I N T E R - O F F I C E   M E M O

Memo No.: 70-01
Date: 3 February 1970

TO: F. L. Dickey

CC: B. G. Bromberg, R. A. Pepping

SUBJECT: MDAC-ED Capabilities Briefing

Reference: (a) B. G. Bromberg's Memo No. 02-46 dated 2 January 1970

Enclosure: (1) Selected Data and Photographs from the Gemini/Gemini "B" Programs

1. The Gemini/Gemini "B" Program Briefing Material as requested in Reference (a) is submitted as Enclosure (1).

B. R. Burkindine
Program Analyst
AAP Program

BRB:cms

MCDONNELL DOUGLAS ASTRONAUTICS COMPANY
EASTERN DIVISION

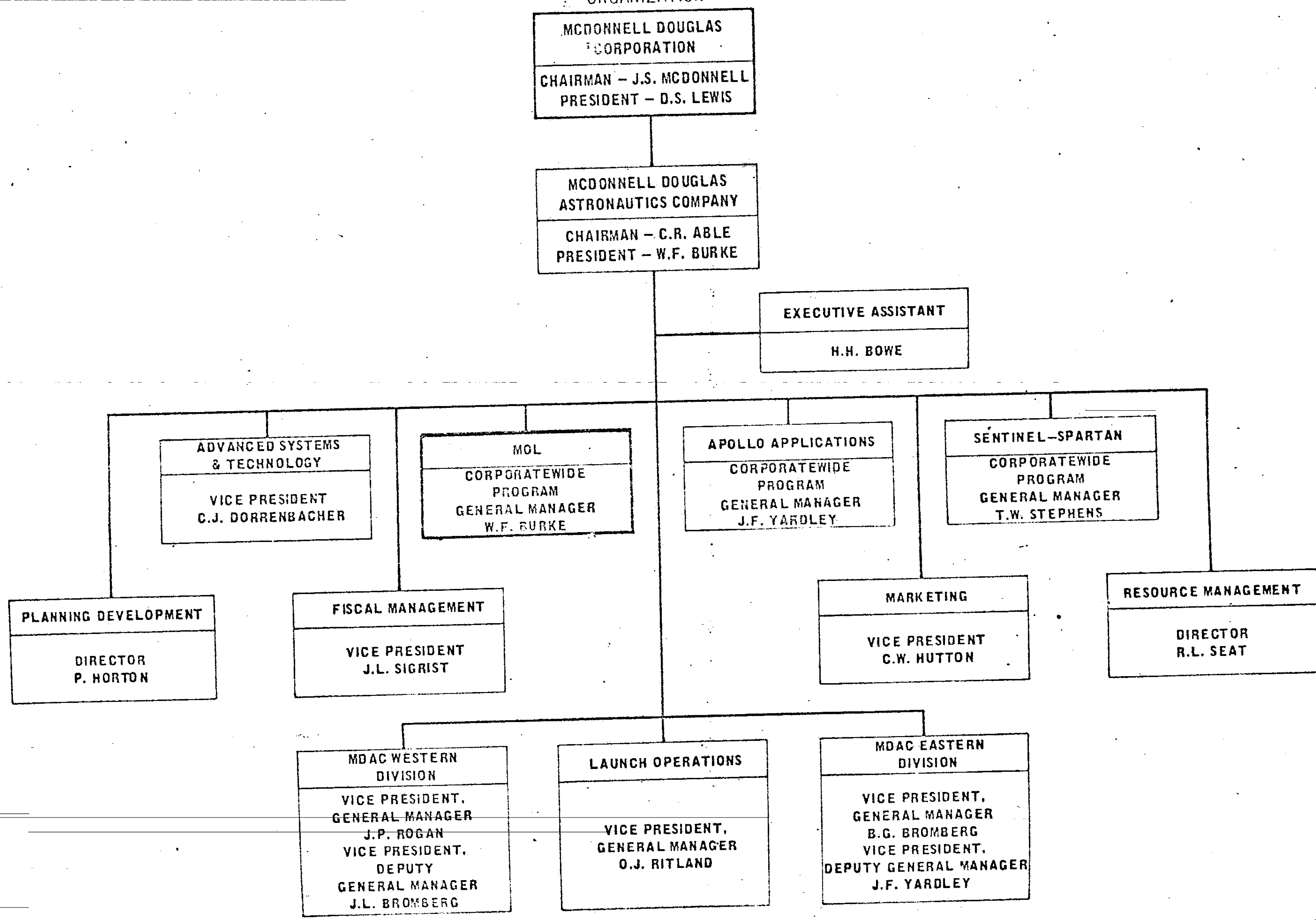
Enclosure (1)
Memo No.: 70-01

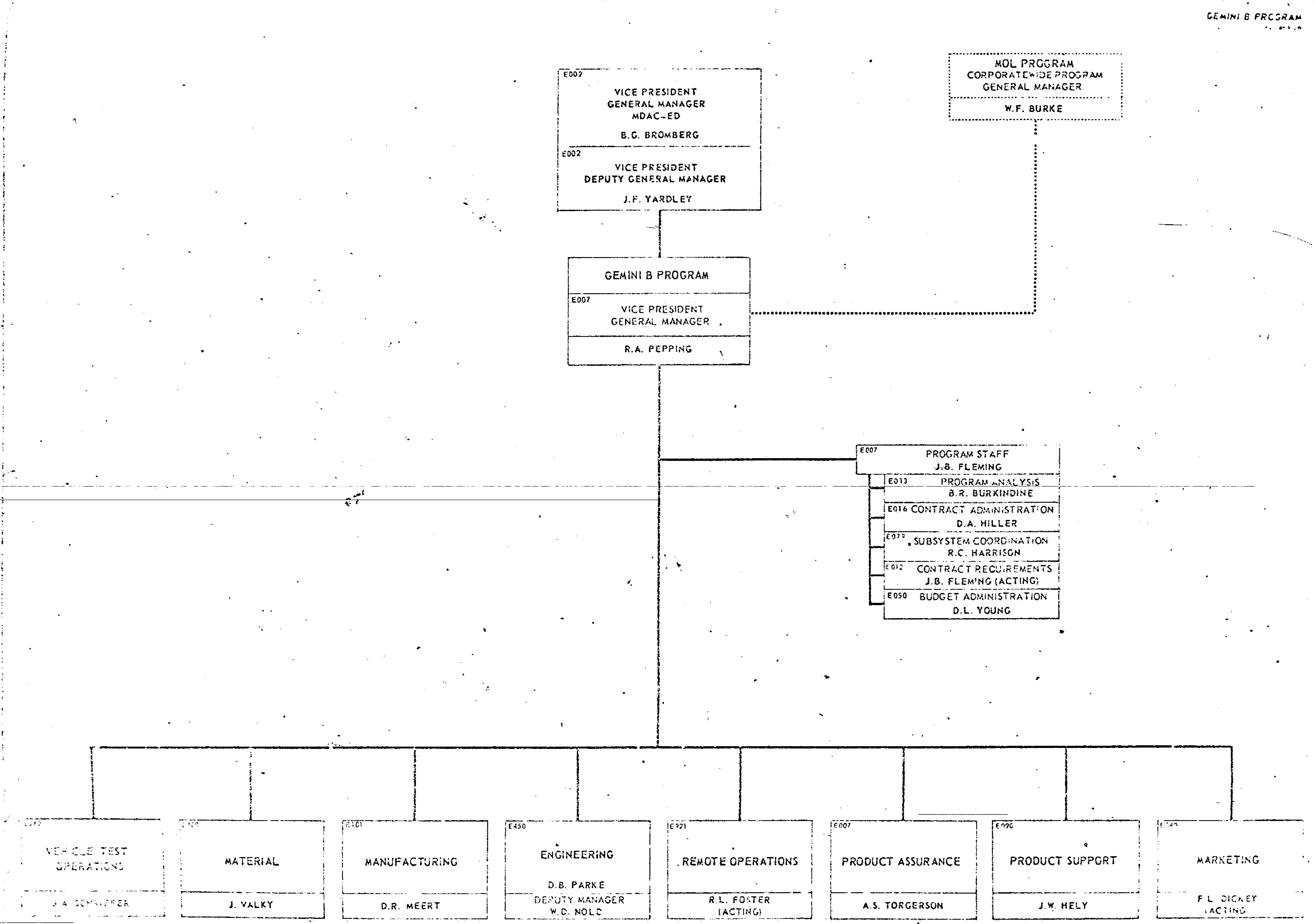
GEMINI/GEMINI "B" DATA PACKAGE

GEMINI B

MDAC-ED
75-469GB

MCDONNELL DOUGLAS
ASTRONAUTICS COMPANY
ORGANIZATION




GEMINI B PROGRAM
E002
VICE PRESIDENT
GENERAL MANAGER
MDAC-ED
B.G. BROMBERG
E002
VICE PRESIDENT
DEPUTY GENERAL MANAGER
J.F. YARDLEY
MOL PROGRAM
CORPORATEWIDE PROGRAM
GENERAL MANAGER
W.F. BURKE
GEMINI B PROGRAM
E007
VICE PRESIDENT
GENERAL MANAGER
R.A. PEPPING
E007
PROGRAM STAFF
J.B. FLEMING
E013
PROGRAM ANALYSIS
B.R. BURKINDINE
E016
CONTRACT ADMINISTRATION
D.A. HILLER
SUBSYSTEM COORDINATION
R.C. HARRISON
CONTRACT REQUIREMENTS
J.B. FLEMING (ACTING)
E050
BUDGET ADMINISTRATION
D.L. YOUNG
MATERIAL
J. VALKY
MANUFACTURING
D.R. MEERT
E450
ENGINEERING
D.B. PARKE
DEPUTY MANAGER
W.D. NOLD
REMOTE OPERATIONS
R.L. FOSTER
(ACTING)
E007
PRODUCT ASSURANCE
A.S. TORGERSON
PRODUCT SUPPORT
J.W. HELY
MARKETING

GEMINI B ROLE

- CREW TRANSPORT DURING ASCENT
  - LIFE SUPPORT
  - COMMUNICATIONS
  - ESCAPE AND RECOVERY
  - BACK-UP LAUNCH GUIDANCE
- IN STORAGE DURING ORBITAL OPERATIONS
  - MAINTAIN SYSTEMS WITHIN ENVIRONMENTAL LIMITS
  - MONITOR SYSTEM STATUS
- CREW TRANSPORT FOR LOITER AND RETURN
  - LIFE SUPPORT AND COMMUNICATIONS
    - FOR 14 HOUR IN ORBIT LOITER
    - FOR RE-ENTRY, LANDING AND POST LANDING
  - RE-ENTRY STABILIZATION AND TOUCHDOWN CONTROL
  - HEAT PROTECTION
  - LANDING
- DATA TRANSPORT

NOTES:

GEMINI B - NASA GEMINI DIFFERENCES

ENVIRONMENT/REQUIREMENT	DESIGN
TITAN IIIM VS. TITAN II (GLV)	
ASCENT - HIGHER DYNAMIC PRESSURE	EQUIPMENT VIBRATION LEVELS HIGHER
ABORT - LAUNCH VEHICLE FAILURE NEAR PAD HIGHER TEMPERATURE AND OVER PRESSURE	SIX RETRO-ROCKETS INSTEAD OF FOUR
	SPACECRAFT CONTROL WITH PAD ABORT CONTROL SYSTEM
	DOWNGRADED SEAT EJECTION CAPABILITY
HIGHER DYNAMIC PRESSURE	FLIGHT VEHICLE RATE INDICATION FOR CRITICAL CREW REACTION TIME
HIGH ALTITUDE TRAJECTORY	REDESIGN SHINGLES FOR SEVERER ESCAPE REENTRY
CREW FUNCTIONS	
INTERNAL TRANSFER	HATCHES, TUNNEL AND UMBILICAL ADDED
EXTERNAL TRANSFER	UMBILICAL, HANDRAILS AND EXTERNAL HATCH OPENING DEVICE ADDED
SAFETY	DUAL GAS CAPABILITY AND CABIN FLAMMABLE MATERIAL REDUCTION
	PAD EGRESS

NOTES:

GEMINI B - NASA GEMINI DIFFERENCES (CONTINUED)

ENVIRONMENT/REQUIREMENT	DESIGN
ATTACH TO LABORATORY	
GEMINI B INACTIVE DURING ORBIT OPERATIONS	NEW ADAPTER
	GASEOUS OXYGEN INSTEAD OF CRYOGENIC
	DELETED MANEUVERING PROPULSION
	REMOTE SYSTEMS MONITORING
	BATTERIES ONLY
	INTERFACE HEAT EXCHANGER AND LAB POWER
INTEGRAL LAUNCH	DELETED RENDEZVOUS RADAR AND ASSOCIATED HARDWARE
DATA RETURN	
ORBIT AND RETURN	STORAGE CAPABILITY

NOTES:

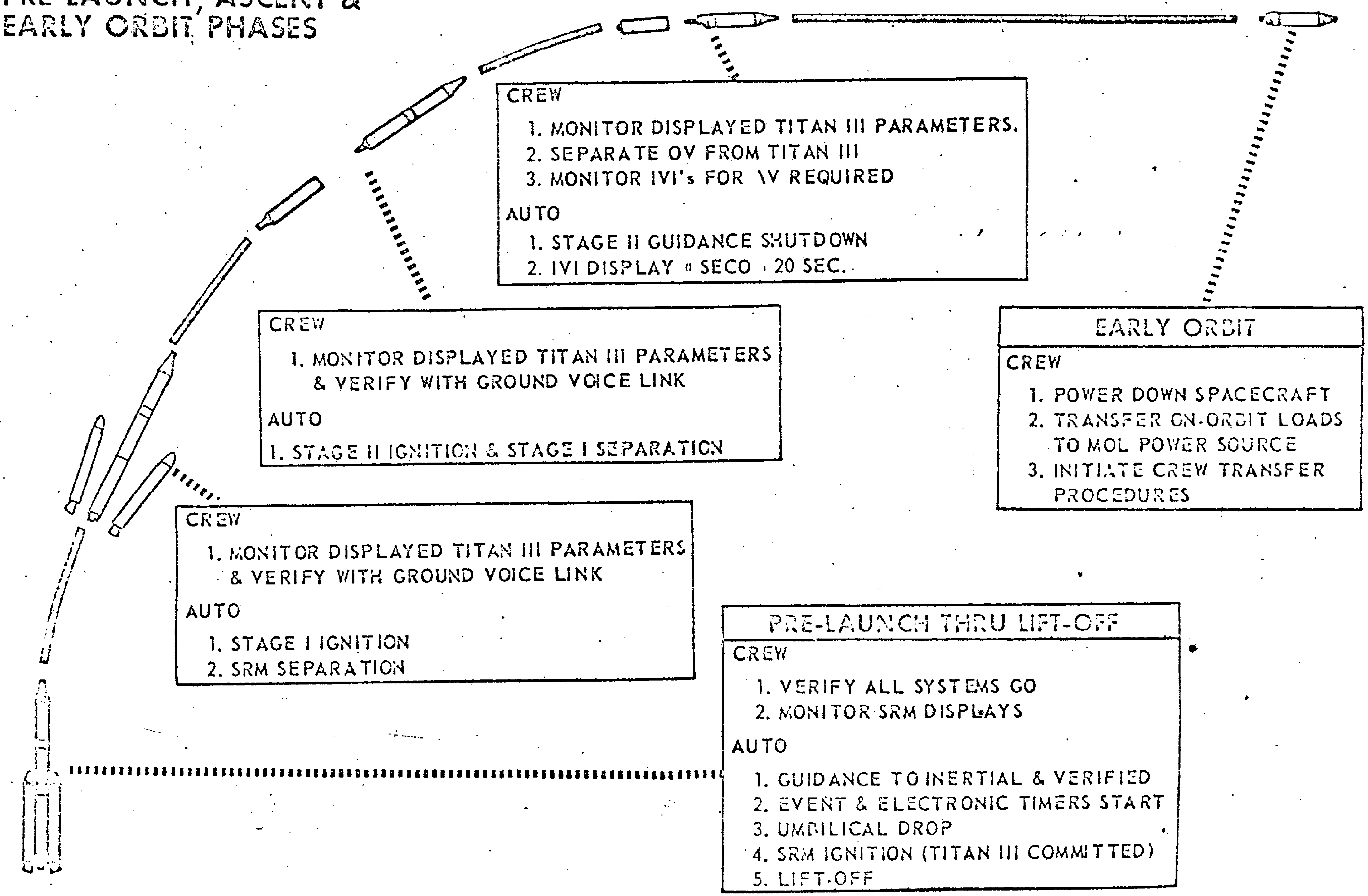
GEMINI B PROGRAM CONTENT

- HEAT SHIELD FLIGHT TEST
- FOUR SPACECRAFT - 1 UNMANNED - 3 MANNED
- MODIFY NASA GEMINI PROCEDURES SIMULATOR
- MODIFY 4 TEST SPACECRAFT:
  - ELECTRONIC SYSTEM TEST UNIT
  - THERMAL VACUUM TEST UNIT
  - DUAL GAS TEST UNIT
  - FLOTATION EGRESS TEST UNIT
- BUILD 23 AND REFURBISH 11 PARTIAL SPACECRAFT SECTIONS FOR DEVELOPMENT TEST
- BUILD 4 AND MODIFY/ADAPT 4 TRAINERS AND MOCK-UPS
- AGE:
  - 6 NEW ELECTRICAL AND THERMO-MECHANICAL SUBSTITUTES
  - 7 NEW AGE ITEMS
  - 1680 REFURBISHED/MODIFIED AGE ITEMS
- LAUNCH SUPPORT
- MISSION PLANNING
- TRAINING
- SUPPORT PARTS AND REPAIR SERVICES

NOTES:

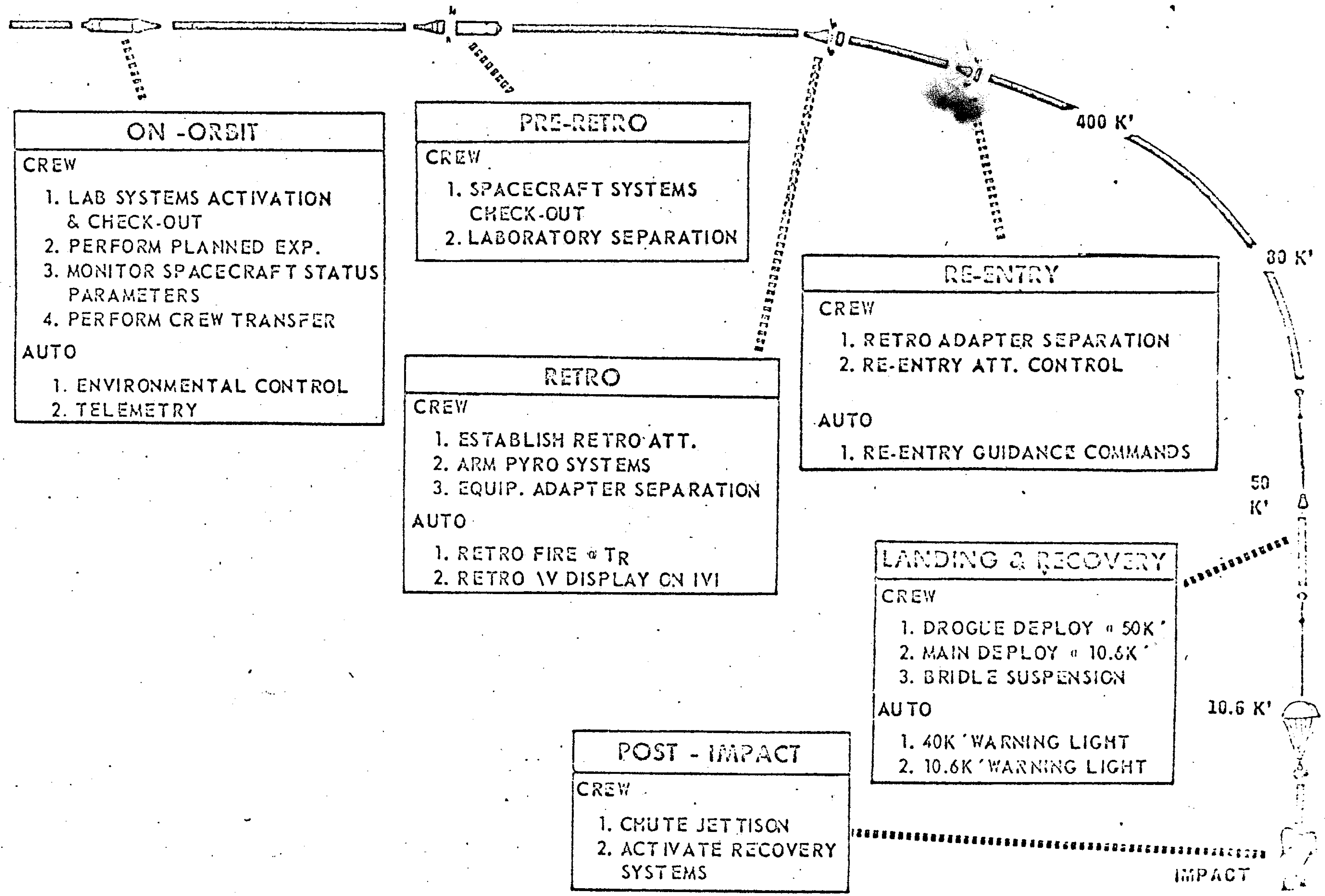
MISSION PROFILE LAUNCH TO ORBIT

PRE-LAUNCH, ASCENT & EARLY ORBIT PHASES

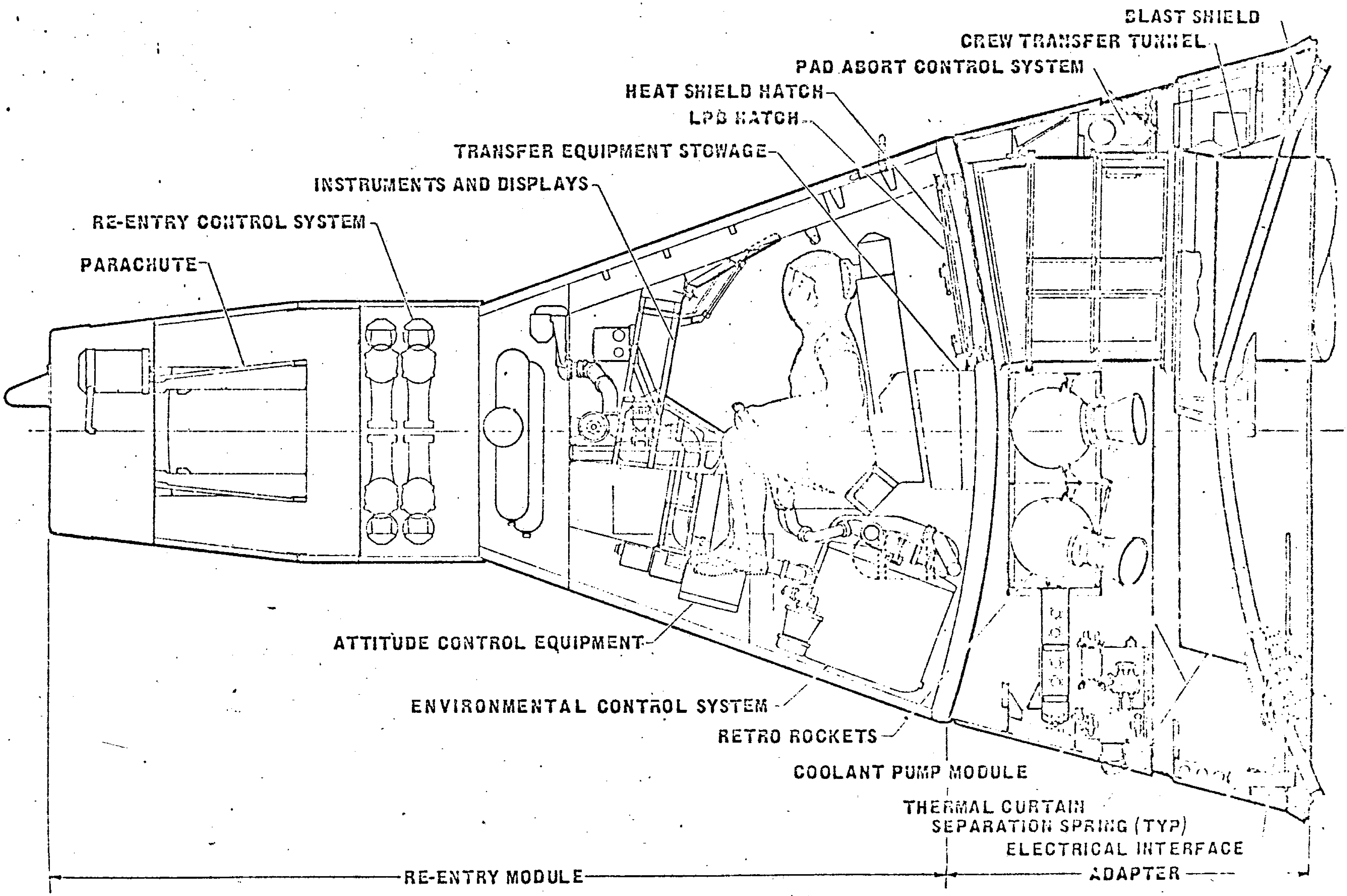


MCASTRO
5-1648B

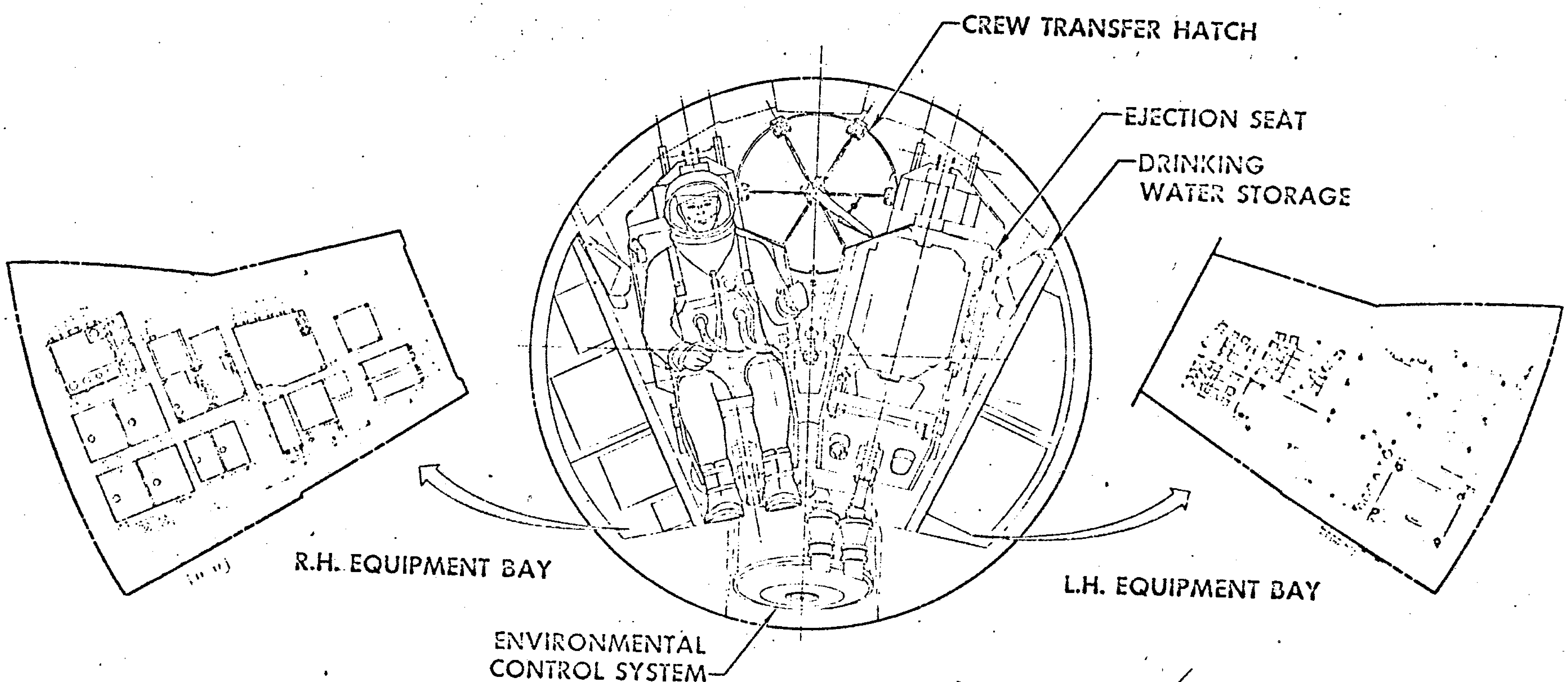
MISSION PROFILE ON-ORBIT THRU LANDING & RECOVERY



GEMINI B - INTERIOR ARRANGEMENT

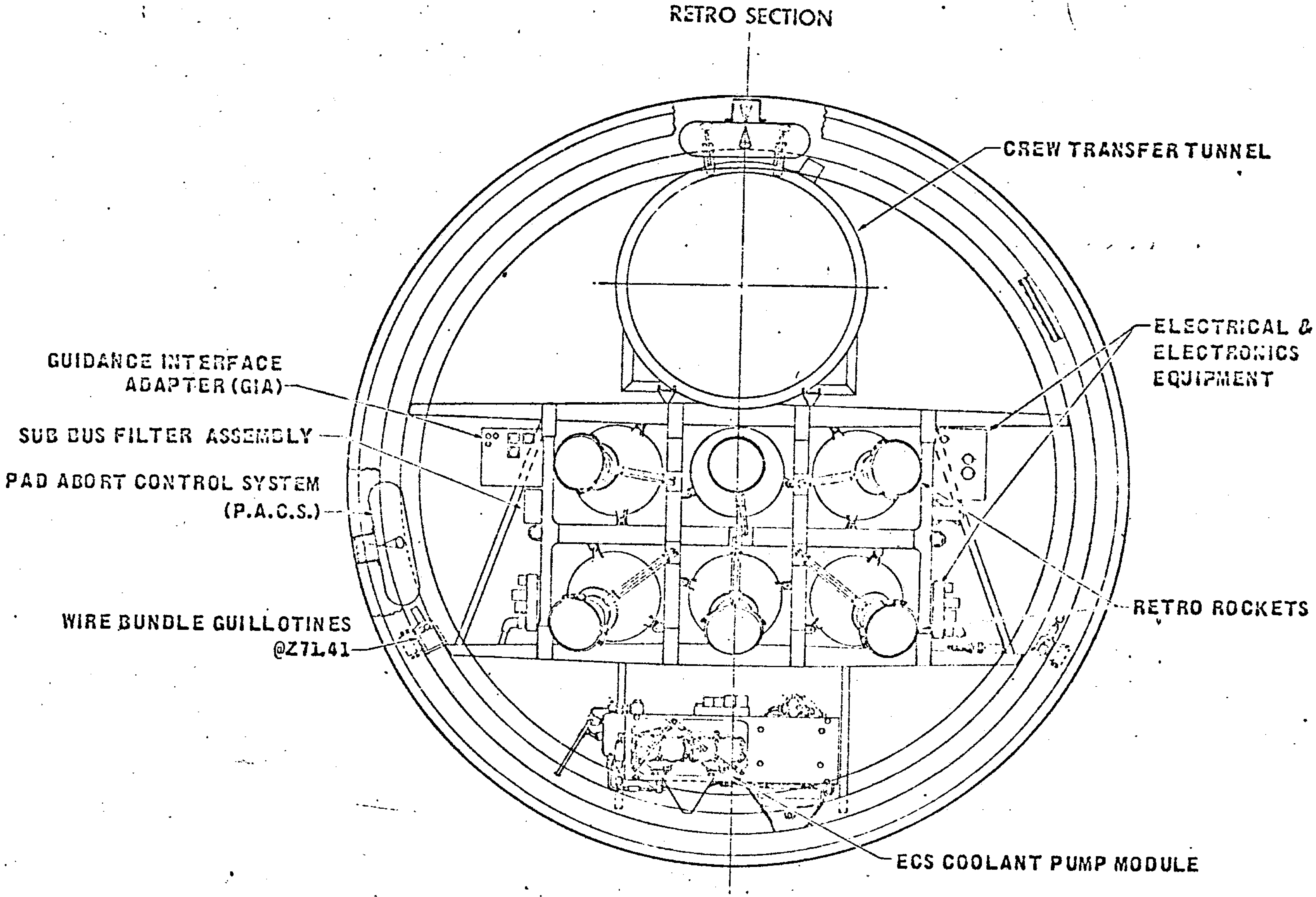


GEMINI B INTERIOR ARRANGEMENT (CONTINUED)



