment controlled by that specific switchlight. Correct cooling problem and/or refer to *figure 1–54* and open circuit breakers selectively to shut down equipment as necessary prior to attempting to reapply power with the associated switchlight. CAUTION light(s) remain illuminated until proper cooling is restored or associated switchlight is pressed OFF.

CAUTION

When illuminated, indicates that one or more mission compartment communications systems are operating without required cooling. Equipment damage will occur if action is not taken.

Figure 3-22 (Sheet 3 of 9)

Warning and Caution Light Initial Actions (Continued)

LIGHT	ACTION AND PROCEDURE REFERENCE
COOLING ALERT FAULT Lamp (Amber – Flashing)	Observe COMM DISCONNECT PANEL switchlights 1 through 5 CAUTION lights. Press OVRD to reset sensing circuitry. Press switchlight(s) that have ON the CAUTION segments illuminated to remove power from equipment that has lost required cooling. Correct cooling problem and/or refer to *figure 1–54* and open circuit breakers selectively to shut down equipment as necessary prior to attempting to reapply power with the associated switchlight. FAULT light flashes until OVRD is pressed, proper cooling is restored, or associated CAUTION switchlight is pressed OFF.

CAUTION

When flashing, indicates that one or more mission compartment communications systems are operating without required cooling. Equipment damage will occur if action is not taken.

DRAW THROUGH COOLING SYSTEM:	
NO FLOW	Verify power available to fan. If airplane pressurized (more than 1.0 PSI), flow should be present (NO FLOW caution light illuminated indicates draw through system flow is blocked). Refer to ABNORMAL OPERATION, subsection I-R.

CAUTION

- If system not operating properly, notify pilot and mission crew. Restrict operation of equipment cooled by draw through system to a minimum.
- If draw through system not operating, shut down flight crew UHF radio.

ELECTRICAL SYSTEM:	
EMERGENCY POWER	Restore normal power. Refer to LOSS OF ALL GENERATORS procedure, this section.
RADAR OFF	If radar power required, coordinate with mission crew, then press RADAR switch.
BUS TIE OPEN	Press GEN CONTR OFF or ON switch (depending on desired generator condition) to close bus tie breaker. Refer to PARALLEL OPERATION OF GENERATORS, subsection I-E.

Figure 3-22 (Sheet 4 of 9)

LIGHT	ACTION AND PROCEDURE REFERENCE
GEN CONTR OFF	Press GEN CONTR ON switch to place generator in operation. Check GCU circuit breaker (P61). Refer to GENERATOR OFF OR BUS TIE OPEN LIGHT ILLUMINATED, subsection I-E.
IDG OHEAT (Copilot's)	

WARNING

Engine fuel line damage can result from IDG case separation. Possible indications of case separation are generator failure, illumination of LOW RPM light, and abnormally high or low IDG oil temperature indication. If any of these conditions exist, check for abnormally high engine fuel flow before disconnecting IDG. If fuel leak is suspected, do not attempt IDG disconnect. Shut down engine if not needed for safety of flight.

	Shut down generator and disconnect IDG. Refer to GENERATOR DRIVE OVERHEAT, this section. If inflight conditions dictate light be turned out immediately, place IDG WARN DISC switch on engineer's panel to down position. Refer to IDG WARN OFF caution light entry.
IDG DISC OHEAT	Shut down generator. Disconnect drive. Refer to GENERATOR DRIVE OVERHEAT, this section.
IDG LOW RPM	Refer to IDG LOW RPM LIGHT ILLUMINATED, subsection I-E.
ENGINE:	
IDG WARN OFF (P11)	Turn out caution light and enable copilot's IDG OHEAT warning annunciator by placing IDG WARN DISC switch to normal (up) position. If copilot's IDG OHEAT annunciator must remain disabled due to inflight conditions, engineer's console should be monitored at all times until the warning light circuit can be restored to normal operation.
OIL PRESS	Check oil pressure gauge. Refer to OIL SYSTEM MALFUNCTIONS, section III.

NOTE

When starting engines the OIL PRESSURE caution light might remain illuminated, or illuminate intermittently for up to four minutes after the oil temperature reaches 40°C at idle rpm. The light shall be out four minutes after the oil temperature reaches 40°C.

Figure 3-22 (Sheet 5 of 9)

Warning and Caution Light Initial Actions (Continued)

LIGHT	ACTION AND PROCEDURE REFERENCE
FIRE DETECTION:	
SHORT LOOP A or SHORT LOOP B	None. System shorted in one loop.
DOOR WARNING:	
DOORS (Any light on Door Warning Panel)	Refer to DOOR CAUTION LIGHT ILLUMINATED, section III. Check door latch completely closed.

NOTE

All doors are inward opening plug type. Doors cannot open in flight, if airplane is pressurized.

FORCED AIR COOLING:	
OBV UNSAF Lamp	When illuminated, set FAC UNPRESS & OVERRIDE switch to OB VALVE position. Refer to UNSAFE OVERBOARD VALVE INDICATION, section III.

NOTE

The OBV UNSAF indicator illuminates during takeoff as the valve transitions to the fully closed position.

NO FLOW	Check circuit breakers and fan speed indicator. Refer to FORCED AIR COOLING OPERATION, subsection I-R. Restart fan(s) if power transfer caused fan(s) to stop.

CAUTION

- If fans are not operating, notify pilot and mission crew so that equipment on this system can be shut down, if required.
- Do not operate flight crew HF radio (HF1) or GINS if aft forced air cooling system is inoperative.

FUEL SYSTEM:	
REFUEL VALVES OFF	If MASTER REFUEL switch ON, check power to refueling valves.
LOW (Quantity)	Check main tank 1, 2, 3, and 4 fuel quantity gages. If quantity is below 6,500 pounds in inboard tanks or 2,500 pounds in outboard tanks, open all crossfeed valves and turn on all boost pumps. Refer to MINIMUM FUEL PROCEDURES, section II.

Figure 3-22 (Sheet 6 of 9)

LIGHT	ACTION AND PROCEDURE REFERENCE
PUMP LOW (Low Pressure Indicator in Pump Switch)	Check pump circuit breakers. Refer to BOOST PUMP FAILURE. Check fuel level. If quantity is below 6,500 pounds in inboard tanks or 2,500 pounds in outboard tanks, open all crossfeed valves and turn on all boost pumps. Refer to MINIMUM FUEL PROCEDURES, section II.

CAUTION

If any combination of boost pump circuit breakers trip, set pump switch to OFF and open all breakers for that pump. In flight, unless required for safety of flight, leave circuit breakers open. Do not reset breakers until maintenance personnel inspect the system.

DUMP CHUTE	Retract chutes. Maximum airspeed 275 KIAS with chute extended. Maximum airspeed 240 knots while chutes retracting. Raise speedbrakes momentarily to reduce airload while retracting chutes.
HEAT EXCH:	
OHEAT	Check fuel temperature. Refer to FUEL TANK OVERHEAT.
OFF	Indicates switch set to close valve. If heat exchanger operation is desired, press switch to open valve.
ICING	If illuminated steadily, set fuel heat switch ON. Refer to FUEL HEAT, subsection I-B and FUEL ICING LIGHT ILLUMINATED, section III. No action required for momentary light on engine start.
MAIN VALVE CLOSED	Normally closed except when refueling. If refueling, check fuel level in tanks. Refer to FUEL LOADING AND MANAGEMENT, subsection I-D.
SLIPWAY DOORS CLOSE	None, unless air refueling. Open doors if required.
DISC	Refer to Inflight Refueling Procedures.
SIGNAL AMPL MAN	Press SIGNAL AMPL NORM switch unless manual operation required.
MANUAL TOGGLE REL	Refer to Inflight Refueling Procedures.

Figure 3-22 (Sheet 7 of 9)

Warning and Caution Light Initial Actions (Continued)

LIGHT	ACTION AND PROCEDURE REFERENCE
CRASH POSITION LOCATOR (DFDR)	If light illuminated continuously, DFDR has failed.
HYDRAULIC SYSTEM:	
AUXILIARY PUMPS PRESS	If power transfer (on ground) caused No 1 pump light to illuminate, press pumps RUD/SPOIL switch twice. If either pump light illuminates in flight, refer to AUXILIARY SYSTEM LOW PRESSURE, section III. If both lights illuminate, refer to AUXILIARY HYDRAULIC SYSTEM LOSS checklist, section III.
AUXILIARY HEAT EXCH OHEAT	Press ORIDE switch.
UTILITY PUMP PRESS	Check pressure gage. If only one light on, refer to HYDRAULIC SYSTEM LEAK ISOLATION, section III. If both lights on, refer to UTILITY HYDRAULIC SYSTEM LOSS, section III.
UTILITY HEAT EXCH OHEAT	Press ORIDE switch.
ROTODOME DRIVE UTIL LUB LOW PRESS or AUX LUB LOW PRESS	If drive has been on over 2 minutes at 21°C or 4 minutes at –54°C or illuminates in flight, change drives.
ICE AND RAIN PROTECTION	Turn on probe heat, check probe heat circuit breakers.
PROBE HEATERS	
HEAT OFF	Check probe heat switches and circuit breakers and refer to FLIGHT WITH UNRELIABLE MACH/AIRSPEED INDICATION, this section, and EFFECTS OF PITOT STATIC ICING in section VII.
WINDOW HEAT OVERHEAT	Turn off window heat. Do not exceed 250 KIAS below 10,000 feet. Refer to WINDOW OVERHEAT LIGHT ILLUMINATED, this section.
LIQUID OXYGEN SYSTEM:	
LOW Quantity	If practicable, descend below 10,000 feet if airplane unpressurized. If descent to 10,000 feet or below is not possible, maintain a cabin altitude of 14,000 feet or below and restrict oxygen use to flight crew only until further descent is possible. Refer to OXYGEN SYSTEM, subsection I-V, for duration chart.

Figure 3-22 (Sheet 8 of 9)

LIGHT	ACTION AND PROCEDURE REFERENCE
NAVIGATION EQUIPMENT	
GINS CONTROL PANEL:	
EGI 1, EGI 2	Restore normal power source as soon as practical. Refer to subsection I-N-3.
RNAV ANNUNCIATORS Panel	
CDU ALERT	Check CDU screen and *figure 1-176*.
SPEED ALERT	Check CDU screen and *figure 1-176*.
YAW DAMPERS:	
YD DISENG	Engage one yaw damper. If series damper disengages, check auxiliary hydraulic system pressure. Refer to RUDDER BOOST MALFUNCTION.
SERIES DISENG	Engage parallel damper.
PARALLEL DISENG	Engage series damper.
IFF	LESS IDG If Mode 4 operation is required, set Mode 4 switches as briefed and load Mode 4 code. If Mode 4 operation is not desired, turn Mode 4 switches OFF.◀ WITH IDG Illuminates if M4 is ON and IFF is in NORM but codes are not loaded. Load Mode 4 codes, as required. Light does not indicate a refusal to respond resulting from incorrect codes or incorrect A–B selection. Via iff test page check M4 status; have maintenance remove and replace, as required. Light resets automatically when any condition, that prevents a response to a recognized friendly interrogation, is corrected. Illuminates for a few seconds during M4 IBIT, and this is normal.◀

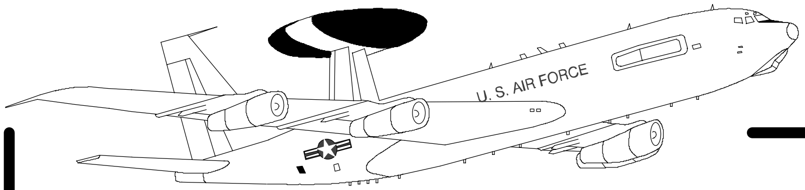
Figure 3-22 (Sheet 9 of 9)

Audible and Tactile Warning and Initial Actions

SIGNAL	CONDITION	INITIAL ACTION PROCEDURE REFERENCE	RESET/SILENCE
BELL – Continuous (also master FIRE warning light)	Fire warning	Silence bell; check engine, APU, wheel well fire warning indicators. Refer to applicable fire procedure.	Press master FIRE warning light.
BELL – Intermittent	Mach/Airspeed warning	Check Airspeed/Mach Number. Reduce airspeed if required.	Resets when speed reduced.
Horn – Intermittent (Throttle not retarded) and/or sweeping high/low tone on PA and interphone	Cabin altitude over 10,000 feet.	Silence horn, check cabin altitude. Oxygen On, 100% (Refer to SUDDEN LOSS OF CABIN PRESSURE.)	Press ALTITUDE HORN CUTOUT switch on F.E. panel.
Horn – Steady (Throttle retarded with flaps ≤25. Sounds at any throttle position with flaps ≥40.) (Also GEAR warning light)	Landing gear unsafe. Gear position does not agree with lever.	Check for 3 green lights (if gear down). Recycle gear. Use manual extension procedure, if required.	Pull HORN CUTOUT lever on aisle stand (flaps 0, 14, 25). Does not cut out at flaps 40, 50. Resets when gear locked up or down.
Horn – (On ground) Intermittent (No 3 Throttle ahead of idle)	Takeoff warning. One or more of: Flaps not 14, speedbrakes up, stabilizer out of trim. If stick shaker operating, flaps are up.	Check flaps, trim and speedbrake position.	Cannot be silenced. Correct the unsafe condition.
Shaking control column (and rattle sound)	Stall warning (in flight). Flaps up (on ground and horn sounding intermittently).	Reduce angle of attack or increase airspeed. Set flaps to 14 (on ground).	Cannot be silenced. Correct the unsafe condition.

Figure 3-23

Section IV



CREW DUTIES

Table of Contents

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INTRODUCTION

This section contains crewmember duties that are in addition to those detailed in Sections II and III. These duties are not necessarily all that may be required of the crewmember.

MINIMUM CREW DUTIES

The duties below are for flights without a mission crew or navigator, or movement of the airplane in extreme emergency, such as to avoid enemy action or severe weather. The minimum crew duties are:

Pilot: The pilot will perform normal duties of the pilot.

Copilot: The copilot will perform normal duties of the copilot. In addition, copilot will set up and operate GINS if required. For EMERGENCY TAXI, Section II, the copilot's seat may be occupied by a mechanic who is qualified for engine run and taxi.

Flight engineer: The flight engineer will perform normal duties and will conduct the mission compartment safety checks if required.

REPORTING MALFUNCTIONS

When reporting airplane malfunctions, either in AFTO Form 781 or by inflight message, give sufficient information to allow maintenance personnel to troubleshoot the problem without a functional check flight or engine run (if possible). Give airplane or system condition at the time of failure with applicable pressures, voltages, load currents, airspeed, altitude, operating mode and any other information which could be useful. Where a system indicates status or malfunction codes, record the complete status word or display.

CREW COORDINATION

This is a large, multi-compartment airplane with several crew stations. Many operational procedures require coordination with the mission crew or with other flight crewmembers. The procedures in Sections II and III indicate where coordination is required. At other times efficient operation is aided by letting the mission crew know what you are about to do.

CAUTION

The complex electrical/electronic equipment in this airplane can be damaged or destroyed by failure to coordinate cooling system operation with equipment operation. All crewmembers must be aware of equipment cooling requirements for the equipment under their control.

PILOT'S DUTIES

The pilot is the pilot-in-command of the airplane. The pilot has overall responsibility for flight safety. The pilot will arrange to have all flight and mission crewmembers briefed on their responsibilities and on normal and emergency procedures relating to their crew stations. Refer to Sections I, II, III, and VII for procedures which are the pilot's responsibility. The pilot should be familiar with the copilot's station, the flight engineer's station, the navigation computer system, and with the information in Sections I and VI.

COPILOT'S DUTIES

The copilot performs the usual duties of a copilot, assisting the pilot in any way needed to perform the assigned mission. Procedures normally assigned to the copilot are listed in Sections II and III. The copilot should be familiar with the flight engineer's station and the navigation system. The copilot must be able to take over from the pilot in an emergency, therefore must be familiar with the pilot's duties.

FLIGHT ENGINEER'S DUTIES

In addition to the specific items listed in Sections II and III, the flight engineer must monitor system operation of all airplane systems under flight engineer's control in all phases of flight. The flight engineer should be familiar with system troubleshooting in all airplane systems and those mission systems which interface with flight engineer's equipment.

NAVIGATOR'S DUTIES

The navigator's primary responsibility is to operate the navigation system. The navigation system provides the position, attitude, and velocity data required for proper operation of the mission equipment and flight instruments. The navigator also operates the HAVE SIREN system. For details of the navigation system/mission equipment interface, refer to T.O. 1E-3A-43-1-1. Detailed operating procedures are in subsection I-N-3. Specific navigator duties not necessarily contained in Sections II and III are listed below.

ALERT PROCEDURES

Refer to Section II, INTRODUCTION, for a discussion of alert procedures and checklist sequencing for alert operations. The navigator is not required to perform a daily preflight during CC3 operations.

DEFINITION OF SYMBOLS

A + symbol preceding any checklist step means the step is contained in Section II and that a response is required when the flight engineer reads the item. Steps requiring coordination with mission crew are indicated by a circle around the step number.

PREFLIGHT INSPECTIONS

BEFORE INTERIOR INSPECTION (N)

1. AFTO Form 781 – Checked

   Note GINS crypto status – Keyed or unkeyed; also note CDU software version (VSN), and EGI version number.

2. Personal Equipment – Checked and Stowed

   Check flight publications, parachute, survival kit, and LPU; stow as required.

– – – If GINS Does Not Contain Currently Effective Encryption Keys, Perform Step 3 – – –

3. Crypto Codes – Loaded (N, CT)
4. Weather Radar – OFF (E, N)
   a. Mode Selector – OFF
   b. ANT STAB Switch – OFF
   c. GAIN Knob – AUTO
   d. TILT Knob – Full UP (15°)
   e. Range Knob – OFF
   f. TGT CLAR Knob – Mid Range
   g. INT Knob – Mid Range
   h. Range Delay Switch – NOR
5. Rendezvous Beacon – OFF

INTERIOR INSPECTION (N)

Due to the time required for equipment warmup and operational checks, the navigator may be required to check several systems at one time when performing the INTERIOR INSPECTION checklist. All applicable INTERIOR INSPECTION checklist items will be completed prior to taxi.

1. Electrical Power – On

   Verify power is available to GINS. Verify all necessary power is available by checking with flight engineer or maintenance personnel.

2. Aft Forced Air Cooling – On

   Confirm cooling system is operating by checking with flight engineer or maintenance personnel.

CAUTION

- If GINS is in operation, ensure aft forced air cooling system is operating in ENG/APU mode and FAN 1 is on LOW SPD and the AFT AFAC ground maintenance panel selector switch is in TAKEOFF, unless ground cart is providing cooling air.
- Do not operate GINS until aft forced air cooling duct temperature is below 100°F. Refer to HOT DAY CABIN COOLING, Section VII.

3. Autopilot Engage Switch – OFF (E, N)

NOTE

If autopilot engage switch is not OFF, check with maintenance or flight engineer to turn it OFF.

4. Weather Radar – TEST
   a. Mode Selector – TEST
   b. Range Knob – 150

      RT caution light illuminates until 3 minute warmup period is complete.

   The normal test pattern is displayed after warmup period.

5. Audio Panel – As Required

   Set audio panel to allow monitoring of primary communications radio and selected guard radio.

6. Panel Lights – As Desired
7. Oxygen, Interphone – Checked, ON, 100%

   The oxygen preflight may be completed before this checklist, if desired.

   a. Set SUPPLY lever to ON.
   b. Connect and don mask and anti-smoke goggles.

c. Check NORMAL and 100% OXYGEN settings.

Set EMERGENCY lever to NORMAL and diluter lever to 100% OXYGEN. Check flow indicator shows white during inhalation and black during exhalation. Pressure should be 290 to 430 psi.

d. Check EMERGENCY and 100% settings.

Set EMERGENCY lever to EMERGENCY. Check mask for proper fit and serviceability of hoses and connectors. Hold breath and check for no flow around edges of mask (blinker remains black). White blinker indicates a leak. On anti-smoke goggles, pull vent valve knob out and verify airflow through anti-smoke goggles. Push vent valve knob in and verify airflow through anti-smoke goggles stops.

e. Breathe normally for two to three cycles.

Blinker shows white during inhalation, black during exhalation.

f. Check NORMAL and NORMAL settings.

Set EMERGENCY and diluter levers to NORMAL. Blinker should show white during inhalation, black during exhalation.

g. Check NORMAL, 100% and OFF setting.

Set EMERGENCY lever to NORMAL, set SUPPLY lever to OFF. (Regulator with test connector and no placard on front should move automatically to 100%.) Set diluter lever to 100%, if required. Attempt to breathe through mask. Ability to breathe indicates faulty regulator.

WARNING

Some regulators with test connector on front panel (*figure 1-241*) do not move diluter lever to 100% when SUPPLY lever is set to OFF. These regulators are usually placarded NO OFF PROTECTION. Always verify diluter lever is set to 100% when setting SUPPLY lever to OFF.

h. Set SUPPLY lever to ON.

i. Check oxygen mask microphone assembly.

j. Ensure the vent valve on the quick don oxygen mask is pushed in.

k. Stow mask.

8. GINS Startup – Performed

a. P6 Panel, GINS NAVIGATION Circuit Breakers – Closed (All)

b. GINS Indicators/Lights – Tested

c. EGI BATTERIES Warning/Caution Lights – Checked

If any are illuminated, record in AFTO Form 781 and proceed with startup.

d. 1553 BUS CONTROL Switch – NORMAL

e. PCMCIA(s) – Installed

f. CPS NAV SOURCE Switch – AUTO

g. CDU Switches (3) – ON

h. BSIU Switches (2) – ON

i. EGI Switches (2) – ON

After EGI power on, it is normal for a NO RAIM annunciation to occur until a GPS solution is achieved.

j. CDU Software Version (3) – Checked

Verify all 3 CDUs have the same software VSN as recorded in the AFTO Form 781. If not, contact maintenance.

k. Start 1 Screen – Displayed

(1) Current Position – Verified or Entered, As Required

Verify position shown on Data Line 1. If incorrect, enter correct position. Enter correct position as soon as practical after power up.

(2) Current UTC Date – Verified or Entered, As Required

(3) Current UTC – Verified or Entered, As Required

(4) Satellite Tracking – Checked (N)

(5) GPS 1 and 2 Inav Pages – Displayed

Normally show STATE 5 and 4 SATS.

(6) RAIM – As Required

Either NO RAIM or RAIM ACT on right side of information line is evidence that RAIM is on.

With RAIM active the solution normally alternates between STATE 5 with 4 SATS and STATE – with 3 SATS. With RAIM off the solution normally shows STATE 5 with 4 SATS.

(7) FREEZE – Accomplished

Press LS2 to FREEZE position (asterisk appears beside FREEZE).

If an asterisk was displayed before verification (at power on), press LS2 to unfreeze the position. Verify or enter the correct position, and then press LS2 to FREEZE position.

l. Start 2 Screen – Displayed

(1) Align Type – GC

(2) INU 1 and INU 2 – Initiated

(3) AUTONAV – As Required

m. Start 3 Screen – Displayed

(1) Data Line 1 Correct – Verified

(2) LS8 – As Required

9. Alignment Progress – Checked

a. INU 1 and 2 Inav Page – Displayed

Verify INU mode is GC ALIGN and that alignment time display is counting.

b. ENAB NAV – As Required (For Each INU)

Prior to taxi, if AUTO NAV was not selected previously, select LS6 (on appropriate inu inav page) to command INU to navigate mode. MODE NAV is displayed.

c. INU 1 and 2 Nav Data Page – Displayed

Verify pitch, roll and true heading.

10. Weather Radar – Test Pattern Checked

11. AUTOPILOT SOURCE Indicator – Checked

12. NAV Data – Loaded

a. Flight Plan – Loaded Into Active fpln Pages

b. Waypoints – Inserted, As Required

c. Steering Patterns – Inserted, As Required

– – – WITH IDG Mode 4 Codes, Step 14., If Required, Should Be Loaded By the CT Before the Navigator Arrives At the Airplane. Mode 4 Codes May Be Loaded Without Either IFF Or CDU Being On. IFF IBITs, Step 15. Should Be Delayed Until Before Start If a Ground Safety Observer Is Not Available – – –

13. CDU – Configured for IFF Operation

If settings other than the defaults are desired or required, the default selections may be changed, before or after the IFF is turned on. The following substeps list the default selections, and the text amplifications describe how to change the default selections. These substeps may be skipped unless changes need to be made.

a. IFF – STBY

Press IFF function key to access tcas/iff control page. Press LS8 to access iff control page. At LS1 observe IFF selected to STBY.

b. MIC – OUT

At LS4 observe MIC selected to OUT.

c. Modes 1, 2, 3A, and C – ON and Codes Entered, As Required

Coordination with CSO may be required to determine Mode 2 code.

Press IFF function key to access tcas/iff control page. Press LS3 to access iff mode 1/2/3/c page. Observe: M1: ON, M2: ON, M3A: ON, and MC: ON. (Modes may be selected OUT, as required.) Via LS5, LS6, and LS7 enter available codes for Modes 1, 2, and 3A.

d. Mode 4 – Configured

Press IFF function key to access tcas/iff control page. Press LS4 to access iff mode 4 page. If Mode 4 operation is not required, then via LS1 select M4: OUT and proceed to next substep. If Mode 4 operation is required, then observe M4: ON, A: CODE, and REPLY: ANN. (These are CDU default selections.) REPLY: AUD may be selected, as desired.

e. Mode S – Configured

Press IFF function key to access tcas/iff control page. Press LS7 to access iff mode s page. Observe MS: ON. Check MS address at LS5 and change if different than last mission. Check AIS at LS6 and change if different than last mission.

14. Mode 4 Codes – Loaded, As Required (CT, N)

If not accomplished previously, and if Mode 4 operation is required, load codes now so that Mode 4 can be tested.

– – – The Following Step May Be Performed When A Ground Safety Observer Is Available, Or Deferred To Before Start – – –

15. IFF Mode IBITs – Performed

a. Personnel – Clear of IFF Antennas (GC, N)

WARNING

On the ground the IFF transponder transmits if selected to NORM. It must be selected to NORM to run any of the mode IBITs. During transmission the minimum personnel safety distance is 10 feet from either antenna. Minimum electro–explosive device distance is 25 feet.

b. Flight Crew – Notified

Notify flight crew prior to accomplishing IFF test.

c. IFF – NORM

Press IFF function key to access tcas/iff control page. Press LS8 to access iff control page. Press LS1 to select IFF: NORM.

d. Mode IBITs – Performed

Press IFF function key to access tcas/iff control page. Press LS6 to access iff test page. Information line should show MODE NORM, as selected at substep c., and results of last antenna self test. The IFF antenna test runs each time any of the individual modes are tested, except for Mode 4.

In sequence press: LS1, LS2, LS3, LS4, LS5, and LS7. LS7 also tests TCAS; expect TCAS TEST OK aural annunciation. Observe that VSI TCAS test pattern is displayed. After each press observe arrow turns to asterisk and back to arrow to indicate IBIT initiation and completion for that mode. Observe GO status for each completed IBIT. ANT status should turn to GO after first IBIT. M4 and KIV should turn to GO with M4 IBIT.

Press LS8 to return to tcas/iff control page.

16. IFF – STBY – (N or CP)

Press LS8 again to access iff control page. Press LS1 to select IFF: STBY. ◀

BEFORE START

+1. Oxygen, Interphone – Checked, ON, 100% (P, CP, N, OBS)

Verify quick don mask is properly stowed.

+2. GINS – Checked and Set (N)

a. FPLN Page(s) – Displayed and Checked

Check LS5 for desired AUTO or MAN modes.

Flight plan verified correct.

b. Pilot/Copilot Str Select Pages – Displayed and Checked, As Required

Select navigation source for pilot and copilot.

Set flight phase and XTK alert limit, as desired.

c. Pilot/Copilot Str Pages – Displayed

d. DESIGNATED PILOT Switch – As Required

e. ADC SOURCE SELECT Switch – As Required

f. 1553 BUS CONTROL Switch – NORMAL

– – – WITH IDG The Following Step Can Have Been Performed Earlier If A Ground Safety Observer Was Available – – –

+3. IFF Mode IBITs – Performed

a. Personnel – Clear of IFF Antennas (GC, N, E)

WARNING

On the ground the IFF transponder transmits if selected to NORM. It must be selected to NORM to run any of the mode IBITs. During transmission the minimum personnel safety distance is 10 feet from either antenna. Minimum electro–explosive device distance is 25 feet.

b. Flight Crew – Notified

Notify flight crew prior to accomplishing IFF test.

c. IFF – NORM

Press IFF function key to access tcas/iff control page. Press LS8 to access iff control page. Press LS1 to select IFF: NORM.

d. Mode IBITs – Performed

Press IFF function key to access tcas/iff control page. Press LS6 to access iff test page. Information line should show MODE NORM, as selected at substep c., and results of last antenna self test. The IFF antenna test runs each time any of the individual modes are tested, except for mode 4. In sequence press: LS1, LS2, LS3, LS4, LS5, and LS7. LS7 also tests TCAS; expect TCAS TEST OK aural annunciation. After each press observe arrow turns to asterisk and back to arrow to indicate IBIT initiation and completion for that mode. Observe NGO turns to GO for each completed IBIT. ANT status should turn to GO after first IBIT. M4 and KIV should turn to GO with MS IBIT. Press LS8 to return to tcas/iff control page.

e. IFF – STBY

Press LS8 again to access iff control page. Press LS1 to select IFF: STBY. ◀

+4. Altimeters – Checked and RESET (P), Checked and RESET (CP), Set _____, Reading _____ Ft (N)

State setting and reading. Navigator's altimeter must indicate within 75 feet of a known elevation.

NOTE

If the difference between any two altimeters exceeds 75 feet, refer to allowable altimeter differences in *figure 5-14*.

5. CDU Baroset – Entered (N)

– – – For Normal Start, Proceed to Starting Engines Checklist. For Cocking, Proceed to Step 6 – – –

6. INU Align Status – As Required (OFF, CC1, CC3) (ALIGN, CC2)

+7. Oxygen – OFF, 100% (ALL)

+8. Forced Air Systems As Required (E, N, MCC)

(OFF, CC1) (Aft System, On, AUTO, CC2)

+9. Weather Radar – OFF (P, N)

a. Indicator PWR/Range Knobs – OFF

b. ANT STAB Switch – OFF

c. Mode Selector – OFF

+10. APU and External Power – As Required (E, N)

(OFF, CC1), (External Power or APU Generator – On, CC2)

STARTING ENGINES

– – – For Normal Starts, Omit Steps 1 Through 4 – – –

+1. APU and External Power – On (E, N)

+2. Aft Forced Air Cooling – On (E, N)

+3. INU Mode – GC ALIGN or NAV

+4. Oxygen – ON, 100% (P, CP, E, N, OBS)

+5. Takeoff Briefing – Reviewed (P, CP, E, N)

Pilots will review TOLD card data and set altimeters, airspeed bugs and EPR bugs. Briefing will include takeoff, emergency, and departure procedures; including pilot not flying airplane will call V_1 and V_{ROT}.

6. Start Page 1, Initial Position – Unfreeze

After INUs transition to MODE NAV, press IDX and LS1 to return to Start 1 psn/time page. Press LS2 to unfreeze position (asterisk changes to arrow).

NOTE

Failure to unfreeze the present position causes misalignment of INUs at the next GC align.

+7. GINS – Ready for Taxi (N)

INUs should be aligned and in NAV mode.

If not in AUTO NAV mode, perform ENAB NAV function for both INUs via INU Inav screens.

+8. HAVE SIREN ELCUs – As Required (N)

On, if system to be used. Turn system on three minutes before takeoff, if possible. Minimum warmup time is one minute. OPR light should illuminate in about one minute after turnon.

TAXI

– – – Steps 1 through 5 May be Completed Before Taxi – – –

NOTE

Do not taxi airplane within one minute of initiating ground alignment. Failure to comply can result in poor alignment quality and excessive INU drift rate. If time permits, a four minute ground alignment should be completed prior to taxi.

1. ATC Clearance – Copied

+2. UHF-ADF – Monitored (P, CP, E, N)

NOTE

At least two crewmembers will monitor guard frequency at all times.

3. Weather Radar – Checked and Set

WARNING

Radar will be in TEST or STBY when personnel are within 60 feet of antenna or when ungrounded electroexplosive devices are within 100 feet of antenna.

a. Mode Selector – TEST

Select WX if conditions dictate.

b. ANT STAB Switch – ON

c. GAIN Knob – AUTO

d. Beam Width – As Desired

Select desired beam width if in MAP mode.

e. Pulse Length – As Required

Select desired pulse length if in MAP mode.

f. TILT Knob – As Desired

g. Range Knob – As Required

4. Rendezvous Beacon – As Desired

Set desired code and select STBY if rendezvous is planned.

5. RMI – Checked, Set to VOR or TACAN, As Desired

Check during turn in either direction for proper operation.

6. Groundspeed – Monitor, As Desired

GS is available on GINS CDU, PSN and/or STR pages.

BEFORE TAKEOFF

1. Seat Belt and Shoulder Harness – Fastened

2. Seat – Facing Forward or 30 Degrees (First Stop) Outboard

WARNING

The seat does not provide maximum crash restraint unless it is facing forward or 30 degrees (first stop) outboard.

3. Altimeter and Flight Instruments – Set, No Flags (P, CP, N)

a. Altimeter – Set

b. RMI – Flags Out of View

c. RMI Selector – Set for Departure

d. CDU Baroset – Checked (N)

Check Pilot/Copilot psn page.

+4. HAVE SIREN System – As Required

5. FPLN Page – As Required

Check LS5 for desired AUTO or MAN mode.

6. Present Position – Checked

Update if required.

– – – After Receiving Clearance Onto Runway, Perform Steps 7 through 10 – – –

+7. Takeoff Announcement – Completed (P or CP)

8. **LESS IDG** IFF MASTER Switch – NORM (CP, E)◀
WITH IDG IFF – NORM (N or CP)

Select IFF to NORM on iff control page. ◀

9. **WITH IDG** TCAS SENS – TA/RA, As Required (N or CP) ◀

If not ready for takeoff when takeoff announcement is made by pilot or copilot, report to pilot.

10. Weather Radar – On, Mode as Required

AFTER TAKEOFF AND CLIMB

+1. UHF GUARD – MONITOR (P, CP, E, N)

+2. Altimeters – Set 29.92 (P, CP, E, N)

+3. CDU Baroset – 29.92 (N)

+4. HAVE SIREN System – OFF (N)

ON light goes out. If fault (caution) lights illuminate, caution lights and ON light go out in about one minute.

NOTE

Shut system down at about 20,000 feet or after 15 minutes of operation, whichever occurs last.

5. Flight Plan Altitude Assignments – As Required

NOTE

- Do not enter same altitude on successive waypoints in flight plan.
- If cartridge-entered flight plan has same altitude assigned to successive waypoints, they must be removed manually to avoid near-constant altitude error alert.

AIR REFUELING PROCEDURES

Navigator procedures during air refueling are contained in T.O. 1-1C-1-27 and 1-1C-1-27CL-2.

DESCENT

The navigator's primary responsibility during descent, penetration, and approach is the close monitoring of the airplane position and altitude relative to route and clearance. This requires that the navigator give his undivided attention to provide timely and effective crew coordination. Mission paperwork and other extraneous actions not directly relating to descent and approach will cease.

+1. Approach Briefing and Landing Data – Reviewed (P, CP, E, N)

Monitor and confirm penetration and approach procedures.

+2. UHF-ADF – Monitored (P, CP, E, N)

+3. Altimeters – Set _____, RESET (P), Set _____, RESET (CP), Set _____ (N)

Pilot not flying notifies crew of current altimeter setting. Pilot flying sets current altimeter setting (QNH or QFE) when cleared below transition level. Pilot not flying and navigator will remain on 29.92 (QNE) until passing transition level, at which time all altimeters will be set to local altimeter setting (QNH or QFE).

WARNING

QFE altimeter setting (station pressure) gives altitude in feet above airport elevation, not feet above sea level.

+4. CDU Baroset – Entered

Check Pilot/Copilot psn page.

5. HAVE SIREN System – As Required (N)

On below 20,000 feet, if system to be used. ON light should illuminate. OPR light should illuminate in about one minute.

APPROACH

This checklist will be completed on each initial approach, and on each instrument approach, before starting final approach.

1. Seat Belt and Shoulder Harness – Fastened

2. Seat – Facing Forward or 30 Degrees (First Stop) Outboard

WARNING

The seat does not provide maximum crash restraint unless it is facing forward or 30 degrees (first stop) outboard.

+3. Approach Briefing and Landing Data – Reviewed (P, CP, N, E)

NOTE

Items on the approach briefing may be omitted, if previously briefed and unchanged.

+4. Altimeters – Set (P, CP, N)

+5. Navigation Radios – Set for Approach (P, CP, N)

   a. For instrument approaches, monitor the appropriate radio IDENT for the entire approach.

   b. If required, set RMI to monitor TACAN or VOR.

   c. Call up PSN page and STR page for designated pilot. Monitor position, groundspeed, wind, and drift, as required.

6. If windshear has been reported or is suspected, compute and monitor minimum groundspeed.

AFTER LANDING/TAXI BACK

+1. Weather Radar – TEST (E, N)

WARNING

Radar will be in TEST or STBY when personnel are within 60 feet of antenna or when ungrounded electroexplosive devices are within 100 feet of antenna.

+2. HAVE SIREN System – As Required (N)

   a. OFF (when leaving active runway)

   If throttle No 1 or No 3 is moved to cutoff, all units shut down.

CAUTION

Leave all ELCU switches ON for at least one minute after shutdown of the HAVE SIREN system to allow automatic one minute cooldown cycle. No 1 and No 3 throttles will not be set to CUTOFF for at least one minute after HAVE SIREN system is shut down.

   b. ON (if system to be used)

   Turn system on three minutes before takeoff, if possible. Minimum warmup time is one minute. OPR light should illuminate about one minute after power is applied.

+3. **WITH IDG** M4 Codes – HOLD, As Required (N)

Power transfer might trigger autozeroization if HOLD is not activated. ◀

4. **LESS IDG** IFF MASTER Switch – STBY (CP or E) ◀
WITH IDG IFF – STBY (N or CP)

Select IFF to STBY on iff control page. ◀

5. GINS – Ready for Taxi (N)

INS aligned and in NAV Mode.

Monitor groundspeed, as desired (GINS CDU, PSN and/or STR pages.)

– – – For Taxi Back Operation, Perform BEFORE TAKEOFF Checklist Prior to Subsequent Takeoff – – –

ENGINE SHUTDOWN

+1. Weather Radar – Set, OFF (P, N)

   a. Range Knob – OFF
   b. Range Delay Switch – NOR
   c. TILT Knob – Full UP (15°)
   d. GAIN Knob – AUTO
   e. ANT STAB Switch – OFF
   f. Mode Selector Knob – OFF

– – – Recocking, Perform RECOCKING Checklist – – –

BEFORE LEAVING AIRPLANE

+1. GINS Classified Steering Patterns – Removed (E, N)

+2. Sortie Data – Saved, As Required

   a. Data Loader 1 Screen – Displayed
   b. LS5, 7, or 8, As Desired – Depressed
   c. Data Loader Screen 2 – Displayed
   d. LS7 and/or 8, As Desired – Depressed
   e. PCMCIA(s) – Removed

+3. Flight Plan/Markpoint Zeroize – Accomplished, As Required

   a. Lock – Zeroize Screen – Displayed
   b. LS2 – Depressed
   c. LS3 – Depressed

NOTE

When zeroizing CDU data via the Lock/Zeroize Page, allow at least three minutes for the non–volatile memory (NVM) in all CDUs to clear before powering down GINS. If a CDU memory is not cleared and that CDU is powered up as bus controller on a subsequent mission, the retained data is propagated to all CDUs.

