

AUGUST 1, 1970

DAC 56694B

**ORBITAL WORKSHOP
DESIGN DATA DOCUMENT**

MCDONNELL DOUGLAS ASTRONAUTICS COMPANY

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vehicle to establish a safe and habitable
nned experimental operations.

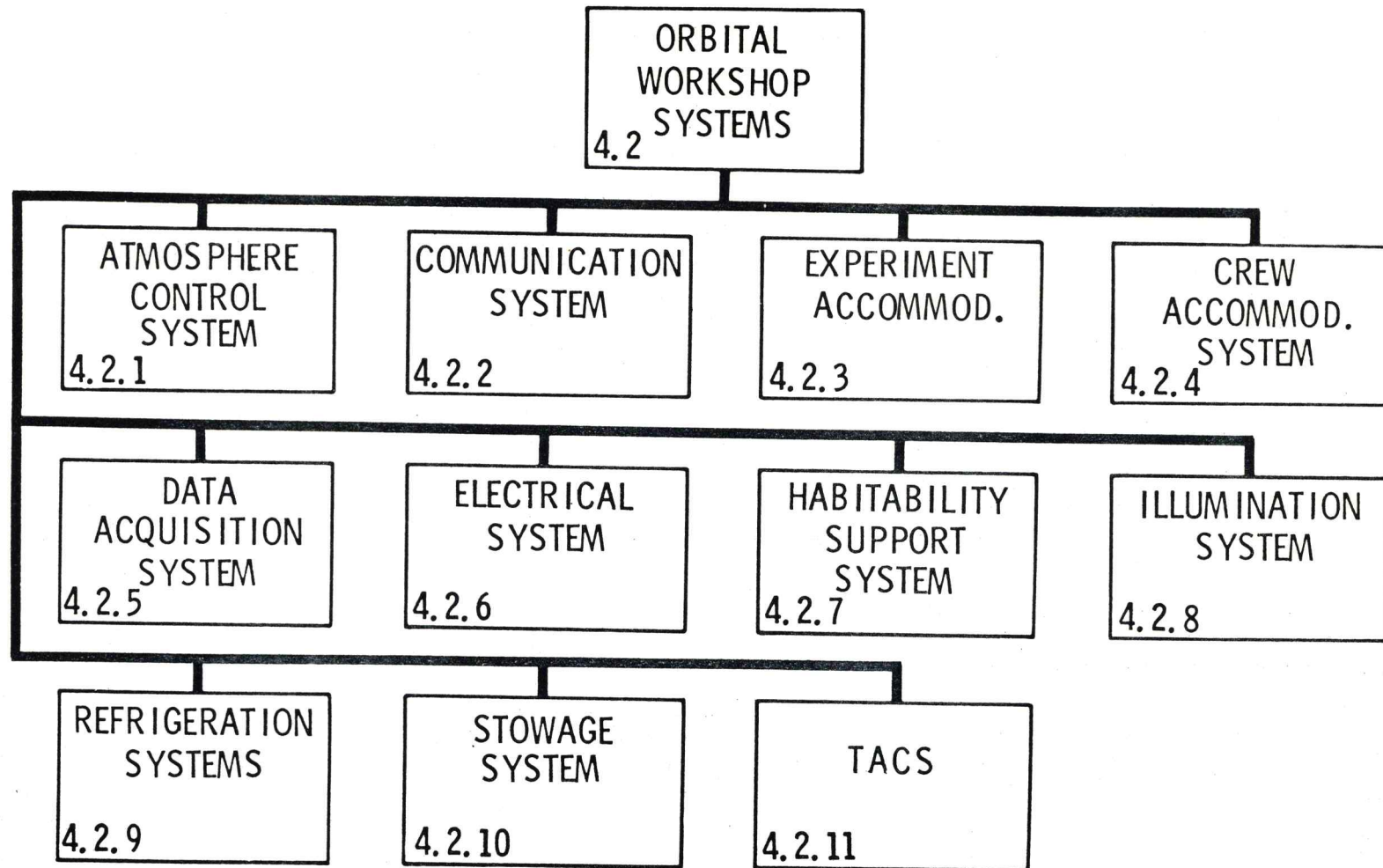
4.2 ORBITAL WORKSHOP SYSTEMS

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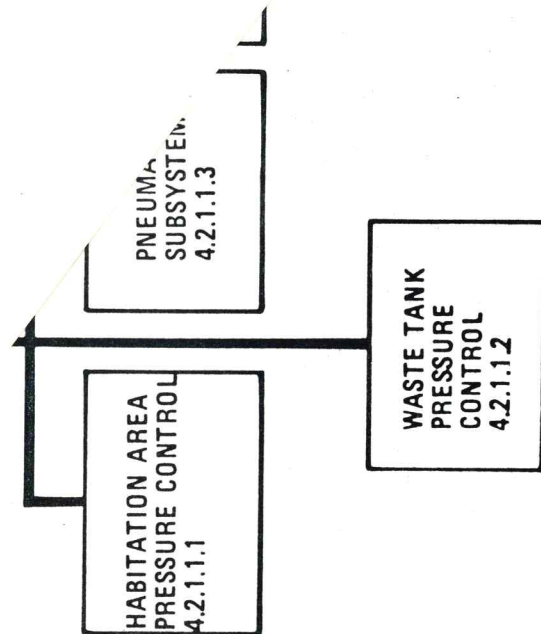
The Orbital Workshop (OWS) systems consist of functional and structural provisions incorporated into the OWS vehicle to establish a safe and habitable astronaut work space and facilitate planned experimental operations.

ORBITAL WORKSHOP

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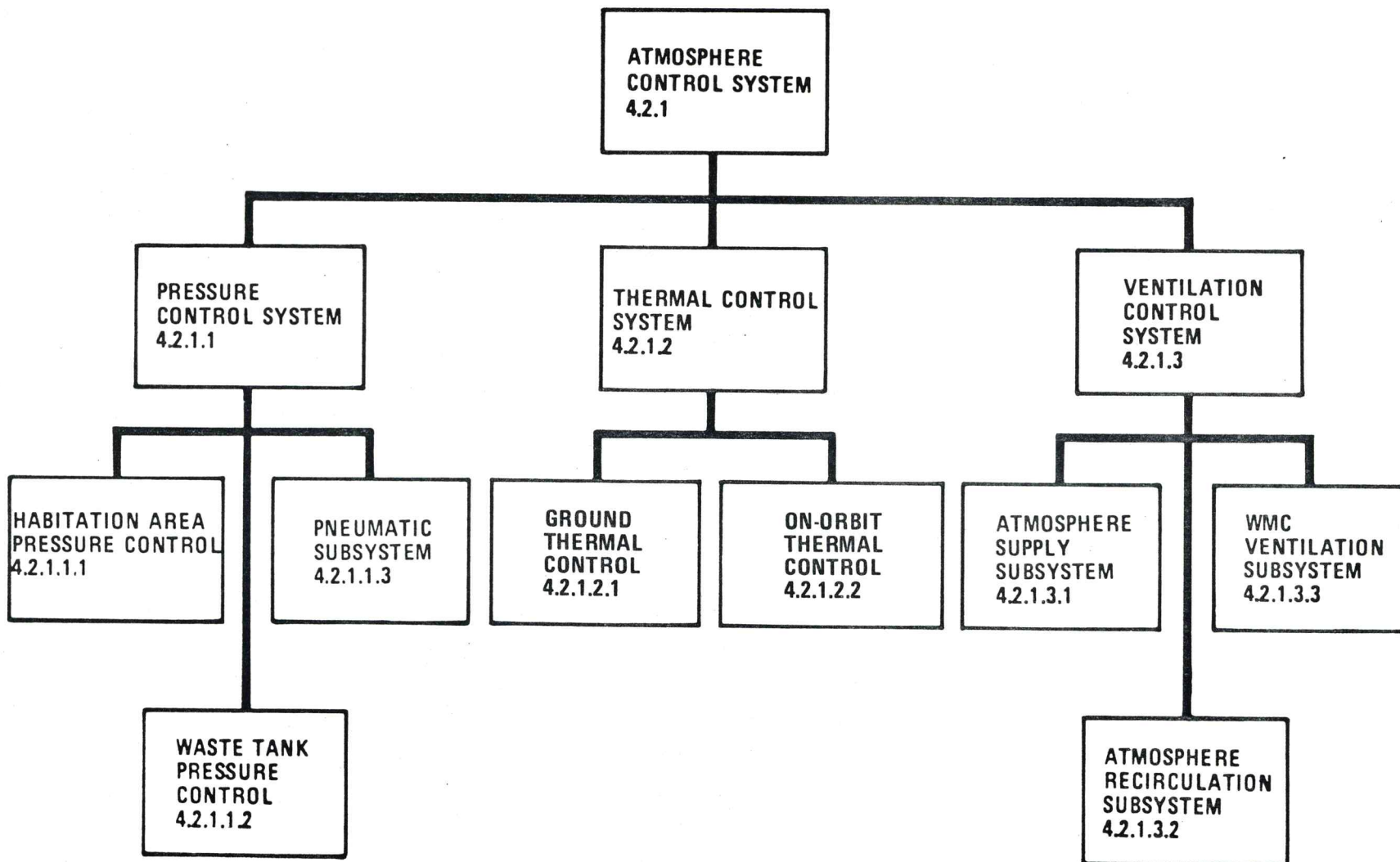


ATMOSPHERE CONTROL SYSTEM



ORBITAL WORKSHOP

O/W-8081
8-11-70



4.2.1 Atmosphere Control System

The atmosphere control system provides for (1) habitation area and waste tank prelaunch pressurization and pressure control during boost, (2) remote orbital pressurization and venting prior to and after crew entry, (3) active and passive control of atmospheric temperatures within the human comfort zone, and (4) controlled atmospheric circulation.

4.2.1.1 Pressure Control System

The pressure control system (Figure 421-1) provides for prelaunch pressurization and controlled inflight venting of the habitation area and the waste tank. Pressure schedules for normal and failure mode operations are tabulated in Table 421-1 and display in Figure 421-2.

4.2.1.1.1 Habitation Area Pressure Control

4.2.1.1.1.1 Habitation Area Vent System

The habitation area vent system includes two sets of valves: (1) a pair of parallel-redundant, normally closed, pneumatically actuated valves used for ground operations, initial blowdown, and automatic relief, and (2) a set of quad-redundant solenoid valves used for venting for storage.

The pneumatic valves (Figure 421-3) are identical to those used on the mainline S-IVB. These valves provide for rapid blowdown of the habitation area after orbital insertion. Venting at this time is desirable in order to minimize roll moment resulting from vent plume impingement on the solar arrays which are deployed about 50 minutes after insertion. The pneumatic valves can be operated only by the IU command system. The Skylab-2 crew will place a sealing device in the port for the pneumatic valves to minimize leakage of habitation area atmosphere. These valves also provide automatic relief capability with a maximum cracking pressure of 26 psia and a minimum reseal of 23 psia.

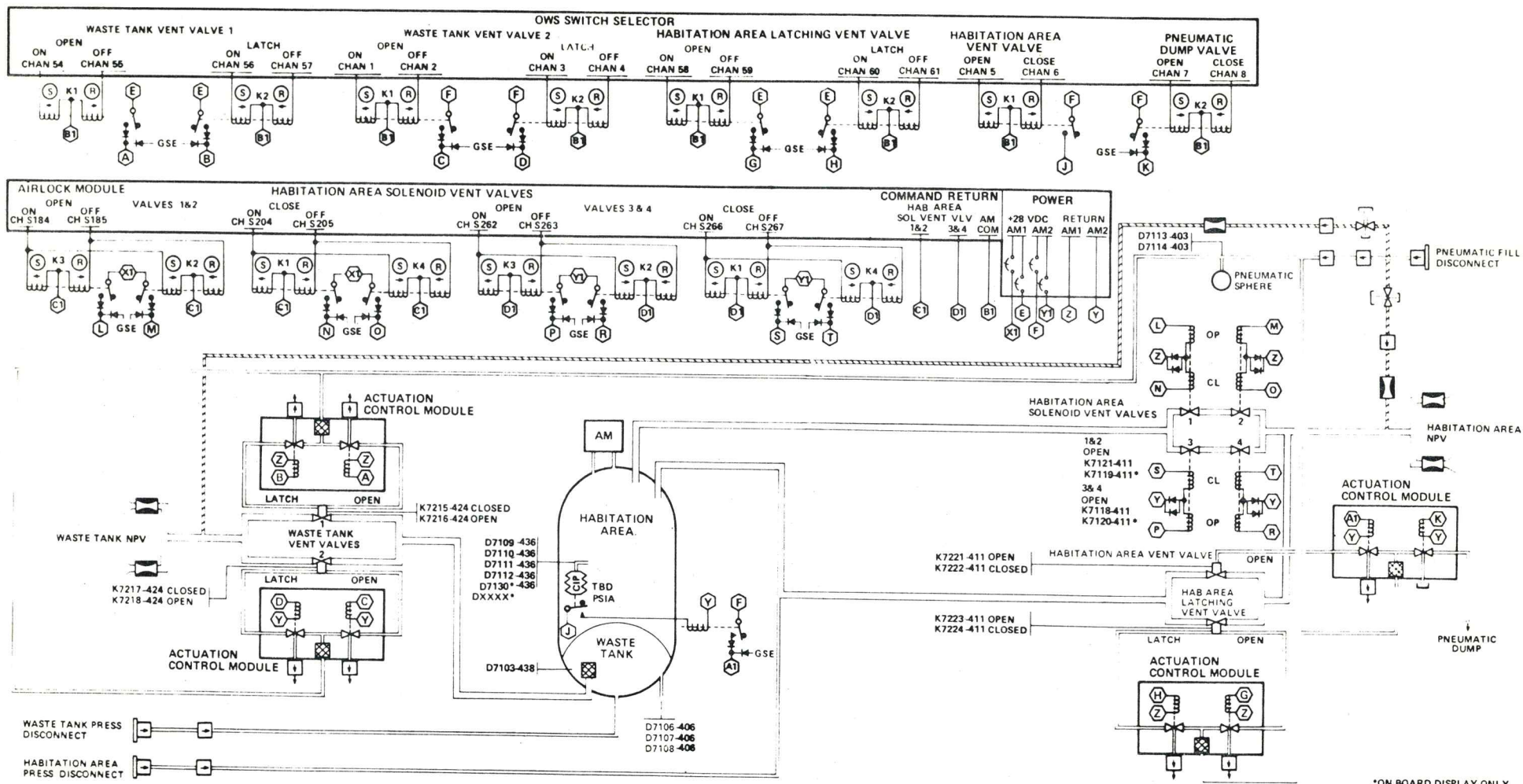
The solenoid valves provide the capability for venting of the habitation area by ground or crew action at any time during the mission. The port for the solenoid valves is also provided with a sealing device which will be in place during habitation periods. The sealing device will be removed at the end of each mission to permit blowdown of the habitation area.

The vent valves pass vapors into two equal length wrap-around ducts, each of which terminates in an orifice plate at the forward skirt. The orifice plates are in a plane perpendicular to the OWS centerline and are directed 180 degrees apart so that venting is nonpropulsive.

4.2.1.1.1.2 Orbital Pressurization System

Orbital pressurization is primarily an AM-controlled system. The OWS part of the system consists only of the connecting lines from the AM/OWS interface to the gas inlet port located in the electrical feedthru collar. The total system is described herein, because of the interrelationship of the AM and OWS systems. The schematic is shown in Figure 421-4.

O/W-813
6-17-70



*ON BOARD DISPLAY ONLY

PRESSURE CONTROL SYSTEM SCHEMATIC,
ORBITAL WORKSHOP

Figure 421-1.

Table 421-1

PRESSURE SCHEDULES - NORMAL AND FAILURE MODE OPERATIONS

| | | Tank Pressure (psia) | | | | | | | |
|---------------------|-------|----------------------|---------|------------|-----------------|-----------------|-------------------|------------|-------------------|
| | | Normal Operation | | | | Failure Mode | | | |
| | | Habitation Area | | Waste Tank | | Habitation Area | | Waste Tank | |
| Period | Notes | Maximum | Minimum | Maximum | Minimum | Maximum | Minimum | Maximum | Minimum |
| Prelaunch | A, B | 26 | Ambient | 26 | Ambient | 26 | Ambient | 26 | Ambient |
| Boost | | 26 | 22 | 26 | 22 | 26 | See Fig. 421-2 | 26 | See Fig. 421-2 |
| Orbital Blowdown | A, C | 26 | 0.4 | 26 | Space Vacuum | 26 | Space Vacuum | 26 | Space Vacuum |
| Habitation | | 5.2 | 4.8 | 0.06 | Space Vacuum | 6.2 | 4.8 | 0.06 | Space Vacuum |
| Storage | | 5.2 | 0.5 | 0.01 | Space Vacuum | 6.2 | Space Vacuum | 0.01 | Space Vacuum |

NOTES:

- A. Normal pressurization and venting operations will be sequenced such that common bulkhead ΔP does not exceed ± 7.5 psid.
- B. Maximum habitation area pressurization rate is 0.2 psi/minute.
- C. Figure 421-2 shows habitation area pressure for orbital blowdown at the maximum possible rate.

