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PROJECT MERCURY FAMILIARIZATION MANUAL [U]

SEDR 104

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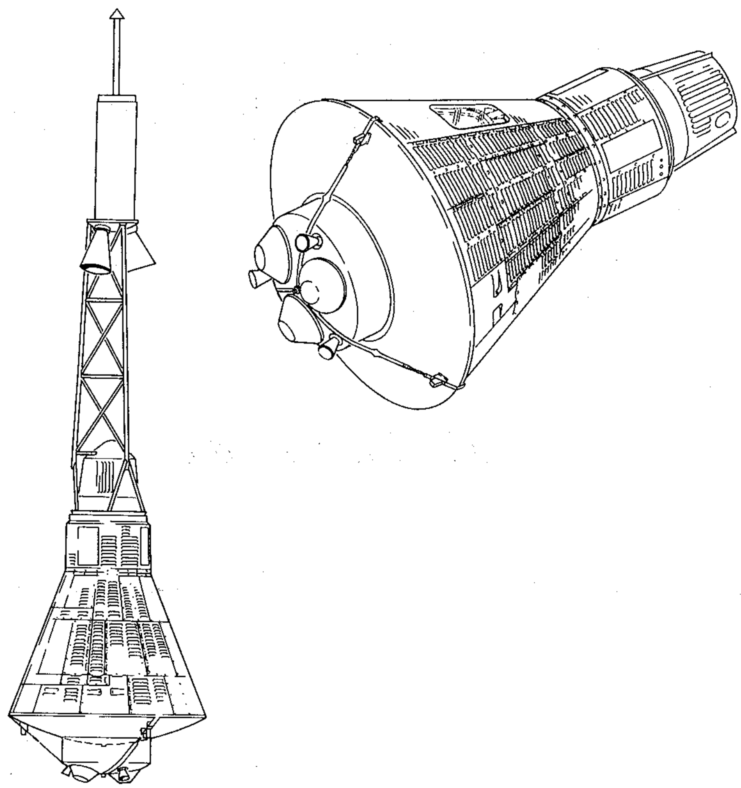

INDEX OF EFFECTIVE PAGES

The pages of this report currently in effect are listed below in numerical order. The letter or number listed after the page number identifies the latest revision effecting that page.

PAGE NUMBER	REV. LTR.	PAGE NUMBER	REV. LTR.	PAGE NUMBER	REV. LTR.	PAGE NUMBER	REV. LTR.
A		2-7		3-21		4-14	
B		8		22		15	
C		9		23		16	
D		10		24		17	
E		11		25		18	
F		12		26		19	
G		13		27		20	
H		14		28		21	
		15		29		22	
1-1		16		30		23	
2		17		31		24	
3		18		32		25	
4		19		33		26	
5		20		34		27	
6		21		35		28	
7		22		36		29	
8		23		37		30	
9		24		38		31	
10		25		39		32	
11		26		40		33	
12				41		34	
13				42		35	
14		3-1		43		36	
15		2		44		37	
16		3		45		38	
17		4		46		39	
18		5		47		40	
19		6				41	
20		7				42	
21		8		4-1		43	
22		9		2		44	
23		10		3		45	
24		11		4		46	
25		12		5		47	
26		13		6		48	
		14		7		49	
2-1		15		8		50	
2		16		9		51	
3		17		10		52	
4		18		11		53	
5		19		12			
6		20		13			

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INDEX OF EFFECTIVE PAGES

The pages of this report currently in effect are listed below in numerical order. The letter or number listed after the page number identifies the latest revision effecting that page.

PAGE NUMBER	REV. LTR.	PAGE NUMBER	REV. LTR.	PAGE NUMBER	REV. LTR.	PAGE NUMBER	REV. LTR.
5-1		6-9		9-18		10-21	
2		10		19		22	
3		11		20		23	
4				21		24	
5				22		25	
6				23		26	
7		7-1		24		27	
8		2		25			
9		3		26			
10		4		27		11-1	
11		5		28		2	
12				29		3	
13				30		4	
14		8-1		31		5	
15		2		32		6	
16		3		33		7	
17		4		34		8	
18		5		35		9	
19		6		36		10	
20		7		37		11	
21		8				12	
22		9				13	
23		10		10-1		14	
24				2		15	
25				3		16	
26		9-1		4		17	
27		2		5		18	
28		3		6		19	
29		4		7		20	
30		5		8		21	
31		6		9		22	
32		7		10		23	
		8		11		24	
		9		12		25	
6-1		10		13		26	
2		11		14		27	
3		12		15		28	
4		13		16		29	
5		14		17		30	
6		15		18		31	
7		16		19		32	
8		17		20		33	

[redacted]

INDEX OF EFFECTIVE PAGES

The pages of this report currently in effect are listed below in numerical order. The letter or number listed after the page number identifies the latest revision effecting that page.

PAGE NUMBER	REV. LTR.	PAGE NUMBER	REV. LTR.	PAGE NUMBER	REV. LTR.	PAGE NUMBER	REV. LTR.
11-34		13-1		13-43			
35		2		44			
36		3		45			
37		4		46			
38		5		47			
39		6		48			
40		7		49			
41		8		50			
42		9		51			
43		10		52			
44		11		53			
45		12		54			
46		13		55			
47		14		56			
48		15		57			
49		16		58			
50		17		59			
51		18		60			
52		19		61			
53		20		62			
54		21		63			
55		22		64			
56		23		65			
		24		66			
		25		67			
12-1		26		68			
2		27					
3		28					
4		29					
5		30					
6		31					
7		32					
8		33					
9		34					
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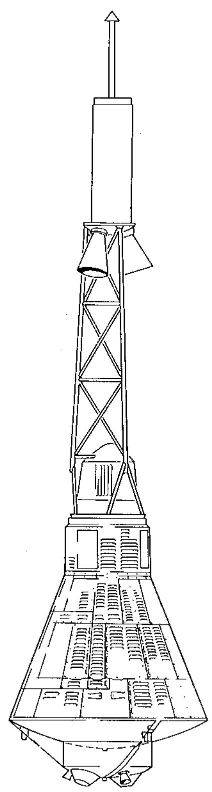
17		42					



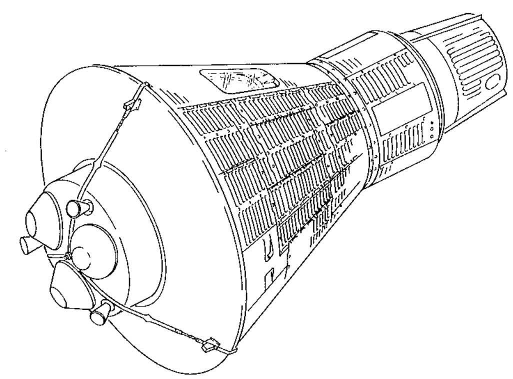
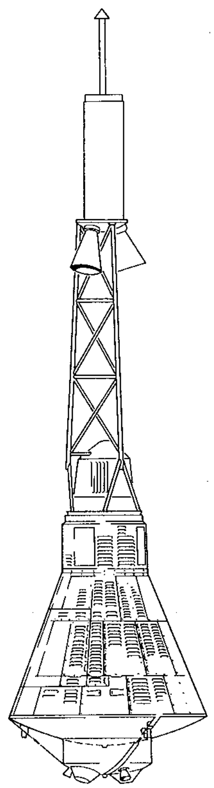
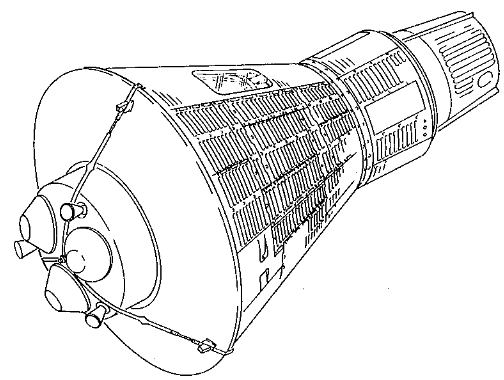


TABLE OF CONTENTS

F





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FOREWARD

The purpose of this document is to present a clear, operational description of the various capsule systems and major components. Two types of usage are visualized. The first is as an orientation-indoctrination type document. The second as a reference document containing relatively detailed information on all systems and components.

Separate information is provided for each capsule test configuration, but not all information will be repeated for each capsule where it is the same as other capsules. The book is divided primarily by capsule systems. The first part of each major section is devoted to description and operation of the "specification compliance" capsule system. This reflects, generally, capsules 18, 19 and 20, which are considered as representative, since they are manned orbital capsules. Immediately following the "spec" system coverage is the #2 capsule system coverage, then the #3, etc. The #2 capsule system is covered on a "like specification compliance capsule except as follows" basis. The #3 and succeeding capsule systems may similarily be compared to either the "spec" capsule system or to any other prior capsule system depending upon which reference causes the least duplication. In no case, however, will the reader be required to refer to more than two prior capsule systems, including the "spec" system.

Since all capsule test configurations will not be finalized, as of this printing, only the earlier capsules are covered. Remaining capsule coverage will appear in subsequent revisions to this document.

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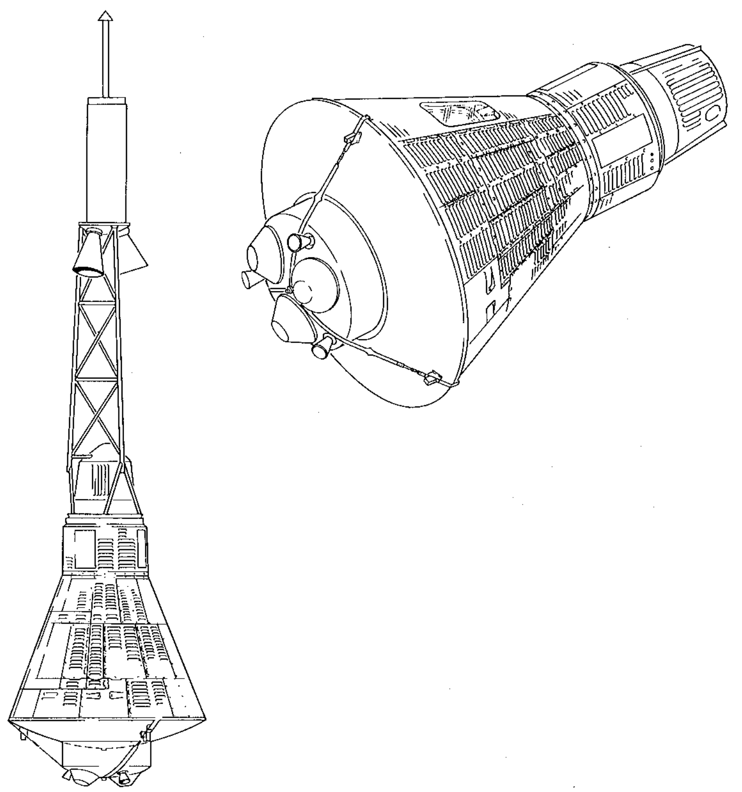

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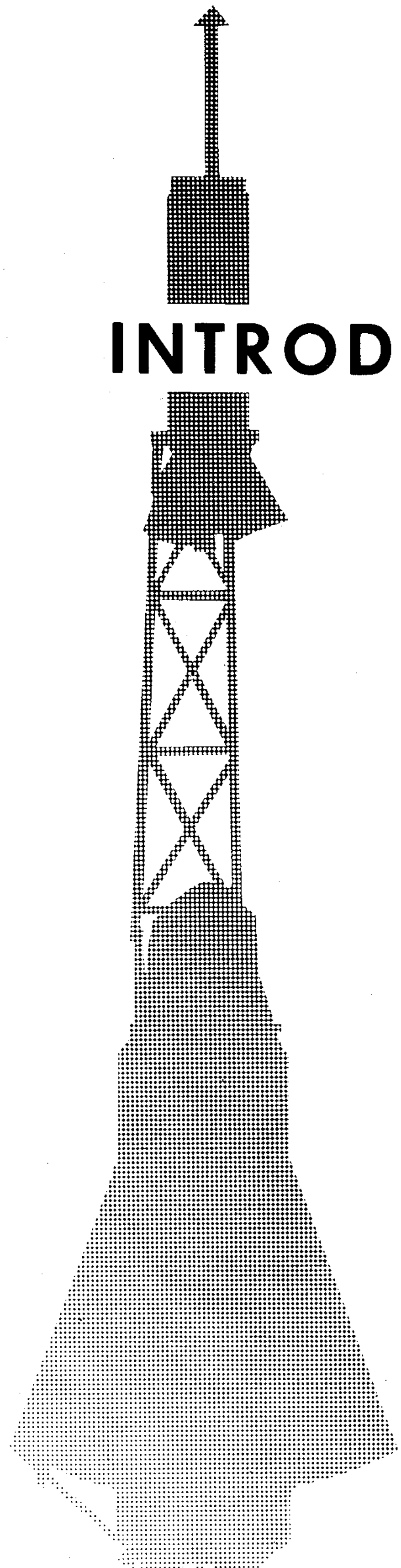
SECTION I



INTRODUCTION

TABLE OF CONTENTS

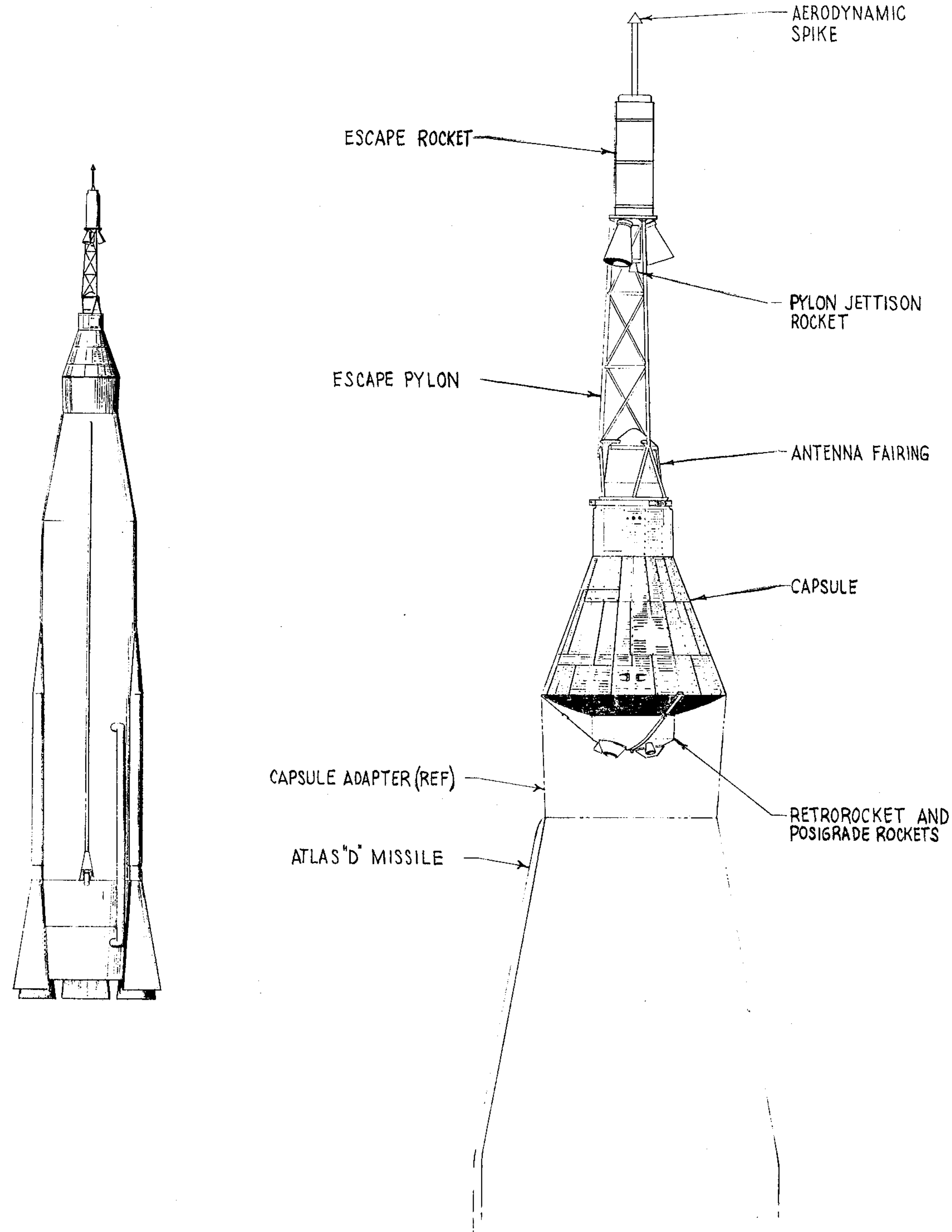


FIGURE 1-1 CAPSULE PRELAUNCH CONFIGURATION

PM45-2A

I. INTRODUCTION TO PROJECT MERCURY

1-1. MISSION DESCRIPTION

The possibility of man venturing into space has shifted quite recently from the fantasy of "science fiction" to the realm of actuality. Scientific progress has slowly but surely loosened man's ties to the earth, and recent technological advances have promised to release him completely. Today, space flight is considered well within the range of man's capabilities.

1-2. Initiated by the National Aeronautics and Space Administration, a space flight program is now underway. Through the research, design and production facilities of McDonnell Aircraft Corporation and their many sub-contractors, an American will shortly make a flight into space. The program that will put him there - Project Mercury.

1-3. Fundamentally, the mission of Project Mercury is the projection of a manned capsule into a semi-permanent orbit about the earth, the study of man's capabilities in space flight, and the subsequent safe return of the capsule and its occupant to the earth's surface. It is immediately obvious that the mission, while simply stated, is of tremendous scope and magnitude, and requires exceptional coordination of manpower and facilities. The data contained in this and succeeding sections will provide detailed information on the equipment and procedures utilized to accomplish that mission.

1-4. CAPSULE DESCRIPTION

1-5. General

See Figures 1-1, 1-2, 1-3 and 1-4. The Project Mercury capsule is basically a conical structure containing a pressurized area suitable for human occupation during launch, orbit, and recovery phases of the mission. The "base" of the cone contains provisions for attachment to the REDSTONE or ATLAS booster

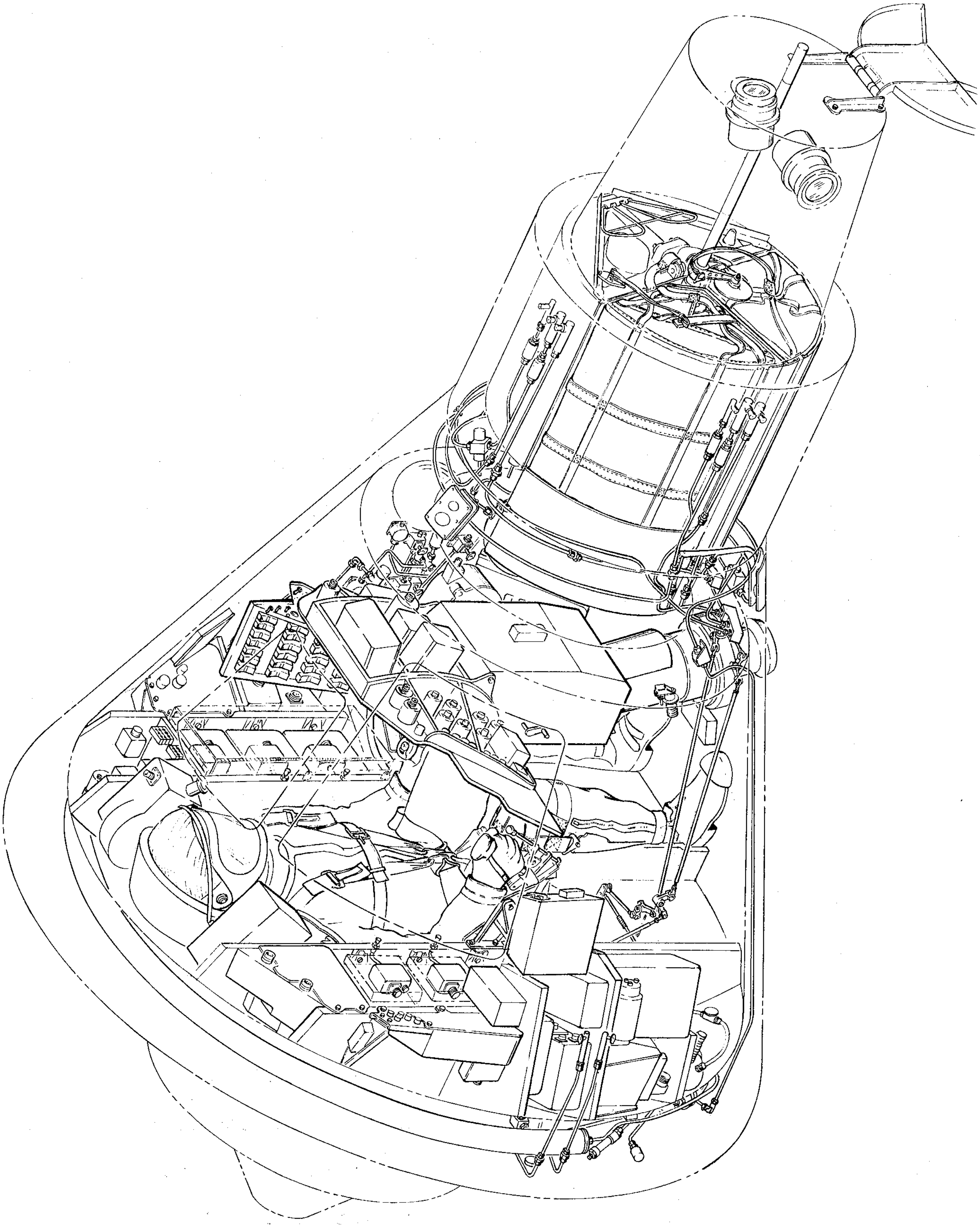


FIGURE 1-2 INTERIOR ARRANGEMENT

PM45-1A

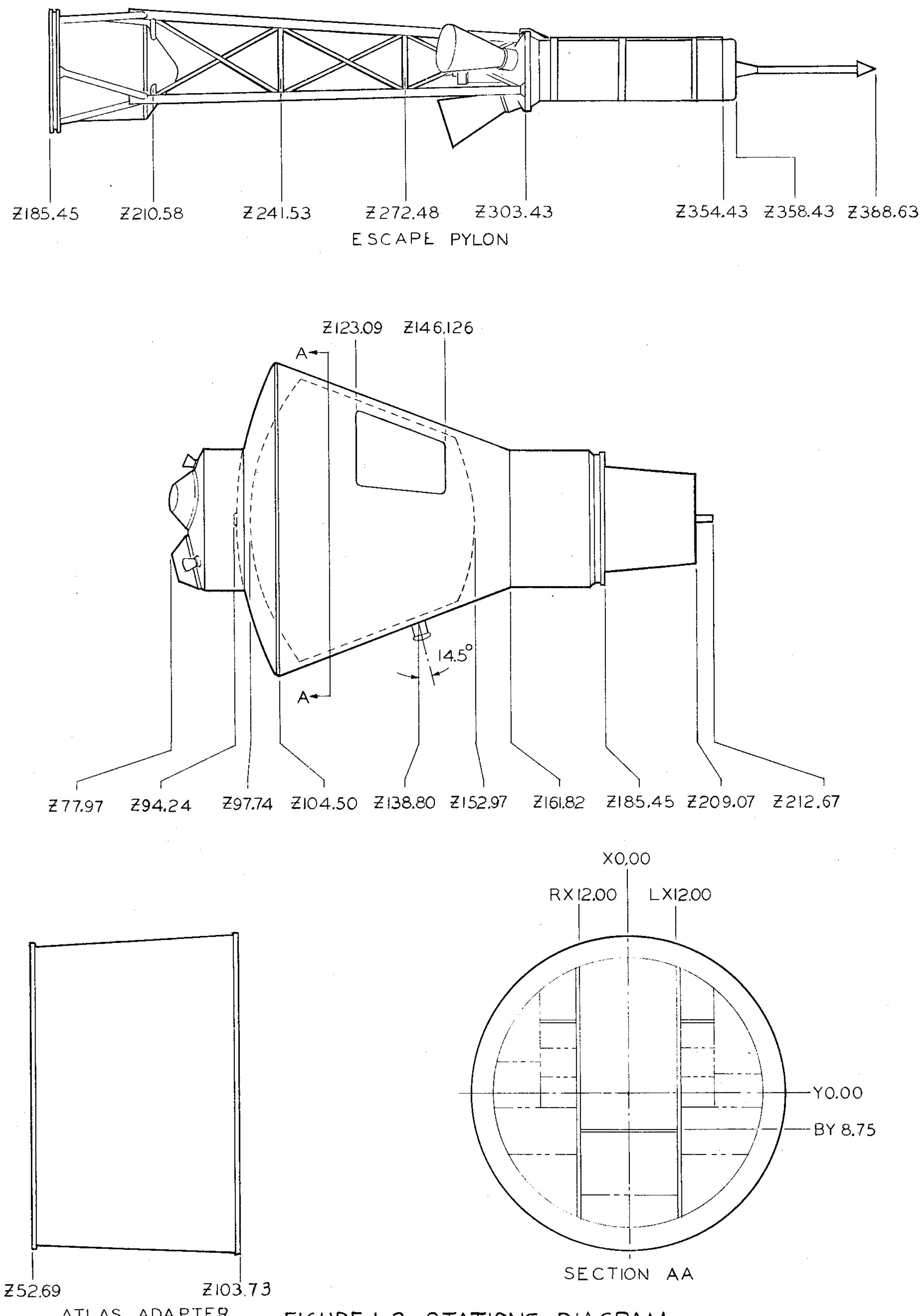


FIGURE 1-3 STATIONS DIAGRAM

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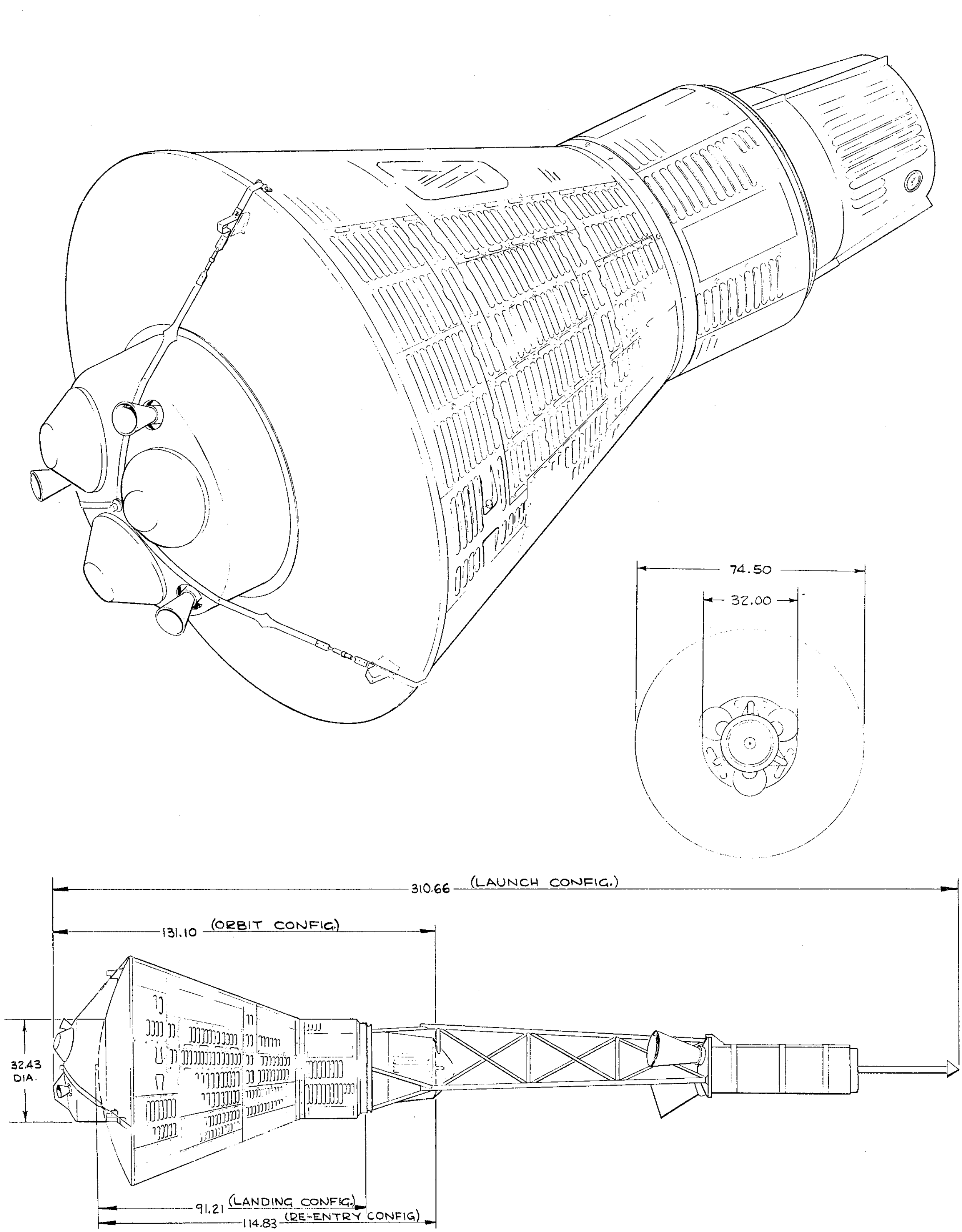

FIGURE 1-4 CAPSULE DIMENSIONS

PM45-15A

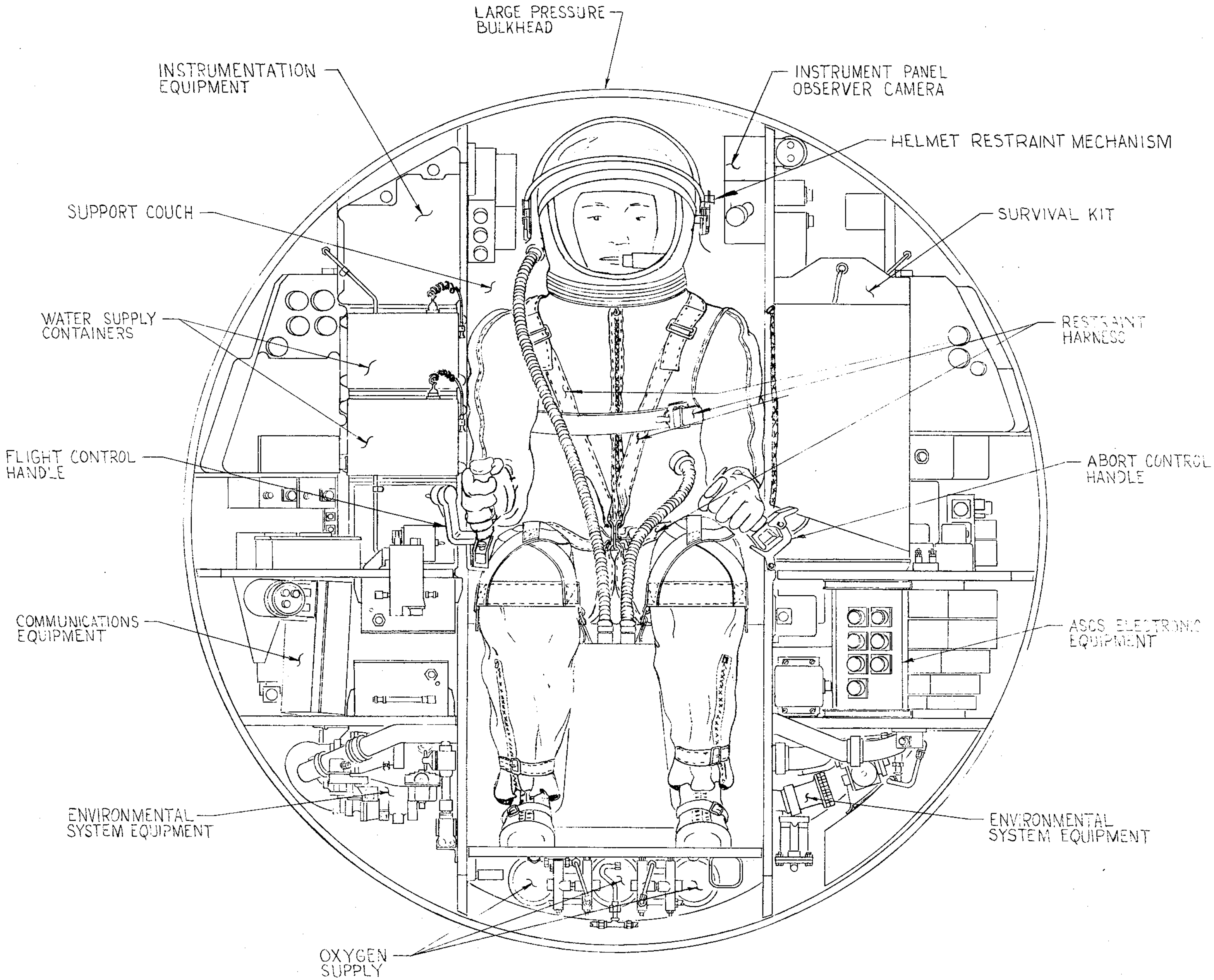

FIGURE 1-5 CABIN EQUIPMENT (SHEET 1 OF 2)

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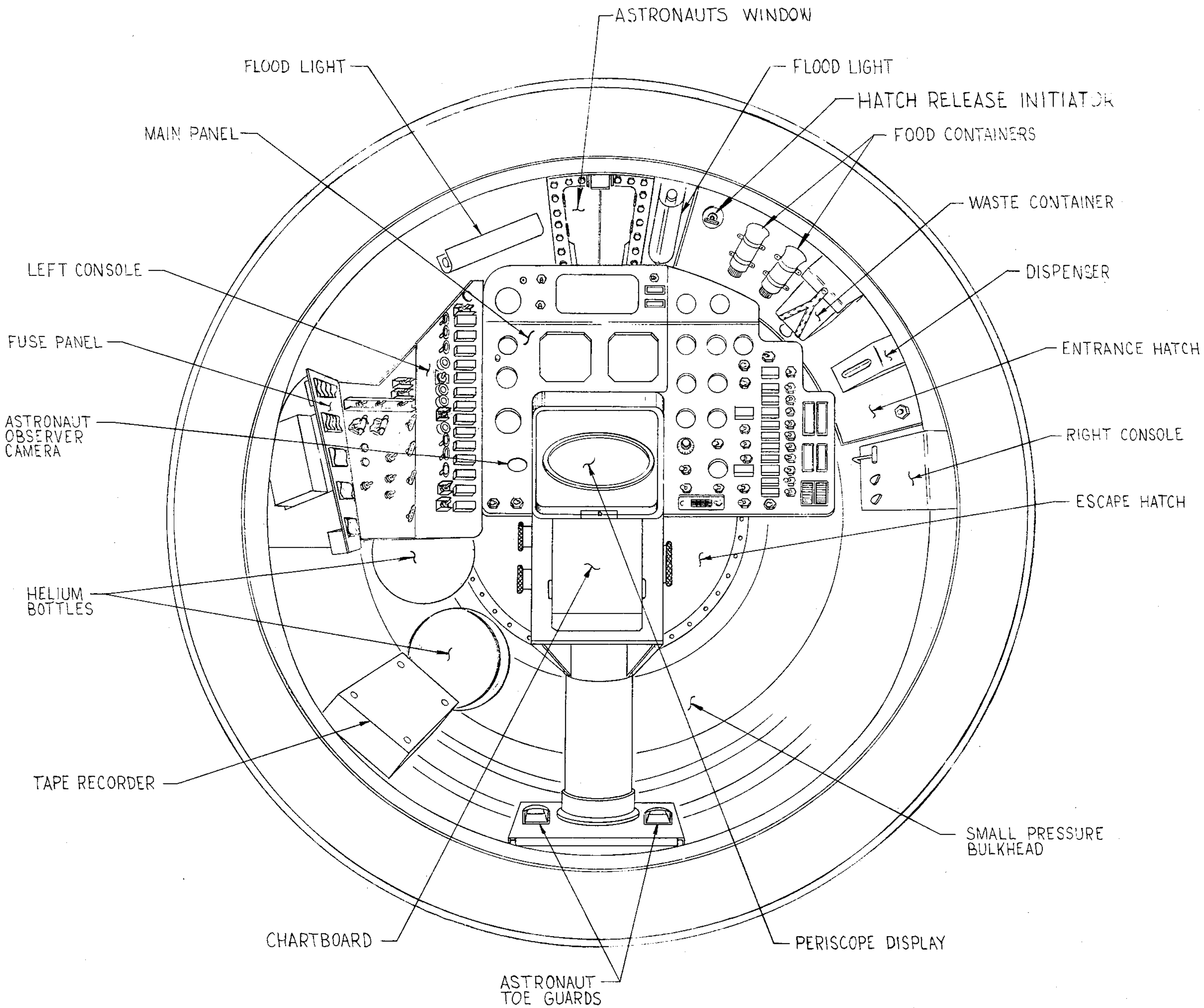

FIGURE 1-5 CABIN EQUIPMENT (SHEET 2 OF 2)

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PM 45-19A-2

through use of special adapters. The "apex" of the cone contains the devices for recovering the capsule at the conclusion of a mission, and equipment which would allow the pilot to escape in the event of an emergency during the launch phase. Provided in the capsule proper are systems which regulate environment, flight attitude, data recording and telemetering, and capsule recovery.

1-6. When in place on the nose of the booster, the small end of the capsule is up. The Astronaut is on his back in a sitting position. During launch and acceleration phase, the Astronaut faces forward with respect to capsule flight path. When the booster-capsule combination reaches a specific altitude, attitude and velocity, they separate. The booster slows, and returns to the earth's atmosphere where it is destroyed. The capsule is stabilized momentarily, then rotated 180° about its yaw axis. Throughout the remainder of the flight, whether orbital or ballistic, the Astronaut faces aft with respect to capsule flight path.

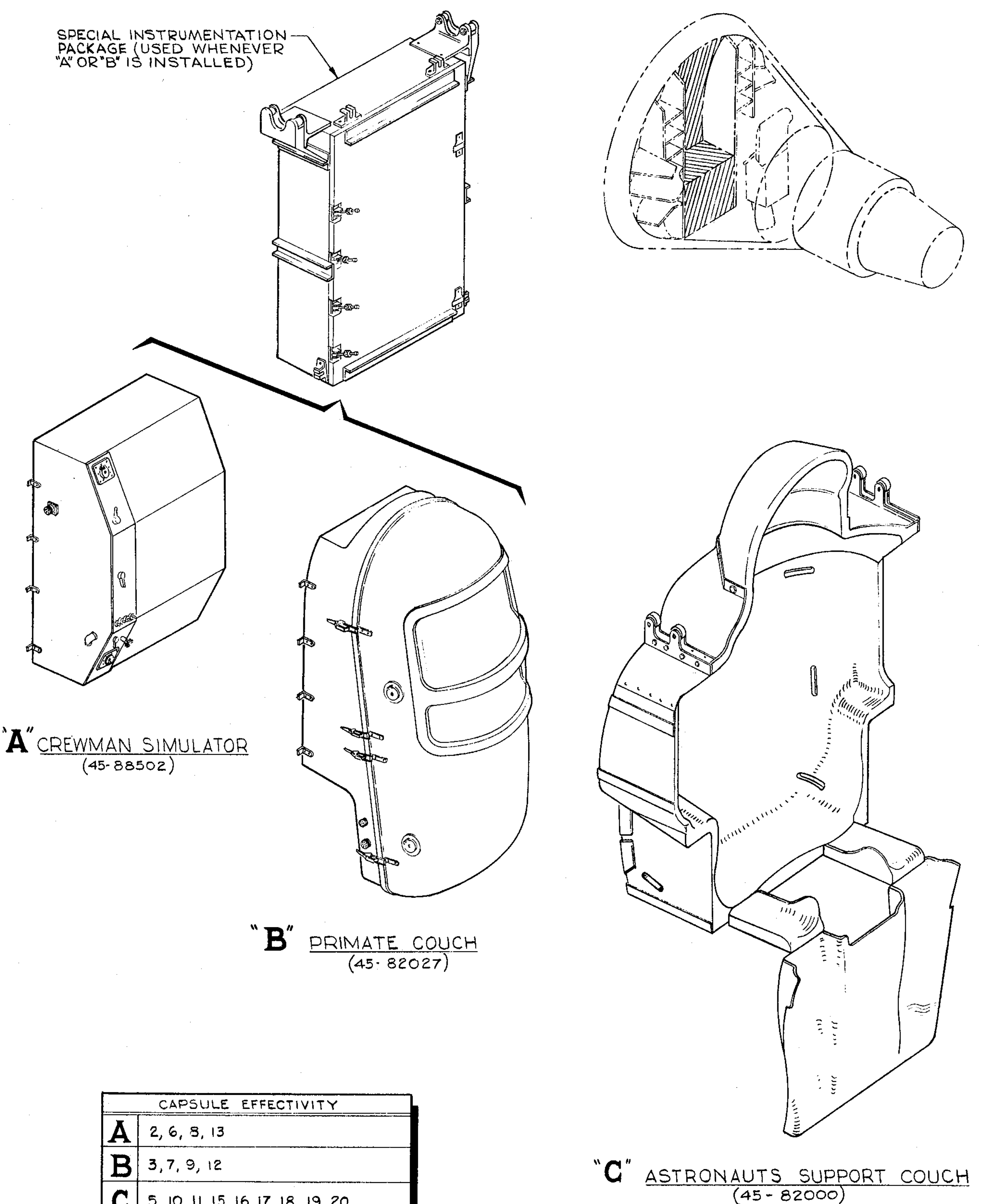
1-7. Cabin

1-8. Arrangement

The equipment within the capsule cabin interior, Figure 1-5, is arranged so that all operating controls and emergency provisions are accessible to the Astronaut when in the normal restrained position. Cabin equipment basically consists of an Astronaut's support couch, a restraint system, instrument and display panels, navigational aids, flight and abort control handles, food and water supply, waste container, survival kit, cameras, and electronic equipment required to operate communication system.

1-9. Support Couch

The Astronaut support couch (see Figure 1-6) is designed to transmit Astronaut body loads and protect the Astronaut from loss of consciousness during capsule



CAPSULE EFFECTIVITY	
A	2, 6, 8, 13
B	3, 7, 9, 12
C	5, 10, 11, 15, 16, 17, 18, 19, 20

FIGURE 1-6 PAYLOAD CONFIGURATION

PM45-135

peak accelerations in the capsule launch, re-entry, and landing phases. The support couch is centrally located adjacent to the large pressure bulkhead. The couch is constructed of a crushable, honeycomb material, bonded to a Fiberglas shell, and lined with a protective rubber padding. The support couch is molded to the contour of a specific Astronaut's body to provide maximum body support during capsule flight. The couch is fabricated in sections to enable couch installation through the capsule entrance hatch.

1-10. Restraint System

The Astronaut's restraint system (see Figure 1-7) is designed to firmly restrain the Astronaut in the support couch during capsule maximum deceleration. The restraint system consists of helmet restraint guard, shoulder and chest straps, leg straps, crotch strap, lap belt, and toe guards. The helmet guard is adjustable and may be rotated from the restraining position. The shoulder straps may also be adjusted to restrain or release the Astronaut, by a harness reel control handle, located on the upper left side of the support couch. The leg straps and toe guards firmly restrain the Astronaut's legs and feet. The Astronaut's hands and arms are restrained by gripping the abort and flight control handles, located near the ends of the support couch arm rests.

1-11. Instrument Panels (See Figures 1-8 and 1-9)

The capsule instruments are located on a main instrument panel, a left hand console, and a right hand console. The main instrument panel is located directly in front of the Astronaut's support couch, as viewed by the Astronaut, and is attached to the periscope housing. The main panel is designed so that the periscope display scope forms the lower control section of the instrument panel. Navigational instruments are located in the left and center sections of the main panel. Environmental system indicators and controls are located

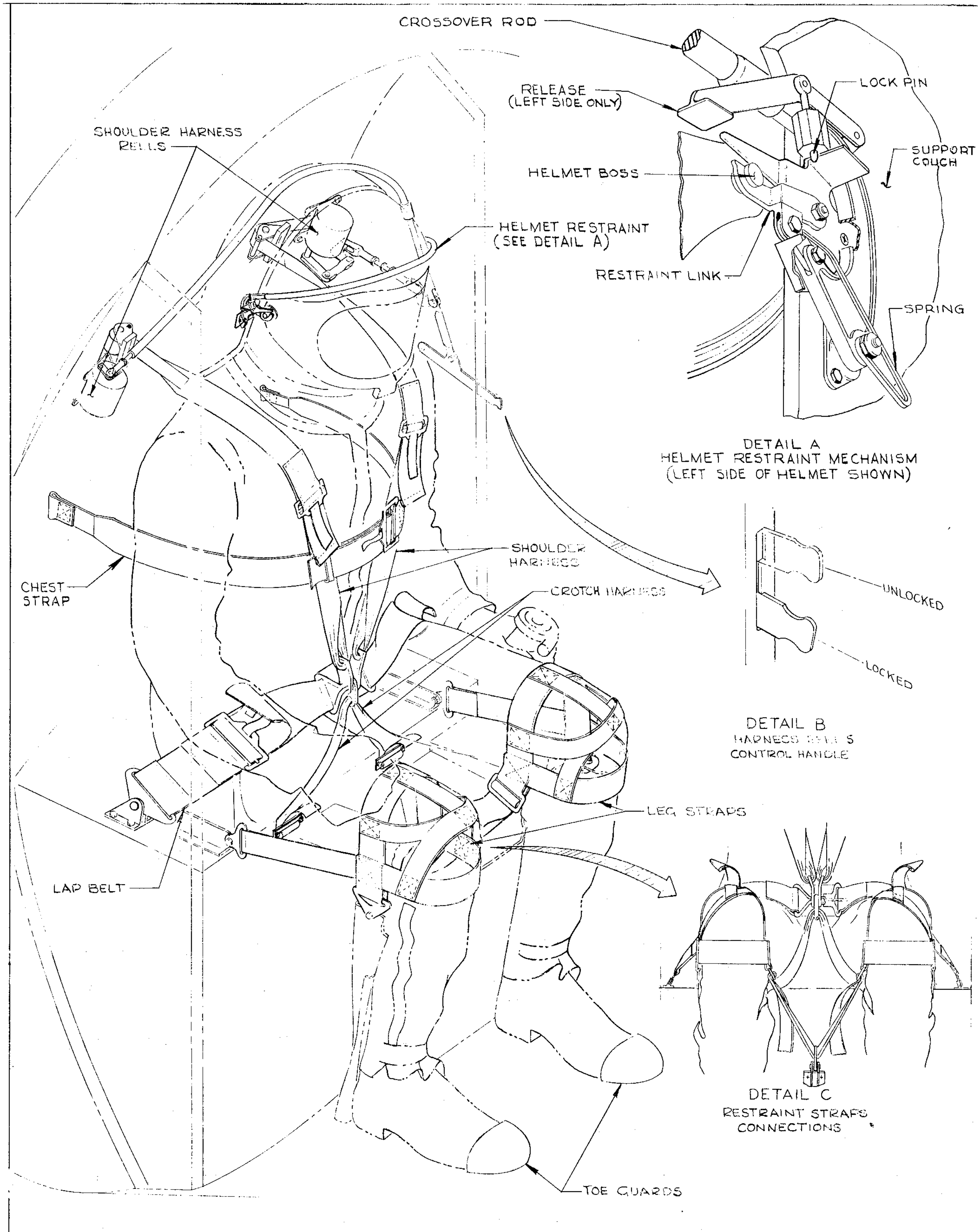


FIGURE 1-7 ASTRONAUTS RESTRAINT SYSTEM

PM45-21A

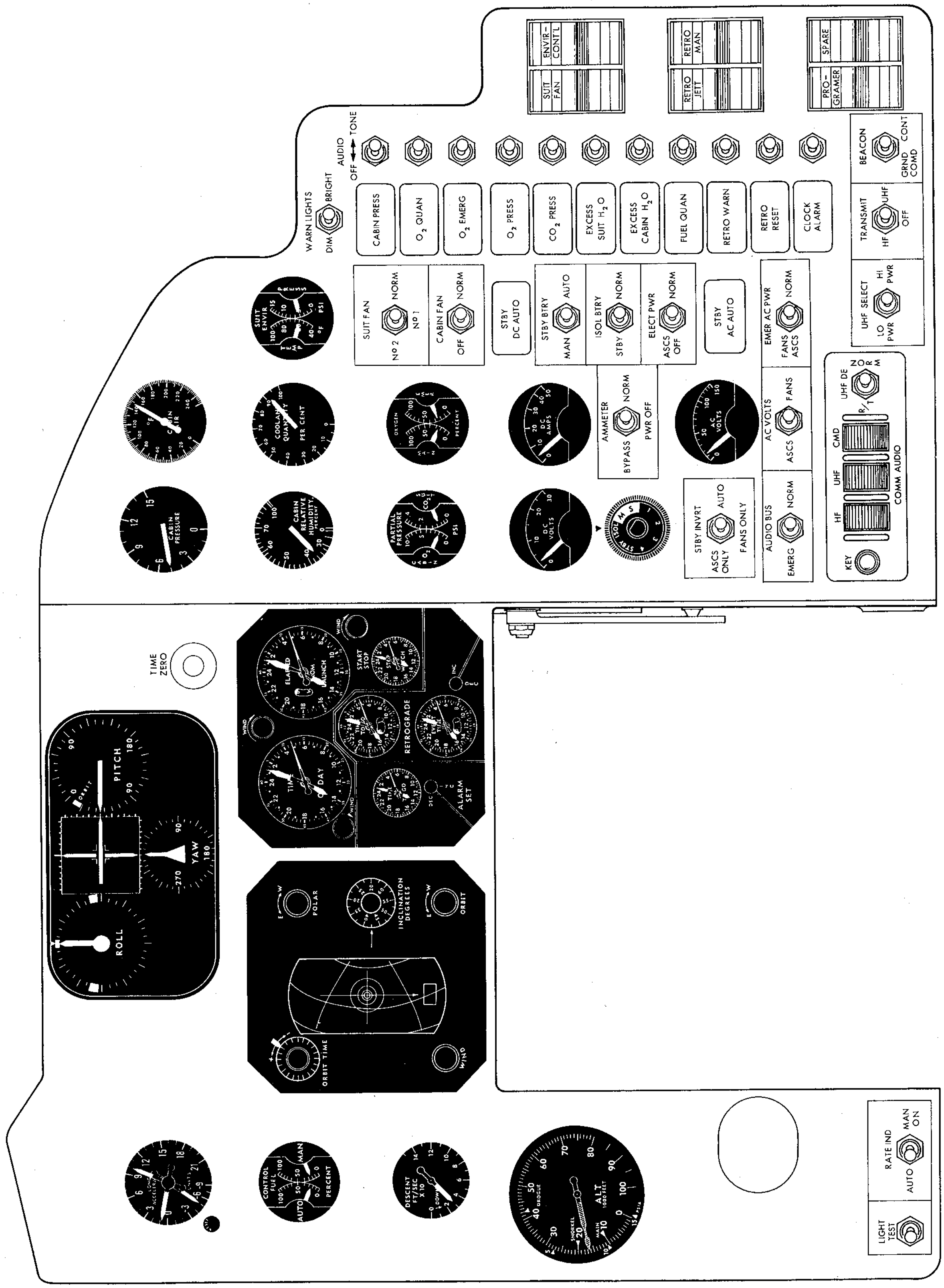


FIGURE 1-8 MAIN INSTRUMENT PANEL

PM45-160

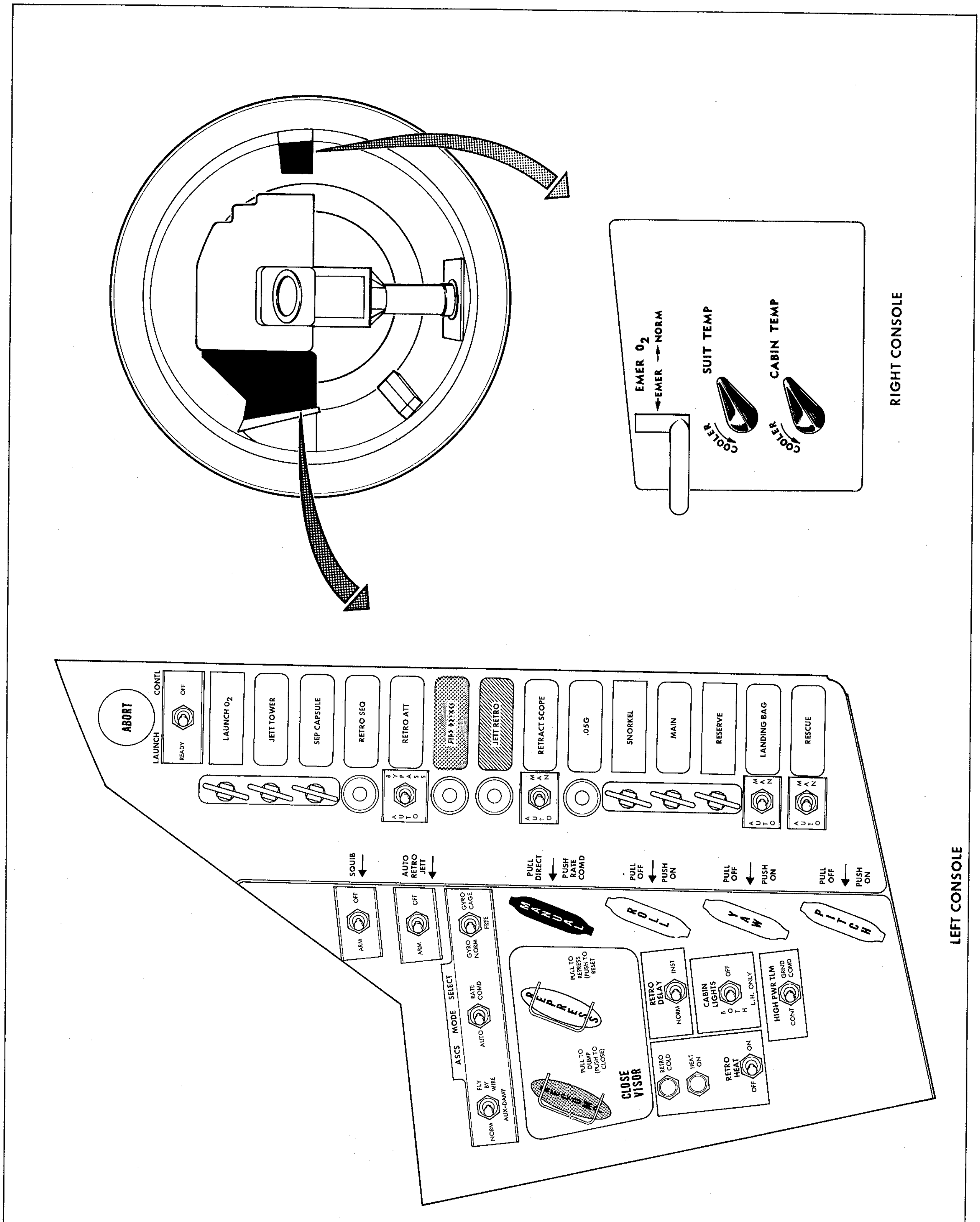


FIGURE 1-9 RIGHT AND LEFT CONSOLE

PM45-161

in the right upper section of the main panel. Electrical switches and indicators and communication system controls are located in the lower right section of the main panel. The left hand console is located on the left side of the main panel and is arranged to provide accessibility and visibility to the pilot when in the fully restrained position. The console includes a telelight sequence and warning panel, and indicators and controls for the capsule automatic stabilization control system, environmental control and landing system. The right hand console, located below the capsule entrance hatch, includes controls for the environmental control system.

1-12. Navigational Aids

Refer to Section XIII "Navigational Aids and Instruments".

1-13. Controls

Capsule controls are located forward of each arm rest of the support couch. An emergency escape handle is located forward of the support couch left arm rest. The escape handle is utilized to initiate the abort sequence. To prevent inadvertent actuation of the escape system, the escape handle is provided with a manual lock. The manual control handle, located forward of the support couch right arm rest, is utilized to control flight attitude of the capsule in the event the automatic control system failed. This handle is also normally locked.

1-14. Food, Water and Waste Storage

All manned capsules will be provided with food and water sufficient for the particular mission. The food will provide approximately 3,000 calories. The 6 pound water supply is contained in two flat bottles, each fitted with an extendable tube. For missions longer than 28 hours, an additional water supply of approximately 6 pounds can be obtained from the suit circuit water separator of the environmental control system. A container for liquid waste is located near the entrance hatch.

1-15. Survival Equipment

The survival kit, stowed at the left side of the couch, contains the following:

PK - 2 Raft	Signal Mirror
Desalting Kit (for 8 pts.)	AN/PRC-32 Radio
Shark Repellant Packages	Survival Ration
3 Dye Markers	Matches
First Aid Kit	Whistle
3 Distress Signals	Nylon Cord (10 ft.)

The Astronaut also has a knife and flashlight attached to the pressure suit.

1-16. Cameras

One 16 mm. camera is mounted in the lower left panel for viewing the Astronaut's head and shoulders. A second 16 mm. camera is positioned to record instrument panel readings. These cameras operate continuously during launch and orbit, and at regular intervals during orbit.

1-17. BOOSTER DESCRIPTION

The launch vehicle, or booster, used to project the Project Mercury capsule into orbit is the ATLAS "D" missile, although a number of ballistic flights will be made utilizing the REDSTONE missile. Capsule adapters replace the nose cones of the missiles. The capsule "base" is then attached to the adapter with a segmented clamp ring. At the proper time, explosive bolts in the clamp ring are fired, releasing the capsule. The adapter remains with the booster.

1-18. CAPSULE RECOVERY

A normal mission is intended to terminate with the capsule landing in a predetermined area of the ocean. Under normal circumstances, ships and helicopters will be standing by with provisions to pick up the buoyant capsule immediately after landing. Considering the possibility that the capsule could land in other than the intended area, numerous devices, both electronic and visual, are automatically energized or deployed at the time of landing to aid in locating the capsule. Depending upon weather, possible capsule damage, etc., the Astronaut may either stay in the capsule, or take to the life raft which is provided as part of the survival equipment.

1-19. CREW

1-20. Requirements

The capsule crew consists of a one man representing the peak of physical and mental accuity, training and mission indoctrination. Much more will be required of the crewman than is normally required of the modern aircraft test pilot. The crewman must not only observe, control and comment upon the capsule system, but must scientifically observe and comment upon his own reaction while in a new, strange environment.

1-21. Selection

From the large number of men who volunteered for Project Mercury, a relatively small group has been selected. Each man in the group has undergone extensive testing and examination which has proven conclusively that he possesses the intelligence, stamina and mental stability required for a project of this type.

1-22. Training

An extensive training program is being conducted for the Astronauts and other designated personnel associated with Project Mercury. The program will provide detailed descriptions and operation of all capsule components in such a manner that the trainee will fully understand the function of each component and the reasons for selecting a particular design. Supplementary briefings will be held so that current design decisions can be made known. Initial training will be of the "group discussion" type, progressing to procedural trainers. Training aids and equipment will be designed to train the Astronauts to achieve the highest attainable degree of proficiency in all normal and emergency procedures.

The following objectives will be sought:

1. The Astronaut will be indoctrinated in the general purpose and plans of the space program.

2. He must be completely familiar with all normal and emergency procedures. Emphasis will be placed on this point, so that normal procedures are performed alsmost automatically.

3. He must be indoctrinated as far as possible in the environmental and physiological aspects of the mission.

4. Since the Astronaut himself has the highest utility value and is the most flexible component in the capsule, he must be able to handle the normal work load in the capsule and still function as an efficient scientific observer.

The completion of an adequate training program will assure a far higher level of reliability with respect to crew function, and of course, increase the probability of a successful mission.

1-23. Physiological Preparation

To minimize the possibility of the Astronaut having to pass body waste solids for the duration of a mission, strict dietary control will be maintained for a considerable period prior to flight. This will allow a nutritional and physical buildup in anticipation of the stringent demands which will be placed upon the Astronaut's physical and mental facilities, and at the same time, control the type of solid waste which will remain in the digestive and elimination systems. Finally, only non-residue type food will be supplied for the Astronaut's consumption during flight.

1-24. Aeromedical Instrumentation

It is extremely important that certain bio-physical functions be measured and recorded during all phases of the mission. Such measurements will assist in monitoring the Astronaut's mental accuity and physical fittness, and will contribute significantly to aeromedical research. Indications of EKG, respiratory rate and volume, and body temperature pickups are attached to the Astronaut's body. Leads are routed from the Astronaut's body to terminals which extend through the suit. Capsule wiring will attach to the suit at these points. The instrumentation will be accomplished in laboratory facilities at the launching site prior to donning the pressure suit. The data thus derived is fed intermittently to the capsule tape recorder and continuously to the telemetry equipment.

1-25. Astronaut's Apparel

The Astronaut's apparel will consist of a completely enveloping pressurized suit with helmet, and suitable undergarments and boots. The helmet face plate can be opened while the capsule interior is pressurized although normal procedure will be to keep the face plate closed. Each Astronaut is specially fitted and trained in the use of his suit. Air, regulated as to temperature, pressure and humidity, is supplied to the suit for breathing and ventilation. For Astronaut comfort, ventilating air should be supplied to the suit at all times.

1-26. TEST CONFIGURATION #2 CAPSULE

1-27. General

Capsule #2 is similar to the specification capsule except in the following general areas. (Structural differences are enumerated in Section II.)

1-28. Mission Description

Capsule #2 is an unmanned capsule and therefore the objectives to be achieved by this capsule differ from those of the specification capsule. The objectives of capsule #2 are as follows:

(a) To qualify capsule-booster combination during boost phase of flight designed to give maximum deceleration load factor during re-entry and a period of weightlessness of approximately 5 minutes.

(b) Qualify capsule during re-entry at maximum deceleration load factor of 11g.

(c) Qualify retro-rocket after short period of weightless flight in environment of space.

(d) Qualify, in part, operation of the parachute system, attitude control system, horizon scanner and other major components.

(e) Qualify recovery system.

(f) Obtain experience in launch, tracking and recovery phase of operation.

1-29. Cabin

1-30. Cabin Arrangement

The cabin arrangement of capsule #2 is the same as the specification capsule except that some items, unnecessary to an unmanned flight, have not been installed. Cabin equipment basically consists of a crewman simulator, instrument and display panels, navigational aids, flight and abort control handles, cameras, and electronic equipment required to operate communications equipment.

1-31. Support Couch

There is no support couch utilized in capsule #2 since this is an unmanned vehicle, In place of the support couch, an instrument package and a crewman simulator is installed. (See Figure 1-6.) The crewman simulator is a box-like structure containing a carbon dioxide tank, water tank, strip heaters, solenoid valves and controls. This device simulates the carbon dioxide output, perspiration output and oxygen consumption of a human being. The simulator is calibrated prior to capsule flight and is activated automatically when the capsule special instrumentation package is energized.

1-32. Instrument Panels

The instrument panels on capsule #2 are in the same location as those in the specification capsule. However, the location and types of some of the instruments and controls mounted in these panels are different. See Figures 1-10 and 1-11 for instrument panel configuration for capsule #2.

1-33. Food, Water and Waste Storage

Since capsule #2 is an unmanned vehicle, the food, water and waste storage containers will not be installed.

1-34. Cameras

The camera configuration of capsule #2 differs from the specification capsule in that capsule #2 does not contain a pilot observer camera to photograph the Astronaut's head and shoulders. However, a 70 mm. camera is installed which will photograph a portion of the earth and sky through a window in the lower right hand portion of the cabin. Photos will be taken at regular intervals during launch and re-entry and at less frequent intervals during orbit.

1-35. TEST CONFIGURATION #3 CAPSULE

1-36. General

Capsule #3 is similar to the specification capsule except in the following general areas. Refer to Section II for structural differences.

1-37. Mission Description

The flight of capsule #3 will qualify the capsule and escape system at a com-

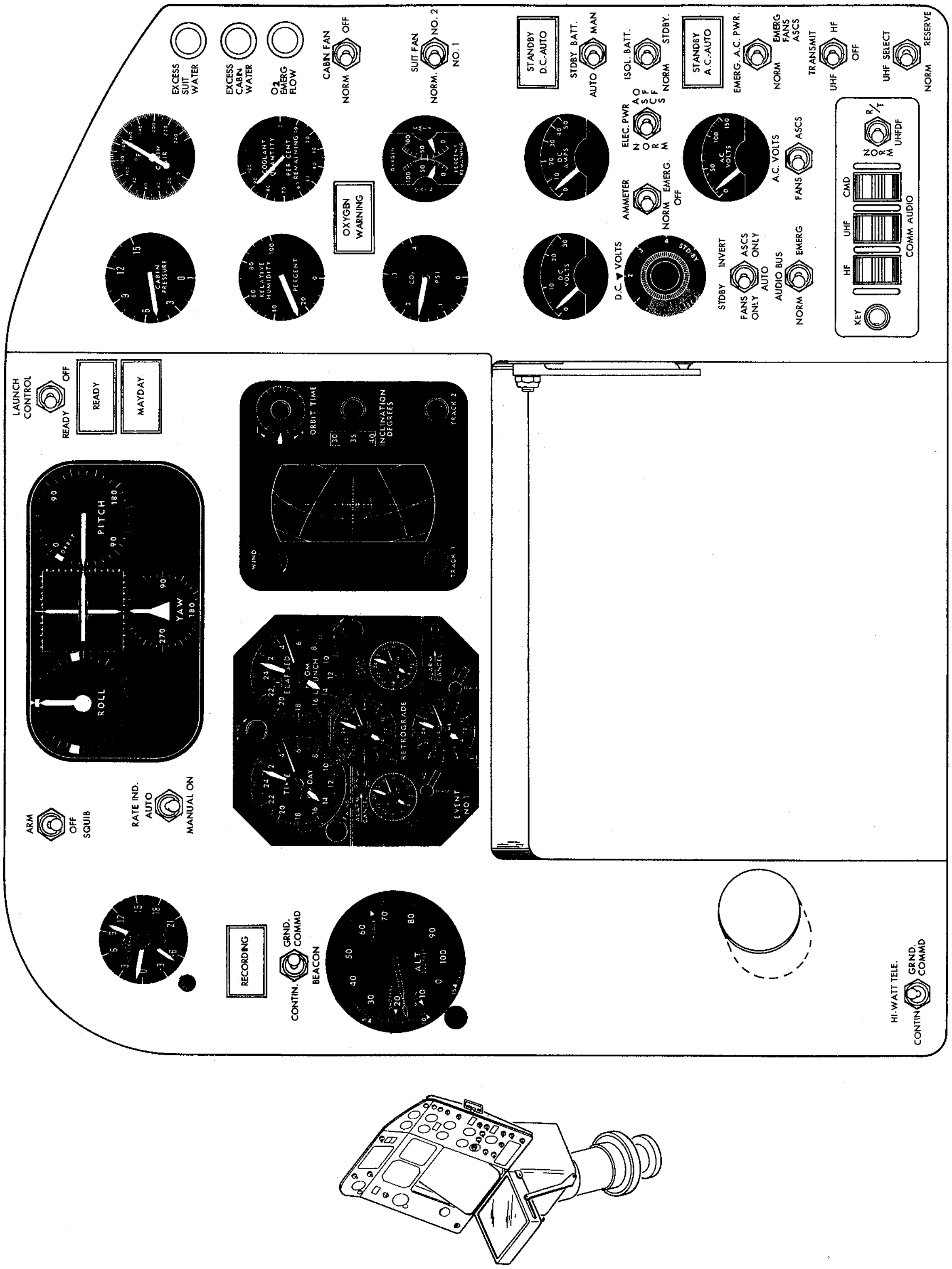


FIGURE 1-10 MAIN INSTRUMENT PANEL (CAPSULES 2, 3, 4)

PM45-119

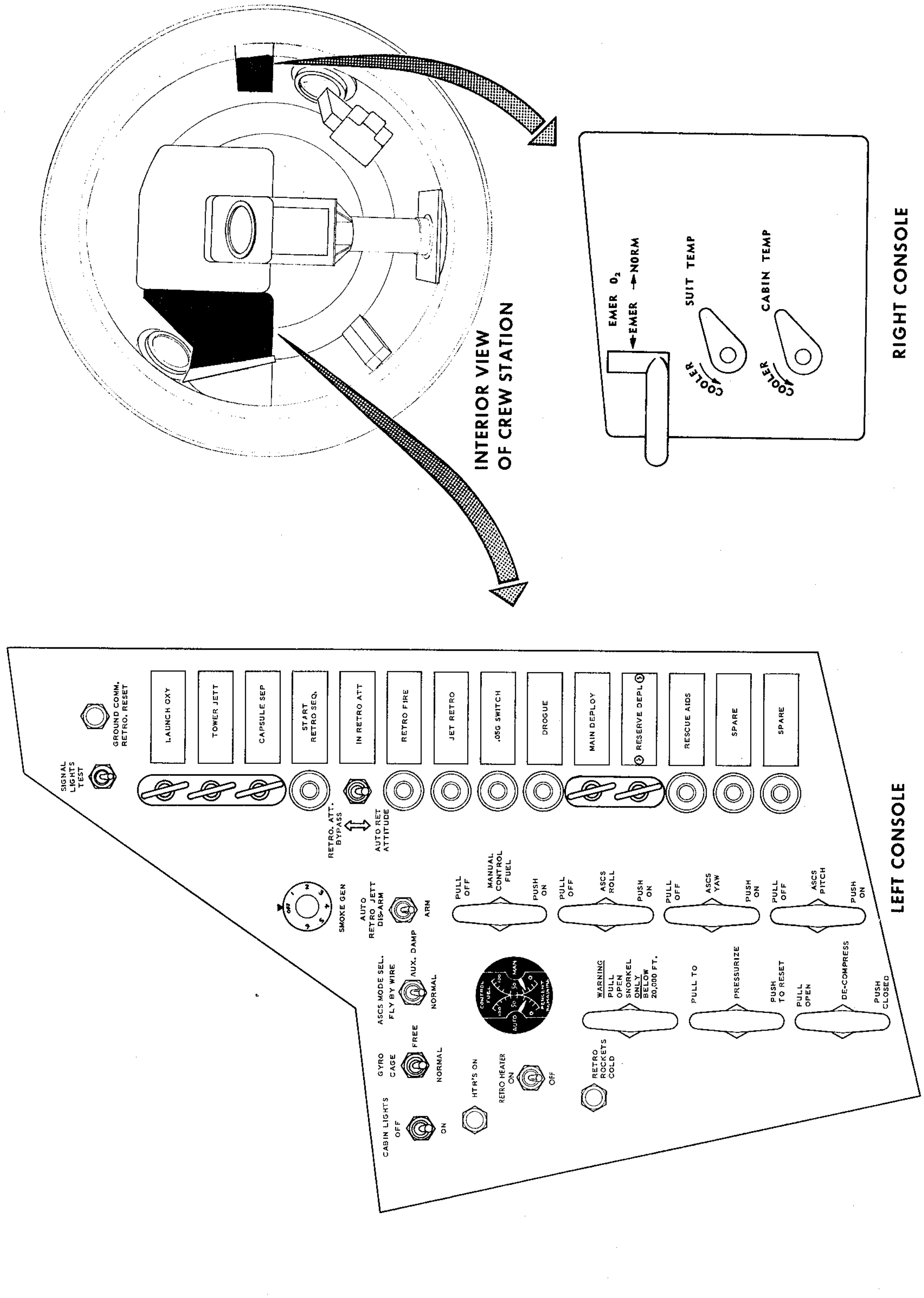


FIGURE 1-11 RIGHT AND LEFT CONSOLES (CAPSULES 2, 3, 4)

PM45-120

bination of dynamic pressure, mach number, altitude, and flight path angle that represent the most severe conditions anticipated for an escape maneuver to be considered during an orbital launch. It will also qualify, in part, the landing and recovery system. This capsule will also be used to determine the physiological effects of acceleration on a medium-size primate (chimpanzee). The primate has been trained to respond to a particular stimulus which will be provided during the flight. His ability to respond during unusual conditions will assist in predicting, to a degree, what man's ability will be under similar conditions. Respiration, heartbeat and other physiological functions of the primate will also be monitored during the flight.

1-38. Cabin

1-39. Cabin Arrangement

The cabin arrangement of capsule #3 is the same as capsule #2 except that another camera has been installed (ref. Paragraph 1-43) and a primate support couch replaces the crewman simulator.

1-40. Support Couch

The primate support couch utilized in capsule #3 (see Figure 1-6) is designed to contain, sustain and support a medium-sized primate (chimpanzee) during an unmanned capsule mission. The couch contains an instrument panel and controls to test the primate's reactions during capsule flight. This unit is essentially a two-section container. The aft section is the actual couch that supports and restrains the primate; the forward section contains the instrument panel, controls, and observation window. The primate couch, including occupant, is installed just prior to capsule launch.

1-41. Instrument Panels

The instrument panels in capsule #3 are the same as those in capsule #2.

1-42. Food, Water and Waste Storage

Same as capsule #2.

1-43. Cameras

Capsule #3 contains the same camera set-up as found in capsule #2 except that the pilot observer camera (not installed in #2), is installed in this capsule to photograph the primate during flight.

1-44. TEST CONFIGURATION #4 CAPSULE

1-45. General

Capsule #4 differs from the specification capsule in that this capsule is a ground test vehicle only. The general objectives to be accomplished with #4 are as follows.

1-46. Mission Description

The following tests will be performed on this capsule to determine structural dynamic characteristics.

(a) Vibration response

(b) 150% environmental test

(c) Capsule noise and vibration will be checked with the capsule mounted, in-flight condition, on the nose of a Redstone booster. Checks will be made during booster operation of 20 seconds and 141 seconds.

(d) Following these tests, the capsule will be disassembled and inspected for structural damage.

1-47. Cabin

1-48. Cabin Arrangement

The cabin arrangement in capsule #4 is the same as capsule #2 except that the Astronaut's support couch (ref. Para. 1-9) and water and waste containers are installed in this capsule.

1-49. Instrument Panels

Same as Capsule #2.

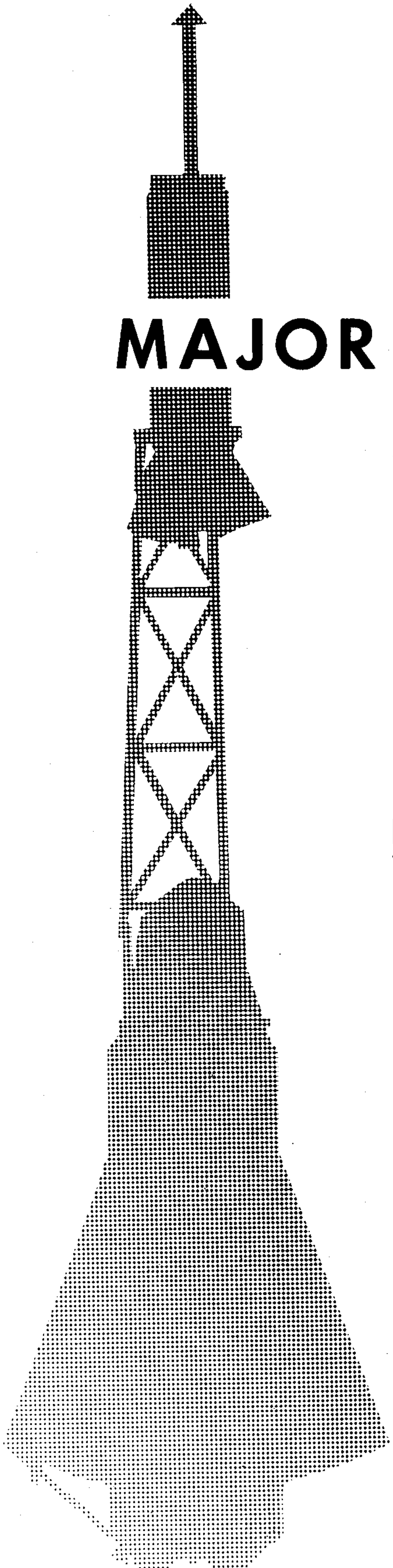
1-50. Food, Water and Waste Storage

Capsule #4 does not have the food storage container installed. (Water and waste containers are installed.)

1-51. Cameras

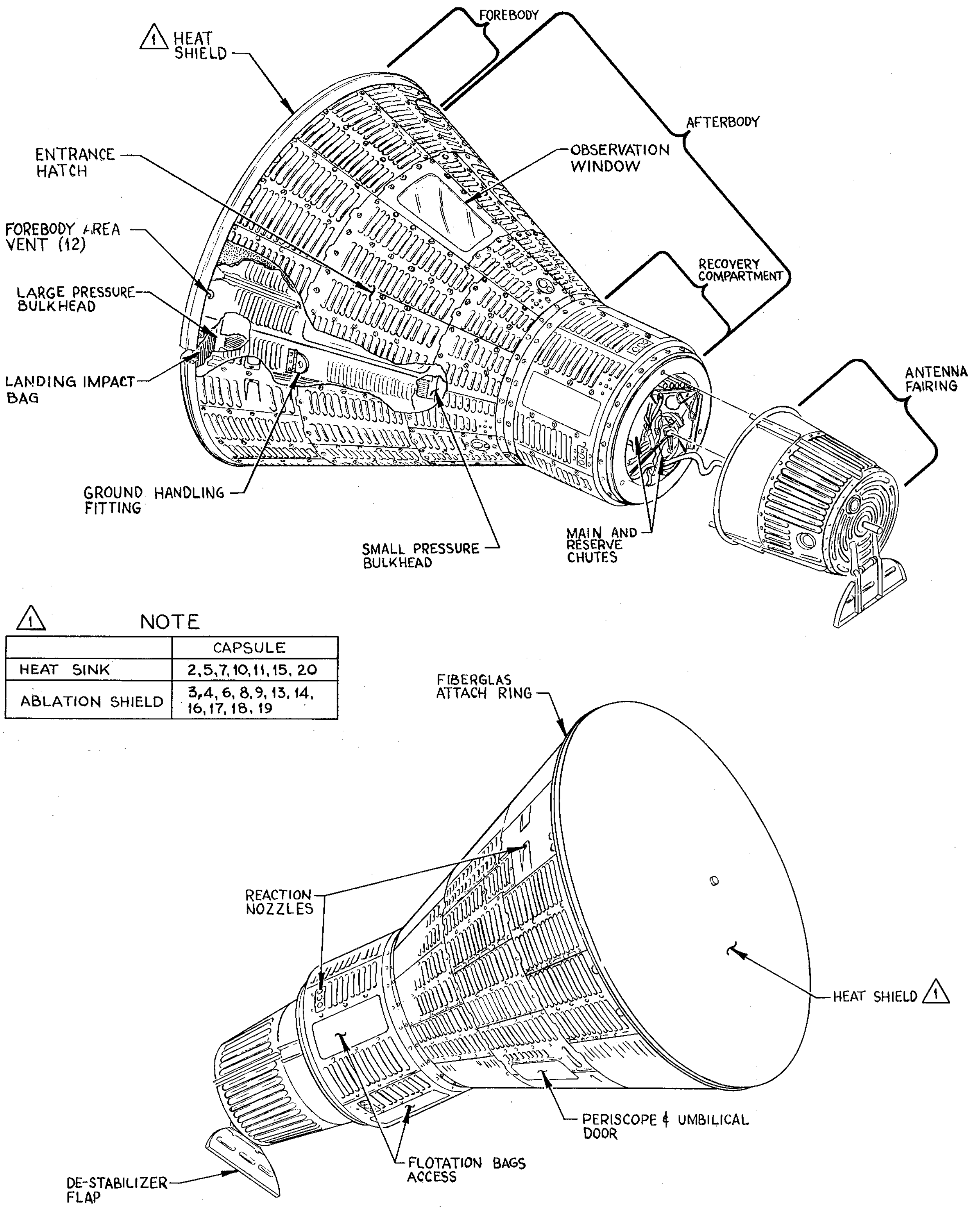
In capsule #4 all three cameras, pilot observer camera, earth and sky observer camera, and instrument panel observer camera, are installed.

SECTION II



MAJOR STRUCTURAL ASSEMBLIES

TABLE OF CONTENTS



⚠1 NOTE

	CAPSULE
HEAT SINK	2, 5, 7, 10, 11, 15, 20
ABLATION SHIELD	3, 4, 6, 8, 9, 13, 14, 16, 17, 18, 19

FIGURE 2-1 CAPSULE STRUCTURE (SPECIFICATION CAPSULE)

PM45-16A

II. MAJOR STRUCTURAL ASSEMBLIES

2-1. CAPSULE STRUCTURE

The Project Mercury satellite capsule, Figure 2-1, is designed to contain an Astronaut, primate, or crewman simulator during capsule ballistic or orbital flight. Capsule payload will depend upon mission purpose. (See Figure 1-6, Section I.) The capsule will also contain recording equipment, environmental provisions, and equipment necessary to control the capsule during flight. The capsule is basically of a conical configuration consisting of a forebody and afterbody. During orbital flight, the capsule forebody is forward with respect to the capsule flight path. The capsule forebody is the large, dish-shaped structure forward of the cabin area. The capsule afterbody consists of a conical mid-section attached to a small cylindrical section. The capsule is of a conventional semi-monocoque construction utilizing titanium for the primary structure. Capsule construction is designed to protect the internal cabin from excessive heating, noise and meteorite penetration. Provisions are incorporated in the capsule to permit cabin entry, exterior viewing, and emergency exit.

2-2. Prior to capsule flight, an escape tower and antenna fairing are attached to the capsule afterbody cylindrical section. The escape tower, designed to aid in capsule-missile emergency separation, consists of a pylon framework equipped with rockets. The antenna fairing is a cylindrical shaped structure containing the capsule radio main receiving and transmitting antenna. The escape tower is jettisoned during the capsule launch phase or after an escape sequence. During the capsule landing phase the antenna fairing is ejected and serves to deploy the capsule main chute.

2-3. Forebody

The capsule forebody, Figure 2-1, mainly consists of a large, blunt, dish-shaped structure that is supported by the large pressure bulkhead and adjoins the afterbody conical section. The large pressure bulkhead internally separates the forebody from the afterbody. The forebody dish-shaped structure is a heat shield that is designed to protect the capsule from extreme thermal conditions during orbital and re-entry flight. It is also designed to prevent capsule damage upon landing impact. The heat shield is attached to the heat shield attach ring, which in turn is riveted to the capsule conical section inner skin. The heat shield attach ring incorporates elongated holes, for the installation of the heat shield to the capsule, to allow for thermal expansion. Either of two interchangeable types of forebody heat shields, namely the heat sink and the ablation shield, is used on the capsule. The heat sink is constructed of pressed beryllium and is designed to absorb heat. The ablation shield is designed to ablate heat and is constructed of fiberglass shingles, radially laminated to form a smooth contour. A retrograde package assembly is attached to the heat shield, by means of three straps. The retrograde package is jettisoned from the capsule following retrograde rocket firing, which initiates capsule re-entry.

2-4. The forebody area, between the large pressure bulkhead and the heat shield, is vented to atmosphere through a series of vents located around the periphery of the capsule forebody, adjacent to the forebody and afterbody junction. Located in the forebody area are two torodial shaped hydrogen peroxide tanks, reaction control valves and nozzles. A landing impact bag is also stored in the capsule forebody area. The rubber-cloth impact bag, attached to the capsule heat shield attach ring and the heat shield, is designed to absorb high energy shock loads encountered during a capsule landing on land. During the capsule landing phase, the heat shield is released, and extends the full length of the impact bag, thereby inflating the impact bag. Upon heat shield contact with land, air within the impact bag is forced out through a series of holes located in the impact bag wall, which in turn provides a cushion-like effect. The afterbody conical section exterior shingle arrangement extends beyond the large pressure bulkhead, to the forebody heat shield, and encloses the equipment located between the large pressure bulkhead and the heat shield. Located adjacent to the capsule forebody and afterbody juncture, and bolted to the heat shield attach ring, is a fiberglass attach ring. During capsule-adapter installation, the fiberglass attach ring and the adapter attach flange are clamped together with a segmented clamp ring. Receptacles for the capsule retro-package, adapter, and the clamp ring pneumatic and electrical connectors are located under the forebody shingles adjacent to fiberglass attach ring. Six spring loaded access doors, for the receptacles are incorporated in the shingles.

2-5. Afterbody

The capsule afterbody, Figure 2-1, basically consists of the short cylindrical section and the truncated cone shaped structure. The cylindrical section is referred to as the capsule recovery system compartment and contains the landing parachutes, recovery aids, and the reaction control nozzles. The truncated cone shaped structure, referred to as the capsule afterbody conical section, encloses the pressurized cabin. The recovery system compartment is a cylindrical formed titanium skin structure, reinforced with longitudinal hat stringers, and covered with a corrugated cobalt shingle arrangement. A layer of thermoflex insulation is installed between the hat stringers and the external shingles to prevent excessive heating within the compartment. The cobalt shingles are individual panels bolted to the hat sections with allowances for thermal expansion. A set of four flotation bags, equally spaced around the outer periphery of recovery compartment, are located beneath the shingles. Flotation bags are provided to prevent possible submersion of capsule during Astronaut's egress, following capsule water landing. A set of reaction control exhaust nozzles are internally located every 90°, between the compartment inner skin and the external shingle installation. The recovery system compartment interior is structurally divided into a left and right section. The compartment left section houses the recovery aids, electrical wiring and plumbing routed through the compartment. The right section of the compartment houses a fiber-glass container, structurally divided into two sections that contain the main and reserve parachutes. The container is removed by the Astronaut from the cabin following capsule landing, to permit egress.

2-6. The capsule afterbody conical mid-section is constructed of a conically formed inner and outer titanium shell, seam welded together. The outer skin is beaded to form small sealed pressure panels capable of withstanding high pressures and structural loads. The outer conical skin is reinforced with longitudinal hat stringers. A blanket of thermoflex insulation is bonded, in between the hat stringers, to the outer (beaded) conical skin. Thermoflex insulation is also installed over the hat sections and covered with a shingle arrangement. The shingle arrangement is similar to the shingle installation used on the recovery system compartment. The aft end of the conical section adjoins the recovery system compartment. The foreward end of the conical section is attached to the forebody heat shield. The combination of the conical section beaded outer skin, the hat section reinforcements, thermoflex insulation, and external shingle installation provide the capsule with adequate heat, noise and meteorite protection.

2-7. An entrance hatch, Figure 2-2, is located on the right side of the afterbody conical section as viewed from the capsule crew member station. An explosive charge, moulded in the hatch sill, is provided to enable Astronaut's rapid egress from the capsule in the event the capsule lands on land. Entrance hatch construction, similar to the conical section construction, consists of an inner and outer (beaded) skin seam welded together and reinforced with hat stringers. An explosive charge initiator is located in the upper aft corner of hatch and is linked to a release control arm. A pressure valve, located below the initiator in the lower aft corner of the hatch, enables pressurization of the capsule during capsule ground checkout operations. Prior to capsule launch, the hatch is bolted and sealed into position with bolts, and two corrugated shingles are installed over the hatch. The bolts are inserted through entrance hatch sill, which incorporates the explosive charge, and threaded into the capsule sill. A magnesium gasket, with inlaid rubber, forms the hatch seal when the hatch is bolted into position. The hatch shingles are attached to the hatch stringers, but in no manner are they attached to capsule shingles. (This enables the hatch to separate cleanly, upon ignition of hatch explosive charge.) Following capsule impact on land, the Astronaut actuates the hatch release control which in turn explodes the hatch from the capsule. A hatch release control is also provided, on capsule exterior, to enable ground crewman to explode hatch in the event the Astronaut is unable to explode hatch.

2-8. An observation window, Figure 2-3, located on the afterbody conical section, is provided to enable the Astronaut to view the capsule exterior. The window, located above the main instrument panel, consists of an inner and outer

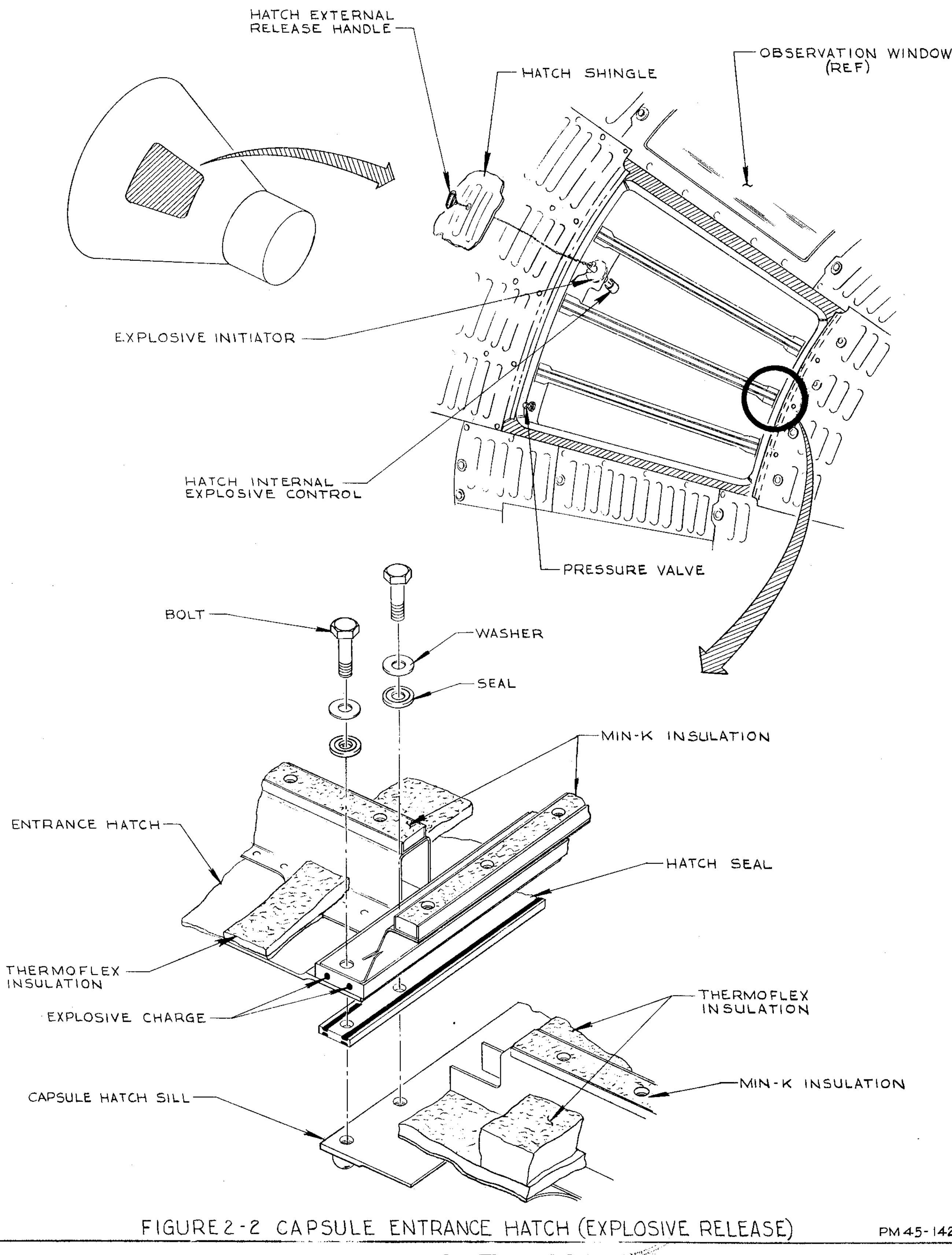


FIGURE 2-2 CAPSULE ENTRANCE HATCH (EXPLOSIVE RELEASE)

PM 45-142

assembly. The inner window assembly is made up of three glass panes sealed in a titanium frame, that is attached to the cabin wall. The panes are independently sealed to provide a pressure seal between the panes. The outer window assembly consists of a glass pane sealed in a titanium frame, that is attached to the capsule outer skin. The outer window assembly is sealed, separately from the inner window assembly, to provide a complete seal. The outer window conforms to the curvature of the capsule conical section. The observation window is equipped with shades and filters, enabling the Astronaut to regulate external light entering the cabin. Located in the bottom of the conical section, as viewed during capsule normal flight attitude, is a retractable door that encloses the periscope lower lens flange and the capsule ground checkout umbilical receptacle. The door, mechanically linked to the periscope housing, automatically opens and closes with periscope extension and retraction. Two auxiliary hoist fittings, attached to left and right side of the capsule, provide ground handling attach points. The hoist fittings are removed prior to capsule launch. The capsule afterbody conical mid-section mainly consists of a pressurized cabin that is supported between a small pressure bulkhead and the large pressure bulkhead. The cabin interior wall is lined with channeled frames to provide additional structural strength and equipment attach points.

2-9. The small pressure bulkhead internally separates the cabin pressurized area from the recovery system compartment and structurally supports the aft conical section. A sealed escape hatch, Figure 2-4, internally actuated, is provided in the small pressure bulkhead to enable the Astronaut's exit following capsule landing. The dish-shaped escape hatch is constructed of a beaded aluminum skin spotwelded to an inner skin, that is reinforced with structural

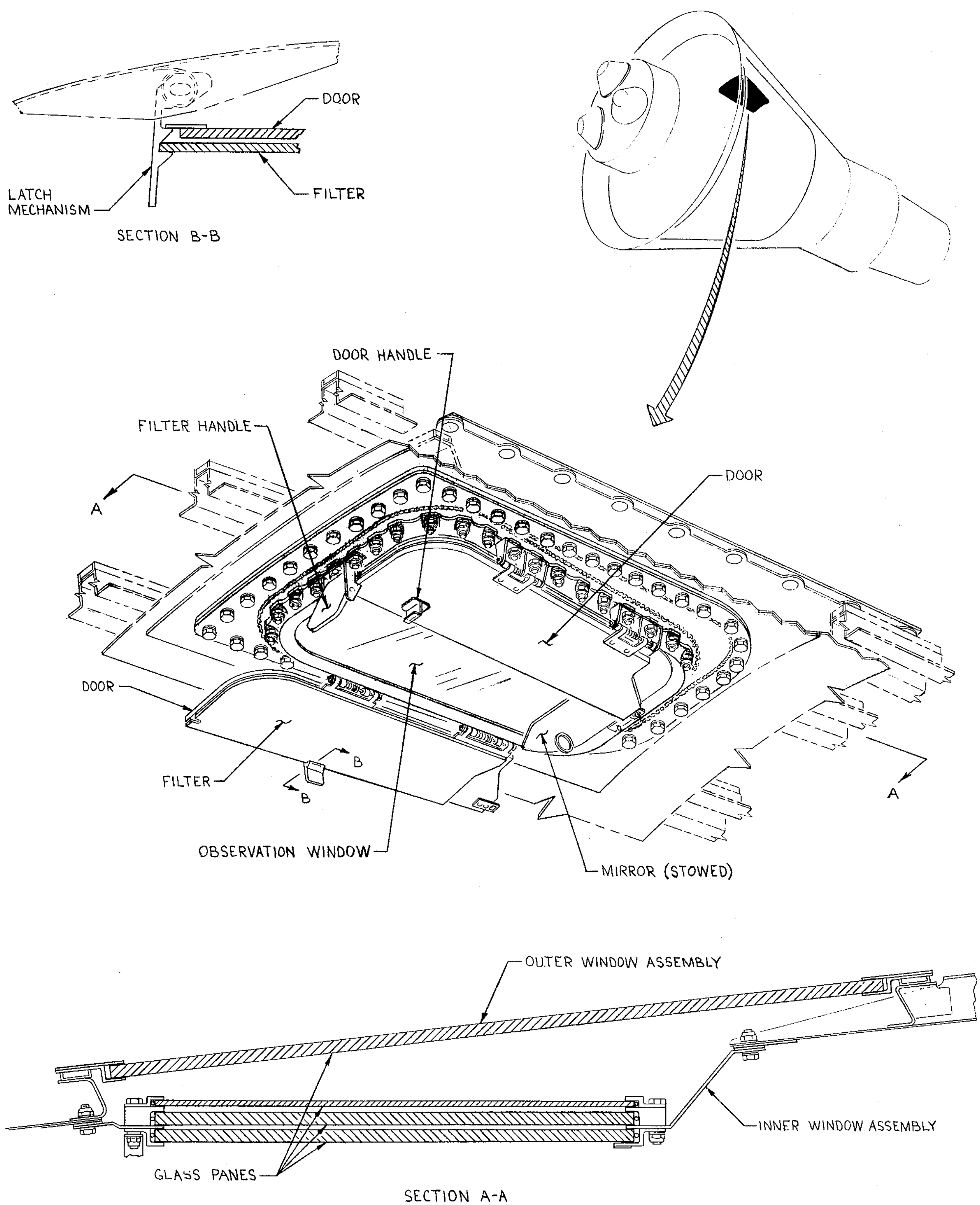


FIGURE 2-3 CAPSULE OBSERVATION WINDOW

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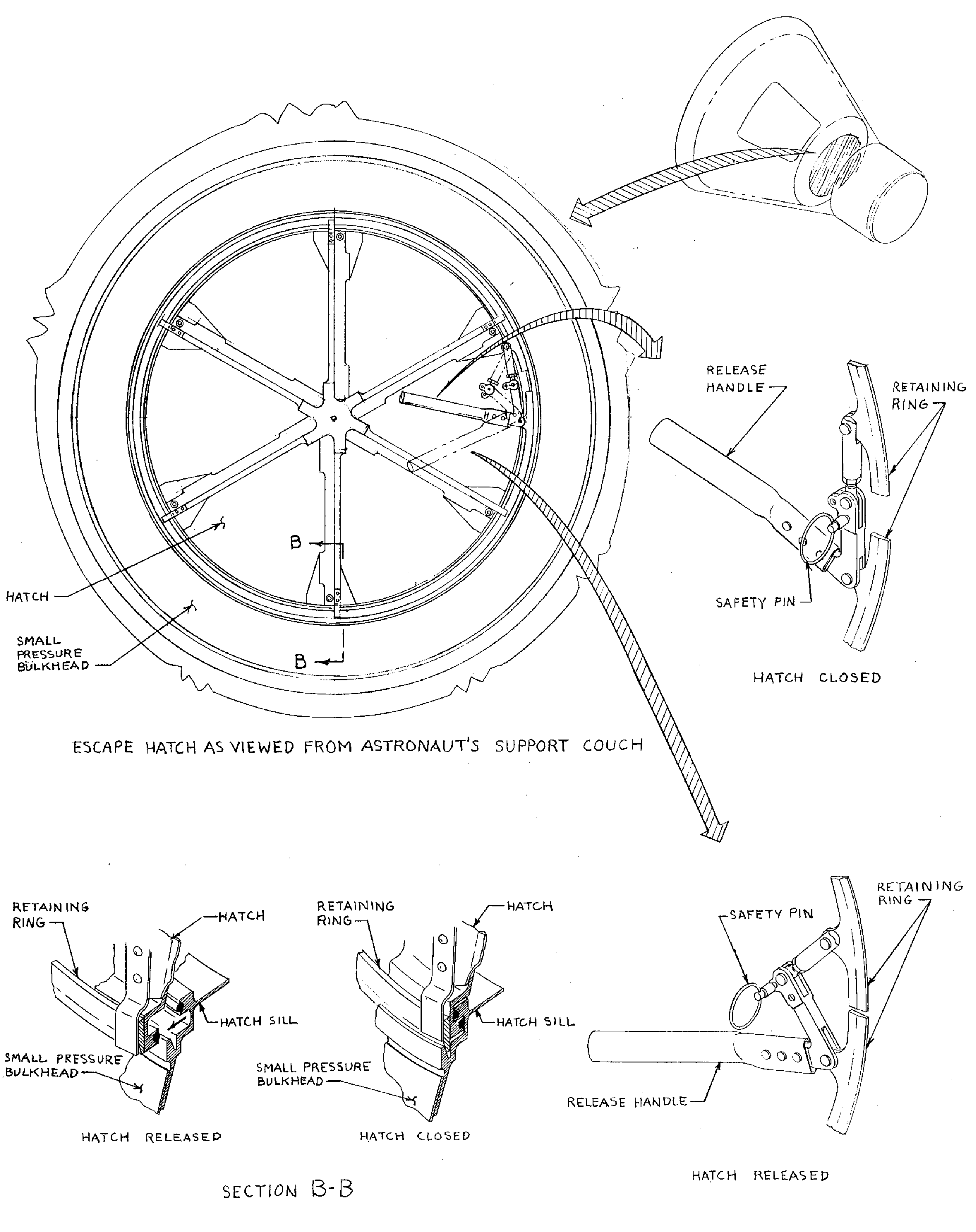

FIGURE 2-4 CAPSULE ESCAPE HATCH

PH45-18

"Z" shaped members. The hatch outer flanged edge fits into the small pressure bulkhead sill and is held in place with a retaining ring. Expanding the retainer ring by raising the hatch handle, wedges the retainer ring between the bulkhead sill and the hatch flanged edge and forces the hatch flange aft to provide a sealing action. The titanium small pressure bulkhead is seam welded to the conical section inner skin and bolted to the conical hat stringers flanges.

2-10. The large pressure bulkhead supports the forward end of the conical section and internally separates the pressurized cabin from the forebody heat shield. The large pressure bulkhead is constructed of a combined inner and outer titanium skin. The outer skin is beaded and seam welded to the inner skin. The bulkhead is reinforced with horizontal channels installed on the outer skin. The bulkhead inner skin is provided with two vertical channels, centrally located and spaced, that furnish structural attach point for the Astronaut support couch. Honeycomb shelves are provided on the bulkhead inner skin, outboard of the two vertical channels, for equipment installation. The bulkhead outer flange ring is bolted to the conical section inner skin and the bulkhead is also bolted to the conical section inner attach ring. Vents are provided in the large pressure bulkhead to enable overboard venting of the capsule battery vapors and environmental control system exhaust steam.

2-11. Antenna Fairing

The capsule antenna fairing, Figure 2-5, is a cylindrical shaped structure that houses the pitch and roll horizon scanners, and basically makes up the capsule radio main receiving and transmitting antenna. The antenna fairing basic structure is of titanium construction and is covered with titanium shingles. An 8 inch window assembly is located around the outer base of the

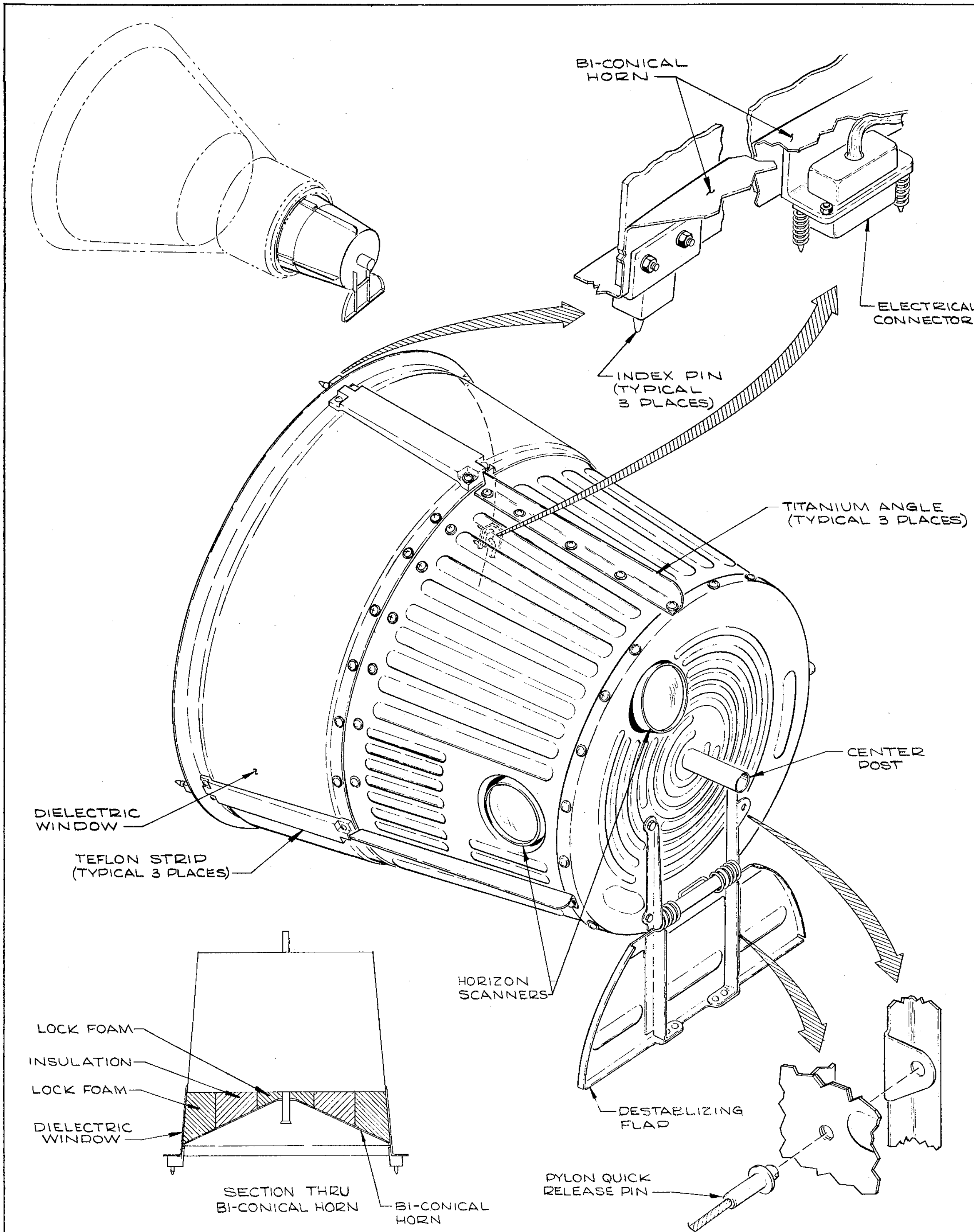

FIGURE 2-5 ANTENNA FAIRING

PM45-144

fairing and acts as a dielectric between the top of the fairing and capsule. The window assembly consists of a silicone base, fiberglass insulation, vycor glass, and teflon strips. In line with the three teflon strips and attached to the antenna fairing shingles, are three titanium angles. The teflon strips and the titanium angles prevent damage to the antenna fairing when the escape tower is jettisoned. A steel post, located in the center of the fairing is the center structure of the fairing. An aluminum bi-conical horn is internally located at the base of the antenna fairing. An electric insulator and lockfoam, located above the bi-conical horn, aid in antenna fairing insulation. A pitch horizon scanner is located at the top of the antenna fairing. A roll horizon scanner is located in the side of the fairing, in line with the pitch horizon scanner. The fairing is attached to the capsule by a mortar gun, located in the capsule recovery compartment, and three index pins in the antenna fairing lower mating flange that align with three holes in recovery compartment mating flange.

2-12. A spring loaded de-stabilizer flap is attached to the top of antenna fairing, opposite the pitch horizon scanner. The de-stabilizer flap ensures capsule correct re-entry attitude during capsule abort and re-entry phases. During capsule launching phase, and up to the capsule-tower separation, the spring loaded de-stabilizer flap is held flat against the antenna fairing by means of a quick release pin attached to the escape tower. Jettisoning of the escape tower releases the flap, which is spring loaded to the outboard position. When the capsule descends to 10,000 feet altitude, the antenna fairing is automatically jettisoned from the capsule by the firing of the fairing mortar gun.

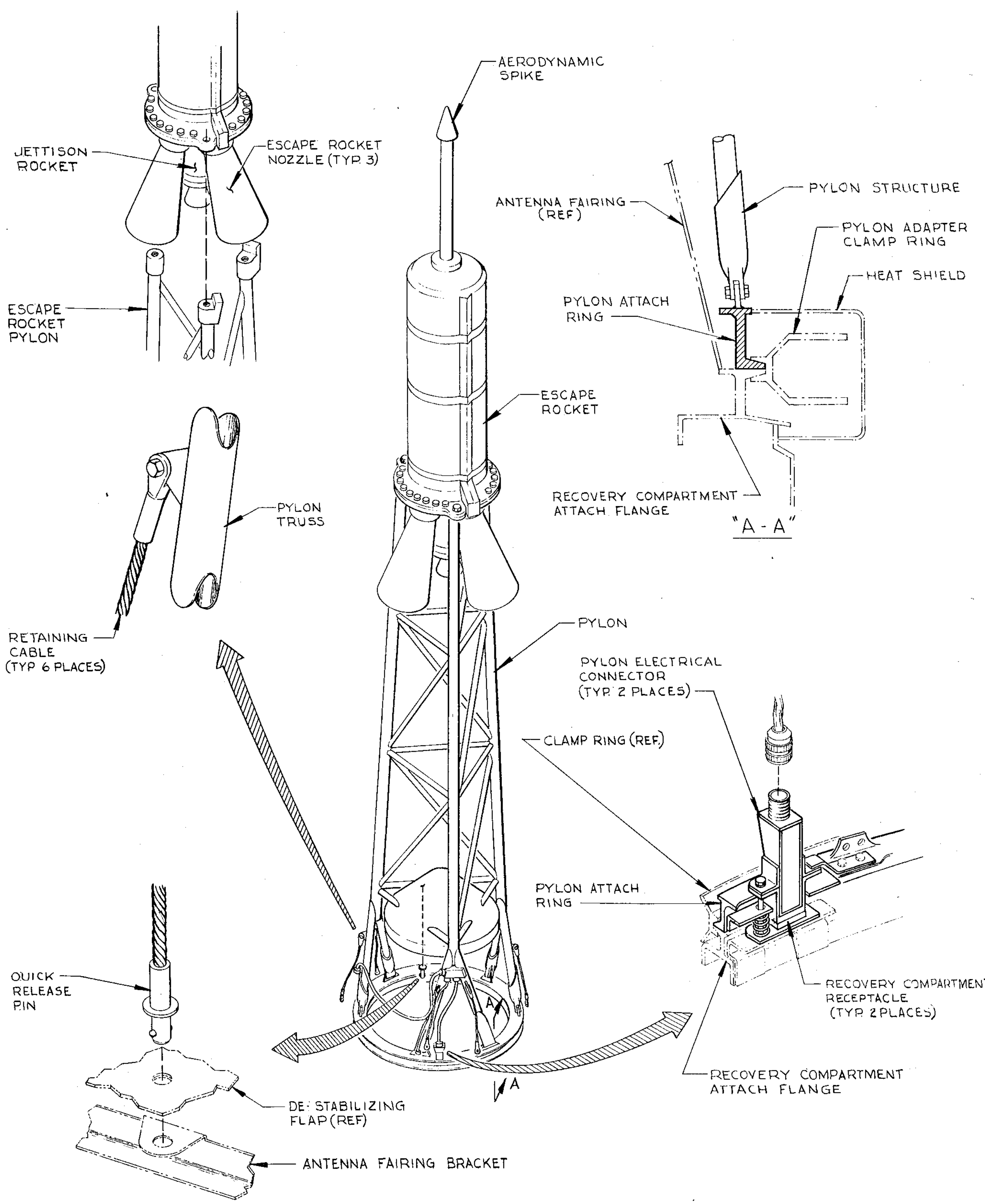

FIGURE 2-6 PYLON

PM45-162

2-13. Pylon

The capsule pylon, Figure 2-6, is a triangular shaped structure that is designed to support an escape rocket and a jettison rocket. The pylon is constructed of 4130 tubular steel and is approximately 10 feet in length. The base of the pylon structural tubing is bolted to a steel flanged attach ring. A four foot escape rocket casing is bolted to the top (apex) of the pylon. Bolted to the bottom of the escape rocket casing is a jettison rocket. Electrical wiring is routed through the structural tubing, from the rockets to connectors, located on the pylon attach ring. Prior to capsule launch the pylon is installed onto the capsule, by clamping the pylon attach ring to the capsule recovery system compartment with a chevron shaped, segmented clamp ring. Explosive bolts connect the clamp ring segments in tension. The bolts are fired to separate the clamp ring when the pylon is jettisoned from the capsule. During capsule normal launch the escape and jettison rockets are fired simultaneously to separate the pylon from the capsule. In the event the capsule escape system is activated, during launch phase, the escape tower is fired to propel the capsule away from the missile and then the jettison rocket is fired to separate the pylon from capsule.

2-14. Pylon-Capsule Clamp Ring

The clamp ring consists of three chevron shaped segments that clamp the pylon attach ring to the capsule recovery system compartment flange. Three explosive bolts, with dual ignition provisions, connect the ring segments in tension. The clamp ring is basically the same in design as the capsule-adapter clamp ring (Figure 2-9), but considerably smaller in size. The clamp ring retains the pylon to the capsule until the clamp ring explosive bolts are fired, which in turn separates the clamp ring. The exterior of the clamp ring is covered with a heat shield to protect the clamp ring and explosive bolts from excessive heating during capsule launch. A layer of thermoflex insulation is bonded to the interior of the heat shield. The heat shield is attached to the clamp ring with screws. Six cable straps, bolted to the pylon structure and clamp ring heat shield, aid in capsule-pylon separation by retaining the clamp ring segments to the pylon when the explosive bolts are fired.

2-15. MISSILE ADAPTERS

2-16. Redstone Missile Adapter

The Redstone missile adapter, Figure 2-7, is a shallow, slightly tapered, cylindrical shaped, structure that is designed to mate the capsule with the Redstone missile. The adapter is bolted to the missile and the capsule is attached to the adapter. The adapter is of a semi-monocoque construction, utilizing titanium for the primary structure. Four titanium panels, butt welded together, form the adapter skin. Vertical hat sections, internally welded to the adapter skin, provide structural reinforcement. A steel, flanged ring is riveted to the bottom, outer surface of the adapter. The ring flange is provided with holes to enable the attachment of the adapter to the missile with bolts. Riveted to the top, outer surface of the adapter, is an aluminum, flanged ring. The aluminum ring mates with the capsule forebody fiberglass attach ring during capsule to adapter installation. The top of the aluminum ring is slotted at 120° intervals, to provide adequate clearance for the capsule retrograde rocket assembly attach straps, when the capsule is attached to the adapter. A metal striker bracket is riveted internally, every 120°, to the adapter skin. When the capsule is attached to the adapter, these striker brackets depress (open) the capsule-adapter separation sensing switches, located on the bottom of the retrograde rocket assembly attach straps. The

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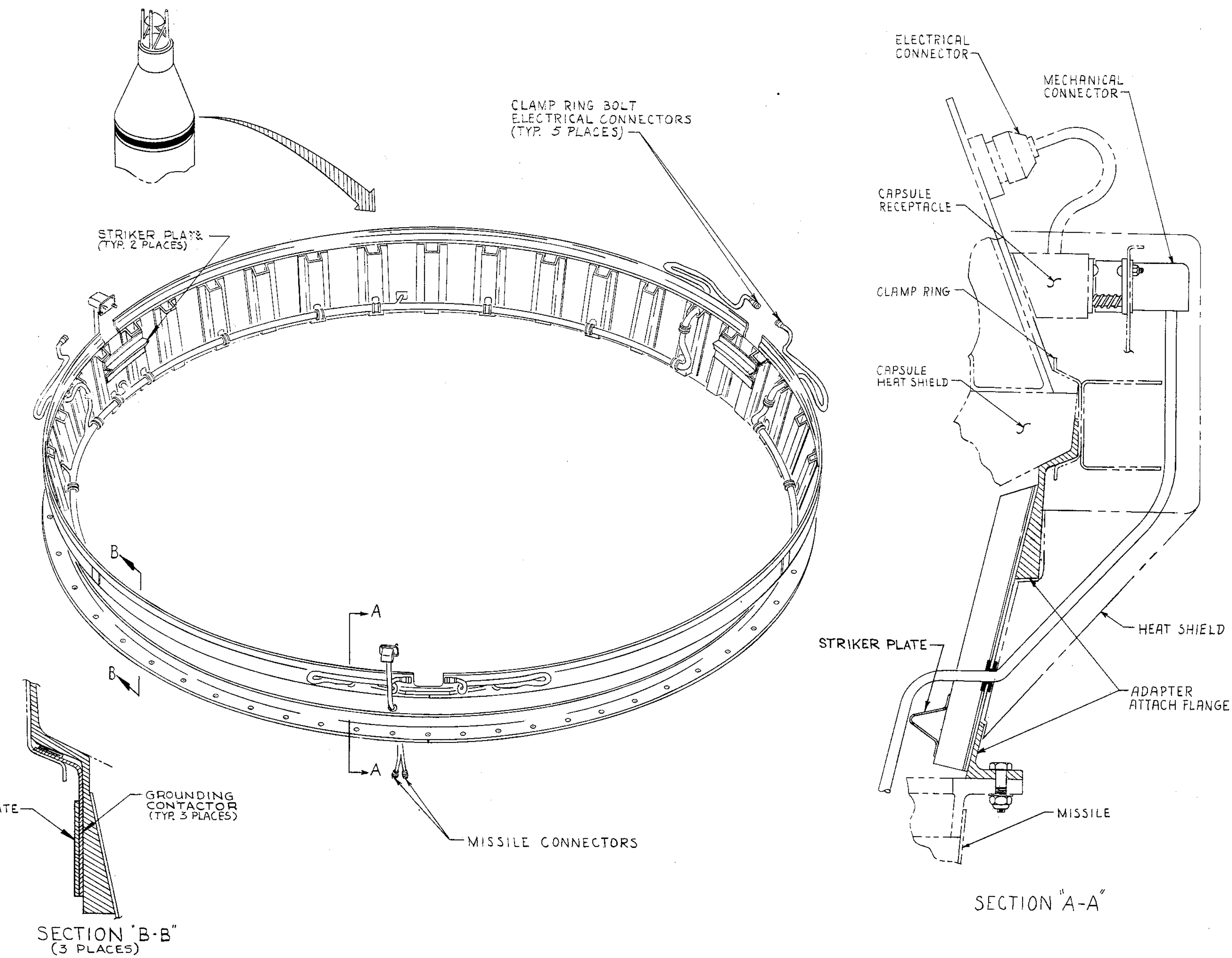

FIGURE 2-7 REDSTONE MISSILE ADAPTER

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capsule is attached to the adapter by installing a chevron shaped, segmented clamp ring over the mated flanges of the capsule forebody fiberglass attach ring and the adapter upper ring.

2-17. Atlas Missile Adapter

The Atlas missile adapter, Figure 2-8, is a slightly tapered, cylindrical shaped structure that is designed to mate the capsule with the Atlas missile. Upon adapter and capsule installation to the missile, the adapter is bolted to the missile and the capsule is attached to the adapter. The adapter is of semi-monocoque construction and is approximately 4 feet in height. The adapter basically consists of an outer corrugated titanium skin assembly, riveted and seam welded to an inner titanium skin assembly, andinternally reinforced with two titanium support rings, riveted between the ends of the adapter. A steel flanged ring is riveted to the bottom, inner surface of the adapter. The flanged ring is provided with holes to enable the attachment of the adapter to the missile with bolts. Riveted to the top, inner surface of the adapter is an aluminum flanged ring. The adapter aluminum ring mates with the capsule forebody fiberglass attach ring during capsule to adapter installation. The top of the aluminum ring is slotted, at 120° intervals, to provide adequate clearance for the capsule retrograde rocket assembly attach straps, when the capsule is attached to the adapter. A metal striker bracket is riveted internally, every 120°, to the adapter skin. When the capsule is attached to the adapter, these striker brackets depress (open) the capsule-adapter separation sensing switches, located on the bottom of the retrograde rocket assembly attach straps. The capsule is attached to the adapter by installing a chevron shaped, segmented clamp ring over the mated flanges of the capsule forebody fiberglass attach ring and the adapter upper ring.