+4 **WITH IDG** IFF Codes – Removed/Zeroized (As Required) (P, CP, N, E)

If required, on iff mode 1/2/3/c page, set desired codes to zero by inserting a minus sign in each code field. On iff mode 4 page, press LS6 to zeroize mode 4 codes. ◀

NOTE

Pressing LS7 (IFF) on the IDX – Lock/Zeroize page will not set Mode 2 code to zero. This must be accomplished on the iff mode 1/2/3/c page.

+5. GINS – As Required – (N, E)

If powering down GINS:

a. EGI Switches (2) – Off

b. BSIU Switches (2) – Off

c. CDU Switches (3) – Off

NOTE

Ensure both EGIs are off before shutting down the CDUs by verifying a NO GO condition on both EGIs, RPUs and BATTs on the EGI Status 2 Page.

+6. Zeroize GINS Crypto Codes – As Required

NOTE

Normally use only GPS CRYPTO ZEROIZE. MASTER ZEROIZE erases GPS internal position.

+7. EMERGENCY POWER Switch – As Required (E, N)

+8. Forced Air Systems – OFF, unless required for maintenance (E, N)

CAUTION

Advise flight engineer if GINS is still on and requires cooling.

+9. APU and External Power – As Required (E, N)

CAUTION

Advise flight engineer if GINS is still on and requires power.

+10. Oxygen – OFF, 100% (P, CP, E, N, OBS)

11. Sextant Mount – Checked, If Required

Open sextant mount drain, check for water, drain if necessary, close drain.

INFLIGHT ALIGNMENT

1. Electrical Power and Cooling – ON

Verify power and aft forced air cooling are available to E14 rack.

– – – If Performing IFA On Only One EGI, Skip Step 2 – – –

2. AHRS 1 and AHRS 2 Heading – Checked

Ascertain that alternate attitude and heading sources are available. Crosscheck with standby compass or other source, as available.

3. CPS Switch – Set to EGI Not Being IFA, As Required

4. Pilot/Copilot Steering Solution – Set to EGI Not Being IFA, As Required

5. DESIGNATED PILOT Selector Switch – As Required

6. ADI Switch – AHRS

For IFA, coordinate with CDMT.

7. EGI Power Switch – OFF (Minimum of 10 Seconds) For EGI Being IFA

8. EGI Power Switch – ON

NOTE

Fly straight and level, with airspeed constant, to initiate IFA. Remain straight and level, and at constant airspeed, for at least 80 seconds after alignment counter starts.

9. Start 1 Page – Displayed

Verify position, UTC date, and UTC.

10. Start 2 Page – Displayed

    a. AUTONAV – As Required

11. INU Inav Page – Displayed

    Verify INU mode transitions to IFA after selecting GPS initiation. Verify align time counter starts running. IFA process should be complete in about ten minutes.

NOTE

Normal turns after 80-second leg can aid in improving accuracy of post-alignment INU drift rates. At least two turns of 20 to 160°, in opposite directions, separated by a straight leg approximately 3 minutes in duration, should be performed if circumstances permit.

– – – When Alignment Complete (As Shown By INU MODE NAV Display) – – –

12. INU Inav Page, Alignment CEP and Difference from Designated Pilot's Navigation Solution – Verified

NOTE

If alignment CEP is greater than 0.8, alignment quality is suspect. Failure of an IFA to complete may be caused by loss of GPS coverage and does not necessarily indicate a failure of equipment. If the alignment fails to complete within 10 minutes, reattempt in–flight alignment and attempt to verify continuous GPS coverage.

13. CPS Switch – Auto, As Desired

14. Pilot/Copilot Steering Solution – As Desired

NOTE

Navigation information must be cross checked (position, TH, GS, and cross track (XTK) /track error (TKE)) before using the EGI aligned inflight as a source of information for the applicable ADI or the autopilot.

15. Designated Pilot – As Desired

16. ADI – As Desired

EGI UNKEYING PROCEDURE

1. CPS Switch – Set to EGI Not Being Unkeyed, As Required

2. Pilot/Copilot Steering Solution – Set to EGI Not Being Unkeyed, As Required

3. DESIGNATED PILOT Selector Switch – As Required

④ EGI to Be Unkeyed – Zeroize at the KEY LOAD Port On E14 Rack (N, CT)

5. GPS sa/as Screen – Confirm NONE For Unkeyed EGI

   NONE in GPS1 or GPS2 column indicates no keys present in associated EGI.

EGI KEYING PROCEDURE

1. CPS Switch – Set to EGI Not Being Keyed, As Required

2. Pilot/Copilot Steering Solution – Set to EGI Not Being Keyed, As Required

3. DESIGNATED PILOT Selector Switch – As Required

④ Crypto Key Loader – Connect To LOAD PORT On E14 Rack for EGI To Be Keyed and Load Keys Per Instructions On Crypto Key Loader (CT, N)

5. GPS sa/as Screen – Confirm LOADED (or VERIFIED) For Keyed EGI

   LOADED in GPS1 or GPS2 column indicates keys are present but not yet verified in associated EGI. VERIFIED appears automatically as soon as keys are verified.

6. CPS Switch – As Desired

7. Pilot/Copilot Steering Solution – As Desired

8. DESIGNATED PILOT Selector Switch – As Desired

NAVIGATION 1553 BUS SPLITTING PROCEDURE

NOTE

- The purpose of the 1553 bus split switch is to isolate the unit(s) which may be causing problems on the 1553 bus. This action is solely for troubleshooting purposes only. The switch should be returned to NORMAL once troubleshooting is complete.
- During split bus operation, any changes to the flight plan must be made separately on CDU 1 and either CDU 2 or CDU 3. Two flight plans exist when the bus is split, one for each of the two bus control CDUs. CDU 1 displays the pilot's flight plan. CDU 2 and CDU 3 display the other flight plan. If changes are made to a flight plan, they may be lost when the 1553 BUS CONTROL switch is returned to NORMAL, since only the flight plan stored in the CDU that is bus controller after the bus is returned to NORMAL is retained

– – – If All Three CDUs Display NO INPUT, Proceed to Step 2 – – –

1. 1553 Bus Status – Checked

   Check 1553 bus status of each LRU via individual status pages, using a functional CDU. Note any bus NGO indications.

2. Autopilot NAV MODE – Selected, If Desired.

   Select an autopilot NAV MODE other than GINS, if autopilot use is desired.

3. Pilot Steering Source – EGI 1 Selected

   On pilot's steering page, select EGI 1 as steering source.

4. 1553 BUS CONTROL Switch – ISOLATE

   Set 1553 BUS CONTROL switch to ISOLATE.

NOTE

- With bus split, pilot can use only EGI 1 navigation solution; copilot can use only EGI 2.
- With bus split, data loader is not accessible from CDU 1; the navigation database is not available to pilot.

5. CDU Status Pages – Checked

   Check CDU status pages for proper isolated operation per table below.

LRU	Bus Status on Pilot's CDU	Bus Status on Copilot's and Navigator's CDUs
CDU 1	GO	NGO
CDU 2	NGO	GO
CDU 3	NGO	GO
BSIU 1	GO	NGO
BSIU 2	NGO	GO
EGI 1	GO	NGO
EGI 2	NGO	GO
Data Loader	NGO	GO
JTIDS	NGO	GO
IFF	NGO	GO
IFF IS	NGO	GO
IFF XPNDR	GO	NGO
CADC 1	GO	NGO
CADC 2	NGO	GO

6. Faulty LRU – As Required

   Attempt to correct the suspect LRU (LRU which does not agree with table) by cycling power and/or verifying that the bus coupler is connected. If unable to correct the faulty LRU, leave the faulty LRU in a power off configuration.

7. 1553 BUS CONTROL Switch – NORMAL

   Set 1553 BUS CONTROL switch to NORMAL. Once this step is accomplished, system should return to normal operation.

8. Autopilot NAV MODE – Selected, As Desired

   Select GINS as autopilot NAV MODE, if desired.

RECOCKING CHECK

If takeoff is not made on a scramble or normal alert launch, perform the AFTER LANDING, ENGINE SHUTDOWN and the RECOCKING checklists to reconfigure the GINS into Alert Condition II. Then perform the BEFORE START checklist.

– – – For Recocking Into Alert Condition II Disregard Steps 1, 2, and 3 – – –

1. EGI Switches (2) – Off
2. BSIU Switches (2) – Off
3. CDU Switches (3) – Off

NOTE

Ensure both EGIs are off before shutting down the CDUs by verifying a NO GO condition on both EGIs, RPUs and BATTs on the EGI Status 2 Page.

– – – If GINS Contains Currently Effective Encryption Keys, Continue As Directed Below. If Not, Load Applicable Keys Before Continuing – – –

– – – For Recocking Into Alert Condition I, Disregard Steps 4 Through 7 and Perform BEFORE START Checklist – – –

CAUTION

If GINS is in operation, ensure aft forced air cooling system is operating in ENG/APU mode and FAN 1 is on LOW SPD and the AFT AFAC ground maintenance panel selector switch is in TAKE-OFF, unless ground cart is providing cooling.

4. GINS Startup – Performed

   a. P6 Panel, GINS NAVIGATION Circuit Breakers – Closed (All)

   b. GINS Indicators/Lights – Tested

   c. EGI BATTERIES Warning/Caution Lights – Checked

      If any are illuminated, record in AFTO Form 781 and proceed with startup.

   d. 1553 BUS CONTROL Switch – NORMAL

   e. PCMCIA(s) – Installed

   f. CPS NAV SOURCE Switch – AUTO

   g. CDU Switches (3) – ON

   h. BSIU Switches (2) – ON

   i. EGI Switches (2) – ON

   j. CDU Software Version (3) – Checked

      Verify all 3 CDUs have the same software VSN as recorded in the AFTO Form 781. If not, contact maintenance.

   k. Start 1 Screen – Displayed

      (1) Current Position – Verified or Entered, As Required

      Verify position shown on Data Line 1. If incorrect, enter correct position. Enter correct position as soon as practical after power up.

(2) Current UTC Date – Verified or Entered, As Required

(3) Current UTC – Verified or Entered, As Required

(4) Satellite Tracking – Checked (N)

(5) GPS 1 and 2 Inav Pages – Displayed

Normally show STATE 5 and 4 SATS.

(6) FREEZE – Accomplished

Press LS2 to FREEZE position (asterisk appears beside FREEZE).

If an asterisk was displayed before verification (at power on), press LS2 to unfreeze the position. Verify or enter the correct position, and then press LS2 to FREEZE position.

l. Start 2 Screen – Displayed

(1) Align Type – GC

(2) INU 1 and INU 2 – Initiated

(3) AUTONAV – As Required

m. Start 3 Screen – Displayed

(1) Data Line 1 Correct – Verified

(2) LS8 – As Required

5. Alignment Progress – Checked

a. INU 1 and 2 Inav Page – Displayed

Verify INU mode is GC ALIGN and that alignment time display is counting.

b. ENAB NAV – As Required (For Each INU)

Prior to taxi, if AUTO NAV was not selected previously, select LS6 (on appropriate inu inav page) to command INU to navigate mode. MODE NAV is displayed.

c. INU 1 and 2 Nav Data Page – Displayed

Verify pitch, roll and true heading.

d. Initial Position – Unfreeze

After INUs transition to MODE NAV, press IDX and LS1 to return to Start 1 psn/time page. Press LS2 to unfreeze position (asterisk changes to arrow).

6. GINS – Checked and Set

a. Start 1 Page – Displayed, Checked

Check (or enter) position, time, date chart datum.

b. Start 2 Page – Displayed, Checked

c. Start 3 Page – Displayed, As Required

Load/modify/replace flight plan, as required.

d. Fpln Page(s) – Displayed, Checked

Verify flight plan correct.

e. Pilot/Copilot Str Select Pages – Displayed, As Required

Select navigation solution for pilot and for copilot.

f. Pilot/Copilot Str Pages – Displayed

g. DESIGNATED PILOT Switch – As Required

h. ADC SOURCE SELECT Switch – As Required

i. 1553 BUS CONTROL Switch – NORMAL

7. GINS – Ready for Taxi

INUs aligned and in NAV mode

or

ATTD RDY (1 and/or 2) displayed; up to five minutes required to complete alignment in flight

or

ATTD RDY (1 and/or 2) not displayed; up to about ten minutes required to complete alignment in flight.

NOTE

If urgency requires taxi prior to ATTD RDY status (normally about one minute from EGI power up), power down EGIs and wait ten seconds before moving airplane. Repower EGIs after takeoff.

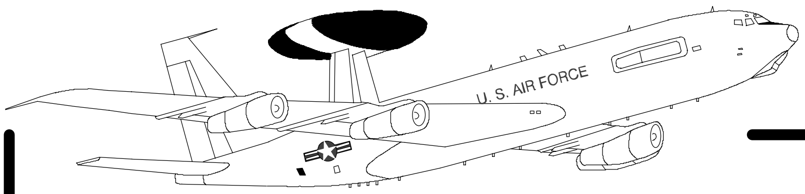
TOWING AND PUSHBACK

+1. GINS – Ready for Towing (E, N)

GINS may be powered up or down during ground movements.

– – – For Post Flight, Refer to BEFORE LEAVING AIRPLANE – – –

Section V



OPERATING LIMITATIONS

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INTRODUCTION

This section covers the operating limitations of the airplane and airplane systems, including some restrictions on operation of mission systems which must be observed during normal operation. A limitation is the maximum or minimum (red line) value at which a system may be operated, not the normal operating range (green line) of a system. Normal and caution operating ranges, where indicated on an instrument, are shown under INSTRUMENT MARKINGS. Normal operating ranges of other systems are described in section I.

NOTE

- The special limitations which apply to airplanes in acceptance test flying or to airplanes assigned to the test program are contained in the Flight Test Supplements, T.O. 1E-3A-1-300 TEMP, T.O. 1E-3A-1-301 TEMP, T.O. 1E-3A-1-302 TEMP and T.O. 1E-3A-1-303 TEMP, which are issued only to personnel involved in these programs.
- If any system or equipment is operated outside the limits specified in this section (except momentary overshooting during takeoff or go-around), the incident shall be recorded in AFTO Form 781.

INSTRUMENT MARKINGS

Special attention must be paid to the instrument markings shown in *figure 5-1*. The instrument markings are used to indicate to the flight crew, at a glance, that an instrument reading is in the normal, caution or unsafe region. The instrument markings consist of three colors. Red, used as a minimum marking, indicates that unsafe operation exists below that point. When red is used as a maximum limit marking, operation is prohibited above the red line. Short, red radial lines indicate limits under special conditions. Long, red lines indicate the maximum allowable value. Green indicates the normal operating range. Yellow indicates a caution range, either high or low.

MINIMUM CREW REQUIREMENTS

A pilot, copilot and flight engineer constitute the minimum crew to operate this airplane. A navigator will be carried for missions requiring specialized navigation techniques. Mission crew carried depends on assigned mission.

The minimum crew for emergency taxi is two pilots and one flight engineer or one pilot in left seat, one flight engineer and one mechanic (qualified for engine run and taxi) in copilot's seat.

AIRPLANE OPERATIONAL LIMITATIONS

A summary of airplane operational limitations is shown in *figure 5-2*.

The outboard engine EPR readings are sometimes restricted to allow control of the airplane if an outboard engine fails during takeoff or go-around. Refer to parts II and VII of T.O. 1E-3A-1-1 for maximum allowable EPR settings for outboard engines. Maximum EPR settings are provided to allow control of the airplane in the air if a single outboard engine fails with either rudder boost operating or off and with rudder boost on if a second engine failure occurs on the same wing. During a go-around maneuver the maximum EPR settings for the outboard engines shall not be exceeded.

ENGINE LIMITATIONS

A summary of engine operating limitations is contained in *figure 5-3*.

ENGINE THRUST LIMITATIONS

Maximum EPR and N_1 rpm values for takeoff rated thrust (TRT), military rated thrust (MRT) and normal rated thrust (NRT) limits are presented on the appropriate thrust setting charts in T.O. 1E-3A-1-1.

Takeoff Rated Thrust (TRT)

Takeoff rated thrust (TRT) is the highest value of thrust which the engine will deliver. This rating is restricted to 5 minutes of operation. Go-around thrust provides the same level of thrust and is likewise restricted to 5 minutes.

Military Rated Thrust (MRT)

The military rated thrust (MRT) is primarily intended for use in other than normal situations at the discretion of the pilot or where flight at maximum allowable thrust is necessary for flight operating conditions for up to 30 minutes. MRT will be used if mission requirements dictate use of MRT climb data.

Normal Rated Thrust (NRT)

Normal rated thrust (NRT) is the maximum thrust approved for continuous use.

Idle

This is not an engine rating but is a throttle position suitable for minimum thrust operation on the ground or in flight.

ENGINE RPM LIMITATIONS

Low pressure compressor (N_1) RPM limit is 101.1% (6,870 RPM). High pressure compressor (N_2) RPM limit is 104.5% (10,095 RPM).

Engine idle RPM should stabilize within five minutes of operation.

ENGINE FUEL ENRICHMENT OPERATION

Fuel enrichment will not be used except for starting. Increased fuel flow could cause engine damage in case of compressor stall.

If airplane is fueled with aviation gasoline (*figure 5-4*) do not use fuel enrichment for starting, regardless of temperature. Increased fuel flow could damage engine.

ENGINE FUEL FLOW LIMITATIONS VS. GENERATOR LOAD

Maintain fuel flow above 2,000 pounds per hour when mission radar is operating at high power, except that thrust may be reduced to idle below 34,000 feet (29,000 feet with anti-ice on) if at least 6 generators are in parallel. Do not stabilize thrust in surge bleed valve operating range. Move throttles through surge bleed valve operating range in 2 seconds or less.

ENGINE OIL TEMPERATURE LIMITATIONS

Normal operating oil temperature range is 40°C to 132°C. An operating oil temperature from 80°C to 100°C is recommended. The oil temperature may indicate in the range of 132°C to 165°C for a period not to exceed 15 minutes. No operation is permitted above 165°C. Provided engine operation is otherwise normal, no minimum oil inlet temperature need be observed before commencing a takeoff; however, an increase in temperature indication is desirable (*figure 5-3*).

ENGINE OIL PRESSURE LIMITATIONS

The normal operating oil pressure is 40 to 60 psi except at idle (35 psi minimum). Oil pressures between 35 and 40 psi and 60 to 65 psi are undesirable and should be tolerated only for the completion of the flight, preferably at a reduced power setting. The oil pressure may not exceed 60 psi or be below 35 psi except as noted below.

a. In flight, continued oil pressures below 35 psi or above 65 psi require engine shutdown or landing as soon as practicable, using the minimum thrust required.

b. A temporary high pressure of above 60 psi at temperatures below 0°F (–18°C) is not dangerous but delay takeoff until the pressure drops below 65 psi.

c. Oil pressure may indicate up to 65 psi following rapid advance of throttles to takeoff or go-around power provided oil pressure decreases to between 40 and 60 psi during climbout.

d. Oil pressure may decrease to 30 psi (caution light illuminated) during rapid engine deceleration. This is acceptable if oil pressure increases to above 35 psi (caution light out) within 10 minutes.

e. When starting engines, the OIL PRESS caution light may remain illuminated or illuminate intermittently for up to four minutes after the oil temperature reaches 40°C at idle rpm. The light shall be out four minutes after the oil temperature reaches 40°C.

ENGINE IGNITION

Ignition is intended for use during start. Also, as a protection against flameout, continuous ignition must be on as follows:

a. During takeoffs with continuous ignition remaining on until the airplane has been cleaned up and the thrust reduced for climb.

b. If inlet icing conditions are encountered, continuous ignition should be on prior to turning on the anti-icing system.

c. Continuous ignition will be on for any emergency condition requiring rapid rate of descent.

d. During a suspected EGW leak from liquid cooling system into the fuel tank.

Continuous ignition shall not be used for ground starts or for inflight starts except in an emergency where the thrust of the inoperative engine is required for flight.

Ignition may also be used in turbulence or any flight condition in which airflow through the engine could be disturbed.

Use of FLT START position should not exceed 10 minutes at one time.

STARTING CYCLE LIMITATIONS

The following limitation applies to starting or motoring the engine with APU bleed, cross-start or external air source:

> The starter duty cycle is one and one half minutes on and 5 minutes off for any number of start or motoring cycles. If starter is inadvertently disengaged during start, it may be re-engaged as soon as N_2 rpm is zero.

FLIGHT START LIMITATIONS

Do not use FLT START switch position for more than 10 minutes.

ALTERNATE FUELS

Alternate fuels are fuels which may be substituted for the recommended fuel with possible restrictions to airplane performance. Use of alternate fuels does not cause permanent damage to the engine or fuel systems but the engine may have to be retrimmed. *Figure 5-4* lists recommended, alternate and emergency fuels with United States, United Kingdom and NATO specification numbers. Engine operating limits listed in this section also apply when alternate fuels are used.

When using aviation gasoline (avgas), it can be necessary to retrim the engines to obtain full takeoff thrust. To determine if retrim is needed, check TRT on one engine. If rated EPR is not obtained, retrim is probably required. If a landing is made at a base where only aviation gasoline is available and engines cannot be retrimmed, only enough fuel should be loaded for flight to a base where recommended or alternate fuel can be obtained.

When aviation gasoline is used, the rate of climb above the boiling altitude of the fuel must be limited. This is required because approximately 0.5% of the fuel evaporates per 1,000 feet of altitude above the boiling attitude. A rapid rate of climb causes rapid boiling, with increased fuel vapor flow in the vent system and high tank pressures. Monitor tank temperatures if liquid cooling system is operating. There are no climb rate restrictions if the fuel mixture contains less than 10% gasoline, the fuel temperature does not exceed 85°F at takeoff, and altitude does not exceed 35,000 feet at any time.

GROUND FUEL TEMPERATURE °F	LIMITING ALTITUDE –FEET (BOILING ALTITUDE)
80	36,000
90	30,000
100	25,000
110	20,000

AERODYNAMIC AND STRUCTURAL LIMITATIONS

AIRSPEED AND MACH LIMITS

Speed limits for the airplane include maximum operating limit speeds for the various configurations and limit speeds for the conditions of flaps extended, landing gear operating, landing gear extended, dump chutes operating, dump chutes extended and extension of retractable landing lights. These limits are imposed by structural limitations of the airplane.

Maximum Operating Limit Speed

The maximum operating limit speeds (VH and MH) are illustrated in *figure 5-5*.

The maximum operating limit speed shall not be deliberately exceeded in any regime of flight (climb, cruise or descent).

WARNING

> Airplane shall not exceed 0.75 Mach when airplane gross weight is below 250,000 pounds and the CG is aft of 32% MAC. Above 0.75 Mach at these conditions, the airplane can become pitch sensitive and control inputs from either the pilot or autopilot can result in pitch oscillations that may exceed structural limitations. If oscillations occur, the pilot should release the control column or disengage the autopilot. Airspeed should then be reduced to 0.75 Mach or less.

- At altitudes below 29,000 ft, fly at or below 0.74M, unless an operational need exists. If an operational need exists to fly above 0.74M, fly at 0.78M and minimize operations in the 0.75M through 0.77M range. This speed restriction does not apply for altitudes at or above 29,000 ft. When aircraft speeds approach 0.76M, the airflow through the struts produces air separation and shock wave effects equivalent to flying at 1.0M. This shock wave effect has been determined to be the contributing factor for the extensive vertical fin and rudder panel cracks leading to the reduction in panel service life. This effect is only applicable at speeds ranging from 0.75M to 0.77M.

Flaps Extension Speeds

The limit speeds for flaps extension and retraction are as follows:

Extension:

From 0 to 14 – 223 KIAS
From 14 to 25 – 215 KIAS
From 25 to 40 – 200 KIAS
From 40 to 50 – 195 KIAS

Retraction:

From 50 to 40 – 195 KIAS
From 40 to 25 – 200 KIAS
From 25 to 14 – 215 KIAS
From 14 to 0 – 223 KIAS

For split or asymmetric flaps, observe the limit for the greater extension.

Flaps shall not be extended above 20,000 feet. Placard speeds at high altitudes have not been verified. Excessive roll rates can result with outboard ailerons unlocked (flaps down) above 20,000 feet due to reduced aerodynamic damping.

Landing Gear Speeds

The normal limit speed for operation of the landing gear is 270 KIAS or 0.78 M. In emergency conditions, the limit speed for operation of the landing gear is 320 KIAS or 0.78 M (*figure 5-5*).

The limit speed with the landing gear extended is 320 KIAS or 0.78 M.

Dump Chutes Speeds

The limit speed for operation of the fuel dump chutes is 240 KIAS or 0.78 M.

The limit speed with the fuel dump chutes extended is 275 KIAS or 0.78 M.

Retractable Landing Lights

Retractable landing lights shall not be extended above 223 KIAS. They may be retracted at any speed; however, operating life of lights increases if retracted below 223 KIAS.

ACCELERATION LIMITS

Maneuvering limit load factors are depicted in *figure 5-8* for variations in altitude, gross weight and flap configuration. The limit load factors for gross weights up to and including 322,500 pounds, with flaps up are +2.5g to –1.0g. With any flap extension for gross weights up to and including 325,000 pounds, the limit load factors are +2.0g to –0.0g. The limit load factors for gross weights greater than 325,000 pounds (not to exceed 344,000 pounds) with flaps up are +2.0g to –1.0g. With any flap extension for gross weights greater than 325,000 pounds, the limit load factors are +1.8g to –0.0g. The gross weight limit for a given load factor decreases with altitude as depicted in *figure 5-8*.

ENGINE STRUT LIMITS

If engine droop stripes are not aligned, airplane will not be accepted for flight until maintenance check of strut is performed.

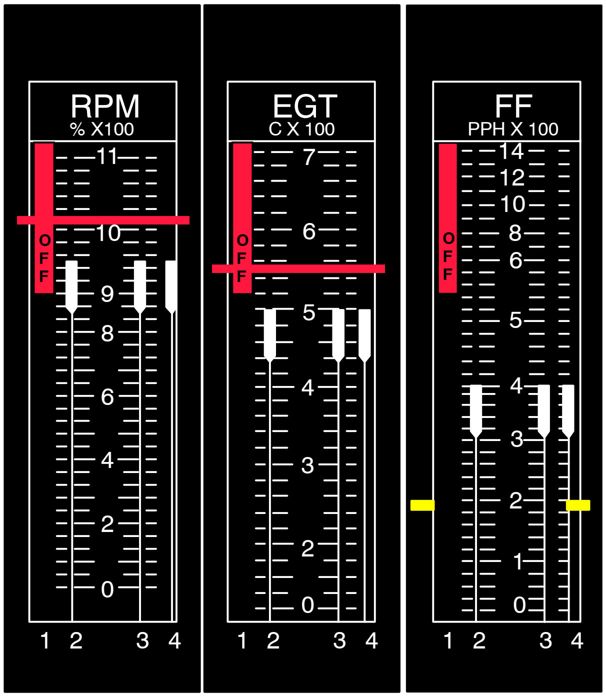
PROHIBITED MANEUVERS

Aerobatics of any kind are prohibited. This includes intentional spins, vertical stalls and steep dives or any other maneuver that results in abrupt accelerations.

Rudder kicks (full and rapid movement of rudder to maximum and back to neutral) are prohibited. Full, rapid rudder input may be used in case of engine failure but avoid checking back to neutral.

Air refueling with parallel yaw damper on or rudder boost off is prohibited, except in an actual fuel emergency.

Instrument Markings



N_1 TACHOMETER

🟥 MAXIMUM RPM 101.1%

EXHAUST GAS TEMPERATURE GAGE (EGT)

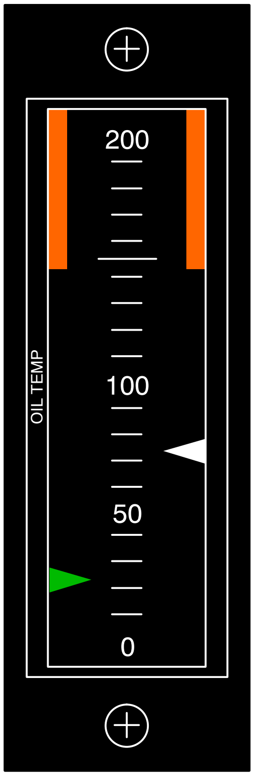
🟥 MAXIMUM EGT 555 °C

FUEL FLOW INDICATOR

🟨 REFER TO FUEL FLOW LIMITATIONS VS. GENERATOR LOAD

ALL INDICATORS:

OFF FLAG IN VIEW: SCALE LIMIT EXCEEDED OR POWER OFF TO INDICATOR

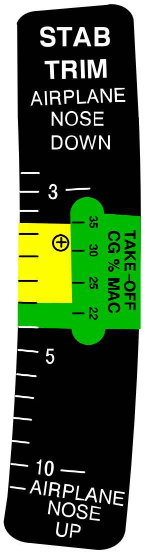


IDG TEMPERATURE GAGE

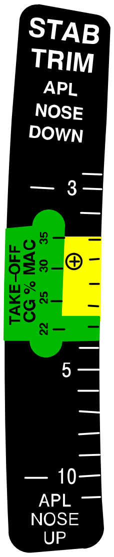
🟧 155 - 200 CAUTION RANGE
163± 5 OVERHEAT

WARNING

DISREGARD C.G. TAKEOFF % MAC. SCALE ON STABILIZER TRIM DECAL. USE CHART IN T.O. 1E-3A-1-1.



PILOT



COPILOT

STABILIZER TRIM INDICATOR

🟩 SAFE TAKEOFF RANGE

🟨 CAUTION RANGE (HIGH CONTROL FORCES ON TAKEOFF)

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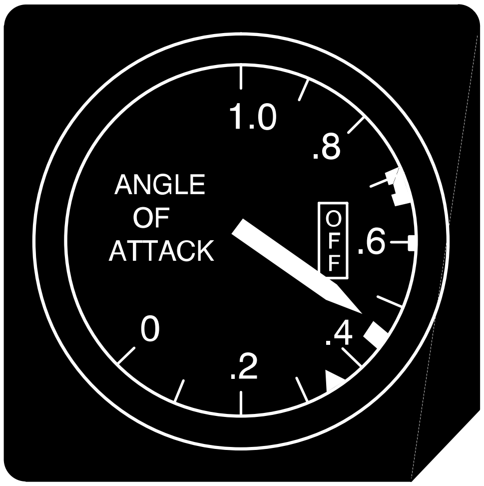
Figure 5-1 (Sheet 1 of 4)



ANGLE OF ATTACK INDICATOR

▲ LONG RANGE CRUISE INDEX .34

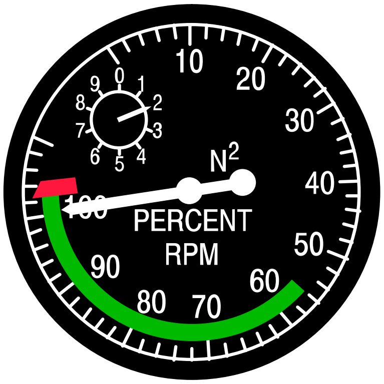
■ MAXIMUM ENDURANCE INDEX .46

▀ APPROACH INDEX .60

▐ CLIMBOUT INDEX .64 TO .71
(STALL REVCOVERY INDEX .71)

MACH AIRSPEED INDICATOR

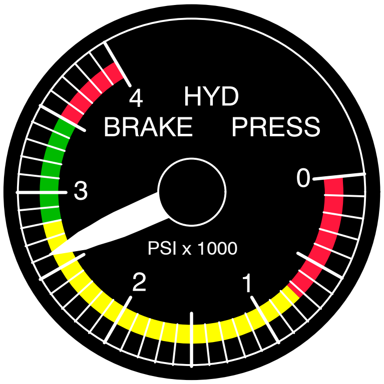
🟥🟩 MAXIMUM ALLOWABLE AIRSPEED V_H



N2 RPM TACHOMETER

🟥 MAXIMUM 104.5%

🟩 NORMAL RANGE



BRAKE PRESSURE GAGE

RED 🟥 ABOVE 3500 PSI BELOW 750 PSI

YELLOW 🟨 750 TO 2800 PSI

GREEN 🟩 2800 TO 3500 PSI

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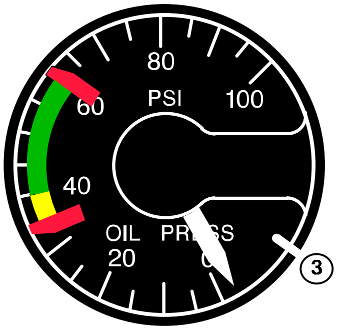
Figure 5-1 (Sheet 2 of 4)

Instrument Markings (Continued)

AUXILIARY HYDRAULIC SYSTEM PRESSURE GAGE

🟥	WARNING	ABOVE 3500 PSI BELOW 2000 PSI
🟨	CAUTION	3200 TO 3500 PSI 2000 TO 2600 PSI
🟩	NORMAL RANGE	2600 TO 3200 PSI



OIL PRESSURE GAGE

🟥	LIMIT	60 PSI MAX ① ② 35 PSI MIN
🟨	CAUTION	35 TO 40 PSI ②
🟩	NORMAL RANGE	40 TO 60 PSI

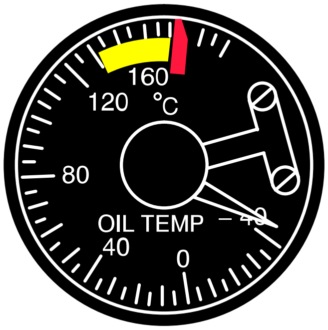
① 65 PSI ALLOWABLE DURING ENGINE ACCELERATION

② REFER TO OIL PRESSURE LIMITATIONS AND SECTION VII FOR COLD WEATHER LIMITS

③ WHITE INDEX MARK FOR GLASS ALIGNMENT (LOCATION VARIES)

UTILITY HYDRAULIC SYSTEM PRESSURE GAGE

🟥	WARNING	ABOVE 3500 PSI BELOW 2000 PSI
🟨	CAUTION	3100 TO 3500 PSI 2000 TO 2400 PSI
🟩	NORMAL RANGE	2400 TO 3100 PSI



OIL TEMPERATURE GAGE

🟥	MAXIMUM	165°C
🟨	CAUTION	132°C TO 165°C ④

④ OPERATION IN 132°C TO 165°C RANGE PERMITTED FOR UP TO 15 MINUTES

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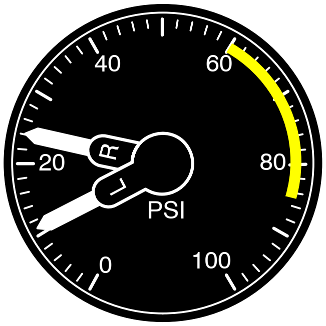
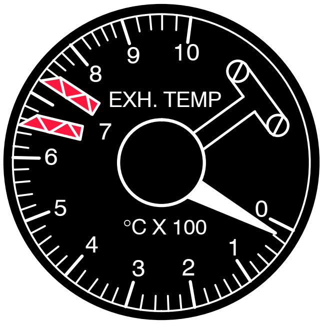
Figure 5-1 (Sheet 3 of 4)



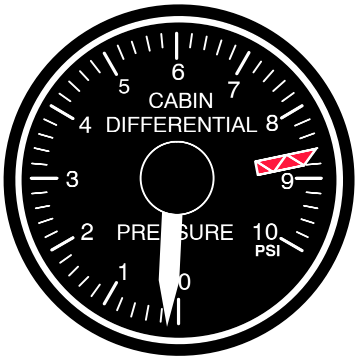
DUCT PRESSURE GAGE

🟨 CAUTION – 60 TO 85 PSI



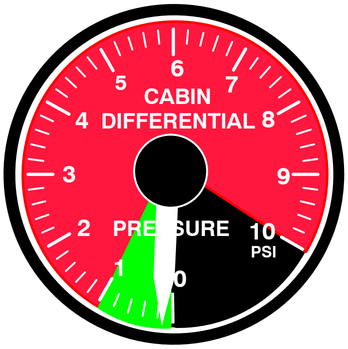
APU EXHAUST TEMPERATURE GAGE

🟥 MOMENTARY MAXIMUM – 720°C
CONTINUOUS MAXIMUM – 650°C



(ENGINEER'S PANEL)
CABIN DIFFERENTIAL PRESSURE GAGE

🟥 MAXIMUM 8.6 PSI



(BAILOUT CHUTE)

🟥 MORE THAN 1.0 PSI
DO NOT OPEN BAILOUT CHUTE

🟩 1.0 PSI OR LESS OPERATING
RANGE FOR BAILOUT CHUTE

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Figure 5-1 (Sheet 4 of 4)

Summary of Limitations

Refer to applicable discussions within this section for the values shown below.

WEIGHT POUNDS

Max Taxi	325,000	Max Normal Landing (600 ft/min Sink Rate)	250,000
Max Inflight (Flaps Up)	344,000	Max Landing (Mission Req) (360 ft/min Sink Rate)	325,000
With Reserve Tanks Empty	283,000	Max Landing (Emergency Req) (300 ft/min Sink Rate)	344,000
		Max Zero Fuel	205,000

SPEED KNOTS INDICATED AIRSPEED

Max Operating	See *figure 5-5*	Landing Gear		
		Normal Operating	270	–0.78M
		Emergency Operating	320	–0.78M
Flaps Extended Between		Extended	320	–0.78M
14 Degrees and 0	223①			
(UP)		Dump Chutes		
25 Degrees and 14	215①	Operating	240	–0.78M
40 Degrees and 25	200①	Extended	275	–0.78M
50 Degrees and 40	195①	Max Tire Speed	195 Knots Ground Speed	

① Do not exceed this speed if flaps are between the settings shown.

Figure 5-2 (Sheet 1 of 2)

SYSTEM LIMITS	
HYDRAULIC	PRESSURIZATION
Max System Pressure 3,500 psi	Cabin Differential Pressure Max 0.125 psi Takeoff & Landing Max 8.6 ± 0.15 psi Inflight Pressurization Relief Valve 9.42 ± 0.15 psi
STARTER	
One and one half minutes on, 5 minutes off for any number of starter cycles, including motoring.	
LANDING LIGHTS	ELECTRICAL
ALL LANDING LIGHTS OFF (except for momentary checks) unless airplane is moving.	Max Generator Load (at 115 Volts) Continuous: 218 Amperes Five minutes: 262 Amperes Five seconds: 348 Amperes
RETRACTABLE LANDING LIGHTS	115V ± 4V ac Normal operating range
Extension: 223 KIAS, maximum Retraction: No limit	400 ± 20 Hz Design range for equipment 400 ± 8 Hz* Normal operating range (isolated) with a maximum allowable oscillation of 4 Hz about a mean value within the 400 ± 8 Hz* band.
Do not operate retractable landing lights for daylight touch and go or daylight full stop landing.	Under a steady load, APU generator frequency is 400 ± 10 Hz* with a maximum allowable oscillation of ±2 Hz about a mean value within the 400 ± 10 Hz* band.
	Max T-R Load (at 28 Volts) continuous: 75 Amperes one minute: 200 Amperes
	* Indicates values read at the Flight Engineer's Station

Figure 5-2 (Sheet 2 of 2)

Engine Limitations

OPERATING CONDITION	TIME LIMIT	MAXIMUM EGT ②	OIL TEMPERATURE RANGE ⑥	OIL PRESSURE NORMAL ⑧
Takeoff (TRT)	5 minutes	555°C	40–132°C ⑦	40–60 psi
Military (MRT)	30 minutes ⑩	510°C	40–132°C	40–60 psi
Normal Rated (NRT)	Continuous	490°C ③	40–132°C	40–60 psi
Idle	Continuous	340°C ④	40–132°C	35 psi minimum
Starting	15 seconds	455°C ⑤		
Acceleration		555°C ①	40–132°C	40–65 psi ⑨

① During an engine acceleration, the EGT must not exceed, and should stabilize at or below, the noted limit for the higher thrust setting within 2 minutes of advancing the throttle.