ORBITAL WORKSHOP MINIMUM HABITATION AREA PRESSURE DURING BOOST - FAILURE MODE

O/W-8884
8-7-70

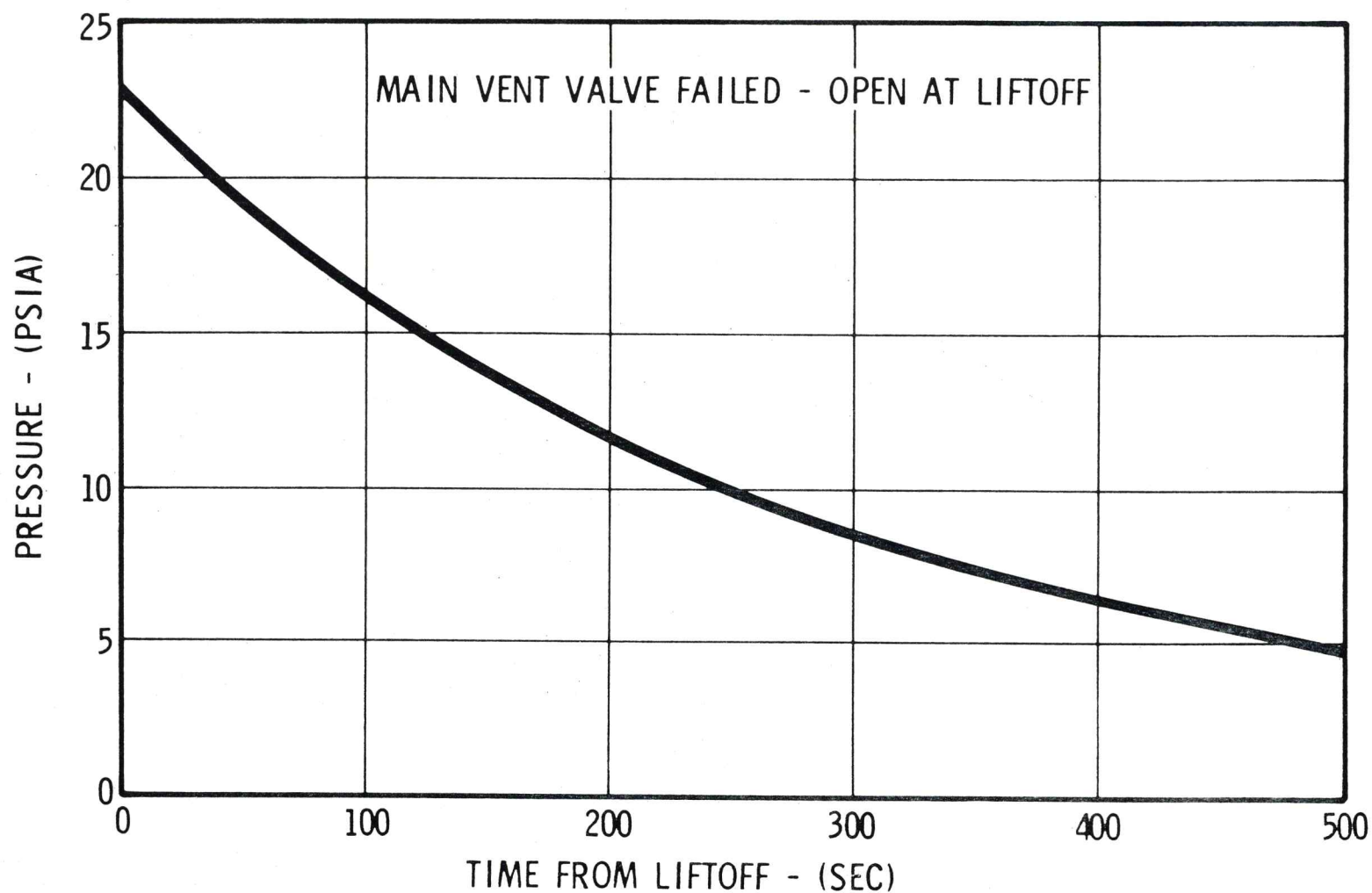
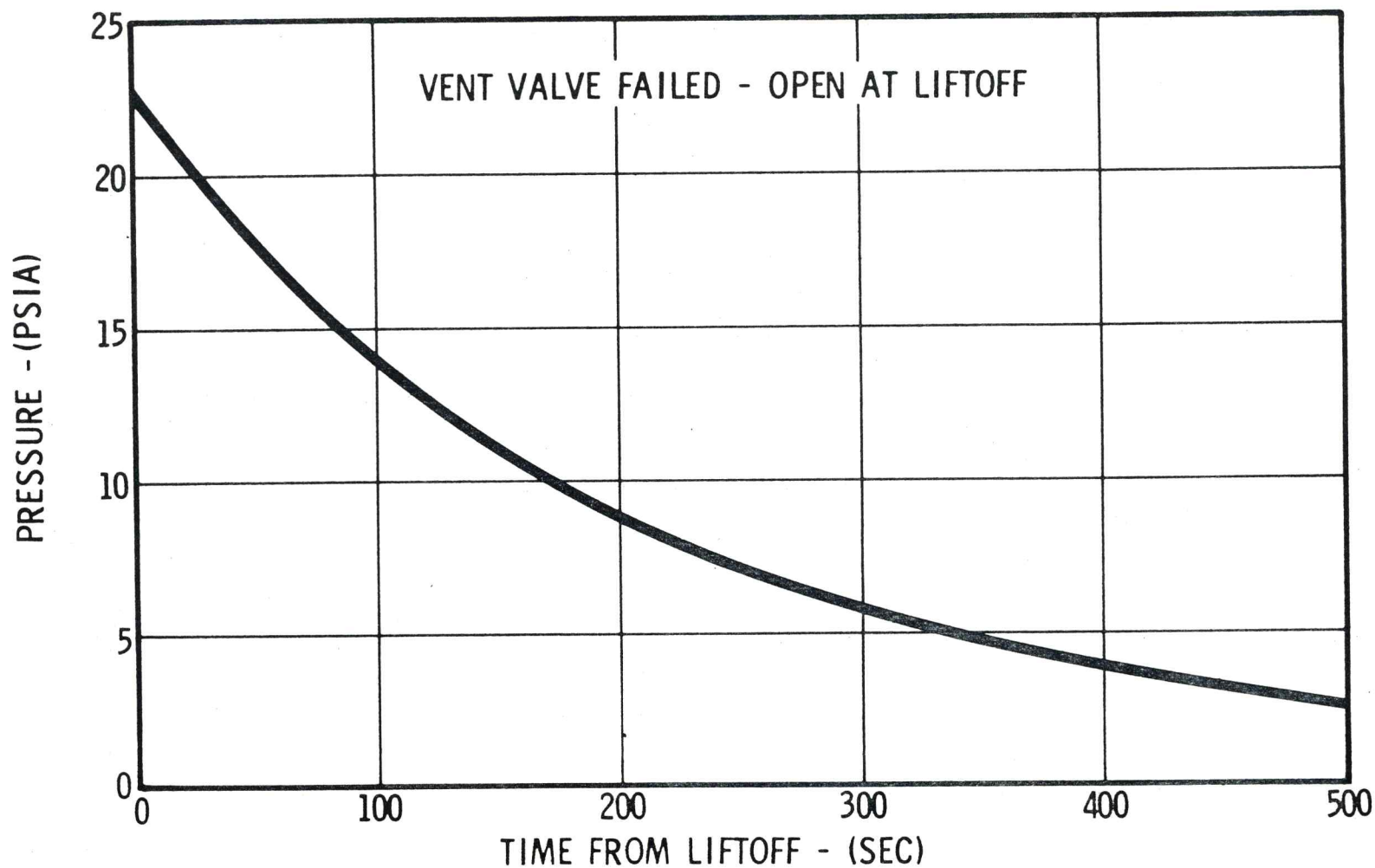


Figure 421-2. (Sheet 1 of 3)

ORBITAL WORKSHOP MINIMUM WASTE TANK PRESSURE DURING BOOST - FAILURE MODE

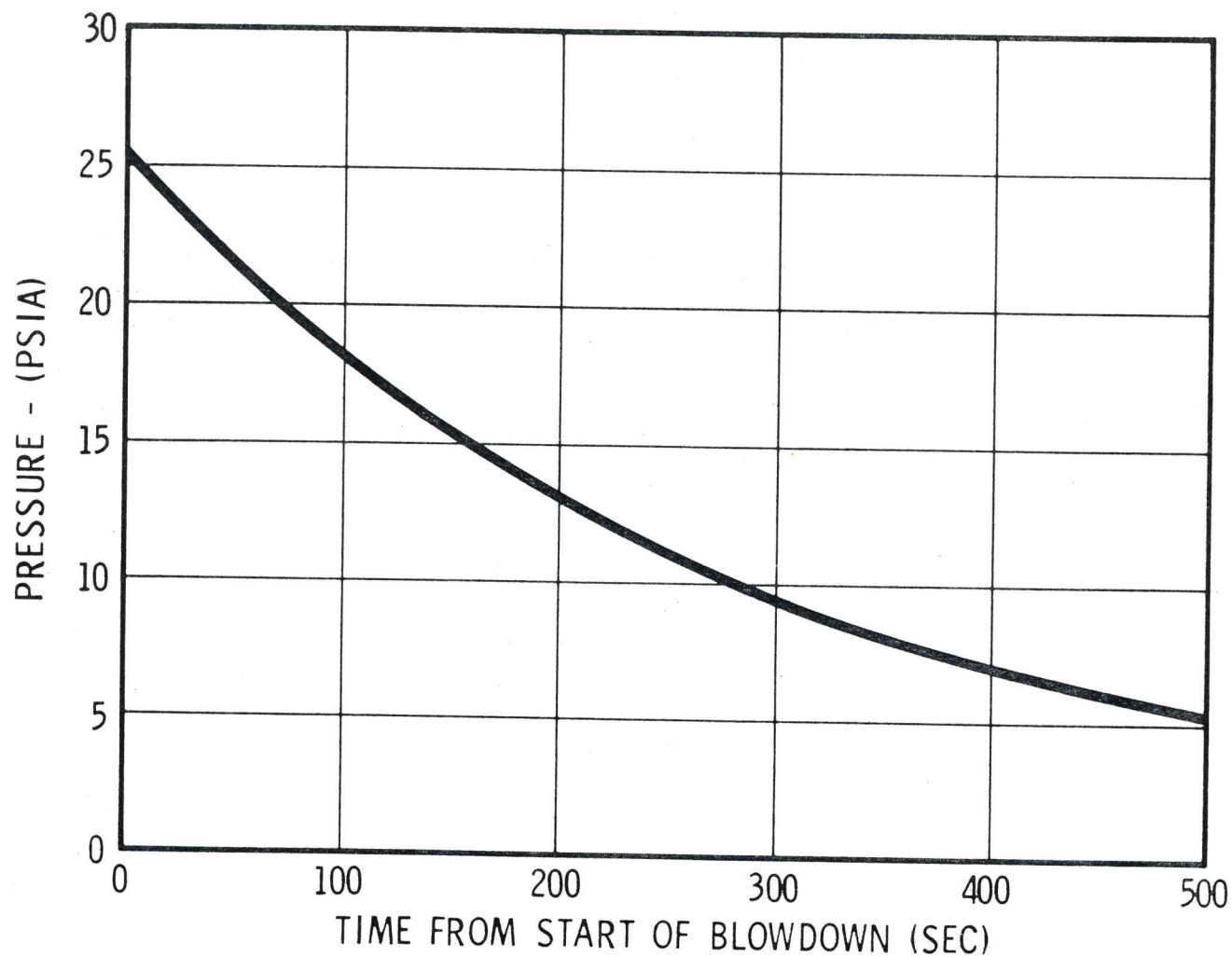
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ORBITAL WORKSHOP HABITATION AREA - MAXIMUM RATE OF BLOWDOWN

O/W-8886
8-7-70

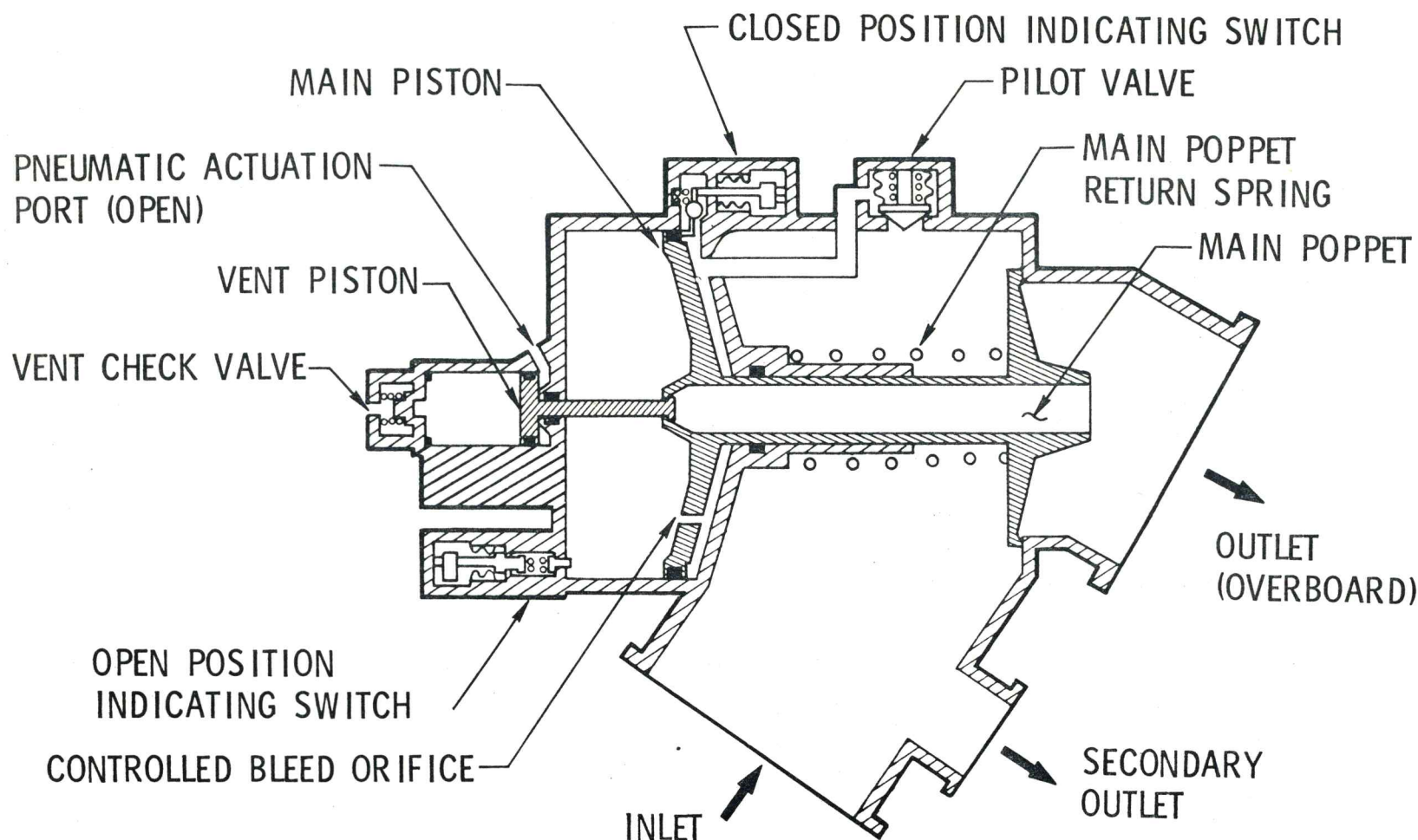


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Figure 421-2. (Sheet 3 of 3)

ORBITAL WORKSHOP HABITATION AREA VENT VALVE 1A48257-527 (SCHEMATIC)