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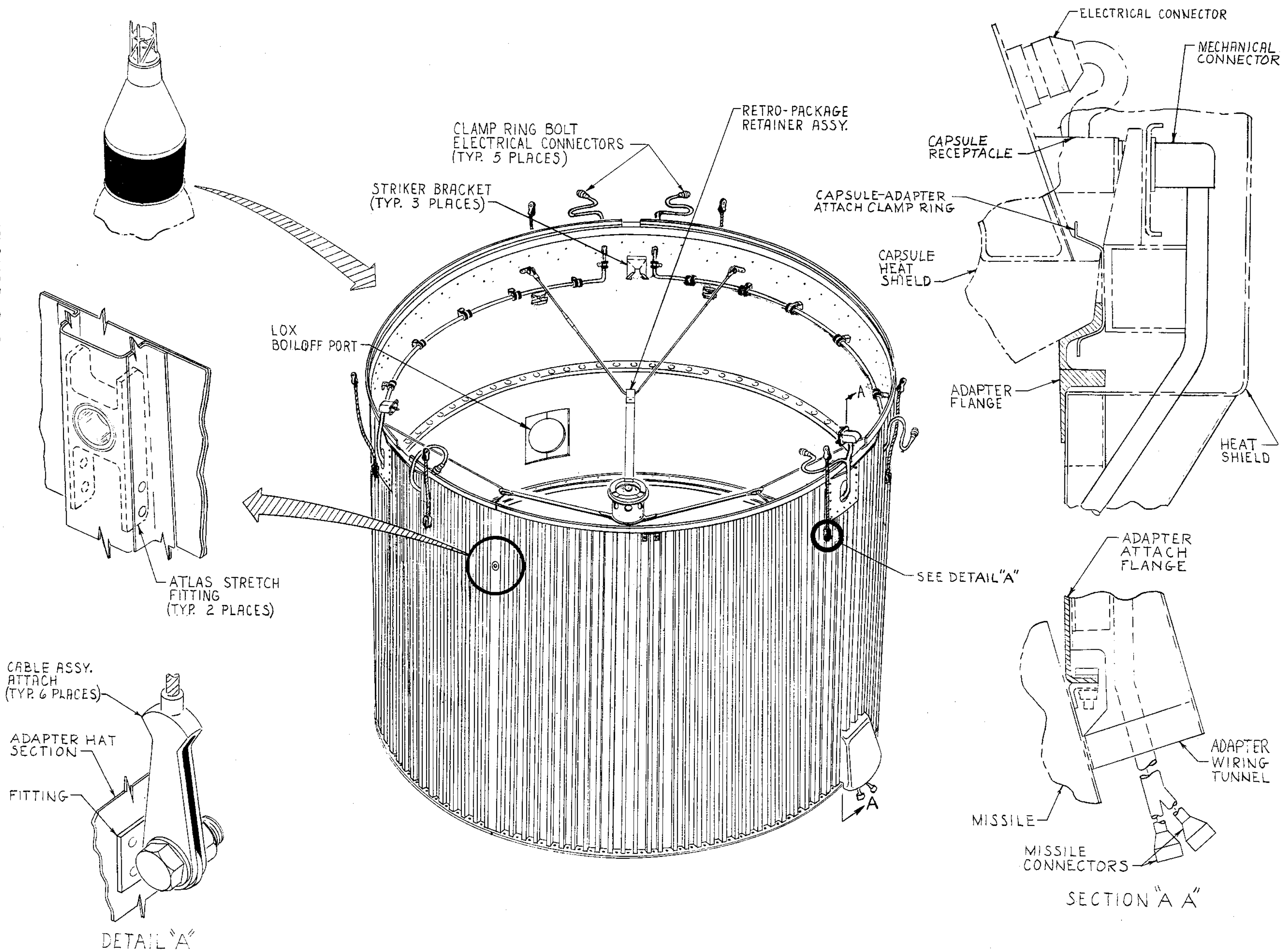

FIGURE 2-8 ATLAS MISSILE ADAPTER

PM45-23A

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2-18. A retainer assembly, attached to the adapter interior skin, is provided to prevent the retro-package and the explosive bolt fragments from striking the Atlas missile adapter LOX tank. The retainer assembly is a cup shaped structure that fits over the retro-package dome, and is supported by three metal straps that are attached to the adapter with cable assemblies. A vent port, located in the adapter skin, receives the missile boil-off valve tube and enables the relieving of liquid oxygen from the mixxile. A fiberglass shield, attached above the vent port opening, streamlines the adapter and shields the boil-off tube. Two stretch fittings, located 180° apart at the upper section of the adapter, provide a means of supporting (stretching) the missile while in the vertical position, following adapter installation. Six cable assemblies, attached to fittings spaced around the adapter outer corrugated skin, are attached to the clamp ring that attaches the capsule to the adapter. The cables retain the clamp ring to the adapter following capsule-adapter separation.

2-19. Capsule-Adapter Clamp Ring

The capsule-adapter clamp ring, Figure 2-9, is provided to attach the capsule to the adapter. The clamp ring secures the capsule to the adapter throughout the capsule launching phase until the clamp ring is separated, by means of explosive bolts, which in turn allows the capsule to separate from the adapter. The clamp ring consists of three chevron shaped segments that when installed, mate with the capsule forebody fiberglass attach ring and the adapter upper support ring. Three explosive bolts, with dual ignition provisions, connect the 3 clamp ring segments in tension. A metal striker bracket is bolted, every 120°, to the inside of the clamp ring. When the clamp ring is installed, the striker brackets depress the capsule ring separation sensing switches,

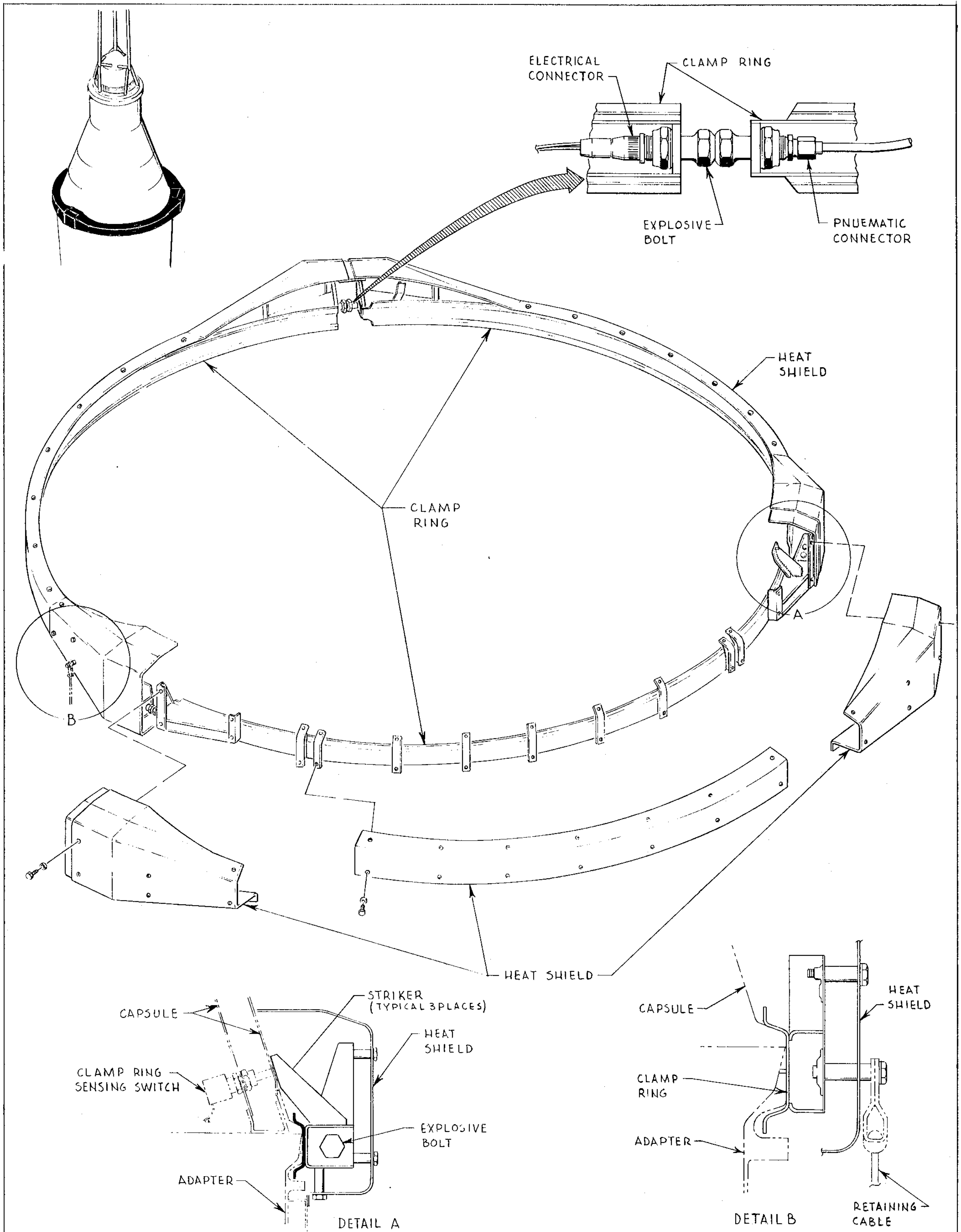

FIGURE 2-9 CAPSULE ADAPTER CLAMP RING

PM45-26

located in the outer periphery of the capsule forebody.

2-20. The exterior of the clamp ring is covered with a heat shield that protects the explosive bolts from excessive heating. Thermoflex insulation is provided on the clamp ring shield interior. The heat shield is attached to the clamp ring with screws. Six cable straps are bolted to the clamp ring heat shield and to the missile adapter. These straps aid in capsule-adapter separation, by retaining the clamp ring to the adapter, when the explosive bolts are fired. An electrical cable, clamped around the interior of the adapter, is connected to each of the clamp ring explosive bolts, to two receptacles in the capsule forebody area and to two receptacles on the missile. A pneumatic line is also connected to one end of the explosive bolts and to a quick disconnect in the capsule forebody.

2-21. TEST CONFIGURATION CAPSULES 2, 3 AND 4

Capsules 2, 3 and 4 differ from the specification capsule in the following manner.

2-22. Forebody

Capsules 2, 3 and 4 do not contain a landing impact bag. Instead the heat shield is bolted directly to the heat shield attach ring.

2-23. Afterbody

Capsules 2, 3 and 4 entrance hatches (Figure 2-10) can only be removed externally. Hatch removal is accomplished by removing the attach bolts that secure the hatch to the capsule. Hatch sealing is similar to the specification capsule. The entrance hatch stringers are interlocked (bolted) with the capsule stringers, when the capsule is bolted in place.

2-24. Capsules 2, 3 and 4 contain two windows, but do not contain an observation window (Figure 2-11). One window is located on the upper left side as

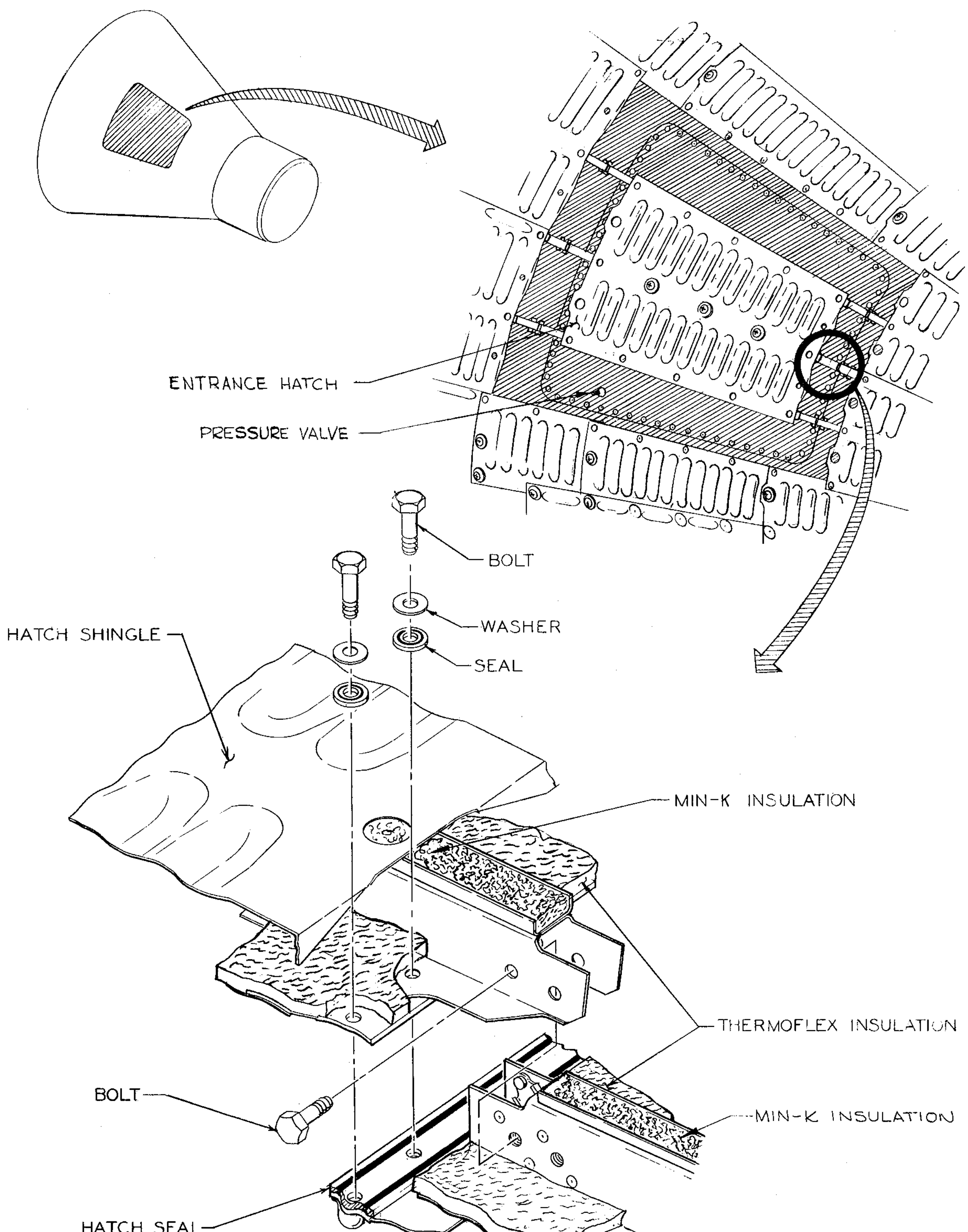

FIGURE 2-10 CAPSULE ENTRANCE HATCH

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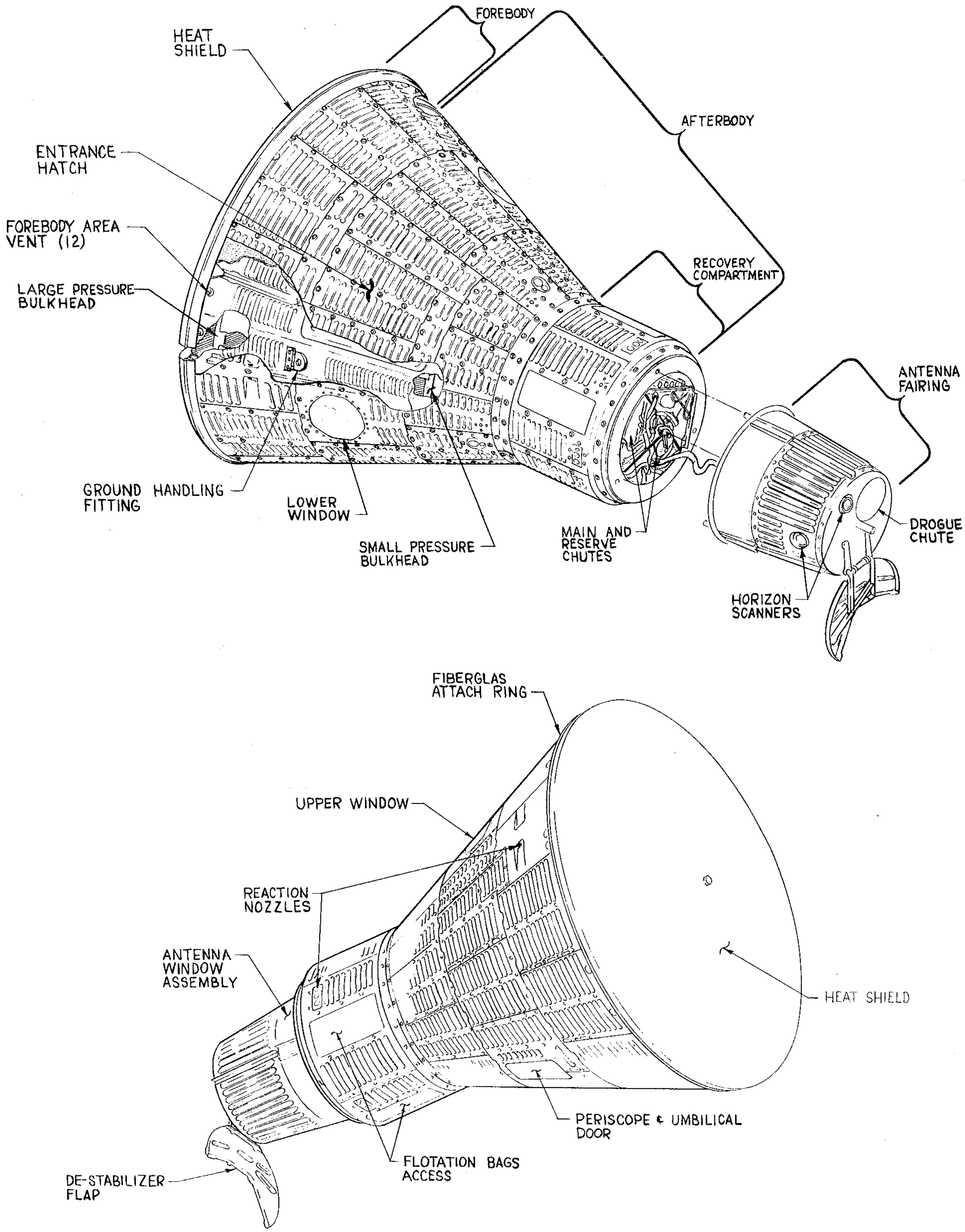


FIGURE 2-11 CAPSULE STRUCTURE (CAPSULE 2)

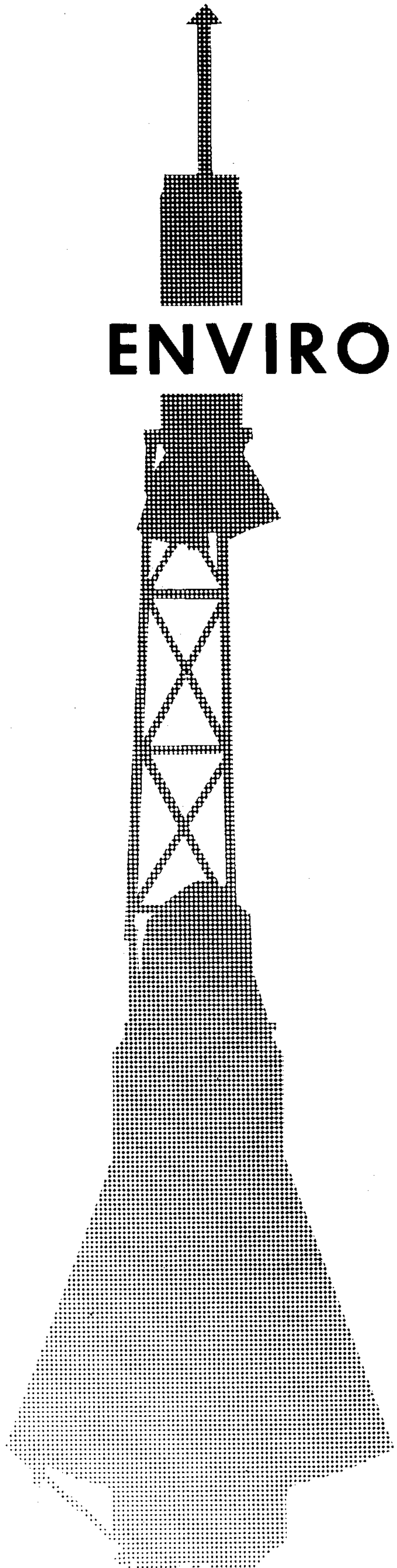
PM45-16

viewed from the capsule crew member station, to permit Astronaut's exterior viewing. Located in the lower right side of the capsule is a window that enables the photographing of the earth and sky during capsule flight. A camera is internally located adjacent to this window. The main cabin window consists of four glass panes sealed in a titanium frame attached to the cabin wall. The glass panes are spaced and independently sealed to provide a pressure seal between the panes. The outer cabin window consists of a glass pane sealed in a titanium frame that is attached to the capsule outer skin. The outer pane conforms to the curvature of a capsule conical section. The outer three glass panes are sealed with a wire mesh type seal and the two inner panes are sealed with silicone type seals. The windows are equipped with adjustable shades to enable the Astronaut to completely close off external light.

2-25. Antenna Fairing

Capsules 2, 3 and 4 antenna fairing destabilizing flaps are smaller and of a different shape than the specification capsule. (See Figure 2-5.) The antenna fairings also house a drogue chute, that stabilizes the capsules during landing phase. The drogue chute is automatically deployed from the antenna fairing when the capsule has descended to 42,000 feet altitude.

SECTION III



ENVIRONMENTAL CONTROL SYSTEM

TABLE OF CONTENTS

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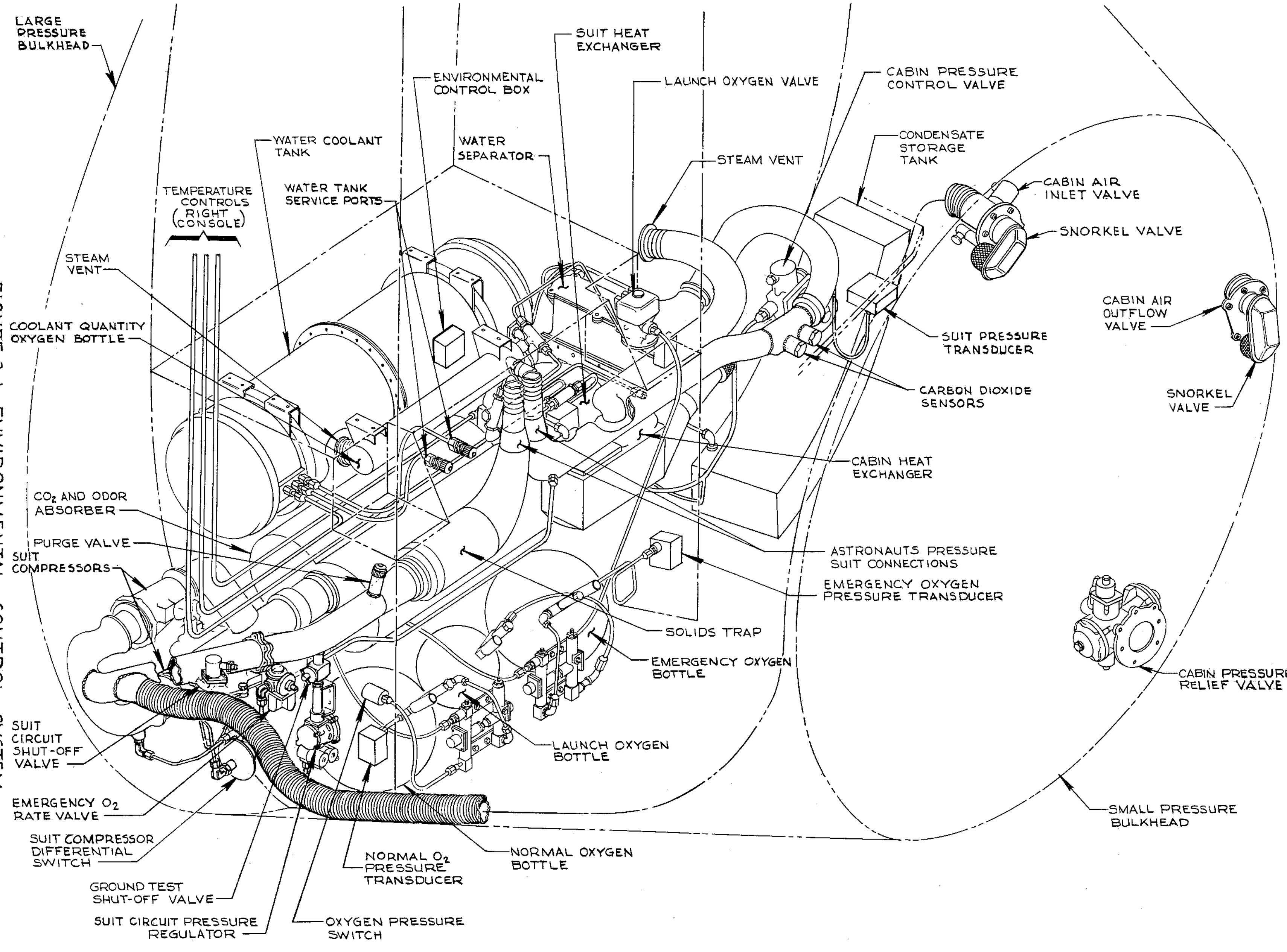

FIGURE 3-1 ENVIRONMENTAL CONTROL SYSTEM

III. ENVIRONMENTAL CONTROL SYSTEM

3-1. DESCRIPTION

3-2. Environmental Control System

The environmental control system, Figure 3-1, provides the capsule cabin and the astronaut with a 100 per cent oxygen environment, to furnish the breathing, ventilation, and pressurization gas required during the capsule orbital flight. The environmental system is designed to automatically control the environmental conditions within the cabin and the astronaut's pressure suit during all phases of capsule flight. The system also provides manual controls to enable system operation in the event the system automatic control malfunctions.

3-3. The environmental control system basically consists of two individual control circuits, namely cabin and suit, that operate simultaneously during normal operating conditions. (See Figure 3-2). In the event either control circuit malfunctions, the remaining control circuit will continue to operate. The environmental system is designed to be operated in either of three modes, depending upon existing conditions within the system, to ensure astronaut's survival in the event an emergency condition or malfunction occurs. The system primary mode, cabin environmental control, is normally utilized and enables the astronaut to function while exposed to cabin environment. The secondary mode, suit environmental control, enables the astronaut to function in the closed suit circuit in the event the cabin environmental control malfunctions. The emergency mode, suit emergency control, ensures astronaut's survival in the event both the cabin and suit environmental control circuits malfunction.

3-4. A common oxygen supply, normal and emergency, provides the breathing, ventilation, and pressurization gas for both the cabin and suit environmental control circuits. A launch oxygen supply, independent from the normal and

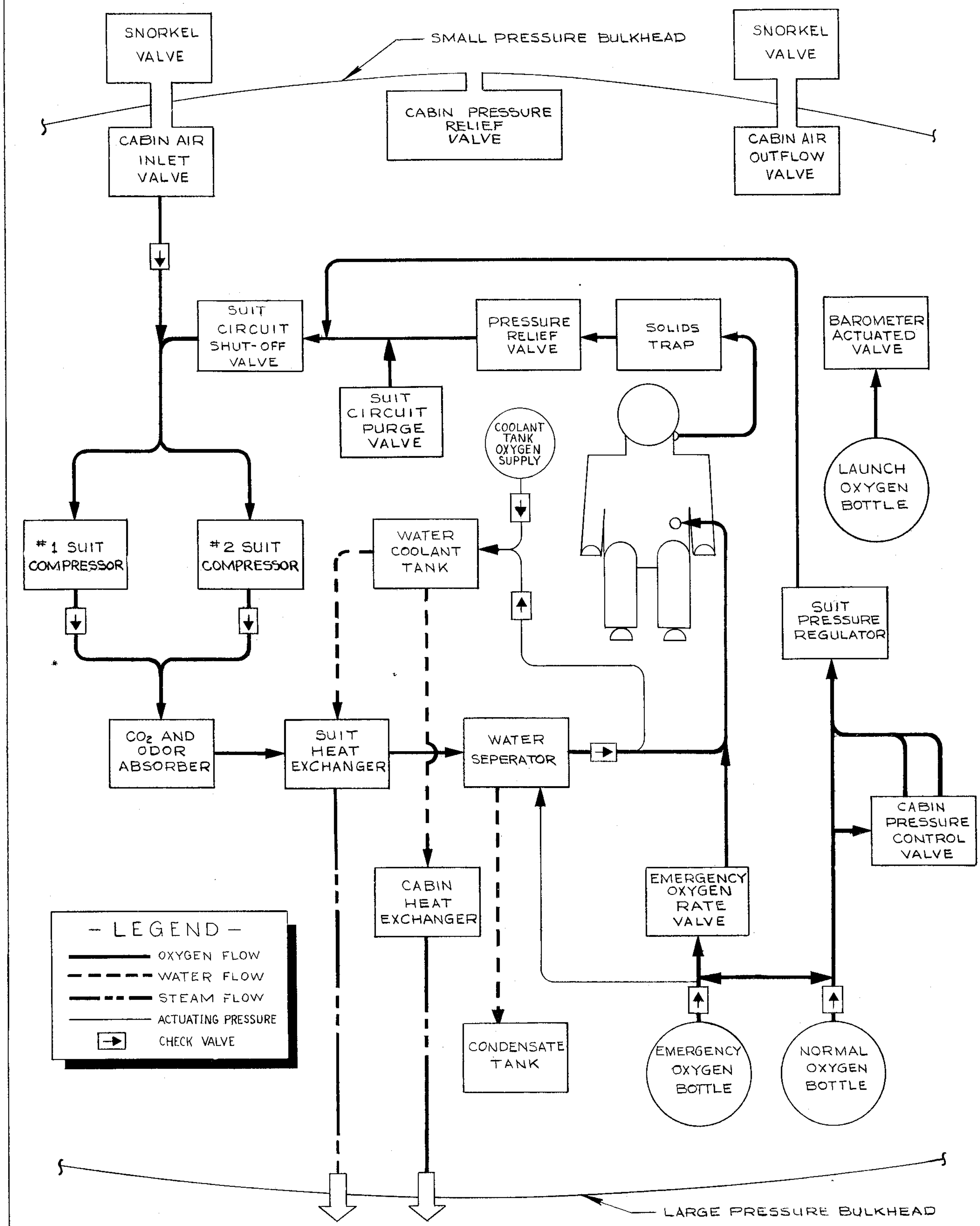

FIGURE 3-2 ENVIRONMENTAL CONTROL SYSTEM BLOCK DIAGRAM PM45-33A

emergency supply, is provided to purge the cabin during the capsule launch phase. A manually controlled cooling circuit, common to cabin and suit environmental control equipment, is provided to control cabin and suit temperatures during capsule flight. The suit environmental control circuit also contains equipment to remove impurities and moisture from the suit circuit oxygen supply. The capsule environmental control system components are located below the astronaut's support couch, adjacent to the large pressure bulkhead. System components are also located on the interior of the small pressure bulkhead, adjacent to the capsule escape hatch. System indicating instruments and warning lights are located on the main instrument panel, and the systems manual controls are located on the left and right consoles.

3-5. Cabin Environmental Control

During capsule normal orbital flight, the environmental control system is normally operated in the cabin environmental control mode. Operation in the cabin control mode permits the astronaut to function with his helmet faceplate open, exposing the astronaut to cabin environment. The capsule normal and emergency oxygen supply furnishes the cabin with pressurization, breathing, and ventilation gas. The cabin is equipped with automatic and manual controls for cabin ventilation, decompression, pressurization, temperature control, landing and post landing ventilation.

3-6. During orbital flight, cabin pressure is automatically controlled to $5.1 \pm .2$ psia by a cabin pressure control valve. A cabin pressure relief valve prevents excessive pressure buildup within the cabin and provides a manual means of decompressing the cabin in the event of a fire or buildup of toxic contaminants. A water coolant supply tank, common to both cabin and suit circuits heat exchangers, provides cabin cooling. Cabin temperature is controlled by a manually controlled selector valve, which regulates the amount of water entering the cabin heat exchanger, and in turn provides cabin cooling by means of water evaporation. The cabin fan, located on the inlet side of the heat exchanger, forces cabin air through the exchanger to provide cabin cooling and ventilation. Cabin air inlet and outflow valves, located on the small pressure bulkhead, provide ventilation during the capsule landing and post landing phase.

3-7. Suit Environmental Control

During capsule normal orbital flight, the common oxygen supply furnishes oxygen simultaneously to the suit and cabin environmental control circuits. In the event of a cabin circuit malfunction, such as cabin decompression, the astronaut must immediately switch to the suit environmental control mode by closing his helmet faceplate. Closing of the helmet faceplate, confines the astronaut to the closed suit control circuit and excludes cabin environment.

3-8. While operating in the suit environmental control mode, the suit pressure regulator controls the suit pressure to 5 psia during normal suit control circuit operation. The suit environmental control circuit incorporates compressors, filters, absorbers, and a temperature-humidity control to ensure astronaut's maximum comfort. Suit circuit temperature is controlled by a manually controlled selector valve, that regulates the amount of water entering the suit circuit heat exchanger from the water coolant tank, which in turn provides suit circuit cooling by means of water evaporation. Suit circuit pressure is also utilized as a secondary means of pressurizing the water coolant tank in the event the cooling circuit oxygen supply fails. A water separator, utilizes suit circuit pressure to remove moisture from the suit circuit oxygen supply. A compressor located on the upstream side of the suit circuit heat exchanger, forces the suit circuit oxygen supply throughout the circuit, providing suit circuit ventilation and pressurization. In the event the normal compressor fails, a secondary compressor automatically operates. During the capsule landing and post landing phase, atmospheric air is drawn in through the cabin air inlet valve to provide suit circuit ventilation.

3-9. Suit Emergency Control

The suit emergency control mode is automatically activated, in the event the environmental system malfunctions while operating in the suit environmental control mode, to ensure astronauts survival. A control handle is provided to enable manual selection of the emergency control, in the event the automatic control failed. During the capsule landing phase, the emergency control is automatically activated to increase astronaut's cooling. The environmental system oxygen rate valve and suit circuit shutoff valve, automatically or manually, actuate simultaneously to switch the environmental system from the suit environmental control mode to the suit emergency control mode.

3-10. Operation in the suit emergency control mode basically consists of eliminating suit circuit oxygen flow through the suit circuit impurity removers, temperature control units, water separator unit, and the compressors. Elimination of oxygen flow through these accessory components, while operating in the suit emergency control mode, reserves the oxygen supply to remove the astronauts generated heat, pressurize the astronaut's pressure suit, and provide a breathing source for the astronaut.

3-11. An O_2 EMERG light, located on the main instrument panel, and a tone generator indicates when the environmental system is operating in the suit emergency control mode. Manual provision, to activate the suit emergency control, is located on the right console.

3-12. Oxygen Supply

The environmental system is supplied with oxygen, from normal, emergency, and launch oxygen bottles. The normal and emergency oxygen spherical shaped bottles, each contain a capacity of 4 pounds of oxygen stored under a 7500 psig pressure. The launch oxygen spherical shaped bottle contains a capacity of 1 pound of oxygen stored under 7500 psig pressure. The normal and emergency oxygen bottles are indirectly interconnected by a supply line that forms a common oxygen supply line to the cabin pressure control valve, suit pressure regulator, water coolant tank, and the suit circuit water separator. The normal and emergency oxygen supply lines incorporate shutoff valves, pressure transducers, pressure reducers, and check valves. The pressure transducers transmit oxygen pressure present in the normal and emergency oxygen bottles to a dual quantity indicator, tape recorder, and to a telemetry unit. The normal oxygen bottle pressure of 7500 psig is reduced to 110 psig by the normal oxygen pressure reducer. Two normal oxygen pressure reducers are provided to ensure oxygen pressure reduction in the event one pressure reducer failed. The emergency oxygen bottle pressure of 7500 psig is reduced to 80 psig by one emergency pressure reducer. The oxygen supply line check valves prevent oxygen backflow between the normal and emergency oxygen bottles.

3-13. The launch oxygen bottle is independent of both the normal and emergency oxygen bottles, and is provided to purge nitrogen from the cabin during the capsule launch phase, and also provides an additional breathing source. The launch oxygen supply line incorporates a shutoff valve, pressure reducer, a barometer controlled valve. The launch oxygen pressure of 7500 psig is reduced to 100 ± 15 psig by the pressure reducer. The normal, emergency, and launch oxygen bottles are located beneath the astronaut's support couch, adjacent to the capsule conical section and the large pressure bulkhead. Each bottle is equipped with a servicing valve that enables servicing of the bottles installed in the capsules.

3-14. Cooling Circuit

The environmental system cooling circuit furnishes the cabin and the suit circuit with provisions to independently control the cabin and suit circuit temperatures during the capsule normal orbital flight. Water is supplied, under oxygen pressure, from the water coolant tank to the cabin and suit circuit heat exchangers, which in turn provides cooling by water evaporation. Heat exchanger water absorbs heat, from the cabin and suit circuit oxygen, and boils off as steam when the capsule is at orbital altitude.

3-15. The cooling circuit contains an independent oxygen bottle that provides pressure necessary to pressurize the water coolant tank, enabling water flow to the heat exchangers. The oxygen bottle pressure is also used as a reference pressure for the coolant quantity indicator. A line, interconnected between the suit circuit line and the coolant tank pressurization line, ensures water coolant tank pressurization, in the event the coolant quantity oxygen bottle malfunctioned and failed to pressurize the water coolant tank. The cooling circuit basically consists of water coolant tank, cabin and suit temperature control valves, heat exchangers, and indicators. A coolant quantity indicator, EXCESS CABIN H_2O and EXCESS SUIT H_2O lights are located on the main panel. Temperature control valves are located on the right console.

3-16. OPERATION

3-17. Environmental Control System

The environmental control system is designed to sequentially operate automatically, during the launch, orbit, re-entry, and post-landing phases of capsule flight. The mode in which the environmental system is operated, is dependent upon the existing conditions within the cabin and suit circuits.

3-18. Pre-Launch - During the pre-launch phase of operation, the capsule oxygen supply and water coolant supply are fully serviced. Refrigerated air is ducted through the capsule hatch to precool the capsule cabin and equipment, during the capsule preflight checks. Astronaut is then connected to the suit circuit by attaching astronaut's pressure suit personal leads to the suit circuit ducting. The suit circuit is then purged with an external low pressure oxygen supply through the suit circuit purge valve. Astronaut closes his pressure suit helmet facepiece and a suit circuit leakage check is performed. Refrigerated air supply is then removed and an external supply of freon coolant is provided to the cabin and suit heat exchangers, through the capsule umbilical plug, to continue precooling of capsule structure and equipment. The suit compressor and cabin fan are then activated and the system oxygen supply bottles shutoff valves opened. The capsule entrance hatch is bolted into position, and a capsule leakage check is performed.

3-19. Launch and Orbit - Forty-five seconds prior to capsule launch the capsule umbilical plug is disconnected and automatically discontinues the flow of freon coolant to the capsule. When the capsule reaches an altitude of 10,000 feet, the launch oxygen (barometer actuated) valve opens and purges the cabin air. The launch oxygen supply is depleted at approximately 45,000 feet altitude. Cabin pressure remains the same as atmospheric pressure up to an altitude of approximately 27,000 feet. Above 27,000 feet altitude, the cabin pressure control valve and the cabin pressure relief valve maintain the cabin pressure to 5 psia. The suit pressure regulator maintains suit circuit pressure to 5 psia. During capsule orbital flight, the suit circuit solids trap removes foreign matter such as hair, etc., emitted from the astronaut. Odors and carbon dioxide given off by the astronaut are filtered from the suit circuit oxygen by an CO_2 and odor absorber unit. Moisture is removed from the suit circuit oxygen by the pneumatically operated water separator, and the moisture is stored in a condensate tank. Cabin and suit circuit temperatures are controlled by manually operated metering valves that regulate the water flowrate from the water coolant tank to the cabin and suit circuit heat exchangers. When the capsule reaches an altitude, where the boiling point of water temperature is lower than the cabin and suit circuit gas temperatures, the cabin and suit heat exchangers will provide cooling by water evaporation.

3-20. Re-entry and Post-landing - Prior to capsule re-entry from orbital flight, the astronaut will position his temperature control valves to a COOLER setting, and also close his pressure suit helmet facepiece. When the capsule descends to an altitude of approximately 20,000 feet the cabin air inlet and outflow valves open, and circulates atmospheric air into the cabin air inlet valve, through the suit circuit, and out through the cabin air outflow valve. Simultaneously, with the opening of the cabin air inlet and outflow valves, the environmental system operation switches to the suit emergency control mode, which in turn provides a greater cooling capacity for the astronaut. In the event of a capsule low altitude abort, explosive squibs, located at the cabin air inlet and outflow valves, will open the valves when the antenna fairing is ejected. Snorkel valves, located on the cabin air inlet and outflow valves, prevent water from entering the cabin in the event the capsule lands in a water environment. During post-landing phase the astronaut may continue to operate his suit circuit fan to provide pressure suit ventilation, by drawing outside air through the cabin air inlet valve into the suit circuit. Cabin fan may also be operated to ventilate cabin.

3-21. Cabin Environmental Control

Operation of the environmental control system in the cabin environmental control mode, Figure 3-3, after the capsule has entered the orbital flight path, permits the Astronaut to open his helmet facepiece and be exposed to cabin environment. Cabin pressure is automatically controlled while operating in the cabin control mode. The cabin control circuit also provides a manual method for decompressing and repressurizing the cabin. During the capsule launching phase, the cabin pressure will remain constant with atmospheric pressure, until an altitude of approximately 27,000 feet is reached. At approximately 27,000 feet altitude, the cabin pressure relief valve closes and maintains cabin pressure below 5.5 ± .2 psia. In the event the cabin pressure decreases, below 5 psia, the cabin pressure control valve will sense the pressure drop and open. Opening of the cabin valve allows oxygen to flow into the suit circuit. Suit pressure regulator will sense the increase in pressure and relieve excess pressure into the cabin. Routing the cabin pressure control valve oxygen supply through the suit circuit, provides a constant purging of the suit circuit. Cabin pressure control valve maintains cabin pressures to 5.1 ± .2 psia. An O_2 PRESS warning light and a tone generator are provided to indicate when cabin oxygen partial pressure has decreased below 3 psi. The PARTIAL PRESSURE indicator, located on main panel, is a dual face indicator that indicates the partial pressures of oxygen and carbon dioxide.

3-22. During orbital flight, cabin air is circulated throughout the cabin by the cabin fan, located at one end of the cabin heat exchanger. The cabin fan forces the cabin air through the cabin heat exchanger. The cabin air circulating through the cabin, absorbs heat generated by the cabin electronic equipment and in turn, is cooled when the air passes through the cabin heat exchanger. Water from the water coolant tank, circulates through the heat exchanger and absorbs heat from the cabin air passing through the heat exchanger. The heated water boils, evaporates, and passes overboard through the large pressure bulkhead steam vent. Regulating the amount of water entering the heat exchanger provides cabin temperature control. A cabin temperature control valve, located on the right console, is manually operated by the Astronaut to control cabin temperature.

3-23. In the event of a fire or buildup of toxic contaminants, within the cabin, the Astronaut may manually decompress the cabin by actuating the DECOMPRESS "T" handle, located on the left console. The decompression handle is interconnected to the cabin relief valve with a cable. During decompression of cabin, the cabin pressure control valve closes when cabin pressures decrease to 4.1 psia. Following fire extinguishment or the removal of toxic contaminants, the Astronaut may repressurize the cabin by closing the DECOMPRESS "T" handle and actuating the REPRESS "T" handle. The pressurization handle is interconnected to the cabin pressure control valve with a cable. When cabin has been repressurized to 5 psia, the REPRESS "T" handle should be closed. In the event of a cabin decompression, due to a meteorite penetration or excessive cabin leakage, the cabin pressure control valve will automatically close and prevent oxygen flow to the cabin after the cabin has decreased to 4.1 psia. Closing of the cabin pressure control valve reserves the remaining oxygen supply for the suit environmental control circuit enabling the Astronaut to continue the mission.

3-24. Prior to capsule re-entry from outer space the Astronaut should close his helmet facepiece and pre-cool the cabin structure and equipment by posi-

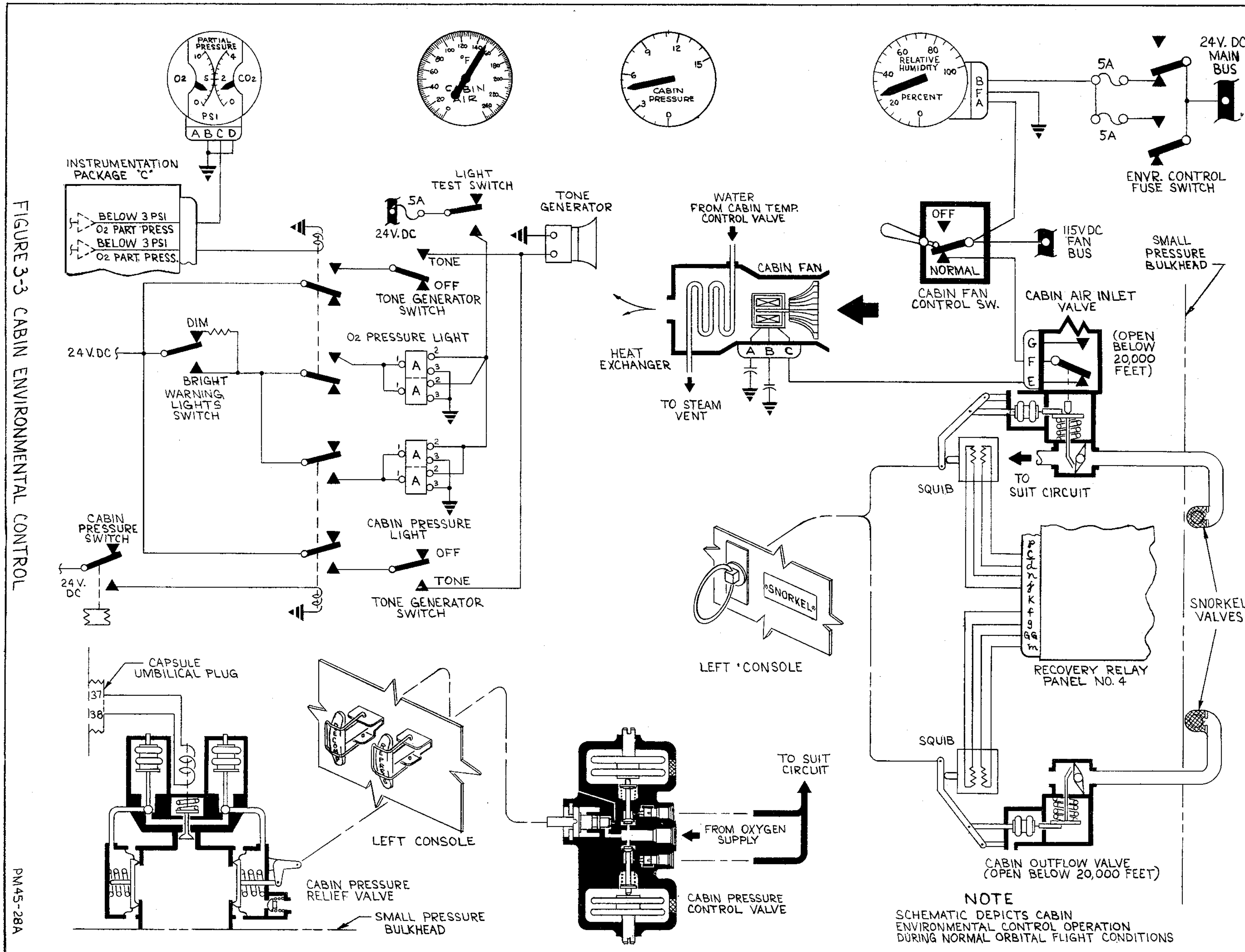

FIGURE 3-3 CABIN ENVIRONMENTAL CONTROL

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tioning the cabin temperature control valve and suit temperature control valve to COOLER settings. During capsule descent, cabin pressure is maintained at 5 psia pressure until the capsule descends to an altitude of approximately 27,000 feet. At 27,000 feet altitude the cabin pressure relief valve begins to open, allowing atmospheric air to enter the cabin and equalize capsule internal and external pressures. When the capsule reaches 20,000 feet altitude the cabin air inlet and outflow valves open and the cabin fan ceases operation. Opening of cabin air inlet valve provides outside air ventilation for this suit circuit and cabin. Suit circuit air is then vented to the cabin and out through the cabin outflow valve. In the event the cabin air inlet and outflow valves fail to open at 20,000 feet altitude, the astronaut should actuate the SNORKEL pull ring to open the valves. Snorkel valves provided on the inlet side of cabin air inlet valve and the outlet side of the outflow valves prevent water from entering the cabin when the capsule lands in the water. Following capsule landing the astronaut may utilize cabin fan and suit compressor for ventilation.

3-25. A cabin pressure indicator and a cabin temperature indicator are provided on the main instrument panel to indicate cabin pressures and temperatures. A humidity indicator, with an incorporated sensor and amplifier, is also provided on the main instrument panel to indicate relative humidity content of the cabin air. A CABIN PRESS light and tone generator, located on the main panel, indicate when cabin pressure has decreased to an unsafe pressure.

3-26. Suit Environmental Control

The suit environmental control circuit, Figure 3-4, is supplied oxygen through the suit pressure regulator, from the environmental system oxygen supply. During capsule launch and re-entry phases, when the astronaut's helmet facepiece is closed, the suit pressure regulator references cabin pressure to control the suit circuit pressure. While operating in the suit environmental control mode, (helmet facepiece closed), oxygen from the suit pressure regulator flows through the suit compressor, CO_2 and odor absorber, suit heat exchanger, water separator, Astronaut's pressure suit, and the suit circuit solids trap. In the event the suit circuit oxygen pressure decreases slightly below 5 psia, the suit pressure regulator will sense the pressure drop and open, to replenish the suit circuit supply to maintain the suit circuit pressure of 5 psia.

3-27. The suit circuit incorporates two compressors that are installed parallel to each other. During normal suit circuit operation the #1 suit compressor circulates the suit oxygen from the pressure suit outlet, throughout the suit circuit. A differential pressure switch is vented to the inlet and outlet ducting of the #1 suit compressor. In the event the #1 suit compressor malfunctions or fails to operate, the differential switch senses the pressure drop across the #1 suit compressor and in turn provides power to operate the #2 suit compressor. A SUIT FAN switch is provided on the main instrument panel to enable operation of either compressor. Oxygen flowing from the compressors, then passes through the CO_2 and odor absorber, where Astronaut's emitted odors and carbon dioxide, are removed from the suit circuit oxygen. The absorber basically is divided into individual sections that contain a supply of activated charcoal, and lithium hydroxide. The activated charcoal removes the odor from the oxygen and lithium hydroxide removes the carbon dioxide from the oxygen to prevent any discomfort to the Astronaut. Filters, incorporated in the absorber, remove charcoal or lithium hydroxide dust from entering the suit circuit oxygen. A CO_2 sensor, located in the suit circuit to pressure suit inlet duct, transmits the amount of carbon dioxide present in the suit circuit to the PARTIAL PRESSURE indicator. The PARTIAL PRESSURE indicator is a dual face instrument, located on main panel, that indicates CO_2 and O_2 partial pressures. Also provided on the main panel are a CO_2 PRESS indicator light and a tone generator, that indicate when suit circuit carbon dioxide content is in excess of .155 psi.

3-28. Suit circuit temperature is controlled by a suit heat exchanger that removes heat from the suit circuit oxygen that passes through the heat exchanger. Water flow to the heat exchanger is controlled by a suit temperature control valve located on the right console. Suit circuit oxygen pressure is also utilized to pressurize the water coolant tank in the event the coolant quantity oxygen bottle, normally utilized to pressurize the water tank, malfunctioned. Suit pressure and temperature sensors, located in the suit circuit transmit suit circuit pressure and temperature to the SUIT ENVIR. indicator. The SUIT ENVIR. indicator, located on the main panel, is a dual face indicator and indicates SUIT PRESS and SUIT TEMP. The water separator is basically a filter-type sponge that collects moisture from the suit circuit oxygen flowing through the separator. At timed intervals the sponge is pneumatically removed from the oxygen flowstream, and is compressed to squeeze the water from the sponge. Water removed from the sponge is drained into a condensate storage tank,located adjacent to the water separator. The sponge is removed from the oxygen flow stream by a piston that is actuated by oxygen pressure. The capsule instrumentation package "C" provides 24V d-c electrical power to energize the water separator solenoid valve for 30 seconds every 30 minutes. Energizing the solenoid valve, opens the valve to allow oxygen (5 psia) pressure to actuate the water separator piston. Oxygen flowing through the water separator, then flows to the closed emergency oxygen rate valve and through the Astronaut's pressure suit. Oxygen from the pressure suit then passes through a solids trap, that is provided to remove any foreign matter such as food particles, hair, nasal excretions, etc., from the suit circuit oxygen supply. The solids trap incorporates a relief feature, to prevent the possibility of foreign matter blocking suit circuit flow. The suit circuit shutoff valve, located downstream of the solids trap is mechanically locked in the open position during operation in the suit environmental control mode.

3-29. During capsule pre-launch phase, the suit circuit is purged and saturated with oxygen from an external low pressure source. Suit heat exchanger is also supplied with a freon coolant,from an external ground supply, to provide suit circuit cooling. The suit circuit oxygen circulates throughout the suit circuit, during the suit environmental control mode operation. During capsule flight the pressure within the suit circuit is automatically maintained at 5 psia by the pressure regulator. During the capsule landing phase when the capsule descends to an altitude of approximately 20,000 feet, the cabin air inlet and outflow valves open and provide adequate suit circuit ventilation. In the event cabin air inlet and outflow valves failed to open, the Astronaut may open the valves manually by actuating the SNORKEL pull ring, left console. Opening of the cabin air inlet valve automatically positions the environmental system to the suit emergency control mode. When the cabin air inlet valve opens, electrical power is directed to close the suit circuit shutoff valve, which in turn mechanically opens the emergency oxygen rate valve and provides electrical power to illuminate the O_2 EMER. light and operate a tone generator. The #1 suit compressor continues to operate to increase suit circuit ventilation. Suit circuit air is then vented through the suit pressure regulator to the cabin and in turn is vented out of the capsule through the cabin outflow valve. During the capsule post-landing phase, ventilation is provided by operating

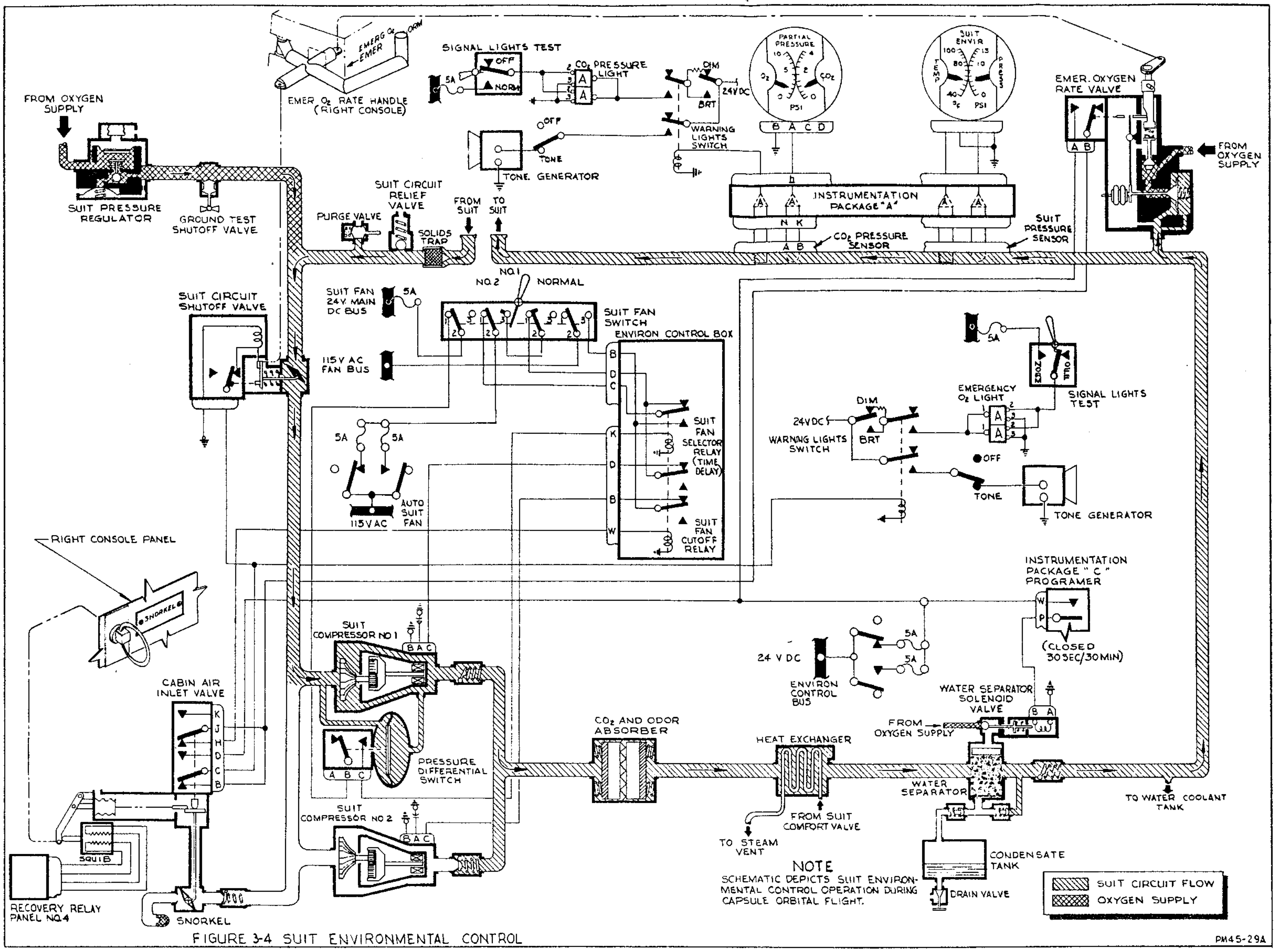

FIGURE 3-4 SUIT ENVIRONMENTAL CONTROL

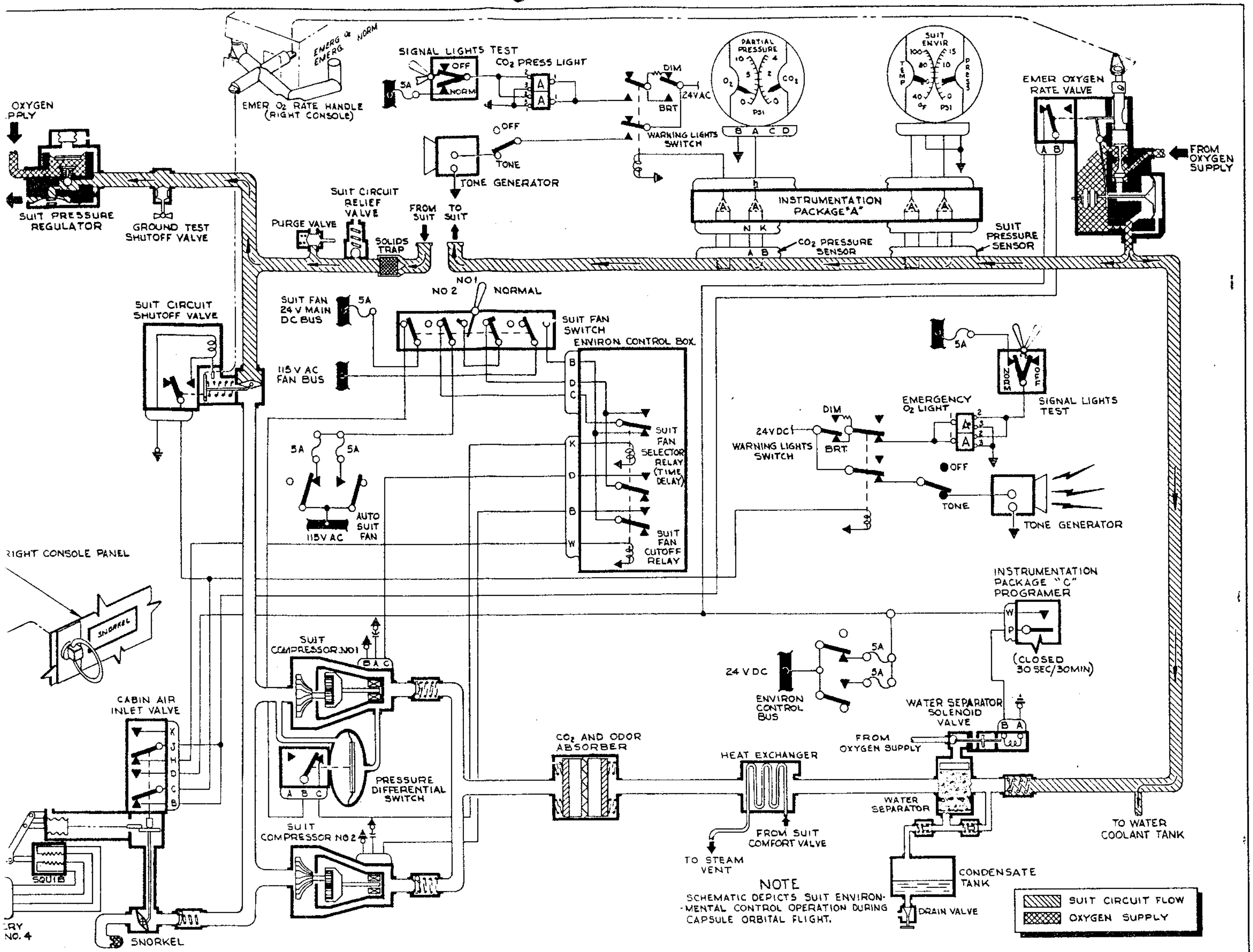

FIGURE 3-5 SUIT EMERGENCY CONTROL

the suit circuit compressor, which in turn draws outside air in through the cabin air inlet valve and vents cabin air out the cabin outflow valve.

3-30. Suit Emergency Control

The suit emergency control, Figure 3-5, is provided to ensure Astronaut's survival in the event the cabin and suit environmental control circuits malfunction. Operation in the suit emergency control mode basically consist of opening the emergency oxygen rate valve, to supply oxygen at a rate greater than normal, and the closing of the suit circuit shutoff valve which in turn eliminates oxygen flow through the temperature control and impurity removing units. Illumination of the O_2 EMERG. light and the movement of the EMERG O_2 rate handle to EMERG. position indicates environmental system operation in the suit emergency control mode.

3-31. When operating in the suit environmental control mode, during capsule orbital flight, the emergency oxygen rate valve is closed, the suit circuit shutoff valve is open, and the suit pressure regulator is controlling oxygen flow to the suit circuit. The emergency oxygen rate valve remains closed as long as suit circuit pressure remains at 5 psia pressure. When the suit circuit pressure drops to 4.0 psia pressure, the rate valve internal aneroid extends to offseat a poppet and allows oxygen from the oxygen supply to flow through the rate valve and into the suit circuit. The extension of the rate valve aneroid, due to low pressure, indirectly actuates a limit switch that provides electrical power to energize the suit circuit shutoff valve relay, the suit fan cutoff relay, illuminates the O_2 EMERG. light, and operates a tone generator. Energizing the suit fan cutoff relay removes the 115 V a-c electrical power to operate the suit circuit compressor. Energizing the shutoff valve relay releases the shutoff valve locking pin and allows the spring loaded shutoff valve to move to the closed position. The shutoff valve closing action actuates a cable, connected to shutoff valve shaft arm, and mechanically moves the EMERG. O_2 handle, right console, to the EMERG. position. Movement of the EMERG. O_2 handle moves a cable, that is connected to the emergency oxygen rate valve shaft arm, and mechanically actuates the emergency rate valve to maintain the rate valve in the open position. With the emergency oxygen rate valve open and the suit circuit shutoff valve closed, oxygen from the oxygen supply flows into the pressure suit and is discharged through the suit pressure regulator relief valve.

3-32. Actuating the EMERG O_2 handle to the NORM position resets the shutoff valve to the open position, the emergency oxygen rate to the close position, starts suit compressor operation, and extinguishes the O_2 EMERG. lite, and in turn switches the suit circuit operation to the suit environmental control mode. The Astronaut may manually select suit emergency control by moving the EMERG. O_2 rate handle to the EMERG. position, in the event the emergency oxygen rate valve failed to open during a suit circuit malfunction. The suit emergency control mode is also selected automatically during capsule landing phase, when the capsule has descended to an altitude of approximately 20,000 feet. At 20,000 $\pm$ 3,000 feet the cabin air inlet valve opens. Opening of the cabin air inlet valve actuates a limit switch that provides electrical power to close the shutoff valve, which in turn mechanically opens the emergency oxygen rate valve.

3-33. Oxygen Supply

During the capsule pre-launch phase, and prior to installation of the capsule entrance hatch, the capsule oxygen supply shutoff valves are manually opened by ground crewmen to activate the oxygen supply. Opening of the normal and emergency oxygen supply shutoff valves, Figure 3-6, provides oxygen to the cabin pressure control valve, suit pressure regulator, suit emergency oxygen

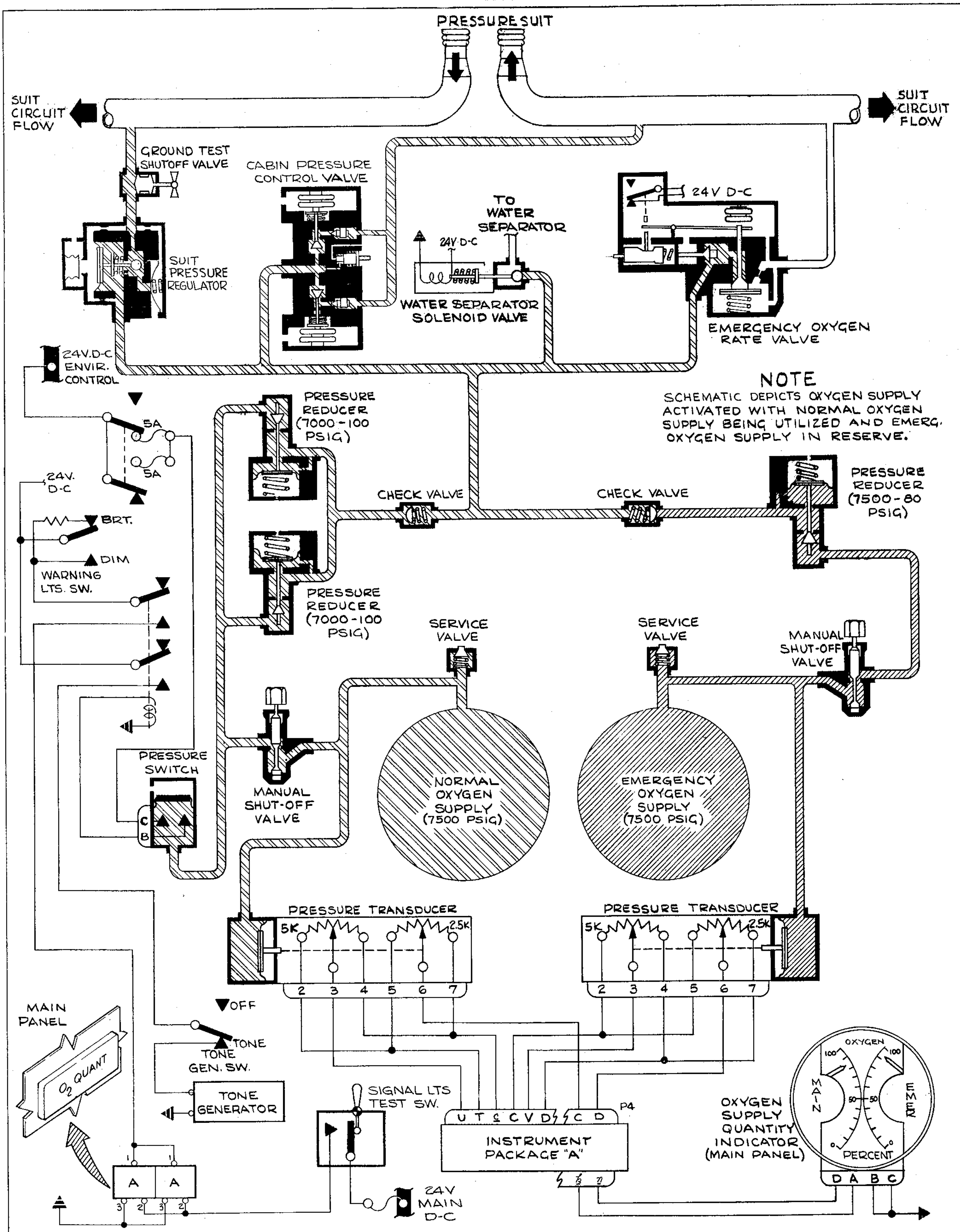

FIGURE 3-6 NORMAL AND EMERG. OXYGEN SUPPLY

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rate valve, and the suit circuit water separator. The normal oxygen supply pressure reducers decrease the normal oxygen pressure of 7500 psig to an operating pressure of 100 psig. Two reducers are provided for the normal oxygen supply pressure line, to ensure system pressure reduction in the event one pressure reducer failed. The emergency oxygen supply provides one pressure reducer to decrease the emergency supply 7500 psia pressure to 80 psia. The normal oxygen supply reduced pressure, being greater than the emergency oxygen supply reduced pressure, permits the normal oxygen supply to be utilized during normal conditions with the emergency oxygen supply in reserve.

3-34. When the normal oxygen bottle pressure drops below approximately 200 psia, due to near depletion of the normal oxygen supply, the emergency oxygen supply line pressure will override the normal oxygen supply line pressure and continue to supply the environmental system with oxygen. A pressure switch, located in the normal oxygen supply line, will close when the normal oxygen bottle pressure drops to approximately 200 psia. Closing of the pressure switch directs 24 V d-c electrical power to illuminate the O_2 QUAN light and operate the tone generator. The O_2 QUAN light, located on the main instrument panel, and the tone generator are provided to indicate to the Astronaut that the emergency oxygen supply is being utilized. A quantity indicator gage, located on the main instrument panel, is provided to indicate remaining oxygen supply. Two transducers, normal and emergency supply, are provided to enable telemetering of oxygen quantity remaining.

3-35. The launch oxygen supply 7500 psia pressure is reduced to 100 psia pressure by a pressure reducer. The pressure reducer incorporates a relief valve to relieve excessive pressures within the reducer. Although the launch oxygen supply shutoff valve, Figure 3-7, is opened simultaneously with the

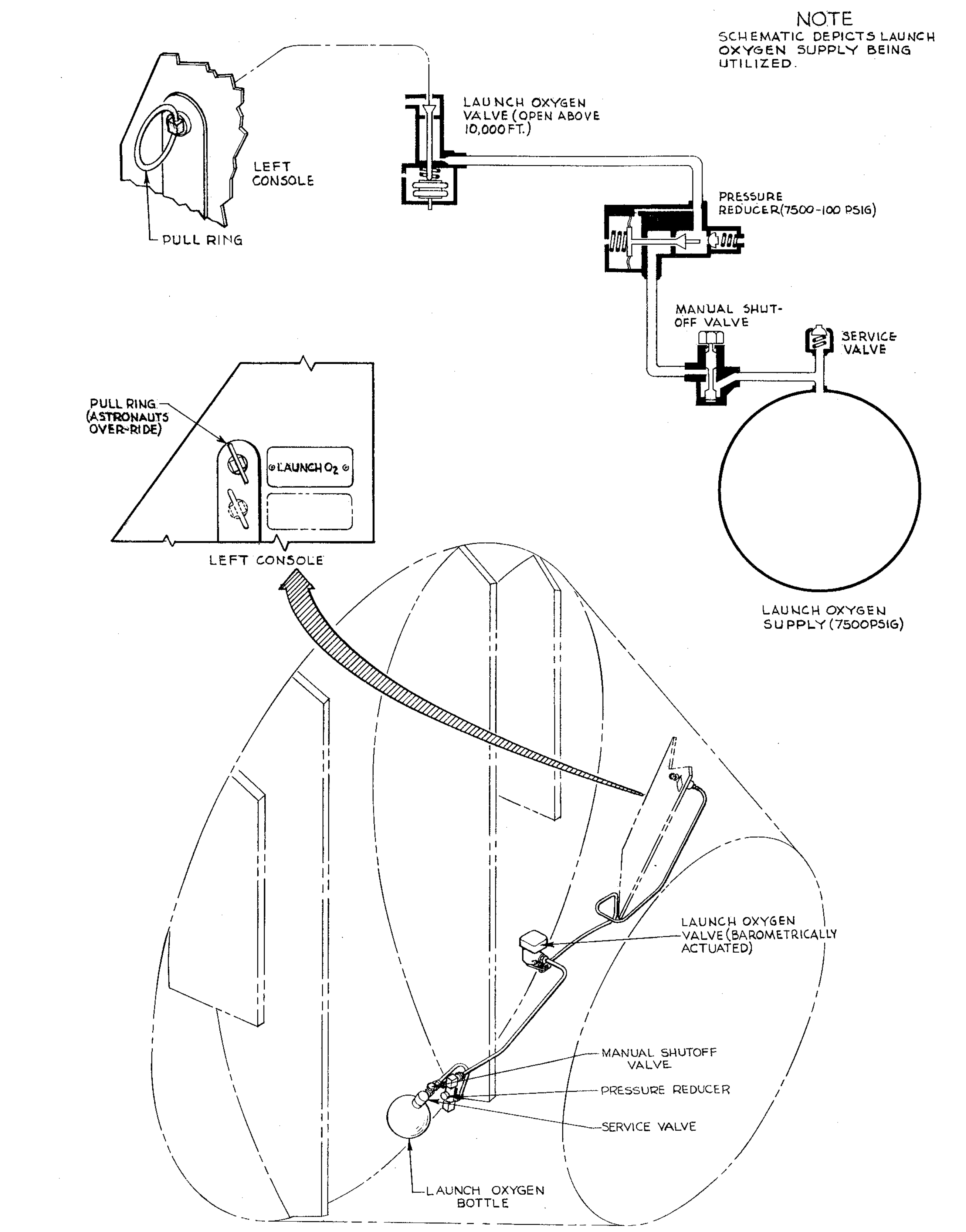

FIGURE 3-7 LAUNCH OXYGEN SUPPLY

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normal and emergency oxygen supply, launch oxygen is not provided to the cabin until the capsule reaches an altitude of approximately 10,000 feet during launching. At 10,000 feet altitude, the launch oxygen (barometer actuated) valve automatically opens to permit launch oxygen to purge the cabin air until the launch oxygen supply is depleted at an approximate altitude of 45,000 feet. After the capsule has entered orbital flight, the Astronaut actuates the launch oxygen pull ring, left console, to ensure the cabin has been purged, in the event the launch oxygen barometer actuated valve failed to open. The launch oxygen pull ring is interconnected to the launch oxygen barometer valve with a cable.

3-36. Cooling Circuit

The cooling circuit, Figure 3-8, basically consists of a water coolant tank, cabin and suit temperature control valves, cabin and suit heat exchangers, coolant quantity indication circuit, and an excessive water warning circuit. During capsule pre-launch, after the entrance hatch has been installed, cabin and suit circuit cooling is achieved by supplying freon (F-114) through the capsule umbilical connector and into the cabin and suit heat exchangers. The freon coolant absorbs heat from the cabin and suit air flowing through the heat exchangers, and boils overboard through the environmental system steam vents, located in the larger pressure bulkhead. Forty-five seconds prior to capsule launching, the freon coolant supply is discontinued. When the capsule has reached orbit altitude, cabin and suit circuit cooling is achieved by water evaporation, that occurs within the suit and cabin heat exchangers.

3-37. Water from the water coolant tank is supplied, under a 5.5 psi pressure, through the temperature control valves, to the suit and cabin heat exchangers. Oxygen, stored under a 500 psi pressure in the coolant quantity oxygen bottle, is utilized to pressurize the water coolant tank. A pressure regulator decreases the coolant oxygen supply 500 psi pressure to 5.5 psi pressure. Oxygen pressure within the water coolant tank tends to move the tank diaphragm, which in turn forces the water supply out of the tank at a rate dependent upon the position of the temperature control valves. In the event the coolant quantity oxygen supply should deplete or malfunction, oxygen, at 5 psi pressure, from the suit circuit will continue to pressurize the water coolant tank. The temperature control valves control the amount of water entering the heat exchangers, which in turn controls cabin and suit temperature. Water within the heat exchangers absorbs heat from the cabin and suit oxygen, flowing through the heat exchangers. The heated water boils, evaporates, and flows out through the steam vents located in the large pressure bulkhead. Indicator lights are provided on the main instrument panel to indicate extreme cold conditions, in the cabin and vent heat exchangers exhaust ducts, which could possibly freeze and plug the overboard steam vents. When the heat exchangers exhaust ducts temperatures drop below 50° F, a thermal switch, located in each of the exhaust ducts actuate close. Closing of either thermal switch directs 24 V d-c electrical power to illuminate either the EXCESS CABIN H_2O or the EXCESS SUIT H_2O light, and operate the tone generator, thus indicating to the Astronaut of extreme cold temperatures in the heat exchangers exhaust ducts. The Astronaut must then position the cabin or suit temperature control valve to a warmer setting in order to reduce the possibility of water freezing in the exhaust duct.

3-38. A coolant quantity indicator, main instrument panel, is provided to indicate the quantity of water coolant remaining in the water coolant tank. The indicator operates in direct relationship to the oxygen remaining in the coolant quantity oxygen bottle, through a pressure transducer and instrumenta-

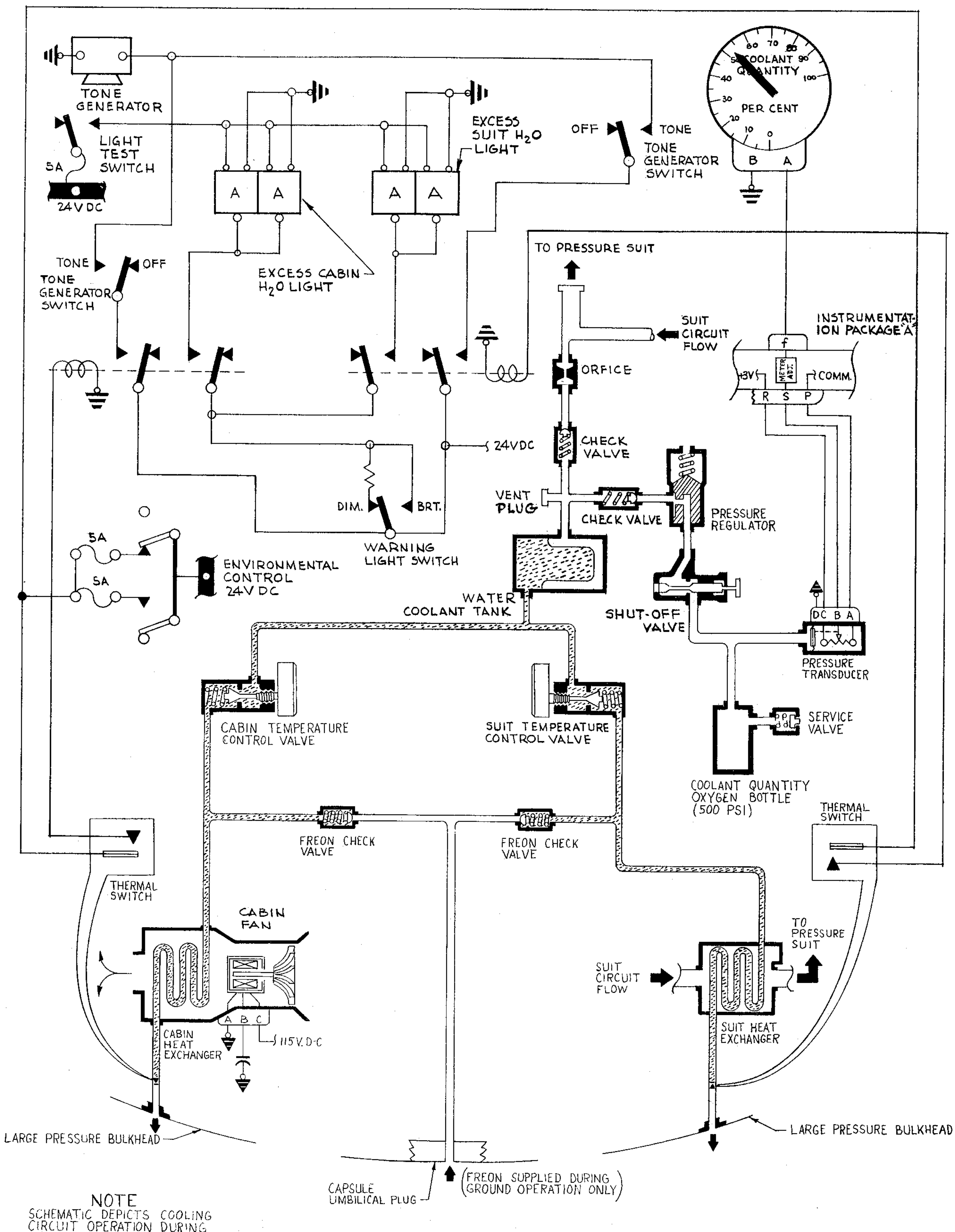

FIGURE 3-8 COOLING CIRCUIT

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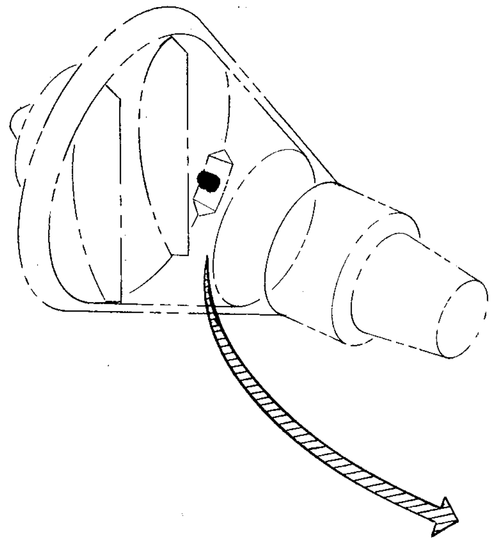
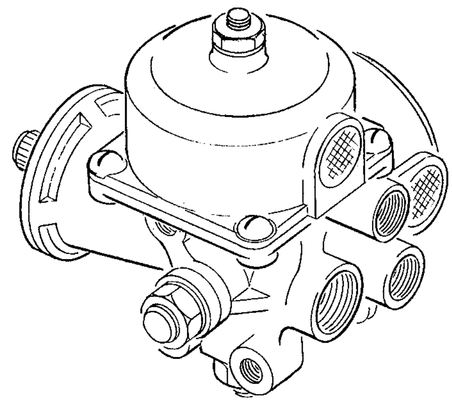
tion package. When the coolant quantity oxygen bottle is full, (500 psi), the coolant quantity indicator will read 100%. As the coolant oxygen bottle pressure decreases, as a result of water being utilized, the coolant quantity indicator reading will decrease accordingly.

3-39. SYSTEM UNITS

3-40. Cabin Pressure Control Valve

The cabin pressure control valve, Figure 3-9, is provided to maintain cabin pressure to $5.1 \pm .2$ psi. The control valve contains two aneroids that sense cabin pressure. Whenever cabin pressure drops below $5.1 \pm .2$ psia,the aneroids partially expand and unseat the spring loaded metering pins, which in turn permit oxygen to flow into the suit circuit. The suit pressure regulator senses increase in pressure, and relieves suit circuit pressure to the cabin. Directing oxygen flow through suit circuit, provides constant purging of suit circuit. When cabin pressure increases to $5.1 \pm .2$ psia the aneroids contract, allowing the metering pins to seat and shut off the oxygen flow. In the event of cabin decompression or whenever cabin pressure drops below $4.0 \pm {}^{.2}_{.1}$ psia, the aneroids fully expand and seat against the inlet port. This prevents oxygen flow through the cabin pressure control valve, and reserves the remaining oxygen supply for the suit circuit. Two aneroids are provided in the valve to ensure valve operation in the event one aneroid failed. A manual control is also provided to enable cabin repressurization in the event cabin depressurization was manually selected. Actuation of the REPRESS "T" handle in the cabin offseats a spring loaded poppet in the valve and allows oxygen to flow directly into the cabin. REPRESS "T" handle should than be pushed in, following cabin repressurization, to enable cabin pressure control valve automatic operation.





CABIN PRESSURE CONTROL VALVE (45-83700-35)

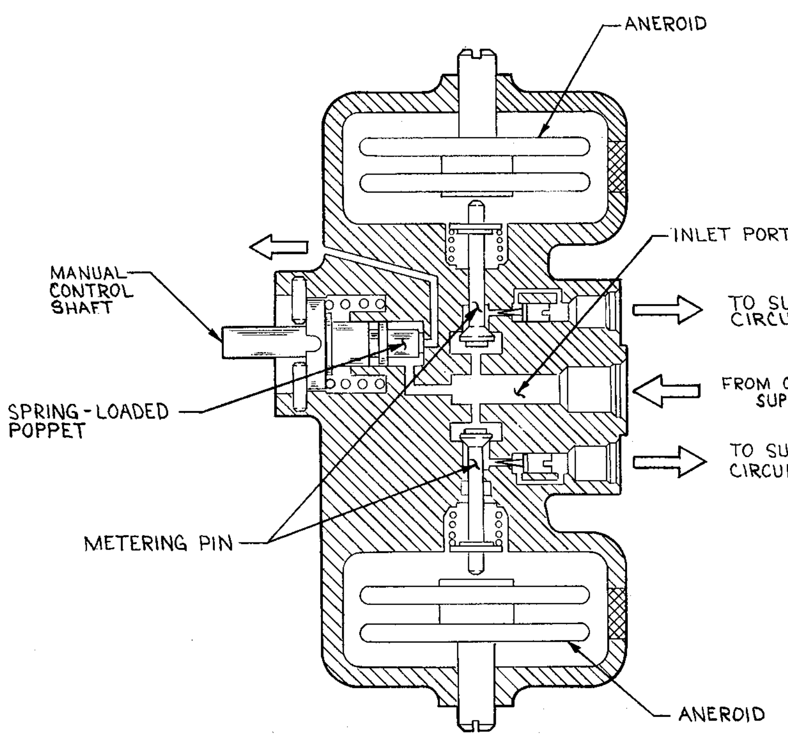


FIGURE 3-9 CABIN PRESSURE CONTROL VALVE

PM45-158

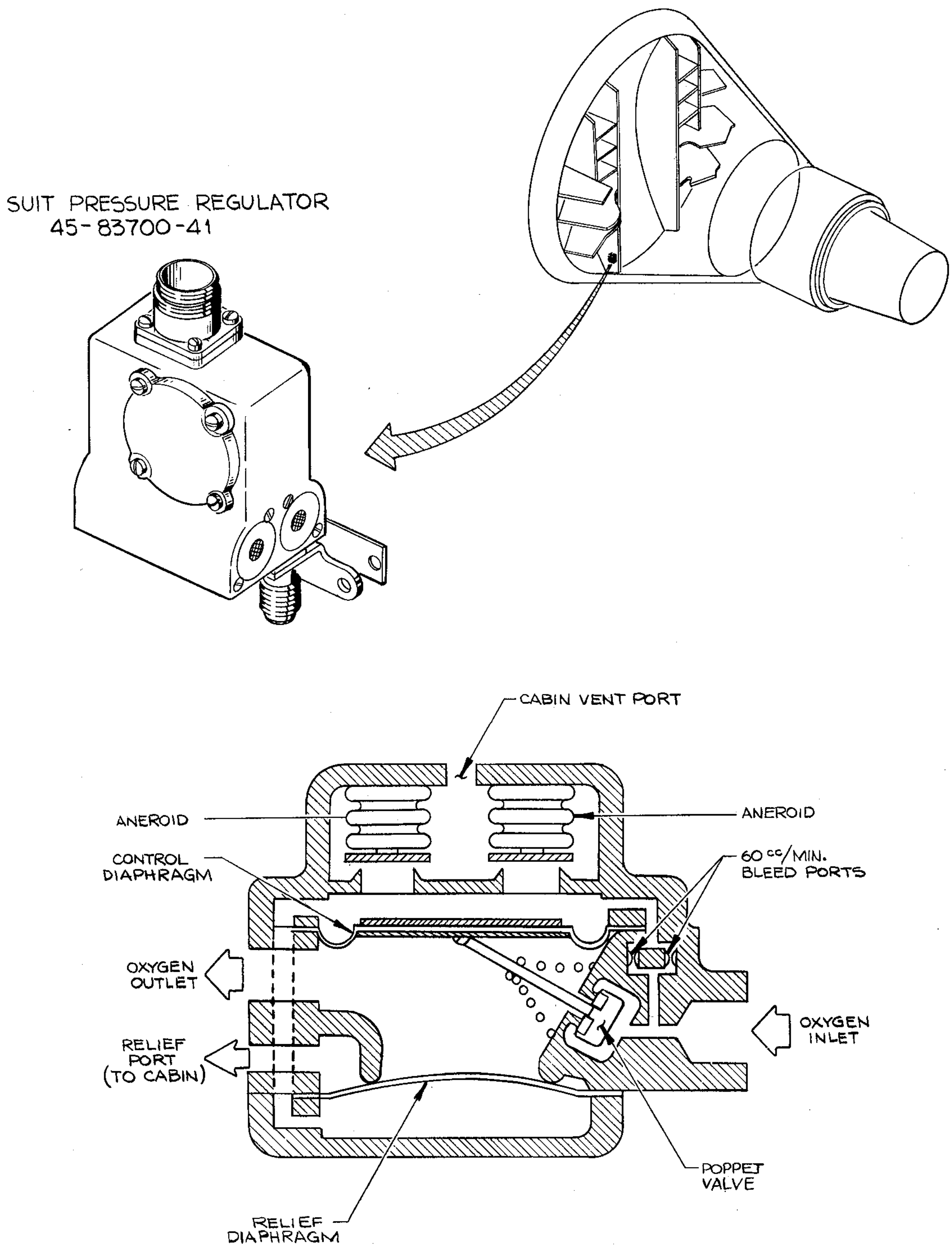


FIGURE 3-10 SUIT PRESSURE REGULATOR

PM45-159

3-41. Suit Circuit Pressure Regulator

The suit circuit pressure regulator, Figure 3-10, is provided to regulate oxygen pressure to the suit circuit and to replenish suit circuit oxygen consumed by the Astronaut, absorbed by moisture or carbon dioxide, or lost through leakage. The regulator is a demand type, diaphragm operated regulator that controls suit circuit pressure in reference to cabin pressure. Suit circuit pressure is maintained approximately 1" H_2O below cabin pressure during normal system operation. Cabin pressure is sensed on the upper side of the regulator control diaphragm and suit circuit pressure is sensed on the lower side of the diaphragm. The regulator also contains a resilient type diaphragm that is used to relieve excessive suit circuit pressures. Two aneroids are provided to shut off cabin vent port of regulator in the event cabin pressure decreases below $4.6 \pm .2$ psia.

3-42. During normal capsule ascent, cabin pressures decreases, and the regulator relief diaphragm will relieve suit circuit pressure to within 2 - 9 inches H_2O above cabin pressure. During capsule normal orbital flight, the control diaphragm will regulate suit circuit pressure in relationship to cabin pressure. An increase in cabin pressure will act on the diaphragm to offseat a poppet valve and allow suit circuit pressure to increase to within 1 inch H_2O below cabin pressure. In the event cabin pressure decreases below $4.6 \pm .2$ psia, the aneroids will extend and close off cabin vent port of regulator. Two 60 cc/min bleed ports will then bypass the poppet valve to the cabin sensing side of the control diaphragm and regulate suit circuit pressure to $4.6 \pm .2$ psia. Two aneroids and two bleed ports are provided to ensure regulator operation in the event either aneroid or either bleed port fails to function. Descent operation of the regulator would be the same as an increase in cabin pressure during capsule normal orbital flight.

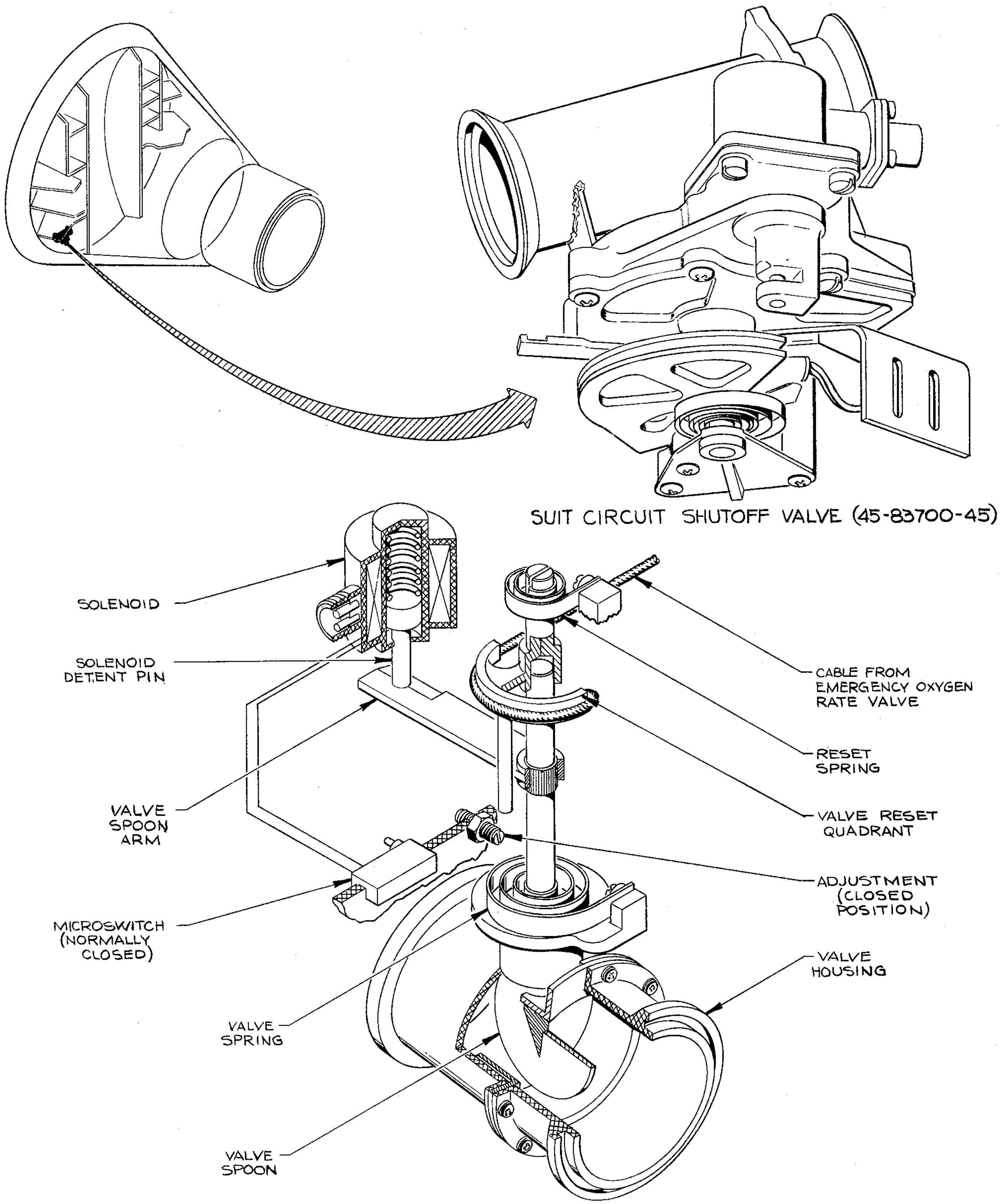


FIGURE 3-11 SUIT CIRCUIT SHUTOFF VALVE

PM45-152

3-43. Suit Circuit Shutoff Valve

The suit circuit shutoff valve, Figure 3-11, is designed to shut off oxygen flow to the suit environmental circuit accessory components, whenever the suit circuit is operating in the emergency mode. Closing of the suit circuit shutoff valve reserves the remaining oxygen supply for the Astronaut's pressure suit. The shutoff valve, spring loaded to the close position, is latched in the open position during normal suit circuit operation. Valve is maintained in the open position by a solenoid controlled detent pin engaged into the valve spoon arm. A micro switch, depressed by the valve arm, completes the solenoid circuit when the valve is latched open. Opening of either the emergency oxygen rate valve or the cabin air inlet valve directs an electrical signal to energize the shutoff valve solenoid. Energizing the solenoid retracts the detent pin and allows the valve spring to rotate the valve spoon to the close position. Closing of the valve opens the solenoid circuit and opens the emergency oxygen rate valve through an interconnecting cable. The shutoff valve is mechanically opened by the EMER. O_2 control handle, located in capsule. The shutoff valve is interconnected to the emergency rate valve, so that when the emergency rate valve is closed the shutoff valve opens.

3-44. Emergency Oxygen Rate Valve

The emergency oxygen rate valve, Figure 3-12, is provided to supply a regulated amount of oxygen directly into Astronaut's pressure suit in the event a malfunction occurs in the suit circuit operation. The rate valve is designed to operate automatically and contains provisions for manual operation. The valve, closed during normal suit circuit operation, contains an aneroid that senses suit circuit pressure. Whenever suit circuit pressure drops below $4.0 \pm .1$ psia , the aneroid extends to offseat a spring loaded poppet and allow oxygen

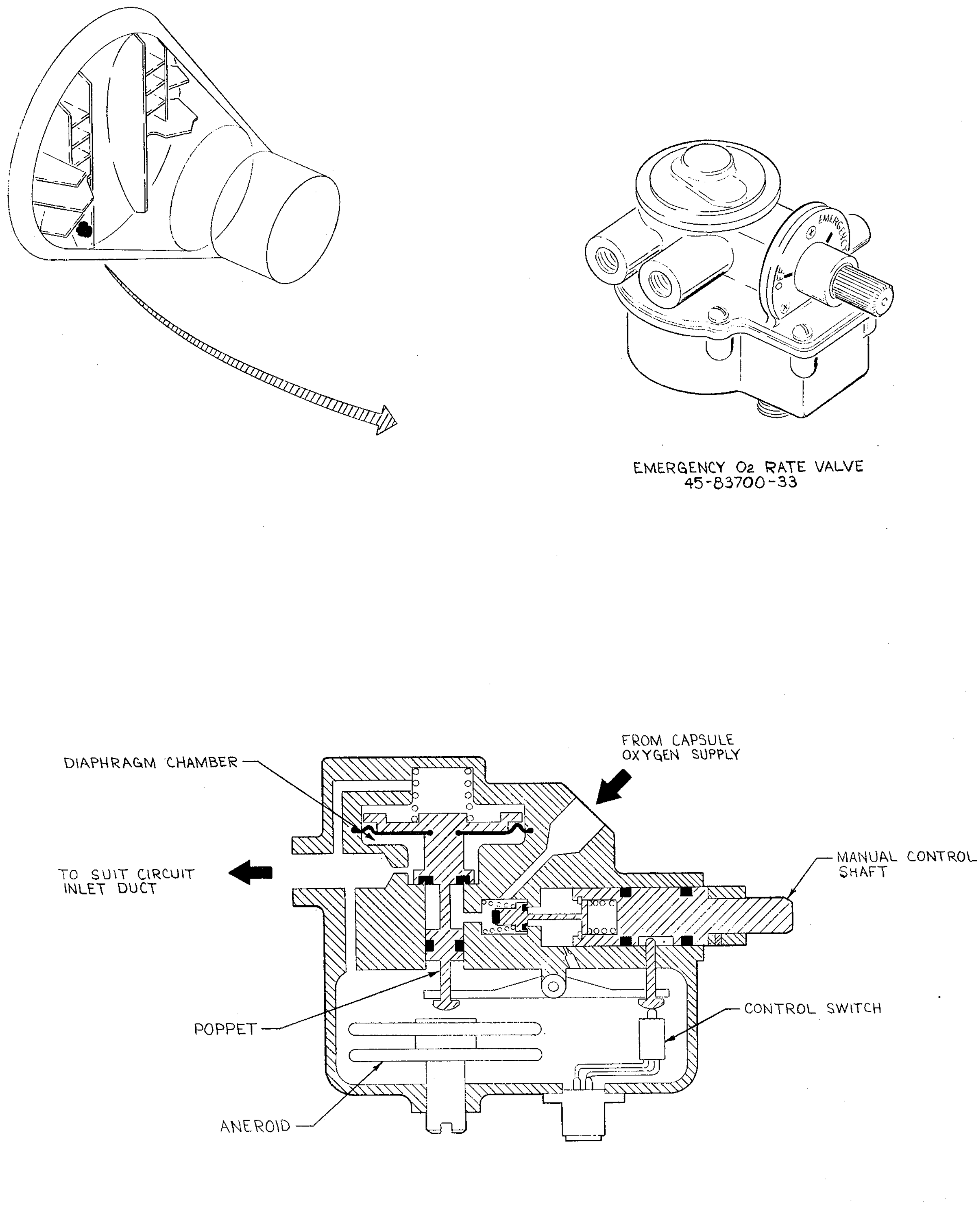


FIGURE 3-12 EMERGENCY O_2 RATE VALVE

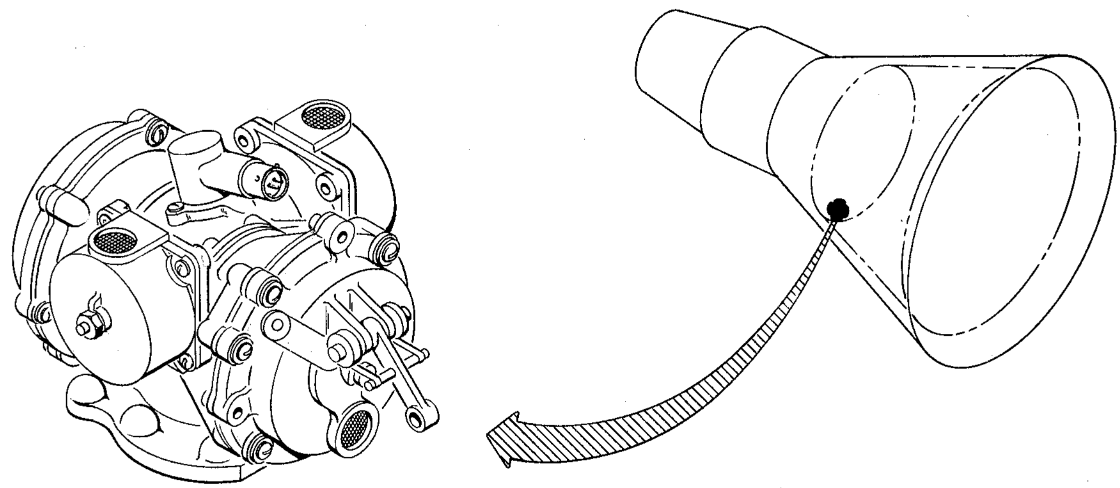
PM45-153

pressure to enter the diaphragm chamber. The pressure in the diaphragm chamber increases and fully strokes the poppet, allowing oxygen to flow into the Astronaut's suit at a fixed flow of .030 to .040 #/min. Simultaneously with the offseating of the poppet, a control switch is actuated through a lever mechanism, and directs electrical power to close the suit circuit shutoff valve, illuminate the O_2 EMER. light, and stop suit circuit compressor operation during capsule orbital flight. Suit circuit shutoff valve is interconnected with emergency oxygen rate valve. Therefore, closing of the shutoff valve actuates the emergency oxygen rate valve manual control shaft to close off oxygen flow to valve poppet inlet. Oxygen then flows directly into suit circuit through the valve aneroid chamber.

3-45. Emergency rate valve control shaft actuation also actuates a pin to depress control switch, and also moves EMER. O_2 control handle (right console) to EMER. position. Emergency oxygen rate valve may be opened manually by selecting EMER. position with EMERG. O_2 control handle. Operation will be same as control shaft arm operation described above. Whenever the EMER. O_2 control handle is moved to NORM, the suit circuit shutoff valve opens and emergency oxygen rate valve closes.

3-46. Cabin Pressure Relief Valve

The cabin pressure relief valve, Figure 3-13, is provided to automatically control cabin pressure in reference to ambient pressure during capsule launch, orbit, and re-entry flight. The valve also incorporates provisions to manually decompress cabin, and also prevents water from entering cabin following a capsule water landing. The valve contains two aneroids that sense and control cabin pressure. In the event one aneroid fails, the remaining aneroid continues to operate. Two poppet valves, located within the diaphragm chamber, are pro-



CABIN PRESSURE RELIEF VALVE
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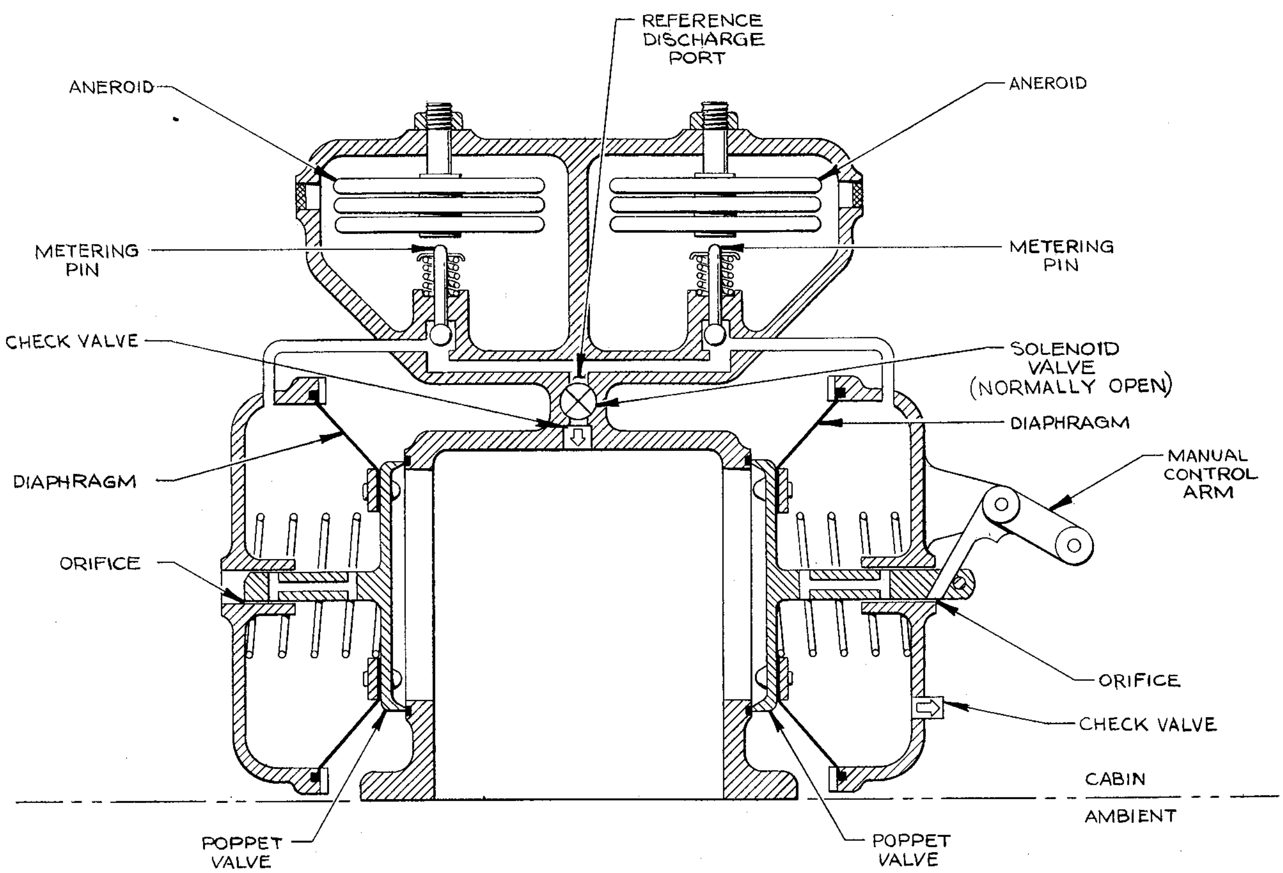

FIGURE 3-13 CABIN PRESSURE RELIEF VALVE

PM45-151

naut to manually decompress the cabin by actuating the DEPRESS "T" handle. In the event capsule lands in water, poppet valves will not open until water pressure exceeds the cabin pressure by 5" H_2O water. The cabin pressure relief valve also provides a solenoid shutoff valve to enable capsule pressure testing at sea level. When energized the solenoid valve closes and in turn retains a zero differential pressure across the poppet valve, rendering valve inoperative.

3-49. Launch Oxygen Valve

The launch oxygen valve, Figure 3-14, is provided to purge the cabin air of nitrogen and increase the oxygen content in the cabin. The valve is barometrically controlled and provides a manual provision for valve actuation. The valve remains closed during the launch phase until the capsule reaches an approximate altitude of 10,000 feet. At 10,000 feet the aneroid senses decreasing cabin pressure and extends to offseat a poppet which in turn allows oxygen to flow into the cabin. As capsule altitude increases, cabin pressure decreases, the aneroid strokes the poppet further, thereby supplying more oxygen to the cabin. The launch oxygen flow will continue until approximately 45,000 feet, at which time the launch oxygen supply is depleted. No indication is provided in the event the valve fails to open, therefore the Astronaut will be instructed to pull the LAUNCH OXYGEN pull ring when the capsule reaches orbit altitude. This in turn will actuate the valve shaft arm and open the poppet, allowing oxygen flow into the cabin.

3-50. Cabin Air Inlet Valve

The cabin air inlet valve, Figure 3-15, provides ventilation and cooling for the suit circuit and cabin during capsule landing and post landing phases. It is a spring loaded close spoon type valve and is barometrically controlled. Prior to capsule launch the valve is manually latched closed so that the

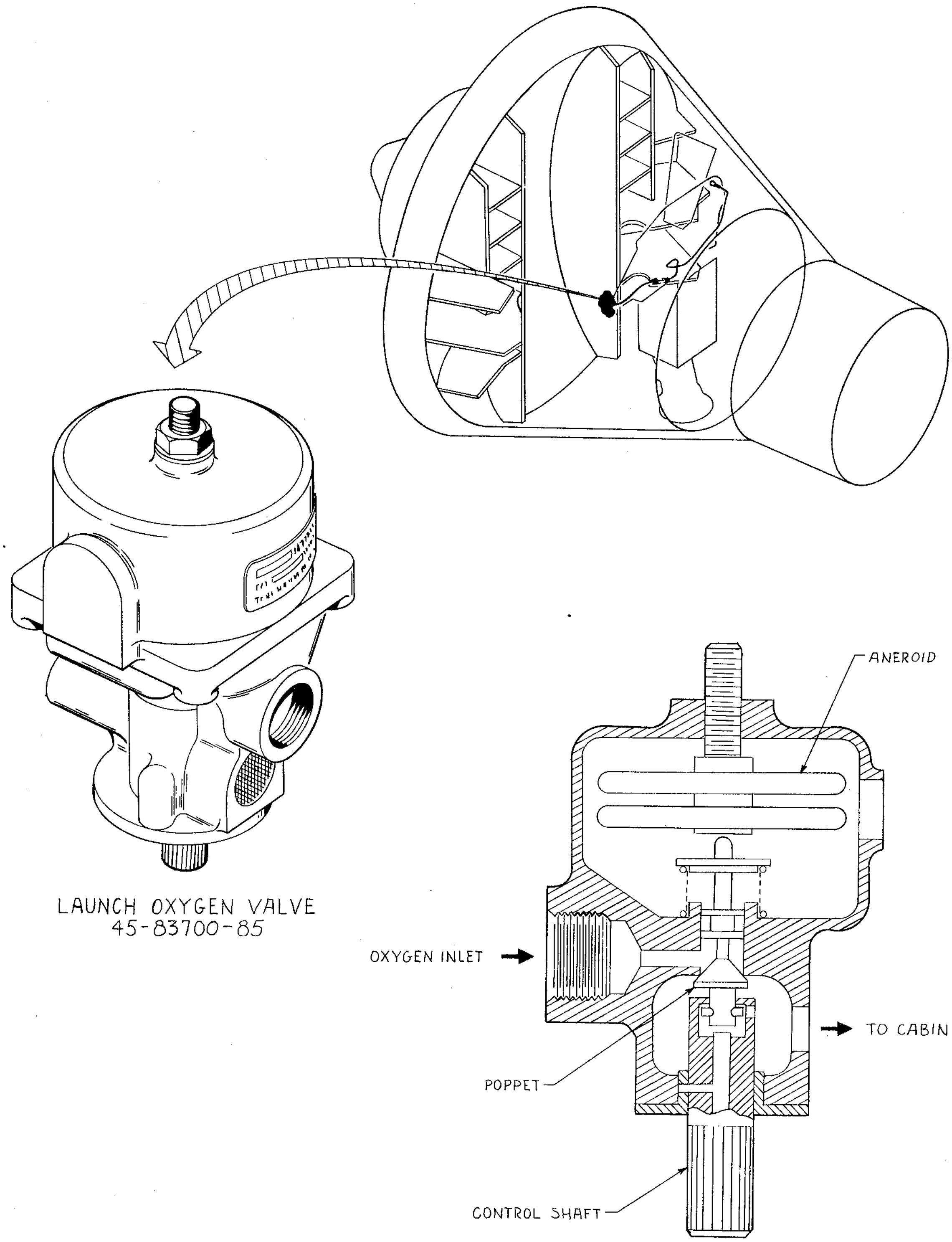

FIGURE 3-14 LAUNCH OXYGEN VALVE

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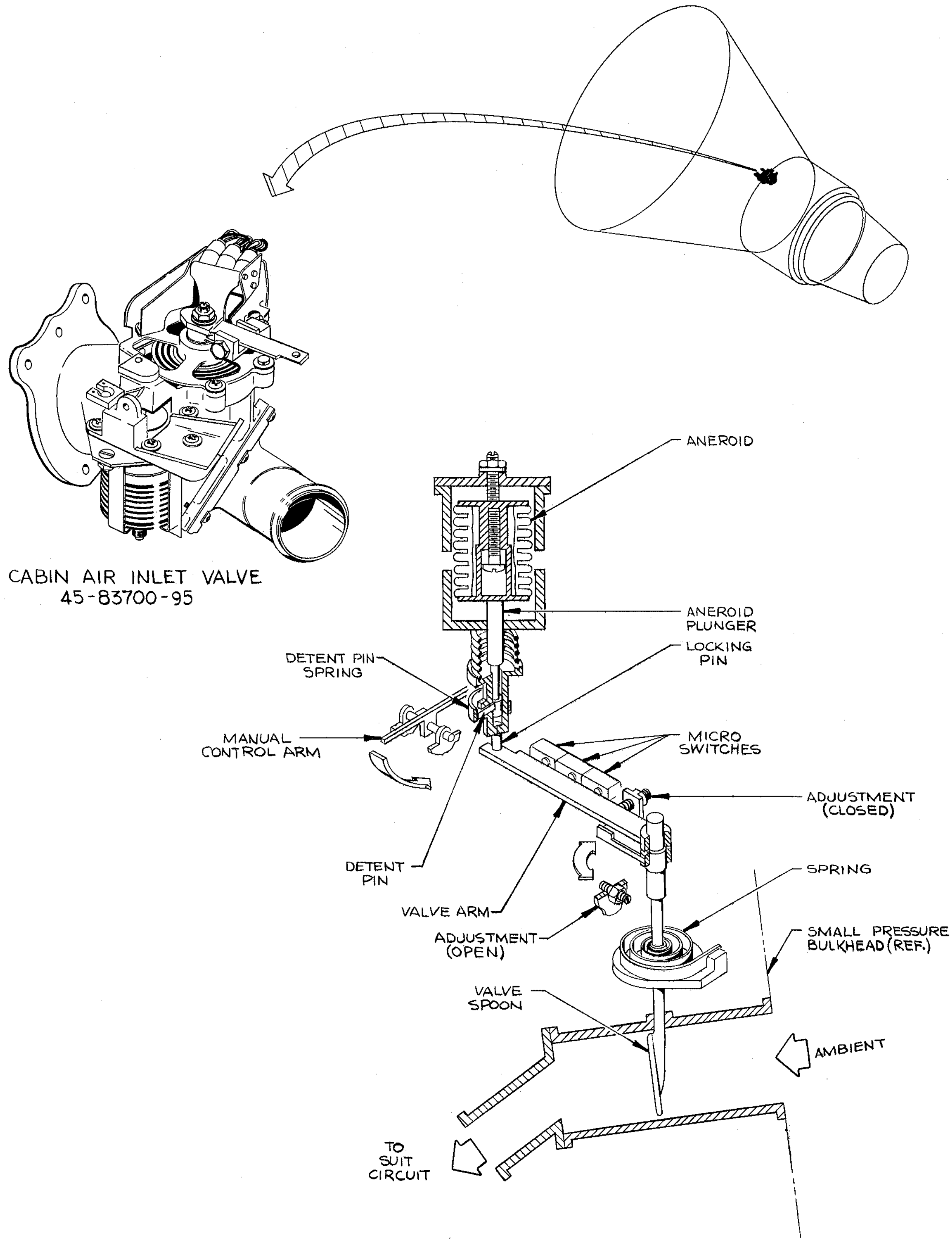

FIGURE 3-15 CABIN AIR INLET VALVE

PM45-154

mechanism spring loaded detent pin rides on the large diameter of the aneroid plunger, and the valve arm is engaged by the spring loaded aneroid locking pin. During capsule launch the aneroid expands due to decreasing cabin pressure, and forces the aneroid plunger down. The valve mechanism detent pin then slips off the plunger large diameter onto the plunger small diameter.

3-51. During capsule landing phase, when the capsule descends to an altitude of approximately 20,000 $\pm$ 3,000 feet, the aneroid retracts cabin pressure increases. Retraction of the aneroid moves the aneroid plunger upward, engaging the detent pin against the plunger larger diameter which in turn compresses the aneroid lockingpin spring. This action releases the locking pin out of the valve arm and allows spring loaded valve to close. The valve arm is attached to valve shaft and moves with valve closing, thereby disengaging micro switches. Disengagement of micro-switches directs electrical power to stop cabin fan operation, close suit circuit shutoff valve which in turn opens the emergency oxygen rate valve. A manual control arm is provided to enable valve opening in the event valve failed to open at specified altitude. Actuation of the manual control arm contracts the locking pin and disengages locking pin from valve arm, allowing valve to close. In the event of a capsule low altitude abort, an explosive squib will force locking pin up to enable valve opening. Valve must be manually reset to close position. Opening of the valve enables suit compressors to draw ambient air into suit circuit to provide suit circuit and cabin ventilation.

3-52. <u>CO_2 and Odor Absorber</u>

The CO_2 and odor absorber, Figure 3-16, is provided to remove Astronaut emitted odors and carbon dioxide from the suit circuit. The absorber is basically a metal cannister divided into two sections. The inlet section contains activated

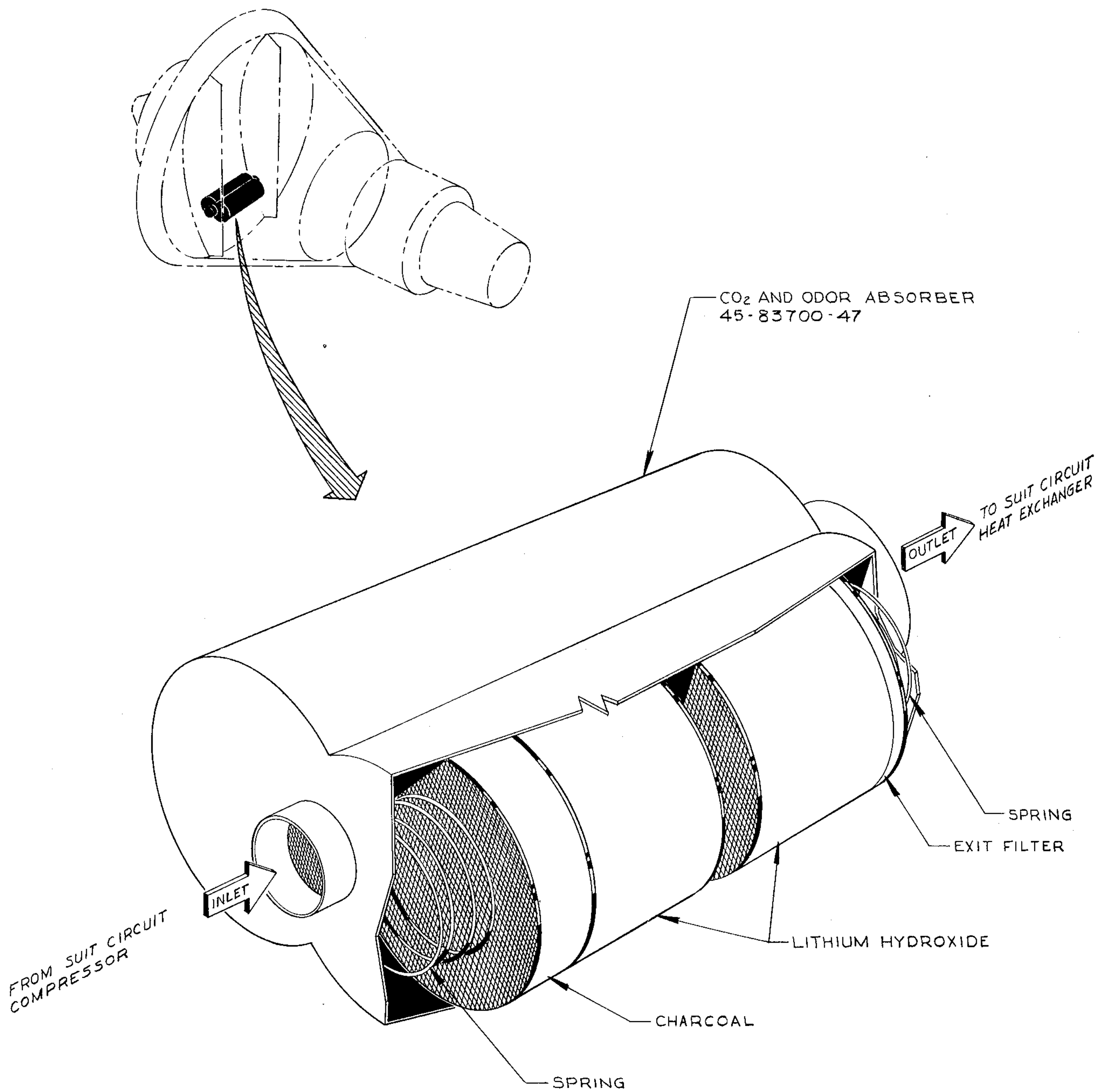

FIGURE 3-16 CO_2 AND ODOR ABSORBER

PM45-156

charcoal that removes objectionable odors from the suit circuit oxygen. Lithium hydroxide, located in the center sections removes carbon dioxide. The outlet section is an exit filter, provided to prevent charcoal and lithium hydroxide dust from entering the suit circuit oxygen flow. The charcoal and lithium hydroxide granules are compressed by a spring force. The CO_2 and odor absorber has an operating life of approximately 31 hours, and to ensure proper absorber operation the absorber should be replaced prior to capsule mission.

3-53. Water Separator

The water separator, Figure 3-17, is provided to remove moisture, condensed as a result of suit heat exchanger operation, from the suit circuit oxygen. The separator is basically a filter type sponge that collects moisture from the oxygen passing through it. The sponge, pneumatically squeezed, removes the condensate from the sponge and the condensate drains into a condensate storage tank. During suit circuit operation, the sponge filters moisture from the oxygen flowing through the sponge. Once every 30 minutes, for a duration of 30 seconds, the capsule programmer supplies electrical power to energize the water separator solenoid valve. Energizing the normally closed solenoid valve opens the valve and allows oxygen from oxygen supply to flow to both sides of the water separator piston.