② If the EGT exceeds 565°C at any time, shut down the engine, if thrust is not needed for safety of flight, or land as soon as practicable. When shutting down an engine for this purpose, allow a five minute cooling period at idle, unless it is obvious that continued operation may result in further damage to the engine.

③ The EGT limits for cruise conditions below normal rated thrust are the same as those for normal rated thrust.

④ A guide to indicate the EGT which, if exceeded, can signify an engine malfunction.

⑤ EGT limit is 455°C for up to 15 seconds. If this temperature and/or time limit is exceeded, it will be reported to maintenance and a discrepancy will be recorded. During start if EGT is rising rapidly or exceeds 405°C, shut down the engine. Note maximum EGT after shutdown. Also note time EGT remains at 455°C or higher so proper maintenance action can be performed.

⑥ Normal range shown. Refer to discussion of engine oil temperature, this section. Operation between 132°C and 165°C is permitted for up to 15 minutes in flight.

⑦ If engine operation is otherwise normal, no minimum oil temperature need be observed before starting takeoff.

⑧ Normal pressures shown. Refer to discussion of engine oil pressure, this section.

⑨ Following rapid advance of throttles to takeoff or go-around power, oil pressure gage may indicate as high as 65 psi provided oil pressure decreases to between 40 and 60 psi during climbout.

⑩ MRT may be used for 30 minutes from the time MRT is set.

Figure 5-3

Fuel Grade Properties and Limits

USE	FUEL TYPE	GRADE	NATO CODE	FLIP CODE	U.S. MILITARY SPECIFICATION	UNITED KINGDOM SPECIFICATION
PREFERRED FUEL	KEROSENE	JP-5	F-44 ⑥	J5	MIL-T-5624	DERD 2,498
		JP-8	F-34 ⑥	J8	MIL-T-83133	DERD 2,453
		COMMERCIAL JET A–1	⑥ F-35 ⑦	A1	NONE	DERD 2,494
		RUSSIAN TS–1				
		COMMERCIAL JET A–50	Unknown	A50	NONE	Unknown
		COMMERCIAL JET A	NONE	A	NONE	DERD 2,482
		RUSSIAN T–1				
	WIDE CUT GASOLINE TYPE FUEL	JP-4	⑥ F-40	J4	MIL-T-5624	DERD 2,486
		COMMERCIAL JET B	NONE	B	NONE	DERD 2,486
EMERGENCY FUEL	AVIATION GASOLINE (AVGAS)	80/87	F-12	80	MIL-G-5572	
	PLUS 3% GRADE 1,065 OR	100/130	F-18	100	MIL-G-5572	DERD 2,485
	1,100 OIL MIL-L-6082	115/145	F-22	115	MIL-G-5572	DERD 2,485

Figure 5-4 (Sheet 1 of 2)

Fuel Grade Properties and Limits (Continued)

WEIGHT – LB/GAL (MAX–MIN AT 60°F)	FREEZE POINT		LIMITS
	°F	°C	
7.06 – 6.51	–51	–46	① ② ⑧
7.00 – 6.47	–58	–50	① ② ⑧
6.92 – 6.47	–53	–47	① ② ⑦ ③ ⑧
6.92 – 6.47	–50	–45	① ② ⑦ ③ ⑧
6.92 – 6.47	–36	–38	① ② ⑦ ③ ⑧
6.69 – 6.27	–72	–58	① ②
6.69 – 6.27	–56	–49	① ② ③
5.89 ④	–76	–60	⑤ ⑨ ⑩ ⑪
5.86 ④	–76	–60	⑤ ⑨ ⑩ ⑪
5.87 ④	–76	–60	⑤ ⑨ ⑩ ⑪

① Monitor fuel temperature indicator and avoid flight at altitudes where tank fuel temperature approaches the freeze point. Do not allow fuel temperature to cool to 3°C (6°F) above the freeze point. Do not attempt air refueling at a temperature less then 3°C above freezing point shown.

② If outside (total) air temperature is less than 3°C above freezing point of fuel and airplane is fueled with JP-5, JP-8 (F34 or F35) or commercial equivalent, transfer reserve fuel as soon as possible after reaching 285,000 pounds gross weight to prevent freezing of fuel in reserve tank. Fuel transfer time is longer with alternate fuels than with JP-4.

③ Prior to using commercial fuel, obtain freeze point from vendor or airplane supplying the fuel, then follow limit ① above. The pilot should exercise caution if he/she suspects or observes improper fuel handling procedures. If there is any indication that cleanliness is not up to standard, a fuel sample should be taken in a glass container and observed for fogginess, presence of water or rust.

④ Average value; limits are not controlled by specification.

⑤ Follow climb restrictions in alternate fuels, this section.

⑥ Fuel identified by NATO codes F-34, F-40 and F-44 contain fuel system icing inhibitor. No deviation from fuel freezing limits is allowed if inhibitor is present.

⑦ Commercial Jet A/A-1 from many sources contains the same water dispersant/anti-icing additive as JP-8/F-34. Consult the fuel vendor to verify presence of additive.

⑧ Engine and APU starts can be difficult or impossible to perform with these fuels at fuel temperatures below –30°C.

⑨ Aviation gasoline and JP-4 fuel mixed in any proportion are suitable for continuous operation from the standpoint of engine performance. However, the use of aviation gasoline must be restricted to emergency situations to minimize lead deposit in the engines and to avoid damage to engine fuel pump due to the poor lubricating quality of gasoline.

⑩ When using fuel containing over 10% gasoline in any tank, rate of climb must be limited to 200 feet per minute above the boiling altitude listed in ALTERNATE FUELS, this section.

⑪ Range is reduced if boiling altitude is exceeded. Allow 0.5% loss of aviation gasoline for each 1,000 feet above boiling altitude.

⑫ JP–8 + 100 is acceptable for use as a preferred fuel. See ball note ⑬

⑬ If defueling is required, notify base fuels that aircraft has +100 additive and/or commercial fuel.

⑭ Russian TS–1 (Jet A–1) and T–1 (Jet A) are acceptable substitutes for JP–8 with the injection of FSII, CI/LI and SDA. TS–1 is preferred; all other notes per commercial jet fuel.

Figure 5-4 (Sheet 2 of 2)

Maximum Allowable Airspeeds

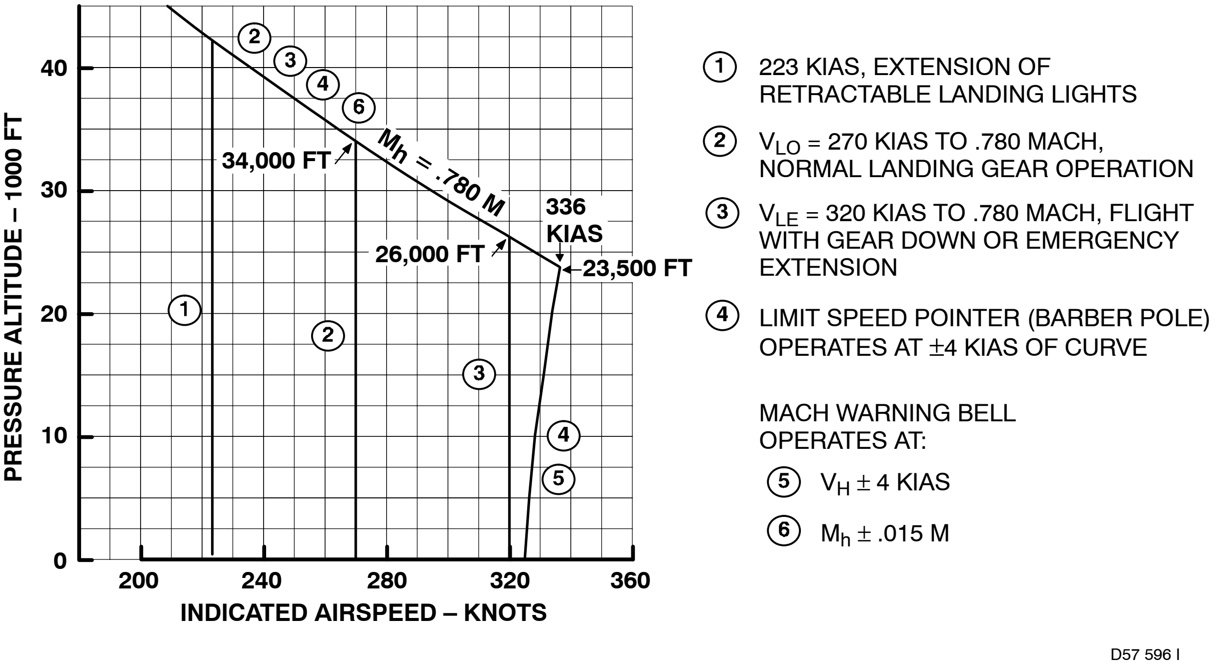


Figure 5-5

CENTER OF GRAVITY LIMITATIONS

Center of gravity (cg) limits at gross weights, up to the maximum allowable 344,000 pounds, are shown in *figure 5-6*. The charts in *figures 5-6*, 5-7 and *5-8* reflect the applicable envelope for all flight operations.

In all cases, airplane cg can be controlled by following correct payload loading procedures and by adherence to proper fuel loading and inflight fuel management.

WEIGHT LIMITATIONS

Maximum taxi weight is 325,000 pounds (structural limit) or less as limited by cg location.

Any weight in excess of applicable maximum inflight weight must be fuel consumed during taxi and takeoff.

Maximum inflight weight with flaps up depends upon the distribution of load and the pressure altitude. The maximum inflight weight is defined in *figure 5-6*. *Figure 5-8* shows maximum gross weight versus altitude.

If the gross weight in *figure 5-8* is exceeded, limit load factors to the specified limits until gross weight is reduced.

The normal maximum landing weight is 250,000 pounds at a maximum sink rate of 600 ft/min (which is structural limit). If the mission requires, the airplane may be landed at any gross weight up to the maximum ground operations weight at a sink rate decreasing to 360 ft/min at 325,000 pounds. If emergency conditions require, the airplane may be landed at any gross weight up to the maximum inflight weight at a sink rate decreasing to 300 ft/min at 344,000 pounds. Refer to *figure 5-7*. Touch and go landings at gross weights above 250,000 pounds are prohibited. Operational landing weight can be less as limited by performance limitations or as defined by landing field length required.

Maximum zero fuel weight is 205,000 pounds or less and can be limited by center of gravity location. If ballast fuel must be retained in center wing tank to maintain airplane c.g. within the c.g. envelope, the amount of ballast fuel is limited by 205,000 lb minus actual zero fuel weight (operating weight).

Factors such as airport elevation, runway length and/or slope, obstructions, wind and temperature can impose further limitations on these maximum weights.

The maximum inflight weight at which reserve tanks can be empty is 283,000 pounds when using Standard Ground or Aerial Fuel loads.

Refer to *figures 5-6*, 5-7 and *5-8* for a graphic presentation of weight limitations.

RUNWAY STRENGTH LIMITATIONS

Refer to part VIII, T.O. 1E-3A-1-1.

FUEL LOADING AND MANAGEMENT

The fuel usage procedures in subsection I-D are based on proper fuel loading

FUEL LOADING

Fuel loading will be shown in subsection I-D, whether or not standard fuel loading tables are used. Improper loading can cause center of gravity to be outside limits with resulting stability, control and structural fatigue problems.

Fuel tanks will not be filled beyond the maximum quantities shown in *figure 1-31*, as corrected for actual fuel temperature and density.

Outboard reserve tanks will be filled when inflight gross weight will exceed 285,000 pounds when using Standard Ground or Aerial Fuel Loads.

FUEL USAGE LIMITATIONS

The procedures in subsection I-D or T.O. 1-1B-50 or T.O. 1E-3A-5–2 will be followed; except that deviation may be made for mission or training requirements if center of gravity, gross weight and LCS requirements are considered. Calculate cg effects before attempting non-standard fuel use. The computer program can also be used to calculate non-standard fuel use.

The transfer of fuel from the reserve tanks must not be initiated at gross weights above 285,000 pounds when using Standard Ground or Aerial Fuel Loads.

WARNING

Center wing fuel tank pumps must be off unless personnel are available in the flight deck to monitor LOW pressure lights. Each center wing tank fuel pump switch must be positioned to off without delay when the respective center wing tank fuel pump LOW pressure light illuminates.

FUEL SYSTEM LIMITATIONS

FUEL PUMP LIMITATIONS

The center tank override fuel pumps are not qualified for flight using JP-4 or Jet-B fuel at temperatures exceeding 85°F, or at altitudes exceeding 35,000 feet.

Main tank fuel boost pumps are not qualified for flight using JP-4 or Jet-B fuel at fuel temperatures exceeding 85°F, or at altitudes exceeding 35,000 feet.

NOTE

When ground refueling following an operation where any amount of JP-4, Jet-B or AVGAS has been mixed with fuel in the main or reserve tanks, all transferrable fuel will be transferred to the center tank before wing tanks are filled with a fuel for which the fuel pumps are not temperature/altitude limited. The Ground Handling–Service and Airframe Manual T.O. 1E–3A–2–7 contains a procedure for tank–to–tank transfer.

HEAT EXCHANGER

Due to fuel boost pump cooling limitations, the maximum fuel tank temperature is 49°C (120°F). Maximum allowable fuel temperature for LCS heat exchanger operation is shown in *figure 5-9*. The OHEAT caution lights on the flight engineer's fuel control panel illuminate when fuel temperature exceeds this limit. When less than 5,000 pounds of fuel is contained in a main fuel tank with LCS heat exchanger circuit operating, monitor tank temperature and coordinate with mission crew to monitor LCS coolant temperature. Any tank with both fuel boost pumps inoperative shall not feed more than two engines at engine powers above cruise thrust.

FUEL DUMPING LIMITATIONS

Extend and retract dump chutes with flaps up. Dump fuel with speed brakes retracted and with flaps up. Observe the appropriate limitations under AIRSPEED AND MACH LIMITS, this section.

If emergency conditions require, fuel may be dumped with flaps at 25 degrees or less but flow rate from wing tanks is reduced and flow rate from center wing tank is negligible, due to blocking of the vent air inlet by the leading edge flaps.

If emergency conditions require, retractable dump chutes may be extended or retracted with wing flaps down; however, chute actuators can be damaged and shall be replaced prior to next flight.

All except approximately 4,100 pounds of fuel in each outboard wing tank (No. 1 and 4), 3,700 pounds of fuel in each inboard wing tank (No. 2 and 3) and 1,600 pounds of fuel in the center wing tank can be jettisoned. For fuel grades other than JP-4, refer to *figure 1-31*.

Do not use full and rapid aileron control while dumping fuel.

Do not retract fuel dump chutes until all fuel dump valves have been closed for 2 minutes or it can be determined by observation that fuel is no longer flowing from the chute.

Gross Weight/Center of Gravity Envelope

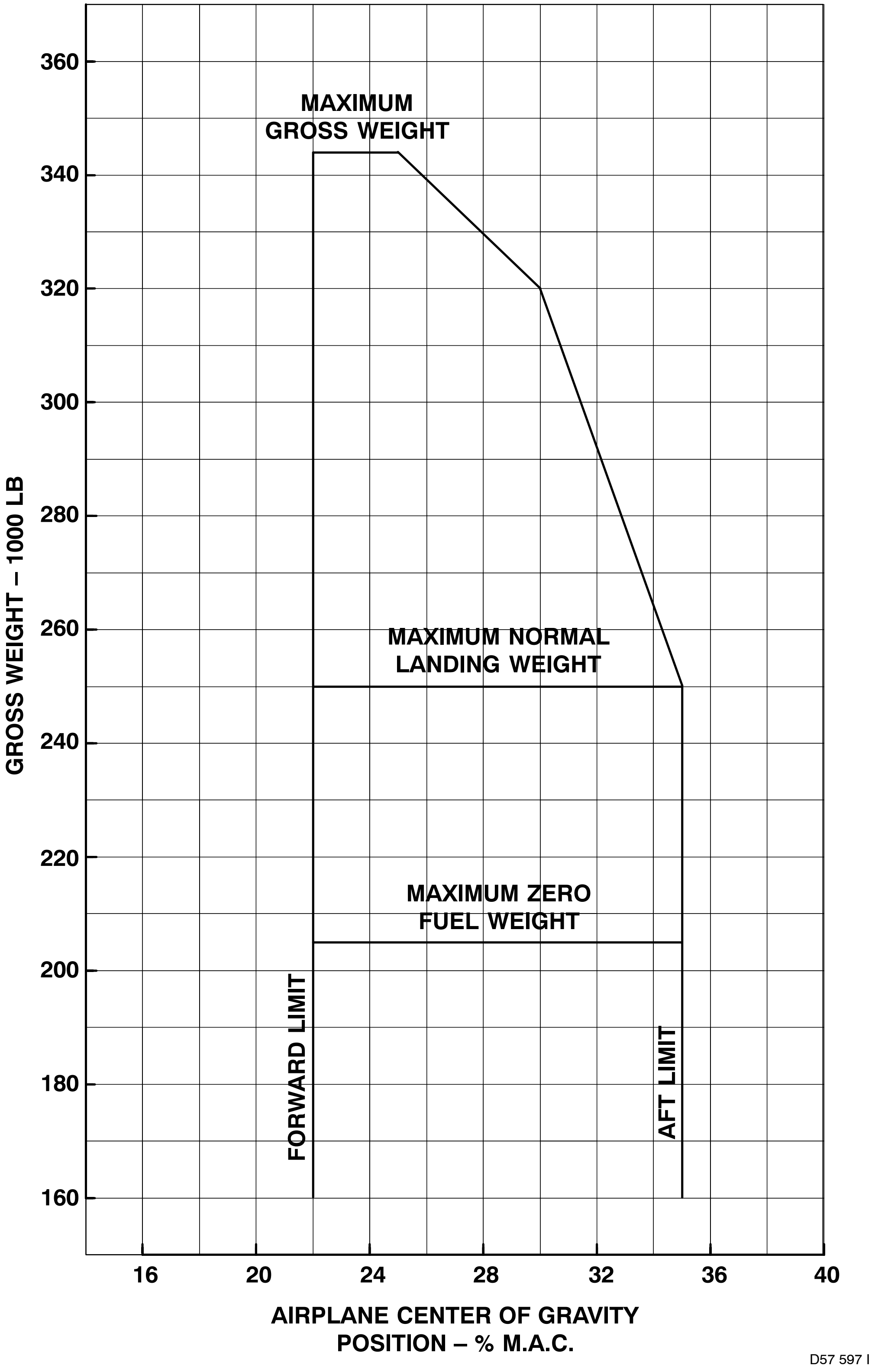
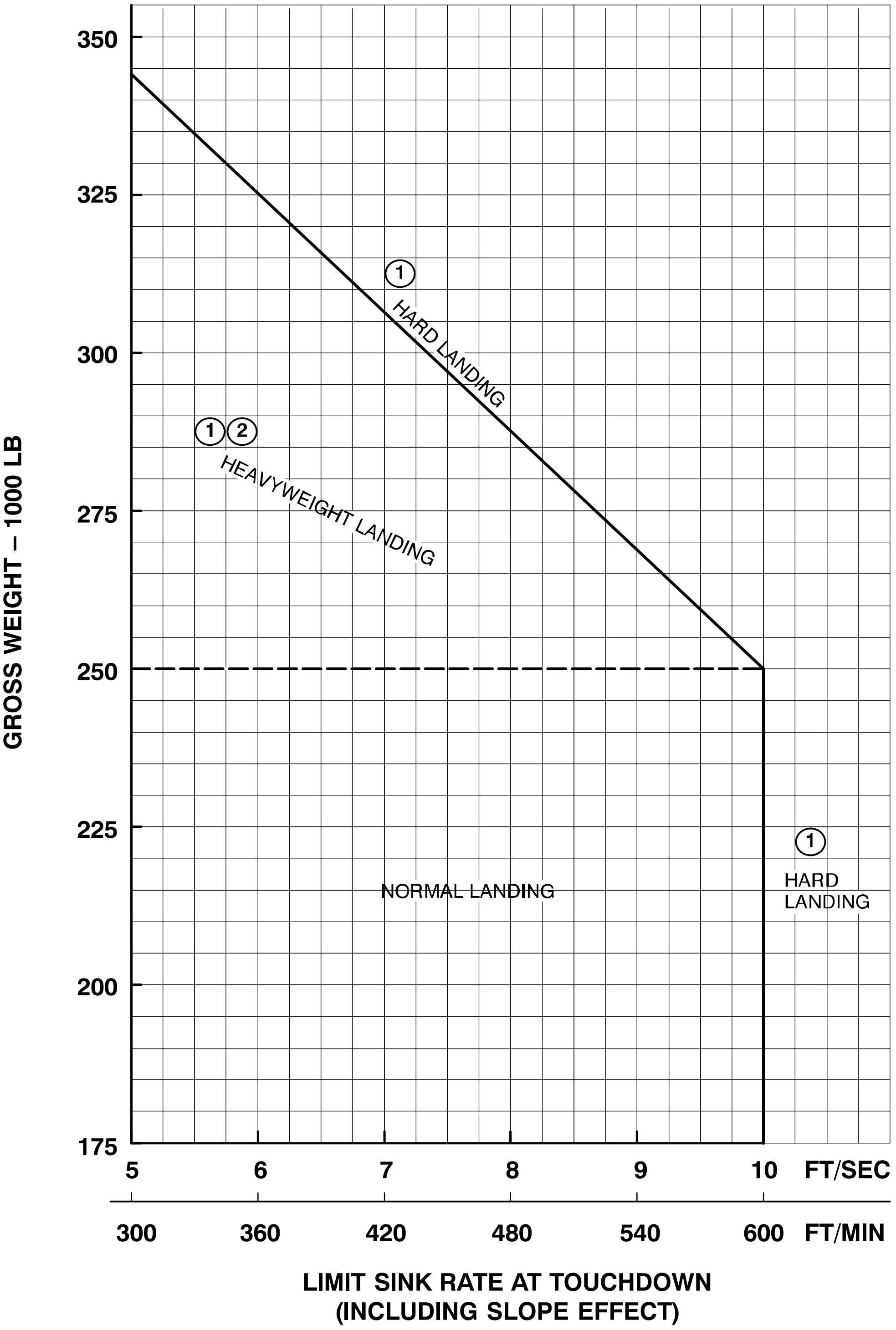


Figure 5-6

Landing Sink Rate Limits



① MAINTENANCE INSPECTION (T.O. 1E-3A-6)
REQUIRED BEFORE NEXT TAKEOFF

② IF MISSION REQUIRES

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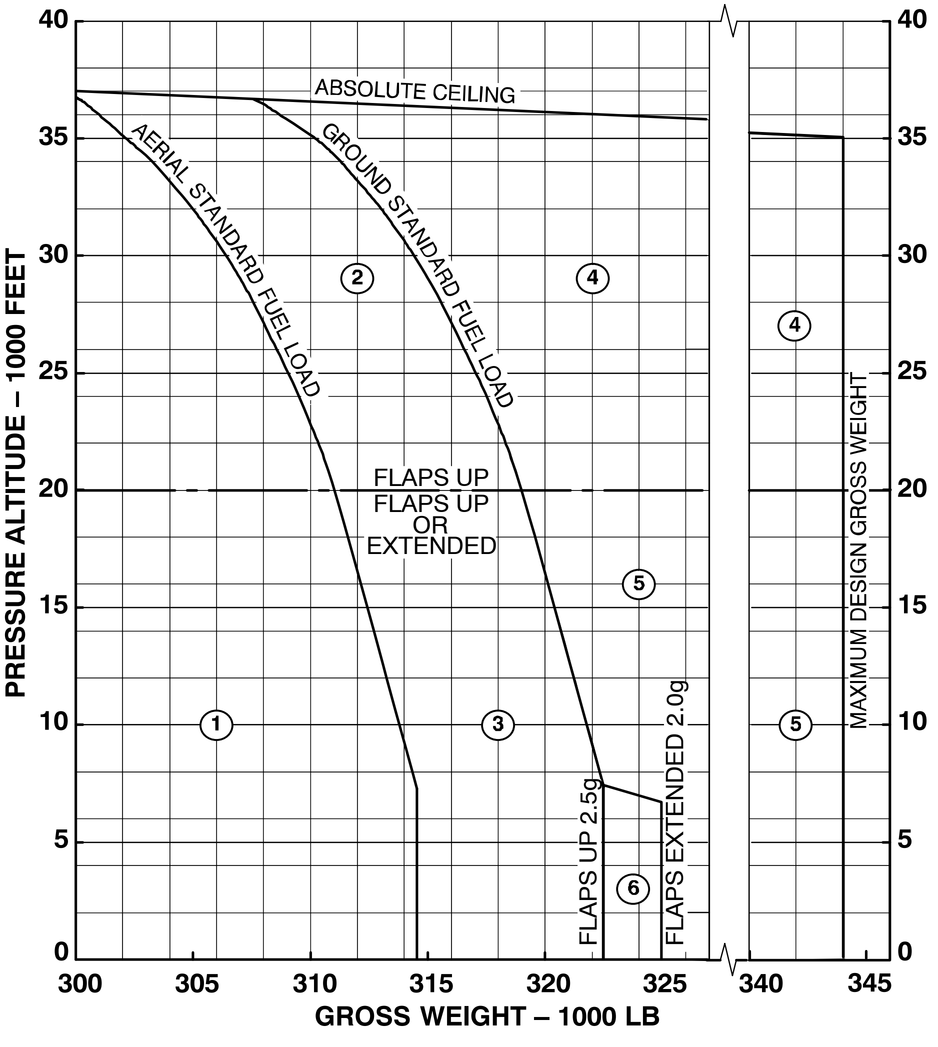
Figure 5-7

Gross Weight Limit Versus Altitude and Maneuvering Load Limits

NOTE: Maneuvering load limit +2.5g/–1.0g applies, except as reduced by limiting conditions stated below. If two conditions are listed in a region of chart, the more restrictive condition, if prevalent, applies.

REGION OF CHART	DESCRIPTION OF REGION	LIMITING CONDITION	REDUCED LOAD LIMITS
①	Below 20,000 ft, left of Aerial SFL Curve	Flaps Extended	+2.0g/–0.0g
②	Above 20,000 ft, between SFL Curves	Aerial SFL	+2.0g/–1.0g
③	Below 20,000 ft, between SFL Curves	Aerial SFL Flaps Extended	+2.0g/–1.0g +2.0g/–0.0g
④	Above 20,000 ft, right of Ground SFL Curve	Ground or Aerial SFL	+2.0g/– 0.8g
⑤	Below 20,000 ft, right of Ground SFL Curve	Ground or Aerial SFL Flaps Extended	+2.0g/– 0.8g +1.8g/–0.0g
⑥	Region between SFL curves where flap extension increases gross weight capability	Ground or Aerial SFL Flaps Extended	+2.0g/–1.0g +2.0g/–0.0g



WARNING

Maneuvering load limits given in this chart for various conditions of gross weight, altitude, flap setting and type of Standard Fuel Load (SFL) shall not intentionally be exceeded.

NOTE

20,000 feet maximum altitude with flaps extended.

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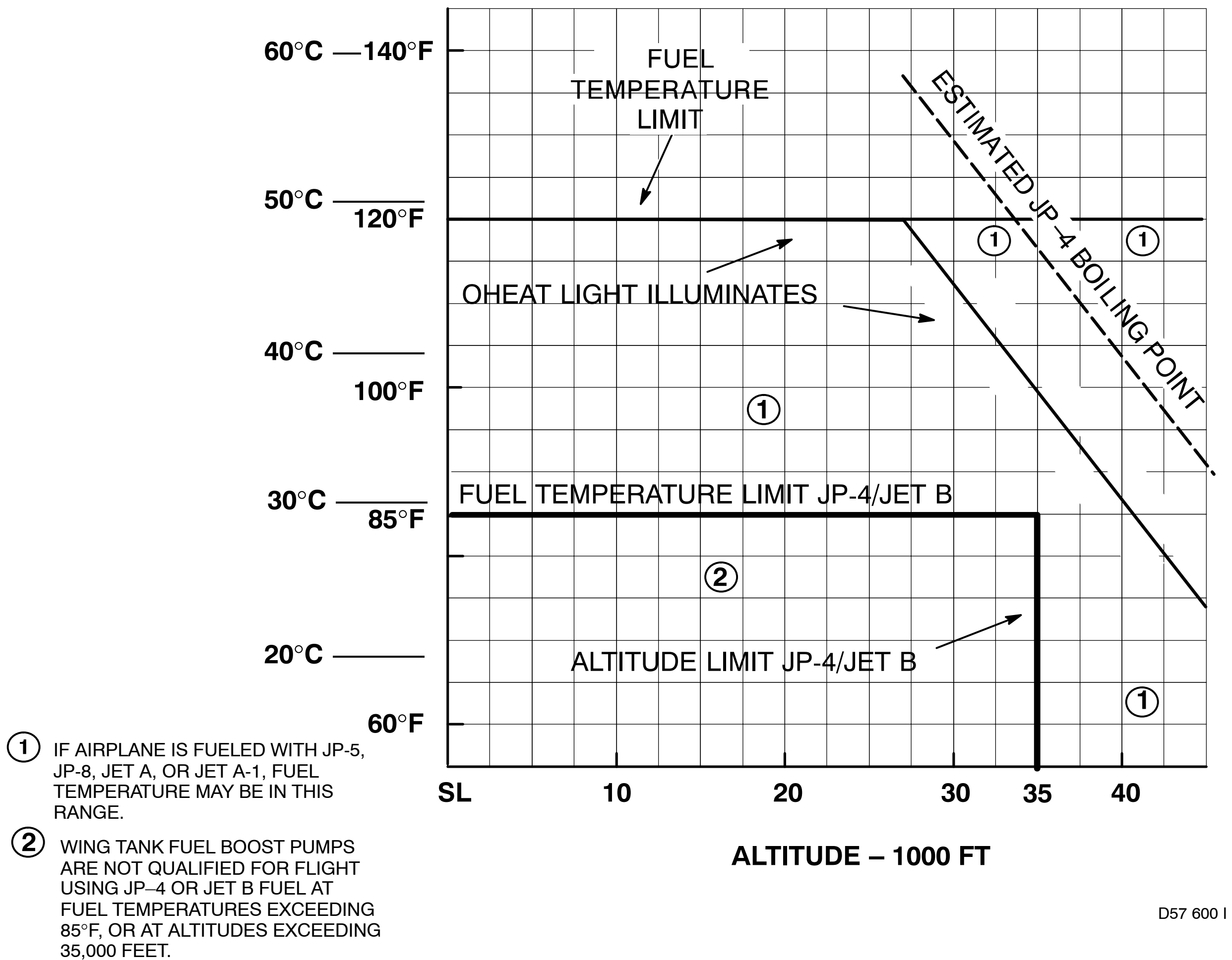
Figure 5-8

Fuel Temperature Limits



① IF AIRPLANE IS FUELED WITH JP-5, JP-8, JET A, OR JET A-1, FUEL TEMPERATURE MAY BE IN THIS RANGE.

② WING TANK FUEL BOOST PUMPS ARE NOT QUALIFIED FOR FLIGHT USING JP–4 OR JET B FUEL AT FUEL TEMPERATURES EXCEEDING 85°F, OR AT ALTITUDES EXCEEDING 35,000 FEET.

Figure 5-9

LANDING GEAR AND BRAKE LIMITATIONS

WHEEL BRAKE SYSTEM LIMITATIONS

The maximum pressure of the hydraulic brake system is limited to 3,500 psi.

Do not depress brake pedals while applying pneumatic brakes.

Brake energy limits are shown in *figure 5-10*. Refer to BRAKE ENERGY CAPACITY, Section I.

SEVEN- OR SIX-BRAKE OPERATION

When specifically authorized (see PERMISSIBLE OPERATIONS in the introduction), takeoff or landing with one or two inoperative brakes is permitted if:

a. The performance data in T.O. 1E-3A-1-1 is used.

b. The following RCR limits are observed:

   (1) for takeoff or landing with 7 brakes, RCR 10 or greater.

   (2) for takeoff or landing with 6 brakes (two inoperative on one main gear), RCR more than 15.

(3) for takeoff or landing with 6 brakes (one inoperative on each main gear), RCR more than 5.

c. The inoperative brake has been deactivated (per T.O. 1E-3A-2-32-1).

NOTE

> If T.O. 1E-3A-2-32-1 is not available, deactivate the inoperative brake (not more than 2 brakes) by cracking the bleed valve, applying minimum pedal pressure, allowing deboost valve handle to move into the valve until deboost valve bottoms out (handle up against inboard stop), then closing bleed valve.

ANTISKID SYSTEM LIMITATIONS

When specifically authorized (refer to PERMISSIBLE OPERATIONS in the introduction), takeoff or landing with antiskid inoperative is permitted if performance data in T.O. 1E-3A-1-1 is used.

TIRE LIMITATION

Takeoff Minimum Ground Time

Minimum ground times are shown in *figure 5-10*.

Maximum Ground Speed

The maximum tire ground speed as limited by the tire placard speed is 195 knots (225 mph). The allowable takeoff weight of the airplane can be limited because the liftoff speed must not be greater than the tire placard speed. This is determined from part II of T.O. 1E-3A-1-1.

TAXI/TOW LIMITS WITH FLAT TIRES

Refer to *figure 5-11* for taxi and tow limits with flat tire.

Brake Limitations

EXAMPLE:

GIVEN:

Full stop landing flaps 50
Gross weight = 220,000 lb
Brakes applied speed = 120 KIAS
Pressure altitude = 2,000 ft
Temperature = 20°C
10 kt headwind
Runway slope = 1% uphill

FIND:

Are brakes safe for another takeoff?

SOLUTION:

Following example line, the K.E. per brake = 14.3 million foot pounds. This is 3.3 million in excess of 10 million. Required ground cooling time is 23.1 minutes before another subsequent takeoff, or 9.9 minutes airborne cooling.

NOTE

- To obtain brake application speed, subtract full value of headwind component, add full value of tailwind component. Do not use INS groundspeed.
- This chart valid for refused takeoffs or minimum distance landings with full spoilers. Add one million foot pounds per brake with spoilers retracted.
- This chart valid at any flap setting for eight brakes operating. For 7 brakes operating increase energy by 14%; for 6 brakes operating increase energy by 33%. If a tire fails during stop, consider that brake to be inoperative for entire stop when determining cooling requirements.
- Brake ground cooling time begins when airplane reaches a complete stop. Cooling times are valid only when brakes are released.

Brake Limitations

EXAMPLE 1:
GIVEN:
Full stop landing, flaps 50
Gross weight = 220,000 lb
Brakes applied speed = 120 KIAS
Pressure altitude = 2000 ft
Temperature = 20°C
Wind = 10 kt headwind
Runway slope = 1% uphill

FIND:
Are brakes safe for another takeoff?

SOLUTION:

Following example line, the K.E. per brake = 14.3 million foot pounds. This is 3.3 million in excess of 10 million. Required ground cooling time is 23.1 minutes before another subsequent takeoff, or 9.9 minutes airborne cooling.

NOTE

- To obtain brake application speed, subtract full value of headwind component, add full value of tailwind component. Do not use INS groundspeed.
- This chart is valid for refused takeoffs or minimum distance landing with full spoilers, add 1 million foot pounds per brake with spoilers retracted.
- This chart is valid at any flap setting for eight brakes operating, for 7 brakes operating increase energy by 14%, for 6 brakes operating increase energy by 33%. If a tire fails during stop consider that brake to be inoperative for entire stop when determining cooling requirements.
- Brake ground cooling time begins when airplane reaches a complete stop. Cooling time are valid only when brakes are released.
- Any normal full stop landing is above 10 million foot pounds.
- Brake applications during taxi can add large amounts of heat to the brakes.

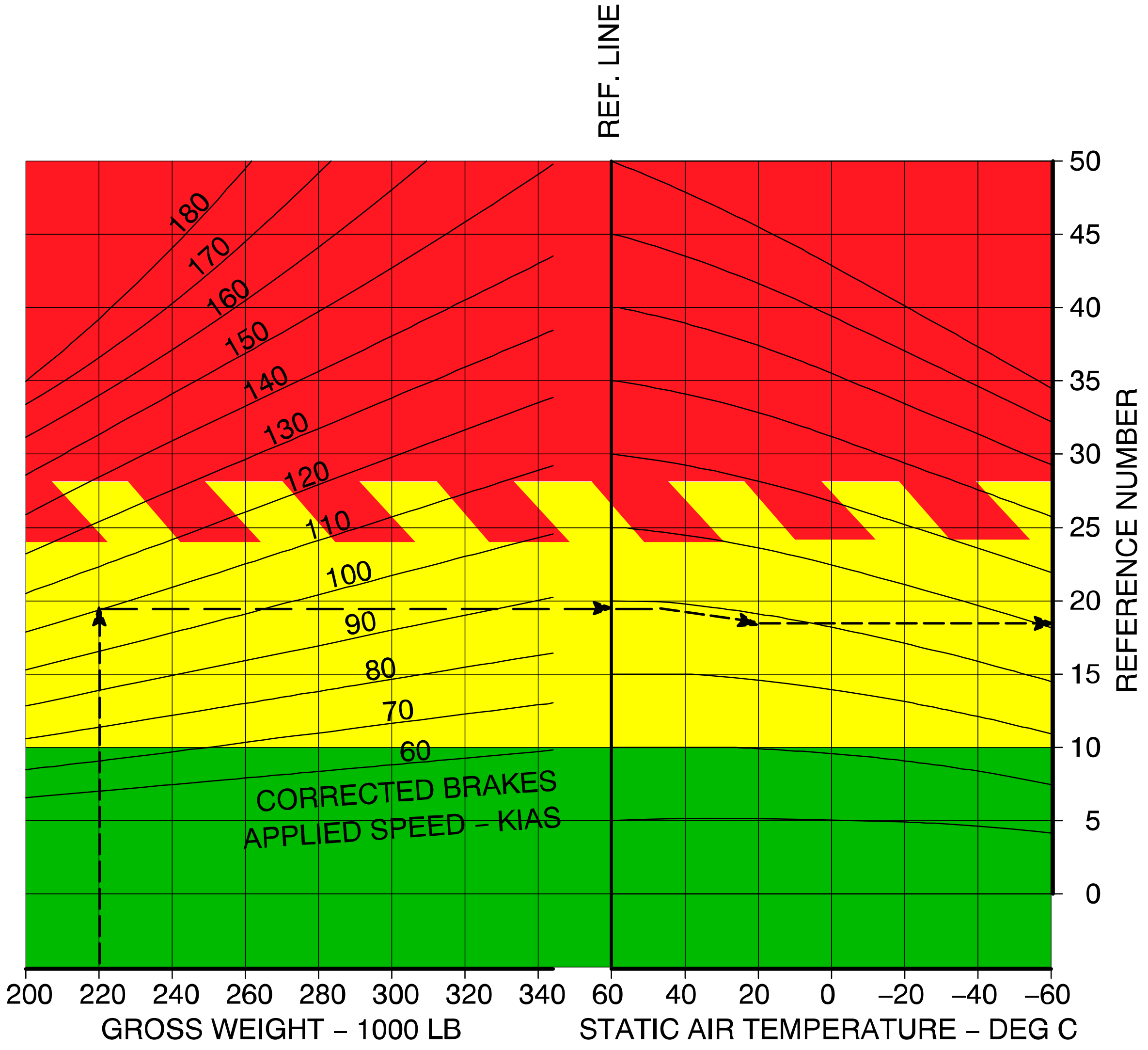


Figure 5-10 (Sheet 1 of 3)

EXAMPLE 2:

GIVEN:

Aborted takeoff, Flaps 14

Gross weight = 310,000

Brakes applied speed = 135

Pressure altitude = 1000 feet

Temperature = 10°C

Wind = 5 kt headwind

No slope

Spoilers failed to deploy

FIND:

Brake Energy

SOLUTION:

Enter from the bottom of the chart, up to 130 kts, then right to the SAT slider to 10°C (32 MFP). Enter sheet 2, correct for PA (34 MFP). Add 1 million foot pounds for failed spoilers (35 MFP)

WARNING

If a takeoff is attempted without brake cooling after a stop in the 10 million to 24 million foot pound range, and the takeoff is aborted (or landing is made without required airborne cooling time), add the brake energy of the first stop to the brake energy of the second stop to determine brake cooling requirements.