O/W-8890
8-6-70

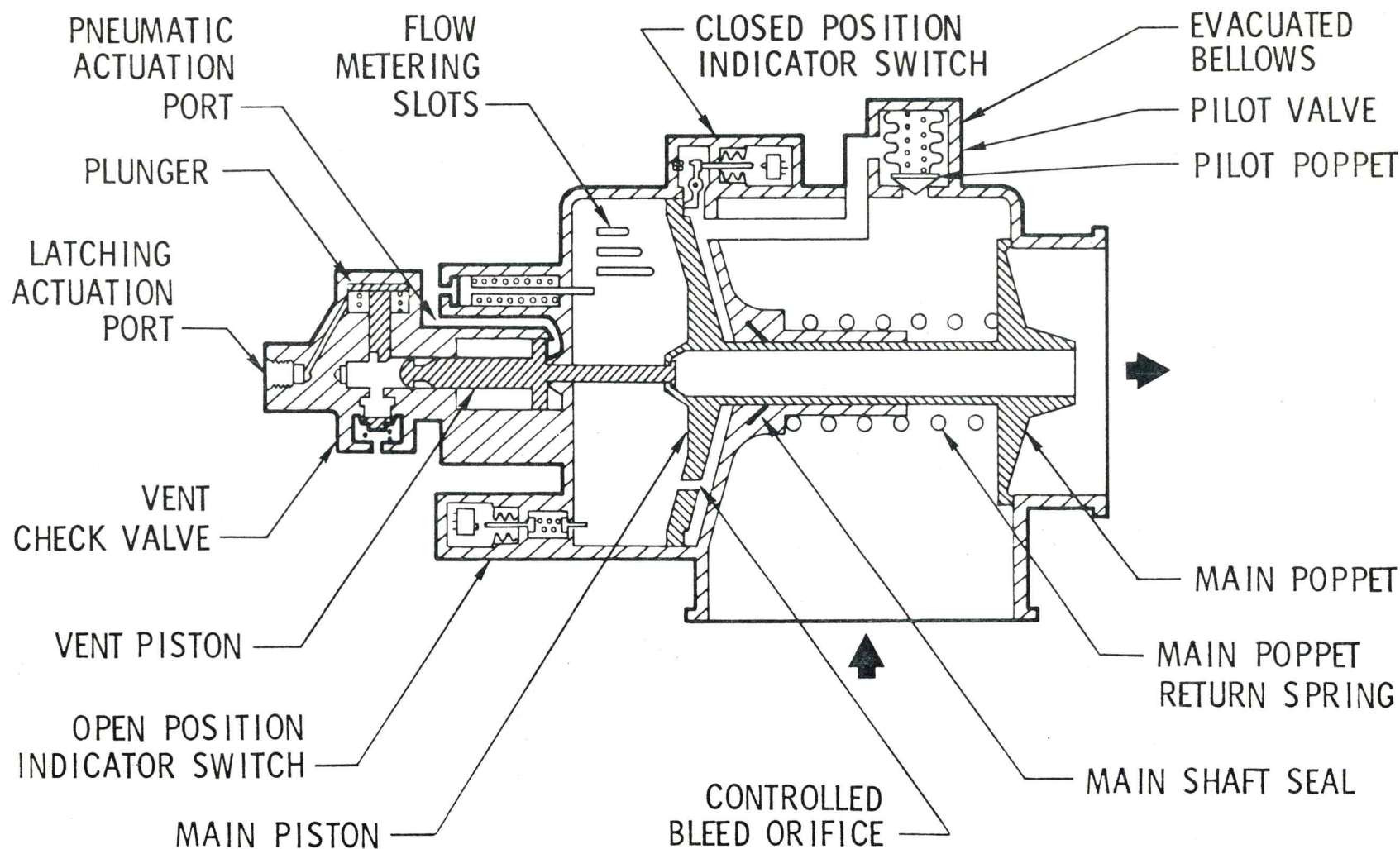


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Figure 421-3. (Sheet 1 of 2)

ORBITAL WORKSHOP HABITATION AREA LATCHING VENT VALVE AND WASTE TANK VENT VALVE 1B74535-501

O/W-8891
8-7-70



4-40

Figure 421-3. (Sheet 2 of 2)

ORBITAL WORKSHOP AM/OWS PRESSURIZATION SYSTEM

4-41



4.2.1.1.1.3 Habitation Area Vent Line Sealing Devices

The habitation area vent line sealing devices, Figure 421-5, are lever-actuated diaphragm mechanisms which provide sealing force to a standard O-ring.

The sealing devices are placed onto a flange adapter and rotated approximately 20 degrees clockwise to engage the latch, which prevents further rotation. Sealing is accomplished by rotating the handle 180 degrees from open to the closed position. A latch is also provided to positively lock the handle in the desired position with a backup trigger lock in the closed position.

4.2.1.1.1.4 OWS Access Hatch

The OWS access hatch (Figure 421-6) is attached to the habitation area forward dome by means of an adapter which utilizes the existing S-IVB access-cover bolt pattern and Conoseal. The adapter provides a sealing interface with the AM to ensure sealing integrity between the AM and OWS before launch and during boost. The hatch is sealed to the adapter when latched closed. Leakage is prevented by this seal between the hatch and the adapter.

A mechanism is incorporated into the access hatch to permit equalization of the pressure between the AM and habitation area before the hatch is opened in orbit. (Figure 421-7)

In orbit, the astronaut manually actuates the pressure-equalization mechanism and opens the access hatch after the OWS is pressurized.

4.2.1.1.1.5 Habitation Area Pressure Control Operations

The habitation area is pressurized to the relief valve setting (23-26 psia) with nitrogen prior to launch to assure structural integrity at maximum dynamic pressure during boost. This pressurization is accomplished by a modified S-IVB system made up of the 7851861 disconnect, 1B65673 check valve, and associated tubing.

After orbital insertion, the habitation area is vented through the pneumatic vent valves. This blowdown is terminated by a pressure switch at TBD psia. The habitation area is then pressurized to 5 psia with O₂ by the AM pressurization system. Initial pressurization occurs through a system separate from that used to supply O₂ and N₂ during habitation. This procedure permits flow of O₂ only and assures accurate knowledge of the O₂ and N₂ concentrations for initial occupation. Pressurization requires about nine hours.

During the 28-day Skylab-2 mission the AM pressurization system automatically keeps the habitation area pressure at 5.0 psia, with O₂ partial pressure of 3.7 psia, and N₂ partial pressure of 1.3 psia.

At termination of the Skylab-2 mission, the solenoid vent sealing device is removed by the crew. After the crew has departed, the habitation area is vented to not less than 0.5 psia through the solenoid valves by ground command. Prior to Skylab-3 launch the habitation area is pressurized to 5 psia. Procedures for deactivation after Skylab-3 and activation prior to Skylab-4 are identical.

ORBITAL WORKSHOP VENT LINE SEALING DEVICE

O/W-5031
5-21-70

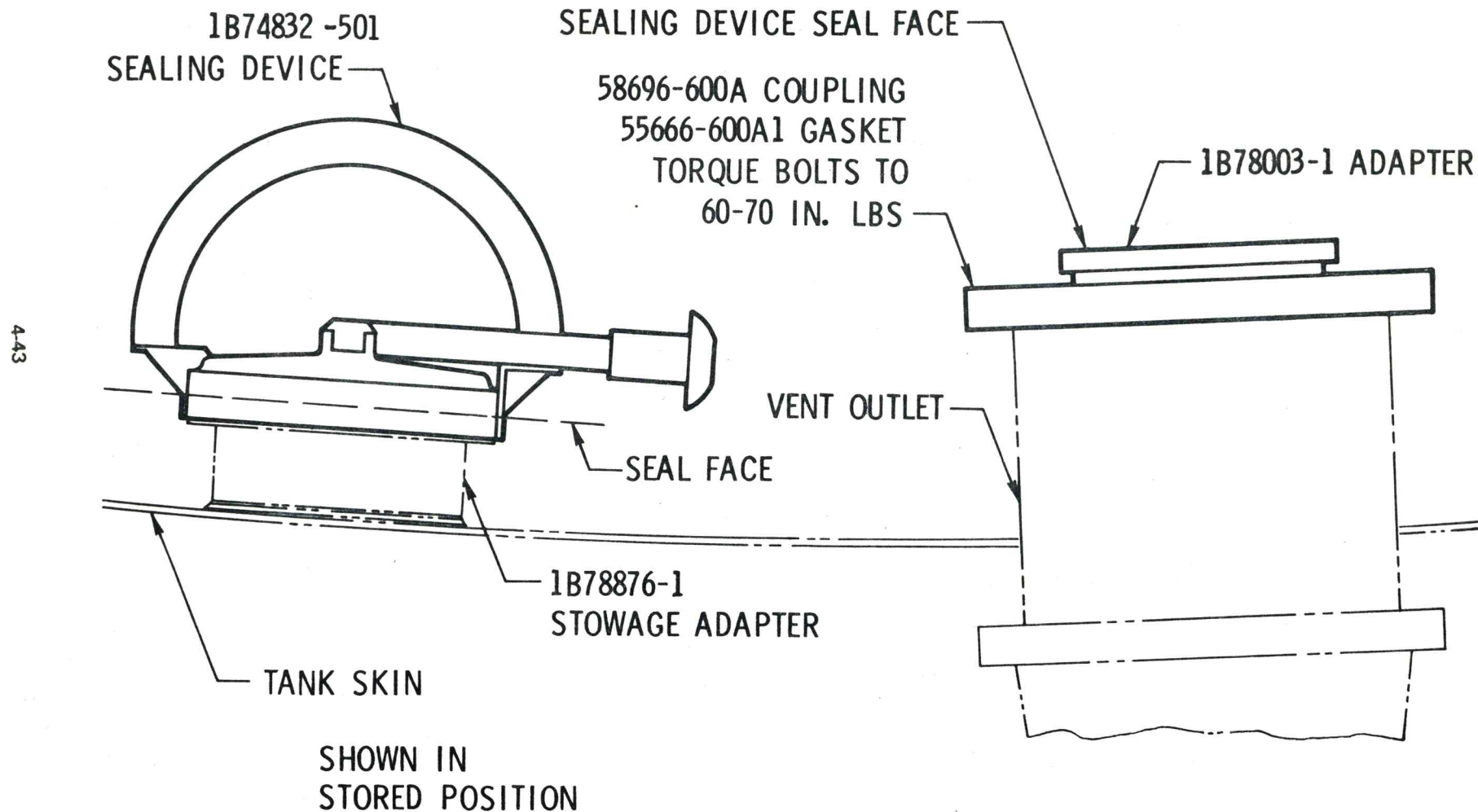
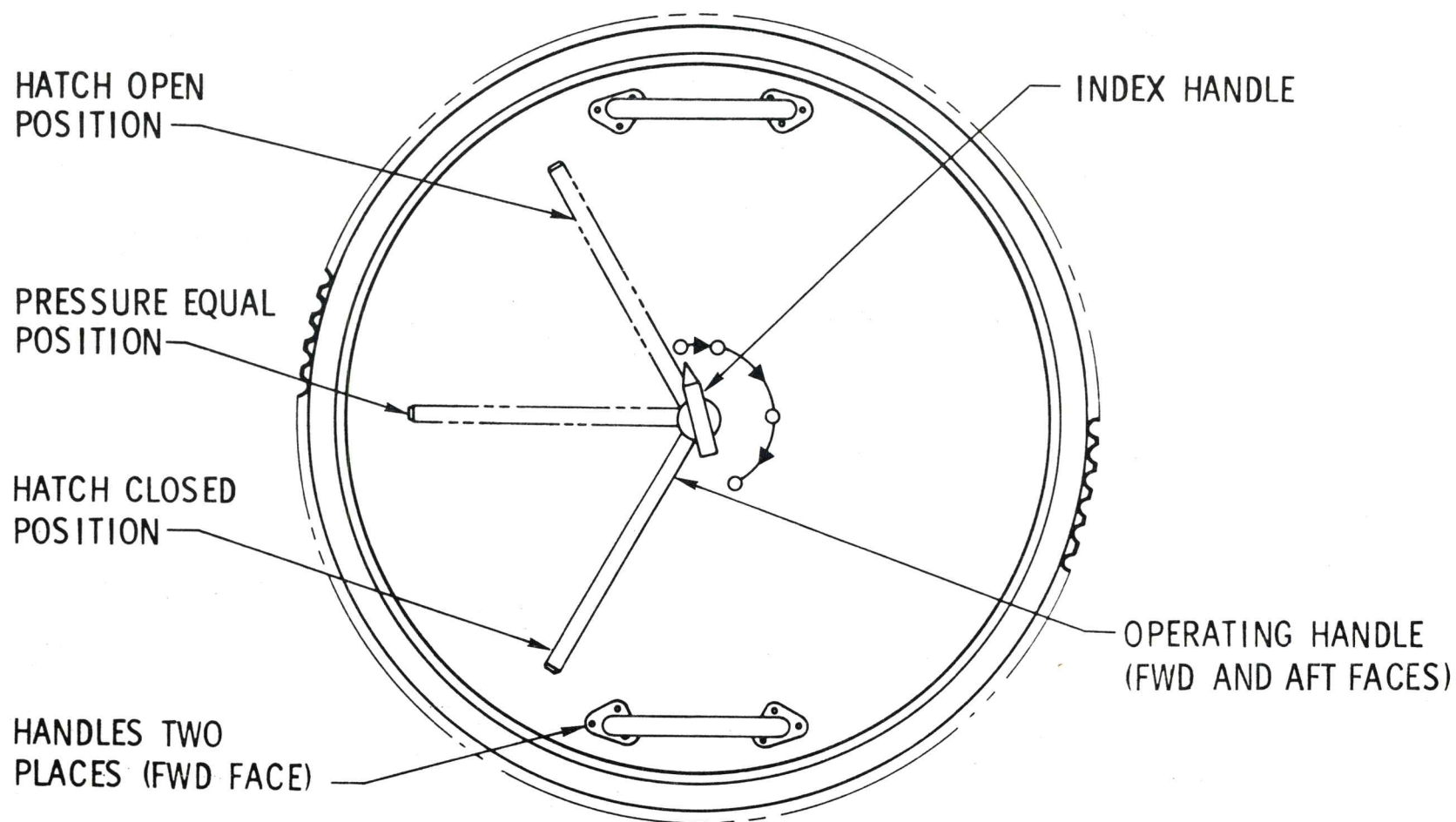


Figure 421-5.

ORBITAL WORKSHOP ENTRY HATCH

O/W-56
5-21-70

VIEW LOOKING AFT



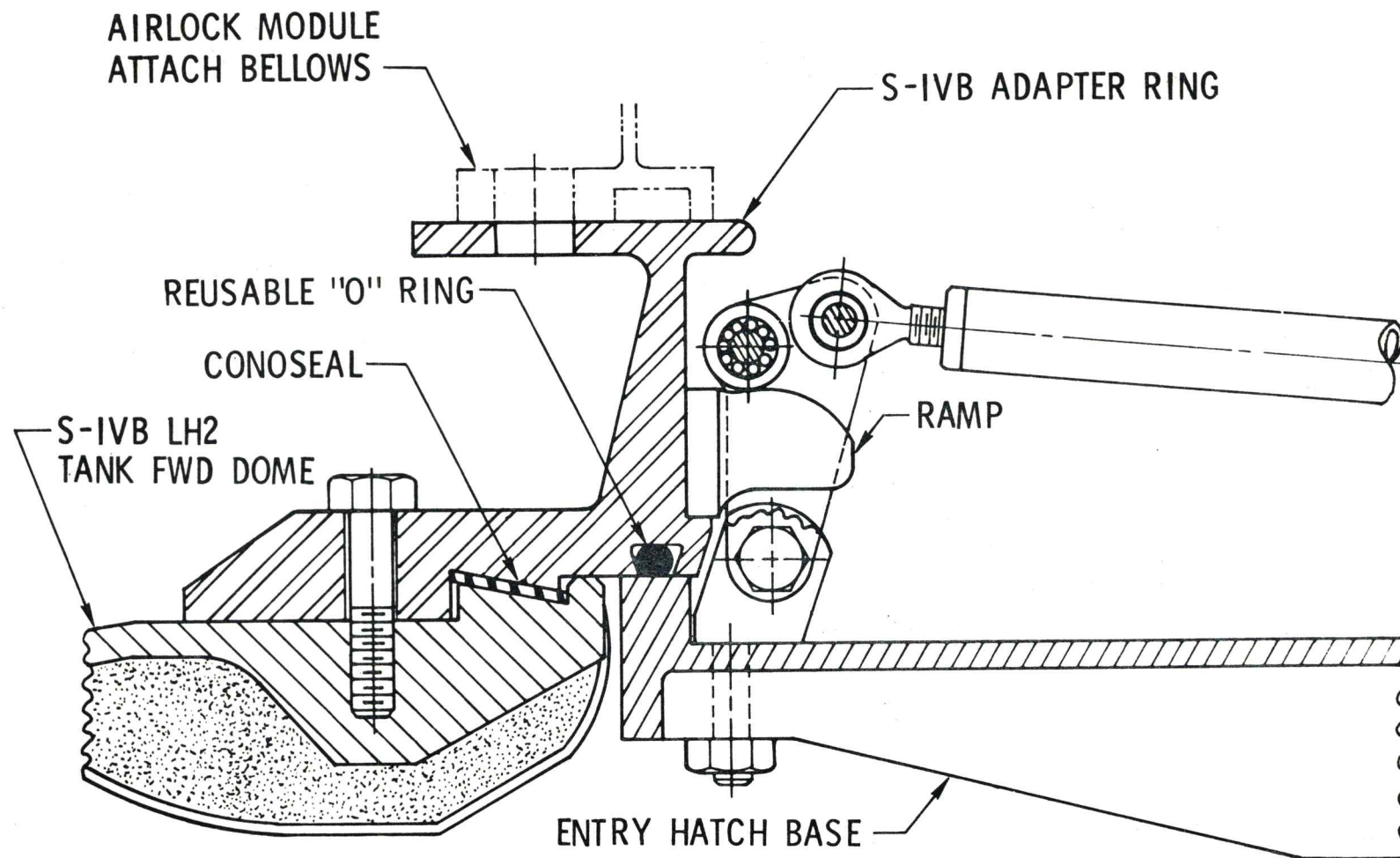
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Figure 421-6. (Sheet 1 of 4)