3-54. Due to the difference in area, on each side of piston, the piston raises the sponge out of the suit circuit oxygen flow and is compressed against the separator housing plate. Water squeezed out of the sponge drains into the condensate tank. Following the termination of squeezing (30 seconds) the water separator solenoid valve is de-energized and the solenoid valve closes. Oxygen below the separator piston is vented to cabin through the separator solenoid valve. Oxygen above the piston, entrapped by a check valve, forces the piston charcoal that removes objectionable odors from the suit circuit oxygen. Lithium hydroxide, located in the center sections removes carbon dioxide. The outlet section is an exit filter, provided to prevent charcoal and lithium hydroxide dust from entering the suit circuit oxygen flow. The charcoal and lithium hydroxide granules are compressed by a spring force. The CO_2 and odor absorber has an operating life of approximately 31 hours, and to ensure proper absorber operation the absorber should be replaced prior to capsule mission.

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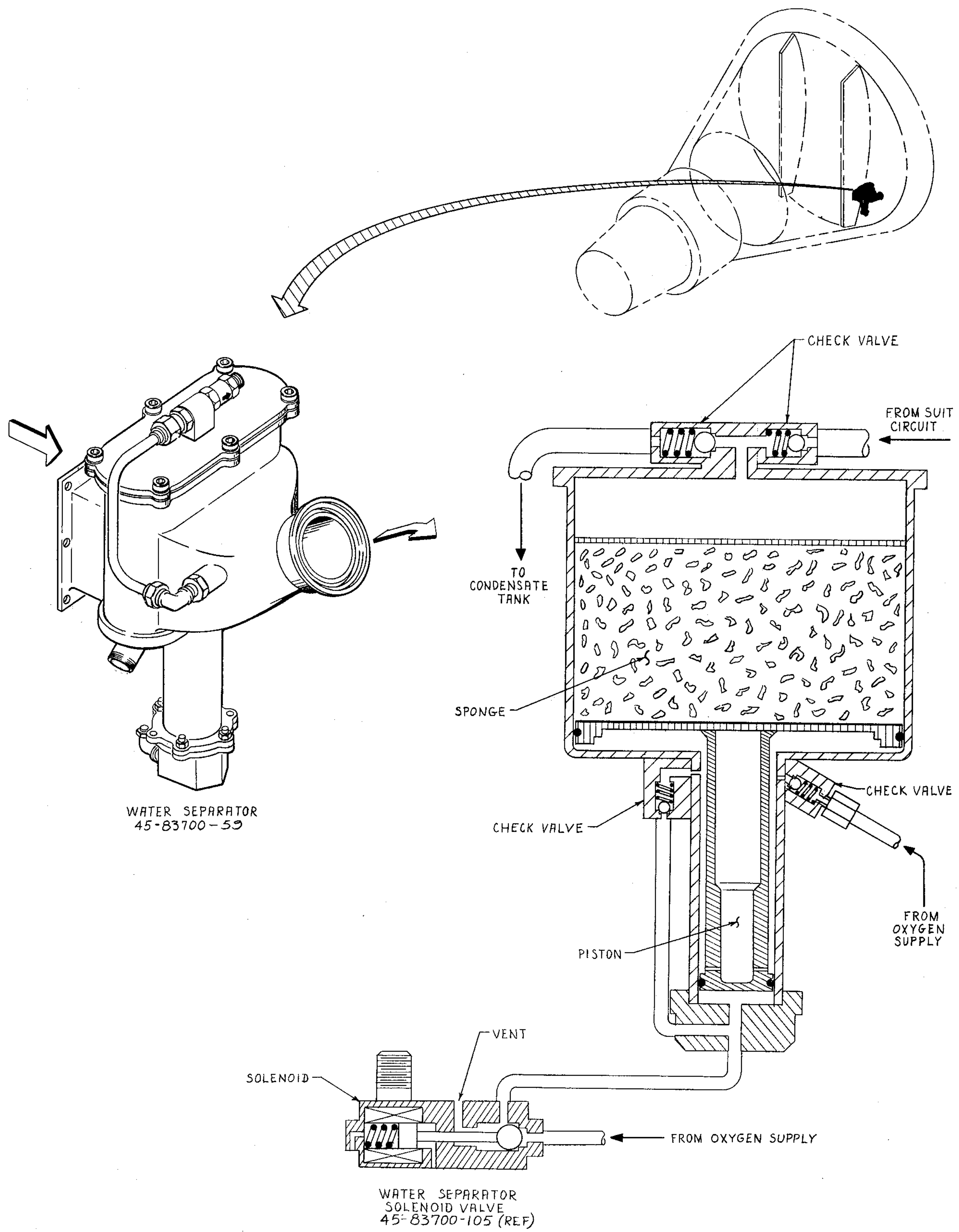


FIGURE 3-17 WATER SEPARATOR

PM45-157

down thus returning the sponge into suit circuit oxygen flow. Suit circuit pressure is also supplied to top of separator to aid in forcing sponge down. Two check valves, located on top of separator, prevent water to enter suit circuit and also prevent water backflow into top of separator. A check valve is supplied to prevent oxygen depletion in the event separator mechanisms developed a leak. During squeezing operation suit circuit oxygen flow will not be affected, as oxygen will continue to flow through area normally occupied by the sponge.

3-55. TEST CONFIGURATION CAPSULE 2 AND 3

Capsules 2 and 3 environmental control systems differ from the specification capsule environmental system in the following manner.

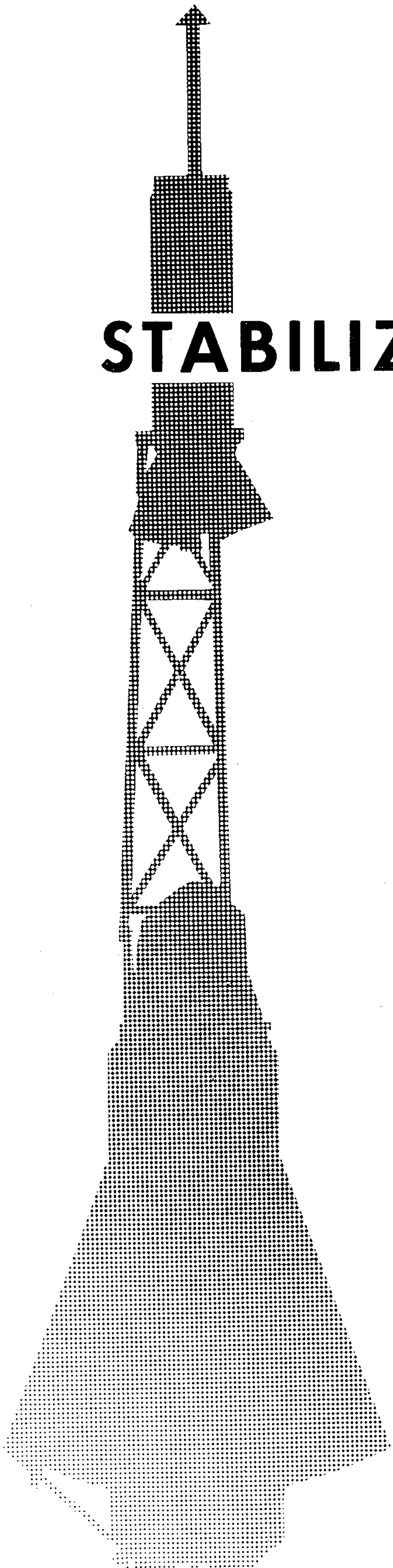
3-56. Capsules 2 and 3 do not contain a water coolant indicating system and an emergency oxygen system. Cabin air inlet valve is located approximately 100° from the cabin air outflow valve, on the small pressure bulkhead. Capsules 2 and 3 do not contain SUIT ENVIR. and PARTIAL PRESSURE (O_2) indicators, CABIN PRESS, O_2 PRESS, CO_2 PRESS warning lights. Capsules 2 and 3 do contain a LAUNCH OXY warning light which illuminates in relationship to cabin oxygen partial pressure (below 3 psi). Capsules 2 and 3 do not incorporate a tone generator warning system. The DECOMPRESS, REPRESS and SNORKEL controls, left console, areslightly positioned in different locations on the left console. Capsule 3 incorporates a special solids trap designed for the primate.

3-57. TEST CONFIGURATION CAPSULE 4

Capsule 4 environmental control system differs from the specification capsule environmental system in the following manner.

3-58. Capsule 4 does not contain SUIT ENVIR and PARTIAL PRESSURE (O_2) indicators, CABIN PRESS, O_2 PRESS, CO_2 PRESS warning lights. Capsule 4 does contain a LAUNCH OXY light that illuminates when cabin oxygen partial pressure is below 3 psi. Capsule 4 does not contain a tone generator warning system. Environmental control system controls, left console, are slightly different in both type (handle) and location than the specification capsule. Cabin air inlet valve is located 180° from the cabin air outflow valve on the small pressure bulkhead.

SECTION IV



STABILIZATION CONTROL SYSTEMS

TABLE OF CONTENTS

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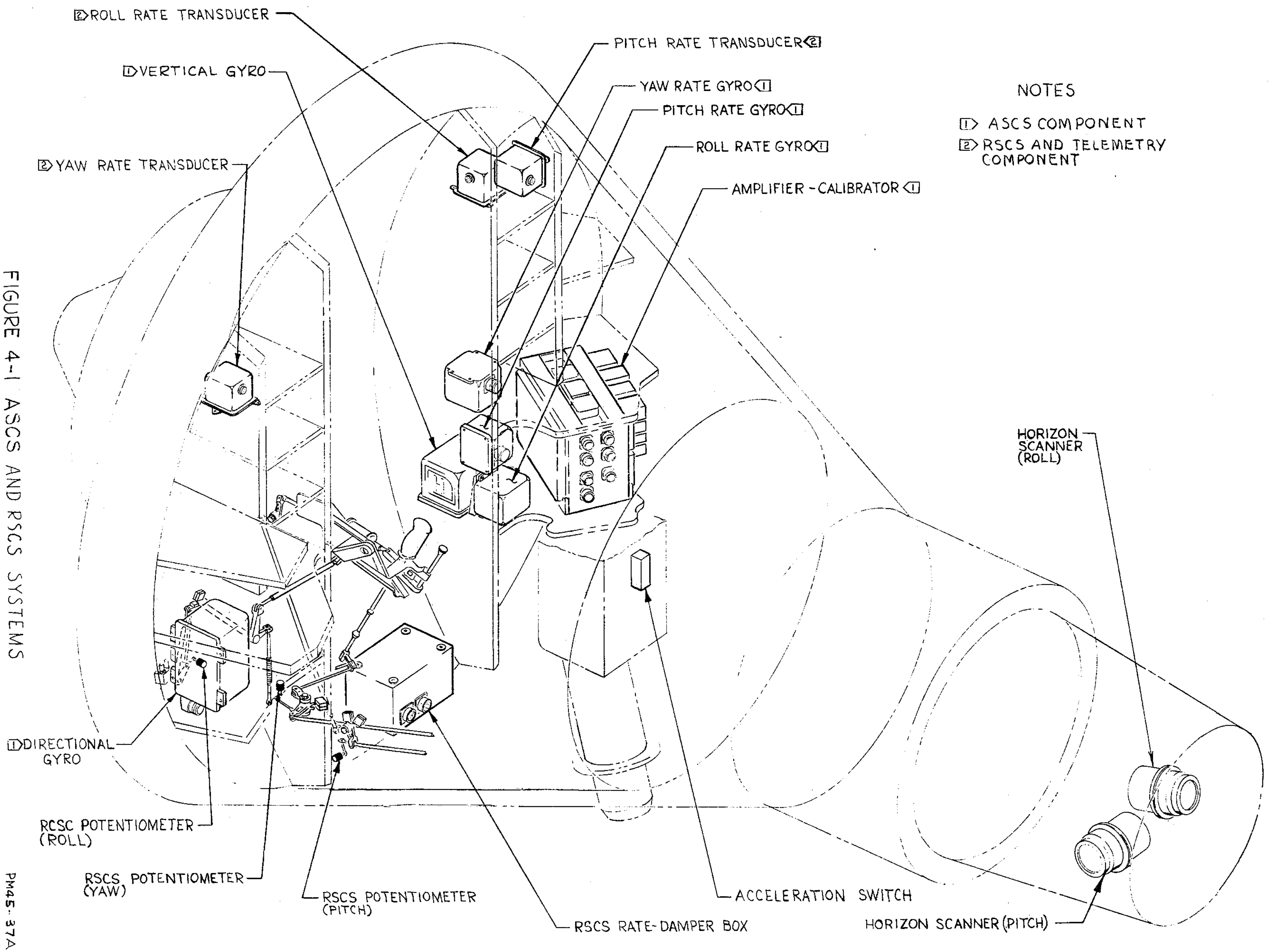

FIGURE 4-1 ASCS AND RSCS SYSTEMS

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IV. STABILIZATION CONTROL SYSTEMS

4-1. GENERAL

Stabilization of the capsule in space is accomplished by the Automatic Stabilization Control System in conjunction with two sub-systems, the Horizon Scanners and the Reaction Control System. These systems establish and maintain a stable platform with four basic automatic modes; Damper, Orientation, Attitude Hold and Re-entry. A redundant rate "back-up" system, the Rate Stabilization Control System (RSCS), is also provided. The RSCS provides the Astronaut with an emergency method of controlling the capsule with a "rate-stick" in the event of a failure in the Automatic Stabilization Control System rate-damper. In addition, a visual indication of yaw, roll, and pitch attitude is provided. The following paragraphs 4-2 through 4-62 briefly describe the individual systems and functions involved for the specification compliance (orbital) capsule.

AUTOMATIC STABILIZATION CONTROL SYSTEM

4-2. System Description

The Automatic Stabilization Control System (ASCS) is composed of a Directional Gyro, Vertical Gyro, .05g accelerometer switch, Rate Gyros (yaw, roll and pitch), a rate damper, and an Amplifier Calibrator Unit. Location of the individual components within the capsule is shown in Figure 4-1. Total weight of the ASCS is approximately 59 pounds. System energy consumption (maximum, exclusive of rate damper) for a full 28 hour mission is 88 watt hours of d-c energy and 1857 watt hours of 115 V a-c energy.

4-3. Three switches are provided in conjunction with the ASCS. The GYRO switch, AUTO/RATE COMD switch, and the NORM-AUX DAMP-FBW switch are located on the Astronaut's left console. With the NORM-AUX DAMP-FBW switch in the NORMAL position and the AUTO-RATE COMD switch in AUTO, stabilization is accomplished in a completely automatic manner, requiring no assistance from the Astronaut. In the FLY-BY-WIRE position, the automatic feature is disabled (except rate damping) and 24 V d-c power is connected to the Fly-By-Wire limit switches on the Astronaut's control stick. In this position stabilization is accomplished through an electro-mechanical arrangement (see Figure 4-9) by movement of the Astronaut's control stick in the desired plane. The AUX DAMP position disables both the automatic and fly-by-wire functions, permitting rate damping as a singular feature. The GYRO switch is a three position switch incorporating a CAGE, FREE, and NORMAL position. In the CAGE position the Attitude gyros are mechanically caged and the Horizon Scanner slaving function is disabled. In the FREE position the Attitude gyros are uncaged; the Horizon Scanner slaving function remains disabled. The NORMAL position uncages the attitude gyros and permits Horizon Scanner slaving. The AUTO/RATE COMD switch provides a method of energizing either the RSCS or ASCS systems as desired. In the RATE COMD position, the attitude gyros and slaving circuits remain energized although they are not used to control the capsule. See Figure 4-12.

4-4. ASCS Sequencing

The following paragraphs, 4-5 through 4-18, describe the ASCS sequential operation under normal and abort conditions. Figures 4-2, 4-3 and 4-4 are provided for clarity and should be followed closely in conjunction with the text concerning the various modes of operation.

4-5. Normal Sequencing

In Figure 4-2, the progress of a normal orbital mission is shown divided into eight phases appropriate to the following discussion.

4-6. The ASCS is in the "ready" status prior to separation of the escape tower, its gyros are running and all circuits except the final 12 output relays are

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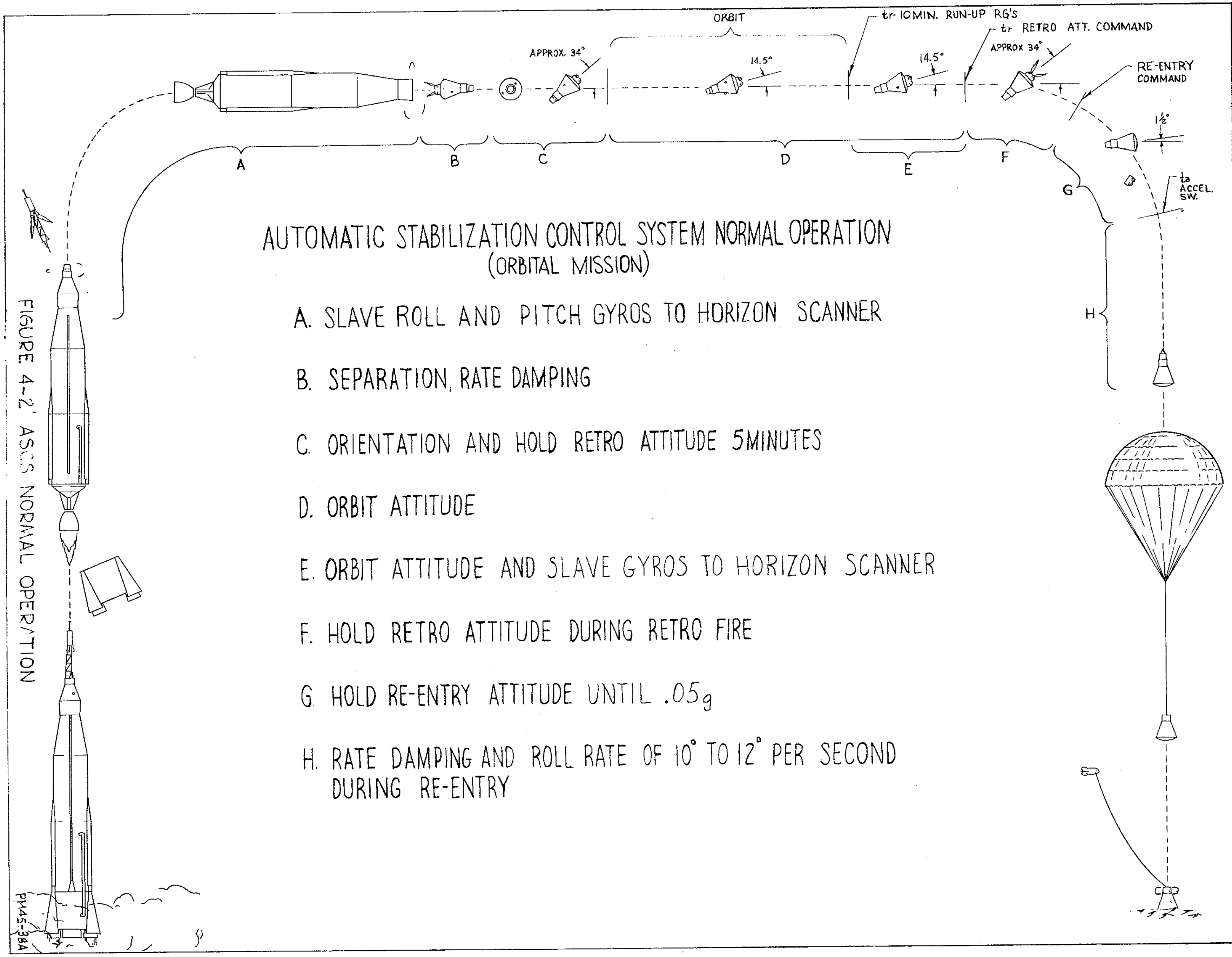

FIGURE 4-2 ASCS NORMAL OPERATION

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fully energized. RSCS operation is prevented by the AUTO/RATE COMD switch being in the AUTO position. Phase (A), involving gyro slaving to the Horizon Scanner pitch and roll outputs during ascent, is to minimize gyro errors which may accumulate while the capsule is being boosted.

4-7. Phase (B) starts after capsule separation when a brief, five-second signal commands the ASCS to provide rate damping to stop any tendency to tumble. Commands then cause capsule turn-around in the yaw plane and pitch-up to retrograde-firing angle.

4-8. Phase (C) is a five minute period of holding this attitude to provide readiness in the event that ground-tracking computations indicate the trajectory is not desirable and an immediate "late abort" is required. Pitch, roll and yaw slaving to the Horizon Scanners is also provided during phase (C) to yield a good yaw-angle reference prior to settling down in orbit.

4-9. In phase (D) the capsule is in orbit. The retrograde-attitude command has ceased and a pitch attitude of -14.5° (small end down) is held so that the periscope's field of view is not obstructed by the capsule's blunt end. Present planning calls for Horizon Scanner usage at a cycle of 6 minutes on, 14 minutes off, throughout phase (D). It is noted, however, that Scanner programming for normal orbital missions remains flexible at this time, and will be affected by experience gained on early test capsules. During the orbit phase manual control and fly-by-wire control may be utilized as desired. Rate damping is automatically provided when in the fly-by-wire condition. Rate damping becomes optional under manual control conditions by positioning of the ASCS MODE SELECT switches and RCS controls. By switch manipulation, rate damping is provided by either the ASCS or RSCS. See Paragraph 4-2. Rate gyro run-up is continued throughout phase (D), although in "normal" situations damping will be unnecessary.

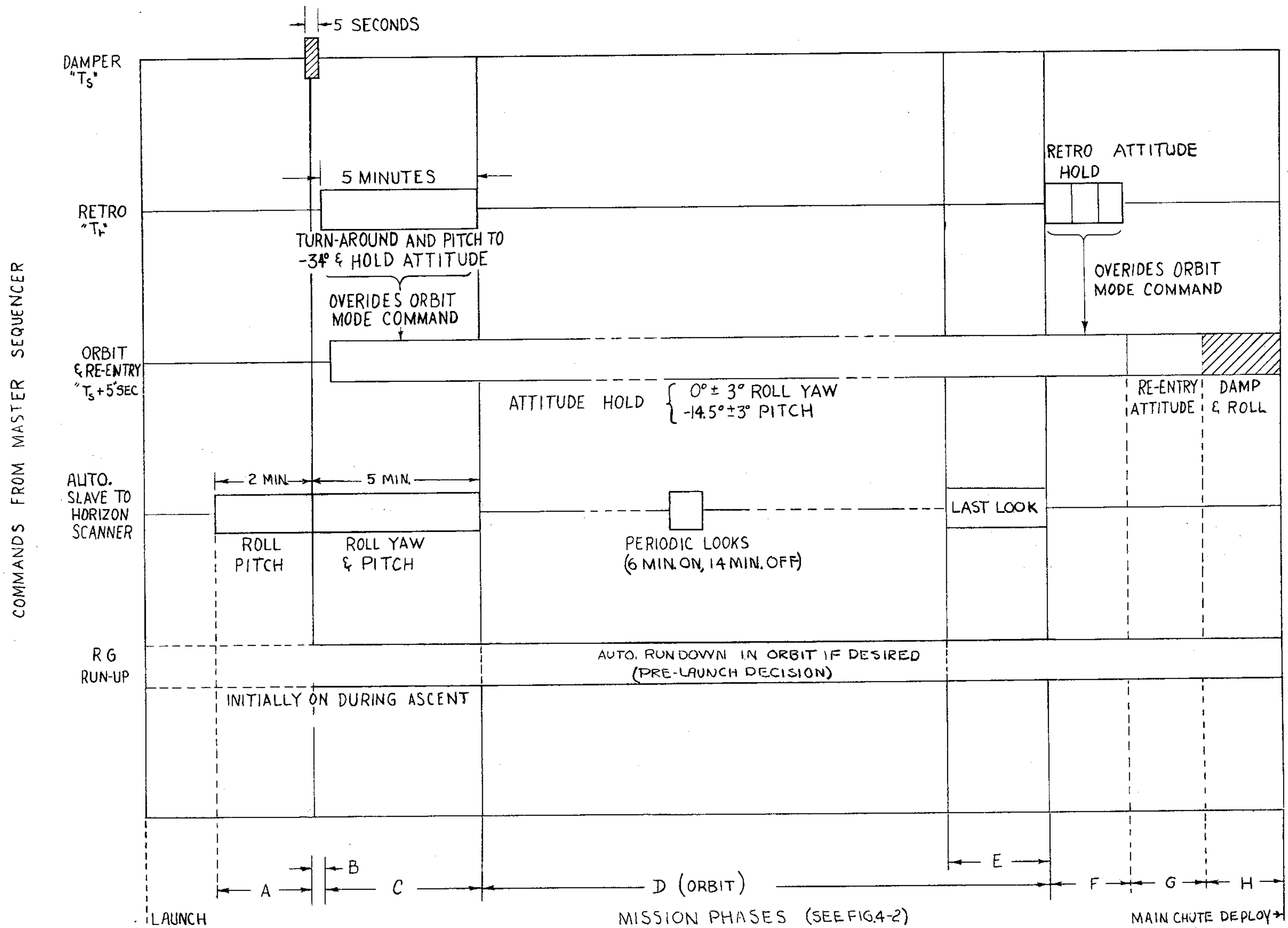

FIGURE 4-3 ASCS MISSION PROFILE

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The Astronaut can (by simple switch manipulation) place the ASCS back in "ORIENTATION" status which quickly damps any rate disturbance until the rate is less than 0.5°/sec. Orientation will automatically be initiated by the NASA switch should the capsule drift (from orbit attitude) beyond the limits of the attitude permission limit switches ($\pm 12^{\circ}$ pitch, $\pm 30^{\circ}$ roll and yaw).

4-10. In phase (E) of Figure 4-2, rate gyro run-up is automatically assured by relay switching 10 minutes prior to retrograde attitude. During this period a "last look" utilizing the Horizon Scanners is also provided by relay switching. At the discretion of the Astronaut, capsule attitude may be changed by placing the gyro switch to the free position, positioning capsule manually, then caging and uncaging gyros.

4-11. The ASCS pitches the capsule to retrograde attitude for a second time (phase F) upon an externally received command. Thirty seconds after retrograde attitude command, the retro rockets are fired. During this period the ASCS holds the capsule within approximately three degrees of the ideal angles. The ASCS utilizes hightorque action (only) during this period.

4-12. Upon completion of retro rocket firing, the ASCS automatically pitches the capsule to the post-retro fire attitude (phase G) in preparation for re-entry drag. Rate gyro run-up continues, however damping will be unnecessary in "normal" situations.

4-13. Finally, when re-entry is sensed by the .05g accelerometer switch, the eighth and last phase (H) of the ASCS performance starts with the turning off of the attitude gyro power. During this period the ASCS initiates and maintains a constant roll rate of 10° to 12° per second to minimize touchdown dispersion. Rate damping is provided to stabilize the re-entry trajectory. ASCS operation in this phase continues until main chute deployment, at which time all ASCS power is removed.

4-14. It should be pointed out that pilot-override provisions permit interruptions of the preceding "normal" sequence by manual, fly-by-wire or RSCS stick-steering control manipulation and return to the "normal" ASCS MODE. Thus to a significant degree the Astronaut is the intelligent "back-up" for the ASCS. Full utilization of this reliability augmentation principle has led to gyro caging and other switching features which are intended to make the capsule manually controllable. The following table lists the switch and control positions necessary to achieve the four basic modes of control after attaining orbit. It is noted that variations of the various modes can be obtained by further switch maniuplation, as an example, the manual mode shown may be changed to manual mode without rate-damper by placing the AUTO/RATE COMD switch to RATE COMD. A more detailed discussion of the control modes available is contained in SEDR 109, Astronaut's Handbook.

CONTROL MODE	SWITCH POSITION		RCS "T" HANDLE POSITION	
	Auto/Rate Comd	Norm-Aux Damp-FBW	Auto Fuel Sys.	Manual Fuel Sys.
AUTOMATIC	AUTO	NORMAL	PUSH ON	RATE COMD
FLY BY WIRE (With Rate Damper)	AUTO	FLY-BY-WIRE	PUSH ON	RATE COMD
RATE-STICK	RATE COMD	NORMAL	PULL OFF	RATE COMD
DIRECT (With Rate Damper)	AUTO	AUX. DAMP	PUSH ON	DIRECT

4-15. Abort Sequencing

In general, abort sequencing (see Figure 4-4) is programmed to correspond to the safest procedures at all times. The possible abort situations can be divided into three types, namely (1) abort, before staging when ASCS rate damping is required; (2) abort after staging but before the trajectory is truly orbital; and (3) abort from orbit. The following paragraphs 4-16 through 4-18

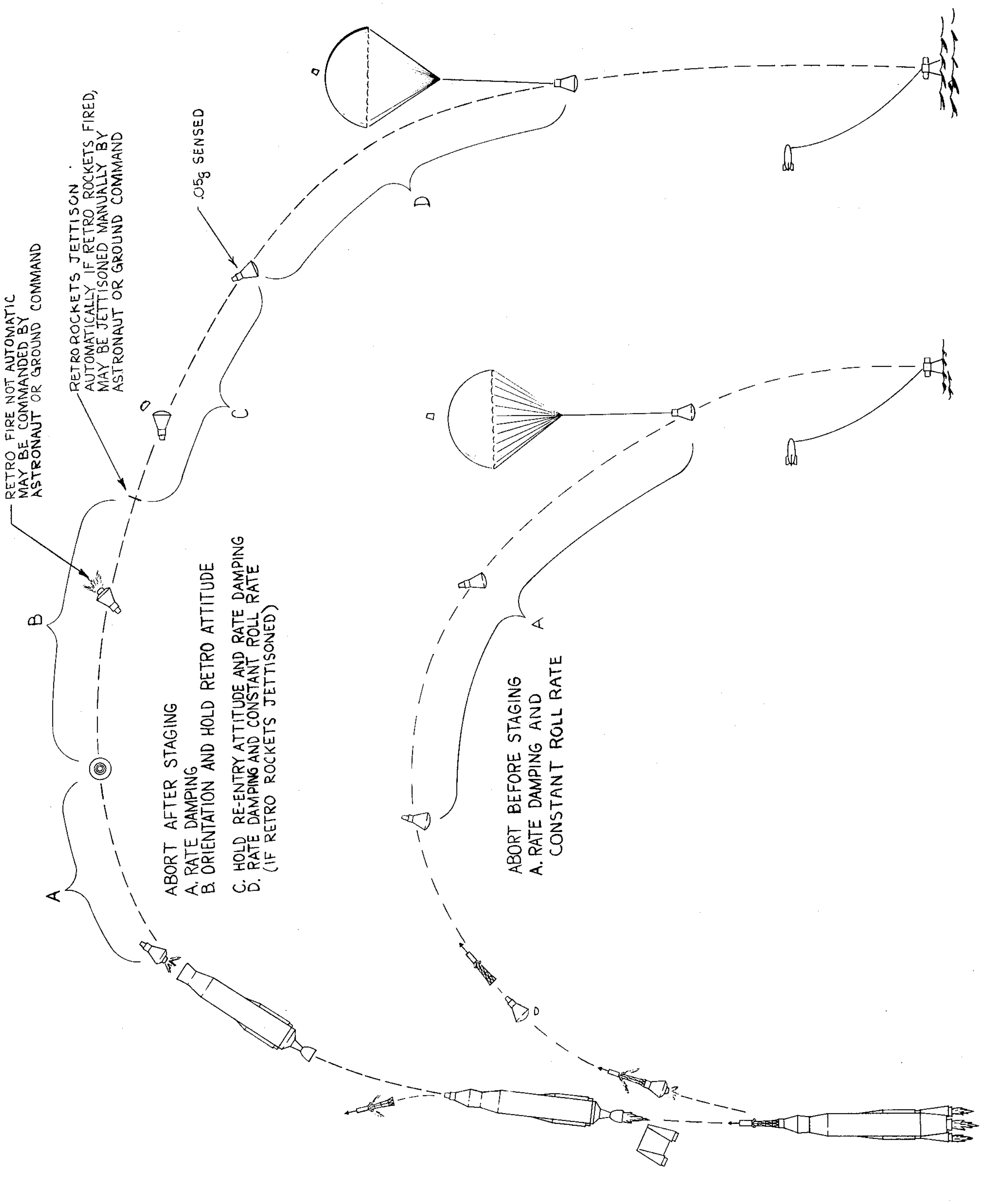

FIGURE 4-4 ASCS EMERGENCY OPERATION

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discuss ASCS sequencing in each of the abort conditions.

4-16. Abort before staging -- If an abort mission is started during the period when the booster and sustainer engines are burning, the ASCS is utilized for rate damping only after the following external operations have been achieved.

(1) Booster and sustainer engines cut-off.

(2) Capsule separation from adapter.

(3) Escape tower rocket firing.

(4) Retro rocket separation from capsule.

(5) Timed arrival of approximate peak of trajectory.

(6) Separation of escape tower from capsule.

Upon completion of the latter operation, the ASCS is commanded to provide rate damping, using the rate gyros which are continuously energized during the normal ascent and "abort trajectory" flight. A constant roll rate of 10° to 12° per second is employed. Rate damping ceases upon deployment of the main chute.

4-17. Abort after staging -- The first operation is engine cut-off. This is followed immediately by capsule separation, posigrade firing, and the normal mission post-separation signal sequence to the ASCS. The effect is immediate damping of any capsule tendency to tumble. Next the automatic sequence commands retrograde attitude. Upon achieving the proper roll, pitch and yaw angles within rather wide "permission" bounds, the ASCS enables rapid-sequence retro rocket firing to proceed.

NOTE

ASCS "permission interlock" during retro fire can be over-ridden at any time by either the pilot or ground-initiated commands. It is also noted that the Astronaut may switch to the Rate

Stabilization Control System at any time during an abort situation should a malfunction occur in the Automatic Stabilization Control System.

After retrograde operation, the abort mission in this case proceeds as in the normal mission post-retrograde sequence (except for the difference in trajectory time and distance intervals).

4-18. Abort from orbit -- Whenever an abort from orbit is initiated, the normal automatic or manual retrograde operations will apply. However, the pre-retrograde operations of "last look" with the Horizon Scanners and rate gyro run-up may be shortened to approximately one minute if necessary.

4-19. System Operation

Overall system operation is best explained by Figure 4-5. The Amplifier Calibrator receives inputs from sensors on the left side of the page and generates outputs to Display and Reaction Control devices on the right. The four basic operations are slaving, repeating, mode switching and torque switching. Data flow pertaining to the individual Yaw, Roll and Pitch channels is illustrated in Figures 4-6, 4-7 and 4-8. In general these diagrams are straightforward and require no explanation. However, the method utilized in deriving Directional information (Figure 4-7) is unique to a degree and warrants the following discussion.

4-20. The Pitch gimbal (vertical gyro) is processed continuously during the orbital phase of the normal mission, so that the capsule "local vertical" reference revolves 360 degrees during each orbital cycle. The gyro slaving principles which permit Directional (yaw) information to be derived are as follows: After initial slaving and settling of the roll and pitch loops, the

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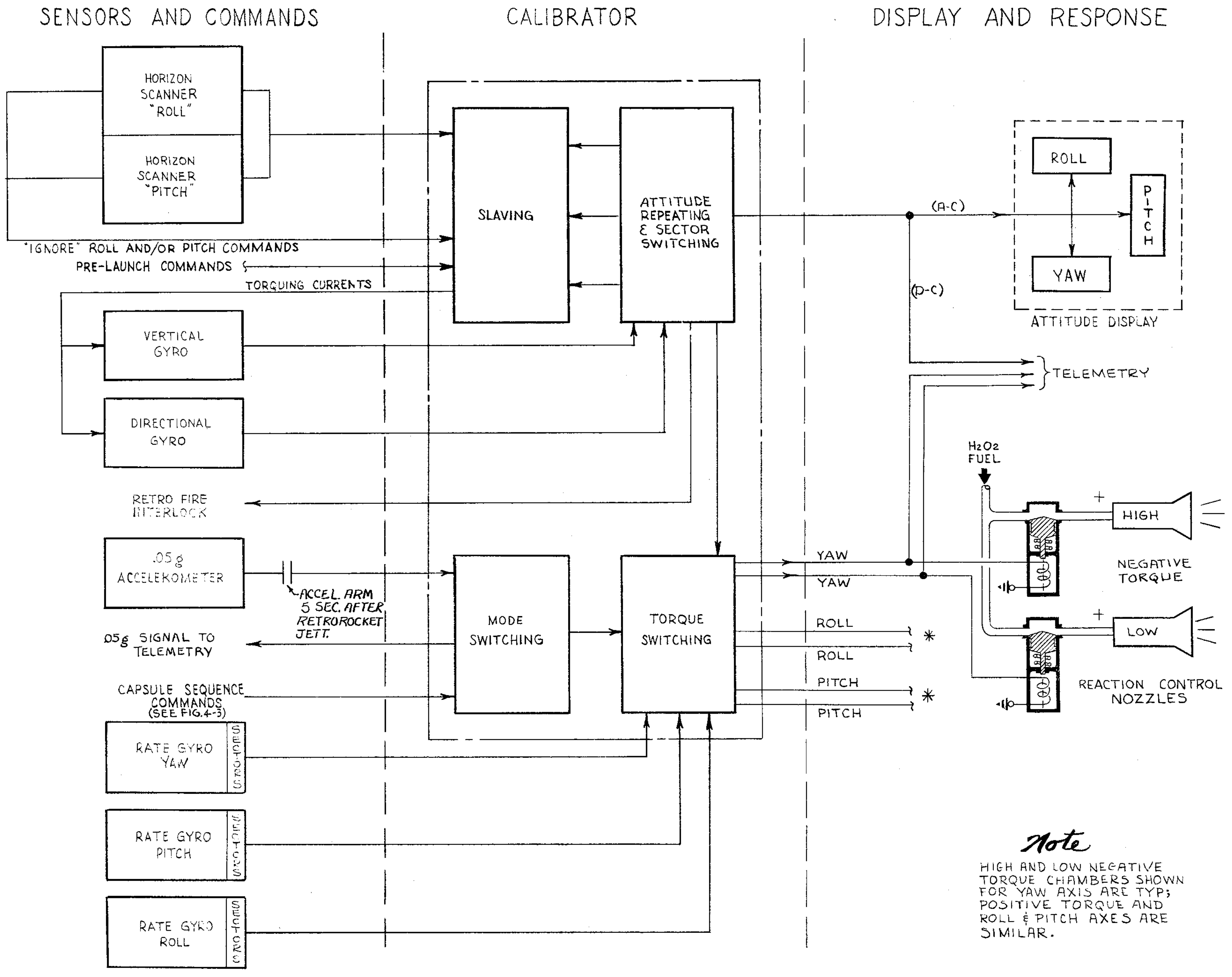

FIGURE 4-5 ASCS BLOCK DIAGRAM

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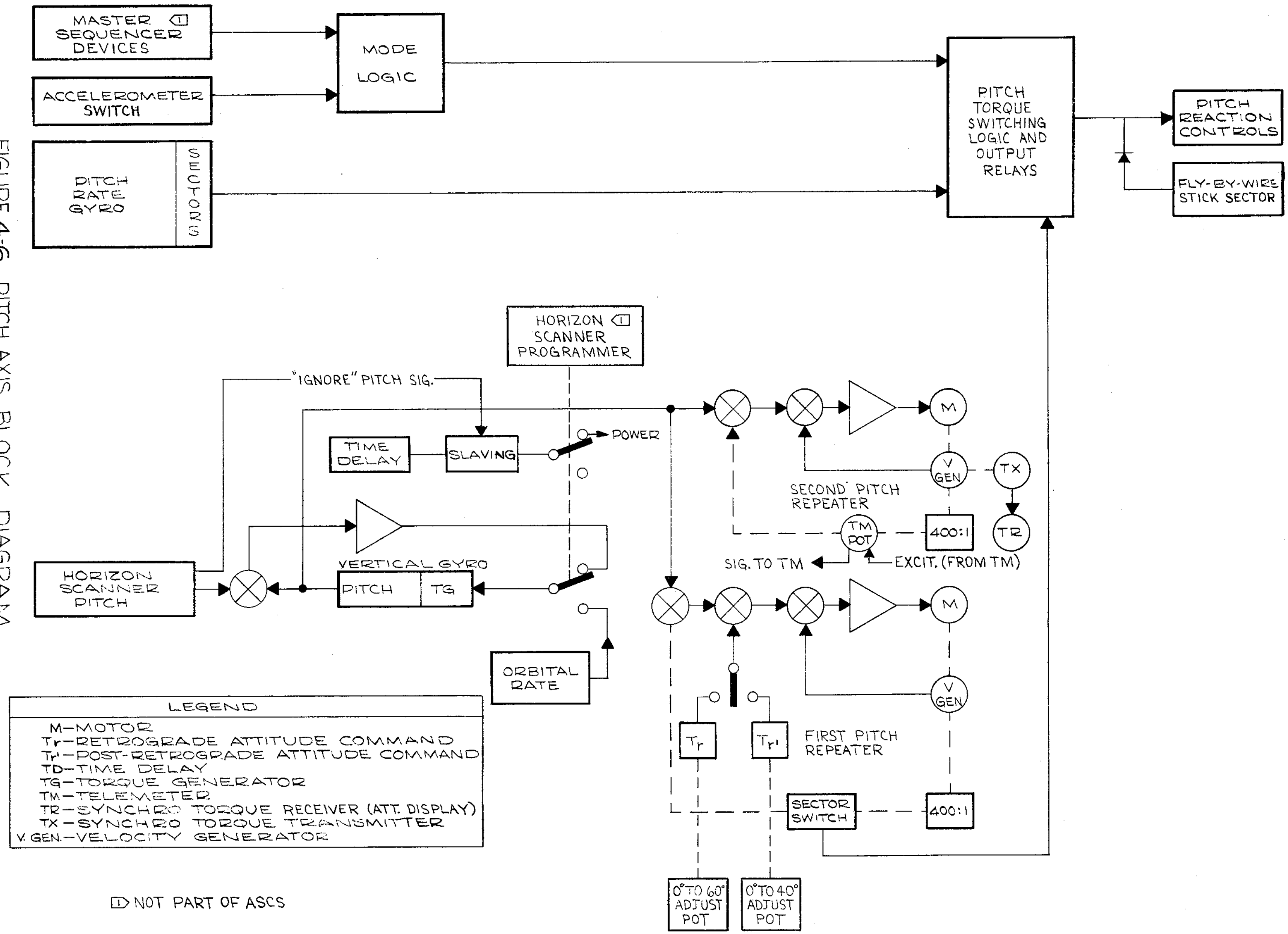

FIGURE 4-6 PITCH AXIS BLOCK DIAGRAM

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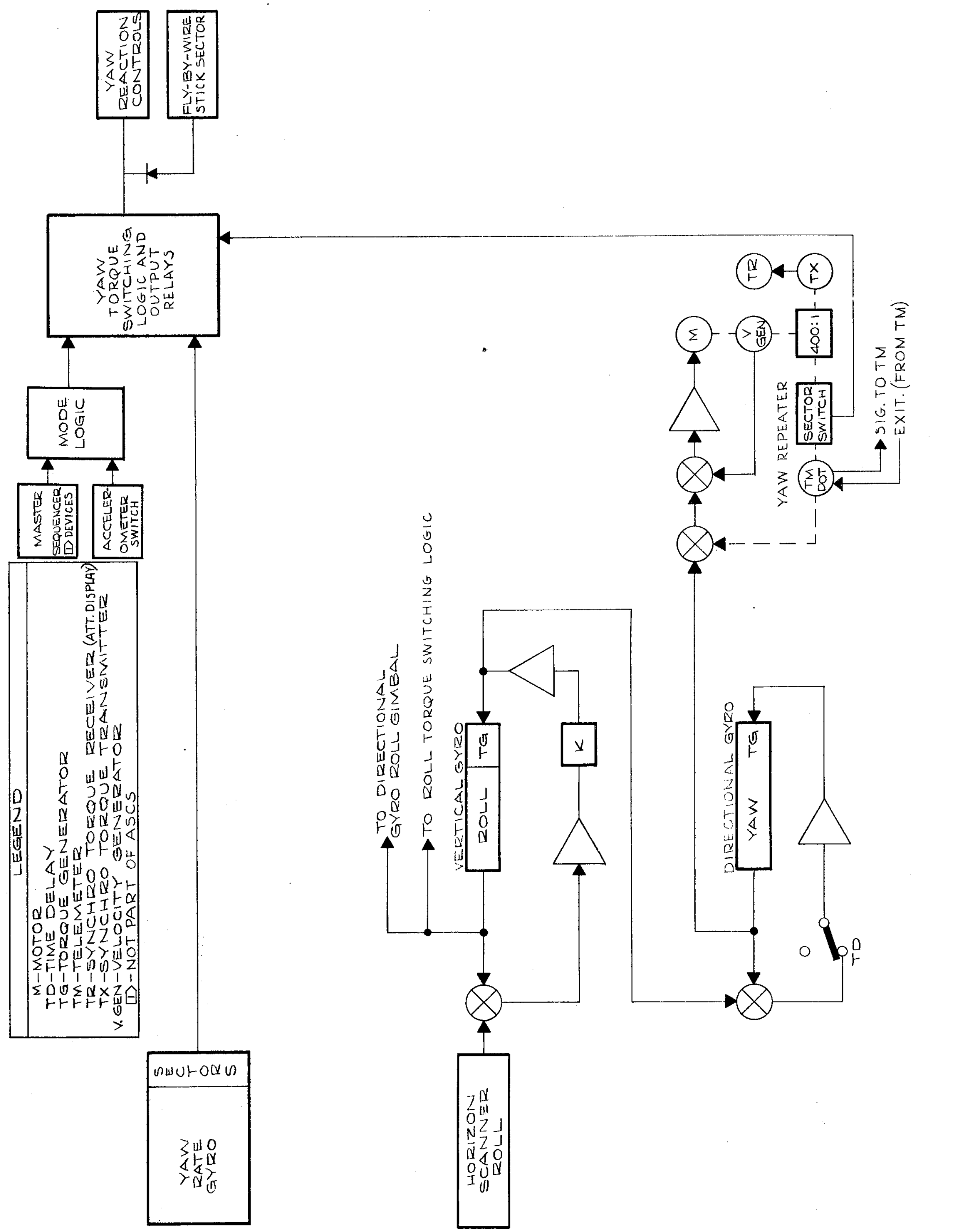


FIGURE 4-7 YAW AXIS BLOCK DIAGRAM

PM45-43A

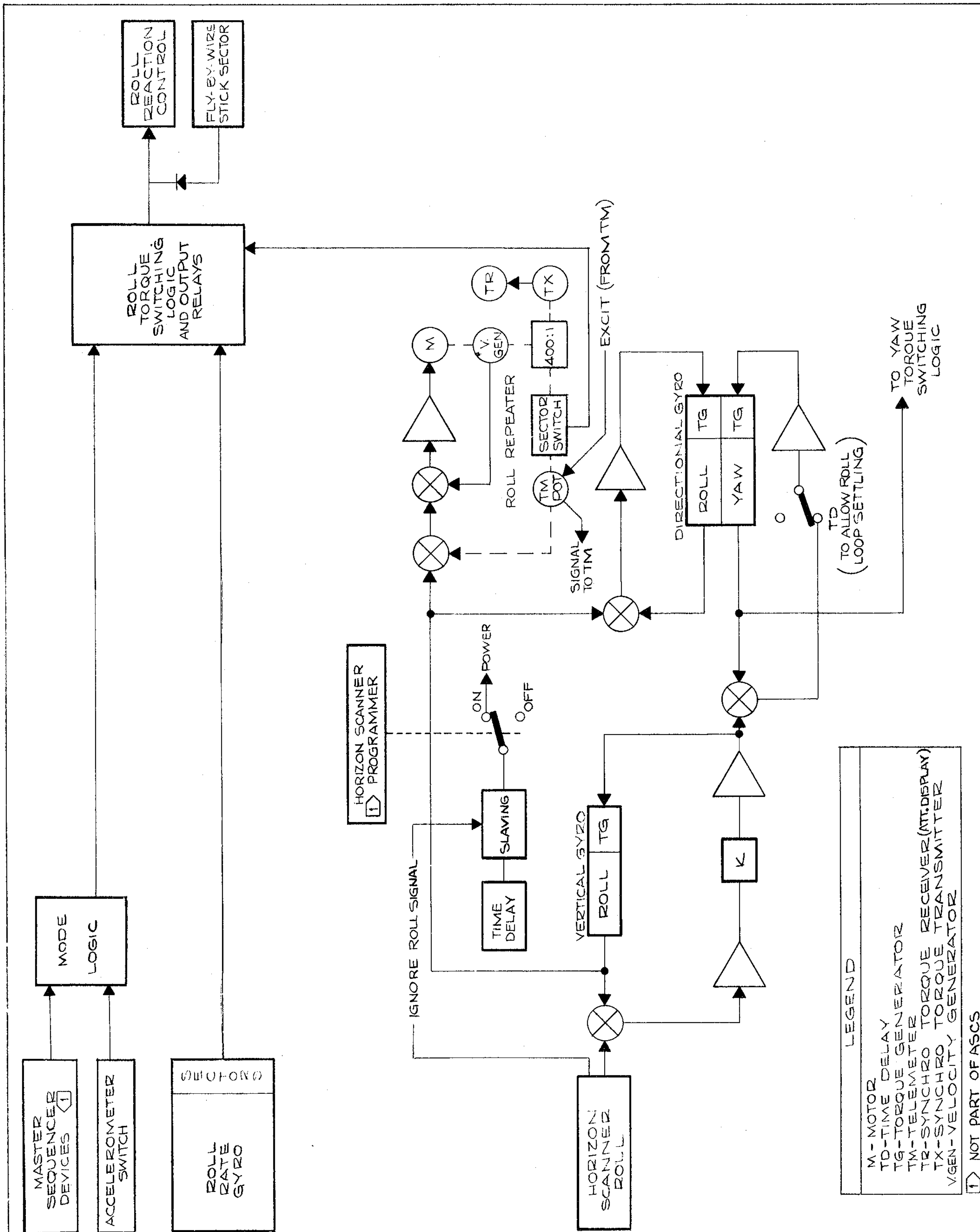


FIGURE 4-8 ROLL AXIS BLOCK DIAGRAM

PM45-44A

ASCS controls the capsule to the command pitch attitude, depending upon the mission phase such as "orbit" or "retrograde", and to level roll attitude. Initially, after separation and capsule turn-around, some yaw error (as great as 10 degrees) may exist due to directional drift during boost. Since the Roll gimbal of the vertical gyro is the inner gimbal, yaw misalignment of the capsule causes the Roll gimbal output to contain an error component due to the constant orbital (pitch) angular rate. Thus a comparison of the Roll Horizon Scanner and vertical gyro roll indications will provide an error signal producing a roll gimbal torqueing rate. This torqueing rate which is a direct function of yaw error is simply used to slave the yaw gimbal of the directional gyro.

4-21. Another area that warrants discussion is that of torque switching, i.e., the thrust output of the Reaction Control System in conjunction with the various modes of ASCS operation.

4-22. Figure 4-10 serves as an introduction to the torque switching behavior of the ASCS. For maximum conservation of control fuel, the behavior varies according to the ASCS mode appropriate at a given time. A so-called "phase-plane" plot of angular rate vs. angle is shown in the lower right corner of Figure 4-10 adjacent to a typical Pitch time-history for the "Orbit" mode. Current ASCS design permits a plus or minus three degree oscillation about the nominal orbital attitude, which in turn is referenced to the Horizon Scanner's sensed "Horizontal". The oscillation is non-sinusoidal because of the discontinuous torque program; pitch rate is a square wave, and pitch angle a sawtooth, both having a characteristic period of 240 seconds. Portrayed on the phase-plane, the "Orbit" mode oscillation is a gentle drift from -3 degrees relative pitch angle to +3 degrees relative pitch (-17.5 to -11.5 degrees,

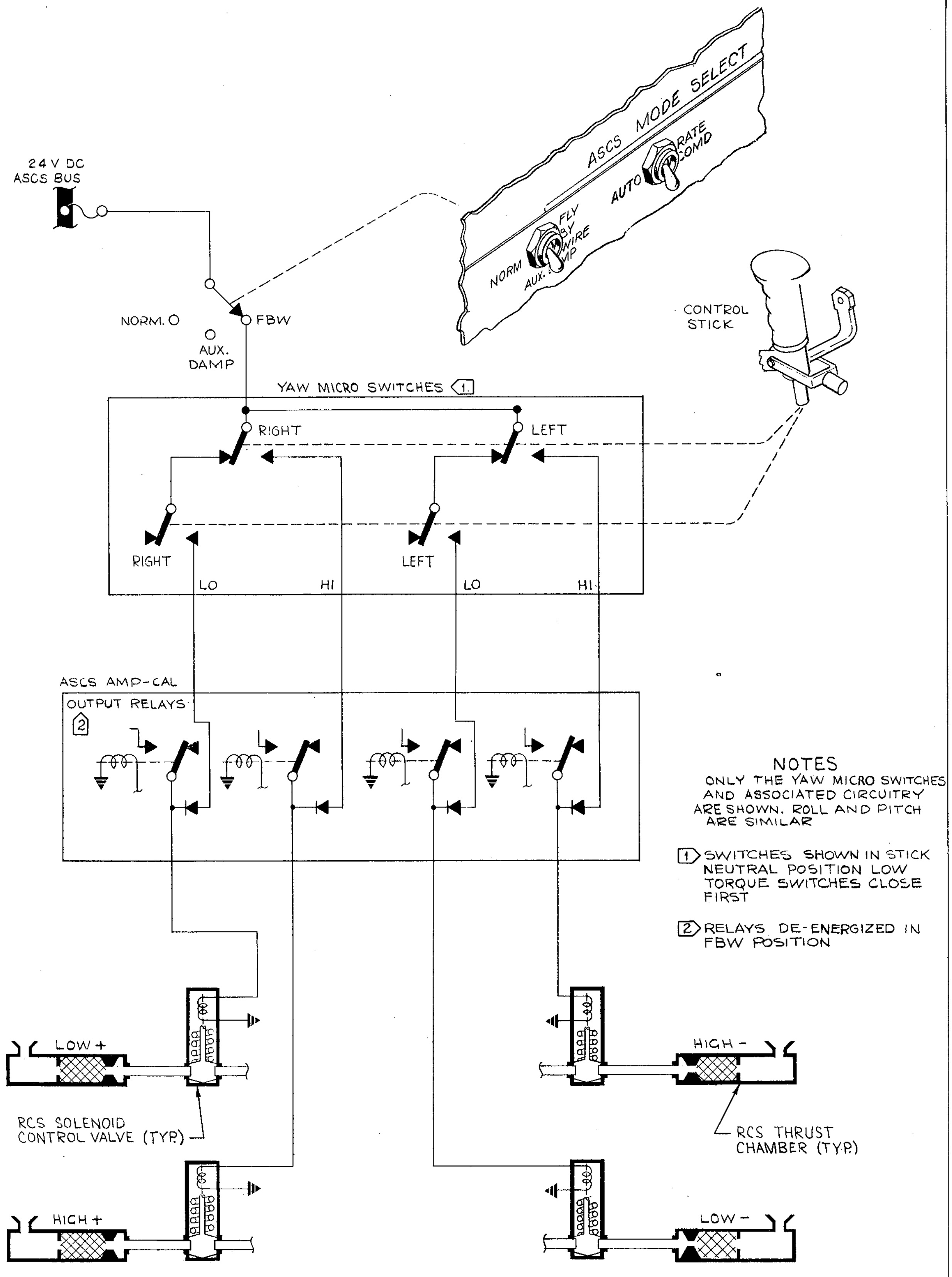


FIGURE 4-9 ASCS FLY-BY-WIRE CONTROL

PM45-40A

referenced to true horizontal). This drift lasts for approximately one half-period of two minutes. When the error becomes $\pm$ 3 degrees, a low torque pulse causes the angular rate to reverse from $+\frac{1}{2}$ to $-\frac{1}{2}$ deg/sec., where upon the second half-period is spent drifting slowly through zero to -3 degrees error.

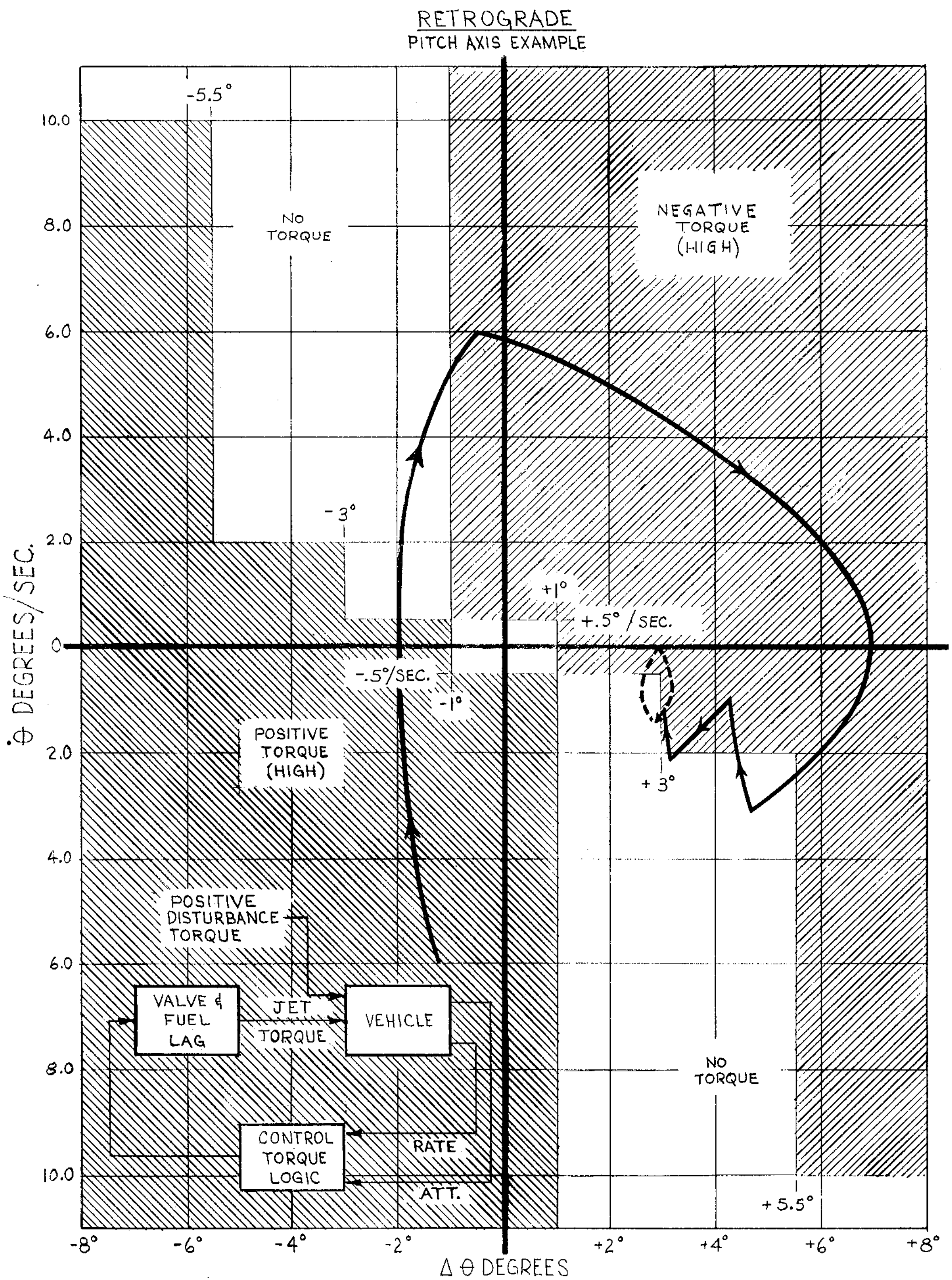
4-23. As another example of ASCS torque-switching, Figure 4-10 shows the "Retrograde-Hold" torque logic phase-plane diagram. In this case high-torque nozzles are utilized instead of the low-torque nozzles which were adequate to control the gentle orbit oscillation. A series of six attitude gyro repeater sector switches and six rate-gyro pickoff sector switches are used to define step-like boundaries within the phase-plane. A typical contour is shown to illustrate the motion resulting from a large disturbance torque while in this mode. When the capsule motion results in a pitch rate value above the right-hand stair step, high negative torque is applied until the capsule attains a negative rate and rotates into the "no-torque" region. The inverse occurs if the retro-rocket thrust eccentricity or other disturbances force the capsule into a situation calling for positive thrust. The net effect of the torque-switching logic shown is to maintain rapid and reliable control during the important operation of retrograde firing.

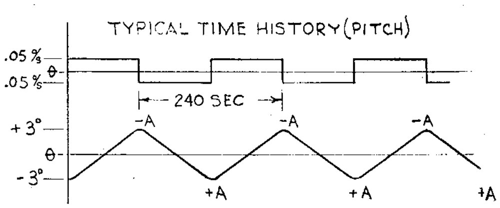
4-24. Other modes of operation requiring torque switching logic are "Orientation" and "Rate Damper". During orientation mode both high and low torqueing is utilized to rotate the capsule to new preset attitudes. Both high and low torque is also applied during rate damper mode but only rate gyro signals are needed as a basis for switching logic. In this case, torque switching boundaries are horizontal lines on the phase plane.

4-25. System Units

4-26. Amplifier Calibrator

The Amplifier Calibrator unit can be "functionally" divided into four sections.





ORBIT
(PITCH AXIS EXAMPLE)

PULSE	DURATION IN SEC.
±A	0.2
±B	0.147
±C	0.252
±D	0.437
±E	0.755

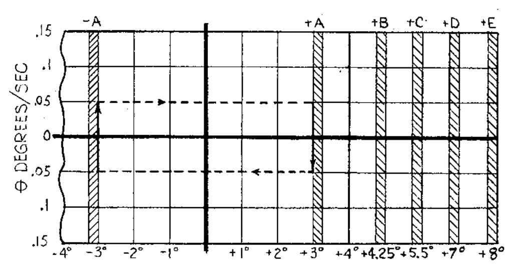


FIGURE 4-10 TORQUE LOGIC PHASE PLANE DIAGRAM

PM45-56A

These functional sections are slaving, repeating, mode switching and torque switching.

4-27. Attitude gyro slaving -- This section contains amplifiers and summing networks which accept roll and pitch information from the Horizon Scanners and generate currents to torquers in the attitude gyros. Thus, upon command from an external timing device, the Gyros' Roll, Pitch and Yaw gimbals are aligned with corresponding directions in, or perpendicular to the orbit plane. (Ref. Para. 4-20.)

4-28. Repeater section -- The repeater section is a group of servo-mechanisms (four in present design, including two for pitch angle repeating). Attitude gyro outputs, which are received at the calibrator in proportional or "analog" form, are amplified and used to drive shafts which serve as roll, pitch and yaw signal sources for both internal (torque switching) and external (display and telemetry) purposes. The on-off reaction control of the Mercury Capsule makes it desirable to use conductive sectors on the shafts of three of the repeaters. The sectors serve as attitude-level references for torque switching.

4-29. Mode switching section -- This section of the Calibrator establishes the proper attitude angle bias, torque switching status, and interlock signals corresponding to the ASCS mode commanded by external devices.

NOTE

> The sum of all such external devices is, for ASCS design purposes a "master sequencer" which coordinates all automatic functions.

The mode-switching section uses compact, solid-state switching circuits. Although these circuits contain many transistors, diodes, etc., they are of a class that is not critically dependent upon reference voltage or temperature levels.

4-30. Torque switching section -- The torque switching section contains transistor and diode circuits similar to those in the mode-switching section. Torque switching circuits receive the step-function outputs of the attitude gyro repeaters, plus the outputs of the rate gyros. The latter (rate) signals come from sector switches replacing the usual proportional rate gyro pickoffs. Using these step-wise indications of attitude and rate conditions, along with the mode switching section output defining the current phase of the mission, "decisions" are made which result in energizing of the appropriate Reaction Control valves.

4-31. Accelerometer Switch

The accelerometer switch is of conventional design, incorporating single contact switching. Contact closure occurs when an acceleration equal to or greater than .05g is sensed. Actuation of the accelerometer switch is used to initiate the ASCS re-entry mode.

4-32. Attitude Gyros

The function of the attitude gyros (vertical and directional) is to determine attitude angles between a set of fixed axes in the moving capsule and the reference axes which are fixed in the orbital plane but which are moving with the local vertical. Both attitude gyros are "free" gyroscopes with slaving capability. A means is incorporated for caging and for obtaining electrical signal (synchros) outputs which define the attitude of the gyros with respect to two mutually perpendicular axes. The attitude gyros possess unrestricted mechanical freedom in the outer axis and $\pm 83^{\circ}$ (minimum) of mechanical freedom in the inner axis. It is noted that the degree of gyro freedom does not necessarily reflect the attitudes permissible by manually steering the capsule in orbit. Due to limitations in the Horizon Scanner system and the repeater section of the Amplifier Calibrator, manual control of the capsule should be limited to $\pm 30^{\circ}$ in all axes. However, barring equipment malfunction, exceeding these limits will not prejudice the success of a mission. If these limits are exceeded, it is recommended that the gyro switch be placed in the FREE position. Input power requirements are 115 volt 400 cps single phase (gyro motor), and 24 volt, 400 cps (synchro and torque motor).

4-33. Attitude and Rate Indicator

The Attitude and Rate Indicator is mounted on the upper portion of the Main Instrument panel. The indicator provides visual indications of Capsule Rate and Attitude in the Yaw, Pitch and Roll planes. The attitude indicators are mechanically coupled to synchros which are in turn driven by the Attitude Gyro synchro outputs (through the Amplifier Calibrator). The attitude indicators are calibrated to indicate capsule attitude (yaw, pitch and roll) within a range of $\pm 180^\circ$. The rate portion of the indicator is driven by the miniature rate transducers (see Para. 4-41) which also serves as sensing elements for the Rate Stabilization Control System. The range of rate indication is 0 to $\pm 6^\circ$/sec for all three indicators. The roll rate indicator has the additional capability of being externally switched to a range of 0 to 15°/sec in order to monitor re-entry roll rate.

4-34. Rate Gyros

The rate gyros perform electrical circuit switching functions at specific rates of angular velocity about an axis perpendicular to the base of each unit, referred to as the "input axis". Rate gyros are used in the pitch, roll and yaw axes respectively. Each rate gyro consists of a high speed rotor, mounted in a gimbal ring, in such a manner that it is free to precess about one axis only (the output axis) which is perpendicular to the spin axis of the rotor. The output signals are generated by the motion of wipers, attached to the gimbal ring, moving across the contacts of sector switches. Input power requirements are met by 115 volts, 400 cps.

RATE STABILIZATION CONTROL SYSTEM

4-35. System Description

The Rate Stabilization Control System provides an excellent alternate means of capsule attitude control in the event of failure in the Automatic Stabilization Control System. It has been shown by flight simulation studies of the manual control problem that the Astronaut should, by utilizing the Rate Stabilization Control System, be able to approximate retrograde attitude error performance of the Automatic Stabilization Control System. In addition, the Rate Stabilization Control System provides a completely redundant rate-damper and programmed roll rate during re-entry.

4-37. The Rate Stabilization Control System consists of three miniature rate gyros, three (signal pickup) potentiometers, three channels of electronics (rate damper) contained in a 300 cubic inch box, one switch, and six solenoid control valves, which utilize the manual reaction control fuel and thrust chambers. Figure 4-1 shows the location of the major components within the capsule. Total weight of the Rate Stabilization Control System is approximately 25 pounds. Although the additional weight of 25 pounds appears significant, the overall net weight cost is on the order of 7.5 pounds. This is explained by the removal of the drogue chute upon installation of the Rate Stabilization Control System. The re-entry rate damper feature of the Automatic Stabilization Control System when backed-up by the additional Rate Stabilization Control System, eliminates the need for the additional redundant stabilization offered by the drogue chute. Power requirements for the Rate Stabilization Control System are met by 24 volt d-c and 115 volt, 400 cycle a-c. Power is connected directly to the rate damper box through the AUTO/RATE COMD switch mounted on the left console. See Figure 4-12. Maximum power consumption is estimated 3.0 watts at 115 V a-c and 6 watts at 24 V d-c.

4-38. System Operation

Figure 4-11 is a functional block diagram of the Rate Stabilization Control System. A typical channel is shown. In general, the Rate Stabilization Control System provides the Astronaut with a redundant rate damping and "rate-stick" steering feature. The outputs of the rate transducers and the control stick potentiometers are combined in the summation amplifiers. The summation amplifiers compute the capsule's angular rate errors and, if errors exceed preset dead-zones on the order of $\pm$ 3 deg/sec, the appropriate off-on corrective torque is commanded by energizing solenoid control valves in the Manual Reaction Control System. With the control stick at zero deflection (Rate Stabilization Control System operational) an automatic three axis rate-damper is achieved, including an automatic 7 deg/sec constant roll rate when re-entry is sensed. By manipulation of the control stick, steady-state angular rates other than zero (approximately proportional to stick deflection) may be attained if desired. This is in contrast to the proportional acceleration (torque) response which remains as an alternative in event of malfunction in the Rate Stabilization Control System.

4-39. System Units

4-40. Rate-Damper Box

The rate damper box provides three channels of transistorized electronics comprising the rate-damper portion of the Rate Stabilization Control System. Each channel contains a summation amplifier, preamplifier and demodulator, and two trigger circuits. The $5\frac{1}{2}$ x 6 x 9 in. box weighs approximately seven pounds and is mounted below and immediately aft of the control stick. The rate-damper box mounts two AN type electrical connectors, one for GSE and one for capsule interconnection. Dead band adjustments covering a range from $\pm$ 1

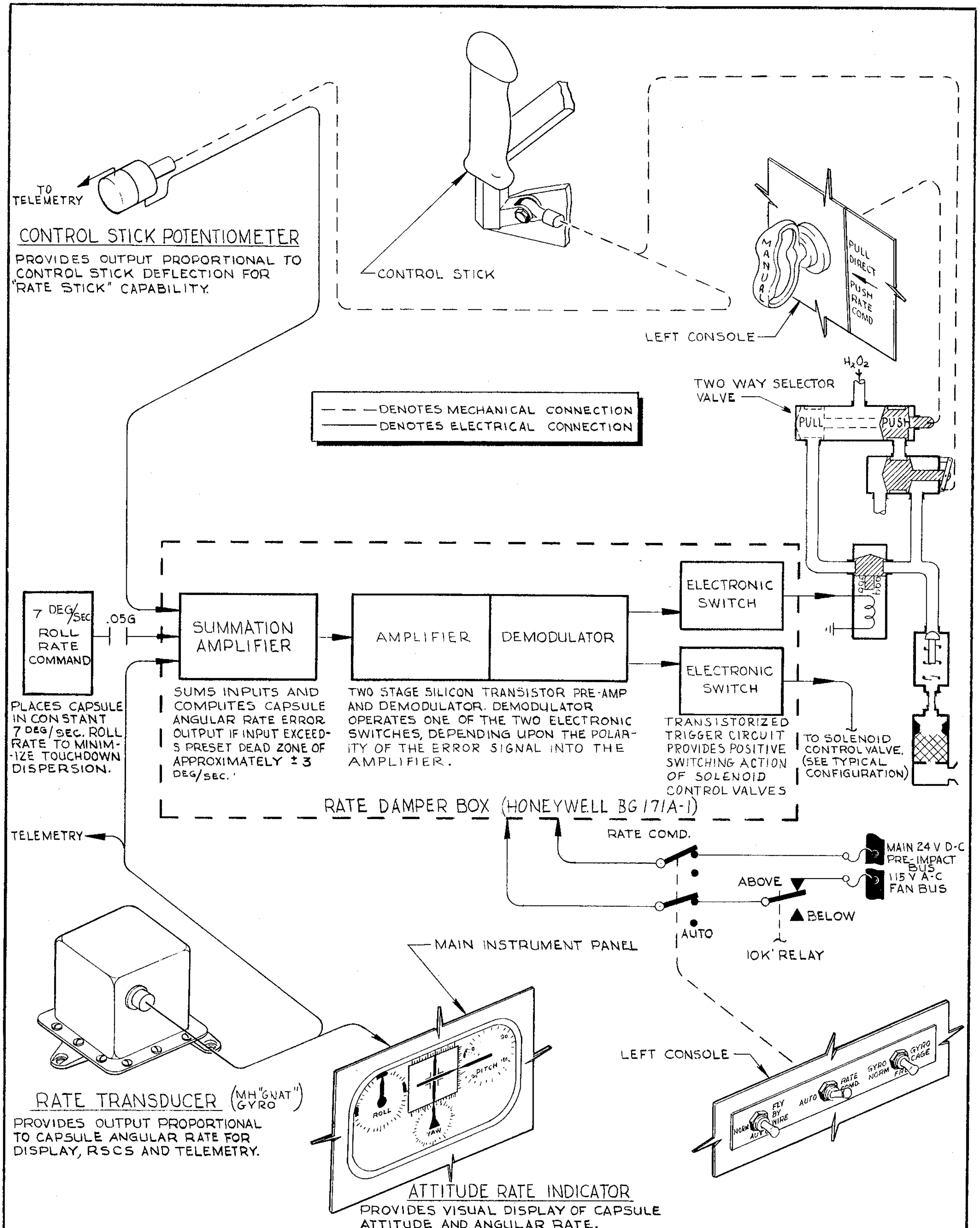


FIGURE 4-11 RSCS BLOCK DIAGRAM

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deg/sec to ± 4 deg/sec are provided. The rate-damper box accepts inputs from the rate transducers and control stick potentiometers, computes the capsule angular rates and supplies a 24 V D-C signal out to the appropriate solenoid control valve such that corrective torque is applied.

4-41. Miniature Rate Transducers

Each of the miniature rate transducers consists of a gyroscope, an amplifier, and a demodulator. These components function together to produce an A-C output signal proportional to input rate of change of attitude. All three rate transducers are identical except for gyro orientation in the transducer base. A special indexing feature prevents installation in the wrong location. Input power utilized by the rate transducers is 115 volts, 400 cycle A-C.

4-42. Control Stick Potentiometers

The three identical 1000 ohm 120 turn potentiometers are connected to the manual control stick linkage in such a manner that output signals are produced proportional to stick deflection in the yaw, roll, and pitch planes. Active sector is equal to 40 degrees with a minimum of 10 degrees of over-travel without electrical discontinuity.

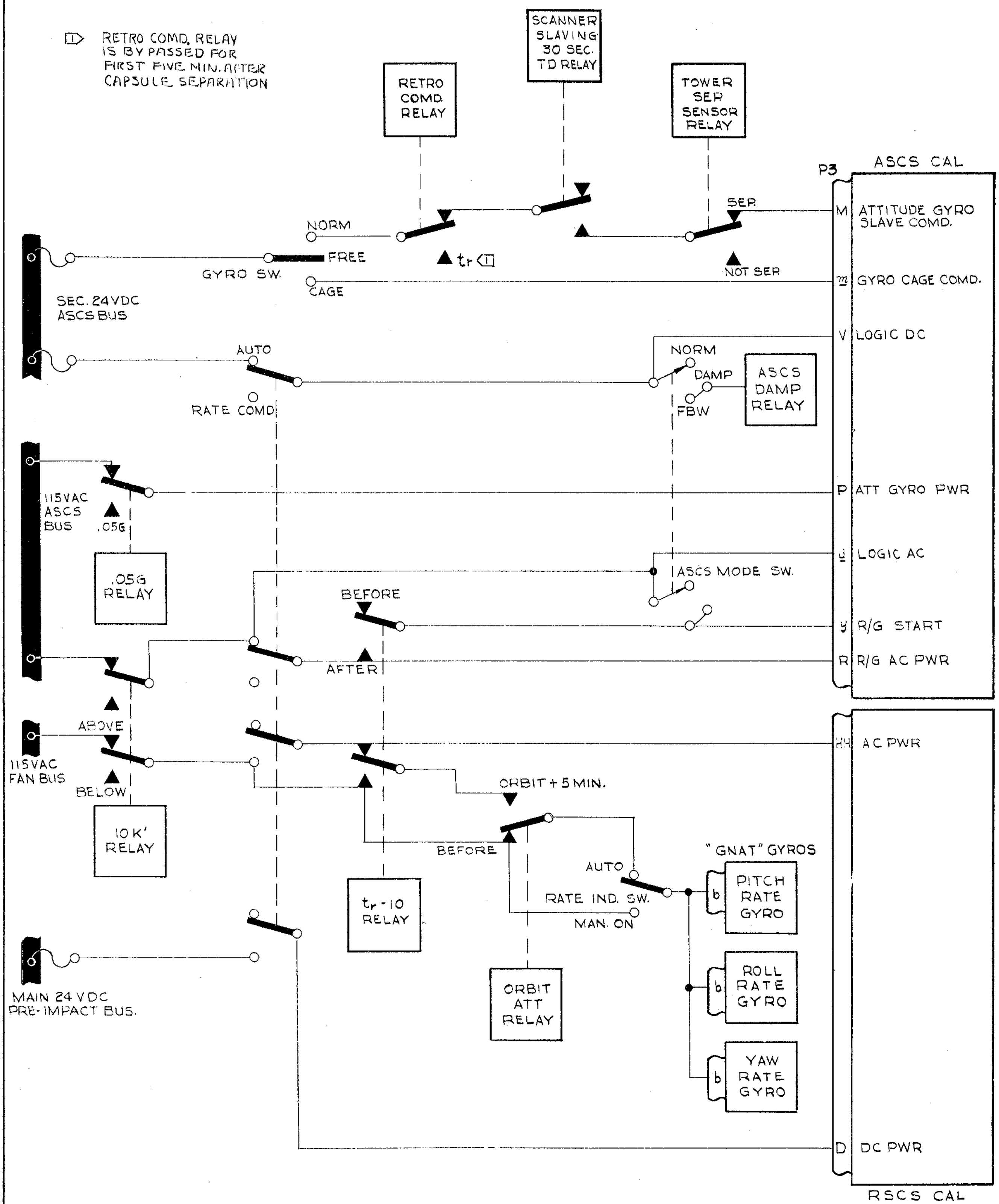

FIGURE 4-12 POWER DISTRIBUTION DIAGRAM

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REACTION CONTROL SYSTEM

4-43. System Description

The Reaction Control System is used for capsule yaw, pitch and roll control. The system is a pressure fed monopropellant, catalyst bed design. The right angle thrust chambers obtain thrust by decomposition of 90% hydrogen peroxide (H2O2). The system is divided into two individual systems; one for automatic control (ASCS), and one for manual control (control stick and RSCS). The automatic system consists of a pressurization system, an "electrically" controlled solenoid fuel distribution system, and twelve thrust chambers. The manual system is similar to the automatic system except that it consists of only six thrust chambers. The manual system also utilizes proportional "manually" controlled fuel distribution valves in addition to the electrically operated solenoid control valves. Figure 4-13 shows the location of all system components within the capsule.

4-44. System Operation

The following paragraphs, 4-45 through 4-52, briefly describe the operation of the automatic and manual systems. Figure 4-18 and 4-19 should be followed closely in conjunction with the following test.

4-45. Automatic System

The automatic system consists of twelve hydrogen peroxide monopropellant thrust chambers of fixed thrust levels and their associated valves, lines, H_2O_2 tank, pressure regulator and pressurization bottle. (See Figure 4-14.) The automatic system can be essentially divided into three sections; pressurization and fuel supply, distribution, and propulsion units. The fuel supply is non-stable hydrogen peroxide (H_2O_2) contained inside a flexible bladder which in turn is contained in a half toroidal tank. The flexible bladder has a fuel capacity

This information will be supplied when available.

FIGURE 4-13. REACTION CONTROL SYSTEMS

of approximately 32 pounds of liquid H_2O_2. Helium, under pressure, surrounds the bladder containing the H_2O_2 and acts as the pressurization agent. The spherical helium tank, pre-serviced to 3000 psi, has a capacity of 265 cubic inches.

4-46. The following sequence of events occurs in producing a thrust output. Assume the bladder is serviced with H_2O_2 and the helium sphere pressurized to 3000 psi. Upon opening the helium regulator manual shutoff valve, helium is allowed to pass through the filter, regulator, check valve, and finally surrounds the bladder pressurizing it to 450 psi. The helium pressure forces the H_2O_2 out of the bladder through the perforated transfer tube and into the down-stream lines. By opening the manual push-pull shutoff valves the H_2O_2 becomes available at the "electrically" operated solenoid shutoff valves. Upon receiving a 24 V d-c signal from the ASCS or fly-by-wire control system, the appropriate solenoid valve opens. H_2O_2 passes into the corresponding thrust chamber where it is decomposed and produces the desirable thrust.

4-47. System components not directly associated with thepreceding explanation of a thrust output are explained as follows. The helium pressure transducer provides a means of monitoring (by proper calibration) the percentage of H_2O_2 present in the bladder. The squib actuated valve is actuated at the completion of a mission and allows the remaining helium pressure to inflate the capsule aerodynamic kite. The perforated tube in the propellant tank (external of the bladder) is used to prevent the possibility of trapping helium pressure while servicing the H_2O_2 bladder.

4-48. Manual System

The manual system (see Figures 4-15 and 4-16) consists of six thrust chambers of the same configuration as those in the automatic system with proportional

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FIGURE 4-14. AUTOMATIC RCS INSTALLATION

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FIGURE 4-15. MANUAL RCS INSTALLATION

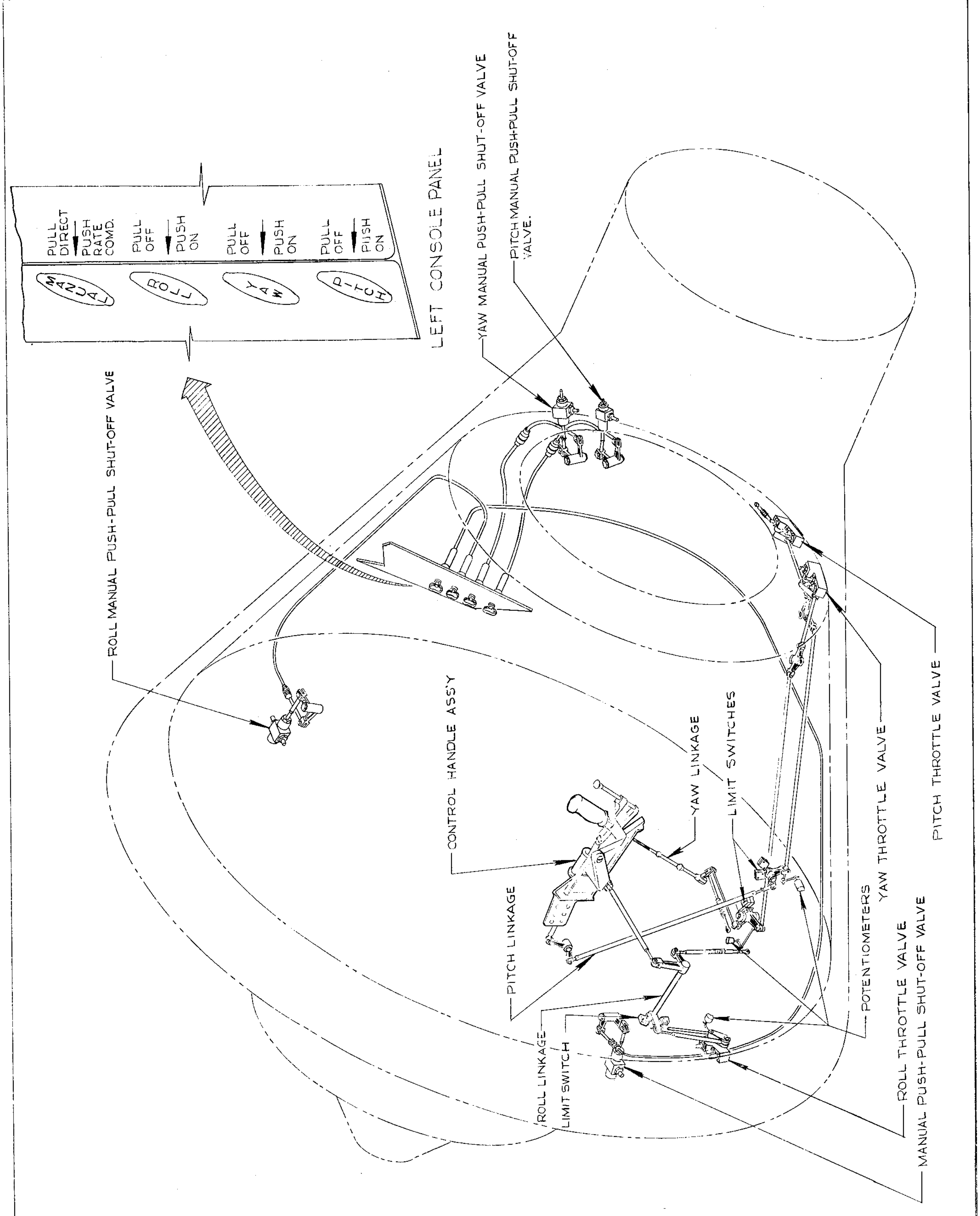

FIGURE 4-16 RCS CONTROL LINKAGE

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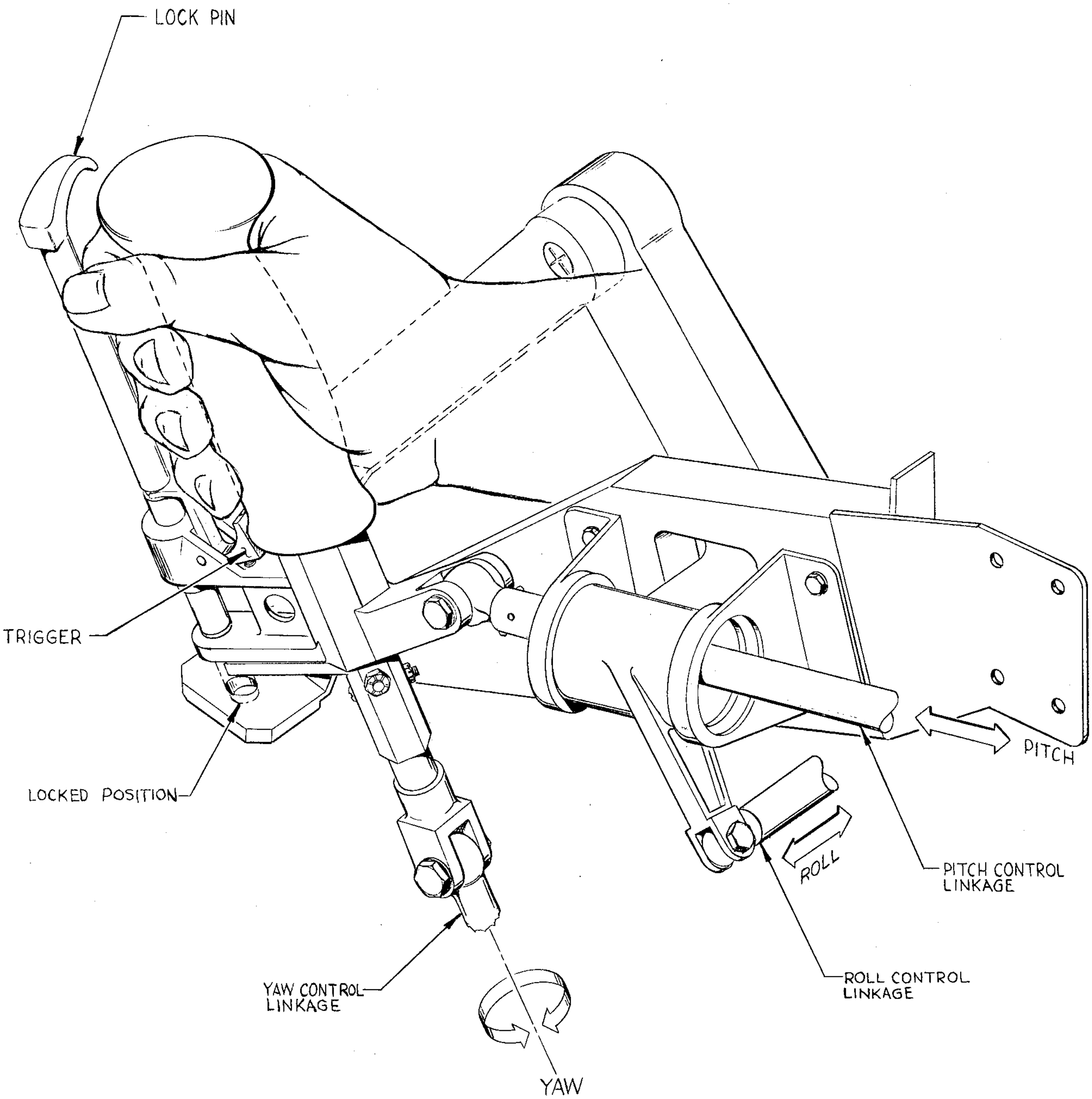

FIGURE 4-17 THREE AXIS HAND CONTROLLER

thrust output added. The fuel flow in the manual system may be controlled in either of two ways: (1) by manually controling the proportional control valves, or (2) by electrical solenoid control valves. A two position selector valve is provided such that the method of control may be selected. See Figure 4-19. The manual control valves have a dead band of $\pm$ 1/16 of an inch from theoretical neutral and a total stroke of 3/8 of an inch from theoretical neutral for each thrust chamber. The remainder of the manual control system is similar to the automatic system except for fuel tank capacity, which is 23.4 lbs. of H_2O_2 for the manual system.

4-49. System Units

Due to the simple nature of the system components, a discussion of each is considered unnecessary. However, two items (thrust chambers and propellant fuel) do warrant brief explanations.

4-50. Propellant Fuel (H_2O_2)

Hydrogen peroxide is a clear, colorless liquid soluble in all proportions in water and most substances which are miscible with water. Hydrogen peroxide when catalytically decomposed releases water vapor, oxygen gas, and heat. H_2O_2 decomposition when properly contained and controlled is capable of producing usable thrust. One pound of H_2O_2 solution (90%) when properly decomposed will produce approximately 60 cubic feet of gas. Hydrogen peroxide (90%) freezes at 11.3°F, and boils at 286°F.

4-51. Thrust Chamber

The thrust chamber assemblies (see Figure 4-20) consist of a stainless steel chamber that contains a metering orifice, a distribution disc followed by a catalyst bed and then a nozzle. The catalyst bed contains a stack of removable nickel screen wafers. The screen gauge resembles common household screen. The

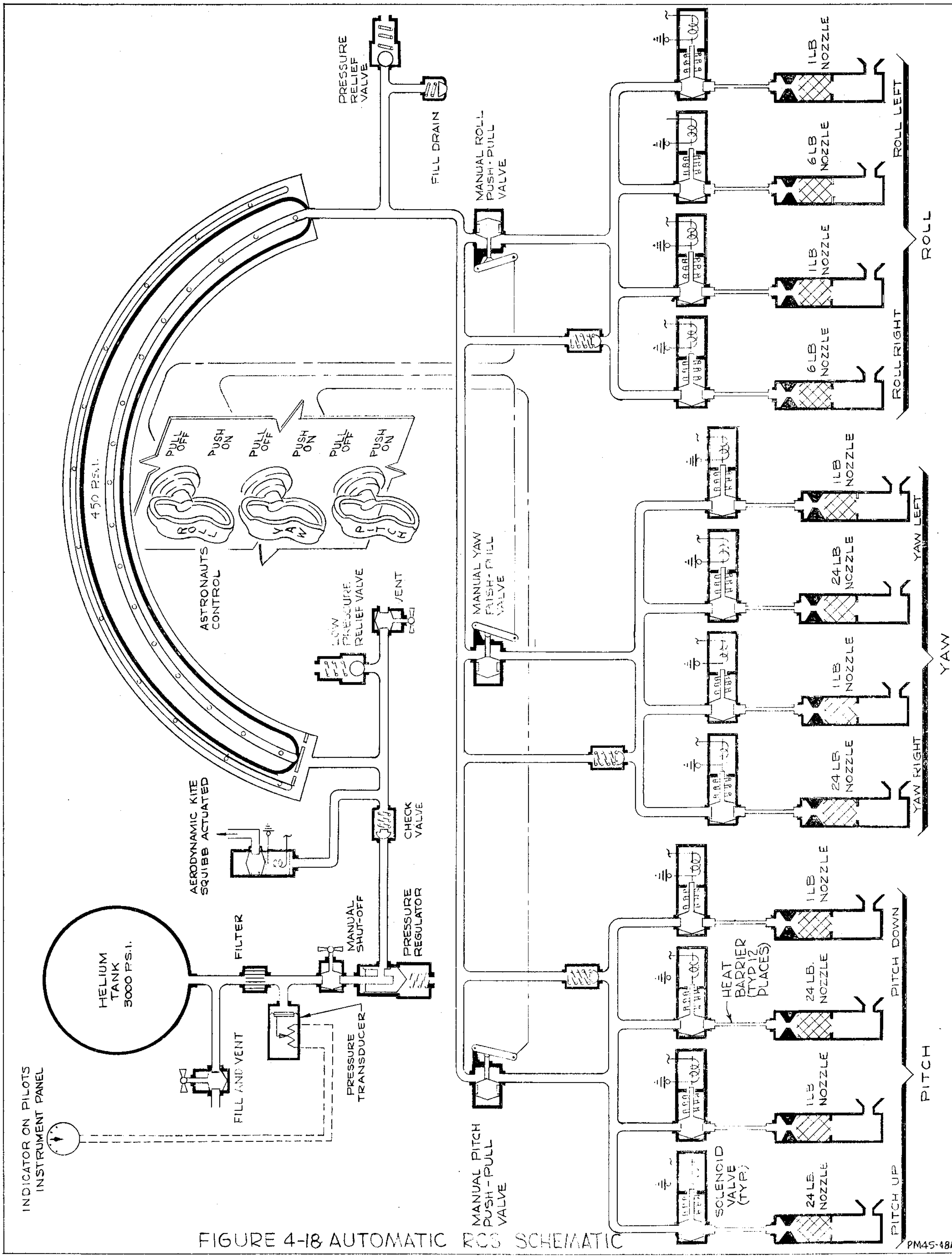

FIGURE 4-18 AUTOMATIC RCS SCHEMATIC

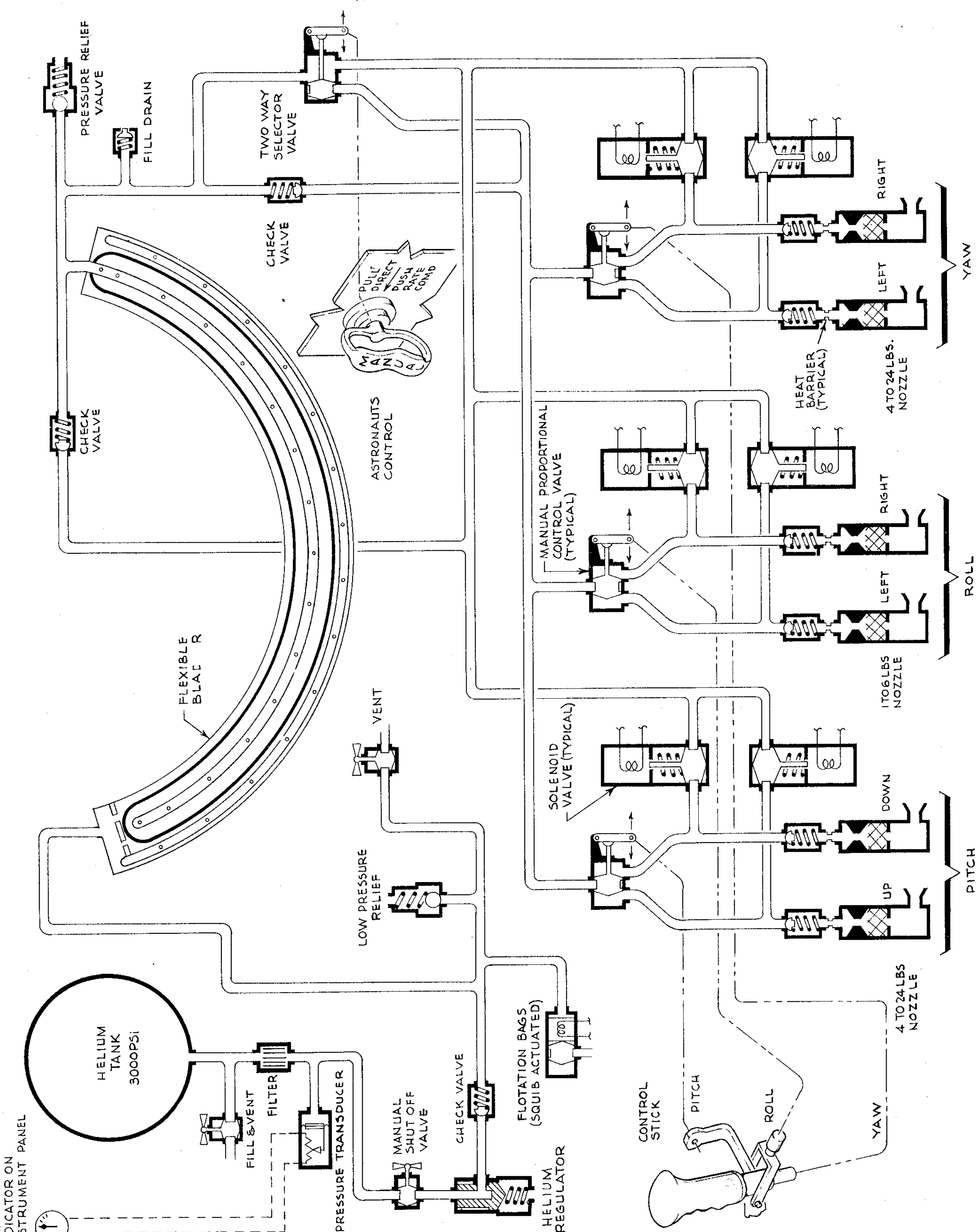

FIGURE 4-19 MANUAL RCS SCHEMATIC DIAGRAM

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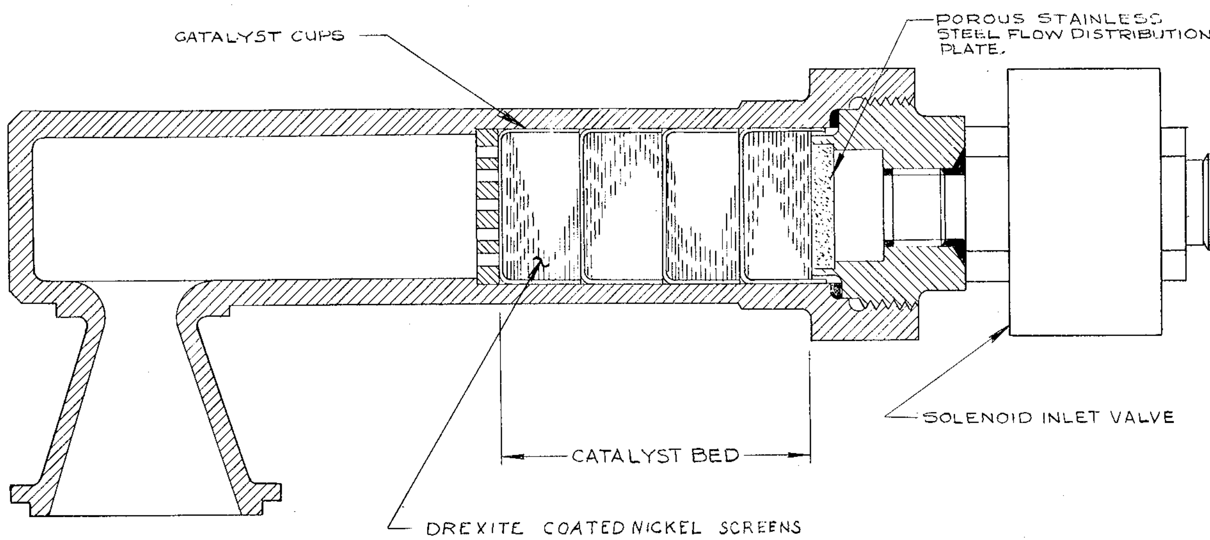
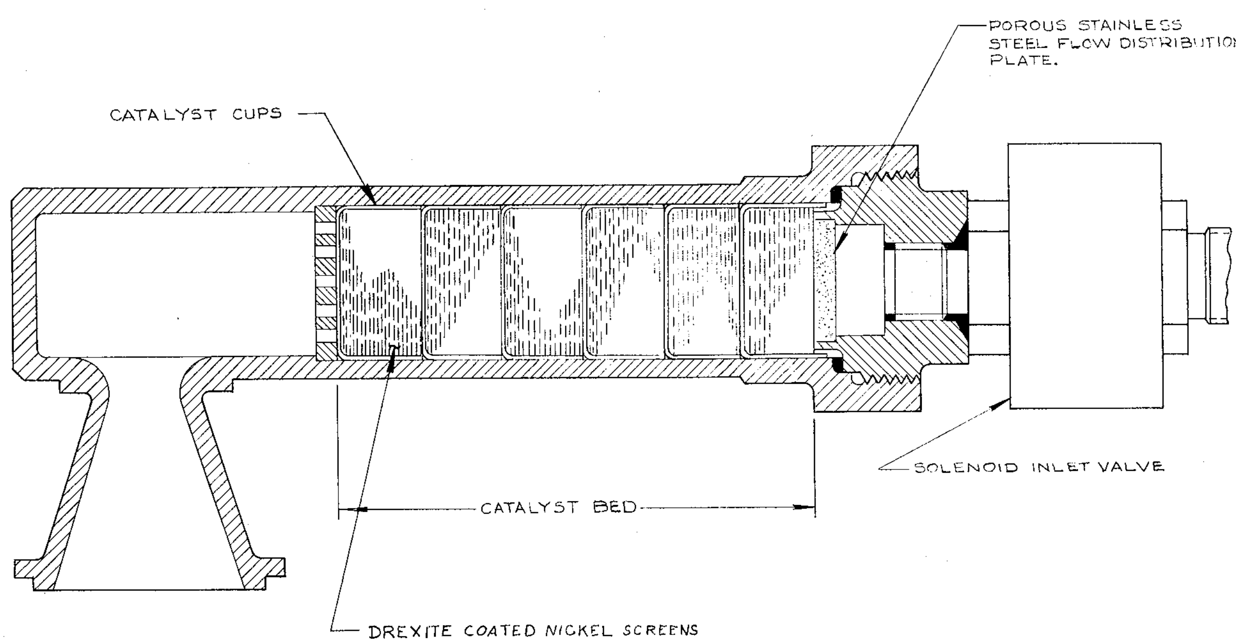


1 LB AND 6 LB. THRUST



24 LB. THRUST

FIGURE 4-20 REACTION CONTROL THRUST CHAMBERS

PM45-51A

screen is covered with an electrolytically deposited coating of 90% silver and 1% gold (called drexite) that enhances the catalytic properties of the nickel. The open area between the catalyst bed and the right angle nozzle forms a short plenum chamber to smooth out the flow prior to reaching the nozzle throat.

4-52. H_2O_2 enters the thrust chamber through a metering orifice upon actuation of the solenoid valve. The stainless steel porous plate distributes the flow and presents the catalyst bed with a uniform input. Upon entering the first stage of the catalyst bed, a violent reaction takes place. Expanding gases rush through the remainder of the catalyst bed resulting in a thrust output in the right angle nozzle. The majority of the decomposition (and most violent) takes place within the first two catalyst cups. Temperatures of approximately 1400° F. can be expected in this area. The remainder of the catalyst cups are to assure a complete decomposition process and to prevent any liquid form of H_2O_2 from reaching the nozzle.

HORIZON SCANNER SYSTEM

4-53. System Description

The Horizon Scanner System incorporates two identical scanning units(see Figure 4-1). The purpose of the Horizon Scanner system is to provide a roll and pitch reference during the orbital phase of the normal mission. The scanners produce an output signal that slaves the ASCS attitude gyros to the proper angles upon command from an external programmer.

4-54. System Operation

Operation of the Horizon Scanners depends upon infrared radiation received from the earth as compared to the essentially zero radiation from space. These differences in radiation levels provide a sharp radiation discontinuity at the horizon. The Scanner system uses this discontinuity for both day and night vertical reference sensing. When the capsule is oriented so that the earth is present in its scanning path, there will in general be two points where the scan intersects the earth's horizon. The scanner detects the thermal discontinuity, or change in radiation level, between the earth and space at the two horizon points. The Scanner then bisects the included angle from itself to the Horizon points, compares the direction of the bisector with that of a fixed reference in the capsule and generates linear error signals proportional to the angle between the bisector and the fixed reference. As previously stated, these error signals (roll and pitch) are used to slave the ASCS attitude gyros.

4-55. Figure 4-21 shows a simple block diagram of the Horizon Scanner. The following discussion entails a brief explanation of the functioning of each block as related to the overall operation.

4-56. The scanning system consists of a prism rotating at 30 r.p.s. in front of the lens, producing a conical scan of 90°. The prism causes a 45° inclina-

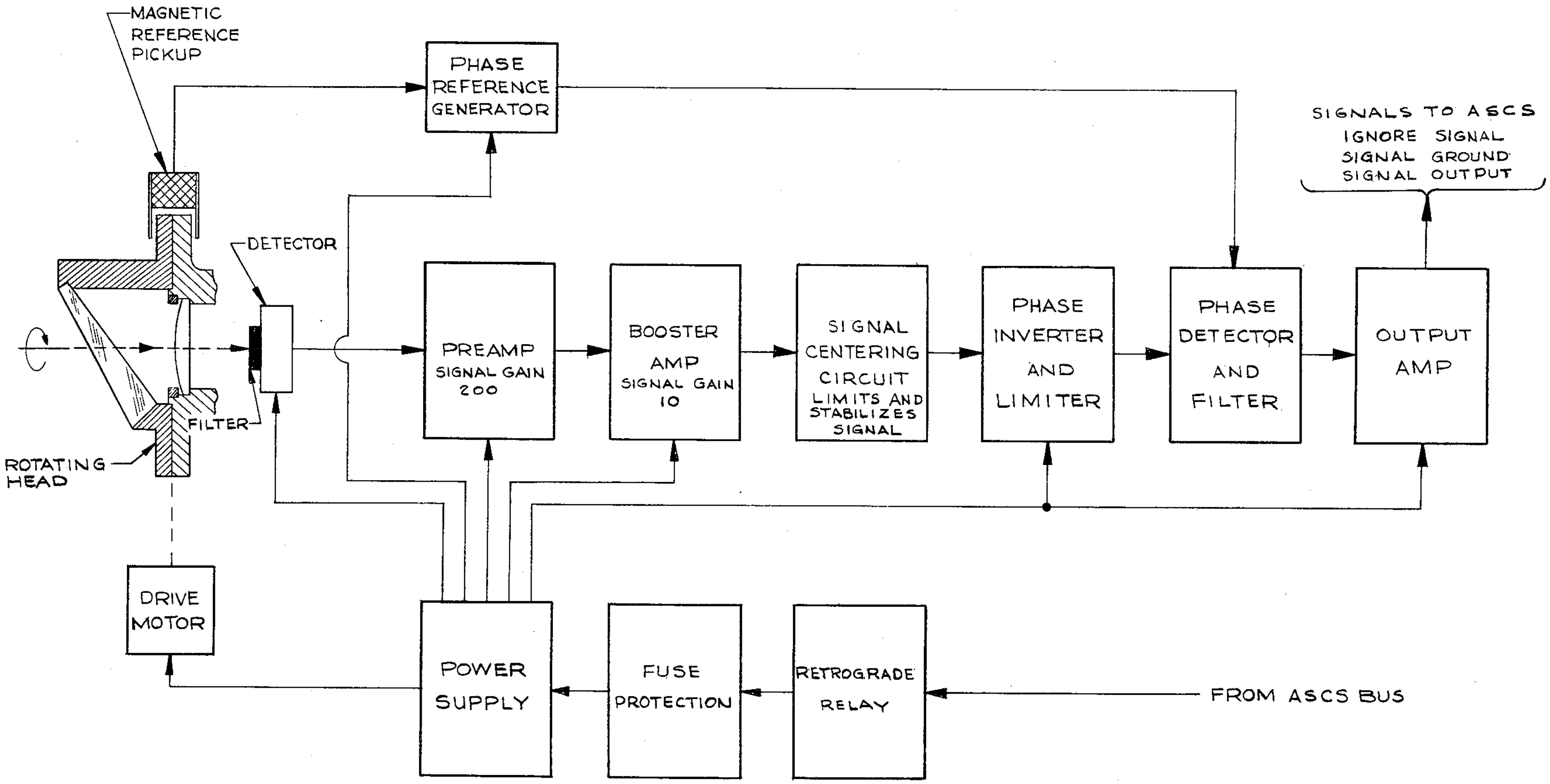


FIGURE 4-21 HORIZON SCANNER BLOCK DIAGRAM

PM45-53

tion of the optical beam from the rotational axis. When the prism is rotated, the 90° conical scan is produced. The scan will occasionally pass over the Sun, at which time the scanner ignore circuitry will produce an output to energize a relay in the ASCS, thereby disconnecting power from the ASCS gyro slaving circuits. An ignore output is also initiated when the scanner loses the Horizon. In each instance, slaving to a false Horizon is prevented.

4-57. When the conical scan circle intersects the horizon, the thermal discontinuity between the earth and space will cause essentially a rectangular wave shape to be generated at 30 c.p.s. The phase of this signal with respect to an internal reference is used to detect the tilt of the horizon with respect to the capsule axis. Circuitry is used to process the error signal into an error output signal.

4-58. The amplifier section comprises a feedback preamplifier and a booster amplifier. Direct coupling is used to maintain the original rectangular wave shape and phase. The frequency response is established by RC networks in the preamplifier feedback loop which reduces the gain to unity at zero frequency and provides high frequency boost to compensate for the detector time constant. This maintains the rectangular wave shape.

4-59. The signal centering circuit is used to limit the amplifier output signal in order to make the error signal dependent only upon horizon tilt and independent of variations in power supply voltage, amplifier gain, detector sensitivity and earth radiance. The limiter samples a thin horizontal slice from the wave. The duty cycle of the rectangular wave signal (ratio of the duration of the positive and negative portions) will change with the altitude because of the depression of the horizon. An RC network distributes the signal about ground such that equal areas will be positive and negative. It is then obvious that the wave shape moves up and down. For this reason a signal centering circuit is used to produce a signal for the limiter such that amplitude rather than areas are balanced about ground.

4-60. The phase inverter and limiter consists of two transistor stages which act as a phase inverter to produce a push-pull signal. This signal is limited by a diode bridge and a Zener diode. The limiting voltage is determined only by the Zener potential, and is independent of the supply voltage. The resulting limited rectangular wave is then fed to the phase detector.

4-61. The phase reference generator circuit consists of a magnetic pickup, a controlled multivibrator and a power amplifier. The magnetic pickup is a coil wound on a small magnet mounted just behind the rotating assembly. A semi-cicular iron vane on this assembly generated pulses in the pickup. These pulses synchronize the multivibrator which generates a square wave. This wave is amplified and used to drive the two highspeed synchronous switches which comprise the phase detector. The push-pull signal coming from the phase inverter and limiter is connected to one set of switch contacts and the output to the other set. The moving contacts are connected to capacitors, and are phased so that when one capacitor is sampling the signal, the other is connected to the output and vice versa. There is no ripple in the output since the output is only connected to the capacitor when it is disconnected from the signal. There is never any direct connection between the signal square wave and the output. The output is the steady voltage across the capacitor corresponding to the integrated change accumulated during the previous signal sampling cycle. An example of this is: With a centered horizon with no tilt error, the switching will occur at the midpoints of the square waves. The net charge from each capacitor will be zero during the signal sampling half cycle. When the capacitor is switched to the output no voltage will be across it, and hence no error signal. As the horizon tilts, shifting the phase with respect to switch points equal negative or positive charges are accumulated on each capacitor during the signal sampling half cycle. Therefore, a steady positive or negative d-c error signal will result with no ripple.

4-62. The emitter follower is directly coupled and provides a low impedance output without loading the phase detector circuit.

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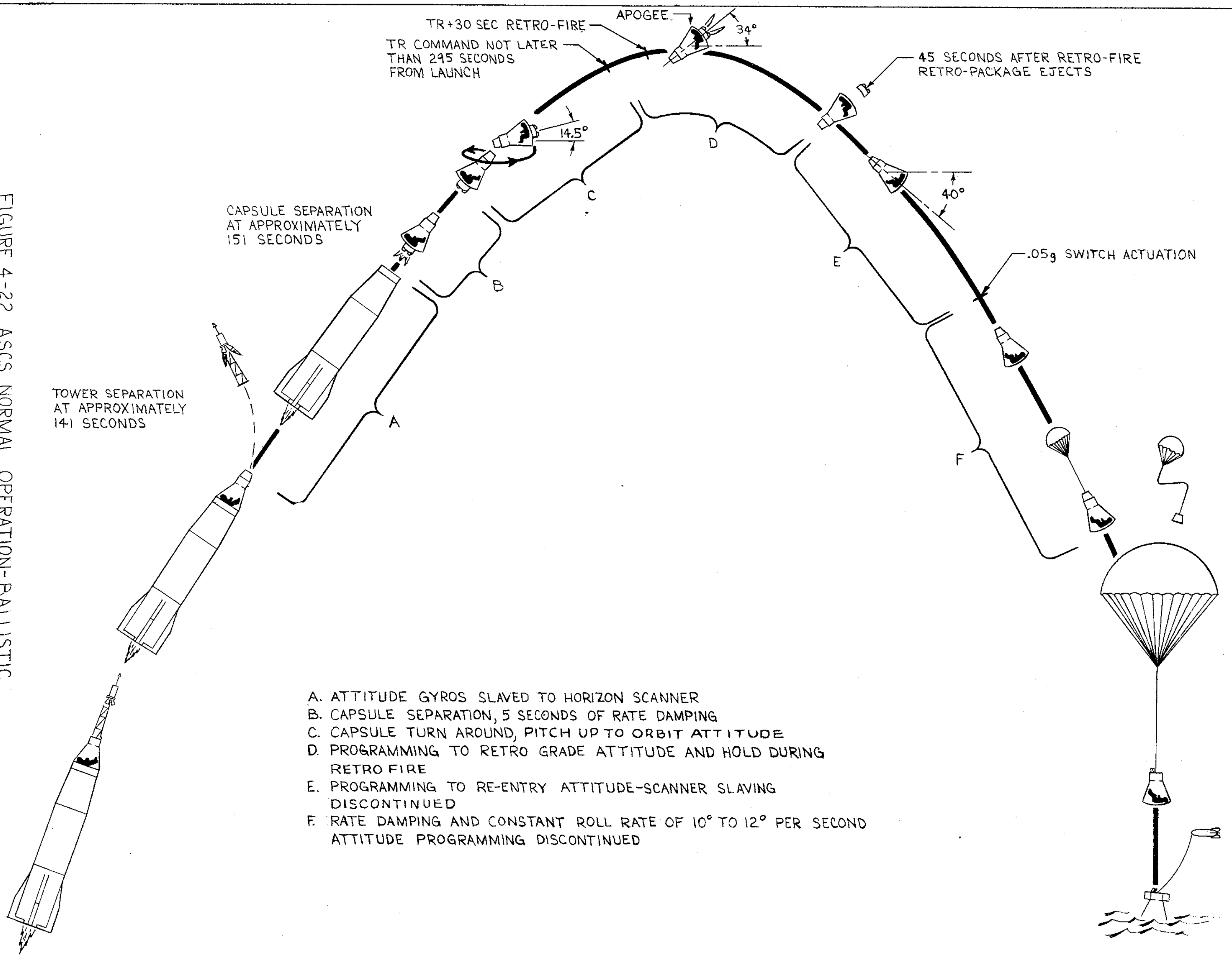

FIGURE 4-22 ASCS NORMAL OPERATION-BALLISTIC

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4-63. TEST CONFIGURATION - NO. 2 AND 3 CAPSULES

4-64. General

The Automatic Stabilization Control Systems for capsules No. 2 and 3 are identical to those discussed in Paragraphs 4-1 through 4-62 (specification compliance capsule) with the exceptions noted in the following paragraphs, 4-65 through 4-75.

4-65. Automatic Stabilization Control System

In general, the discussion contained in Paragraphs 4-2 through 4-34 applies. However, due to the different missions involved, ie., orbital vs ballistic, Figures 4-2 and 4-3 are to be disregarded for capsule No. 2 and 3. The following paragraph discusses ASCS normal operation for a ballistic type mission.

4-66. Normal Sequencing

Figure 4-22 shows the progress of a normal ballistic mission divided into six phases appropriate to the following discussion.

4-67. The ASCS is in the "ready" status prior to separation of the escape tower, its gyros are running and all circuits except the final 12 output relays are fully energized. Phase (A), involving gyro slaving to the Horizon Scanner pitch and roll outputs during ascent, is to minimize gyro errors which may accumulate while the capsule is being boosted.

4-68. Phase (B) starts after capsule separation when a brief, five second signal commands the ASCS to provide rate damping to stop any tendency to tumble.

4-69. Phase (C) is initiated at the completion of the five second rate damping period when an external command causes capsule turn-around in the yaw plane. Attitude programming such that the capsule is pitched to 14.5 degrees (small end down) is also accomplished at this time. Constant scanner slaving continues throughout phase (C).

4-70. Phase (D) is initiated with an external command that causes the capsule

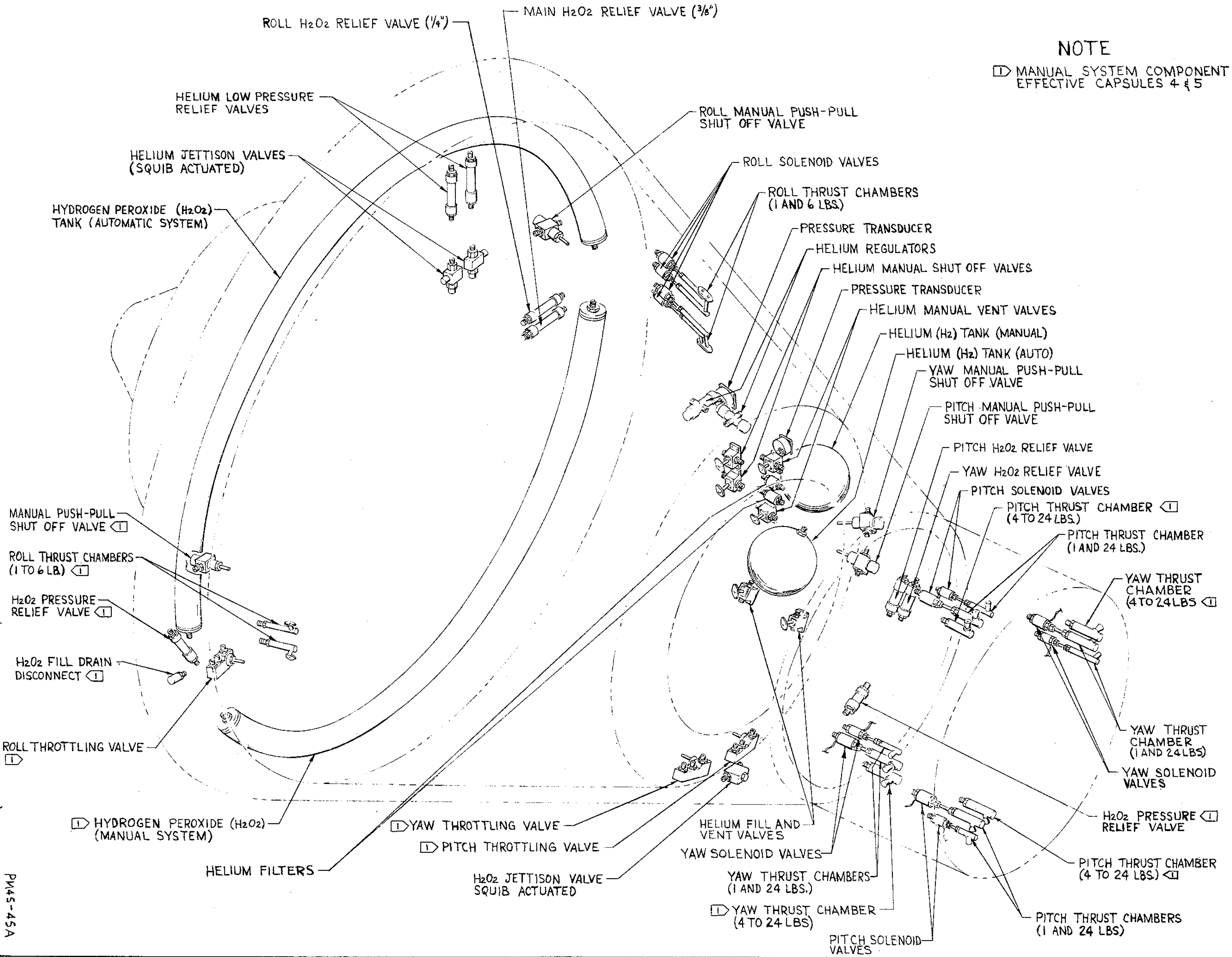

FIGURE 4-23 REACTION CONTROL SYSTEMS (CAPSULE 2 THRU 8)

PM45-45A

to pitch up to retrograde attitude. Thirty seconds after retrograde command (provided the proper attitude has been attained) the retro-rockets fire. During this period the ASCS holds the capsule within approximately three degrees of the ideal angles. The ASCS utilizes high torque action (only) during this period. Scanner slaving continues throughout phase (D).