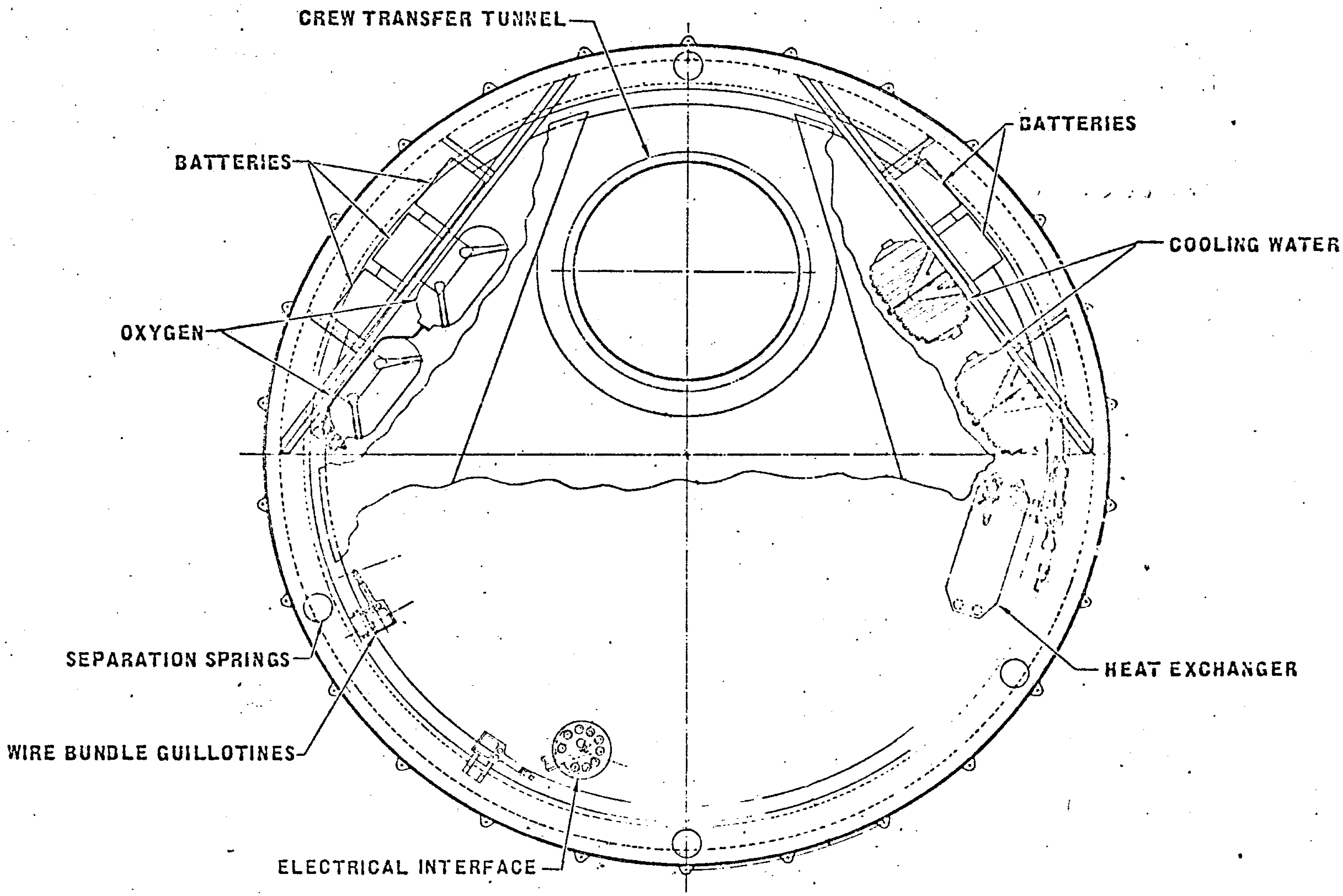
N/C

GEMINI B-INTERIOR ARRANGEMENT ADAPTER



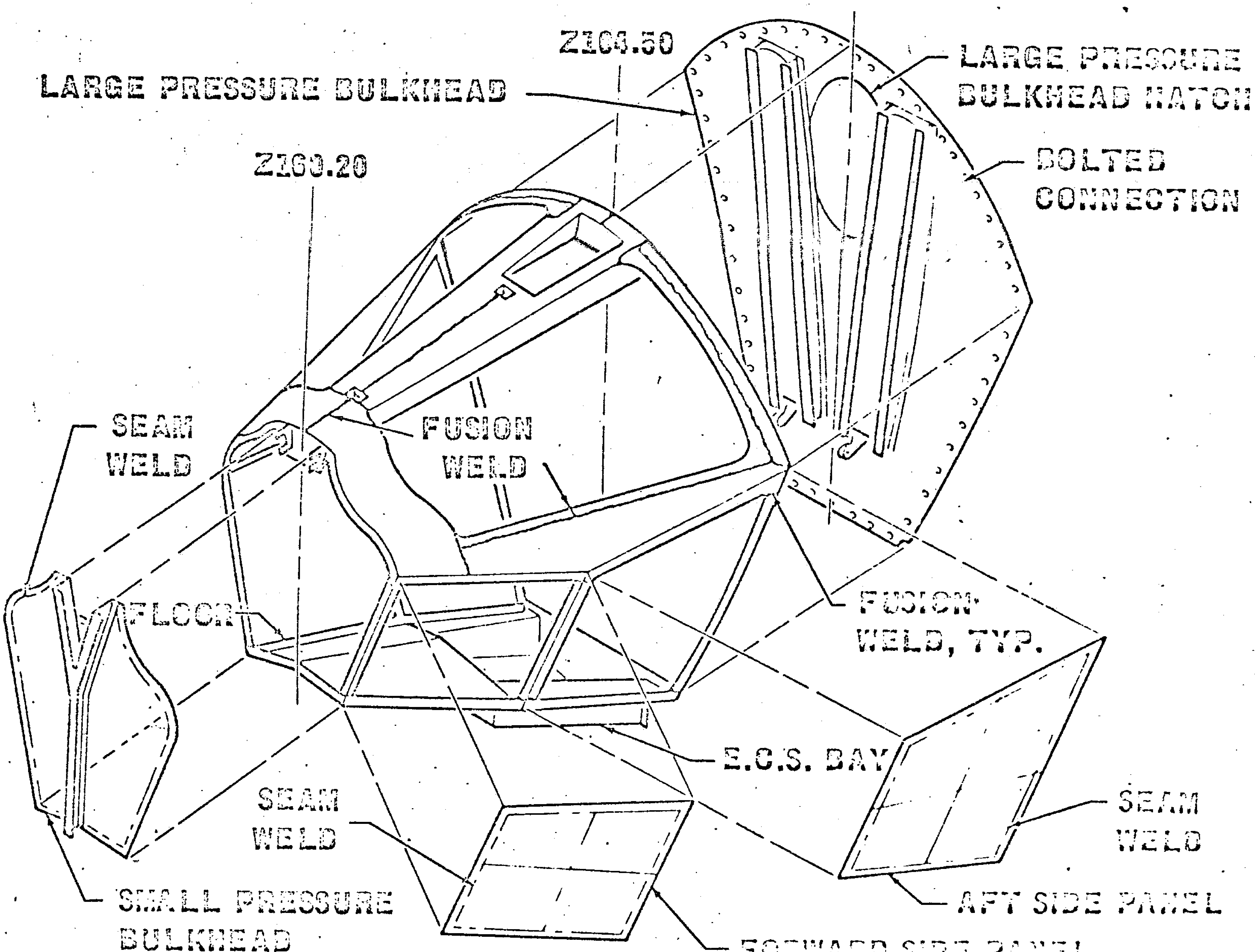
GEMINI B-INTERIOR ARRANGEMENT ADAPTER

EQUIPMENT SECTION



MCDONNELL
71-267 GB

PRESSURE VESSEL STRUCTURE



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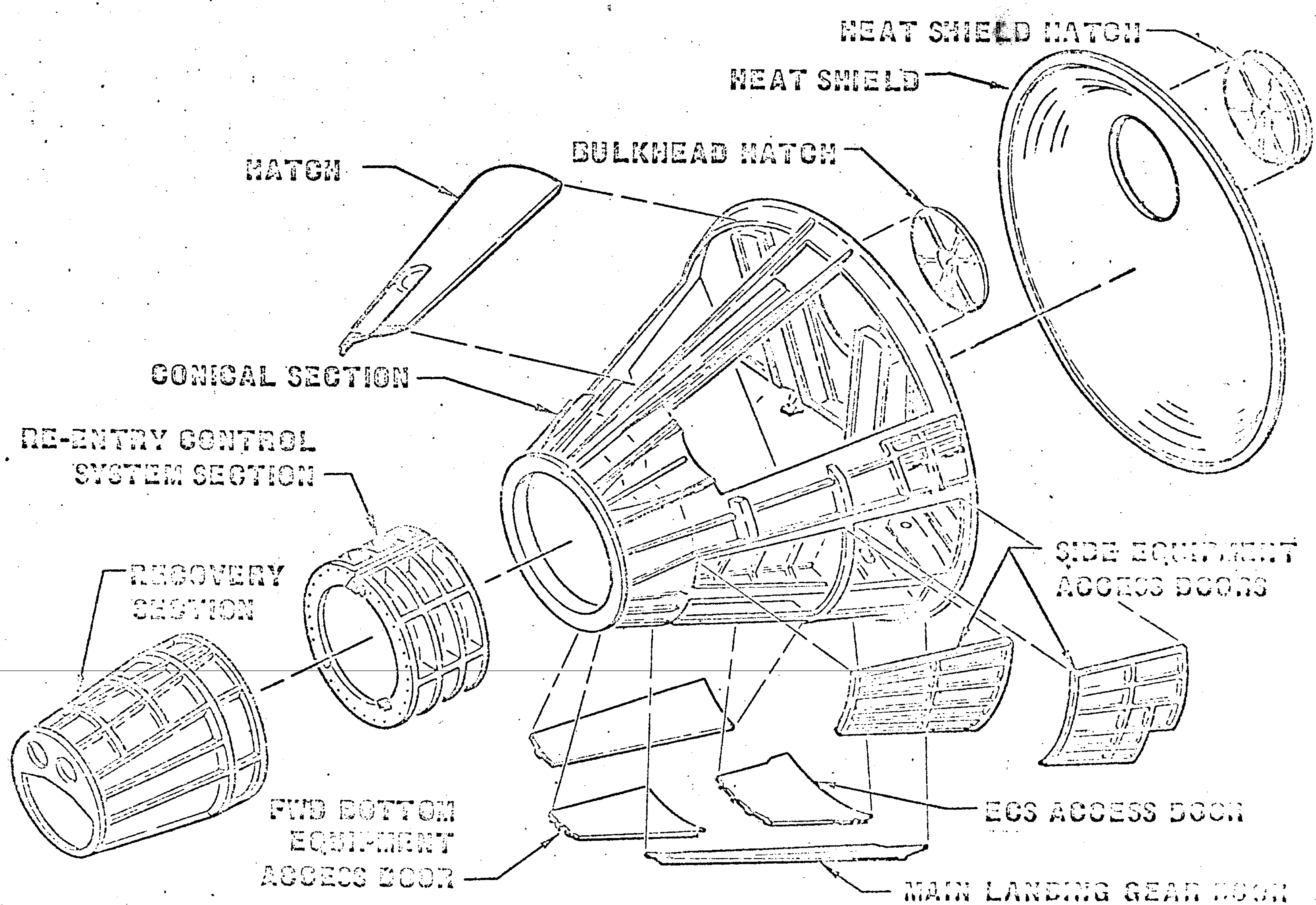
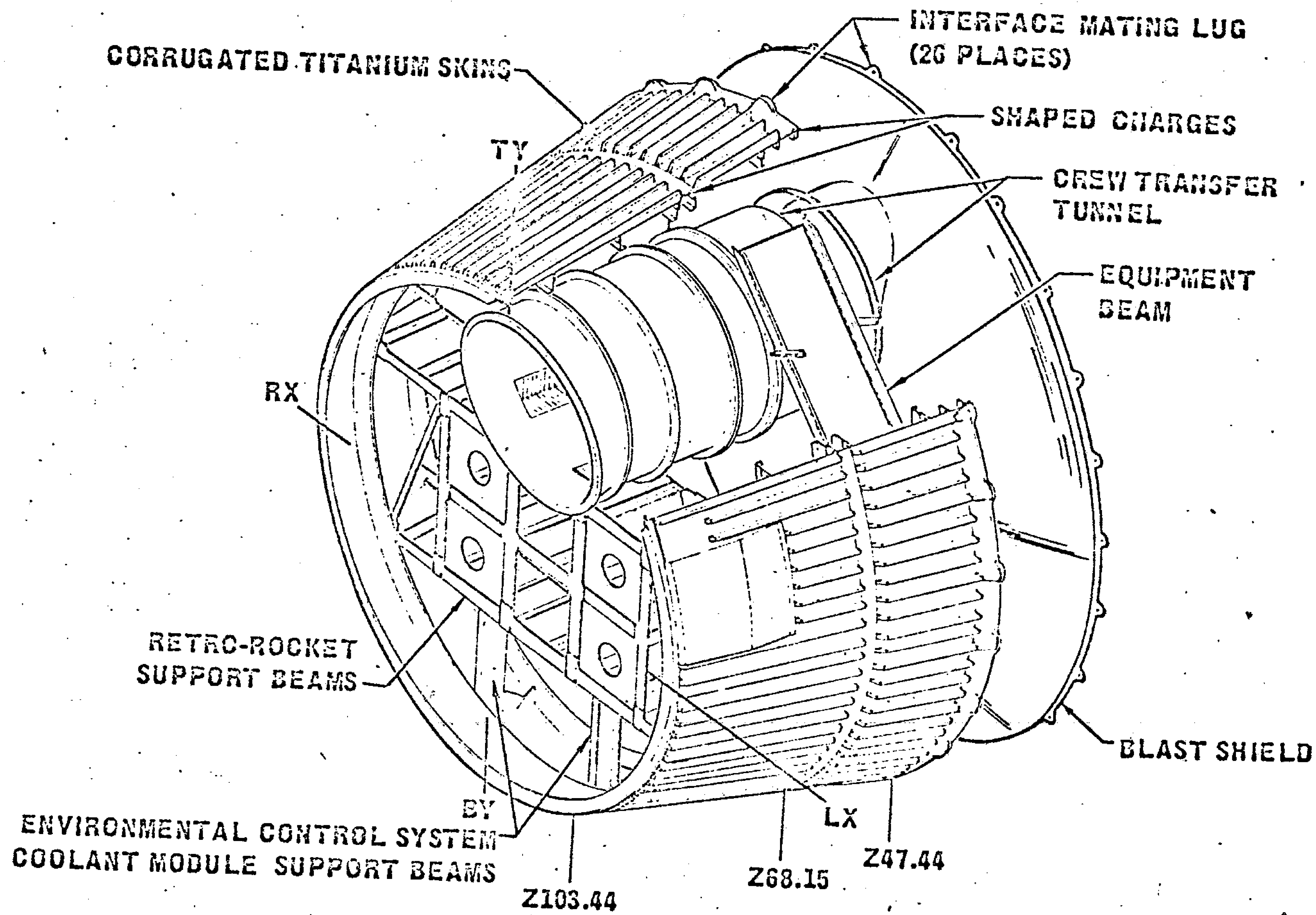
72-267 GB

RE-ENTRY MODULE STRUCTURE



ADAPTER STRUCTURE



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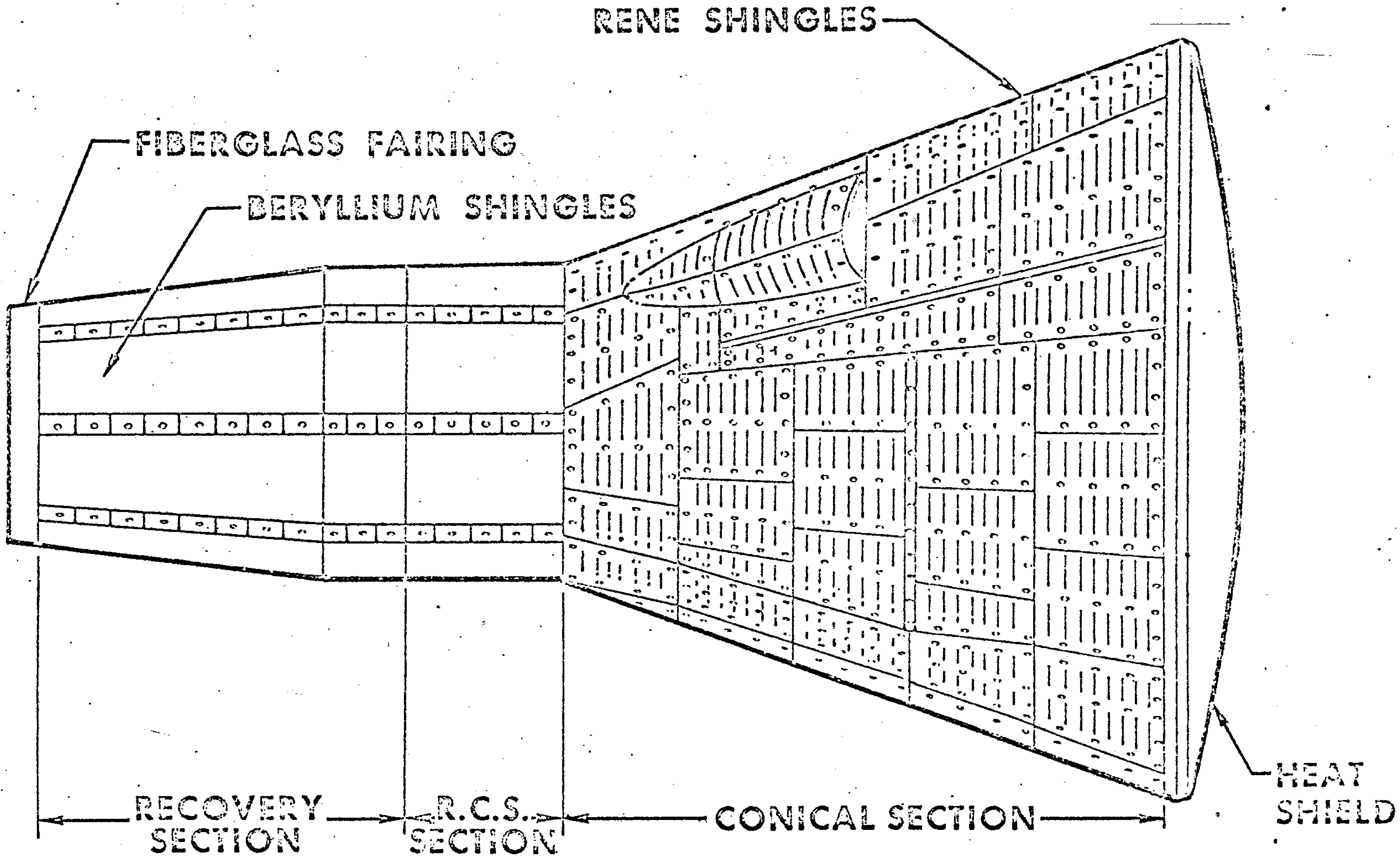
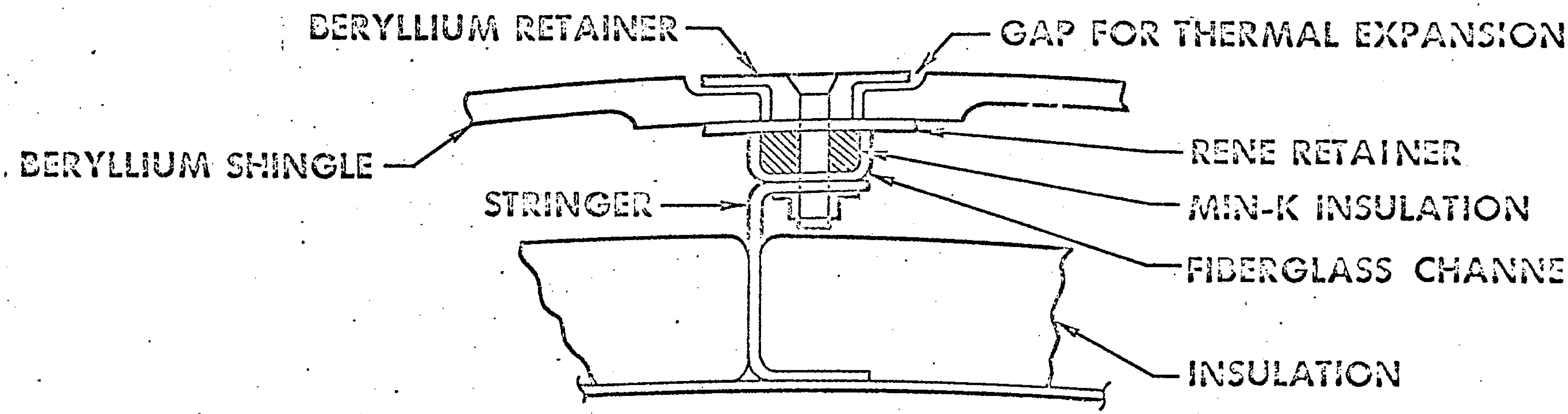
22-266 GBM

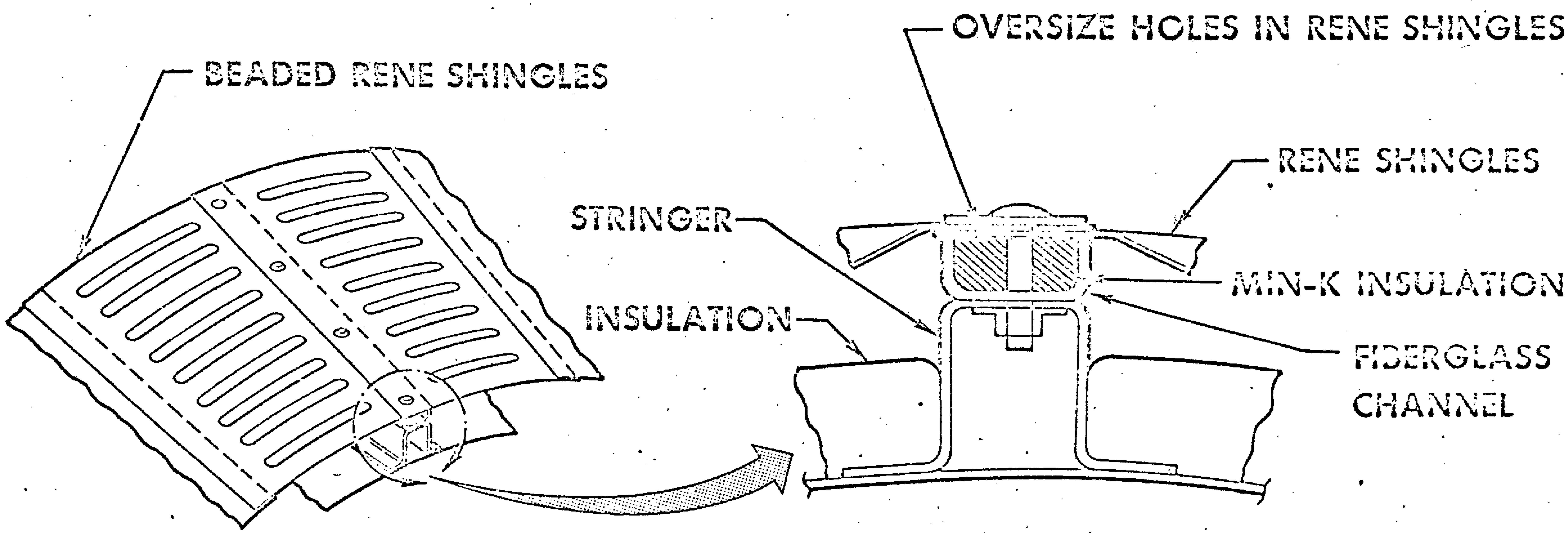
HEAT PROTECTION



HEAT PROTECTION STRUCTURAL DETAILS



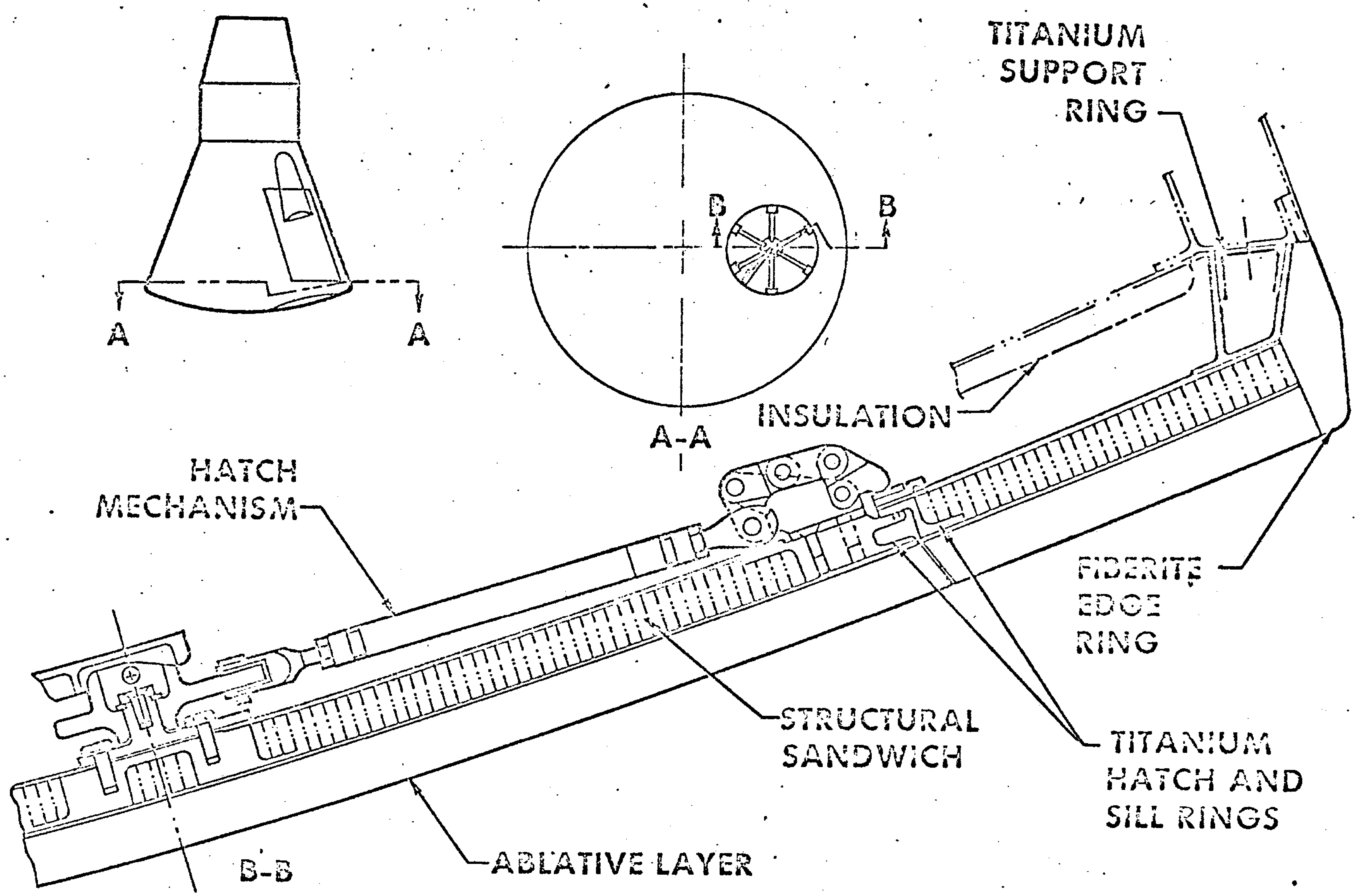
TYPICAL SUPPORT FOR BERYLLIUM SHINGLES



TYPICAL SUPPORT FOR RENE SHINGLES

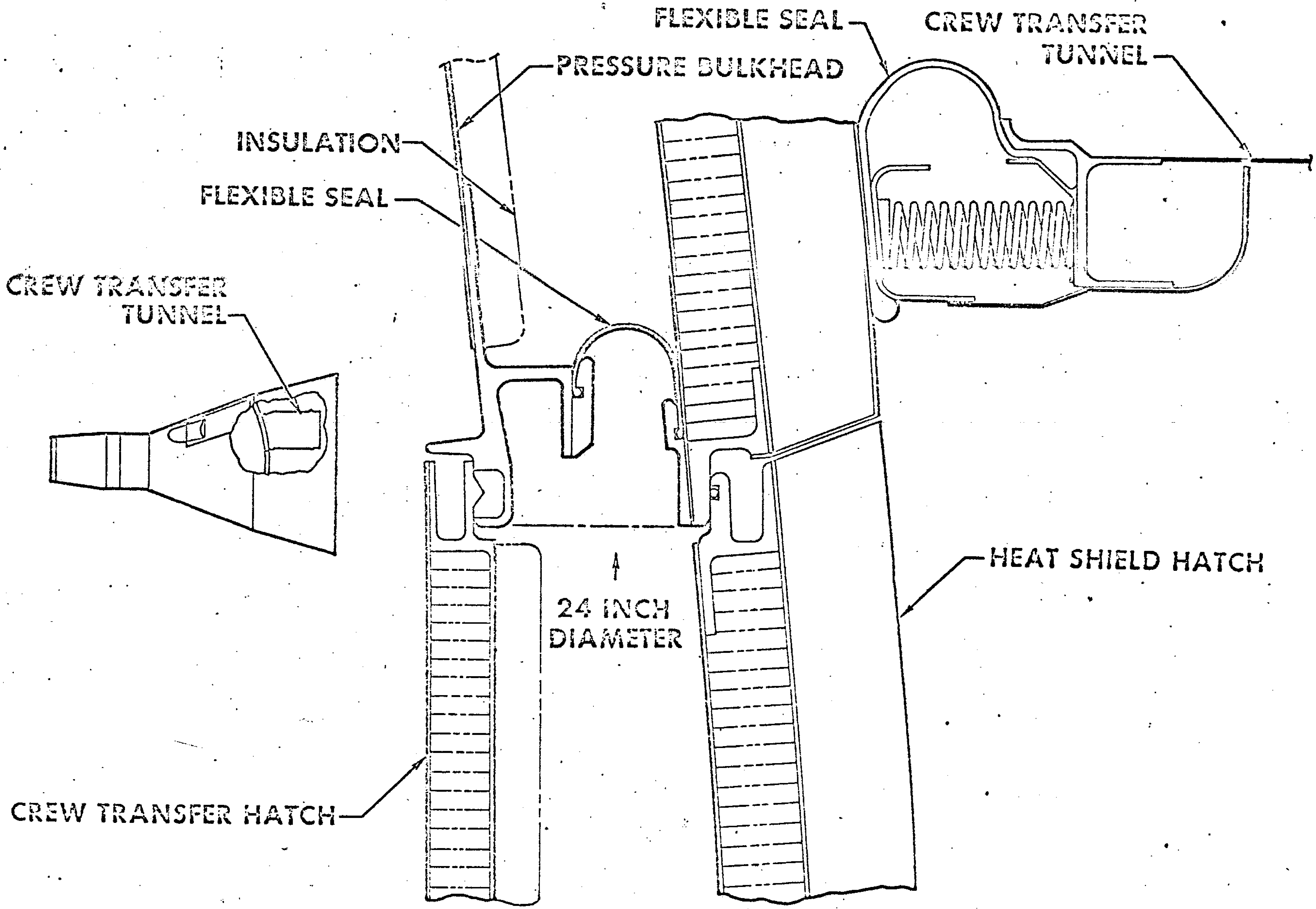
MCDONNELL
21-266 GBM

HEAT SHIELD STRUCTURE

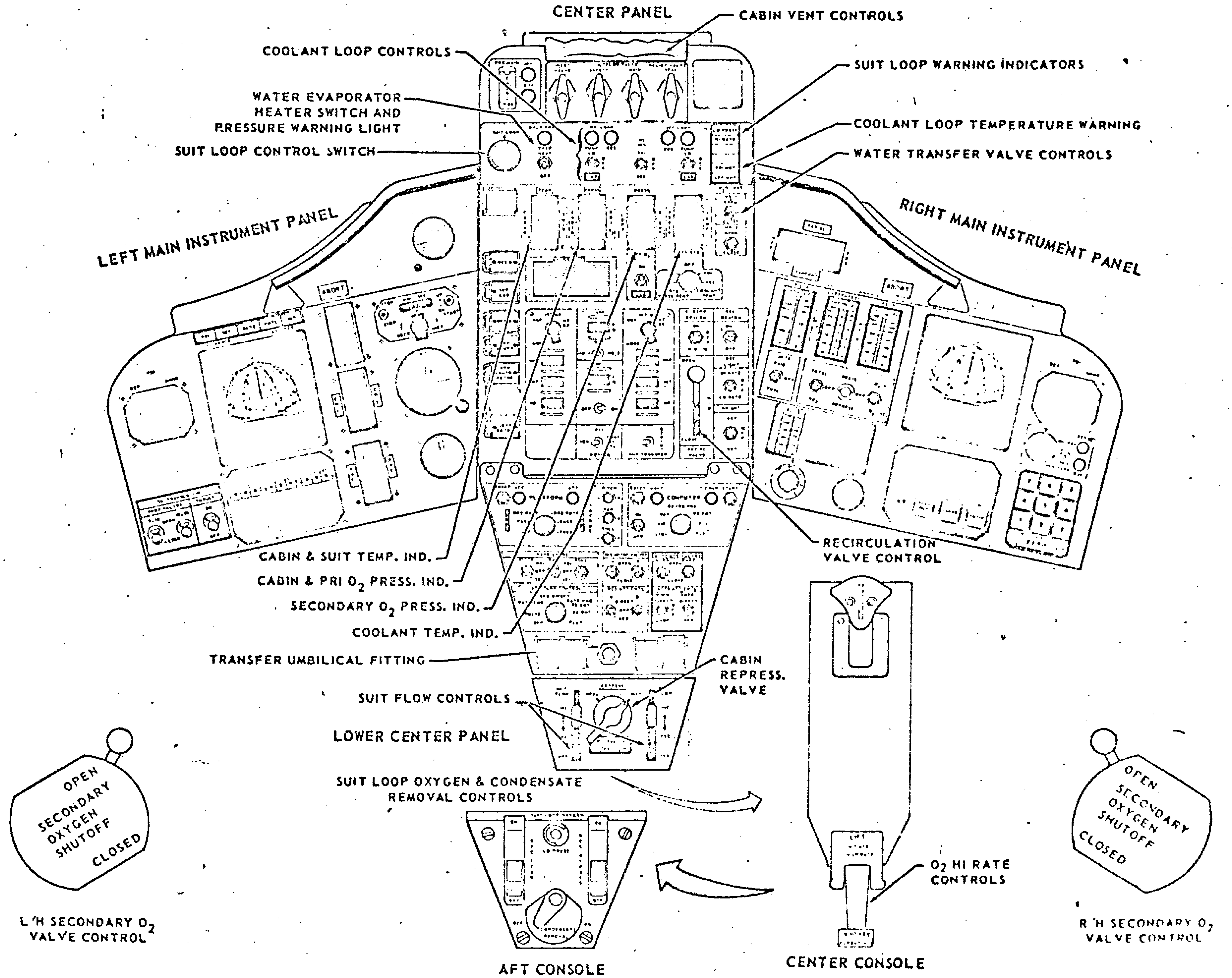


MCDONNELL
20-266 GBM

CREW TRANSFER TUNNEL AND HATCH DETAILS



ECS CONTROLS & DISPLAYS-GEMINI B INSTRUMENT PANEL



GEMINI B
ENVIRONMENTAL CONTROL SYSTEM
DESIGN CRITERIA

- METABOLIC
  - O_2 CONSUMPTION .... 2.0 LB./MAN-DAY
  - CO_2 PRODUCTION .... 2.5 LB./MAN-DAY
  - HEAT PRODUCTION .... 500 BTU/MAN-HOUR

- GAS SUPPLY
  - PRIMARY – TWO 5000 PSIA O_2 TANKS (GASEOUS, 7 LB./EA.)
  - SECONDARY – TWO 5000 PSIA O_2 TANKS (GASEOUS, 7 LB./EA.)