CAUTION

- Do not open wheel well doors after a stop with brake energy above 24 million foot pounds.
- With brake energy in caution range, minimize subsequent taxi until required cooling period has elapsed.

NOTE

Use uphill or downhill slope

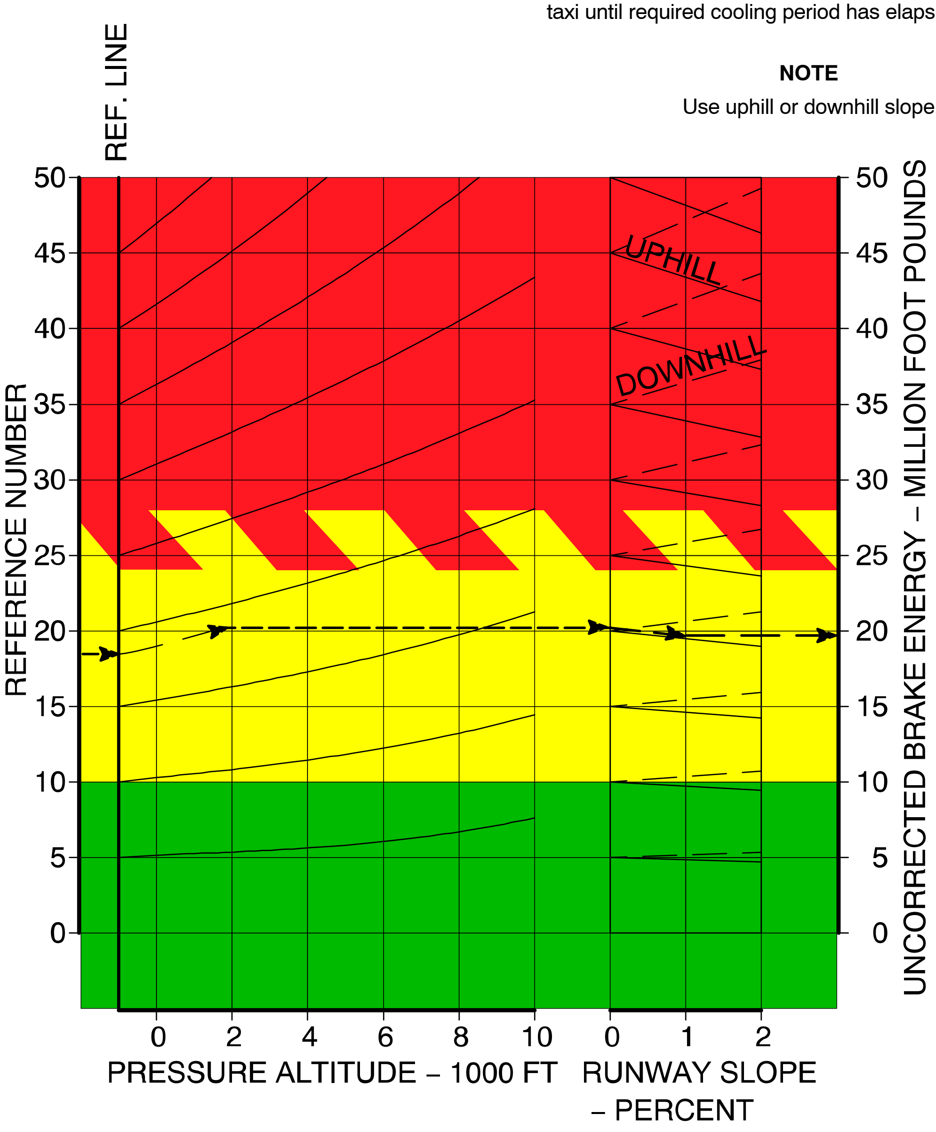


Figure 5-10 (Sheet 2 of 3)

NOTE

- Use landing correction for all landings.
- Use landing flap setting correction if actual landing flap setting is less than 50.
- For “split” or asymmetric flaps, use average of two settings
- If speed brakes are retracted add 1 million foot pounds to charted brake energy

RED (DANGER) ABOVE 28 MILLION FT–LB

1. Clear runway immediately after stop since tires will deflate.
2. Do not set parking brake.
3. Alert fire extinguishing equipment for hydraulic fluid, grease or tire fire. Dry chemical extinguisher preferred, fog or foam acceptable.

WARNING

If one or more tires remain inflated, approach cautiously from front or rear only and do not spray extinguisher or coolant directly on inflated tire or wheel.

4. Evacuate the airplane using Ground Evacuation checklist.
5. After tires deflate, fog or foam may be used for brake cooling, otherwise 2 to 3 hours are required for brakes to be cool enough for safe removal.
6. Mandatory tire, wheel and brake removal.

NOTE

Maximum demonstrated brake capacity is approximately 40.3 million ft–lb per brake.

7. Do not open wheel well doors.

RED/YELLOW (CAUTION) 24 TO 28 MILLION FT–LB

1. Park airplane but do not set parking brakes.
2. Do not approach for 1/2 hour.
3. Delay subsequent takeoff for 1–1/2 hours, or until hand can be held on brake housing.
4. Before second takeoff, make complete visual check with pressure on. Check for brake seal leakage and tire damage (melting or charring at bead seat). Actuate brakes fully 5 or 6 times and during final application check for leaks. Check brake wear indicator.
5. Do not open wheel well doors.

YELLOW (CAUTION) 10 TO 24 MILLION FT–LB

1. Delay subsequent takeoff 7 minutes for each one million ft–lb in excess of 10 million (ground cooling), or,
2. If immediate takeoff is made; after cleanup height is reached and the flaps are retracted, extend gear and leave down for 3 minutes for each 1 million ft–lb in excess of 10 million (air cooling). Loss in rate of climb of approximately 300 fpm can be expected due to landing gear extension at high gross weights with flaps extended. With flaps retracted a loss in climb rate in excess of 800 FPM can result from gear extension.

GREEN (NORMAL) BELOW 10 MILLION FT–LB

No special procedures required.

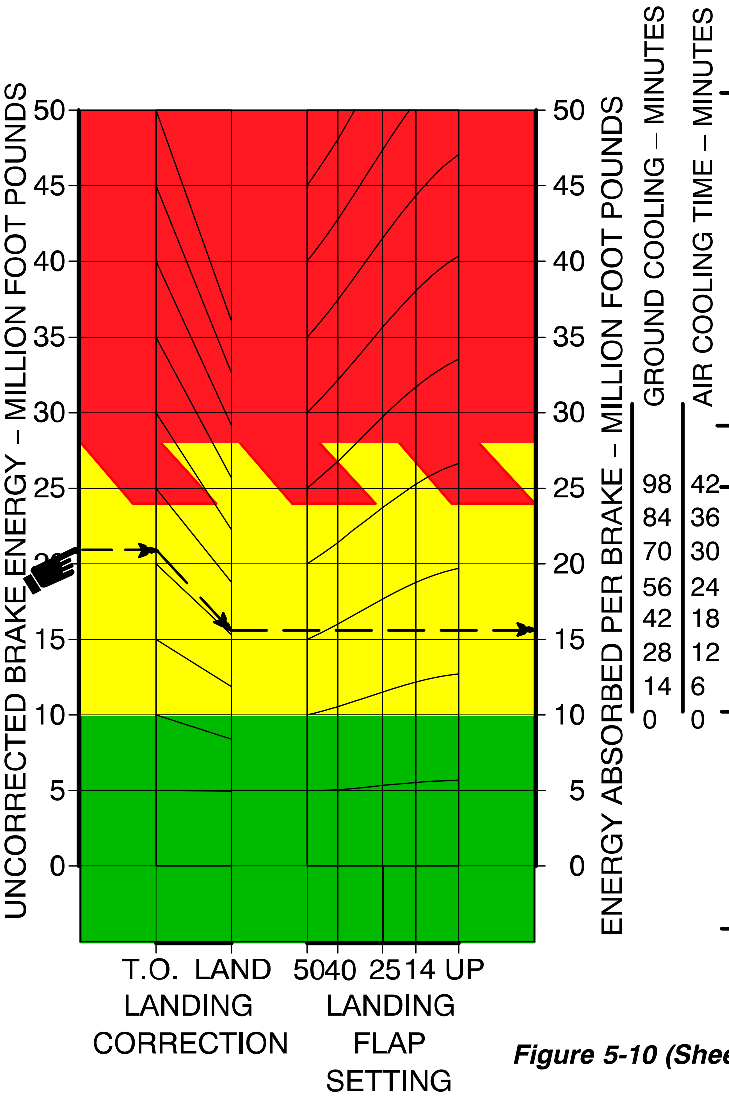
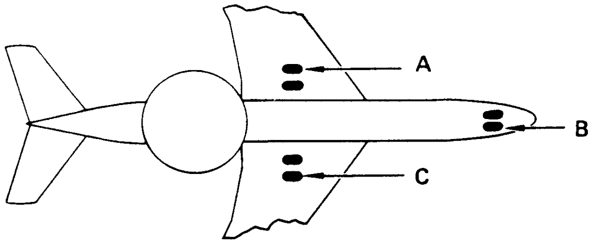


Figure 5-10 (Sheet 3 of 3)

Taxi/Tow Limits With Flat Tires



NOTE

- Black tire indicates flat tire position. However, the flat tire(s) may be in any other position(s) as long as it is comparable to the one shown.
- Use ground observer when taxiing or towing with flat tires.

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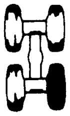
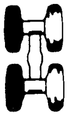
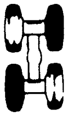
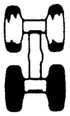
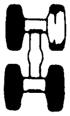
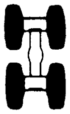
CONDITION		FLAT TIRE POSITION			TAXIING AND TOWING LIMITATION
		A	B	C	
1	Nose gear one flat tire				None; however, if two flat tires occur, tow to clear runway, then install at least one good tire, using axle jack.
2	One flat tire any position, either or both gears				None
3	Two flat tires in tandem, either or both gears				None
4	Two flat tires diagonal, either or both gears				None
5	Two flat tires on front or rear axle, either or both gears				(A) Minimum to clear runway, if necessary. (B) After clearing runway, switch tire to condition 4. (C) Inspect snubber/centering cylinder for damage. If snubber is damaged, inspect truck beam.
6	Three flat tires, either or both gears				(A) Minimum to clear runway if necessary and if airplane weight is low enough to permit movement on one or two tires. (B) Install serviceable tire at diagonal position to satisfy condition 4. (C) Inspect snubber/centering cylinder for damage. If snubber is damaged, inspect truck beam.
7	Four flat tires, either or both gears				(A) Establish condition 4 prior to towing. (B) Inspect snubber/centering cylinder for damage. If snubber is damaged, inspect truck beam.

CAUTION

Avoid sharp turns when taxiing or towing with flat tires.

NOTE

This chart is intended as a guide for abnormal taxiing or towing of airplanes with flat tires. No attempt is made to list all possible combinations of flat tires or additional factors which might be considered for specific towing operations.

Figure 5-11

ELECTRICAL SYSTEMS LIMITATIONS

AC SYSTEM LIMITATIONS

As indicated by airplane instruments:

a. Generator frequency:

   400 ± 20 Hz design range for equipment 400 ± 8 Hz. Normal operating range (isolated) with a maximum allowable oscillation of 4 Hz about a mean value within the 400 ± 8 Hz band.

b. Generator voltage: 115 ± 4 volts.

c. Generator load: continuous operation 218 amperes; five minute operation 262 amperes; five seconds 348 amperes per generator.

d. APU generator load: continuous operation 170 amperes; five minute operation 262 amperes; five seconds 348 amperes.

APU generator frequency: 400 ± 10 Hz. Under steady load, frequency may vary a maximum of ±2 Hz about a mean value within the 400 ± 10 Hz band.

e. External power: Maximum current 290 amperes for 7 seconds, 240 amperes continuous. Frequency: 400 ± 20 Hz. Voltage: 115 ± 4 volts.

NOTE

BPCU may kick off above 240 amps in less than 7 seconds.

f. During starting and shutdown, the first generator connected and the last one disconnected must carry the entire connected load. This load must, therefore, not exceed approximately 218 amperes or 170 amperes if switching to APU.

DC SYSTEM LIMITATIONS

The dc load on any one transformer rectifier (T/R) unit must not exceed 75 amperes continuous and 200 amperes for one minute. Any or all powered T/R units must indicate a positive output when under load.

AUXILIARY POWER UNIT LIMITATIONS

EGT limits are: No Load, 400°C (752°F), Maximum Continuous, 650°C (1202°F). APU shall be shut down if temperature exceeds 650°C (1202°F), except that temperature may be between 650°C (1202°F) and 720°C (1328°F) for up to 10 seconds during start or load application. APU shall be shut down if EGT exceeds 720°C (1328°F).

APU shall not be used to supply both electrical power and air conditioning while starting engines with APU bleed air.

If EGT rise is not indicated within two seconds of APU accumulator pressure stabilizing after pressure drop for APU starter, shut down APU.

APU accumulator pressure must be at least 2,500 psi if temperature is above –18°C (0°F), 3,000 psi if temperature is between –18°C and –40°C (0°F and –40°F) and 3,500 psi below –40°C (–40°F) to start APU.

HYDRAULIC SYSTEM LIMITATIONS

HYDRAULIC SYSTEMS

Maximum hydraulic power system pressure is 3,500 psi.

Except when an emergency dictates, a utility system hydraulic fluid shutoff switch should not be set to OFF nor should the corresponding engine fire switch be pulled. If a utility pump is operated under either of the above conditions for more than 5 minutes, the operating time must be reported on AFTO Form 781. Fluid shutoff periods are not cumulative; however, the time between any two such periods shall not be less than 10 minutes (minimum time required for pump to cool after fluid shutoff).

ROTODOME DRIVE

Rotodome must be rotating at all times when engines are running.

Auxiliary rotodome drive shall not be operated at 6 RPM (XMIT) for takeoff, landing or go-around.

FLIGHT CONTROL LIMITATIONS

SPEED BRAKE LIMITATIONS

Speed brakes shall not be deployed while dumping fuel.

Speed brakes shall not be deployed while flaps are extended, except on the ground or when split spoiler operation is required for pitch trim.

TAKEOFF WITH PARTIAL SPOILERS

This is an unusual operation and will not be performed unless specifically authorized (see PERMISSIBLE OPERATIONS in the INTRODUCTION). The following limitations apply: Plan takeoff using data in T.O. 1E-3A-1-1. Only one set of spoilers may be inoperative. Both hydraulic systems shall be operational.

RUDDER BOOST LIMITATIONS

For normal operations, the rudder boost system must be operating for takeoff and landing.

Rudder override switch must be set to NORMAL above 250 KIAS.

If rudder mode does not change to 2,290 psi at airspeeds above 185 KIAS or to 1,450 psi at airspeeds above 265 KIAS, either limit airspeed to below 250 KIAS or shut off rudder boost, disengage series yaw damper and engage parallel yaw damper until below 250 KIAS.

With two engines out on same wing, do not exceed 250 KIAS. Straight and level flight cannot be maintained when cruise power is set on remaining engines if rudder boost switches to 1,450 psi mode.

Turning off rudder boost disengages series yaw damper and autopilot. Autopilot may be reengaged after turning on parallel yaw damper.

With the rudder boost system inoperative, observe the minimum control speeds (V_{MCA}) for rudder boost inoperative.

When operating with rudder boost at 3,000 psi at airspeeds between 175 and 250 KIAS, full and rapid rudder movement is not permitted except in case of loss of engine thrust.

If applying rudder in case of engine failure, apply rudder smoothly, without checking back to neutral rudder or reversing rudder application, if possible.

YAW DAMPER LIMITATIONS

For normal operation, the airplane will not be dispatched with series yaw dampers inoperative. If both yaw dampers are inoperative, observe the limitations in *figure 5-12*. Parallel damper shall not be used during takeoff and landing (below 200 feet altitude) or during air refueling, except in a fuel emergency. (Refer to section VI.)

When both yaw dampers are inoperative, the airplane shall be operated only in the more restricted flight envelope as defined in *figure 5-12*. The minimum airspeed, 315 KIAS for gross weights in excess of 275,000 pounds, is greater than the normal air refueling speed. Altitude limitations for air refueling (at 275 KIAS) can give slightly negative dutch roll damping with pilot workload increased compared to other conditions shown.

STABILIZER TRIM LIMITATIONS

Maximum allowable coast with main electric trim is 3.4 turns of the horizontal stabilizer trim wheel.

WING FLAP LIMITATIONS

Emergency flap ground operation limit is one complete extension and retraction, then 30 minutes OFF before further operation.

Wait six seconds for bypass valves to operate between setting emergency flap switch to ON and operating electric drive motors.

Wait six seconds for clutches to disengage before reversing flap travel or returning to hydraulic operation. Flap drive motors can be damaged if clutches do not disengage.

To protect the aileron control system from wind damage on the ground, the flaps should be up whenever the airplane might be subjected to wind of 35 knots or more. In addition, for wind of 65 knots and above, position airplane into the wind.

Yaw Damper Inoperative Limitations

BOTH YAW DAMPERS INOPERATIVE LIMITATIONS

The airplane shall be operated only in the more restricted flight envelope as defined in the following tables for this condition.

RUDDER BOOST OPERATIVE

FLAPS	GROSS WEIGHT LESS THAN 225,000 POUNDS		GROSS WEIGHT BETWEEN 225,000 AND 275,000 POUNDS		GROSS WEIGHT GREATER THAN 275,000 POUNDS	
	MINIMUM AIRSPEED	MAXIMUM ALTITUDE	MINIMUM AIRSPEED	MAXIMUM ALTITUDE	MINIMUM AIRSPEED	MAXIMUM ALTITUDE
UP	235 KIAS ①	29,000 feet	285 KIAS ① (275 KIAS) ②	29,000 feet (29,000 feet) ②	315 KIAS ① (275 KIAS) ②	26,000 feet (25,000 feet) ②

	GROSS WEIGHT LESS THAN 250,000 POUNDS		GROSS WEIGHT BETWEEN 250,000 AND 275,000 POUNDS	
	MINIMUM AIRSPEED	MAXIMUM ALTITUDE	MINIMUM AIRSPEED	MAXIMUM ALTITUDE
14°	V_{REF} + 30 knots	20,000 feet	V_{REF} + 30 knots ③	20,000 feet
25°	V_{REF} + 20 knots	20,000 feet		
50°	V_{REF}	10,000 feet		

① Reduced 4 KIAS for each 1,000 feet below the maximum altitude down to 10,000 feet.

② Air refueling only.

③ Dutch roll can result from extending flaps at heavy gross weight with both yaw dampers inoperative. With both yaw dampers inoperative, do not extend flaps to 14 until gross weight is at or below 275,000 lb. Do not extend flaps beyond 14 until gross weight is at or below 250,000 lb.

Figure 5-12 (Sheet 1 of 2)

RUDDER BOOST INOPERATIVE

FLAPS	GROSS WEIGHT LESS THAN 225,000 POUNDS		GROSS WEIGHT BETWEEN 225,000 AND 275,000 POUNDS		GROSS WEIGHT GREATER THAN 275,000 POUNDS	
	MINIMUM AIRSPEED	MAXIMUM ALTITUDE	MINIMUM AIRSPEED	MAXIMUM ALTITUDE	MINIMUM AIRSPEED	MAXIMUM ALTITUDE
UP	245 KIAS ①	29,000 feet	295 KIAS ① (275 KIAS) ②	29,000 feet (29,000 feet)②	315 KIAS ① (275 KIAS) ②	22,000 feet (20,000 feet) ②

	GROSS WEIGHT LESS THAN 250,000 POUNDS		GROSS WEIGHT BETWEEN 250,000 ③ AND 275,000 POUNDS	
	MINIMUM AIRSPEED	MAXIMUM ALTITUDE	MINIMUM AIRSPEED	MAXIMUM ALTITUDE
14°	V_{REF} + 30 knots	15,000 feet	V_{REF} + 30 knots ③	10,000 feet
25°	V_{REF} + 30 knots ④	10,000 feet	③	
50°	V_{REF} ⑤	5,000 feet	③	

④ Airspeed may be reduced to V_{REF} + 20 KIAS for landing.

⑤ Do not extend flaps beyond 25 until landing assured. Airspeed may be reduced V_{REF} for landing.

Figure 5-12 (Sheet 2 of 2)

BLEED AIR, AIR CONDITIONING, ELECTRONICS COOLING AND PRESSURIZATION SYSTEMS LIMITATIONS

BLEED AIR SYSTEM

The airplane may be dispatched with one firewall valve inoperative, if the valve is closed.

ELECTRONICS COOLING SYSTEM LIMITATIONS

The following limitations apply to the electronics cooling system:

Forced Air System

a. The forward or aft forced air system will not be operated unless all rack doors on the system receiving cooling air are closed except as provided in T.O. 1E-3A-43-1-1. This is to assure adequate cooling air flow to all equipment installed in the racks being cooled.

b. Ground maintenance panels will be set to TAKEOFF before flight.

c. Maximum allowable forced air system duct temperature for ground startup of electronic equipment cooled by the system is 100°F.

Draw Through System

The system must be operating before applying power to any equipment that is cooled by the system. Refer to ELECTRONICS COOLING SYSTEMS.

Liquid Cooling System

a. Maximum allowable fuel tank temperature for heat exchanger operation is (49°C) 120°F, decreasing with altitude as shown in *figure 5-9*.

b. When less than 5,000 pounds of fuel is contained in a main fuel tank with LCS heat exchanger circuit operating, monitor tank temperature and coordinate with mission crew to monitor LCS coolant temperature.

PRESSURIZATION SYSTEM

Maximum pressure differential is approximately 8.6 psi. (See *figure 5-13*.) The pressure relief valve setting is approximately 9.4 psi differential positive pressure and 0.3 psi negative pressure.

When the maximum pressure differential cannot be controlled because of malfunctions during flight, the pressurization system may be allowed to operate on the relief valves without affecting the safety of the airplane.

Airplane may be pressurized to a maximum of 250 feet (0.1 psi) positive cabin pressure differential on the ground.

ICE AND RAIN PROTECTION SYSTEMS LIMITATIONS

Operation of the nacelle anti-ice systems in dry air at total air temperatures in excess of 10°C at engine power settings above 70% N_1 can cause damage to the engine.

WINDOW HEAT LIMITATIONS

To have design specification window strength and to prevent damage to the window, window heat must be on the main (No. 1) and sliding (No. 2) windows for all normal flight operations and must be turned on LOW for these windows 10 minutes prior to operation on HIGH. Operate window heat in LOW for 10 minutes (unless mission accomplishment procedures dictate otherwise) before setting to HIGH to avoid possible damage to windows. With window heat inoperative on HIGH to any of the number 1 or 2 cockpit windows, restrict airspeed to 250 KIAS below 10,000 feet for maximum bird strike protection.

Cabin Differential Pressure Limitations

CONDITIONS: PILOT ALTIMETER CORRECTED BY ADC (RESET MODE)

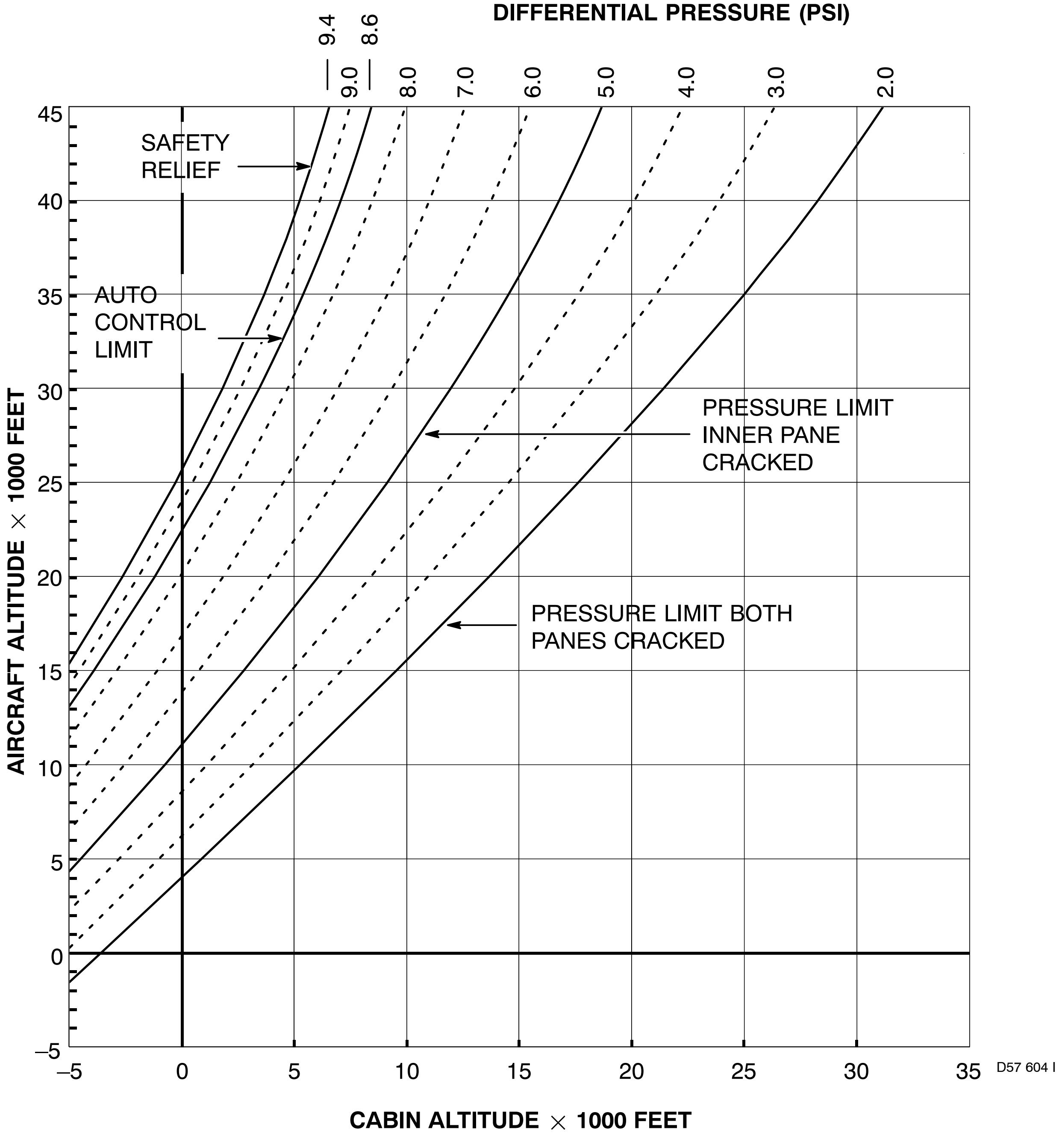


Figure 5-13

Allowable Altimeter Differences

ALTIMETER RESET- TO-RESET CROSSCHECK TABLE

PRESSURE ALTITUDE – FEET	ALLOWABLE DIFFERENCE BETWEEN INDICATORS – FEET
0	75 Zero Speed
5,000	80 Zero Speed
10,000	85 Zero Speed
0	90 Inflight
5,000	100 Inflight
10,000	110 Inflight
15,000	120 Inflight
20,000	140 Inflight
25,000	150 Inflight
30,000	160 Inflight
35,000	170 Inflight
40,000	190 Inflight

ALTIMETER RESET-TO-STBY (OR RESET-TO-NAVIGATOR ALTIMETER) CROSSCHECK TABLE

PRESSURE ALTITUDE – FEET	ALLOWABLE DIFFERENCE BETWEEN INDICATORS – FEET
0	80 Zero Speed
5,000	100 Zero Speed
10,000	125 Zero Speed
0	100 Inflight
5,000	120 Inflight
10,000	140 Inflight
15,000	170 Inflight
20,000	200 Inflight
25,000	230 Inflight
30,000	260 Inflight
35,000	290 Inflight
40,000	330 Inflight

ALTIMETER STBY-TO-STBY CROSSCHECK TABLE

PRESSURE ALTITUDE – FEET	ALLOWABLE DIFFERENCE BETWEEN INDICATORS – FEET
0	85 Zero Speed
5,000	125 Zero Speed
10,000	170 Zero Speed
0	110 Inflight
5,000	140 Inflight
10,000	180 Inflight
15,000	230 Inflight
20,000	280 Inflight
25,000	330 Inflight
30,000	380 Inflight
35,000	430 Inflight
40,000	480 Inflight

NOTE

- If the difference between the RESET and STBY mode indications of a single altimeter (or altimeters) exceeds the allowable difference in the crosscheck table after position correction is applied, determine the faulty mode and switch that altimeter to the other mode. If the fault cannot be isolated to a single mode (RESET or STBY) both modes of one altimeter can be malfunctioning. Enter any reading in excess of the crosscheck table allowable difference in the AFTO Form 781.
- (Inflight Only) For RESET-to-STBY crosschecks, apply ADC OFF position error correction as shown in T.O. 1E-3A-1-1 to all readings of navigator's altimeter (or pilots' altimeters when in STBY) before crosschecking with altimeter in RESET mode. Do not apply position error correction for STBY-to-STBY crosschecks.
- Interpolate between altitudes.

Figure 5-14

GINS LIMITATIONS

EGIs cannot be ground or inflight aligned at latitudes greater than 80 degrees due to inability to sense the small amount of earth rotation at these latitudes.

EGI Battery Life Limitations

EGI battery life limits are 30 minutes minimum, or up to 2 hours if batteries are fully charged.

EGI Altitude Limits

The EGI can operate to minus 2300 feet and to positive 75,000 feet pressure altitude; and for a maximum of two minutes at altitudes between 75,000 feet and 80,000 feet.

EGI Alignment Latitude Limit

EGIs cannot be ground or inflight aligned at latitudes greater than 80 degrees due to inability to sense the small amount of earth rotation at these latitudes.

EGI Temperature Limits

Each EGI can meet all performance requirements while operating at any temperature from –54°C to +71°C. The storage (non operating) temperature range is –57°C to +95°C.

WEATHER RADAR LIMITATIONS

The weather radar will be in OFF, TEST or STBY during fueling or within 100 feet of fueling operations, fuel spills or cargo or within 100 feet of ungrounded electro-explosive devices or when personnel are within 60 feet.

If weather radar is operating on the ground, all personnel not inside the airplane must be kept outside a 240° arc with a 60-foot radius centered on the nose radome. To prevent possible ignition of fuel vapors, maintain a 100-foot clearance from nose radome to any equipment being refueled or defueled and from ungrounded electro-explosive devices.

Weather radar will not be operated at cabin altitudes above 20,000 feet.

LIGHTING LIMITATIONS

When the airplane is stopped on the ground, limit operation of landing and runway turnoff lights to momentary checks to verify operation. Lights may be used as required when airplane is in motion on the ground.

Retractable landing lights may be retracted at any airspeed up to V_H/M_H and may be extended from the retracted position at airspeeds below 223 KIAS. However, the operating life of the lights increases if lights are retracted below 223 KIAS.

COMMUNICATIONS EQUIPMENT LIMITATIONS

Do not transmit on HF radio on the ground if ground personnel can touch the exterior of the airplane or are using headsets connected to the airplane. Transmission causes electrical voltages on exterior of airplane which are not dangerous but could shock personnel causing sudden movement, thus causing injury. To prevent possible ignition of fuel vapor, do not transmit on HF within 200 feet of equipment being refueled or defueled.

To prevent possible ignition of fuel vapor, do not transmit on UHF high power radio within 200 feet of equipment being refueled or defueled.

SURVEILLANCE RADAR LIMITATIONS

In flight, do not transmit on surveillance radar within 1,300 feet horizontally or 650 feet vertically from another aircraft.

Because of the high power of the surveillance radar and the resulting large safety distances, operation of the surveillance radar on the ground is prohibited except for radar maintenance operations performed by radar maintenance personnel in accordance with radar maintenance technical orders.

Do not operate the surveillance radar above 40,000 feet pressure altitude.

If the surveillance radar is operating on the ground, observe the following safety distance limits from the rotodome:

> 1,300 feet for personnel not inside airplane and for refueling and defueling operations
>
> 3,000 feet for unshielded electro-explosive devices

EMERGENCY EQUIPMENT LIMITATIONS

The firefighter's oxygen mask (smoke mask) shall not be used above 43,000 feet cabin (pressure) altitude.

CREW ACCOMMODATIONS LIMITATIONS

Crew bunks will not be used for cargo tiedown.

When crew baggage/cargo is loaded on the J compartment baggage plate using method one, the following limits apply:

a. Do not obstruct emergency equipment.

b. Do not stack load more than 40 inches above the baggage plate.

c. Maximum load is 2,598 pounds, not to exceed 90 pounds per square foot.

d. Approved cargo net must be used with all straps properly affixed.

e. Seats 43, 44, 45 and 46 will not be occupied. Refer to T.O. 1E-3A-5-2.

When crew baggage/cargo is loaded on the J compartment baggage plate using method two, the following limits apply:

a. Do not obstruct emergency equipment.

b. Do not stack load more than 40 inches above the baggage plate. Light weight items may protrude above 40 inches if secured below 40 inches.

c. Use straps per T.O. 1E-3A-5-2 to restrain each piece of cargo from moving fore/aft, inboard/outboard, and vertically.

d. Maximum load is 2,598 pounds, not to exceed 90 pounds per square foot.

Refer to T.O. 1E-3A-5-2 for complete baggage/cargo tiedown instructions.

When crew baggage/cargo is loaded on the J compartment baggage plate using method three, the following limits apply:

a. Do not obstruct emergency equipment.

b. Do not stack load more than 40 inches above the baggage plate. Light weight items may protrude above 40 inches if secured below 40 inches.

c. Personnel may not occupy additional mission crew seats 43, 44, 45 and 46 when baggage/cargo loaded on the baggage plate exceeds 30 inches above tiedown area.

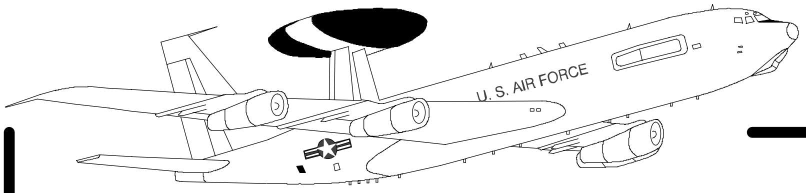
d. Maximum load is 2,598 pounds, not to exceed 90 pounds per square foot.

e. Alternate cargo net (Brueggemann) fittings and three CGU–1B tiedown devices must be properly affixed.

HAVE SIREN SYSTEM LIMITATIONS

Design operating altitude limit is 20,000 feet. Design non-operating altitude limit is 40,000 feet. Operating temperature range is –55°C to +55°C. Minimum desired operating time after turnon is 15 minutes.

Section VI



FLIGHT CHARACTERISTICS

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INTRODUCTION

The airplane is a high altitude, high performance transport modified for a basic mission of airborne early warning and control. The flight envelope includes the capability of sustained cruise flight at sea level at a maximum operational speed of 325 KIAS or 0.78 Mach, and a maximum altitude capability of 42,000 feet pressure altitude (while maintaining 10,000 feet cabin altitude). While the airplane has normal flight characteristics throughout the flight envelope, there are some differences, due to the higher engine thrust, addition of rotodome struts, and at light gross weights the aft center of gravity due to the location of mission equipment and rotodome.

STALLS

The airplane has adequate stall warning with the stall warning system (stick shaker), and exhibits normal stall characteristics.

STALL WARNING

Stall warning is considered to be any warning readily identifiable by the pilot, whether by initial buffet on airframe surfaces or by the stall warning system. The stall warning system, operable for all flight conditions, alerts the pilots to an impending stall condition. The stall warning system alerts the pilot by vibrating the control columns (stick shaker operation). Also, stick shaker operation provides a warning at takeoff if over-rotation to an extreme nose high attitude occurs. Refer to STALL WARNING SYSTEM, subsection I-H for further description. The angle of attack indicator indicates approximately 1.0 at stall.

At altitudes above 20,000 feet, with flaps up, first stall warning is usually by initial buffet. At lower altitudes, first stall warning is usually the stick shaker, except at high gross weights. *Figur*e *6–1* shows stick shaker actuation speeds for several flap settings. With flaps up, natural stall warning first appears as a very gentle airframe buffet or tremor 15 to 20 knots above the true initial buffet speed. As the speed is reduced and angle of attack increased, airflow separation and the tremor intensity gradually increase until a definite air frame buffet occurs. This speed is defined as initial buffet speed. With the flaps down, the tremor is masked by the normal flap buffeting, and the first obvious stall warning comes with the definite airframe buffeting at initial buffet speed. If the speed is reduced and angle of attack increased further toward a complete stall, the rate of descent and level of buffeting increases significantly. The initial buffet speeds for some specific conditions are shown in *figure 6–1*. Stick shaker and initial buffet speeds are approximately 2 knots lower at aft c.g. Stall and initial buffet speeds increase 10 to 15 knots if leading edge devices are inoperative (utility hydraulic system inoperative). Stall speeds increase when the airplane is in ground effect (within 150 feet of the ground).

STALL CHARACTERISTICS

Stall buffet, as distinct from initial buffet, is identified by vertical motion in the flight deck. Stall buffet is more pronounced with flaps up, but at high gross weights it is severe in all configurations.

A mild pitch-up tendency, easily controlled by elevator, occurs as the stall is approached. At the minimum speed with the control column full back, the nose pitches down, after which an effective recovery may be made in the conventional manner.

The loss of altitude during stalls varies with configuration and is greater with flaps and gear down.

Lateral control, using ailerons and spoilers, is effective through the stall and recovery. The inboard ailerons become less effective at initial buffet, but spoilers provide adequate roll control. Outboard ailerons are locked out with flaps up, but become effective when flaps are at 14 or more. Outboard ailerons are effective through stall speed. The use of spoilers has little effect on stall and buffet speeds (no effect on stick shaker) but spoiler buffet tends to mask the initial airframe buffet.

Directional control is best accomplished by maintaining wings level with ailerons and spoilers. Improper use of the rudder during stall can initiate excessive roll due to yaw.

WARNING

> If speed brakes are extended, the resultant buffet tends to mask the actual initial buffet. Consequently, speed brakes will not be used when the flaps are extended, except on the ground, or when split spoiler operation is required for pitch trim.

Power normally used for practicing approach to stall warning has a negligible effect on these speeds; however, the use of full power can result in excessively nose-high attitudes, particularly at the lighter gross weights.