4-71. Approximately 45 seconds after retro-fire, the retro-package ejects and initiates phase (E). Scanner slaving is discontinued and the capsule is positioned to the re-entry attitude.

4-72. When re-entry is sensed by the .05g accelerometer switch, phase (F) starts with the turning off of the attitude gyro power. During this period the ASCS initiates and maintains a constant roll rate of 10° to 12° per second to minimize touchdown dispersion. Rate damping is provided to stabilize the re-entry trajectory. ASCS operation in this phase continues throughout drogue chute deployment but ceases with main chute deployment, at which time all ASCS power is removed.

4-73. Rate Stabilization Control System

Capsules No. 2 and 3 are not equipped with a Rate Stabilization Control System; therefore, Paragraphs 4-35 through 4-42 do not apply.

4-74. Reaction Control System

Capsules No. 2 and 3 are not equipped with a manual RCS system. All text contained in Paragraphs 4-43 through 4-52 pertaining to the automatic system applies with the exception of component location. For automatic system component location and tubing configuration, see Figures 4-23 and 4-24.

4-75. Horizon Scanner

Same as Specification Compliance.

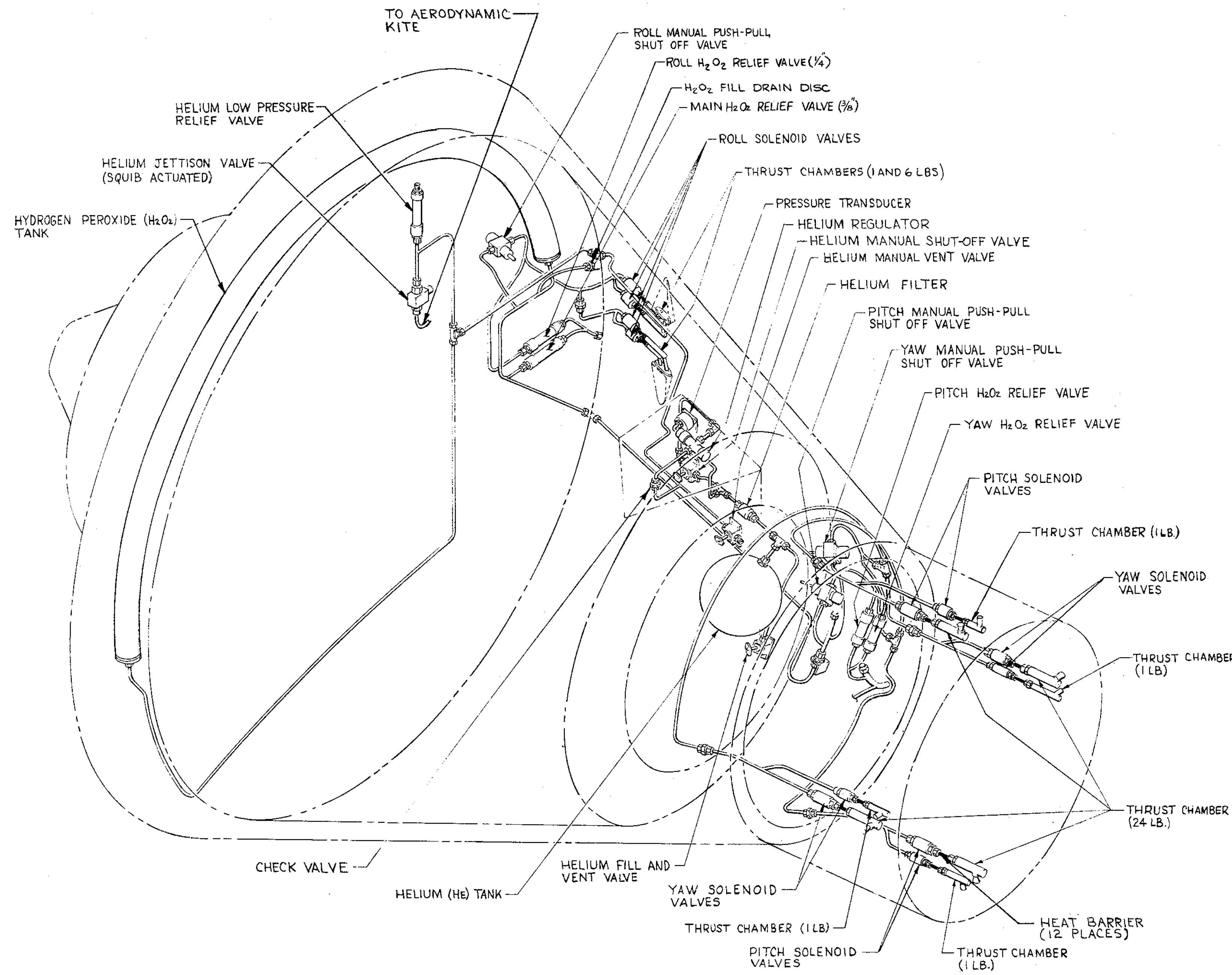

FIGURE 4-24 AUTOMATIC RCS INSTALLATION (CAPSULE 2 THRU 8)

4-76. TEST CONFIGURATION NO. 4 AND 5 CAPSULES

4-77. General

The Automatic Stabilization Control Systems for capsules 4 and 5 are identical to those discussed in Paragraphs 4-1 through 4-62 (Specification Compliance capsule) with the exception noted in the following paragraphs, 4-78 through 4-80.

4-78. Automatic Stabilization Control System

Same as capsules No. 2 and 3. Refer to Paragraph 4-65.

4-79. Rate Stabilization Control System

Capsules No. 4 and 5 are not equipped with a Rate Stabilization Control System, therefore Paragraphs 4-35 through 4-42 do not apply.

4-80. Reaction Control System

Capsules No. 4 and 5 are equipped with both automatic and manual systems. All text contained in Paragraphs 4-43 through 4-52 pertaining to the automatic system applies with the exception of component location. Figures 4-23 through 4-25 may be referred to for component location and tubing configuration applicable to capsules No. 4 and 5. Due to the absence of the Rate Stabilization Control System in capsules No. 4 and 5, the Manual Reaction Control System differs schematically with the specification capsule. See Figure 4-26. Operationally speaking, the manual system is controllable from the control stick only.

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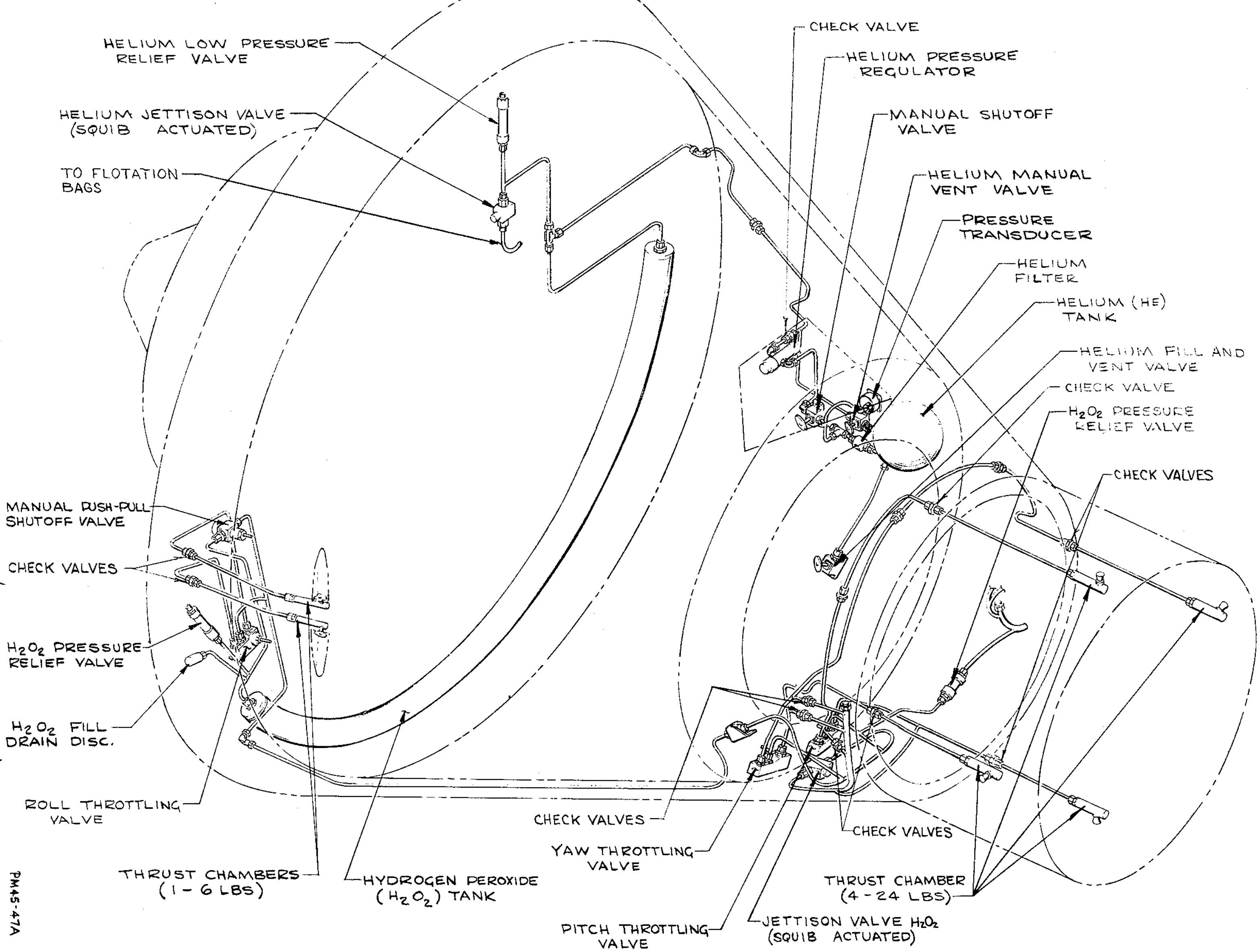

FIGURE 4-25 MANUAL RCS INSTALLATION (CAPSULES 4 & 5)

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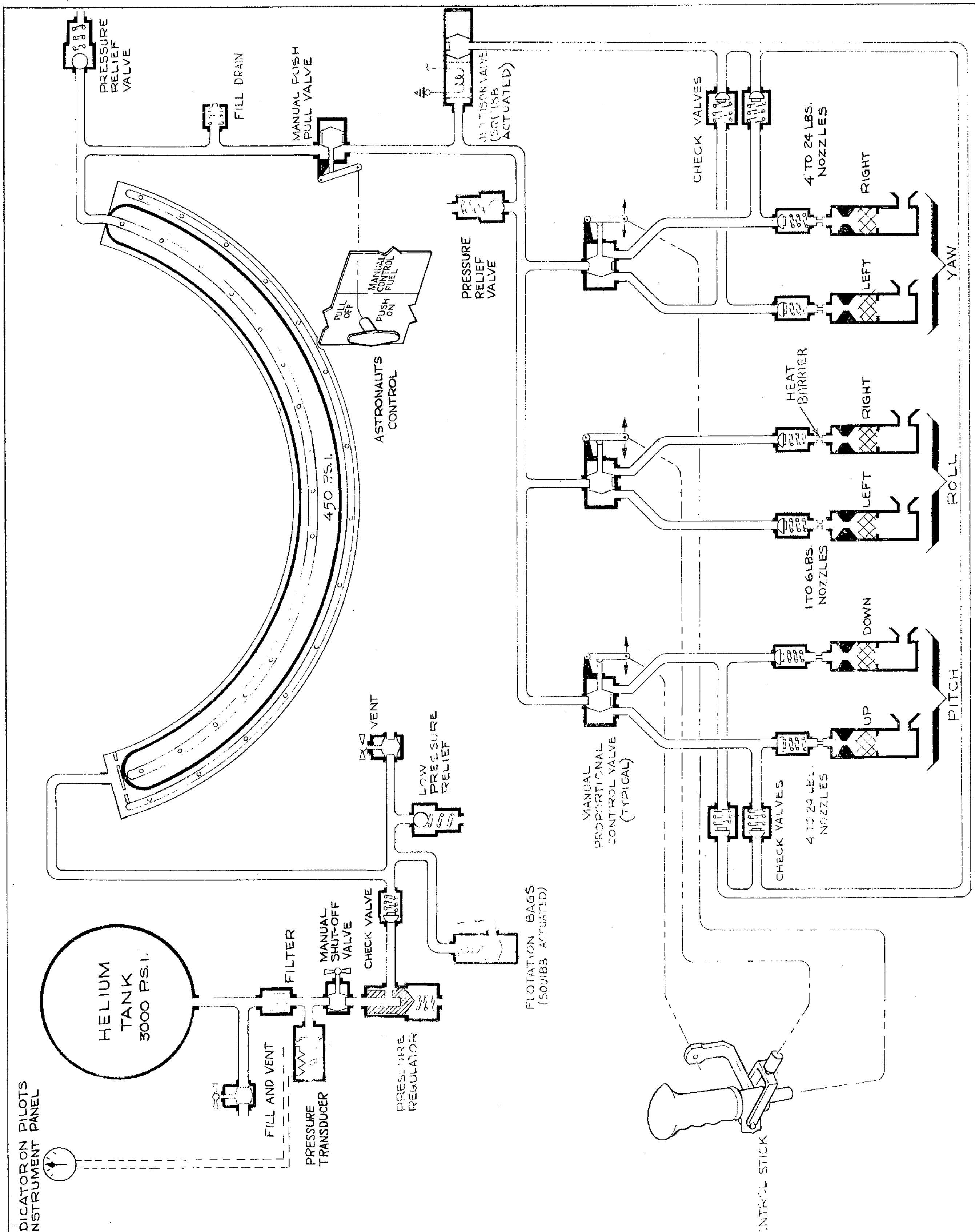
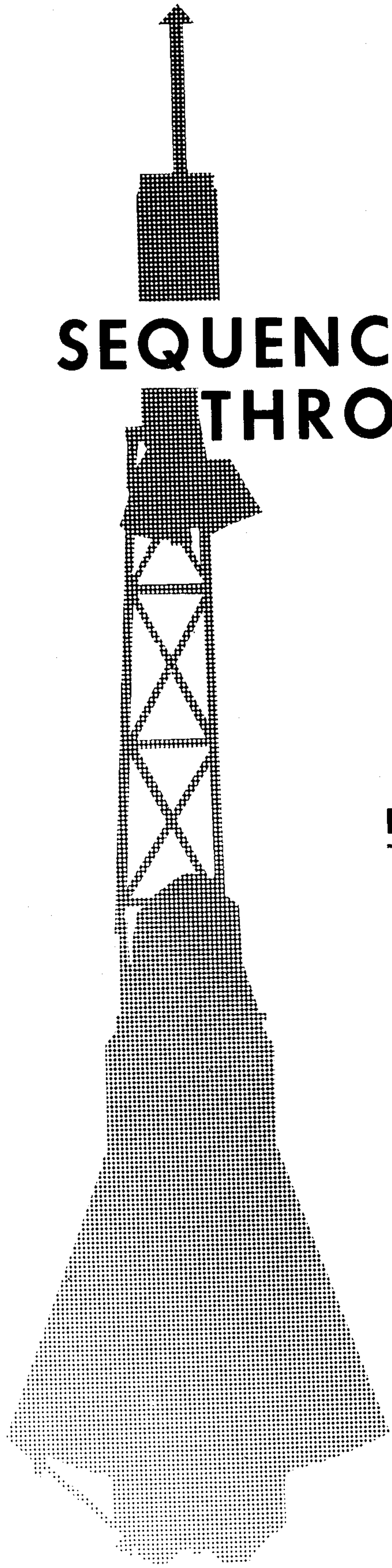


FIGURE 4-26 MANUAL RCS SCHEMATIC DIAGRAM (CAPSULE 4 & 5)



SECTION V

SEQUENCE SYSTEM, LAUNCH THROUGH RETROGRADE OR ABORT

TABLE OF CONTENTS

DESCRIPTION	PAGE

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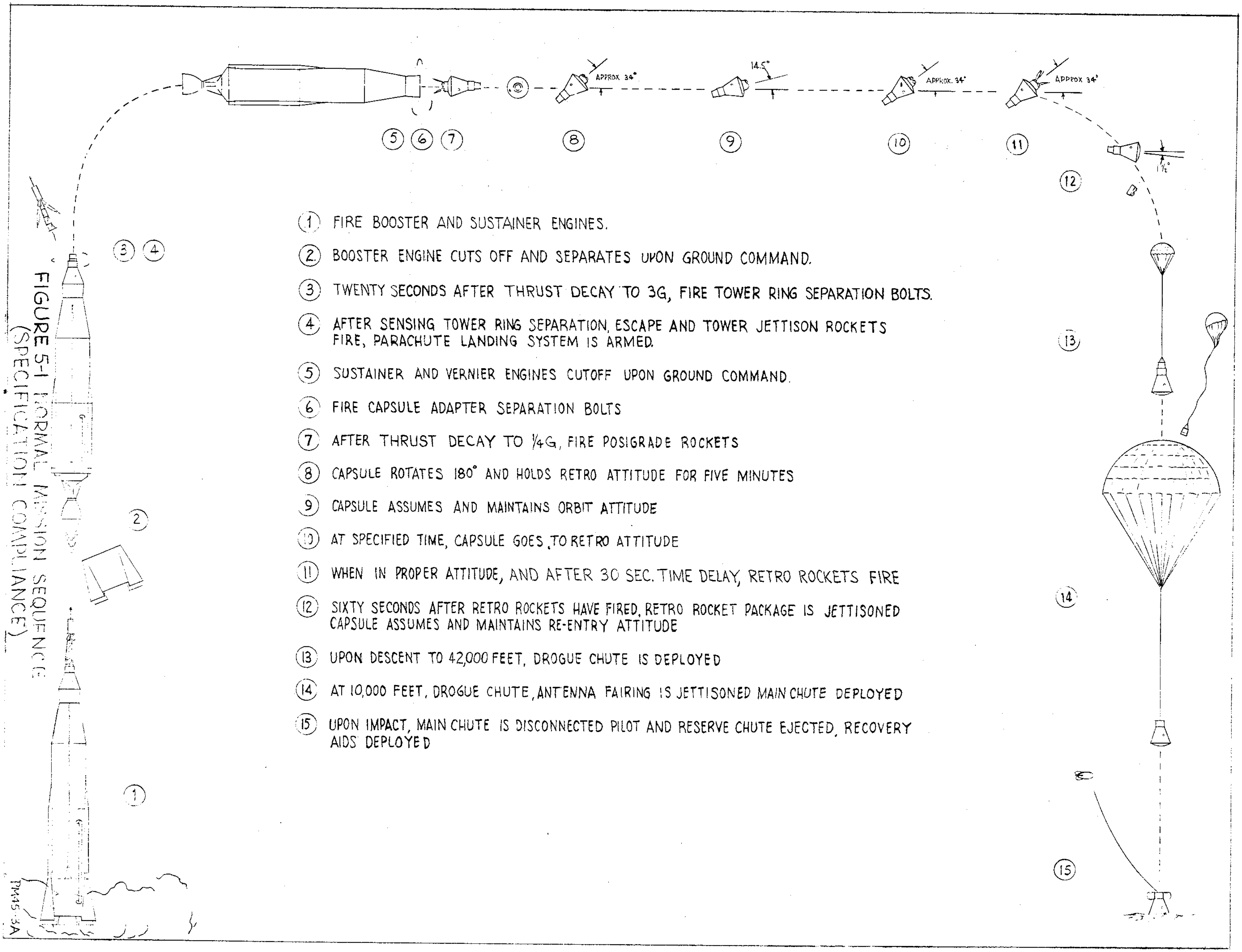

FIGURE 5-1 NORMAL MISSION SEQUENCE (SPECIFICATION COMPLIANCE)

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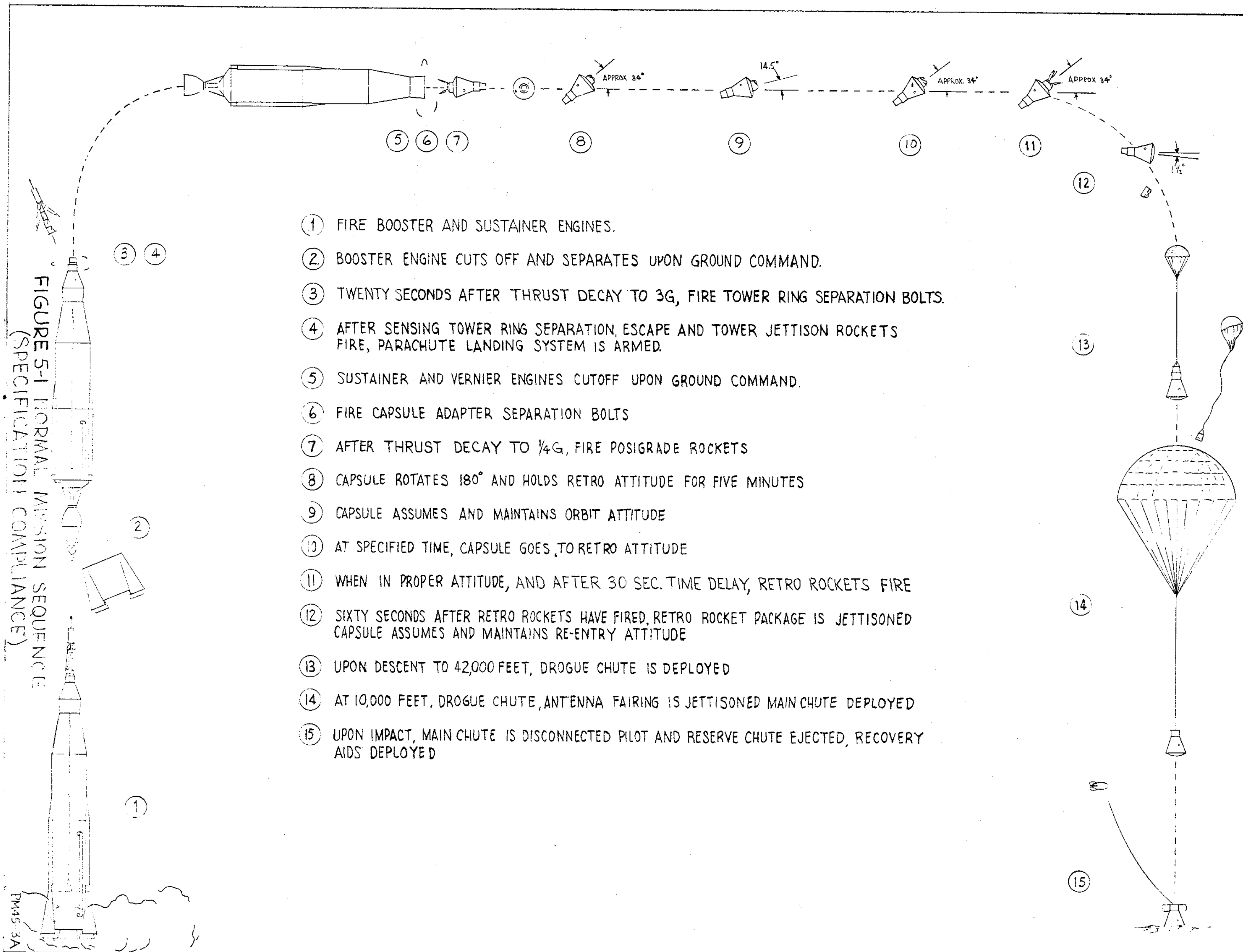


(1) FIRE BOOSTER AND SUSTAINER ENGINES.

(2) BOOSTER ENGINE CUTS OFF AND SEPARATES UPON GROUND COMMAND.

(3) TWENTY SECONDS AFTER THRUST DECAY TO 3G, FIRE TOWER RING SEPARATION BOLTS.

(4) AFTER SENSING TOWER RING SEPARATION, ESCAPE AND TOWER JETTISON ROCKETS FIRE, PARACHUTE LANDING SYSTEM IS ARMED.

(5) SUSTAINER AND VERNIER ENGINES CUTOFF UPON GROUND COMMAND.

(6) FIRE CAPSULE ADAPTER SEPARATION BOLTS

(7) AFTER THRUST DECAY TO 1/4G, FIRE POSIGRADE ROCKETS

(8) CAPSULE ROTATES 180° AND HOLDS RETRO ATTITUDE FOR FIVE MINUTES

(9) CAPSULE ASSUMES AND MAINTAINS ORBIT ATTITUDE

(10) AT SPECIFIED TIME, CAPSULE GOES TO RETRO ATTITUDE

(11) WHEN IN PROPER ATTITUDE, AND AFTER 30 SEC. TIME DELAY, RETRO ROCKETS FIRE

(12) SIXTY SECONDS AFTER RETRO ROCKETS HAVE FIRED, RETRO ROCKET PACKAGE IS JETTISONED CAPSULE ASSUMES AND MAINTAINS RE-ENTRY ATTITUDE

(13) UPON DESCENT TO 42,000 FEET, DROGUE CHUTE IS DEPLOYED

(14) AT 10,000 FEET, DROGUE CHUTE, ANTENNA FAIRING IS JETTISONED MAIN CHUTE DEPLOYED

(15) UPON IMPACT, MAIN CHUTE IS DISCONNECTED PILOT AND RESERVE CHUTE EJECTED, RECOVERY AIDS DEPLOYED

FIGURE 5-1 NORMAL MISSION SEQUENCE
(SPECIFICATION COMPLIANCE)

CONFIDENTIAL

V. SEQUENCE SYSTEM, LAUNCH THROUGH RETROGRADE OR ABORT

5-1. NORMAL MISSION SEQUENCE (See Figure 5-1)

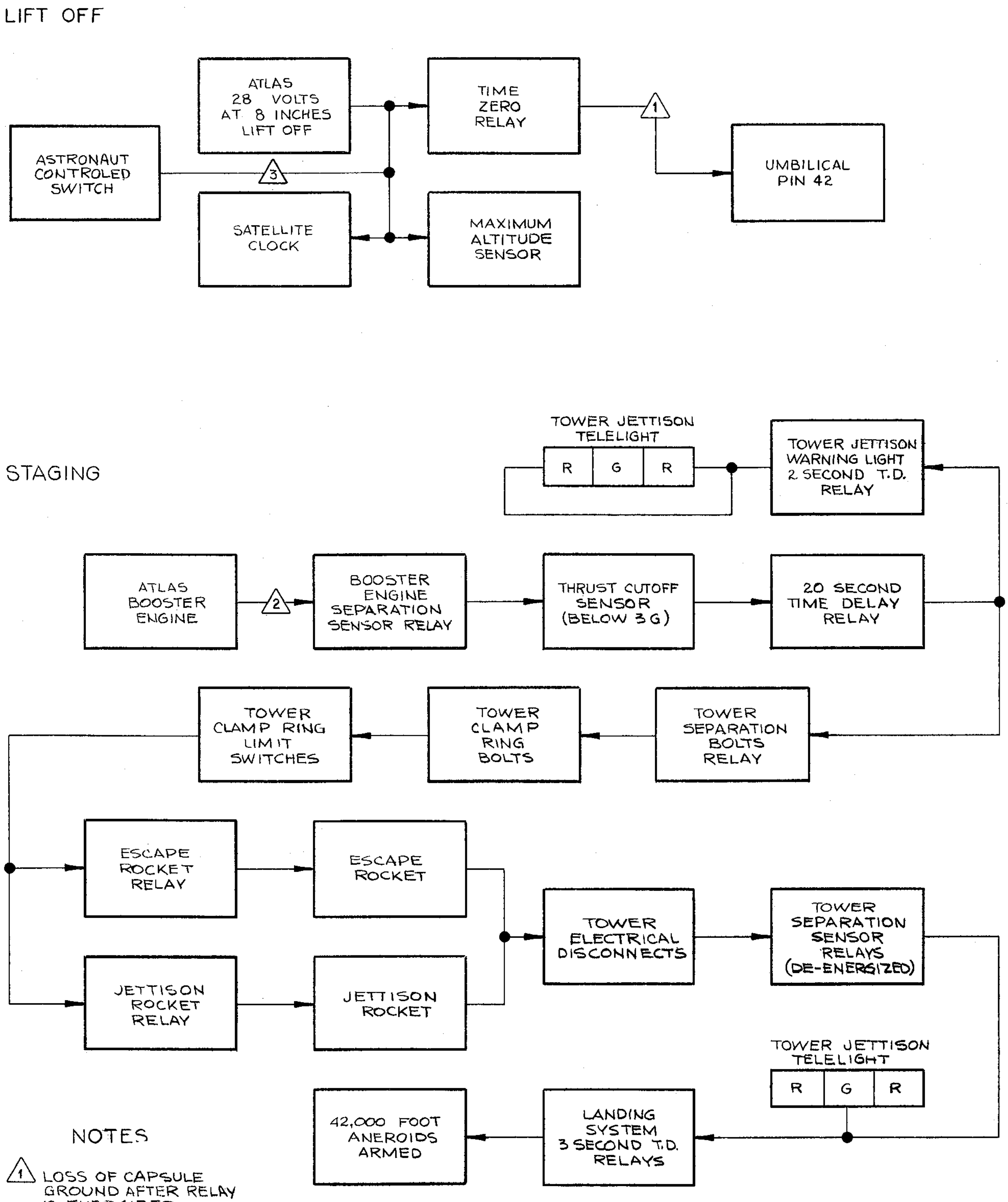
5-2. Launch Through Staging

5-3. Description

The launch through staging sequence establishes basic references at time of launch and then remains inactive until staging. At staging the missiles booster engine separates, resulting in the escape tower bolts being fired after a combination of thrust decay and twenty seconds time delay. The escape and jettison rockets are fired immediately after tower bolt detonation and subsequently the landing system becomes armed.

5-4. Operation (See Figure 5-2)

The sequence system is initiated by two 28 V d-c signals from the missile which occur at 8 inches after liftoff. This is known as time zero reference and energizes a Time Zero latching relay in the No. 3 Launch and Orbit relay box located within the capsule. Effective on capsules 5, 9 and up, an Astronaut controlled back-up switch will be provided in the event the 28 V signals from the missile do not reach the capsule. These same signals are also sent to the Maximum Altitude Sensor and the Satellite Clock. The signal to the Maximum Altitude Sensor results in establishing the function of time liftoff versus the time an abort may occur. At approximately 130 seconds (33 miles altitude) missile staging will occur whereby the mechanical separation of the booster engine will cause the loss of capsule power to the Booster Engine Separation Sensor relay located in the No. 2 Launch and Orbit relay box. Through this de-energized relay, power will be applied to pin H of the Thrust Cutoff Sensor. When missile thrust decays from approximately 6g down to 3 g, the power applied



NOTES

1. LOSS OF CAPSULE GROUND AFTER RELAY IS ENERGIZED.
2. LOSS OF 28V D-C POWER.
3. USED ONLY IF ATLAS FAILS TO PRODUCE LIFTOFF SIGNAL.

FIGURE 5-2 LAUNCH THROUGH STAGING (BLOCK DIAGRAM)

PM45-59A

to pin H will return through pin J and energize the 20 second Thrust Cutoff Time Delay relay located in No. 2 Launch and Orbit relay box. After the 20 second time delay, power will be directed through the energized contacts to the Tower Separation Bolts Power relay energizing this relay which is also located in the No. 2 Launch and Orbit relay box. Also, power will be directed to the Tower Jettison Warning Light 2 Second Time Delay relay located in the No. 4 Launch and Orbit relay box. The Tower Separation Bolts Power relay is armed at the n.o. contacts by both main battery and isolated battery power through the SQUIB ARM switch. Therefore, when energized, both power sources are directed to the three tower separation bolts. The isolated battery power fires two of the five squibs (2 bolts) and main battery power fires three of the five squibs (3 bolts). The dual end of the third bolt is designed to be operated by a gas charge which is initiated by manual Astronaut over-ride through selection of the pull-ring adjacent to the JETT TOWER telelight. As the three segmented clamp rings separate, three limit switches spring to the normal position and allow isolated and main battery power through their contacts. The isolated battery power energizes both the Emergency Escape Rocket Fire relay and the Emergency Jettison Rocket Fire relay, while the main battery power energizes both the Escape Rocket Fire relay and the Jettison Rocket Fire relay. As the contacts of the Emergency Jettison and Jettison Rocket Fire relays are connected in parallel, either relay will fire both squibs of the jettison rocket from the two different power sources. The Emergency Escape and Escape Rocket Fire relays are connected in the identical same manner and will fire both squibs of the escape rocket from both power sources. As a result both jettison and escape rockets fire simultaneously and separate the tower from the capsule. When this is accomplished, two electrical disconnects between the tower and capsule are separated and remove power from the three Tower Separation Sensor relays located in No. 3 Launch and Orbit relay box. Through the de-energized No. 1 Tower Separation relay the green JETT TOWER light on the telelight panel illuminates. Through the de-energized No. 2 and No. 3 Tower Separation Sensor relays two circuits are completed to the two Three Second Time Delay relays located in the landing system Sequence Controllers, A and B respectively. After the three second delays, power is completed through the two energized relays to the below 10,000 foot contacts of the two 10,000 foot aneroid switches. The power circuit will hold at these two points until the capsule descends down through the 10,000 foot range at which time the landing sequence is initiated. Refer to Section IX of this manual.

5-5. Second Staging

5-6. Description

Second staging is initiated by sustainer engine cutoff at which time the capsule adapter bolts are fired providing acceleration has decayed to $\frac{1}{4}$G. The three posigrade rockets and the four explosive electrical disconnects are fired immediately after the bolts are detonated and result in capsule separation. Capsule separation is sensed and initiates five seconds of rate damping which is followed by five minutes of retro-fire position and then orbit attitude position.

5-7. Operation (See Figure 5-3)

At approximately 321 seconds after launch or the equivalent of approximately 105 miles altitude, second staging will occur at which time a 28 volt d-c signal will be directed from the missile to the Sustainer Engine Cutoff Latching relay, located in No. 2 Launch and Orbit relay box, energizing and latching this relay. Main battery power having been directed through the de-energized Capsule Separation Sensor relay, the de-energized Orbit Attitude relay, the de-energized No. 3 Tower Separation Sensor relay, and the energized Sustainer Engine Cut-off Latching relay to pin E of the Thrust Cutoff Sensor. As missile thrust decays from approximately 9g to $\frac{1}{4}$g, the Thrust Cutoff Sensor returns the signal out of pin F to the Capsule Separation Bolts Power relay and also to the Capsule Separation Warning Light 2 Second Time Delay relay. Unlike the escape and jettison rockets fire circuit, the Emergency Capsule Separation Bolts Power relay is not energized unless the manual over-ride method is employed. Therefore, through the energized Capsule Separation Bolts Power relay all five squibs of the three capsule bolts are fired. Main battery power fires three of the squibs and isolated battery power fires the other two. The tri-segmented capsule-to-adapter clamp ring now separates allowing three Capsule Adapter Separation Ring Limit switches to spring to their normal positions. Two poles of each of the three limit switches are powered by the main battery and deliver power through their normally open position to the coils of the Posigrade Rocket Fire relay and the Emergency Posigrade Rocket Fire relay energizing both relays. These relays are located in the No. 1 Launch and Orbit relay box. Also, power is directed to the coil of the Capsule Adapter Disconnect Squib Fire relay resulting in the firing of the two capsule adapter explosive disconnects. The other two poles of the Capsule Adapter Separation Ring Limit switches are used under an abort condition. As in the case of the escape and jettison rocket fire circuit the contacts of the Emergency Posigrade and Posigrade Rocket Fire relays are connected in parallel; therefore, either relay will fire all six squibs of the three posigrade rockets and accomplish the firing by either main battery or isolated battery power.

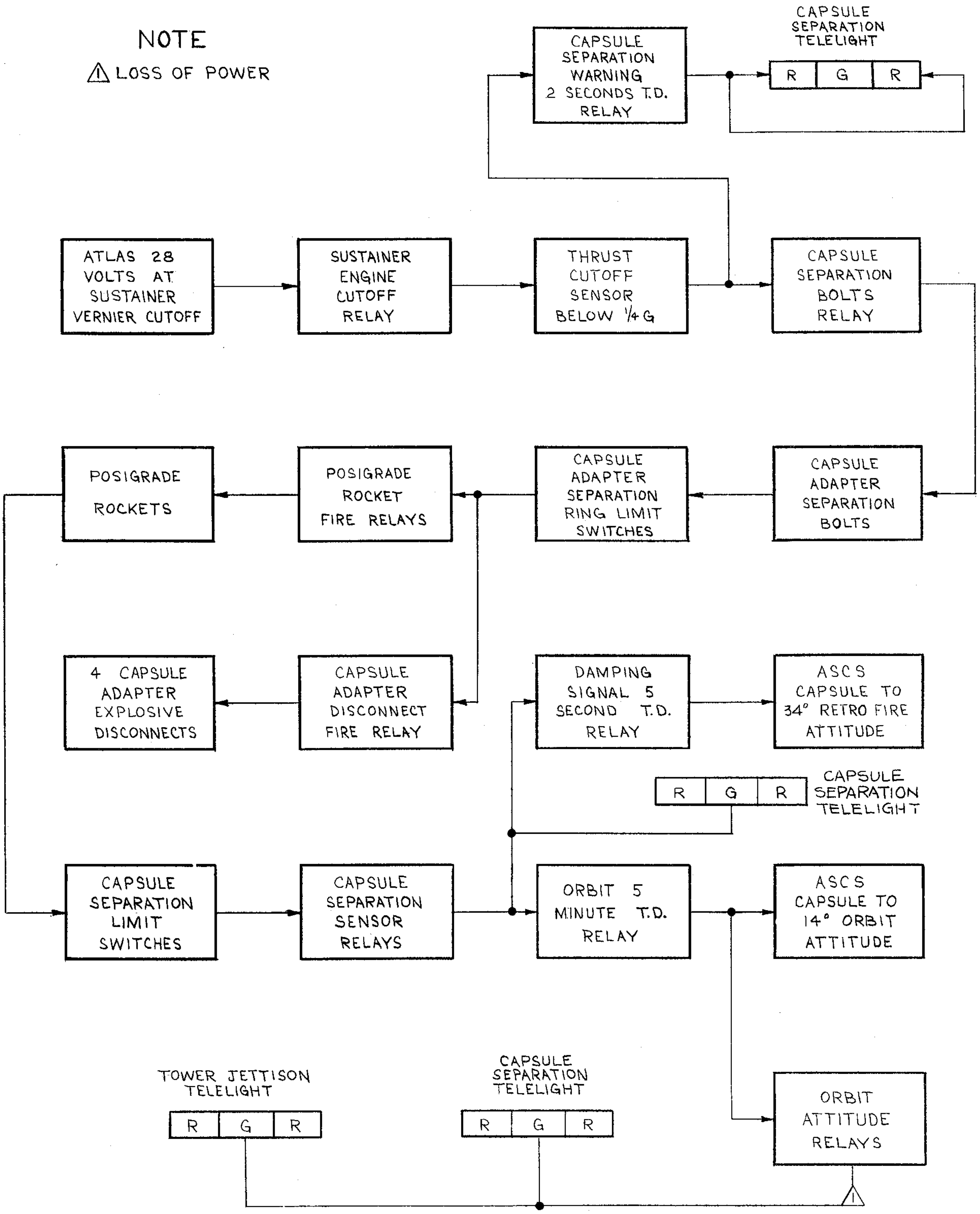


FIGURE 5-3 SECOND STAGING (BLOCK DIAGRAM)

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The posigrade rockets create sufficient thrust to separate the capsule and adapter. This allows the three limit switches which are attached to the retrograde straps to spring to their normal position. Main battery power is then completed through any one of the three switches, which are connected in parallel, to the two Capsule Separation Sensor relays, energizing the relays. Through the energized No. 1 Capsule Separation Sensor relay, power is directed through the de-energized No. 1 Tower Separation Sensor relay to the Damping Signal 5 Second Time Delay relay and the Orbit 5 Minute Time Delay relay, both located in the No. 4 Launch and Orbit relay box. For five seconds there is rate damping applied to the capsule to stop any roll, pitch or yaw movements which may be present. At the end of the five seconds, the capsule is rotated to the 34° (blunt end up) retro fire attitude and held there by the RCS for a period of five minutes. At the end of the five minutes the capsule assumes the orbit attitude of 14° (blunt end up). Also, at the end of the five minutes the three Orbit Attitude Latching relays located in the No. 3 Launch and Orbit relay box are energized and the JETT TOWER and SEP CAPSULE telelights extinguish.

5-8. Re-Entry to .05G

5-9. Description

In order for the capsule to impact at a designated area, the re-entry sequence must be initiated approximately 3000 nautical miles up range of the touchdown point. This sequence may be started by any of five various methods: The intended method is for ground control to pre-set the satellite clock through capsule command receivers after the first orbit time has been carefully computed. The Astronaut may pre-set the satellite clock when he deems it necessary under conditions of an out of orbit abort or desired early re-entry. The direct method, using ground command transmitters and capsule command receivers, will bypass the satellite clock and initiate the re-entry sequence immediately. The fourth method is by Astronaut manual control of the RETRO SEQ button, and the fifth method is the final back-up system whereby the satellite clock is pre-set before launch for a calculated re-entry time and starts timing at missile lift off. The method of initiating re-entry sequence as described in the operation (Para. 5-10) concerns the switch closure within the satellite clock and thereby covers three of the five possible methods. A brief resume of the sequence starts with a command to retro fire attitude and a thirty second time delay. After the attitude is reached and the time delay has run-out the three retro rockets will be fired five seconds apart. After retro rockets one and two have fired, a sixty second time delay is initiated which,when depleted, will allow retrograde package jettison, providing the Astronaut's Auto Retro Jett. switch is in the ARM position. The retro package separation is sensed and results in firing the three retro package electrical umbilicals.

5-10. Operation (See Figure 5-4)

The satellite clock retro fire switch is armed by power from the main battery through the de-energized Retro Rocket Assembly Separation relay and the energized (capsule separated) No. 2 Capsule Separation Sensor relay. These relays are located in the No. 3 Launch and Orbit relay box. When the satellite clock retro fire switch closes by either of the three previously mentioned methods, power is directed into the No. 2 Retrograde relay box where it energizes three Retrograde Command relays, one of which is a latching relay. Through the energized contacts of the non-latching K85-32 Retrograde Command relay, power is applied to the RETRO SEQ telelight, illuminating the light green. Through the energized contacts of the non-latching K85-22 Retrograde Command relay, power is applied to the Retro Rocket Sequencial Fire 30 Second Time Delay relay located in the No. 1 Retro relay box, and to the Retro Attitude Command relay located in the No. 2 Retro relay box. The energized Retro Attitude Command relay completes a circuit to the ASCS system commanding the capsule to the 34° retro fire position. As soon as the capsule reaches the retro fire position, a retro interlock switch located in the ASCS calibrator is closed which completes a circuit from the main battery to the No. 1 and No. 2 Attitude Permission relays located in the No. 2 Retro relay box. Through the energized contacts of the No. 2 Attitude Permission relay, a circuit is completed to the RETRO ATT telelight, illuminating the light green. Through the energized contacts of the No. 1 Attitude Permission relay, a circuit is completed to the C pole of the Retro Rocket Sequential Fire 30 Second Time Delay relay. At the end of the 30 second time delay, power is directed to energize the three Retro Rocket Fire Relays in the No. 1 Retro relay box and the Retro Rocket Fire Signal Latching relay located in the No. 2 Retro relay box, and to fire the retrograde rockets at five second intervals. Through the Retro Rocket Fire Signal Latching relay, a circuit will be completed to energize the Retro Fire Signal Disengage 30 Second Time Delay relay located in the No. 1 Retro relay box. The power to the coil of this relay is also directed through its de-energized contacts to the coil of the Retro Fire Sequence relay which completes a circuit to the ASCS resulting in hi-torque RCS operation. This high-torque operation will last for 30 seconds, which is 10 seconds more than the duration of total retro fire. The high-torque mode holds the capsule in the 34° attitude while the retros are firing. At the end of 30 seconds the Retro Fire Signal Disengage 30 Second Time Delay relay will energize removing power from the Retro Fire Sequence relay and thus removing the high-torque signal. Two other circuits are also completed simultaneously by the Retro Rocket Fire

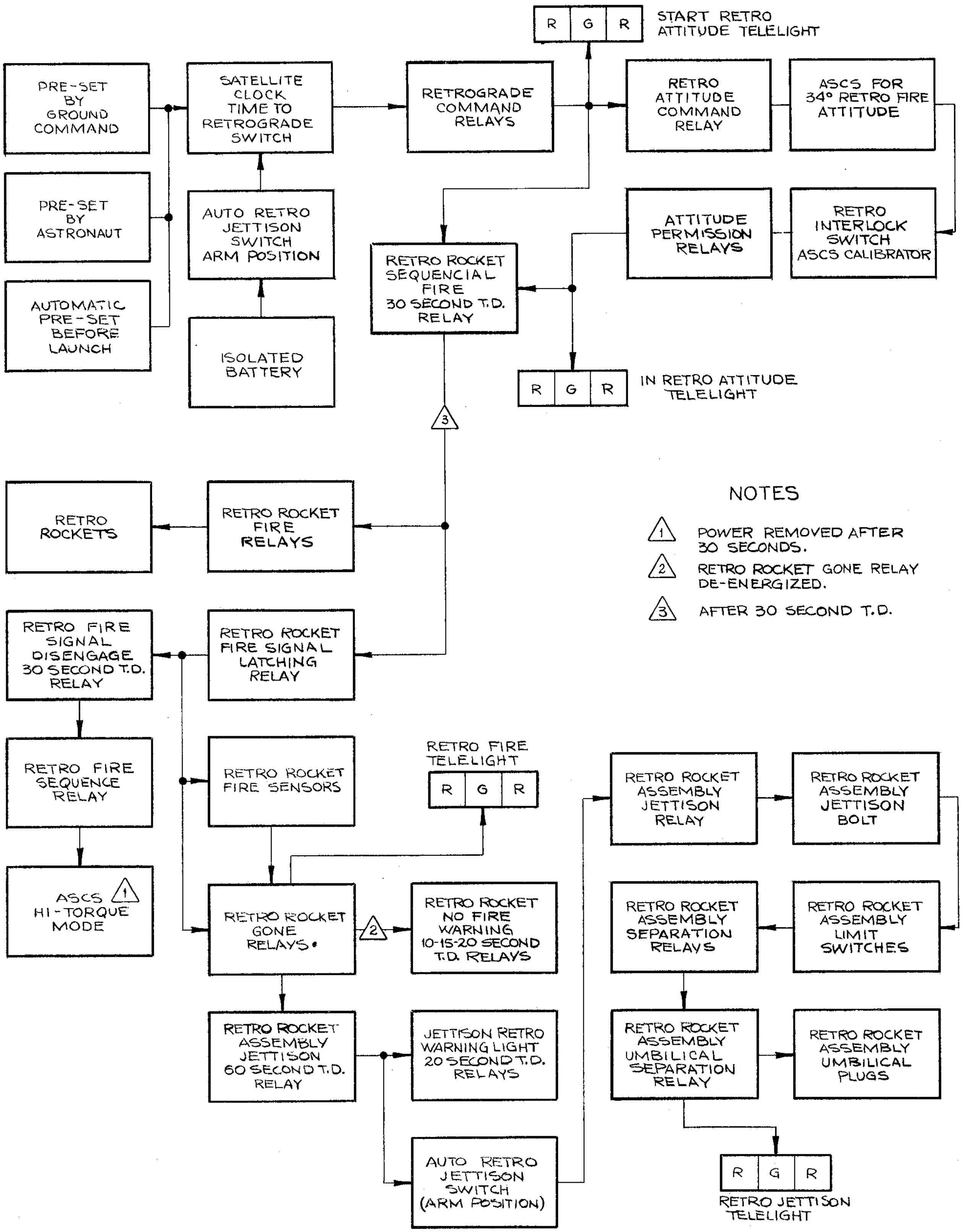


FIGURE 5-4 RE-ENTRY THROUGH .05 G (BLOCK DIAGRAM)

PM45-137

Signal Latching relay. One supplies power to the three retro rocket firing sensors for a return circuit after firing is detected. The other circuit is completed through the de-energized Retro Rocket Gone relays to the No. 1 Retro Rocket No Fire Warning 10 Second Time Delay Relay, the No. 2 Retro Rocket No Fire Warning 15 Second Time Delay Relay and the No. 3 Retro Rocket No Fire Warning 20 Second Time Delay Relay. Therefore, if the No. 1 retro rocket does not fire within 10 seconds causing its fire sensor to send power to the coil of the No. 1 Retro Rocket Gone relay, then the No. 1 Retro Rocket No Fire Warning 10 Second Time Delay relay will energize after 10 seconds and complete a circuit to the FIRE RETRO telelight, illuminating the light red. The same function applies for the No. 2 and No. 3 retro rockets. After the No. 1 and No. 2 retro rockets have fired and their fire sensors have returned a signal to the respective retro rocket gone relays, a circuit will be completed to the coil of the Retro Rocket Assembly Jettison 60 Second Time Delay relay. During the 60 seconds delay , the No. 3 retro rocket will fire and therefore complete a series circuit through the three Retro Rocket Gone relays to the FIRE RETRO telelight, illuminating the light green. At the end of the 60 second delay, the same main battery power circuit that energized the time delay relay will be directed through the energized contacts of the relay, to the coil of the Jettison Retro Warning Light 20 Second Time Delay relay, and also through the Astronaut's AUTO RETRO JETT. switch (in the ARM position) to energize the Retro Rocket Assembly Jettison relay. Through this energized relay,main battery power and isolated battery power is directed to the two squibs of the retro rocket assembly jettison bolt. The bolt will fracture and the package will drop free of the capsule, being assisted by a coil spring installed between the heat shield and retro package assembly for this purpose.

The dropping of the retro package assembly from the capsule will allow three single pole limit switches to spring to their free position allowing a power source from the .05G switch in its closed position (prior to .05G) to pass through the closed contacts of the limit switches to the No. 1 and No. 2 Retro Rocket Assembly Separation relays, energizing the two relays. Through the energized No. 2 Retro Rocket Assembly Separation relay, a circuit also from the .05G switch is completed to the Retro Rocket Assembly Umbilical Separation relay, energizing the relay. Through this energized relay main battery power is directed to the six squibs of the three retro rocket package umbilicals, jettisoning the electrical umbilical plugs milliseconds after the dropping of the retro package. Also, through a set of contacts of this same relay the JETT RETRO telelight is illuminated green. As the capsule re-enters the earth's atmosphere the .05G switch will open, thereby dropping power at the Retro Rocket Assembly Umbilical Separation relay, and thusly turning out the green JETT RETRO telelight.

5-11. ESCAPE SYSTEM

5-12. Description

The escape system primarily consists of a tower assembly designed to provide a safe means of abort between prelaunch and staging. By utilizing the posigrade rocket system, escapes may still be initiated after booster staging and throughout sustainer operation until orbit. The tower assembly consists of a 10 foot, tubular steel structure with a 4 foot escape rocket mounted to its tapered end. A segmented clamp ring with 3 explosive bolts secures the base of the tower to the recovery compartment upper flange. Attached to the escape rocket nozzle adapter plate is a jettison rocket which is used to jettison the tower assembly after the escape rocket has been fired for an abort; however, under normal launch conditions both the escape and jettison rockets are fired simultaneously to accomplish tower jettison at time of booster engine separation.

5-13. Escape Before Liftoff Before Umbilical Disconnect

Only one ground controlled signal will energize the three Mayday relays located in the No. 3 Launch and Orbit relay box. This signal is a direct hardline from the blockhouse abort switches through the missile to the capsule Mayday relays. In the event that the capsule must be aborted and the missile is unable to transmit the hardline abort signal, there is one other method which may be selected. Umbilical pins 44 and 45 are abort wired and transmit 28 V power from the blockhouse to the capsule's Ground Command Abort Signal Latching relay, energizing and locking in the relay. Through this energized relay capsule 28 V Squib Arm Bus power is transmitted to the pole of the Ground Test Umbilical relay; however, power will not continue through this relay until the relay is de-energized. The only way the relay may be de-energized is by ejecting the umbilical. Therefore, if this abort method is required to be used it would be necessary for the blockhouse conductor or range safety officer to first select the applicable Abort switch (power to pins 44 and 45) and then milliseconds thereafter eject the umbilical.

5-14. Escape Before Liftoff After Umbilical Disconnect

During countdown there will be approximately 50 to 90 seconds between time of capsule umbilical eject and time zero, which is eight inches liftoff. During this period,the three available methods of abort are: (1) The blockhouse to missile hardline abort signal as explained in the previous paragraph; (2) Ground command receiver abort signal; (3) Astronaut's Abort handle. These three methods all result in energizing the three Mayday relays located in the No. 3 Launch and Orbit relay box.

5-15. Escape After Liftoff

After 8 inches of liftoff, which is effectively missile umbilical eject, there are three methods by which an abort may be initiated. They are: (1) Ground command receiver abort signal and (2) Astronaut Abort handle, both of which were possible methods in the previous paragraph, (3) the Booster Catastrophic Failure Detection system. This third method has been non-effective in the two previous paragraphs due to the Time Zero relay being de-energized. However, the Time Zero relay is energized at 8 inches liftoff and therefore will complete a circuit to the Mayday relays if the Catastrophic Failure Detection relay is de-energized by loss of power from the missile.

5-16. Operation (See Figures 5-5 and 5-6)

When the three Mayday relays are energized, the abort sequence will occur as follows: the ABORT light on the main instrument panel will illuminate through the contacts of the energized No. 3 Mayday relay. Through parallel contacts of the energized No. 1 and No. 2 Mayday relays, the Capsule Separation Bolts Power relay is energized, the Capsule Separation Warning Light Time Delay relay is energized, and the Maximum Altitude Sensor receives a power signal.

NOTE

Approximately 7.5 seconds from this time the escape tower will be jettisoned.

The capsule separation bolt squibs will be fired and the bolts fractured, releasing the capsule-adapter clamp ring and allowing the three limit switches to spring to their normal positions. Two of the four poles on each limit switch are used to complete circuits to the Emergency Escape Rocket Fire

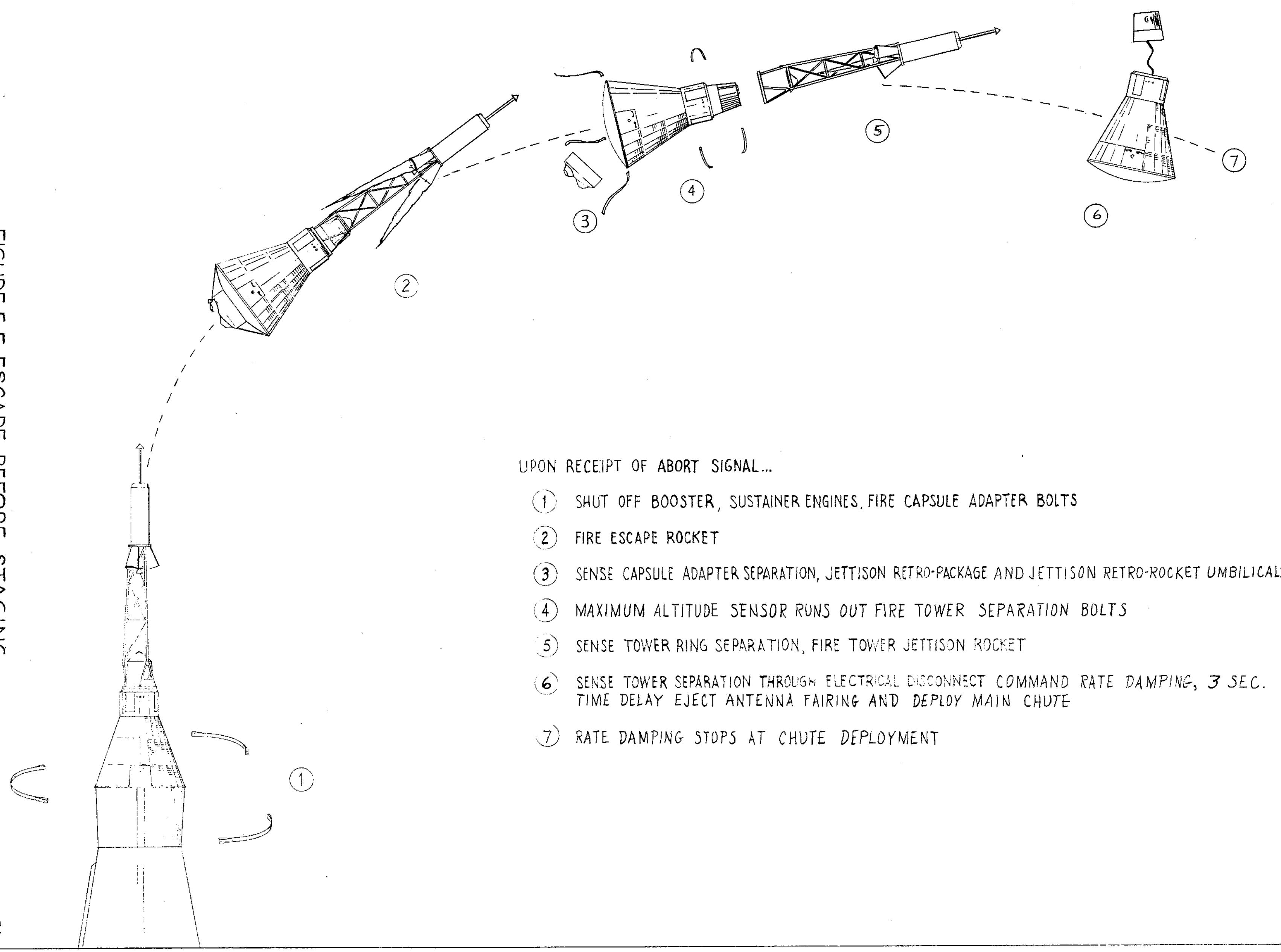


FIGURE 5-5 ESCAPE BEFORE STAGING

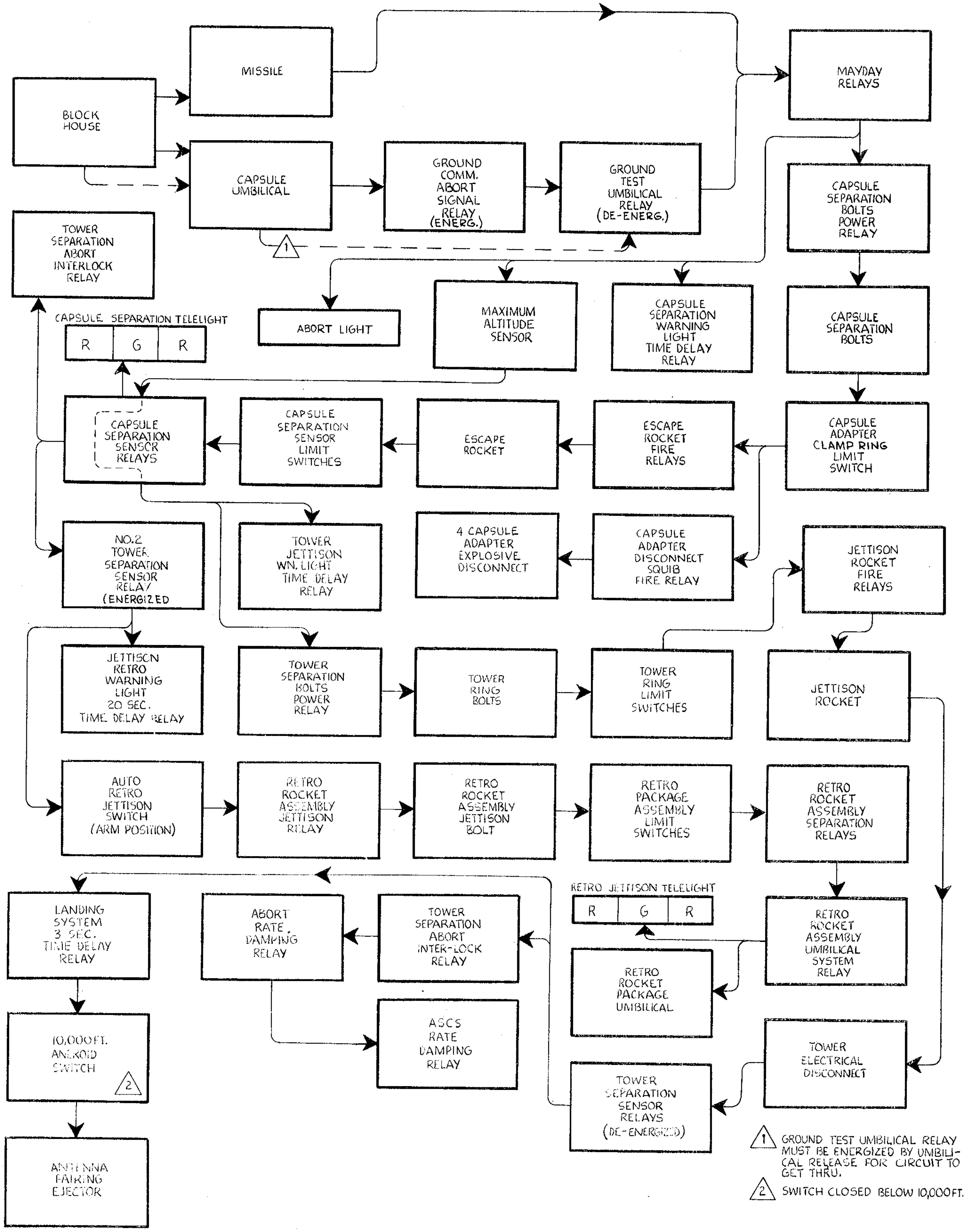


FIGURE 5-6 ESCAPE BEFORE STAGING BLOCK DIAGRAM

PM45-61A

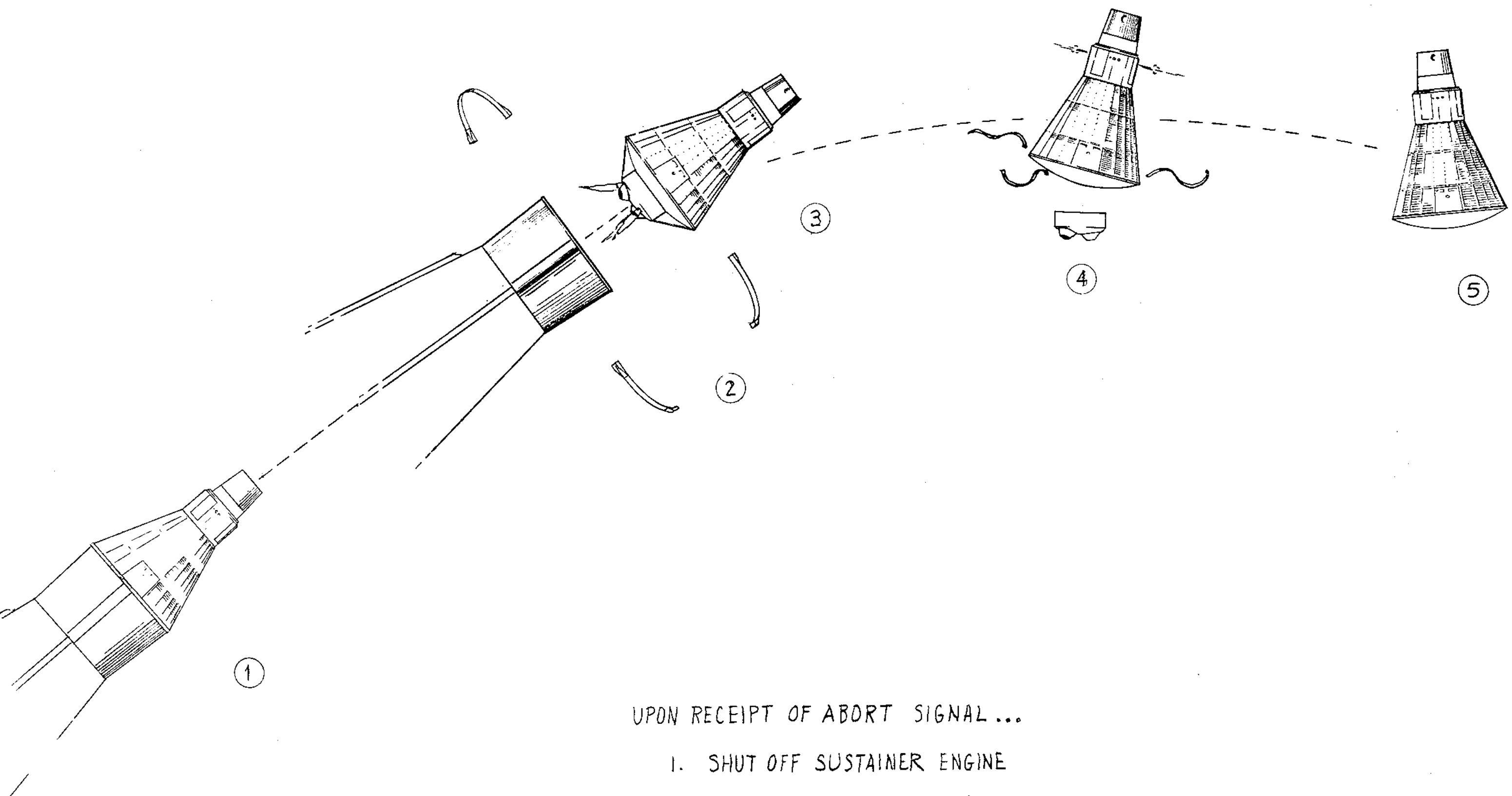
relay, the Escape Rocket Fire relay and the Capsule Adapter Disconnect Squib Fire relay. Simultaneously, isolated and main battery power fire the escape rocket through the parallel contacts of the Emergency Escape and Escape Rocket Fire relay and the four capsule adapter explosive disconnects are fired, two by main battery power and two by isolated battery power. The escape rocket's 60,000 pounds of thrust will separate the capsule from the missile and carry it to an altitude of 2500 feet on a trajectory which will assure water impact. The actuation of the capsule separation sensor limit switches at time of capsule separation allows main battery power to be completed through any one of the three limit switches which are connected in parallel, to the two Capsule Separation Sensor relays, energizing the relays. Through the energized No. 1 Capsule Separation Sensor relay (pole D) main battery power is transmitted to the coil of the Tower Separation Abort Interlock Latching relay and also to the energized contacts of the No. 2 Tower Separation Sensor relay. After passing through this relay, power is distributed to the Jettison Retro Warning Light 20 Second Time Delay relay and to the Astronaut's AUTO RETRO JETT. switch which when in the ARM position completes power to the Retro Rocket Assembly Jettison relay, energizing the relay. Both relays are located in the No. 1 Retrograde relay box. Through the energized contacts of the Retro Rocket Assembly Jettison relay main and isolated battery power is directed to the two squibs of the retro rocket assembly jettison bolt. The bolt will fracture and the package will drop free of the capsule, being assisted by a coil spring installed between the heat shield and retro package assembly for this purpose. The dropping of the retro package assembly from the capsule will allow three single pole limit switches to spring to their actuated position allowing the same circuit which energized the Retro Rocket Assembly Jettison relay to pass through the closed contacts of the limit switches to the No. 1 and No. 2 Retro Rocket Assembly Separation relays, energizing the relays. Through the energized No. 2 Retro Rocket Assembly Separation relay, the same power which energized the Retro Rocket Assembly Jettison relay is completed to the Retro Rocket Assembly Umbilical Separation relay, energizing the relay. Through the energized relay main battery power is directed to the six squibs of the three retro rocket package umbilicals, jettisoning the electrical umbilical plugs milliseconds after the dropping of the retro package. Also, through a set of contacts of this same relay, the JETT RETRO telelight is illuminated green. The green light will stay illuminated until the escape tower is jettisoned. Through pole C of the energized No. 1 Capsule Separation Sensor relay a circuit is completed to the SEP CAPSULE telelight illuminating the light green. Through pole B of this relay a circuit is prepared from the Maximum Altitude Sensor to the Tower Jettison Warning Light Time Delay relay and the Tower Separation Bolts Power relay. This circuit will be energized 7.5 to 8.5 seconds after the Mayday relays have been energized at which time the tower bolts will be fired by both main and isolated battery power. As the three tower bolts are fractured, the segmented tower clamp ring, separates allowing the three tower ring limit switches to spring to their actuated position. Main and isolated battery power will now pass through the actuated positions of the limit switches to the Emergency Jettison and Jettison Rocket Fire Relays energizing both relays. Through these relays and their parallel contacts main and isolated battery power will fire the two squibs of the jettison rocket. The tower will be jettisoned clear of the capsule resulting in separating the two tower to capsule electrical disconnects. The separation of either disconnect will de-energize the three Tower Separation Sensor relays and result in completing a circuit from pole F of the No. 1 Capsule Separation Sensor relay through the No. 1 de-energized Tower Separation Sensor relay to the coil of the Abort Rate Damping relay. This relay will send a signal to the ASCS commanding rate damping until time of main chute deployment. Through one set of de-energized contacts of the No. 2 and No. 3 Tower Separation Sensor relays, power is applied to the coils of the two, Three Second Time Delay relays located in the A and B recovery Sequence Controller boxes. After the three second time delay, power is directed to the two aneroid switches which are unactuated (below 10,000 feet), resulting in firing of the antenna fairing and subsequent main chute deployment.

5-17. Escape After Staging

The methods of initiating an abort after staging are identical to the methods named for the escape after liftoff and are: (1) Ground command receiver abort signal; (2) Astronaut Abort handle; (3) Booster Catastrophic Failure Detection system. Any of the three methods will energize the three Mayday relays within the No. 3 Launcn and Orbit relay box. The sequence which occurs by the energizing of these relays is described in the following paragraph.

5-18. Operation (See Figures 5-7 and 5-8)

The signal which energizes the three Mayday relays also is transmitted to the missile to shut down the sustainer engine. Through contacts of the energized No. 3 Mayday relay, a power circuit is completed to the ABORT light on the main instrument panel. Through parallel contacts of the energized No. 1 and No. 2 Mayday relays, a circuit is completed to pin E of the thrust cutoff sensor. As thrust decays to $\frac{1}{4}$G, relay closure will be made within the thrust cutoff sensor and the power will return out of pin F to the Capsule Separation Bolts Power relay in No. 2 Launch and Orbit relay box. The Capsule Separation Warning Light Time Delay relay will also be energized by this circuit. Through the energized double pole Capsule Separation Bolts Power relay, all five squibs of the three capsule separation bolts will be fired. Bolts one, two and three will be fired by main battery power while the dual squibs of bolts one and two will be fired by isolated battery power. The dual feature of bolt No. three is detonation by gas cartridge and is utilized only when the abort handle is selected. As the bolts are fired the capsule to adapter clamp ring is released allowing three capsule adapter separation ring limit switches to spring to their actuated position. Three of the four poles of each limit switch are powered and therefore complete three circuits which energize the Emergency Posigrade and Posigrade Rocket Fire relays and the Capsule Adapter Disconnect Squib Fire relay. Simultaneously the three posigrade rockets and the two capsule adapter explosive disconnects are fired by both main and isolated battery power. The posigrade rockets develop the required thrust to separate the capsule from the adapter. Upon separation the three capsule separation sensor limit switches spring to their actuated position, allowing power to pass through their parallel contacts to energize the No. 1 and No. 2 Capsule Separation Sensor relays. Through the energized No. 1 Capsule Separation Sensor relay, the SEP CAPSULE telelight will illuminate green and a circuit to the Damping Signal 5 Second Time Delay relay is completed. Another circuit is also completed which provides a t_r signal to the ASCS. During the 5 second time delay a circuit is provided to the Damping relay which provides a signal to the ASCS resulting in rate damping. After 5 seconds the signal is removed and applied to the Orbit Orientation Relay from the energized Damping Signal 5 Second Time Delay relay. The energizing of the Orbit Orientation relay completes a circuit to the ASCS commanding a $t_r + 5$ second signal resulting in rotating the capsule. The capsule will assume the 34^o retro fire attitude and remain there until either ground control or Astro-



UPON RECEIPT OF ABORT SIGNAL...

1. SHUT OFF SUSTAINER ENGINE
2. SENSE THRUST DECAY TO 1/4 G AND FIRE CAPSULE ADAPTER BOLTS
3. SENSE CLAMP RING RELEASE, FIRE POSIGRADE ROCKETS AND FIRE CAPSULE TO ADAPTER EXPLOSIVE DISCONNECTS
4. SENSE CAPSULE-ADAPTER SEPARATION AND START 5 SEC. RATE DAMPING, ASTRONAUT OR GROUND COMMAND JETTISONS RETRO-PACKAGE
5. LANDING AND RECOVERY SEQUENCE WILL BEGIN AT 10,000 FEET

FIGURE 5-7 ESCAPE SYSTEM AFTER STAGING

PH45-7A

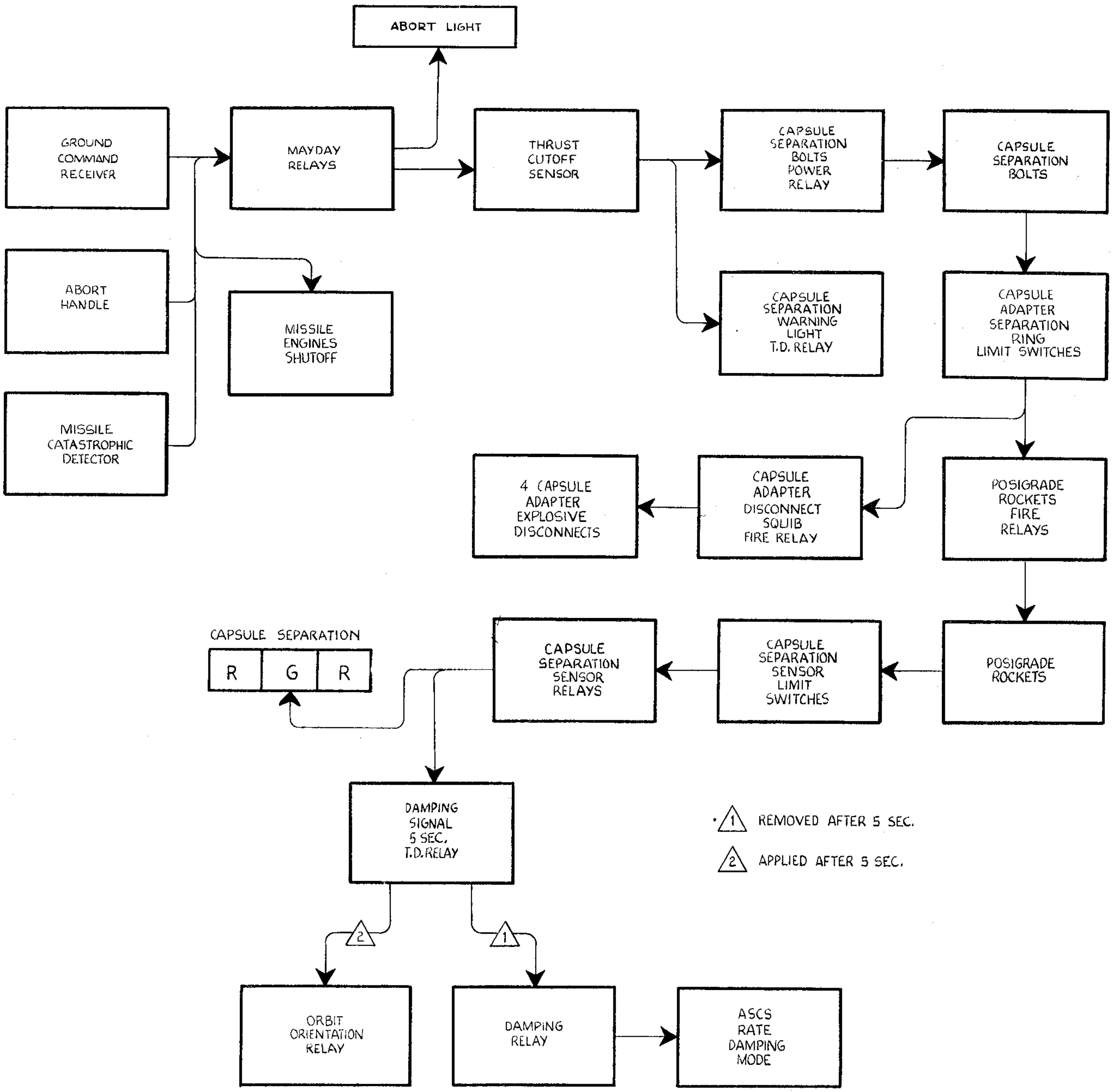


FIGURE 5-8 ESCAPE SYSTEM AFTER STAGING BLOCK DIAGRAM

PM45-60A

naut selection fires the retro rockets. If it is not deemed necessary to fire the retro rockets either ground control or Astronaut selection may jettison the retro package. The aneroid switches were armed at staging (tower separation) and therefore will execute the landing sequence when the capsule descends to 10,000 feet.

5-19. TEST CONFIGURATION NO. 2 CAPSULE (See Figure 5-9)

5-20. General

Capsule No. 2 is electrically designed for an un-manned ballistic mission using the Redstone missile as the booster vehicle. The normal mission sequence and escape sequence are therefore modified from that of the Specification Compliance description and the differences are discussed in the following paragraphs.

5-21. Launch Through Staging (See Figure 5-10)

The sequence system is initiated by two 28 volt dc signals from the missile which occur at 3/32 of an inch liftoff. These two signals energize the Time Zero relay located in the No. 3 Launch and Orbit relay box and also transmit voltage to the Maximum Altitude Sensor and the Satellite Clock. At approximately 141 seconds, or 37½ miles altitude, missile staging will occur whereby the booster engine will burn out, resulting in two signals from the missile to the Booster Engine Cutoff relay and Sustainer Engine Cutoff relay located in No. 2 Launch and Orbit Relay box and also to the Booster Abort Signal Disarm relay located in the No. 4 Launch and Orbit relay box. Through energized contacts of the Booster Engine Cutoff Relay the Tower Separation Bolts Power relay and the Tower Jettison Warning Light Time Delay relay are energized, and the tower bolts fired. Through energized contacts of the Sustainer Engine Cutoff relay the Booster Cutoff 10 Second Time Delay relay is energized. Immediately upon

firing the tower bolts, the tower ring limit switches spring to their actuated position and complete a circuit to the Emergency Jettison and Jettison Rocket Fire relays and to the Emergency Escape and Escape Rocket Fire relays. Through these four relays which are connected in parallel for each rocket circuit, the two rockets are fired and the tower separates from the capsule. As the tower separates two electrical disconnects between the tower and capsule also separate causing the three Tower Separation Sensor relays to de-energize. Through the de-energized contacts of No. 3 Tower Separation Sensor relay a circuit is completed from the Booster Cutoff 10 Second Time Delay relay (after the 10 second delay) to pin E of the thrust cutoff sensor. When missile thrust has decayed to $\frac{1}{4}$G the thrust cutoff sensor will return the signal out of pin F to the Capsule Separation Bolts Power relay and the Capsule Separation Warning Light Time Delay relay. This thrust decay and 10 second run-out will occur at approximately 47 miles altitude; however, the velocity of the capsule is approximately 6800 feet per second which will continue the capsule's flight to approximately 105 miles. Through the energized Capsule Separation Bolts Power relay, the five squibs of the three capsule separation bolts will be fired thereby releasing the capsule to adapter clamp ring, and allowing the capsule to adapter separation ring limit switches to spring to their actuated position. In their actuated position power will be continued to energize the Emergency Posigrade and Posigrade Rocket Fire relays and the Capsule Adapter Disconnect Squib Fire relay. The posigrade rockets will fire separating the capsule from the adapter and simultaneously the two capsule adapter explosive disconnects will be fired. Three capsule separation sensor limit switches which are mounted to the retro package retension straps, sense the separation and spring to their actuated position allowing power to pass through their parallel connected contacts to

firing the tower bolts, the tower ring limit switches spring to their actuated position and complete a circuit to the Emergency Jettison and Jettison Rocket Fire relays and to the Emergency Escape and Escape Rocket Fire relays. Through these four relays which are connected in parallel for each rocket circuit, the two rockets are fired and the tower separates from the capsule. As the tower separates two electrical disconnects between the tower and capsule also separate causing the three Tower Separation Sensor relays to de-energize. Through the de-energized contacts of No. 3 Tower Separation Sensor relay a circuit is completed from the Booster Cutoff 10 Second Time Delay relay (after the 10 second delay) to pin E of the thrust cutoff sensor. When missile thrust has decayed to $\frac{1}{4}$G the thrust cutoff sensor will return the signal out of pin F to the Capsule Separation Bolts Power relay and the Capsule Separation Warning Light Time Delay relay. This thrust decay and 10 second run-out will occur at approximately 47 miles altitude; however, the velocity of the capsule is approximately 6800 feet per second which will continue the capsule's flight to approximately 105 miles. Through the energized Capsule Separation Bolts Power relay, the five squibs of the three capsule separation bolts will be fired thereby releasing the capsule to adapter clamp ring, and allowing the capsule to adapter separation ring limit switches to spring to their actuated position. In their actuated position power will be continued to energize the Emergency Posigrade and Posigrade Rocket Fire relays and the Capsule Adapter Disconnect Squib Fire relay. The posigrade rockets will fire separating the capsule from the adapter and simultaneously the two capsule adapter explosive disconnects will be fired. Three capsule separation sensor limit switches which are mounted to the retro package retension straps, sense the separation and spring to their actuated position allowing power to pass through their parallel connected contacts to

firing the tower bolts, the tower ring limit switches spring to their actuated position and complete a circuit to the Emergency Jettison and Jettison Rocket Fire relays and to the Emergency Escape and Escape Rocket Fire relays. Through these four relays which are connected in parallel for each rocket circuit, the two rockets are fired and the tower separates from the capsule. As the tower separates two electrical disconnects between the tower and capsule also separate causing the three Tower Separation Sensor relays to de-energize. Through the de-energized contacts of No. 3 Tower Separation Sensor relay a circuit is completed from the Booster Cutoff 10 Second Time Delay relay (after the 10 second delay) to pin E of the thrust cutoff sensor. When missile thrust has decayed to $\frac{1}{4}$G the thrust cutoff sensor will return the signal out of pin F to the Capsule Separation Bolts Power relay and the Capsule Separation Warning Light Time Delay relay. This thrust decay and 10 second run-out will occur at approximately 47 miles altitude; however, the velocity of the capsule is approximately 6800 feet per second which will continue the capsule's flight to approximately 105 miles. Through the energized Capsule Separation Bolts Power relay, the five squibs of the three capsule separation bolts will be fired thereby releasing the capsule to adapter clamp ring, and allowing the capsule to adapter separation ring limit switches to spring to their actuated position. In their actuated position power will be continued to energize the Emergency Posigrade and Posigrade Rocket Fire relays and the Capsule Adapter Disconnect Squib Fire relay. The posigrade rockets will fire separating the capsule from the adapter and simultaneously the two capsule adapter explosive disconnects will be fired. Three capsule separation sensor limit switches which are mounted to the retro package retension straps, sense the separation and spring to their actuated position allowing power to pass through their parallel connected contacts to

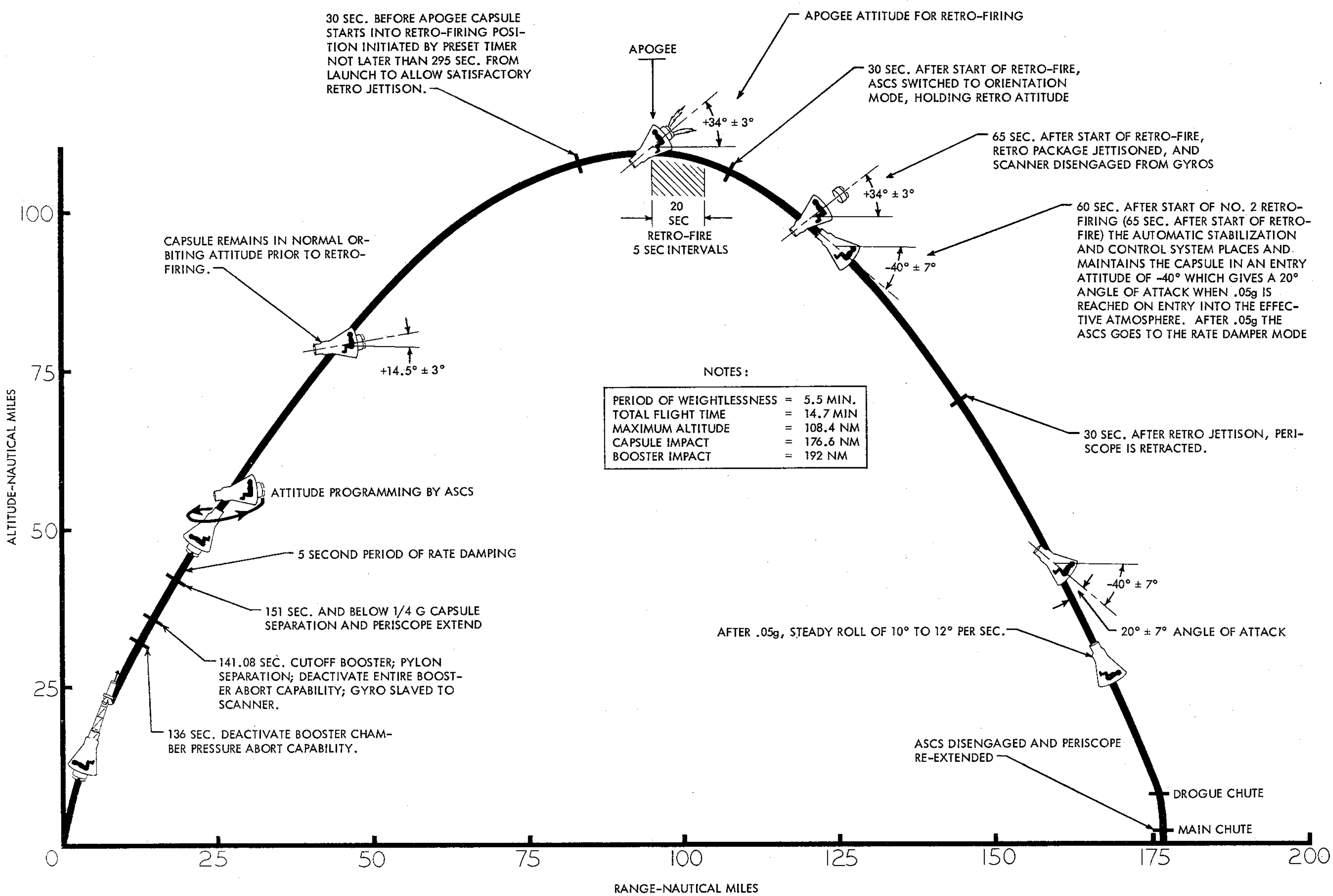


FIGURE 5-9 NORMAL MISSION SEQUENCE (CAPSULE NO. 2)

PM45-150

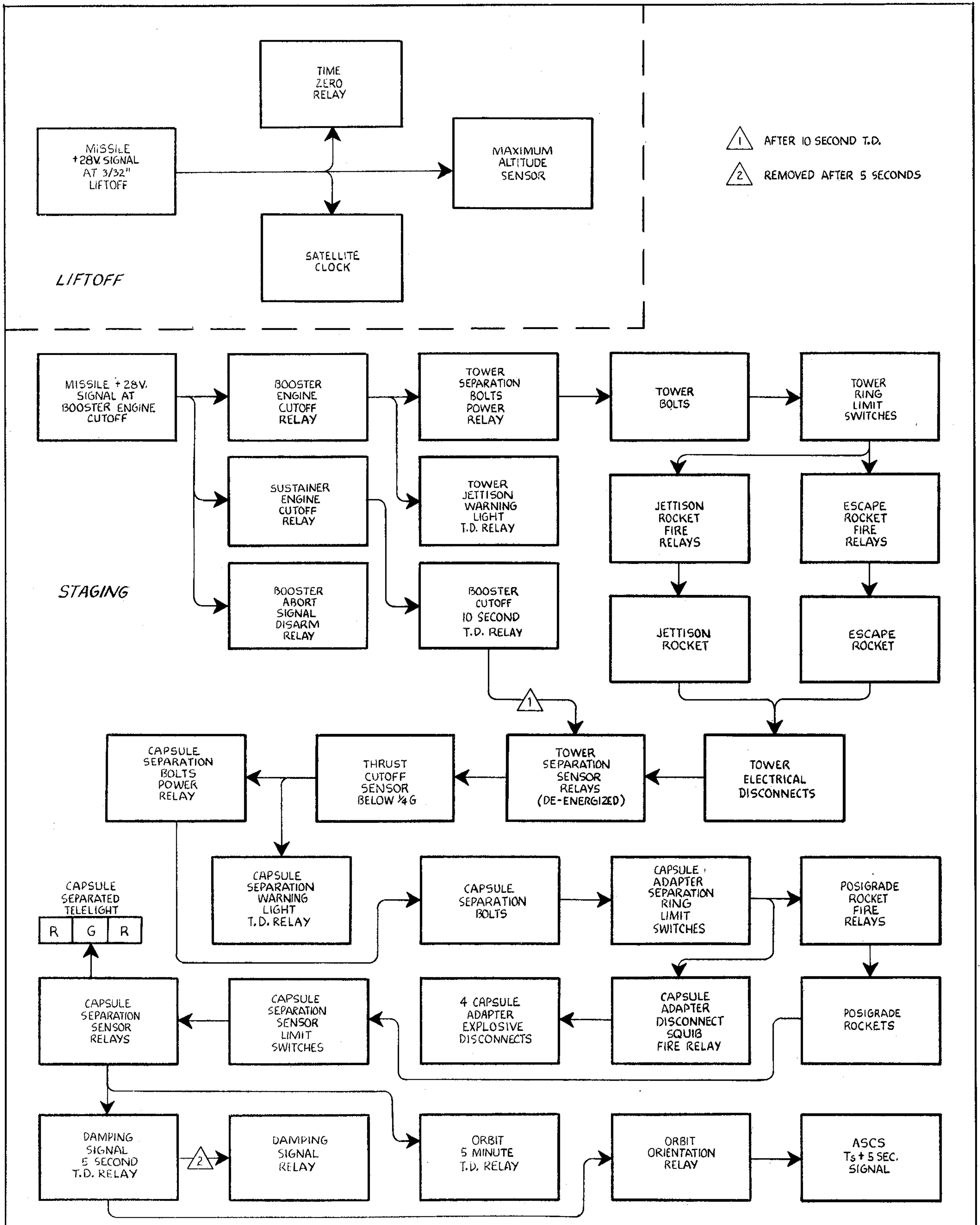


FIGURE 5-10 LAUNCH THROUGH STAGING (CAPSULE NO. 2)

PM45-149

the two Capsule Separation Sensor relays, energizing the latching relays. Through the No. 1 energized Capsule Separation Sensor relay the SEP CAPSULE telelight is illuminated green and the Damping Signal relay and Orbit 5 Minute Time Delay relay are energized. Through the energized Damping Signal relay the ASCS is commanded to provide rate damping. This rate damping signal will be removed after five seconds by the Damping Signal 5 Second Time Delay relay energizing. Now, the same power which was applied to the Damping relay is applied to the Orbit Orientation relay, energizing this relay. Through the energized Orbit Orientation relay, a ground is provided for the ASCS system resulting in a t_s + 5 sec. signal commanding the capsule to rotate and assume the orbit attitude of 14.5° blunt end up. This orbit attitude will be held until retro command which for Capsule No. 2 will be given before the run-out of the Orbit 5 Minute Time Delay relay; therefore, the run-out of this relay will have no function in the sequence.

5-22. <u>Second Staging</u>

Second staging is not applicable to the mission of Capsule No. 2.

5-23. <u>Re-Entry To .05G</u>

Re-entry for Capsule No. 2 will primarily be initiated from the pre-set satellite clock; however, the ground command receiver system will be available and used if the situation requires. The Satellite clock will be pre-set by the ground crew so that the time to retrograde will be 295 seconds after lift-off. In respect to the overall mission, 295 seconds will be approximately 30 seconds before apogee. The sequence occuring at satellite clock time to retrograde run-out is identical to that of the Specification Compliance capsule as explained in Paragraph 5-10.

5-24. ESCAPE SYSTEM

5-25. Description

The escape system is basically the same as the Specification Compliance capsule with only minor electrical changes and deviations in methods of initiating the abort due to the un-manned mission. The abort conditions are discussed in the following paragraphs.

5-26. Escape Before Liftoff Before Umbilical Disconnect

Same as Specification Compliance. (Refer to Paragraph 5-13.)

5-27. Escape Before Liftoff After Umbilical Disconnect

Same as Specification Compliance except as shown below. (Refer to Paragraph 5-14.) During countdown there will be 45 seconds between time of capsule umbilical eject and time zero, which is 3/32 of an inch liftoff. During this period two methods of abort are available: (1) The blockhouse to missile hard-line abort signal; (2) Ground command receiver abort signal. These two methods result in energizing the three Mayday relays located in the No. 3 Launch and Orbit relay box.

5-28. Escape After Liftoff

Same as Specification Compliance except as shown below. (Refer to Paragraph 5-15.) After 3/32 of an inch liftoff which is effectively missile umbilical eject, there are two methods by which an abort may be initiated: (1) Ground command receiver abort signal; (2) Booster catastrophic failure detection system. This second method has been non-effective in the two previous paragraphs due to the Time Zero relay being de-energized. However, the Time Zero relay is energized at 3/32 of an inch liftoff, and therefore will complete a circuit to the Mayday relays if the Catastrophic Failure Detection relay is de-energized by loss of 28 V power from the missile.

5-29. Operation

Same as Specification Compliance. (Refer to Paragraph 5-16.)

5-30. Escape After Staging

For Capsule No. 2, the escape after staging sequence may be accomplished by only one abort method which is the ground command receiver system. However, it should be noted that the length of time that this signal is worthwhile is only 144 seconds. This figure is the time difference beween capsule separation (151 seconds) and per-set time to retrograde (295 seconds). If the abort command is given during this period the following will occur.

5-31. Operation

Main 28 V power will be applied to pole A of the energized No. 3 Mayday relay and will be continued through the closed contact to the de-energized No. 2 Retro Assembly Separation relay. Through this de-energized relay the circuit will be continued through the de-energized No. 1 Retro Command Relay to the coil of the Retro Attitude Command relay. The Retro Attitude Command relay when energized will direct power to the ASCS resulting in a t_r signal causing the capsule to assume the 34^o retro fire attitude. The normal retrograde firing and retro package separation will continue per the Specification Compliance description. (Refer to Paragraph 5-10.)

5-32. TEST CONFIGURATION NO. 3 CAPSULE

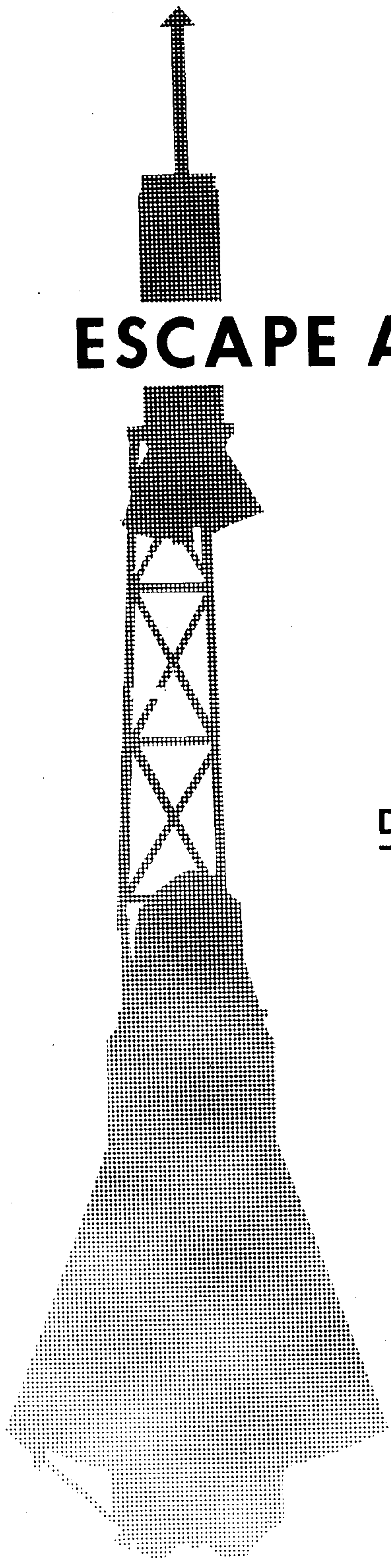
5-33. General

The sequence and escape system operation of Capsule No. 3 is identical to that of Capsule No. 2 with the following exception. Electrical wiring has been changed to provide for the installation and connection of an aerodynamic pressure sensor to be installed at the top of the escape rocket. This sensor will be the primary means of initiating the abort for which the capsule mission is intended. The Mayday relays will be energized at time of sensor actuation and the abort sequence will be placed into operation. (Refer to Paragraph 5-19.)

5-34. TEST CONFIGURATION NO. 4 CAPSULE

5-35. General

Same as Capsule No. 2. (Refer to Paragraph 5-19.)



SECTION VI

ESCAPE AND JETTISON ROCKET SYSTEMS

TABLE OF CONTENTS

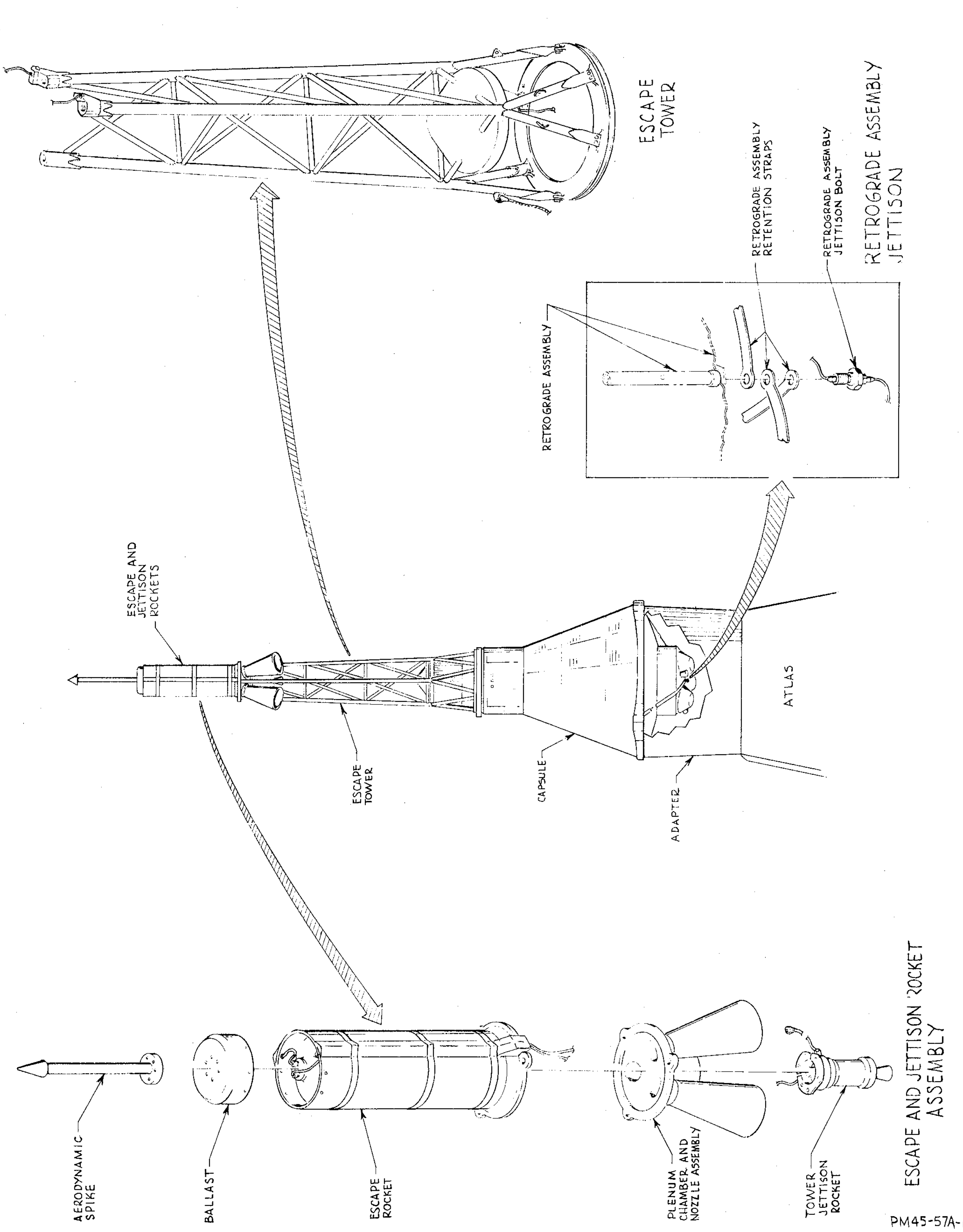


FIGURE 6-1 ESCAPE SYSTEM (SHEET 1 OF 2)

VI. ESCAPE AND JETTISON ROCKET SYSTEM

6-1. SYSTEM DESCRIPTION

6-2. General

The overall escape system consists not only of the pylon and its escape and jettison rockets, but includes such items as are illustrated on Figure 6-1. These items are not necessarily part of the escape system, but certainly become involved in the complete escape function. Under normal flight conditions where an abort is never initiated, all of the associated items perform their same function but in different sequence. For a written description of the escape system and electrical schematics of the items under discussion, refer to Section V.

6-3. System Operation

The capsule electrical system provides for an abort any time after the gantry is removed. When abort is initiated, the capsule adapter clamp ring is released, the escape rocket ignited, and the capsule carried to approximately 2500 feet altitude. At this time, by means of the altitude sensor, the capsule tower clamp ring is released, the tower jettison rocket ignited, and the escape tower jettisoned. Three seconds after tower jettisoning, the landing system is armed and the impact bags inflated. During a normal mission where the escape system is not utilized, the escape rocket serves no function. The tower jettison rocket still carries away the tower at a predetermined altitude; however, the landing system and impact bags do not function until the landing sequence is initiated.

6-4. Abort Handle

The abort handle, located at the Astronaut's left, is his method of initiating the escape sequence. It is also used as a restraint handle during launch.

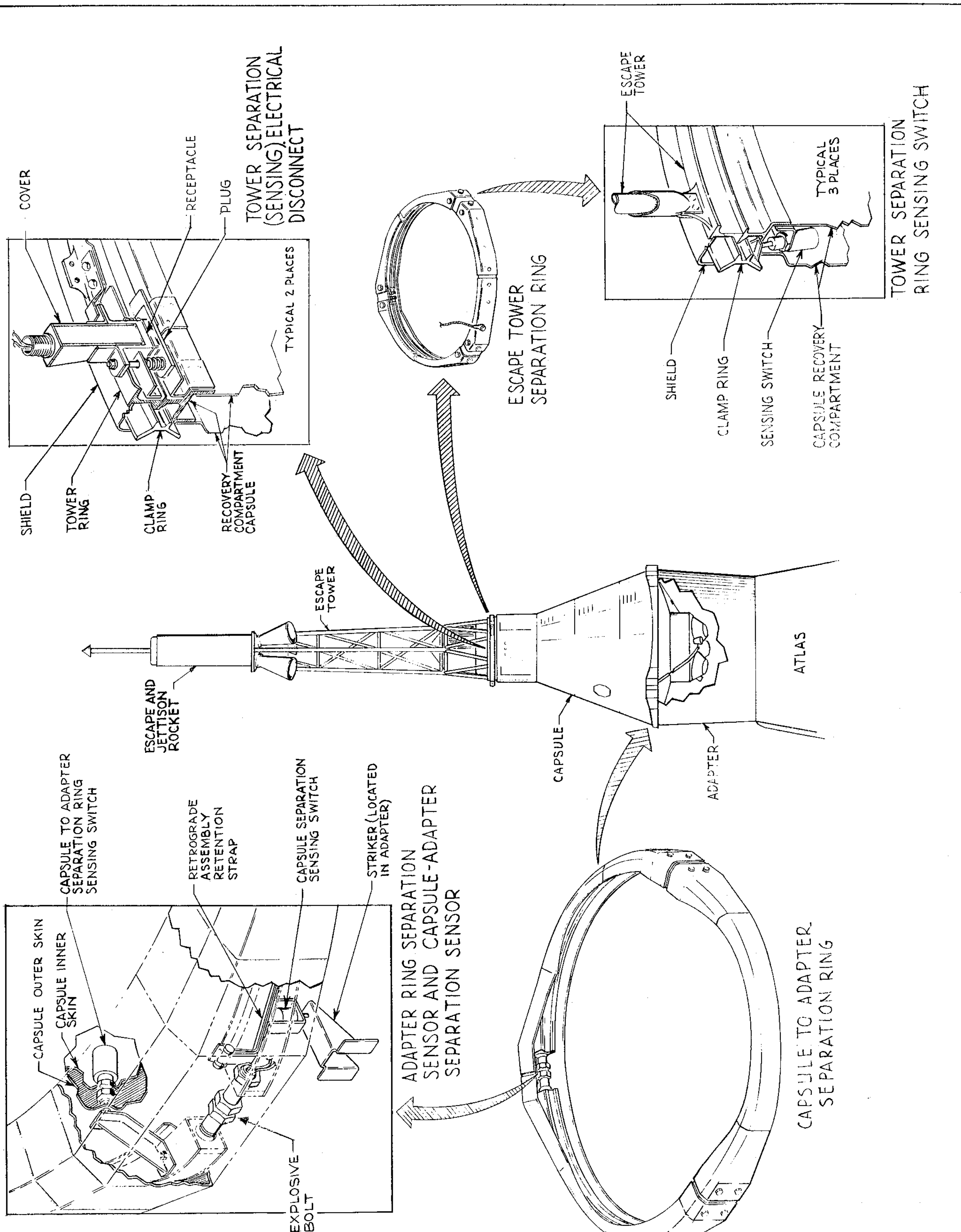


FIGURE 6-1 ESCAPE SYSTEM (SHEET 2 OF 2)

PM45-57-2

In the event of an abort, the release button at the top of the handle must be depressed, allowing the handle to be moved outboard. When moved to the abort (outboard) position, an electrical switch and gas initiator are actuated, both of which act to detonate the capsule-to-adapter clamp ring bolts. The escape sequence is then initiated, providing that the main umbilical has been disconnected. Before umbilical release, the abort handle is inoperative. (See Figure 6-2.)

6-5. ESCAPE ROCKET

6-6. Description

The escape rocket consists of a $\frac{1}{4}$ inch, 4130 steel case, a rocket nozzle adapter plate and solid fuel propellant. See Figure 6-4. Total weight of the assembly is 621 pounds. For aerodynamic stability, approximately 175 pounds of ballast is added to the top of the rocket. The nozzle adapter plate incorporates three equally spaced nozzles which are canted at 19 degrees so as to direct the rocket blast outward and away from the tower and capsule. Provisions for installation of a jettison rocket are also provided on the adapter plate. For off the pad escape, the rocket will provide a separation distance of approximately 250 feet in one second and obtain a maximum capsule altitude of 2500 feet. Also, the path of escape will deviate laterally 30 feet per second in one second from the plane of trajectory. For escapes close to booster staging,the separation distance for the first second will be approximately 125 feet and the minimum lateral deviation under maximum aerodynamic pressures will not be less than 15 feet per second.

6-7. The escape rocket propellant is a polysulfide ammonium perchlorate formulation which is widely used in the rocket industry. The propellant grain is an internal burning nine point star, cast directly into and bonded to the

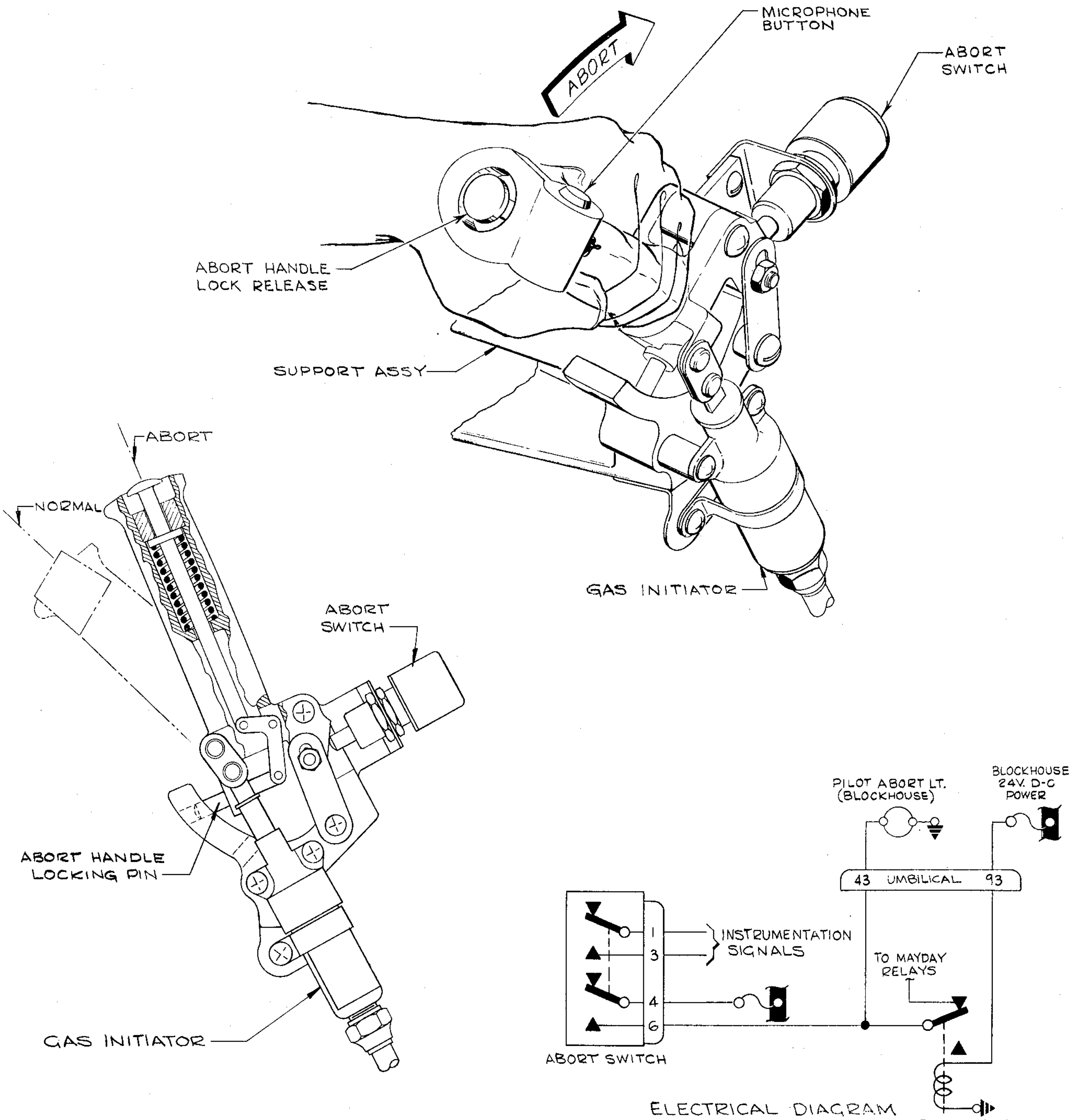


FIGURE 6-2 ABORT HANDLE

PM45-62

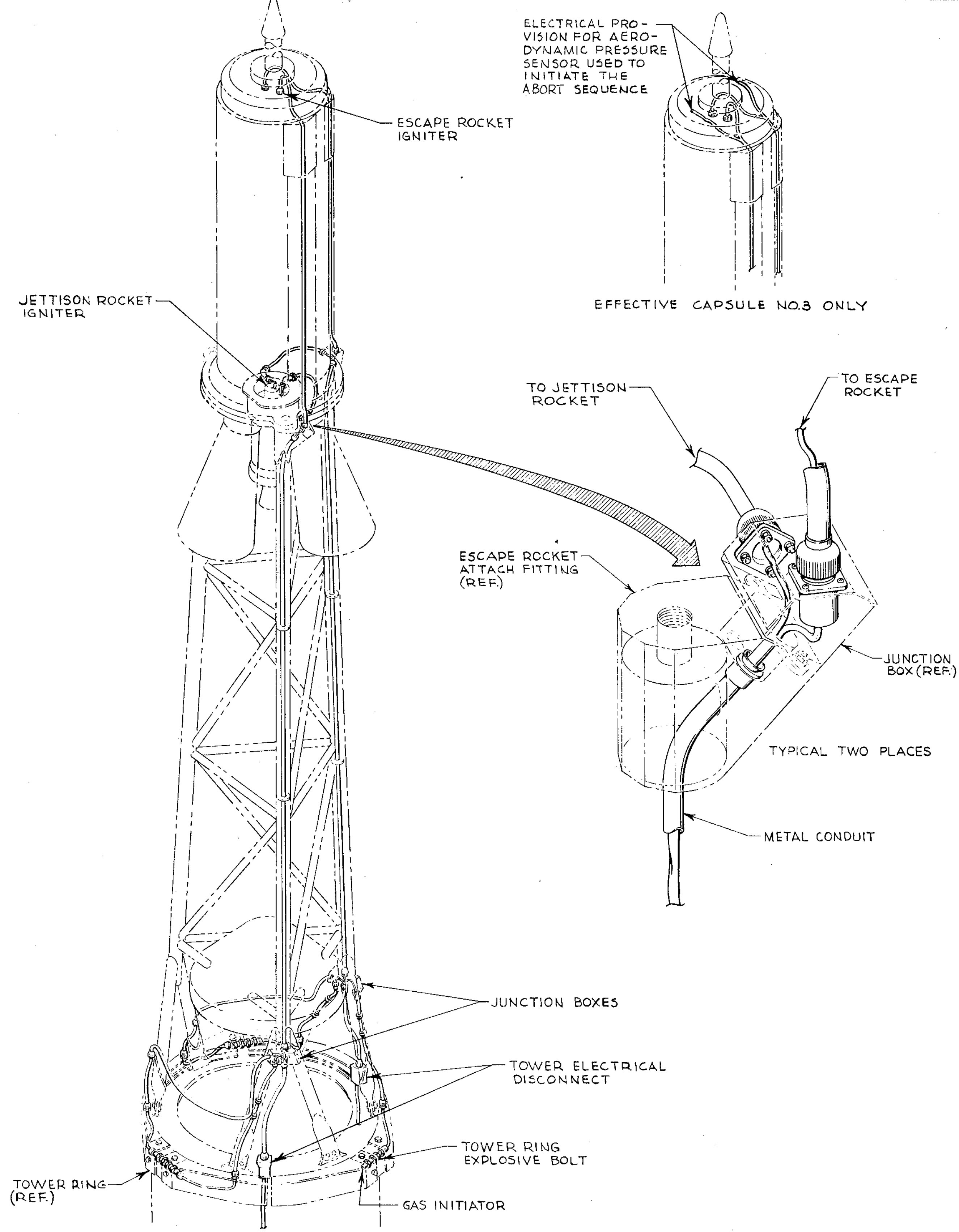


FIGURE 6-3 ESCAPE AND JETTISON ROCKETS ELECTRICAL INSTALLATION PM45-64A

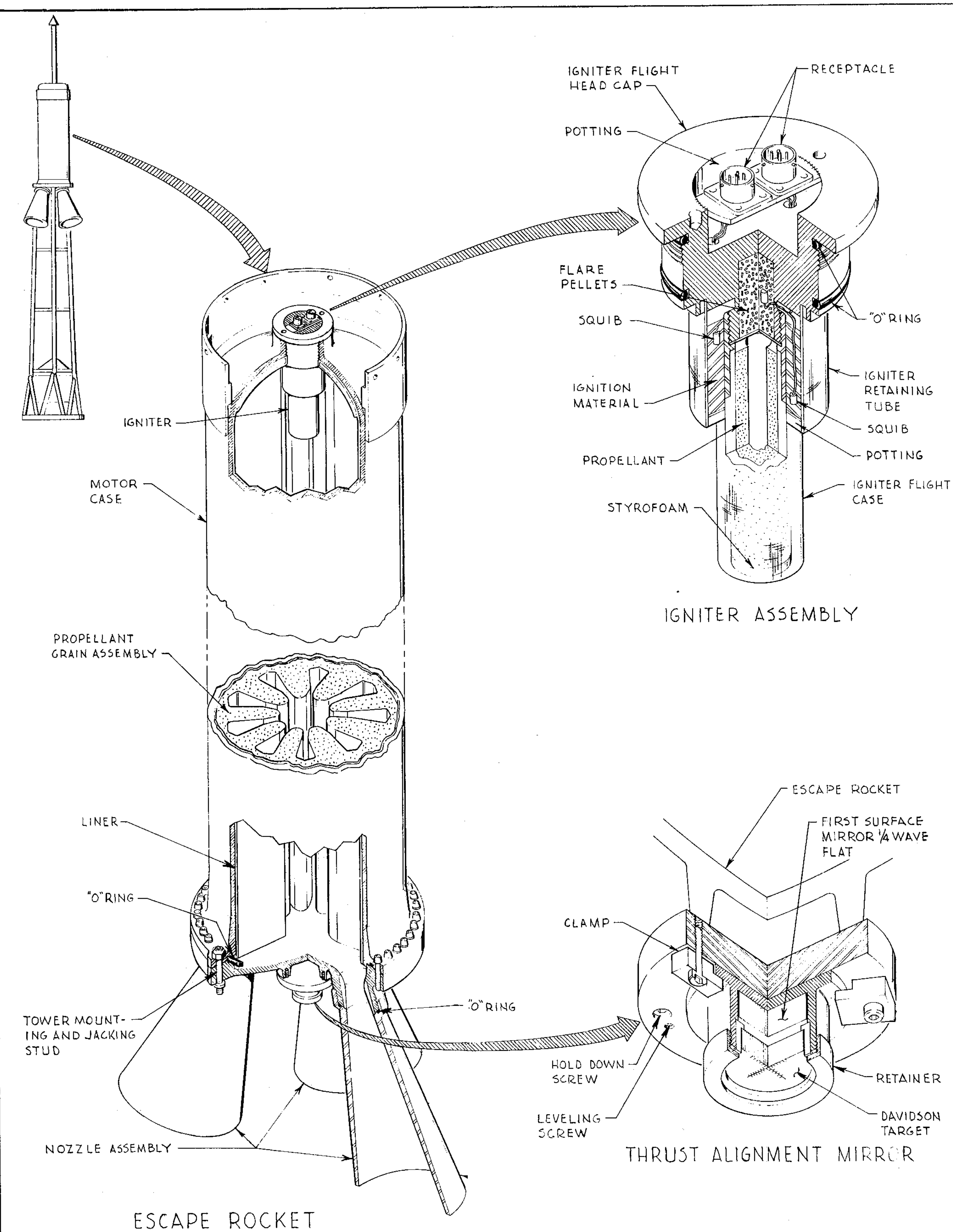


FIGURE 6-4 ESCAPE ROCKET

case. With the nine-pointed port design the possibility of thrust misalignment is reduced due to the improved alignment between the star points and the exhaust nozzles. The nominal resultant axial thrust at 70 degrees F. is 60,000 pounds for 0.62 of a second, it then drops off uniformly to 5000 pounds in the next 0.6 of a second, and then diminishes at a reduced rate to zero. The total impulse of the motor is 55,000 pound seconds.

6-8. The escape rocket igniter is a head mounted dual unit with two completely independent initiation systems to each unit. The dual initiation system to each unit has independent circuitry from different batteries. This igniter is cylindrical in shape, with a central dynaflow type long duration igniter which is essentially a miniature rocket motor. It incorporates a small propellant grain which can be ignited by either of two squibs surrounded by boron-potassium nitrate pellets. Surrounding this is an annular plastic tube filled with a metal-oxidant mixture in which are located two sets of three squibs. Either set is capable of initiating the igniter. Therefore, these are two separate igniters, each capable of firing the rocket. Each igniter has two initiation systems, either of which can start the igniter in the event some of the squibs are inoperative.