- ATMOSPHERIC PURIFICATION
  - METHOD OF CO_2 REMOVAL .... LIOH (NASA GEMINI 2 DAY SUPPLY)
  - METHOD OF WATER REMOVAL .... WICK TYPE WATER SEPARATOR
  - METHOD OF ODOR REMOVAL .... ACTIVATED CHARCOAL

- CABIN PRESSURE
  - LAUNCH – ZERO PSIG AT S.L. TO 6.0 PSIG MAX.
  - ORBIT – 5.1 PSIA (NOMINAL, OPERATIONAL)
  - ON-ORBIT STORAGE – 0.1 PSIA MINIMUM

VOICE AND TRACKING SYSTEM DESIGN

HARDLINE COMMUNICATION WITH LCC

VOICE CONTROL CENTER GROUND INTERCOMMUNICATION IDENTICAL TO NASA GEMINI

VHF VOICE COMMUNICATION

NASA GEMINI VOICE CONTROL CENTER AND REDUNDANT VHF TRANSCEIVERS

ANTENNA SYSTEM CONSISTS OF VHF NOSE STUB AND DESCENT WHIP

VHF BACKUP TO LAB SGLS

LAB VCC INTERFACES WITH GEMINI VHF T/R

AWAITING MOL/SPO RESPONSE TO MCDONNELL RECOMMENDATIONS

VOICE AND TRACKING SYSTEM DESIGN (CONTINUED)

CREW INTERCOMMUNICATION

VOICE CONTROL CENTER COMPATIBLE WITH LOW LEVEL, LOW IMPEDANCE HEADPHONES AND MICROPHONES

REQUIRES CHANGE FOR COMPATIBILITY WITH LAB 600 OHM BASELINE SYSTEM

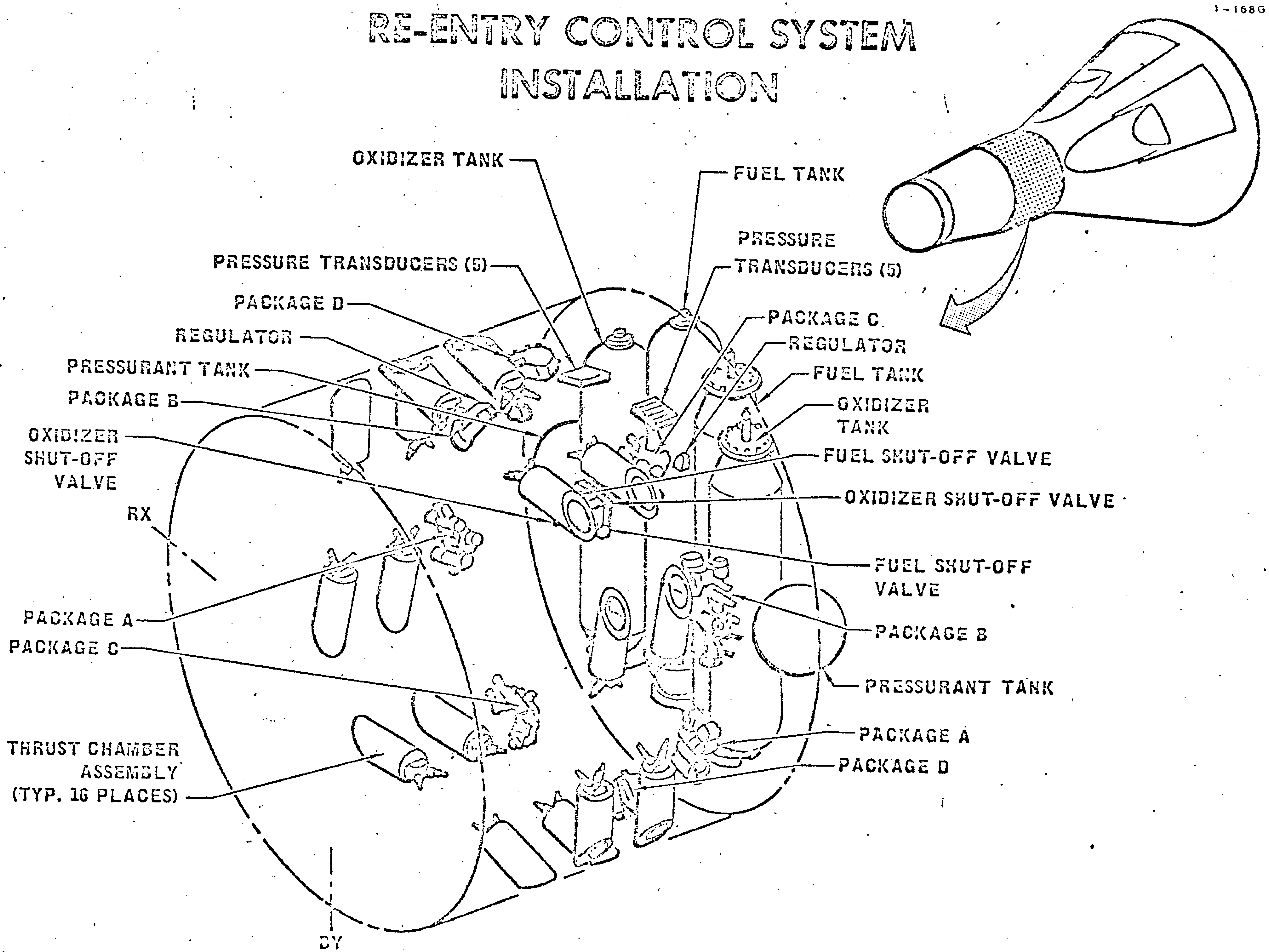
C-BAND TRACKING

MOTOROLA C-BAND TRANSPONDER DEVELOPED FOR SATURN PROGRAM

IMPROVED QUALITY OVER NASA GEMINI TRANSPONDER

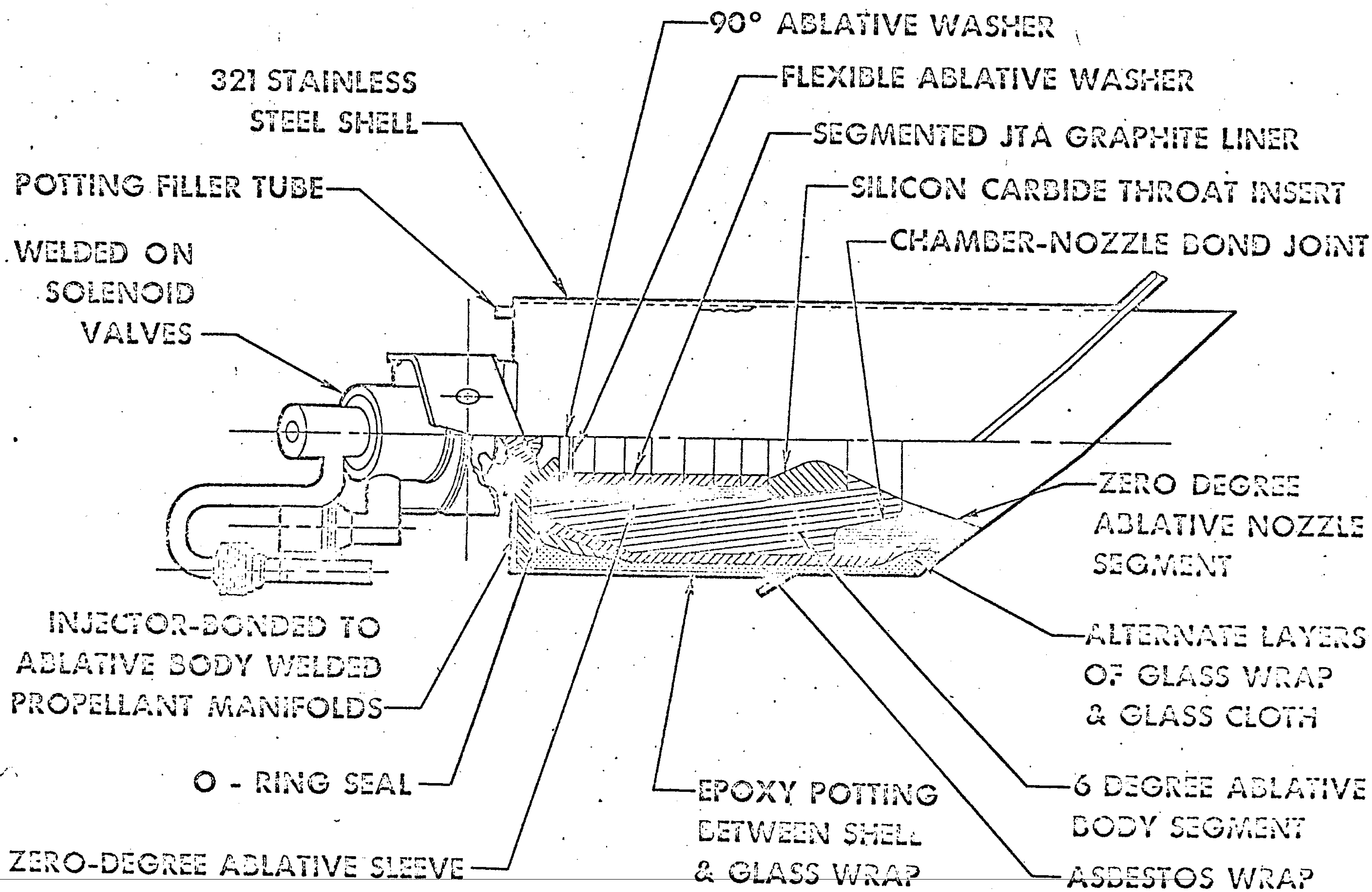
ANTENNA SYSTEM CONSISTS OF A THREE HELIX ARRAY WITH PHASE SHIFTER

RE-ENTRY CONTROL SYSTEM INSTALLATION

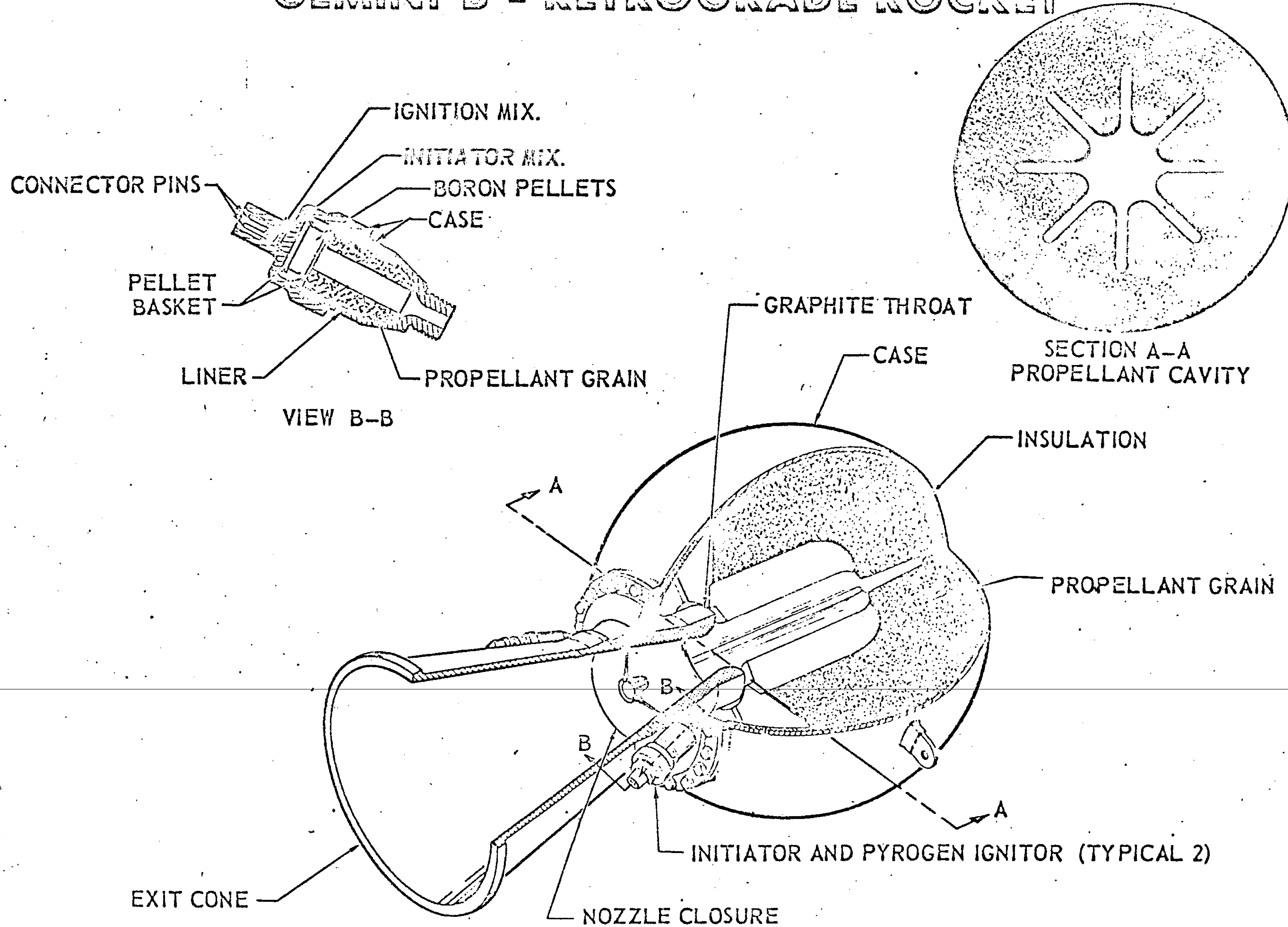


MCDONNELL
8-266 GBM

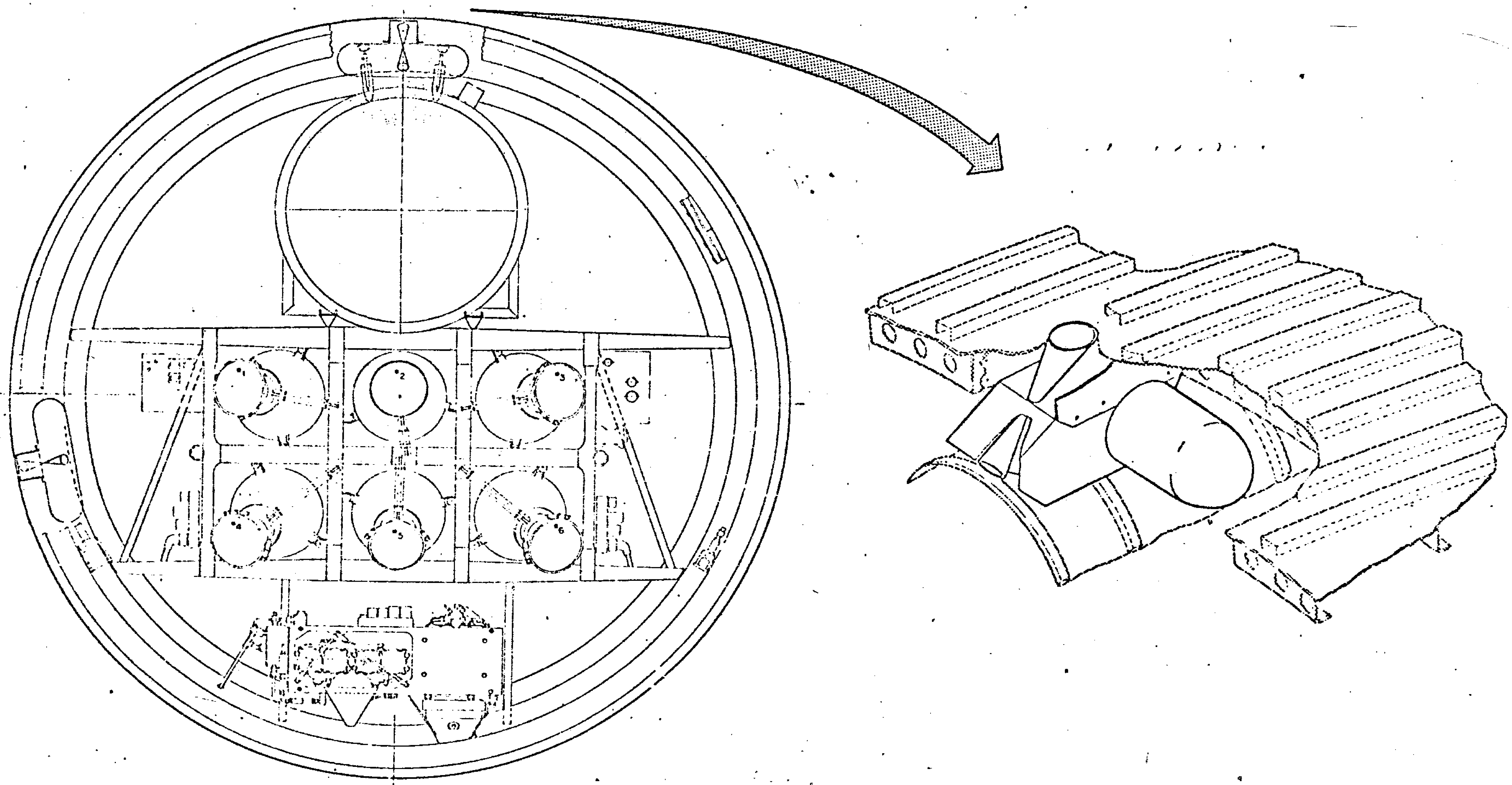
GEMINI B - RCS - THRUST CHAMBER ASSEMBLY



GEMINI B - RETROGRADE ROCKET

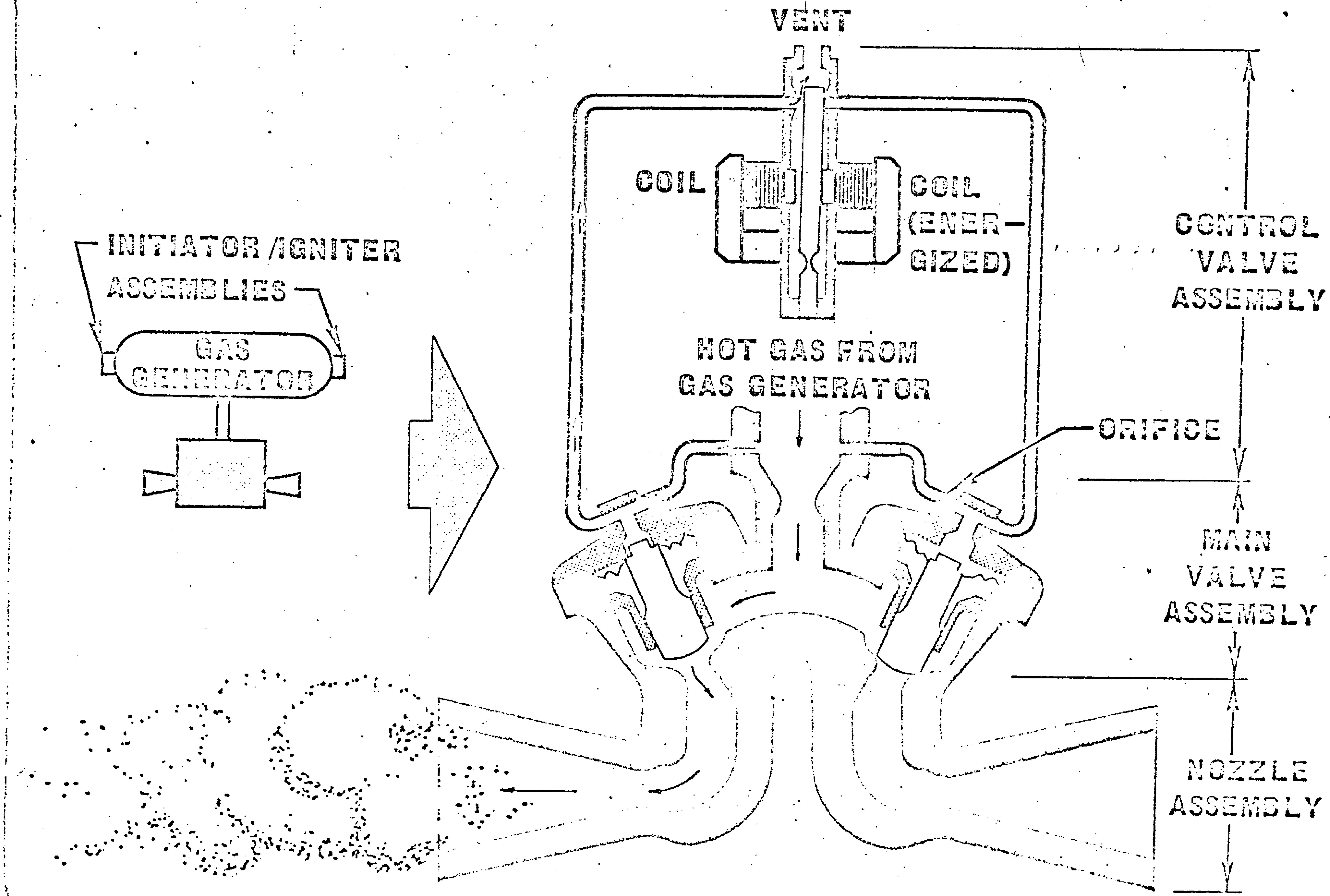


ABORT THRUSTER - PACS INSTALLATION



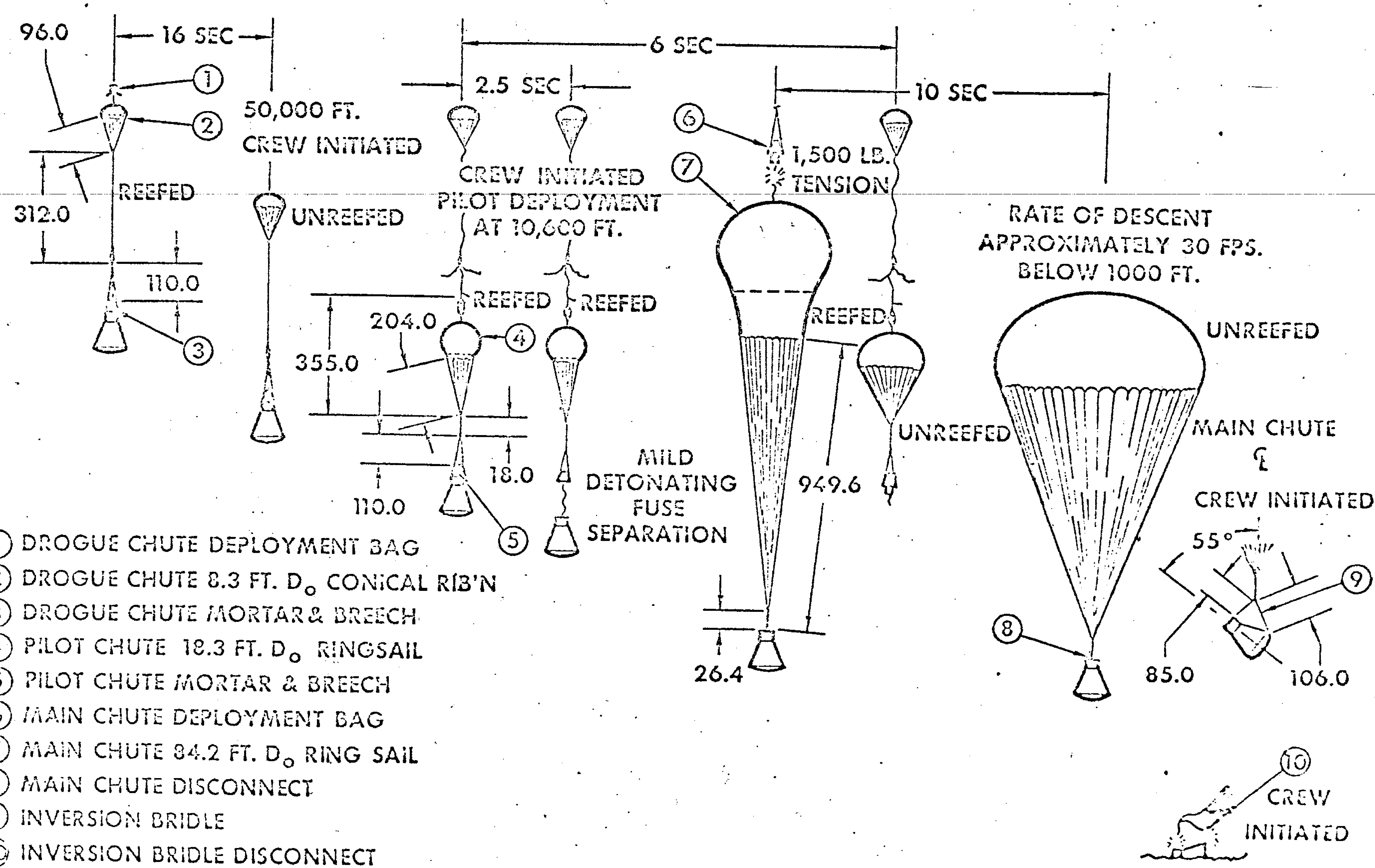
MCDONNELL
54-167 GB

PACS THRUSTER ASSEMBLY SCHEMATIC



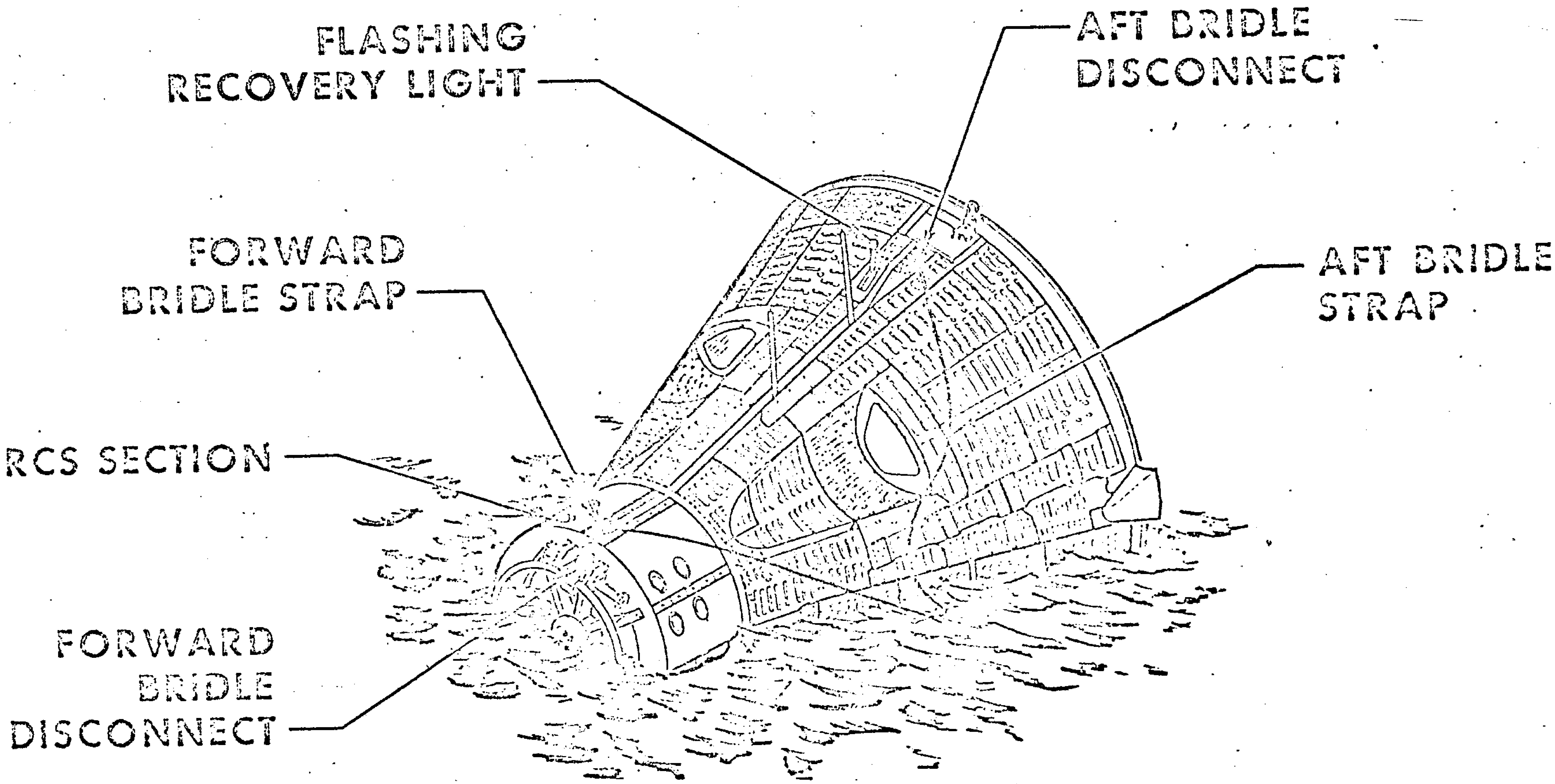
MCDONNELL
1-266 GBM

TANDEM VERSION
LANDING SYSTEM CONFIGURATION



1. DROGUE CHUTE DEPLOYMENT BAG
2. DROGUE CHUTE 8.3 FT. D_o CONICAL RIB'N
3. DROGUE CHUTE MORTAR & BREECH
4. PILOT CHUTE 18.3 FT. D_o RINGSAIL
5. PILOT CHUTE MORTAR & BREECH
6. MAIN CHUTE DEPLOYMENT BAG
7. MAIN CHUTE 84.2 FT. D_o RING SAIL
8. MAIN CHUTE DISCONNECT
9. INVERSION BRIDLE
10. INVERSION BRIDLE DISCONNECT