ORBITAL WORKSHOP ENTRY HATCH DETAIL NO. 1

O/W-2093-1
5-21-70

O-RING COMPRESSION MECHANISM



4-45

Figure 421-6. (Sheet 2 of 4)

ORBITAL WORKSHOP ENTRY HATCH ASSEMBLY

O/W-2093
5-19-70

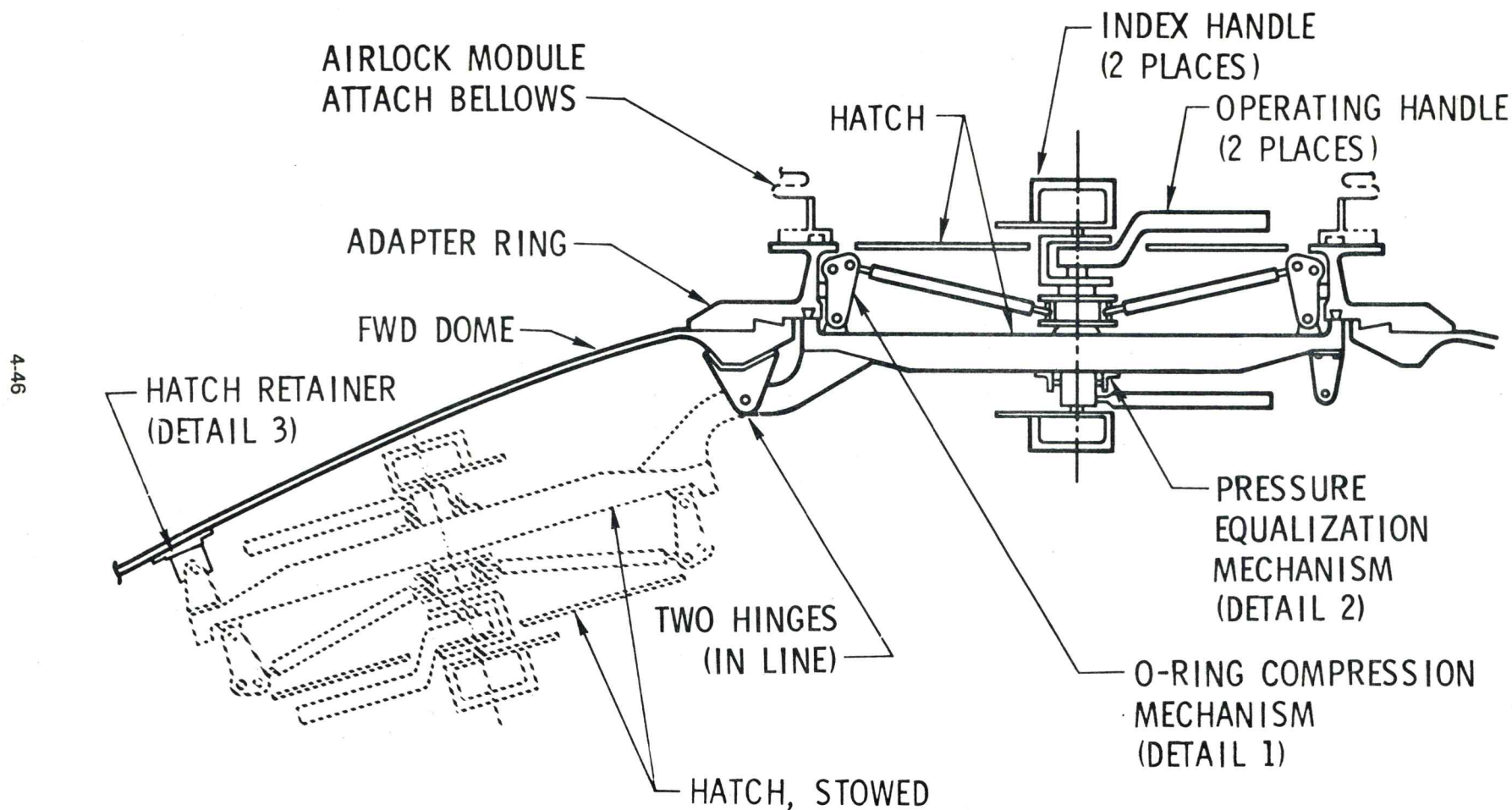


Figure 421-6. (Sheet 3 of 4)

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ORBITAL WORKSHOP HATCH RETAINER DETAIL 3

O/W-2093-4
5-21-70

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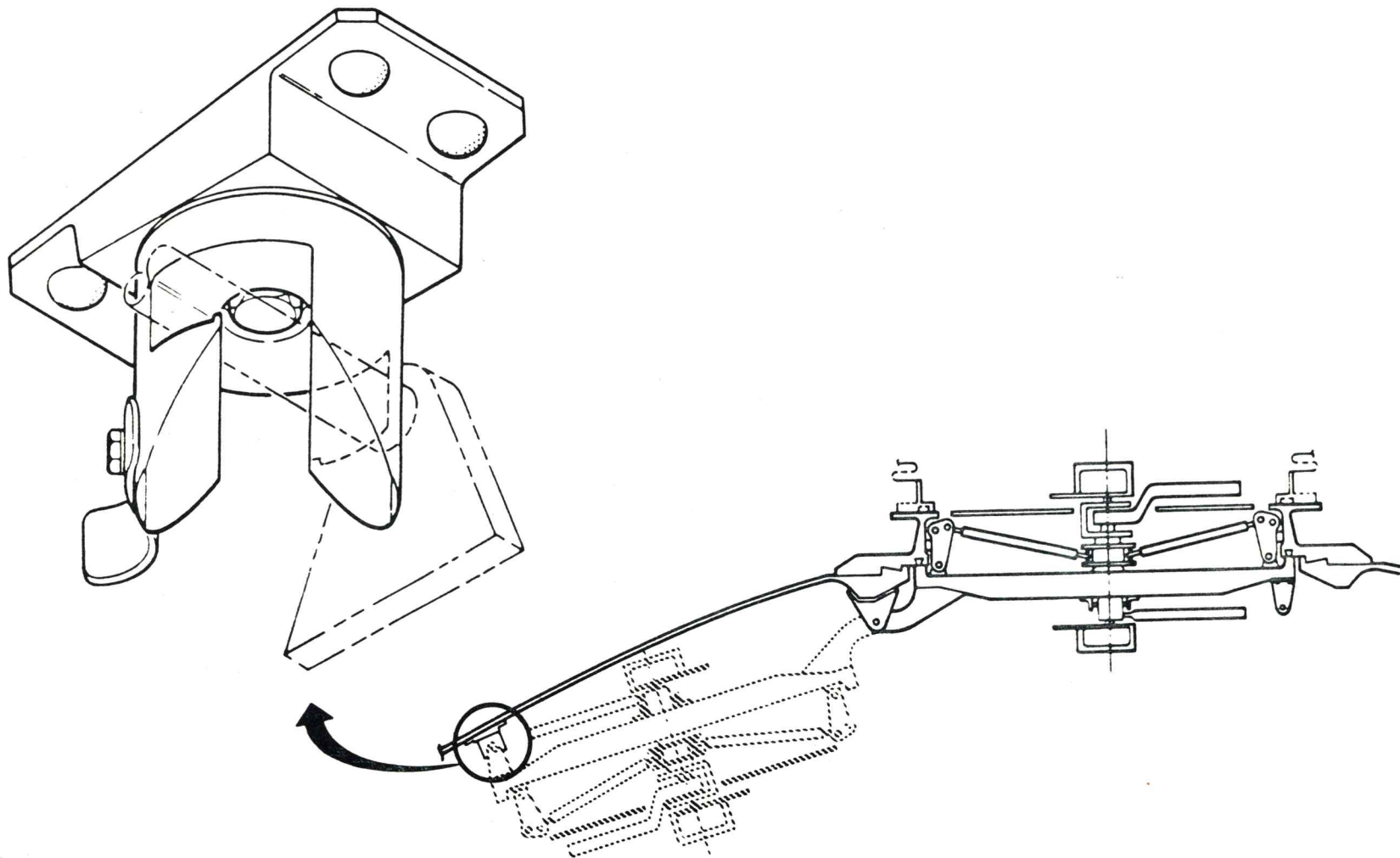
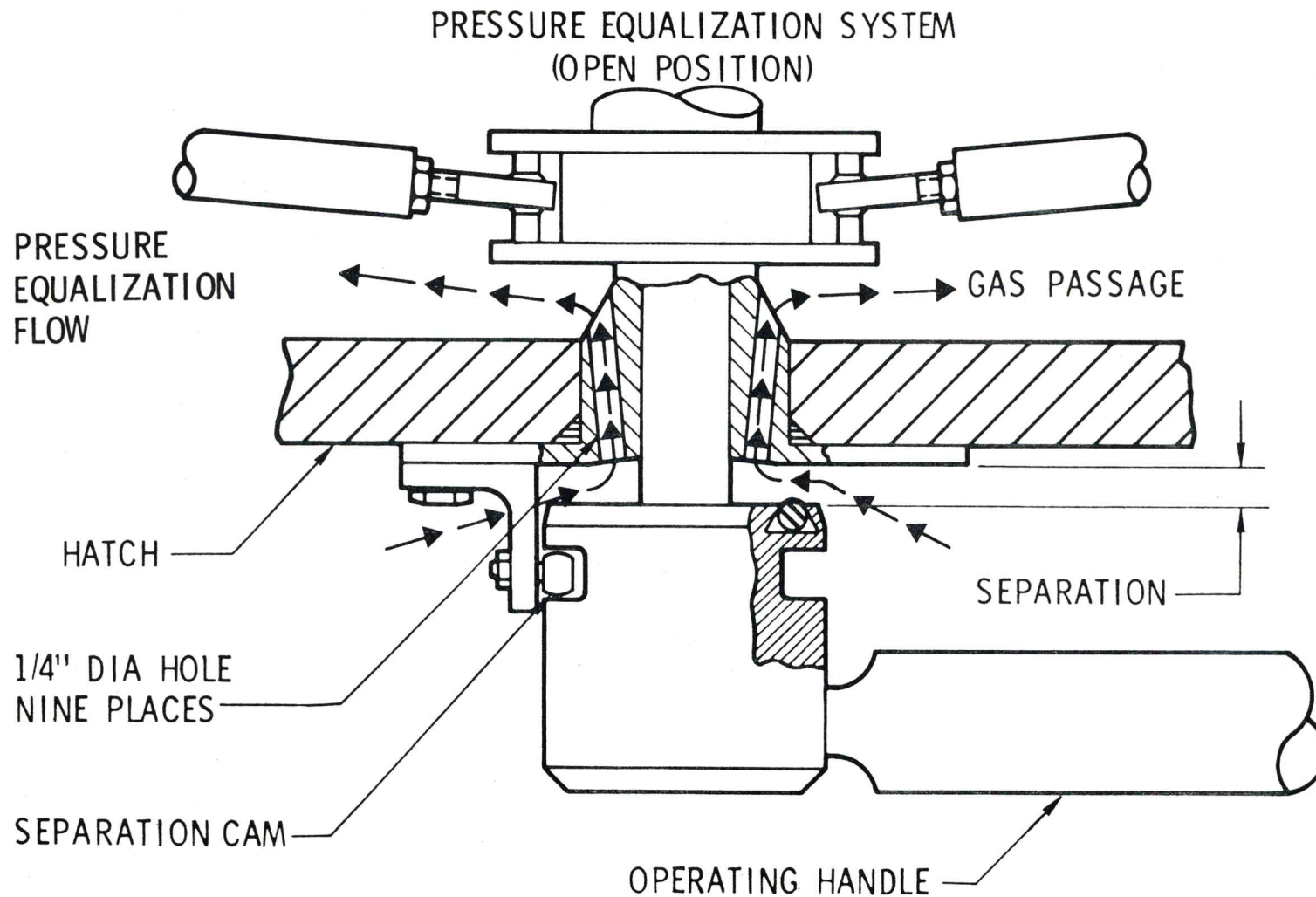


Figure 421-6. (Sheet 4 of 4)

ORBITAL WORKSHOP ENTRY HATCH DETAIL 2

O/W-2093-2
5-18-70



4-48

Figure 421-7.

4.2.1.1.2 Waste Tank Pressure Control

4.2.1.1.2.1 Waste Tank Vent System

The vent system consists of two wrap-around ducts connected to the waste tank through a pair of parallel-redundant, pneumatically actuated, normally closed vent valves (Figure 421-8). The valves tee into a common inlet pipe which enters the waste tank. Each valve is equipped with a pneumatically actuated latching mechanism so that the valve, once latched, remains open without pneumatic or electrical power. The valves also provide relief capability with a maximum cracking pressure of 26 psia and a minimum reseal of 23 psia.

Each wrap-around duct terminates in a supersonic nozzle. The nozzles are in a plane perpendicular to the OWS centerline and are directed 180 degrees apart so that venting is nonpropulsive.

4.2.1.1.2.2 Waste Tank Pressure Control Operations

The waste tank is pressurized to the relief valve setting (23-26 psia) with nitrogen prior to launch to avoid large reverse differential pressures on the common bulkhead when the habitation area is pressurized. This pressurization is accomplished by a modified S-IVB system made up of a disconnect, Part No. 7851844, check valve, Part No. 1B40824, and associated tubing. Following orbital insertion, both waste tank vent valves are latched open and the tank vented to space for the remainder of the mission (Figure 421-9).

4.2.1.1.3 Pneumatic System

The pneumatic system provides the means for opening and closing the habitation area and waste tank vent valves used to control internal pressures during boost and blowdown after orbital insertion. It also provides for ground purging of the habitation area and waste tank vent systems.

The system consists of a 4.5 ft³ pneumatic supply sphere pressurized to 750 psia with nitrogen, and one actuation control module (Figure 421-10) for each pneumatic valve. Each control module contains two solenoid valves. For each of the two waste tank vent valves and the habitation area latching vent valve, one solenoid is used to supply pneumatics to open the vent valve and the other is used to supply pneumatics to latch the vent valve open. For the habitation area vent valve, one solenoid is used to supply pneumatics to open the vent valve and the other solenoid is used as a pneumatic system vent for ground use only. The 750 psia operating pressure eliminates the need for passivation of the pneumatic supply. The system is loaded through an existing mainline S-IVB quick disconnect and the supply sphere is isolated from the purge lines by check valves and hand valves carried over from the mainline.

The pneumatic supply pressure decay for maximum system leakage is illustrated in Figure 421-11.