6-9. JETTISON ROCKET

6-10. Description

The function of the jettison rocket is to provide a means of ejecting the tower from the capsule after the escape rocket has been utilized for an abort. For normal missions where the tower leaves the capsule twenty seconds after booster staging, both the escape and jettison rockets fire simultaneously. The jettison rocket is a qualified Thor retro unit and is manufactured by Atlantic Research Corporation. It weighs seventeen pounds, has a length of fifteen

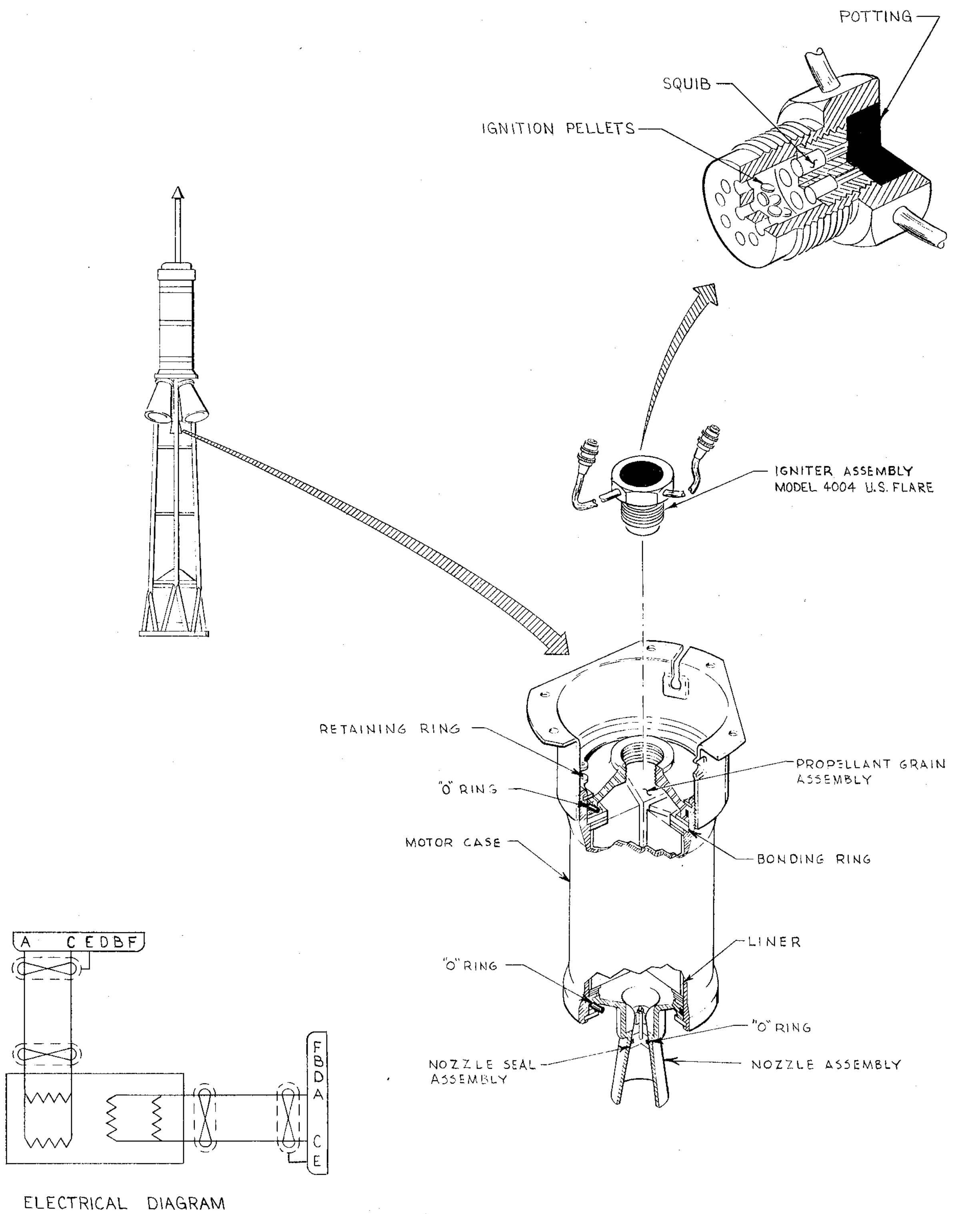


FIGURE 6-5 JETTISON ROCKET

PH45-132A

inches, a diameter of five and one half inches, and produces 855 pounds of thrust for 1.4 seconds at 70° F. in vacuum. The rocket has been successfully fired from -75° F. to +175° F., and from sea level to vacuum. (See Figure 6-5.)

6-11. The jettison rocket igniter is a head mounted unit with dual ignition capabilities. This unit is cylindrical in shape with a hexagonal head and threads into the top of the jettison rocket. The igniter contains approximately 7 grams of USF-2D ignition pellets which are ignited by either of two squibs. Each squib has independent circuitry from a different power source and either squib is capable of igniting the pellets.

6-12. TEST CONFIGURATION #2 AND #3 CAPSULES

6-13. General

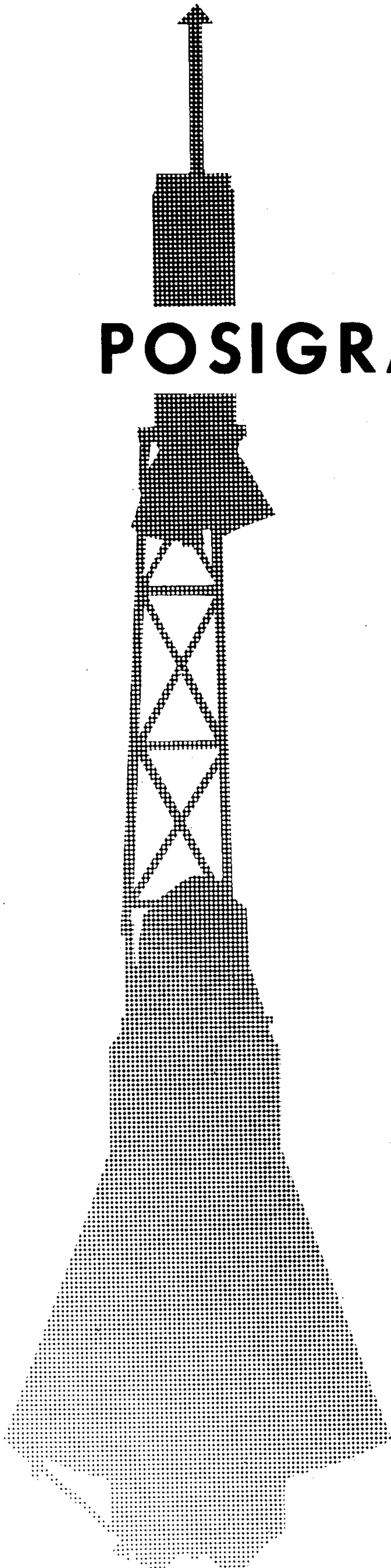
Same as specification compliance capsule.

6-14. TEST CONFIGURATION # 4 CAPSULE

6-15. General

Capsule #4, a vehicle to be used for ground test purposes only, utilizes dummy components in place of "live" pyrotechnics in the escape system. Dummy components used are:

1. Escape rocket
2. Tower jettison rocket
3. Capsule adapter bolts
4. Tower jettison bolts.



SECTION VII

POSIGRADE ROCKET SYSTEM

TABLE OF CONTENTS

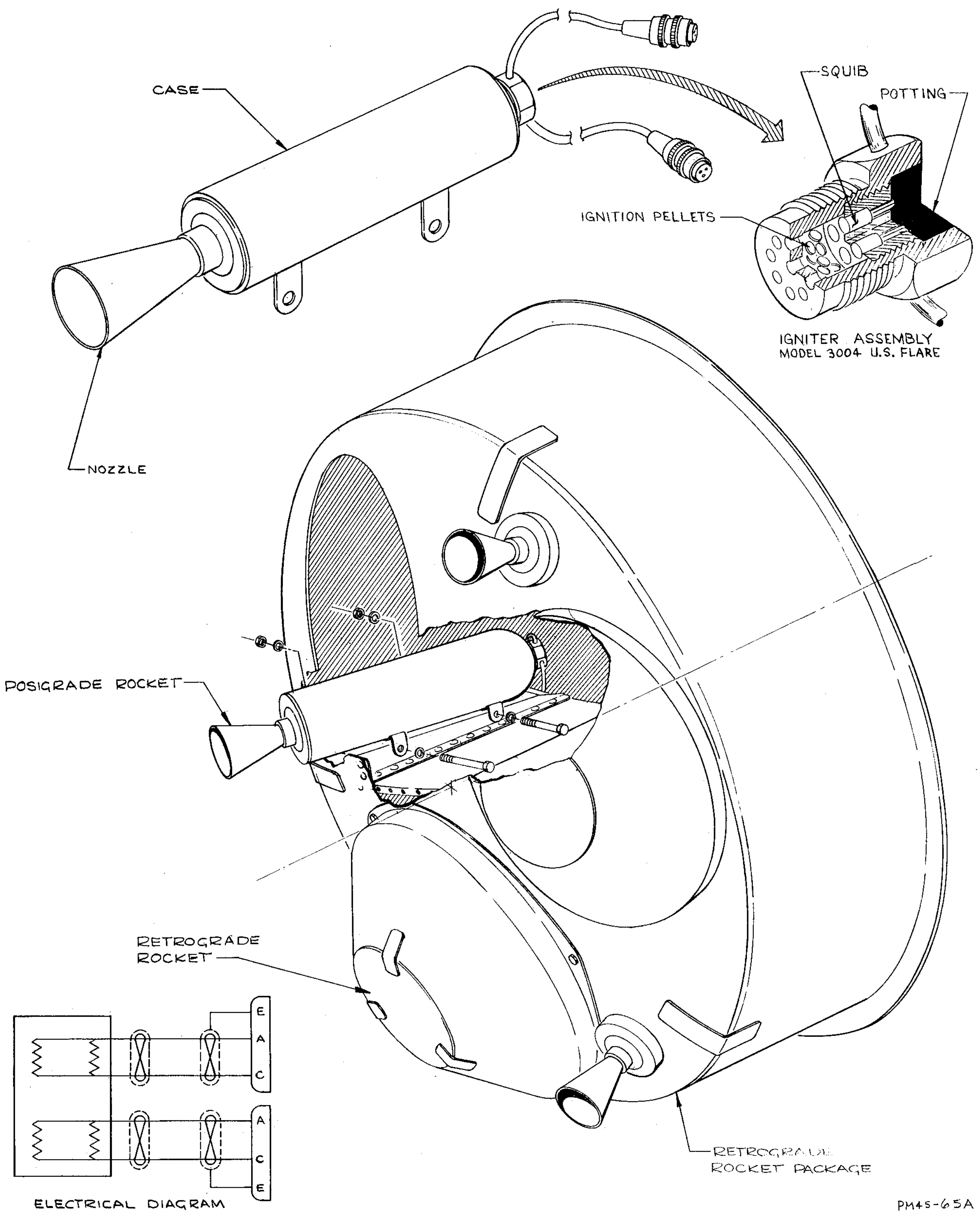


FIGURE 7-1 POSIGRADE ROCKET SYSTEM

VII. POSIGRADE ROCKET SYSTEM

7-1. SYSTEM DESCRIPTION

The posigrade rocket system consists primarily of the three posigrade rockets and igniters mounted in the retrograde package and the associated wiring necessary to ignite the rockets at the proper time. (See Figures 7-1 and 7-2.)

7-2. SYSTEM OPERATION

The purpose of the posigrade rockets is to accomplish separation between the capsule and booster at a rate of 15 feet per second when orbital velocity has been achieved. They also perform the same separation function during an abort after tower separation. The three rockets are fired simultaneously; however, should two of them fail, the remaining unit would successfully affect separation.

7-3. POSIGRADE ROCKET

7-4. Description

The posigrade rocket is a cylindrical device 13 3/4 inches long, 2.8 inches in diameter and weighing 4.8 pounds. On one end is found the rocket nozzle, on the other, the igniter. This rocket is basically an Atlas retro-rocket with minor changes for increased reliability. Reliability has been gained by two methods; (a) Dual ignition of the igniter squibs from two different buses, (b) only one of the three rockets is necessary to accomplish successful separation. Due to the wide temperature range of these rockets, a temperature control system is not required. The propellant utilized in the escape rocket is Polyvinyl Chloride (Arcite 377) which provides 420 pounds of thrust for one second in a vacuum.

7-5. Rocket Igniter

The posigrade rocket igniter is a head mounted unit with dual ignition capa-

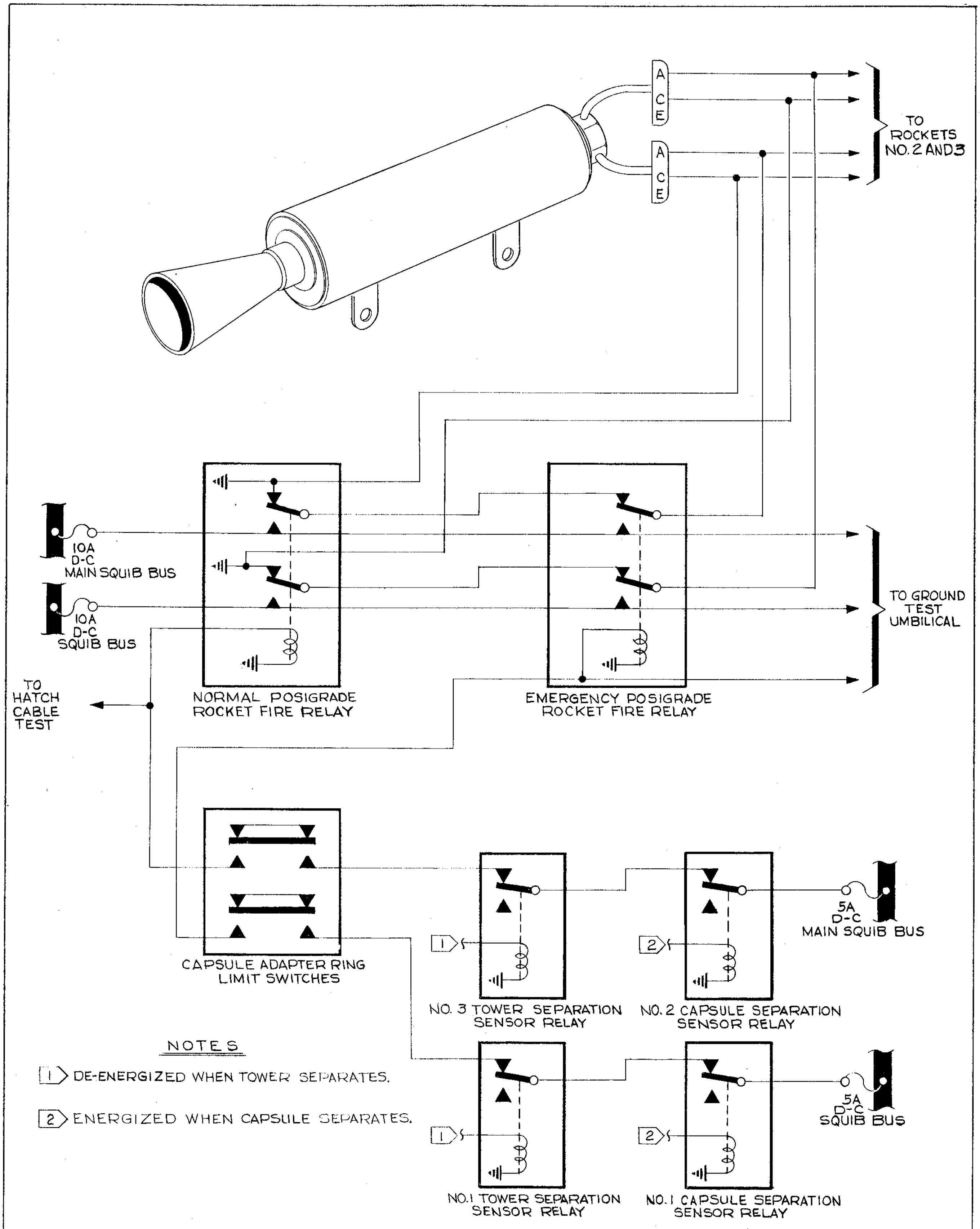


FIGURE 7-2 POSIGRADE ROCKET IGNITION SYSTEM SCHEMATIC

PM45-66A.

bilities. The igniter is cylindrical in shape with a hexagonal head for threading it into the top of the posigrade rocket (see Figure 7-1). This unit contains approximately 3 grams of ignition pellets which are ignited by either of two squibs. Each squib has independent circuitry from a different power source and either squib is capable of igniting the pellets.

7-6. TEST CONFIGURATION NO. 2 AND 3 CAPSULES

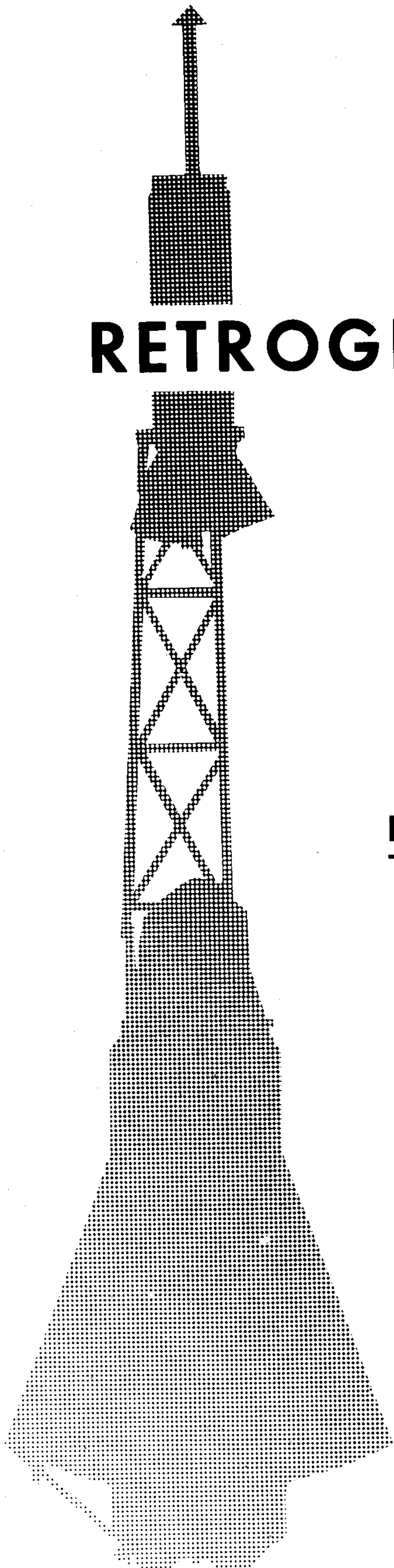
Same as specification capsule.

7-7. TEST CONFIGURATION NO. 4 CAPSULE

7-8. Posigrade Rockets

Dummy posigrade rockets are being utilized in this vehicle.

SECTION VIII



RETROGRADE ROCKET SYSTEM

TABLE OF CONTENTS

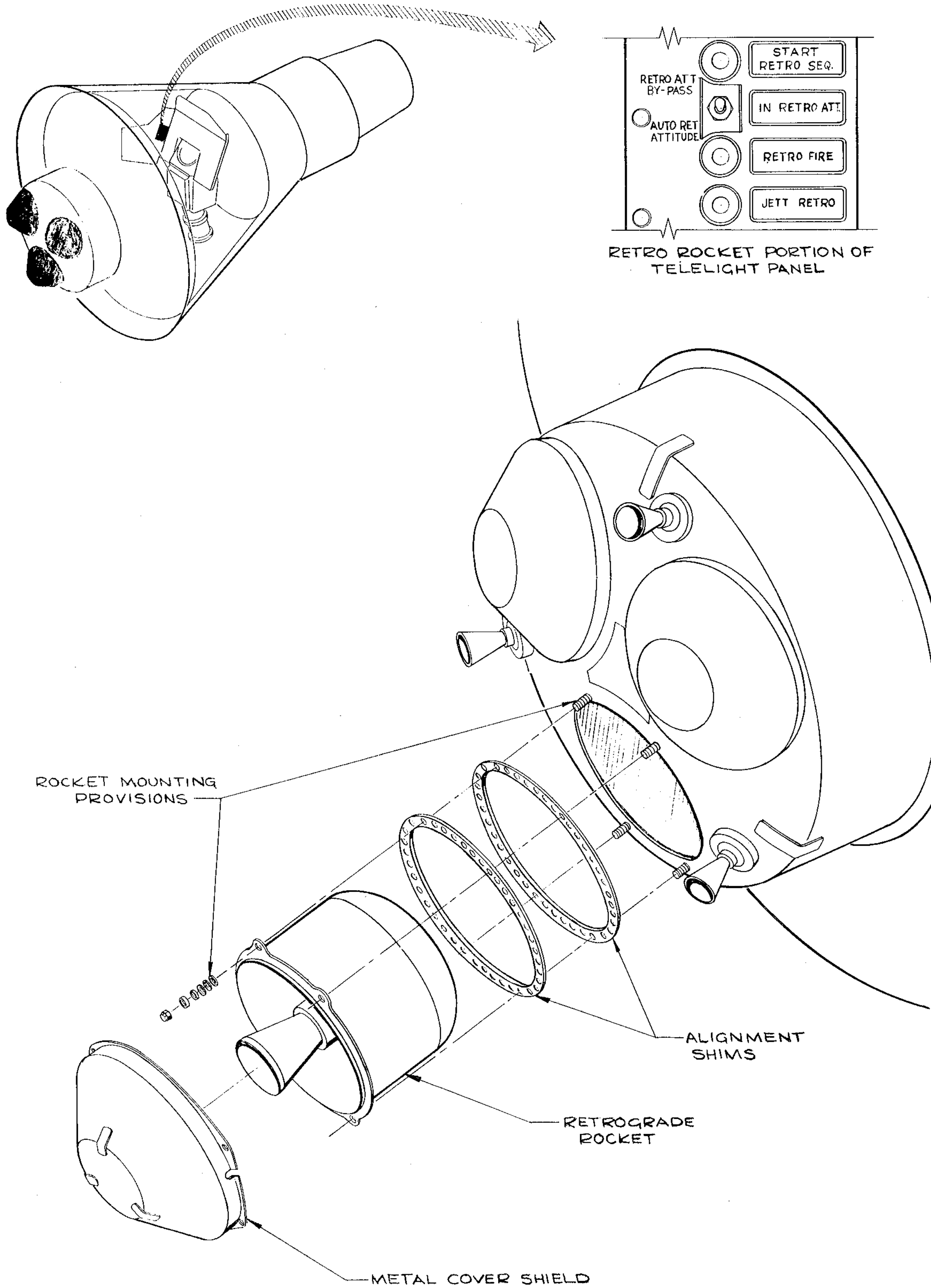


FIGURE 8-1 RETROGRADE ROCKET SYSTEM

PM45-68

VIII. RETROGRADE ROCKET SYSTEM

8-1. SYSTEM DESCRIPTION

The retrograde rocket system consists primarily of the three retro-rockets, their igniters, and the associated wiring necessary for rocket ignition. The retro-rockets are housed in the jettisonable retrograde package along with the posigrade rockets. See Figure 8-1.

8-2. SYSTEM OPERATION

The purpose of the retrograde rocket system is to slow the capsule prior to re-entry. Actual firing of the rockets is preceded by a 30 second period during which the capsule is positioned to the "retro" attitude. "Retro" attitude is defined as follows: $34^\circ \pm 12.5^\circ$ Pitch, $0^\circ \pm 30^\circ$ Roll or Yaw. The firing sequence will not begin, normally, until the "retro" attitude limits have been attained, and will be temporarily interrupted should the capsule exceed the attitude limits after the sequence has begun. Should the need arise, however, the above limits may be manually over-ridden. Firing of the rockets, which occurs at five second intervals can be initiated by any of the following: (1) Satellite clock runout; (2) Astronaut selection; (3) Ground command. Any one of the rockets will effect a satisfactory re-entry in the event the other two fail to fire. Sixty seconds after retro fire, the entire retrograde package is jettisoned.

8-3. RETROGRADE ROCKET

The retrograde rocket, manufactured by Thiokol Chemical Corporation, is a variation of the Model TE-236. Leading particulars are: weight 66.4 pounds, length 15.4 inches, diameter 12 inches and thrust 1148 pounds. Due to the importance of the retrograde system to the overall mission a redundant rocket firing system has been employed. Dual ignition to all igniters has been provided from separate electrical sources.

8-4. Rocket Mounting

The retro-rockets are mounted in the retro-package which, in turn, is mounted to the capsule by means of three straps joined at the bottom center of the package by an explosive bolt. Sixty-five seconds following No. 1 rocket ignition, the bolt detonates, the straps are released, and a coil spring ejects the package away from the capsule. To protect the rockets, particularly from micro-meteorites, each rocket has a metal cover over its exposed nozzle end. The cover is blown off by rocket blast at time of light-off. Mounting of the rockets is so designed as to direct the resultant thrust vector towards the capsule's predetermined center of gravity at time of firing.

8-5. Rocket Firing

All three rocket fire relays receive 24 V d-c simultaneously, however, the No. 2 and No. 3 rocket fire relays have a five and ten second time delay respectively. Therefore, the following table shows when each rocket receives its fire signal and the length of burning time thereafter. Note that the asterisk indicates time of firing.

```
No. 3 RKT                      *______________________________+

No. 2 RKT           *__________________________+

No. 1 RKT  *_________________+

           1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
                              SECONDS
```

The retro rockets are fired sequentially to avoid the ineffective results from a failure of either of the first two rockets. Consequently, if No. 1 rocket failed to a degree which would disrupt the retro attitude position, the ASCS attitude interlock would remove power from the attitude permission relay and also the No. 2 rocket fire relay. The capsule would be re-positioned by the

ASCS or by the fly-by-wire system and upon regaining the 34° position, the No. 2 rocket fire relay would receive power and fire. The same sequence would occur if the No. 2 rocket were to fail. (See Figure 8-2.)

8-6. Retro Rocket Emergency Override

There are four telelights on the Astronaut's left console which concern the retrograde system. The first one is RETRO SEQ. and is a green function light. This light will illuminate when the retro sequence is started, either by the satellite clock or by the button adjacent to the light. The purpose of the button and light assembly is to initiate re-entry prior to satellite clock run-out or failure of same. (See Figure 8-3.)

8-7. The next two telelights in the retrograde sequence are RETRO ATT. and FIRE RETRO. For a normal flight, the switch adjacent to the RETRO ATT. light should always be in AUTO. The RETRO ATT. light will illuminate green as soon as the capsule reaches the +34° retro attitude position. Forty seconds later the FIRE RETRO telelight should illuminate green. If the RETRO ATT. telelight illuminates red, the Astronaut must check the capsule attitude in order to determine if the capsule is in correct retro fire position. If the capsule is found to be in the correct attitude, then the Astronaut should select the switch adjacent to the RETRO ATT. light to the BY PASS position, and also push the FIRE RETRO button. Ten seconds later the FIRE RETRO light should illuminate green. However, if the Astronaut determined that the capsule was not in the correct position, the fly-by-wire system should be employed in order to correctly position the capsule in the +34° attitude. (See Section IV.) When this is accomplished the RETRO ATT. telelight should illuminate green.

8-8. If the RETRO ATT. telelight illuminates green, but the FIRE RETRO telelight illuminates red, the button adjacent to the FIRE RETRO telelight should

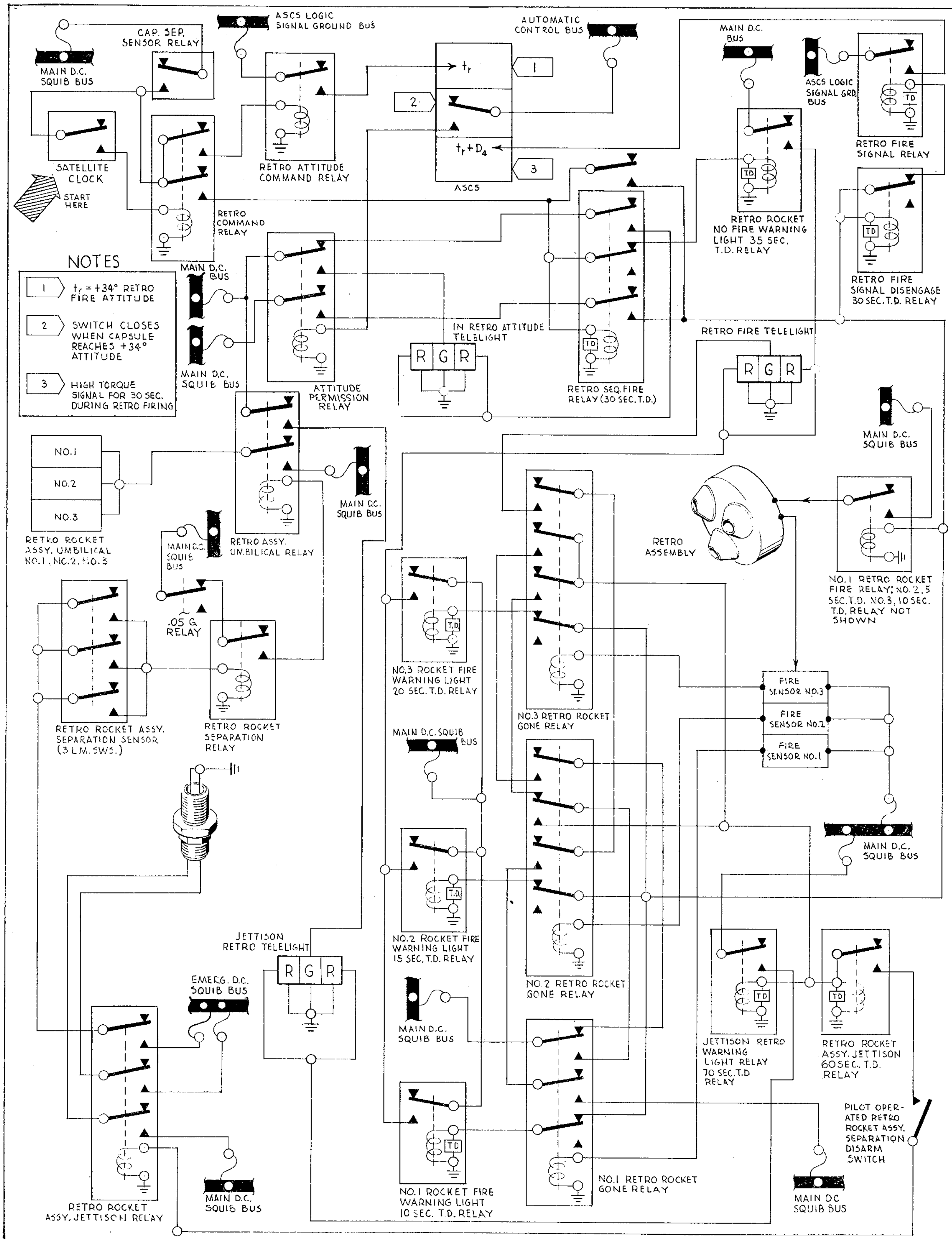
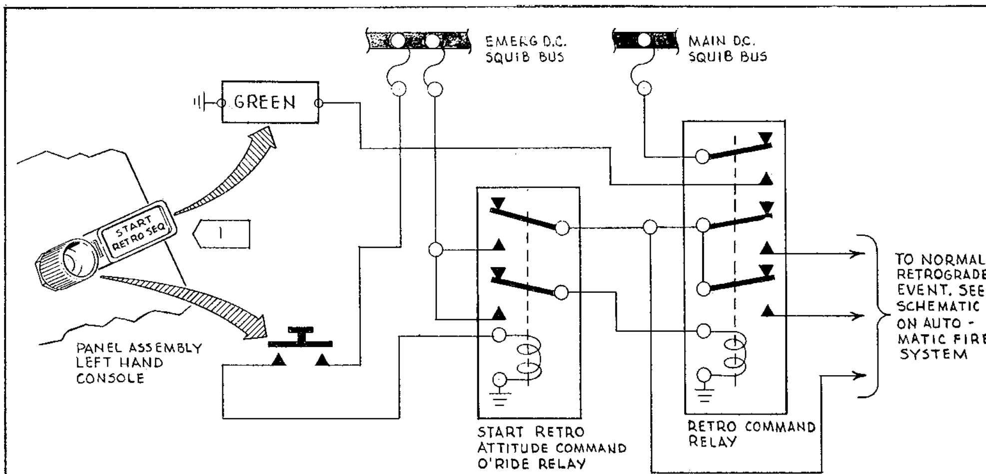


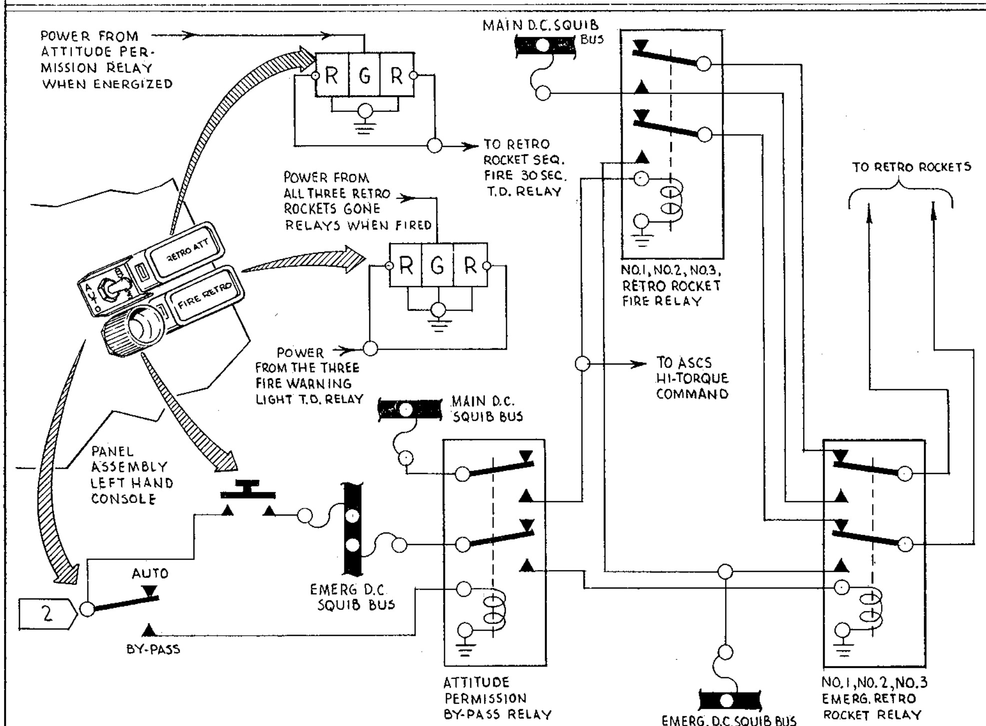
FIGURE 8-2 RETROGRADE ROCKET AUTOMATIC FIRING SYSTEM SCHEMATIC

PM45-70A

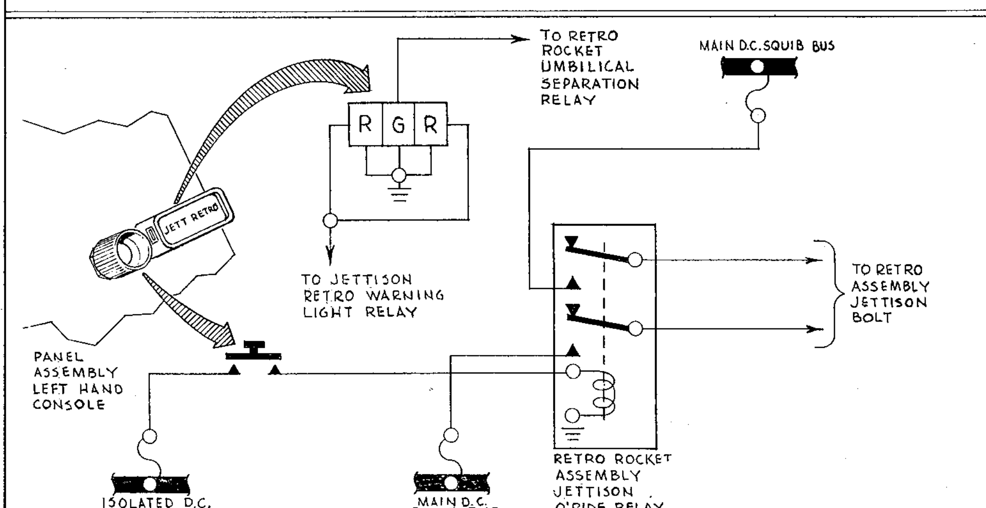


REASON FOR SELECTION

1. FAILURE OF SATELITE CLOCK TO FUNCTION
2. EARLY RE-ENTRY BEFORE CLOCK RUN-OUT



1. THE "RETRO ATTITUDE" LIGHT DOES NOT ILLUMINATE OR ILLUMINATES RED, BUT VISUAL AIDS INDICATE CAPSULE IS IN RETRO ATTITUDE.



1. "JETTISON RETRO" LIGHT ILLUMINATES RED

NOTES

1 GREEN LIGHT ONLY

2 IF THE "RETRO ATT" LIGHT IS GREEN AND "RETRO FIRE" LIGHT ILLUMINATES RED THE "RETRO ATT" SWITCH SHOULD BE LEFT IN THE "AUTO" POSITION AND THE "FIRE RETRO" BUTTON DEPRESSED. CIRCUITRY WILL PASS THROUGH ENERGIZED ATTITUDE PERMISSION RELAY BUT WILL BY-PASS THE 30 SEC. T.D. SEQ. FIRE RELAY.

FIGURE 8-3 RETRO-ROCKET OVERRIDE FIRING SYSTEM SCHEMATIC

PM45-71A

be pushed, leaving the above switch in the AUTO position.

8-9. The fourth telelight is the JETT. RETRO. This telelight will illuminate green 60 seconds after the illumination of the FIRE RETRO telelight. In the event this light illuminates red, the adjacent button should be selected to supply an alternate source of power to the jettison bolt. If the retro package cannot be jettisoned by the automatic or override method it will be ejected sometime during re-entry when the extreme heat encountered will detonate the explosive bolt or burn the retension straps to allow the coil spring to eject the package.

8-10. Retro Package Electrical Wiring

The retro package is electrically supplied through three electrical explosive disconnects that are equally positioned around the base of the capsule. Electrical wire bundles from the disconnects follow the three retrograde package retension straps down to the retro package, where they enter this unit through rubber grommets. From within the package all wiring for the retro rockets, their sensors and heaters are routed back to the outside of the package face and theninto each retro rocket through the slotted metal shield. Posigrade rocket wiring and explosive bolt wiring remain within the package. (See Figure 8-4.)

8-11. Retro Rocket Heaters

The retrograde rockets are equipped with blanket type heaters and temperature sensing devices. If the ambient temperature decreases to $+40^{\circ}$ F, a light will illuminate on the left console indicating to the Astronaut that the retro heater switch must be positioned to ON. With the switch in the ON position, a heater on light will illuminate and the retro rocket cold light will go out as the temperature increases above $+40^{\circ}$ F. While the heater switch is in the

ON position each rocket is individually controlled by another set of thermostats. These thermostats will control the temperature between $+49° \pm 4°$ F. and $60° \pm .5°$ F. Therefore, once the Astronaut positions the heater switch to ON, he will not have to monitor the retro rockets for temperature control during the remainder of the mission.

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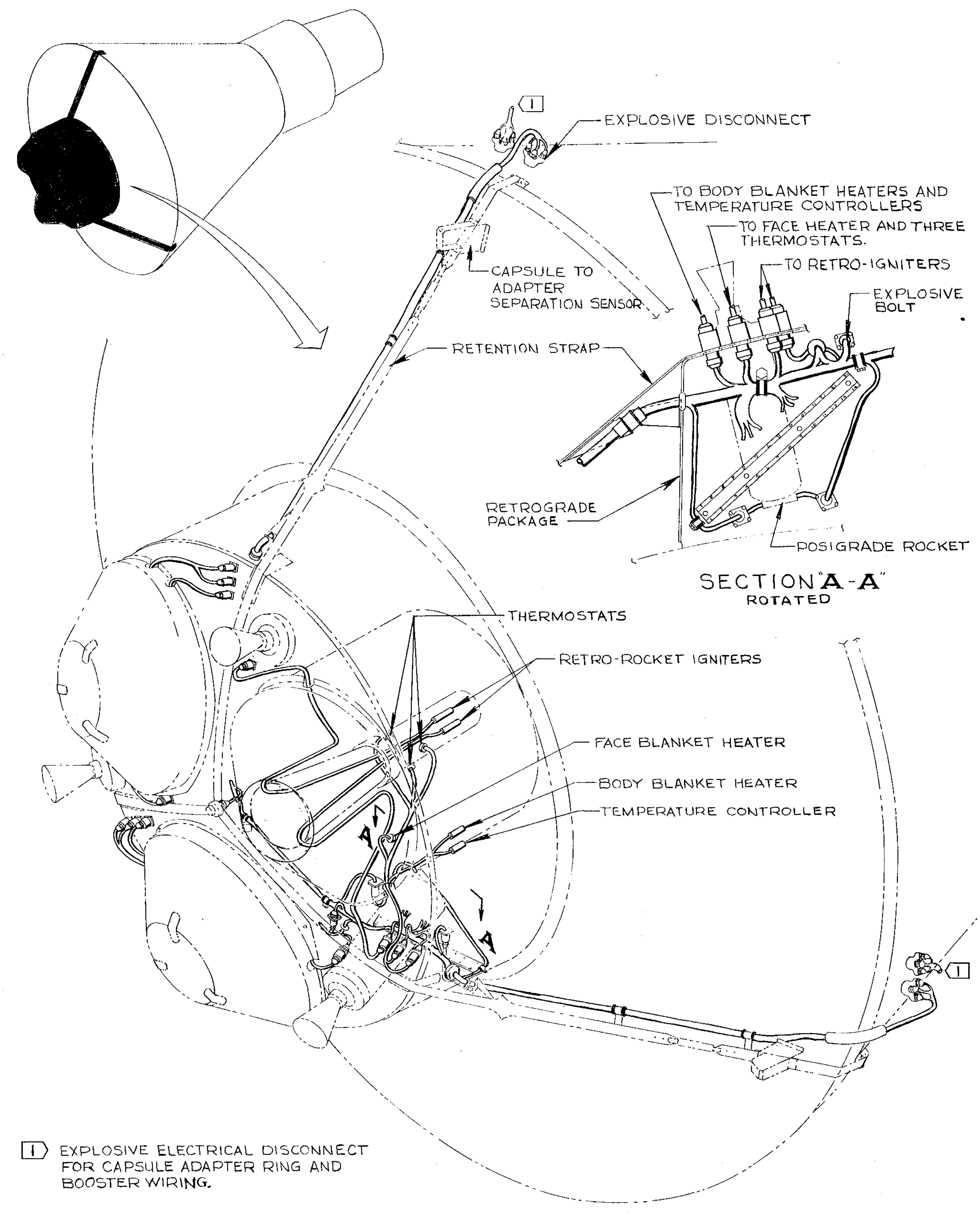

1 EXPLOSIVE ELECTRICAL DISCONNECT FOR CAPSULE ADAPTER RING AND BOOSTER WIRING.

FIGURE 8-4 RETRO PACKAGE ELECTRICAL INSTALLATION

PM45-73

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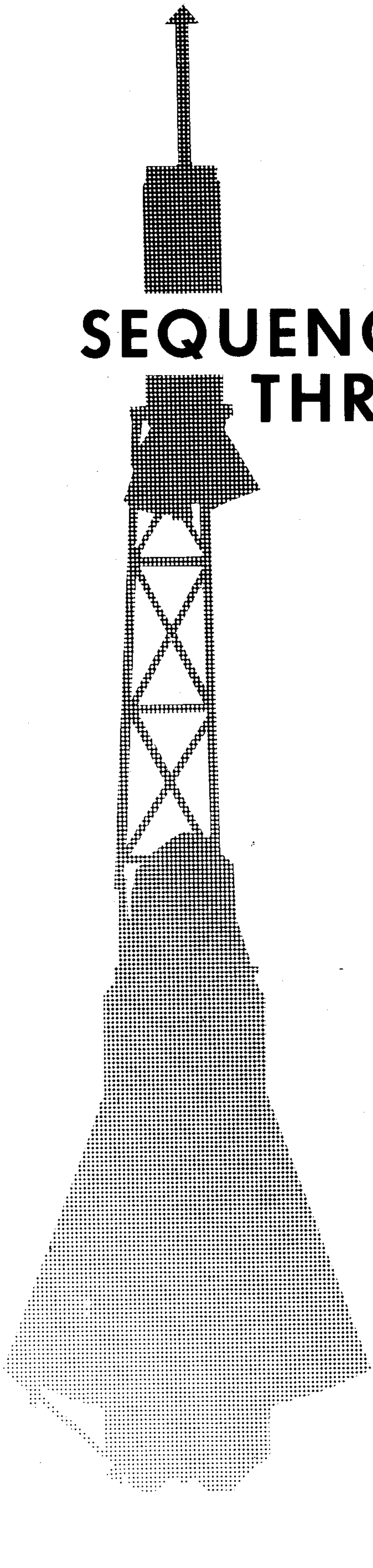

SECTION IX

SEQUENCE SYSTEM LANDING THROUGH RECOVERY

TABLE OF CONTENTS

DESCRIPTION **PAGE**

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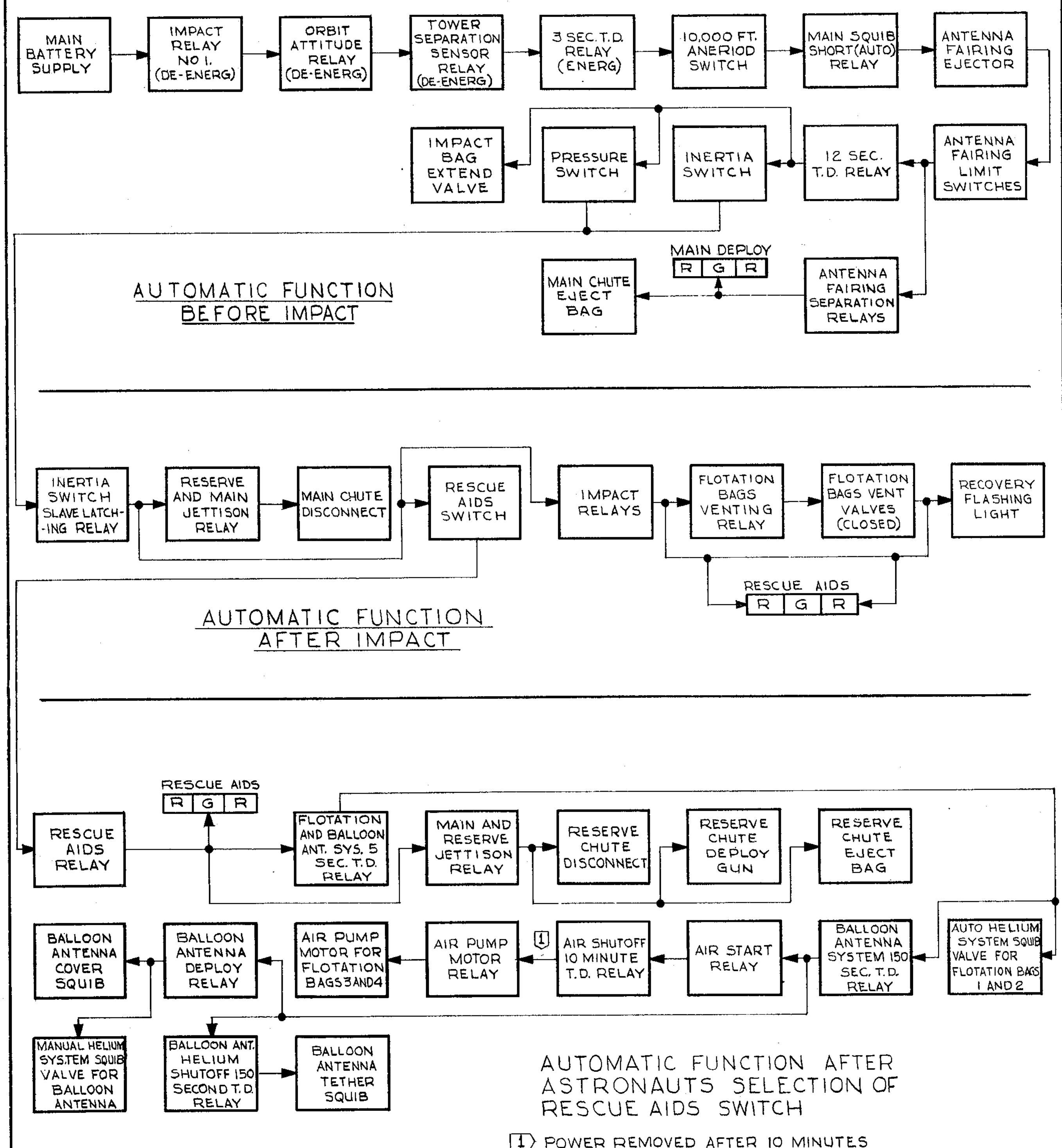

FIGURE 9-1 LANDING AND RECOVERY SYSTEM BLOCK DIAGRAM

PM45-134A

IX. SEQUENCE SYSTEM LANDING THROUGH RECOVERY

9-1. AUTOMATIC SEQUENCE

9-2. Description

The landing and recovery sequence system provides automatic electrical sequencing to land the capsule safely after an abort or after re-entry, and to initiate locating aids for assistance in the subsequent recovery. Capsule landing is accomplished by a 63 foot diameter parachute which is deployed at 10,000 feet. This is referred to as the main chute. In the event of a main chute failure, a 63 foot diameter reserve chute may be deployed by Astronaut manual selection. Both main and reserve chutes are reefed to limit shock loads at initial opening. Automatically, the reefing line is severed after a predetermined time delay and the chute will open fully lowering the capsule at the prescribed landing speed. Twelve seconds after main chute deployment the landing impact bag starts to inflate, providing a cushioning effect for the landing impact. At time of impact the main chute is automatically disconnected and the reserve chute ejected along with one sofar bomb and a water dye packet. The Astronaut may then egress through the recovery compartment taking with him the survival kit which contains a life raft among other survival aids.

9-3. Operation (See Figure 9-1)

The capsule's landing system is armed by 28 volt d-c power at time of escape tower separation. Both isolated and main battery power circuits are applied through the de-energized impact relay No. 1 located in the No. 1 recovery relay box, through the de-energized No. 2 and No. 3 orbit attitude relays and the de-energized No. 2 and No. 3 tower separation sensor relays located in the No. 3 launch and orbit relay box, to the two 3 second time delay relays located in sequence controllers, units A* and B. After the 3 second time delay both relays are energized and complete two separate circuits to the two 10,000 foot aneroid switches. The aneroid switch contacts will be open due to altitude being in excess of 10,000 feet, and therefore the power circuit will stop at the open contacts of the switches. As capsule descent passes through the 10,600 foot level, the two aneroid switches will close causing dual circuits through the small pressure bulkhead disconnects to the system A and B sequence controllers. These two circuits energize a main squib short (auto) relay within each controller unit, resulting in the removal of ground circuits for all four squibs of the antenna fairing ejector. At the same time, and by the same power that energized the relays, power is applied to the pre-grounded circuits of the four antenna fairing squibs through the de-energized main over-ride relay. As the circuits are completed to the four squibs, two other branch circuits are applied to the two antenna fairing separation sensor limit switches. The firing of the four squibs causes the antenna housing to separate from the capsule. A lanyard, connected to the antenna housing and the main chute, extracts the main chute from the main chute compartment. The separation of the housing from the capsule allows two antenna fairing separation sensor limit switches to spring to their actuated position. Through these two double poled, actuated limit switches, three signals are returned, two entering the system A and B sequence controllers where they start two 12 second time delay relays, and the third signal entering the No. 1 recovery relay box whereit energizes the three antenna fairing separation relays. This same signal continues out ot the No. 1 recovery relay box and enters the No. 4 recovery relay box where it energizes the fourth antenna fairing separation relay. Through the energized No. 3 antenna fairing separation relay, in the No. 1 recovery relay box, a 28 V signal is completed to the main deploy telelight, illuminating the light green. The remaining two poles of this same relay are used to remove the closed loop ground circuits of the two main chute eject bag squibs and through their pre-grounded circuits 28 volts is applied to fire both squibs. The firing of the squibs allow the eject bag to be gas inflated and therefore, simultaneously eject the main chute as the chute is being extracted by the antenna fairing lanyard. At the run-out of the two twelve second time delay relays the relay coils are energized causing power to leave each sequence controller and continue to the arming contacts of the inertia switch and impact pressure switch, and also to the squib of the impact bag extend valve. The heat shield will be released and the impact bag will be extended, also the torus bag at base of impact bag will be inflated to 10 psi.

9-4. (See Figure 9-2) At time of landing the inertia switch and/or the pressure switch which are wired in parallel will sense the impact and complete two 28 V signals to the two inertia switch slave latching relays located in system A and B sequence controllers. These two relays when energized will in turn energize the two reserve and main jettison relays in their respective sequence controller boxes. The energized reserve and main jettison relays will fire the two squibs of the main chute disconnect thereby releasing the main chute from the capsule. The reserve chute disconnect will not be fired at this time. The main battery power circuit that energized the system A reserve and main jettison relays through the inertia switch slave relay is now continued out of the system A sequence controller to the No. 1 recovery relay box. This is the first time in the overall sequence that a dual redundant circuit is not provided. This 28 V circuit to the No. 1 recovery relay box passes through this relay box to the No. 2 recovery relay box where it again passesthrough the de-energized air shutoff relay and out of the No. 2 recovery relay box after branching into

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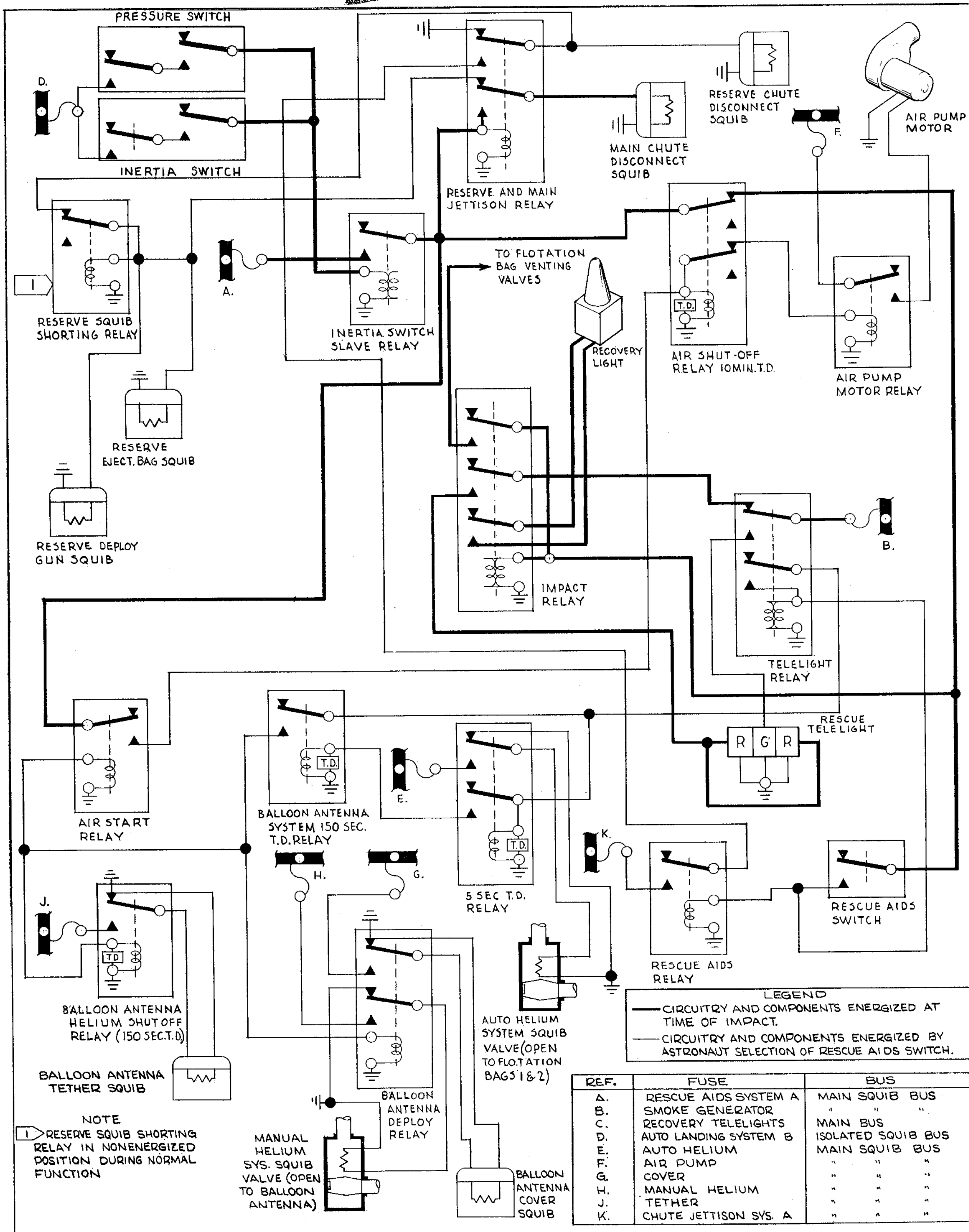


REF.	FUSE	BUS
A.	RESCUE AIDS SYSTEM A	MAIN SQUIB BUS
B.	SMOKE GENERATOR	" " "
C.	RECOVERY TELELIGHTS	MAIN BUS
D.	AUTO LANDING SYSTEM B	ISOLATED SQUIB BUS
E.	AUTO HELIUM	MAIN SQUIB BUS
F.	AIR PUMP	" " "
G.	COVER	" " "
H.	MANUAL HELIUM	" " "
J.	TETHER	" " "
K.	CHUTE JETTISON SYS. A	" " "

FIGURE 9-2 AFTER IMPACT ELECTRICAL SCHEMATIC

two circuits. One circuit is applied directly to the Astronaut's rescue aids switch and the other is returned to the No. 1 recovery relay box where it energizes the four impact relays. Through the energized No. 3 impact relay a 28 V circuit is directed to the coil of the flotation bags venting relay in No. 4 recovery relay box. Through this energized relay main battery power is completed to the eight squibs of the four flotation bag vent valves, resulting in closing the vent valves. Through the energized No. 1 impact relay the self-powered recovery flashing light circuit is closed starting the flashing light to operate. Also, the rescue aids telelight is illuminated red indicating to the Astronaut that the rescue aids switch should be selected to the AUTO position. Through this same relay,power is removed from the two 3 second time delay relays and the main deploy telelight will go out.

9-5. With the selection of the Astronaut's rescue aids switch to AUTO position, a 28 V circuit is completed to the No. 1 recovery relay box where it energizes two rescue aids relays, one of which is a latching type relay. Through the energized latching relay the rescue aids telelight is illuminated green, and the flotation bags and balloon antenna system 5 second time delay relay is energized and starts timing. Through the energized non-latching rescue aids relay main battery power is directed to the system A, energized main and reserve jettison relay and isolated battery power is directed to system B energized main and reserve jettison relay. Both power sources through these two energized relays are completed to the two squibs of the reserve chute disconnect, and also to the two squibs of the reserve chute deploy gun and the two squibs of the reserve chute eject bag. Simultaneously, the reserve chute is disconnected, the reserve chute pilot chute is deployed extracting the reserve chute and the eject bag beneath the reserve chute is inflated forcing the chute out. As the reserve chute leaves its compartment a sofar bomb and dye marker packet are forced out along with the chute. After the run-out of the flotation bags and balloon antenna system 5 second time delay relay, the relay is energized and completes a circuit to the two squibs of the auto system helium squib valve opening the valve, and also another circuit to the balloon antenna system 150 second time delay relay. While the 150 seconds are being timed, the No. 2 and No. 4 flotation bags are being inflated by the auto helium system. At the end of the 150 second time delay a series of events take place starting with energizing the air start relay which in turn energizes a 10 minute time delay relay and also energizes the air pump motor relay, which starts the air pump motor and inflates the No. 1 and No. 3 flotation bags. Also, the balloon antenna deploy relay is energized which results in firing the one balloon antenna cover squib and the two squibs of the manual system helium squib valve. The last event which takes place is the energizing of the balloon antenna helium shutoff 150 second time delay relay. During this latter 150 second delay, the balloon antenna is being inflated by the manual helium system; however, at the run-out of the 150 seconds one tether squib will be fired resulting in releasing the balloon antenna and thereby shutting off the helium system fill line. At the end of the 10 minute time delay, the air pump motor will be shut off.

9-6. EMERGENCY SEQUENCE

9-7. Description

The emergency provisions of the landing system basically consist of a reserve parachute, two gas generators and two emergency tee handles which ignite the gas generators and inititate the electrical sequence. The emergency system is divided into two separate functions which are associated with a manual re-initiation of the antenna fairing and secondly, the deployment of the reserve system.

9-8. Operation (See Figure 9-3)

The telelight labeled MAIN will illuminate red two seconds after the 10,000 foot aneroid switch has closed if the antenna fairing has not separated. Therefore, if the antenna fairing does separate within two seconds after aneroid switch closure, the red light circuit will be dis-armed and the green light circuit will be made. It should also be noted that if a failure were to occur in the dual aneroid switches or in the power supply to the aneroid switches, the red light would not illuminate. In such a condition the tee handle would still be utilized as the Astronaut would be aware of the altitude and the non-existing shock from the main chute deployment. Three events are created by the selection of the tee handle and are: (1) a gas initiator is released sending a charge of gas to the antenna fairing ejector resulting in firing the ejector; (2) Main battery power is available through the switch fuse panel and through the tee handle switch contacts to the system A sequence controller where it energizes the main over-ride relay. The same power circuit that energizes this relay will pass through the energized contacts thereby substituting the normal circuit from the main squib short (auto) relay and aneroid switches. Refer to Paragraph 9-3. The remaining sequence is identical to the normal sequence. (3) Isolated battery power is available through the switch fuse panel and through the tee handle switch contacts to the system B sequence controller where it performs the redundant function to System A sequence controller.

9-9. The RESERVE telelight is actually not a light and only serves to label the adjacent tee handle. Selection of the tee handle will be made only when the Astronaut has determined that the main chute has not deployed. This will be evident by visual inspection through the Astronaut's window or by the absence of the increased G load from main chute deployment. To describe the function of

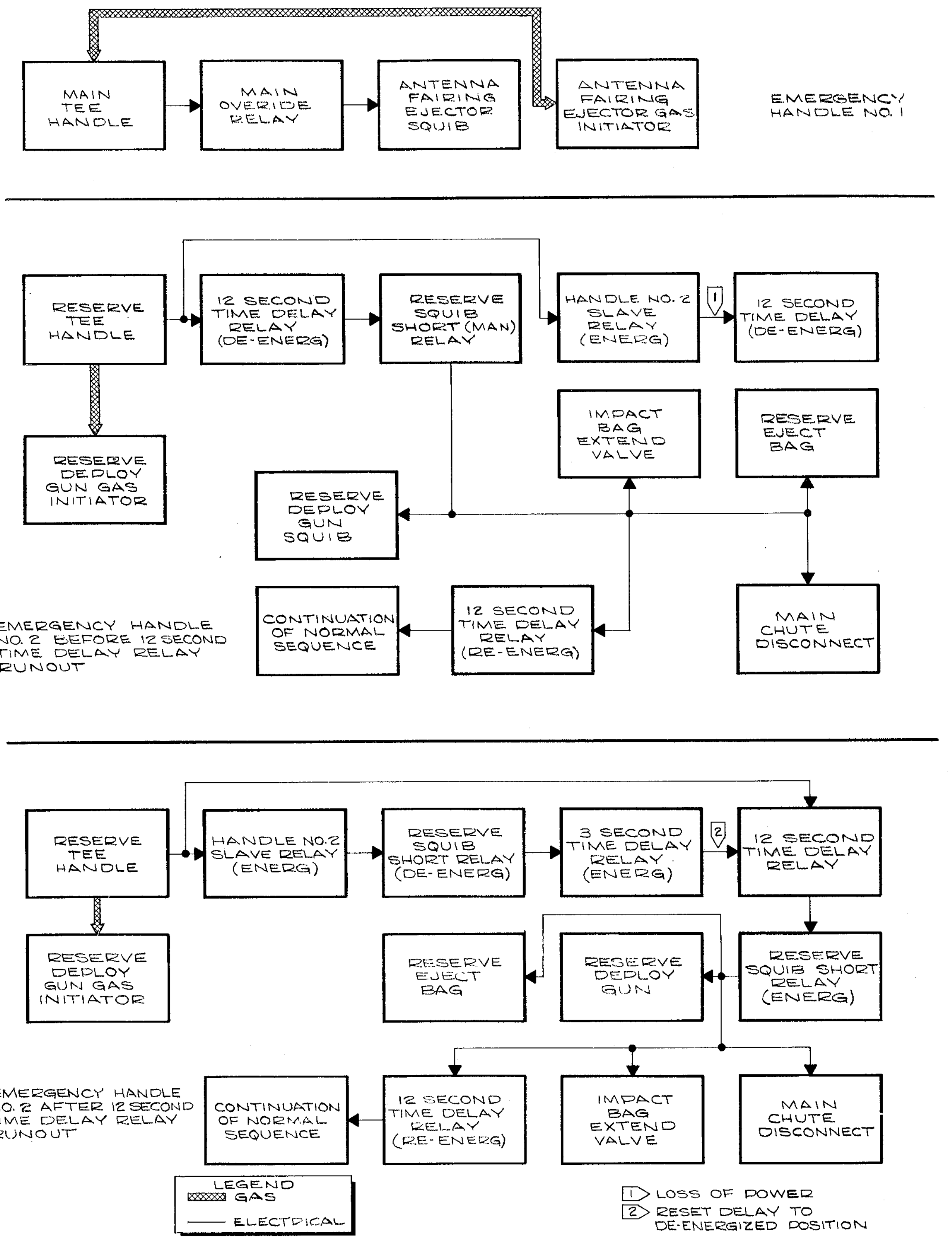


FIGURE 9-3 LANDING AND RECOVERY EMERGENCY SYSTEM BLOCK DIAGRAM

the tee handle it must first be assumed that the antenna fairing has separated either by the automatic sequence or by the first tee handle. If the second tee handle is pulled prior to the 12 second run-out of the 12 second time delay, which was started at antenna fairing separation, the relay and its timing device will be stopped. However, if the 12 second time delay has run-out, a power signal will be directed to reset the relay and thereby remove power from the arming contacts of the inertia and pressure switch. (Refer to automatic sequence Paragraph 9-3). This action has been accomplished within both system A and B sequence controllers by main and isolated battery power from the two poles of tee handle switch. Also, within both sequence controllers and by the respective power sources the reserve squib shorting relay is energized. Through the energized contacts of this relay, power will be directed to the reserve deploy gun squib, the reserve eject bag squib and the main chute disconnect squib. Also, the 12 second time delay relay will be re-energized through the energized Handle No. 2 Slave relay. Simultaneously with thetee handle initiated sequence, the reserve deploy gun receives a gas charge from the tee handle operated gas initiator. This provides a redundant firing of the gun. The reserve chute will be extracted from its compartment by the reserve deploy gun and the reserve chute's pilot chute, along with the assistance from the reserve chute eject bag. (See Figure 9-4.) The sofar bomb and dye marker packet will be forced out of the compartment along with the chute; however, the dye marker will be retained by a steel wire lanyard to prevent its loss. At the end of the 12 second time delay run-out, the sequence system will be continued in the same manner as explained under normal operation in Paragraph 9-3.

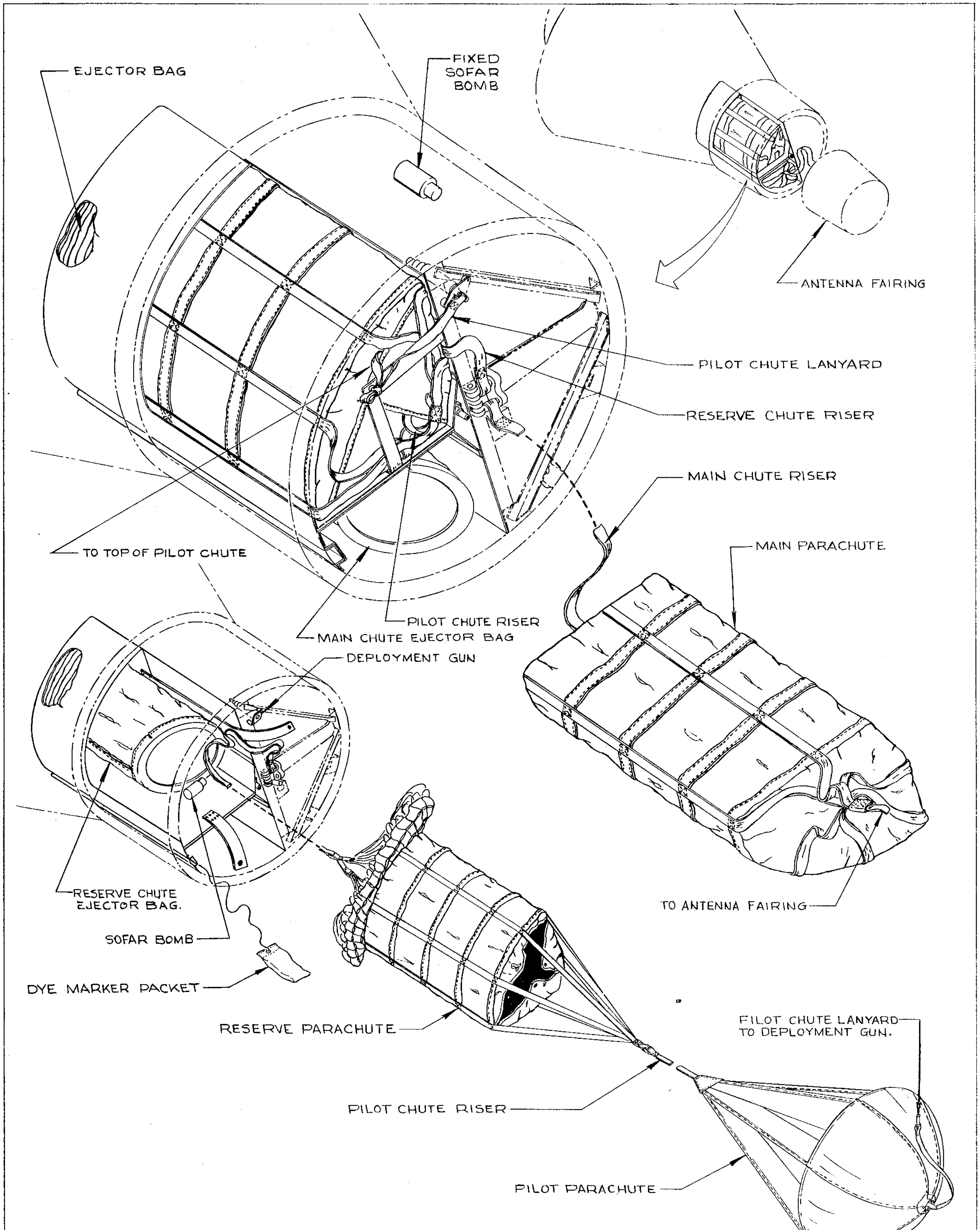


FIGURE 9-4 MAIN AND RESERVE PARACHUTE SYSTEM

PM45-76A

9-10. COMPONENTS (See Figure 9-5.)

9-11. Main Parachute (See Figure 9-6.)

The main parachute assembly consists of: main parachute canopy, riser, deployment bag, and parachute disconnect. The main parachute canopy is a 63 foot nominal diameter ringsail type. The ringsail parachute is a slotted canopy similar in design to the ringslot parachute. The parachute is fabricated from 2.25- and 1.1- ounce per square yard nylon parachute cloth into 48 gores with 48 suspension lines of 550-pound tensile strength. The main parachute is packed in a deployment bag which provides a low snatch force and orderly deployment. The bag is manufactured from cotton sateen fabric, reinforced with nylon webbing and covered at the upper end with Thermoflex and glass cloth insulation. Inside the bag, midway along its length, are a pair of transverse locking flaps. Their function is to separate the canopy fabric from possible entanglement with the lines and to cause full line stretch-out before canopy deployment.

9-12. Parachute Disconnect (See Figure 9-7.)

Both main and reserve parachutes are attached to the capsule by a device designed to sustain the parachute loads during descent and to disconnect the parachute on ground impact. The disconnect function is necessary to prevent capsule upset or damage by dragging in surface winds after touchdown. The assembly consists of 5 separate details installed in a mounting structure which is an integral part of the capsule. The parachute riser is looped around arm which transmits the load to the structure through the piston. The shear pin restrains the piston from any motion tending to displace it. On ground impact, an electrical impulse from the inertia switch and/or pressure switch, reaches the squib cartridge causing it to fire. The gas pressure, thus generated, forces the piston forward into the arm recess, cutting the shear pin in the process.

1. ANTENNA FAIRING EJECTOR GUN
2. PILOT CHUTE DEPLOYMENT GUN
3. PILOT CHUTE
4. SOFAR BOMBS (2)
5. DYE PACKET
6. FLOATATION BAGS (4)
7. RESERVE CHUTE AND BAG
8. EJECTION BAGS (2)
9. GAS GENERATORS (2)
10. INERTIA SWITCH
11. SEQUENCE CONTROLLER BOXES (2)
12. SURVIVAL KIT
13. MAIN CHUTE AND BAG
14. ANEROID SWITCHES (2)
15. ANTENNA LANYARD
16. CHAFF PACKET
17. RECOVERY LIGHT
18. BALLOON ANTENNA
19. PARACHUTE DISCONNECTS (2)

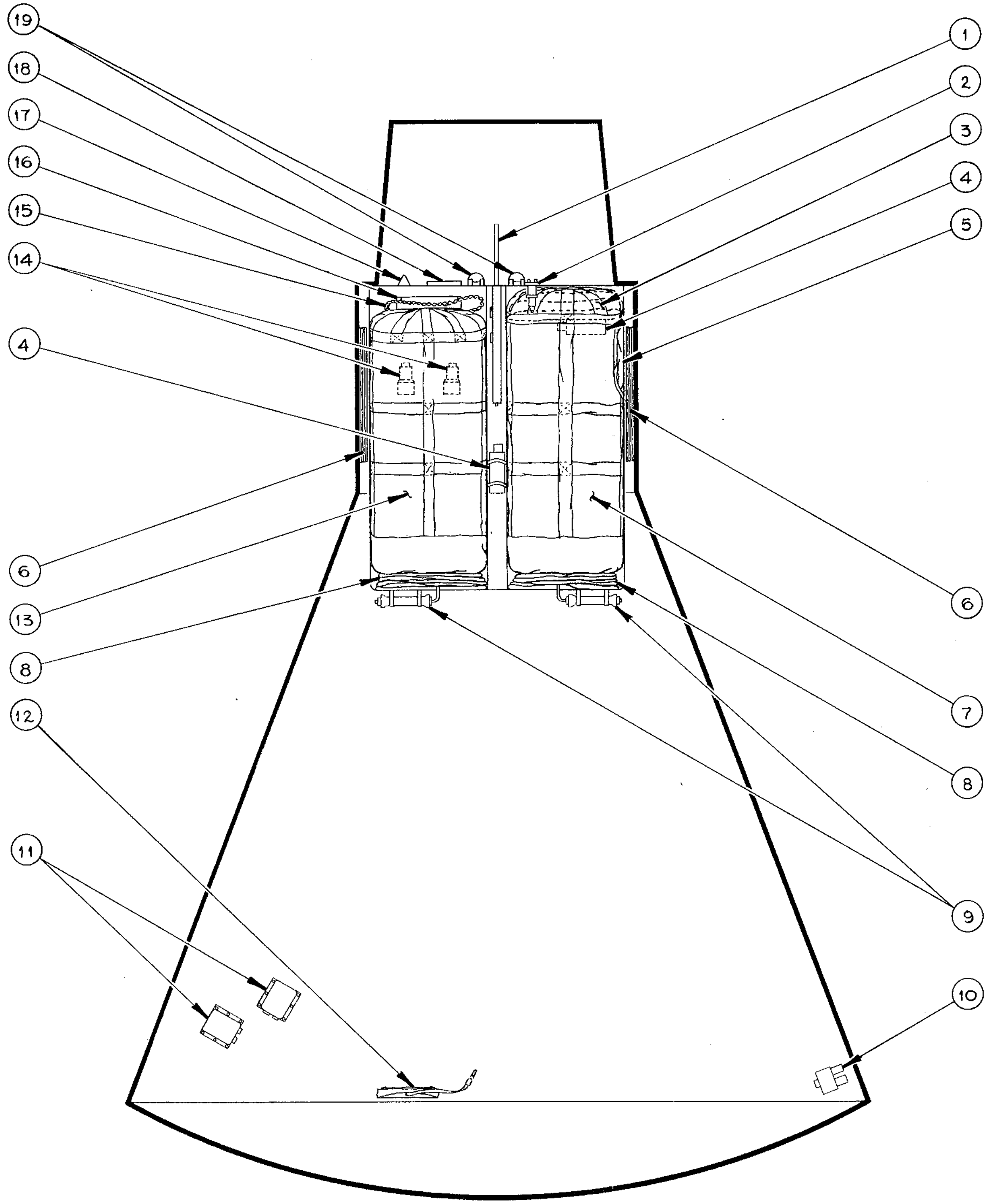


FIGURE 9-5 LANDING AND RECOVERY SYSTEM INSTALLATION

PM45-74A

Full displacement of the piston removes parachute load transmission to structure, allowing the arm to rotate around the pivot pin. The loop of the parachute riser slips off the arm and the disconnect function is complete. The lead buffer serves to absorb energy of moving piston and prevents rebound of the piston back into the locked position.

9-13. Reserve Parachute

The reserve parachute assembly consists of: the pilot chute deployment gun and lanyard, pilot parachute, reserve parachute canopy, reserve parachute deployment bag, and reserve parachute disconnect. The reserve parachute deployment bag is similar to the main parachute deployment bag with the addition of flaps at the upper end of the bag to contain the packed pilot chute. The reserve parachute disconnect is identical to that used to disconnect the main parachute. The reserve parachute canopy is identical to the main parachute canopy.

9-14. Pilot Parachute

The pilot parachute is a springless 6-vane type, 42 inches in diameter. It is manufactured of 3.5-ounce per square yard fabric in the canopy and 2.25-ounce fabric in the vanes.

9-15. Pilot Chute Deployment Gun (See Figure 9-8)

The pilot chute deployment gun initiates the first step in the sequence of reserve parachute deployment. Either gas pressure or an electrical impulse will cause the gun to fire, thus expelling an 8-ounce projectile to which is attached the reserve parachute pilot chute. The pilot chute inflates and in turn pulls out the reserve landing chute, completing the sequence. Whether fired electrically or pneumatically, a one-second time delay is provided between receipt of the impulse and detonation of the main charge. This delay permits the main parachute (if deployed and damaged) to separate from the capsule, to avoid entangle-

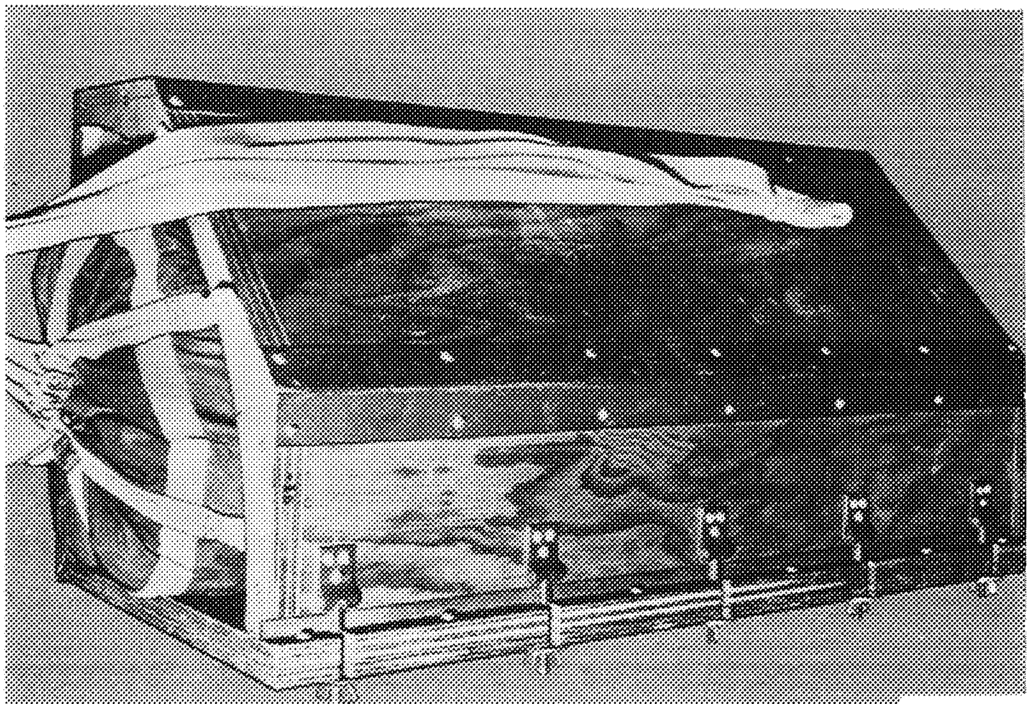
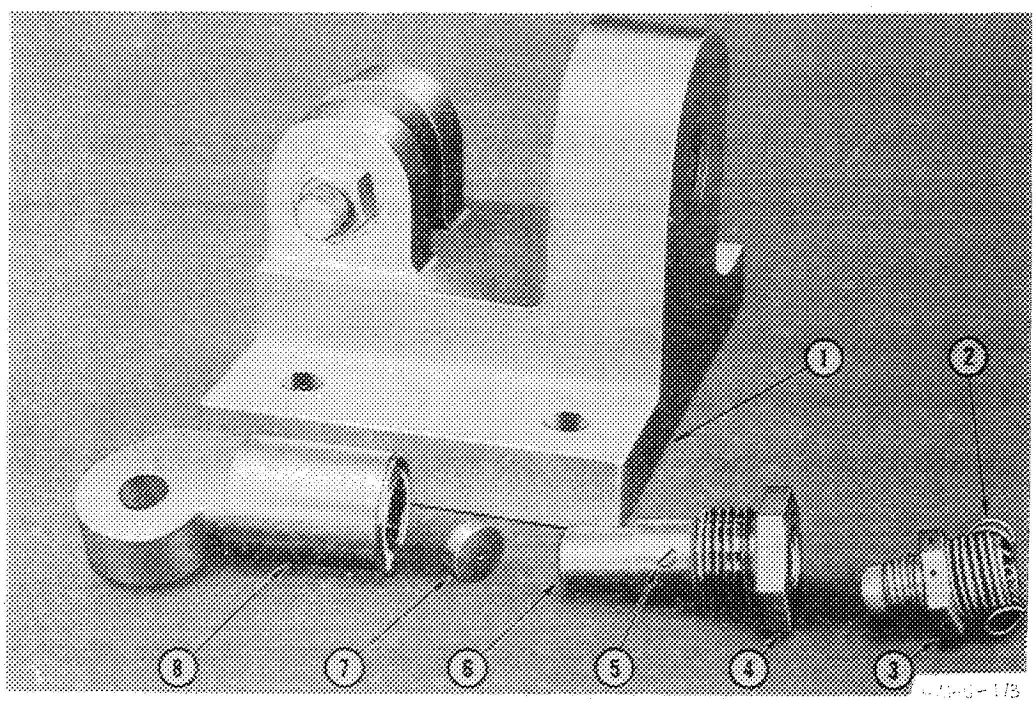


FIGURE 9-6 MAIN PARACHUTE AND PACKING BOX



1. STRUCTURE	5. -11 SHEAR PIN
2. SHORTING WIRE	6. -7 PISTON
3. SQUIB CARTRIDGE	7. LEAD BUFFER
4. -5 BUSHING	8. -3 ARM

FIGURE 9-7 MAIN AND RESERVE CHUTE DISCONNECT

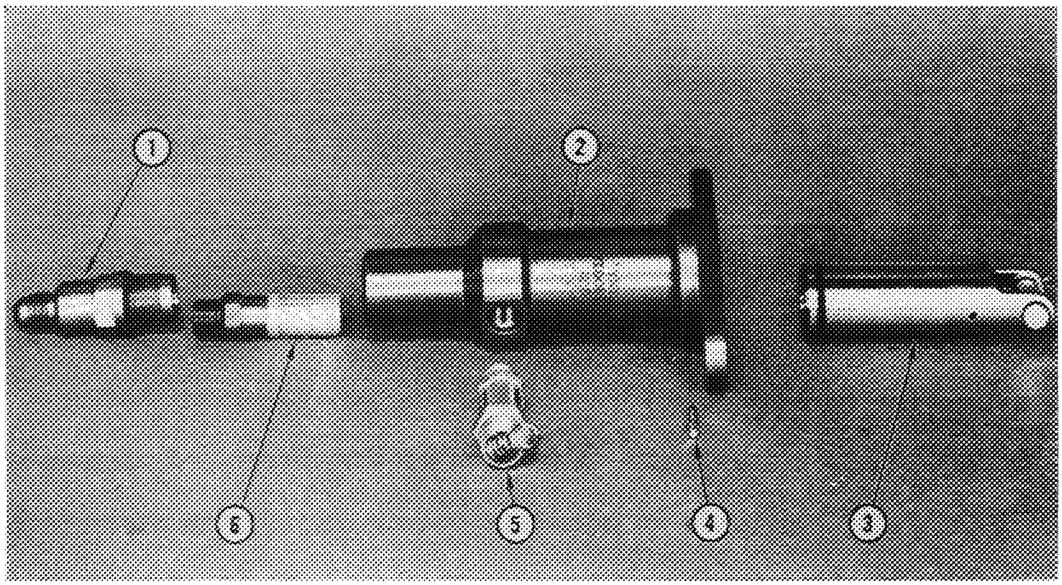
ment with the reserve parachute to be deployed. The gun is basically a tubular body which contains the main firing cartridge and the projectile assembly. The projectile assembly is held in place by a pin which is sheared when the projectile is expelled. The main cartridge, which generates the gas pressure to eject the projectile, is fired as follows: (1) Gas pressure, through the gas firing mechanism (supplied when RESERVE tee handle is pulled), drives a firing pin into the primer lap at the base of the main cartridge, initiating a time delay train, causing a subsequent detonation of the charge. A minimum of 750 psi gas pressure is required for pneumatic operation. (2) An electric impulse is received at the time delay igniter installed through the side of the gun. After a one-second delay, the igniter fires through the wall of the main cartridge and detonates it instantaneously. Firing characteristics of the igniter cartridge are as follows: All Fire Current 2.5 amps per bridge, All Fail Current 0.5 amps per bridge, and Bridge Resistance 2.6 $^{+.4}_{-1.0}$ ohms. The ignition circuit consists of two individual bridges terminating in a 4-pin receptacle which mates with a Bendix PC-06PE-8-4S connector. Muzzle velocity of the projectile is 125-150 ft/sec.

9-16. <u>Parachute Ejector Bags</u> (See Figure 9-9)

The ejector bags are inflatable air cells made of lightweight rubberized nylon fabric. The design inflated shape is that of a cylinder, 11 inches in diameter and approximately 35 inches in height. The upper end of the bag is slanted at full inflation to promote jettison of the parachute pack overboard on landing impact.

9-17. <u>Parachute Ejector Gas Generator</u> (See Figure 9-10)

This is a device to provide a rapid and sufficient volume of gas to inflate the main and reserve parachute ejector bags. The reserve parachute gas genera-



1. FIRING MECHANISM	4. SHEAR PIN
2. BODY	5. ELECTRIC CARTRIDGE
3. PROJECTILE	6. MAIN CARTRIDGE

FIGURE 9-8 PILOT CHUTE DEPLOYMENT GUN

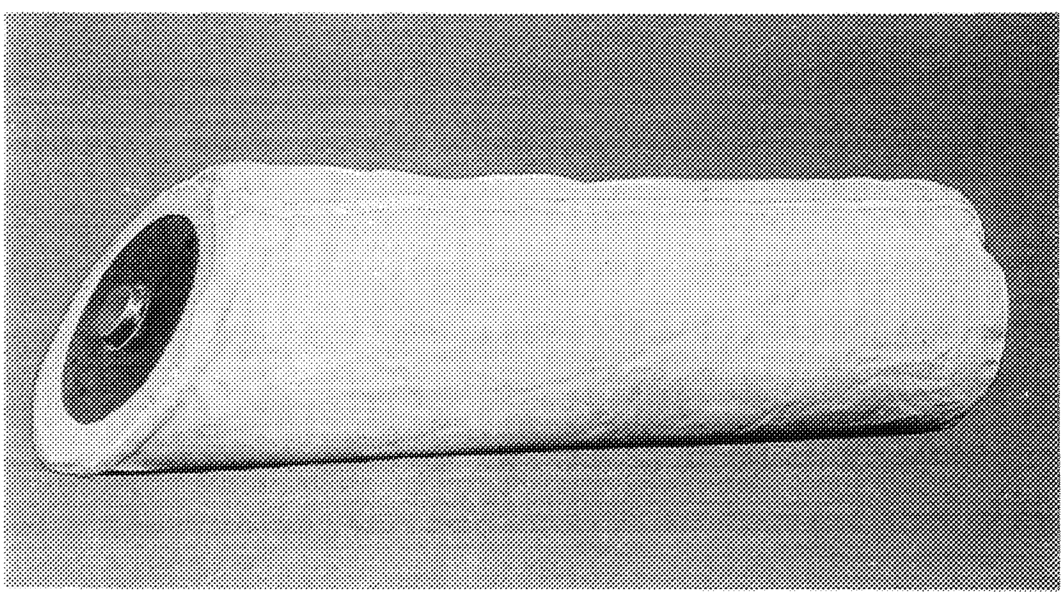


FIGURE 9-9 PARACHUTE EJECTOR BAG

tor is identical to that used for the main parachute with the additional feature of one second delay in ignition time. The generator functions to produce gas by the relatively slow burning of a solid powder propellant in the main chamber The gas is directed from the main chamber into the ejector bags through a 3/8 in. diameter stainless steel tube. The tube serves also as a heat exchanger to reduce temperatures to within tolerable values prior to entry into the ejector bag. The generator body is equipped with lugs for mounting to the parachute container with four (4) AN-3 bolts. Ignition circuit characteristics are as follows: All Fire Current 2.5 amps, All Fail Current 0.5 amps and Resistance (per bridge) 6.5 $\pm$ 1.0..

9-18. Flotation Bags

The flotation bags are inflatable cells of rubberized nylon fabric which will displace approximately 10 cubic feet when fully inflated. The fabrication technique is the simplest possible, which eliminates unnecessary bulk and permits stowage in a compartment of minimum volume. Flotation bags 2 and 4 are filled by remaining helium from the automatic system, while bags 1 and 3 are filled 150 seconds thereafter by a separate air supply system.

9-19. Chaff Packet

The chaffpacket is a locating aid which performs its function by distributing finely divided metal foil having radar reflecting capability. The foil strips act as miniature antennae and are capable of providing an average echo area of 600 square feet, covering the S-, L- and C-band radar frequencies. The package is ejected on deployment of the main parachute. The chaff is packed in a cardboard package of rectangular shape with dimensions approximately 1 x 3 x 5 inches. When jettisoned into the airstream, the package spills open and disperses its contents.

9-20. Sofar Bombs (See Figure 9-11)

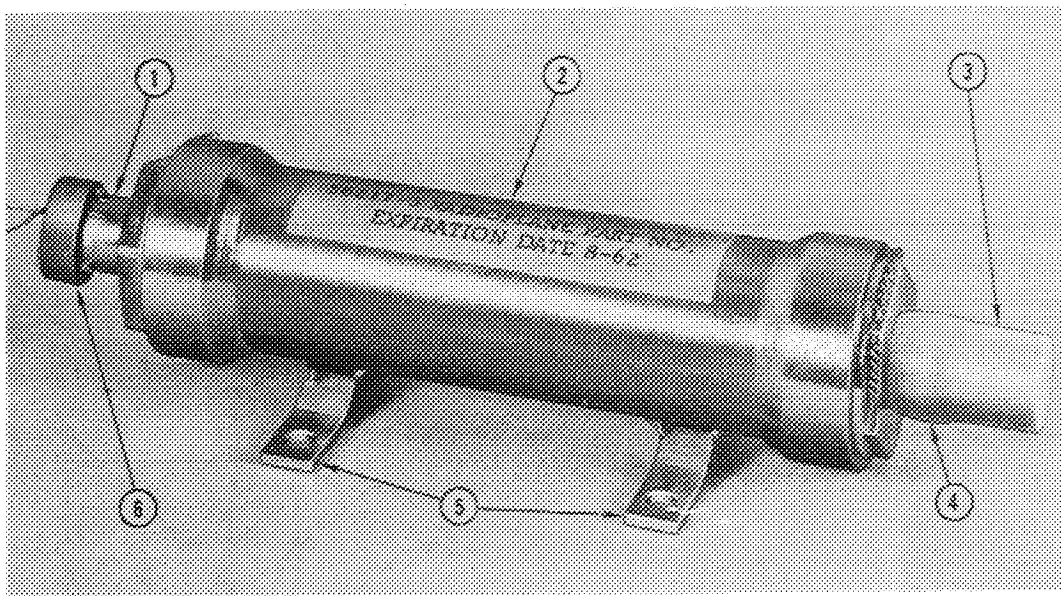
A post-landing recovery aid. SOFAR is an abbreviated form for "sound fixing and ranging". This component performs its function when it detonates by hydrostatic pressure at a predetermined water depth. Shock waves from the explosion are received by sound detection devices aboard picket ships or shore bases and a position fix on the capsule is thus made. The maximum range of the Mercury SOFAR bombs is 3000 miles. Two bombs are carried aboard the capsule; one set to detonate at 4000 feet depth and one set for 3500 feet. The bomb weighs approximately 2 pounds. One 3500 foot bomb is tossed overboard by action of the reserve chute ejection system. The second SOFAR bomb remains with the capsule and only serves to notify the search party that the capsule is sufficiently below the water's surface to render it non-recoverable.(See Figure 9-12 for Operation.)

CAUTION

> The bombs are relatively safe to handle, but it should be remembered that they are high explosive devices and hence common sense precautions should be practiced.

9-21. Dye Marker Packet (See Figure 9-13)

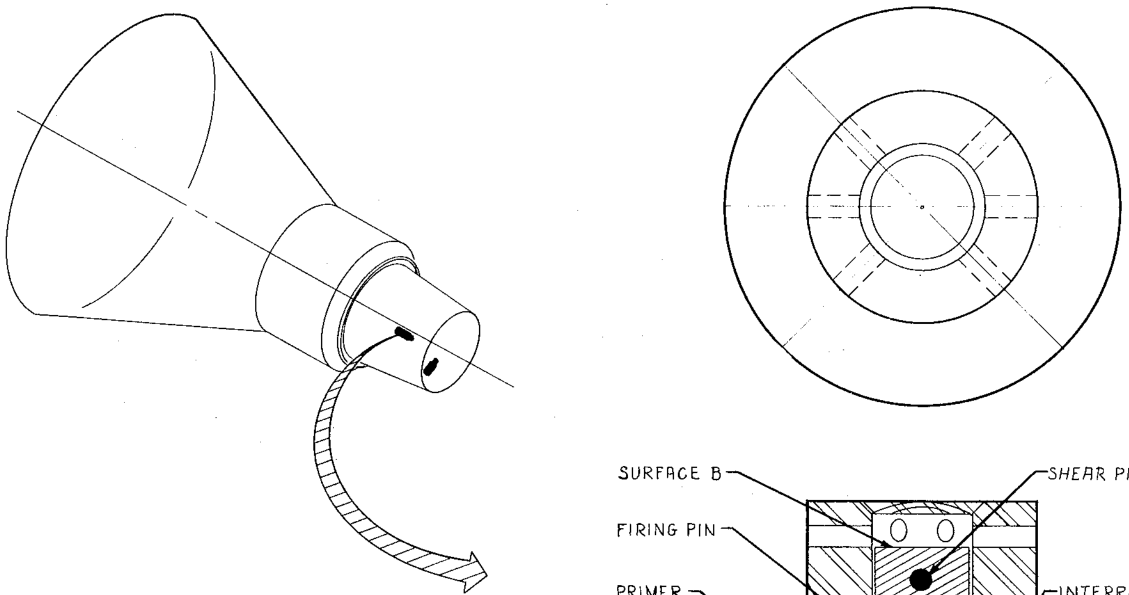
The dye marker packet is a post landing recovery aid which performs its function by dissolving in water, thus producing a highly visible yellow green patch. Approximately 1 pound of fluorescein dye is packed into a nylon cloth bag, which in turn is packed into an outer bag of water soluble plastic. The entire packet assembly is ejected overboard, together with the SOFAR bomb and reserve parachute, at the time of reserve chute ejection. The dye marker packet is tethered to the capsule by a stainless steel cable 1/32-inch in diameter. The fluorescein dye forms a spot on the ocean surface which is visible from an airplane 10,000

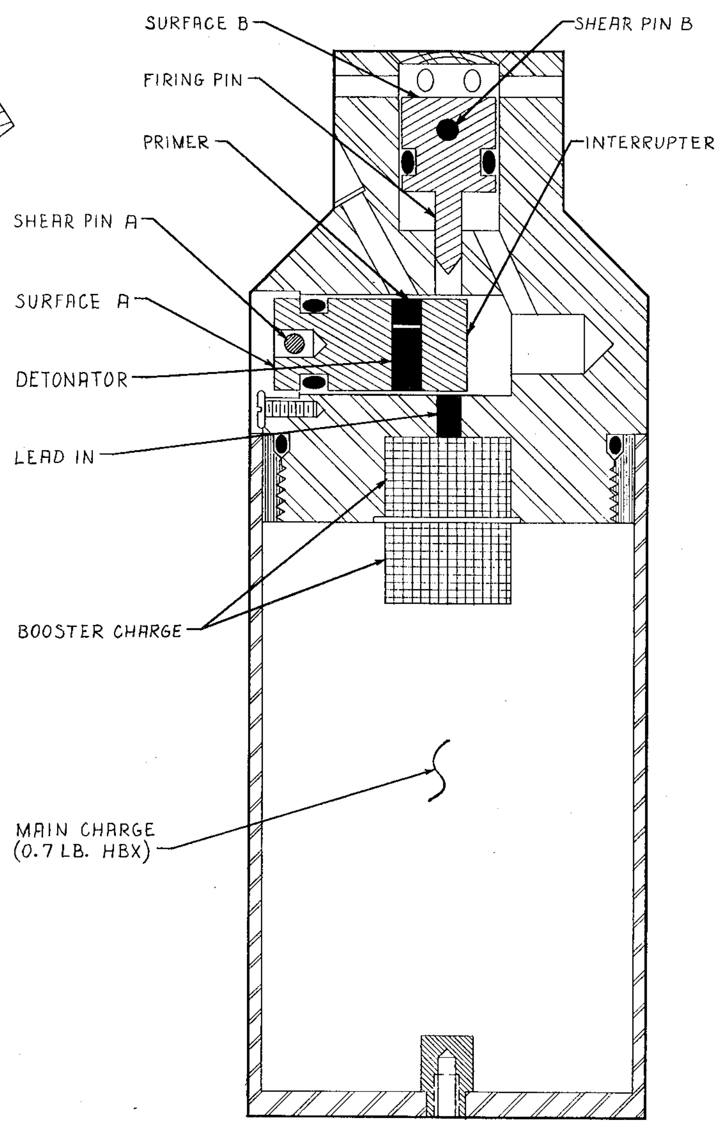


1. ELECTRICAL CONNECTOR	4. TUBE FITTING
2. MAIN CHAMBER	5. ATTACHMENT LUGS
3. PROTECTIVE CAP	6. SHORTING PLUG

FIGURE 9-10 MAIN AND RESERVE CHUTE GAS GENERATOR

FIGURE 9-11 SOFAR BOMB





OPERATION

DETONATION OF THE MAIN CHARGE IS ACCOMPLISHED IN TWO STAGES:

A. WATER PRESSURE ON SURFACE "A" CREATES A FORCE SUFFICIENT TO BREAK SHEAR PIN "A" PERMITTING THE INTERRUPTER BLOCK TO MOVE UPWARD AGAINST THE STOPPING SHOULDER. WHEN IN THIS POSITION, THE PRIMER CHARGE IS IN LINE WITH THE FIRING PIN.

B. WATER PRESSURE ON SURFACE "B" CREATES FORCE TO BREAK SHEAR PIN "B" AND DRIVE THE FIRING PIN INTO THE PRIMER CHARGE. THE PRIMER CHARGE BLASTS INTO THE BOOSTER CHARGE VIA THE LEAD IN ORIFICE, AND THE BOOSTER CHARGE CAUSES THE MAIN CHARGE TO DETONATE. STRENGTH OF SHEAR PIN "B" IS PREDETERMINED FOR DESIRED DETONATION DEPTH. STRENGTH OF SHEAR PIN "A" IS SUCH THAT IT WILL SHEAR AT A DEPTH OF APPROXIMATELY ONE HALF THE DEPTH REQUIRED TO SHEAR PIN "B".

FIGURE 9-12 SOFAR BOMB SCHEMATIC

PM45-166

feet high at a distance of 10 miles on a clear day. The dye solution will remain in one patch for at least three hours in calm water and $1\frac{1}{2}$ hours in rough water.

CAUTION

The dye market package should be stored in a dry place and not be exposed to water in any way.

9-22. Recovery Light

To aid in the visual location of the capsule after landing, a flashing light is installed in the recovery compartment. The intensity of the light is such that it will be visible in normal darkness for 50 nautical miles and up to 12,000 feet altitude. The flashing rate is approximately 15 flashes per minute. Powered by self-contained, dry cell batteries, the light's circuit will be closed through an energized impact relay, which will be energized by the inertia switch or pressure switch upon impact. The light will operate for approximately 28 hours.

9-23. Balloon Antenna

To provide operation of the HF voice receiver-transmitter and HF recovery beacon, a balloon type antenna is used. The balloon is stowed in a collapsed condition in its recovery compartment container and when inflated is approximately 6 feet long, 3 feet in diameter and has 3 fins for stabilization. The balloon will suspend 30 feet of antenna wire above the capsule and due to its teardrop design, will limit the drift to a 60° cone under conditions up to and including a 30 K. wind. The manual helium system squib valve will be fired upon 155 seconds after the rescue aids button has been selected allowing the balloon to start filling. At the same time the balloon cover squib is also fired,

FIGURE 9-13 DYE MARKER PACKET

releasing the cover. 150 seconds after the balloon has started to fill, a squib fire signal is sent to the tether squib, which has been restricting the balloon until completely filled, and releases the balloon and antenna wire.

9-24. Survival Kit (See Figure 9-14)

The survival kit is stowed in the pressurized section of the capsule and is conveniently accessible to the Astronaut. A strap with a latch type hook is attached to the kit and will be used by the Astronaut for connecting the survival kit to the pressure suit when starting to egress. For items contained within the kit, see Figure 9-14.

9-25. Sequence Controller Assembly (See Figure 9-15)

There are two landing and recovery system sequence controllers located within the pressurized section of the capsule. These sequence controllers in conjunction with three relay boxes accomplish all the system sequencing and provide other capsule systems with initial commands. The two controller assemblies are identical in design and content; and therefore provide for a completely redundant system if one controller assembly developed a failure.

9-26. Baroswitches (See Figure 9-16)

There are one pair of baroswitches used in the recovery system. Each baroswitch directs a power signal to the redundant sequence controllers. In these baroswitches, an over-center spring is included in the design to minimize chatter during vibration and shock and to prevent contact oscillation. Both baroswitches are set to close at 10,600 $\pm$ 750 feet. The switches are located in the recovery compartment where they are connected to a plenum chamber. The plenum chamber collects ambient air pressure through four static pressure ports equally located around the recovery compartments outer surface .

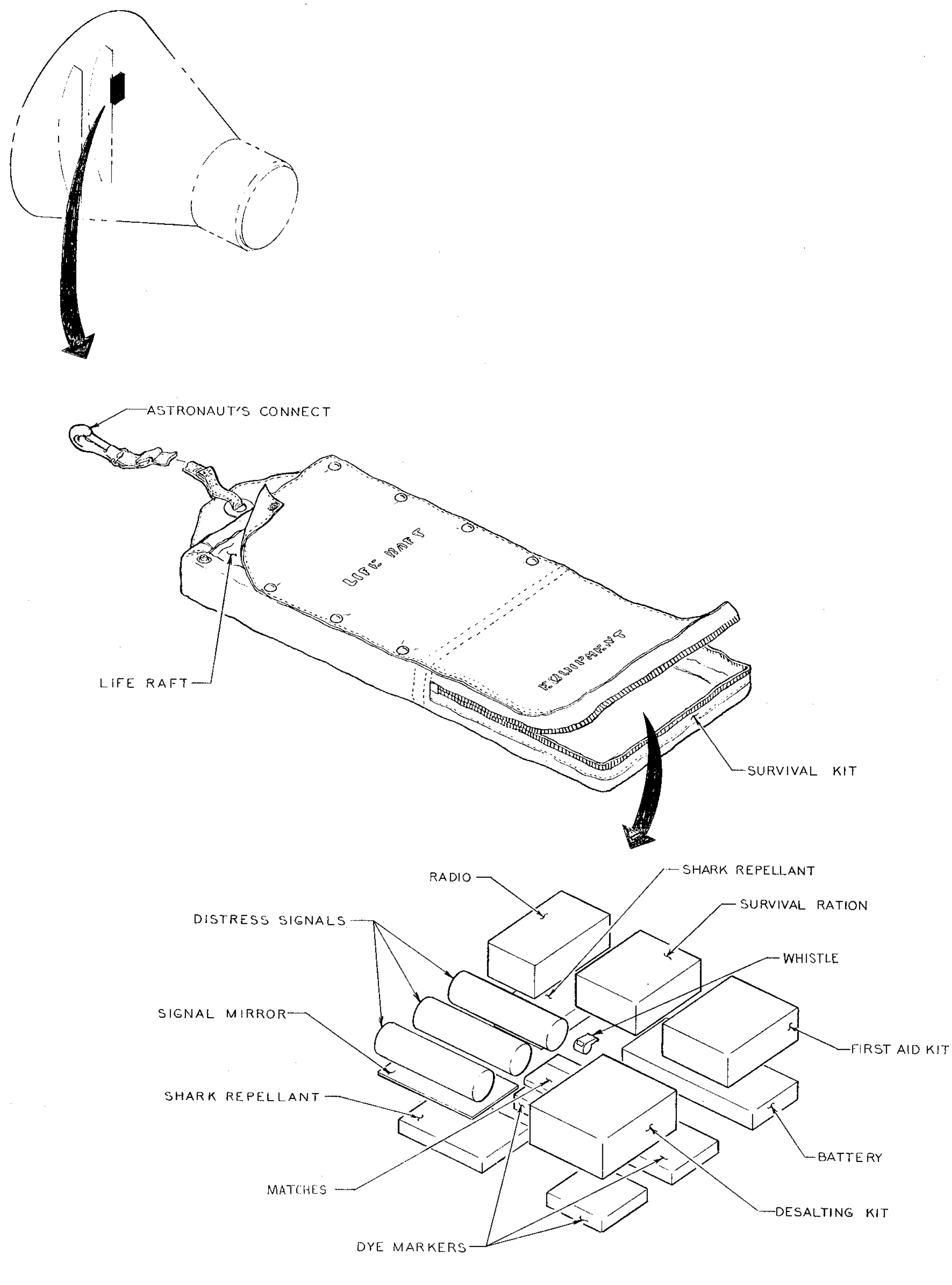


FIGURE 9-14 SURVIVAL KIT

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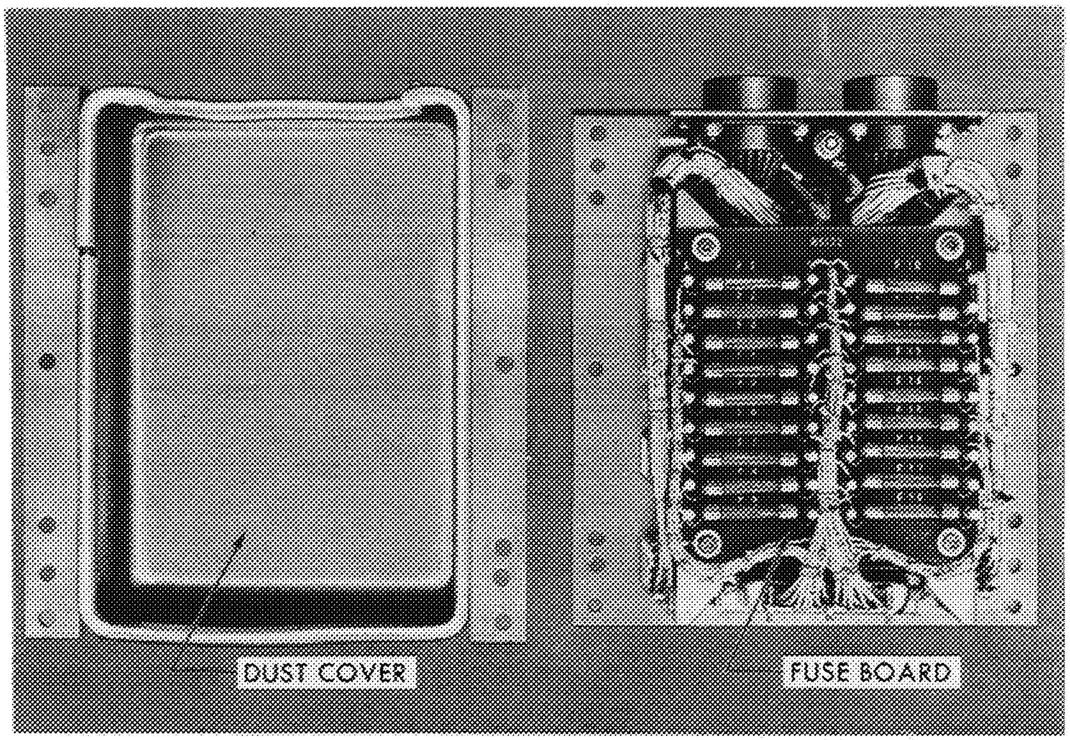


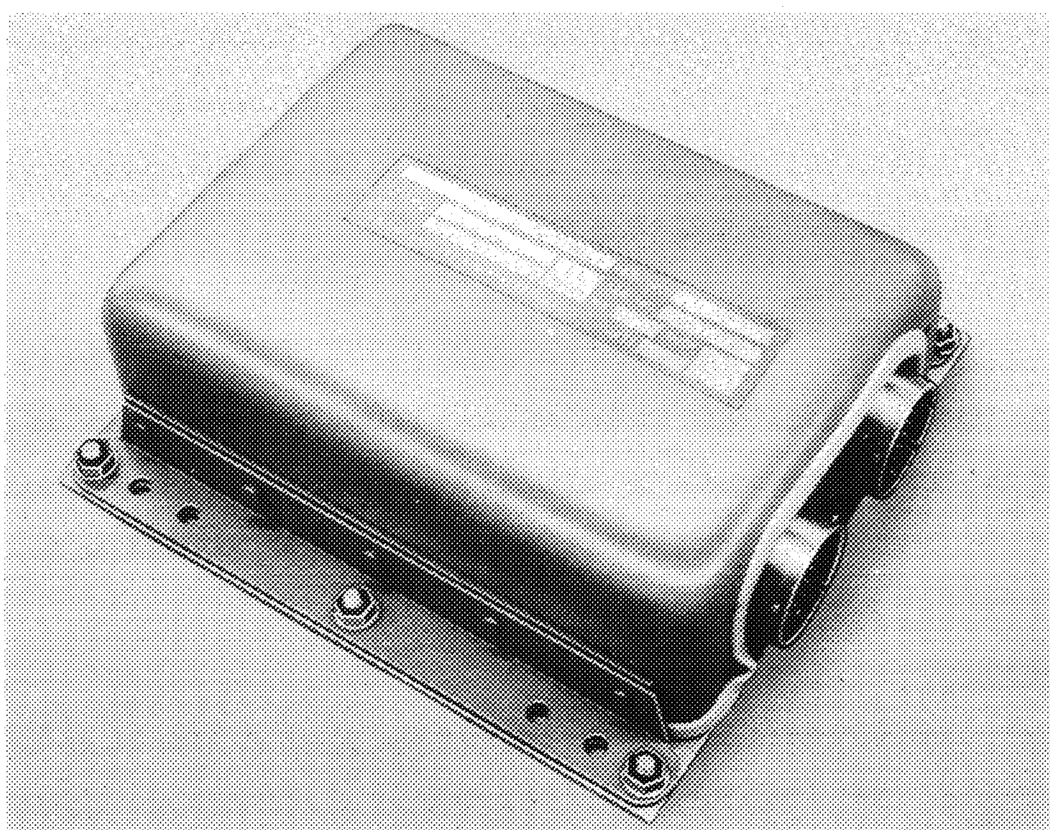


FIGURE 9-15 SEQUENCE CONTROLLER SYSTEM A AND B

9-27. Inertia Switch (See Figure 9-17)

The inertia switch is essentially a spring device actuated by mass. A landing shock of $6\frac{1}{2}$ plus 1 minus $\frac{1}{2}$g's minimum will produce momentary closing of two electrical contacts, thus completing an electrical circuit. This switch is used in conjunction with a latching relay which receives an electrical pulse and, by latching into a latched position, provides continuous electrical continuity. The inertia switches used consist of four separate snap-action switches and two separate masses, all housed in a common case.

9-28. TEST CONFIGURATION NO. 2 CAPSULE

9-29. General

As a result of mission diversification and design changes the landing and recovery system of capsule No. 2 is sufficiently different from the Specification Compliance capsules. The major differences consist of a 42,000 foot deployed drogue chute and the use of a force sensor to detect main chute failure. All components and sequencing which are not identical to the Specification Compliance capsule are discussed in the following paragraphs.

9-30. AUTOMATIC SEQUENCE

9-31. Description

Same as Specification Compliance except as shown below. A force sensor is used in lieu of the RESERVE tee handle to initiate deployment of the reserve chute. A drogue chute is used to stabilize capsule descent from 42,000 feet to 10,000 feet.

9-32. Operation

The capsule's landing system is armed by 28 volt d-c power at time of escape tower separation. Both isolated and main battery power circuits are applied

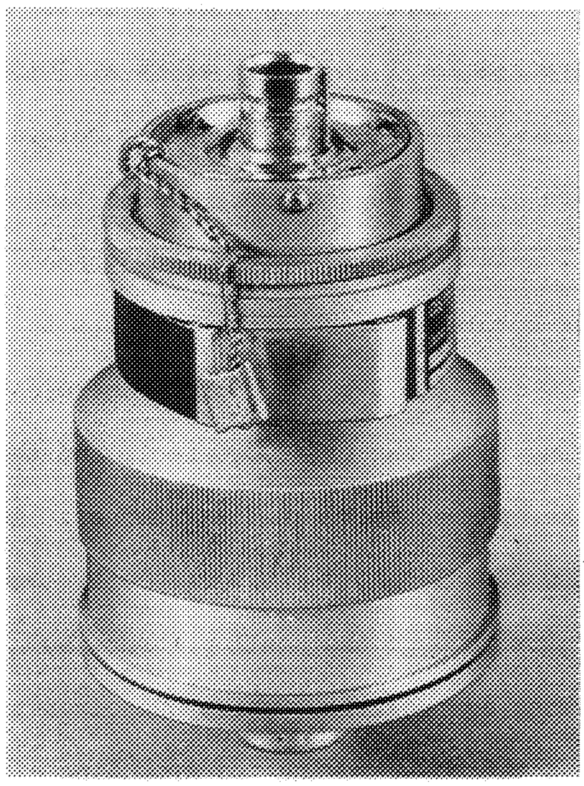


FIGURE 9-16 ANEROID SWITCH

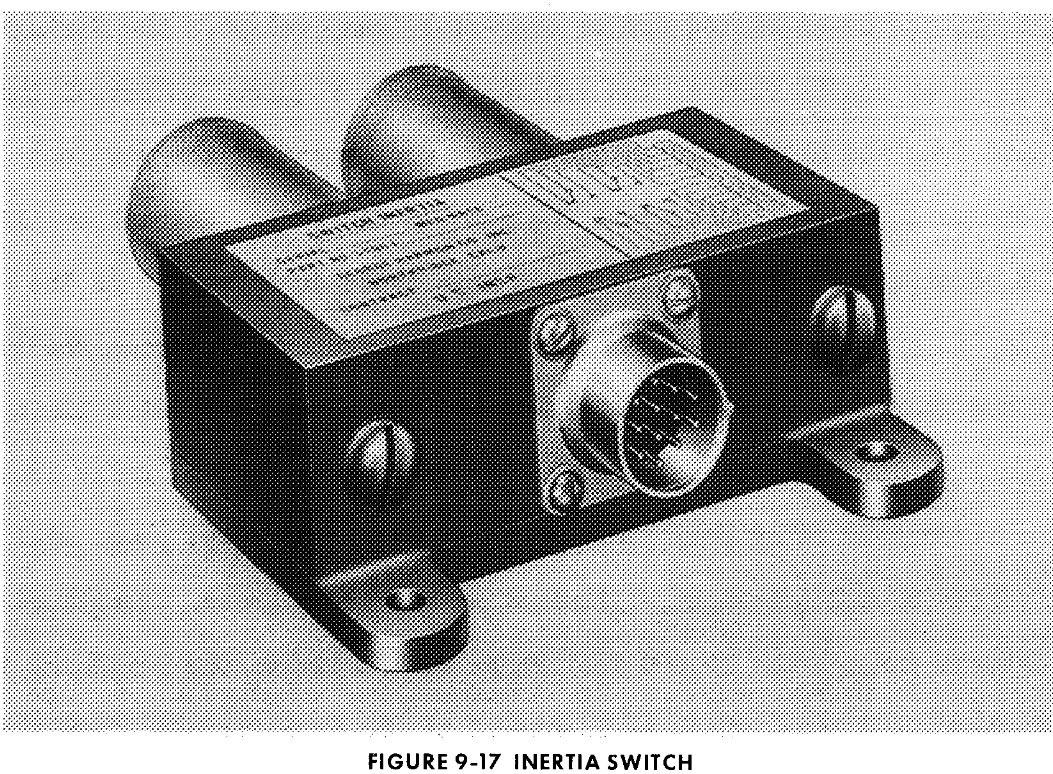


FIGURE 9-17 INERTIA SWITCH

through the de-energized No. 1 impact relay located in the No. 1 recovery relay box, through the de-energized No. 2 and No. 3 orbit attitude relays and the de-energized No. 2 and No. 3 tower separation sensor relays located in the No. 3 Launch and Orbit relay box, to the two 3 second time delay relays located in sequence controllers, units A and B. After the 3 second time delay, both relays are energized and complete two separate circuits to the four aneroid switches. The two 42,000 foot and two 10,000 foot aneroid switches will be open due to altitude being in excess of 42,000 feet; and therefore the power circuits will stop at the open contacts of the switches. As capsule descent passes through the 42,000 foot level, the two respective aneroid switches will close causing dual circuits through the small pressure bulkhead disconnects to the system A and B sequence controllers. These two circuits energize the drogue squib short (auto) relays thereby removing the grounding circuit from the two squibs of the drogue chute mortar, and completing power circuits to the two squibs through the de-energized drogue over-ride (man) relays. The firing of the drogue mortar squibs creates the explosive power required to propel the drogue chute from the drogue mortar tube. The deployment of the six foot diameter drogue chute will decelerate the capsule and reduce descent oscillations to a permissible rate for subsequent main chute deployment. As the drogue chute is propelled from its mortar tube the chute pack forces the tube cover off and thereby releases a limit switch. Through the actuated limit switch, power is directed to energize the drogue door separation relay located in the No. 1 recovery relay box. Through this energized relay, power will be directed to the DROGUE telelight, illuminating the light green. Continued capsule descent through the 10,000 foot range will activate the remaining landing and recovery sequence, which is identical to the Specification Compliance sequence until after the run-out of the two 12 second time delay relays. (Refer to Paragraph 9-3.) The power circuit which is directed through this energized time delay relay performs an additional function. This additional function is a definite Specification Compliance but limited to un-manned missions only. The additional power circuit from each 12 second time delay relay is directed to the dual force sensor switches. If the main chute has deployed within the 12 second period prior to this signal, then the force sensor switches will be open and the circuit will terminate at the open contacts. The normal sequence would follow per Paragraphs 9-2, 9-3 and 9-4. However, if the main chute were to fail and thereby not apply a load to the force sensor, the sensor switches would remain closed and continue the circuit to the two force sensor hold relays located in the recovery relay box which is in the recovery section. Through these two relays, circuits will be completed to both system A and B sequence controllers where the same function will occur as in Paragraph 9-9 where the function of selecting the RESERVE tee handle after the 12 seconds run-out was discussed. Providing the main chute deployed as expected resulting in non-use of the force sensor, then the remaining landing and recovery sequence will be the same as explained in Paragraphs 9-3, 9-4 and 9-5. The RESCUE switch will be pre-selected to the AUTO position before launch for all un-manned missions.

9-33. EMERGENCY SEQUENCE

9-34. Description

The landing and recovery emergency system of the un-manned capsule No. 2 has only one emergency feature which is the force sensor in the event of main chute failure. There are no ground command receiver signals for either the drogue chute or the antenna fairing.

9-35. Operation

For operation of the force sensor emergency sequence, refer to Paragraph 9-32.