MAIN PARACHUTE RELEASE



OXYGEN SAFETY STUDY

AREAS OF CONCERN

- IGNITION SOURCES
- COMBUSTIBLE MATERIALS
- CREW EVACUATION PROVISIONS
- ATMOSPHERE

MCDONNELL
18-667 GB

OXYGEN SAFETY STUDY

TASK 1 – NASA GEMINI ECS DATA

TASK 2 – MATERIALS SUMMARY

TASK 3 – EQUIPMENT REVIEW

TASK 4 – CABIN EGRESS

TASK 5 – PROCEDURES – TEST & FLIGHT

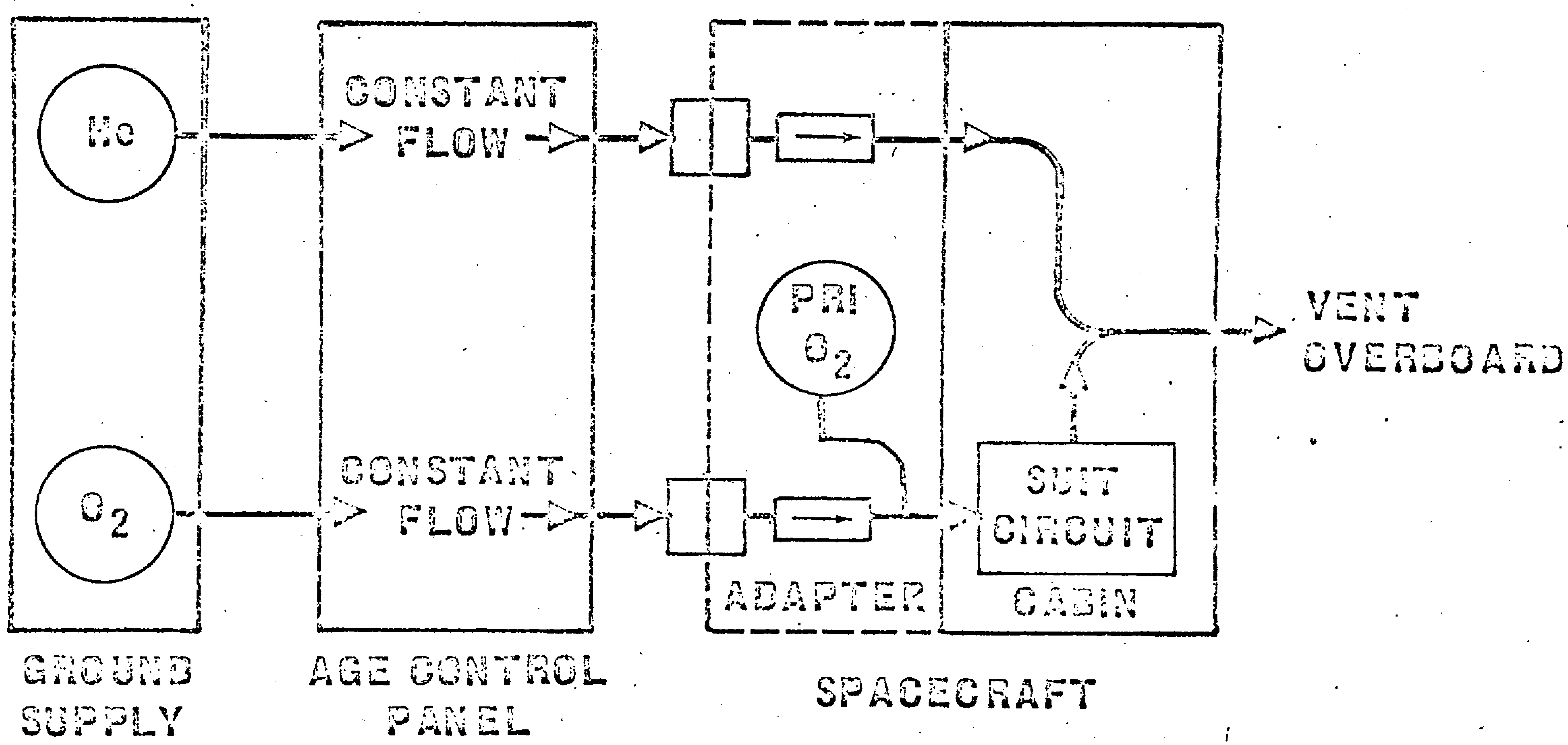
TASK 6 – TWO-GAS SYSTEM

TASK 7 – INFLIGHT EMERGENCY OPERATIONS

TASK 8 – TESTING

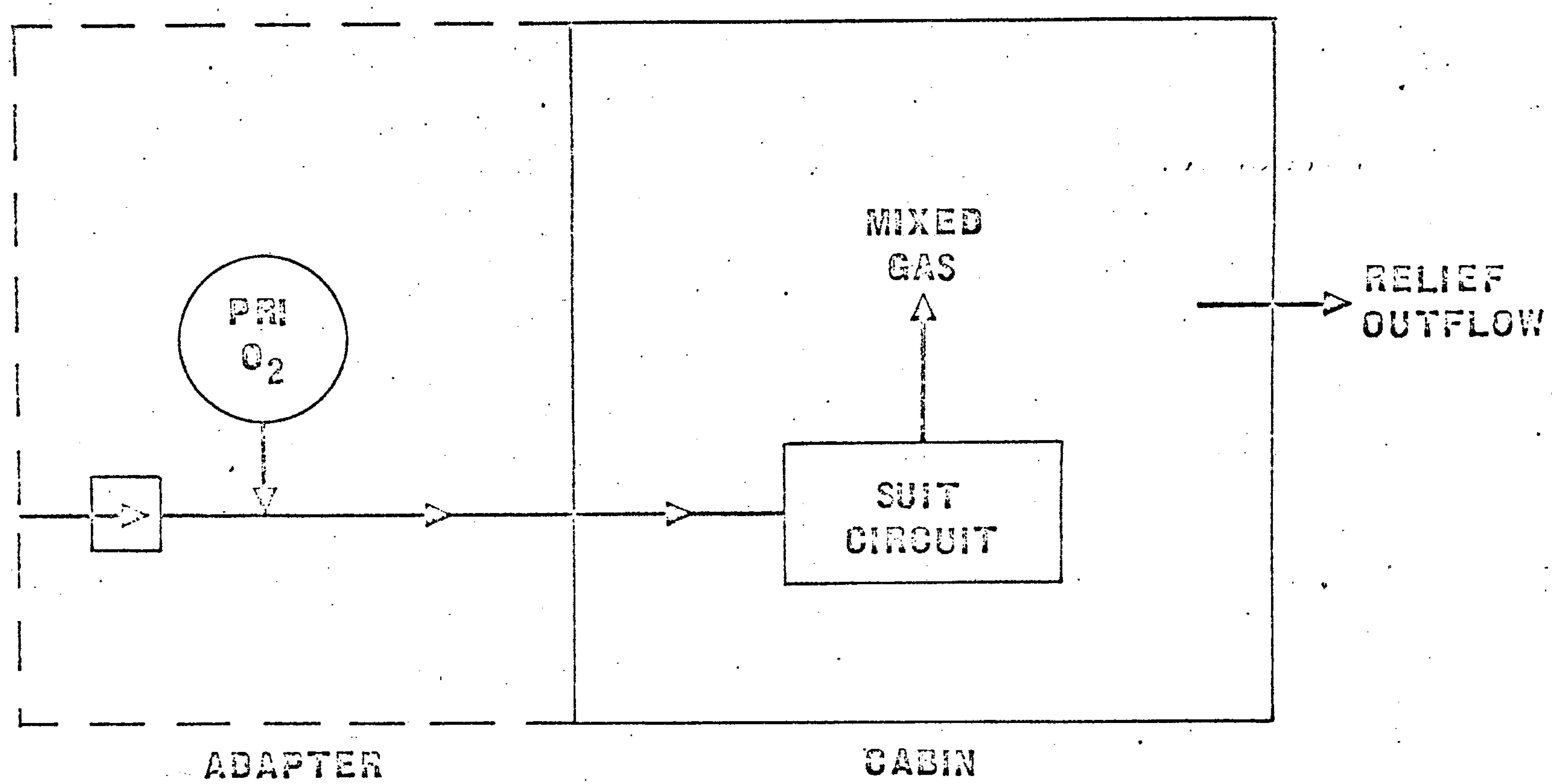
TASK 9 – RECOMMENDATIONS

SIMPLIFIED TWO GAS ATMOSPHERE ON PAD OPERATION



SIMPLIFIED TWO GAS ATMOSPHERE ASCENT OPERATION

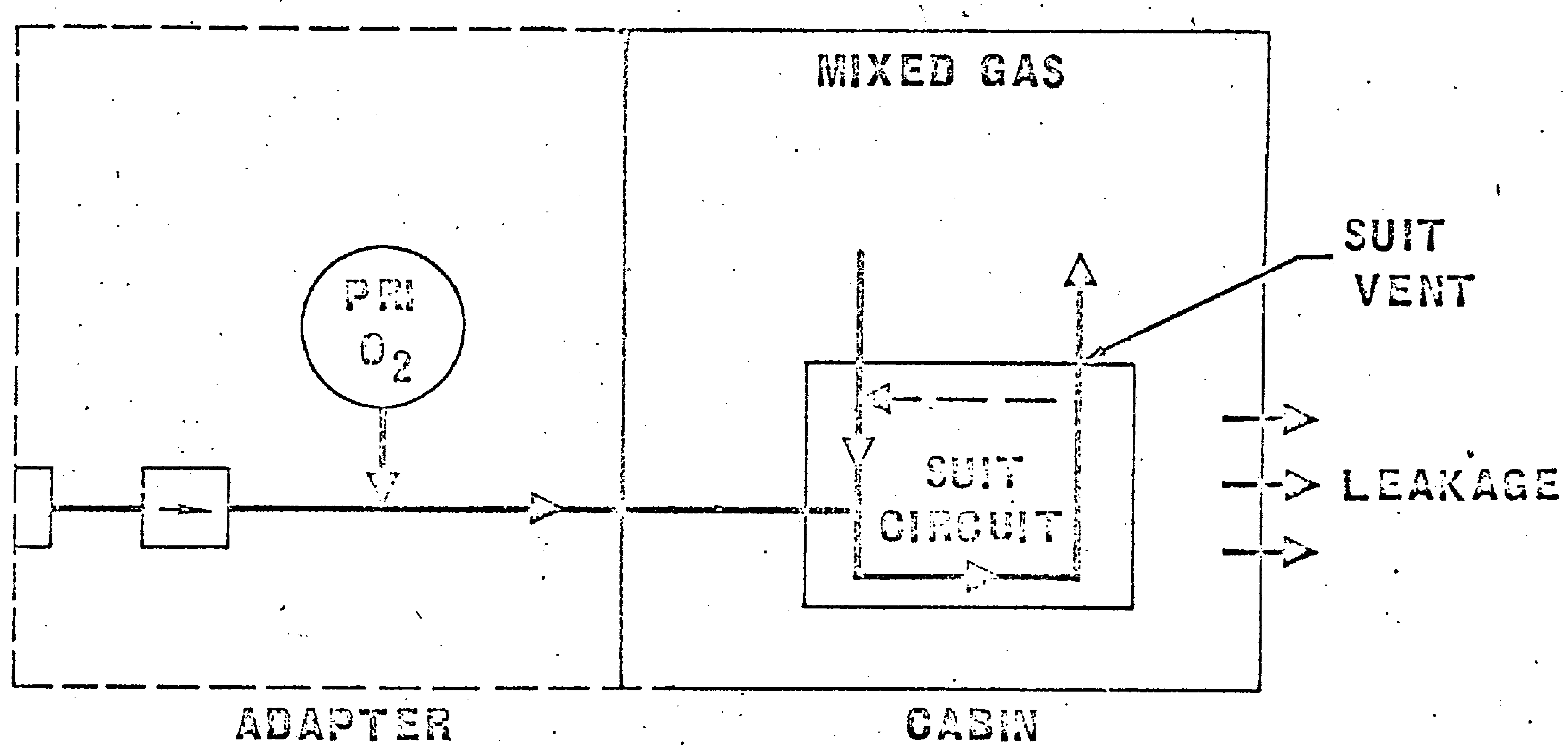
ASCENT OPERATION

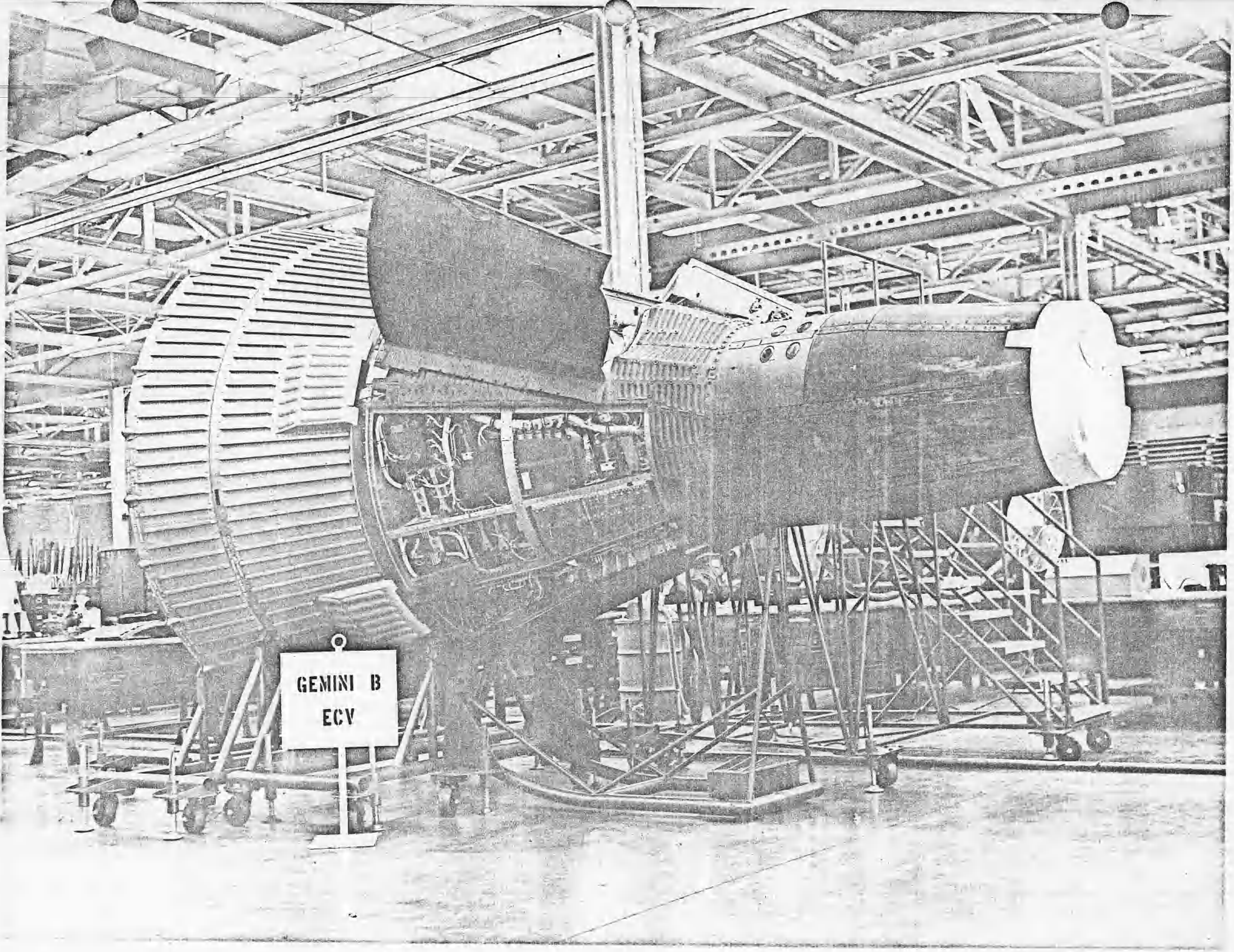


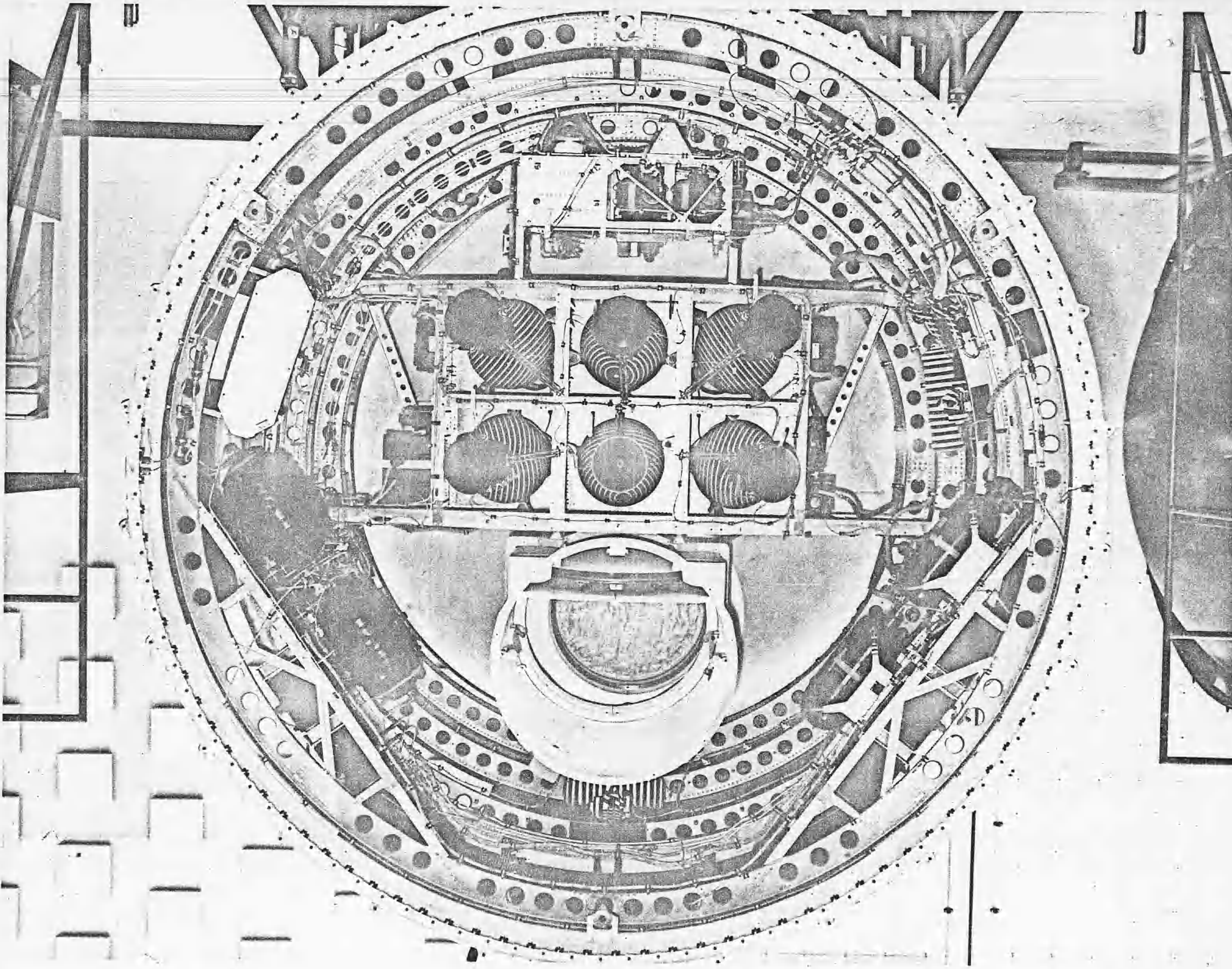
HI RATE O_2 FLOW
AUTO PRESSURE RELIEF
SUIT LOOP CLOSED

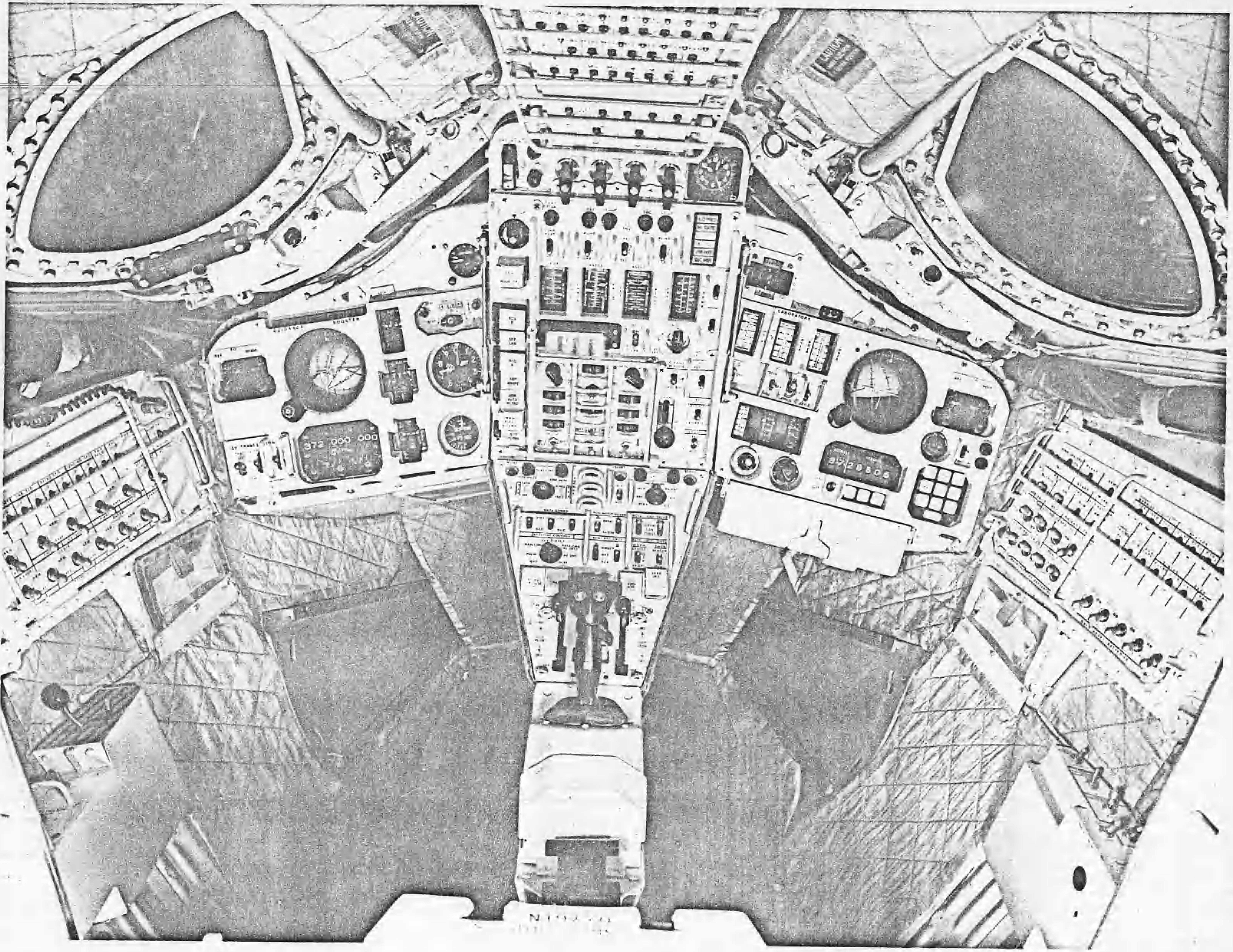
SIMPLIFIED TWO GAS ATMOSPHERE

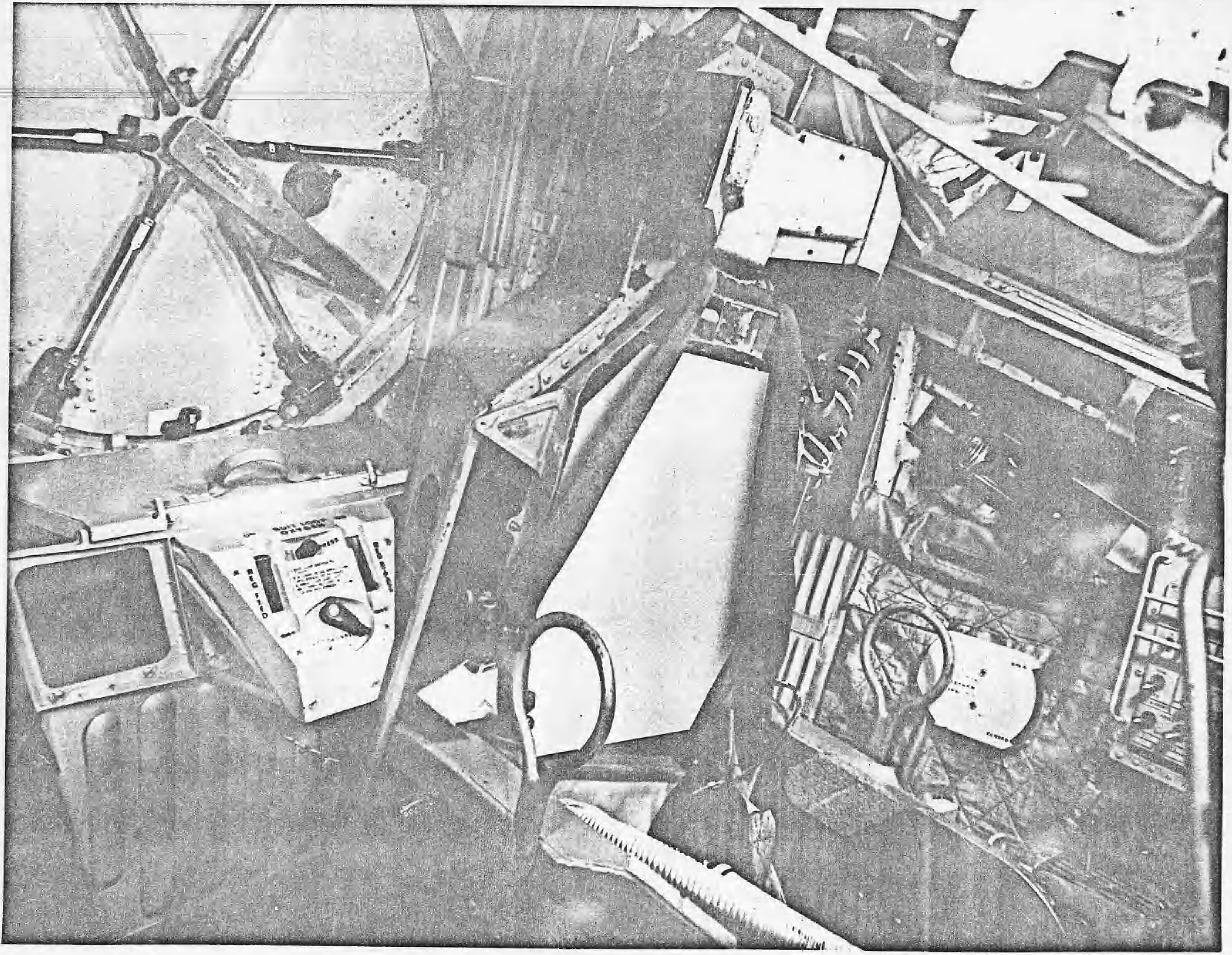
ORBIT OPERATION

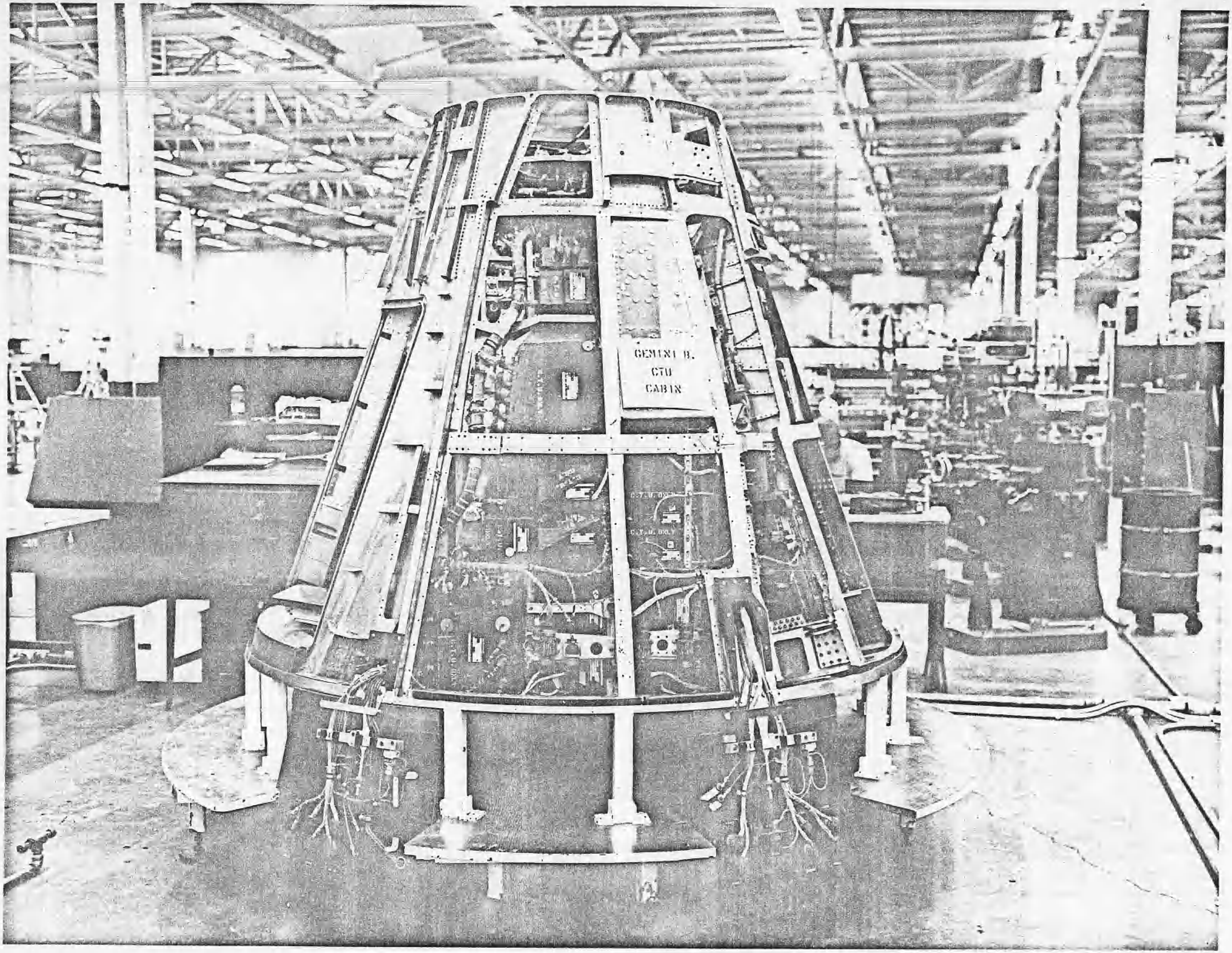


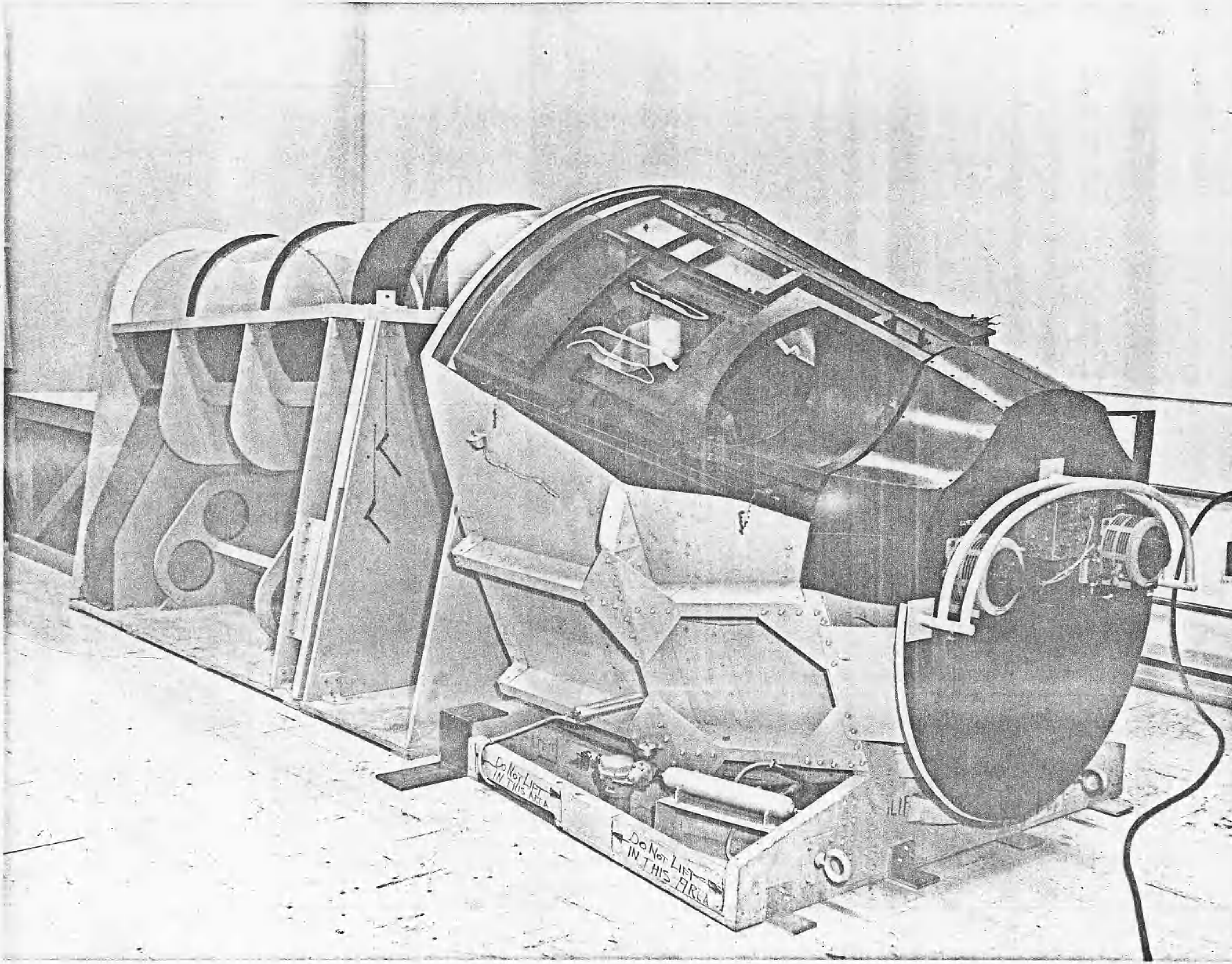

GEMINI B
ECV




GUIDANCE
BOOSTER
372 000 000
LABORATORY


OXYGEN
REG FEED


GEMINI B.
CTU
CABIN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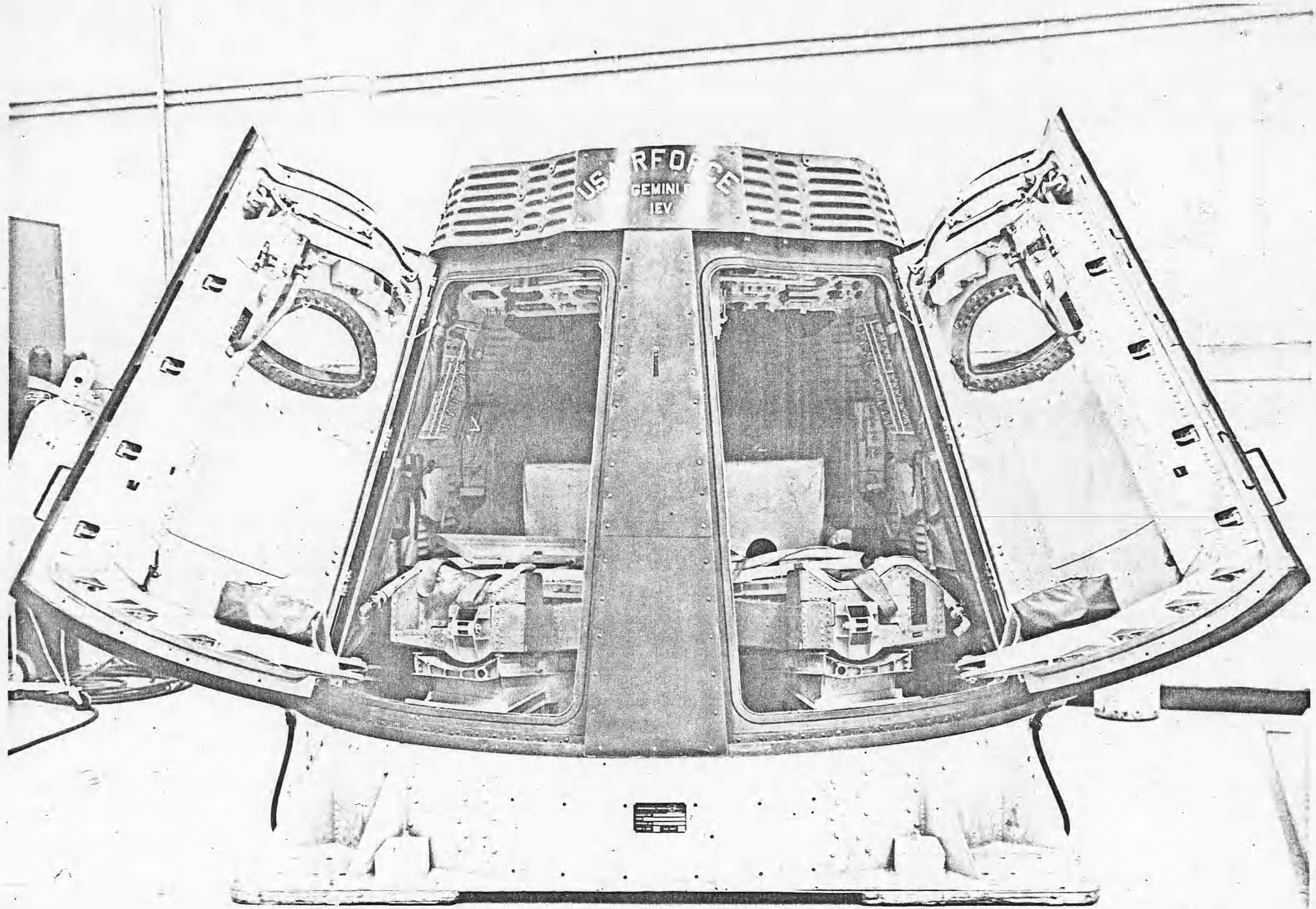
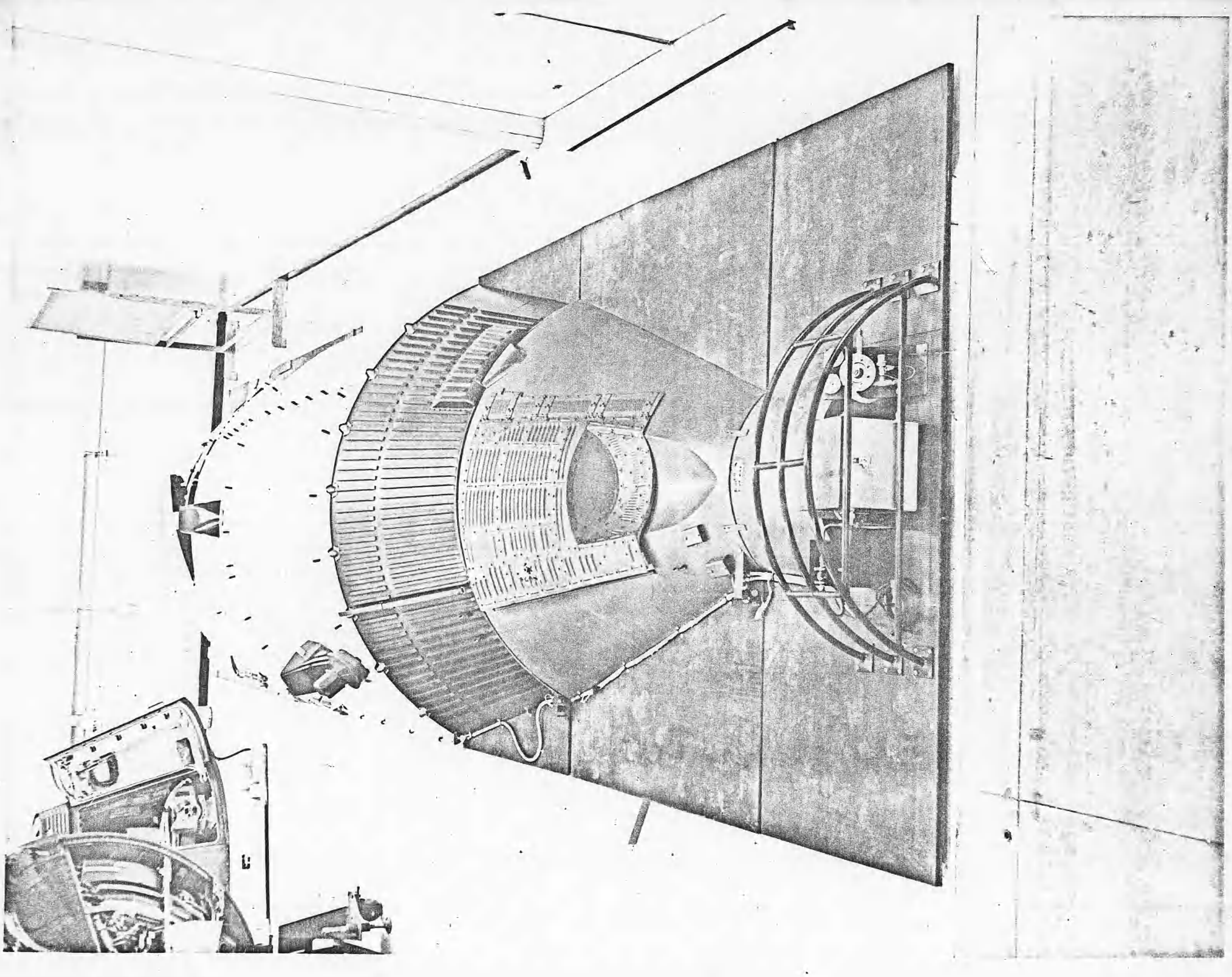
DO NOT LIFT IN THIS AREA