ORBITAL WORKSHOP WASTE TANK VENT VALVE 1B74535-501

O/W-8892
8-7-70

4-50

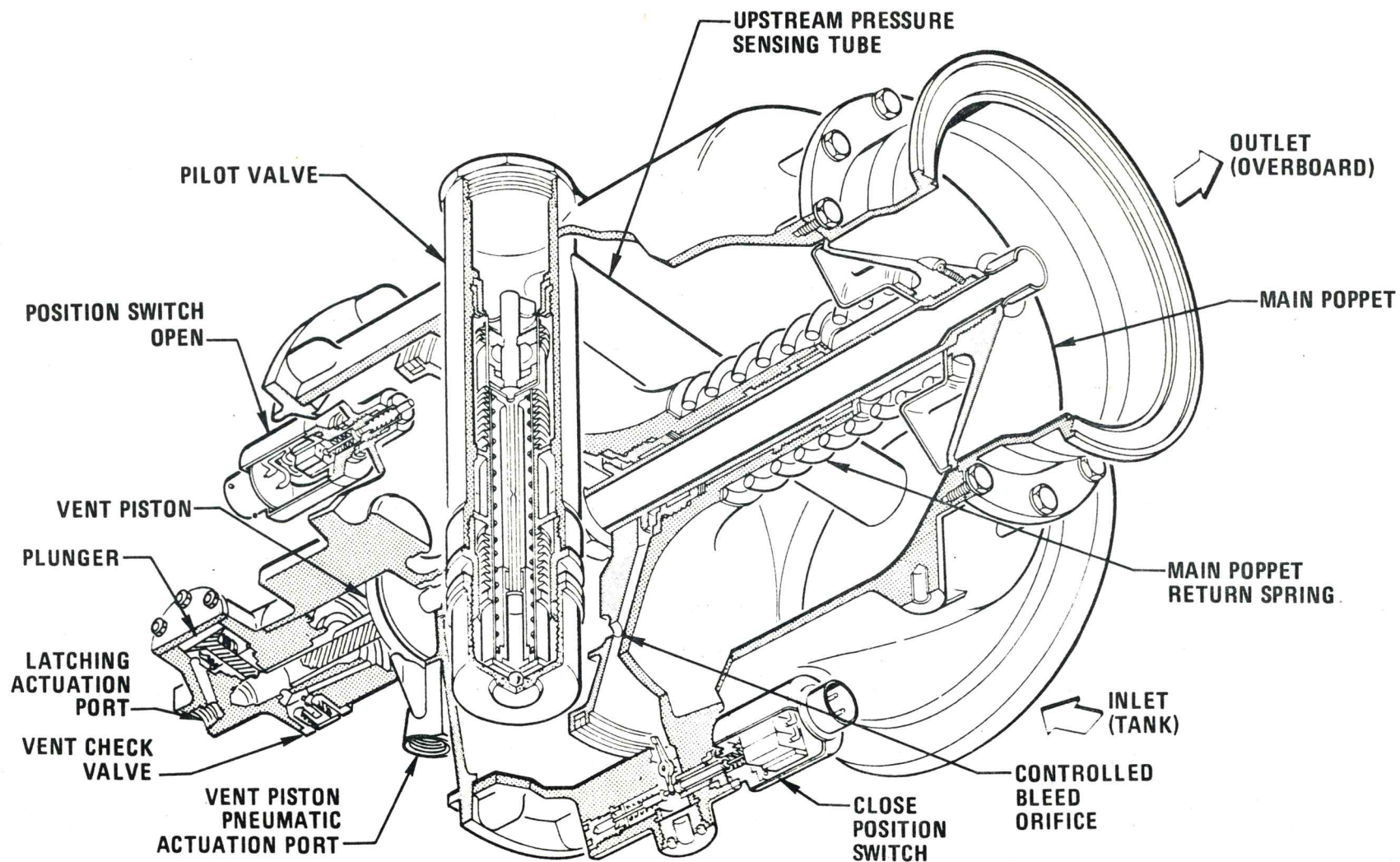


Figure 421-8. (Sheet 1 of 2)

ORBITAL WORKSHOP HABITATION AREA LATCHING VENT VALVE AND WASTE TANK VENT VALVE 1B74535-501

O/W-8891
8-7-70

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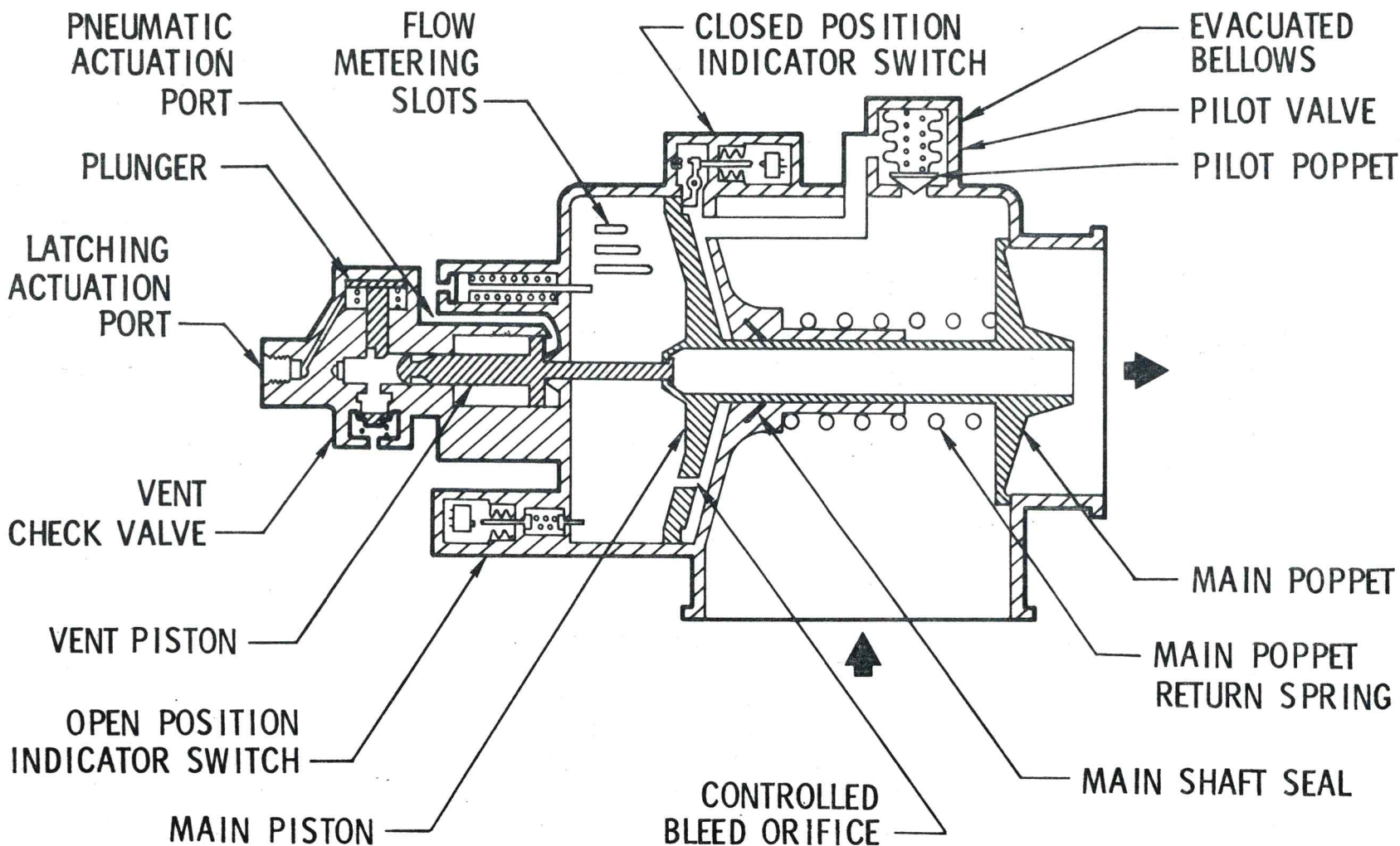


Figure 421-8. (Sheet 2 of 2)

ORBITAL WORKSHOP WASTE TANK INITIAL BLOWDOWN

O/W-8893
8-7-70

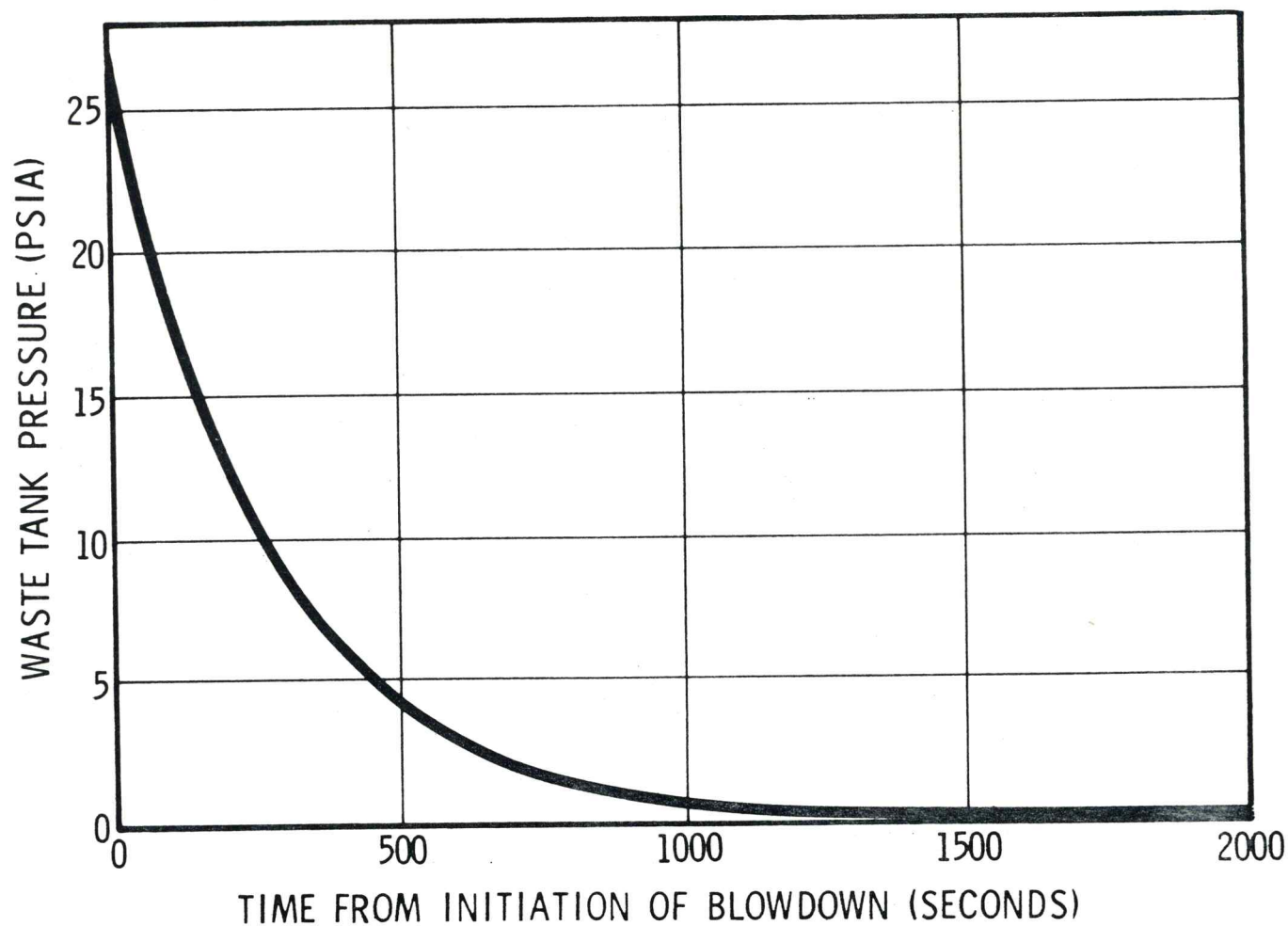


Figure 421-9.

ORBITAL WORKSHOP ACTUATION CONTROL MODULE

O/W-8894
8-10-70

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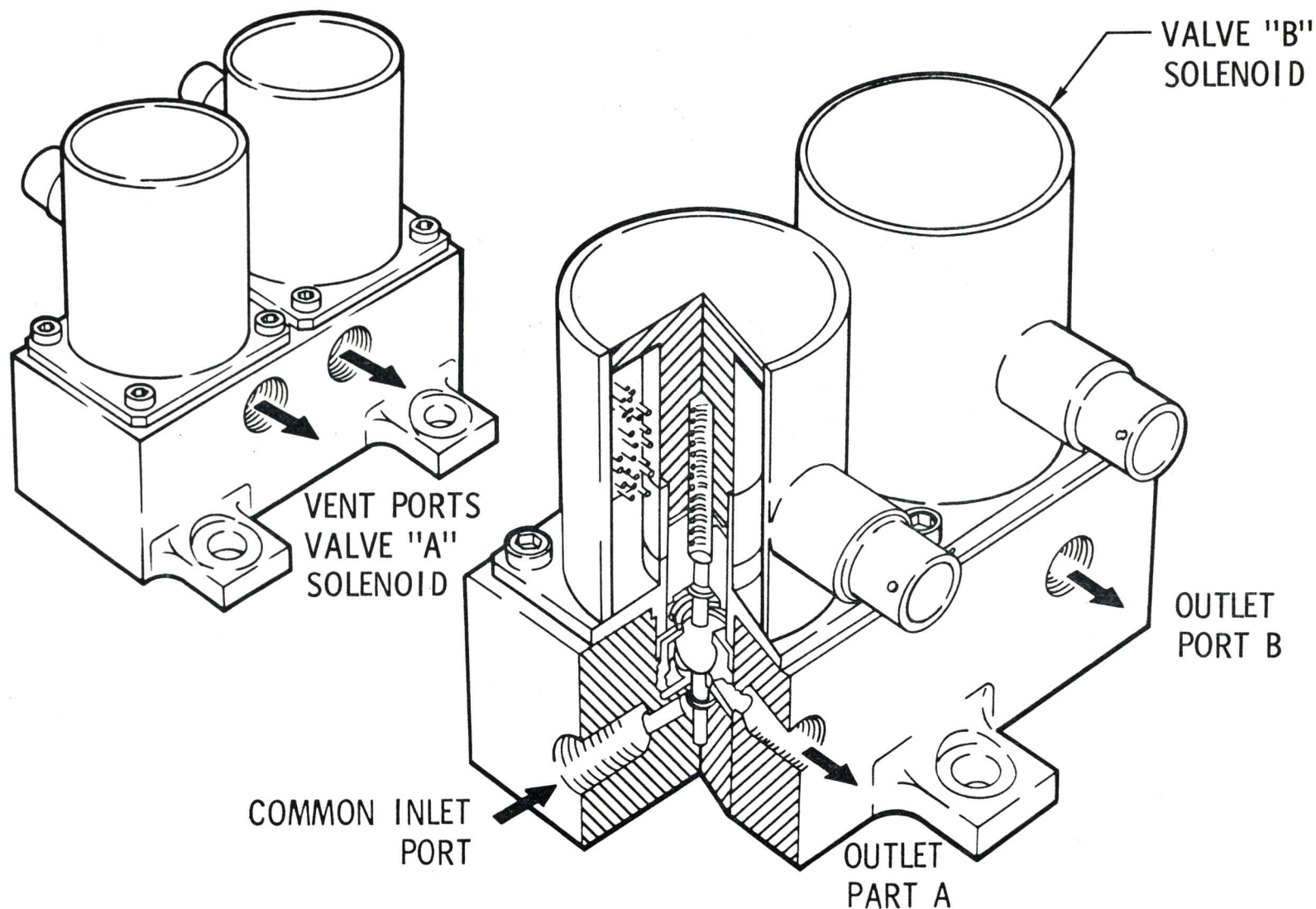


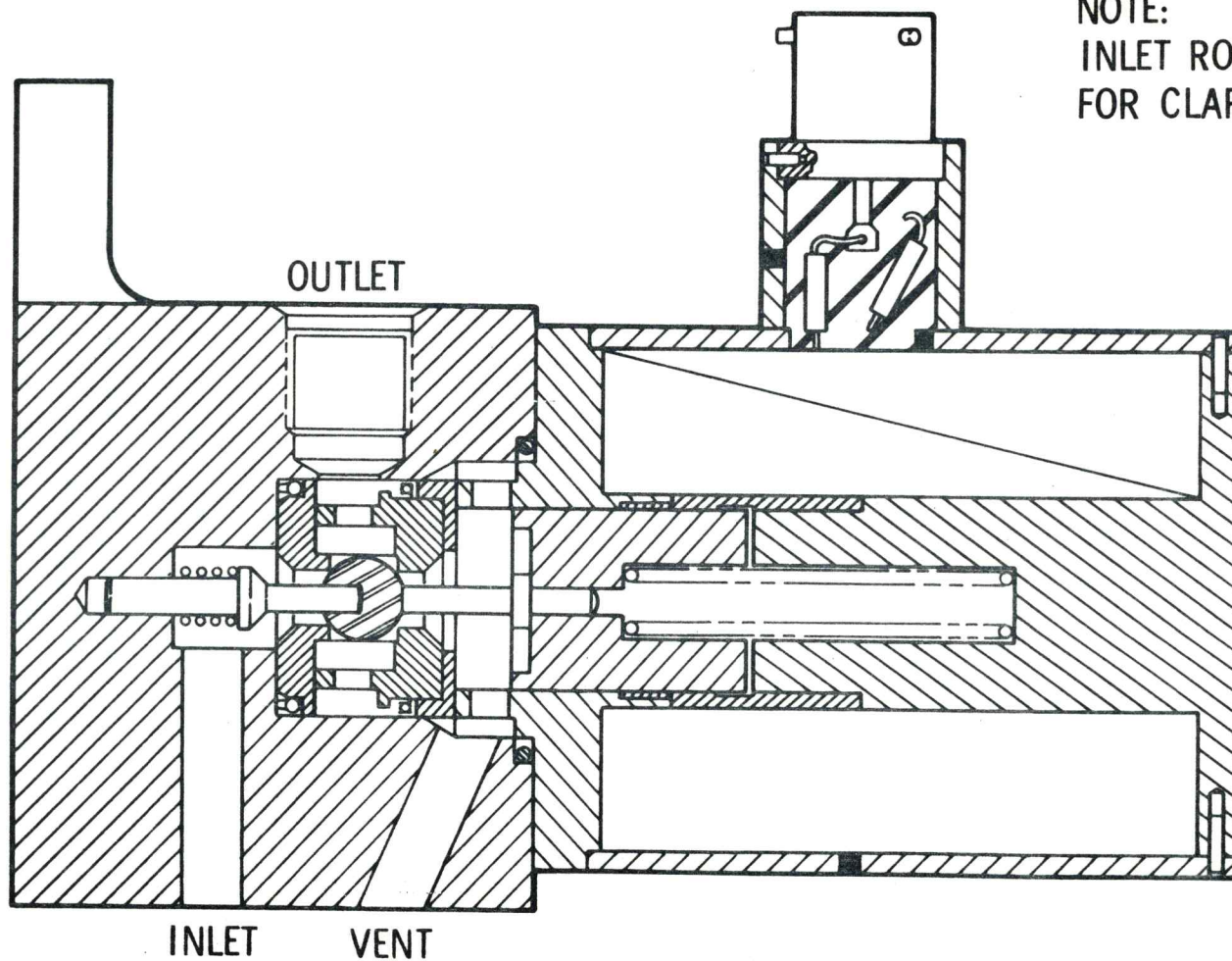
Figure 421-10. (Sheet 1 of 2)