9-36. COMPONENTS

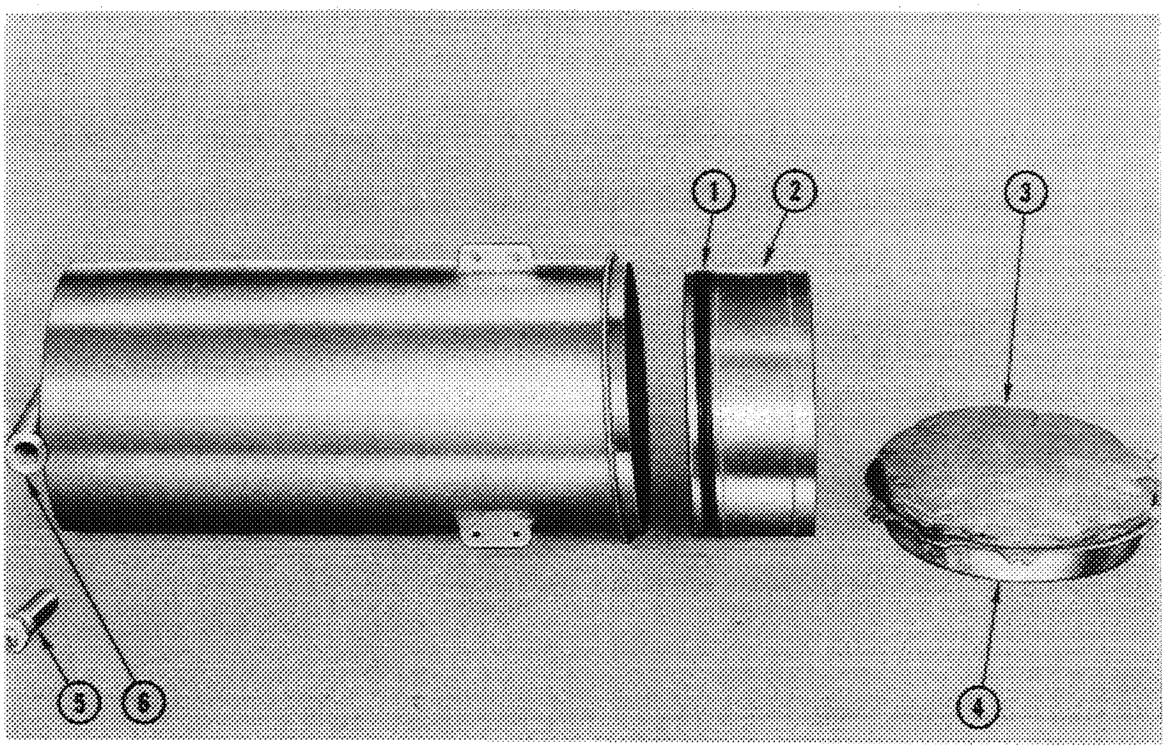
9-37. Drogue Parachute (See Figure 9-18)

The drogue parachute assembly consists of a conical ribbon-type drogue canopy with integral riser, drogue deployment bag, drogue mortar, sabot, chaff packet, and drogue mortar cover. The drogue parachute canopy is a conical ribbon parachute having 8 gores of 2-inch wide, 460-lb. tensile strength ribbons and 8 tubular nylon suspension lines of 100-lb. tensile strength each. The parachute is constructed to a diameter of 6.85 feet and permanently reefed (restricted) to an effective diameter of 6.0 feet by means of pocket bands. The constructed total porosity is 27.9% and the effective porosity (through reefing) is 36.3%. The 30-ft. long integral riser is made from three layers of 300-lb. tensile strength low-elongation hot-stretched Dacron webbing. The drogue parachute stabilizes and decelerates the capsule to an airspeed of 150 knots E.A.S. The canopy weighs 2.9 lbs without riser and 5.9 lbs including the 30-ft. Dacron riser. The drogue parachute deployment bag serves a dual function of (1) protecting the drogue parachute during ejection and (2) providing means for orderly deployment of the drogue parachute. The bag is manufactured of cotton sateen fabric reinforced with nylon webbing and covered at the upper end with a heat insulator of glass cloth. The bag is weighted at the upper end with a 0.5 lb. lead disc which assists in stripping the bag from the canopy at the completion of line and riser stretchout. Inside of the bag are 4 cotton tapes to which the riser is secured during packing in order to provide orderly riser deployment. The mouth of the bag is closed with a light cotton cord.

FIGURE 9-18 DROGUE PARACHUTE

9-38. Drogue Chute Mortar and Sabot (See Figure 9-19)

The drogue parachute ejection mortar is a device for positively deploying the drogue parachute with sufficient energy to overcome local pressure gradients and gravitational forces. The drogue parachute is packed in a protective bag and stowed in the mortar tube on top of a lightweight sabot. The sabot functions as a piston to eject the parachute pack, when pressured from below by gasses generated from a pyrotechnic charge. The propellant charge is initially fired into a breach chamber of small volume, to produce high pressure which is subsequently vented through a small orifice and into the main chamber at relatively lower pressures. In this manner, reaction loads are kept to a minimum, since the pressure energy is not expended instantaneously. The pressure sealing quality of the sabot is derived from an "O" ring, installed in a groove near the base. Two small holes are located in the "O" ring groove to vent air trapped in the mortar tube underneath the sabot on installation. For proper operation, the "O" ring and the inner wall of the mortar tube, which is always in contact with the "O" ring, are lubricated before installation. The drogue parachute pack is retained in its stowed position within the mortar tube by a thin stainless steel cover which is attached to the upper surface of the antenna housing. Three cut-out sections, provided in the sides of the cover, permit routing of the steel cable risers into the drogue chute can. The cover is designed to constrain the chute in its compartment against negative decelerations and also to require minimal forces to break loose from its attachments at the time of deployment. Pressure of the chute pack causes the cover to deflect such that attachment tabs pull out from under attaching screw heads through a slotted hole designed for this purpose. The energy required to expel the drogue chute from its compartment is provided from high pressure gases, generated by



1. "O" RING
2. SABOT
3. INSULATION
4. COVER
5. CARTRIDGE
6. CHAMBER

FIGURE 9-19 DROGUE CHUTE MORTAR ASSEMBLY ignition of a pyrotechnic charge. The cartridge is loaded with 60 grains of powder, contained in a propellant can attached to a steel body which houses the ignition wiring, and terminates in an electrical coonector. The ignition circuitry consists of two separate and individual bridges, either of which is capable of igniting the powder charge upon application of the proper current.

9-39. Force Sensor (See Figure 9-20)

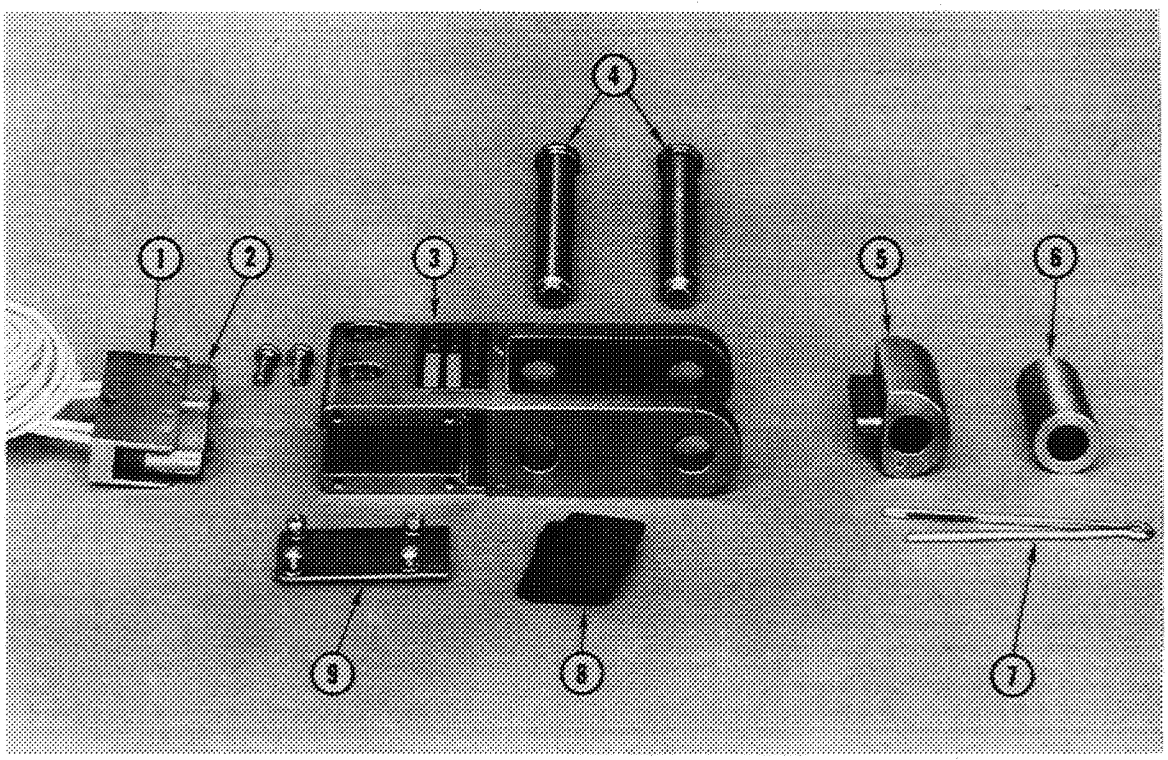
This is an electro-mechanical device installed in the main parachute riser. The force sensor contains a stack of small steel leaf springs which, when deflected, operate a pair of precision snap-action switches. When the weight of the capsule acts against the drag force of the inflated parachute, the normally closed switches are held open by the parachute force. Low forces (less than 1000 pounds), exerted by a failed parachute, cause the switches to close, thus actuating the reserve parachute system. Two switches are used, one for each of the parallel electrical sequence systems.

9-40. TEST CONFIGURATION NO. 3 CAPSULE

Same as Specification Compliance.

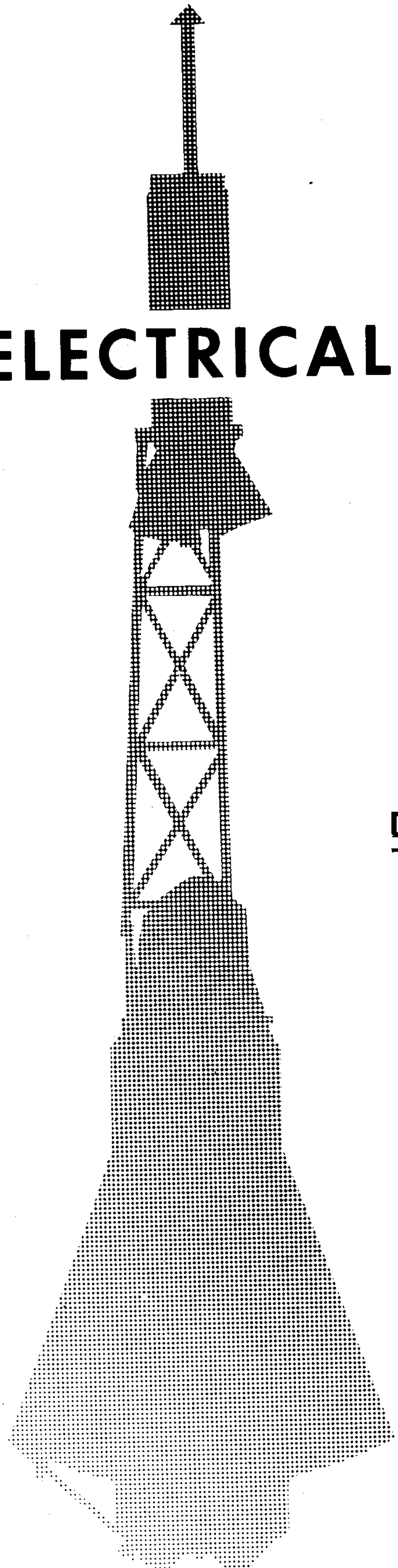
9-41. TEST CONFIGURATION NO. 4 CAPSULE

Same as Specification Compliance.



1. SWITCH BRACKET	6. SPACER
2. SWITCHES	7. COTTER KEY
3. FRAME	8. LEAF SPRINGS
4. PINS	9. COVER
5. SLIDE	

FIGURE 9-20 MAIN PARACHUTE FORCE SENSOR



SECTION X

ELECTRICAL POWER AND INTERIOR LIGHTING SYSTEMS

TABLE OF CONTENTS

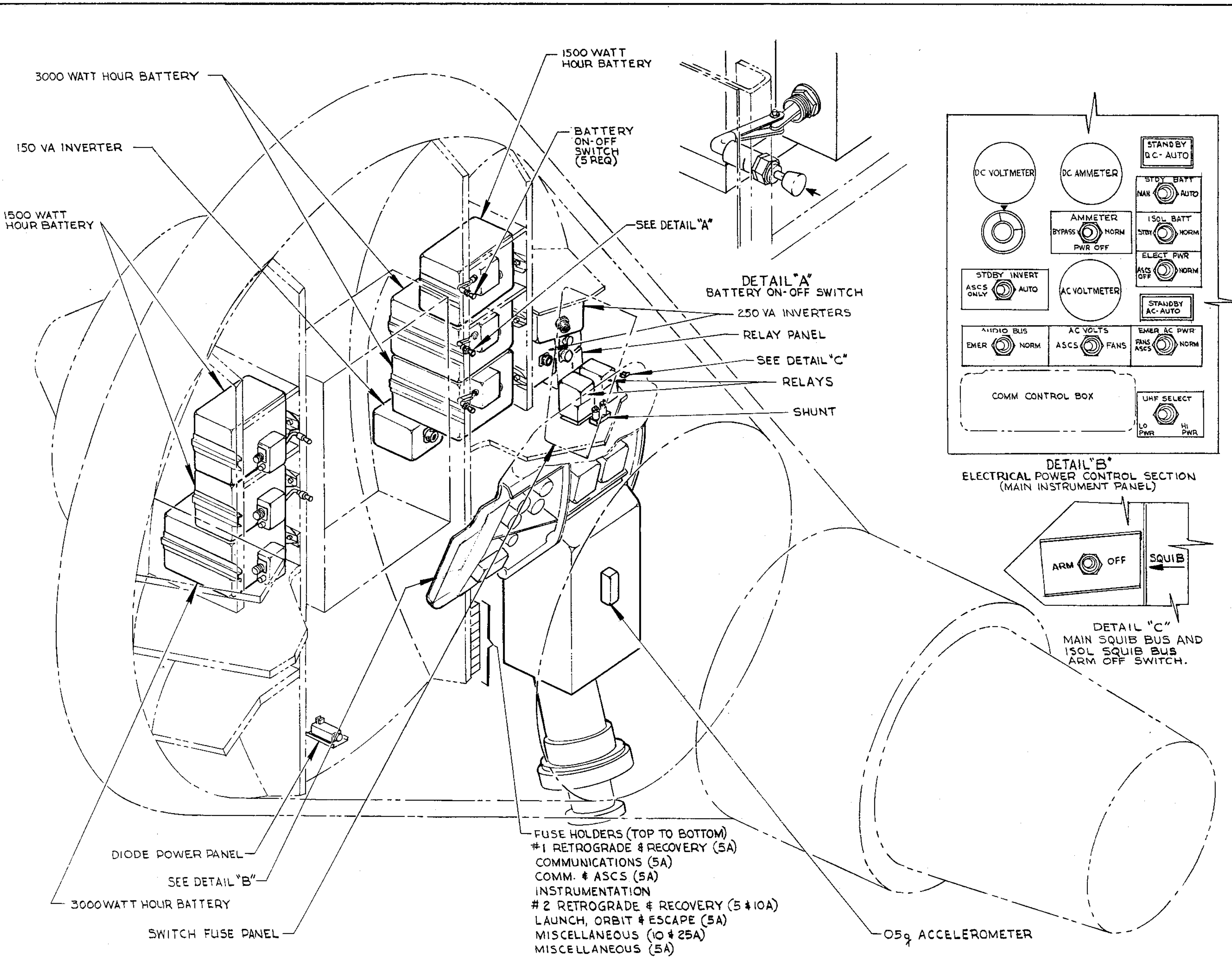


FIGURE 10-1 ELECTRICAL POWER SUPPLY SYSTEM

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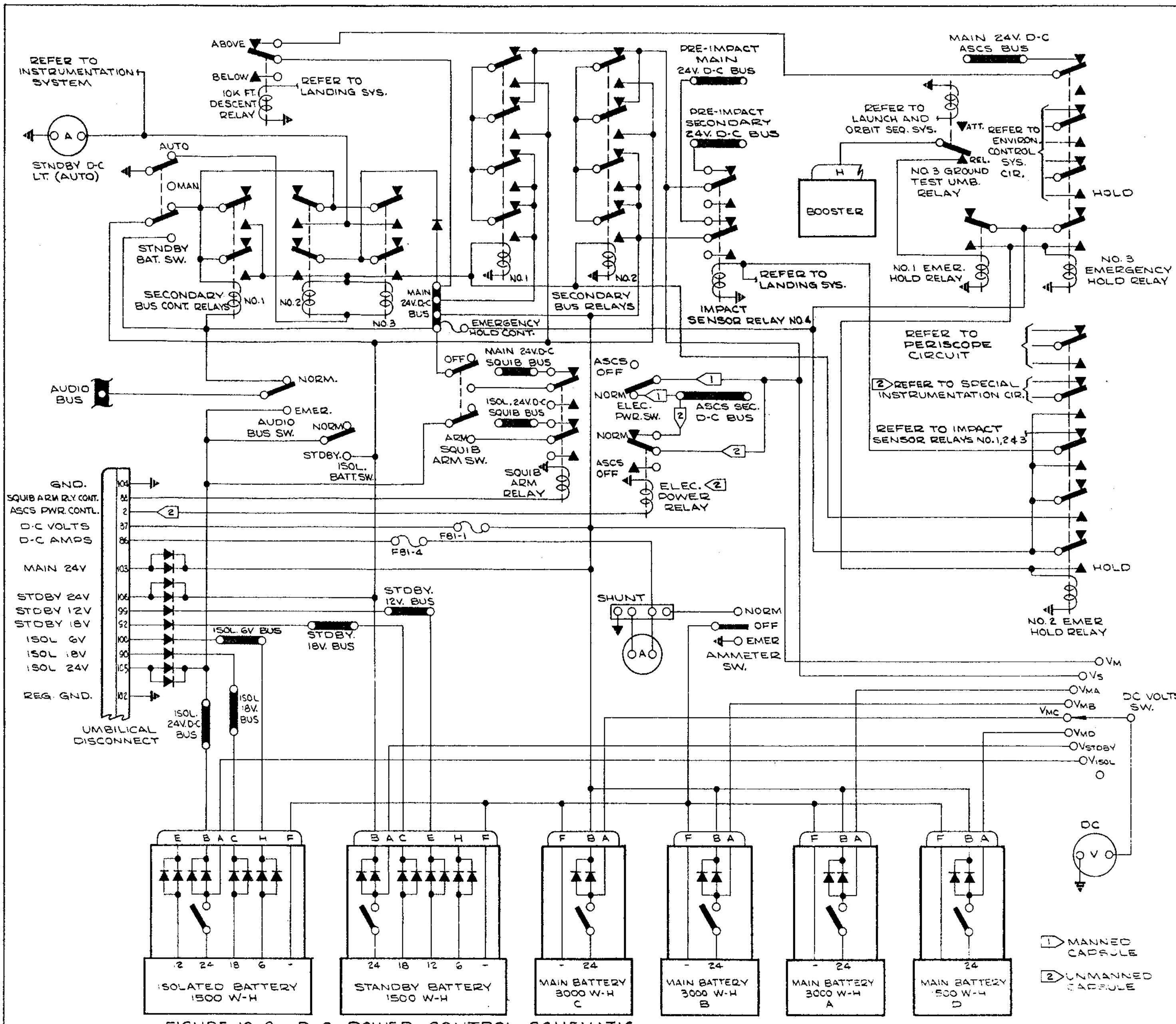


FIGURE 10-2 D-C POWER CONTROL SCHEMATIC

power source prior to launch, is applied to the main d-c bus. The main d-c bus is connected through the secondary bus relay to the secondary bus.

10-7. One 1500 watt hour standby battery is installed in the capsule to supply communications bus voltage and to act as a standby battery for the main system. The standby battery incorporates reverse current protection and is connected to the circuit through an ON-OFF switch located on the battery.

10-8. Battery taps supply 12 and 18 volts d-c to the communication buses. Prior to launch these circuits are energized by external power through the umbilical disconnect and external power diode package.

10-9. Standby battery 24 volt d-c power application is controlled by the standby battery control switch. This switch may be placed in the AUTO or MANUAL position. In the AUTO position, a decrease in main battery voltage to a level more than six volts below standby battery voltage causes the No. 1 secondary bus control relay to energize. Power is applied through normally open contacts of this relay to energize the No. 2 and No. 3 secondary bus control relays. These relays have holding contacts which lock their solenoids to the main d-c bus. With the No. 2 and No. 3 control relays energized, power is applied to the solenoids of the secondary bus relays. Energizing the secondary bus relays removes voltage from the secondary bus and connects the standby battery 24 volt output to the main bus in parallel with the reduced main battery output. The secondary bus relay also energizes the STANDBY D-C AUTO indicator light indicating automatic use of the standby battery. Signal voltage indicative of STANDBY D-C AUTO lamp operation is supplied to the instrumentation system.

10-10. The MANUAL position of this switch connects the standby battery 24 volt output directly to the main 24 volt D-C bus and through the secondary bus relay to the secondary 24 volt d-c bus. No visual indication is made of this use of the standby battery other than Astronaut checks of current and voltage.

10-11. An emergency hold circuit is utilized in the event of a "hold" command after umbilical separation. The emergency hold circuit removes power from the secondary bus and the main ASCS bus, applies power to the cabin vent squibs and to the extend motor of the periscope. Circuit switching is accomplished as follows. The "hold" signal from the booster is applied through normally closed contacts of the No. 3 ground test umbilical relay to the solenoid of the No. 1 emergency hold relay. Power from the main d-c bus is applied through normally open contacts of the No. 1 emergency hold relay to the solenoids of the No. 2 and No. 3 emergency hold relays. These relays have holding contacts which lock the solenoids to the main d-c bus. Other normally open contacts of the No. 2 emergency hold relay apply power to the solenoids of the secondary bus relays and No. 4 impact sensor relay and to the extend motor of the periscope. Other normally open contacts of the No. 3 emergency hold relay apply power to the cabin vent squibs and remove power from the main 24 volt d-c ASCS bus.

10-12. A 1500 watt hour isolated standby battery is installed to provide communications bus voltages and alternate source voltages for communications, squib firing and standby power. The isolated standby battery also incorporates reverse current protection and is connected to the circuit through an ON-OFF switch.

10-13. Battery taps supply 6 and 18 volts d-c to communications buses. The 24 volt isolated standby battery output is available through the ARM position of the squib arming switch and through the EMERG position of the AUDIO BUS switch to the associated buses.

10-14. The 24 volt d-c output may also be connected in parallel with the 24 volt output of the standby battery through the STANDBY position of the ISO-BATT switch.

10-15. External d-c power is supplied through the umbilical cable to capsule circuitry. This power is used for pre-launch operations in order to conserve the capsule battery supply. 6, 12, 18 and 24 volts d-c are supplied through the external power diode package.

10-16. A d-c voltmeter and a d-c voltmeter selector switch permit the Astronaut to read individual battery, main and secondary bus voltages as desired. The d-c ammeter can be used, by operation of the ammeter switch, to indicate d-c load current from the batteries in the circuit.

10-17. A-C POWER AND CONTROL

10-18. Main

Main, 115 volt, 400 cycle a-c power is supplied by one 250 volt ampere inverter and one 150 volt ampere inverter. See Figure 10-3. The a-c load is divided between the ASCS bus and the fan bus. During orbital flight when the ASCS is the primary a-c load, the 250 volt ampere inverter powers that bus while the 150 volt ampere inverter powers the fan bus. During re-entry, at approximately 300,000 feet, the fan system becomes the primary a-c load. Therefore, the inverters are switched such that the higher capacity inverter powers the fan bus. The main d-c bus supplies input power to the inverter feeding the fan bus while the secondary d-c bus supplies input power to the inverter feeding the ASCS bus. The output from one inverter energizes the ASCS BUS RELAY while the output of the other inverter energizes the FAN BUS RELAY. Inverter output is then supplied through the energized bus relays to the appropriate bus. An A-C VOLTMETER is provided with a spring loaded A-C VOLTMETER SWITCH which normally closes the voltmeter circuit to the fan bus and must be manually operated to read ASCS bus voltage.

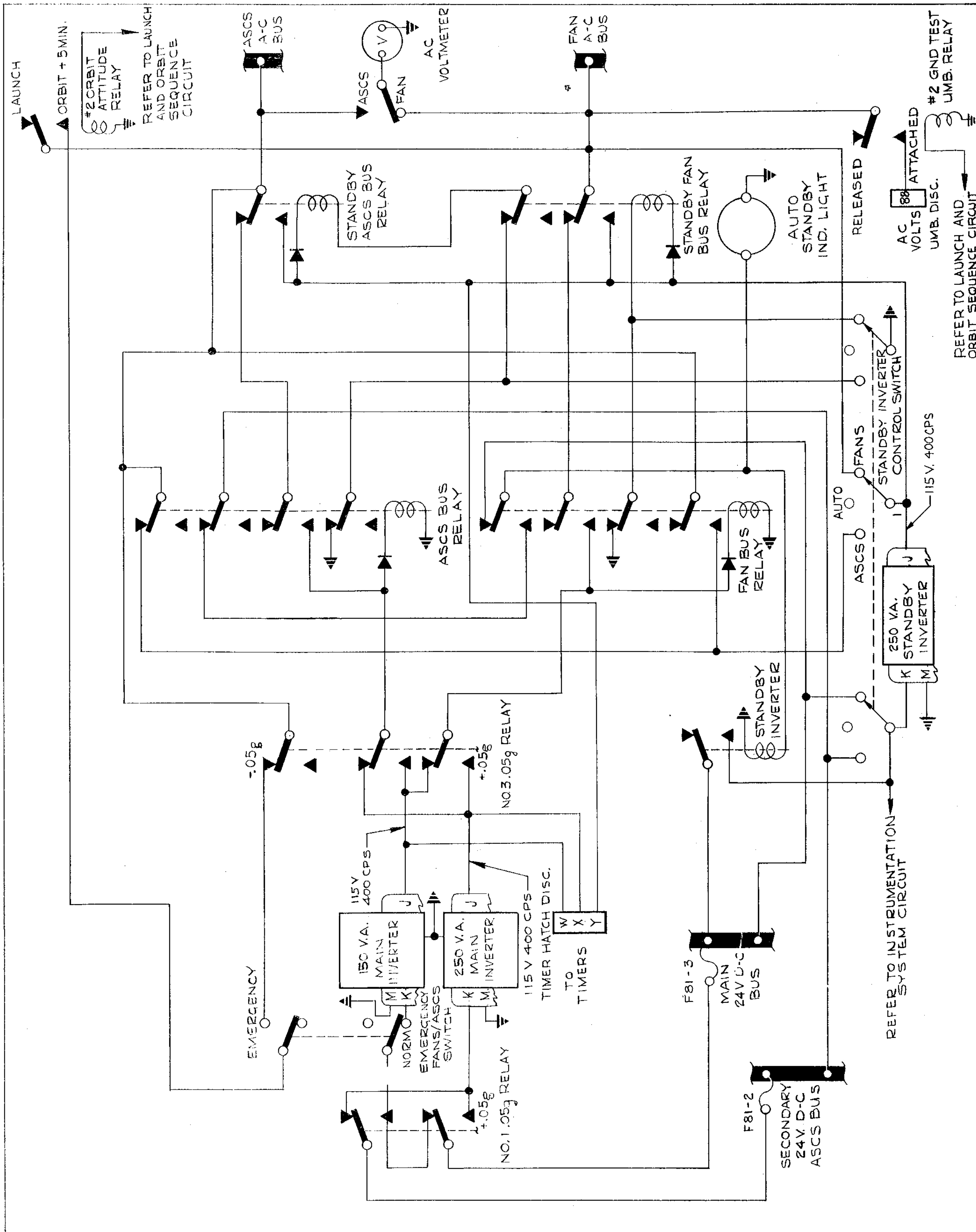


FIGURE 10-3 A-C POWER CONTROL SCHEMATIC

PM45-89A

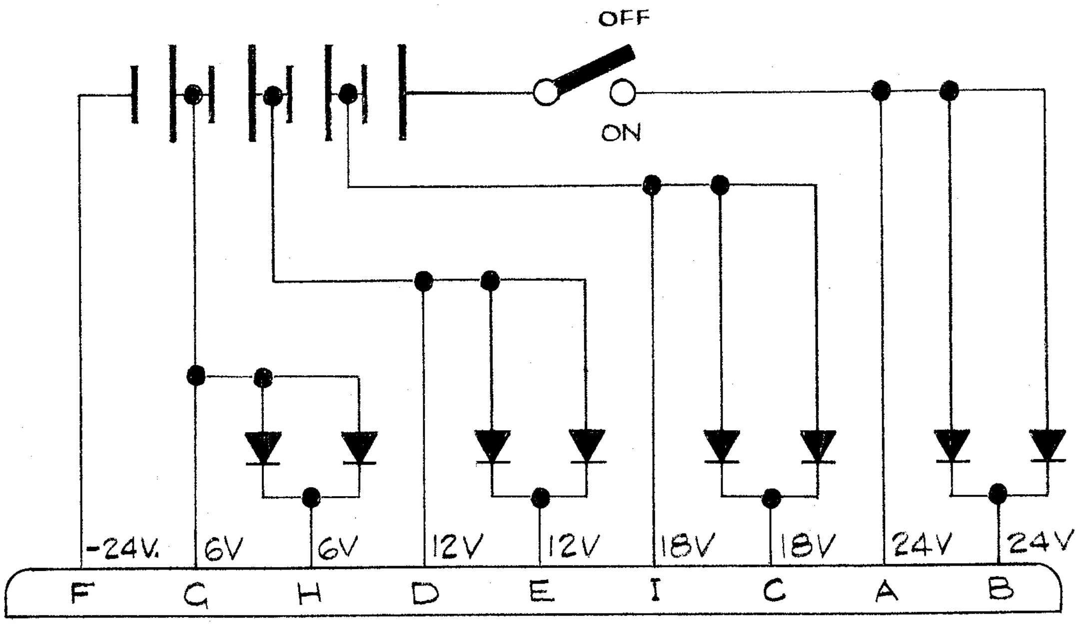
10-19. Standby

Standby, 115 volt, 400 cycle a-c power is supplied by one 250 volt ampere inverter. The STANDBY INVERTER switch determines which d-c bus shall supply the standby inverter input voltage and whether the a-c output voltage shall power the ASCS bus or the fan bus or shall automatically power either bus in the event of main inverter failure. With the STANDBY INVERTER SWITCH in the ASCS position, the standby inverter is energized by 24 volts d-c from the secondary d-c bus. The standby inverter output energizes the STANDBY ASCS BUS RELAY. The energized STANDBY ASCS BUS RELAY removes the main inverter output from the line and applies the standby inverter output.

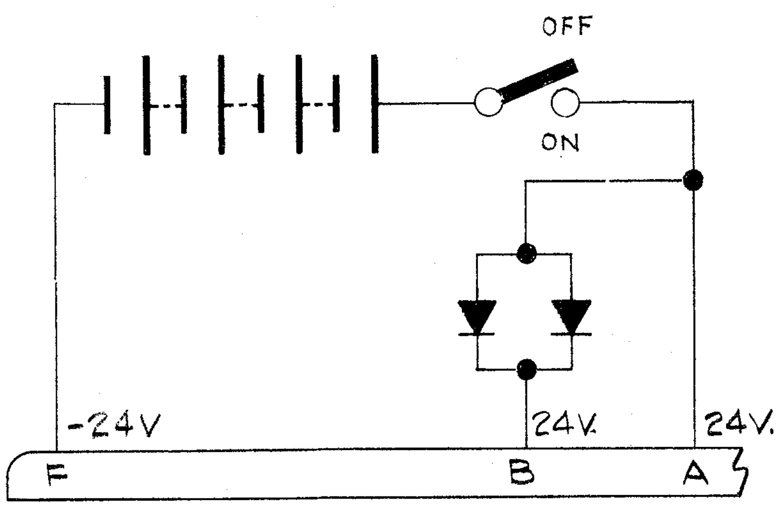
10-20. When the STANDBY INVERTER switch is in the FANS position the standby inverter is energized by 24 volts d-c from the main d-c bus. The standby inverter output energizes the STANDBY FAN BUS RELAY. The energized STANDBY FAN BUS RELAY removes the main inverter output from the line and applies the standby inverter output.

10-21. The AUTO position of the STANDBY INVERTER CONTROL SWITCH allows the inverter to power either a-c bus should the main inverter feeding one of them fail. Failure of a main inverter causes the associated bus relay to de-energize. This connects the standby inverter input to the d-c bus used by the failed main inverter and feeds the output to the proper a-c bus. The STANDBY A-C AUTO light illuminates during standby inverter operation while in the automatic mode. Should both main inverters fail while in automatic mode, the standby inverter, operating from the main d-c bus, will power the fan a-c bus. Signal voltage indicative of STANDBY A-C AUTO light operation is supplied to the instrumentation system.

10-22. A-C power may be supplied from the fan bus to the ASCS bus by placing



1500 WH BATTERY



3000 WH BATTERY

FIGURE 10-4 BATTERY INTERNAL WIRING DIAGRAM

PM45-93

the Emergency a-c Power Switch to the EMERG FANS ASCS position. This may be done at any time subsequent to capsule-booster separation but prior to dense air re-entry. The .05g Switch automatically disconnects the ASCS bus from the fan bus at approximately 300,000 feet, to allow full utilization of a-c power for fan operation.

10-23. System Units

10-24. Batteries 3000 Watt Hour and 1500 Watt Hour

The batteries consist of series connected silver-zinc rechargeable cells having a nominal potential rating of 24.5 volts and a minimum capacity rating of 3000 watt hours for three of the four main batteries and 1500 watt hours each for the fourth main battery, the standby battery and the isolated battery. Each battery is equipped with a pressure relief valve designed to maintain internal pressure from 5.5 to 14.9 psi. The pressure relief valve is internally mounted. The rated capacity of the 3000 watt-hour battery is at a 40 hour rate, but short pulse currents up to 42 amperes can be delivered.

10-25. The battery electrolyte consists of a 40 percent solution of reagent grade potassium hydroxide and distilled water and is used to activate the dry charged battery initially. After the first discharge cycle, the battery may be recharged by any constant current battery charger. Charging rates of 10 amperes for five hours then reduced to 3.5 amperes for 20 hours should be used. The battery is designed for five complete cycles of discharge and charge; however, for highest reliability, units should not exceed four cycles or an activated life of 60 days prior to flight. For internal wiring of the 1500 and 3000 watt-hour batteries, see Figure 10-4.

10-26. Inverters 250 Volt-Ampere, 150 Volt Ampere

The d-c to a-c inverters installed in the Project Mercury space capsule are of

ISOLATED 24V D-C BUS

ISOLATED 6V D-C BUS

UHF BEACON (F89-19)
TELEM'D SEQ (F93-1)

ISOLATED 18V D-C BUS

AUX. COM'D DECODER A (F89-11)
COM'D RCVR/DECODER A (SF89-9)

AUDIO BUS 24V D-C

FUSED

NO. 2 AUDIO (F89-7)
UHF COMM. (F89-8)
HF RECOVERY (F89-16)
UHF BACKUP (F89-18)
ANTENNA SWITCH

MAIN 24V D-C BATTERY BUS

FUSED

AUTO H_2O_2 JETT. (F90-1)
NO. 1 AVOID(F89-2)
INST. D-C NO. 6 (F92-13)
RR TELELTS. (F85-15)
RR BLICT. HTR(F85-9)
RR BLKT. HTR (F85-16)
RR BLKT. HTR (F85-17)
PERISCOPE RETICLE (F95-2)
SATELLITE CLOCK (F94-1)
STAELLITE CLOCK (F94-2)
TELELTS. TEST (F88-1)
MAIN INV. FANS (F81-3)
D-C VOLTS MONITOR
EMER HOLD CONT.
AUTO. SUIT FAN CONT. (F91-7)
LAUNCH AND ESCAPE TELELTS. (F84-18)
AIR PUMP
RECOVERY TELELTS.

MAIN 24V D-C BUS

SWITCH FUSED

ENVIRON. CONT. (SF91-3)
PROGRAMMER (SF92-3)
PERISCOPE CONT.

SECONDARY 24V D-C ASCS BUS

MAIN INVERTER ASCS(F81-2)
ATT. GYRO CONT. (F90-8)
ASCS LOGIC(F90-4)

PRE-IMPACT SECONDARY 24V D-C BUS

SWITCH FUSED

LOW WATT TELEM TRANS. (SF92-1)

FUSED

PILOT'S AND INST. CAMERA(F92-5)
INST. D.C. NO. 1(F92-8)
INST. D.C. NO. 3(F92-10)
INST. D.C. NO. 5(F92-12)
AUX. COMMAND (F89-20)
"S" BAND BEACON (F89-3)
EARTH AND SKY CAMERA(F92-2) 2

MAIN 24V D-C ASCS BUS

FUSED

FLY-BY-WIRE(F90-6)
RATE GYRO CONT. (R90-11)

MAIN 24 V D-C ASCS BUS

SWITCH FUSED

ASCS .05G (SF90-5)
EMERGENCY .05G(SF90-10)

STANDBY 24V D-C BUS

STANDBY 18V D-C BUS

AUX. COM'D DECODER B (F89-12)
COM'D RCVR/DECODER B (F89-10)

STANDBY 12V D-C BUS

HF BEACON (F89-17)

ISOLATED 24V D-C SQUIB BUS

FUSED

ABORT CONTROL (F87-1)
CAP ADAP. UMB. (F84-16)
EMER. CAP SEP. BOLTS (F84-12)
EMER. CAP SEP. CONT. (F84-15)
CHUTE JETT.-SYS. B (F86-16)
RESCUE AIDS-SYS. B (F86-7)
AUTO LDG.-SYS. B(F86-10)
VENT VALVES
CABIN VENT VALVES

ISOLATED 24V D-C SQUIB BUS

SWITCH FUSED

EMER. POS. RKT. (SF84-4)
EMER. TWR. ESC. RKT. (SF84-10)
EMER. TWR. SEP. CONT(SF84-14)
EMER. TWR. JETT. RKT. (SF84-7)
EMER. TWR. SEP. BOLTS (SF84-9)
RESERVE DEPLOY.-SYS. B (SF86-4)
EMER. MAIN-SYS. B (SF86-2)
EMER. DROGUE DEPLOY (F86-1)
EMER. RETRO-RKT. ASSY. JETT. (SF85-5)
EMER. RR MAN. CONT. (SF85-11)
EMER. NO. 1 RR FIRE (SF85-6)
EMER. NO. 2 RR FIRE (SF85-7)
EMER. NO. 3 RR FIRE (SF85-8)

MAIN 24V D-C SQUIB BUS

FUSED

RETRO-GRADE SEQUENCE CONTROL(F85-10)
NO. 1 RETRO-ROCKET FIRE (F85-2)
NO. 2 RETRO-ROCKET FIRE (F85-3)
NO. 3 RETRO-ROCKET FIRE (F85-4)
RETRO ROCKET ASSY. JETTISON(F85-1)
TOWER SEPARATION CONTROL(F84-1)
TOWER SEPARATION BOLTS(F84-8)
TOWER JETTISON ROCKET(F84-6)
TOWER ESCAPE ROCKET(F84-5)
POSIGRADE ROCKET(F84-2)
CAPSULE SEPARATION CONTROL(F84-13)
CAPSULE SEPARATION BOLTS(F84-11)
RR ASSY. UMB. (F85-12)
RR ASSY. UMB. (F85-13)
RR ASSY. UMB. (F85-14)
CAP. ADAP. UMB. (F84-17)
MAN. H_2O_2 JETT. (F90-2)
CABIN VENT VALVES
AUTO. He. VALVE (F86-12)
VENT VALVES
MAIN He. VALVE (F86-17)
COVER SQUIB (F86-16)
TETHER SQUIB(F86-13)
CHUTE JETT. - SYS. A (F86-14)
MAIN SMOKE GEN. (F86-5) 1
RESCUE AIDS - SYS. A (F86-8)
AUTO. LDG. - SYS. A (F86-9)

MAIN 24V D-C SQUIB BUS

SWITCH FUSED

RESERVE DEPLOY-SYS. A (SF86-6)
EMER. MAIN-SYS. A (SF86-3)

PRE-IMPACT MAIN 24V D-C BUS

FUSED

HF COM'D(F89-1)
"C" BAND BEACON (F89-4)
COM'D RCVR/AUDIO (F89-6)
TAPE RECORCER (F92-6)
HI WATT TELEM. TRANS. (F92-15)
INST. PWR. SUPPLY(F92-7)
INST. D-C NO. 2(F92-9)
INST D-C NO. 4 (F92-11)
INST. D-C NO. 7(F92-14)
TELEM. COM'D(F92-16)

PRE-IMPACT MAIN 24V D-C BUS

SWITCH FUSED

PERISCOPE CONT (SF95-1)
ANTENNA SWITCH (SF89-5)

1 CAPSULES 2 THRU 5
2 CAPSULES 2 THRU 8

FIGURE 10-5 D-C POWER DISTRIBUTION SCHEMATIC

PM45-131A

a solid state design capable of operating continuously at full rated power output in an ambient atmosphere of 160°F. or at 80°F. at 5 psia 100% oxygen. The output is 115 volts a-c ± 5%, single phase to ground, with a frequency of 400 cycles ± 1.0% and essentially sinusoidal in wave-form. A short circuit across the output of an inverter will not damage the inverter or the wiring involved in the short circuit.

10-27. D-C Ammeter 0-50 Ampere

The d-c ammeter is located on the main instrument panel and provides the Astronaut with an indication of total current drain from all batteries. The basic ammeter meter movement has a 50 millivolt sensitivity. A shunt of suitable resistance is connected across the input of the meter providing a low resistance path to ground with proper voltage drop for the meter movement.

10-28. D-C Voltmeter 0-30 Volts

A d-c voltmeter, and its selector switch, are located on the main instrument panel. Approximate battery condition can be determined by placing the D-C VOLTS switch to the appropriate positions and reading the individual battery voltages.

10-29. POWER DISTRIBUTION

10-30. <u>D-C Power Distribution</u>

See Figure 10-5.

10-31. POWER LOADING

10-32. <u>D-C Power Loading</u>

See Table 10-1.

TABLE 10-1. D-C POWER LOADING (MAX)

NO. OF UNITS	EQUIPMENT	WATTS TOTAL	OPER. TIME HRS.	WATT HOURS TOTAL
	COMMUNICATIONS			
1	HF Transmitter (Ready)	4.0	0.20	0.80
	HF Transmitter	30.0	0.10	3.00
1	HF Receiver	1.0	8.77	8.77
1	UHF Transmitter (Ready)	3.8	2.50	9.5
	UHF Transmitter	6.0	1.52	9.12
	& Receiver	1.2	8.6	9.32
	UHF Booster (Ready)	5.0	3.5	17.5
	Transmit	15.0	1.52	19.8
1	Telemetry Power Supply (Low)	17.7	5.47	95.8
1	Telemetry Power Supply (High)	17.7	6.97	12.34
1	S-Band	28.0	5.47	153.0
	Interrogate	7.0	9.39	2.73
1	C-Band	28.0	6.97	195.0
	Interrogate	7.0	0.59	3.83
1	Audio Box (Cont)	0.8	18.4	14.7
	(Transmit)	2.8	2.62	7.34
1	HF Recovery (Receive)	5.6	12.0	67.2
	(Transmit)	6.4	1.0	6.4
1	UHF Back-Up (Ready)	5.0	12.0	60.0
	(Transmit)	6.0		
2	Antenna Switch	128.8		
2	Command Receivers (18 V)	2.4	17.2	41.1
2	Decoders (18 V)	2.0	3.2	6.4
1	HF Rescue Beacon (12 V)	3.3	12.0	39.6
1	UHF Rescue Beacon (6V)	5.3	12.1	64.1
	AUTOMATIC STABILIZATION CONTROL SYSTEM			
1	ASCS Calibrator D-C			48.2
1	Reaction Control	57.6	.43	25.4
	SEQUENTIAL SYSTEM			
1	Thrust Cutoff Sensor	3.25	2.03	6.6
1	Maximum Altitude Sensor	6.0	2.03	12.2
	MISCELLANEOUS			
	Flotation Bag Pump	120.0	0.17	20.4
	Diodes (Power System)			182.0
	Mayday System (Abort Only)	16.2		
	Retrograde Heaters	570.0		

TABLE 10-1. D-C POWER LOADING (MAX) (Continued)

NO. OF UNITS	EQUIPMENT	WATTS TOTAL	OPER. TIME HRS.	WATT HOURS TOTAL
	LIGHTING SYSTEM			
	Warning Telelights	2.24	.6	1.5
	Periscope Light	2.24	8.1	18.10
	Flashing Rescue Light	Self Contained		
	CABIN INSTRUMENTS			
	Humidity Indicator	0.2	20.6	4.12
	Satellite Clock	3.0	1.1	3.3
	Periscope (Extend-Retract)	60.0		
1	Voltmeter D-C	.030	20.6	.618
1	Ammeter D-C	.050	20.6	1.03
1	Ammeter Shunt		20.6	
	ENVIRONMENTAL			
1	Water Separator	18.0	.347	6.25
	INSTRUMENTATION			
1	Package A	11.49		459.6
	3.0 Volt Power Supply			
	Body Temperature Amp.			
	Com-Keyer-Record Amp.			
	400 Cycle Power Supply			
	CO_2 Partial Pressure			
1	Package B	5.41		74.8
	Mixer Amplifier			
	Accelerometer			
	Noise Level			
	VCO			
	EKG Amplifier			
	Compensating Oscillator			
1	Package C	296.63		252.0
	O_2 Partial Pressure Amp.			
	D-C Current Amp			
	Programmer			
	Vibration Data Anal.			
	Coding Light			
	Pilot Camera			
	Instrument Camera			
	Tape Recorder			

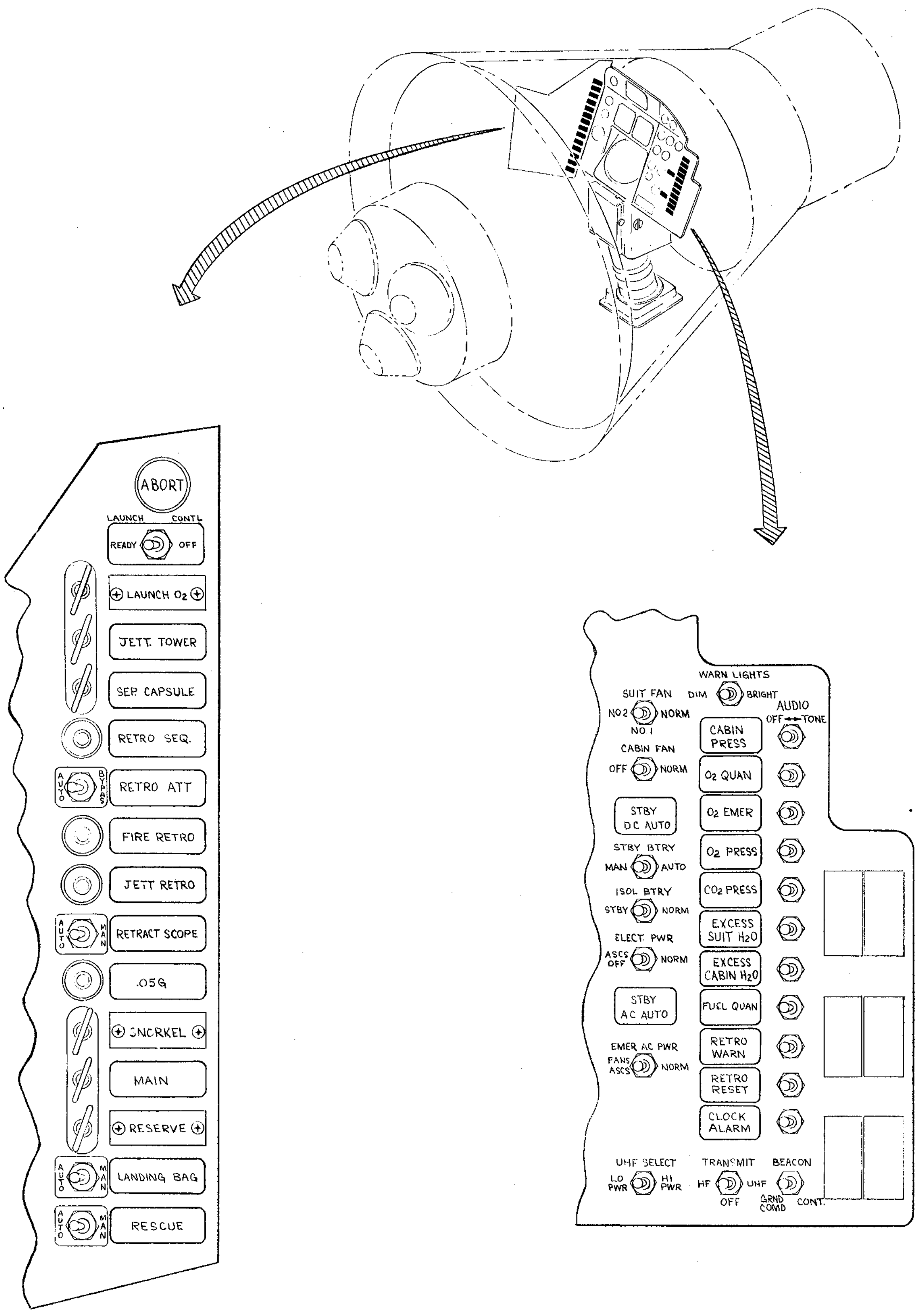


FIGURE 10-6 INTERIOR LIGHTING AND WARNING LIGHTS SYSTEM

PM45-181

10-33. INTERIOR LIGHTING SYSTEM

10-34. General

The data contained in Paragraph 10-35 applies to the specification compliance capsule. Deviations from this data as applicable to test configuration capsules are covered in Paragraphs 10-36 through 10-50.

10-35. Description

Complete data concerning the interior lighting system for the specification compliance capsule is not available at this time. The interior lighting systems for capsule No. 9 and subsequent capsules are being designed in conjunction with the new instrument and console panels. Figure 10-6 shows the proposed lighting system arrangement. Figure 10-7 is a schematic of the system.

10-36. TEST CONFIGURATION NO. 2 CAPSULE

10-37. GENERAL

The data contained in Paragraphs 10-1 through 10-35 applies to the specification compliance capsule. Deviations from the data as applicable to test configuration capsules are covered in Paragraphs 10-38 through 10-50.

10-38. ELECTRICAL POWER SYSTEM

10-39. Description

The electrical power system in capsule No. 2 is the same as that installed in the specification compliance capsule except for differences in d-c power control operation and d-c power distribution and loading. In addition, a different instrument panel is utilized in capsule No. 2. (See Figure 10-8.)

10-40. D-C Power Control Operation

D-c power control circuitry in capsule No. 2 is the same as that used in the specification compliance capsule except for control of the ASCS secondary 24 volt d-c bus. (See Figure 10-2.) In capsule No. 3 the electrical power relay

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ST. LOUIS, MISSOURI

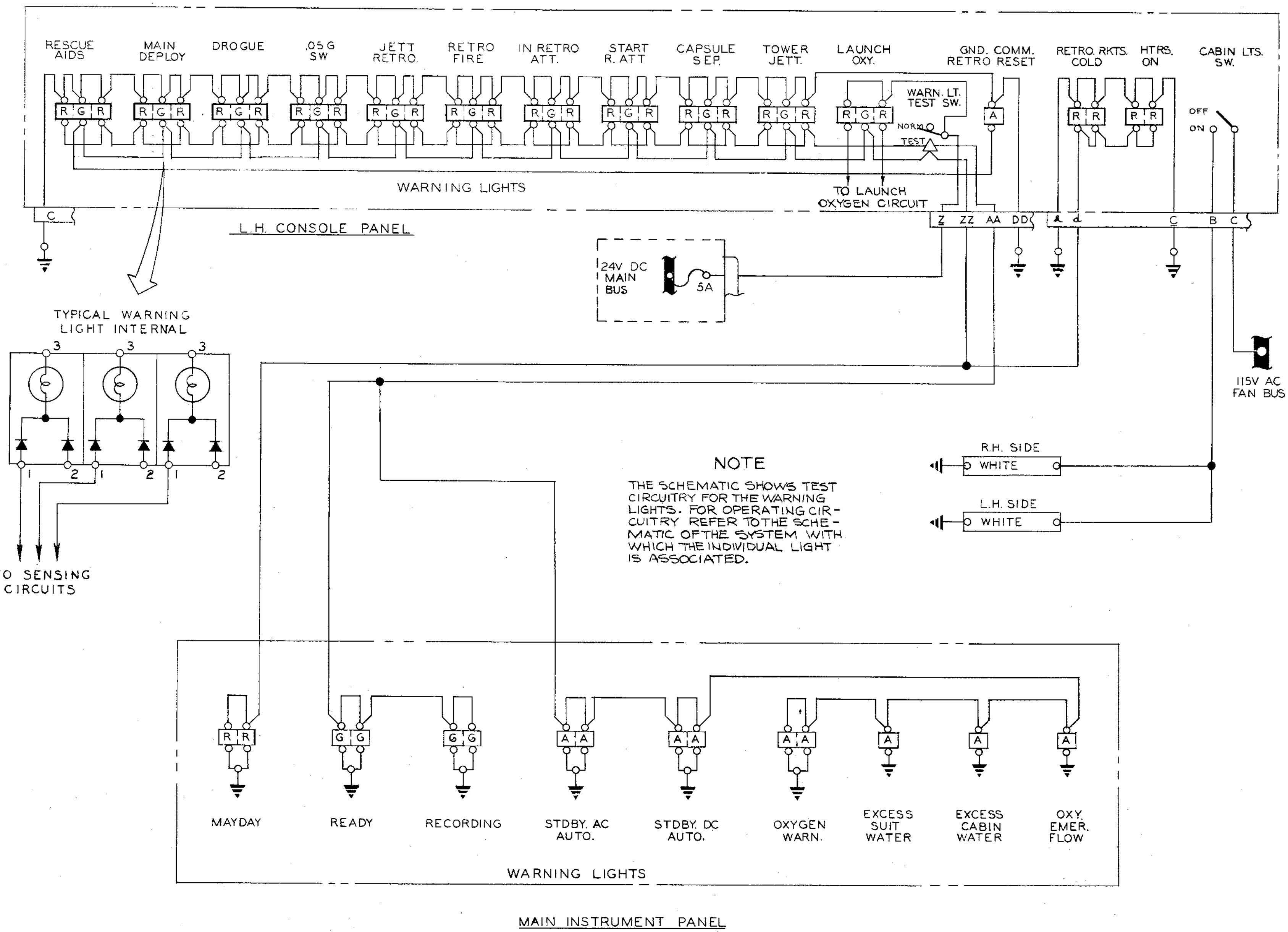


FIGURE 10-7 INTERIOR LIGHTS AND WARNING LIGHTS SCHEMATIC

PM45-90A

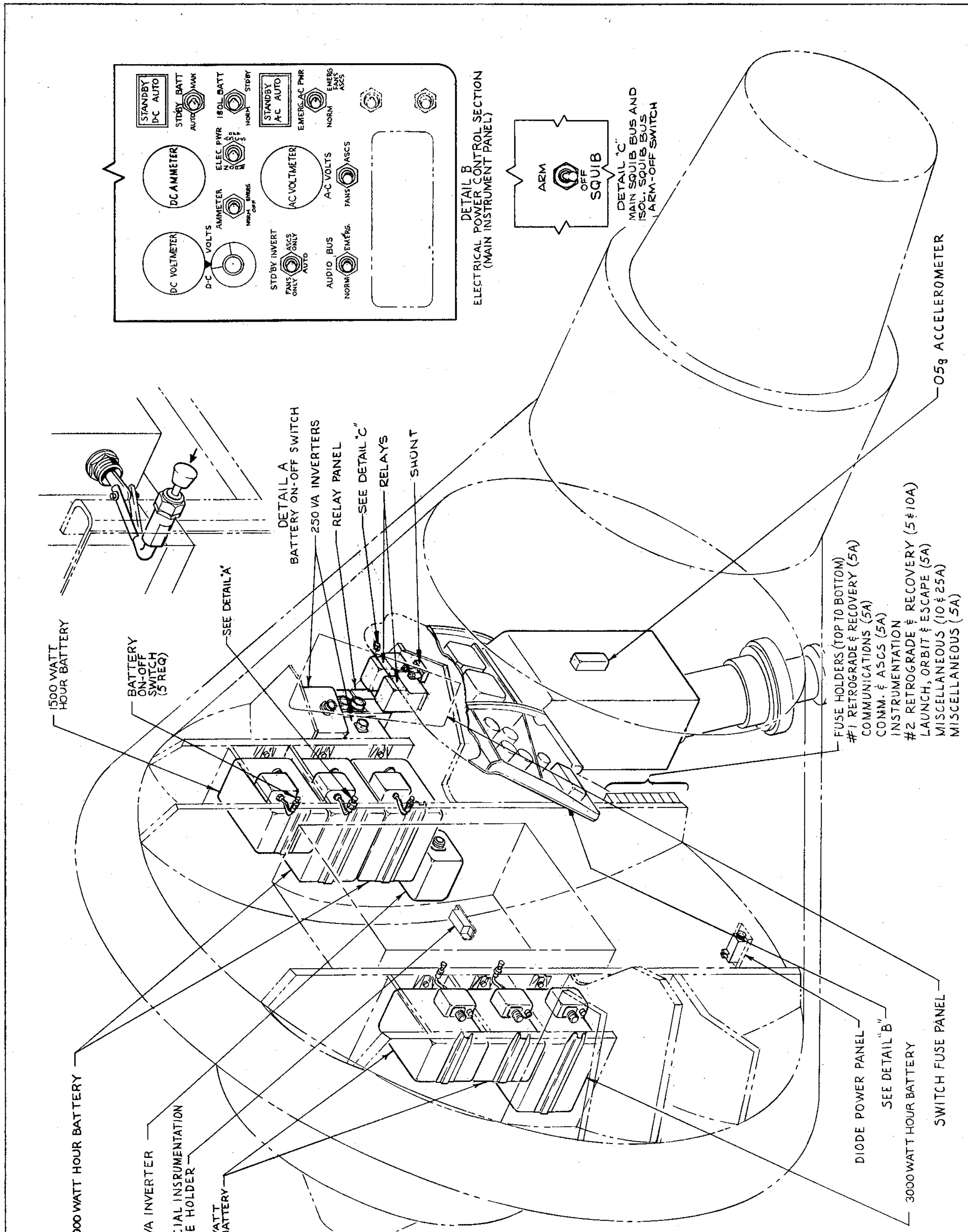


FIGURE 10-8 ELECTRICAL POWER SUPPLY

is utilized to control application of power to this bus. Power from the main d-c bus is applied to the ASCS secondary d-c bus through normally closed contacts of the electrical power relay. The solenoid of this relay is connected to the umbilical disconnect to allow external control of bus power.

10-41. D-C Power Distribution

See Figure 10-5.

10-42. D-C Power Loading

See Table 10-2.

TABLE 10-2. D-C POWER LOADING (CAPSULE NO. 2)

NO. OF UNITS	EQUIPMENT	TOTAL WATTS	OPERATING TIME-HRS.	TOTAL WATT HOURS
	COMMUNICATIONS			
1	HF Trans. (XMIT)	34.0		
	(REC)	1.0	2.25	2.25
1	UHF Trans. (XMIT)	9.8	12.15	119.0
	(REC)	1.2	2.25	2.70
2	Telemetry Transmitters	57.4	0.45	25.8
1	S-Band Transponder	28.0	0.45	12.6
	Interrogate	7.0	0.35	2.45
1	C-Band	28.0	0.45	12.6
	Interrogate	7.0	0.35	2.45
1	Audio Box	0.75	14.25	10.7
		2.75	12.15	33.4
1	HF Recovery (REC)	5.0	12.0	60.0
	(XMIT)	7.0	12.0	84.0
1	UHF Back-Up	11.0		
2	Command Receiver (18 V)	2.4	2.25	5.4
2	Decoder (18 V)	2.0	0.45	0.9
1	HF Beacon (12 V)	3.3	12.0	39.6
1	UHF Beacon (6 V)	5.3	12.0	63.6
	ASCS			
1	Calibrator			
	DC			32.9
	Reaction Control	57.6		
	Sequential System			
1	Thrust Cut-Off	3.25	2.1	6.83
1	Max. Altitude Sensor	6.0	2.1	12.6
	Miscellaneous			
	Flotation Bag Pump	120	0.17	20.4
	Squibs	432.0		
	Diodes (Power System)		14.25	
	Mayday System	16.2		
	Lighting			
	Warning Telelights		0.25	
2	Periscope	1.12	2.1	2.35
1	Tape Record "ON"	2.24	0.45	1.09
	Cockpit Instruments			
1	Humidity Indicator	.2	14.25	2.85

TABLE 10-2. D-C POWER LOADING (CAPSULE NO. 2) - Continued

NO. OF UNITS		TOTAL WATTS	OPERATING TIME-HRS.	TOTAL WATT HOURS
	Cockpit Instruments Continued...			
1	Satellite Clock	3.0	0.15	0.45
1	Periscope Motor	60.0		
1	Voltmeter DC	.03	14.25	0.43
1	Ammeter DC	.05	14.25	0.71
1	Ammeter Shunt		14.25	
1	Environmental	18.0	0.233	4.2
	Instrumentation			
1	Vibration Analysis System	3.5	2.25	7.88
1	Earth & Sky Camera	43.2	.009	0.39
1	Instrument Camera	26.4	0.45	11.9
1	Tape Recorder	10.1	0.45	4.55
	Package "A"	11.74	13.5	158.8
	3 V Power Supply			
	Comm. Key. Record Amp "A"			
	"B"			
	400 Power Supply			
2	CO_2 Partial Pressure			
2	Cabin Air Temperature			
2	Body Temperature			
	Package "B"	2.51	11.25	28.4
3	Accelerometer			
	Noise Level			
	Mixer & 4 VCO's			
	Mixer, 4 VCO's & 1 SCO			
4	Amp. EKG			
	Package "C"	180.90	11.25	2030.0
	O_2 Partial Pressure (Hi)			
	(lo)			
	DC Current Amp. (Hi)			
	(Lo)			
	Programmer			
	Simulated Crewman			
	Relays	9.0	0.45	4.05
	Solenoid	24.0	0.45	10.8
	Heaters	117.2	0.45	52.8
	Diodes	5.8	0.45	2.62

10-43. INTERIOR LIGHTING SYSTEM

10-44. Description

Two four watt fluorescent floodlights provide interior lighting for the capsule. The 115 volt a-c fan bus supplies power to the panel selector switch allowing the lights to be turned OFF or ON. (See Figure 10-6.) Power for the Warning Telelight system is supplied through a 5 ampere fuse located on the miscellaneous fuse holder block.

10-45. System Units

10-46. Cabin Lights On-Off Switch

A single pole, single throw toggle switch mounted on the left hand console is used to control the cabin lights. (See Figure 10-9.)

10-47. Cabin Lights

Two self-contained fluorescent lights are provided for cabin lighting. These units provide lighting of high actinic value and low thermal heating. (See Figures 10-9 and 10-10.)

10-48. Warning Telelights

The various warning telelights are mounted on the left console and the main instrument panel. For the location of the warning lights, see Figure 10-9 and 10-10. The warning lights provide a wide area of illumination as well as a direct reading indication.

10-49. TEST CONFIGURATION CAPSULE NO. 3

The electrical power supply and lighting circuitry in Capsule No. 3 is the same as that used in Capsule No. 2. (Refer to Paragraphs 10-36 through 10-48.) D-c power loading in Capsule No. 3 varies from the loading in Capsule No. 2. See Table 10-3 for d-c power loading data pertinent to Capsule No. 3.

10-50. TEST CONFIGURATION CAPSULE NO. 4.

The electrical power supply and lighting circuitry in Capsule No. 4 is the same as that used in the specification compliance capsule. (Refer to Paragraphs 10-1 through 10-48.) D-c power loading in Capsule No. 4 differs from the loading in the specification compliance capsule. D-c power loading data for Capsule No. 4 will be supplied when available.

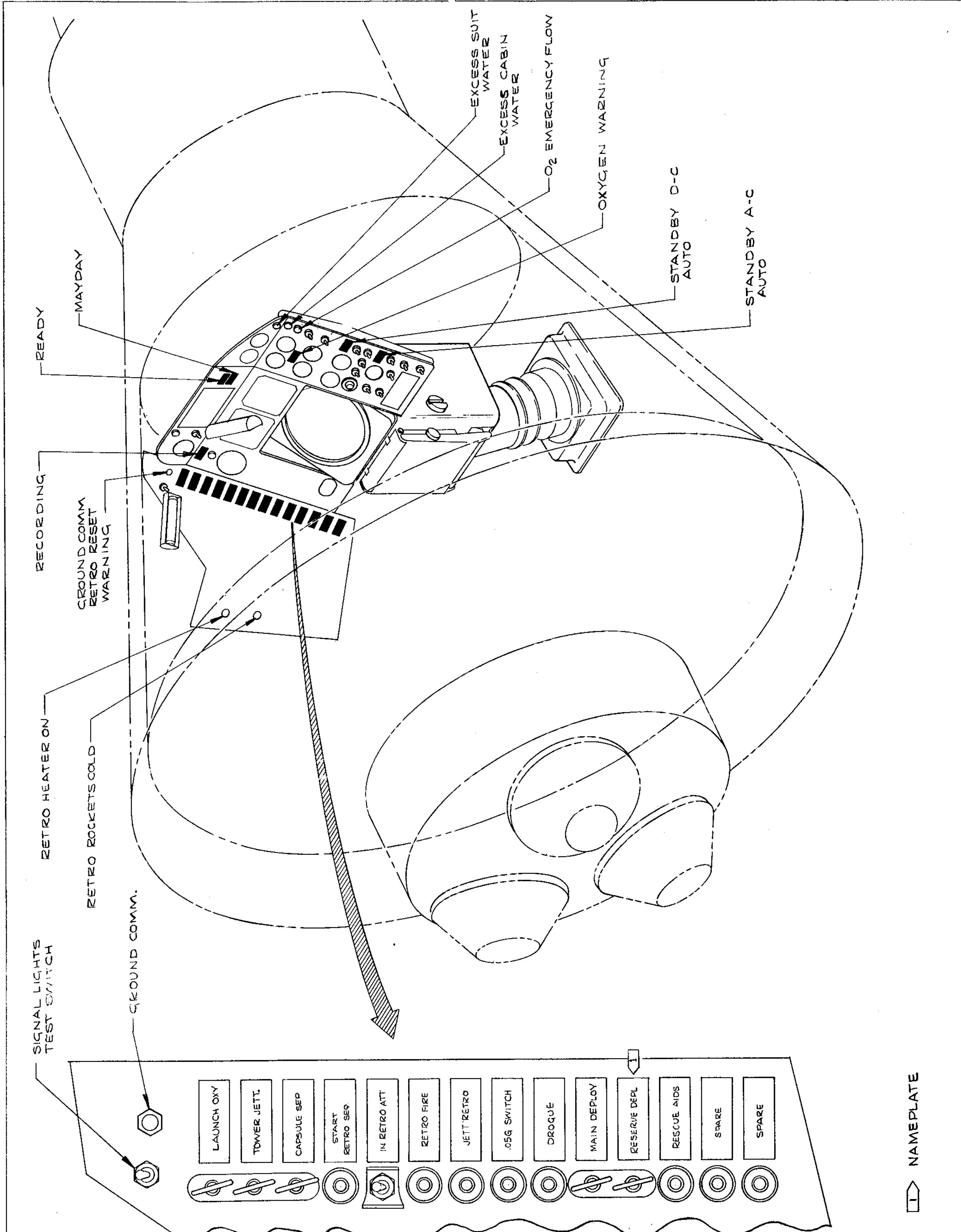


FIGURE 10-9 INTERIOR LIGHTS AND WARNING LIGHTS (CAPSULES 2 THRU 8) PM45-91

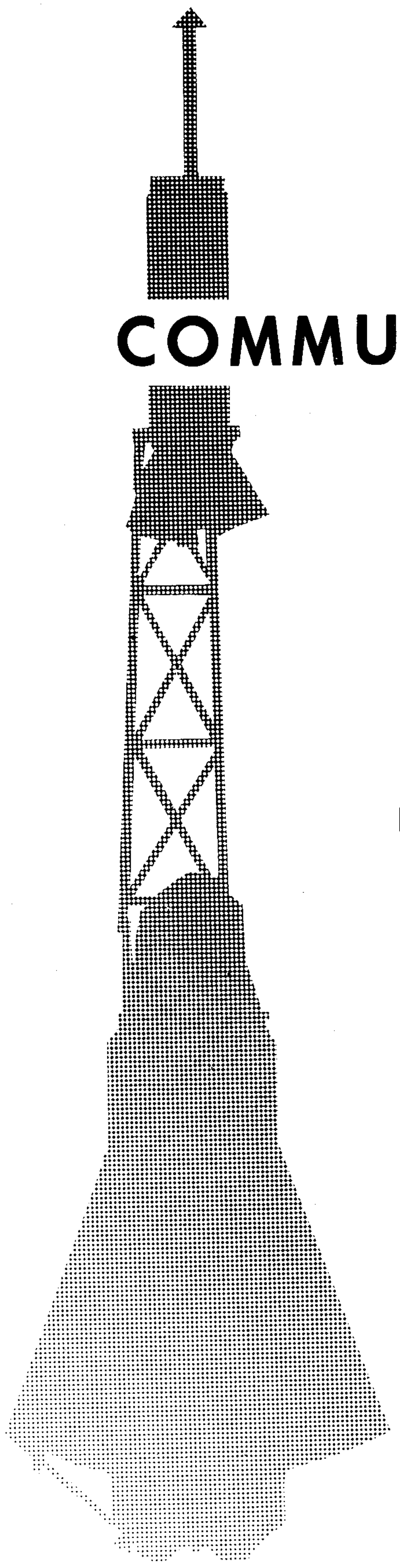
TABLE 10-3. D-C POWER LOADING (CAPSULE NO. 3)

NO. OF UNITS	EQUIPMENT	TOTAL WATTS	OPERATING TIME-HRS.	TOTAL WATT HOURS
	Communications			
2	Telemetry	57.4	0.35	20.1
1	UHF Transmit	11.0	12.0	132.0
1	UHF Back-Up	11.0		
1	UHF Rescue Beacons	5.3	12.5	66.2
1	"S" Band Transponder	28.0	0.35	9.8
	Interrogate	7.0	0.25	1.75
1	"C" Band Transponder	28.0	0.35	9.8
	Interrogate	7.0	0.25	1.75
1	HF Rescue Beacons	3.3	12.00	39.6
1	Audio Box	0.75	14.15	10.6
2	Command Receivers	2.4	2.15	5.16
2	Decoders	2.0	2.15	4.30
	ASCS			
1	Calibrator (DC)			32.1
1	Reaction Control	57.6		
	Sequential System			
1	Mayday System	16.2	12.13	197.0
1	Thrust Cut-Off	3.25	2.02	6.57
1	Max. Altitude Sensor	6.0	2.02	12.12
	Miscellaneous			
1	Flotation Bag Pump	120.0		
	Squibs			125.0
	Lighting			
	Warning Telelights			12.15
	Periscope Reticle	1.12	2.1	2.33
	Tape Record "ON"	2.24	0.35	0.84
	Cockpit Instruments			
1	Humidity Indicator	.2	14.15	2.83
1	Satellite Clock	3.0	0.05	0.15
1	Periscope Motor	60.0		
1	Rate Indicator	13.5		
1	Voltmeter			
	DC	.03	14.35	43.0
1	Ammeter DC	.05	14.35	71.8
1	Ammeter Shunt		14.15	
	Environmental Control			
1	Water Separator	18.0	0.05	0.9
	Instrumentation			
1	Earth & Sky Camera	43.2	0.003	.130

TABLE 10-3. D-C POWER LOADING (CAPSULE NO. 3) - Continued

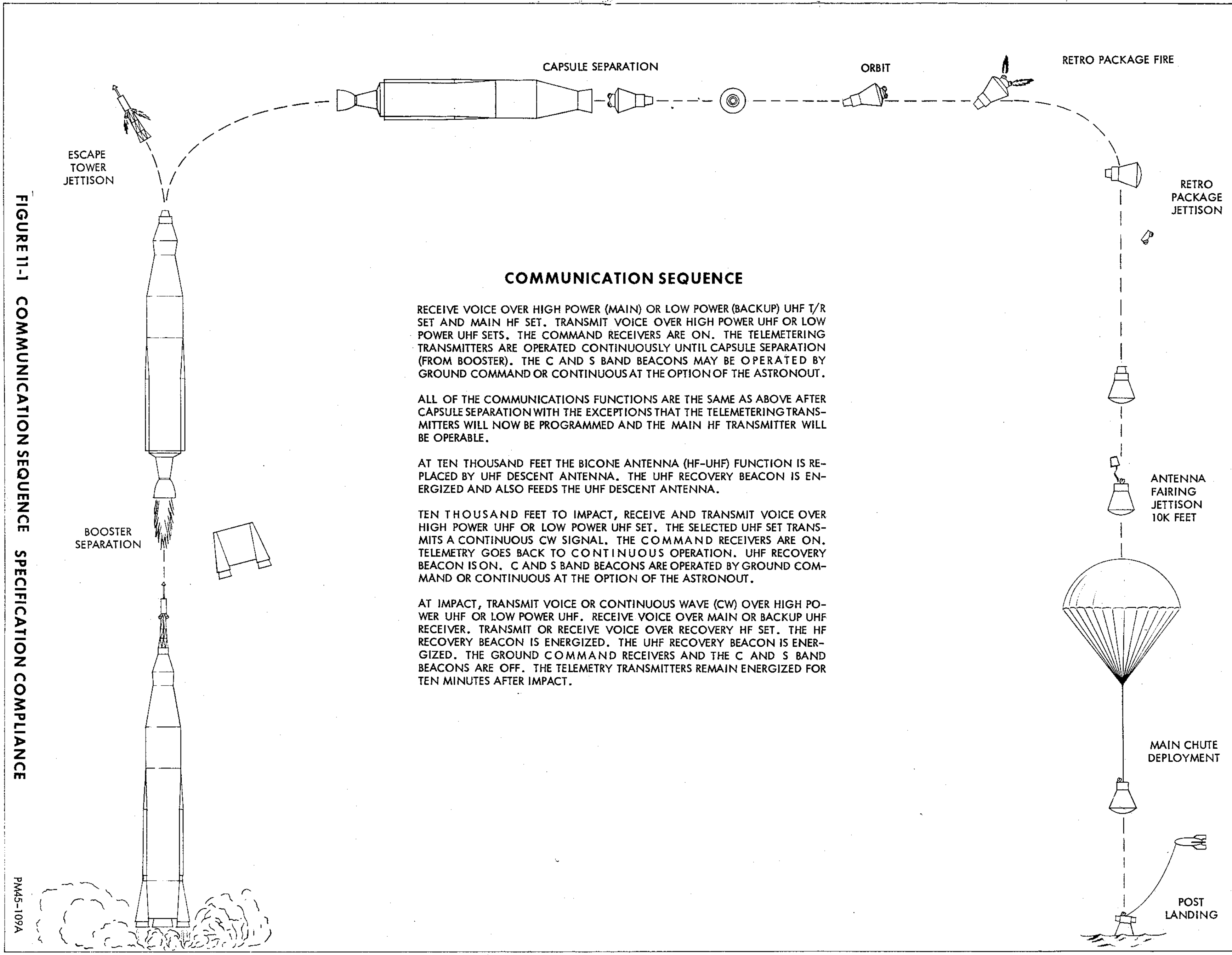
NO. OF UNITS	EQUIPMENT	TOTAL WATTS	OPERATING TIME-HRS.	TOTAL WATT HOURS
	Instrumentation - Continued			
1	Chimp Camera	26.4	0.114	3.02
1	Instrument Camera	26.4	0.35	9.25
1	Tape Recorder	9.65	0.35	3.38
1	Vibration Analysis System	3.5	2.15	7.54
	Package "A"	12.24	12.9	158.0
1	3V Power Supply			
2	Com. Keyer Record Amp.			
1	400 Power Supply			
2	CO_2 Partial Press. (Lo) (Hi)			
2	Cabin Air Temp.			
2	Body Temp.			
	Package "B"			
3	Accelerometer	1.99	10.75	21.4
1	Noise Level			
	Mixer Amp. 4 VCO's & 1 SCD			
	Mixer Amplifier & 4 VCO's			
4	Amplifier EKG			
	Package "C"	181.4	6.45	1170.0
2	O_2 Partial Pres. (LO) (Hi)			
2	DC Current Amp (2)			
1	Programmer			
	Special Instrumentation			
1	Psychomotor (constant)	4.0	0.35	1.4
1	(Shock) $\frac{1}{2}$ Sec/20 Sec	81.0	.008	0.65

SECTION XI



COMMUNICATION SYSTEM

TABLE OF CONTENTS



COMMUNICATION SEQUENCE

RECEIVE VOICE OVER HIGH POWER (MAIN) OR LOW POWER (BACKUP) UHF T/R SET AND MAIN HF SET. TRANSMIT VOICE OVER HIGH POWER UHF OR LOW POWER UHF SETS. THE COMMAND RECEIVERS ARE ON. THE TELEMETERING TRANSMITTERS ARE OPERATED CONTINUOUSLY UNTIL CAPSULE SEPARATION (FROM BOOSTER). THE C AND S BAND BEACONS MAY BE OPERATED BY GROUND COMMAND OR CONTINUOUS AT THE OPTION OF THE ASTRONOUT.

ALL OF THE COMMUNICATIONS FUNCTIONS ARE THE SAME AS ABOVE AFTER CAPSULE SEPARATION WITH THE EXCEPTIONS THAT THE TELEMETERING TRANSMITTERS WILL NOW BE PROGRAMMED AND THE MAIN HF TRANSMITTER WILL BE OPERABLE.

AT TEN THOUSAND FEET THE BICONE ANTENNA (HF-UHF) FUNCTION IS REPLACED BY UHF DESCENT ANTENNA. THE UHF RECOVERY BEACON IS ENERGIZED AND ALSO FEEDS THE UHF DESCENT ANTENNA.

TEN THOUSAND FEET TO IMPACT, RECEIVE AND TRANSMIT VOICE OVER HIGH POWER UHF OR LOW POWER UHF SET. THE SELECTED UHF SET TRANSMITS A CONTINUOUS CW SIGNAL. THE COMMAND RECEIVERS ARE ON. TELEMETRY GOES BACK TO CONTINUOUS OPERATION. UHF RECOVERY BEACON IS ON. C AND S BAND BEACONS ARE OPERATED BY GROUND COMMAND OR CONTINUOUS AT THE OPTION OF THE ASTRONOUT.

AT IMPACT, TRANSMIT VOICE OR CONTINUOUS WAVE (CW) OVER HIGH POWER UHF OR LOW POWER UHF. RECEIVE VOICE OVER MAIN OR BACKUP UHF RECEIVER. TRANSMIT OR RECEIVE VOICE OVER RECOVERY HF SET. THE HF RECOVERY BEACON IS ENERGIZED. THE UHF RECOVERY BEACON IS ENERGIZED. THE GROUND COMMAND RECEIVERS AND THE C AND S BAND BEACONS ARE OFF. THE TELEMETRY TRANSMITTERS REMAIN ENERGIZED FOR TEN MINUTES AFTER IMPACT.

FIGURE 11-1 COMMUNICATION SEQUENCE SPECIFICATION COMPLIANCE

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XI. SPECIFICATION COMPLIANCE COMMUNICATIONS SYSTEM

11-1. SYSTEM DESCRIPTION

11-2. Voice Communication

The Astronaut is provided with voice communications throughout the entire mission. (See Figure 11-1.) A dual headset and microphone contained within the Astronaut's helmet, operate through the audio control circuits to the selected voice communications set. A capsule-pad interphone system is available prior to umbilical cable disconnect.

11-3. HF reception is available through the main HF voice communication set during launch and orbit. HF voice transmission may beused only after capsule separation by Astronaut selection of the HF position of the Transmit Switch. The main set is disabled during re-entry as the antenna fairing is jettisoned. It will be de-energized and replaced by the recovery HF set upon landing. The recovery HF voice communications set provides reception and transmission, during the post landing phase of the mission.

11-4. UHF reception is available throughout the entire mission by the High Power (main) UHF voice communications set and its UHF Booster Amplifier. Transmissions over this set may be made when the UHF position of the TRANSMIT switch is selected by the Astronaut. A backup (low power) UHF voice communication set identical to the main set,but without the UHF Booster Amplifier, may be placed in operation by the Astronaut at any point during the mission.

11-5. The selected transmitter may be energized by operation of a push-to-talk switch. After the capsule has separated from the booster, a voice operated relay is available. By speaking into the microphone, the selected transmitter is automatically energized. Normally the selected UHF transmitter will automatically be energized upon landing to provide a direction finder signal.

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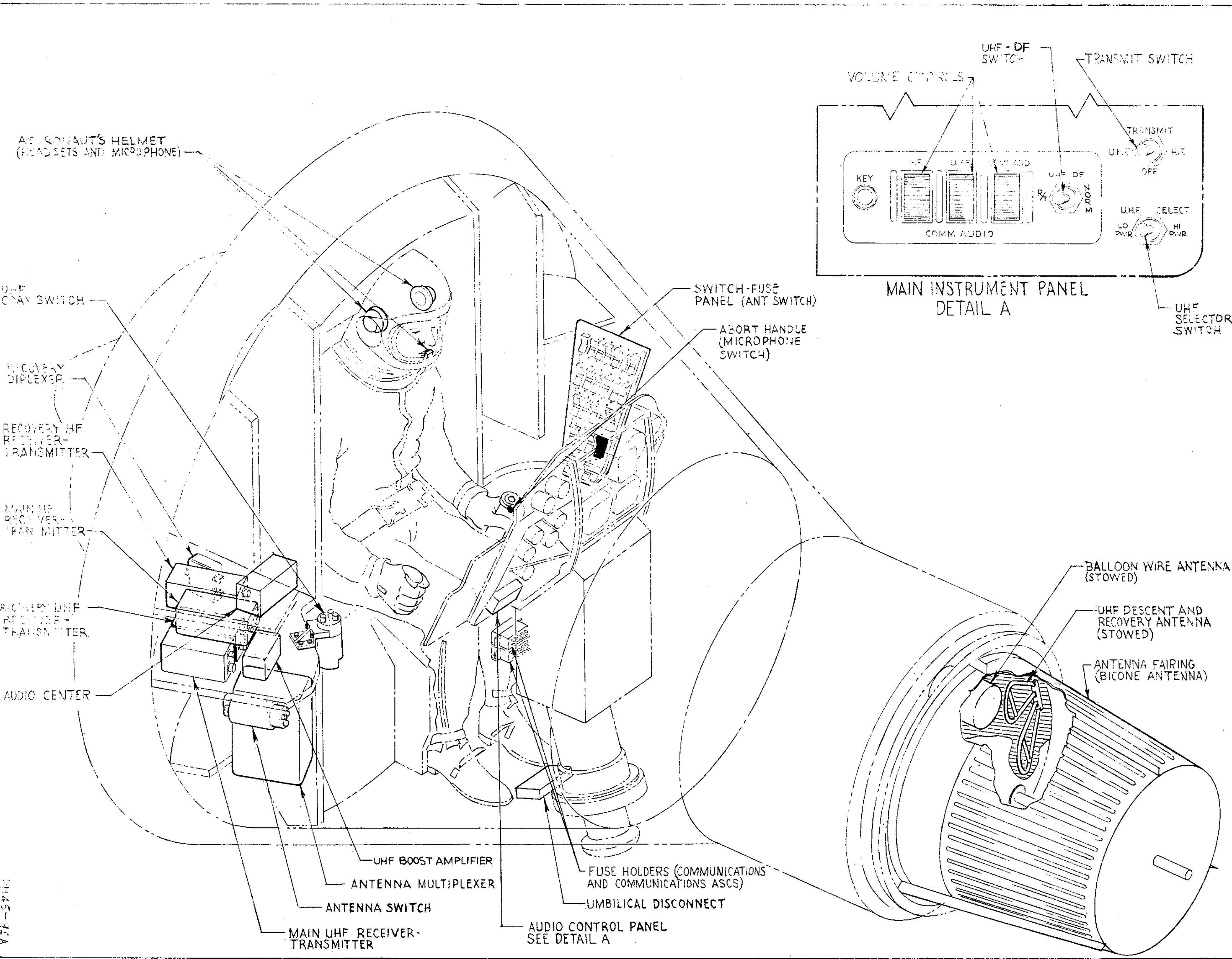

FIGURE 11-2 VOICE COMMUNICATIONS SYSTEM

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This automatic feature may be overriden by the Astronaut.

11-6. The Command Receivers provide an emergency ground station-to-capsule voice communications channel prior to capsule impact.

11-7. Power for the voice communications systems is supplied through fuses located in the Communications and the Communications and ASCS Fuse Holders. (See Figure 11-2.)

11-8. Command Receivers

Two separate sets of receiver-decoder and auxiliary decoder units are used for reception and decoding of ground command signals. These signals are for the purpose of activating various capsule control circuits.

11-9. Power for the command receivers is supplied through the fuses located in the Communications and the Communications and ASCS Fuse Holders. (See Figure 11-3.)

11-10. Telemetry

Telemetry transmitters are provided for communicating capsule information to ground stations. Information is picked up throughout the capsule in the form of voltages from voltage divider circuits. These voltages are modified by coding circuits to supply suitable inputs to the telemetry transmitters. (Refer to the Instrumentation Section of this manual.) Two transmitters are used for transmission of the telemetry information. Transmitters are operated continuously until capsule separation after which they are programmed for intermittant operation until ten thousand feet prior to impact. At this time the telemetry transmitters go back on continuous operation and remain in this mode until impact (see Figure 11-1). The power outputs of the telemetry transmitters are fed to either the main or the descent antenna.

11-11. Power for the system is obtained from fuses located in the Instrumentation Fuse Holders. (See Figure 11-4.)

11-12. Beacons

The beacons provided in the capsule to aid tracking by ground stations are a C-Band and an S-Band beacon, a UHF recovery beacon, energized during re-entry, and an HF recovery beacon, energized upon landing. These beacons provide signals compatible with direction finding equipment used by the recovery crews. The UHF voice communications transmitter may be keyed upon landing to provide an additional signal for direction finders. A flashing light is installed for visual location of the capsule after landing. (See the Recovery Aids Section of this manual.)

11-13. Capsule power for the beacons system is supplied through fuses located in the Communications and ASCS fuse holders. (See Figure 11-5.)

11-14. Antennas

The voice communications, telemetry and beacon receivers and transmitters, with their various frequencies and types of outputs require an antenna system with wide capabilities. Therefore, four types of antennas are used to fulfill the entire mission requirements. A main HF-UHF antenna is used for the major portion of the mission. During re-entry this antenna must be jettisoned to allow main parachute deployment. To replace the UHF function, a compact UHF descent antenna is automatically placed in operation. Upon landing, a balloon is released, elevating an antenna wire to permit HF operation. Throughout the entire mission, C and S band antennas are provided for operation of radar beacons. Antenna switching and multiplexing are performed automatically by the RF circuitry. (See Figure 11-6.)

11-15. Power requirements for antenna switching are supplied through a switch-fuse located on the left console switch-fuse panel.

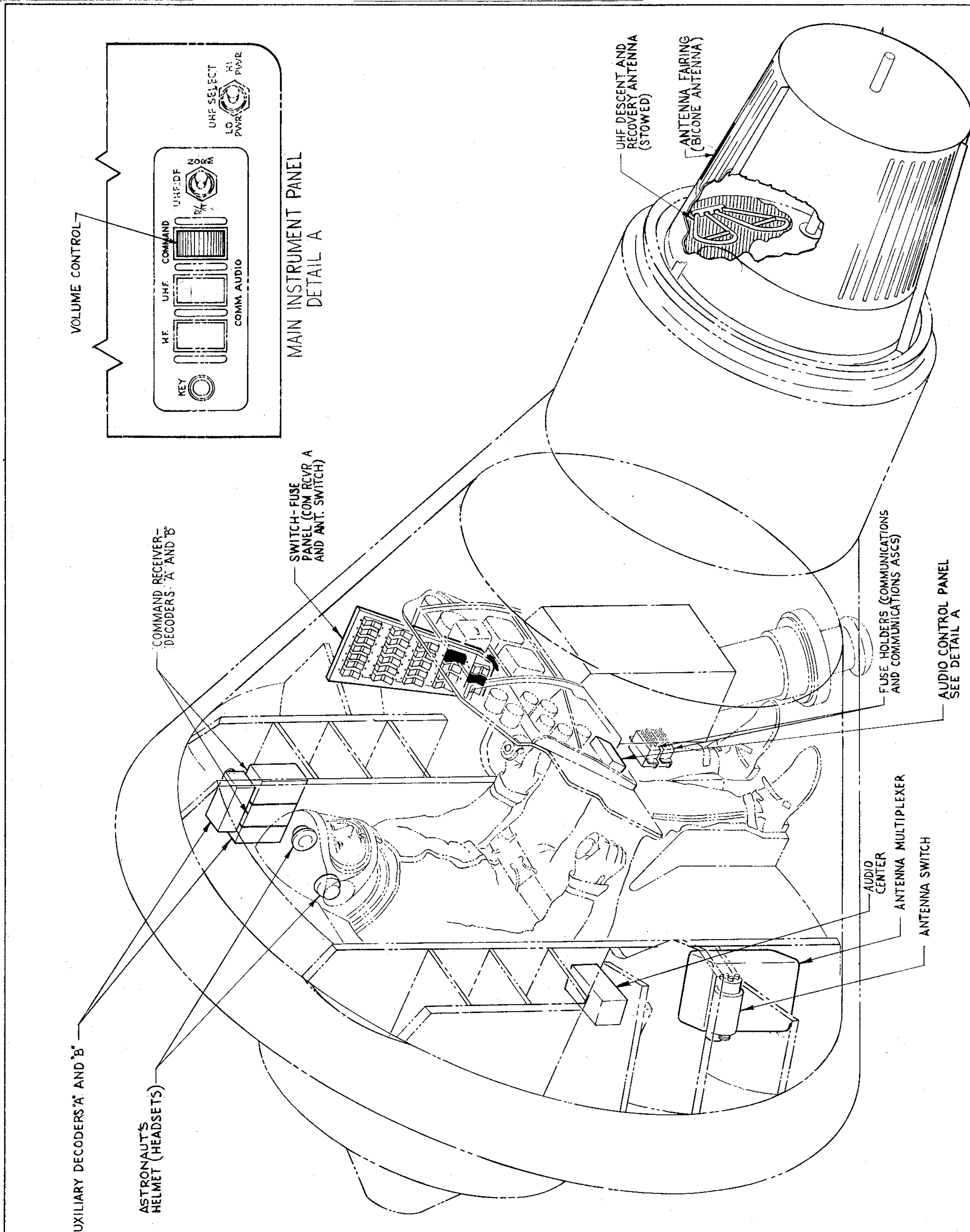

FIGURE 11-3 COMMAND RECEIVERS SYSTEM

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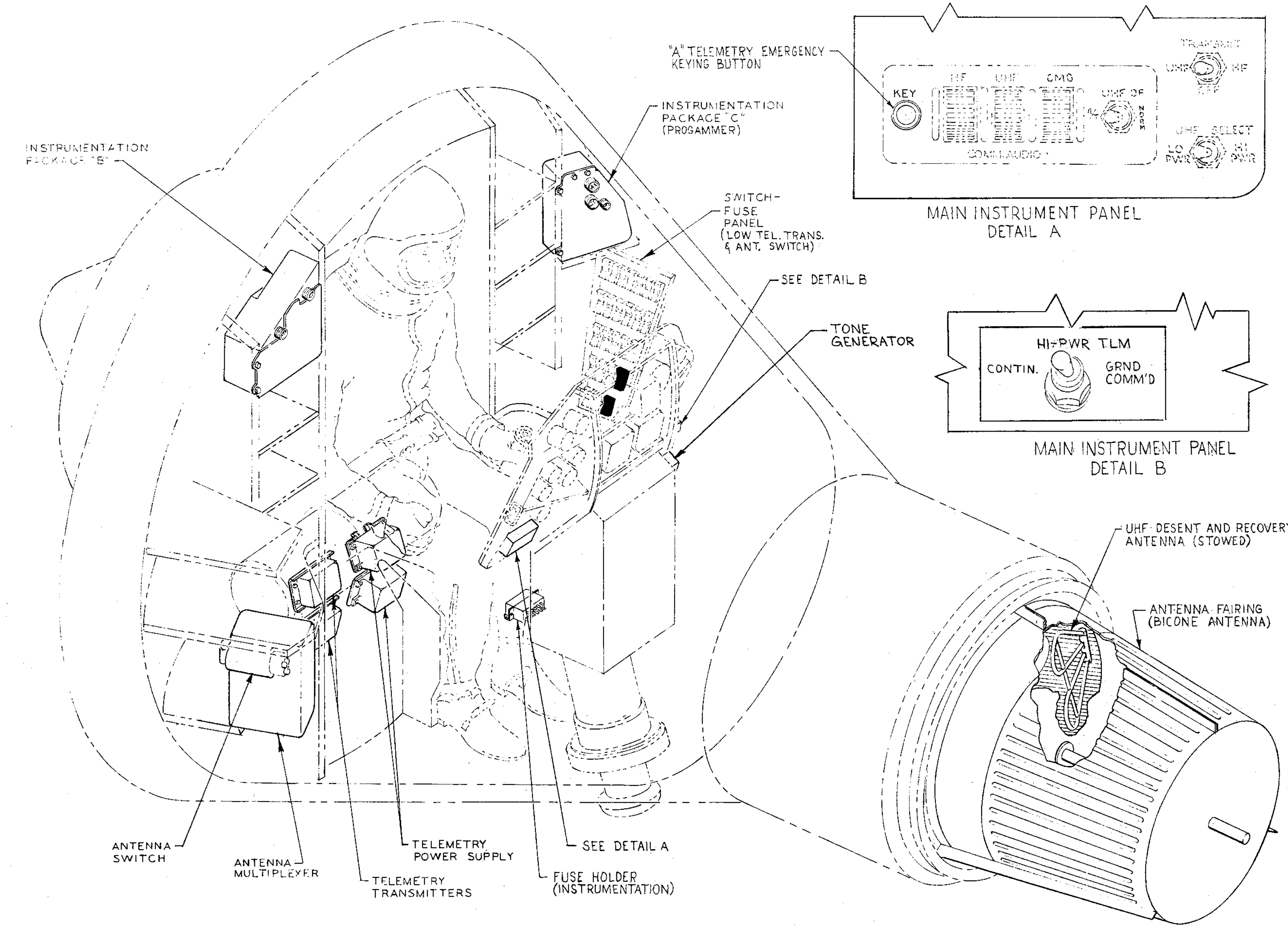

FIGURE 11-4 TELEMETRY SYSTEM

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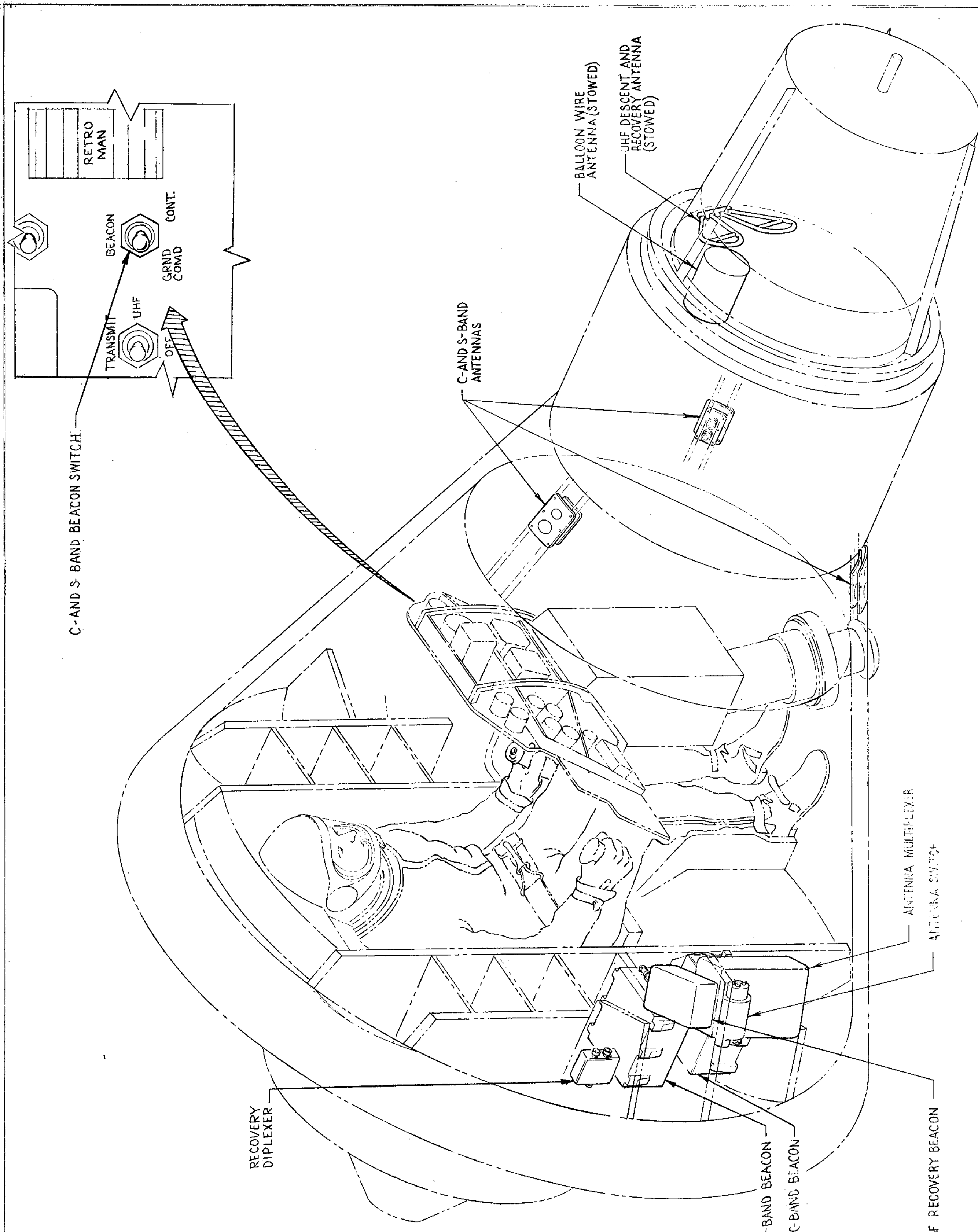

FIGURE 11-5 BEACONS SYSTEM INDEX DRAWING

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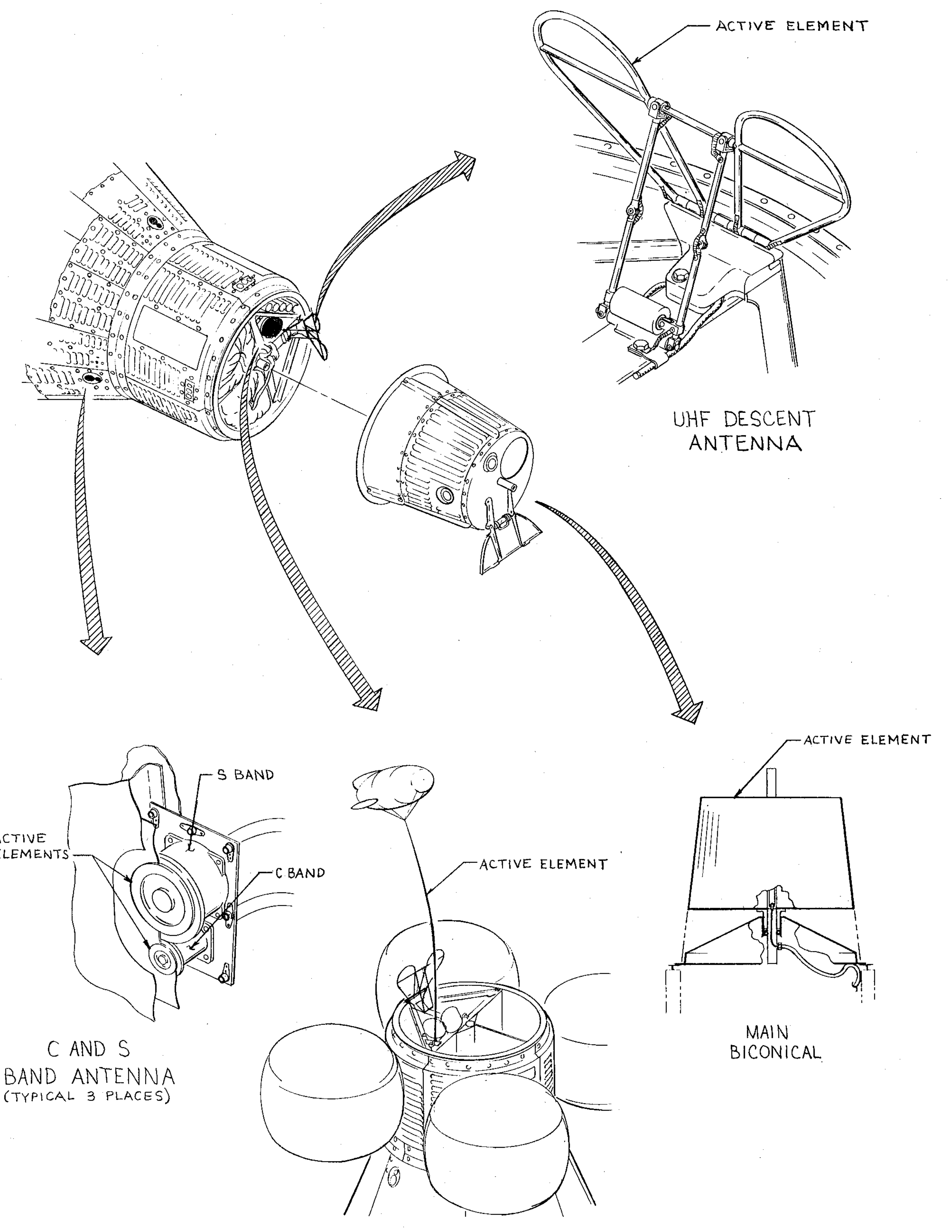

FIGURE 11-6 ANTENNA SYSTEM UTILIZATION

PM45-107A

11-16. SYSTEM OPERATION

11-17. Voice Communications

11-18. Audio Control and Ground Interphone System

(See Figure 11-7.) HF and UHF receiver outputs are routed to the control panel. This panel provides one volume control for HF audio and one volume control for UHF audio. Outputs from the two command receivers are connected to the Communication Control Panel for mixing. Separation of command and voice audio signals by a low pass filter, and amplification of resulting voice audio is done in the Audio Center. Amplified audio is then supplied to the command volume control in the control panel.

11-19. Communication audio signals from the volume controls, the interphone audio from the pad-to-the-pilot and alarm tones from the satellite clock are supplied to the tape recorder relay and the two headset amplifiers in the audio center. The headset amplifiers serve to amplify the audio signals and feed them to the individual earphones in the Astronaut's helmet. The de-energized tape recorder relay supplies incoming communications audio for recording during periods of tape recorder operation.

11-20. Audio from the microphone is fed to two separate microphone amplifiers in the audio center. These two amplifiers serve to amplify microphone output to a level sufficient to supply modulation circuits of the voice transmitters. The microphone amplifier output is also fed to the input of the VOX (voice operated relay circuitry). In the period of time from pre-launch to capsule separation, the voice circuits must be energized by use of the Push to Talk switch on the abort handle. After capsule separation the VOX circuit becomes operative in addition to the push to talk mode.

11-21. HF Voice Communications

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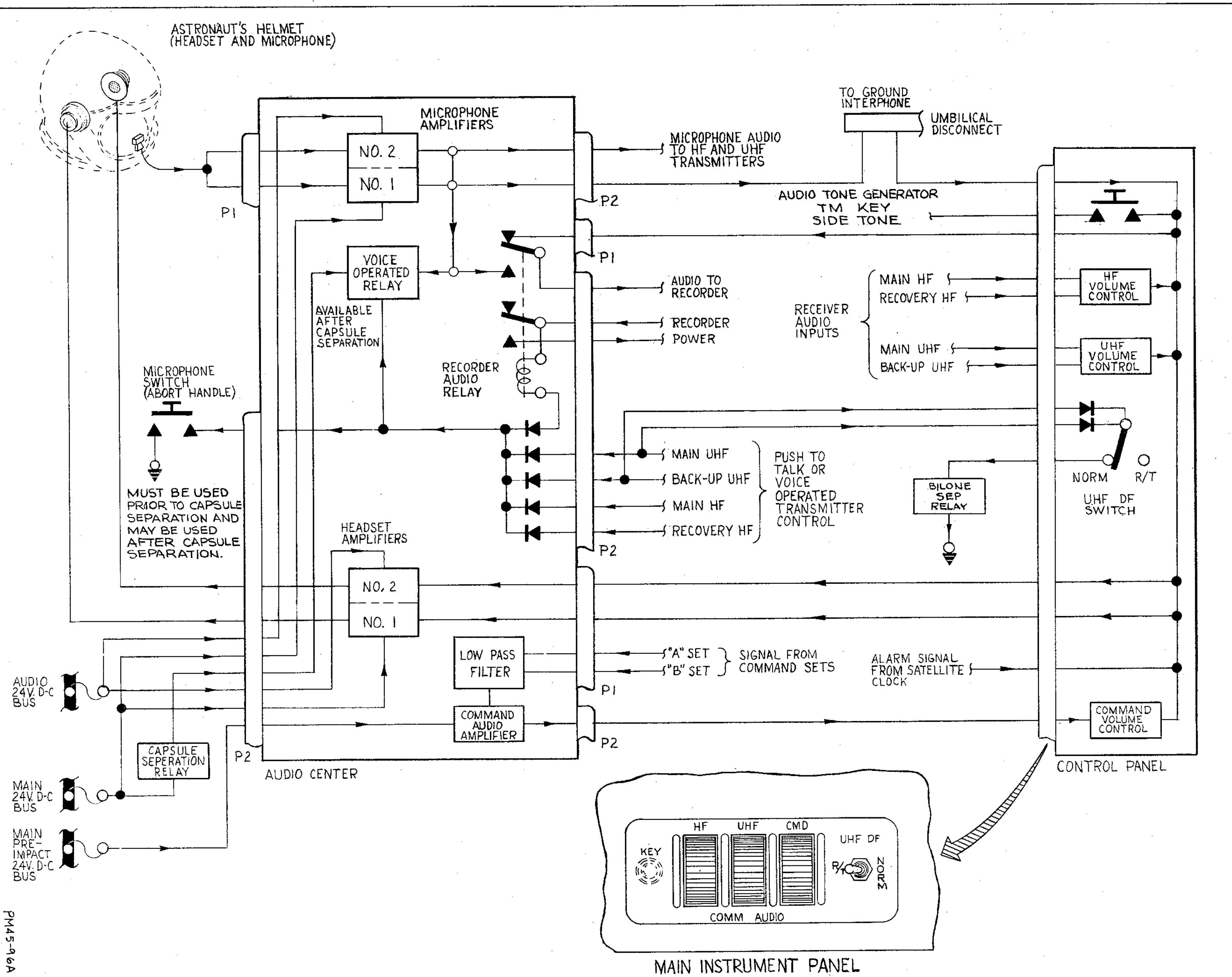

FIGURE 11-7 AUDIO CONTROL AND GROUND INTERPHONE SYSTEM

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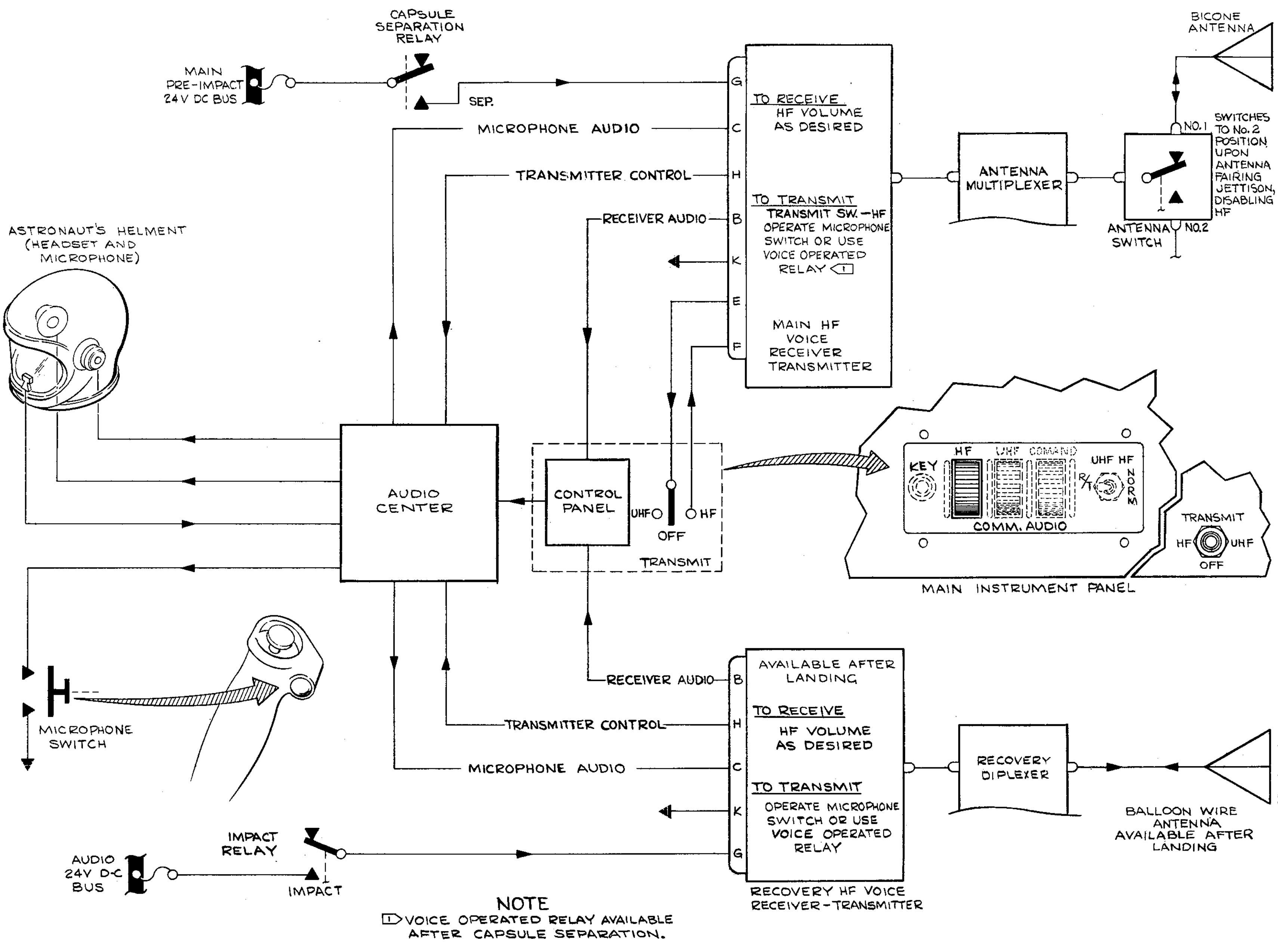

FIGURE 11-8 HF COMMUNICATIONS DATA FLOW

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(See Figure 11-8.) The main HF voice communications set is an AM receiver-transmitter unit designed to operate on a frequency of approximately 15 MC.

11-22. Power from the main pre-impact 24 volt d-c bus is fed directly to the receiver section of the set. The transmitter is fed 24 volts d-c through the HF position of the Transmit Switch and the closed contacts of the capsule separation relay, after capsule separation. Audio input to the transmitter portion of the unit is from the microphone amplifier in the audio center. The transmitter is energized either automatically through the VOX circuit or manually by the Astronaut's use of the push to talk switch.

11-23. The antenna connection from the set is through the antenna multiplexer and the antenna switch to either the bicone or the descent antenna. HF radiation from the descent antenna is negligible. Audio output from the receiver, including sidetone during transmission is routed to the HF volume control in the control panel.

11-24. The recovery HF voice communications set is basically the same as the main HF unit but with the transmitter having a lower output.

11-25. The power input to the recovery HF unit is supplied upon landing, through the impact relay, from the audio 24 volt d-c bus. Audio is supplied and keying of the transmitter is in the same manner as the main set.

11-26. The antenna connection is through the recovery diplexer to the balloon elevated recovery antenna. Audio output from the receiver, including sidetone, is routed through the HF volume control in the control panel through the audio center and to the headsets.

11-27. UHF Voice Communications

(See Figure 11-9.) The main UHF voice communications set is an AM receiver-transmitter unit designed to operate on a frequency of approximately 299 MC.

The transmitter output is increased by a separate UHF amplifier.

11-28. Power from the audio 24 volt d-c bus is fed through the NORM position of the UHF Selector Switch directly to the receiver section of the set. This power is also fed to the Transmit Switch. Power for the transmitter section of the set is then taken from the UHF position of the Transmit Switch. At bicone antenna separation the bicone separation relay contacts assume the same function as the UHF contacts of the Transmit Switch thus providing a continuous UHF signal for DF purposes. Audio input to the transmitter portion of the unit is from the microphone amplifiers in the audio center. The transmitter is energized either automatically or manually by the Astronaut. When the HI POWER set is selected with the UHF Selector Switch, it will be energized automatically at bicone separation to provide a UHF signal for direction finding equipment. This feature may be overriden by operation of the UHF DF Switch on the control panel to the OFF or the UHF position.

11-29. Antenna connection from the set is through the UHF booster amplifier, coax switch, antenna multiplexer, and the antenna switch to either the main or descent antenna. Operation of the microphone switch or energizing the voice operated relay while in the UHF mode causes the booster amplifier to be inserted in series with the coax line. Transmitter output is then boosted by this amplifier to 2 watts. The booster is also available after landing. The multiplexer output is connected through the antenna switch to either the main or descent antenna.

11-30. Audio output from the receiver, including sidetone during transmission is routed to the UHF volume control in the control panel.

11-31. The Lo power UHF voice communications set is identical to the main set but without the booster amplifier. It may be energized by Astronaut operation of the UHF Selector Switch to the RESERVE position. Power input, audio input,

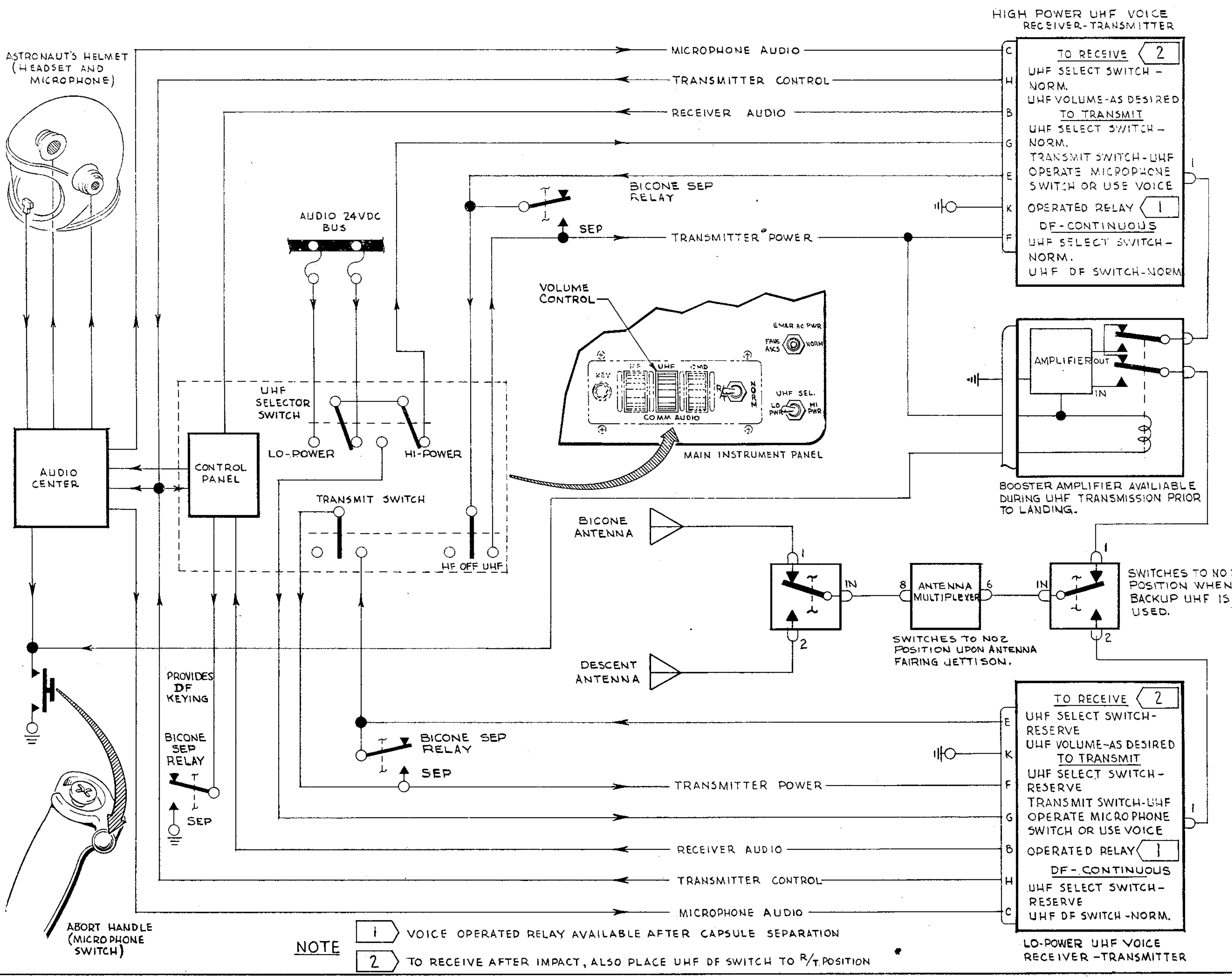

FIGURE 11-9 UHF VOICE COMMUNICATIONS DATA FLOW

receiver output, and the control of the transmitter is in the same manner as used for the main UHF set.

11-32. Antenna connection is routed through the UHF coax switch, which has been energized by selecting the Lo Power position of the UHF Selector Switch, through the UHF booster's coax switch, the antenna multiplexer and the antenna switch to either the main or descent antenna.

11-33. Command Receivers

(See Figure 11-10.) The receiver-decoder unit consists of an FM receiver operating in the frequency range of 406 to 450 MC. The received signal may be modulated with a maximum of six of a possible twenty audio frequencies. The receiver reduces the input signal to the modulation frequencies which operate individual control relays.

11-34. Each control relay provides contacts for a normally open or a normally closed control channel. Ten channels are provided in the "A" receiver-decoder with an additional ten available in the "A" auxiliary decoder. These 20 channels are paralleled by the output of the "B" receiver-decoder, auxiliary decoder units. Command channel assignments are not disclosed for security reasons.

11-35. Emergency voice communications may be had from the ground station to the capsule through the command receivers. Receiver outputs are supplied through a filter and amplifier in the audio center circuits to the Astronaut's headset.

11-36. Power for the command set "A" is supplied from the isolated 18 volt d-c bus while power for the command set "B" is supplied from the standby 18 volt d-c bus. Both power circuits are routed through sections of the impact relays in order to de-energize the set upon landing.