Stick Shaker, Initial Buffet and Stall Speeds

Flaps Up and Flaps 14°

MODEL:	E-3A
ENGINES:	TF-33-PW-100A
DATE:	APRIL 1999
DATA BASIS:	FLIGHT TEST

CONDITIONS:

NO GROUND EFFECT
POWER OFF
GEAR UP OR DOWN
C.G. AT 22% MAC
1-G LOAD FACTOR

NOTE

FOR C.G. AFT OF 22% SUBTRACT ONE KNOT FOR EVERY 5% INCREASE IN C.G. POSITION

EXAMPLE:

GIVEN:
Gross weight = 230,000 lb
Flaps 14
C.G. at 27% MAC

FIND:
Stick shaker, initial buffet and stall speeds

SOLUTION:
Stick shaker speed = 126–1 = 125 KCAS
Initial buffet speed = 119–1 = 118 KCAS
Stall speed = 117–1 = 116 KCAS

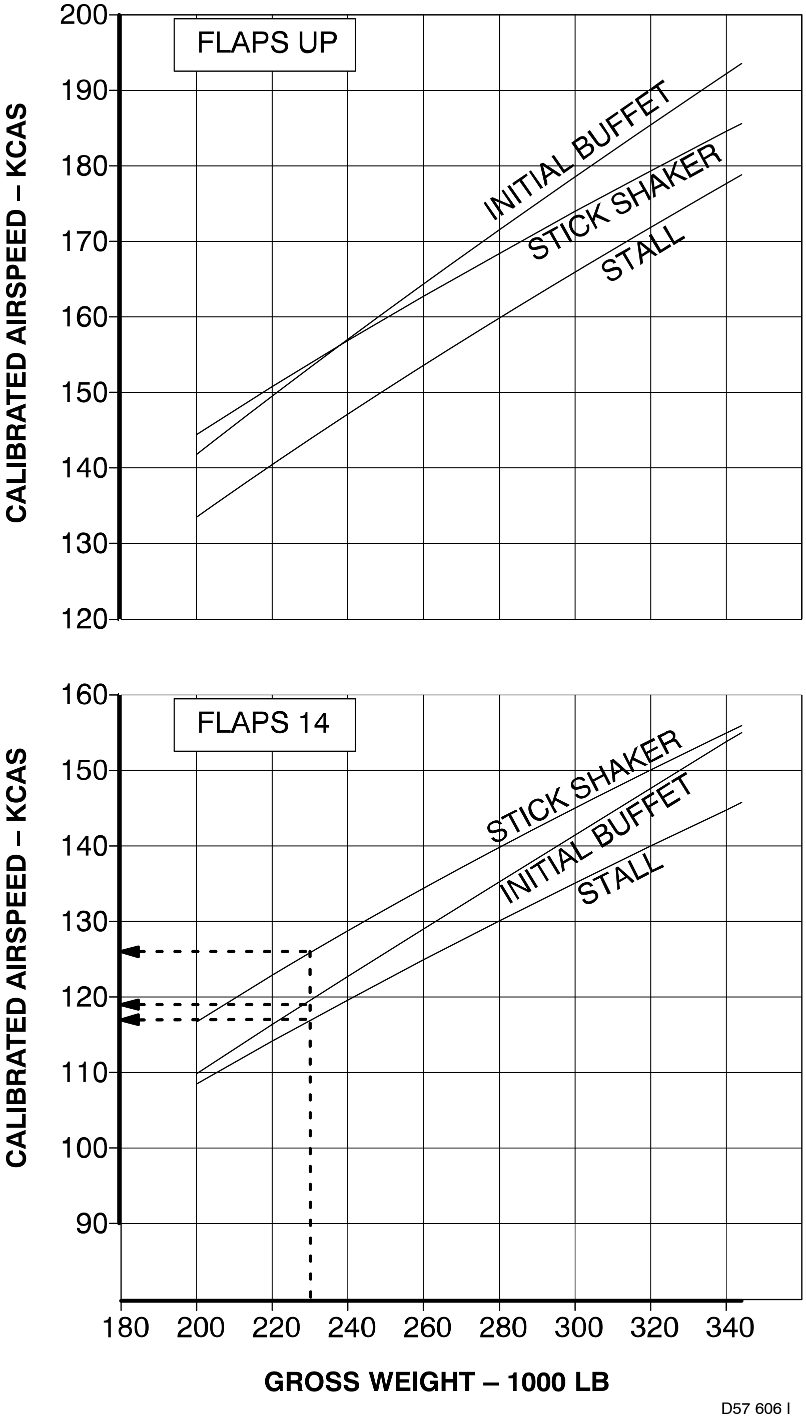

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Figure 6–1 (Sheet 1 of 2)

Stick Shaker, Initial Buffet and Stall Speeds (Continued)

Flaps 25° and Flaps 50°

MODEL:	E-3A
ENGINES:	TF-33-PW-100A
DATE:	APRIL 1999
DATA BASIS:	FLIGHT TEST

CONDITIONS:

NO GROUND EFFECT
POWER OFF
GEAR UP OR DOWN
C.G. AT 22% MAC
1-G LOAD FACTOR

NOTE

- BUFFET AND STALL SPEEDS INCREASE APPROXIMATELY 15 KNOTS IF LEADING EDGE FLAPS ARE INOPERATIVE
- FOR C.G. AFT OF 22% SUBTRACT 1 KNOT FOR EACH 5% INCREASE IN C.G. POSITION

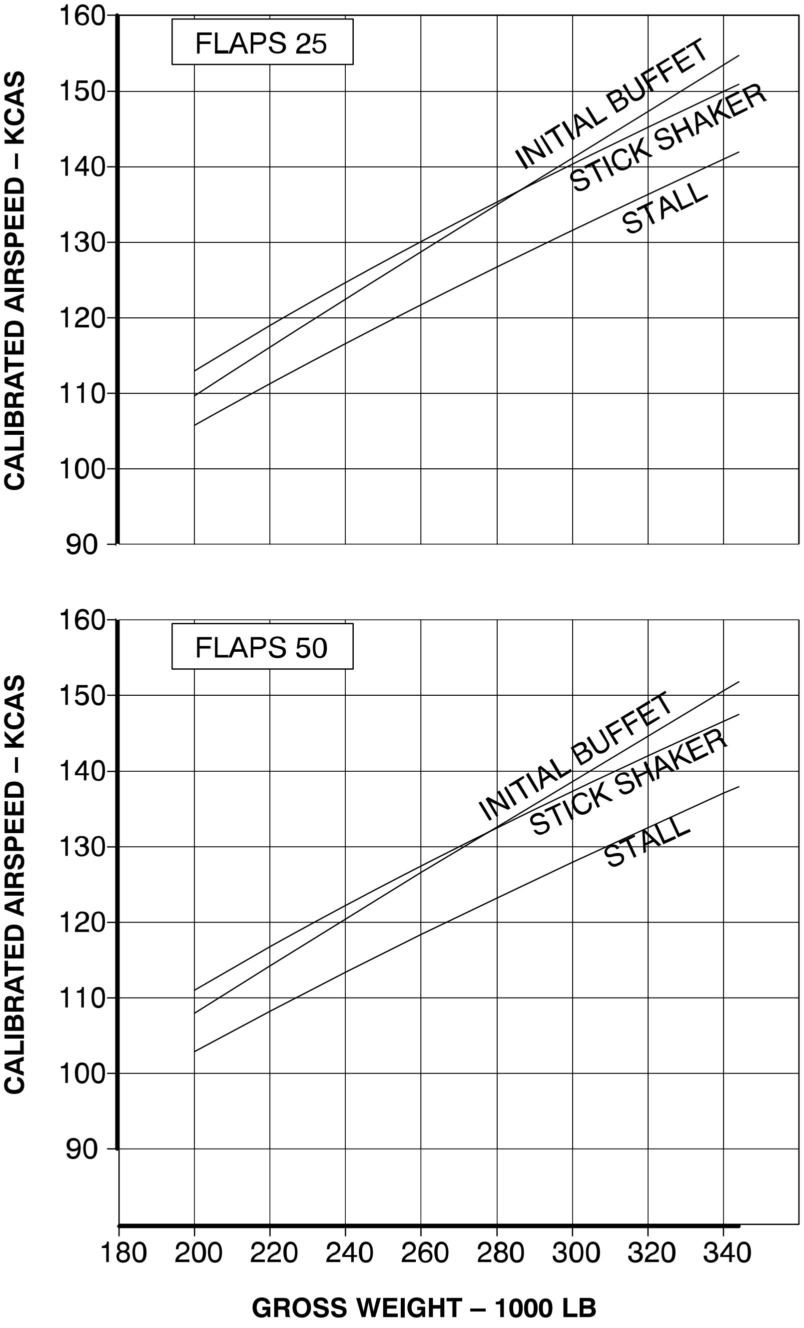

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Figure 6–1 (Sheet 2 of 2)

Pages 6–5 and 6–6 deleted.

ACCELERATED STALLS

Accelerated stall characteristics are generally similar to unaccelerated (1g) stall characteristics except that buffet is more pronounced at all flap settings. Pitch changes are not as great since the load factor cannot be maintained. Stall speeds increase with load factor. (Refer to T.O. 1E-3A-1-1.)

STALL RECOVERY

A stall recovery should be started at the first warning or indication of an impending stall; it is not recommended to continue the approach to the stall beyond this point. Therefore at initial buffet or stick shaker, initiate the recovery by simultaneously accomplishing the following (*figure 6*–2):

a. Smoothly decrease pitch attitude to approximately 0.7 AOA or as required to minimize altitude loss. As airspeed increases, sink rate can be arrested. If initial buffet occurs in a turn, lower the nose before attempting to roll the wings level. (Do not use the rudder.)

b. Add power by advancing the throttles to go-around thrust. The application of thrust during recovery results in minimum altitude loss. However, thrust application causes some pitch-up which could result in an entry into secondary buffet. Consequently, some nose-down elevator will be required to prevent excessive pitch-up as the engines are accelerating. The combination of autopilot nose up trim and power application may require pilot nose down trim to gain sufficient elevator authority.

c. Accelerate to the speed for which the airplane was trimmed before the stall (trim speed).

The procedure for stall recovery does not call for any change in flap position. This results in less altitude loss and a simplified recovery. In the case when the flaps are up, the stall recovery is usually completed before the flaps can be extended. Furthermore, flap extension above 20,000 feet is not permitted. Do not retract the flaps from the landing position, especially when near the ground, as a greater altitude loss results during the recovery. Therefore, do not change flap position during recovery from a stall.

If the stall entry occurs with the landing gear extended, do not retract the gear until the recovery is complete and a positive rate of climb has been established. Opening the gear doors during the retraction cycle increases the drag and delays airplane acceleration during recovery.

PRACTICE STALLS

Practice stalls should not be attempted with any known or suspected flight control system malfunction or with asymmetric thrust. Stalls should be performed at altitudes which assure recovery by 10,000 feet above the terrain. Use of flaps is prohibited above 20,000 feet.

Figure 6–2 illustrates the recommended procedure for practicing stall recovery. The procedure may be described as follows: The airspeed bug should be set for the reference speed (V_{REF}) for the weight before starting the maneuver; this provides a visual indication of speed margin between recommended speed and stall warning.

Set thrust as indicated in *figure 6*–2 and decelerate in level flight or slight climb (0 to 200 ft/min). Keep the airplane in trim until reaching the trim speed (shown in *figure 6*–2), after which no more trimming should be done. At the first stall warning indication, smoothly decrease pitch attitude two to four degrees to approximately the pitch attitude at trim speed, roll the wings level (if banked), and add go-around thrust. The flight engineer will monitor the thrust application during recovery. Accelerate to initial trim speed with a minimum loss of altitude. Take care to avoid secondary buffet.

The airspeed margins between climbout speed, pattern speed, or approach speed, and initial buffet speed should be noted for each configuration, to give an appreciation for the existing safety margins during takeoff, climbout, and normal approach.

Practice Stall Recovery

INITIAL CONDITIONS

(Set airpseed bug at V_{Ref})

Flaps	Gear	Trim Speed	Bank
0	UP	V_{Ref} + 40	0°
14	UP	V_{Ref} + 30	25°
50	DN	V_{Ref}	0°

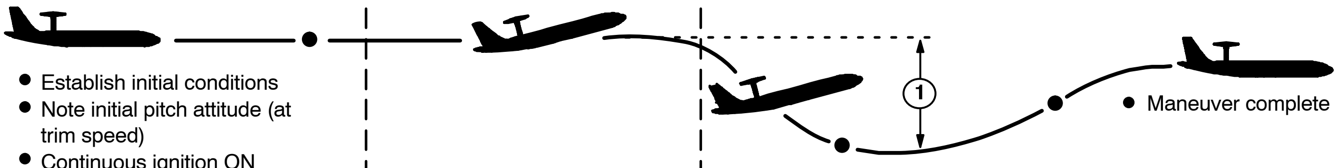
APPROACH

$\%N_1$	Anticipated Stick Shaker
55–60	V_{Ref} +23 kt
65–70	V_{Ref} +1 kt
70–75	V_{Ref} –15 kt

Flaps	AOA
0	.76
14/25	.79
50	.70

RECOVERY

At Buffet or Stick Shaker, Simultaneously:
- Smoothly decrease pitch attitude to approximately initial pitch altitude (or 0.7 AOA), or as required to minimize altitude loss
- Level wings
- Go-around thrust
- Accelerate to initial trim speed



- Establish initial conditions
- Note initial pitch attitude (at trim speed)
- Continuous ignition ON
- Set EPR bug for go-around

- Maneuver complete

① 100 TO 300 FEET (CLEAN)
500 FEET (FLAPS AND GEAR DOWN)

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Figure 6–2

HIGH RATES OF DESCENT OR GO-AROUND

Recovery from a high sink rate or a go-around from an instrument approach calls for a procedure which minimizes the altitude loss and the time required for completion of the maneuver. Both maneuvers are affected by the following factors listed below.

FACTORS AFFECTING RECOVERY FROM HIGH RATES OF DESCENT OR GO-AROUND

Important factors in recovery from high rates of descent or a go-around include engine acceleration, nose-up rotation, and power requirements.

In a go-around from normal glide slopes (see section II for descent rates) airplane drag is reduced by raising flaps to 25. If a flaps 14 approach is discontinued, flaps cannot be raised until reaching bug speed plus 10 knots.

Engine Acceleration

Engine acceleration from idle to takeoff thrust takes about ten seconds. During the first two seconds the thrust increase is negligible. After four seconds only 20% of takeoff thrust is received. Between four and six seconds after throttles are advanced, power reaches 90% of takeoff thrust and the last 10% after an additional three seconds. Engine acceleration from idle to the 50% (of TRT) required for level flight takes approximately five seconds. During this time, the airplane descends an additional 150 feet if the initial sink rate was 2,000 fpm and if V_{REF} is maintained during the recovery.

Engine acceleration from normal flaps 50 approach settings (approximately 1.25 EPR for four engines) to TRT requires approximately 4 seconds. With all engines operating, altitude loss can be kept to less than 50 feet. From the lower power settings used in a flaps 14 (or no-flap) approach, engine acceleration can take up to 8 seconds to TRT.

Rotation (Flare Capability)

When thrust is increased quickly in a propeller-driven airplane, the lift is simultaneously increased, with no change of attitude, because of increased airflow over the wing. When thrust is increased in a jet airplane, there is no immediate increase in lift. In a jet airplane, with no change in angle of attack, additional lift is produced only as airspeed is increased.

The only way to increase lift quickly in a jet airplane is to rotate nose up and increase the angle of attack. A swept wing requires more attitude change than a straight wing to produce the same lift increment. Thus, swept wing airplanes require greater rotation than straight wing airplanes to recover from a high rate of descent. It is extremely difficult to judge consistently the point at which flare should be initiated from steep descents. For this reason, idle thrust approaches and high rates of descent near the ground must be avoided.

From a normal 3 or 4 engine approach (see section II for sink rate), rotate the airplane at the same rate as takeoff rotation (about 1 degree per second). A pitch change of only 3 or 4 degrees provides enough additional lift to stop descent, even in a no-flap condition. With only 2 engines, or with go-around EPR reduced for rudder boost off, let the airplane accelerate and then rotate. Pitch attitude should not exceed the 8 ± 2 degrees (the flight director go-around command) until reaching bug +10 KIAS. The go-around attitude allows continuous fuel feed to the engines and provides tail clearance in case of accidental ground contact. Refer to MINIMUM CONTROL SPEED.

Power Requirements

Idle power gives a rate of descent of approximately 2,000 feet per minute at maximum landing weights, V_{REF}, gear down and flaps 50°. This results in an eight degree glide slope.

Approximately 1.25 EPR or 70% N_1 is required to maintain a glide slope of three degrees with a rate of descent of about 700 feet per minute.

WARNING

- If one inboard engine and/or rudder boost is inoperative, do not exceed the inboard engine go-around EPR shown in T.O. 1E-3A-1-1. If desired, both outboard engines may be set to the inboard engine EPR for improved climb. If an outboard engine is inoperative, do not exceed go-around EPR shown in T.O. 1E-3A-1-1. Do not decrease airspeed below bug speed shown in T.O. 1E-3A-1-1. If airspeed decreases below bug speed, use symmetrical thrust until above bug speed. Go-around performance shown in T.O. 1E-3A-1-1 is based on loss of an inboard engine. Refer to MINIMUM CONTROL SPEED.

- There is no performance data for go-around with 2 engines and rudder boost off, for flaps 25 with two engines inoperative, or for flaps 25 with one engine and rudder boost inoperative.

- If flaps are extended beyond 25 with two engines (or one engine and rudder boost) inoperative, airplane is committed to land.

PRACTICE RECOVERY FROM HIGH RATES OF DESCENT

This maneuver is practiced only to familiarize the pilot with the large altitude loss, early thrust application and large rotation required to recover from a high rate of descent in the landing configuration.

WARNING

- Do not attempt to perform this maneuver to an actual landing.
- If outboard main tank 1 or 4 has less than 2,500 pounds of fuel, or if inboard main tank 2 or 3 has less than 6,500 pounds of fuel, or if any fuel boost pump PRESS caution light illuminates, open all crossfeeds and turn on all boost pumps. Do not turn a boost pump off if a PRESS caution light flashes or illuminates steadily. Do not exceed 8 degrees nose up or 10 degrees nose down in this condition, to prevent uncovering boost pump or gravity feed intakes because engine flameout can occur. Add thrust slowly and only as necessary to recover.

It is not the intent of this maneuver to train a pilot to become proficient in recovering from a high rate of descent to a landing.

Descend at idle thrust for 2,000 feet at V_{REF} in landing configuration from at least 8,000 feet above terrain. At the selected altitude for start of level off, rapidly advance throttles to go-around thrust and simultaneously rotate nose up to stop the rate of descent while holding the airspeed at V_{REF}. Note the time required for engine acceleration and the change of attitude required from start of recovery to level off. The recovery procedure is illustrated in *figure 6–3.*

In a descent with flaps 50, idle power and airspeed at V_{REF} (sink rate approximately 2,000 fpm) rotation to at least 10 degrees nose-up is required to reduce sink rate while engines accelerate. The rotation rate required gives a load factor of approximately 1.3. The added load factor increases stick shaker and buffet speeds by 15%, so stick shaker speed is approximately V_{REF} minus five knots.

When making a go-around from normal approach descent rates, the load factor required is about 1.1, which increases stall speeds about 5%. If a turning pullup is made, load factor and stall speed increase.

SPINS

Spins are prohibited in this airplane. If a spin is entered inadvertently, recovery shall be started immediately. Inadvertent spins can best be avoided by recovering immediately from any stall condition.

NORMAL SPINS

In case a spin is entered accidently, initiate a standard recovery procedure. Immediately apply full rudder against the spin, followed by forward control column with neutral control wheel. Reduce power to idle. Apply some nose-down trim, and retract the speed brakes if they are extended.

If the spinning is not stopped or diminished, as a last resort to augment the rudder, apply throttles asymmetrically to develop thrust against the spin.

As spin rotation stops, neutralize the rudder to avoid entering a spin in the opposite direction. Return throttles to symmetric thrust, if asymmetric thrust was applied. Recover from the dive attitude by using elevator as necessary. Extend the speed brakes to prevent speed from building up rapidly during the recovery.

INVERTED SPINS

Recovery from an inverted spin must be accomplished by the method least hazardous to airplane structure. Reduce power to idle, apply full rudder against the spin until rotation stops, then roll out of the inverted position. Make a dive recovery using the procedures recommended under DIVING.

Practice Recovery from High Rates of Descent

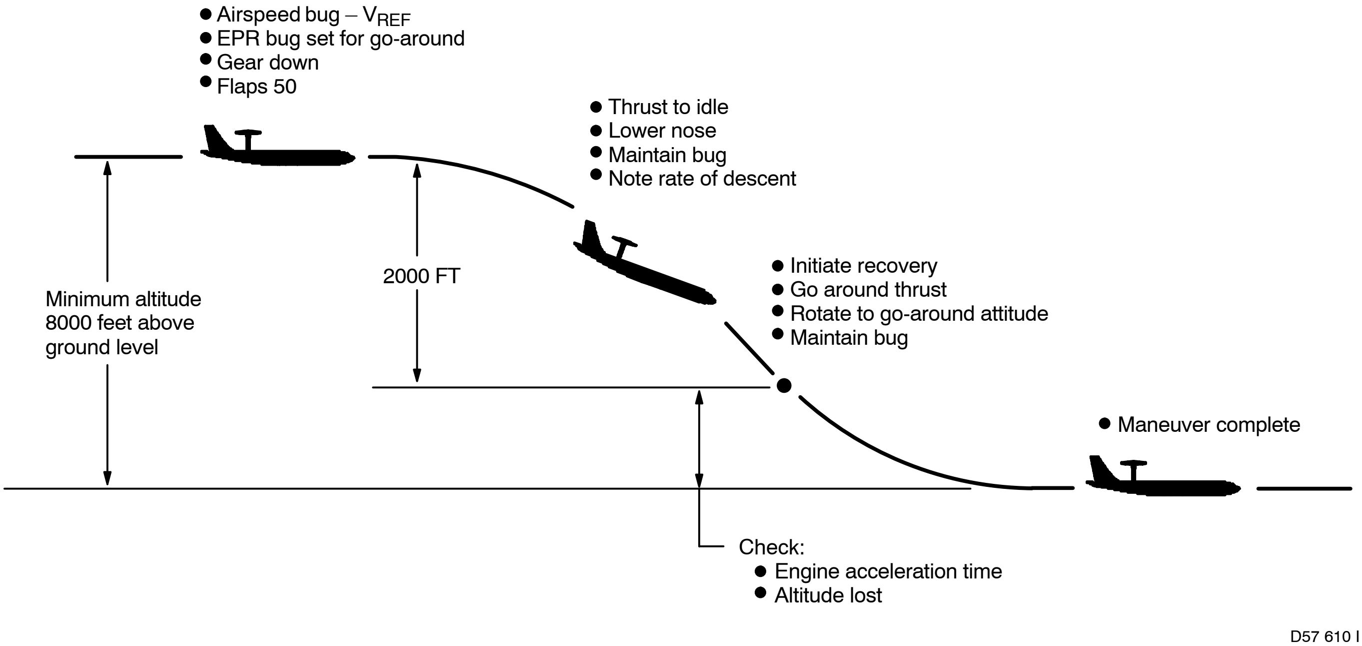


Figure 6–3

FLIGHT CONTROLS

The primary flight controls are the elevator, ailerons, and rudder. The secondary flight controls are the flaps and the speed brake, spoilers, and stabilizer trim.

PITCH CONTROL

The elevator is the primary means for controlling the airplane pitch attitude. It is deflected by control tabs in response to control column movement, and is assisted by aerodynamic balance panels. The elevator, alone, is not capable of controlling the airplane longitudinally through its entire speed range with reasonable control forces. Therefore it is supplemented by the movable horizontal stabilizer.

Pitch Trim

The primary longitudinal trim device is the movable horizontal stabilizer. *Figure 6–4* contrasts the principle of this device with that of fixed stabilizer airplanes. The stabilizer is electrically operated with a manual cable backup. The control column remains in the neutral position when the elevator is faired with the stabilizer, and the airplane is trimmed hands off. Trimming the airplane nose-up moves the stabilizer leading edge down and top of the manual trim wheel moves aft. The main electric stabilizer trim rate is capable of countering the trim changes associated with rapidly changing airspeed and large changes in flap position.

If high control column forces are encountered, and electric trim is inoperative, it can be necessary to release or reverse column loads in order to move manual trim. Refer to FLIGHT CONTROL ABNORMAL OPERATION, subsection I-H. If trim movement appears impossible, split flap operation can be used for trim. Refer to placards on overhead panel (*figure 1-7*) and to JAMMED STABILIZER LANDING, section III-A.

NOTE

The flight deck trim indicators can be up to ±1/2 unit off of correct reading. At takeoff rotation speed, 1/2 unit of trim causes a 10-pound change in required pull force.

Elevator and Stabilizer Pitch Control

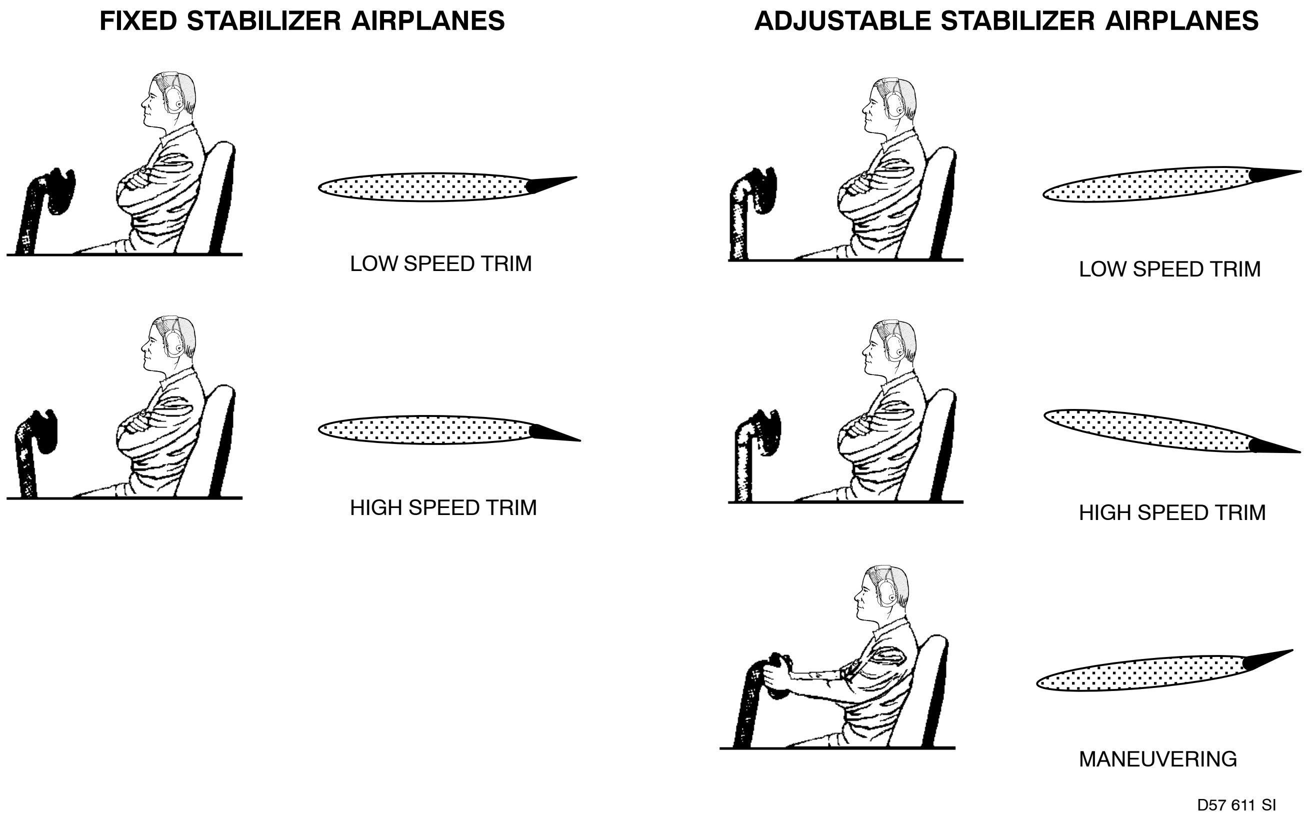


Figure 6–4

Pitch Changes

Almost any change in flight regime or airplane configuration affects the pitch attitude of the airplane, and requires either elevator input or pitch trim change by the pilot. Factors which cause pitch changes include airspeed, thrust, speed brakes, flaps, landing gear and center of gravity. Simultaneous changes of two or more of these factors cause increased pitch changes as the effects are added. As the airplane center of gravity moves aft, the airplane becomes more sensitive to pitch inputs and pitch oscillations.

As airspeed is increased, the airplane tends to pitch nose-up. As airspeed is decreased, the airplane tends to pitch nose-down and descend. Changes in airspeed require greater changes in trim than do the other possible factors. As a result, speed changes occasionally mask the pitch effects of other configuration changes.

Increasing thrust causes nose-up pitching, and decreasing thrust causes nose-down pitching. Pitching effect due to thrust is more apparent at light weights. Thrust increase is usually associated with the speed increase and thus the nose-up pitch is greater. The pitch-up is further increased if flap retraction takes place simultaneously, as in a missed approach situation. The pitch down condition can be aggravated if thrust reduction and flap extension occur at the same time.

Normal smooth operation of the speed brakes causes no appreciable pitch change. However, when the speed brakes are raised rapidly, the sudden change of airflow causes a momentary nose-up pitching, but the stabilized pitch effect is negligible. Because the wing is swept, raising only the inboard speed brakes decreases the lift inboard which is forward of the normal center of pressure, shifting it outboard and aft, causing nose-down pitch. Similarly, raising only the outboard speed brakes causes nose-up pitching, as lift is decreased outboard which is aft of the center of pressure. This effect, known as split spoiler operation, is used for pitch trim if the stabilizer trim is jammed. Refer to placards on overhead panel (*figure 1-7*) and to JAMMED STABILIZER LANDING, section III-A.

Flap extension from 0 to 14 degrees causes slight pitch-up. Flap extension from 14 degrees onwards causes nose-down pitch. The nose-down tendency is substantial when flaps are extended from 25 to 50 degrees. Conversely, flap retraction between 50 degrees and 14 degrees results in nose-up pitch. The combination of rapidly increasing airspeed and flap retraction during a missed approach can require the pilot to hold substantial forward pressure on the control column if stabilizer trimming is delayed.

When the airplane is less than approximately 150 feet (one wing span) from the ground (in ground effect), a nose down trim change occurs at aft c.g.

NOTE

- Flap extension from 14 to 50 in a single movement (as in emergency procedures with rudder boost inoperative or with two engines inoperative) causes a large nose down pitch change. This change is increased when combined with the entry into ground effect, possible thrust reduction and reduction in speed from V_{REF} + 30 KIAS to V_{REF}. If the airplane is not kept in trim during flap extension, high pitch control forces can occur during flare and touchdown.
- If electric trim is inoperative, it is recommended that flaps not be extended beyond 25 for landing from a flaps 14 approach.

The extension cycle of the main landing gear causes a temporary change in airflow over the stabilizer, inducing a momentary pitch-up. Landing gear extension at airspeeds greater than landing pattern speeds causes the nose to pitch up noticeably. At the placard speed for emergency descent extension, the nose-up pitch is large and must be anticipated.

ROLL CONTROL

The airplane has good roll rates at all airspeeds, and lateral control is adequate even after complete loss of hydraulic power.

Roll control authority is provided by outboard and inboard ailerons, and spoilers. Spoilers are the same control surfaces as the speed brakes; they act as spoilers when they are moved differentially by the control wheel for lateral control.

Spoilers and Speedbrakes

The control wheel operates the spoilers as well as the ailerons. With the control wheel held for right wing down, the right wing spoilers are raised and the loss of lift on that wing causes a roll to the right. Full control wheel travel raises the appropriate spoiler 40 degrees. If the spoilers have been moved out of the faired position by the speed brake lever, turning the control wheel causes a double action of the spoilers, moving the down-wing spoilers further up and the up-wing spoilers down. This increases the roll rate, making the airplane seem oversensitive with a tendency to overcontrol. When the speed brake lever is at the 60-degree position, there is no double action and only the upwing spoilers move down, causing normal roll response. Full control wheel travel still commands a spoiler difference of 40 degrees. When simultaneous use of control wheel and speed brakes is required, as after touchdown in a crosswind, in an emergency descent or during air refueling, move the lever as rapidly and smoothly as possible from the 0 to the 60-degree position unless the added roll rate is desired.

WARNING

If speed brakes are extended, the resultant buffet tends to mask the actual initial buffet. Consequently, speed brakes will not be used when flaps are extended, except on the ground or when split spoiler operation is required for pitch trim.

The spoilers blow down as the airspeed increases above approximately 200 knots. The amount of blowdown may vary with each spoiler panel because of differences in balance between airload and individual spoiler actuation force. The result is a slight and easily controlled roll tendency during speed brake operation. For improved roll control at high speeds above 310 KIAS, use the 30 degree detent position.

If either the inboard or outboard set of spoilers is deactivated, roll rate and capability for crosswind landings are reduced. Refer to part VII of T.O. 1E-3A-1-1.

Inboard and Outboard Ailerons

With the flaps up, the outboard ailerons are mechanically locked in the faired position. At flaps-up airspeeds the inboard ailerons, assisted by spoiler action, give excellent roll control. As airspeed increases and spoiler blowdown occurs, the inboard ailerons provide adequate roll control at high speeds.

As the outboard flaps lower, the outboard ailerons are gradually unlocked and follow control wheel position. The outboard ailerons provide adequate control capability with the outboard flaps at 14 degrees and reach full travel when the outboard flaps reach 23 degrees. This added surface easily compensates for decreased inboard aileron and spoiler effectiveness at low speeds.

Roll Changes

Various factors can cause a roll input. Fuel imbalance between the wing tanks can cause a noticeable roll tendency; proper fuel management corrects this condition. Aileron mistrim and raised spoilers are also potential sources of unwanted roll.

YAW CONTROL

The single rudder is normally operated hydraulically and becomes tab operated when hydraulic pressure fails or is shut off. A mechanical system provides pedal feel when hydraulic power is on. Rudder trim is available with power on or off. Refer to FLIGHT CONTROLS, subsection I-H.

Rudder Boost-On Operation

Rudder operation with boost on is normal, except that rudder hydraulic pressure is reduced in two steps (by airspeed switches) to limit available rudder travel and reduce structural loads. The hydraulic pressure available at maximum pedal deflection is reduced from 3,000 PSI to 2,290 PSI at 175 ±10 KIAS and reduced to 1,450 PSI at 250 (±15) KIAS.

When additional rudder deflection is needed at airspeeds below 250 KIAS, the rudder override switch may be used to bypass the airspeed switches and restore full system pressure. The pressure supplied to the rudder actuator varies with pedal movement. The amount of rudder deflection available decreases as airspeed increases above 130 KIAS.

As you can see from *figure 2-9* or the takeoff and climbout speed charts in T.O. 1E-3A-1-1, all takeoff and go-around maneuvers with one engine inoperative are started at or below 175 KIAS, unless gross weight is over 315,000 pounds. (Initial climbout is at approximately V_{CO} and go-around is at V_{REF} + 10 KIAS, or approximately V_{CO}).

Since minimum control speed is always less than V_{ROT} for takeoff or equal to V_{BUG} for approach, the possibility of flying at less than V_{MC} is remote, even in wind shear (refer to MINIMUM CONTROL SPEED and WIND SHEAR, section VII). Even if an engine fails between V_1 and V_{ROT}, the airplane continues to accelerate as the landing gear is retracted, so less rudder input is required.

If an outboard engine fails above 175 ±10 KIAS, reduce the rudder pressure by using rudder trim. Both the engineer and copilot can reach the trim crank. If you cannot hold heading with full rudder (or all the rudder pressure you can maintain), set the RUDDER override switch to OVERRIDE. Full hydraulic pressure is not applied to the rudder until the pedal reaches the stop. (You can observe this by watching the rudder ground test gage on preflight.)

In case of a second engine failure, reduce outboard EPR to the two-engine go-around EPR as shown in part VII of T.O. 1E-3A-1-1. If obstacle clearance climb is not critical, bank angle toward operating engines may be increased, to maintain heading if thrust cannot be reduced. Refer to MINIMUM CONTROL SPEED.

WARNING

- Before operating RUDDER or OVERRIDE switch in flight, physically identify both RUDDER (lower) and OVERRIDE (upper) switch to make sure proper switch is operated. Operation of wrong switch can cause loss of directional control or structural damage.
- When setting RUDDER switch to ON in flight, ensure rudder and rudder trim are in neutral (centered) position. This is to prevent excessive structural loads caused by rapid increase in rudder deflection and to maintain aircraft control during the transition to powered rudder.
- When setting override switch to override above 175 ±10 KIAS with rudder pedal fully deflected, expect increased rudder motion as pressure is increased.
- Do not set rudder override switch to OVERRIDE at speeds above 250 KIAS. Structural damage could result from full or rapid rudder movement with full rudder pressure.
- Flight at airspeeds above 250 KIAS is not allowed with the rudder boost pressure at 3,000 or 2,290 PSI. Either limit airspeed to below 250 KIAS or shut off rudder boost, disengage series yaw damper and engage parallel yaw damper.

- Yaw control capability above 250 KIAS with rudder pressure reduced to 1,450 PSI can require more than 5 degrees of bank to balance one outboard engine at TRT and the opposite engine failed. Maintain below 250 KIAS until thrust is reduced.

Rudder Feel and Trim

The rudder feel system combines pressures from two sources, a pressure proportional to pedal deflections (the centering spring) and a pressure proportional to dynamic pressure (the Q-spring). The centering spring can be moved by the rudder trim crank to change the zero pressure point. At low speeds with boost on, a small pedal movement causes low feel forces and large rudder movement. This can cause over control, especially during flare and landing roll in crosswinds.

Rudder Boost-Off Operation

When hydraulic pressure to the rudder fails or is shut off, the rudder tab is unlocked and pedal (or trim crank) motion operates the tab, which moves the rudder. Rudder deflection with boost off is about half and pedal forces about doubled, as compared to boost on condition. At low indicated airspeeds, such as during takeoff and landing, a large tab movement is required to move the rudder. This can make the pilot think that the rudder has not moved. You should expect this effect when making a boost off landing, especially with one engine out.

Yaw Damping Characteristics

The airplane has positive yaw damping (when yaw dampers are inoperative) within the limits shown in section V. Yaw damping decreases as altitude or gross weight increases, as center of gravity moves aft, and as flaps are extended. Loss of hydraulic pressure to the rudder also reduces yaw damping.

Yaw Dampers

The airplane is equipped with two independent yaw damper systems acting through one rudder actuator unit. The series yaw damper is intended to be used at all times, including taxi, takeoff and landing. The parallel yaw damper is used as a backup damper in case the series damper is inoperative. The yaw damper switches are interlocked so only one damper can operate at a time. The parallel yaw damper acts through a servomotor to move the rudder pedal control cables while the series yaw damper adds a signal within the rudder actuator and does not move the pedals.

The series damper is normally used because it does not cause the rudder pedals to move while it controls the rudder to stabilize the airplane in the yaw axis. The parallel yaw damper moves the rudder pedals and so is not normally used for aerial refueling or during takeoff and landing where large rudder pedal deflections can be required. All turns during normal maneuvers are made through aileron control only, with either yaw damper operating, since excellent rudder coordination is provided by either yaw damper. Rudder pedal inputs are necessary only during takeoff and landing, when some crossing of controls is common in crosswinds, or countering abnormal yaw forces, as in engine-out maneuvering.

The parallel yaw damper provides reduced yaw damping with the loss of auxiliary hydraulic pressure when rudder is controlled by control tab and balance panel system. While available rudder deflection is decreased with boost off, the dutch roll control available with the parallel damper is greater than the control with no yaw damper. Engage the parallel yaw damper if turbulence is encountered or if lateral overcontrol occurs when the rudder boost is inoperative. If airplane response is not satisfactory, observe the yaw damper inoperative flight limits in section V. Do not use parallel yaw damper during air refueling.