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ACTUATION CONTROL MODULE 1B66692 (SCHEMATIC)

O/W-8894-1
8-10-70

NOTE:
INLET ROTATED 90°
FOR CLARITY



4-54

Figure 421-10. (Sheet 2 of 2)

ORBITAL WORKSHOP PNEUMATIC BOTTLE PRESSURE DECAY (MAXIMUM SPEC. LEAKAGE)

O/W-8895
8-7-70

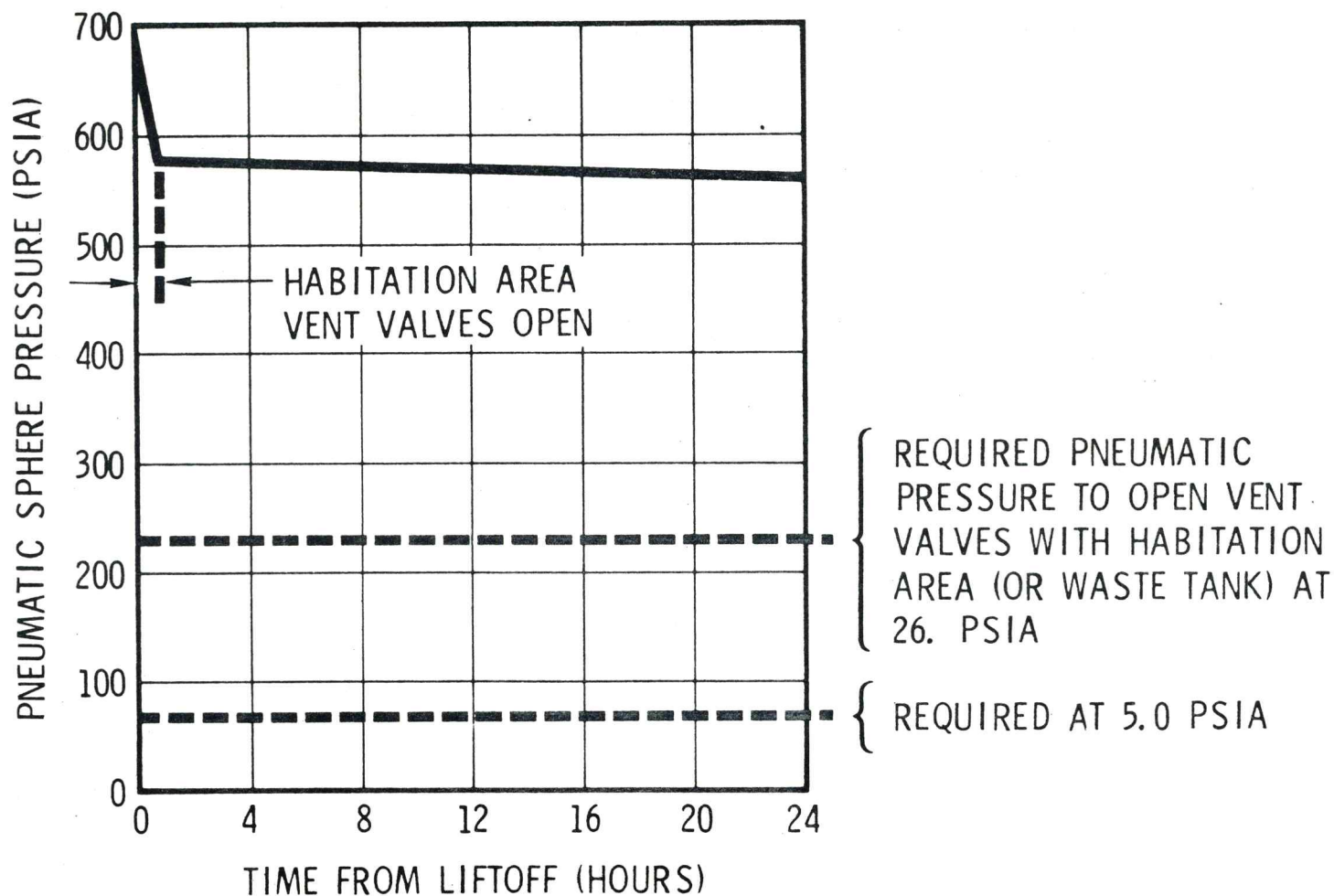


Figure 421-11.

4.2.1.2 Thermal Control System

The Thermal Control System (TCS) is designed to meet the OWS thermal requirements from ground-hold conditions through orbital activation, habitation, and orbital storage. During ground hold and orbital storage, the OWS is thermally conditioned to satisfy the temperature requirements of the food and film stored in the OWS. During orbital activation of the vehicle (prior to astronaut habitation) the TCS warms the internal structure and maintains the temperatures to levels that satisfy the astronaut entry requirements. During habitation, the TCS maintains the internal wall and gas temperatures at levels that satisfy the astronaut "shirtsleeve" comfort criteria.

The overall view of the ground thermal control system is shown on Figure 421-12. The system consists of two subsystems: the vehicle subsystem and the Ground Support Equipment (GSE) subsystem. The system involves circulation of conditioned dry nitrogen within the habitation area. Circulation is effected by operation of one or two fans which force the nitrogen across heat exchangers providing the temperature conditioning. The heat exchangers and the two fans are located in the vehicle Wardroom in Entertainment center as shown in Figure 421-13. Alternate finned passages in the heat exchangers provide a path for water/ethylene glycol which is conditioned by GSE on the Mobile Launch Tower (MLT). Logic, as depicted in Figure 421-14, is used to control the operation of the fans in the Habitation Area and is provided on the MLT. The logic also controls the GSE heater and both redundant Government Furnished Equipment (GFE) Thermal Conditioning Units (TCU's). Manual logic and instrumentation is provided in both the MLT and the Launch Control Center (LCC). The water/ethylene glycol is purged from the vehicle by GSE gaseous nitrogen prior to launch. At least one circulating fan will be in operation from "Button-up" in the VAB until launch. Either the GSE heaters or one of the two TCU's operate as directed by the logic to provide heating or cooling of the water/ethylene glycol. A modification to the purging GSE is included in Paragraph 4.2.1.2.1.5 to meet system performance constraints imposed by the system constraints of purging.

The orbital thermal control system consists of active and passive subsystems. The active thermal control subsystem provides continuous control of the OWS internal environment during periods of astronaut habitation. The cabin gas temperature is controlled by cabin gas heat exchangers in the AM and by convective heaters in the three VCS ducts. Reconstituted air from the AM is mixed with recirculated air in the OWS. Prior to habitation, radiant heaters maintain temperatures that satisfy food and film storage requirements as well as astronaut entry requirements.

The passive thermal control subsystem consists of optical property control of the vehicle interior and exterior surfaces. Also included in the passive system is the polyurethane foam insulation on the interior of the forward tank, and the high performance insulation blanket on the forward dome. These reduce heat loss from the OWS. The exterior surface finishes of the OWS control the net energy balance between the OWS and the external space environment. The heat loss rates from the habitation area to the meteoroid shield, and from the forward and aft dome areas, are regulated by surface finish control. Also, the interior habitation area wall temperatures are made more uniform with optical property control of these surfaces.

ORBITAL WORKSHOP GROUND THERMAL CONDITIONING SYSTEM GROUND CONDITIONING SYSTEM

O/W-4214B
8-11-70

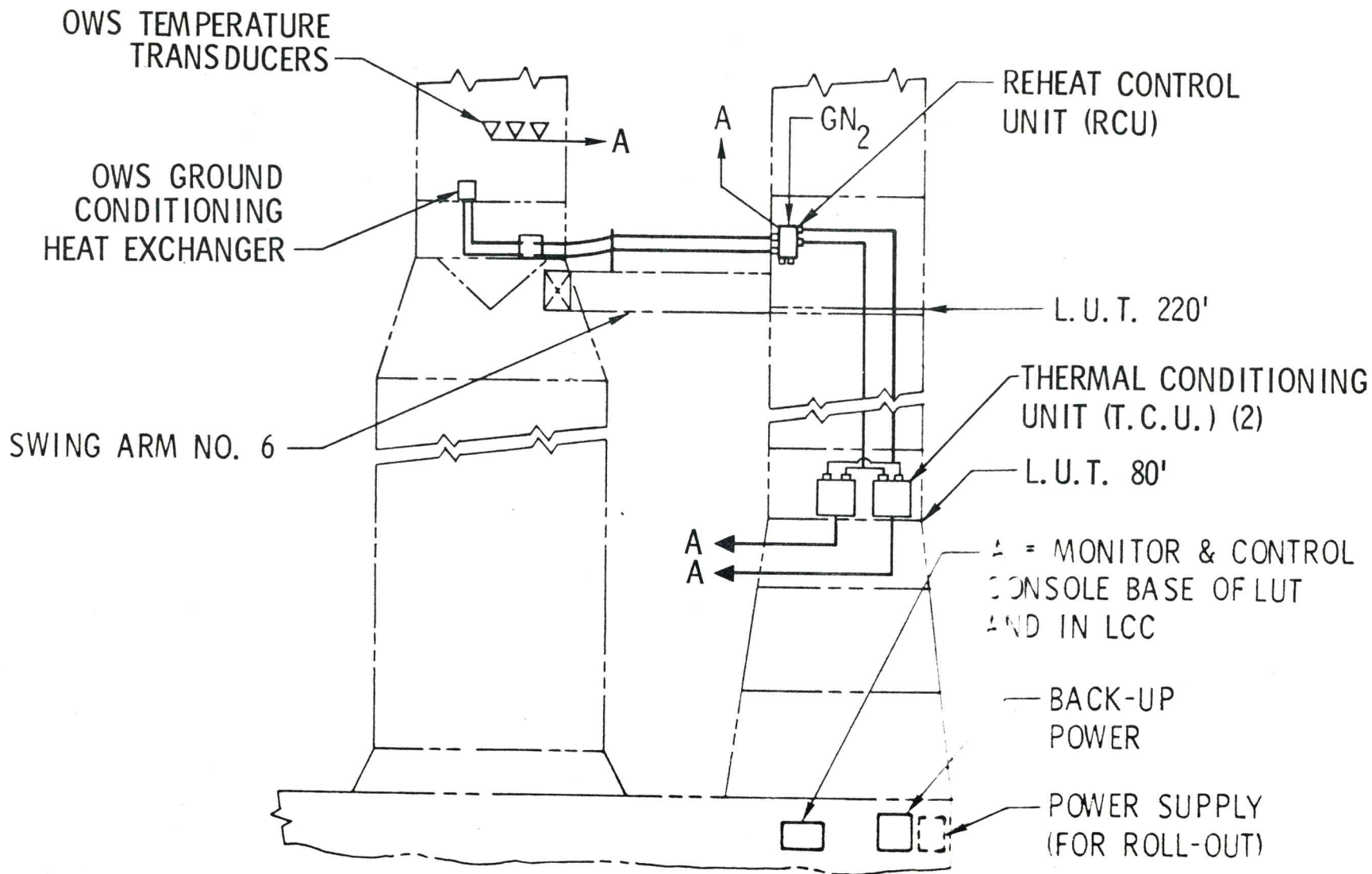
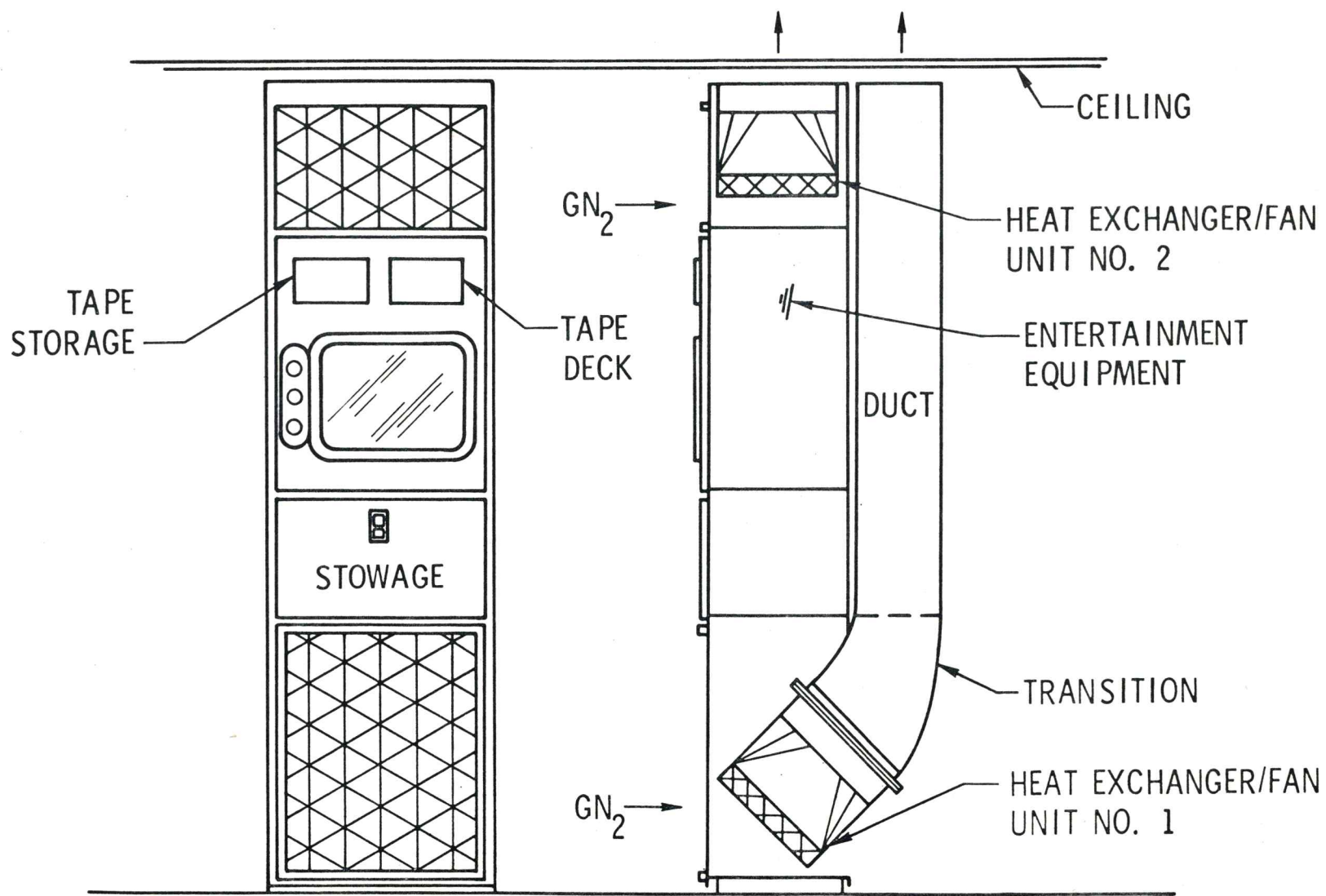


Figure 421-12.

ORBITAL WORKSHOP ENTERTAINMENT CENTER

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8-11-70



4-58

Figure 421-13.