11-37. Antenna input is from the main or descent antenna through the antenna

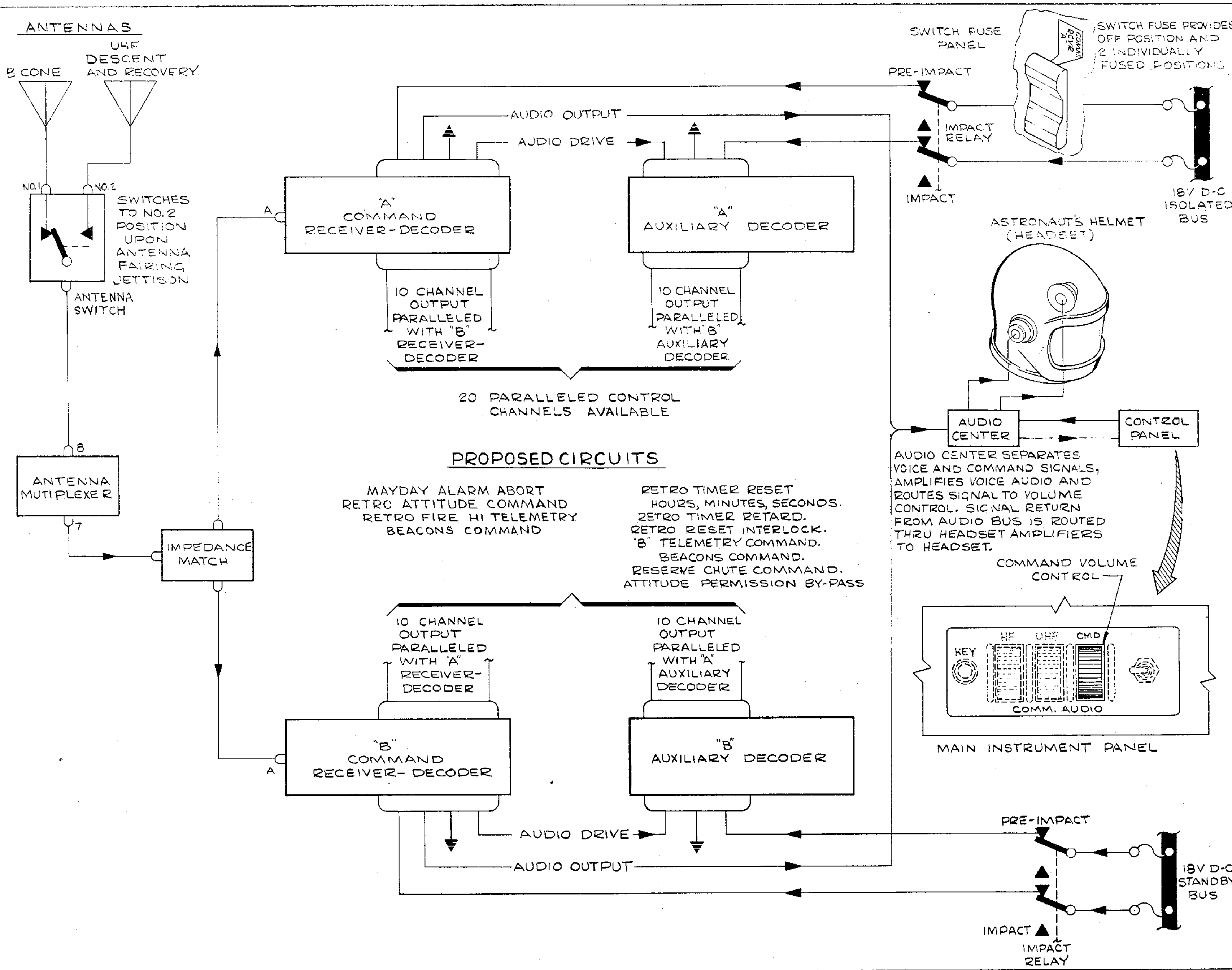

FIGURE 11-10 COMMAND RECEIVERS DATA FLOW

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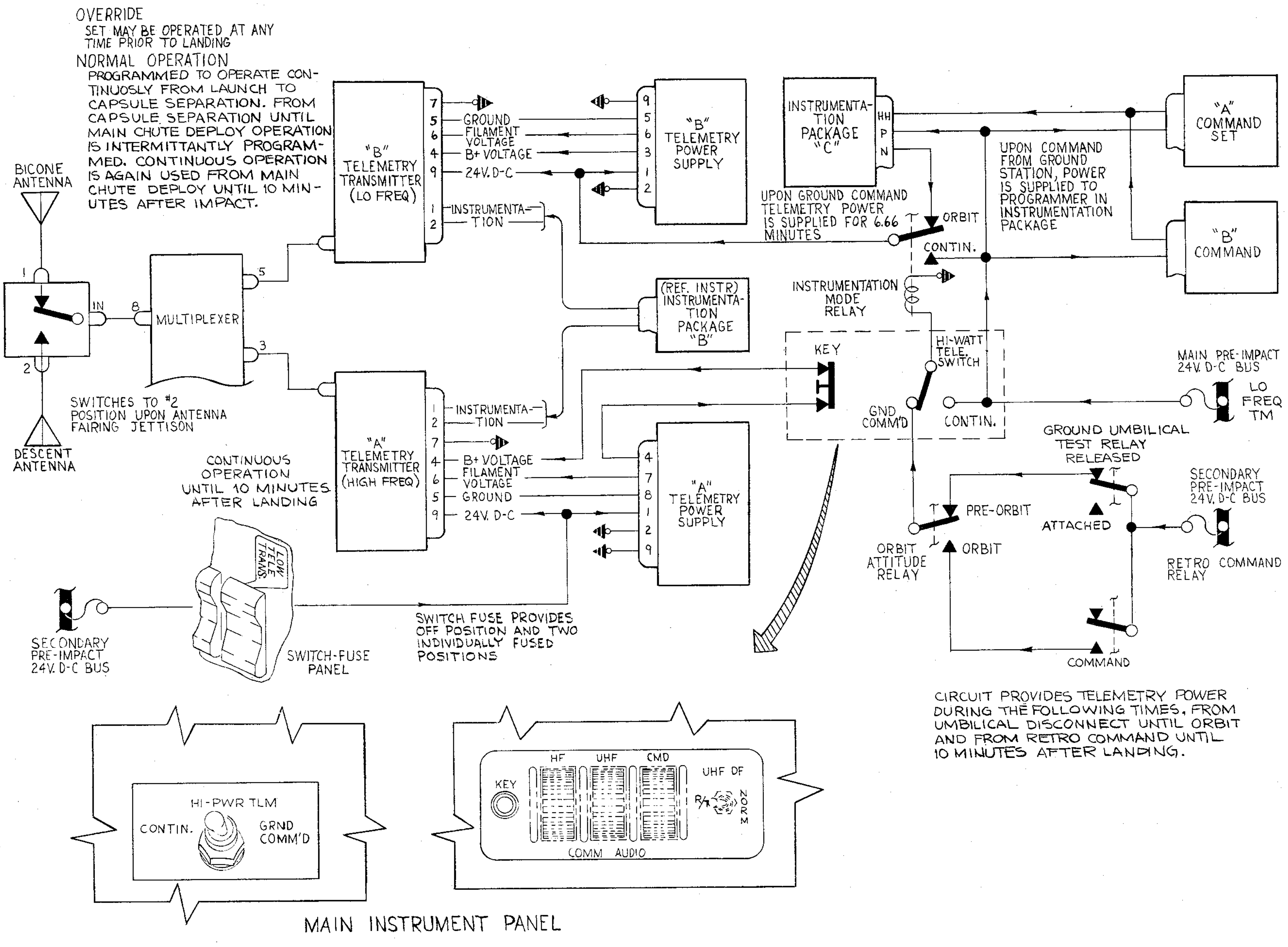

FIGURE 11-11 TELEMETRY SYSTEM DATA FLOW

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PM45-100A

switch and antenna multiplexer to an impedance match which supplies both receivers.

11-38. Telemetry

11-39. "B" Telemetry (Lo Frequency)

(See Figure 11-11.) The Lo frequency, "B" telemetry set is an FM transmitter operating on a frequency of approximately 228 MC.

11-40. A power supply provides filament and B+ voltages to the transmitter. Both the transmitter and the power supply receive 24 volts d-c through the #1 Instrumentation Mode Relay. This relay is energized from umbilical drop until orbit attitude is attained and again from retro command until landing. During these times power for the low frequency "B" telemetry is obtained directly through the normally open relay contacts.

11-41. While in orbit, the #1 Instrumentation Mode Relay is normally de-energized. Power for the low frequency telemetry is then supplied through the normally closed relay contacts from the programmer in instrumentation package "C". This programmer is controlled by ground command through the command receiver-decoders. Upon ground command for low frequency telemetry the programmer closes the transmitter and power supply 24 volt d-c circuit for 6.66 minutes. The Astronaut may override the programmer while in orbit by placing the Lo Freq Telemetry Transmitter Switch in the CONTIN. position. This will again energize the #1 Instrumentation Mode Relay and directly power the "B" (Lo Freq) telemetry set.

11-42. Coded instrumentation information is supplied from the instrumentation package "B", and used to frequency modulate the transmitter. (See the Instrumentation Section of this manual.)

11-43. RF power output is fed to the antenna multiplexer where it is routed through the antenna switch to the main or descent antenna.

11-44. "A" Telemetry (Hi Frequency)

(See Figure 11-11.) The "A" telemetry set operates on a frequency of approximately 260 MC.

11-45. Input power for the set is from a separate telemetry power supply operating from the secondary pre-impact 24 volt d-c bus and supplying filament and B+ voltage. The B+ voltage supply is routed through the key on the control panel. This allows the Astronaut to interrupt the circuit, transmitting code, in the event the voice communications fail.

11-46. Coded instrumentation information is supplied from the instrumentation package "B" to frequency modulate the transmitter. (See the Instrumentation Section of this manual.)

11-47. RF power output is fed to the main or descent antenna through the antenna multiplexer and the antenna switch.

11-48. Beacons

11-49. C-Band Beacon

(See Figure 11-12.) The C-band beacon is a transponder unit consisting of a receiver and transmitter operating on a frequency of approximately 5400 to 5900 MC. The beacon is compatible with the FPS-16 radar. Upon ground command, through the command receivers, or by Astronaut selection of the CONTIN. position of the Beacon Switch, the beacon receiver is energized. Interrogation by ground radar will then result in a coded reply from the beacon transmitter.

11-50. Input power is from the main pre-impact 24 volt d-c bus through the beacon relay controlled by the command receivers, or through the Beacon Switch.

11-51. Beacon antenna connection is through the C-band power divider to the three C and S band beacon antennas.

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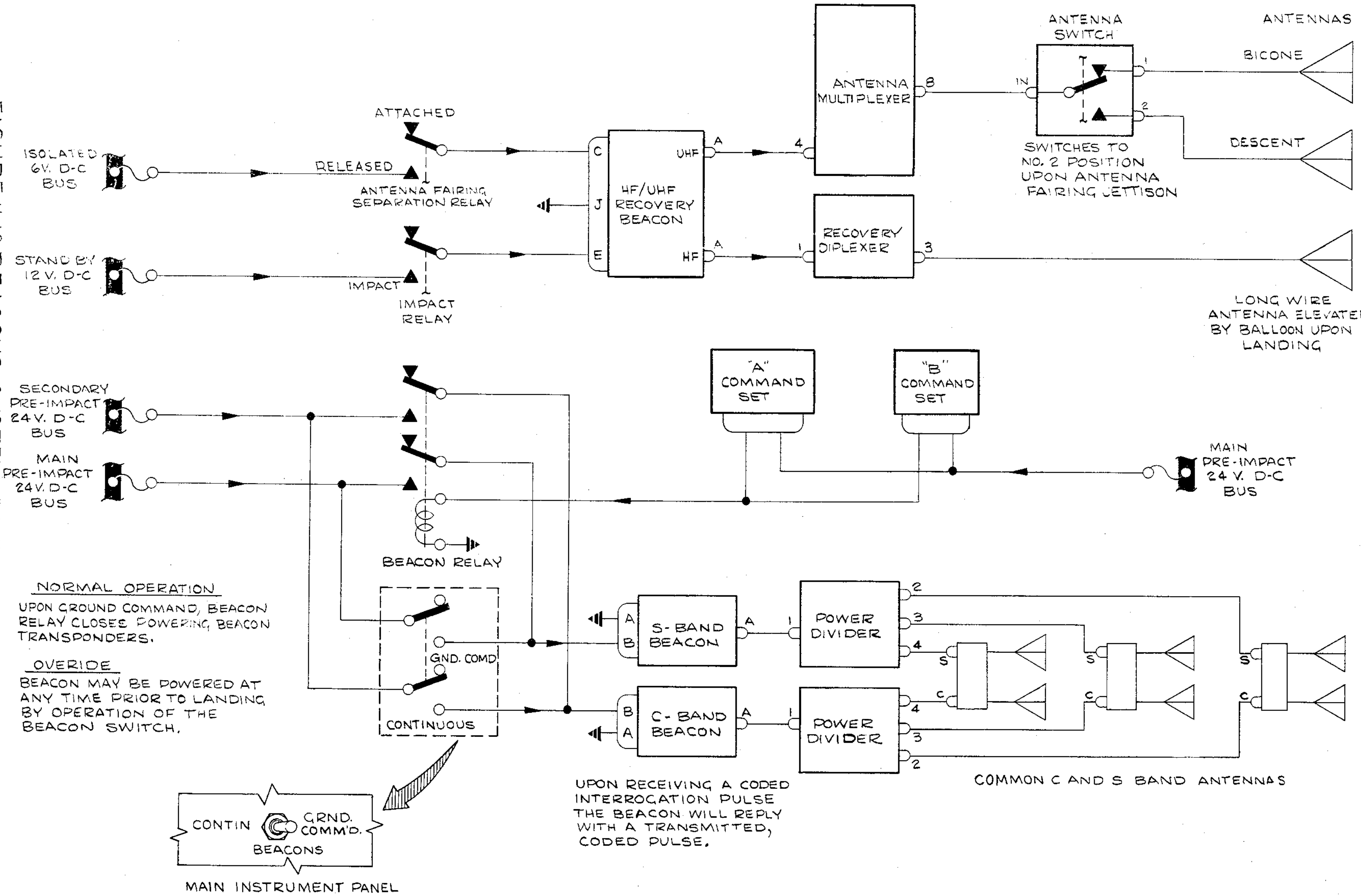

FIGURE 11-12 BEACONS SYSTEM DATA FLOW

PM45-108A

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11-52. S-Band Beacon

(See Figure 11-21.) The S-band beacon is also a transponder unit consisting of a receiver and transmitter. This unit operates on a frequency of approximately 2700 to 2900 MC and is compatible with the SCR-584 MOD II radar.

11-53. Power circuits, interrogation and reply are in the same manner as the C-Band beacon.

11-54. Beacon antenna connection is through the S-Band power divider to the three C and S band beacon antennas.

11-55. HF/UHF Recovery Beacon

(See Figure 11-12.) Two recovery beacons are combined into one unit. One beacon operates on high frequency, while the other operates on ultra high frequency. Both are energized to provide radio signals for recovery direction finder equipment.

11-56. The HF beacon operates on a frequency of 8.364 MC with a tone modulated output. It is powered by the 12 volt standby bus through the impact relay and is energized upon landing. The RF power output is fed through the recovery diplexer to the balloon elevated recovery antenna.

11-57. The UHF beacon operates on a frequency of 243 MC with pulse modulation. It is powered by the 6 volt isolated bus through the antenna fairing separation relay. This circuit is energized during re-entry when the antenna fairing is jettisoned. The RF power output is fed through the antenna multiplexer and the antenna switch to the descent antenna.

11-58. Antennas

(See Figure 11-13.)

11-59. Main

A biconical antenna is used for pre-launch, launch, orbit and initial re-entry

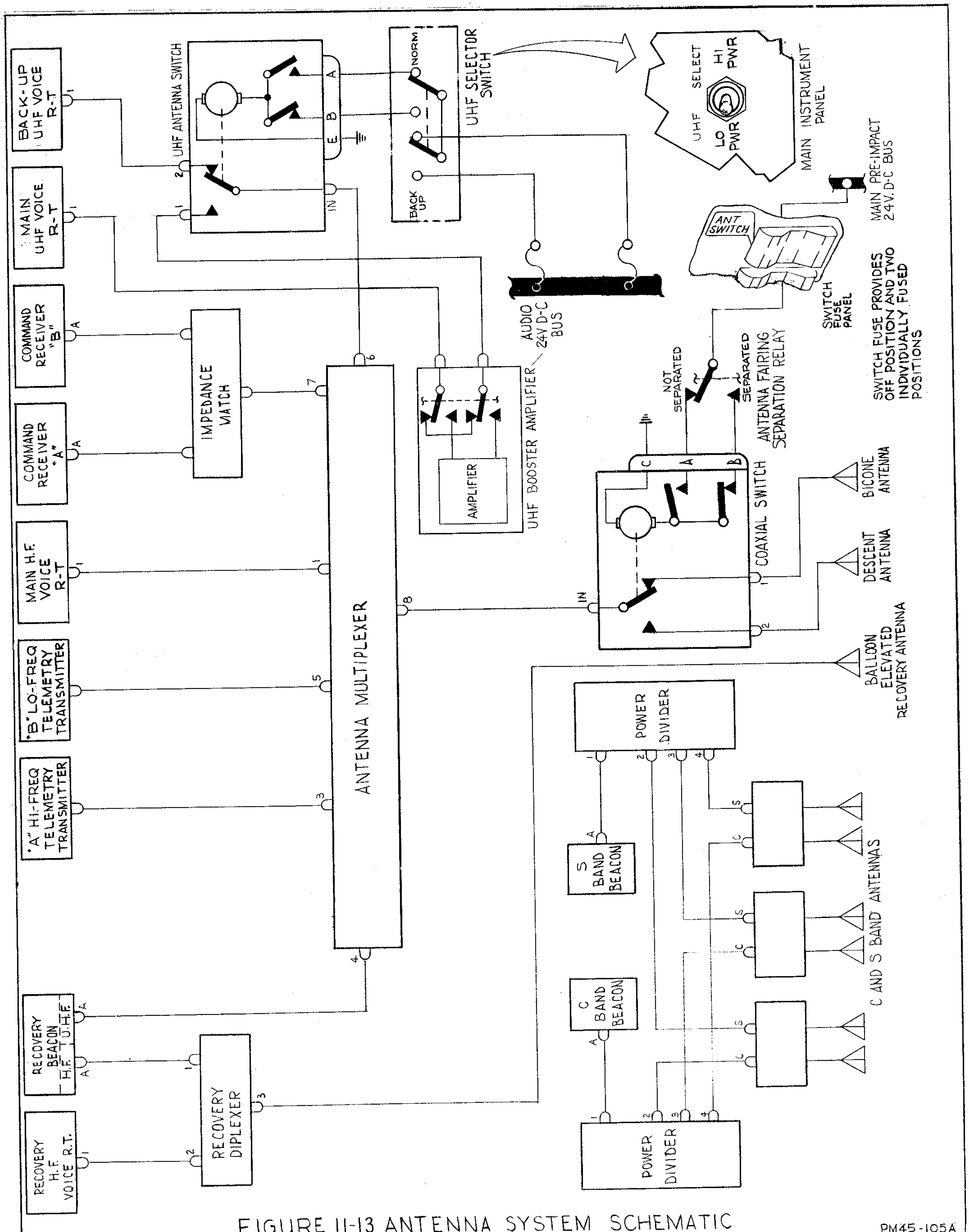

FIGURE 11-13 ANTENNA SYSTEM SCHEMATIC

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phases of the mission. This antenna is an integral part of the antenna fairing and is located over the open end of the recovery system compartment of the cylindrical capsule afterbody. The biconical antenna serves the main HF voice receiver-transmitters, the command receivers, and the telemetry transmitters. The active element of the biconical antenna forms the upper portion of the antenna fairing while the lower portion of the fairing and the capsule body forms the ground plane for the antenna.

11-60. UHF Descent and Recovery

An UHF descent antenna is used for the final phase of re-entry, landing and recovery. It is a compact antenna located on the open surface of the recovery systems compartment. The antenna is folded when the antenna fairing is installed. When the fairing is jettisoned the UHF descent antenna is erected and serves the UHF voice receiver-transmitters, the UHF portion of the recovery beacon, the command receivers, and the telemetry transmitter. The main HF voice receiver-transmitter is connected and operating but radiation from this antenna is negligible.

11-61. Main and Descent Antenna Feed

The various radio systems are connected to the biconical horn antenna or the UHF descent antenna in the following manner:

(1) The main HF voice receiver-transmitter antenna lead is connected to the antenna multiplexer.

(2) The UHF Selector Switch determines whether the main or the back-up UHF receiver-transmitter is used. It also energizes the UHF coax switch to connect the operating UHF set to the antenna multiplexer.

(3) The two command receiver antenna leads are connected to an impedance matching network. This enables both receivers toshare a single antenna lead from

the impedance match to the antenna multiplexer.

(4) The "A" and "B" telemetry transmitters each feed directly to the antenna multiplexer.

11-62. The antenna multiplexer enables simultaneous or individual operation of the radio systems using one antenna. Effectively this is a radio frequency junction box. Final connection to the antenna is through the antenna switch to either the biconical antenna, or the UHF descent antenna. The antenna switch is operated by the antenna fairing separation relay to cause the automatic shift from the main antenna to the descent antenna upon antenna fairing jettison.

11-63. Balloon Wire Antenna

A balloon antenna is provided to permit HF radio transmission and reception after landing. The balloon and antenna wire are stowed in a container located in the recovery systems compartment. Impact forces close control circuitry causing the balloon to inflate with helium and release, elevating the antenna wire.

11-64. The balloon is of an aerodynamic lifting shape capable of keeping the antenna elevated in winds up to 30 knots. Once erected, the antenna is used for the HF recovery voice receiver-transmitter and the HF portion of the recovery beacon.

11-65. Antenna leads from the HF recovery voice receiver-transmitter and the HF recovery beacon are connected to the HF recovery diplexer. This diplexer allows simultaneous or individual operation over the single lead to the balloon antenna wire.

11-66. C and S Band Antennas

Three C and S band antenna units are installed in the capsule structure for the

C and S-band beacons. These units are equally spaced about the circumference of the conical section. Each antenna unit consists of one helix as a C-band antenna and one helix as an S-band antenna.

11-67. Antenna leads from the C-band and S-band beacons are routed through individual power dividers to the three associated helix antennas.

11-68. SYSTEM UNITS

11-69. Audio Center

The audio center provides transistorized audio amplifiers, a "voice operated relay" (VOX), an audio filter, tape recorder control circuitry and transmitter control circuitry. All components are contained in a light weight, foam encapsulated unit.

11-70. Two fixed gain headset amplifiers are used to bring audio signals up to headset level and feed the headsets separately. Two fixed gain amplifiers are provided to increase the dynamic microphone output to a level suitable to be used with the various transmitters.

11-71. A low pass filter, with a cutoff for frequencies above 300 cps, filters the audio supplied from the command receivers. Output from the filter is fed to a variable gain, command audio amplifier.

11-72. The "voice operated relay" is a transistorized amplifier with separate adjustable threshold level and release time controls. The amplifier operates a relay to provide a grounding circuit for transmitter control. This unit parallels the external microphone switch.

11-73. The audio center furnishes circuit to apply the transmitter control ground potential to the various transmitters. Each circuit is protected from the rest by a crystal diode.

11-74. A relay is installed in the audio center for supplying power and audio signals to the tape recorder. In the de-energized condition, the relay closes a circuit to the tape recorder input. Thus audio received by the capsule is recorded whenever instrumentation programs tape recorder operation.

11-75. When the microphone switch or VOX is operated, the tape recorder relay is energized. One set of closed relay contacts now completes the recorder power circuit independent of instrumentation programming, while a second set of contacts routes signal from the microphone amplifiers to the recorder input.

11=76. The circuits in the audio center operate directly from the capsule 24 volt d-c inputs with no further regulation or voltage increase.

11-77. Control Panel

The audio control panel provides controls and circuits for the audio signals of the various capsule receivers.

11-78. The two HF and two UHF circuits are routed through individual T-pads to volume controls. The two HF circuits share a single volume control. The same is true of the two UHF circuits.

11-79. A separate volume control is provided for the command audio circuit. Fixed inputs are used for the alarm tone and ground interphone circuits.

11-80. Audio output from the panel contains signals from each input.

11-81. The panel also contains a switch override for the impact keying feature used with the UHF transmitters.

11-82. A keying button on the panel may be used to interrupt the "A" Hi-Frequency telemetry B+ supply.

11-83. Main HF Voice Receiver-Transmitter

The main HF voice set is an AM receiver-transmitter designed as a small, light weight unit operating near 15 MC.

11-84. The receiver section of the unit is a transistorized TRF circuit using a crystal filter, crystal diode detector and class B audio amplifier. The final audio amplifier is used for sidetone during transmissions.

11-85. The transmitter section of the unit utilizes vacuum tube stages for the crystal controlled oscillator, driver and power amplifier. The power amplifier may be modulated up to 90% by a transistorized speech amplifier and modulator. These audio stages are also used for sidetone. Transmitter output is 10 watts.

11-86. Capsule power, 24 volts d-c, is supplied to the unit. Voltage regulation is provided by a Zener diode, transistor circuit. Power is routed through an external switch and contacts of the capsule separation relay which controls transmitter filament power, relay operation and a transistorized power converter. High voltage from this converter is used for the transmitter power amplifier.

11-87. Antenna switching is accomplished by a solid state circuit which blocks the receiver during transmissions. D-C voltage is also removed from the receiver RF stages.

11-88. <u>Recovery HF Voice Receiver-Transmitter</u>

The recovery HF voice set is similar to the main set. The main difference lies in the transmitter section. This section consists of a crystal controlled oscillator and power amplifier delivering 1 watt output.

11-89. <u>High Power (Main) and Back Up UHF Voice Receiver-Transmitter</u>

The main and backup sets are identical. They consist of an AM receiver-transmitter designed as a small, lightweight unit operating near 299 MC. Transmitter output is .5 watt.

11-90. The receiver section of the unit is a transistorized superheterodyne circuit using a crystal controlled local oscillator, crystal filter and crystal diode detector. The audio section of the receiver also serves as the speech amplifier, modulator and provides sidetone for the transmitter.

11-91. The transmitter section of the unit utilizes a crystal controlled oscillator, tripler and power amplifier. The RF section uses vacuum tubes while the modulation circuits are transistorized.

11-92. Capsule power, 24 volts d-c, is supplied to the set. This voltage is applied to the receiver, audio circuits and back through an external transmit switch to an internal power converter. This transistorized converter supplies B+ voltage to the transmitter RF sections. Transmitter filament voltage is also applied by the external transmit switch or the bicone separation relay after bicone separation.

11-93. Switching from receiver to transmitter operation is accomplished when ground potential is applied to a switching relay and a blocking circuit. The relay provides antenna and power converter switching. The blocking circuit removes receiver voltage.

11-94. UHF Booster Amplifier

A booster amplifier is used prior to landing to increase the .5 watt output of the Main UHF transmitter to 2.0 watts. The higher power is available after landing.

11-95. Signal input to the booster is routed through a double pole, double throw relay. When the relay is de-energized, the signal is routed through the contacts to the output jack. Energizing the relay feeds the signal through the amplifier and takes the amplifier output to the output jack.

11-96. Command Receiver-Decoders

The command receiver-decoder is a transistorized unit consisting of an FM receiver designed to operate in the frequency range of 406 to 450 MC, and a decoder unit to operate control circuits.

11-97. The receiver section of the unit is a dual conversion superheterodyne circuit. The first local oscillator is crystal controlled and uses two stages of frequency multiplication. Two stages of amplification are used for the first IF, 78 MC signal. The second local oscillator is also crystal controlled, mixing with the first IF and giving a resultant second IF of 10.75 MC. Output from the IF strip is through a limiter to the discriminator.

11-98. Audio amplifiers boost the discriminator output for the command voice channel and the decoder driver. The driver in turn supplies the ten decoder channels in the set.

11-99. The individual decoder channels each provide filters for their specific command frequency and amplifiers to operate a double pole, double throw relay for each channel. The ten relays thus make available normally open and normally closed contacts for external control circuit operation.

11-100. Capsule power, 18 volts d-c, is used to power the set. A Zener diode circuit, within the unit, is used for voltage regulation.

11-101. Auxiliary Decoders

An auxiliary decoder operates with each of the two receiver-decoder unit, allowing an additional ten channel capability.

11-102. The decoder channels in the auxiliary decoder are identical to the decoder channels of the receiver-decoder, with the exception of the command frequencies at which they operate.

11-103. The auxiliary decoder operates from capsule 18 volt d-c power. No further voltage regulation or increase is required.

11-104. Telemetry Power Supplies

The telemetry power supplies generate voltages used in the telemetry transmitters.

11-105. The unit is transistorized and uses crystal diodes. Capsule power, 24 volts d-c, is applied to a transistor switching circuit operating into the primary of a power transformer.

11-106. A full wave, crystal diode rectifier is used on one secondary, with voltage regulation, to provide 200 volts d-c. The other secondary winding supplies 6.3 volts a-c output.

11-107. Telemetry Transmitters

The main telemetry transmitters are essentially identical. They must be ground adjusted for an output of 3.3 watts. One set is operated at approximately 228 MC while the other is tuned to approximately 260 MC.

11-108. The transmitter is an FM unit using modulation inputs from instrumentation circuits. Modulation signals are applied to the oscillator which through four stages of doubling feeds a power amplifier stage. All stages, with the exception of the final doubler and the power amplifier, are transistorized.

11-109. Filament voltage, 6.3 volts a-c, and B+ voltage, 200 volts d-c, are obtained from the separate power supply. Capsule power, 24 volts d-c, is applied to the transmitter, which provides voltage regulation.

11-110. C-Band Beacon

The C-Band transponder is a pressurized superheterodyne receiver and pulse modulated, 400 watt peak output transmitter, operating in the frequency range of 5400 to 5900 MC. With the exception of the magnetron, the unit is transistorized.

11-111. The receiver consists of a pre-selector, local oscillator, 40 MC IF amplifier strip, pulse detector, pulse amplifier and decoder. Resonant cavities are used for the pre-selector and local oscillator.

11-112. The transmitter section accepts decoder outputs and pulse modulates the transmitter magnetron output.

11-113. The unit contains a power supply for converting capsule 24 volt d-c input to filtered 24 volt d-c and regulated 115 and 150 volt d-c.

11-114. Antenna switching is through an internal diplexer.

11-115. S-Band Beacon

The S-Band transponder is a pressurized superheterodyne receiver and pulse modulated, 1,000 watt peak output transmitter operating in the frequency range of 2700 to 2900 MC. Like the C-Band beacon, the unit is transistorized except for the magnetron.

11-116. Receiver and transmitter circuits are the same as those used in the C-Band beacon with the exception of the pre-selector, local oscillator and transmitter cavities which are designed for S-Band frequencies.

11-117. HF/UHF Recovery Beacon

The recovery beacon combines an HF, tone modulated, 8.364 MC transmitter and a UHF, pulse modulated, 243 MC transmitter into one small, foam encapsulated unit.

11-118. The UHF section of the beacon is a one tube circuit with a pulse coding network.

11-119. The HF section of the beacon is a transistorized crystal oscillator and two stage power amplifier with tone modulation supplied from a power converter.

11-120. The beacon utilizes 6 and 12 volts d-c from the capsule power system. The UHF section is energized by applying the 6 volt d-c to a transistorized power converter. A full wave, crystal diode circuit is used to rectify the power converter output which is applied to the UHF stage. Applying 12 volts d-c energizes the HF section of the beacon. No power converter is required for the 12 volt input.

11-121. Modulation for the HF section is provided by routing the 12 volt supply to the power amplifier stages through a secondary winding of the power converter

11-122. Antenna Multiplexer

The antenna multiplexer allows reception and transmission of the many capsule frequencies over one line to the main or descent antenna.

11-123. The unit consists of a number of filters arranged so that all capsule frequencies between 15 and 450 MC can be multiplexed on the single feed line. Each input channel is provided 60 db of isolation.

11-124. Recovery Diplexer

The recovery diplexer unit is used for the recovery voice receiver-transmitter and HF section of the recovery beacon. One low pass and one high pass filter is used to diplex 8.364 and 15 MC on one feed line to the balloon wire antenna.

11-125. Coaxial Switches (Antenna Switch)

RF switching is accomplished with motor driven SPDT switches. Application of capsule 24 volts d-c through external circuits drives the switch to the appropriate RF position and opens the power circuit for that position.

11-126. Bicone Antenna

The capsule is electrically divided in two sections. The antenna fairing structure at the junction of these sections resembles a discone antenna. This junction is center fed by a coaxial cable from the communications sets.

11-127. At frequencies between 225 and 450 MC the antenna fairing acts like a discone antenna. A lower frequency of 15 MC causes the unit to resemble a "center fed" dipole. Between the upper and lower limits, at 108 MC, the unit behaves as a composite dipole-discone antenna.

11-128. Thus the bicone antenna serves all capsule frequencies, with the exception of C and S-bands, allowing reception and transmission within limits of the capsule system.

11-129. Bicone Isolator

An isolator is provided to shield electrical wires that pass through the bicone antenna fairing structure. The isolator is formed into a tube which is curved to allow mounting beneath the periphery of the antenna fairing.

11-130. UHF Descent and Recovery Antenna

The descent and recovery antenna takes over the UHF functions of the bicone antenna when the antenna fairing is jettisoned. The UHF antenna is a fan shaped, vertically polarized monopole located on the top of the recovery compartment.

11-131. HF Balloon Wire Antenna

Upon landing, impact circuits initiate a sequence for the balloon wire antenna. A check valve between the helium tank and the balloon compartment is opened. The balloon compartment door is opened. The balloon is filled and released from the compartment. The elevated balloon is tethered by the antenna wire which acts as a vertically polarized monopole for HF frequencies.

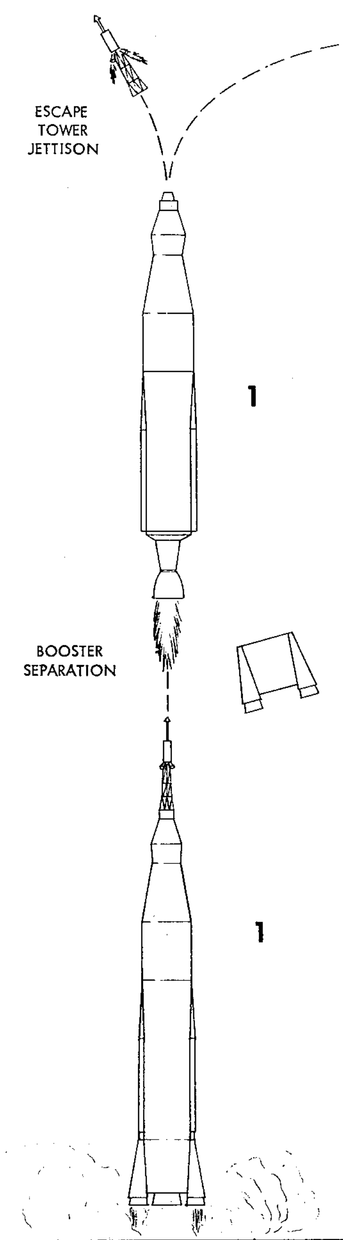
11-132. C and S-Band Antennas

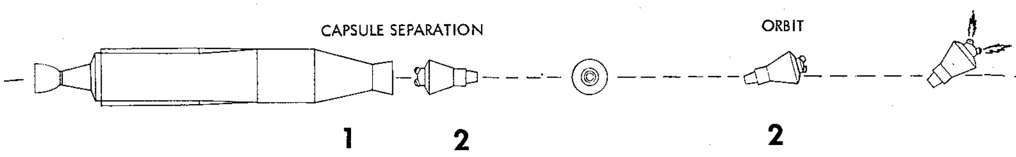
Three antenna units serve the C and S band beacons. Each unit consists of a C and a S band radiator. Each radiator is a cavity mounted helix antenna.

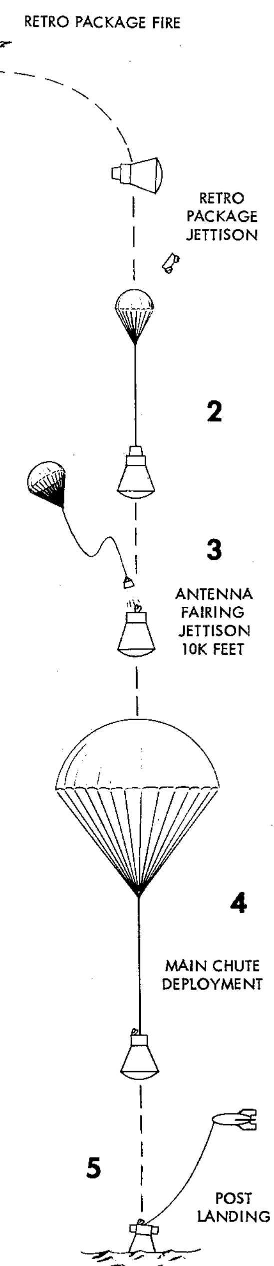
11-133. TEST CONFIGURATION NUMBER 2 CAPSULE

11-134. General

(See Figure 11-14.) The number two capsule communications system configuration is the same as the specification compliance capsule except for the following differences. The numerous differences which are mainly small do, however, affect the operation of the communications systems considerably. Differences mainly involve such things as UHF Transmitter power output, pre-recorded tape method of voice modulating transmitters, sequencing differences in transmitter operation, umbilical control C and S band beacons. Certain items common to the manned







COMMUNICATION SEQUENCE CAPSULE NO. 2

1 RECEIVE VOICE OVER MAIN UHF T/R SET AND MAIN HF COMM T/R SET. TRANSMIT VOICE OVER MAIN UHF SET. THE COMMAND RECEIVERS ARE ON. THE TELEMETRY TRANSMITTERS ARE OPERATED CONTINUOUSLY. THE C AND S BAND BEACONS ARE OPERATED BY GROUND COMMAND.

2 AT TEN THOUSAND FEET THE BICONE ANTENNA UHF FUNCTION IS REPLACED BY THE UHF DESCENT ANTENNA. THE UHF RECOVERY BEACON IS ENERGIZED AND ALSO FEEDS THE UHF DESCENT ANTENNA.

3 TEN THOUSAND FEET TO IMPACT, RECEIVES AND TRANSMITS VOICE OVER THE MAIN UHF. THE COMMAND RECEIVERS ARE ON, TELEMETRY IS CONTINUOUS. UHF RECOVERY BEACON IS ON. C AND S BAND BEACONS ARE OPERATED CONTINUOUSLY.

4 AT IMPACT, RECEIVES AND TRANSMITS VOICE OVER MAIN UHF COMM T/R. HF RECOVERY T/R IS ENERGIZED AND RECEIVES AND TRANSMITS VOICE. HF RECOVERY BEACON IS ENERGIZED. UHF RECOVERY BEACON IS ON. COMMAND RECEIVERS, TELEMETRY AND C AND S BAND BEACONS OFF.

COMMUNICATIONS SEQUENCE CAPSULE NO. 3

1 RECEIVE VOICE OVER MAIN UHF SET AND COMMAND RECEIVERS. TRANSMIT CW OVER MAIN UHF SET, TRANSMIT TELEMETRY INFORMATION OVER TELEMETRY TRANSMITTERS. C AND S BAND BEACONS ARE CONTINUOUS.

2 BICONE ANTENNA UHF FUNCTION REPLACED BY UHF DESCENT ANTENNA. UHF RECOVERY BEACON ENERGIZED.

3 RECEIVE VOICE AND TRANSMIT CW OVER MAIN UHF SET. COMMAND RECEIVERS ON. TELEMETRY CONTINUOUS, UHF RECOVERY BEACON ON, C AND S BAND BEACONS ON.

4 RECEIVE VOICE AND TRANSMIT CW OVER MAIN UHF SET. HF RECOVERY BEACON ENERGIZED. UHF RECOVERY BEACON ON. COMMAND RECEIVERS, TELEMETRY AND C AND S BAND BEACONS OFF.

FIGURE 11-14 COMMUNICATIONS SEQUENCE (CAPSULES 2 AND 3.)

PM45-165

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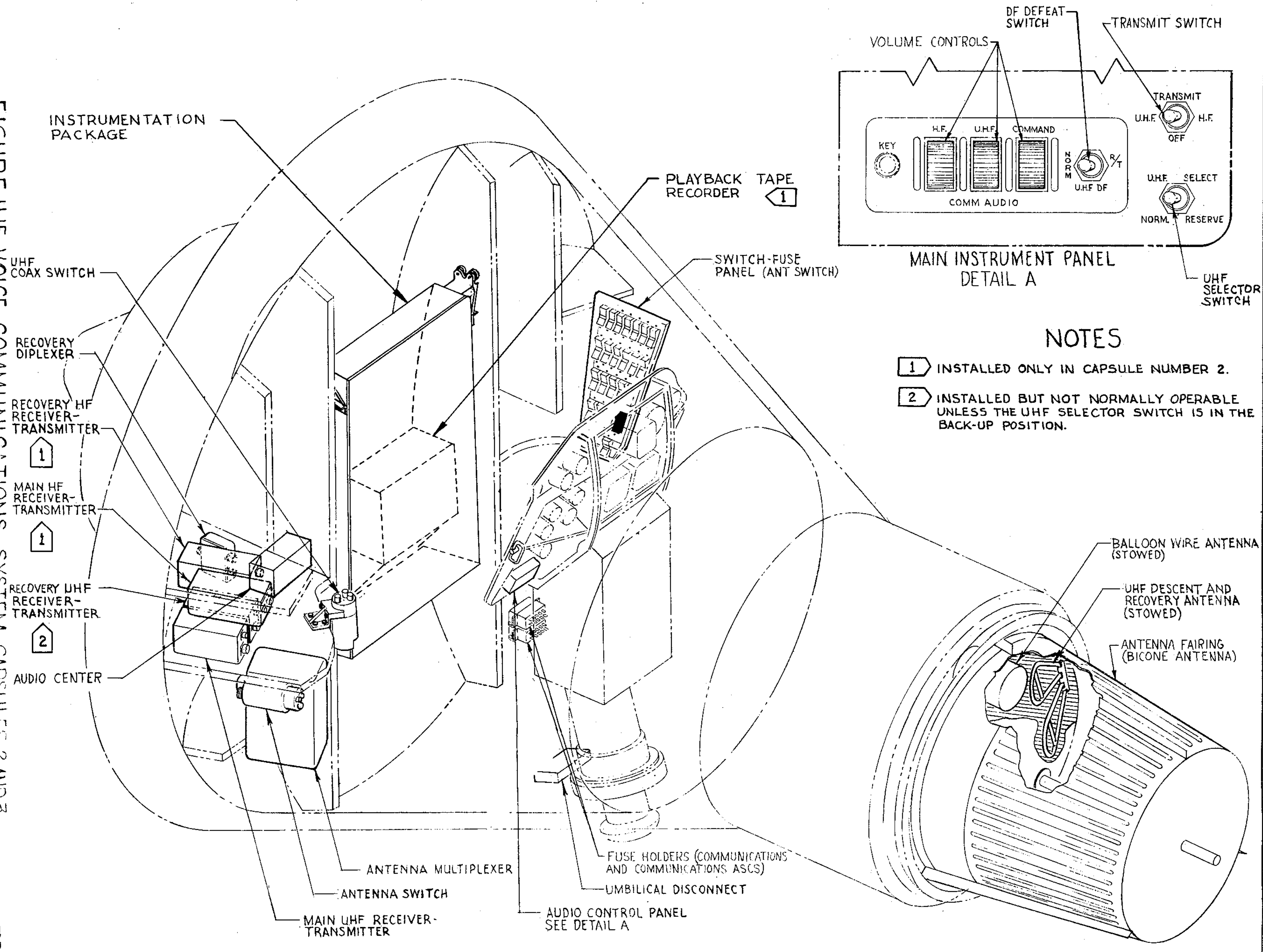

NOTES

1. INSTALLED ONLY IN CAPSULE NUMBER 2.
2. INSTALLED BUT NOT NORMALLY OPERABLE UNLESS THE UHF SELECTOR SWITCH IS IN THE BACK-UP POSITION.

FIGURE 11-15 VOICE COMMUNICATIONS SYSTEM CAPSULES 2 AND 3

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capsule will not be utilized in the number 2 capsule. Such items as the telemetering key, push to talk switch, umbilical interphone, headset amplifier output and beacon switch modes of operation.

11-135. SYSTEMS DESCRIPTION

11-136. Voice Transmission and Reception

The No. 2 (ballistic) capsule is provided with a playback tape recorder to simulate the voice of an Astronaut. The pre-recorded tape will modulate, intermittantly, the transmitters in the capsule, until the tape is depleted. (See Figure 11-15.)

11-137. Single ended output from the playback tape recorder is fed to the two separate microphone amplifiers in the Audio Center which energizes the voice operated relay circuit in the Audio Center. The voice operated relay in turn completes a ground circuit to the tape recorder relay thus causing the modulation signal to berouted to the main tape recorder as well as modulating the HF and UHF transmitters.

11-138. HF reception through the HF Comm T/R is available continuously until bicone separation.HF voice transmission is also transmitted through the HF Comm T/R unit until bicone separation or until the pre-recorded tape is exhausted, whichever occurs first.

11-139. HF reception after impact is through the energized HF Recovery T/R. HF voice transmission, after impact is also through the HF Recovery T/R. Voice transmission will continue until the pre-recorded tape is exhausted after which a continuous wave CW signal is emitted.

11-140. UHF transmission and reception is available throughout the mission and after impact through the UHF Comm T/R unit. After impact the receiver will continue to feed its output to the main tape recorder. The UHF transmitter capsule will not be utilized in the number 2 capsule. Such items as the telemetering key, push to talk switch, umbilical interphone, headset amplifier output and beacon switch modes of operation.

11-135. SYSTEMS DESCRIPTION

11-136. Voice Transmission and Reception

The No. 2 (ballistic) capsule is provided with a playback tape recorder to simulate the voice of an Astronaut. The pre-recorded tape will modulate, intermittantly, the transmitters in the capsule, until the tape is depleted. (See Figure 11-15.)

11-137. Single ended output from the playback tape recorder is fed to the two separate microphone amplifiers in the Audio Center which energizes the voice operated relay circuit in the Audio Center. The voice operated relay in turn completes a ground circuit to the tape recorder relay thus causing the modulation signal to berouted to the main tape recorder as well as modulating the HF and UHF transmitters.

11-138. HF reception through the HF Comm T/R is available continuously until bicone separation.HF voice transmission is also transmitted through the HF Comm T/R unit until bicone separation or until the pre-recorded tape is exhausted, whichever occurs first.

11-139. HF reception after impact is through the energized HF Recovery T/R. HF voice transmission, after impact is also through the HF Recovery T/R. Voice transmission will continue until the pre-recorded tape is exhausted after which a continuous wave CW signal is emitted.

11-140. UHF transmission and reception is available throughout the mission and after impact through the UHF Comm T/R unit. After impact the receiver will continue to feed its output to the main tape recorder. The UHF transmitter will only transmit voice as long as the pre-recorded tape continues to provide a voice signal. If the pre-recorded tape is depleted after impact, the UHF transmitter will continue to emit a CW signal to provide a direction finder signal.

11-141. After impact the HF Recovery T/R unit's receiver will begin to feed its receiver output through the communications control panel and the audio center to the main tape recorder. The transmitter section will after impact begin to emit the pre-recorded voice signal and continue until tape depletion after which the transmission will be a cw signal.

11-142. The audio output of the UHF Ground Command receivers is fed through the audio center filter and amplifier and through the Comm Control Panel to the Main Tape recorder and is operable until impact.

11-143. C and S Band Beacons

The C and S band beacon operation is the same as the specification compliance capsule with the exception that the units are energized by control through the umbilical. (See Figure 11-23.) Likewise the Beacon Switch serves only as an ON-OFF device so that the beacons may be controlled through the umbilical. The Ground Command Receivers have no control over the C and S Band Beacons in capsule No. 2.

11-144. Command Receivers

The Ground Command Receivers control functions differ from those in the specification compliance capsule. The only communications circuit affected by the ground command receiver is the C and S Band Beacon control. (See Figure 11-16.)

11-145. Telemetry

The two telemetry transmitters in capsule number two perform their functions in the same manner as the telemetry transmitters in the specification compliance

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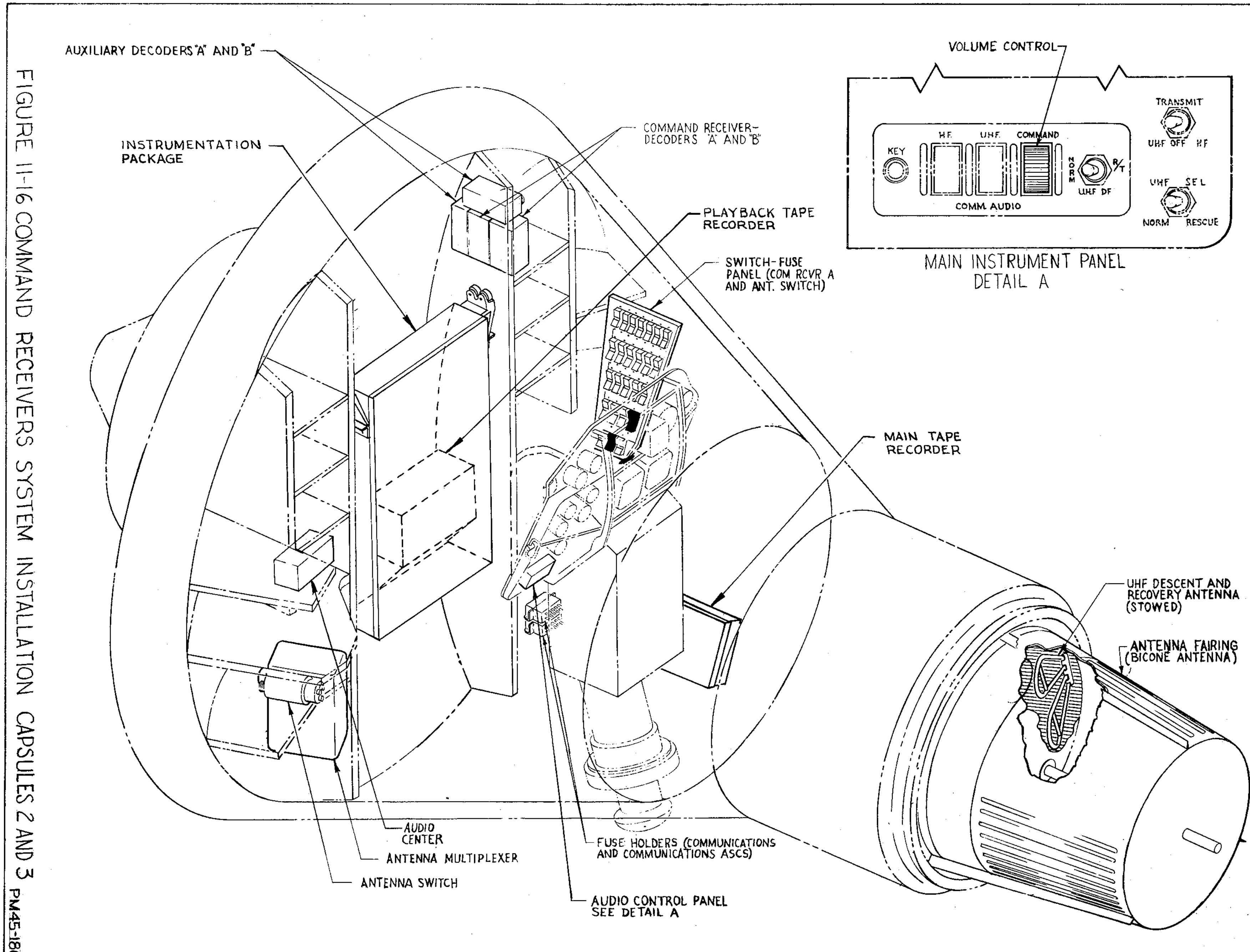

FIGURE 11-16 COMMAND RECEIVERS SYSTEM INSTALLATION CAPSULES 2 AND 3

PM45-186

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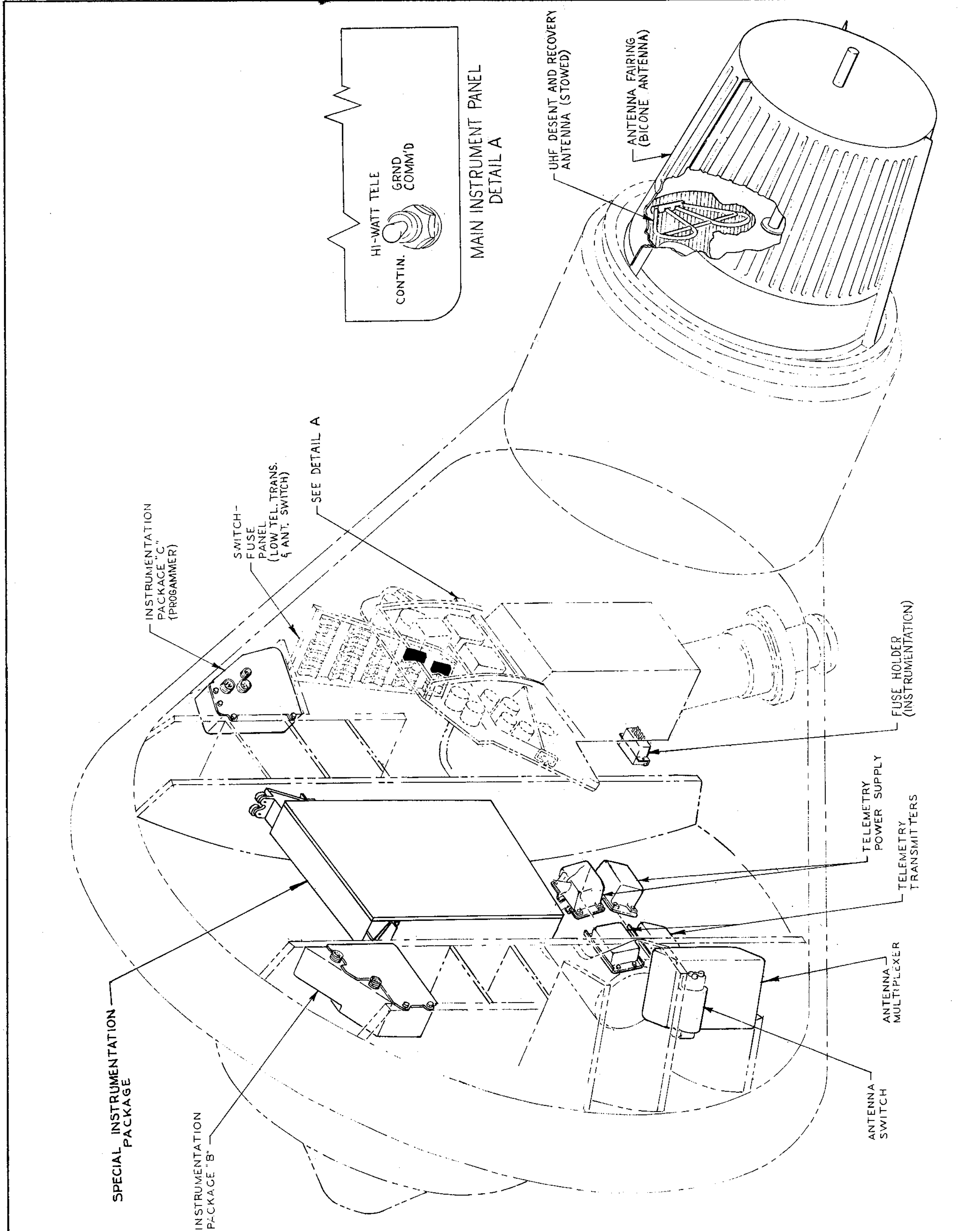

FIGURE 11-17 TELEMETRY SYSTEM (CAPSULES 2 & 3)

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capsule with the following exceptions. Continuous operation of the telemetry transmitters is provided in the No. 2 capsule with no interruption in transmission until impact at which time the pre-impact buses will be de-energized. (See Figure 11-17.) Neither ground command or emergency keying provisions are installed in the No. 2 capsule.

11-146. Beacons

The C and S Band Beacons are operated continuously from umbilical drop until impact. (See Figure 11-23.)

11-147. SYSTEM OPERATION

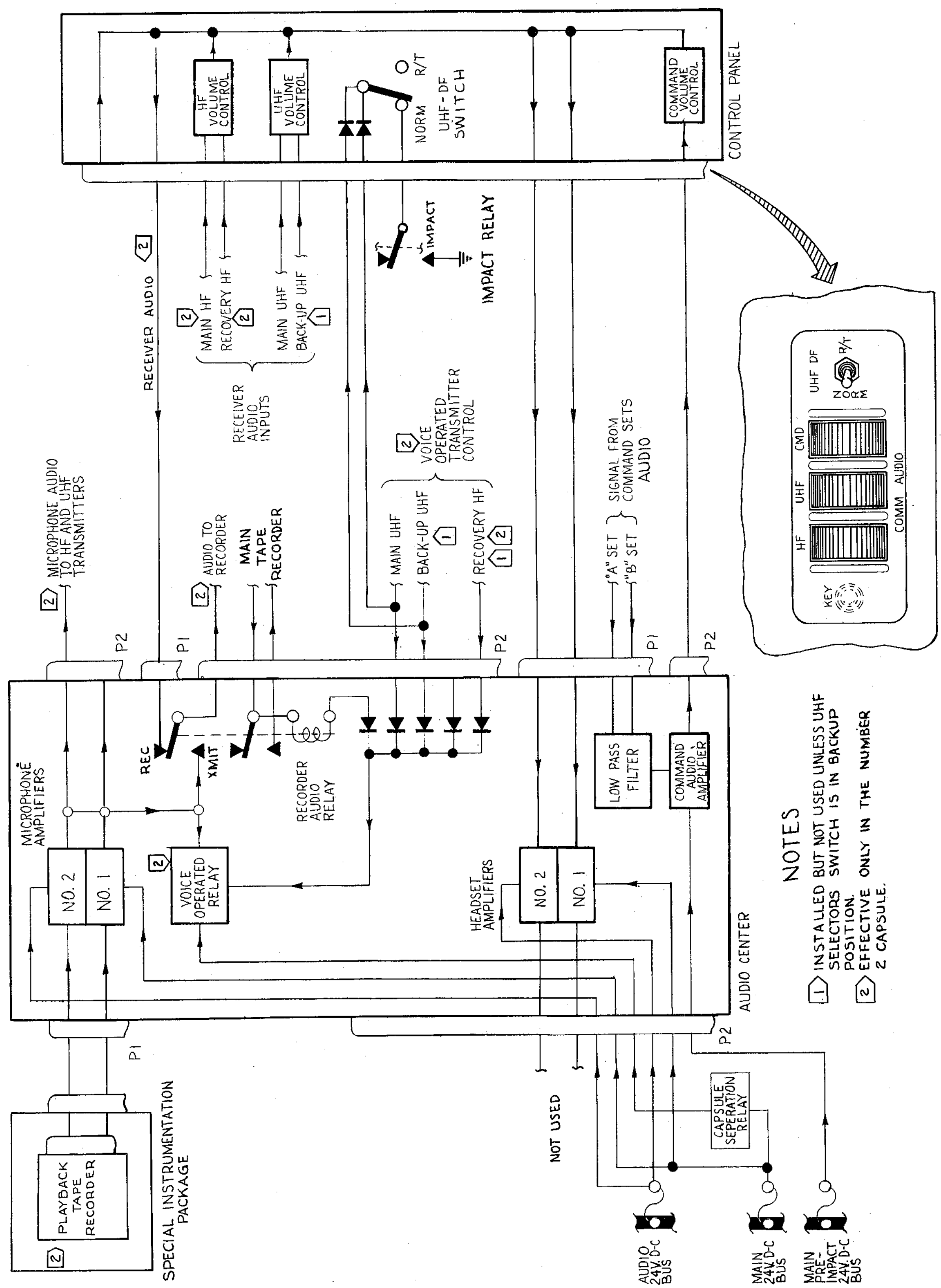
11-148. Voice Communications

11-149. Audio Control

(See Figure 11-18) After the HF and UHF receiver audio output enters the Audio Center, the audio is not routed through the headset amplifiers but goes only to the normally de-energized contacts of the tape recorder relay in the audio center. The de-energized tape recorder relay routes incoming communications audio out of the Audio Center to the Main Tape Recorder. An extra channel in the main tape recorder is utilized in the No. 2 capsule to record UHF receiver audio.

11-150. The playback tape recorder starting is controlled by contacts of the camera and tape record relay. (See Instrumentation Section.) The playback tape recorder operation begins prior to launch and continues throughout the mission until tape depletion. A push to talk switch is not provided in capsule 2.

11-151. The HF Comm T/R unit does not have pin E energized with 24 V d-c. This effectively disables the transmitter portion of the unit but still allows continuous HF receiver operation.



NOTES

1. INSTALLED BUT NOT USED UNLESS UHF SELECTORS SWITCH IS IN BACKUP POSITION.
2. EFFECTIVE ONLY IN THE NUMBER 2 CAPSULE.

FIGURE 11-18 AUDIO CONTROL SYSTEM (CAPSULES 2 & 3)

PM45-190

11-152. Audio output from the HF receiver is fed to the main tape recorder. Audio output is not fed through the headset amplifiers in the audio center and likewise no headset is installed.

11-153. HF Voice Communications

(See Figure 11-19) The HF Recovery voice communications set, after impact, is voice modulated by the pre-recorded tape. Between voice modulated messages and upon depletion of the tape, the transmitter will emit a continuous wave signal. Push to talk keying is not provided for the HF Recovery transmitter.

11-154. UHF Voic e Communications

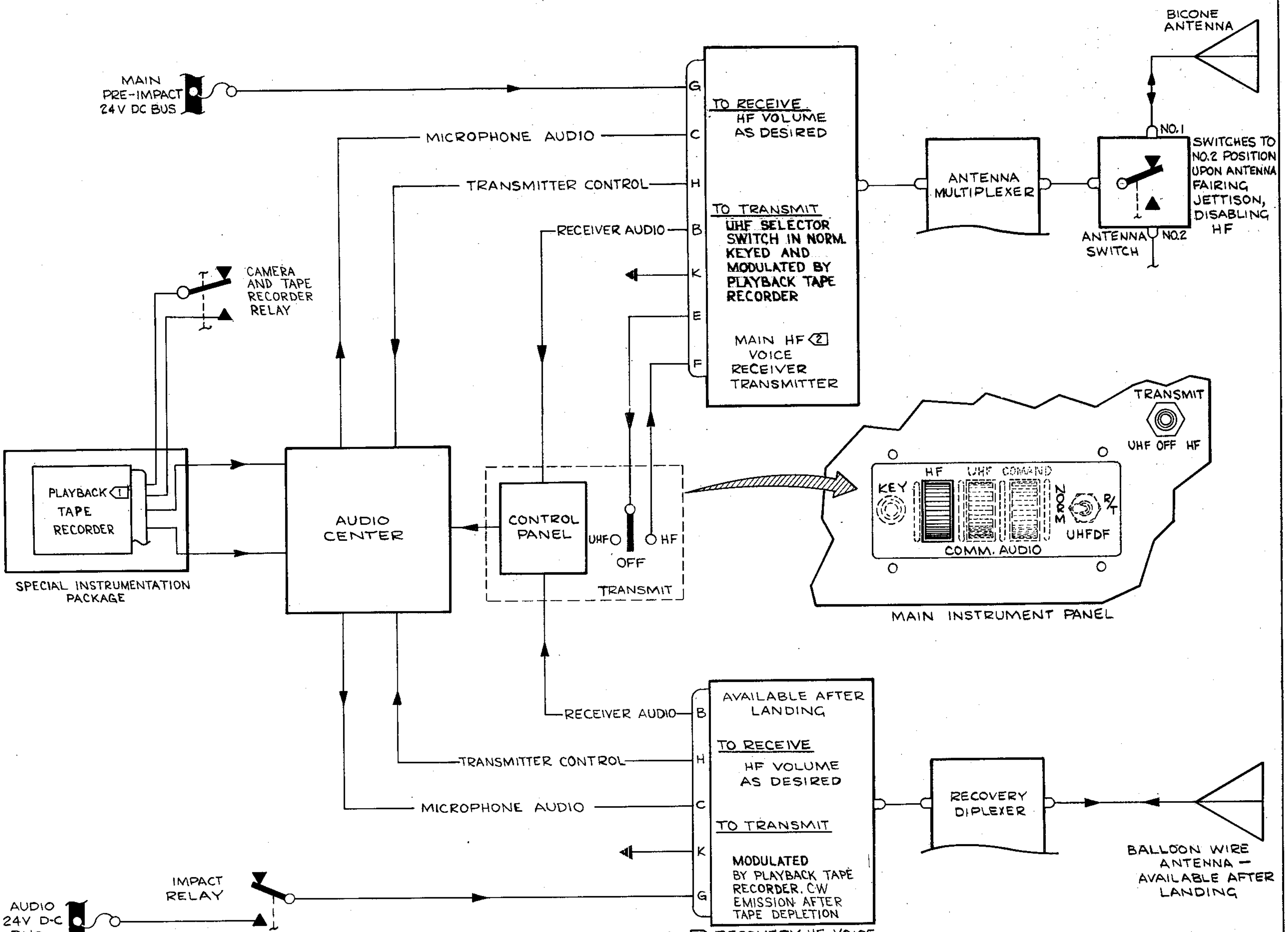
(See Figure 11-20.) The UHF Communications T/R set does not utilize a separate UHF Booster Amplifier in the No. 2 capsule but feeds directly into the coax switch and subsequent antenna system. Control of the transmitter circuit is not through a Transmit Switch but through a Filament Power Relay.

11-155. An impact sensor relay instead of a bicone separation relay as in the specification capsule, causes the UHF transmitter to go into a continuous wave (cw) mode of operation at the end of the mission.

11-156. Audio modulation of the UHF transmitter is accomplished by the pre-recorded tape in theplay-back tape recorder. The UHF Selector switch should be in the NORM position prior to launch time. Push to talk keying is not provided for the UHF transmitter.

11-157. Audio output from the main UHF receiver is fed to the main tape recorder. Audio output of the UHF receiver is not fed through the headset amplifiers and likewise no headset is provided.

11-158. The backup UHF voice communications set, which is identical to the Main UHF set, is not utilized in the No. 2 capsule unless the UHF Selector Switch should be placed in the BACKUP position.



NOTES
1 INSTALLED AND OPERABLE ONLY IN NO. 2 CAPSULE
2 NO. 3 CAPSULE HAS DUMMY UNITS INSTALLED

FIGURE 11-19 HF VOICE COMMUNICATIONS DATA FLOW (CAPSULES 2 & 3)

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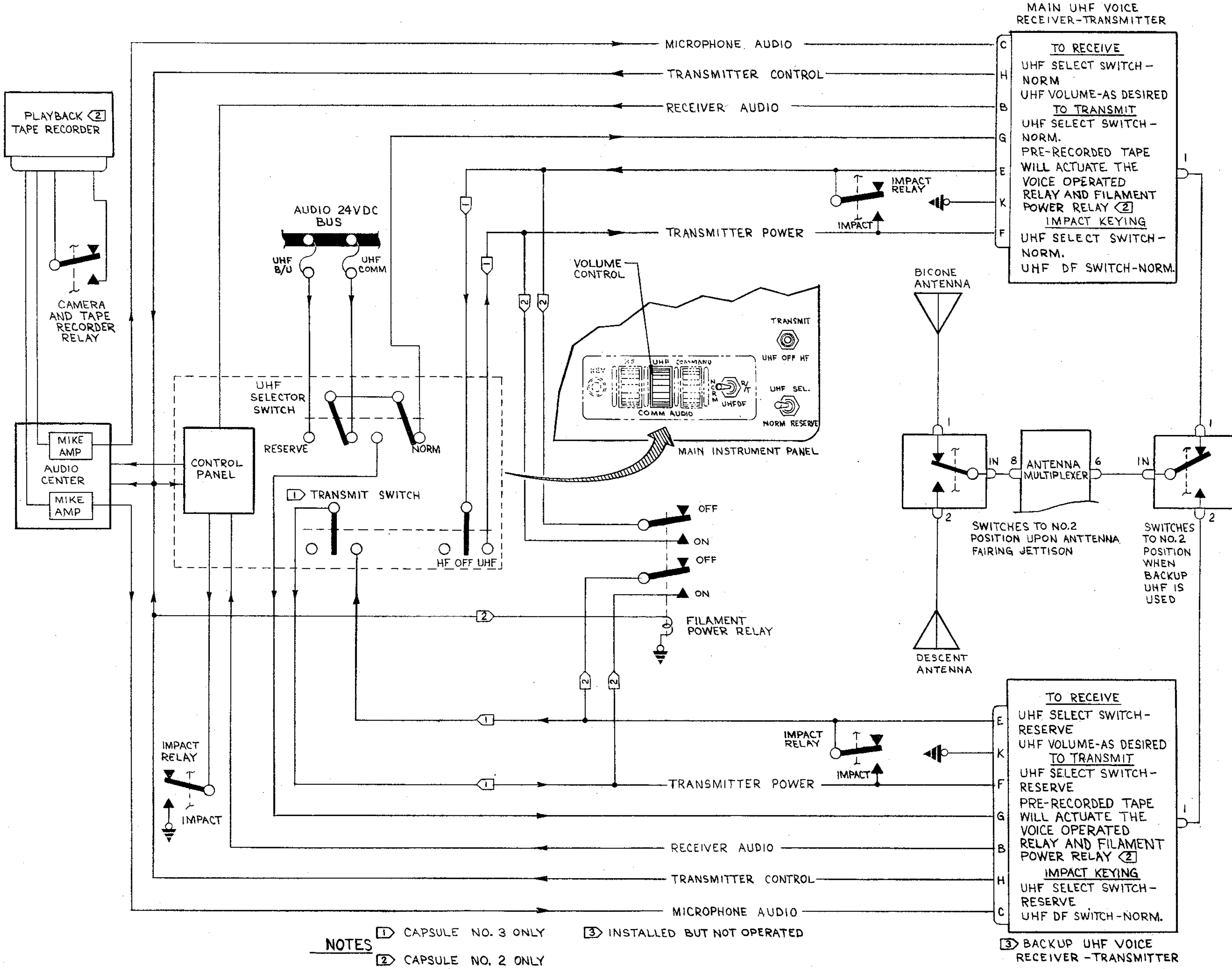

FIGURE 11-20 UHF VOICE COMMUNICATIONS DATA FLOW (CAPSULES 2 & 3)

NOTES
1 CAPSULE NO. 3 ONLY
2 CAPSULE NO. 2 ONLY
3 INSTALLED BUT NOT OPERATED

PM45-182

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11-159. Command Receivers

The backup voice reception provided by the Command receivers is not reproduced in headsets as in the specification compliance circuitry, but is routed to the main tape recorder only. Control functions are as shown in Figure 11-21.

11-160. Antennas

For differences in the No. 2 capsule antenna system, see Figure 11-24.

11-161. Telemetry

11-162. "A" and "B" Telemetry

The telemetry transmitters are run continuously from launch until impact. The telemetry keying circuitry will not be provided; therefore, the KEY control on the Communications Control Panel will not interrupt the telemetry transmitters.

11-163. Beacons

11-164. C and S Band Beacons

(See Figure 11-23) The C and S Band Beacons are operated continuously during the entire capsule mission. The ground command receivers have no control over the C and S beacons in the number 2 capsule. Similarly the Beacon Switch is wired in series with the 24 V d-c power which is fed through the Beacon Relay to provide an over-ride OFF position. The Beacon Relay, instead of being controlled by the ground command receiver, is controlled (de-energized) by applying 24 V d-c through the umbilical to the relay solenoid. (See Figure 11-23.)

11-165. SYSTEMS UNITS

11-166. Playback Tape Recorder

(See Figure 11-15.) The ballistic capsule (No. 2 capsule) is provided with a playback tape recorder containing a pre-recorded tape which will voice modulate intermittantly the HF and UHF transmitters. This playback tape recorder is provided with a dual track recording which will simulate the microphone

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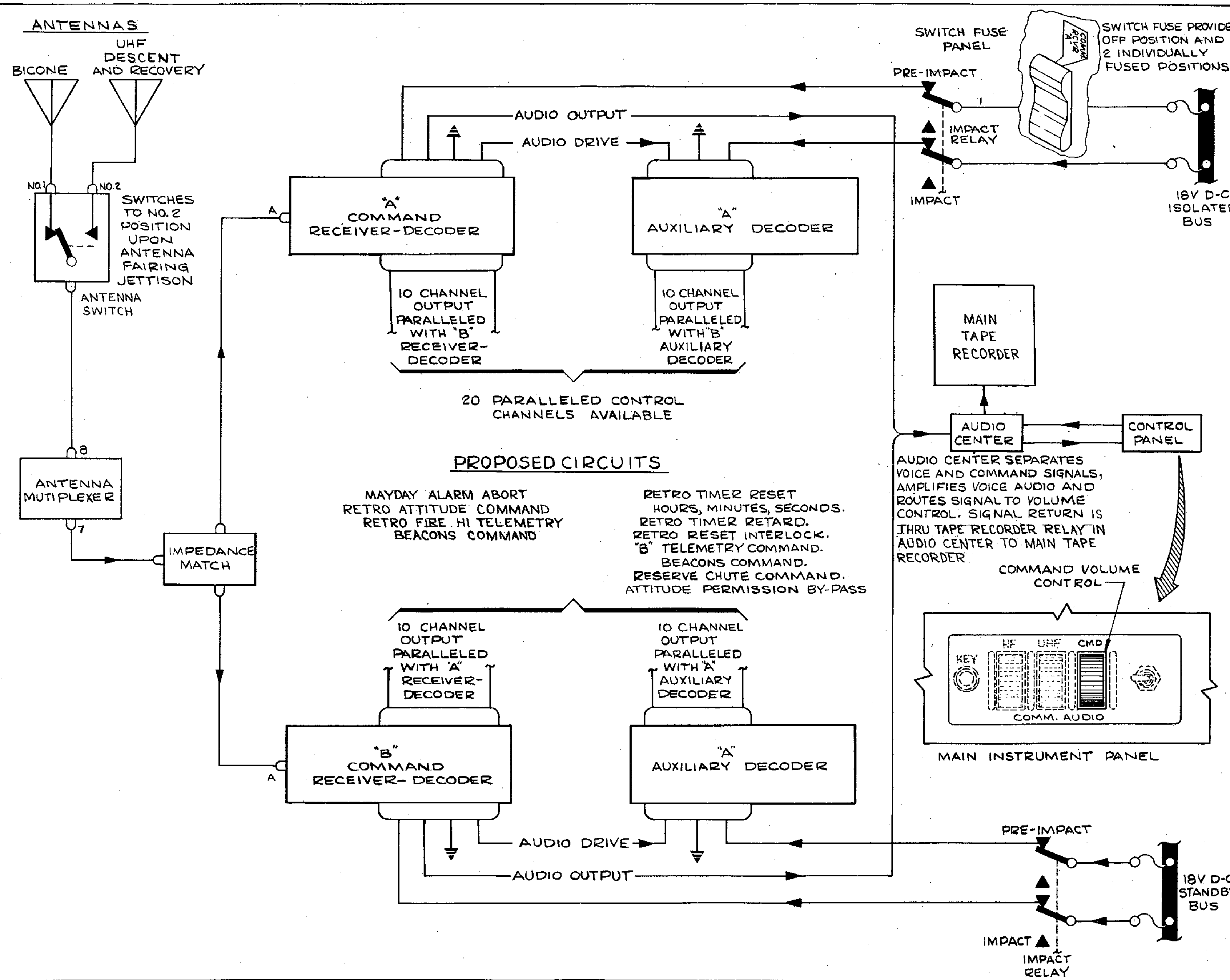

FIGURE 11-21 COMMAND RECEIVERS DATA FLOW (CAPSULES 2 & 3)

PM45-188

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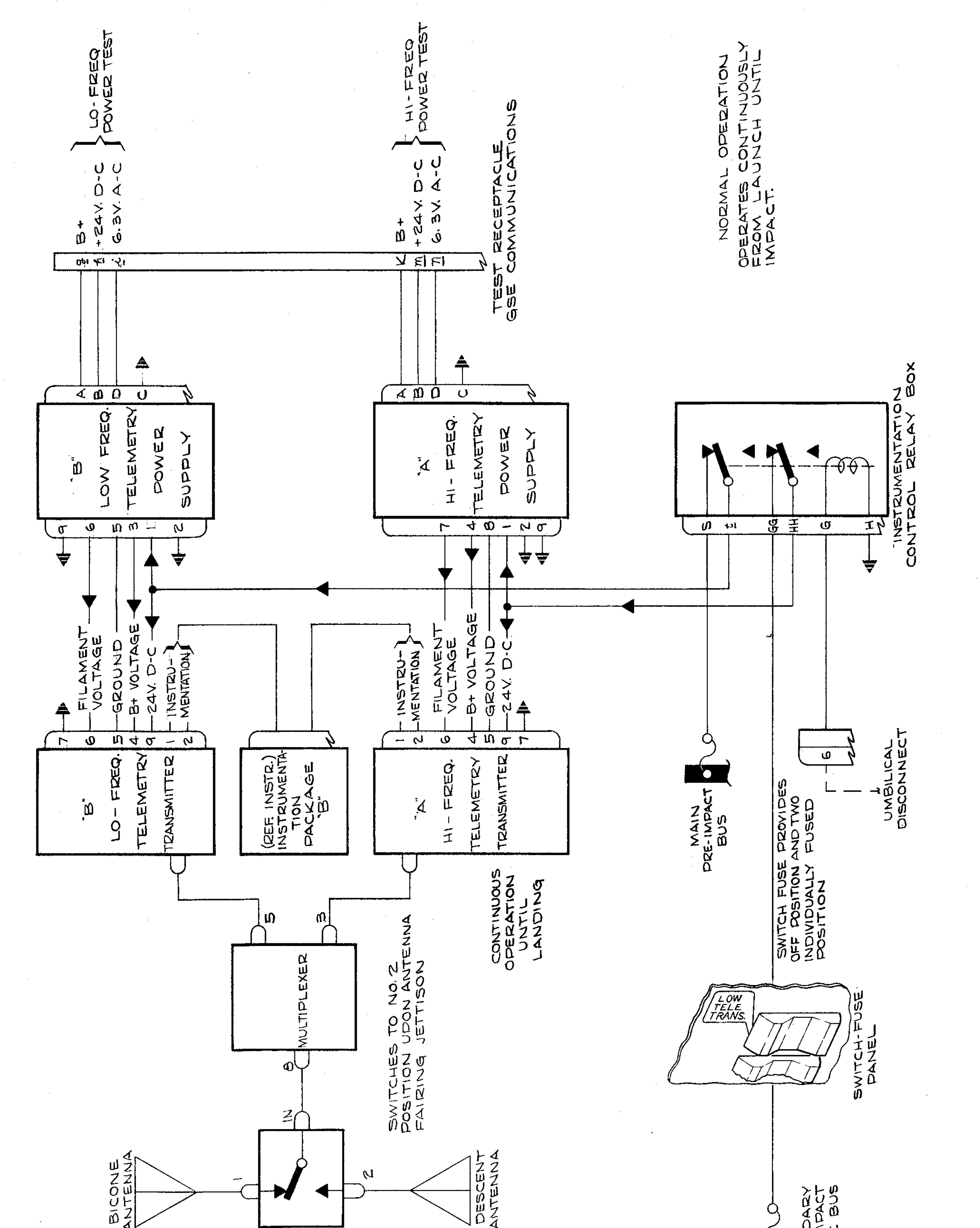

CAPSULES 2 AND 3
FIGURE 11-22 TELEMETRY SYSTEM DATA FLOW

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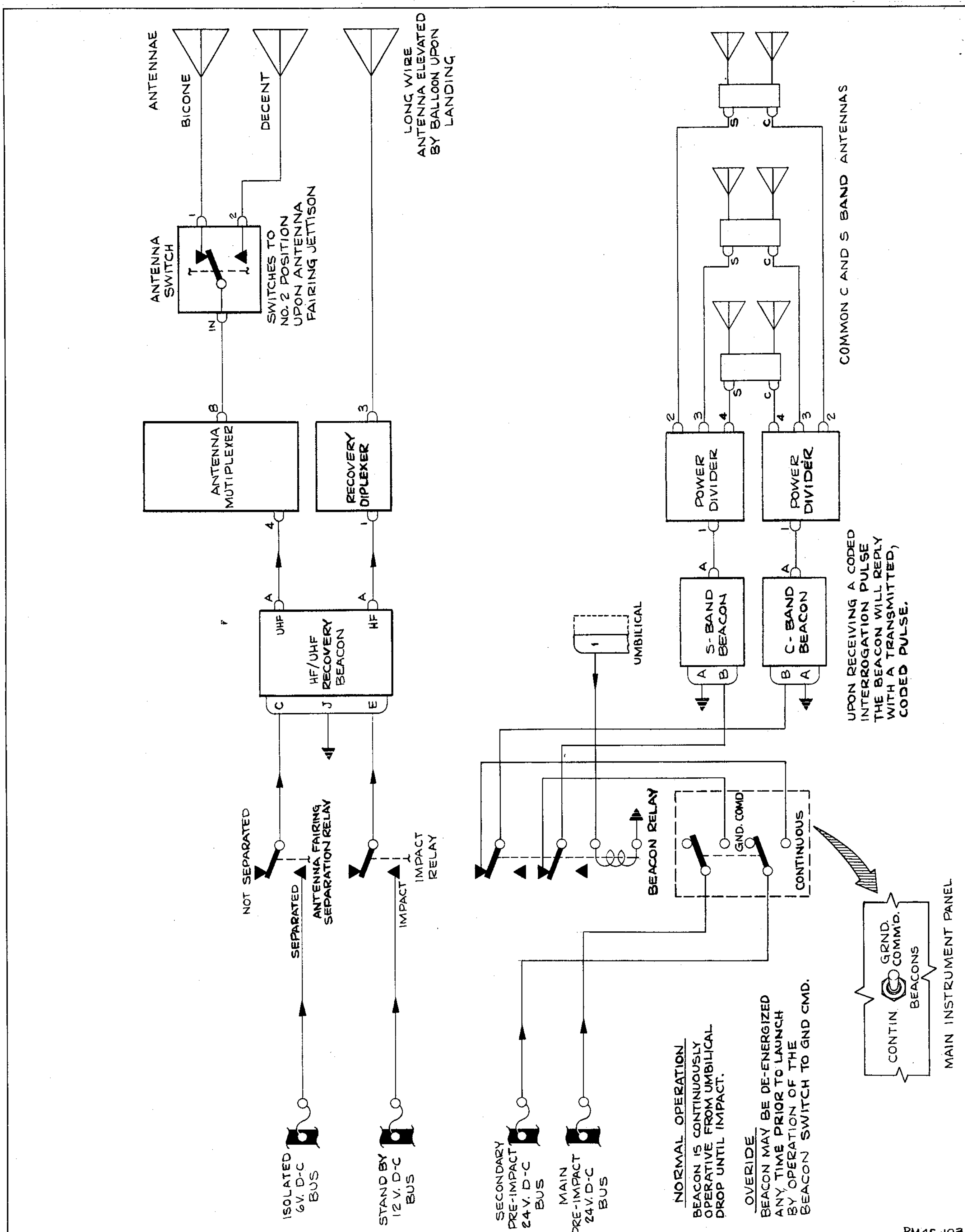

FIGURE 11-23 BEACON SYSTEM DATA FLOW (CAPSULES 2&3)

output from the Astronaut's helmet. Starting of the tape recorder is controlled at the beginning of the mission by the CAMERA AND TAPE RECORDER switch in the blockhouse. During the tape recorder running time of approximately 45 minutes, the modulation on the two tape channels is staggered, as shown below, on a dual track tape and played back on a dual track playback mechanism in the capsule. See Figure 11-24.

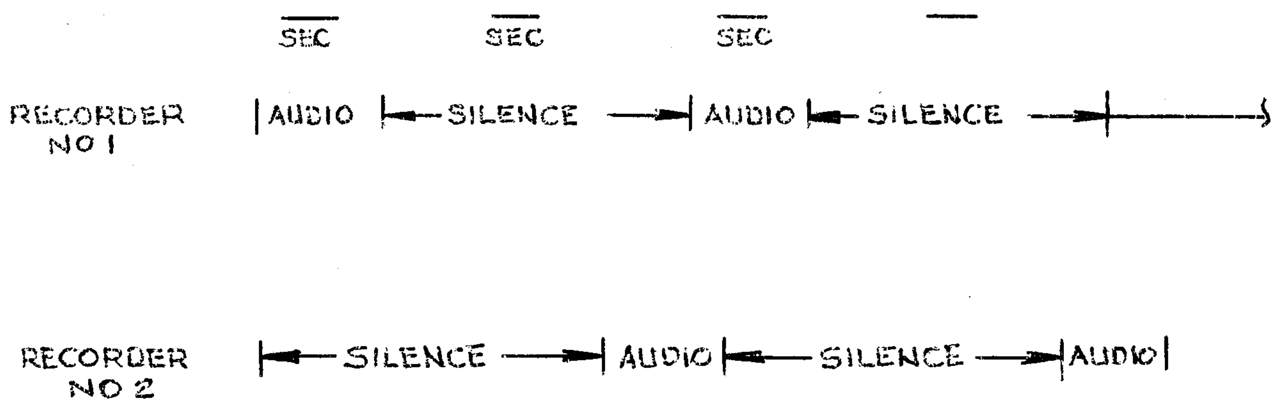

FIGURE 11-24 PRE-RECORDED TAPE SEQUENCE

11-167. Audio Center

The two fixed gain headset amplifiers in the audio center are not utilized in the No. 2 capsule. The Push-to-talk control circuit likewise is not used. A pre-recorded tape message from a playback tape recorder simulates a microphone input to the Audio Center.

11-168. The Tape Recorder relay is not programmed by the instrumentation system but is energized when the voice operated relay is energized.

11-169. Control Panel

The telemetering key located on the Communications Control Panel is not wired

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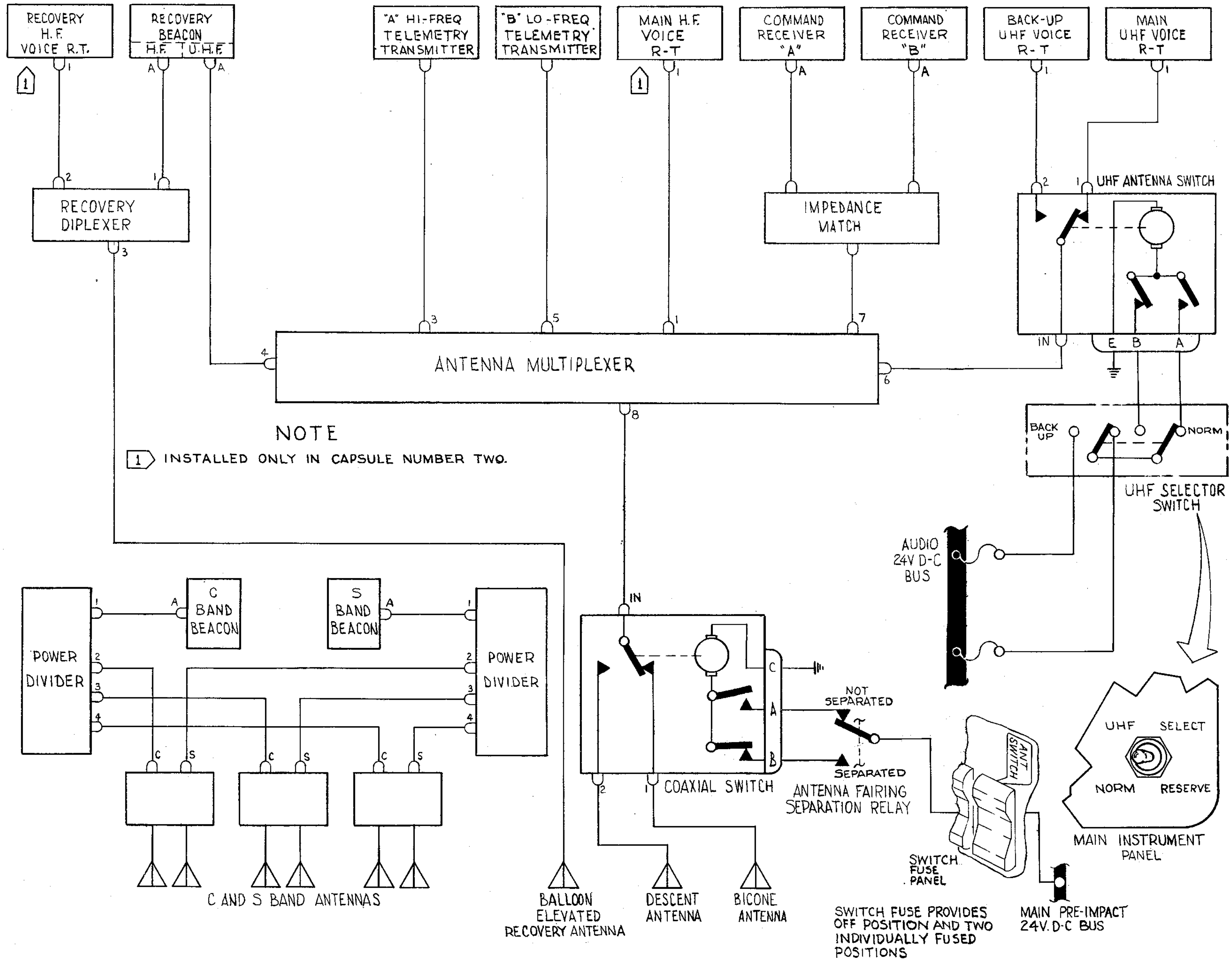


FIGURE 11-25 ANTENNA SYSTEM SCHEMATIC CAPSULES 2 & 3

PM45-184

CONFIDENTIAL

into the telemetering circuitry in the ballistic capsule. The UHF-DF switch will be placed in the NORM position during a normal capsule mission.

11-170. Main HF Voice Receiver-Transmitter

The transmitter function of the Main HF R/T unit is permanently de-energized and will not transmit at any time during the capsule mission.

11-171. UHF Booster Amplifier

No UHF Booster Amplifier is used in the No. 2 capsule.

11-172. TEST CONFIGURATION NUMBER 3 CAPSULE

11-173. General

The No. 3 capsule communications system configuration is the same as the specification compliance capsule except for the following differences.

11-174. SYSTEMS DESCRIPTION

11-175. Voice Transmission and Reception

(See Figures 11-14 and 11-15.) No voice transmission isprovided in the No. 3 capsule. The number 3 capsule has neither HF voice R/T unit installed. Although wiring provisions are installed, the HF Communications T/R and the HF Recovery T/R have dummy units in their places. These units not being installed precludes therefore any HF voice transmission or reception prior to impact.

11-175. Although the UHF Comm T/R and UHF Backup T/R are installed, no audio transmission will take place over these units, since no microphone (or playback tape recorder) are installed.

11-176. The audio output of the UHF Ground Command receivers is fed through the Audio Center filter and amplifier as in the specification capsule; however, the output is not fed through the headset amplifier since no headsets are used.

11-177. The UHF Communications T/R set will upon impact, have the transmitter section energized continuously. In the specification compliance capsule this action takes place at bicone separation. Energizing the transmitter produces a continuous wave output which will continue until battery depletion or manual shut-off is accomplished.

11-178. Command Receivers

The Ground Command Receiver control circuitry does not control the C and S Band Beacons as is done in the specification capsule. The receivers are operated continuously from umbilical drop until impact. (See Figure 11-16.)

11-179. Telemetry

Telemetry transmitters are operated continuously from the time of umbilical separation until impact. (See Figure 11-17.)

11-180. Beacons

The C and S Band beacons are operated continuously from the time of umbilical separation until impact. (See Figure 11-23.)

11-181. Antennas

Although the main Bicone Antenna in the No. 3 capsule is identical to the specification capsule antenna, the only signals fed to this antenna are UHF signals. HF signals are not used to energize this antenna in this No. 3 capsule configuration. See Figure 11-25.

11-182. SYSTEM OPERATION

11-183. Voice Communications

11-184. Audio Control and Ground Interphone

No HF R/T units are installed;therefore, no HF receiver outputs are available as in the specification capsule. (See Figure 11-18.)

11-185. No capsule interphone provisions are installed in the No. 3 capsule. Through the hatch interphone may be used for pad to capsule communications.

11-186. The UHF Backup T/R, though installed, i s not utilized unless the UHF Selector switch should beplaced in the BACKUP position.

11-187. Headset Amplifiers in the Audio Center or headsets themselves are not used. Likewise no microphone is installed, hence the dual microphone amplifiers are not used either. Push to Talk wiring is not included in the Capsule circuitry.

11-188. HF Voice Communications

No provision is made for HF voice transmission or reception.

11-189. UHF Voice Communications

(See Figure 11-20.) No UHF voice transmission is provided. UHF voice reception is provided only through the UHF Comm T/R unless prior tolaunch the ground crew should place the UHF Selector Switch to BACKUP, in which case the UHF Backup T/R will receive voice signals. The UHF Ground Command Receivers provide continuous emergency voice reception in addition to their normal function.

11-190. Telemetry

11-191. "A" and "B" Telemetry (Transmitters)

The telemetry sets in the No. 3 test capsule are energized continuously from umbilical disconnect until impact. (See Figure 11-22.)

11-192. Beacons

11-193. C and S Band Beacons

Ground command operation of the beacons is not possible in the No. 3 capsule. C and S Beacons are operated continuously from umbilical disconnect until capsule impact. (See Figure 11-23.)

11-194. Antennas System

The Antenna Switch (coax type switch) in the No. 3 capsule is energized from the 24 V d-c Audio bus instead of the 24 V DC Pre-Impact bus. (See Figure 11-25.)

11-195. SYSTEM UNITS

11-196. General

System units in the No. 3 capsule are the same as are used in the specification capsule with the following exceptions: The HF Com T/R units are dummy units. No UHF booster is installed. Also no headset or microphone provisions are made.

11-197. TEST CONFIGURATION NUMBERS 4 AND 5 CAPSULES.

11-198. General

Same as specification compliance.

SECTION XII

NAVIGATIONAL AIDS

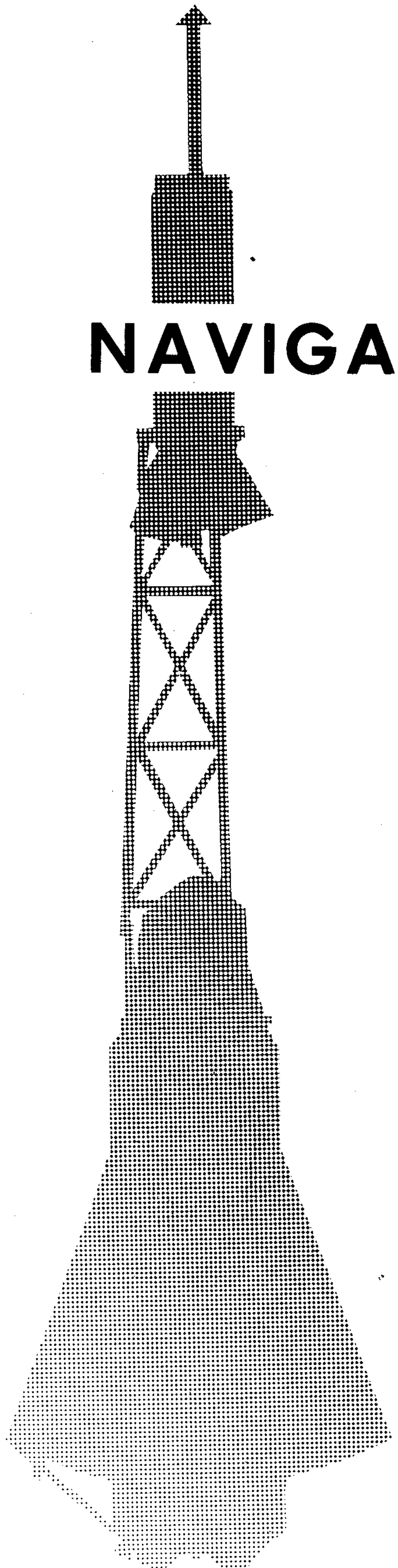


TABLE OF CONTENTS

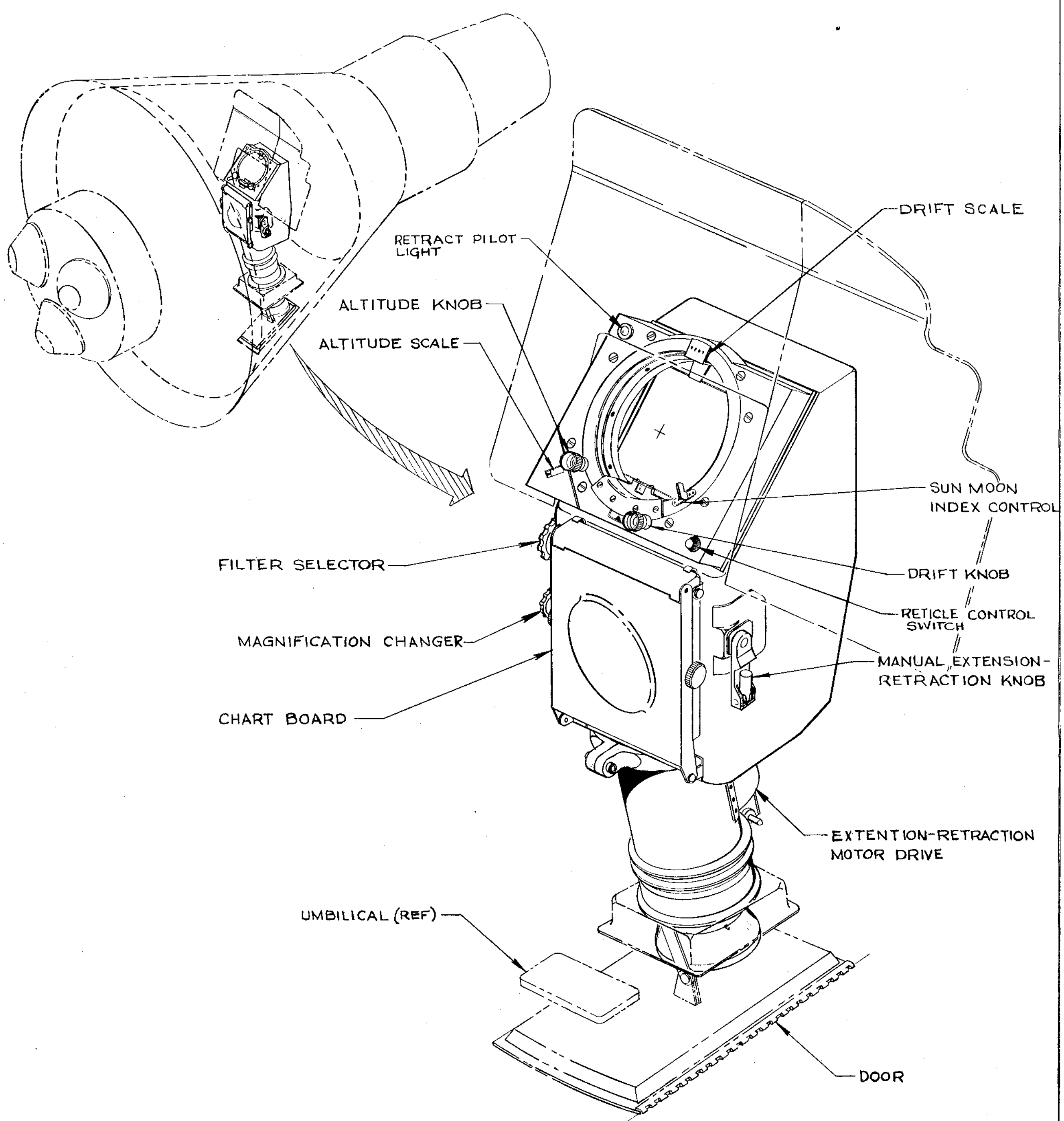


FIGURE 12-1 PERISCOPE ASSEMBLY

PM45-110

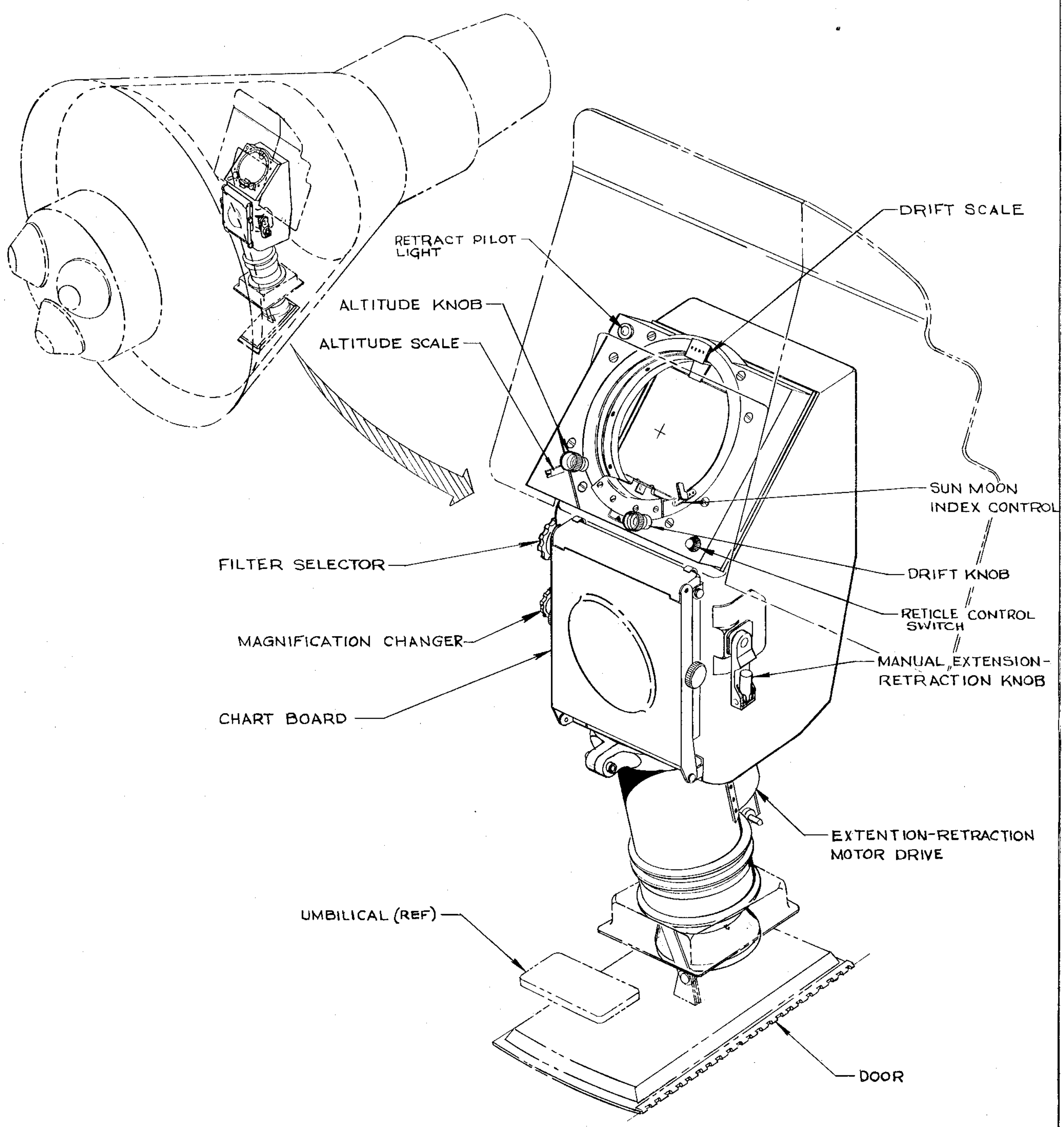


FIGURE 12-1 PERISCOPE ASSEMBLY

PM45-110

XII. NAVIGATIONAL AIDS AND INSTRUMENTS

12-1. GENERAL

Normally the Astronaut will not find it necessary to compute any of the factors relative to his flight or landing. In the event the need should arise, however, the Astronaut is provided with all the equipment required to compute altitude, course, velocity and landing data, and to attain and maintain the proper attitude for each phase of the flight.

12-2. PERISCOPE

12-3. General Description

See Figure 12-1. The periscope, which is the primary instrument for manual navigation, provides the Astronaut a downward view of the earth's entire horizon. Suitable indices on the periscope display permit the Astronaut to orient the capsule to orbit attitude, retrograde attitude or earth's vertical. It may also be used to determine orbit altitude, earth position and drift. When used with the Hand Computer (refer to Paragraph 12-13) and the Satellite Clock (refer to Paragraph 12-9), it may be used to compute orbit velocity or for sun and star navigation. The periscope display has two magnifications. At low magnification the display shows an overall view of the earth's surface approximately 1900 nautical miles in diameter. At high magnification, the center portion of the display covers approximately 80 nautical miles. Clear, yellow, polariod or high neutral density filters, installed in the periscope, may be selected by the Astronaut. Normally, the periscope is electrically extended and retracted automatically. A manual system is provided, should the automatic system fail. Periscope programming, during a normal mission, begins with the periscope extended while the capsule and booster are still on the pad. Upon capsule umbilical disconnection, the periscope retracts and remains retracted

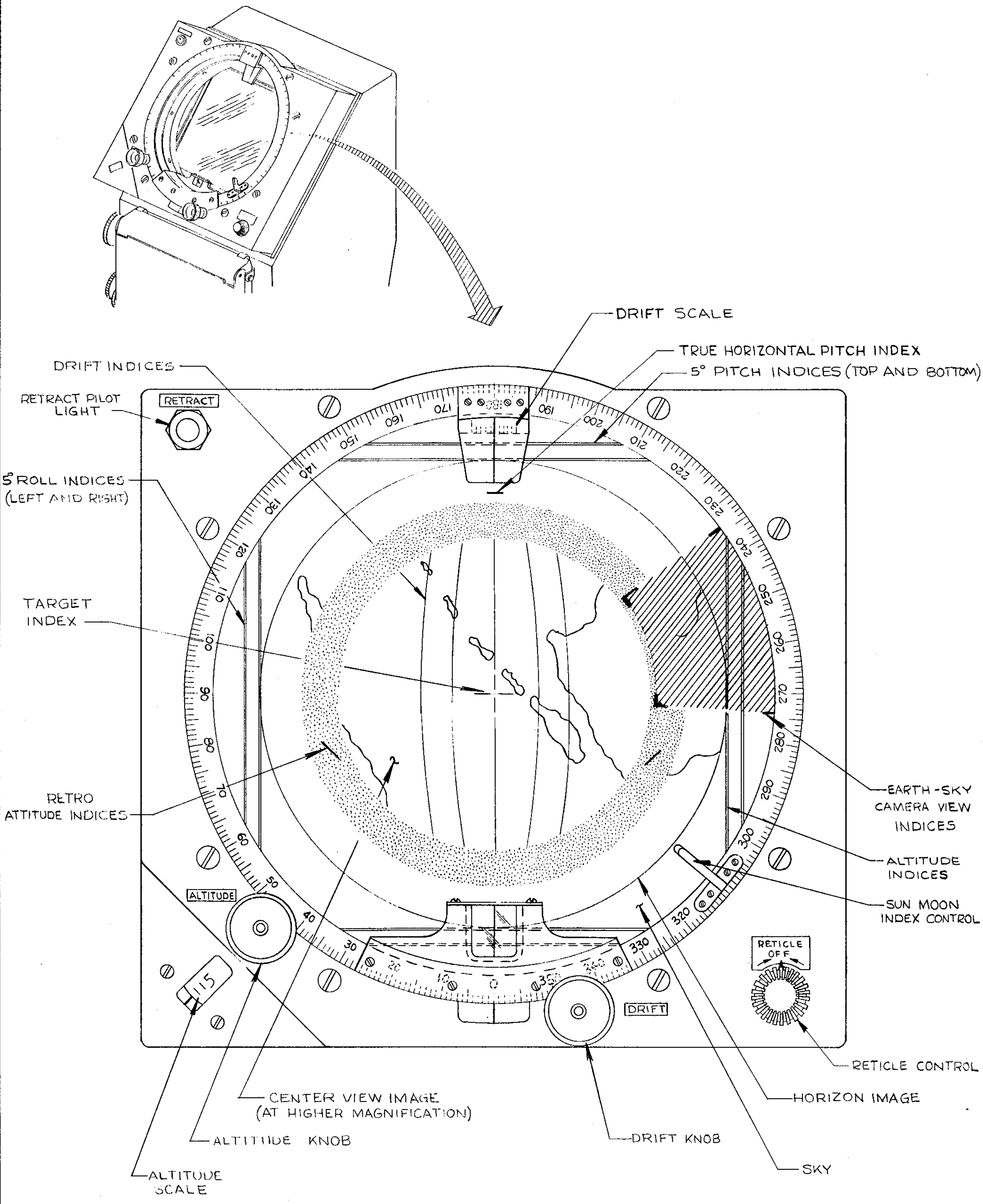
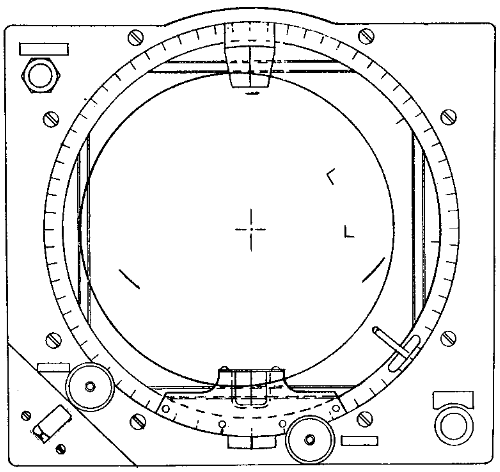
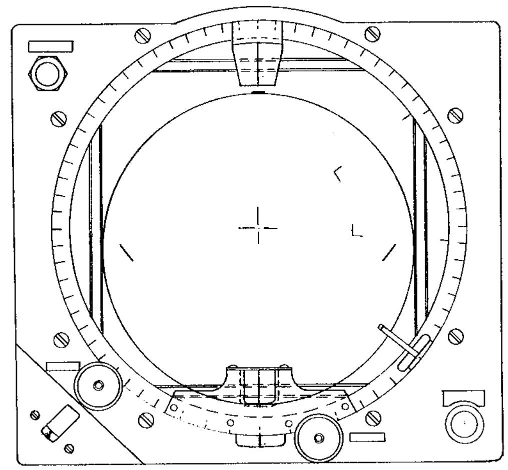


FIGURE 12-2 PERISCOPE DISPLAY (SHEET 1 OF 2 SHEETS)

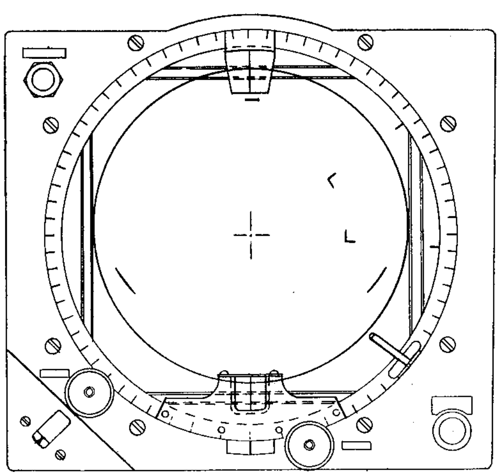
PM45-112A-1



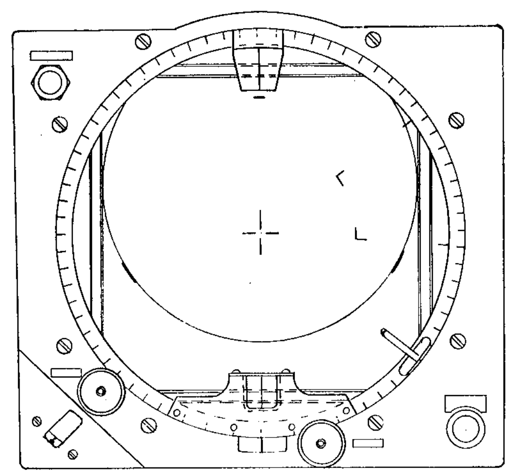
5° LEFT ROLL
EXAMPLE NO. 1.



CAPSULE LEVEL
EXAMPLE NO. 2.



CAPSULE SMALL END
PITCHED 5° BELOW ORBIT ATTITUDE
EXAMPLE NO. 3.



CAPSULE IN RETROGRADE
ATTITUDE
EXAMPLE NO. 4.

FIGURE 12-2 PERISCOPE DISPLAY (SHEET 2 OF 2)

PM45-112-2

until capsule separation. At this time the periscope extends and remains extended during orbit. Thirty seconds after retro-package separation, the periscope is again retracted. At 10,000 feet altitude the periscope is extended for the last time and remains extended through impact. An additional feature of the periscope is that following umbilical disconnection and just prior to launch, if the "hold" sequence is initiated the periscope will automatically extend.

12-4. Altitude

See Figure 12-2. The size of the earth's image is proportional to the altitude of the capsule. With the capsule in orbit attitude, movable indices are adjusted to coincide with the earth horizon image. The capsule altitude is then read directly from a scale.

12-5. Attitude

See Figure 12-2. Fixed indices are provided to define orbit attitude, retrograde attitude, and true capsule vertical. When the capsule is in the orbit attitude, the horizon image will be centered in the pitch and roll indices. When the capsule is in the retrograde attitude, the horizon image will be aligned with the roll and retro pitch indices. When the capsule is horizontal, the horizon image will be aligned with the roll and horizontal pitch indices.

12-6. Earth's Position

See Figure 12-2. The periscope has an index at the center of the scope which indicates the position of the capsule when it is in orbit attitude. The capsule's position can be measured within $\pm$ 2 nautical miles at high magnification if an identifiable checkpoint is available.

12-7. Drift

See Figure 12-2. The periscope has five drift lines on the face of the scope.

To find the drift angle, the drift index control knob is rotated until ground checkpoints follow the drift lines as they cross the scope. The drift angle is then read from the drift set scale at the top of the scope.

12-8. Orbit Velocity

Two identifiable checkpoints in the orbit path and the distance between them are required to compute the orbit velocity. Start the stopwatch provided on the satellite clock when the first checkpoint passes under the target index and stop it when the second checkpoint passes under the target index. After finding the time required, use the satellite hand computer to compute orbit velocity. (Ref. Paragraph 12-13.)

12-9. SATELLITE CLOCK

The satellite clock is a manually wound spring motor driven device located in approximately the center of the main instrument panel (see Section I). This unit indicates TIME OF DAY, ELAPSED TIME FROM LAUNCH, TIME OF RETROGRADE (with respect to time of launch), RETROGRADE TIME-TO-GO and an arbitrary time-to-go called "EVENT #1". Upon reaching "time-of-retrograde" a set of contacts within the clock close, initiating the retrograde sequence. The time of retrograde is normally computed and set prior to flight, but the time can be manually changed by the astronaut or remotely set electrically through the command receivers. Elapsed time and time of retrograde indicators provide outputs for telemetering. In addition to the time displays, the satellite clock visually indicates 5 minutes before retrograde event or 5 minutes before EVENT #1 by lighting the specific indicator face yellow. Similarly, the clock initiates an aural signal to the astronaut's headset 30 seconds prior to either of the two events. Finally, ten minutes prior to retrograde time, the clock transmits a signal to the ASCS to start rate gyro operation, etc., in preparation for retro operation. The satellite clock is automatically started by 28 V DC power at liftoff (8 inches off pad). Should this not occur, a push button switch has been provided above and adjacent to the clock to allow the Astronaut to energize the clock (and altitude sensor) manually.

12-10. EARTH PATH INDICATOR

See Figure 12-3. The earth path indicator consists of a spherical map (globe) of the earth gimballed and rotating in a manner to indicate ground position under the capsule and approximate touchdown point when retrograde is initiated at indicated ground position. The indicator is spring motor powered and is capable of running 48 hours without re-winding. The globe, which is approximately 4.38 inches in diameter, will display the following geographical features:

(1) All continents.

(2) All bodies of water having major dimensions of 300 statute miles.

(3) All political boundaries where bordering countries have major dimensions of 300 statute miles.

(4) The sixteen largest rivers of the world.

(5) All islands having major dimensions of 500 statute miles.

(6) All known islands or island clusters separated from continents by 300 statute miles and having major dimensions less than 500 statute miles shall be identified by an .020 diameter circle.

(7) The fifty largest cities of the world are identified by .020 dots.

(8) 15° latitude and longitude lines are presented and numbered.

Controls are provided on the face of the indicator to wind the spring motor and to adjust the orbit time, orbit inclination, to slew the globe about the earth and the orbital axes.

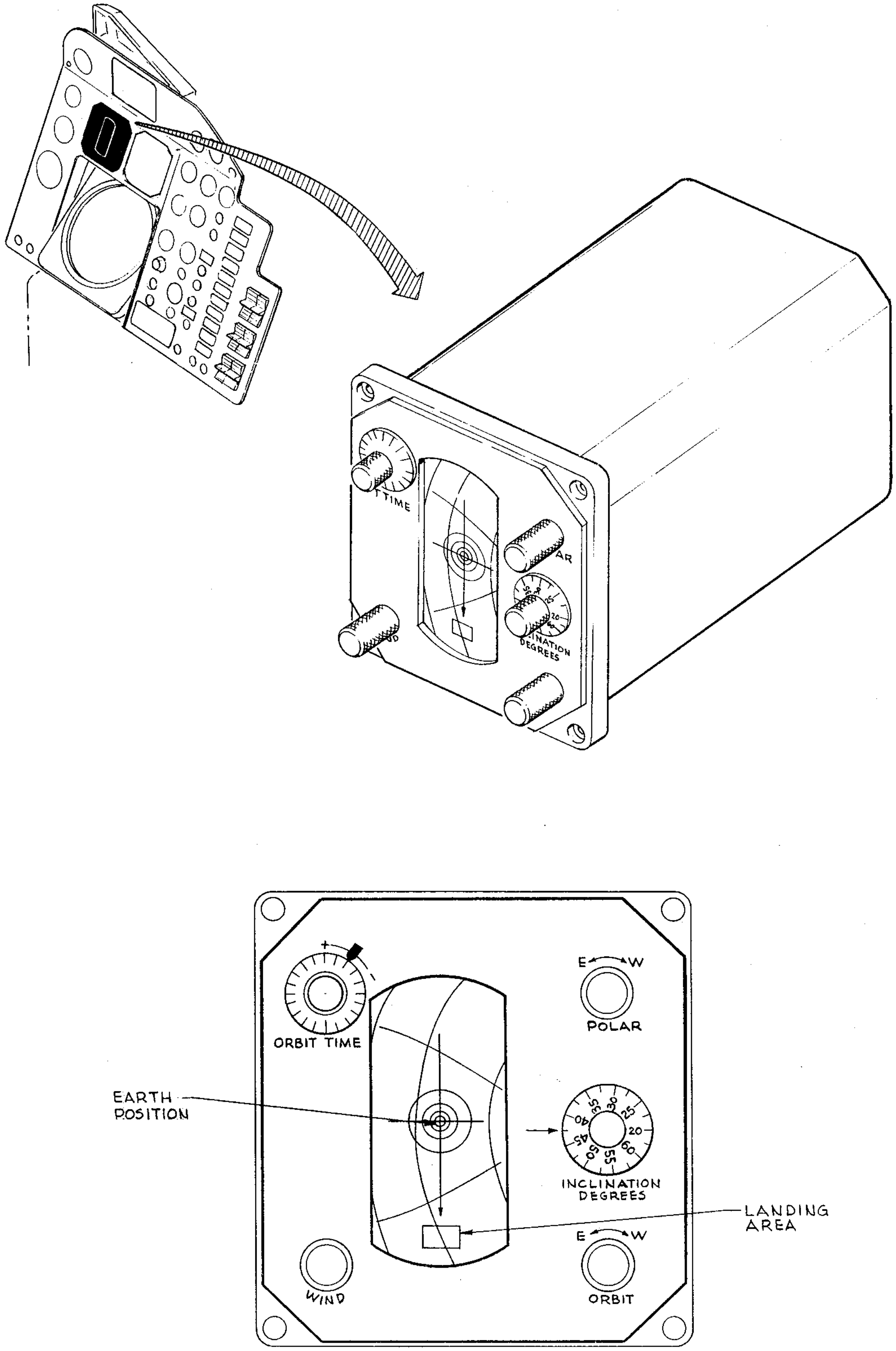


FIGURE 12-3 EARTH PATH INDICATOR

PM45-113A

12-11. ALTIMETER

See Section I - INTRODUCTION TO PROJECT MERCURY for location. The altimeter visually indicates external pressure above sea level. It is a single revolution type, calibrated from 0 to 100,000 feet, with a marker at 10,000 feet to indicate the altitude at which the main parachute will deploy. Static pressure is obtained from a centrally located plenum chamber which connects to four static ports spaced equally around the small end of the capsule conical section.

12-12. LONGITUDINAL ACCELEROMETER

See Section I - INTRODUCTION TO PROJECT MERCURY for location. The indicator provided is a self-contained longitudinal accelerometer. The unit is calibrated from -10 to +22g units and incorporates memory pointers which record the highest positive and negative "g" forces encountered.

12-13. HAND COMPUTER

See Figure 12-4. The satellite hand computer, physically resembling a circular slide rule, is provided to aid the Astronaut in solving navigation problems. The computer consists of three discs; a basic fixed disc, a small top fixed disc and a rotating intermediate disc. The computer is attached to the chart board for convenience and accessibility. The computer may be used to find orbital tangential velocity, orbital angle, drift, through ground speed, indicated ground speed, and for multiplication, division and proportions. Operation of the computer is as follows.

12-14. <u>Orbital Tangential Velocity</u>

To find orbital tangential velocity when ground distance, altitude, and time are known, set time on scale B opposite ground distance on scale A. (See Figure 12-4.) Then read orbital tangential velocity in nautical miles per minute on scale C opposite altitude and in knots on scale A opposite altitude (at 60 on scale B).

Sample problem:

Ground distance 2880 N.M. in 12 min. at 120 N.M. altitude.

(a) Set 12 min. on scale B opposite 2880 on scale A.

(b) On scale C, read 248.39 N.M/min. opposite 120.

(c) On scale A, read 14,903.4 knots opposite 120.

To find the orbital tangential velocity when angular position, time and altitude are known, set time on scale B opposite angular position on scale A. Read orbital tangential velocity in nautical miles per minute on scale D and in knots on scale A opposite altitude scale (at 36 on scale B).

Sample problem:

Angular position 48° in 12 min. at 120 N.M. altitude. Find orbit velocity in N.M./sec. and knots.

(a) Set 12 min. on scale B opposite 48 degrees on scale A.

(b) On scale D, read 248.39 N.M./min.

(c) On scale A, read 14,903.4 opposite 120.

To find tangential orbital velocity when ground speed and altitude are known, set 0 on altitude scale (at 60 on B scale) opposite ground speed on A scale. Read orbital tangential velocity in nautical miles per minute on scale A opposite orbit altitude on altitude scale.

Sample problem:

Ground speed 239.6 N.M./sec. and altitude 120 N.M. Find orbital tangential velocity.

(a) Set altitude 0 on altitude scale opposite 239.6 N.M./sec. on A scale.

(b) On scale A, read 248 N.M. opposite 120 N.M. altitude.