Yaw Changes

Induced yaw can be caused by thrust asymmetry, particularly involving the outboard engines. Also during high altitude cruise, when thrust is limited, slight asymmetry can develop due to varying accessory demands.

The application of aileron trim can raise the spoilers on one wing, thereby increasing drag on that wing and contributing to a yawed condition.

Minimum Control Speeds

Minimum control speed, V_{MC}, is the lowest speed at which directional control can be maintained after a sudden outboard engine failure with all other engines at a specified thrust level. T.O. 1E-3A-1-1 gives ground and air minimum control speeds for various conditions. Ground and air minimum control speeds are defined below.

When the basic airplane was modified by adding the rotodome and engines with higher thrust, there were some changes in performance with one or more engines inoperative. Higher engine thrust causes a greater turning tendency when an outboard engine is inoperative. Addition of the rotodome struts has the same effect as adding additional vertical fin area. The rudder is slightly less effective at some airspeeds. To correct for the effects of these changes, outboard engine thrust must be reduced in some conditions, in order to reduce minimum control speed.

Ground Minimum Control Speed, V_{MCG}

Ground minimum control speed, V_{MCG}, as shown in T.O. 1E-3A-1-1, is the lowest speed at which the airplane can be controlled on a heading parallel to the runway centerline (and within 30 feet of the centerline) after the sudden loss of thrust on an outboard engine with all other engines at the specified takeoff thrust. Rudder control and nosewheel tire friction are considered in computing V_{MCG} on dry runways. As runway condition reading (RCR) decreases from 26 (dry runway) to 10 (wet runway), the nosewheel friction is assumed to decrease to zero. With some conditions of crosswind, gross weight, and RCR, outboard engine thrust is reduced to reduce V_{MCG} and to reduce the required accelerate-stop distance, reducing takeoff field length. (Refer to part of T.O. 1E-3A-1-1.)

CAUTION

- To prevent skidding of nosewheel tire and possible tire failure, nosewheel steering input above 80 KIAS will be limited to the pressure needed to prevent castering action of the nosewheel. (Refer to ENGINE FAILURE AFTER V_1, section III.)
- The values of V_{MCG} given in T.O. 1E-3A-1-1 have been demonstrated in flight test. In order to obtain the performance shown, the procedures in sections II and III calling for holding nosewheel steering centered and also applying forward pressure on the control wheel until approaching V_{ROT} must be followed.
- If an outboard engine fails on takeoff, the pilot must immediately apply full rudder and pressure to return nosewheel steering to neutral position. A delay of one-half second for pilot reaction time and one second for full rudder deflection has been included in the computation of V_{MCG} data in T.O. 1E-3A-1-1.

Air Minimum Control Speed, V_{MCA}

Air minimum control speed, V_{MCA}, as shown in T.O. 1E-3A-1-1, Part II, is the minimum airborne speed in the takeoff configuration at which an outboard engine can fail, and with no change to the thrust of the remaining engines, the airplane can be kept on a straight flight path with rudder boost on and no more than five degrees of bank away from the failed engine (toward the operating engine).

Minimum control speeds were demonstrated in flight test with five degrees of bank. If wings are kept level, a speed higher than V_{MCA} can be required to maintain a straight flight path. Air minimum control speed, V_{MCA}, as shown in T.O. 1E-3A-1-1, Part VII, is the minimum airborne speed in the go-around configuration at which an outboard engine, or both engines on the same side, can fail with the remaining engines at go-around thrust and the airplane can be kept on a straight flight path with maximum available rudder and no more than five degrees of bank away from the failed engine(s) (toward the operating engines).

Go-Around Thrust

Go-around EPR settings in T.O. 1E-3A-1-1 reduce outboard engine thrust so that if an engine fails, V_{MCA} is equal to the no-wind approach speed for the particular flap setting (V_{REF} for flaps 50 approach, V_{REF} plus 30 KIAS for flaps 25 or 14 approach). Go-around climb performance charts in T.O. 1E-3A-1-1 are based on failure of an inboard engine in any condition where outboard engine EPR is reduced. Climb performance with an inboard engine failed may be improved by increasing outboard engine thrust to charted inboard engine EPR. Climb performance with outboard engine failure is better than chart values.

WARNING

- With rudder boost inoperative or with one or more engines inoperative, do not exceed the go-around EPR shown in part VII of T.O. 1E-3A-1-1. Do not decrease airspeed to below bug speed. If airspeed is inadvertently decreased below bug speed, use symmetrical thrust until airspeed is above bug speed.
- If two engines are inoperative on same side, reduce outboard engine thrust or increase bank angle beyond five degrees as required to maintain heading. (Climb performance is reduced.)

Yaw Control With Engine Failure in Flight

When an engine fails in flight, the airplane yaws toward the failed engine and the wing with the operating engines rises due to sideslip. At the first indication of loss of an engine, counter the yaw with the rudder and use the wheel to hold wings level. Rudder application should always be smooth and matched to the thrust decay rate if possible. Thrust asymmetry can be controlled with the wheel by allowing the airplane to sideslip, but this is not recommended.

Add thrust to maintain airspeed. Use inboard engines to increase thrust if possible, because of the large moment unbalance with a failed outboard engine. Check the minimum airspeed and accelerate or hold the minimum airspeed for the failure and flight condition. With flaps at 14° (takeoff position) hold the airspeed above V_{REF} + 30 KIAS. Set rudder OVERRIDE switch to OVERRIDE. With the rudder boost unit off or two engines failed on one wing, the minimum control speed is higher and a restriction in the outboard engine EPR can be necessary. (Refer to T.O. 1E-3A-1-1.)

Under instrument conditions, changes in roll or yaw are the first indication of an asymmetric thrust situation. As yaw develops from thrust asymmetry, the slip indicator ball deflects away from the inoperative engine. The turn needle also indicates the direction and rate of yaw due to asymmetric thrust. The control wheel is applied first, to maintain desired (5°) bank angle. Rudder is then applied to center the wheel, left rudder if wheel is rotated to left).

When the proper amount of rudder is applied, the ball is nearly centered. There is still a small amount of sideslip in this condition. With the proper rudder applied, no lateral control displacement or trim is necessary. Flying with some lateral control applied manually or with aileron trim can cause spoilers on one wing to be raised. This increases drag in cruise as well as decreasing crosswind capability for landing. With the control wheel centered, full lateral control is available in both directions and this helps prevent pilot-induced oscillations. Make turns at a constant airspeed and hold rudder displacement constant. Do not attempt to coordinate rudder and lateral control in turns. Adjust the rudder correction after completing the turn.

With the rudder boost off, the control techniques are the same as with the boost on, but the minimum control speed is much higher. (Refer to section III.) Rudder trim can be used to help relieve the high pedal pressures and thrust can be adjusted to be as near symmetrical as possible and still maintain airspeed and flight path.

When necessary to perform a landing with rudder boost off and one engine inoperative, use the flaps 14° landing data shown in part VII of T.O. 1E-3A-1-1. Go-around EPR settings are limited to reduce thrust so that air minimum control speed is equal to the no wind approach speed.

Flaps may be extended to 25 on approach and 50 for landing with rudder boost inoperative or with two engines inoperative. Do not attempt a go-around with flaps extended beyond 25.

WARNING

- If one inboard engine and/or rudder boost is inoperative, do not exceed the inboard engine go-around EPR shown in T.O. 1E-3A-1-1. Both outboard engines will be set to the inboard engine EPR for improved climb. If an outboard engine is inoperative, do not exceed go-around EPR shown in T.O. 1E-3A-1-1. Do not decrease airspeed below bug speed shown in T.O. 1E-3A-1-1. If airspeed decreases below bug speed, use symmetrical thrust until above bug speed. Go-around performance shown in T.O. 1E-3A-1-1 is based on loss of an inboard engine. Refer to MINIMUM CONTROL SPEED.

- There is no performance data for go-around with two engines and rudder boost off, for flaps 25 with two engines inoperative, or for flaps 25 with one engine and rudder boost inoperative.

ROLL AND DIRECTIONAL TRIM TECHNIQUE

Trimming the airplane in roll and yaw requires coordination of thrust, flight controls, rudder trim and aileron trim. The following procedure can be used for trimming the airplane:

a. Set equal EPR on all engines (correcting for anti-ice or inoperative bleed air valves as required).

b. When thrust level has stabilized, level the wings with the control wheel, leaving aileron trim at zero.

c. Use rudder trim as necessary to hold heading. (Disengage parallel yaw damper while trimming rudder.)

d. Use aileron trim to remove any control wheel force.

On a properly rigged (and balanced) airplane, the control wheel should be approximately centered when the airplane is trimmed.

DUTCH ROLL

Dutch roll is a combined yawing-rolling motion of the airplane. It is a characteristic of swept-wing airplanes and may be considered only a nuisance unless allowed to progress to large bank angles. Large rolling yawing motions can become dangerous unless properly damped.

Dutch roll may be excited by rough air, or by lateral-directional overcontrolling. Once induced, it is damped by normal airplane stability. The higher the angle of attack, however, the lower the damping. The highest angles of attack are reached during takeoff, landing, high altitude and any low speed flight condition approaching initial buffet.

NOTE

> High gross weight, high altitude, low indicated airspeed, aft c.g. flap extension, and/or rudder boost inoperative tend to reduce dutch roll damping.

The primary means of controlling dutch roll is the yaw damper. Since one yaw damper is normally in use at all times, it eliminates any tendency toward dutch roll. Therefore, it is recommended to engage or attempt to engage a yaw damper any time dutch roll is recognized, even when a yaw damper is assumed to be on.

If the yaw damper is inoperative, manual recovery is accomplished by the proper use of lateral control inputs only. The rudder will not be used in correcting for dutch roll. *Figure 6–5* shows how lateral controls are moved to stop the rising wing. Stop the rising wing at the desired bank angle with aileron. As the wing stops, center the control wheel and prepare to stop the other wing from rising. Continue control wheel inputs until the dutch roll stops. The first inclination of a pilot inexperienced with this maneuver is to put too much lateral control and hold it too long. Use a control wheel input roughly equal to the degree of oscillation. If the oscillations are ±10 degrees around the bank angle, use about ±10 degrees of control wheel. Holding this input too long tends to increase the dutch roll by exciting another oscillation in the opposite direction. Several cycles may be required to damp out dutch roll. If an input opposing the roll should be too small to stop the rising wing, a second pulse in the same direction as the first should not be applied as that could be out of phase and increase the oscillations. The next lateral control input should be delayed until the start of the next roll oscillation and then be applied to stop the rising wing, quickly centering the wheel as the roll stops. Once the roll oscillations are small, it should be easy to apply control smoothly to reach a desired bank angle for turns or level flight.

Obviously, since the yaw damper uses rudder alone to correct for dutch roll, a pilot could also use rudder if properly applied and coordinated. However, pilot application of rudder is not recommended. Wrong application of rudder can easily result in a more serious situation, whereas lateral control alone allows the inherent stability of the airplane to damp the oscillation. If the pilot concentrates solely on maintaining initial bank angle, the combination of this lateral control application and natural damping will prevent the development of dutch roll.

SLOW FLIGHT

The speed range between V_{REF} and initial buffet is referred to as the slow flight range. As the airspeed decreases, increasing nose-up trim or pull force is required. If thrust is increased, as in a stall recovery or go-around, the airplane tends to pitch up. As described above, airframe tremor increases as speed is reduced.

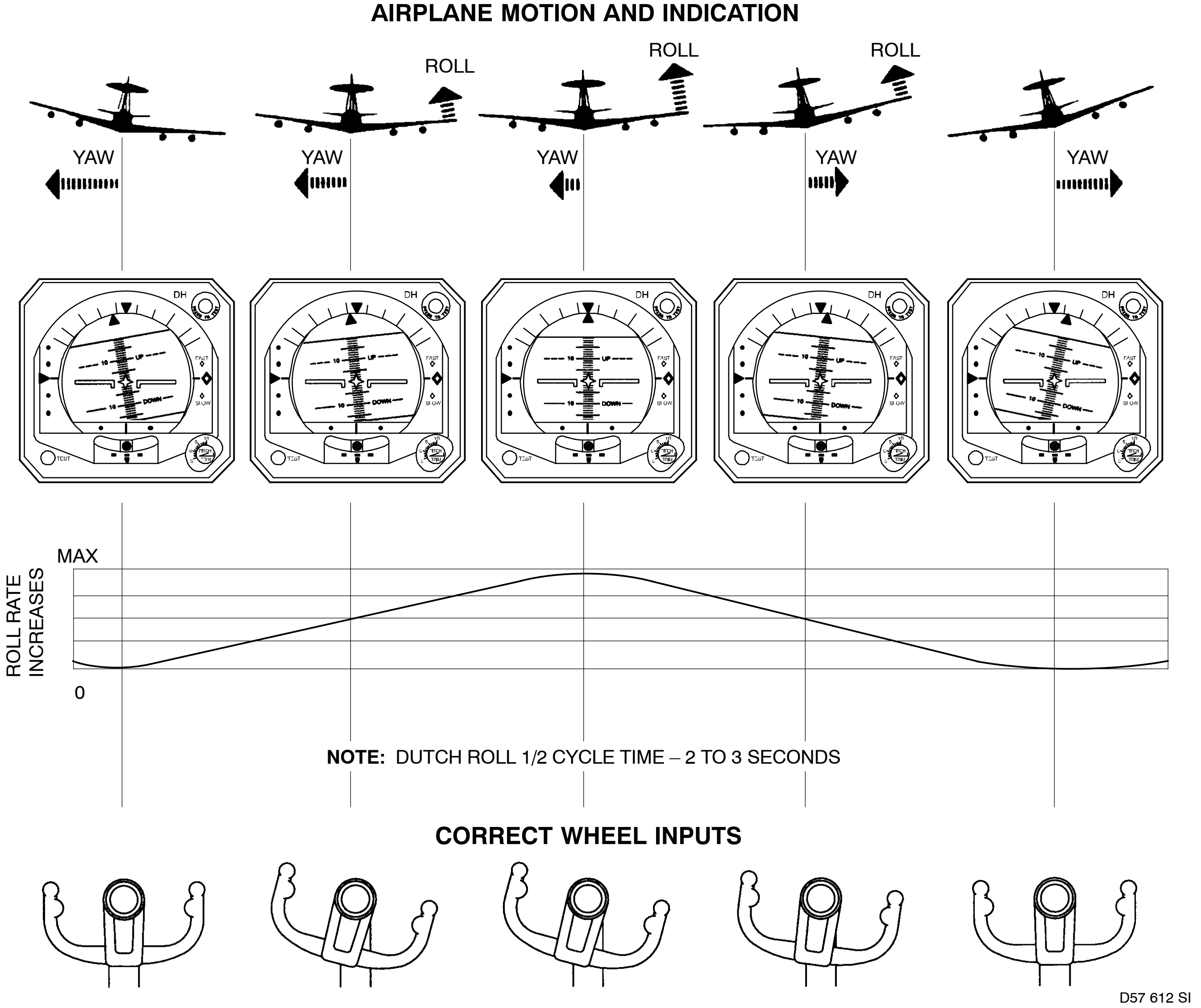
Since the elevators are tab operated, a larger tab deflection (and larger control column force) is required to obtain a given elevator deflection at low speed, and a larger elevator deflection is needed to produce a given pitch rate.

With flaps up, roll control becomes less effective as speed is reduced. With flaps down, outboard ailerons are available and roll control is effective down to stall speeds. At lower airspeeds a greater control deflection is required for a given roll rate.

With rudder boost on, rudder control is normal in slow flight. If rudder boost is inoperative, rudder response decreases at low airspeeds, due to the large tab deflection required for rudder movement.

In a go-around, thrust addition causes a pitch up, flap retraction from 50 to 25 causes a nose-up trim change, and landing gear retraction causes a slight momentary pitch down. If electric trim is inoperative, the pilot must be prepared for the combined effects of thrust and flap changes and allow time for manual trimming.

Dutch Roll Damping Technique



PILOT ACTION				
Roll motion to right stopped. Wheel centered.	Rolling motion to left beginning. Wheel to right to counteract rolling motion to left.	Wing level. Roll rate to left at maximum. Wheel to right approximately equal to max bank angle to left expected.	Roll rate to left reducing. Wheel to right reduced.	Rolling motion to left stopped. Wheel centered.

Figure 6–5

LEVEL FLIGHT

The critical Mach number of a wing is dependent, among other things, upon the wing sweep and airfoil shape. The thinner the airfoil section and the greater the wing sweep, the higher the critical Mach number. The airfoil on this airplane is a laminar flow shape which is a compromise to give satisfactory low speed and high speed performance. The wings are swept to aid in delaying the formation of the shock wave.

The airplane decelerates slowly after thrust reduction in level flight. This is due to its aerodynamic cleanness. The use of full speed brakes reduces deceleration time by approximately half, but increased buffet, and noise are evident.

LOW SPEED

Flight characteristics at low speed are normal, with no unusual traits. Refer to STALL WARNING and SLOW FLIGHT.

BUFFET BOUNDARY

If high speed buffet and low speed buffet are plotted against altitude on the same graph, the curves intersect at the maximum altitude for the particular gross weight. At this point, low-speed and high-speed buffet are indistinguishable. Maneuvering changes the load factor (usually increases). For example, a 25° bank turn increases the load factor to 1.1g and initial buffet speed increases about 5%.

NOTE

- If the intersection point is reached, and both high and low speed buffet occur, altitude must be reduced by increasing drag or reducing thrust. Airspeed cannot be reduced (do not pull up) or stalling is possible.
- Stick shaker, angle of attack system, and attitude indicators are the best indicators of which buffet condition is being felt. High speed buffet usually occurs at low angles of attack or high load factors, except at the intersection point of the high and low speed buffet curves. If stick shaker operates, reduce angle of attack by initiating stall recovery. Refer to STALLS, this section and TURBULENCE PROCEDURES, section VII.

HIGH SPEED

The airplane is speed stable (requires push force on control wheel with increasing airspeed and pull force on control wheel with decreasing airspeed). There is increasing buffet at speeds approaching M_H (0.78 Mach).

WARNING

Airplane shall not exceed 0.75 Mach when airplane gross weight is below 250,000 pounds and the CG is aft of 32% MAC. Above 0.75 Mach at these conditions, the airplane can become pitch sensitive and control inputs from either the pilot or autopilot can result in pitch oscillations that may exceed structural limitations. If oscillations occur, the pilot should release the control column or disengage the autopilot. Airspeed should then be reduced to 0.75 Mach or less.

MANEUVERING FLIGHT

TURNS

The normal maneuvering bank angle is 25 to 30 degrees. This bank angle provides satisfactory turn rates, adequate radius of turn, reasonable crew comfort, and safe margins above stall warning when flying at or above the appropriate flap speed schedule.

STEEP TURNS

Steep turns (beyond 30 degrees of bank) may be accomplished without difficulty if performed smoothly and if rapid roll rates are avoided. It is necessary to add a small amount of thrust to maintain airspeed. Elevator back pressure is increased to hold altitude. The elevator back pressure is relaxed during the rollout to hold constant altitude, then a small amount of forward pressure applied to return the pitch attitude to normal flight. The thrust is retarded to the original setting as required to maintain the entry airspeed.

ENDURANCE SPEED

Constant altitude and airspeed are required during on-station operation of the airplane. Additional attention is required to hold airspeed, particularly during turning flight, so that flight speed is not reduced below the endurance speed, and flight altitude is maintained. Minimum speeds at which the airplane may be operated are shown in Part I of T.O. 1E-3A-1-1 and *figure 6–6*. The thrust limits on the figure are for normal and military rated thrust of the engines. If a large heading change is required and the airplane is trimmed at a speed below the minimum maneuvering speed for the desired bank turn, normal rated thrust must be applied and the airplane should be allowed to accelerate prior to entering the turn.

For all turning maneuvers during low speed on-station flight, additional engine thrust should be applied prior to entering the turn. Additional thrust increases and reductions in bank angle during the turn will be required if airspeed cannot be maintained.

DIVING

Because of the normal margin, at cruise, between cruise Mach and high speed buffet, a shallow dive may be made without encountering buffet. However, the low drag of the airplane in cruise configuration permits the speed to increase rapidly any time the nose is dropped or a dive commenced. Therefore, recovery should be made promptly any time that buffet is encountered on a dive. Extend the speed brakes. At the same time, start to level out, but avoid an abrupt pullout that would increase the load factor and possibly damage the airplane.

NOTE

If pitch trim is not available, it can be undesirable to decrease power sharply. Chopping the throttles results in a nose-down tendency which could further aggravate the dive unless compensated for by trimming. If trimming is attempted, it can be necessary to relieve control column force in order to avoid stalling the stabilizer trim motor. Refer to FLIGHT CONTROL ABNORMAL OPERATION, subsection I-H.

In those cases where a rapid rate of descent is desired, refer to RAPID DESCENT in section III.

AIR REFUELING

When air refueling, the airplanes are essentially flying formation and are therefore subject to effects not otherwise encountered.

AERODYNAMIC EFFECTS

Airplanes flying in close formation have an aerodynamic effect on each other due to the interaction of the airflow around the two airplanes. The closer the two airplanes are, the stronger the effect. The strength is proportional to the size and weight of the airplanes. Aerodynamic effects also vary with position relative to the tanker; for example, roll is influenced by side to side movement and pitch by fore and aft or up and down movements. Since this airplane is somewhat larger than the tanker (KC-135), it can cause large disturbances to the tanker. Also the aerodynamic effect increases with decreasing airspeed since the distortion in the airflow is greater at slower speeds.

Because of these effects, and to minimize the possibility of mid-air collision, all air refueling operations will be conducted in accordance with air refueling flight manual, T.O. 1-1C-1-27.

CONTROL RESPONSES

All of the aerodynamic effects described result in changing control requirements as the two airplanes maneuver near each other. These control variations become more rapid and pronounced when the positions are changed rapidly. The tanker is affected by the bow wave of the receiver. Therefore, the relative positions of the airplanes must be changed gradually and smoothly to allow both pilots adequate time to compensate for the variations.

With a large fuel transfer, the weight change results in a change of both trim and power settings while hooked up to maintain constant airspeed and altitude. Care must be taken to load fuel symmetrically so lateral or directional trim changes are at a minimum. The changes occur gradually which allows the pilot to make the compensation for weight changes slowly.

Maneuver Envelope

MODEL:	E-3A
ENGINES:	TF-33-PW-100A
DATE:	APRIL 1999
DATA BASIS:	FLIGHT TEST

CONDITIONS:

FLAPS UP
PRESSURE ALTITUDE = 29,000 FT
NORMAL RATED THRUST

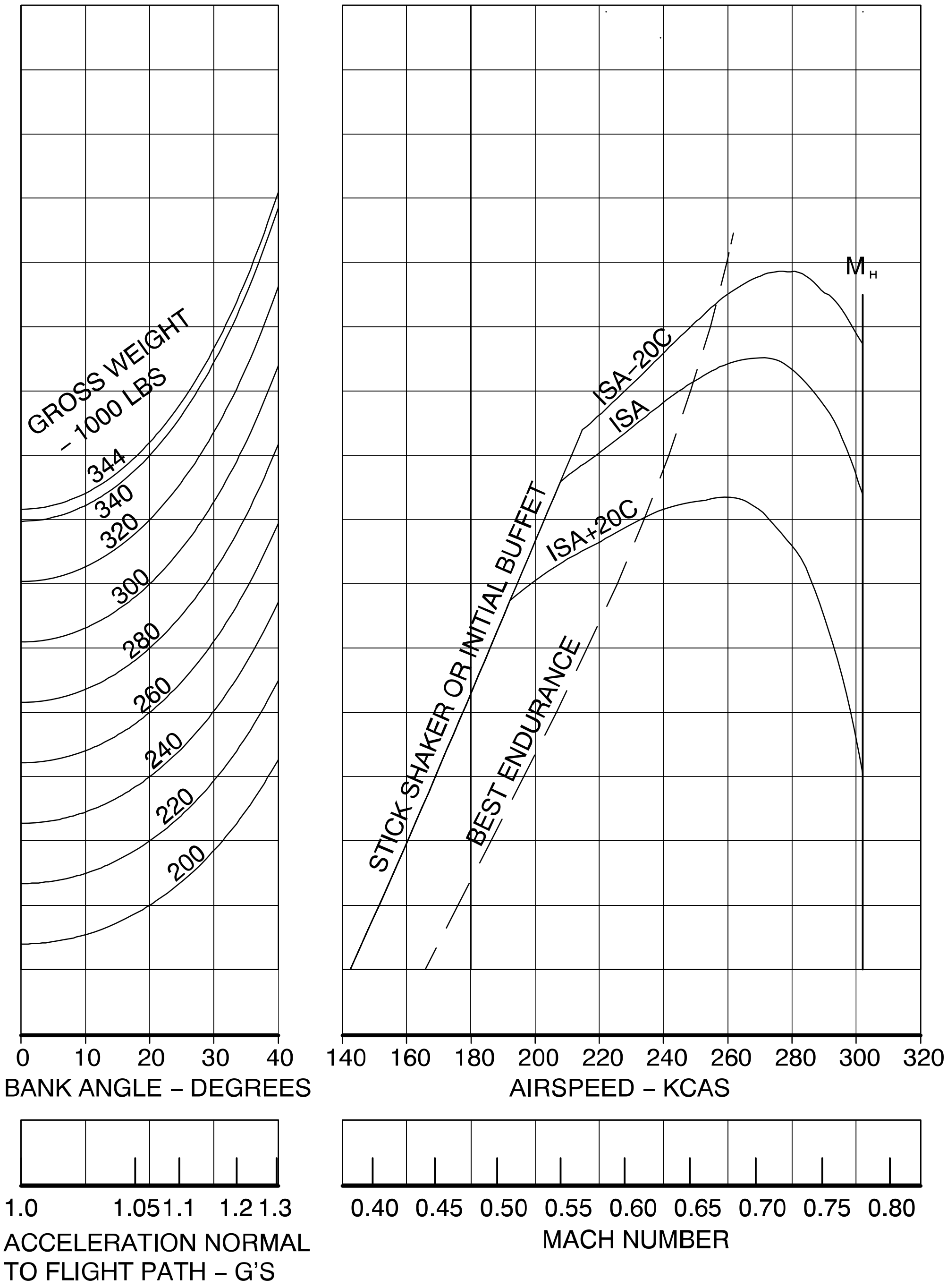


Figure 6–6

Some small amount of aileron or rudder control is required if the receiver airplane is not directly behind the tanker within the refueling envelope limits. Try to keep wheel inputs small to avoid spoiler operation. Turns can be made while in contact, provided turn entry is gradual.

The series yaw damper is the preferred system to damp out dutch roll because no feedback reaches the rudder pedals. If series yaw damper only fails, turn both yaw dampers OFF. The parallel yaw damper will be OFF from precontact position until refueling is completed. The parallel yaw damper and autopilot can be engaged after completing refueling.

The parallel yaw damper is normally not used during refueling since any yaw input, whether caused by gusts and turbulence or by pilot inputs to maintain refueling position, are opposed by the parallel yaw damper, causing rudder pedal motion.

NOTE

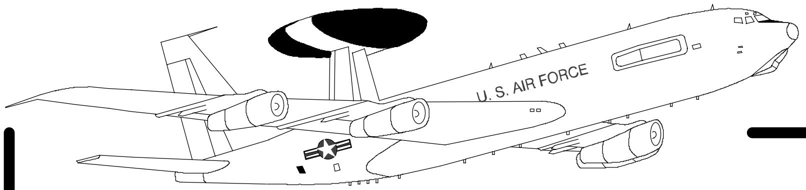
When the c.g. is aft of approximately 32%, the airplane becomes more sensitive to pitch inputs. This is most noticeable during initial air refueling training. For ease of refueling, it is recommended that contacts be planned for c.g. forward of 32%. (With normal fuel management, c.g. is forward of 32% at gross weights above 205,000 pounds.) Refueling was successfully accomplished in flight tests at 33.5% c.g.

CROSSWIND LANDING CHARACTERISTICS

The flight characteristics during landing approach and touchdown are normal and present no unusual problems.

Crab, sideslip, wing low or a combination are accepted methods for correcting for a crosswind during approach and landing. Regardless of which method is used, there is sufficient rudder and aileron control available to execute crosswind landings. Refer to CROSSWIND LANDING in section II for a discussion of the procedures to be used. Refer to T.O. 1E-3A-1-1 for crosswind limits for various landing configurations.

Section VII



ADVERSE WEATHER OPERATIONS

Table of Contents

INTRODUCTION

Except for some repetition necessary for emphasis, clarity or continuity of thought, this section contains only those procedures that differ or are in addition to the normal operating procedures covered in sections I and II.

THUNDERSTORM AVOIDANCE WITH WEATHER RADAR

The weather radar can give much information about a storm if you interpret it properly. Weather radar can show the following things (you must make a few adjustments and calculations):

a. Intensity of a cell (contour mode and shadowing of ground targets behind a storm).

b. Gradient (how far from no storm to contour).

c. Movement of a storm over the ground.

d. Height of tops (you must adjust tilt and calculate height).

e. Point/area of greatest turbulence (hooks, scallops, fingers, or unsymmetrical cores).

Severe thunderstorms (meaning a rainfall rate of 0.5 in/hr or greater) show red in WX or MAP mode.

TURBULENCE AND THUNDERSTORMS

WARNING

> Flight through thunderstorm activity or known severe turbulence is not recommended and should be avoided if at all possible. The pilot must use careful judgment in determining capability to enter or circumnavigate areas of severe turbulence or thunderstorm activity safely.

When flying in severe turbulence, it is possible to impose excessive structural loads on the airplane; also, the airplane attitude can reach undesirable extremes. Established turbulence penetration procedures minimize attitude excursions as much as possible and maintain structural loads within acceptable limits. Evidence indicates that almost every structural breakup that occurs in severe turbulence is preceded by a severe change in attitude with a subsequent combination of high stresses from both the recovery maneuver and the severe turbulence. The flexible swept back wing and high wing loading of the airplane make it highly possible that any structural damage which occurs in severe turbulence results from airplane upset and recovery maneuvers in combination with turbulence, rather than the effects of turbulence alone. Retention of fuel in the reserve tanks until its use is required or until the last portion of the mission improves the wing bending loading distribution.

CONTROL PARAMETERS

Penetration of severe turbulence requires proper attention to airplane airspeed, attitude, thrust, altitude and proper use of the automatic flight control system.

Airspeed and Flaps

While flight at low speeds is satisfactory in moderate turbulence, there are several disadvantages to flying at low speeds in severe turbulence. First, the airplane is closer to stall buffet, and since the angle of attack changes caused by severe turbulence can be high, there is a greater chance of encountering strong and alarming buffeting. This buffeting is accompanied by high drag resulting in loss of altitude and tempts the pilot to make undesirable thrust changes. Airplane trim changes due to thrust changes are greater at low speed compounding the difficulty of maintaining adequate attitude control. Second, when encountering severe turbulence at lower speeds, the airplane is more easily upset both directionally and laterally.

Because of the disadvantages of low-speed flight, a sufficiently high penetration speed is used to provide adequate control without subjecting the airplane to excessive structural loads. For simplicity, only one speed is chosen as target speed, realizing that sizable and rapid variations are likely to occur depending on the severity of the turbulence.

It is undesirable to chase airspeed, either with elevator or throttle manipulation, since these efforts are usually ineffective and can become dangerous by compounding an unstable situation. Moderate variations, either above or below the recommended penetration speed, are of minor consequence. Therefore, avoid excessively abrupt or severe control or throttle movements.

The best airspeed and wing configuration to use in the presence of severe turbulence is one that affords ample protection both from stall and from structural deformation. The airplane can withstand higher gust intensity with flaps retracted. At altitudes below 15,000 feet and landing weights associated with the approach pattern, the airplane can be slowed to 250 knots. Adequate stall margin exists under these conditions in the event severe turbulence is encountered. Delay flap extension in an area of known turbulence as long as possible. Diversion to another area is the best policy if severe turbulence persists.

Attitude

Flying under extremely turbulent conditions requires techniques which can be contrary to a pilot's natural reactions. Moderate control inputs normally considered desirable do not always allow very precise attitude control. In extreme turbulence, control pitch attitude using only small or moderate elevator inputs to avoid overcontrolling or overstressing airplane structure. The natural stability of the airplane tends to minimize the loads imposed by turbulence. The pilot should rely to a major extent on this natural stability and not become too concerned about pitch attitude variations. Since the direction, timing and size of the next gust is always uncertain, it is often better to do nothing at all than to attempt to control airplane pitch attitude too rigidly. Ideally, apply smooth elevator control in a direction to resist motions away from the desired attitude. Return the elevator to neutral when the airplane is progressing toward the desired attitude. This technique helps prevent overcontrolling, reduces the size of pitch attitude excursions and results in less g loads than a technique which very closely controls pitch attitude.

Control pitch attitude solely with the elevator, never with stabilizer trim. Rapid changes in airspeed and attitude due to extreme gusts make stabilizer trim difficult to apply effectively. If trim is applied to counter the first gust, the second gust, which is usually in the opposite direction, exaggerates the out-of-trim condition. Therefore, leave the stabilizer trim alone in severe turbulence.

WARNING

Engine flameout can occur if airplane pitch attitude exceeds 8 degrees nose up or 10 degrees nose down when any outboard main tank contains less than 2,500 pounds or any inboard main tank contains less than 6,500 pounds. Refer to MINIMUM FUEL PROCEDURES, section II.

Thrust

The most desirable thrust setting is one which provides near level flight at the recommended penetration speed in smooth air. T.O. 1E-3A-1-1 provides rpm settings that can be used to maintain optimum penetration airspeed. The most important objective is to obtain an initial thrust setting reasonably close to the correct one. Once the proper thrust setting for the recommended penetration airspeed is achieved, it is undesirable to make thrust changes during severe turbulence. Large variations in airspeed and altitude are certain to occur in severe turbulence. If EPR gages fluctuate excessively, use engine N_1 rpm as an indication of thrust.

Flying in turbulence or hail can cause engine inlet airflow distortion. This distortion, along with engine icing, angle of attack changes and high altitude engine surge margins can result in engine surge and flameout. Turn on continuous ignition as soon as turbulence is encountered.

Altitude

Because of the high velocity updrafts and downdrafts in severe turbulence, large variations in altitude are certain to occur. Too much concern about these variations leads to excessive control manipulations which causes large structural load variations and unwanted airspeed excursions. Allow altitude to vary within reasonable bounds.

At high altitudes or during high-speed cruise at intermediate altitudes, turbulence encounters can produce high-speed buffeting. The airplane flight tests indicate that no unusual flight characteristics occur during high-speed buffet. High-speed buffet or shaking is similar to but more severe than the shaking that occurs when speed brakes are extended. When experienced in combination with severe turbulence, high-speed buffet can be incorrectly interpreted as increased severity of the atmospheric disturbance. Even though prescribed procedures are used, occasional high-speed buffet can occur when encountering unexpected severe turbulence above 30,000 feet. Do not misinterpret high-speed buffet as a low speed stall with an accompanying rapid pushover for recovery. Use the angle of attack indicator and stall warning system to aid in deciding whether the buffet is high speed (requiring pull up) or low speed (requiring push over). These systems are reliable indications of approaching stall, even if the pitot-static system is not available, unless the nose radome is missing. (Refer to FLIGHT WITH UNRELIABLE AIRSPEED/MACH INDICATIONS, this section and section III-A.) High speed buffet occurs at relatively low angles of attack unless a high g load factor is encountered. If stall warning (stick shaker) occurs, a stall is imminent regardless of airspeed, and recovery must be initiated by decreasing angle of attack. Any such action can increase the buffet situation by increasing the Mach number. The tendency to encounter high-speed buffeting in severe turbulence is increased with increasing altitude. Therefore, climbing in an attempt to avoid an area of expected severe turbulence could lead to high-speed buffet if the turbulent region could not be completely topped. When flying at 30,000 feet or higher, do not climb over the turbulent area unless it obviously can be overflown well in the clear.

Autopilot

The autopilot should be engaged when turbulence is encountered. The autopilot has limited authority for pitch inputs to the elevator. If a pitch signal to the elevator is such that a trim change is required, the stabilizer trims to the new position, thereby nulling out the elevator signal (elevator returns to faired position). The autopilot maintains the airplane in trimmed condition at all times. Disengage autopilot, however, if sustained trimming occurs. Monitor pitch trim indicator. Do not use altitude hold.

Yaw Dampers

The airplane has low dutch roll damping. This type of rolling motion is uncomfortable and can be difficult to cope with from a piloting standpoint. Because the motion is easily initiated and poorly damped on swept wing configurations, the airplane is equipped with two yaw dampers to provide yaw damping to aid the pilot in flying the airplane. Flight test data indicates important benefits are obtained from the use of the yaw damper during turbulence penetration. Excursions in sideslip and roll are minimized, even though the rudder control can be more active, the structural loads imposed on the vertical tail are considerably reduced.

TURBULENCE PROCEDURES

Use the following procedures for flight in severe turbulence.

a. AIRSPEED – For level flight approximately 280 KIAS or Mach 0.70 ± 0.01, whichever is lower. Severe turbulence causes large and often rapid variations in indicated airspeed. DO NOT CHASE AIRSPEED. For climb and descent, use normal airspeeds shown in section II.

b. AUTOPILOT – Use autopilot. (Do not use ALT HOLD mode). Monitor pitch and trim activity. If sustained trimming occurs, disengage autopilot. Yaw damper must be engaged at all times. Do not aid or resist lateral control motion.

c. THRUST – Turn on continuous ignition. Make an initial thrust setting of N_1 rpm for the target airspeed depending on gross weight and altitude. Refer to T.O. 1E-3A-1-1.

d. ATTITUDE – Maintain wings level and smoothly control pitch attitude. Use attitude indicator as the primary instrument. In extreme drafts, large attitude changes can occur. DO NOT USE SUDDEN LARGE ELEVATOR CONTROL INPUTS.

e. STABILIZER (MANUAL OPERATION) – Maintain control of the airplane with the elevators. After establishing the trim setting for penetration speed, DO NOT CHANGE STABILIZER TRIM.

f. ALTITUDE – Allow altitude to vary. Large altitude variations are possible in severe turbulence. Sacrifice altitude in order to maintain the desired attitude and airspeed. DO NOT CHASE THE ALTIMETER.

g. SEAT BELTS – Ensure seat belts are fastened. Advise personnel to fasten seat belts in sufficient time to strap firmly in prior to entering areas of forecast or suspected turbulence.

h. ANTI-ICING – Turn engine anti-icing on, if in icing conditions.

CAUTION

Observe fuel flow vs generator load limits in section V with anti-ice on.

RECOVERY FROM UNUSUAL ATTITUDES

If a severe pitch upset occurs, control airspeed by extending speedbrakes (and landing gear, if required). In a nose-high attitude, negative g condition during recovery can be reduced by turning but stall speed is increased. Refer to DIVING, section VI.

CAUTION

- If landing gear is extended above 320 KIAS, damage to gear doors is possible. Main gear locking can be delayed (GEAR warning light on and no green lights).
- Do not extend flaps above 20,000 feet or above flap placard speed. Airplane load factor is limited to +2.0g, –0.0g for gross weights up to 325,000 pounds with any flap extension. For gross weights greater than 325,000 pounds, the limit load factors are +1.8g to –0.0g with any flap extension. Yaw damping is decreased and roll rate increased with flaps down. Flap damage due to airload could cause unsymmetrical loss of flaps, leading to high roll rate.
- Expect roll rate to be higher than normal when speedbrakes are in blowdown range (above 200 KIAS).
- If a large pull force is needed, do not reduce thrust. Reducing thrust causes nose down pitch change. Split spoilers (inboards off) can be used to assist in reducing pull force.