US RFORCE
GEMINI
IEV



2.2.1 Gemini Project and Objectives - In April 1961, McDonnell was authorized by the National Aeronautics and Space Administration (NASA) to begin an engineering study program to develop alternate concepts of design and arrangements which would effectively carry-on the United States manned space flight program. McDonnell began study of a two-man spacecraft which would be similar in design to the Mercury capsule but 50% larger in volume.

The notification to McDonnell that it had been selected to design and manufacture a two-man spacecraft, named "Gemini" after the constellation containing the twin stars Castor and Pollux, was received on 15 December 1961. Engineering go-ahead on the new program was authorized on 23 December 1961; however, the formal cost-plus-fixed-fee contract was not executed until 29 March 1963.

As defined by NASA, McDonnell, as prime contractor, was to design, develop and manufacture a two-man reentry vehicle, a launch vehicle adapter module, and a target docking adapter. In addition, the company was to fabricate trainers, training aids and simulators to assure crew familiarity with spacecraft systems and procedures. Static articles and boilerplate modules were to be furnished for use in an intensive test program.

The contract also specified that McDonnell support NASA operations at Cape Kennedy and supply personnel in support of the mission simulators and the translation and docking trainer located at the Manned Spacecraft Center, Houston, Texas.

On 28 January 1965 a supplement to the Gemini contract was negotiated with the NASA whereby the cost-plus-fixed-fee arrangement was converted to a cost-plus-incentive-fee plan based on schedule performance, spacecraft and system performance, and program cost reduction. These provisions were made retroactive to 1 April 1964.

The vehicles supplied by McDonnell under the Gemini Contract (NAS 9-170) comprised the following:

	Entry Module	Adapter Module
S/C No. 1 Unmanned Flight	1	1
Adapter 1A (Spare)	–	1
S/C No. 2 Unmanned Flight	1	1
S/C No. 3A (Thermal Qualification Test Unit)	1	1
S/C No. 3 through 12 Manned Flight	10	10
Total	13	14

7 Agena Target Cocking Adapters (TDA's)

2 Mission Simulators

SECTION 2.2

1 Translation and Docking Trainer
6 Boilerplate Entry Modules
5 Static Entry Modules
4 Static Launch Adapters
2 Static TDA's
2 System Test Units
(Electronic System Test Unit, ESTU)
(Compatibility Test Unit, CTU)
1 Egress Trainer (Formerly one of five Static Entry Modules listed above)
1 Crew Station Mock-Up Trainer
1 Centrifuge Trainer
1 TDA Electrical Simulator
1 Spacecraft Simulator
1 Electrical and Sequential Training Panel
1 Attitude and Maneuvering Control System Trainer
1 Ejection Seat Trainer

The contract also specified that MDAC support NASA operations at Cape Kennedy and supply personnel in support of the mission simulators and the translation and docking trainer located at the Manned Spacecraft Center, Houston, Texas.

Twelve missions - two unmanned and ten manned - were assigned and flown in the course of the Gemini Program. All spacecraft were launched from Complex 19, Cape Kennedy, Florida. The launch vehicle was a modified Titan II ICBM, "man-rated" for Gemini usage. A synopsis of each mission is presented in Table 2-2.

The Gemini program achieved the following objectives:

- Continuous Program at Minimum Cost - To provide a continuation program of manned space flight objectives at minimum cost with major milestones to be complete as soon as practical. Gemini was completed months ahead of the schedule that was estimated in early 1963. Spacecraft 2 through 12 each was delivered at least a month ahead of schedule. A modular system design concept was the major contributing factor to achievement of this goal. Gemini's modular system design, which replaced Mercury's stacked system concept, simplified construction, testing, and operation of the spacecraft. Modular design permitted virtually independent design, qualification, and system checkout. Reliability analysis was possible without the complications of interacting influences of associated systems.

TABLE 2-2

GEMINI FLIGHT RECORD

Mission	Crew (Command pilot first)	Launch	Splashdown	Length	Remarks
Gemini 1		April 8, 1964	April 12, 1964		Unmanned test of spacecraft/launch vehicle integrity.
Gemini 2		January 19, 1965	January 19, 1965		Unmanned ballistic test of spacecraft and heat shield.
Gemini 3	Virgil I. Grissom John W. Young	9:24:00 A.M. EST, March 23, 1965	2:17 P.M. EST, March 23, 1965	3 revolutions 4 hours, 53 minutes	First U.S. two-man flight. First successful orbit changing of a manned satellite.
Gemini 4	James A. McDivitt Edward H. White, II	10:15:59 A.M. EST, June 3, 1965	12:12:30 P.M. EST, June 7, 1965	4 days, 62 revolutions 97 hours, 56 minutes, 31 seconds.	First U. S. extravehicular activity (EVA) by Pilot White, which lasted 20 minutes.
Gemini 5	L. Gordon Cooper, Jr. Charles Peter Conrad, Jr.	9:00:00 A.M. EST, August 21, 1965	7:56 A.M. EST August 29, 1965	8 days, 120 revolutions 190 hours, 56 minutes	First Gemini use of fuel cells. First eight-day manned flight.
Gemini 7	Frank Borman James A. Lovell, Jr.	12:30:03 P.M. EST, December 4, 1965	9:05:06 A.M. EST, December 18, 1965	206 revolutions 330 hours, 35 minutes, 17 seconds.	First U.S. two-week manned space flight.
Gemini 6	Walter M. Schirra Jr. Thomas P. Stafford	08:37:26 A.M. EST, December 15, 1965	10:29:09 A.M. EST, December 16, 1965	17 revolutions 25 hours, 51 minutes, 43 seconds	World's first successful rendezvous of two orbiting spacecraft as it came within 1 ft. of Gemini 7 and stayed within 62.13 miles of it for 20 hours, 22 minutes.
Gemini 8	Neil A. Armstrong David R. Scott	11:41:02 A.M. EST, March 16, 1966	10:23:08 P.M. EST, March 16, 1966	7 revolutions 10 hours, 42 minutes, 6 seconds	First successful docking of two spacecraft in orbit. Mission aborted early when spacecraft attitude control rockets malfunctioned.
Gemini 9	Thomas P. Stafford Eugene A. Cernan	8:39:33 A.M. EST, June 3, 1966	9:00:47 A.M. EST, June 6, 1966	46 revolutions 72 hours, 21 minutes, 14 seconds	Pilot Cernan spent 2 hours, 9 minutes and set a new world's record for an astronaut attached to spacecraft by only a tether.
Gemini 10	John W. Young Michael Collins	5:20:26 P.M. EST, July 18, 1966	4:06:11 P.M. EST, July 21, 1966	44 revolutions 70 hours, 46 minutes, 14 seconds	Used Agena to go to altitude of 410 nautical miles. First dual rendezvous with Agena 10 and later with Agena 8 target vehicle. Two EVA periods.
Gemini 11	Charles Conrad Richard F. Gordon, Jr.	9:42:26 A.M. EST, September 12, 1966	8:59:34 A.M. EST, September 15, 1966	45 revolutions 71 hours, 17 minutes, 8 seconds	Set new manned space flight record of 739.4 nautical miles. Also, world's first one-orbit rendezvous. Two EVA periods.
Gemini 12	James A. Lovell, Jr. Edwin Aldrin	3:46:00 P.M. EST, November 11, 1966	2:22 P.M. EST, November 15, 1966	59 revolutions 94 hours, 36 minutes	Three-orbit rendezvous to simulate lunar program rendezvous. Aldrin set world record for total EVA during one mission with 5 hours, 37 minutes.

SECTION 2.2

Spacecraft 7/6 mission was made possible because launch crews were able, despite a tight time schedule, to remove the rendezvous and recovery section (R & R) of Spacecraft 7 and modify it for tracking by Spacecraft 6. Another example of the effectiveness of the modular design was the Gemini XII mission which was totally changed and replanned within two weeks. Gemini system design was simplified by extensive use of manual sequencing and systems management, utilizing the astronaut's ability to diagnose failures and to take corrective action.

- Rendezvous, Docking and Maneuvering - To rendezvous and dock with a second orbiting vehicle and then perform combined maneuvering. Rendezvous was first achieved by Spacecraft 6; Spacecraft 8 was the first to dock. Maneuvering in orbit using the Agena Target Vehicle was first achieved by Spacecraft 10.
- Long Duration Missions - To expose two astronauts and their life support systems to long-duration missions to prepare for future earth orbit and lunar flights. Spacecraft 5 remained in orbit for 8 days and Spacecraft 7 remained in orbit for 14 days, demonstrating man's capability in a space environment.
- Precision Reentry, Landing, and Recovery - To develop and exercise precision reentry, landing, and recovery of manned spacecraft. From Gemini VI on, all spacecraft landed within seven miles of the aiming point. The last five Gemini Spacecraft came down within three miles of the target. All landings were made in the ocean. However, early designs had provided for land landings, but the rate of technological development for such landings did not keep pace with the remainder of the program so that the land landing capability for the spacecraft was subsequently abandoned.
- Extravehicular Activity - To undertake extravehicular activity to evaluate man's ability to perform tasks in a zero g environment. Although EVA was not an original objective of the Gemini program, it was made possible by the design of personnel hatches with mechanical latches which enabled the astronauts to open and close the hatches manually. Astronauts on Spacecraft 4, 9, 10, 11, and 12 performed EVA.
- Scientific Investigations - To utilize the Gemini Spacecraft as an experimental test platform for scientific investigations, including photography,

SECTION 2.2

biomedical experiments, communications, navigation, meteorology, etc. Experiments were carried on all manned Gemini Spacecraft.

2.2.2 Spacecraft Description - The Gemini Spacecraft, designed to provide life support for two orbiting astronauts, is an approximately 8000 lb. (equipped) conical structure 18.82 ft long and 10 ft in diameter at its base. It is composed of two major assemblies, a reentry module and an adapter module. Both structural bodies are all metal, of stressed skin and semimonocoque construction. In addition, the reentry module is designed to withstand the extreme heat of reentry. The general arrangement of the Gemini spacecraft is shown in Figure 2-2. Overall spacecraft dimensions are given in Figure 2-3.

The methods of construction and the materials used guarantee high strength-to-weight ratios. The requirement of heat resistance led to the choice of titanium and magnesium as the prinicpal metals used in spacecraft fabrication. High-strength titanium bolts (Ti-6Al-4V) were used extensively; titanium was also used for the rings, stringers, interior skin, and bulkheads of the reentry module. Aluminum was used inside the cabin where temperatures are not structurally critical. Stringers and longerons were spaced around the circumference of the shell to carry nearly all axial and bending loads and to stiffen the framework. To protect against distortion to large, thin gauge panels, chemical milling rather than mechanical milling was employed. A breakdown of the major structural elements is shown in Figure 2-4.

For ease in identifying particular areas, the spacecraft is cut by two reference planes, one running longitudinally from adapter to nose, the other at right angles to this one as shown in Figure 2-2. Looking forward from the end of the adapter, one may divide a section of the spacecraft into four quadrants, thus creating four cardinal points - TY (Top Y) and BY (Bottom Y) for the Y axis, and RX (Right X) and LX (Left X) for the X axis. A particular location on the circle is measured in degrees from any one of these points.

The Z station locations are measured longitudinally from the rear of the spacecraft (adapter) and increase in magnitude as one approaches the nose. For example, the separation point between the reentry module and the adapter is station Z 102.00 (in.); the nose of the spacecraft is station Z 239.53 (Z 239.28 plus 0.25 in. of ablative material).

The interior arrangement of the spacecraft is presented in Figure 2-5. The systems shown in the interior arrangement are summarized in Section 2.2.3. A

SECTION 2.2

SPACECRAFT GENERAL ARRANGEMENT

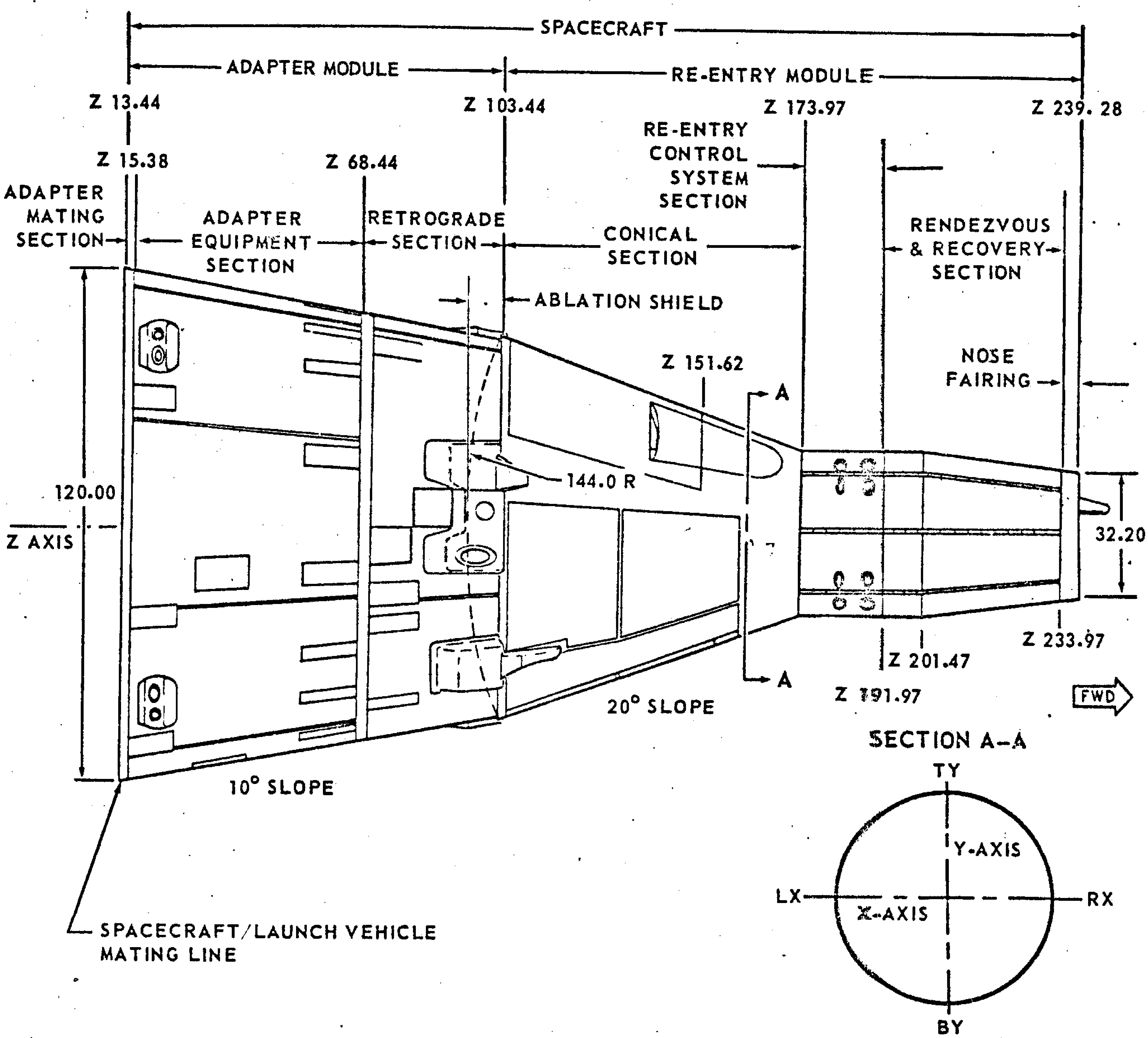
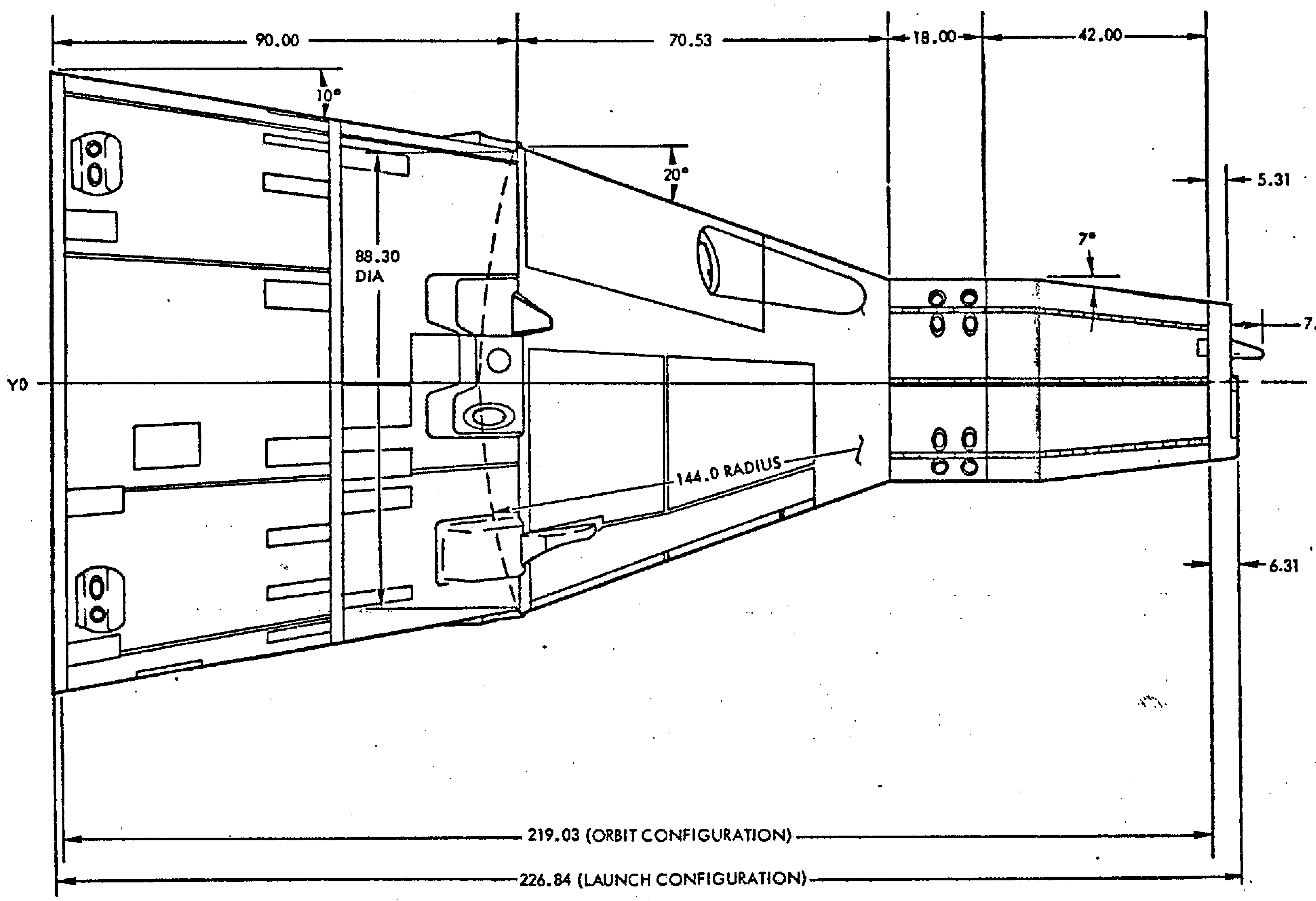


FIGURE 2-2

SECTION 2.2

SPACECRAFT DIMENSIONS



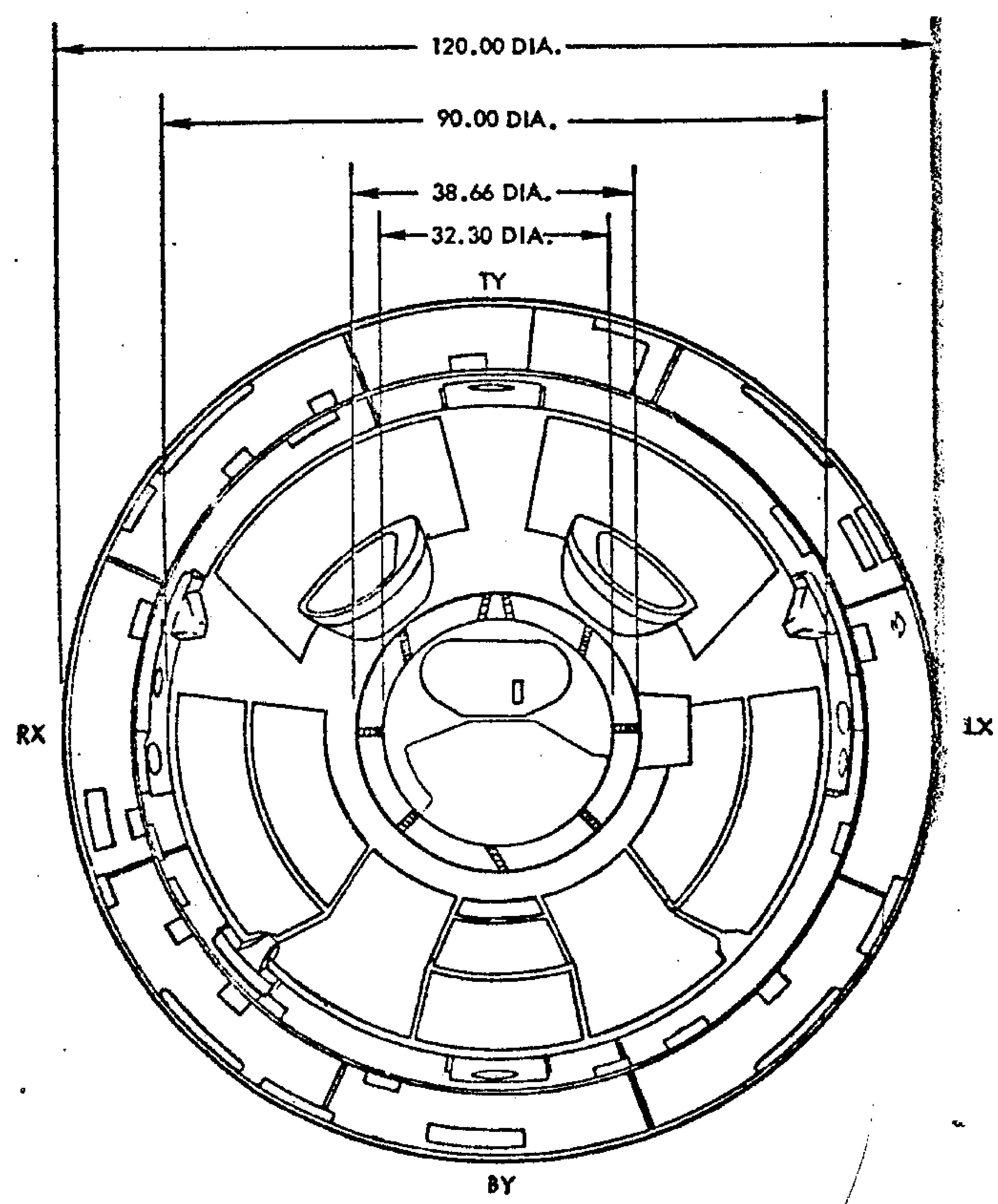


FIGURE 2-3

STRUCTURE BREAKDOWN

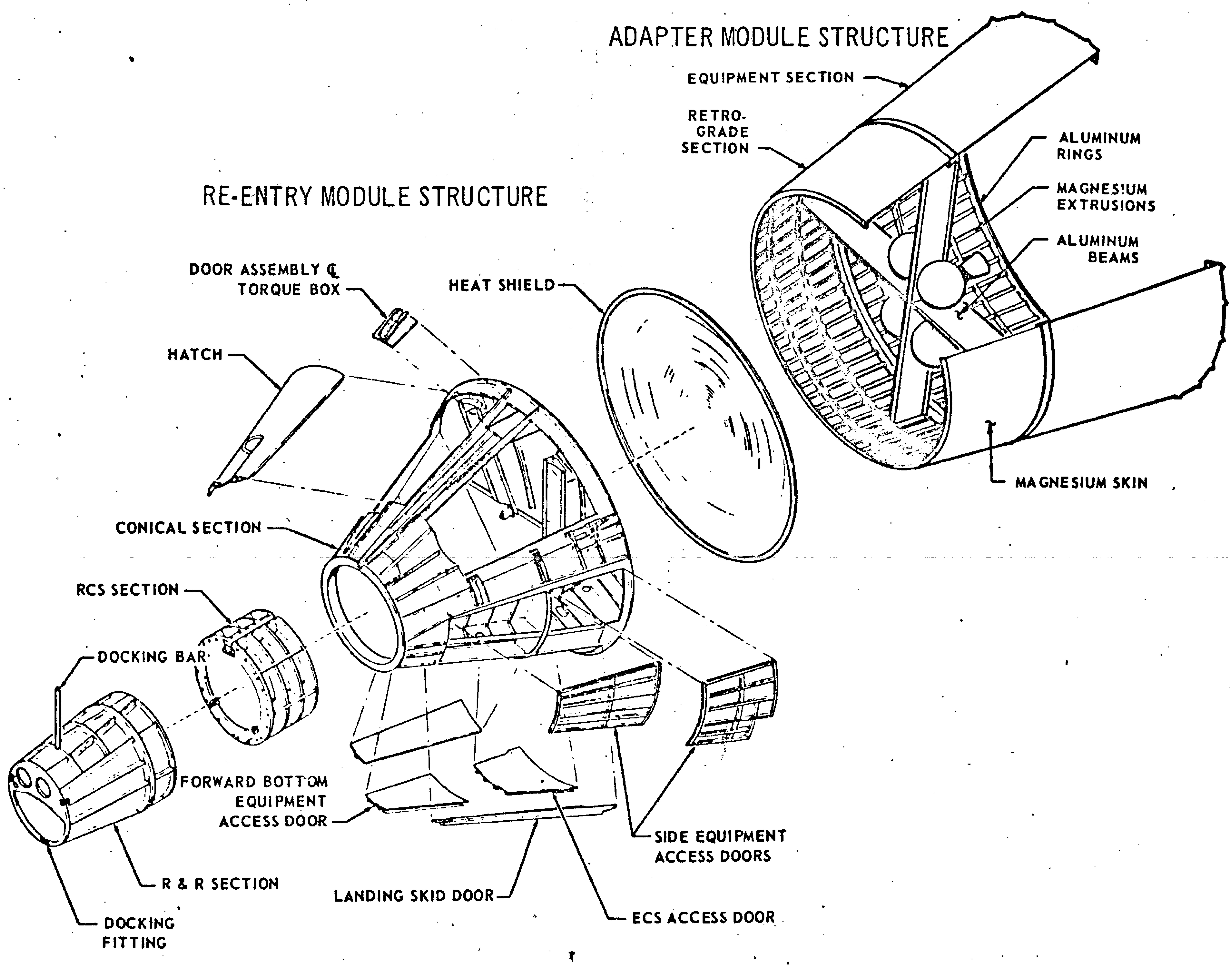


FIGURE 2-4

INTERIOR ARRANGEMENT

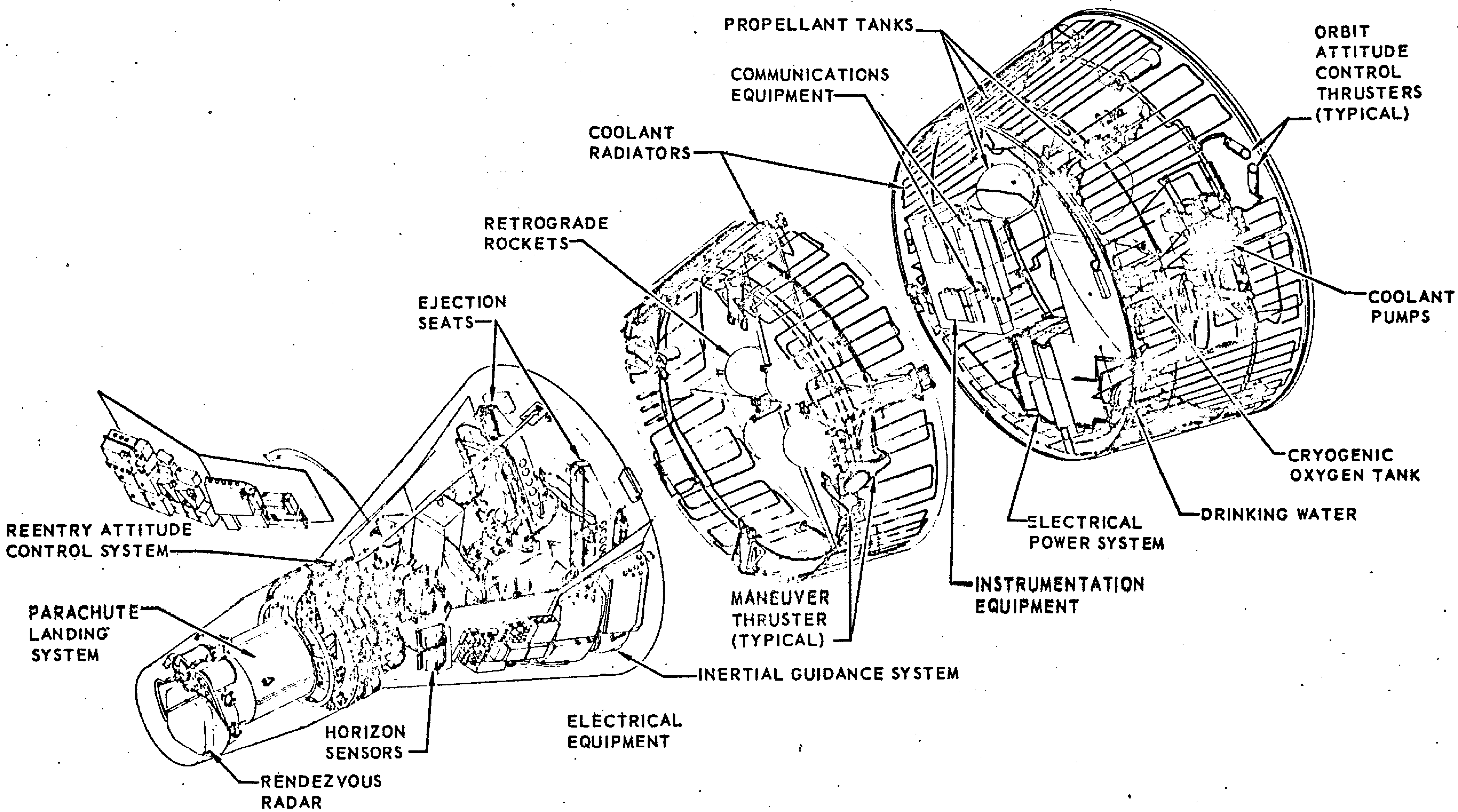


FIGURE 2-5

weight summary for Spacecraft 12 (3 day mission) and Spacecraft 7 (14 day mission) is presented in Table 2-3.