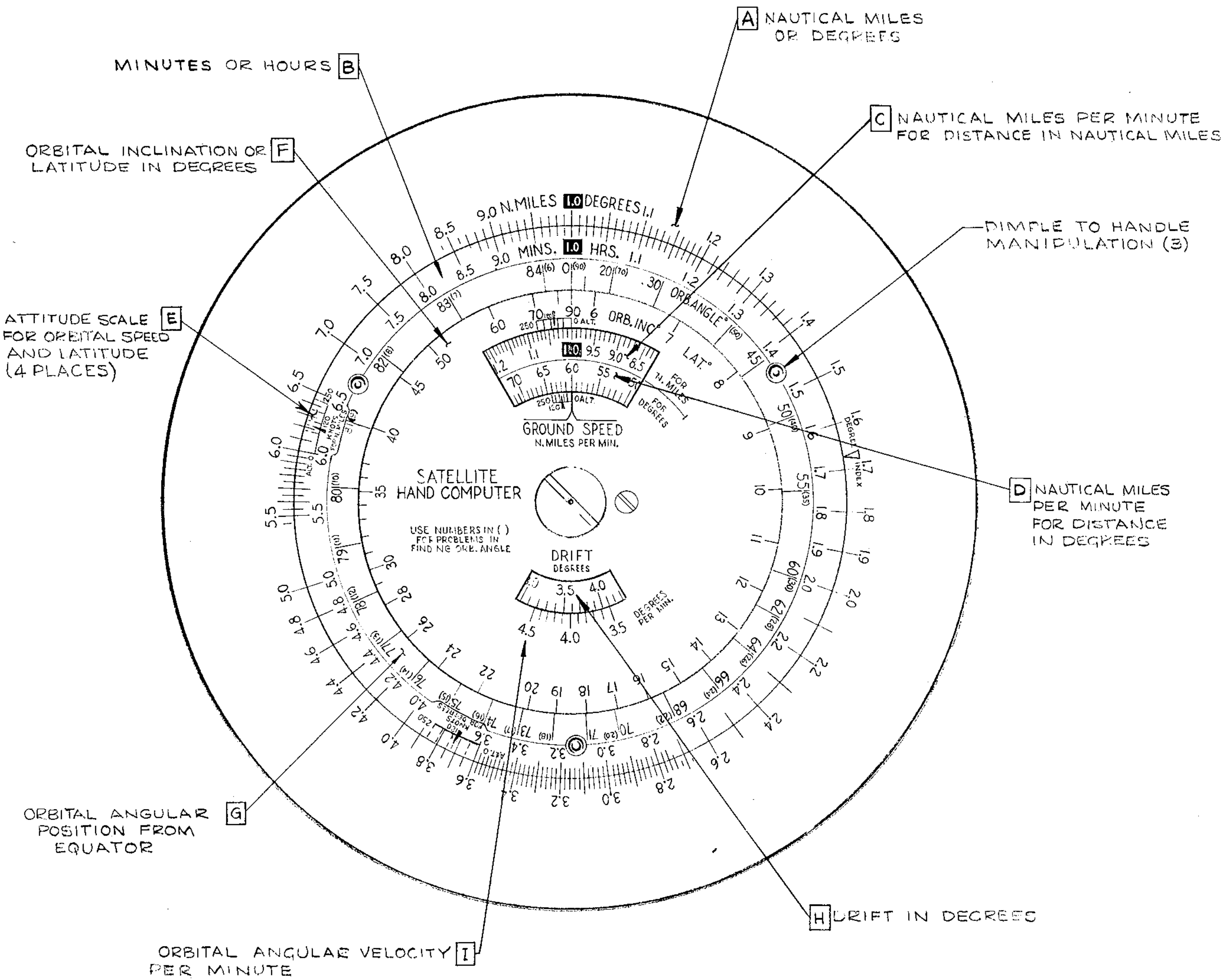


FIGURE 12-4 HAND COMPUTER

PM45-115

NOTE

To convert orbital tangential velocity to ground speed, reverse the above procedure, set orbit altitude opposite orbital tangential velocity and read ground speed opposite 0 altitude.

12-15. Orbital Angle

To find orbital angle when ground distance is known, set 1.0 on B scale opposite index mark (at 1.67) on scale A. Read equivalent orbital angle on scale A opposite distance on B scale.

Sample problem:

Ground distance is 2880.

(a) Set 1.0 on B scale opposite index mark on A scale.

(b) On A scale read 48° orbital angle opposite 2880 N.M. on B scale.

NOTE

To convert orbital angle to ground speed, read distance on B scale opposite orbital angle on A scale.

To find orbital angle when instantaneous latitude and orbital inclination are known, set 0 on G scale opposite latitude on F scale. Read orbital angle on G scale opposite orbital inclination on F scale.

Sample problem:

Ground latitude 14° 29' and orbital inclination 30° .

(a) Set 0 of G ( ) scale opposite 14° 29' on F scale.

(b) On G ( ) scale, read 30° orbital angle opposite 30° orbital inclination on F scale.

NOTE

For latitude when orbital angle and orbital inclination are known, set orbital angle on G ( ) scale opposite orbital inclination on F scale and read latitude on F scale opposite 0 and G scale.

NOTE

For angle of inclination, when latitude and orbital angle are known, set 0 of scale G opposite latitude on F scale and read orbital inclination on F scale opposite orbital angle on G ( ) scale.

NOTE

G scale has two sets of numbers. The plain numbers, increasing clockwise, are used for finding drift while the numbers in parenthesis, increasing counterclockwise, are used for finding orbital angle.

12-16. Drift

To find drift when orbital angle, orbital velocity in degrees per minute and orbital inclination are known, set orbital angle on G scale opposite inclination on F scale and read drift on H scale opposite orbital velocity on I scale.

Sample problem:

Orbital inclination 32°, orbital angle 0° (starting point at equator), and orbit angular speed 4°/min.

(a) Set 0° orbital angle on G scale opposite 32° orbital inclination on F scale.

(b) Read 1.897° drift on H scale opposite 4°/min. on I scale.

12-17. Orbital Ground Speed

To find orbital ground speed, find the effective component of the earth's tangential velocity and add it to indicated ground speed. To find earth tangential velocity component, the orbital inclination, orbital angle, and earth's tangential velocity at equator, must be known. Set the orbital inclination on G scale opposite the orbital angle on F scale and read the earth's tangential velocity on A scale opposite earth's tangential velocity at the equator on B scale.

Sample problem:

Orbital inclination 30°, orbital angle 0°, earth's tangential velocity of equator 15 N.M./min., and indicated ground speed 240 N.M./min.

(a) Set 30° orbital inclination on G scale opposite 90 (0°) orbital angle on F scale.

(b) Read 12.99 N.M./min. earth's tangential velocity on scale A opposite 15 N.M./min. earth's tangential velocity at equator on scale B.

(c) Add 12.99 N.M./min to 240 N.M./min. indicated ground speed and get 252.99 N.M./min orbital ground speed.

NOTE

Since effective earth velocity is constant, orbital ground speed can be considered constant for any given orbit.

12-18. CHARTBOARD

See Figure 12-5. The chartboard display is a belt type mercator projection of the earth with an orbit path overlay. The chartboard is attached to the periscope with a folding linkage which permits it to be stowed flat against the periscope when not in use. The chartboard also contains the hand computer and celestial charts.

12-19. CELESTIAL CHARTS

Under certain circumstances, it may be desirable to attempt celestial navigation. For this reason, a bound set of celestial charts is provided.

12-20. ANGULAR RATE INDICATOR

See Section I - INTRODUCTION TO PROJECT MERCURY for location. The rate indicators are mounted in the same case as the attitude indicator. (Refer to Section IV.) From the standpoint of reliability, the rate indicators receive signals from three rate gyros separate from those of the ASCS. Each axis is calibrated to $\pm$ 6 deg/sec.

12-21. TEST CONFIGURATION #2, 3 and 4 CAPSULES

12-22. General

Capsules 2, 3 and 4 are fundamentally the same as the specification capsule. Some differences will exist in the location of the various instruments, but the instruments themselves will remain the same. (See Section I for instrument panel illustration.) Other differences are enumerated in the following paragraphs.

12-23. Altimeter

The altimeter used in capsule 2, 3 and 4 has markings at the 42,000 and 10,000 foot level to indicate when the drogue and main parachutes, respectively, will deploy. The specification capsule does not contain a drogue chute; therefore, this marking has been eliminated from later altimeters (capsules 5, 9 and up).

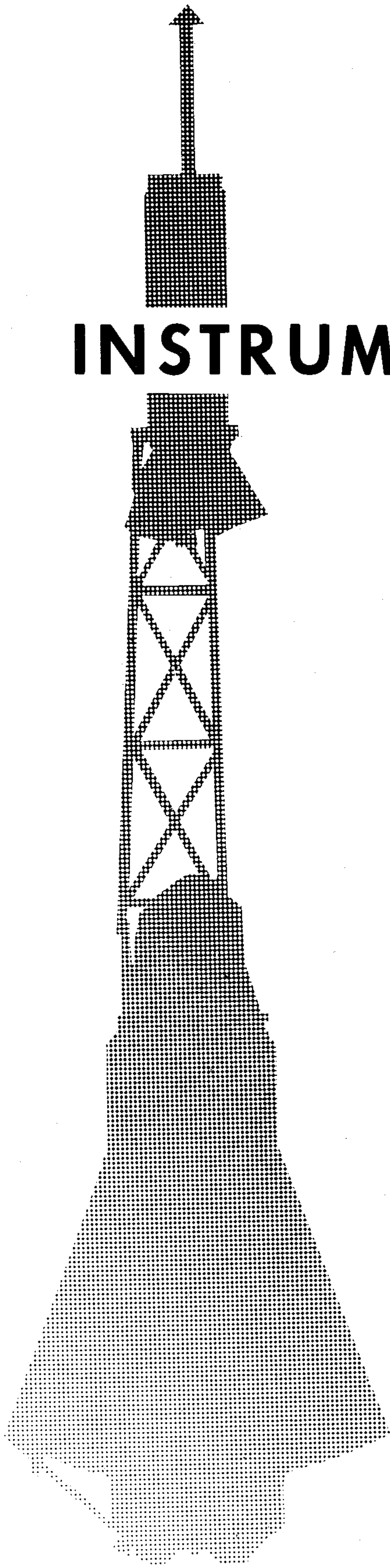
12-24. Periscope

On capsules 2, 3 and 4 the periscope programming is the same as the specification capsule except that the periscope will extend following tower separation instead of following capsule separation.

This information will be supplied when available.

FIGURE 12-5 CHARTBOARD

SECTION XIII



INSTRUMENTATION SYSTEM

TABLE OF CONTENTS

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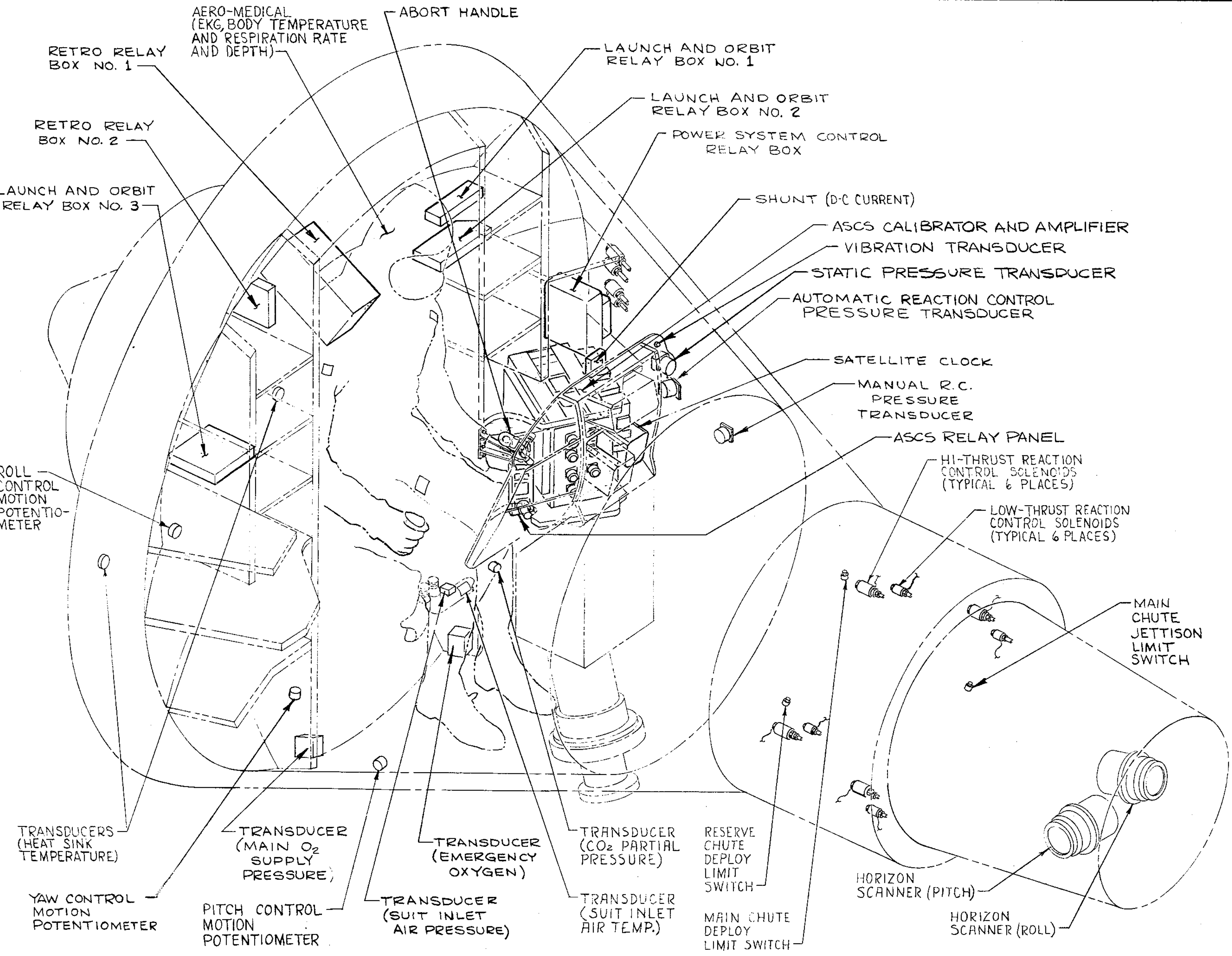

FIGURE 13-1 INSTRUMENTATION SYSTEM (SHEET 1 OF 2)

PM45-129A-1

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XIII. INSTRUMENTATION SYSTEM

13-1. GENERAL

The data contained in Paragraphs 13-2 through 13-124 applies to the specification compliance capsule. Deviations from this data as applicable to test configuration capsules are covered in Paragraphs 13-125 through 13-230.

13-2. SYSTEM DESCRIPTION

The instrumentation system monitors the physical condition and environment of the Astronaut, capsule characteristics and condition and the operation of capsule controls. This information is applied to telemetry transmitters and a tape recorder to provide data for analysis and evaluation. Cameras are installed to observe and record the Astronaut's facial expressions and the capsule instrument panel. The instrumentation system also provides programmed control power to operate instrumentation and other system components.

13-3. The major components used to monitor, code, record and control are shown in Figure 13-1. Table 13-1 lists the various parameters monitored by the instrumentation system.

13-4. SYSTEM OPERATION

Instrumentation is divided in monitoring, control and recording groups. In addition, a special instrumentation pallet is utilized on unmanned missions.

13-5. Monitoring Instrumentation

Monitoring instrumentation consists of the signals taken from points in the capsule which indicate operation and conditions during the mission. These signals are coded for telemetry and recording. Figure 13-2 is a block diagram of monitoring instrumentation.

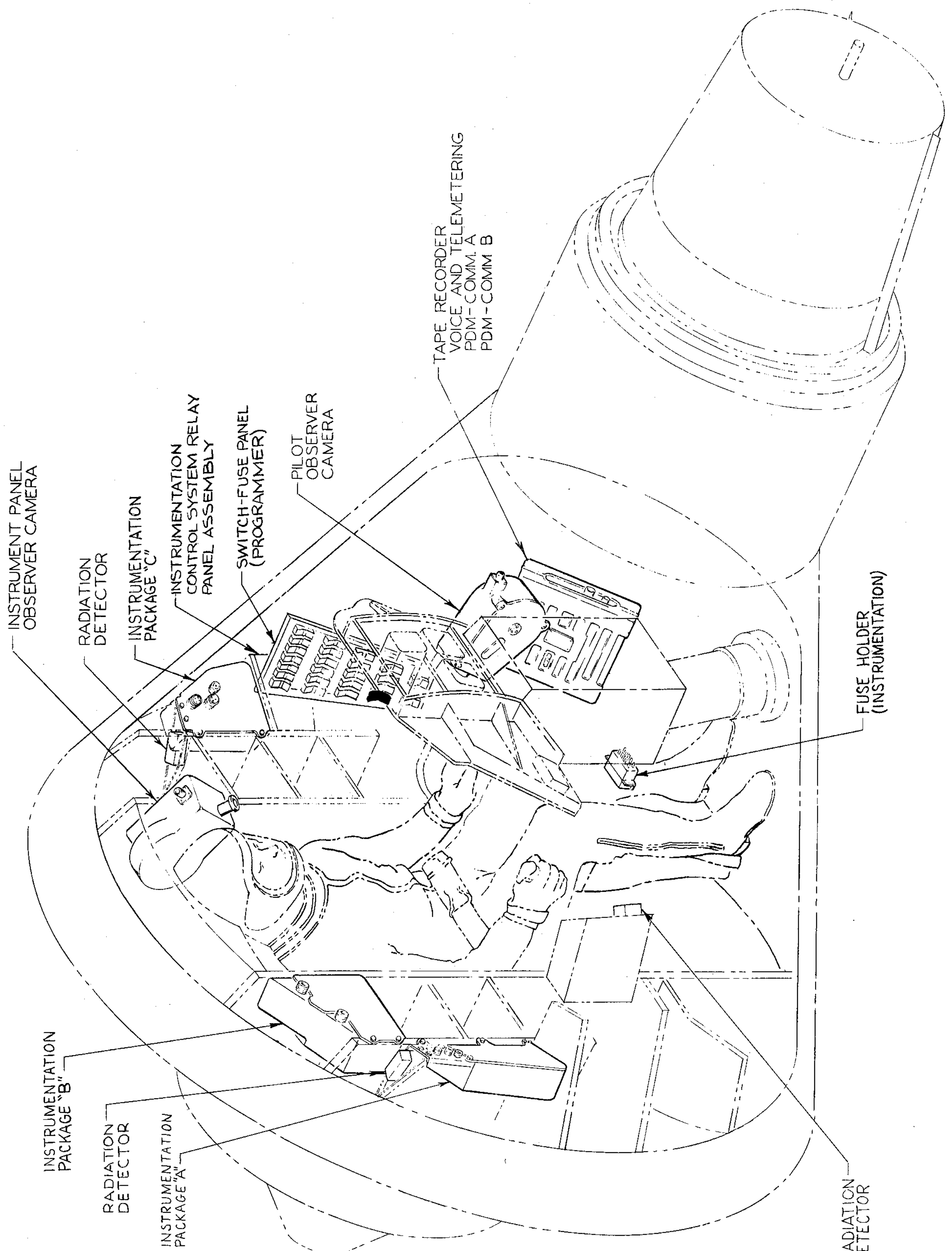

FIGURE 13-1 INSTRUMENTATION SYSTEM (SHEET 2 OF 2)

PM45-129-2A

Table 13-1. Instrumentation Parameters

PARAMETERS	SPECIFICATION CAPSULE COMMUTATOR		CAPSULE 2 COMMUTATOR		CAPSULE 3 COMMUTATOR		CAPSULE 4 COMMUTATOR	
	A	B	A	B	A	B	A	B
Electrical Power Sys.								
115V 400 CPS Monitor	41	41	41	41	41	41	41	41
D-C Current	42	42	42	42	42	42	42	42
Standby Inverter ON	62	62	62	62	62	62	62	62
Standby Batteries ON	63	63	63	63	63	63	63	63
24 Volts D-C	83	83	83	83	83	83	83	83
Instrumentation Power Supplies								
3 Volt D-C Reference	1	1	1	1	1	1	1	1
Zero Volt Reference	2	2	2	2	2	2	2	2
7 Volt 400 CPS	3	3	3	3	3	3	3	3
Static Pressure	22	22	22	22	22	22	22	22
Vibration	5,27, 49,71		5,12, 27,49, 71,85		5,12, 27,49, 71,86		5,27, 49,71 85	
Sound Level		5,27, 49,71		5,12, 27,49 71,85		5,12, 27,49 71,86		5,27 49,71 85
Calibration ON	64	64	64	64	64	64	64	64
Environmental Control System								
CO_2 Partial Pressure	6	6	6	6	6	6	6	6
O_2 Partial Pressure	7	7	7	7	7	7	7	7
Suit Inlet Air Pres.	8	8	8	8	8	8	8	8

Continued - Table 13-1. Instrumentation Parameters

PARAMETERS	SPECIFICATION CAPSULE COMMUTATOR		CAPSULE 2 COMMUTATOR		CAPSULE 3 COMMUTATOR		CAPSULE 4 COMMUTATOR	
	A	B	A	B	A	B	A	B
Main O_2 Supply Pres.	9	9	9	9	9	9	9	9
Cabin Temperature	10	10	10	10	10	10	10	10
Suit Inlet Air Temp.	11	11	11	11	11	11	11	11
Reserve O_2 Supply Pres.	12	12					12	12
Cabin Pressure	82	82	82	82	82	82	82	82
Coolant Quantity	84	84					84	84
Reaction Control System								
Reaction Control Supply Pressure (Automatic)	39	39	39	39	39	39	39	39
Reaction Control Supply Pressure (Manual)	40	40	40	40	40	40	40	40
Hand Control Position								
Roll	23	23					23	23
Pitch	24	24					24	24
Yaw	25	25					25	25
Acceleration								
Y Axis	13,43 73	13,43 73	13,23 43,73	13,23 43,73	13,43 73	13,43 73	13,43 73	13,43 73
X Axis	14,44 74	14,44 74	14,44 74	14,44 74	14,44 74	14,44 74	14,44 74	14,44 74
Z Axis	15,45 75	15,45 75	15,24 45,75	15,24 45,75	15,45 75,85	15,45 75,85	15,45 75	15,45 75
Structural Temperature								
Heat Sink Temp.	19	19	19	19				
Ablation Shield Temp.					19	19	19	19

Continued - Table 13-1. Instrumentation Parameters

PARAMETERS	SPECIFICATION CAPSULE COMMUTATOR		CAPSULE 2 COMMUTATOR		CAPSULE 3 COMMUTATOR		CAPSULE 4 COMMUTATOR	
	A	B	A	B	A	B	A	B
Outer Skin Temp.	20	20	20	20	20	20	20	20
Inner Skin Temp.	21	21	21	21	21	21	21	21
Aeromedical Data								
[1] Electrocardiograph	1.7 & 2.3 kc VCO's				1.7 & 2.3 kc VCO's		1.7 & 2.3 kc VCO's	
[1] Respiration	1.3 kc VCO's				1.3 kc VCO's		1.3 kc VCO's	
0.05G Relay	87	87	87	87	87	87	87	87
Horizon Scanner								
Pitch Output	86		86	86				
Roll Output	88		88	88				
Pitch Ignore	85		25	25				
Roll Ignore	85		59	59				
Attitude								
Pitch	[2] 16	[2] 16	16,84	16,84	16,50 88	16,50 88	16,86	16,86
Roll	[2] 17	[2] 17	17	17	17,59 84	17,59 84	17,88	17,88
Yaw	[2] 18	[2] 18	18	18	18,51	18,51	18	18
Attitude Rate								
Pitch	[3] 16	[3] 16,85	2.3 kc VCO's [1]					
Roll	[3] 17	[3] 17,86	1.7 kc VCO's [1]					
Yaw	18 [3]	18,88 [3]	1.3 kc VCO's [1]					
RCS Control Solenoids								
Pitch High Up	65	65	65	65	65	65	65	65

Continued - Table 13-1. Instrumentation Parameters

PARAMETERS	SPECIFICATION CAPSULE COMMUTATOR		CAPSULE 2 COMMUTATOR		CAPSULE 3 COMMUTATOR		CAPSULE 4 COMMUTATOR	
	A	B	A	B	A	B	A	B
Pitch High Down	66	66	66	66	66	66	66	66
Pitch Low Up	67	67	67	67	67	67	67	67
Pitch Low Down	68	68	68	68	68	68	68	68
Roll High CW	69	69	69	69	69	69	69	69
Roll High CCW	70	70	70	70	70	70	70	70
Roll Low CW	76	76	76	76	76	76	76	76
Yaw High Left	78	78	78	78	78	78	78	78
Yaw High Right	79	79	79	79	79	79	79	79
Yaw Low Left	80	80	80	80	80	80	80	80
Yaw Low Right	81	81	81	81	81	81	81	81
Satellite Clock (Elapsed Time)								
10 seconds	26	26	26	26	26	26	26	26
1 Minute	28	28	28	28	28	28	28	28
10 Minutes	29	29	29	29	29	29	29	29
1 Hour	30	30	30	30	30	30	30	30
10 Hours	31	31	31	31	31	31	31	31
30 Hours	32	32	32	32	32	32	32	32
Satellite Clock (Retrograde Time)								
10 Seconds	33	33	33	33	33	33	33	33
1 Minute	34	34	34	34	34	34	34	34
10 Minutes	35	35	35	35	35	35	35	35

Continued - Table 13-1. Instrumentation Parameters

PARAMETERS	SPECIFICATION CAPSULE COMMUTATOR		CAPSULE 2 COMMUTATOR		CAPSULE 3 COMMUTATOR		CAPSULE 4 COMMUTATOR	
	A	B	A	B	A	B	A	B
1 Hour	36	36	36	36	36	36	36	36
10 Hours	37	37	37	37	37	37	37	37
30 Hours	38	38	38	38	38	38	38	38
Body Temperature	4	4			4	4	4	4
Package Temperature			4	4				
Normal Launch Sequence								
Tower Release	46	46	46	46	46	46	46	46
Capsule Separation	47	47	47	47	47	47	47	47
Retro Attitude Comd.	48	48	48	48	48	48	48	48
Retro Rocket No. 1 Fire	50	50	50	50			50	50
Retro Rocket No. 2 Fire	51	51	51	51			51	51
Retro Rocket No. 3 Fire	52	52	52	52			52	52
Retro Rocket Assy. Jettison	53	53	53	53	53	53	53	53
Emergency Escape Sequence								
Pilot Abort	59	59					59	59
Mayday	60	60	60	60	60	60	60	60
Tower Escape Rocket	61	61	61	61	61	61	61	61
Landing System Sequence								
Drogue Chute Deploy			54	54	54	54	54	54

Continued - Table 13-1. Instrumentation Parameters

PARAMETERS	SPECIFICATION CAPSULE COMMUTATOR		CAPSULE 2 COMMUTATOR		CAPSULE 3 COMMUTATOR		CAPSULE 4 COMMUTATOR	
	A	B	A	B	A	B	A	B
Antenna Fairing Release	55	55	55	55	55	55	55	55
Main Chute Deploy	56	56	56	56	56	56	56	56
Main Chute Jettison	57	57	57	57	57	57	57	57
Reserve Chute Deploy	58	58	58	58	58	58	58	58
Periscope Retract	72	72	72	72	72	72	72	72
Primate Reaction								
Total Animal Response								
R.H.					23	23		
L.H.					52	52		
Duration of Blue Light					24	24		
Shock Occurrence					25	25		

1 Not commutated.

2 With 0.05g relay de-energized.

3 With 0.05g relay energized and retrograde assembly jettisoned.

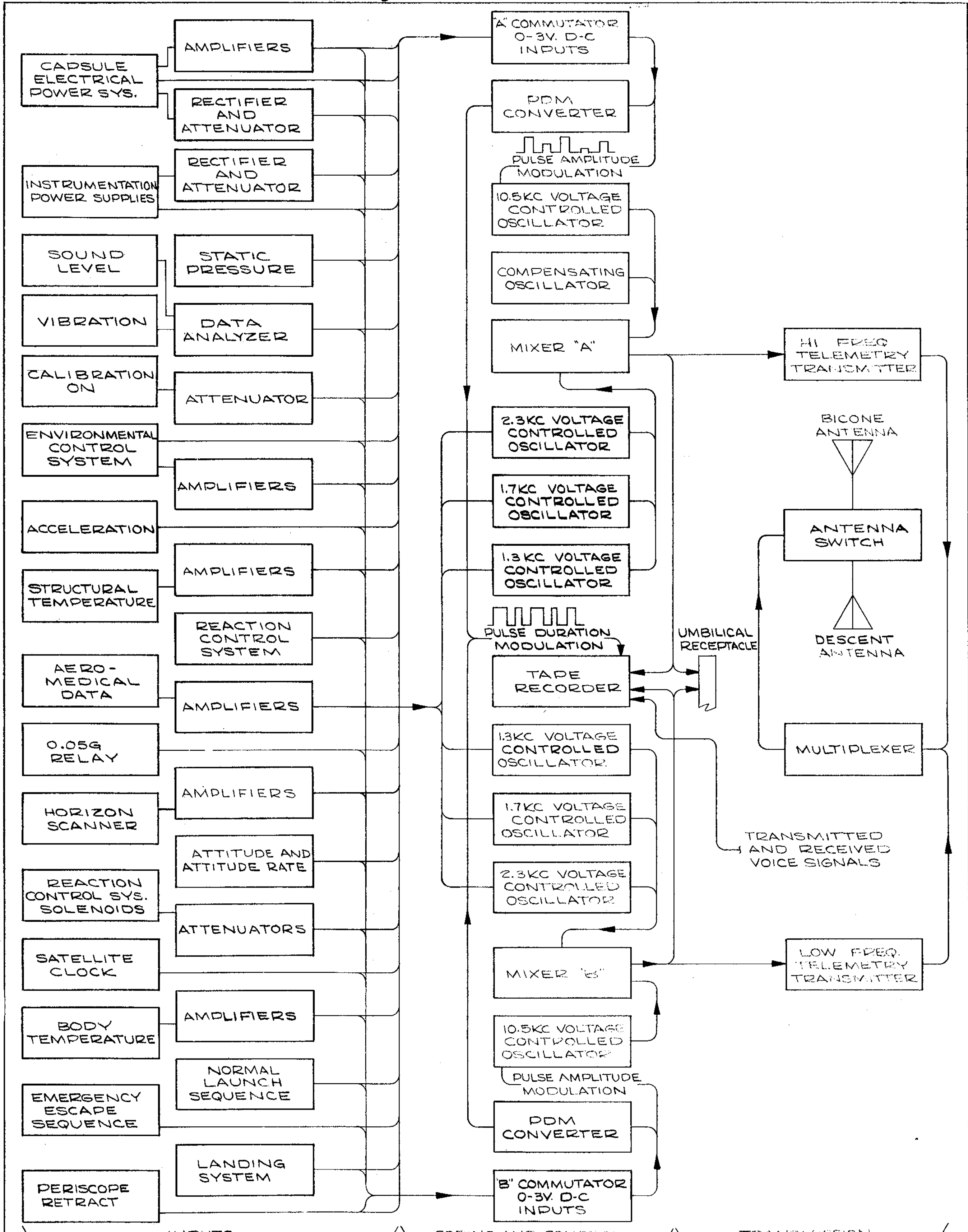

FIGURE 13-2 MONITORING INSTRUMENTATION BLOCK DIAGRAM

PM45-130A

13-6. The various systems are monitored by converting the pressures, temperatures, sequence events, etc., to proportional voltages within common maximum and minimum values. These voltages are applied to a pair of commutators (electronic switches), A and B. The majority of corresponding A and B commutator channels are paralleled for redundancy. Each commutator continuously samples its input channels. Thus a train of voltage pulses is generated from each commutator. The pulse train from the "A" commutator is applied to a 10.5 kc voltage controlled sub-carrier oscillator. The changing voltages of the pulse train vary the frequency of this oscillator. The output of this and other voltage controlled oscillators driven by aero-medical information are mixed with the output of a recorder synchronizing oscillator andused to modulate the high frequency telemetry set. They are also directly recorded in the capsule. (On capsules utilizing a 1 7/8 ips tape speed, the frequency response of the tape is limited and the 10.5 kc oscillator signal does not record.) The pulse amplitudes of commutator "A" output are also converted to pulse durations which are directly recorded in the capsule.

13-7. The pulse train from the "B" commutator is also supplied to a 10.5 kc voltage controlled sub-carrier oscillator. The frequency modulated output of this oscillator and other oscillators controlled by aero-medical information are mixed and used to modulate the low frequency telemetry transmitter. The pulse amplitudes of commutator "B" output are also converted to pulse durations which are directly recorded in the capsule.

13-8. Capsule Electrical Power System

Capsule electrical power system instrumentation consists of the monitor circuits for 115 volts a-c, d-c current, 24 volts d-c, standby inverter on and standby batteries on. (Refer to Figure 13-2.)

13-9. Fan bus 115 volt a-c is applied to a 115/6.3 volt transformer in instrumemtation package A. The secondary output is rectified, filtered and attenuated prior to being applied to the commutators as a zero to three volt d-c signal. A three volt signal (full scale) represents 120 volts.

13-10. D-c current amplitude is sensed by the shunt for the instrument panel ammeter. This shunt is in the negative lead of all capsule batteries and senses total battery current. The voltage across the shunt is 50 millivolts when 50 amperes are flowing. This voltage is applied to two d-c amplifiers in package C which amplify it to a zero to three volt level. A three volt level (full scale) represents 50 amperes battery current. The output of one amplifier is applied to commutator A, the other amplifier output is applied to commutator B.

13-11. The volt d-c monitor circuit is made up of a voltage divider network in package A. Voltage from the main pre-impact 24 volt d-c bus is applied to this divider. A three volt signal (full scale) represents 30 volts bus voltage.

13-12. The standby batteries on signal comes from the secondary bus relay No.2. This relay energizes if the STANDBY BATTERY switch is in AUTO position and main bus voltage is below 18 volts. With the relay energized, 24 volts d-c (nominal) is applied to an attenuator in package C. Attenuator output (2.8 volts d-c, nominal) is applied to the commutators.

13-13. The standby inverter on signal is obtained through normally open contacts of the standby inverter relay. This relay energizes when either of the main inverters fails. With the relay energized, 24 volts d-c is applied to an attenuator in the power and control relay box. Attenuator output (2.2 volts d-c, nominal) is applied to the commutators.

13-14. Instrumentation Power Supplies

Instrumentation power supplies instrumentation consists of the monitor circuits for the 3 volt d-c reference, zero reference, and 7 V 400 cps power supplies. (See Figure 13-2 and Table 13-1.)

13-15. The 3 volt d-c reference power supply furnishes excitation for all potentiometer type instrumentation pick-ups. The power supply is located in package A. It is a zener diode regulated supply from the 24 volt bus. The output from the power supply is applied directly to the commutators and serves as a reference full scale signal.

13-16. The zero reference signal is signal ground and is also the return for the 3 volt d-c reference power supply output.

13-17. The 7 volt 400 cps power supply furnishes excitation for the input bridge circuits utilized with the resistance element amplifiers. Power supply output is rectified, filtered and attenuated to a zero tothree volt level. This zero to three volt signal is applied to the commutators. A three volt signal (full scale) represents a 7 volt output level. The power supply is a transistorized power inverter which operates on 24 volts d-c to provide the 7 volt 400 cps output. It is located in package A.

13-18. Static Pressure

Static pressure instrumentation consists of a potentiometer type transducer which is operated by static pressure. The potentiometer is excited with 3 volts d-c from the instrumentation power supply and wiper voltage output is proportional to static pressure. A three volt signal (full scale) is representative of 15 psia.

13-19. Sound Level and Vibration

Noise level instrumentation is applied to numerous telemetry channels of commutator B only. Vibration instrumentation is applied to the same channels of commutator A. Sound level is in the frequency range of 37 to 9600 cps and the vibration data appears in the range of 45 to 200 cps. A microphone and amplifier are located in package B for sound level pick-up. A piezo-electric/diaphragm type microphone senses a pressure level of 100 to 140 db with a frequency range of 37.5 to 9600 cps. The vibration transducer is a piezo-electric crystal which measures a frequency range of 10 to 2000 cps. A transistorized amplifier is used to increase the output of the vibration transducer. The amplified sound and vibration signals are coupled to a dual channel spectrum analyzer. The analyzer converts these input signals to amplitude vs. frequency signals. The output of the analyzer is applied to the commutators.

13-20. Calibration On

Calibration on instrumentation consists of a circuit which monitors presence of the full scale and zero scale calibration command signals. This signal is present when the CALIBRATION switch in the telemetry trailer is placed to FULL SCALE or ZERO position. In addition, the capsule utilizes a programmed calibration signal while in orbit. (Refer to Table 13-2.) When the full scale calibrate command is present, 24 volts d-c is applied to an attenuator in package C. The output of the attenuator (2.8 volts d-c, nominal) is applied to the commutators. When the zero scale calibrate command is present, 24 volts d-c is applied to a different input point on the same attenuator network. The output of the attenuator (1.5 volts d-c, nominal) is applied to the commutators. Thus, an upper scale signal indicates presence of the full scale calibrate command and a half-scale signal indicates presence of the zero scale calibrate command. These command signals energize relays which apply calibrate signals to numerous other instrumentation channels.

13-21. Environmental Control System

Environmental control system instrumentation consists of circuitry which monitors main and emergency oxygen supply pressures, suit inlet air pressure and temperature, cabin pressure and temperature, CO_2 and O_2 partial pressures and coolant quantity.

13-22. Main and emergency supply pressures are sensed by pressure actuated dual potentiometers in the environmental area. One potentiometer operates a panel indicator while the other wiper picks off a value used for instrumentation. Wiper voltage output is linearly proportional to pressure. Excitation is applied from the 3 volt d-c instrumentation power supply. The zero to three volt (full scale) wiper output represents a pressure range of zero to 10,000 psi. Outputs from the main and emergency oxygen supply pressure transducers are applied to both commutators.

13-23. Suit inlet air temperature is sensed by two resistance element transducers in the suit inlet air line. Transducer resistance varies proportionally with temperature. Each transducer is part of a bridge input circuit to an amplifier in package A. The zero to three volt (full scale) output from the amplifier is representative of a temperature range of 40° to 100°F. One amplifier output is applied to commutator A; the other amplifier output is applied to commutator B.

13-24. Suit inlet air pressure instrumentation consists of a potentiometer type transducer which is pressure actuated. The potentiometer is excited with 3 volts d-c from the instrumentation power supply and wiper voltage output varies linearly with pressure. The zero to three volt (full scale) output represents a pressure range of zero to 25 psia.

13-25. Cabin pressure instrumentation consists of a potentiometer type pressure transducer installed in package C. The potentiometer is excited with

3 volts d-c from the instrumentation power supply and wiper voltage output is linearly proportional to cabin pressure. The zero to three volt (full scale) output from the wiper represents a pressure range of zero to 25 psia.

13-26. Cabin air temperature is sensed by two platinum resistance wire transducers mounted in package A. Transducer resistance varies proportionally with temperature. Each of the transducers is part of a bridge input circuit to an amplifier in package A. The zero to three volt (full scale) output from the amplifier is representative of a temperature range of zero to 200°F. Amplifier outputs are applied to commutator A and B.

13-27. O_2 partial pressure is sensed by a transducer in package C consisting of cadmium-gold reference electrodes, polyethylene membrane and a pressure type body. The amount of oxygen passing through the membrane causes a change in the gaseous pressure around the electrode and results in a variation of output potential. Transducer output is applied to two amplifiers to raise it to a zero to three volt level. This signal voltage range represents a range of zero to 253 mm Hg (zero to five psia) oxygen partial pressure. Amplifier outputs are applied to commutators A and B. At or above 60% full scale output, a switching circuit in the amplifier operates to turn off the O_2 PRESS light.

13-28. CO_2 partial pressure in the suit is sensed by a transducer which consists of a platinum reference electrode in an electrolytic solution, a teflon membrane and a thermistor circuit. The amount of CO_2 passing through the membrane causes a change of the Ph factor of the solution which causes a variation in output voltage level. Electrolyte life is approximately 40 hours. The thermistor provides temperature compensation. Transducer output is applied to two amplifiers in package A to obtain a signal level of zero to three volts (full scale). This signal range represents pressures between 0.1 to 20 mm. of of mercury. The output curve is logarithmic. Amplifier outputs are applied to commutators A and B and to an indicator on the main instrument panel.

13-29. Coolant quantity is measured by sensing the pressure of the oxygen bottle used to force water from the coolant tank. This bottle supplies five hundred pounds pressure. As coolant quantity decreases, the confined volume of the oxygen increases with a resulting decrease in oxygen pressure. A pressure potentiometer excited by three volts d-c from the instrumentation power supply monitors oxygen pressure. Wiper output is applied to commutators A and B and through an attenuator in package A to the coolant quantity indicator. Zero to three volt (full scale) covers a range of zero to 100% coolant quantity. Oxygen pressure at 100% coolant quantity is 500 psi.

13-30. Reaction Control System

Reaction control system instrumentation consists of monitors for automatic and manual reaction control supply pressure and astronaut hand control position.

13-31. The monitor circuits for reaction control supply pressures are identical in operation. A helium source of 3000 psi is utilized to expell hydrogen peroxide from a bladder. As hydrogen peroxide is expelled, the confined volume of the helium increases and helium pressure decreases. A pressure potentiometer senses this change in pressure. The potentiometer is excited with three volts from the instrumentation power supply. Wiper output voltage is applied to both commutators and through an attenuator to an indicator. Transducer range is zero to 3500 psi. A pressure of 3000 psi provides a reading of 100% on the indicator. Hydrogen peroxide is exhausted at approximately 900 psi. helium pressure. Indicator reading at this pressure is approximately 25%.

13-32. Astronaut hand control position is monitored by three potentiometers. The wipers of these potentiometers are driven by linkage to the hand control.

Three volts from the instrumentation power supply is utilized to excite the potentiometers. Zero to three volt signal level represents $\pm$ 13° hand control movement in the roll and pitch planes and $\pm$ 10° movement in the yaw plane. Wiper outputs are applied to both commutators.

13-33. Capsule Acceleration

Capsule acceleration instrumentation consists of circuitry which monitors acceleration along the mutually perpendicular axes. Three accelerometers installed in package B provide zero to three volt d-c outputs proportional to acceleration along the longitudinal, lateral and normal axes of the capsule. The accelerometer outputs are linear with a zero acceleration providing a 1.5 volt d-c signal. The longitudinal axis accelerometer covers a range of $\pm$ 30g to provide zero to three volt output signals. The normal and lateral axes accelerometers operate in two ranges. During launch and re-entry, a zero to three volt signal represents accelerations between $\pm$ 4g. During orbit, a zero to three volt signal represents accelerations between $\pm$ 0.5g. These zero to three volt signals are applied to the commutators.

13-34. Structural Temperature

Structural temperature instrumentation consists of monitor circuits for heat shield, outer skin and inner skin temperatures.

13-35. Heat sink temperature is sensed by two resistance element transducers mounted in the center and edge of the heat sink. Transducer resistance varies proportionally with temperature. Each of these transducers is part of a bridge input circuit to an amplifier in package A. The zero to three volt (full scale) output from the amplifier is representative of a temperature range of -60 to 1800°F. The output from the amplifier associated with the center transducer is applied to commutator A. The edge transducer amplifier output is applied to commutator B.

13-36. Outer skin temperature is sensed by two resistance element transducers welded to the inside surface of the outer skin shingles in forward and aft locations. Transducer resistance varies proportionally with temperature. Each of these transducers is part of a bridge input circuit to an amplifier in package A. The zero tothree volt (full scale) output from the amplifier is representative of a temperature range of -60 to +1800° F. The output from the amplifier associated with the aft transducer is applied to commutator A. The forward transducer amplifier output is applied to commutator B.

13-37. Inner skin temperature is sensed by two resistance element transducers adhering to the inner skin in forward and aft positions. Transducer resistance varies proportionally with temperature. Each of these transducers is part of a bridge input circuit to an amplifier in package A. The zero to three volt (full scale) output from the amplifier is representative of a temperature range of -10 to +250° F. The output of the amplifier associated with the aft transducer is applied to commutator A. The forward transducer amplifier output is applied to commutator B.

13-28. Aeromedical

Aeromedical instrumentation consists of monitor circuits for electrocardiograph and respiration signals.

13-39. Electrocardiograph signals are obtained from transducers attached to the Astronaut. The outputs from the transducers are applied to amplifiers in package B. The outputs of the amplifiers vary between zero and 1.5 volts and are applied to the 1.7 and 2.3 kc voltage controlled sub-carrier oscillators. The signal level varies for each Astronaut and amplifier gain is adjustable to provide usable signals. Circuit frequency response if from 0.1 to 25 cps.

13-40. Respiration rate and depth signals are obtained from a potentiometer in a chest harness. Astronaut breathing actuates this potentiometer. A circumferential expansion of one-half inch provides a full scale output signal. The potentiometer is excited with three volts d-c from the instrumentation power supply. Wiper output voltage amplitude is indicative of respiration depth and the frequency of variation is respiration rate. Wiper output is applied through a calibrate card in package C to the 1.3 kc voltage controlled sub-carrier oscillators in package B.

13-41. 0.05G Relay

Instrumentation of 0.05g relay operation consists of an on-off type signal which indicates whether the relay is energized or de-energized. The relay may be energized by operation of the 0.05g sensor or by the command receiver. When the relay is energized a d-c signal is applied to commutators A and B.

13-42. Horizon Scanner

Horizon scanner instrumentation monitors for the pitch and roll horizon scanner outputs and ignore signals for each of these outputs.

13-43. The horizon scanner system utilizes two identical infra-red scanning units to provide pitch and roll reference signals. During a ballistic mission these signals are used constantly, but during an orbital mission the reference signals are applied to the ASCS attitude gyros only upon command from the programmer. (Refer to Table 13-2.) The signals that are applied to the gyros are monitored by instrumentation. The pitch and roll signals range between $\pm$ 10 volts d-c. These signals are applied to a biased attenuator card to provide a zero to 2.68 volt output which is coupled to separate channels of commutators A and B. The signals represent an output range of -66.5° to $\underline{~}42^{\circ}$

13-44. Occasionally a scanner sweeps across the sun. Since the scanners are infra-red devices, sweeping of the sun introduces error voltage. To prevent utilization of this voltage, the scanner supplies an "ignore" signal to the ASCS. This "ignore" signal is monitored as an on-off type of signal by instrumentation. Pitch ignore and roll ignore signals are applied to commutator A only. A half scale signal represents presence of the pitch ignore signal and full scale level indicates presence of the roll ignore signal.

13-45. Attitude

Attitude instrumentation consists of telemetry channels which monitor capsule pitch, roll and yaw attitudes. Each attitude is read out of a synchro actuated potentiometer. The synchros are driven by the automatic stabilization control system. Excitation for the potentiometers is furnished by the three volt d-c instrumentation power supply. Signal voltage varies along a multiple slope function with capsule attitude. Pitch and roll signals cover a range of +130° to -190°. Yaw signals cover a range of +70 to -250°. Each of the attitude signals is applied to separate channels of commutators A and B. After retrograde assembly jettison and energizing of a 0.05g relay, the potentiometer-positioning synchros become inoperative. At this time, attitude signals are removed from the commutators and attitude rate signals are applied to the relinquished commutator channels.

13-46. Attitude Rate

Attitude rate instrumentation utilizes signals from rate gyros. The gyros are part of the attitude rate indicating system. A zero to three volt signal level represents a rate level of decreasing 40° per second to increasing 40° per second. Attitude rate signals are applied to commutators A and B. Roll, pitch and yaw rates are assigned to separate channels. In addition, attitude rates are applied to the channels normally occupied by attitude data when attitude data is no longer generated. (Refer to Paragraph 13-45.)

13-47. Reaction Control System Solenoids

The reaction control system solenoids control the thrust jets used for capsule stabilization in flight. These solenoids can be energized manually or automatically. When a solenoid is energized, 24 volts d-c is applied through an attenuator in package C to commutators A and B. Each of the twelve solenoids is represented by a separate commutator channel. This on-off signal is presented to instrumentation circuitry from the amplifier-calibrator in the ASCS system.

13-48. Satellite Clock

The satellite clock utilizes potentiometers to provide electrical signals representative of elapsed time from launch and retrograde time. These potentiometers are excited with three volts from the instrumentation power supply. The outputs for each type of tome are divided in signals representative of 0 to 10 seconds, 0 to 1 minute, 0 to 10 minutes, 0 to 1 hour, 0 to 10 hours and 0 to 30 hours. Wiper output is linearly proportional from zero to three volts for each time span. Wiper outputs are applied to commutators A and B.

13-49. Body Temperature

Body temperature is sensed by a rectal temperature pick-up. The pick-up is a thermistor element which is utilized as one leg of a bridge input to two amplifiers. The outputs of the amplifiers are between zero to three volts (full scale). Each output is applied to one of the commutators. Temperature range of the probe is 95 to 108 degrees Fahrenheit.

13-50. Normal Launch Sequence

Normal launch sequence instrumentation consists of monitor circuits for tower release, capsule separation, retrograde angle command, retrograde rocket assembly jettison and retrograde rocket No. 1, No. 2 and No. 3 fire signals. These signals are all on-off type functions and each is applied to commutators A and B.

13-51. When the tower separates from the capsule, the No. 3 tower separate sensor relay de-energizes and applies three volts d-c to the commutators. This signal is present for the remainder of the mission.

13-52. When the capsule separates from the booster, a limit switch closes and causes the No. 1 capsule separate sensor relay to energize. While this relay is energized a three volt d-c signal is applied to both commutators. This relay remains energized for the remainder of the mission.

14-53. The retrograde angle command signal normally occurs when the retrograde clock runs out. It may also be caused by ground command or by operation of a bypass switch on the instrument panel. This signal remains present until the retrograde rocket assembly is jettisoned (approximately 95 seconds). Signal level is approximately three volts. Normally open contacts of the retrograde attitude command relay in retrograde relay box No. 2 closes to route the signal to commutator A and B.

13-54. The retrograde rocket fire signals occur at five second intervals. The first fire signal occurs thirty seconds after reception of retrograde clock run-out if the retrograde interlock is closed in the ASCS. The fire signals remain present until retrograde assembly jettison occurs. The rocket fire sensing relays are energized by pressure switches mounted in each rocket. A d-c signal of approximately three volts is applied through normally open contacts of these relays to commutators A and B.

13-55. The retrograde rocket assembly jettison signal occurs 60 seconds after the firing of the second retrograde rocket. The signal is routed through normally open contacts of the retrograde rocket assembly separation sensor relay in retrograde relay box No. 1. This relay is energized by limit switches which close when the retrograde assembly is blasted away from the capsule. The relay remains energized until the 0.05g relay drops out. (The 0.05g relay de-energizes at 10,000 feet.)

13-56. Emergency Escape Sequence

Emergency escape sequence instrumentation consists of Mayday and tower escape rocket fire signal monitors.

13-57. The Mayday signal is produced by the Mayday alarm relay. This relay is energized by any abort signal. With the relay energized, three volts d-c (nominal) is applied to commutators A and B. Once initiated, this signal is present for the remainder of the mission. The Mayday alarm relay is in launch and orbit relay box No. 3.

13-58. The tower escape rocket signal is obtained from the emergency escape rocket fire relay in launch and orbit relay box No. 2. This relay remains energized for less than one second but a capacitor is connected across the input to commutators A and B to maintain a signal level of more than 0.3 volt for approximately 30 seconds.

13-59. Landing System

Landing system instrumentation consists of monitor circuits for chute deploy and jettison and release of the antenna fairing. These signals are approximately three volts and are applied to commutators A and B. Main and reserve chute deploy signals are obtained from limit switches in the chute compartment. Presence of these signals indicates the chutes have left the can. The main chute jettison signal is obtained through a limit switch in the chute compartment. The antenna fairing release signal comes from the antenna fairing separation relay in recovery relay box No. 1. This relay is energized through a limit switch. All landing system signals remain on until impact.

13-60. Periscope Retract

The periscope retract signal monitors the voltage applied to the retract relay. While the periscope is retracting, 24 volts d-c is applied through an attenuator in package C to both commutators. Input level to the commutators is approximately three volts.

13-61. Coding and Control

The signals applied to commutators A and B are sampled once every $1\frac{1}{4}$ seconds. Commutator outputs are square wave pulses with amplitude between -1 and +3 volts. These pulses are applied to voltage controlled oscillators and pulse duration modulation converters.

13-62. The frequencies of the voltage controlled oscillators are varied between 10.5 kc $\pm$ $7\frac{1}{2}\%$ by the commutated pulse amplitude signals. This frequency band corresponds to IRIG Channel 12. The frequency modulated outputs of the 10.5 kc voltage controlled oscillators are applied to two mixers.

13-63. Commutator pulse amplitude modulation signals are also applied to pulse duration modulation converters. The converters reshape the pulse amplitude waveshapes to obtain pulse duration wave trains. These wave trains are then applied to the tape recorder.

13-64. Amplified aeromedical signals are coupled to pairs of 1.3 kc, 1.7 kc and 2.3 kc voltage controlled oscillators. A zero to full scale signal causes a deviation in center frequency of $\pm$ $7\frac{1}{2}\%$. The frequency bands of these oscillators correspond to IRIG Channels 5, 6 and 7. The oscillator outputs are applied to mixers.

13-65. In the mixers, the commutated outputs and the aeromedical signals are combined. Mixer A also accepts a signal from the compensating oscillator.

(This signal serves as a reference during data evaluation to indicate fluctuations in tape speed.) The composite signal from each mixer is applied to the tape recorder, the ground test umbilical and a telemetry transmitter.

13-66. Transmission

Ground testing and control of the instrumentation system is provided through the umbilical receptacle. Non-radiating checks can be performed toevaluate system operation. Radiating checks are performed through the telemetry link. Refer to Section XI for further information regarding telemetry.

13-67. Instrumentation Control (See Table 13-2)

The instrumentation system controls and programs power to its own and other systems equipment.

(a) The ASCS horizon scanners are powered at regular intervals during the mission to provide reference signals for the capsule gyros.

(b) The water absorber in the environmental control system is also programmed at regular intervals during the mission.

(c) The tape recorder is programmed to operate continuously during the ascent and descent, to operate intermittently during orbit, and to operate at any time the Astronaut is making voice transmissions from the capsule.

(d) The pilot and instrument panel observer camera operate at a high rate of speed during launch and re-entry, and at slower rates during the orbit phase.

(e) Calibration voltages, R-calibrate for maximum readings and Z-calibrate for minimum readings, are supplied periodically to the monitoring instrumentation circuits. This is done prior to launch and at intervals during

CONTROLLED EQUIPMENT OR FUNCTION	MISSION PHASE		
	LAUNCH UNTIL ORBIT	ORBIT	RETRO COMMAND UNTIL LANDING
ASCS HORIZON SCANNERS	←	ON 8.5 MINUTES EVERY HOUR	→
ECS WATER EXTRACTOR	←	ON 30 SECONDS EVERY 30 MINUTES	→
TAPE RECORDER	ON	ON 1 MINUTE-OFF 3 MINUTES	ON
	←	ON DURING ANY VOICE TRANSMISSION FROM THE CAPSULE	→
PILOT OBSERVER CAMERA	180 FRAMES PER MINUTE	20 FRAMES PER HOUR	180 FRAMES PER MINUTE
INSTRUMENT PANEL OBSERVER CAMERA	180 FRAMES PER MINUTE	6 FRAMES PER MINUTE	180 FRAMES PER MINUTE
R-CALIBRATION (FULL SCALE)	OFF	[1] 3 SECONDS EVERY 28 MINUTES AND 3 SECONDS DURING GROUND COMMANDED LOW FREQUENCY TELEMETRY OPERATION	OFF
Z-CALIBRATION (O-SCALE)	OFF	[1] 3 SECONDS EVERY 28 MINUTES AND 3 SECONDS DURING GROUND COMMANDED LOW FREQUENCY TELEMETRY OPERATION	OFF
LOW FREQUENCY TELEMETRY	ON	ON FOR 6.66 MINUTES WHEN COMMANDED BY GROUND STATION. ON AT ANY TIME BY PILOT SELECTION.	ON
"B" TELEMETRY EKG AMPLIFIERS, VCO's AND MIXER	ON	ON DURING OPERATION OF LOW FREQUENCY TELEMETRY	ON
"B" COMMUTATOR, RECORD AMPLIFIER	ON	[2] ON 1 MINUTE - OFF 3 MINUTES ON DURING OPERATION OF LOW FREQUENCY TELEMETRY	ON
"B" COMMUTATOR BODY TEMP., CO_2 PARTIAL PRESS. AND D-C CURRENT AMPLIFIERS.	ON	[2] ON 1 MINUTE - OFF 3 MINUTES ON DURING OPERATION OF LOW FREQUENCY TELEMETRY	ON
NOISE LEVEL AND VIBRATION AMPLIFIERS AND ACCOUSTICAL AND VIBRATION ANALYZER.	ON	OFF	ON
X,Y AND Z AXIS ACCELEROMETER OUTPUTS.	X,Y AXES ±4G Z AXIS ± 30G	X,Y AXES ± 0.5G Z AXIS ± 30G	X,Y AXES ± 4G Z AXIS ± 30G

[1] R-CALIBRATE IS IMMEDIATELY FOLLOWED BY Z-CALIBRATE

[2] CONCURRENT

TABLE 13-2 INSTRUMENTATION CONTROL AND PROGRAMMING

TABLE 13-2

orbit. Calibration will also occur when the low frequency telemetry is commanded into operation by a ground station.

(f) The low frequency telemetry set is programmed for continuous operation during ascent and descent. During orbit the set normally transmits only while passing over a station, by ground command from that station. However, the Astronaut may cause the set to operate continuously.

(g) Electrocardiogram amplifiers, voltage controlled oscillators and the mixer amplifier associated with the low frequency telemetry set are powered only when that set is energized.

(h) The "B" commutator and record amplifier which serve both the low frequency telemetry and the tape recorder are scheduled for operation whenever the low frequency telemetry set is used. During orbit, if the low frequency telemetry is not on, the commutator and record amplifier are programmed at intervals to coincide with tape recorder operation.

(i) Body temperature, CO partial pressure and d-c current amplifiers associated with "B" commutator operation are powered only when the commutator is energized.

(j) Noise level and vibration amplifiers, and the accoustical and vibration analyzer are powered only during ascent and descent.

(k) The X and Y axes accelerometer ranges are $\pm$ 4g from launch until orbit and from retro command until landing. These ranges are changed to $\pm$ 0.5g while the capsule is in orbit. The Z axis accelerometer range is $\pm$ 30g throughout the mission.

13-68. These control functions are achieved by mode relays and a programmer. The mode relays, in turn, are controlled by mission events and the Astronaut. The programmer allots time intervals for the power circuits involved.

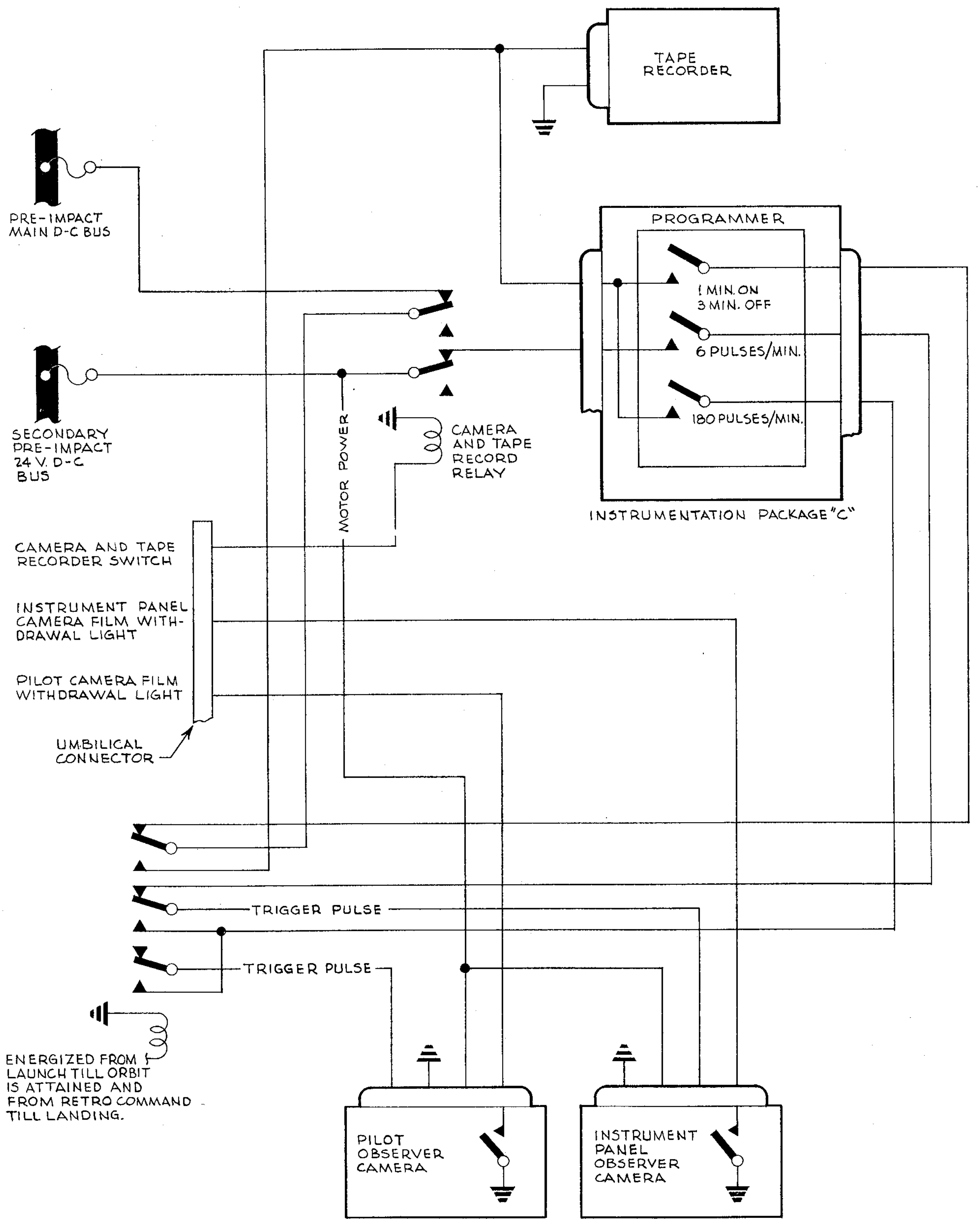

FIGURE 13-3 CAMERAS AND TAPE RECORDER CONTROL CIRCUIT

PM45-117A

13-69. Recording Instrumentation (See Figure 13-3.)

Recording instrumentation consists of a tape recorder and two cameras.

13-70. Tape Recorder

A low power, lightweight tape recorder provides seven channels for data recording. Mixer A output, voice communications, commutator B pulse depth modulation and commutator A pulse depth modulation signals are applied to channels 1, 3, 5 and 7, respectively. The tape recorder operates continuously during ascent and descent, and is on 1 minute and off 3 minutes during orbit. In addition, the recorder is turned on during any voice transmission from the capsule. Recorder speed is 1 7/8 inches per second.

13-71. Cameras

A 16 millimeter camera is installed in the capsule to observe the main instrument panel. This camera is mounted to the left of the Astronaut's head and views the panel from over his shoulder. The camera is supplied 24 volts d-c from the capsule power system. Operation of the camera is controlled by also applying 24 volt d-c power pulses to the camera clutch. Each pulse trips the shutter, exposing one frame, and advances the film for the next exposure. Power is applied through an Instrumentation Mode Relay. The programmer located in Instrumentation Package "C" uses this voltage to generate the pulses. Power pulses are supplied at the rate of 180 pulses per minute during ascent and descent, and at the rate of 6 pulses per minute during orbit.

13-72. A 16 millimeter camera mounted behind the lower left corner of the main instrument panel views the Astronaut. This camera is also supplied 24 volt d-c power and trigger pulse voltage. Operation is similar to that of the instrument panel observer camera. Power pulses are supplied at the rate of 180 per minute during ascent and descent and 20 per hour during orbit.

13-73. The cameras and tape recorder can be controlled through the umbilical during ground checkout. Return circuits from these components to the umbilical provide indications of component operation.

13-74. Special Instrumentation

Not applicable to a manned capsule.

13-75. SYSTEM UNITS

13-76. Transducers

Potentiometer type transducers are connected across instrumentation 3 volt d-c power. The wiper is activated by the action to be measured. Wiper voltage is then proportional to the action.

13-77. Control Stick Motion Potentiometers

Control stick motion is translated into rotary potentiometer movement. One potentiometer is provided for each axis of motion.

13-78. Satellite Clock Potentiometers

The satellite clock (refer to Section XII) utilizes potentiometers to indicate elapsed time from launch and time to retrograde outputs for 0-10 seconds, 0-1 minute, 0-10 minutes, 0-1 hour, 0-10 hours and 0-30 hours.

13-79. Manual and Automatic Supply Helium Pressure Potentiometers

Helium supply pressure, 3000 psig maximum, actuates the wiper of each potentiometer transducer to a resistance position proportional to the pressure.

13-80. Attitude Potentiometers

The ASCS calibrator, refer to Section IV, provides snychro actuation of potentiometers for pitch, roll and yaw. Each wiper output is then proportional to the capsule attitude for that axis.

13-81. Main and Reserve Oxygen Pressure Potentiometers

Each oxygen system pressure actuates a dual potentiometer transducer. A low resistance linear element is used to operate a panel indicator while a higher resistance linear element is used for instrumentation. Wiper voltage outputs are proportional to applied oxygen pressure.

13-82. Static Pressure, Suit Pressure and Coolant Quantity Pressure Potentiometers

Each pressure transducer is used to provide a linear output proportional to the applied pressure. Pressure ranges are 0-15 psia for static pressure, 0-25 psia for suit pressure and 0-500 psia for coolant quantity pressure.

13-83. Respiration Rate and Depth Potentiometer

Pilot breathing actuates a potentiometer worn in a chest harness. Respiration depth is determined by the extremes to which the potentiometer is actuated while breathing rate determines the frequency of actuation.

13-84. Resistance Element Transducers

Resistance elements are used to measure temperatures. The resistance of the element varies proportionally to its temperature. Mounting of the element depends on the application. Stick-on surface temperature elements are small, lightweight units. Other elements are mounted as an integral part of the capsule structure. The following list indicates the purpose and approximate temperature and resistance ranges for each transducer.

(a) Inner Skin Temperature: 0° to 300°F - 200 to 300 ohms.

(b) Outer Skin Temperature: -65° to 1800°F - 100 to 286 ohms.

(c) Heat Sink Temperature: -65° to 1800°F - 100 to 300 ohms.

(d) Suit Inlet Temperature: 40° to 100°F - 249 to 300 ohms.

(e) Cabin Air Temperature: 0° to 100°F - 216 to 316 ohms.

13-85. Body Temperature Transducer

The body temperature transducer is a rectal temperature pickup which consists of a thermistor imbedded in sealing compound at the end of a flexible pigtail.

13-86. D-C Current Shunt

The shunt resistance used for the instrument panel ammeter also supplies voltage for instrumentation. This shunt is discussed in Section XI of this manual

13-87. Electrocardiogram Pickups

Cardiac activity is picked up by three, one half inch square, stainless steel wire screens. These electrodes are attached with silver metalized adhesive to the Astronaut's left and right shoulders and left thigh. The left shoulder is negative in respect to the other electrodes.

13-88. Carbon Dioxide Partial Pressure Transducer

The transducer used to measure the amount of CO_2 pressure in total cabin pressure is a platinum reference electrode, thermistor circuit. The CO_2 pressure causes voltage changes in the circuit. The transducer resistance completes a bridge circuit located in instrumentation package "A".

13-89. Vibration Transducer

A piezo-electric crystal is used as a vibration pickup, measuring a frequency range of 10 to 2000 cps. The transducer is used in conjunction with vibration amplifier.

13-90. Vibration Amplifier

A transistorized amplifier is used to increase the output of the vibration transducer to a level compatible with an accoustical and vibration analyzer.

13-91. Accoustical and Vibration Data Analyzer

A dual channel spectrum analyzer accepts and converts accoustical and vibration data to amplitude vs. frequency signals. Accoustical data is in the frequency range of 37 to 9600 cps while vibration data appears in the range of 45 to 2000 cps. A complete sweep of each frequency spectrum is made every 10 seconds.

Each channel has two frequency marker points for simplifying analysis readings.

13-92. Tape Recorder

A low power, lightweight tape recorder is used in the capsule tomake available 7 channels of recorded data. At the present time channel assignments are as follows: Channel 1, "A" VCO mixer output; Channel 3, voice communications; Channel 5, "B" commutator PDM; Channel 7, "A" commutator PDM. Tape speed is 1-7/8 ips, convertible to 15 ips by a modification kit. Tape capacity is 4800 feet of ½ inch wide mylar base tape. The tape transport consists of a capstan drive, supply reel and take-up reel mechanism. A d-c motor is used, through reduction gearing, for capstan drive. A limit switch is provided to interrupt recorder power should the tape break. Record amplifiers are incorporated in the unit for channels 1 and 3. Channels 5 and 7 utilize amplifiers incorporated in the commutators located in instrumentation package "A".

13-93. Instrumentation Package "C"

The "C" package incorporates units of various functions into one compact panel allowing convenience of mounting and of making electrical connections. These various sub-units are discussed in the following paragraphs.

13-94. Cabin Pressure Transducer

Cabin pressure actuates the wiper of a 10,000 ohm potentiometer located in the "C" package. Three volts d-c from the "A" package is applied across the potentiometer. Wiper output voltage is then proportional to the cabin pressure.

13-95. Oxygen Partial Pressure Transducer

The transducer used to measure the amount of O_2 pressure is the total cabin pressure is a cadmium-gold reference electrode, thermistor circuit. The O_2 pressure causes resistance changes in the circuit. The transducer resistance completes a circuit in two amplifiers used in conjunction with the transducer.

13-96. The instrumentation package utilizes a unique method of construction and mounting of the transistorized amplifiers, power suppliers, attenuators and monitors. Each unit consists of the necessary component parts mounted on a printed circuit, dielectric card withprinted connector contacts at the bottom for plug-in insertion. The card is then covered, with the exception of base connector contacts and side mounting edges, with a thin layer of epoxy resin. This coating is used to provide moisture protection, to insure operation in a 100% oxygen atmosphere and to improve mechanical ridgidity of components. These "Topic Cards" are package mounted in boxes providing side rails, base contact receptacles and printed circuit inter-connections.

13-97. Oxygen Partial Pressure Amplifier Cards

Two d-c amplifiers are used to prepare oxygen partial pressure information for application to the commutators. These amplifiers also supply power for illumination of the O_2 Pressure indicator light should the O_2 pressure fail below a preset value. The amplifier is transistorized and card mounted. The output from one amplifier is applied to the "A" commutator while the output from the other is applied to the "B" commutator.

13-98. D-C Current Amplifier Cards

Two amplifiers are used to bring the d-c current shunt voltage up to a maximum of 3 volts d-c. One amplifier is used for the "A" commutator while the other is used for the "B" commutator. The amplifiers are transistorized and card mounted.

13-99. Respiration Rate and Depth Calibration and Attenuator Card

Relays mounted on this card allow R and Z calibration of the signal supplied from the respiration rate and depth transducer. One relay is supplied for R calibration and one for Z calibration. Energizing the desired relay breaks the normal circuit and applies the calibration voltage to the commutators. Resistors are also mounted on the card for attenuation of 24 volt D-C voltages to proportional voltages compatible with the commutators.

13-100. Voltage Monitor Cards

Resistors, capacitors and circuit isolating crystal diodes are used to attenuate reaction control solenoid valve energizing voltages and standby battery voltage prior to application to the commutators. Each attenuator circuit output, a maximum of 3 volts D-C, is applied to both commutators.

13-101. Programmer

The programmer in the "C" package contains switch contacts which operate control circuits for specific intervals. Different programmers are used for orbital and ballistic missions.

13-102. The programmer used for orbital missions consists of two sections. When power is applied to the programmer, the spring driven, electrically wound, "A" section continuously operates the following wafer contacts.

WAFER SECTION	CONTACTS CLOSED	
	DURATION	RATE
1a, 1b, 1c	1 minute	1 per 4 minutes
2	3 seconds	1 per 28 minutes
3*	3 seconds	1 per 28 minutes
4	110 milliseconds	180 per minute
5	110 milliseconds	6 per minute
6	90 milliseconds	20 per hour
7	8.5 minutes	1 per hour
8**	8 minutes	1 per hour

	CONTACTS CLOSED	
WAFER SECTION	DURATION	RATE
9	30 seconds	1 per 30 minutes

* Wafer 3 pulse immediately follows wafer 2 pulse.

** Wafer 8 pulse starts 30 seconds after wafer 7 pulse starts.

13-103. The "B" section of the programmer is energized through the command receiver-decoders when low frequency telemetry operation is desired during orbit. The spring driven, electrically wound "B" section operates for 6.66 minutes after receiving a control voltage pulse. The wafer contacts are activated for the following intervals.

	CONTACTS CLOSED	
WAFER SECTION	DURATION	RATE
1	3 seconds	1 per 6.66 minutes
2*	3 seconds	1 per 6.66 minutes
3a, 3b, 3c, 3d **	360 seconds	1 per 6.66 minutes
4a, 4b	400 seconds	1 per 6.66 minutes

* Wafer 2 pulse immediately follows wafer 1 pulse.

** Wafer 3 pulses start 40 seconds after wafer 3 pulses.

13-104. Instrumentation Package "A"

The "A" package also incorporates units of various functions into one panel. These sub-units are discussed in the following paragraphs.

13-105. Cabin Air Temperature Transducers

A platinum resistance wire is used to measure cabin air temperature. Temperature changes from 0° to 200°F cause the element to change resistance from 200 to 300 ohms. The resistance element forms a part of an amplifier circuit. Two transducers are used in conjunction with two amplifiers to supply signal to both commutators.

13-106. A filament transformer is used to step down 115 volts 400 cps capsule power to 6.3 volts for use in packages "A" and "C".

13-107. The instrumentation package "A" also utilizes the "Topic Card" principle for amplifiers and power supplies.

13-108. Resistance Element Amplifier Cards

The same type amplifier is used for heat sink, inner skin, outer skin, suit inlet air and cabin air temperature transducer signals. Each amplifier is of dual channel design in order to accomodate the two transducers used to measure each type of temperature. Seven volts, 400 cps is supplied from the resistance element power supply. This voltage is applied across a bridge circuit in each amplifier. The transducer associated with each bridge circuit causes the voltage in the circuit to vary proportionally to the transducer temperature. This voltage change appears across a transformer and is rectified, using crystal diodes, to a maximum output of 3 volts d-c. The two outputs from each amplifier are applied to the commutators. Two relays on each card amplifier allow full scale and zero calibration of each channel. Calibration potentiometers are also provided for each channel.

13-109. Resistance Element A-C Power Supply Card

Resistance element amplifier circuits require 7 volts, 400 cps A-C. Capsule power, 24 volts D-C, is applied to a transistorized power inverter. The inverter, using zener diode-transistor voltage regulation and transistor switching, supplies a 7 volt a-c output which is monitored by an attenuator, rectifier circuit. The monitor output, a maximum 3 volts d-c, is applied to the commutators.

13-110. Body Temperature Amplifier Cards

Two transistorized d-c amplifiers are used to increase the output of the temperature transducer to a maximum 3 volt d-c level prior to application to the commutators. These amplifiers are of the same type as those used in instrumentation package "C" for d-c current amplification.

13-111. Carbon Dioxide Partial Pressure Amplifier Cards

Two amplifiers are used in conjunction with a remote CO_2 partial pressure transducer. One amplifier is used to operate an instrument panel indicator, and provide a maximum 3 volt d-c signal to one commutator. The second amplifier supplies signal to other commutator. The unit is transistorized and card mounted.

13-112. Signal Condition and D-C Supply Card

This "Topic Card" provides four functions in the instrumentation system. Filament transformer output is applied to a monitor circuit. This circuit attenuates and rectifies to provide a maximum 3 volt d-c signal indicating transformer operation. Capsule power, 24 volts d-c, is applied to an attenuator circuit which provides a 3 volt d-c output for the monitoring circuit. This 3 volt output is then applied to the commutators as a monitor of the main 24 volt d-c bus voltage. The signal condition and d-c power supply card also provides meter attenuator resistors which limit current flow in the panel indicator circuits. These circuits involve the main and reserve oxygen supply pressures, the automatic and manual fuel supply pressures and the coolant quantity circuit.

13-113. "A" and "B" Commutator-Keyer-Record Amplifiers

Two units are provided in the "A" package for commutating transducer data and supplying PDM and PAM outputs. The commutator portion of each unit is a 90 x $1\frac{1}{4}$, solid state device which samples sequentially, 88 channels of signal input information. The output produced is a pulse amplitude modulated signal wave train. Each 0 to 3 volts D-C input to the commutator is sampled $1\frac{1}{4}$ times per second per IRIG standards. The PAM wave train output is fed through a buffer stage to a PAM/PDM converter. The PDM output is then applied to a record amplifier which produces a signal capable of directly driving the recorder head in the capsule tape recorder. The PAM output is also fed through a gating circuit which introduces a master pulse and negative pedestal pulses to operate automatic decommutation equipment in the ground station. A power supply is incorporated in the unit to provide the positive and negative voltages required in the circuits.

13-114. <u>Instrumentation Package "B"</u>

The primary function of the "B" package is to convert capsule information to signals capable of modulating the telemetry transmitters. Transducers and amplifiers are also contained in the package to complete capsule information circuits.

13-115. Sound Level Transducer

A microphone and amplifier are located in the "B" package for sound level pickup. A piezo-electric/diaphragm type microphone is used to pick up a pressure level of 100 to 140 db with a frequency range of 37 to 9600 cps. The variable gain, transistorized amplifier consists of an impedance matching stage, filter network, buffer stage and final amplifier. Amplifier output, 3 volts RMS, is used with a data analyzer.

13-116. Accelerometers

Three accelerometers are mounted in the "B" package and used to determine the static longitudinal, lateral and normal accelerations of the capsule. Each unit gives a d-c output which is applied to 3 channels of each commutator.

13-117. Electrocardiogram Amplifier Cards

Four amplifiers are used for the EKG transducer inputs. This allows two EKG circuits, left shoulder to right shoulder and left shoulder to left thigh. Each amplifier increases the transducer output to a 3 volt peak to peak signal.

13-118. The "B" package supplies sub-carrier oscillators to allow two channels of instrumentation data. The "A" channel is associated with the "A" commutator, high frequency telemetry transmitter and tape recorder. The "B" channel is associated with the low frequency telemetry transmitter. The following paragraphs describe the sub-carrier oscillators.

13-119. Compensating Oscillator Card

During playback of a tape, the recorded signal from this oscillator is monitored to detect changes in tape recorder speed. A frequency shift indicates a change in speed. The oscillator is of "Topic Card" construction and operates at 3125 cps. Output level is adjustable.

13-120. Voltage Controlled Oscillator Cards

Instrumentation data voltages are applied to the sub-carrier oscillators causing oscillator frequency shift proportional to the input amplitude. The transistorized oscillator consists of a free running multivibrator and filter. The oscillator functions and frequencies are given below.

1. Channel "A"

   Commutator - 10.5 kcps

Left thigh to left shoulder EKG-1.7 kcps

Right shoulder to left shoulder EKG-2.3 kcps

Respiration rate and depth - 1.3 kcps

Compensating oscillator - 3.125 kcps

2. Channel "B"

Commutator - 10.5 kcps

Left thigh to left shoulder EKG - 1.7 kcps

Right shoulder to left shoulder EKG - 2.3 kcps

Respiration rate and depth - 1.3 kcps

13-121. Power Supply - Mixer Amplifier Card

Capsule power, 24 volts D-C, is converted to 6 volt D-C for use by the subcarrier oscillators. A mixer circuit combines the subcarrier oscillator outputs. Solid state components for these circuits are combined on one "Topic Card".

13-122. Cameras

13-123. Instrument Panel Observer Camera

A standard camera is modified with a special drive motor and housing. Capsule power, 24 volts D-C, is supplied to the camera motor. Operation of the motor, shutter mechanism and film transport begins upon receipt of a 110 millisecond, 24 volt D-C pulse. The camera cycle is complete within 200 milliseconds and ready for another trigger pulse. The camera is operated at rates of 180 or six frames per minute. Film capacity is 426 feet of 16 millimeter film.

13-124. Pilot Observer Camera

The mechanism of the pilot observer camera is the same as that of the instrument panel observer camera. The housing is designed to fit the specific mounting location. This camera will be operated at rates of 20 frames per hour and 180 frames per minute. Film capacity is 225 feet of 16 millimeter film.

13-125. TEST CONFIGURATION NO. 2 CAPSULE

13-126. GENERAL

The data contained in Paragraphs 13-127 through 13-169 pertains to Test Configuration No. 2 Capsule. Deviations from the specification compliance capsule are explained in these paragraphs. If no data is presented for a particular item, this item is the same as that used in the specification compliance capsule. The specification compliance capsule is discussed in Paragraphs 13-2 through 13-124.

13-127. SYSTEM DESCRIPTION

The instrumentation system of Capsule 2 monitors internal and external environment, capsule condition and operation of automatic controls. This information is applied to telemetry transmitters and a tape recorder to provide data for analysis and evaluation. Cameras are installed to observe and record the capsule instrument panel and the view through the window. The system also provides programmed control power to operate the cameras and the water extractor of the environmental control system.

13-128. The major components used to monitor, code, record and control are basically the same as shown in Figure 13-1. A special instrumentation pallet replaces the Astronaut's couch.

13-129. SYSTEM OPERATION

Instrumentation is divided in monitoring, control and recording groups. A special instrumentation package is installed in lieu of the Astronaut's couch.

13-130. Monitoring Instrumentation

Monitoring instrumentation differs from the specification compliance capsule circuitry in that scale factors are changed and several new parameters are substituted. Table 13-1 lists the parameter substitutions. Figure 13-4 is a block diagram of capsule 2 monitoring instrumentation. The following data pertains to the changed scale factors and the new parameters.

13-131. Environmental Control System

Environmental control system instrumentation on Capsule 2 consists of circuitry which monitors main oxygen supply pressure, suit inlet air pressure and temperature, cabin pressure and temperature, CO_2 and O_2 partial pressures. Emergency oxygen supply pressure and coolant quantity are not instrumented in this capsule. (Refer to Paragraphs 13-21 through 13-29.)

13-132. Suit inlet air temperature is sensed and signals are processed in the same manner as the specification compliance capsule. However, a zero to three volt signal level represents a temperature range of 32° to 100°F in Capsule No. 2.

13-133. Reaction Control System

Reaction control system on Capsule No. 2 instrumentation consists of monitors for automatic and manual reaction control supply pressures. Astronaut hand control position is not instrumented on this capsule. (Refer to Paragraphs 13-30 and 13-31.)

13-134. Capsule Acceleration

Capsule acceleration instrumentation consists of circuitry which monitors acceleration along three mutually perpendicular axes. Since Capsule No. 2 is not assigned to an orbital mission, the orbit signal range of the normal and lateral accelerometers is not used. The launch and re-entry signal range is utilized throughout the flight. (Refer to Paragraph 13-33.)

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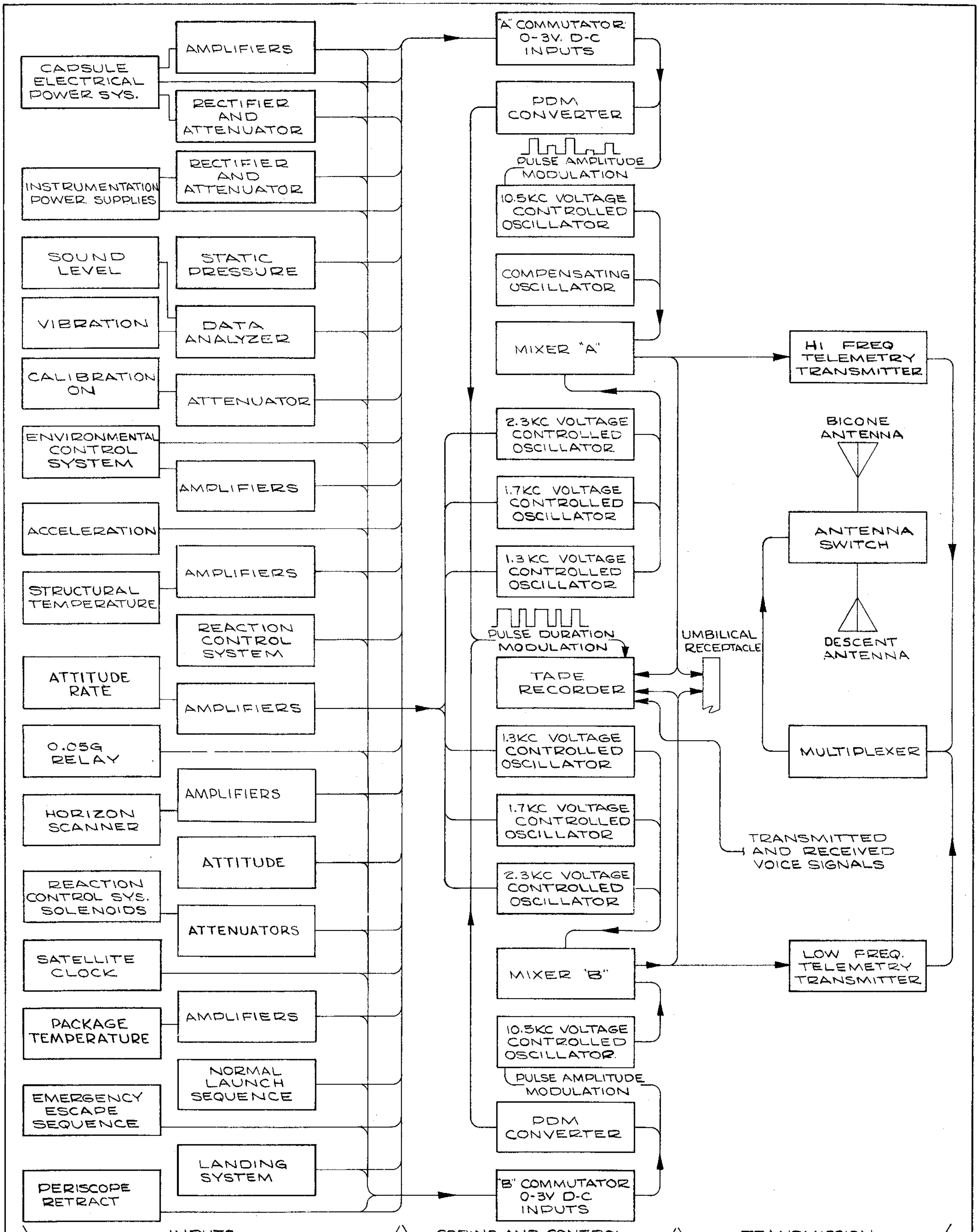

FIGURE 13-4 MONITORING INSTRUMENTATION BLOCK DIAGRAM - CAPSULE 2 PM45-146

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13-135. Structural Temperature

The structural temperature instrumentation circuitry in Capsule No. 2 is similar to specification compliance circuitry. Scale factors differ slightly. In Capsule No. 2 a zero to three volt signal represents a temperature range of -65° to +500°F for heat sink temperature and -65° to +800°F for outer skin temperature. (Refer to Paragraphs 13-34 through 13-37)

13-136. Aeromedical

Since Capsule No. 2 is assigned to an unmanned mission, no aeromedical instrumentation is utilized.

13-137. Horizon Scanner

Capsule No. 2 horizon scanner instrumentation circuitry is the same as specification compliance capsule monitoring except for the processing of the ignore signals. (Refer to Paragraphs 13-32 through 13-34.) In Capsule No. 2, the ignore signals are applied to separate channels of both commutators. A signal level of more than 0.75 volt indicates presence of the appropriate ignore signal.

13-138. Attitude Rate

Attitude rate signals are not commutated in Capsule No. 2. These signals are applied to the voltage controlled subcarrier oscillators that are utilized for electrocardiograph signals in the specification compliance capsule. A 1.5 volt signal level represents a zero attitude rate. A -1.5 volt signal represents a decreasing rate of 6 degrees per second and a plus 1.5 volt signal represents an increasing rate of 6 degrees per second. Pitch rate is applied to the 2.3 kc. oscillators. Roll rate is applied to the 1.7 kc. oscillators. Yaw rate is applied to the 1.3 kc. oscillators. Pitch and roll signals are routed through a biasing circuit to set up the proper center frequency signal level.

13-139. Package Temperature

In Capsule No. 2, package temperature instrumentation is substituted for the body temperature monitor of the specification compliance capsule. Circuitry is the same except for the sensing element. Package temperature is sensed by a thermistor mounted on one of the temperature amplifiers. This thermistor completes a bridge circuit. The bridge is utilized as the input signal source for both temperature amplifiers. Amplifier outputs are applied to commutators A and B. A zero to three volt signal level represents a temperature range of 90 to 100° F.

13-140. Landing System Sequence

Landing system sequence instrumentation on Capsule No. 2 is the same as that for the specification compliance capsule (refer to Paragraph 13-59) except circuitry is added to monitor the drogue chute deploy operation. This signal is obtained from a relay in recovery relay box No. 1. This relay is energized through the drogue door limit switch. The signal remains present until the capsule drops through an altitude of 10,000 feet.

13-141. Coding and Control

Monitoring instrumentation coding and control circuitry for Capsule No. 2 is the same as the specification configuration circuit. The input signals to this circuit are changed but circuit operation remains the same. The most significant deviation is that aeromedical data is replaced by attitude change rate signals. (Refer to Paragraph 13-61.)

13-142. <u>Instrumentation Control</u>

Instrumentation control circuitry in Capsule No. 2 utilizes a different programmer than the specification compliance capsule. The programmer is much simpler and supplies controlled power to only three circuits. The nature of this controlled power is as follows.

a. The environmental control system water extractor is supplied a 30 second pulse every 30 minutes.

b. The instrument panel observer camera is provided with a 110 millisecond pulse six times per second.

c. The earth and sky observer camera is supplied with a 90 millisecond pulse ten times per minute.

13-143. Since Capsule No. 2 has been assigned to a ballistic mission, the Launch-Orbit relays do not operate during the mission. All instrumentation circuitry except the cameras is energized at launch and remains on constantly until impact. The cameras operate as described in Paragraph 13-142.

13-144. Recording Instrumentation

Recording instrumentation consists of a tape recorder and two cameras. The pilot observer camera is omitted from Capsule No. 2 and an earth and sky camera is installed.

13-145. Tape Recorder

Inputs to the tape recorder in Capsule No. 2 include the same signals as applied to the recorder in the specification compliance capsule. (Refer to Paragraph 13-70.) In addition, channel 6 is utilized to record audio in the event the voice-operated relay in the audio control center fails to function properly. The tape recorder operates continuously from launch until impact. Tape speed is 1-7/8 inches per second. (See Figure 13-5). A lamp on the main instrument lights while the tape recorder is operating.

13-146. Cameras

A 16 millimeter camera is installed in the capsule to observe the main

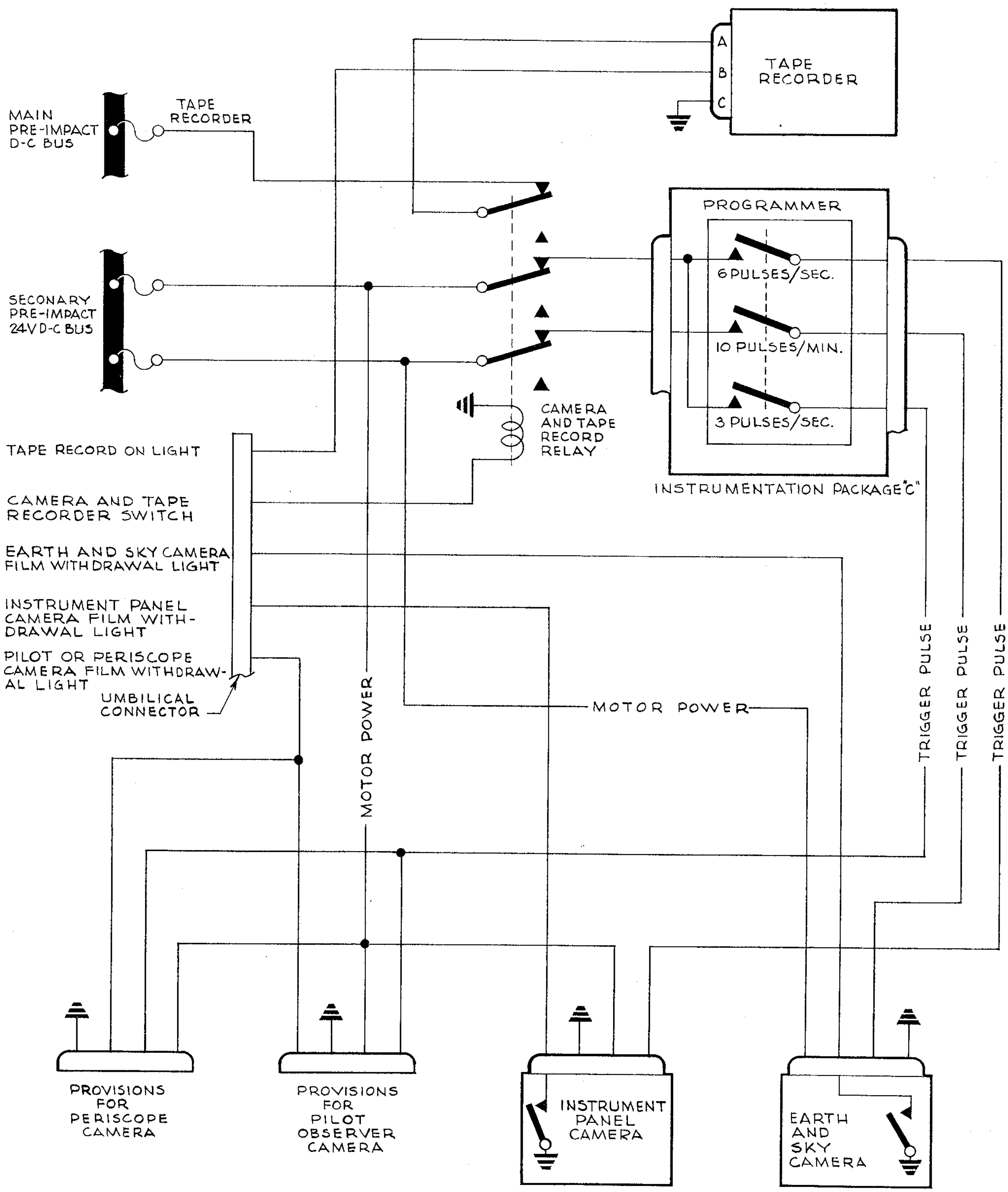

FIGURE 13-5 CAPSULE NO.2 CAMERAS AND TAPE RECORDER CONTROL SCHEMATIC

PM45-164

instrument panel. Camera operation is the same as in the specification compliance capsule except that the camera clutch is energized six times per second from launch until impact. (Refer to Paragraph 13-71.) The programmer in instrumentation package "C" supplies these pulses. (See Figure 13-5).

13-147. A 70 millimeter earth and sky observer camera is mounted at the astronaut's lower right window. This camera is sighted to record a field of view through the window. The image of a timer is superimposed on one corner of each frame. The camera is supplied 24 volt power and pulsing voltage from the capsule power system. Each pulse operates the shutter, exposing one frame and transporting the film for the next exposure. Trigger pulses are applied to the camera at the rate of 20 per hour by the programmer in Instrumentation Package "C".

13-148. Special Instrumentation

The special instrumentation pallet installed in Capsule No. 2 contains two playback tape recorders, two relay panels and a fuse holder.

13-149. The two playback tape recorders are installed in a can in the pallet. Each recorder contains a pre-recorded tape message. The messages are timed so that when one message is being played, the other tape is in a period of silence. The first message is followed by a period of mutual silence. The message on the other tape is then played. Another period of mutual silence occurs and the entire cycle repeats. The taped message operates the voice-controlled relay in the communications system to key the UHF and HF transmitters. A short warm-up period precedes proper transmitter operation. This may cause the first part of each prepared message to be distorted.

13-150. The relay panels contain control circuitry for the playback tape recorders and the crewman simulator. The special instrumentation fuse holder contains fuses to protect the left center battery from excessive load due to a circuit malfunction.

13-151. SYSTEM UNITS

13-152. Transducers

Potentiometer type transducers are connected across instrumentation three volt d-c power. The wiper is activated by the action to be measured. Wiper voltage is then a function of the action.

13-153. Control Stick Motion Potentiometers

These potentiometers are not installed in Capsule No. 2.

13-154. Main and Reserve Oxygen Pressure Potentiometers

Reserve oxygen pressure is not instrumented on Capsule No. 2.

13-155. Static Pressure, Suit Pressure and Coolant Quantity Pressure Potentiometer

Coolant quantity is not instrumented on Capsule No. 2.

13-156. Respiration Rate and Depth Potentiometer

Respiration rate and depth is not instrumented on Capsule No. 2.

13-157. Resistance Element Transducers

Resistance element transducers are used to measure temperatures in Capsule No. 2. The following list indicates the purpose and approximate temperature and resistance ranges for each transducer.

(a) Inner skin temperature, 0° to 300°F, 135 to 235 ohms.

(b) Outer skin temperature, 65° to +800°F, 40 to 100.6 ohms.

(c) Heat sink temperature, -65° to +500°F, 40 to 100 ohms.

(d) Suit inlet air temperature, 32° to 100°F, 250 to 300 ohms.

(e) Cabin air temperature, 0° to 200°F, 216 to 316 ohms.

(f) Package temperature, 90° to 100°F.

13-158. Body Temperature Transducer

Body temperature is not instrumented on Capsule No. 2. The circuitry associated with body temperature is utilized for package temperature.

13-159. Electrocardiogram Pickups

No electrocardiogram pickups areused in Capsule No. 2.

13-160. Tape Recorder

A tape speed of 1-7/8 inches per second is used in Capsule No. 2. The tape recorder input signals are the same as for the specification compliance capsule with an additional communications audio signal applied to input channel 6. (Refer to Paragraph 13-92.)

13-161. Instrumentation Package "C"

The components used in package "C" of Capsule No. 2 are the same as those used in the specification compliance capsule, except for the following units. (Refer to Paragraphs 13-93 through 13-103.)

13-162. Programmer

The programmer in package "C" contains switch contacts which operate control circuits for specific intervals. The unit used in Capsule No. 2 consists of one section of wafer contacts. When power is applied to the programmer, the spring driven, electrically wound, "A" section continuously operated the following wafer contacts. When power is applied to the programmer, the spring driven, electrically wound, "A" section continuously operates the following wafer contact.

Wafer Section	Duration	Rate	Function
1	30 seconds	1 per 30 min.	Water extractor
2	110 milliseconds	6 per second	Instr. panel camera
3	90 milliseconds	20 per hour	Earth & sky camera
4	110 milliseconds	3 per second	Not used

13-163. Horizon Scanner Output Amplifier Card

The horizon scanner output amplifier card in package "C" provides a bias voltage to keep the horizon scanner pitch and roll signals within limits compatible with other system components. Calibrate control relays are installed on the card. Roll ignore and pitch ignore signals are jumpered through the card.

13-164. Instrumentation Package "A"

The components used in package "A" of Capsule No. 2 are the same as those used in the specification configuration capsule, except for the package temperature amplifier cards. (Refer to Paragraphs 13-104 through 13-113.)

13-165. Instrumentation Package "B"

The components used in package "B" of Capsule No. 2 are the same as those used in the specification compliance capsule except for the following units. (Refer to Paragraphs 13-114 through 13-121.)

13-166. Attitude Change Rate Filter and Calibrate Cards

Attitude change rate filter and calibrate cards replace the electrocardiogram amplifier cards. Three attitude change rate cards are used. They are for pitch, roll andyaw parameters. The cards associated with pitch and roll rate provide for application of calibrate signals tothese channels. The yaw rate card provides this function and also contains a bias battery to set up center frequency on the voltage controlled oscillator when yaw rate equals zero degrees per second.

13-167. Voltage Controlled Oscillator Cards

The oscillator cards used in Capsule No. 2 are the same as those used in the specification compliance capsule. (Refer to Paragraph 13-120.) However, attitude rate signals are applied to the oscillators instead of aeromedical signals. Oscillator functions and frequencies are indicated in the following list.

Channel A

Commutator A output is applied to the 10.5 kc oscillator.

Yaw Rate is applied to the 1.3 kc oscillator.

Roll Rate is applied to the 1.7 kc oscillator.

Pitch Rate is applied to the 2.3 kc oscillator.

Compensating Oscillator frequency is 3.125 kc.

Channel B

Commutator B output is applied to the 10.5 kc oscillator.

Yaw Rate is applied to the 1.3 kc oscillator.

Roll Rate is applied to the 1.7 kc oscillator.

Pitch Rate is applied to the 2.3 kc oscillator.

13-168. Instrument Panel Observer Camera

The instrument panel observer camera in Capsule No. 2 is the same as the camera used in the specification configuration capsule. The frame rate is six frames per second. (Refer to Paragraph 13-123.)

13-169. Earth and Sky Observer Camera

The camera used to view the earth and sky from the capsule window provides a 42° square field of view. A mirror is used to direct the view image to the camera. Capsule power, 24 volts d-c, is supplied to the camera drive motor. Operation is initiated by a trigger pulse of 90 millisecond duration. The trigger pulse operates the shutter, drive mechanism and film transport. The camera is operated at the rate of 10 frames per minute. Film size is 70 millimeter. A Hamilton electric watch is installed in the camera, illuminated and optically superimposed on the corner of each picture.

13-170. TEST CONFIGURATION NO. 3 CAPSULE

13-171. GENERAL

The data contained in Paragraphs 13-172 through 13-205 pertains to Test Configuration No. 3 Capsule. Deviations from the specification compliance capsule are explained in these paragraphs. If no data is presented for a particular item, this item is the same as that used in the specification compliance capsule. The specification compliance capsule is discussed in Paragraphs 13-2 through 13-124.

13-172. SYSTEM DESCRIPTION

The instrumentation system monitors the physical condition and environment of the primate, capsule characteristics and conditions, primate response and the operation of capsule controls. This information is applied to telemetry transmitters and a tape recorder to provide data for analysis and evaluation. Cameras are installed to observe and record primate facial expressions, the capsule instrument panel and the view through the capsule window. The instrumentation system also provides programmed control power to operate instrumentation and other system components.

13-173. The major components used to monitor, code, record and control are basically the same as shown in Figure 13-1. A special instrumentation package replaces the Astronaut's couch. Table 13-1 lists the various parameters monitored by the instrumentation system.

13-174. SYSTEM OPERATION

Instrumentation is divided in monitoring, control and recording groups. A special instrumentation pallet replaces the Astronaut's couch.

13-175. Monitoring Instrumentation

Monitoring instrumentation consists of the signals taken from points in the capsule which indicate operation and conditions during the mission. These signals are coded for telemetry and recording. Figure 13-6 is a block diagram of monitoring instrumentation.

13-176. Environmental Control System

Environmental control system instrumentation on Capsule No. 3 is the same as that for Capsule No. 2. (Refer to Paragraphs 13-131 and 13-132.)

13-177. Reaction Control System

Reaction control system instrumentation on Capsule No. 3 is the same as that for Capsule No. 2. (Refer to Paragraph 13-133.)

13-178. Acceleration

Acceleration instrumentation on Capsule No. 3 is the same as that for Capsule No. 2. (Refer to Paragraph 13-134.)

13-179. Structural Temperature

Structural temperature instrumentation on Capsule No. 3 is the same as that for Capsule No. 2 (refer to Paragraph 13-135) except that ablation shield temperature is monitored instead of heat sink temperature. In addition a zero to three volt signal level for inner skin temperature represents a temperature range of zero to 300 degrees Fahrenheit.

13-180. Aeromedical

Aeromedical instrumentation on Capsule No. 3 is the same as that for the specification compliance capsule. (Refer to Paragraphs 13-38 through 13-40.) Since a primate is being used in Capsule No. 3, the scale factors for electrocardiograph and respiration data are different.

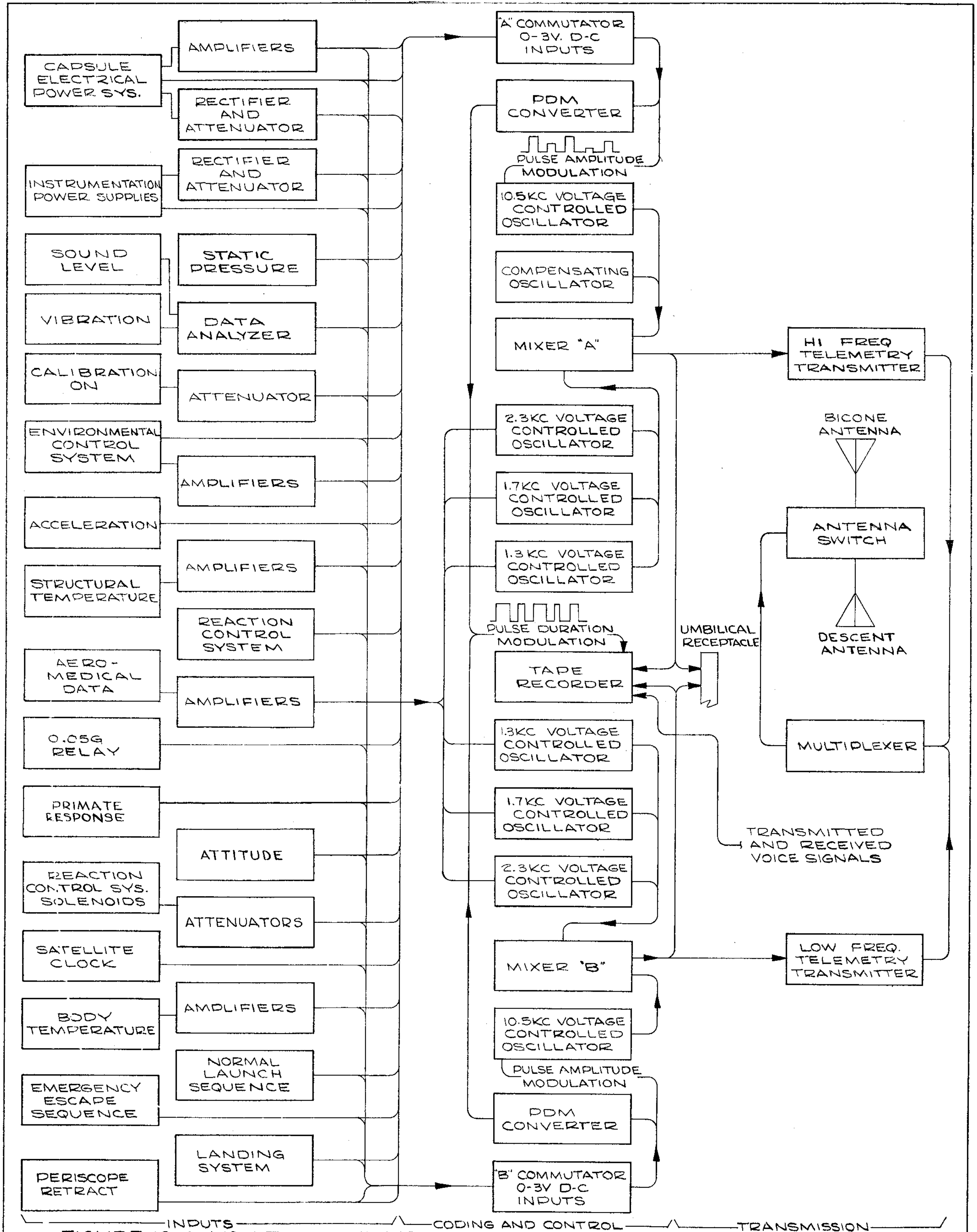

FIGURE 13-6 MONITORING INSTRUMENTATION BLOCK DIAGRAM-CAPSULE 3

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13-181. Horizon Scanner

Horizon scanner outputs are not instrumented on Capsule No. 3.

13-182. Attitude Rate

Attitude rate is not instrumented on Capsule No. 3.

13-183. Normal Launch Sequence

Normal launch sequence instrumentation on Capsule No. 3 is the same as that for the specification compliance capsule, except that the retrograde rocket fire signals are not instrumented. (Refer to Paragraphs 13-50 through 13-55.)

13-184. Emergency Escape Sequence

Emergency escape sequence instrumentation on Capsule No. 3 is the same as that for the specification compliance capsule except that the pilot abort signal is not instrumented.

13-185. Landing System Sequence

Landing system sequence instrumentation on Capsule No. 3 is the same as that for Capsule No. 2. (Refer to Paragraph 13-140.)

13-186. Primate Reaction

Primate reaction instrumentation consists of monitor circuits for primate response, duration of blue light and shock occurrence.

13-187. The primate couch contains a panel with red, white and blue lights and two switches. The red light is on throughout the mission. The primate is trained to operate the right hand switch when the red light is on. Operation of the switch resets a shock control circuit and turns on the white light. The switch has momentary contacts in this position. Upon release of the switch the white light goes out. If the primate allows more than twenty seconds to elapse between consecutive switch actuations, the shock control circuit applies a 50 millisecond pulse to the electrodes attached to the primate. The instrumentation system monitors operation of the switch and shock occurrence. The switch operation signal is referred to as the "total animal response (right hand)" signal. Each operation of the switch causes a 2% full scale increase in signal level. Fifty switch operations give a full scale signal. The cumulative response signal level then returns to zero and subsequent switch operations cause a 2% full scale increase in signal level as previously described. This signal is applied to both commutators. The shock occurrence signal is a 50 milli-second three volt (full scale) pulse. A capacitor across the commutator inputs holds this signal level to allow sampling by the commutators.

13-188. The blue light comes on for five seconds every three and one-half minutes. If the primate fails to operate the left hand switch during this five second interval, a 50 millisecond pulse is applied to the electrodes attached to the primate. The instrumentation system monitors duration of the blue light, operation of the left hand switch and shock occurrence. The duration of blue light signal is a three volt (full scale) signal that is present while the blue light is on. This signal is applied to both commutators. The signal that indicates operation of the left hand switch is referred to as the "total animal response (left hand)" signal. Each operation of the switch causes a 2% full scale increase in signal level. Fifty switch operations provide a full scale signal. The signal level then returns to zero and repeats this cyclw. This shock occurrence signal is the same signal utilized in conjunction with the red light and the right hand switch.

13-189. Instrumentation Control

Instrumentation control circuitry in Capsule No. 3 is the same as that for Capsule No. 2 except an additional controlled output is utilized in Capsule No. 3 to operate the pilot observer camera. This camera views the primate.

The clutch of this camera is pulsed at the rate of three pulses per second. (Refer to Paragraphs 13-142 and 13-143.)

13-190. Recording Instrumentation

Recording instrumentation consists of a tape recorder and three cameras.

13-191. Tape Recorder

The tape recorder in Capsule No. 3 is the same as the recorder used in the specification configuration capsule. (Refer to Paragraph 13-70.) Since Capsule No. 3 has been assigned to a ballistic mission, the tape recorder operates continuously throughout the mission.

13-192. Cameras

The instrument panel and earth and sky observer cameras installed in Capsule No. 3 are the same as those in Capsule No. 2. (Refer to Paragraphs 13-146 and 13-147.) In addition, a pilot observer camera is installed in the lower left corner of the instrument panel to observe the primate. The clutch of this camera is pulsed three times per second by signals from the programmer. (See Figure 13-5.) The pilot observer camera is described in Paragraph 13-72.

13-193. Special Instrumentation

The special instrumentation pallet in Capsule No. 3 contains relay panels and the special instrumentation fuse block.

13-194. The relay panels contain control circuitry for the programmer in the primate couch. The special instrumentation fuse holder contains fuses to protect the left center battery from excessive load due to a circuit malfunction.

13-195. SYSTEM UNITS

13-196. Transducers

13-197. Control Stick Motion Potentiometers

These potentiometers are not installed on Capsule No. 3.

13-198. Coolant Quantity Pressure Potentiometer

Coolant quantity is not monitored on Capsule No. 3.

13-199. Resistance Element Transducers

The resistance element transducers on Capsule No. 3 are the same as those used on the specification compliance capsule (refer to Paragraph 13-85) except for the transducers indicated in the following list.

(a) Ablation shield temperature, -65° to $+500^{\circ}$ F.

(b) Outer skin temperature, -65° to $+800^{\circ}$ F.

(c) Suit inlet air temperature, 32° to 100° F.

13-200. <u>Tape Recorder</u>

Tape recorder speed is 1 7/8 inches per second. The recorder in Capsule No. 3 is essentially the same as the recorder in the specification compliance capsule. (Refer to Paragraph 13-70.)

13-201. <u>Programmer</u>

The programmer used in Capsule No. 3 is the same as that used in Capsule No. 2. (Refer to Paragraph 13-162.) In capsule No. 3 the fourth wafer section is used to pulse the pilot observer camera.

13-202. <u>Cameras</u>

13-203. Instrument Panel Observer Camera

The instrument panel observer camera installed in Capsule No. 3 is the same as that in the specification compliance capsule. (Refer to Paragraph 13-123.) Frame rate is six per second.

13-204. Pilot Observer Camera

The pilot observer camera in Capsule No. 3 is the same as the camera used in the specification compliance capsule. In Capsule No. 3 the camera views the primate. The frame rate for this camera is three per second. (Refer to Paragraph 13-124.)

13-205. Earth and Sky Observer Camera

The earth and sky observer camera used in Capsule No. 3 is the same as that used in Capsule No. 2. (Refer to Paragraph 13-169.)

13-206. TEST CONFIGURATION NO. 4 CAPSULE

13-207. GENERAL

The data contained in Paragraphs 13-208 through 13-230 pertains to Test Configuration No. 4 Capsule. Deviations from the specification compliance capsule are explained in these paragraphs. If no data is presented for a particular item, this item conforms to the specification compliance capsule. The specification compliance capsule is discussed in Paragraphs 13-2 through 13-124.

13-208. SYSTEM DESCRIPTION

The instrumentation system on Capsule No. 4 is very similar to specification compliance capsule instrumentation. (Refer to Paragraph 13-2.) Capsule No. 4 instrumentation differs in that it does not include horizon scanner or attitude rate instrumentation and it has an additional monitor circuit for the drogue chute deploy signal. A special instrumentation circuit is also included.

13-209. SYSTEM OPERATION

Instrumentation is divided in monitoring, control and recording groups. Special instrumentation is added to provide numerous strain and vibration readouts.

13-210. Monitoring Instrumentation

Table 13-1 lists the parameters monitored by the instrumentation system in Capsule No. 4. Figure 13-7 is a block diagram of Capsule No. 4 monitoring instrumentation.

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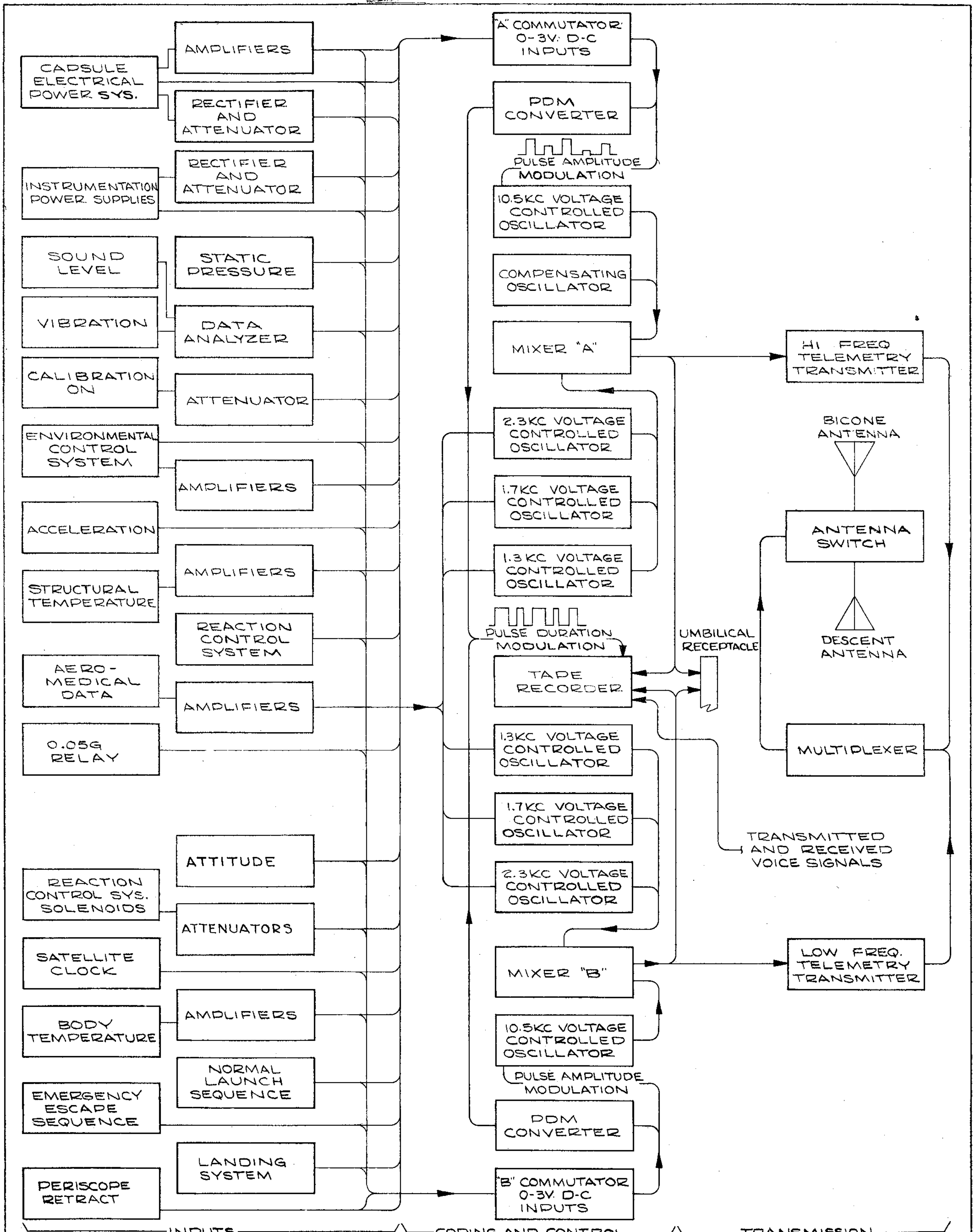

FIGURE 13-7 MONITORING INSTRUMENTATION BLOCK DIAGRAM-CAPSULE 4

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13-211. Structural Temperatures

Structural temperature instrumentation on Capsule No. 4 is the same as for Capsule No. 3. (Refer to Paragraph 13-179.) Scale factors are slightly different and they will be supplied when available.

13-212. Horizon Scanner

Capsule No. 4 instrumentation does not monitor horizon scanner signals.

13-213. Attitude Rate

Capsule No. 4 instrumentation does not monitor attitude rate signals.

13-214. Landing System

Landing system instrumentation in Capsule No. 4 is the same as that in Capsule No. 2. (Refer to Paragraph 13-140.)

13-215 Instrumentation Control

The instrumentation system programs power to its own and other systems equipment.

(a) The water absorber of the environmental control system is on for 30 seconds every 30 minutes.

(b) Calibrate signals are applied to the instrumentation system for 3 seconds every 30 minutes.

(c) The instrument camera and pilot cameras are supplied power at a rate of 180 pulses per minutes when control circuitry is in launch mode. In orbit mode the instrument panel is pulsed 30 times per minute.

(d) The earth and sky camera is pulsed 110 times per hour.

(e) Power is applied to the ASCS horizon scanners at regular intervals when control circuitry is in orbit mode.

(f) The tape recorder is programmed to operate constantly.

(g) The low frequency telemetry, "B" commutator and associated circuitry and the accelerometers are powered in the same manner as in the specification compliance capsule. (Refer to Paragraph 13-67.)

13-216. These control functions are achieved by mode relays and a programmer. The mode relays are controlled by mission events and the Astronaut.

13-217. Recording Instrumentation

13-218. Tape Recorder

The tape recorder used on Capsule No. 4 is the same as the recorder used on the specification compliance capsule. (Refer to Paragraph 13-70.) The recorder on Capsule No. 4 operates constantly.

13-219. Cameras

The cameras used on Capsule No. 4 are the same as those used on Capsule No. 3. (Refer to Paragraph 13-192.) Control of these cameras is accomplished as described in Paragraph 13-215.

13-220. Special Instrumentation

Capsule No. 4 is assigned to static firing tests. The special instrumentation circuit on the capsule consists of noise level, vibration and strain circuitry which is routed through a connector to blockhouse recording circuits. Signals obtained during static firing will be recorded for analysis.

13-221. SYSTEM UNITS

The units utilized in Capsule No. 4 are basically the same as those used in the specification compliance capsule. These exceptions are the structural temperature transducers, the programmer and the special instrumentation components.

13-223. Structural Temperature Transducers

The structural temperature transducers are of the resistance element type.

Outer skin, inner skin and ablation shield temperatures are monitored. Resistance and temperature ranges will be supplied when available.

13-224. Programmer

The programmer in instrumentation package C contains switch contacts which operate control circuits for specific intervals. The programmer used in Capsule No. 4 consists of two sections.

13-225. When power is applied to the programmer, the spring dirven electrically wound "A" section operates the following wafer contacts.

WAFER SECTION	CONTACTS CLOSED	
	DURATION	RATE
1	30 seconds	1 per 30 minutes
2	3 seconds	1 per 30 minutes
3	3 seconds	1 per 30 minutes
4	110 milliseconds	180 per minute
5	110 milliseconds	30 per minute
6	90 milliseconds	110 per hour
7	8.5 minutes	1 per 30 minutes
8	8.0 minutes	1 per 30 minutes

13-226. The "B" section of the programmer is energized by a command signal from the receiver-decoders. The spring driven, electrically wound B section operates for 6.66 minutes after receiving a control voltage pulse. The wafer contacts are activated for the following intervals.

WAFER SECTION	CONTACTS CLOSED	
	DURATION	RATE
1	3 seconds	1 per 6.66 minutes
2	3 seconds	1 per 6.66 minutes
3 a,b,c,d	6 minutes	1 per 6.66 minutes
4 a,b	6.66 minutes	1 per 6.66 minutes

13-227. Special Instrumentation Components

The special instrumentation components used in Capsule No. 4 consist of eight amplifiers, seven accelerometers and a strain gage. In addition, the noise pickup and its amplifier in instrumentation package B are utilized.

13-228. The accelerometers are installed at various points of the capsule to pick up vibration signals.

13-229. The strain gage is used to measure shingle strain.

13-230. Further information on the special instrumentation components will be supplied when available.