If a roll upset occurs, reduce speed as in pitch upset, then roll to upright position. Remember that bank index on the ADI (20, *figure 1–102*) or the standby attitude indicator (7, *figure 5-14*) points straight up except when the ADI tape precesses at ±90° of pitch or the standby attitude indicator exceeds ±85° of pitch. Maximum roll rate can be obtained by using partial speedbrake as follows:

If airspeed is above 310 KIAS, use 30° detent.

If airspeed is between 275 and 310 KIAS, use 35°.

If airspeed is between 250 and 275 KIAS, use 40°.

If airspeed is below 250 KIAS, use full speedbrakes (actual position depends on airspeed above approximately 200 KIAS).

In a combined pitch and roll upset; first, reduce airspeed; second, roll wings level; third, correct pitch attitude. Attempting to pull nose up while banked increases turn rate and load factor, increasing stall speed.

WIND SHEAR

Wind shear is a change of wind speed and/or wind direction over a short distance along the flight path. Vertical wind activity (turbulence) can occur in wind shear areas. Wind shear can occur in thunderstorms, fronts, low level jet streams, virga (rain that evaporates before reaching the ground), or can be produced by terrain irregularities or buildings near a runway. The procedures outlined in this section are for mission accomplishment situations only and will not be considered normal operating procedures.

Wind shear and vertical wind activity can present a potential hazard when flying at low altitudes and low airspeeds. If the airplane is exposed to a decreasing headwind or an increasing tailwind, corrective action must be taken promptly to avoid high rates of descent. In severe conditions, use of go-around thrust and flight well above normal go-around attitude at speeds close to or at stick shaker activation speeds can be required. Wind shears are most threatening below 1,000 feet. At these low altitudes there is very little time or altitude available to respond to and recover from an inadvertent encounter. Attempting to accelerate back to bug speed when in wind shear or downdraft conditions will significantly reduce climb capability. It can be necessary to reduce speed slightly in order to obtain a positive rate of climb. Make pitch corrections slowly and keep maneuvering to a minimum in wind shear.

Flight crews should be familiar with the weather conditions which can produce wind shear. Reported (tower) wind is not always the same as wind in the touchdown zone, final approach or liftoff area. Pilots should be familiar with airplane handling characteristics in the speed range between V_{REF} and stick shaker speed. (Refer to slow flight, section VI.) Remember that the airplane has good climb capability at stick shaker speed if go-around thrust is used. If an engine is inoperative, V_{MCA} is less than or equal to bug speed. The pilot not flying the aircraft should alert the other pilot promptly in case of variation in altitude, airspeed, vertical speed or localizer and glideslope deviation. Navigators will monitor INS for groundspeed readings.

CREW ACTIONS

Avoidance

Consider delaying takeoff or landing to let the adverse atmospheric condition pass the airfield since it is possible to encounter wind shear magnitudes which exceed the performance capability of the aircraft to avoid impact with the ground. The flight crews should search for any clues to the presence of wind shear along the intended flightpath. Carefully assess all available information such as pilot reports of wind shear or turbulence, low level wind shear alerts and weather reports, including thunderstorms and virga activity.

WARNING

Do not penetrate a severe wind shear or downdraft intentionally when below 1,000 feet AGL. As a guideline, severe wind shear can be indicated by uncontrolled changes from normal steady state flight conditions in excess of 15 knots indicated airspeed, 500 feet per minute; vertical speed, 5 degrees pitch attitude or one dot displacement from the glideslope.

Assist other pilots by reporting wind shear encounters precisely and promptly. Accurate pilot reports can be a valuable clue to the severity of a wind shear condition. If wind shear is suspected, be especially alert to any danger signals and be prepared for the possibility of an inadvertent encounter.

Precautions - Takeoff

If wind shear conditions are suspected on takeoff, delay takeoff, if possible. Do not use the flight director for takeoff in suspected wind shear conditions. The attitude indicator is the primary reference for pitch attitude control. During the takeoff roll, monitor airspeed for earliest possible indication of wind shear. INS groundspeed reading can also be used for indication of wind shear. If a decision is made to take off with known/suspected wind shear conditions present, use the longest suitable runway available. If mission accomplishment dictates, consider increasing both rotation speed and climbout speed up to 20 knots, if tire speed allows. If obstacle distance was determined to be critical during mission planning, aircrews should be aware conditions may exist which would not allow sufficient performance to reach the required climbout factor.

WARNING

- If wind shear is suspected, use takeoff rated thrust instead of reduced thrust for takeoff.
- If wind shear is encountered at or beyond the rotate speed (uncorrected for wind shear), do not attempt to accelerate to the increased (corrected for wind shear) rotate speed. Rotate without hesitation.
- In no case should rotation be delayed beyond 2,000 feet from the end of the usable runway surface.
- If a severe wind shear is encountered at or beyond rotation speed (uncorrected for wind shear), obstacle clearance cannot be accurately determined. The factors affecting the aircraft are too numerous and unpredictable to calculate accurately.
- Wind shear plus gust correction should not exceed 20 knots at field pressure altitudes up to 1,000. Reduce this limit by 3 knots for each 1,000 feet above 1,000 feet field pressure altitude. This will ensure the planned increase in rotation speed will not exceed tire limit speed criteria.

NOTE

Wind shear plus gust correction should not exceed 20 knots.

If airspeed was not increased beyond uncorrected rotation speed prior to liftoff, accelerating to higher than normal airspeed after liftoff is not recommended. If wind shear is encountered on initial climbout, perform the unanticipated wind shear recovery procedure, this section.

WARNING

Reducing pitch attitude at low altitude to accelerate will produce a hazard if wind shear is encountered.

Precautions - Approach and Landing

If wind shear is suspected on final approach, delay approach if at all possible. During approach, do not make large power reductions until flare. In order to enhance wind shear penetration capability, select landing flaps 50 and add up to a maximum of 20 knots if performance limitations permit.

WARNING

- Pilots should ensure the planned increase in landing speed will meet performance and tire limit speed criteria.
- If a severe wind shear is encountered during subsequent go-around, obstacle clearance cannot be accurately determined. The factors affecting the aircraft are too numerous and unpredictable to calculate accurately.

NOTE

Wind shear, plus gust correction, should not exceed 20 knots.

The navigator will assist the pilots by computing the approach groundspeed which is the true airspeed corresponding to V_{REF}, plus flap speed correction, plus gust correction, minus steady headwind (or plus steady tailwind) component at airport. This should be the minimum groundspeed observed on the approach (use the STR or PSN displays on the GINS). If wind shear is suspected when below 1,000 feet, maintain a stabilized speed not less than minimum approach ground speed. If total correction for wind (steady state, gust) and ground speed correction exceeds V_{REF} plus 20 knots, discontinue the approach using normal go-around procedures. A decreasing headwind does not necessarily indicate a wind shear situation. If severe wind shear is encountered on any approach, perform the unanticipated wind shear recovery procedure, this section.

Unanticipated Wind Shear Recovery

The flight crew must make the determination of marginal flight path control based on all information available.

The determination is subjective and based on the pilot's judgment of the situation. As a guideline, marginal flight path control may be indicated by uncontrolled changes from normal steady state flight conditions in excess of: 15 knots indicated airspeed, 500 feet per minute vertical speed, 5 degrees pitch attitude or 1 dot displacement from the glideslope. To recover from wind shear, perform the following steps: disengage the autopilot and aggressively position throttles forward to ensure TRT/Go-around thrust is attained.

Rotate smoothly at a normal rate toward an initial pitch attitude of 14 degrees. Pitch attitude in excess of 14 degrees may be required to avoid terrain. Stop rotation immediately if stick shaker or buffet occur. Stick shaker may occur at pitch attitudes below 14 degrees if very severe wind shear is encountered. Do not follow flight director commands. When possible, the flight director should be turned off to eliminate continuous display of inappropriate commands. When thrust is added, the nose may tend to pitch up. This natural pitching characteristic can aid in a smooth increase in pitch attitude. However, significant push force can be required if large thrust increases are made. Additional nose down trim may be required to adequately control the pitch attitude.

Monitor vertical speed and altitude. If the airplane is descending, increase the pitch attitude smoothly and in small increments to stop the descent. Stick shaker must be respected at all times. If stick shaker activates, reduce the pitch attitude just enough to silence the shaker. Flight at intermittent stick shaker may be required to obtain a positive rate of climb.

Smooth, steady pitch attitude control is very important during the recovery especially if pitch attitudes close to stick shaker or buffet are required. Smooth, steady control of pitch attitude will ensure that high pitch rates do not develop and will avoid an overshoot of the pitch attitude at which stall warning is initiated.

Do not attempt to regain lost airspeed until terrain contact is no longer a factor. Also, do not change gear or flap configuration until the vertical flight path is under control.

RAIN AND SLUSH OPERATION

WARNING

- Snow, slush or water on the runway can increase takeoff and stopping distances significantly. Refer to part II, T.O. 1E-3A-1-1. Wet dense slush which results when packed snow partially melts, presents the worst takeoff condition.
- Takeoff or landing will not be attempted with over 1/2-inch of wet snow, slush or standing water on runway. With slush or water on the runway, airplane structure can be damaged by slush or water impinging on the airplane, especially at high speeds. If possible, avoid known slush or water puddles.

Protection of the airplane from freezing rain while on the ground can be accomplished by the use of covers designed for that purpose. Their use is covered under COLD WEATHER OPERATION.

TIRE HYDROPLANING

The possibility of partial or total hydroplaning, during airplane takeoff and landing, exists whenever water or slush stands on the runway. Depending upon runway and tire conditions, tire hydroplaning can occur in depths less than 0.1 inch of slush or water.

Conditions for Hydroplaning

Dynamic hydroplaning occurs whenever a rolling or skidding tire does not displace water or slush at a rate fast enough to permit the complete tire footprint area to contact the runway surface. As the airplane ground speed increases on takeoff, a wedge of water (bow wave) gradually extends into the tire footprint area, decreasing the contact area between the tire and ground. The retarding effect of slush or water on the wheels and airplane structure increases as airplane ground speed increases until the bow wave disappears because the wheels rise on top of the fluid and the retarding force of water or slush therefore decreases. The portion of the tire footprint kept off the runway surface by a film of liquid gradually increases as airplane speed increases. As the wedge of water penetrates the tire footprint area, hydrodynamic pressure is built up between the tire and pavement which lifts the tire from the runway surface. Hydroplaning is a gradual process and partial hydroplaning exists long before total hydroplaning occurs. At total hydroplaning speed, the airplane tires ride entirely on the film and tire contact with the runway is lost. Once total hydroplaning is initiated, it tends to continue even when the airplane speed falls below the beginning speed for hydroplaning. There are two other types of hydroplaning that can occur when water is present on the runway. One is Viscous hydroplaning and the other is Reverted Rubber hydroplaning.

Types of Hydroplaning

a. Dynamic Hydroplaning. Occurs in standing water, moderate and heavy rains. Depends on tread design, tread condition, tread width and tire pressure. At hydroplaning speed the wheels ride up on top of the water. Braking and nosewheel steering is not possible during hydroplaning conditions.

b. Viscous Hydroplaning. Occurs in mist and light rain. Actually, it is a slippery runway condition. Runway contaminants such as dust, oil and JP-4 in the presence of water causes the runway to be slick. Runway roughness is a factor in this type of hydroplaning. A worn runway or paint on the runway makes a tire more susceptible to this type of hydroplaning.

c. Reverted Rubber Hydroplaning. There are three types of reverted rubber hydroplaning.

    (1) Reverted rubber deposited on the runway during landings fills in normal runway roughness in the touchdown zones. These rubber deposits become slick in any type of moisture. (This is also a slippery runway condition.)

    (2) Skids on wet runways cause the tires to heat up. Tire rubber reverts to its natural state and causes tire grooves to close. Steam also forms under the tire and may either aid the heating of the tire rubber or help lift the tire off the runway or both. The net effect is a lowering of the hydroplaning speed.

    (3) Reverted rubber in touchdown zones is heated by the sun. Water is not present. The rubber becomes soft and also may exude oils. Both steering and braking can be impaired in these areas of the runway. (This is also a slippery runway condition.)

Factors Influencing Hydroplaning

Indications are that hydroplaning occurs at lower speeds on dimpled or smooth tires than on ribbed tread tires.

Grooves in the tire tread allow escape of water or slush from the tire footprint area. If no grooves exist in the tire tread, the water or slush has less chance to squeeze out of the tire footprint area. Also, when the water or slush on the runway surface exceeds the depth of the tire grooves, the effect is the same as for a smooth tire.

On dry runway surfaces the coefficient of friction is unaffected by tire wear. On wet runways, however, braking or turning effectiveness is seriously degraded when the tire becomes badly worn.

The minimum depth of fluid on the runway required for hydroplaning depends upon the tire tread design and the roughness of the pavement surface. Hydroplaning with least fluid depth occurs with smooth tires on smooth pavement. Hydroplaning is less likely to occur with ribbed tread tires operating on grooved or textured pavement.

The possibility of hydroplaning conditions existing on a crowned runway is less than on an uncrowned one. The crown allows water to drain off rapidly and usually prevents a deep accumulation except during heavy downpours. Slush does not drain off as readily as water and hydroplaning in slush can be expected even on crowned runways.

The minimum total hydroplaning speed is dependent upon tire inflation pressure. The higher the tire inflation pressure the less likely hydroplaning is to occur.

Effects of Hydroplaning

Hydroplaning results in a marked loss of coefficient of friction between tires and runway surface. The loss in coefficient of friction also reduces the effectiveness of nose wheel steering and consequently the ability of the pilot to cope with crosswinds.

Stopping distances increase considerably when braking traction is lost. Applying brakes to wheels which have already slowed down or nearly stopped due to hydroplaning, does not improve the coefficient of friction between the tire and runway. Tests indicate that at high ground speeds on a wet runway, braking effectiveness is approximately one-third that on a dry runway. In slush, braking effectiveness is approximately one-fifth that on a dry runway.

Pilot Technique for Hydroplaning Conditions

Takeoff Considerations:

Takeoff in slush or on runways with standing water requires special care. Careful planning and using flight manual procedures is mandatory. Refer to TAKEOFF in Section II and to RUNWAY SURFACE CONDITION in T.O. 1E-3A-1-1, Part II.

Landing:

A check with the control tower should indicate braking and wind conditions which can affect ability of the airplane to stop on the runway after landing. Refer to LANDING ON SLIPPERY RUNWAYS, Section II, if water or slush is present on runway.

CAUTION

Paint, rubber deposits, dust, oil and other contaminants make hydroplaning and directional control a problem even at low speeds. Brake early so that only minimal braking is required near the end of the runway where viscous and reverted rubber hydroplaning is more likely to occur.

FLIGHT WITH UNRELIABLE AIRSPEED/MACH INDICATIONS

Unreliable airspeed/Mach indications can contribute to fatal accidents. Erroneous airspeed/Mach indications can be caused by blocking or freezing the pitot static system. Loss of nose radome can also cause unreliable airspeed/Mach indications.

BLOCKED OR FROZEN PITOT SYSTEM

Unreliable airspeed indications can result from blocking or freezing the pitot system. When the ram air inlet to the pitot head is blocked, pressure in the probe is released through the drain holes and the airspeed gradually drops to zero. If the ram air inlet and the probe drain holes are both blocked, trapped pressure within the system reacts unpredictably. The pressure can increase through expansion, decrease through contraction or remain constant. In each case, the airspeed indications are abnormal. This could mean increasing indicated airspeed in climb, decreasing indicated speeds in descent or unpredictable indicated speeds in cruise.

The pilot and copilot have independent pitot-static systems, each with its own power source for anti-icing so the probability of a malfunction occurring in both systems simultaneously is extremely remote. The failure of one system, while easier to recognize, could present a problem in identifying the valid system.

A blocked or frozen pitot and/or static system affects the following primary airplane systems:

a. Airspeed/Mach Indicator

b. Mach/Airspeed Warning

c. Altimeter

d. VVI **LESS IDG** VSI **WITH IDG**

e. True Airspeed

f. Static Air Temperature

g. Rudder Pressure Reducer

h. Autopilot (Altitude Hold)

i. Cabin Pressure

j. INS (Altitude and TAS Inputs)

k. IFF Mode C

l. Flight Recorder

m. Rudder Feel System

n. Flight Director (Altitude Hold)

The charts in *figure 7-1* show the expected indications that can be observed by phase of flight as a result of icing effects on the pitot and/or static systems.

COLD WEATHER OPERATION

Most cold weather operating difficulties are encountered on the ground. The following instructions are intended to supplement the normal operating instructions in Section II and should be followed where applicable. Extreme diligence on the part of both the ground and flight crews is the answer to successful cold weather operation. The airplane is equipped to prevent ice formation on engine inlet areas during flight and to remove frost from the windshield.

ICING DEFINITION

Icing conditions exist when the OAT on the ground and for takeoff is 10°C or below or when TAT in flight is 10°C or below and visible moisture in any form is present (such as clouds, fog with visibility of one mile or less, rain, snow, sleet and ice crystals).

Icing conditions also exist when the OAT on the ground and for takeoff is 10°C or below when operating on ramps, taxiways or runways where surface snow, ice, standing water or slush can be ingested by the engines or freeze on engines, nacelles or engine sensor probes.

WARNING

Depending on the weight of snow, ice or frost accumulated on the airplane, takeoff distances and climbout performance can be seriously affected. The roughness and distribution of the snow, ice or frost varies stall speeds and characteristics to a dangerous degree. Inflight structural damage can result from vibration caused by unremoved accumulations. Therefore, all ice and snow on upper and lower wing and stabilizer surfaces will be removed before flight. Takeoff with light coatings of frost up to 1/8 inch on lower wing surfaces is permissible. Light coatings of frost up to 1/8-inch in thickness on the lower wing surface caused by very cold fuel in the area of the wing tanks (between the front and rear wing spars) are permissible. However, all control surfaces, tab surfaces and balance panel cavities must be free of snow, ice or frost. If deicing is required on any other aircraft surface, the underwing frost shall also be removed. Thin hoarfrost is acceptable on the upper surface of the fuselage and rotodome provided all ports and vents are clear. Thin hoarfrost is a uniform white deposit of fine crystalline texture which usually occurs on a cold and cloudless night and is thin enough to distinguish surface features underneath, such as paint lines or lettering.

Effects of Pitot-Static Icing

PILOT'S AND COPILOT'S SYSTEM

PILOTS' SYSTEMS PITOT PROBES AND PITOT DRAINS ICED; STATIC PORTS OPEN	**CLIMBING FLIGHT PATH**	**CONSTANT ALTITUDE/CRUISE**	**DESCENDING FLIGHT PATH**
Airspeed Indication	Increases	No change or gradual increase	Decreases
Limit Speed Indication	Normal	Normal	Normal
Altitude Indication	Normal	Normal	Normal
Mach Indication	Increases	No change or gradual increase	Decrease
Vertical Speed Indication	Normal	Normal	Normal
Autopilot	Possible degradation of autopilot performance	Normal	Possible degradation of autopilot performance
PITOT PROBES ICED; PITOT DRAINS AND STATIC PORTS OPEN			
Airspeed Indication	Rapid decrease to zero	Rapid decrease to zero	Rapid decrease to zero
Limit Speed Indication	Normal	Normal	Normal
Altitude Indication	Normal	Normal	Normal
Mach Indication	Rapid decrease to minimum indication	Rapid decrease to minimum indication	Rapid decrease to minimum indication
Vertical Speed Indication	Normal	Normal	Normal
Autopilot	Possible degradation of autopilot performance	Possible degradation of autopilot performance	Possible degradation of autopilot performance
PITOT PROBES AND PITOT DRAINS ICED; STATIC PORTS ICED			
Airspeed Indication	Gradual increase or decrease	Gradual increase or decrease	Gradual increase or decrease
Limit Speed Indication	Gradual increase or decrease	Gradual increase or decrease	Gradual increase or decrease

Figure 7-1 (Sheet 1 of 4)

Effects of Pitot-Static Icing (Continued)

PILOT'S AND COPILOT'S SYSTEM (Continued)

PITOT PROBES AND PITOT DRAINS ICED; STATIC PORTS ICED	CLIMBING FLIGHT PATH	CONSTANT ALTITUDE/CRUISE	DESCENDING FLIGHT PATH
Altitude Indication	No change or gradual decrease	No change or gradual decrease	No change or gradual decrease
Mach Indication	Gradual increase or decrease	Gradual increase or decrease	Gradual increase or decrease
Vertical Speed Indication	Zero or slow descent rate	Zero or slow descent rate	Zero or slow descent rate
Autopilot	Possible degradation of autopilot performance	Altitude hold mode: continuous nose-up command possible	Possible degradation of autopilot performance
PITOT PROBES AND DRAINS OPEN AND STATIC PORTS ICED			
Airspeed Indication	Decreases	No change or gradual decrease	Increases
Limit Speed Indication	Gradual increase or decrease	Gradual increase or decrease	Gradual increase or decrease
Altitude Indication	No change or gradual decrease	No change or gradual decrease	No change or gradual decrease
Mach Indication	Decreases	No change or gradual decrease	Increases
Vertical Speed Indication	Zero or slow descent rate	Zero or slow descent rate	Zero or slow descent rate
Autopilot	Possible degradation of autopilot performance	Altitude hold mode: possible continuous nose-up command	Possible degradation of autopilot performance

Figure 7-1 (Sheet 2 of 4)

AUXILIARY SYSTEM

AUXILIARY SYSTEM PITOT PROBES AND PITOT DRAINS ICED; STATIC PORTS OPEN	CLIMBING FLIGHT PATH	CONSTANT ALTITUDE/CRUISE	DESCENDING FLIGHT PATH
Airspeed Switch (Rudder System)	Rudder in high-speed mode	Normal	Rudder in low-speed mode
Mach/Airspeed (V_H/M_h) Switch	Possible false overspeed warning	Possible false overspeed warning	Inoperative
Cabin Differential Pressure Indication	Normal	Normal	Normal
Cabin Pressure Controller	Normal	Normal	Normal
PITOT PROBES ICED; PITOT DRAINS AND STATIC PORTS OPEN			
Airspeed Switch (Rudder System)	Rudder in low-speed mode	Rudder in low-speed mode	Rudder in low-speed mode
Mach/Airspeed (V_H/M_h) Switch	Inoperative	Inoperative	Inoperative
Cabin Differential Pressure Indication	Normal	Normal	Normal
Cabin Pressure Controller	Normal	Normal	Normal
PITOT PROBES AND PITOT DRAINS ICED; STATIC PORTS ICED			
Airspeed Switch (Rudder System)	Possibly locked in low speed mode	Normal	Possibly locked in high speed mode
Mach/Airspeed (V_H/M_h) Switch	Possible false warning or inoperative	Possible false warning or inoperative	Possible false warning or inoperative
Cabin Differential Pressure Indication	Gradual decrease	Gradual decrease	Increases with decreasing cabin altitude
Cabin Pressure Controller	Restricted or no increase in cabin altitude or pressure	Erratic operation	Erratic Operation

Figure 7-1 (Sheet 3 of 4)

Effects of Pitot-Static Icing (Continued)

AUXILIARY SYSTEM (Continued)

STATIC PROBES ICED; PITOT PROBES AND PITOT DRAINS OPEN	**CLIMBING FLIGHT PATH**	**CONSTANT ALTITUDE/CRUISE**	**DESCENDING FLIGHT PATH**
Airspeed Switch (Rudder System)	Rudder in low-speed mode possible	Rudder in low-speed mode possible	Rudder in high-speed mode possible
Mach/Airspeed (V_H/M_h) Switch	Inoperative	Inoperative	Inoperative
Cabin Differential Pressure Indication	Gradual decrease	Gradual decrease	Increases with decreasing cabin altitude
Cabin Pressure Controller	Restricted or no increase in cabin altitude or pressure	Erratic operation	Erratic operation

RUDDER FEEL SYSTEM (Q-SPRING)

PITOT PROBES AND PITOT DRAIN ICED			
Rudder Feel System	Rudder forces increase	Normal	Rudder forces decrease
PITOT PROBE ICED; PITOT DRAIN OPEN			
Rudder Feel System	Rudder forces decrease	Rudder forces decrease	Rudder forces decrease

Figure 7-1 (Sheet 4 of 4)

BEFORE ENTERING THE AIRPLANE

Even though a preflight is completed by the ground crew, the flight crew will make a number of checks in addition to the procedures in section II.

Remove all protective covers. Check engines for internal ice by checking bottom section of front stator blades for evidence of ice and see that all turbine wheels rotate freely. Check pitot tubes and static ports for ice. Ensure all snow and ice accumulations are removed from door openings. Door operation can be difficult if snow or ice builds up in openings.

NOTE

> Engine heat on shutdown melts ice accumulated during flight and the resulting moisture can refreeze in the lower sections of the compressors and turbines. Attempting an engine start under these conditions can result in starter failure. If engine is not free to rotate, apply external heat to forward engine sections to produce thawing. Start engines as soon as possible after the application of heat in order to remove all moisture before refreezing can occur.

Perform the normal section II inspection with the following additions. Check that airplane exterior surface is free of ice, snow and frost. Snow can be removed from the wing and stabilizer areas by using long handled brooms to sweep the surfaces clean of snow. Under conditions of blowing snow or where the airplane is exposed to unusual freezing conditions, the control surfaces balance bays shall be visually inspected for evidence of snow or ice accumulations. Also check rudder actuating mechanism bays. When deicing by applying deicing fluid or by use of portable heaters, flaps should be UP which fairs the outboard ailerons. Hold the yoke horizontal so that inboard ailerons are approximately faired, and spoilers do not rise, while fluid is applied. In the faired position fluid runs off the surfaces. Trim stabilizer full nose down to the electric trim limit (leading edge of horizontal stabilizer up) and hold the control column neutral or slightly forward so that fluid does not run into elevator balance bay areas. Fluid should be applied starting from outer wing toward the wing root and from leading edge toward trailing edge so that fluid is not directed into balance bay areas, unless inspection reveals that ice needs to be removed from balance bay areas. Ensure the balance bay drain holes are open to permit complete draining of area prior to flight. Any ice or slush in the balance bay could limit control surface movement and reduce airplane control. Deice from the leading edge to the trailing edge to prevent runback into the balance bays. All accumulation of snow, ice and heavy frost must be removed from the control surfaces to meet control surface balance requirements. When deicing is completed, grasp the trailing edge of each control surface and move by hand through the full travel to ensure freedom of movement. Do not chip or scrape ice from the surface as this can damage the airplane. MIL-A-8243 Type I and II fluids do not have any holdover times. Anti–icing holdover tables are revised and distributed annually and vary with fluid manufacturer. The Air Force Flight Standards Agency (HQ AFFSA/XOF) manages and makes available the latest authorized tables for Air Force use. Refer to local operation procedures for implementation instructions. These tables determine approximate times until ice starts to reform (functions of anti–icing fluid type and concentration, temperatures, and precipitation type and rate.) Holdover times are to be used only as a guide and must be used in conjunction with the required inspections to unsure the critical areas are clean before takeoff. Holdover time is the estimated time anti-icing fluid will prevent frost, ice or snow from accumulating on the protected surfaces of an aircraft under average weather conditions.

WARNING

- Deicing /anti–icing procedures are designed to prevent fluid from entering control surface balance bay cavities. Repeated or improper application of Type II or Type IV fluids, without subsequent application of Type I fluid or hot water, can cause a residue to collect in these cavities and other aerodynamically quiet areas. This residue can rehydrate and freeze under certain temperature, high humidity and /or rain conditions. This frozen residue can block or impede critical flight control systems.

- Do not transmit on HF radios while deicing/ anti–icing fluid is being applied. HF radio transmissions cause standing wave voltages on airplane skin which can couple through fluid stream to deicing truck or person operating nozzle. Electrical shock could startle operator, causing injury.

- During weather conditions with freezing precipitation (snow or ice), all available means should be used to ensure flight surfaces are clear of snow and ice immediately prior to takeoff. Regardless of holdover time, under no circumstances will takeoff be attempted with snow or ice on any flight surface.

- During preflight, check to see that the airplane is free of snow, ice or frost. When in doubt, follow recommended snow, ice or frost removal procedures.

- Light coatings of frost up to 1/8-inch in thickness on the lower wing surface caused by very cold fuel in the area of the wing tanks (between the front and rear wing spars) are permissible. However, all control surfaces, tab surfaces and balance panel cavities must be free of snow, ice or frost. If deicing is required on any other aircraft surface, the underwing frost shall also be removed.

- Snow will be removed from the nose radome because it tends to blow back on the windshield during takeoff and restrict visibility during this critical period.

- Snow, ice or frost will be removed from the upper wing surface. Do not assume that snow will blow off the wings. A layer of ice can be under the snow.

- Snow, ice or frost will be removed from the fuselage and rotodome upper surface. Heating the pressurized compartment could result in melting of snow and ice on top of the fuselage. As a result, ice could form in the vicinity of the pitot heads and static ports, deforming the airflow and causing inaccurate airspeed indications. Thin hoarfrost is acceptable on the upper surface of the fuselage and rotodome provided all ports and vents are clear. Thin hoarfrost is a uniform white deposit of fine crystalline texture which usually occurs on a cold and cloudless night and is thin enough to distinguish surface features underneath, such as paint lines or lettering.

- An extremely thin layer of frost on the upper wing surface and snow or ice on any surface can degrade performance seriously. Snow, ice or heavy frost accumulations can increase takeoff distances and affect climbout performance, stalling speed and handling characteristics adversely. In flight, structural damage can result from vibrations caused by unremoved accumulations. Extremely thin layers of frost on the upper wing surface can increase stall speeds significantly and affect pitch handling characteristics adversely, causing overrotation into a stall using normal rotation procedures.

- If fuel temperature is below 0°C and below dewpoint, check upper wing surface for frost after refueling.

- Application of deicing/anti-icing fluids may require adjustments to airplane performance, use procedures in T.O. 1E-3A-1-1.

CAUTION

- Light accumulations of snow may be removed by applying hot deicing fluid. Heavier accumulations (greater than one inch in depth), will be removed prior to deicing using procedures in T.O. 1E-3A-2-7.

- Exercise care when removing snow from the wing where vortex generators are installed since these can be damaged.

- If deicing fluid is used, exercise care to prevent contact with plexiglas or plastic since deicing fluid tends to craze or soften these materials.

- If APU is operating, do not spray deicing fluid where spray or liquid can enter APU inlet. Close the APU bleed air value. If deicing fluid liquid or spray is ingested, the air-conditioning system and airplane equipment could be contaminated by smoke.

- Do not direct high pressure fluid flow in a focused, concentrated stream against the ESM antennas or flat radome surfaces. Also, do not direct high pressure fluid flow in a focused, concentrated stream, along the edges of the ESM antennas and at the side fairing panel joints. Antenna damage or fluid leakage into antennas or fairing enclosures may result. Maintain a minimum distance of 6 to 8 feet between the nozzle and structure. A conical or fan spray pattern should be applied at a glancing or indirect angle toward ESM antenna radome surface and fairing panels.

Ensure all dirt or ice is removed from landing gear shock struts, actuating cylinder pistons and limit switches. Ensure exposed parts of shock struts and pistons are wiped with a rag soaked in hydraulic fluid. Check batteries installed and fully charged.

Remove all snow and ice from door openings and edges of doors. Doors and hatches can fail to open if snow or ice builds up in door openings.

ON ENTERING THE AIRPLANE

Flight deck seats can be difficult to adjust if cold-soaked below -20°F (–29°C). It can be necessary to fasten seat belts and shoulder harness in order to adjust seats.

Check control surfaces and trim tabs for proper operation. Operate all control surfaces several times to determine if operation is normal and not hampered by ice in hinge joints, which could not be seen during visual check of the airplane.

NOTE

- If APU has been cold-soaked at temperatures below –40°C, two or more attempts can be required to start APU.
- Increase in control forces during low temperature ground checks can be expected due to binding, cable seals and congealed oil in the snubbers and bearings.
- Fluorescent lights do not operate properly in temperatures below +45°F (+8°C).

BEFORE STARTING ENGINES

Make sure that wheel chocks are placed securely so danger of slipping is minimized during engine start and warmup. Operate brakes several times with increasing pressures before setting parking brakes.

NOTE

Compute takeoff N_1 as a backup for EPR in icing conditions.

STARTING ENGINES

Start engines as described in section II. If engines do not start, ground heating can be used to warm starter valve fuel control unit and ignition system. Starting air pressure range is 20 to 60 psi; however, in cold weather and low pressure altitudes, engines usually require close to 60 psi for a proper start. If air pressure does not drop during cold weather start, starter valve is probably frozen. Use external heat to warm valve, or use manual start procedure in section II. Use engine and nacelle anti-ice any time engine is operating and ambient temperature is at or below 10°C and visible moisture such as fog, rain, or wet snow is present.

CAUTION

If start valve opens but engine rotation is not observed, discontinue start. If engine rotor is frozen, starter damage could result from attempting to start engine.

NOTE

- If airplane is fueled with fuel other than JP-4, engine (and APU) starting can be difficult or impossible if fuel temperature is below –30°C (–22°F).
- When starting engines, the OIL PRESS caution light may remain illuminated, or illuminate intermittently, for up to four minutes after the oil temperature reaches 40°C at idle rpm. The light shall be out four minutes after the oil temperature reaches 40°C.
- On an extremely cold engine, motor engine one minute without fuel prior to starting. This provides quicker starts and reduces accessory drag.
- If airplane is fueled with fuel other than JP-4 or AVGAS, fuel enrichment may be used for starting below 32°F (0°C).
- If airplane is fueled with fuel other than JP-4 or AVGAS, fuel enrichment must be used for starting below 0°F (–18°C).

Check instruments for normal operation and monitor wing flap operation.

WARNING

- In cold weather, ensure all instruments have warmed up sufficiently to ensure normal operations.
- For operation in icing conditions, ensure all anti-ice systems are fully operable.
- On engine run-ups, avoid blowing snow, slush, ice, or water toward flight controls, rear fuselage, or other airplanes.

CAUTION

- Continuous operation of engine inlet anti-ice system above 10°C can cause damage to the engine.
- In severe icing conditions (heavy super cooled fog, freezing rain or wet snow) ice buildup can form on engine inlet guide vanes and the early stages of the compressors during extended ground idle operations with anti-icing air ON. Periodic engine run-ups to as high a thrust setting as practical (at least 55% N_1), dependent on parking area and taxiway conditions, can minimize these ice buildups. Such run-ups should approximate 10 seconds duration every 10 minutes. Subsequent takeoff under these conditions should be immediately preceded by a static engine run-up for observation of EPR, N_1, and EGT to ensure normal engine operation. If surface conditions prevent advancing power enough to dissipate inlet icing or icing remains visible on the inlet cowl or guide vanes, takeoff will not be attempted.
- If engines and/or APU are operating, do not spray deicing fluid where spray or liquid can enter engine or APU inlet. All engine and APU bleed air switches shall be turned to the off position during deicing. Engines should be at idle power during deicing.

NOTE

- The indicated oil pressure can be slow to rise to the normal operating range after starting a cold soaked engine. If some indication of oil pressure is observed when the engine is first started, allow a maximum of three and one half minutes for the indicated oil pressure to reach the minimum limit.
- In extremely cold weather operation, generators can be slow to produce steady power due to cold oil in IDGs. Usually less than one minute is enough time for the IDG to stabilize sufficiently, although up to 5 minutes is within limits. Operate generators isolated until AC voltage and frequency are stable, then close bus tie breakers.
- Do not turn on unnecessary electrical equipment until generators show output.
- Pt_2 probes are deiced when nacelle anti-ice is on.

TAXIING

If snow or slush conditions exist on taxi strips, maintain inboard engine thrust at IDLE; thrust settings above idle on inboard engines can blow snow and slush back on aft fuselage and tail surfaces causing a hazardous flight condition. Use outboard engines for taxi or turning as necessary. Reduce speed and increase normal taxi interval between airplanes on ice or snow covered area. Be especially careful in maneuvering near other airplanes as the blast of the engines develops a great deal of ice on the ramp and takeoff area of the runway and blows snow and slush which freezes into ice on contact. Avoid taxiing in deep snow or slush as steering is more difficult; and brakes, gears, and flaps freeze after takeoff. Do not taxi with flaps down. Exercise the flight controls frequently to check for freedom of movement. During taxiing, exercise the nose wheel steering in both directions to permit the circulation of warm hydraulic fluid through the nose wheel steering cylinders. This minimizes the lag encountered in nose wheel steering at low temperatures.

WARNING

- If the flaps are left up during taxi to avoid slush and ice, complete the BEFORE TAKEOFF checklist after flaps are in takeoff configuration.
- If rotodome is operated at 6 RPM to warm fluid, set SPEED switch to IDLE (1/4 RPM) before takeoff.

CAUTION

- Use extreme caution when taxiing on ice-covered taxiways or runways, as excessive speed or high crosswinds can start a skid. Make all turns at reduced speed. Also, be alert for extreme slipperiness at the approach end of snow-covered runways. The intense heat produced by jet engine blasts can form ice due to melting and refreezing. When taxiing in light powdery snow, it is possible for the air blast from the engine surge bleed valve to blow snow into the flap track area with possible subsequent freezing of flap jack screws. This could cause serious damage to flap mechanism.
- If engines and/or APU are operating, do not spray deicing fluid where spray or liquid can enter or APU inlet. All engine and APU bleed air switches shall be turned to the off position during deicing. Engines should be at idle power during deicing.

NOTE

Taxi time on snow and ice is longer than under normal conditions, so plan the shortest possible route to takeoff point to conserve fuel and reduce the amount of ice fog generated by jet engines. This fog can delay takeoff by lowering the visibility below takeoff minimum.

BEFORE TAKEOFF

Before taking the runway, set flaps to 14.

CAUTION

When operating flaps at low temperatures, observe flap position indicators and leading edge flap lights for positive indication of flap movement. If a flap stops, set flap lever immediately to the same position indicated by the position indicators to prevent damage to flap linkage.

Check for movement of flight controls in both directions. Pilots confirm that leading edge flaps are extended and that wing surfaces and engine inlets are clean.

WARNING

Wing and tail contamination result in reduced wing lift capability and can lead to a stall within the normal takeoff maneuvering envelope before stick shaker activation. The airplane is also mistrimmed in the nose up direction, reducing pitch stability and tends to pitch up easily. Expect higher than normal rotation rate for the same stick force input. Be ready to counteract.

Check free movement of rudder in both directions. At temperatures below –18°C, the rudder will be checked for proper operation. The rudder must be capable of full travel in the manual mode. In the powered mode, the rudder must be capable of moving from stop to stop in one second. Engineer monitors hydraulic gages.

WARNING

Failure to check for adequate rudder movement rate before takeoff could result in loss of the airplane. If the rudder cannot be moved from stop to stop in one second, the V_{MC} performance in T.O. 1E-3A-1-1 cannot be achieved and airplane could be lost if an engine fails on takeoff.

When fuel temperature is 0°C or below, turn on fuel heat for one minute before takeoff. Complete BEFORE TAKEOFF checklist. Observe time limit for effectiveness of deicing agent.

WARNING

Application of deicing/anti-icing fluids may require adjustments to airplane performance, use procedures in T.O. 1E-3A-1-1.

CAUTION

If engines and/or APU are operating, do not spray deicing fluid where spray or liquid can enter engine or APU inlet. All engine and APU bleed air switches shall be turned to the off position during deicing. Engines should be at idle power during deicing.