ORBITAL WORKSHOP GROUND THERMAL CONDITIONING SYSTEM

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8-11-70

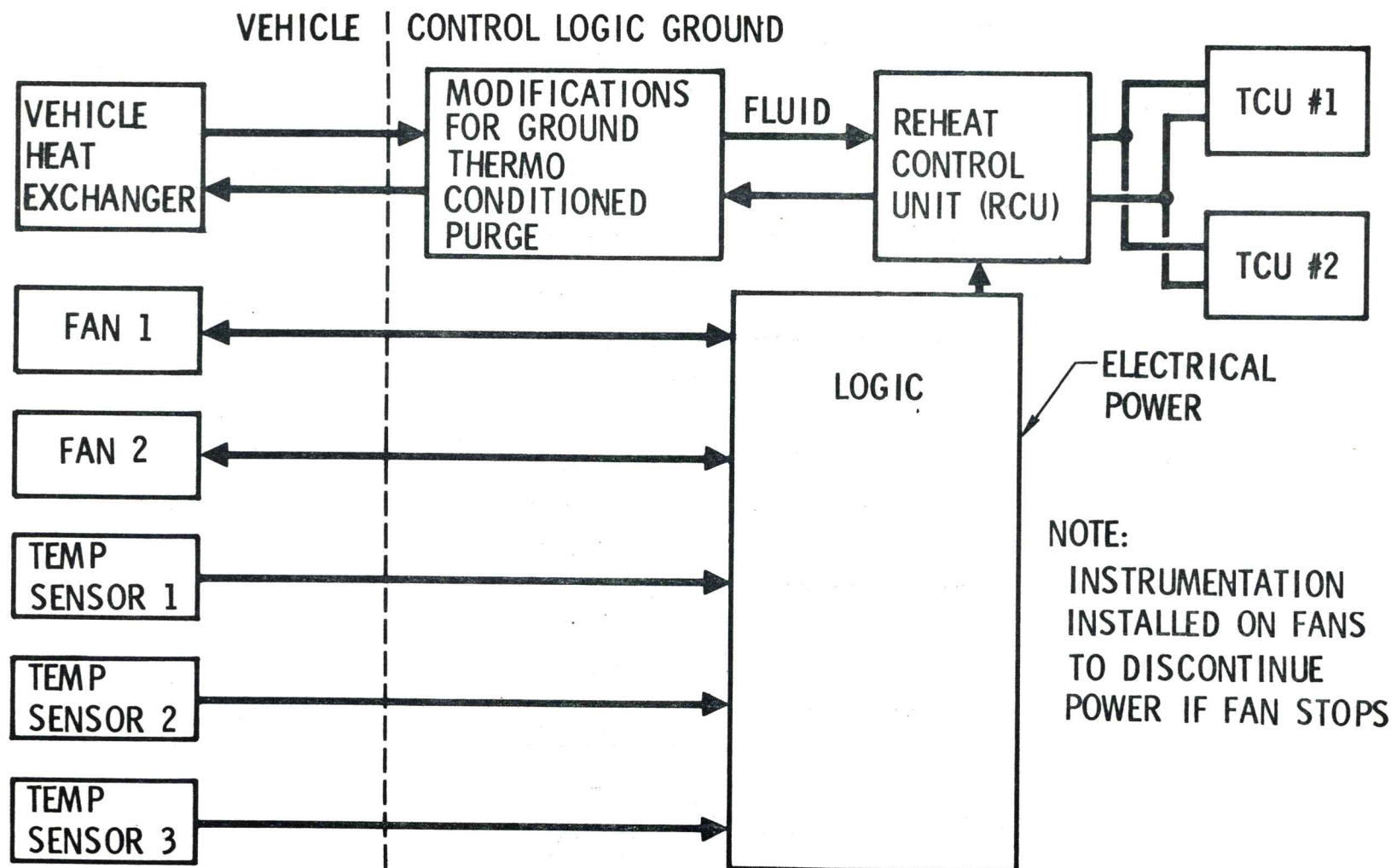


Figure 421-14.

4.2.1.2.1 Ground Thermal Control System

The system description for the Ground Thermal Control System includes:

- a. Requirements, ground rules and guidelines.
- b. Hardware description.
- c. Controls and instrumentation.

4.2.1.2.1.1 Requirements

The general environmental conditioning requirements for the system include temperature and humidity ranges for stowed food, film, and other critical temperature items, as follows:

- a. The temperature range for wet and dried food, film, and other unidentified critical temperature items is 40° to 80°F.
- b. The relative humidity for film is 75 percent maximum.

Groundrules and Guidelines

The following groundrules and guidelines govern the system design:

- a. Maximum temperature of film +80°F.
- b. Maximum relative humidity of film limited to 75 percent.
- c. 40° to 80°F acceptable range for dry and moist food.
- d. Food or other critical temperature items will not be stowed in the aft compartment.
- e. Optimum launch temperature of 50°F based on flight thermal environment (no launch constraints).
- f. Reliability of system coincident with requirements.
- g. Operation of vehicle flight systems not required.
- h. Minimum activity of flight crew desired.
- i. Minimum weight, cost, and schedule impact.

4.2.1.2.1.2 Vehicle Subsystem Hardware Description

The vehicle subsystem consists of the following components:

- a. Two heat exchangers manifolded in series for water/ethylene glycol flow.
- b. Two fans, each forcing gaseous nitrogen flow across one of the above heat exchangers.

- c. Transitions from a fan to a heat exchanger for the purpose of minimum pressure drop and to preclude recirculation of the nitrogen.
- d. Water/ethylene glycol supply and return lines from the aft umbilical to the heat exchanger manifold ports in the Wardroom.
- e. Two temperature sensors located near a stationary dry and moist food storage container.
- f. One temperature sensor located near the film vault.
- g. Miscellaneous supporting attachments.
- h. Power cables routed from the aft umbilical to the fans.
- i. Electrical control logic wiring from the aft umbilical to the three temperature sensors.

The fans operate as required by the following habitation area schedule:

- a. One or two fan operation when purging is taking place.
- b. One fan operation during the process of pressurization.
- c. Two fan operation during leak check.
- d. Two fan operation during venting.
- e. Two fan operation during all other ground periods from "Button-up" in the VAB until launch.

The flow distribution of the gaseous nitrogen, as a result of the fan operation, is shown on Figure 421-15. The nitrogen gas flow distribution is predicted on the following:

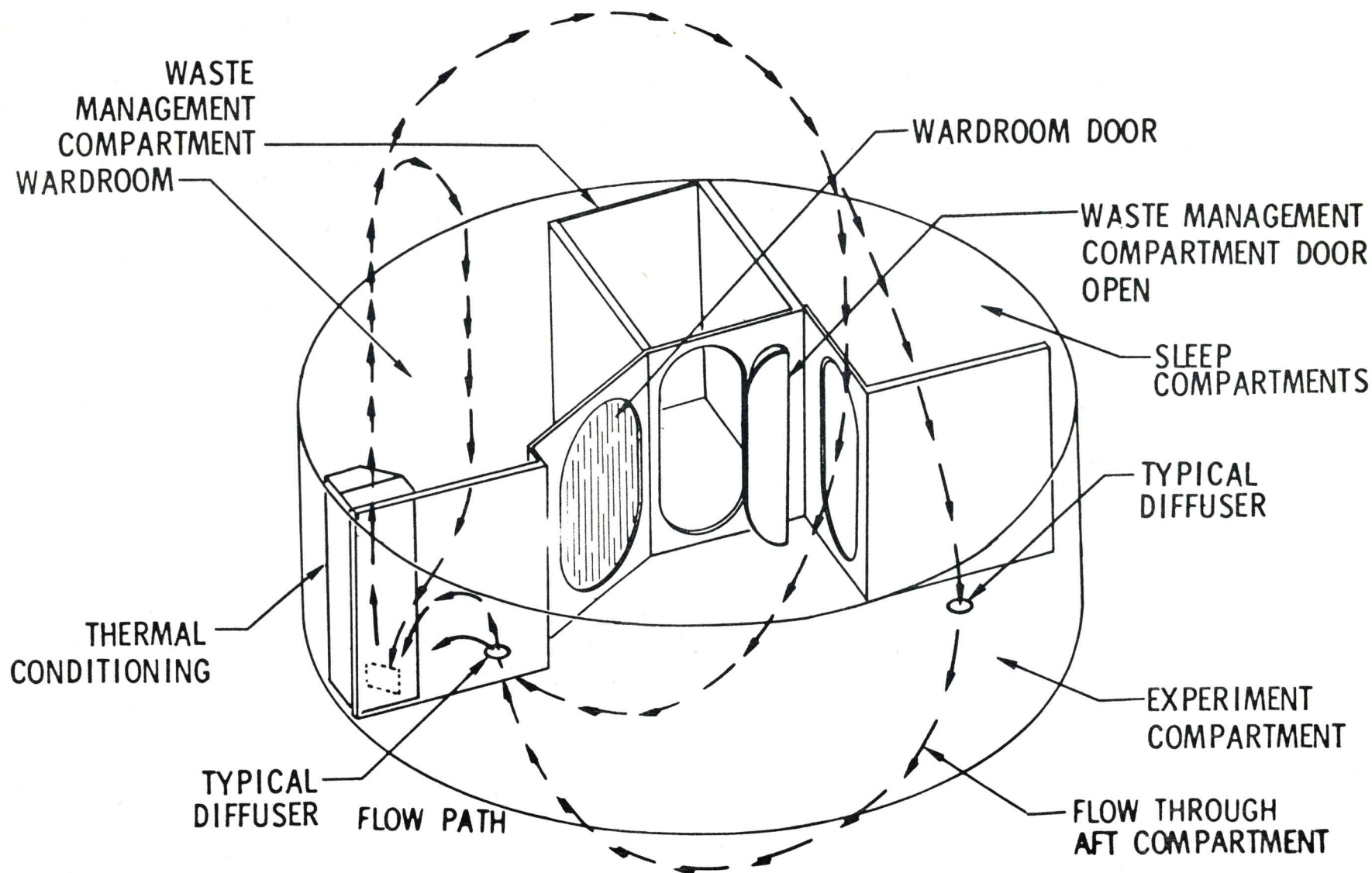
- a. All diffusers and dampers full open for launch.
- b. Nitrogen leaving heat exchanger has sufficient velocity to flow to forward dome through second floor grids.
- c. Nitrogen returns to fans through Wardroom open ceiling grid, through open floor beams, and through Aft Compartment via open diffusers.

The aft compartment, Waste Management Compartment, and Sleep Compartment are not fully conditioned to the 50°F optimum launch condition.

The three temperature sensors interface electrically with the logic located on GSE.

ORBITAL WORKSHOP GROUND THERMAL CONDITIONING SYSTEM FLOW DISTRIBUTION

O/W-8277
6-24-70



4-62

Figure 421-15.

4.2.1.2.1.3 GSE Subsystem Hardware Description

The GSE subsystem consists of the following equipment and components:

- a. Two Thermal Conditioning Units (TCU's) manifolded in tandem for redundancy.
- b. Reheat Control Unit (RCU) having high pressure gaseous nitrogen lines and connections for purging of the water/ethylene glycol supply and return lines.
- c. Umbilical hoses.
- d. Control logic and instrumentation.
- e. Modifications to existing Habitation Area purging GSE.

Primary Ground Conditioning GSE Components

The primary GSE components consist of the two TCU's, the RCU, and the umbilical hoses (Figure 421-16).

The TCU's are a Government Furnished Part (GFP) and each contain a two-stage reciprocating refrigeration compressor suitable for low temperature application, air cooled condenser, assortment of solenoid and thermostatic expansion valves, two liquid to vapor heat exchangers, the evaporator-chiller and water-glycol coolant fluid pumps. This unit is fully instrumented for local-remote control and monitoring.

The RCU is an enclosed insulated cabinet including the following:

- a. Redundant valving system to achieve high functional reliability.
- b. Relief valves to protect the vehicle system from overpressurization.
- c. Pressure and temperature transducers to indicate temperature and pressure of water-glycol before entry into the vehicle.
- d. Heaters for fluid conditioning.
- e. Provisions for gaseous nitrogen purge of the water-glycol vehicle supply and return lines.

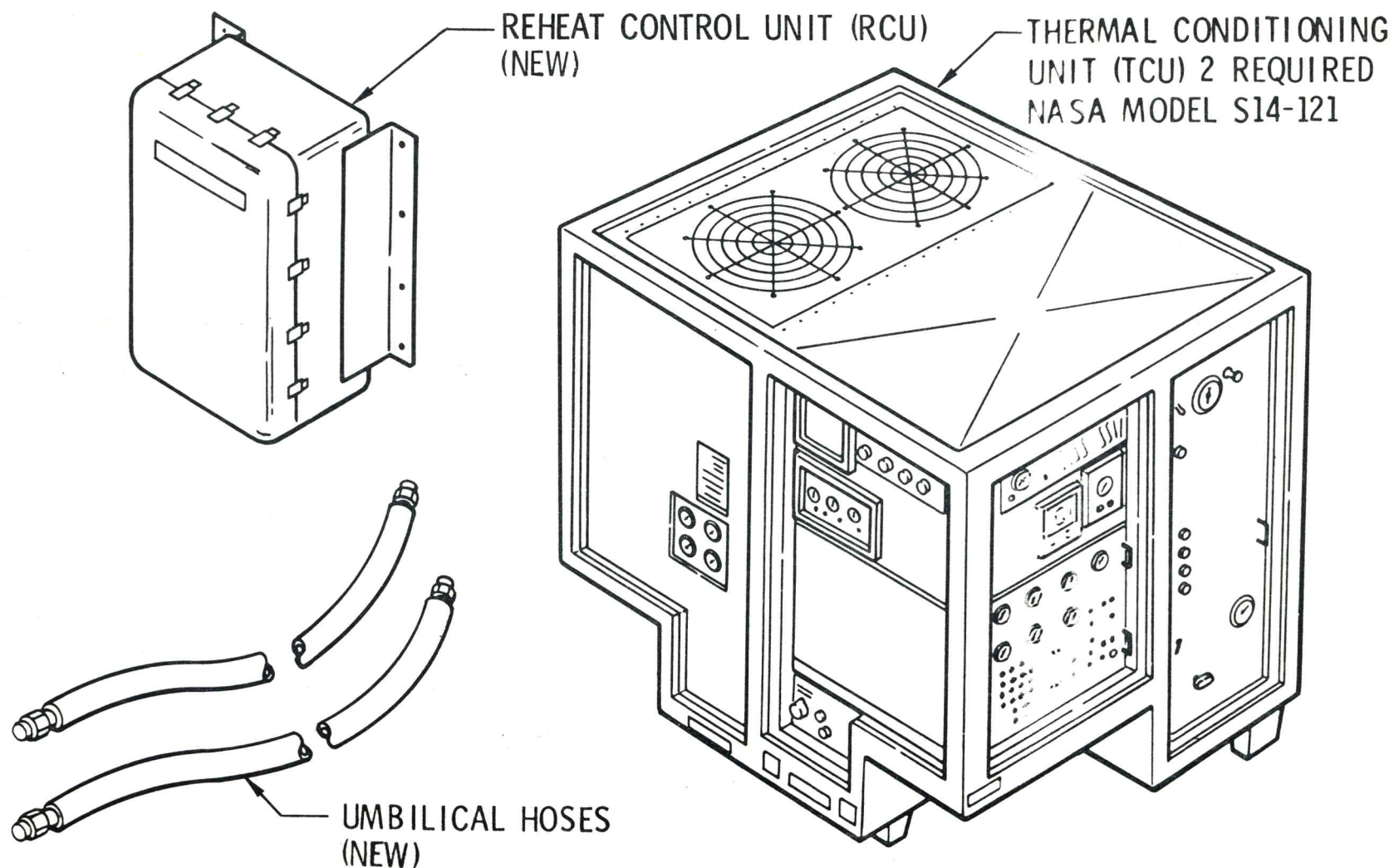
The hose assembly consists of supply and return flexible hoses insulated with a closed cell type insulation. The insulation is covered with aluminum-mylar type tape to give maximum protection from the environment and also to minimize solar heat load on the hose.

The functional TCU, or the RCU operate independently upon demand as described in the following paragraphs and are operated during all ground operations from the time of OWS "Button-up" until launch except during the habitation area purging operation.

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ORBITAL WORKSHOP GROUND THERMAL CONDITIONING SYSTEM GROUND CONDITIONING SYSTEM COMPONENTS

O/W-5970A
8-11-70



4-64

Figure 421-16.

The following parameters and conditions are used in design efforts for Model DSV-7-334, OWS Ground Thermal Conditioning System.

Parameters listed are applicable at point (A) in Figure 421-17.

- a. Water-Glycol Flow Rate = 3 GPM (Min)
- b. Water-Glycol Temperature = 0°F (Max)
- c. Water-Glycol Mixture Ratio: (By Wgt)

| | |
|-----------------|---------------|
| Water | 35.72 percent |
| Ethylene-Glycol | 62.50 percent |
| Inhibitor | 1.78 percent |
- d. Pressure: 200 psig (Max)
- e. Location of TCU's: LUT Level 80 feet
- f. Location of RCU: LUT Level 220 feet
- g. The maximum vehicle heat transfer rate (cooling load) to ground heat exchanger is: 38,000 Btu/hr.
- h. The maximum vehicle heat transfer rate (heating load) from ground heat exchanger is: 12,000 Btu/hr.
- i. Vehicle coolant supply and return line size: 1/2-inch O.D. x 0.020-inch wall minimum. (Insulated)
- j. OWS-Ground Heat Exchanger Pressure Loss will not exceed 15 psi when the flow of water-glycol is 3 gpm at a temperature of 0°F.

The RCU is shown on 1B84920. The schematic for the RCU is shown on Figure 421-18.

The GN₂ and the coolant supply pressure transducer requirements are similar to MRD's (DSV7-301 MRD's) 1B77547 and 1B77546 respectively. the coolant supply and return temperature transducer requirements are similar to MRD's (DSV7-301 MRD's) 1B77548 and 1B77549 respectively, except the temperature range will change. A MRD for each of the four readouts is to be determined.