2.2.3 Gemini Subsystems - The major subsystems of the Gemini Spacecraft include Propulsion; Electrical Power; Environmental Control; Communications; Launch Escape; Guidance, Navigation and Control; Instrumentation; Ordnance; Landing and Crew Systems. A brief description of each of these subsystems and identification in accordance with the NASA CATF WBS is shown in Table 2-4.

2.2.4 Gemini Prime Contractor and Major Subcontractor Division of Effort - As related to the ASSCA Study, the McDonnell effort, in execution of the NASA Gemini contract, may be separated into that directly applicable to the Gemini structural subsystem as an end item vs. the subsystem integration effort required to achieve a flight operable spacecraft and support the operational usage thereof. Activities within these categories are further separated into elements compatible with the NASA Cost Analysis Task Force Work Breadkown Structure (CATF WBS) and described in Section 2.3. Included in the prime contractor's effort was the (1) Structure design, fabrication and test, (2) Subsystem integration, (3) Systems integration and (4) Systems Engineering as outlined in Table 2-5. Distribution of the major contractor's effort and relevant major program milestones and events is shown in Figure 2-6. Chronological milestones for the production spacecraft are presented in Figure 2-7.

The various subsystems associated with the design of the spacecraft include (1) electrical, (2) propulsion, (3) communications, (4) instrumentation, (5) guidance, navigation and control, (6) recovery, (7) environmental control, (8) crew station and (9) pyrotechnics. The elements of each of these subsystems together with the cognizant major subcontractor is outlined in Table 2-6. A summary of the major milestones associated with each major subcontractor is shown in Figure 2-8.

2.2.5 Design, Performance and Operational Characteristics - The environments to be encountered by the spacecraft during its postulated flight profile are predominant factors in establishing the spacecraft environmental design and validation criteria. (A typical Gemini mission profile is shown in Figure 2-9.) The anticipated operational environments and performance requirements associated with such a profile provided the basic input to the Gemini aerodynamic, thermodynamic, and structural analysis which resulted in the vehicle preliminary design. Refinements of these analyses were augmented in the early design phase by experimental data obtained in

SECTION 2.2

TABLE 2-3

GEMINI WEIGHT SUMMARY

SUBSYSTEMS	3 DAY S/C 12			14 DAY S/C 7		
	CM	M.M.	TOTAL	CM	M.M.	TOTAL
Structure	1063	416	1479	1080	408	1488
Ind. Env. Prot	733	15	748	732	11	743
Docking	33		33	8		8
Landing	211		211	211		211
Retro	7	366	373	7	366	373
Entry Att. Cont.	218		218	218		218
Orbit Att. Cont.		1439	1439		777	777
Prime Power	266	489	755	264	563	827
Guid & Nav.	393	33	426	319		319
Inst. & Tele.	125	82	207	128	81	209
Comm.	134	60	194	134	62	196
ECS.	396	298	694	416	665	1081
Pers & Pers. Prøv.	944		944	952		952
Crew Sta. Cont	122		122	124		124
Experiments	166	330	496	118	177	295
Ballast	71		71	89		89
Wt. Adj.	5	30	35	-5	18	13
Total	4887	3558	8445	4795	3128	7923

TABLE 2-4

GEMINI SUBSYSTEM SUMMARY

SUBSYSTEM	CATF WBS	DESCRIPTION
I. Entry Vehicle		
1. Propulsion	01-03-00-00	1. (a) Orbital Attitude and Maneuvering System (OAMS) - Provides propulsive thrust for 3 axes attitude control and 6 direction translation from time of launch vehicle separation to initiation of retrograde. Sixteen (16) engines; 8-23 lb. thrust, 2-85 lb. thrust, 6-94.5 lb. thrust. Propellants: Nitrogen tetroxide (N_2O_4) and Monomethylhydrazine (MMH). 1. (b) Reentry Control System (RCS) - Provides attitude control during the retrograde maneuver and subsequent reentry phase of the mission Eight (8) 23 lb. thrust engines per each of two redundant systems. Propellants: Nitrogen tetroxide (N_2O_4) and Monomethylhydrazine (MMH).
2. Electrical Power	01-05-00-00	2. Electrical energy for equipment operation provided by storage batteries (all missions) supplemented by fuel cells (Missions 5 and 7 through 12) through a multiple bus DC system in the range of 22 to 30 VDC. External ground power used for pre-launch operation.
3. Environmental Control System	01-06-00-00	3. The Environmental Control System (ECS) provides controlled environments for the astronauts, electronic equipment, and regulated temperature for the fuel cells. Redundant atmospheres are provided for the astronauts within a closed pressure suit circuit and the pressurized cabin.
4. Communications	01-07-00-00	4. The telecommunications system provides the link between the ground and spacecraft including: (a) radar tracking of the spacecraft, (b) two-way voice communications between the ground and spacecraft and from astronaut to astronaut, (c) ground to spacecraft data or command link, (d) spacecraft to ground data link and (e) post landing recovery aids.

TABLE 2-4 (CONTINUED)

SUBSYSTEM	CATF WBS	DESCRIPTION
5. Launch Escape System	01-09-00-00	5. The ejection seat system, designed and qualified as the primary crew escape system, consisted of ejection seats, scat rocket/catapult, hatch actuating system, personnel parachute system, and survival equipment.
6. Guidance, Navigation and Control	01-10-00-00	6. The Guidance, Navigation and Control (G, N&C) provides on-board navigation and attitude control during the orbit, rendezvous, and reentry mission phases and serves as a back-up to the Titan launch vehicle during ascent by providing inertially derived steering signals to the launch vehicle control system. Major components consist of the Inertial Guidance System (IGS), Attitude Control & Maneuvering Electronics, Pilot's attitude and maneuver hand controller's, Horizon Sensors and Rendezvous Radar, Time Reference System, and Readout and manual data insertion instrumentation.
7. Instrumentation	01-13-00-00	7. The instrumentation system provides for monitoring performance and operation of the spacecraft through the entire mission. The system is comprised of: (a) sensors, (b) signal conditioners, (c) multiplexers/encoder, (d) tape recorder/reproducer, (e) physiological data acquisition system and (f) telemetry transmission system.
8. Ordnance System	01-14-00-00	8. The ordnance systems utilize both low explosives to generate gas pressure used for device actuation and high explosive pyrotechnics used, in general, to generate a shock front in performance of structural severance. Pyrotechnic devices include mortars, actuators, guillotines, valves, etc. Structural severance was the principle mode of major module separation.
9. Landing Subsystem	01-15-00-00	
9.1 Landing Gear	01-15-04-00	9.1 A three skid spring/pneumatic landing gear was designed, built and qualified for use with the land-landing paraglider configuration. This configuration, however, was cancelled in November 1963 and all Gemini missions employed water landing.

TABLE 2-4 (CONTINUED)

SUBSYSTEM	CATF WBS	DESCRIPTION
9.2 Parachute	01-15-06-00	9.2 A 8.3 ft. dia. drogue parachute, a 18.3 ft. dia. ringsail pilot parachute and a 84.2 ft. dia. ringsail main parachute, sequentially deployed after astronaut initiation of the drogue chute mortar at 40,000 ft. altitude with each chute providing the force to deploy the subsequent chute. A 31.6 ft. per sec. rate of descent is provided for a module weight of 4,400 pounds.
10. Crew Systems	01-16-00-00	10. The crew system is comprised of the displays controls and furnishings. Controls and displays are located on three panels, one centered between the astronauts, one in front of the command pilot seated to the left, and one in front of the pilot seated to the right.
II. <u>Mission Module</u>		
11. Propulsion	02-03-00-00	11. The retrograde propulsion system is comprised of four solid propellant motors, any three of which are sufficient to accomplish the retrograde maneuver. Each motor, equipped with dual igniters, delivers an average thrust of 2584 lbs.

TABLE 2-5

MCDONNELL DOUGLAS EFFORT

- GEMINI SPACECRAFT PRIME CONTRACTOR TO THE NASA
  - STRUCTURE DESIGN, FABRICATION, & TEST
  - SUBSYSTEM INTEGRATION
    - -SPECIFICATIONS
    - -LIAISON AND MONITOR OF SUBCONTRACTOR
    - -SUBSYSTEM TESTS
    - -SUBSYSTEM DESIGN INTEGRATION
  - SYSTEMS INTEGRATION
    - -DESIGN, DEVELOPMENT & QUALIFICATION OF AGE, TRAINERS, SIMULATORS AND MOCK-UPS
    - -SYSTEMS TEST OPERATIONS

      WIND TUNNEL, THERMAL QUALIFICATION, INTEGRATION & COMPATIBILITY, S/C PRE-DELIVERY & LAUNCH CHECK-OUT
    - -TEST HARDWARE
    - -SUSTAINING ENGINEERING, TOOLING, PRODUCTION
  - SYSTEMS ENGINEERING
    - -MISSION PLANNING
    - -DOCUMENTATION, SPECIFICATIONS, PUBLICATIONS
    - -TRAINING SUPPORT

GEMINI PROJECT PRIME CONTRACTOR

EFFORT DISTRIBUTION

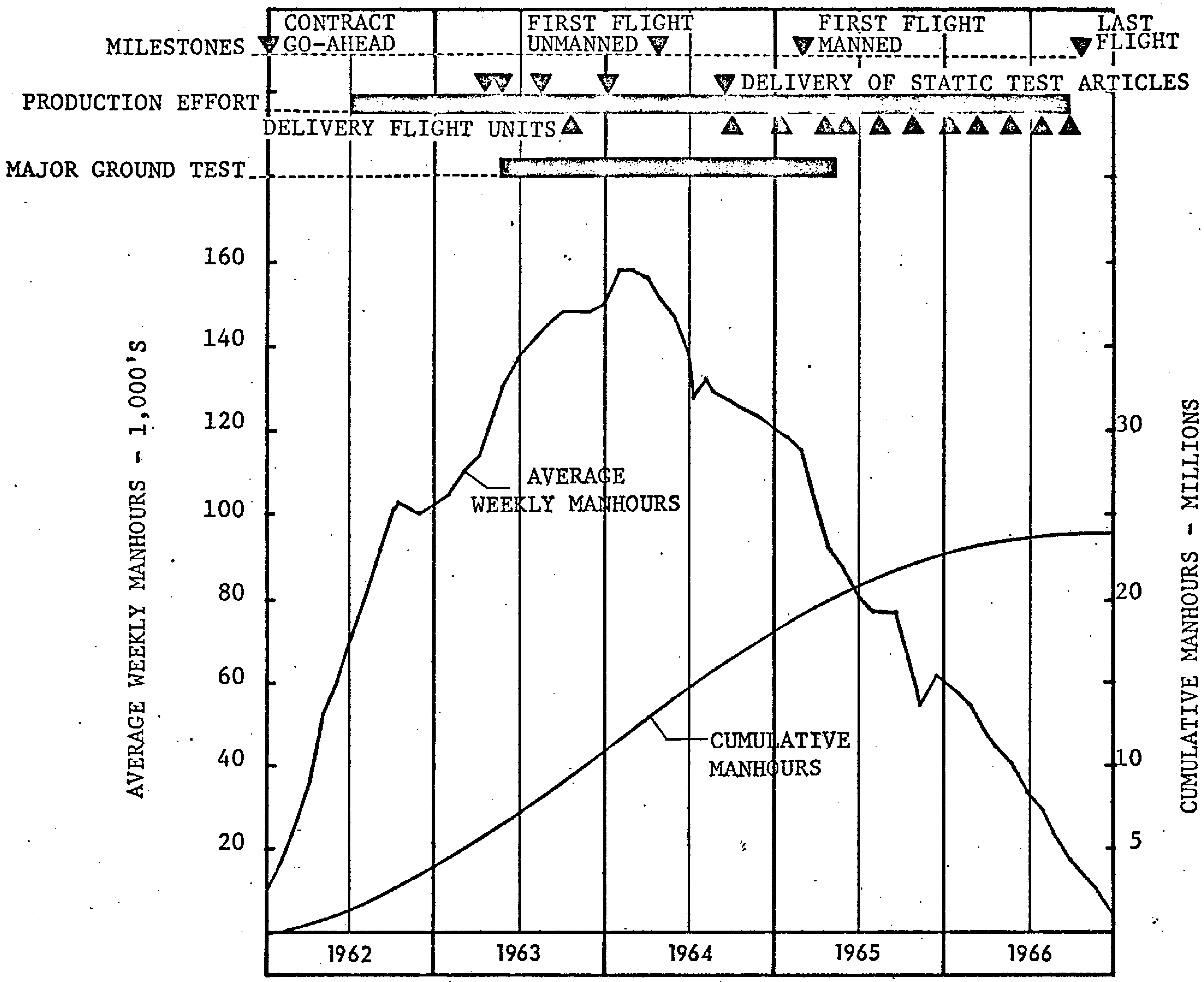


FIGURE 2-6

ADVANCED SPACECRAFT SUBSYSTEM COST ANALYSIS
STRUCTURE/SUBSYSTEM INTEGRATION

PRODUCTION SPACECRAFT CHRONOLOGY

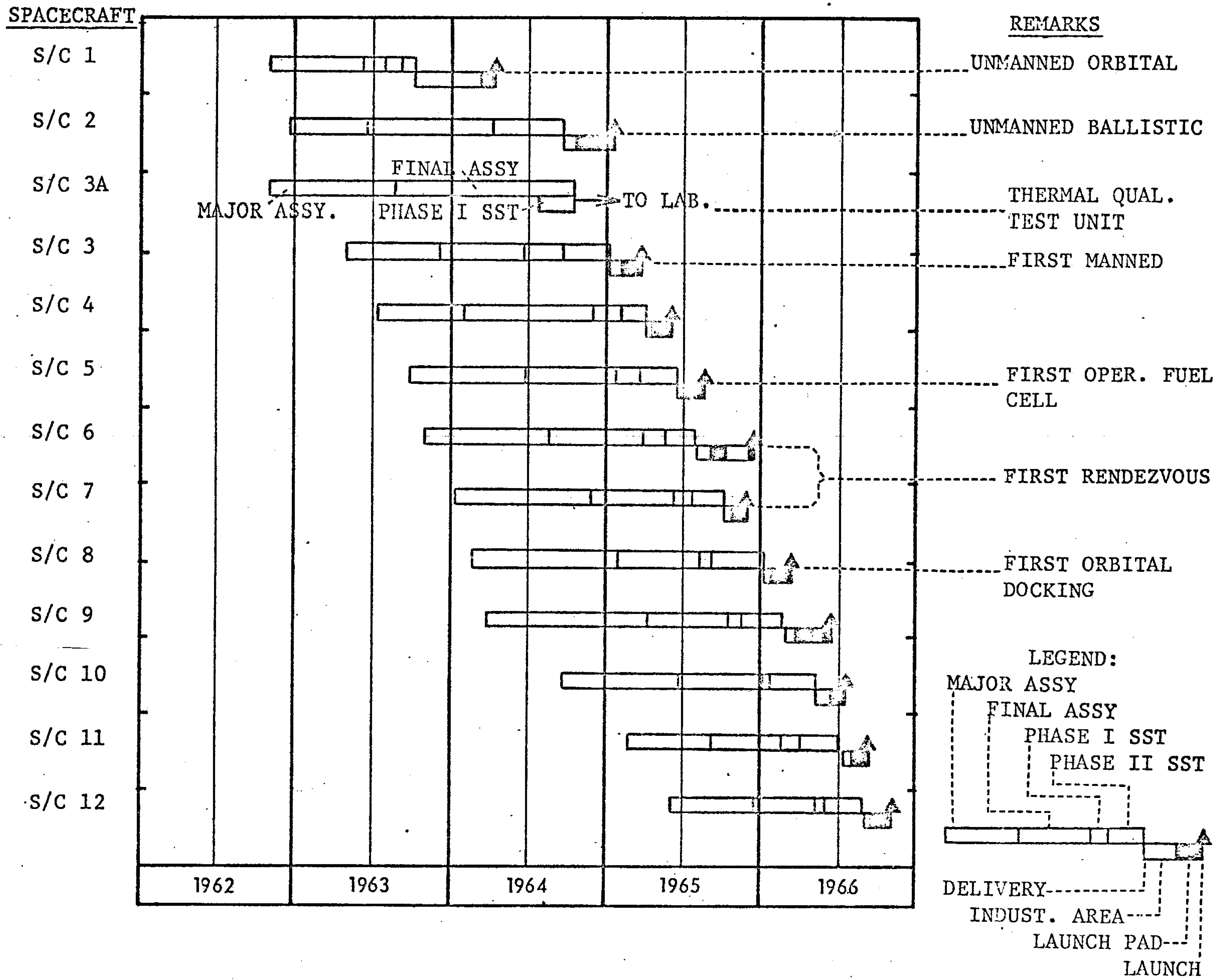


FIGURE 2-7

TABLE 2-6

MAJOR SUBCONTRACTOR IDENTIFICATION

SUBSYSTEM	SUBCONTRACTOR	SUBSYSTEM	SUBCONTRACTOR
o ELECTRICAL		o GUIDANCE, NAVIGATION & CONTROL	
FUEL CELL	GENERAL ELECTRIC	IGS	IBM
REACTANT SUPPLY	AIRESEARCH	IMU & ACME	HONEYWELL
BATTERIES	EAGLE PICHER	ATTITUDE DISPLAY GROUP	LEAR SIEGLER
o PROPULSION		HORIZON SENSORS	ADV. TECH LABS
RCS	ROCKETDYNE	RENDEZVOUS RADAR	WESTINGHOUSE
OAMS	ROCKETDYNE	TIME REFERENCE SYSTEM	MAC-EED
RETRO	THIOKOL	o RECOVERY PARACHUTE DROGUE, PILOT & MAIN	NORTHROP VENTURA
o COMMUNICATIONS		o ENVIRONMENTAL CONTROL	AIRESEARCH
DIGITAL COMMAND SYS	MOTOROLA	o CREW STATION	
VOICE CONTROL CENTER	COLLINS RADIO	EJECTION SEAT	WEBER
RADAR BEACONS (C&S-BAND)	ACF INDUSTRIES	DISPLAYS & INDICATORS	VARIOUS
o INSTRUMENTATION		o PYROTECHNICS	VARIOUS
DATA TRANSMISSION SYS	ELECTRO-MECHANICAL RESEARCH		

MAJOR SUBCONTRACTOR PERFORMANCE

SUMMARY

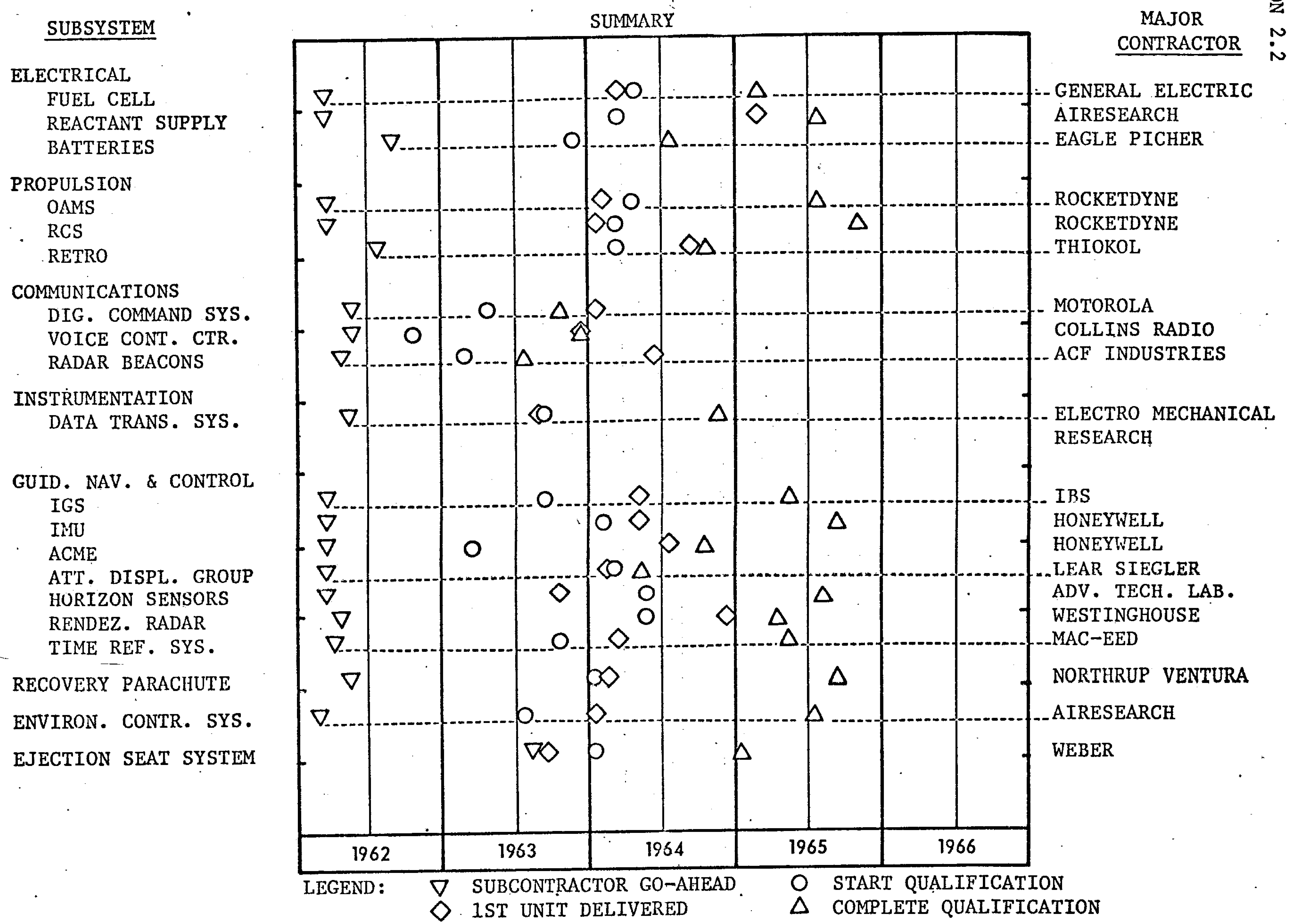


FIGURE 2-8

PROPRIETARY – SEE NOTICE ON TITLE PAGE

GEMINI MISSION PROFILE
(GEMINI VIII FLIGHT PLAN)

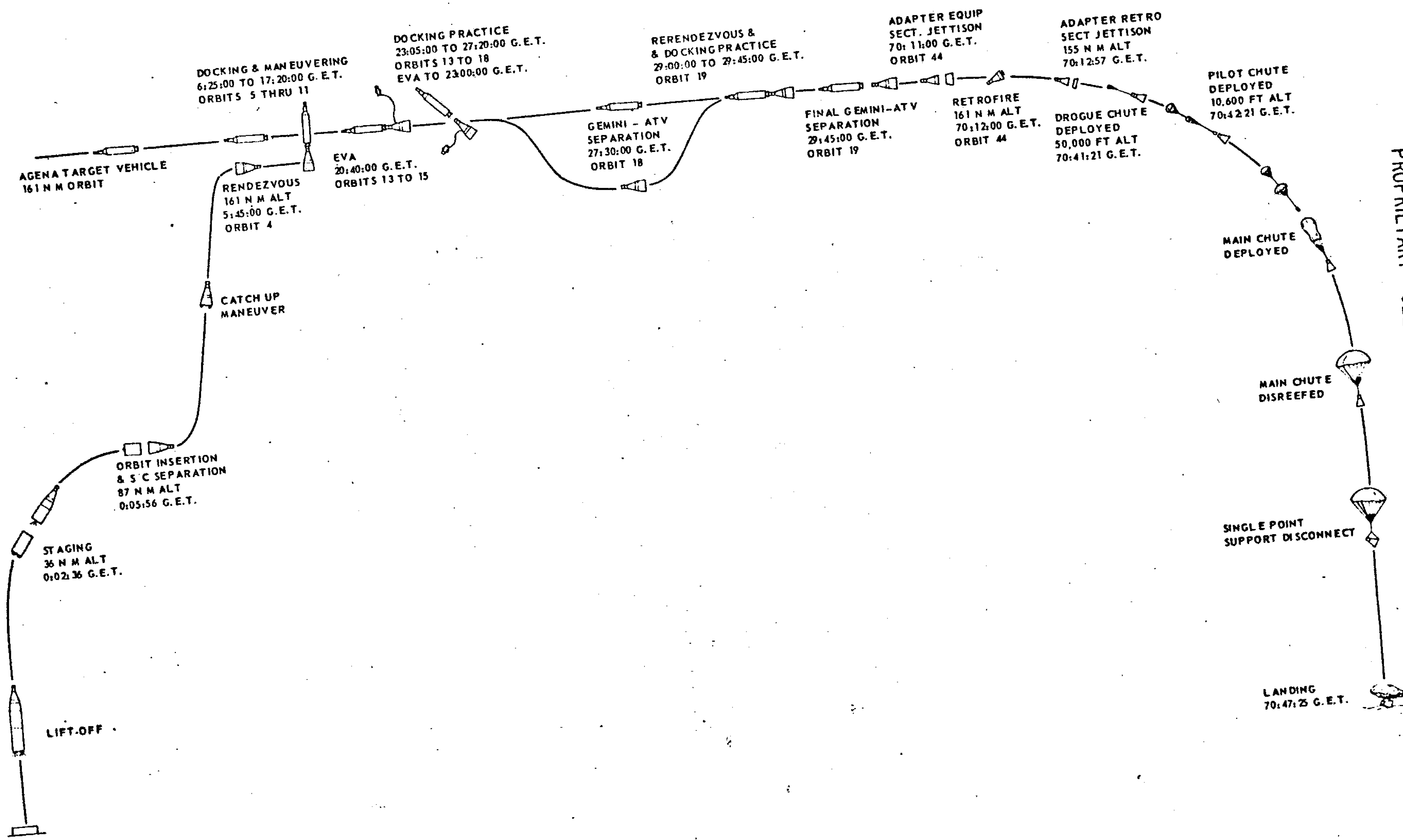


FIGURE 2-9

tests which investigated the design concepts under simulated environmental conditions. In particular, wind tunnel tests were performed to provide aerodynamic and aerothermodynamic data important to resolution of vehicle configuration and further definition of the vehicle design environments. Radiant heat tests, plasma jet tests and structural element tests evaluated the suitability of thermal structure concepts to meet these environments. The resultant spacecraft thermal structure design is described in detail in Section 2.3, CARF WBS 01-01-00-00 (Entry Vehicle) and CATF WBS 02-01-00-00 (Mission Module). Further testing to verify the spacecraft thermal structure environmental design suitability is described in Section 2.3, CATF WBS 92-09-00 and Section 2.3.1, Time-Phased Project Effort.

The environments experienced by the spacecraft during its mission, in addition to those encountered during non-operational phases (ground handling, storage and transportation) play a major role in the design and validation of the spacecraft subsystems and components. The environmental criteria for a particular subsystem considers the interaction of the spacecraft environment with the subsystem as a function of the subsystem physical and functional parameters, location within the spacecraft and environmental protection (shock mounts, cold plates, insulation). The environments to which the Gemini subsystems were qualified are presented with the respective subsystem descriptions in Section 2.3.

The design requirements for the Gemini thermal-structure as related to the launch, orbit, de-orbit and landing phases of its mission profile are presented in Table 2-7. Limit design load factors by various mission phases are given in Table 2-8.

During the Gemini flight program - in particular the unmanned launches and testing programs that duplicated flight environments such as parachute recovery subsystem air drop tests and ejection seat sled tests, actual environments were measured and compared to those generated for the spacecraft design and validation criteria. The latter were adjusted, as appropriate, and reflected in the final design and qualification prior to the manned missions. Actual shingle temperatures recorded during the flight of Spacecraft No. 2 are depicted in Figure 2-10. Maximum shingle temperatures resulted during the entry phase of the mission. The nominal entry velocity profile for the Gemini spacecraft is shown in Figure 2-11.