TAKEOFF

Ice and light coverings of powdery snow on the runway have little effect on takeoff acceleration, however, they affect stopping capability. Refer to part II of T.O. 1E-3A-1-1 to determine their effect on takeoff planning. The rolling resistance of a tire in 3 inches of dry snow is about 4 times that of a tire on dry concrete. Slush and water on the runway also affects takeoff performance. If they remain on the runway, slush and water reduces takeoff acceleration by increasing rolling resistance. The crowned runway design normally allows water to drain away quickly; however, slush is a variable semi-liquid that stays in place on the runway.

Taking off in slush can produce two affects. The most serious is the possibility of the airplane not attaining takeoff speed before reaching the end of the available runway. Slush on the runway can damage the airplane from impingement or by freezing in the flap mechanism.

WARNING

- Snow, slush, or water on the runway can increase takeoff and stopping distances significantly. Refer to part II, T.O. 1E-3A-1-1. Wet dense slush, which results when packed snow partially melts, presents the worst takeoff condition.

- Takeoff will not be attempted with over 1/2-inch of wet snow, slush, or standing water on runway. With slush or water on the runway, airplane structure can be damaged by slush or water impinging on the airplane, especially at high speeds. If possible, avoid known slush or water puddles.

- Takeoff will not be attempted with over 3 inches of dry, powder snow on the runway.

- Reduced thrust takeoffs are prohibited with standing water, ice, slush, or snow on the runway (a reported RSC).

- Under certain conditions, jet engine icing can occur without wing icing. Icing occurs when adiabatic expansion reduces the air temperature in the engine inlet and ingested water droplets impinging on the engine inlet components freeze. Jet engine icing can occur during ground and takeoff operations, when the airplane velocity is low and engines are operated at idle or above thrust settings. Use nacelle anti-icing during climb when visible moisture is present at temperatures below +10°C, particularly at altitudes below 20,000 feet. Visible moisture is defined as clouds, rain, wet snow, or fog with one mile visibility or less.

- In freezing precipitation, make a physical check of the surfaces, pitot masts, and static ports just before takeoff. From the flight deck, it is difficult to see coatings of as much as 1/4 inch of clear ice on the wings. If precipitation freezes on the surface of the airplane, apply deicing fluid not more than 30 minutes before takeoff. Do not attempt takeoff if freezing precipitation is adhering to wings, control surfaces, or rotodome.

NOTE

Remove large glaze ice formations which can develop on the empennage during takeoff by accelerating the airplane at low altitude to raise its indicated temperature several degrees above freezing. At cruise airspeeds, ram air temperature can be increased 8°C by a 100 KIAS increase. In cruise, ignore glaze ice less than 1/2-inch thick and rime ice, as the cruise drag penalty is small.

TAKEOFF TECHNIQUE

When lined up on takeoff runway, check movement of elevators, ailerons, spoilers and rudder again. Check engine inlet guide vanes and nose cowls clean. When needed, use fuel flow of more than 1,500 lb/hr to dissipate inlet icing.

WARNING

If surface conditions prevent advancing engine thrust to dissipate ice, or if ice remains visible on nose cowls or inlet guide vanes, takeoff will not be attempted. Return to ramp for deicing.

When engines look clean and airplane is cleared for takeoff, perform an engine run-up leading into a rolling takeoff. Advance all throttles to vertical and allow engines to accelerate. This procedure also minimizes thrust asymmetry caused by differences in individual engine acceleration, aids in preventing overshooting the desired thrust setting and eliminates engine surges caused by crosswinds. Repeat this run-up on subsequent takeoffs to observe EPR, N_1, EGT and check normal engine operation.

During the start of takeoff roll, advance throttles smoothly to takeoff EPR. Final takeoff thrust adjustments before 80 KIAS are made by the engineer.

NOTE

No engine warmup is required. Observe oil pressure limitations in section V.

During takeoff on icy or snow-covered runways, the pilot must realize the lag in nose wheel steering and the possibility of nose wheel skidding and anticipate corrections. The ailerons can be used for increased directional control between 60 and 100 KIAS. Refer to part II of T.O. 1E-3A-1-1 for takeoff crosswind limitations for various RCRs.

CAUTION

Low OAT can cause the airplane operating limitations to be reached with somewhat lower throttle lever angles.

AFTER TAKEOFF

CAUTION

During operation at low gross weight and particularly at low ambient temperatures, the airplane accelerates very rapidly; therefore, take care not to exceed the flap placard speeds during flap retraction.

CLIMB

Follow normal procedures for climb. Ice collected during climb reduces the rate of climb and range but sublimates after reaching cruise altitude.

WARNING

Icing conditions can be indicated when the airplane seems to be mistrimmed and tends to pitch nose-up without adequate stick force input. Counteract higher than normal rotation rates. Lower nose for a climb rate of 500 ft/min until airspeed increases to V_{CO} + 25 KIAS after takeoff, 250 KIAS after flap retraction, and 280 KIAS above FL 100 (10,000 feet) for better safety margin above stall. Observe obstacle requirements.

NOTE

- Icing of the Pt_2 probe causes a change in EPR depending on changes in altitude and airspeed.
- Check icing of the Pt_2 probe by turning nacelle anti-icing on. If icing is present, indicated EPR drops drastically then increases to normal.
- In icing conditions, always include N_1 in your crosscheck.

DURING FLIGHT

Follow normal procedures and use ice protection as required. Monitor the fuel icing lights, and the fuel temperature in main tanks; if a fuel icing light illuminates, or the fuel temperature in any main wing tank (TAT if using center tank) drops to 0°C or below and using fuel without icing inhibitor (fuel other than JP-4, JP-5, or JP-8; NATO F40, F-44, or F-34), turn on the fuel heaters on all engines for one minute at 30 minute intervals. Fuel transfer (from reserve tanks) or air refueling, with fuels other than JP-4 takes longer at low temperatures.

Occasionally, small quantities of water in the burner pressure sensing line can cause a hung engine deceleration or high flight idle rpm condition. This usually results from ice formation in the fuel control signal line or within the fuel control, which creates a false burner pressure signal. If this situation occurs, turn on fuel heat for a period not to exceed one minute. If the application of fuel heat for one minute appears to help, but does not completely clear the difficulty, repeat the one minute application of heat at intervals as often as necessary.

CAUTION

Excessive continuous operation of the fuel heater can cause overheating of the engine oil. Monitor oil temperature.

NOTE

The fuel temperature in center tank, reserve tank, or a tank without operating LCS heat exchanger is approximately halfway between SAT and TAT. Since center and reserve tanks do not have temperature probes, assume fuel is at TAT to determine when to use fuel heat.

No wing anti-ice protection is provided. Ice less than 3 inches thick has little effect on airplane handling in cruise; therefore, the ice accumulation can be allowed until the icing condition passes. Buffet and stall speeds increase about five knots for each inch of ice on the leading edge. During flight, the bolts on the windshield wiper arms give the first indication of ice forming on the airplane. Severe icing conditions can be indicated if ice begins to build up on pilots' front windshield.

Operation with the leading edge and trailing edge flaps extended for prolonged periods in icing conditions is not recommended. If trailing edge flaps are extended in icing conditions, retraction to less than 25° is not recommended until ice is shed or a ground inspection is made.

CAUTION

- Do not operate nacelle anti-ice above 70% N_1 power when total air temperature is above 10°C unless visible moisture is present. Operation of nacelle anti-ice for more than 10 seconds under these conditions can damage the engine.
- Erratic EPR reading or abnormal EPR relative to N_1 can be an indication of icing on Pt_2 probes and engine inlet.

If icing conditions cannot be avoided, turn on continuous ignition, followed by nacelle anti-ice prior to entering the expected icing area. Activate the system in symmetrical pairs, with sufficient hesitation after activating nacelle anti-ice for each pair to ensure that engine operation is normal. Operate the engines at as high a power setting as practical to obtain the most effective anti-icing protection. Ice buildup on the nose cowl leading edge or nose cone has little effect on engine performance unless large amounts of ice (greater than one inch) are allowed to accumulate.

If ice (greater than one inch) builds up in the engine inlet, engine surge followed by compressor stall and loss of thrust can occur. If ice accumulates on the nose cowl leading edge or nose cone through system malfunction or exceeding the system anti-ice capability, operate the engine at the minimum power practical until the ice accumulation is ingested. This procedure minimizes the possibility of compressor damage.

CAUTION

- In actual icing conditions, with ice buildup, set throttles to as low a setting as practicable, but not below 55% N_1 and turn the continuous ignition on, prior to activating the nacelle anti-icing system. This reduces the possibility of an engine flameout due to inlet ice ingestion.
- The nacelle anti-icing system is designed as an anti-icing system rather than a deicing system; therefore, during potential icing conditions, turn on the system before ice buildups occur.

NOTE

At the relatively high thrust settings used during climb or cruise, ample heat is provided to assure protection. However, during descent at high airspeeds and low thrust settings, the heat supplied can be inadequate if the ice formation is moderate to heavy. Under such circumstances, apply increased thrust in order to provide more heat. If ice is still accumulating in the compressor inlet, surge can occur when the throttle is advanced, indicating that a slower airspeed is necessary until departing the icing region. Descend through light to heavy icing conditions as quickly as possible.

DESCENT

Follow normal procedures for descent, including ice protection system operation if required. When descending through visible moisture and icing conditions exist, set throttles to minimum of 55% N_1 at indicated TAT at or below +10°C. If severe icing conditions are anticipated (as indicated by visible moisture and TAT below –7°C) set throttles to a minimum of 70% N_1. Turn on continuous ignition, followed by nacelle anti-ice, before entering icing conditions.

BEFORE LANDING

If large ice formations remain on wing leading edge or leading edge flaps, add 10 knots (at pilot's discretion) to the reference speed for approach and landing to maintain normal handling characteristics.

LANDING

Use landing procedures listed below for landing on slippery runways, and part VII of T.O. 1E-3A-1-1 for the effects of slush or ice on landing performance. Ice accumulation on the stabilizer can require additional nose-up trim at landing flap settings. Use of manual stabilizer trim can be required.

CAUTION

- If runway is covered by slush or snow and airplane is cold soaked or temperature is near or below freezing, do not retract flaps above 25 until ground crew can verify jackscrews are free of ice and/or snow.
- To protect aileron control system from wind damage on the ground, flaps should be retracted to lock out outboard aileron when airplane can be subjected to wind of 35 knots or more.

LANDING ON SLIPPERY RUNWAYS

Operate the airplane during the approach in a way that minimizes stopping requirements after touchdown without running the risk of landing short.

Aim for a touchdown 1,000 to 2,000 feet from the approach end of the usable runway. While it is important not to land long, it is more important not to land short of the runway. If an unsatisfactory approach is likely to cause a touchdown far down the runway, go around and make a second approach.

Maintain close control over approach speeds and maintain speed recommended for the existing conditions. Control glide slope path to touch down on the runway at approximately 1,000 to 2,000 feet from the approach end of the runway. Fly the airplane smoothly onto the runway at the aiming point even if speed is excessive. See *figure 2-13*.

Once on the ground, use the technique described in BRAKES AND ANTISKID, section II. Timely execution of the following actions permits stopping the airplane with the shortest landing roll.

Extend the speedbrakes as soon as the main gear contacts the runway. Speedbrakes reduce lift, increase drag and increase the main gear loading. Quick extension of the speedbrakes is important because the effects of reduced lift and increased drag are additive in shortening landing distance.

Lower the nose wheels as the speedbrakes are extended. This is desirable because establishing the airplane in a taxi attitude decreases lift, increases main landing gear loading and improves directional stability. Do not hold the nose off and delay braking as aerodynamic braking is relatively ineffective.

Immediately after the nose wheel touches down, apply moderate, steady brake pedal pressure until a safe stop is assured. If wheels appear to be locked, release brake pedal pressure one to two seconds and allow wheels to spin up before applying brakes. Increase brake pedal pressure as airplane speed decreases.

If a skid develops across the runway using normal stopping procedures, release pressure to both brakes. Keep the wings level. Immediately apply rudder and differential braking to bring the airplane back to the centerline. When the airplane is again rolling parallel with the runway and near the centerline, apply brake pedal pressure to develop maximum braking until a safe stop is assured.

Reducing braking effectiveness due to excessive anti-skid cycling on one side can cause airplane to veer toward one side of the runway. Corrective action for this is to release pressure to both brakes, then use rudder and differential braking as required. When airplane is again headed toward center of runway, apply steady brake pedal pressure to develop maximum braking. Reducing pressure to rapidly cycling brakes increases directional control capability.

Avoid large, abrupt steering and rudder pedal inputs that can lead to overcontrol and skidding. Rudder control is effective down to between 60 and 40 knots. Maintain directional control and wings level with appropriate control inputs. The optimum nose wheel steering angle varies with runway conditions and airplane speed and is about 1 to 2 degrees for a very slippery runway. When using nose wheel steering, keep a firm forward pressure on the control column and the wings level. Do not attempt to turn off from a slippery runway until speed is reduced to a safe level to prevent skidding. Monitor ground speed on INS.

CAUTION

Paint, rubber deposits, dust, oil and other contaminants make hydroplaning and directional control a problem even at low speeds. Brake early so that only minimal braking is required near the end of the runway where viscous and reverted rubber hydroplaning is more likely to occur.

POSTFLIGHT

If it is anticipated that ice and snow can accumulate on the airplane after parking, place wing flaps to full up position, set horizontal stabilizer 2.5 units airplane nose down. Have wheel chocks in place so parking brakes can be released. If moisture enters brake assembly, leave parking brakes released to reduce possibility of brakes freezing in position. Service airplane with fuel and oil and drain all sumps before condensates reach freezing point. Check that all plugs and protective covers for intakes, exhausts, pitot tubes, landing gear etc., are installed if there is the slightest possibility of blowing or drifting snow. Remove ice and dirt from shock struts. If freezing, and airplane is not heated, drain all water systems. Ethylene glycol automotive antifreeze can be mixed with the toilet tank charge.

The airplane batteries, GINS batteries, and emergency lighting batteries must be removed if the batteries are expected to be subjected to temperatures of less than –18°C (0°F) for 4 hours or more. Cold soaking reduces battery output and prevents charging until the battery is warmed. When removing batteries from the airplane due to cold temperatures, always store them in a warm place. The batteries need not be removed if the airplane is warmed by operating the APU, or by external heaters.

HOT WEATHER AND DESERT OPERATIONS

Perform the normal section II procedures with these additions. High ambient temperatures on the ground have important effects on airplane performance, on the crew and in the general operating efficiency. High temperatures, alone or coupled with high humidity or blowing sand and dust, complicate normal operations. Proper protection and inspection of the airplane while it is on the ground and observance of the precautions covered in this section ensure successful operation.

High temperatures inflict performance penalties which must be taken into account on the ground before takeoff. When the effects of high temperature are combined with short runways, performance penalties can affect the takeoff gross weight. Study T.O. 1E-3A-1-1 carefully to determine the adverse effects of high temperature on airplane performance.

Make every effort to keep the interior of the airplane as cool as possible. Keep all doors to the airplane closed as much as possible. Do not open the flight deck windows. Turn off window heat and electronic equipment which contributes to a high temperature level while the airplane is exposed to high airport temperatures at in-transit stops. In addition, leave the gasper fan switch on, and the outlets open.

During short stops, use cooling air from the APU, or if available, from an outside source, from immediately after engine shutdown until just prior to engine start.

BEFORE ENTERING THE AIRPLANE

Cool the airplane with APU or a portable air conditioner if one is available. Inspect more closely tires and shock struts for proper inflation and accumulators for proper air charge. Be alert for hydraulic leaks. Clean dust and sand from struts and other hydraulic pistons and from limit switches. Inspect hatch and door seals for deformation and damage due to high temperatures. Remove all protective covers and dust plugs. Be sure that the airplane is positioned to avoid sandblasting other equipment during start and run-up.

HOT DAY CABIN COOLING

CAUTION

> The maximum cabin temperature is 100°F for startup and continuous ground operation of avionics cooled by the draw through cooling system and the forced air cooling systems when operating in the ENG/APU mode.

In this configuration, air for these systems comes from the cabin. To cool the cabin to the 100°F limit, cool the cabin with air conditioning system, but monitor aft forced air cooling system duct temperature on the SUPPLY AIR gage. In severely hot weather, it can take up to 40 minutes to cool the cabin to 100°F. The pressurization mode switch must be set to LANDING. If both forward and aft forced air systems are operated, the lower forward cargo door must be open approximately one foot to provide air and keep cabin temperature balanced. Close outflow valve vacuum pump circuit breakers. (Keep all other doors and hatches closed.)

AFTER ENTERING THE AIRPLANE

Check instruments and electrical equipment for excessive moisture due to high humidity. If operating in a dusty location, check for accumulated dust at control, instrument, and electronic equipment areas inside the airplane. Check that survival kits appropriate to the climate are stowed aboard.

STARTING ENGINES

Complete as much of the preflight as possible before starting the engines to minimize the duration of engine ground operation. Use normal starting procedures. When using engine bleed or APU bleed air for engine start, use minimum of 35 psi at sea level (density altitude). The duct pressure can be reduced one psi per 1,000 feet of density altitude. The engines accelerate to idle more slowly than on a normal or cold day since the air is less dense. Since engine oil is cooled by fuel, oil temperature can be somewhat higher. If fuel temperature exceeds the limits shown in section V, do not operate the engine.

TAXIING

Use brakes as little as possible during taxiing since brake cooling is retarded by high ambient temperatures. Keep sufficient distance between airplanes to prevent sand and dust from blowing into the engines. Taxi with inboard engines only if possible.

CAUTION

> When operating in areas with high ambient temperatures, it is possible for brake temperatures to reach the fuse plug melting point, causing flat tires. Brake cooling should be considered when operating on runways and taxiways exposed to high temperatures, since these areas usually are hotter than ambient air. Avoid excessive brake use and riding brakes. Monitor GINS groundspeed. Intermittent brake use provides a cooling period between applications. Allow the airplane to accelerate, brake to a slow taxi speed, and release brakes completely.

TAKEOFF

Be prepared for sudden gusts of wind during takeoff. Observe takeoff and climbing speeds during extreme high temperature operations because airplane performance decreases with temperature rise. Takeoff distances increase significantly as the temperature rises.

NOTE

> Takeoff gross weight from high altitude airports at high temperatures can be limited by maximum braking speed.

DURING FLIGHT

Avoid flying through dust or sand storms to prevent damage to the engines. At low altitudes monitor duct temperature in forced air cooling systems.

APPROACH AND LANDING

Follow normal landing procedures. Since the air is less dense, true airspeeds are higher at the same indicated airspeeds and true stall speeds are higher. Do not attempt approaches at less than recommended V_{REF} speed over the end of the runway. Anticipate longer ground rolls. Refer to RAIN AND SLUSH OPERATION, Reverted Rubber Hydroplaning, this section. Avoid excessive use of brakes to prevent overheating. Taxi with inboard engines only is recommended.

STOPPING ENGINES

Use the normal procedure for stopping the engines. Insert wheel chocks as soon as the airplane is parked and release the parking brakes to aid in brake cooling. After maximum performance landings or excessive braking, have personnel stay clear of the main landing gear areas as much as possible until the brakes have cooled.

BEFORE LEAVING THE AIRPLANE

Have all protective plugs and covers installed. Except in dusty or rainy weather, leave the doors and hatches open for ventilation and open the nose and main landing gear wheel well doors.

NOTE

> In dusty locations, if it is necessary to leave hatches or doors opened, protect all equipment inside the airplane with dust-proof covers where possible to keep out blowing dust and sand.

GLOSSARY

STANDARD AND NONSTANDARD ABBREVIATIONS

A

A/A – Air-to-Air Mode (TACAN)

A/A REC – Air-to-Air Receive (ARN-118 TACAN)

A/A T/R – Air-to-Air Transmit/Receive (ARN-118 TACAN)

Abort – Discontinue (Reject)

AC, ac – Alternating Current

ACM – Air Cycle (Air Conditioning) Machine

ACU – Antenna Control Unit

ADC – Air Data Computer (See CADC)

ADF – Automatic (Radio) Direction Finder

ADI – Attitude Director Indicator

ADS – Audio Distribution System

ADU – Auxiliary Display Unit

AE – Antenna Electronics

AFAC – Avionic Forced Air Cooling

AGL – Above Ground Level

AHRS – Attitude/Heading Reference System

AIMS – Aircraft Identification Military System

Aircraft Commander – Pilot in command. When used for switch or circuit breaker label, refers to left (pilot) seat.

AIU – Antenna Interface Unit (BI Equipment)

ALM – Almanac

ALT – Altitude

ALE – Automatic Link Establishment

AM – Amplitude Modulation

AMP, amp – Ampere(s)

ANN – Annunciation

ANT STAB – Antenna Stabilization (APS-133)

AOA – Angle of Attack Normalized. (Angle of attack expressed as a fraction of angle of attack for maximum lift).

A/P – Autopilot

APC – Auxiliary Power Contactor (APU power contactor)

APU – Auxiliary Power Unit

A/R – Air Refueling

ARR – Air Refueling Receiver

ART – Airborne Radar Technician (Radar Operator). (Refer to T.O. 1E-3A-43-1-1).

Asymmetric – Not Symmetrical (Unequal on Opposite Sides of a Center Line)

ATC – Air Traffic Control

AUX – Auxiliary

AV – Air Vehicle (Airplane). Used in designation of electrical buses.

AVAC – Air Vehicle (Airplane) Alternating Current

AVDC – Air Vehicle (Airplane) Direct Current

B

BARO – Barometric

BAT (BATT) – Battery

BATH – Best Available True Heading

BBTR – Battery Bus-transfer Relay

BC – Bus Controller

BCR – Battery Charger Relay

BDP – Baseband Distribution Panel

BFO – Beat Frequency Oscillator

BI – Broadcast Intelligence

BIT – Built-in-Test

BOC – Bottom of Climb

BOD – Bottom of Descent

BPCU – Bus Power Control Unit

BR – Battery Relay

BSIU – Bus Subsystem Interface Unit

BTB – Bus-tie Breaker

BU – Battery Unit (of INS)

BUG – Reference marker on an instrument. Can be set to a predetermined value.

BUG Speed – The airspeed at which the bug on the airspeed indicator is set for an airspeed reference.

C

CADC – Central Air Data Computer

CADS – Central Air Data System

CALM – Coarse Air Level Mode (of INS during inflight alignment)

can – Is capable of. Does not imply permission to perform. Refer to may in introduction.

CAS – Calibrated Air Speed. Airspeed corrected for instrument error.

CB – Circuit Breaker (appears in circuit breaker labels)

CBIT – Continuous BIT

CDI – Course Deviation Indicator (see AFM51-37)

CDMT – Computer Display Maintenance Technician (Computer Operator). (Refer to T.O. 1E-3A-43-1-1).

CDU – Control Display Unit (for GINS)

CEP – Circular Error Probable

CG c.g. – Center of Gravity. Usually expressed as a percentage of mean aerodynamic chord (MAC).

CIR – Circle

CP – Copiolot, (Pilot in right seat.) When used in a procedure, indicates step normally performed by copilot.

CPS – Control, Power Supply (Sec IAU). (Refer to T.O. 1E-3A-43-1-1).

CRP – Closed Random Pattern

CRPA – Controlled Reception Phased Array

CSD – Constant Speed (generator) Drive

CSO – Communication Systems Operator

CSU – Central (communications) Switching Unit (also Crew Service Unit)

CT – Communications Technician

CVd – Cryptovariable, Daily

CVR – Cockpit Voice Recorder

CVw – Cryptovariable, Weekly

°C – Degrees Celsius (Centigrade) (for Celsius/Fahrenheit conversion). (Refer to T.O. 1E-3A-43-1-1).

D

DA – Drift Angle (Readout of INU)

DAPG – Data Analysis Programming Group (computer). (Refer to T.O. 1E-3A-43-1-1).

DC, dc – Direct Current

DCL – Declination

DCU – Digital Computer Unit (of Inertial Navigation Set)

DDC – Display Data Controller. (Refer to T.O. 1E-3A-43-1-1).

DDM – Digital Decoder Module

DDS – Digital Data Serial

DF – Direction Finder (Finding)

DFDR – Digital Flight Data Recorder (or Flight Recorder)

DH – Decision Height. The height, above ground, above which the decision must be made (during a precision instrument approach) to land or to execute a missed approach.

DIR – Direct-To

DLDR – Data-Loader

DLY – Delay (APS-133)

Doppler (DPLR) – Doppler (Radar) Navigation Set, AN/APN-213

DPLR/Ω – Doppler Omega. Mode of operation of Navigation Computer System.

DSRTK – Desired Track (Readout of INS)

DTK – Desired Track

Dutch Roll – A combined roll/yaw oscillation of swept wing airplanes.

E

EAC – Emergency AC (Bus)

EACR – Emergency AC Relay

ECM – Electronic Counter Measures

ECP – Engineering Change Proposal (See CODING and SERIALIZATION).

ECS – Electronics Cooling Systems (Sometimes called Environmental Control Systems)

ECU – Electronic Control Unit (HAVE SIREN)

E – Flight Engineer. When used in procedure, indicates step normally performed by flight engineer.

EDC – Emergency DC (Bus)

EDCR – Emergency DC Relay

EFC – Expect Further Clearance

EGI – Embedded GPS/INS

EGR – Embedded GPS Receiver

EGT – Exhaust Gas Temperature (Tt7). Temperature of gas leaving engine exhaust nozzle.

EGW – Ethylene Glycol and Water. Solution used in surveillance radar liquid cooling system.

EHE – Estimated Horizontal Error

E.L.BAT – Emergency Lighting Battery

ELCU – Electrical Load Control Unit

EMER – Emergency

EMP – Electromagnetic pulse (from nuclear explosion)

EPE – Estimated Position Error

EPR – Engine Pressure Ratio. The ratio of total pressure at the engine exhaust (Pt7) to total pressure at the engine inlet (Pt2).

EPRL – EPR Limit

ERCS – ECM Resistant Communications Syatem (See TDMA and JTIDS). Refer to T.O. 1E–3A–43–1–1

EVE – Estimated Vertical Error

ESM – Electronic Support Measures

EXT PWR – External Power

F

FAAC – Flight Avionics Alternating Current (Bus)

FADC – Flight Avionics Direct Current (Bus)

FC-77 – Fluorocarbon Liquid Coolant – Cooling fluid used in surveillance radar rotodome electronics. (Refer to T.O. 1E-3A-43-1-1).

FDAU – Flight Data Acquisition Unit

FDE – Fault Detection and Exclusion (GPS-RAIM)

FDM – Frequency Division Multiplex. (Refer to T.O. 1E-3A-43-1-1).

FF – Fuel Flow

FFT – Fast Fourier Transform. (Surveillance Radar STE)

FG8 – Figure eight (or bit pattern)

FLC – Frequency and Load Controller (See FLCU)

FLCU – Frequency and Load Control Unit

FLT AV – Flight Avionics

FM – Frequency Modulation

FOM – Figure of Merit

FPLN – Flight Plan

FPM, fpm – Feet Per Minute

FREQ – Frequency

FRU – Frequency Reference Unit

FT, ft – Foot, feet

FWD – Forward

°F – Degrees Fahrenheit. (For Fahrenheit/Celsius conversions, refer to T.O. 1E-3A-1-1.)

G

G, g – Unit of Acceleration. One g is the normal acceleration due to gravity.

GA – Go-around. Mode of operation of flight director.

GAL, gal – Gallons (U.S.)

GAS-1 – GPS Antenna System

GC – Ground Crew. When used in procedure, indicates step normally performed by ground crew.

GCA – Ground Controlled Approach. Precision radar controlled instrument approach (PAR).

GCB – Generator Control Breaker

GCU – Generator Control Unit

GDOP – Geometric Dilution of Precision

GEM II – GPS Embedded Module

GHz – Gigahertz (Gigacycles per second) 1,000 MHz

GIG – GPS Integration Guide

Giga – Multiplier Indicating Times 10^9

GINS – GPS Integrated Navigation System

GMT – Greenwich Mean Time (Z). Local time at 0° longitude. Also known as UTC, coordinated universal time.

GPM, gpm – Gallons Per Minute

GPS – Global Positioning System

GS – Glide Slope of ILS System (autopilot and flight director); Ground Speed (INS or INU)

GUK – Group Unique Key

Gust Factor (Gust Increment) – Difference between steady wind and reported highest gust

GUV – Group Unique Variable

H

HAA – Height Above Airport (setting for radio altimeter bug used on non-precision approach.) HAA = (MDA) minus (Airport Elevation)

Halon 1211 – Manufacturer's trade name for bromochlorodifluoromethane; fire extinguishing agent in hand held extinguishers.

Halon 1301 – Manufacturer's trade name for Bromotrifluoromethane; fire extinguishing agent (engine and APU).

HAT – Height Above Touchdown. (Setting for radio altimeter bug used on precision approach.) HAT = (Elevation at decision point) minus (Highest elevation in touchdown zone).

HDG – Heading

Heavyweight landing – Landing at weight greater than 250,000 pounds.

HF – High Frequency (2.0 to 30 MHz)

Hg – Mercury

Hot Bat – Hot Battery (Bus)

HSI – Horizontal Situation Indicator

Hyd – Hydraulic

Hz – Hertz. Unit of frequency equal to one cycle per second.

I

IBIT – Initiated BIT

IDG – Integrated Drive Generator

IAS – Indicated Air Speed. Actual reading on panel instrument.

IAU – Interface Adapter Unit (Control Power Supply). (Refer to T.O. 1E-3A-43-1-1).

ICR – Inverter Control Relay

IF – Intermediate Frequency

IFA – Inflight Alignment

IFF – Identification, Friend or Foe. In this manual refers to Transponder, AN/APX-101.

IFR – Instrument Flight Rules

ILS – Instrument Landing System

IN, in. – Inch (inches)

INAV – Integrated Navigation

INOP – Decal or panel marking indicating inoperative or disabled control.

INPH – Interphone

INT – Intensity (APS-133)

INU – Inertial Navigation Unit

ISA – International Standard Atmosphere. (Refer to T.O. 1E-3A-1-1).

ISU – Interface Simulator Unit. (Refer to T.O. 1E-3A-43-1-1).

J

Joule – Unit of energy equal to one watt-second.

JTIDS – Joint Tactical Information Distribution System. (Refer to T.O. 1E-3A-43-1-1).

K

KCAS – Knots, Calibrated Airspeed

K.E. – Kinetic Energy. Energy of motion.

KHz – Kilohertz (Kilocycles per second)

KIAS – Knots, Indicated Airspeed

Kilo – Multiplier indicating times 10

KIV – Embeddable Cryptographic Module

KPK – Key Production Key

KTAS – Knots, True Airspeed

KVA – Kilovolt Ampere

L

L, LH – Left, Lefthand

Lb – Pound, Pounds

LCS – Liquid Cooling System

LE – Leading Edge

LED – Light Emitting Diode

L/MF – Low and Medium Frequency (Low Frequency = 30 to 300 KHz) (Medium Frequency = 300 to 1,500 KHz).

LOC – Localizer

LORAN – Long Range (Radio) Navigation

LOX – Liquid Oxygen

LRRA – Low Range Radio (Radar) Altimeter

LRU – Line Replaceable Unit

LSB – Lower Side Band (of HF Radio)

LSBI – Low Speed Binary Interface

M

MAAC – Mission Avionics Alternating Current

MAC – Mean Aerodynamic Chord. The arithmetic mean of the wing tip chord and wing root chord. Used to express location of the airplane center of gravity (in percent of MAC).

Mach No. (Mach) – Ratio of true airspeed to local speed of sound.

MADC – Mission Avionics Direct Current (Bus)

MAG – Magnetic

MAR – Minimum Avionics Requirement

MATT – Multimission Advanced Tactical Terminal

MCC – Mission Crew Commander; when used in a procedure, indicates a step performed by, or coordinated with mission crew commander.

MCS – Master Control Switch

MDA – Minimum Descent Altitude. The altitude, referenced to sea level, below which descent is not authorized on a non-precision approach unless the runway is in sight.

MDE – Mode

MFP – Mission Flight Pattern

MGRS – Military Grid Reference System

M_h – Maximum Available Mach No.

MHz – Megahertz (Megacycles per second) 1,000 KHz

Mission Equipment – Equipment or Systems (Mission Systems) installed to perform the basic airplane mission. (Refer to T.O. 1E-3A-43-1-1).

MKPT – Markpoint

MOP – Mission Orbit Pattern

MPC – Situation Display Console (formerly multi-purpose console).

MRT – Military Rated Thrust (30 minute Limit)

N

N – Navigator. When used in procedure, indicates step normally performed by navigator.

N_1 – Low Speed (low pressure) compressor RPM

N_2 – High Speed (high pressure) compressor RPM

NAM – Nautical Air Miles

NATO – North Atlantic Treaty Organization (OTAN)

NAV – Navigation, navigate

NBSV – Narrow Band Secure Voice (KY28-58). (Refer to T.O. 1E-3A-43-1-1).

NCS – Navigation Computer System (AN/ASN-118)

NM, nm – Nautical Miles

NRT – Normal Rated Thrust

NVM – Nonvolatile Memory

O

OAT – Outside Air Temperature. Equal to static air temperature.

OBS – Observer. When used in procedure, indicates step performed by (or with) observer

OBV – Overboard Valve

OBTM&M – Onboard Test Monitor and Maintenance. (Refer to T.O. 1E-3A-43-1-1).

OCU – Operator Control Unit (HAVE SIREN)

P

P – Pilot. When used in procedure, indicates step is normally performed by pilot (in left seat).

PA – Public Address (communication system).

PA – Power Amplifier

PAR – Precision Approach Radar (GCA)

PBIT – Periodic BIT

PI – Performance Index (of NCS).

Pilot – When used in procedure or text, refers to pilot in left seat (or pilot flying the airplane). When used in switch or circuit breaker placard, refers to pilot in right seat (copilot).

PMCU – Processor Memory Control Unit. (Refer to T.O. 1E-3A-43-1-1).

PCMCIA – PC Memory Card International Association (standard)

PPH – Pounds Per Hour

PPS – Pulses Per Second; Precise Positioning Service

PSI – Pounds Per Square Inch

PSID – Pounds Per Square Inch, Differential

PSIG – Pounds Per Square Inch, Gage

PSN – Position

PSU – Power Supply Unit IFF. (Refer to T.O. 1E-3A-43-1-1).

P_{t2} – Inlet Total Pressure

P_{t7} – Exhaust Total Pressure

PTRN – Pattern

PTTI – Precision Time and Time Interval

PVA – Position, Velocity, Acceleration

PVT – Position, Velocity, Time

R

R, RH – Right, Right Hand

RAIM – Receiver Automatic Integrity Monitoring (GINS)

RCR – Runway Condition Reading. Proportional to runway friction coefficient.

RDF – Radio Direction Finding

REL – Release

RELNAV – Relative Navigation

RF – Radio Frequency

RMI – Radio Magnetic (Direction) Indicator

RMS – Root Mean Square

RNAV – Area Navigation

RPID – Reference Point Identifier

RPM – Revolutions Per Minute

RPU – Receiver Processor Unit

RSC – Runway Surface Condition

R/T – Receiver/Transmitter or Receive/Transmit

RTK – Racetrack

S

SA/AS – Selective Availability/Anti-Spoof

SAT – Static Air Temperature. Total air temperature minus ram rise due to compression.

SB – Sideband. See USB, LSB.

SCRAMBLE – Takeoff From Alert Condition (CC1 or CC2)

SDC – Situation Display Console (formerly multipurpose console) (MPC).

SF_6 – Sulfur Hexafluoride. Gas used in mission radar system. (Refer to T.O. 1E-3A-43-1-1).

SIF – Selective Identification Feature (of IFF)

SIM – System Interface Module

Split – When used in reference to flaps, refers to unequal extension of inboard and outboard flaps. When used in reference to spoilers/speed brakes, means extension of only one set (inboard or outboard)

SPS – Standard Positioning Service

SRU – Shop Replaceable Unit

Stabilized – When referring to engine operation, allowing power setting to remain constant for more than two seconds.

STAR – Standard Terminal Arrival

STBY – Standby

STE – Special Test Equipment

STR – Steer

SV – Space Vehicle

Sync – Synchronizing

T

TACAN – Tactical Air Navigation (Radio Set) UHF Navigation Aid

TADIL – Tactical Digital Information (Data) Link. (Refer to T.O. 1E-3A-43-1-1).

TADIXS-B – Tactical Data Information Exchange System – Broadcast

TAS – True Airspeed. Actual speed of airplane through the air. Indicated airspeed, corrected for instrument errors, altitude, temperature, pressure. (Refer to T.O. 1E-3A-1-1).

TAT – Total Air Temperature. Outside (static) air temperature plus ram rise due to compression.

TCTO – Time Compliance Technical Order

TDDS – TRAP Data Dissemination System

TFOM – Time Figure of Merit

TIBS – Tactical Information Broadcast Service

TK – Track (readout of INU)

TKE – Track Angle Error (INU)

TNAV – Time Navigation

TOC – Top of Climb

TOD – Top of Descent

TOLD – Takeoff and Landing Data

T/R – Transformer Rectifier

T/R – Transmit/Receive Mode (TACAN)

T-R – Transmit-Receive

TRAP – Tactical Receive APplications

Trim Speed – Airspeed at which the airplane is trimmed for hands-off flight.

TRT – Takeoff Rated Thrust (5 minute Limit)

TRU – Transformer Rectifier Unit

Tt7 – Exhaust Total Temperature (EGT)

TTG – Time to Go

TTI – Time to Intercept

U

UDID – User Defined Identifier

UHF – Ultra High Frequency (300 MHz to 3 GHz)

UHF-ADF – UHF Automatic Direction Finder (See ADF)

URA – User Range Accuracy

USB – Upper Side Band (of HF)

UTC – (GMT/Z) Coordinated Universal Time

V

V – Velocity (speed)

V1 – Decision Speed, Takeoff. (Refer to T.O. 1E-3A-1-1).

VAC, vac – Volts, Alternating Current

VB – Maximum Brake Energy Speed. Speed at which the kinetic energy of the airplane equals the maximum energy capacity of the brakes.

VCO – Minimum Climbout Speed, Takeoff. (Refer to T.O. 1E-3A-1-1).

VDC, vdc – Volts, Direct Current

VH – Maximum Allowable (Indicated) Airspeed

VHF – Very High Frequency (30 to 300 MHz)

VLF – Very Low Frequency (Below 30 KHz)

VMC – Minimum Control Speed. The minimum speed at which the airplane can be controlled with a sudden failure of an outboard engine and all other engines at the specified thrust level. (Refer to Section VI and T.O. 1E-3A-1-1).

VMCA – Air Minimum Control Speed. (Refer to T.O. 1E-3A-1-1).

VMCG – Ground Minimum Control Speed. (Refer to T.O. 1E-3A-1-1).

VNAV – Vertical Navigation

VOR – VHF Omnidirectional Radio Range (Omnirange) (VHF navigation aid)

VR – Refusal Speed, Takeoff. (Refer to T.O. 1E-3A-1-1).

VREF – Reference Speed, Landing (No-wind approach speed for flaps 50). (Refer to T.O. 1E-3A-1-1).

VROT – Rotation Speed, Takeoff. (Refer to T.O. 1E-3A-1-1).

VS – Vertical Speed

V_S – Stall Speed (Refer to T.O. 1E-3A-1-1).

VSWR – Voltage Standing Wave ratio

W

WBSV – Wide Band Secure Voice

WOW – Weight on Wheels

WPT – Waypoint

WX – Weather Mode (APS-133)

X

X-Band – Radio Frequency Band 8.0 – 10.0 GHz

XTK – Crosstrack Deviation

GREEKLETTERS

Φ, Ø, Phase

Ω Omega. Symbol for omega VLF navigation system

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