SECTION 2.2

TABLE 2-7
MISSION RELATED GEMINI THERMAL STRUCTURE
DESIGN REQUIREMENTS

DESIGN PARAMETER	MISSION PHASE: LAUNCH	ABORT	ORBIT	ENTRY	LANDING
SPACECRAFT ULTIMATE WEIGHT (LB)	8,500	5,900	8,450	Retro: 5900 Entry: 5050 Drogue: 4930 Main Chute: 4550	4,550
DYNAMIC PRESS. ("q"~PSF)	795	795 (Mode I)* 477 (Mode II)**	N.A.	120 (Drogue Deploy)	N.A.
MAX. αq (RAD-PSF)	194.2		N.A.	N.A.	N.A.
MAXIMUM TEMPERATURE (°F)	R&R: 520 Top, 330 Bott. RCS: 320 Top, 180 Bott. Crew: 760 Adapt.: 595	Same As Crew Sect. For Entry Phase	+250 -150	R&R: 1320 Top, 1600 Bott. RCS: 1320 Top, 1600 Bott. Crew Sect.: 1190 Top, 1760 Bott.	N.A.
MAX. HEATING RATES ~ 0° ANGLE OF ATT. STAGNATION	10.0 BTU/Ft^2/Sec	70.0 BTU/Ft^2/Sec	N.A.	70.0 BTU/Ft^2/Sec	N.A.
ACOUSTIC LEVEL (db)	155 (Adapter) 165 (Entry Veh.)	N.A.	N.A.	N.A.	N.A.
VIBRATION LEVEL (g's RMS RANDOM)	8.8	N.A.	N.A.	6.2	N.A.
PRESSURE (PSI)	△ Fairing: +10.3 R&R: +0.35, -4.10 RCS: +3.0, -2.7 Crew: +7.1, -1.0 Window: +8.6	△ Adapter: +2.0, -1.15 (Crew Hatches Open)	Crew Section: 12.0 Burst, 3.0 Collapse	△ R&R: +0.88 RCS: +4.22 Crew: +0.70, -0.76	Ult. Press. Heat Shield: 90 PSI Shingles: 120 PSI

N.A. Not Applicable
* Mode I ~ Astronaut Ejection; 36,500 Ft Alt, M=1.47
** Mode II ~ Retro Abort; 70,000 Ft Alt, M-2.8
△ ~ P (Absolute) - P (Ambient)

SECTION 2.2

TABLE 2-8

GEMINI LIMIT LOAD FACTORS

MISSION PHASE	LOAD FACTORS		
	LONGITUDINAL	LATERAL	VERTICAL
HANDLING:			
GROUND	6.0	6.0	6.0
AIR	2.2	1.65	4.4
SHOCK	15.0	15.0	15.0
LAUNCH	7.25	0	0
SPACE OPERATIONS	1.55	0	0
RETROGRADE	.5	0	0
ENTRY	16.5	4.5	4.5
LANDING	30.0	15.0	15.0
ABORT	11.6	7.25	7.25

ADVANCED SPACECRAFT SUBSYSTEM COST ANALYSIS
STRUCTURE/SUBSYSTEM INTEGRATION

PROPRIETARY – SEE NOTICE ON TITLE PAGE

SECTION 2.2

GEMINI SPACECRAFT
SHINGLE TEMPERATURE

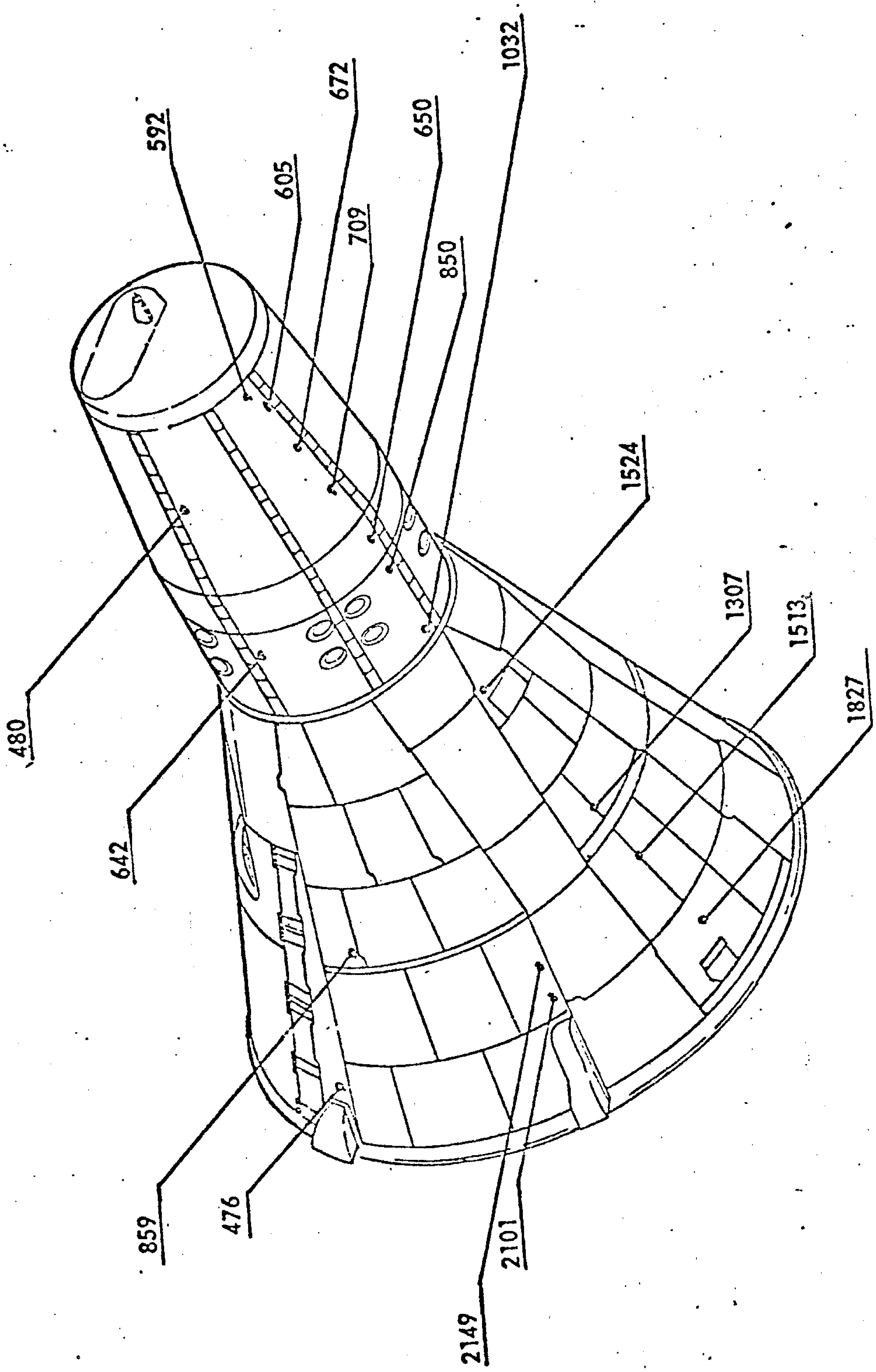


FIGURE 2-10

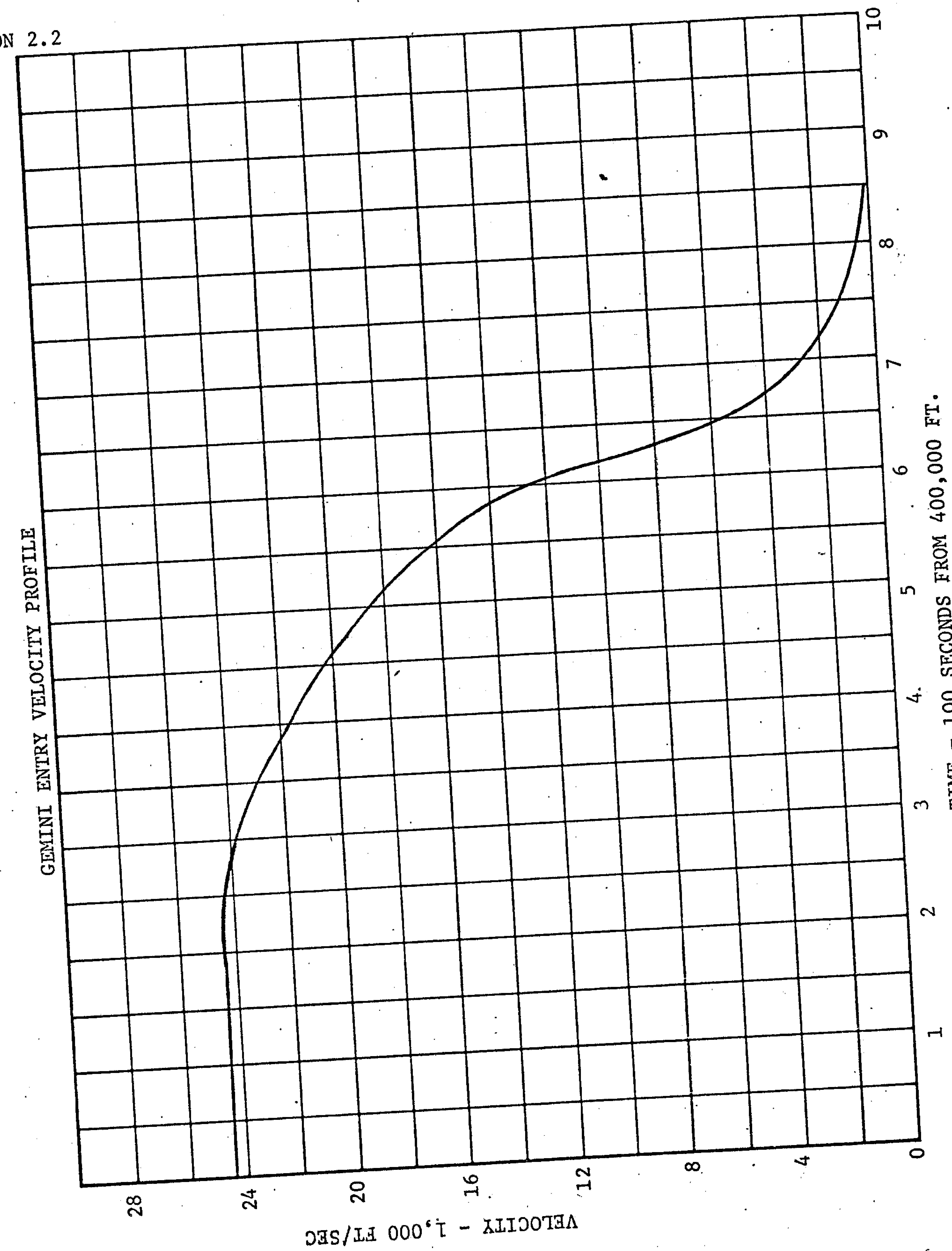

GEMINI ENTRY VELOCITY PROFILE
TIME – 100 SECONDS FROM 400,000 FT.
0
1
2
3
4
5
6
7
8
9
10
VELOCITY – 1,000 FT/SEC
28
24
20
16
12
8
4

FIGURE 2-11

PROPRIETARY – SEE NOTICE ON TITLE PAGE

SECTION 2-3

PROPULSION SYSTEMS ARRANGEMENT

01-03-00-00

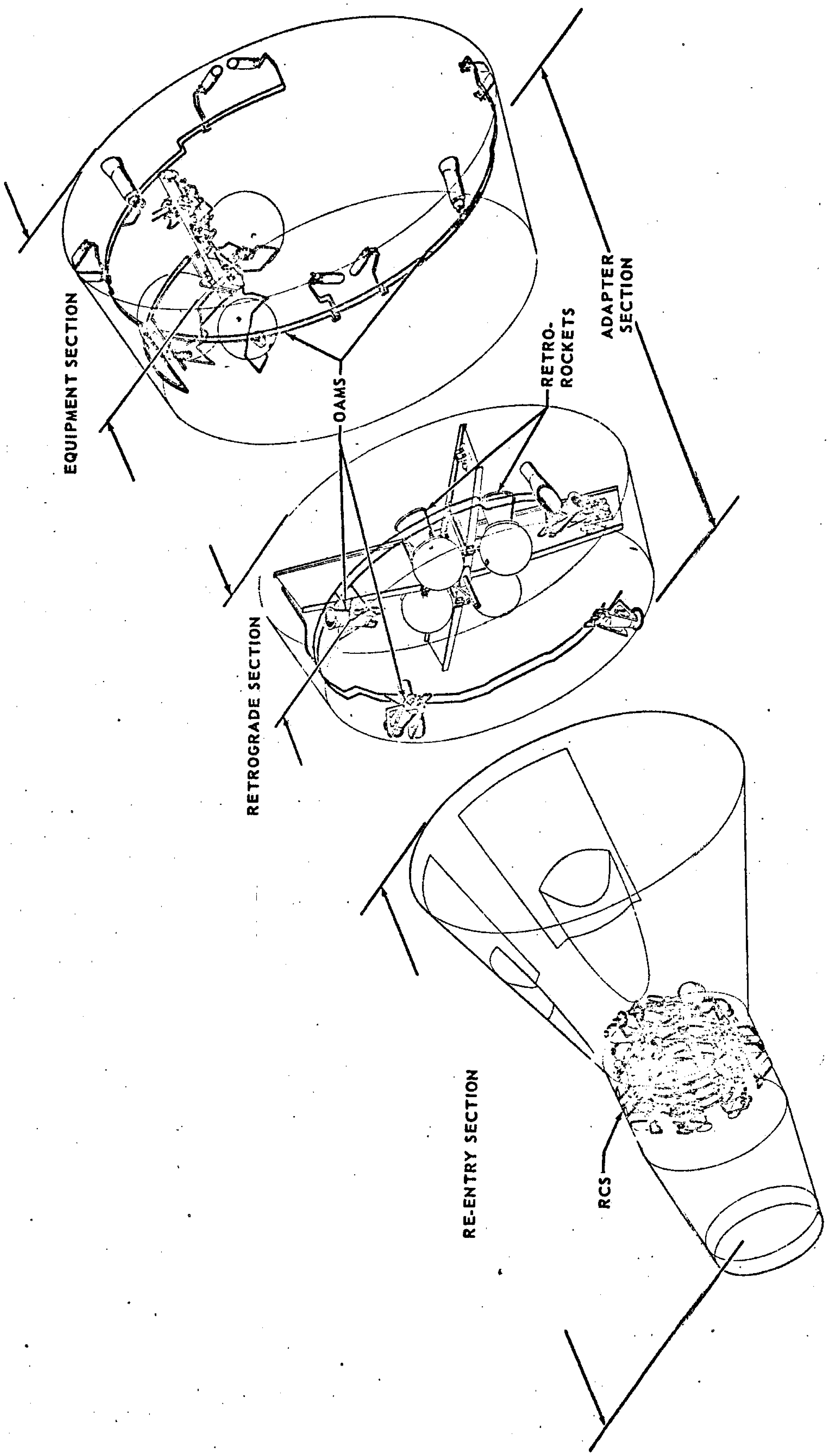


FIGURE NO. 2-19

PROPRIETARY - SEE NOTICE ON TITLE PAGE

SECTION 2.3

ENVIRONMENTAL CONTROL SYSTEM

01-06-00-00

GENERAL ARRANGEMENT

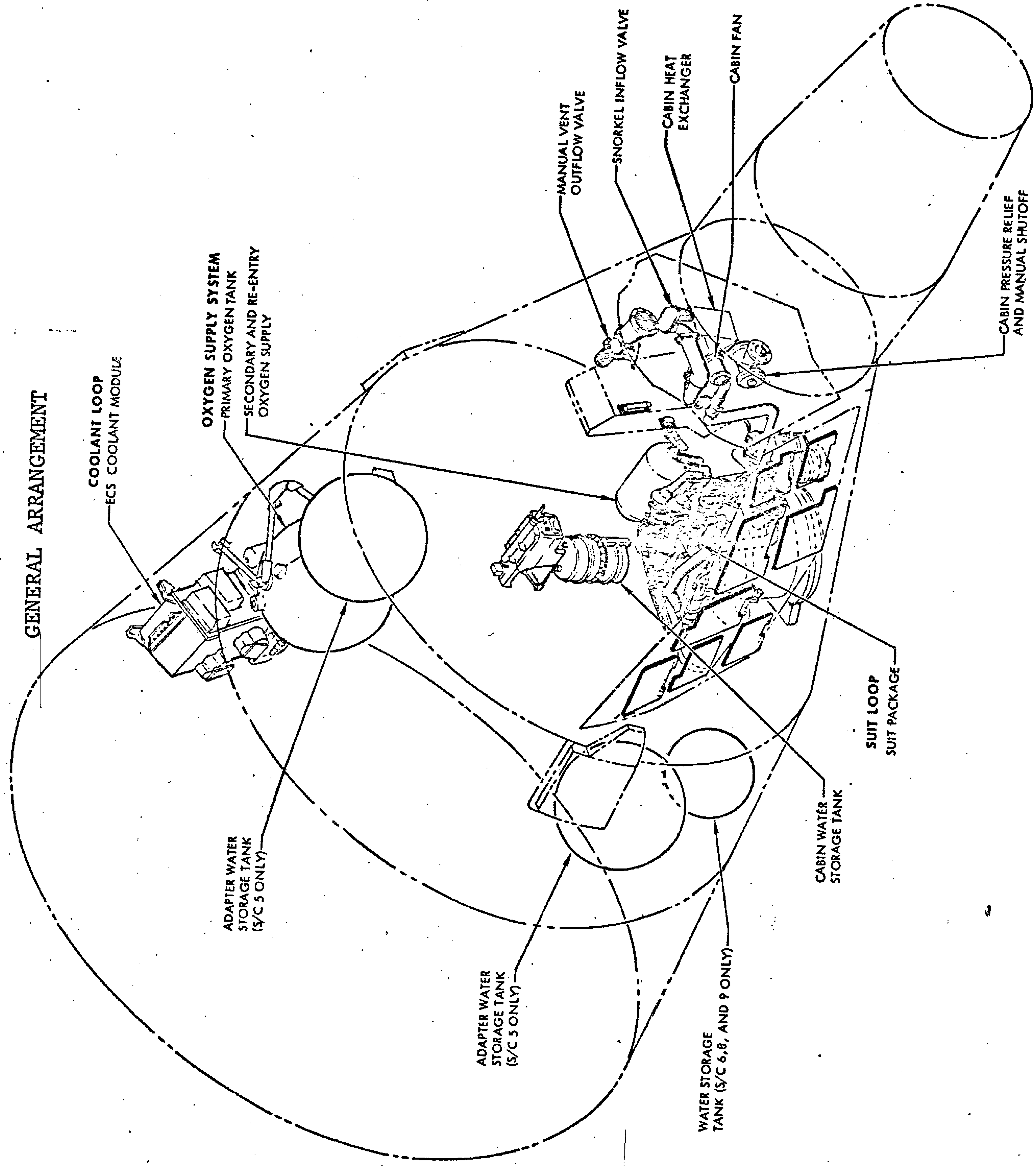


FIGURE NO. 2-24

SECTION 2.3

TABLE 2-48

ENVIRONMENTAL CONTROL SYSTEM

01-06-00-00

DESIGN CRITERIA

METABOLIC	
HEAT PRODUCTION RATE	500 BTU/MAN/HR.
O_2 CONSUMPTION RATE	2.0 LBS./MAN/DAY
CO_2 PRODUCTION RATE	2.5 LBS./MAN/DAY
DRINKING WATER - POST LANDING - CABIN	14 LBS.
- EMERGENCY - SURVIVAL KITS	9 LBS. APPROX.
DRINKING WATER REQUIRED	7.5 LBS./MAN/DAY
WATER STORED IN THE ADAPTER - 14-DAY	210 LBS.
WATER PRODUCTION	
PERSPIRATION AND RESPIRATION	4 LBS./MAN/DAY
URINE	3 LBS./MAN/DAY
FECES	0.5 LB./MAN/DAY
LATENT COOLING	
PRE-LAUNCH	291 BTU/MAN/HR.
LAUNCH	291 BTU/MAN/HR.
ORBIT	AVG. 350-380 BTU/MAN/HR.
RE-ENTRY	480 BTU/MAN/HR.
POST LANDING	540 BTU/MAN/HR.
LEAKAGE	
CABIN (MEASURED AT SEA LEVEL WITH N_2 AND CABIN PRESSURE OF 19.7 PSIA)	500 CC/MIN.
SUIT (MEASURED AT SEA LEVEL WITH N_2 AND SUIT PRESSURE OF 19.7 PSIA)	300 CC/MIN.
CABIN EQUIPMENT HEAT INPUT	683 BTU/HR.
SUPERCRITICAL TANKAGE - ECS	
14-DAY MISSION - WATER SEPARATOR	112 LBS.
- FUEL CELLS	189 LBS. MAX.
ATMOSPHERIC PURIFICATION	
HEAT PRODUCTION RATE	400 BTU/MAN/HR.
MAXIMUM ALLOWABLE CO_2 PARTIAL PRESSURE	8 MM HG.
HEAT GENERATED/LB. CO_2 ABSORBED	1286 BTU
L_iOH REQUIRED/LB. CO_2 ABSORBED	1.08 LB.
L_iOH REQUIRED - 14-DAY MISSION	71.0 LBS.

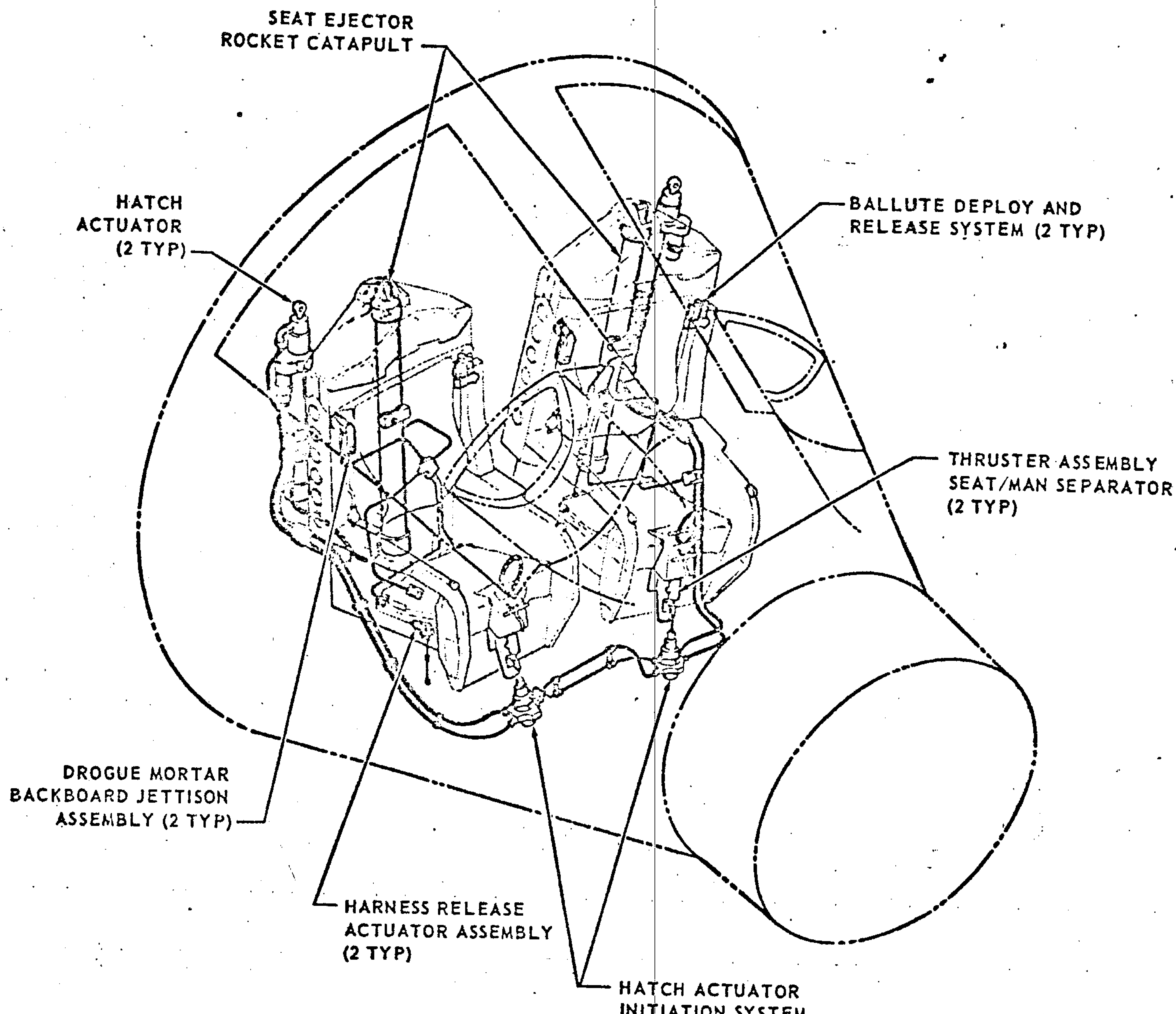
PROPRIETARY – SEE NOTICE ON TITLE PAGE

SECTION 2.3

LAUNCH ESCAPE SUBSYSTEM

01-09-00-00

EJECTION SEAT SYSTEM AND DEVICES

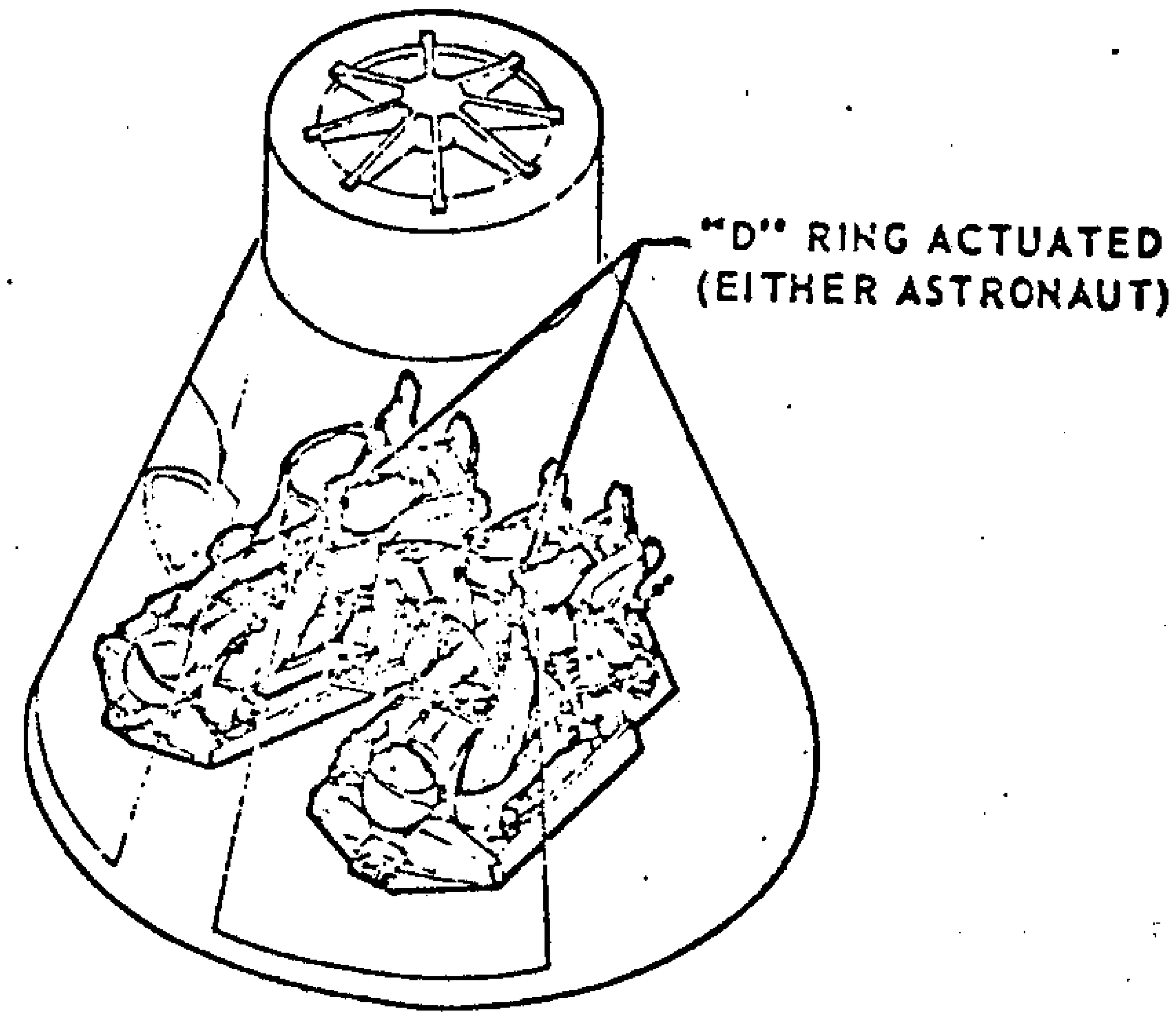


SECTION 2.3

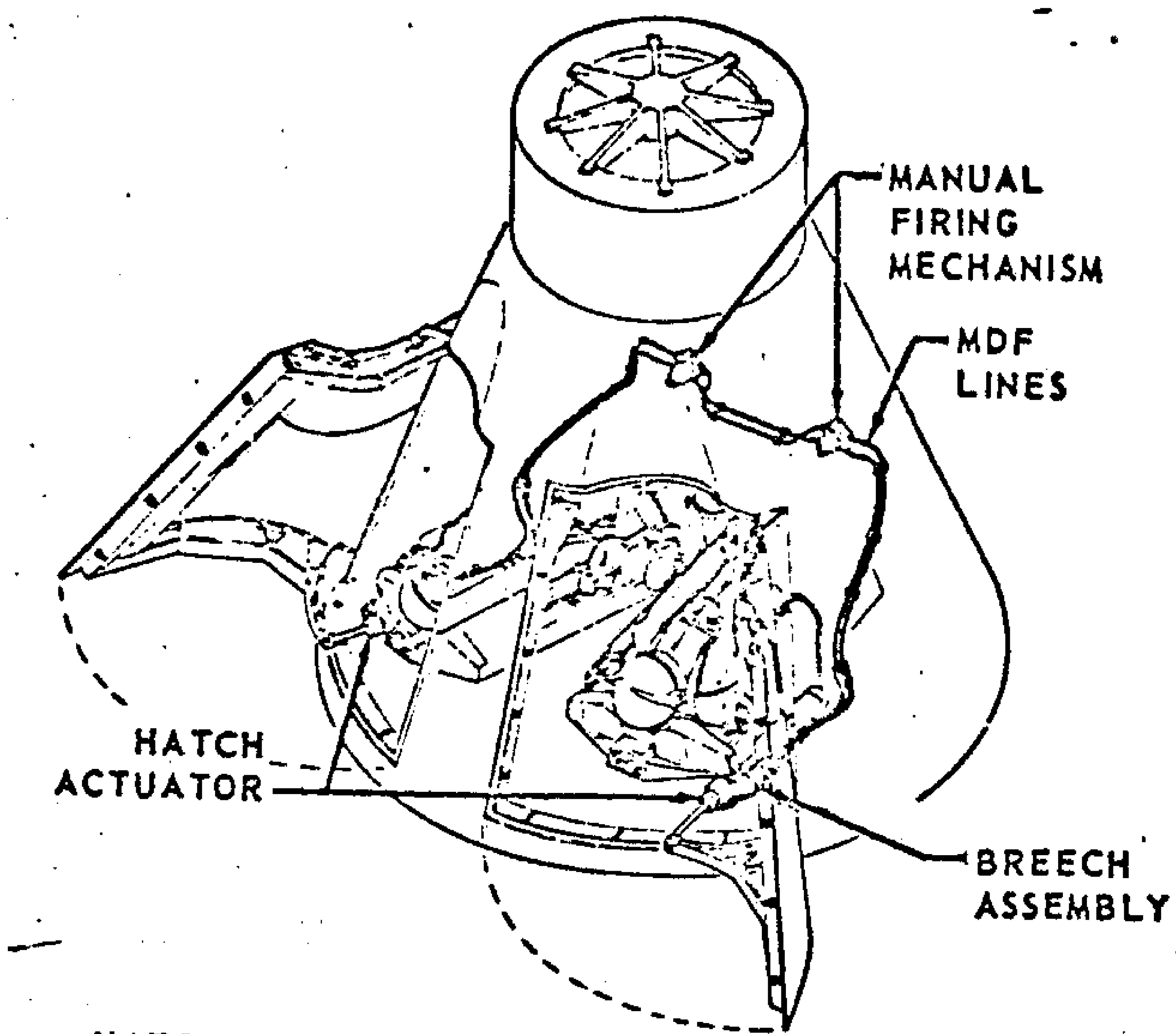
LAUNCH ESCAPE SUBSYSTEM

01-09-00-00

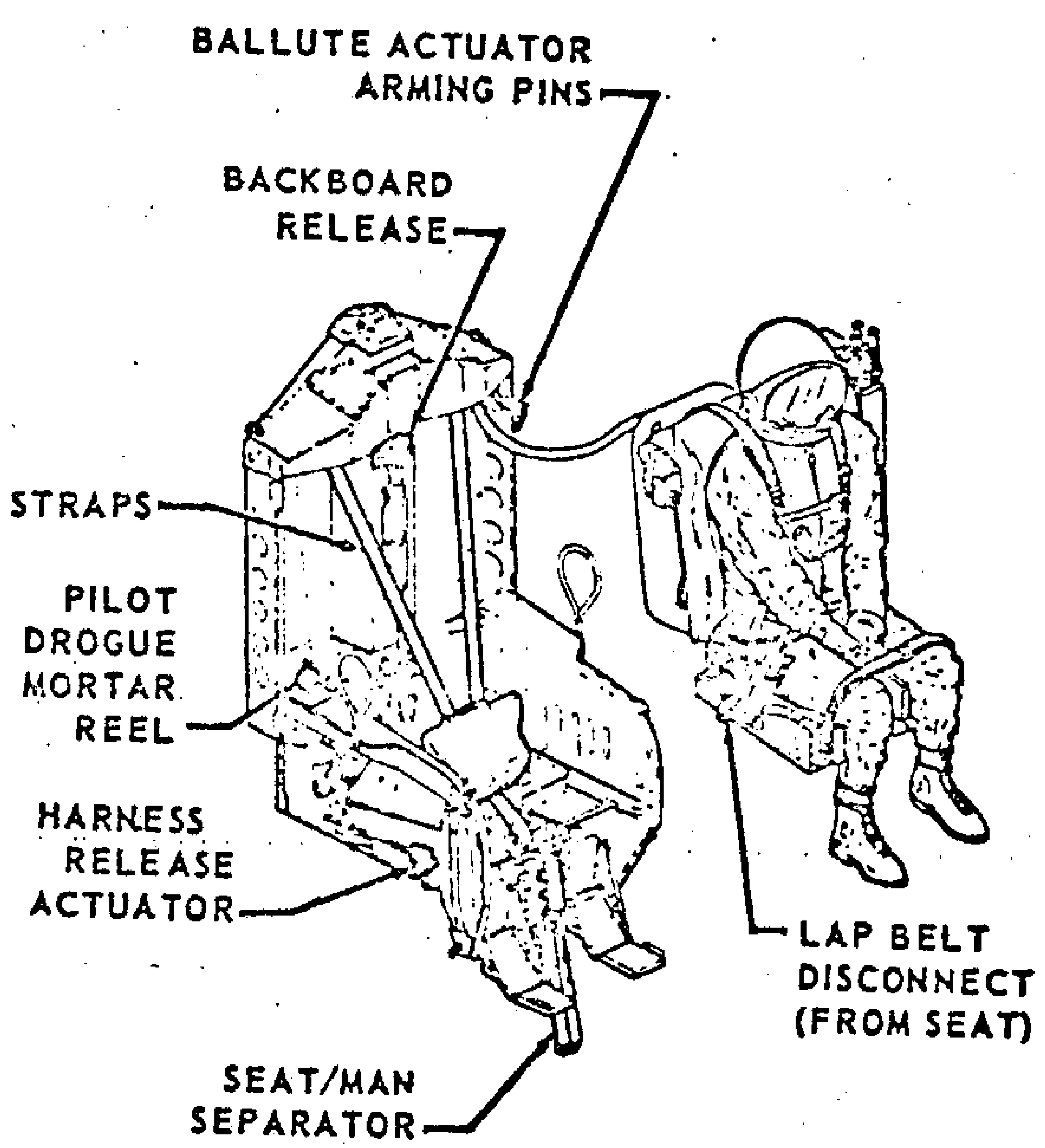
EJECTION SEAT SEQUENCE OF OPERATION



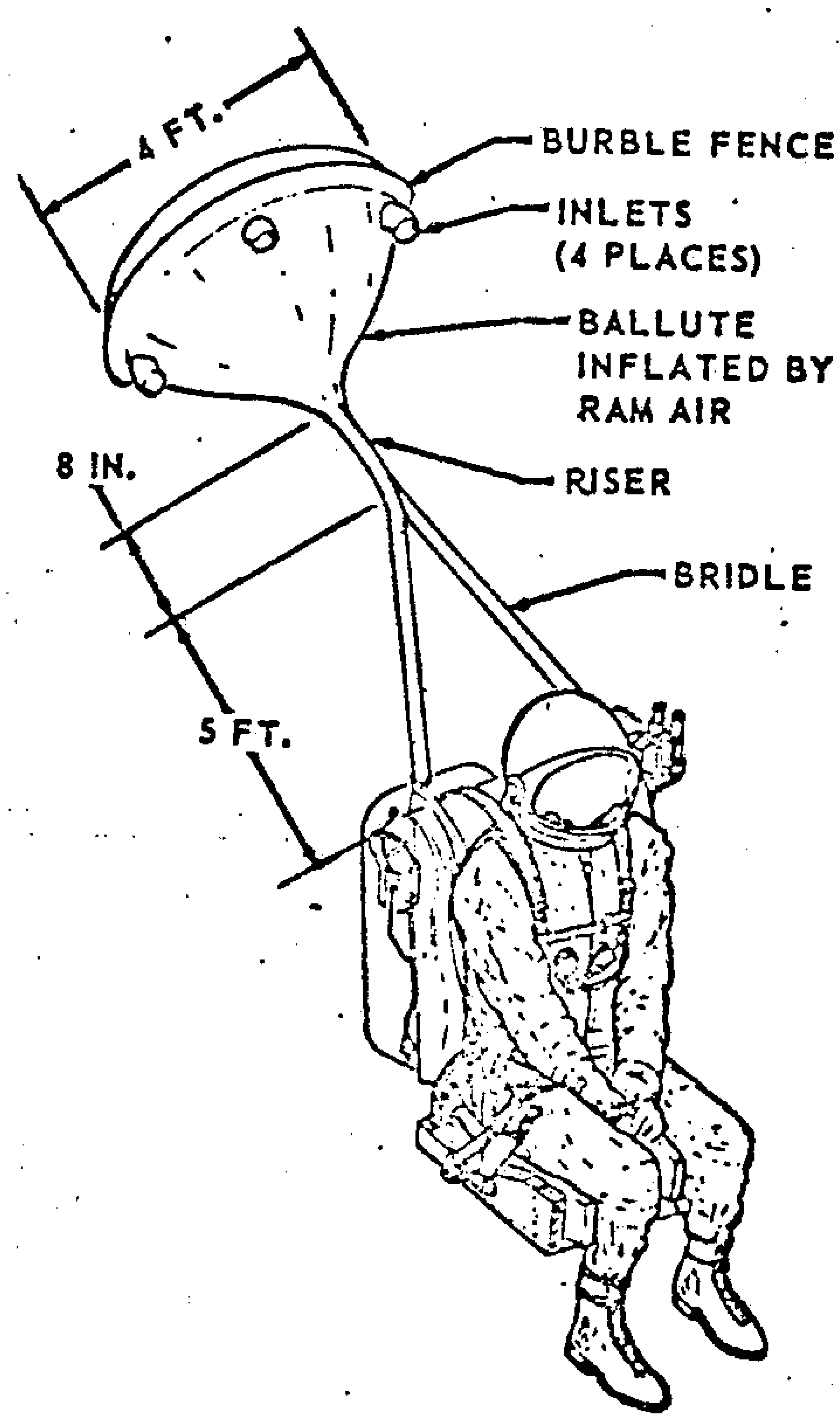
SYSTEM ACTIVATION – 0.0 SECONDS
SEQUENCE –1–



HATCHES OPEN – 0.250 SECONDS
SEQUENCE –2–



HARNESS RELEASE FIRES – 1.474 SEC.
SEAT/MAN THRUSTER FIRES – 1.524 SEC.
SEAT/MAN SEPARATED –
LANYARDS PULLED –



BALLUTE IS DEPLOYED 5.00 SEC.
AFTER SEPARATION
BALLUTE IS RELEASED AT 7500 FT.

FIGURE NO. 2-28

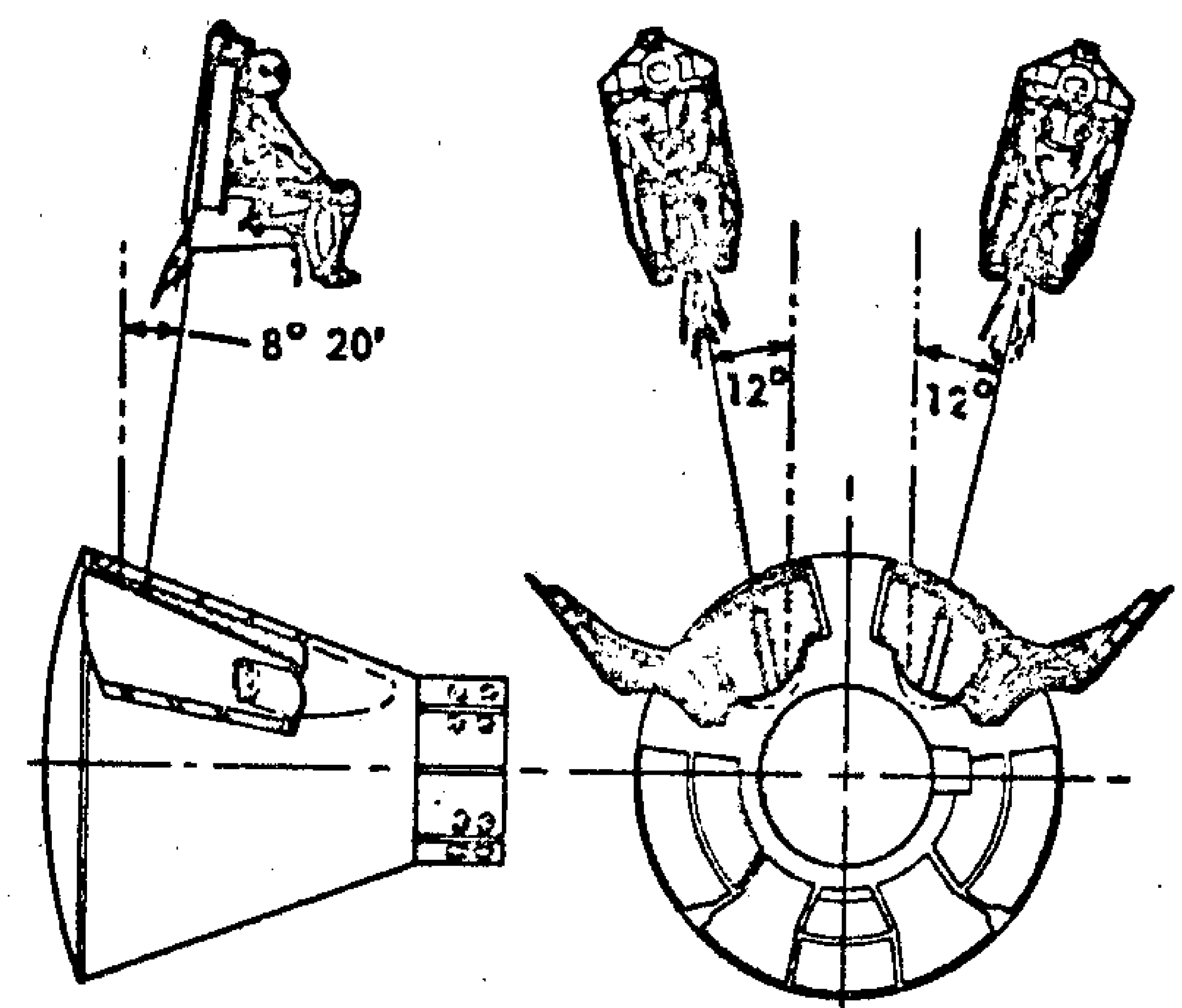
PROPRIETARY - SEE NOTICE ON TITLE PAGE

SECTION 2.3

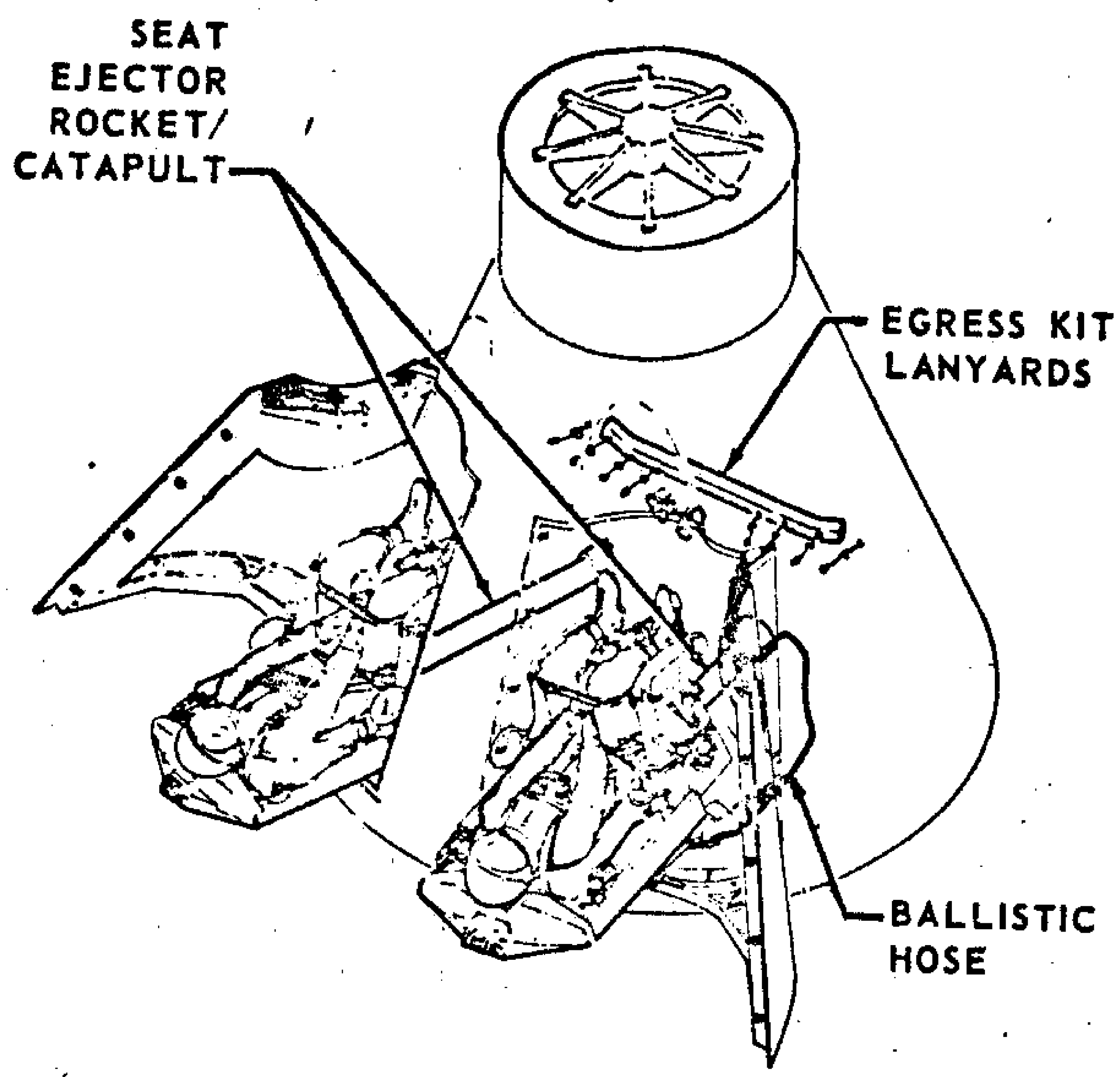
LAUNCH ESCAPE SUBSYSTEM

01-09-00-00

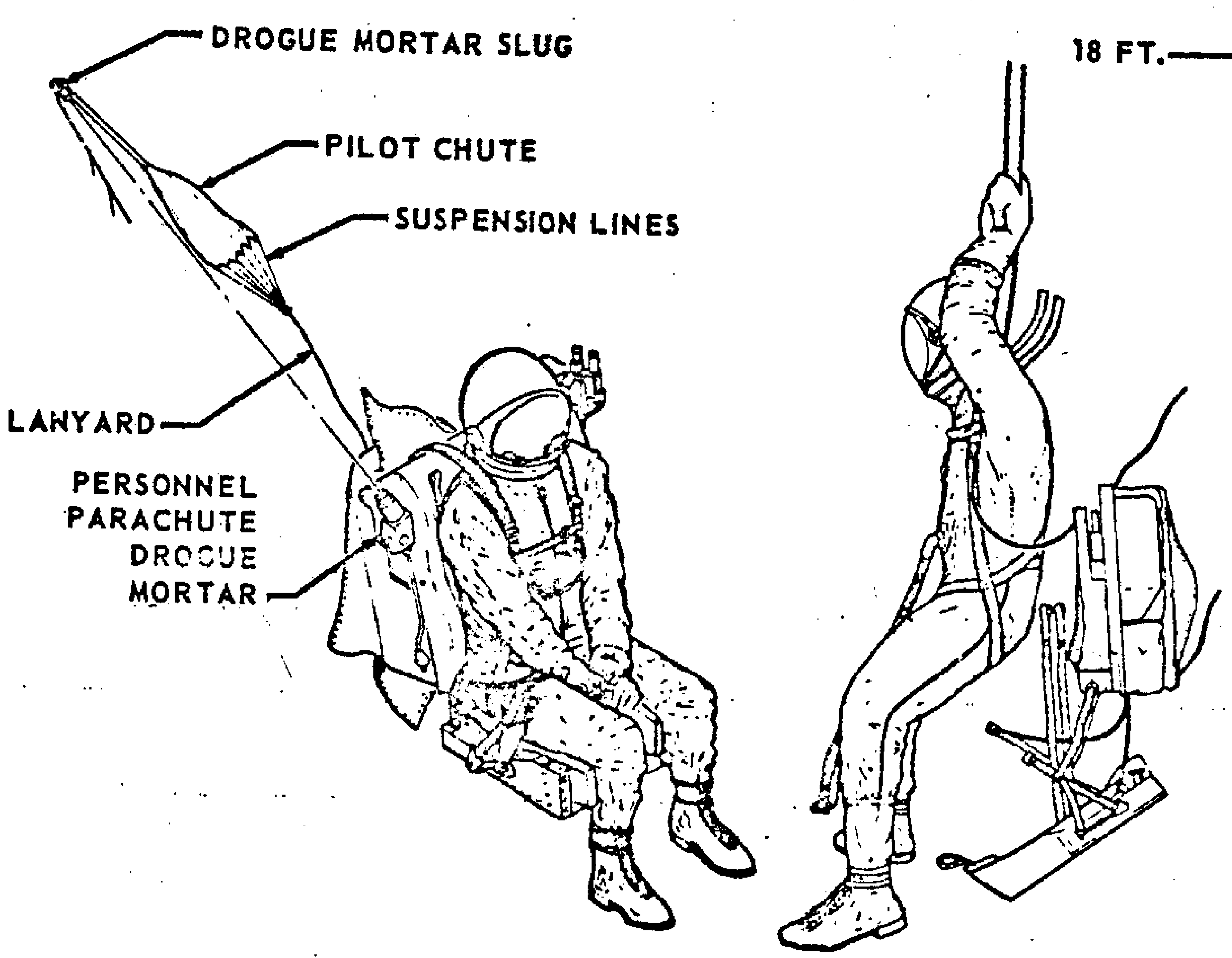
EJECTION SEAT SEQUENCE OF OPERATION (CONTINUED)



SEAT - MAN SEPARATED FROM SPACECRAFT



ROCKET CATAPULT FIRES - 0.333 SEC.
LANYARDS PULLED - 0.394 SEC.
SEQUENCE -3-



DROGUE MORTAR IS ACTUATED AT ALTITUDE OF 5700 FT. OR LESS. 2.30 SEC. TIME DELAY AFTER ACTIVATION FOR FIRING.

BACKBOARD & EGRESS KIT JETTISON 3.00 SEC. AFTER DROGUE MORTAR FIRES.

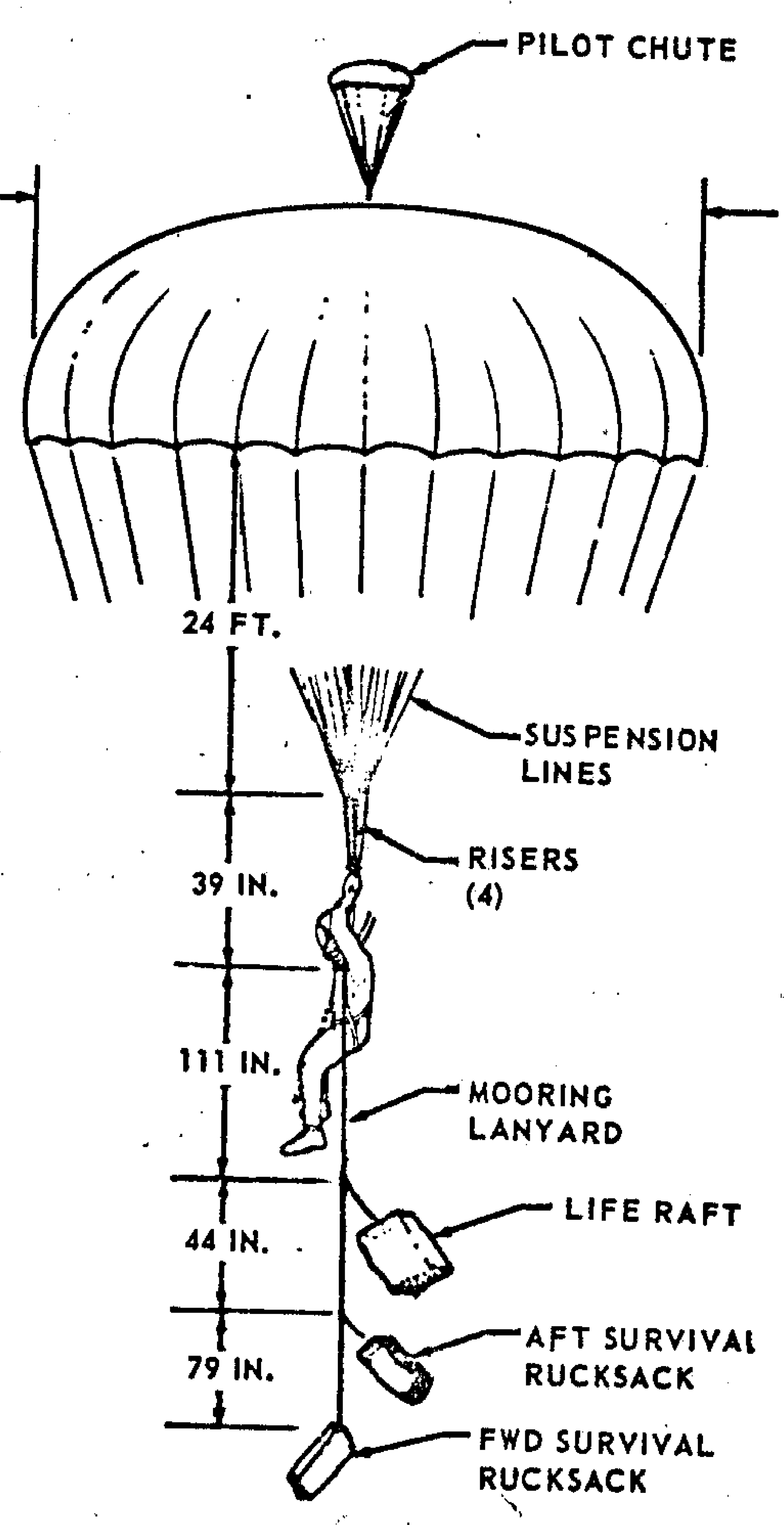


FIGURE NO. 2-28 (CONT'D)

PROPRIETARY – SEE NOTICE ON TITLE PAGE

SECTION 2.3

RECOVERY SUBSYSTEM

01-15-06-00

DEPLOYED PARACHUTE DIMENSIONS

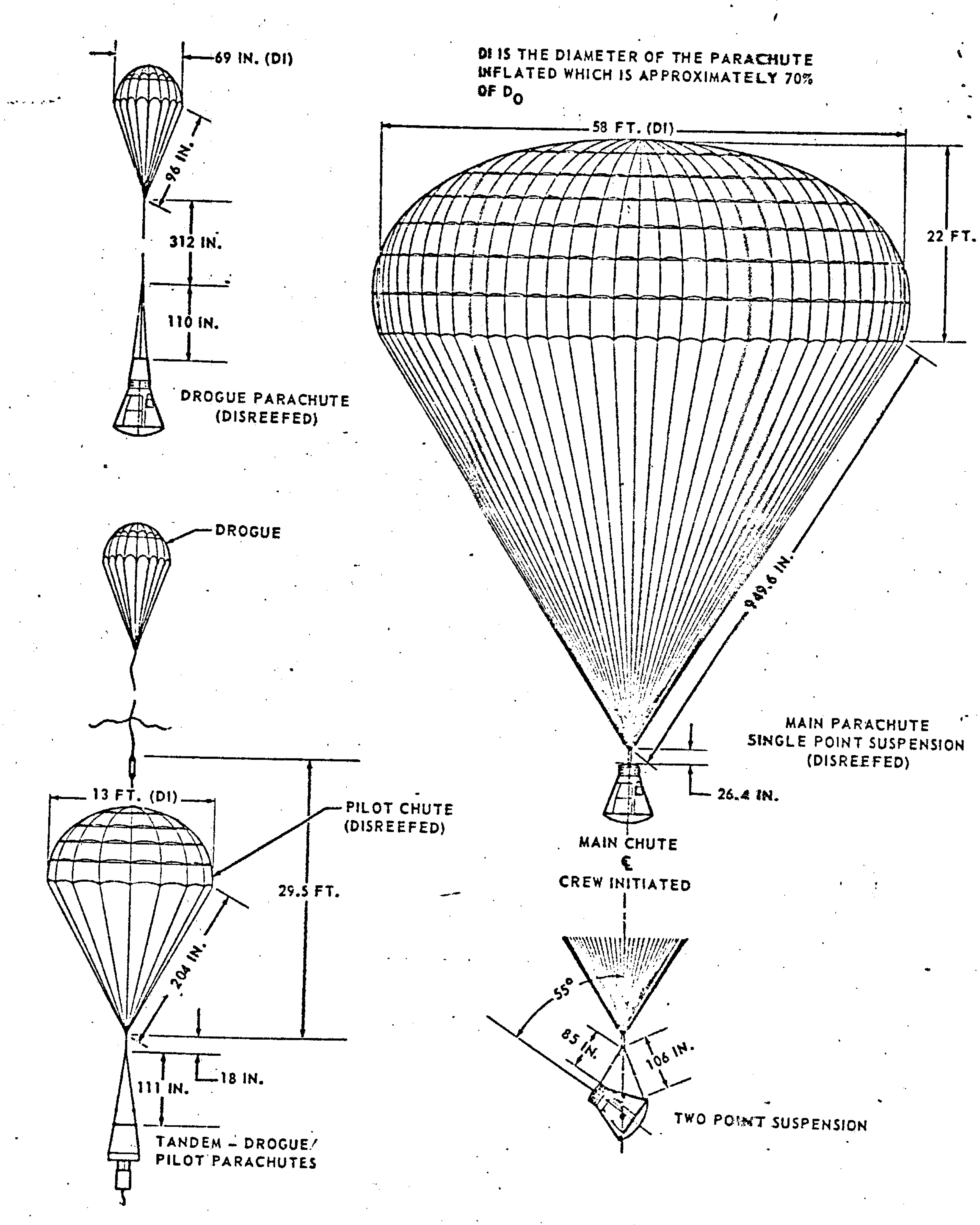
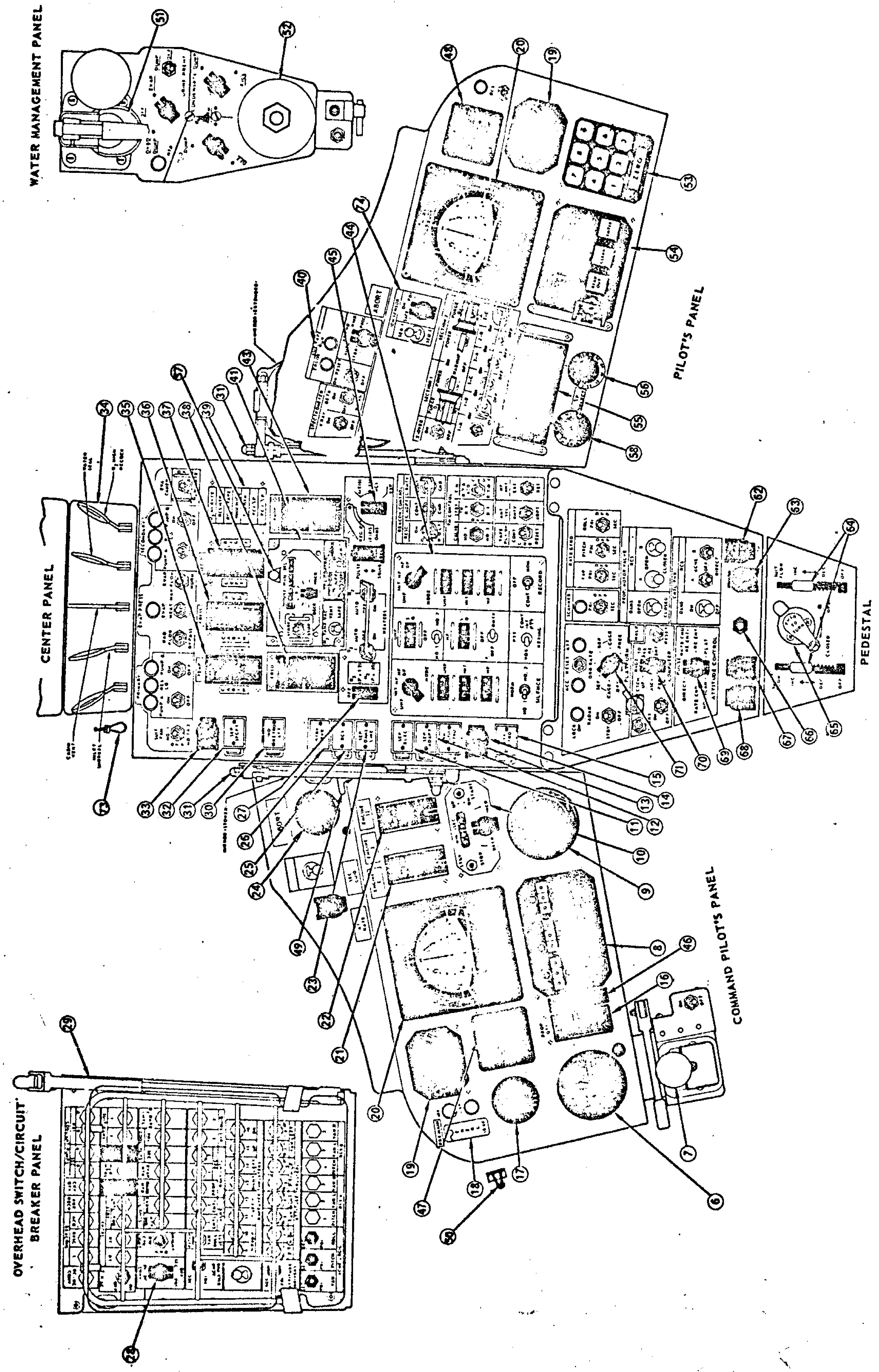


FIGURE NO. 2-33

SECTION 2.3

SPACECRAFT 12 CREW STATION DISPLAYS, CONTROLS AND FURNISHING

01-16-00-00



ADVANCED SPACECRAFT SUBSYSTEM COST ANALYSIS
STRUCTURE/SUBSYSTEM INTEGRATION

PROPRIETARY - SEE NOTICE ON TITLE PAGE

SECTION 2.3

MISSION MODULE PROPULSION

02-03-00-00

RETROGRADE SUBSYSTEM INSTALLATION

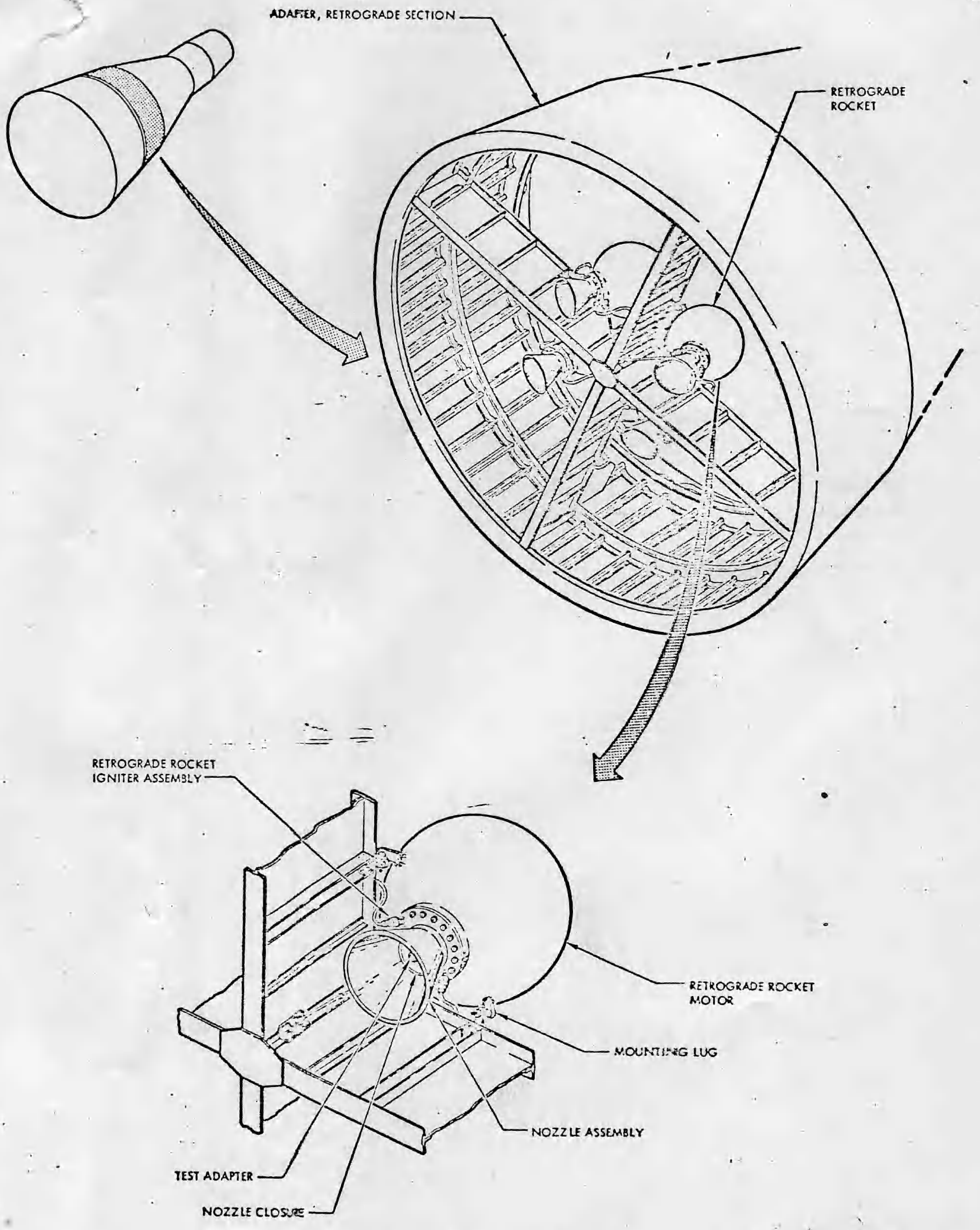


FIGURE NO. 2-39

TOTAL GEMINI PROGRAM COST

($688,505,000)

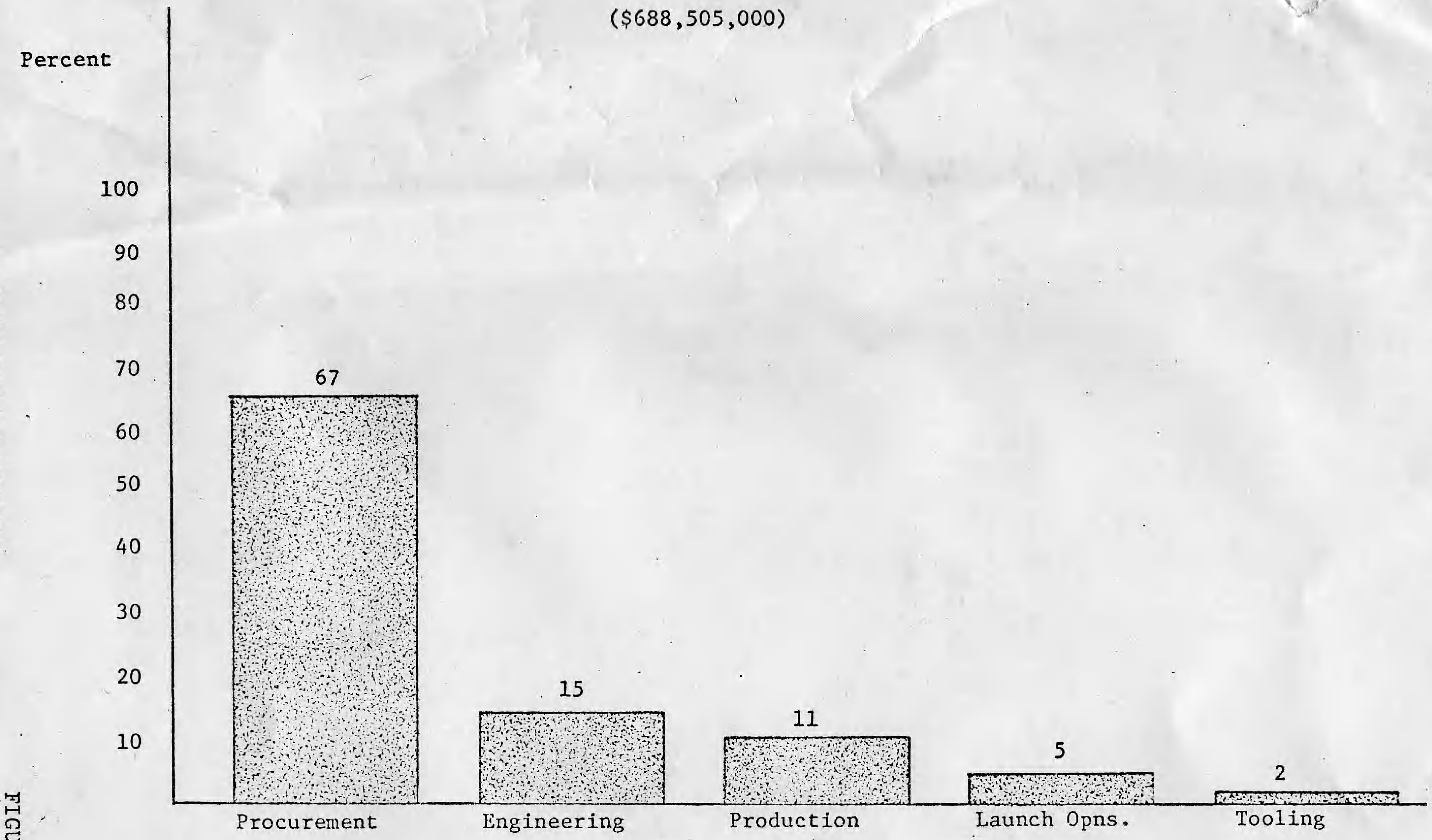


FIGURE 2-73