The heaters will be similar to 1B26961-1 (DSV-4B-359).

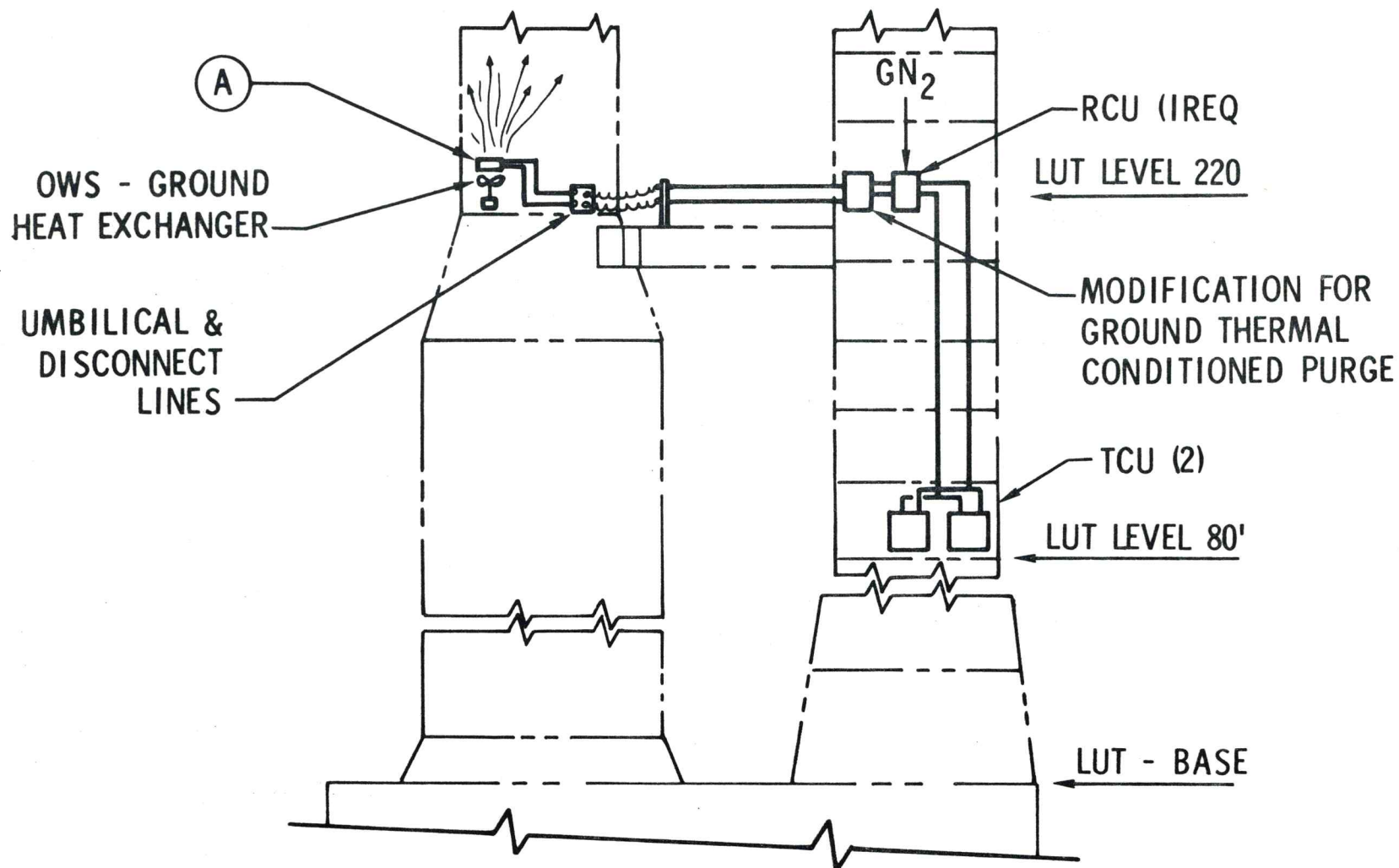
The solenoid valves will be identical to the valves used on the coolant control unit, 1B80322 (DSV7-301).

4.2.1.2.1.4 Control Logic and Instrumentation

Control logic and instrumentation, covering selected methods and controls and displays are described in the following paragraphs.

ORBITAL WORKSHOP GROUND THERMAL CONDITIONING SYSTEM SYSTEM CONCEPT

O/W-8948
8-11-70



4-66

Figure 421-17.

ORBITAL WORKSHOP GROUND THERMAL CONDITIONING SYSTEM REHEAT CONTROL UNIT (RCU) 1B84920

O/W-8949
8-11-70

4-67

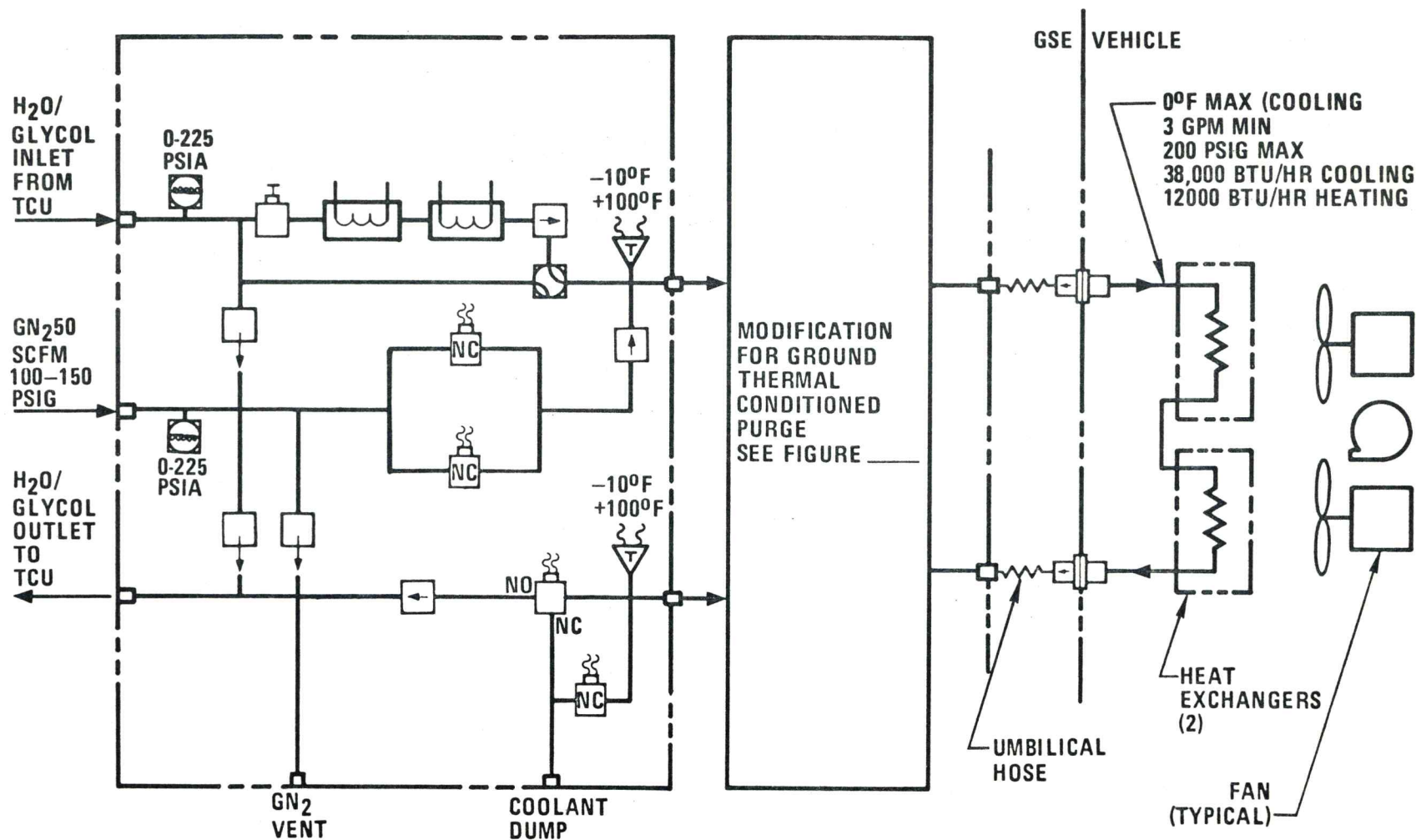


Figure 421-18.

Selected Method

This method utilizes manual control by the ground crew.

There will be times when both air circulation fans in the vehicle are operating and other times when only one fan will be on.

It has been determined that the TCU refrigeration system and water-glycol circulation pumps and the electric heaters would all be individually controlled.

The control logic for the functional TCU and RCU must be nonoperational during any purging operation. Additional control logic will be required for the proposed purging GSE modification.

Controls/Displays

Controls

- a. Refrigeration System ON/OFF.
- b. Circulation Pumps ON/OFF.
- c. Electric Heaters ON/OFF.
- d. Fans (in vehicle) ON/OFF (Automatic Failure Lockout).

Displays

- a. Two RPM (one for each vehicle air circulating fan for failure detection).
- b. Three temperature (one readout for each vehicle temperature sensor).

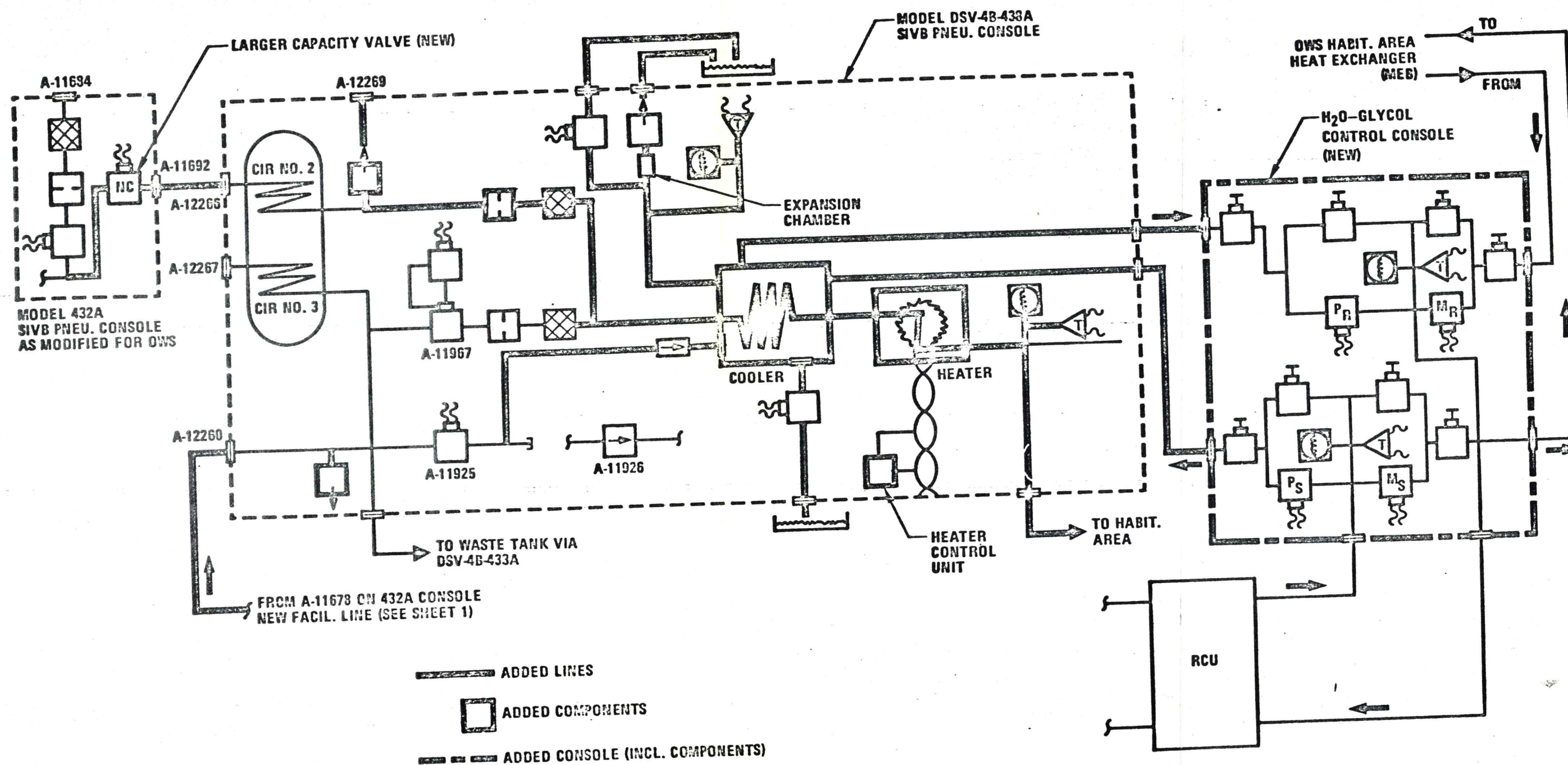
Instrumentation

The same as on GSE Model DSV7-301.

The controls/displays on the TCU portion of the new GSE Model DSV7-334 will be the same as GSE Model DSV7-301, with the exception that the logic will be able to control the refrigeration cycle and circulation pumps in conjunction with the heaters in the new RCU unit.

4.2.1.2.1.5 Modifications to Purging GSE

The capability to maintain habitation area temperatures between 40° and 80°F provided by propulsion GSE as described in A3-250-ADS0-M-9, dated 7-23-70, results in a requirement to provide temperature-conditioned GN₂ to the OWS habitation area at approximately one pound per second (1 lb/sec) for 1/2-hour or more. The modifications are shown on Figure 421-19.



Modifications for Ground Thermal Conditioning System
Thermal Conditioned Purge

Figure 421-19.

The propulsion GSE to provide this capability will consist of two modified pneumatic consoles (DSV-4B-432A and DSV-4B-438A), a new water-glycol control valve system assembly with interconnecting plumbing, one unmodified pneumatic console (DSV-4B-433A), and some additions to Accessories Kit DSV7-300 to provide an adequate purge flow rate to the vent stack. DSV-4B-432A was previously modified by Modification Kit DSV7-329 to provide 750 psig GN₂ for pressurizing the habitation area and waste tank, plus 100 to 150 psig GN₂ to Model DSV7-301. Model DSV-4B-438A was previously modified by Modification Kit DSV7-332 to make -438A compatible with the modified -432A. The water-glycol control valve system is required to direct the water-glycol, chilled by Model DSV7-334 Temperature Control Unit (TCU), to either the new GN₂ cooling unit in DSV-4B-438A, described below, or to the OWS habitation area ground thermal conditioning heat exchanger.

The additional modifications required in Model DSV-4B-432A to satisfy the Ground Thermally Conditioned Purge requirements consist of installing (schematically, if not physically) a larger capacity valve in the location now occupied by solenoid valve A-11740. This will require new and larger tube assemblies on both sides of the new valve, new support brackets for the new valve, and modifications to the DSV-4B-432A cabinet, both for removal and replacement of the valve brackets and for enlargement of interface A-11692. This circuit is to be used only after adjusting regulators A-11735 and A-12059 to a pressure output of 750 to 1000 psig.

The additional modifications required in Model DSV-4B-438A are:

- a. Addition of a GN₂ cooling unit utilizing water-glycol as the coolant. The required heat rejection capacity is 37,500 Btu hr.
- b. Addition of a GN₂ heating unit utilizing electrical resistance as the heat source and equipped with a heater control unit. The required heat input (maximum) is 41,000 Btu hr.
- c. Addition of the following plumbing and components required by the GN₂ cooling unit:
 1. Coolant flow plumbing into and out of the cooling unit.
 2. Coolant vent valve, relief valve, liquid expansion chamber, catch basin and all related plumbing.
 3. A coolant purge system. This circuitry will require the rerouting of the facility hard-line from interface A-11678 on Model DSV-4B-432A to connect it to interface A-11260 on Model DSV-4B-438A to provide low pressure GN₂. Within DSV-4B-438A, this modified circuitry will include addition of a relief valve upstream of the solenoid valve at A-11925, disconnecting and capping the line leading to check valve A-11926, adding a new check-valve-equipped tubing run into the next exchanger, and a solenoid-valve-equipped tubing run out of the cooling unit to a catch basin.

- d. Revision of circuit No. 2 of Model DSV-4B-438A downstream of the existing cryogenic heat exchanger tank as follows:
 1. Add a relief valve in the line leading to interface A-11269 (and disconnect external hardline connected to A-12269).
 2. Continue circuit No. 2 to connect into circuit No. 3 upstream of the new cooling unit. This tubing run shall include an orifice and a filter.
- e. Addition of a pressure transducer downstream of the new heating unit.
- f. Addition of a temperature transducer downstream of the new heating unit.

The new water-glycol control valve system assembly will consist of four solenoid valves, eight hand valves, two pressure transducers and two temperature transducers mounted on a suitable support structure equipped with six interface fittings. The six interfaces are:

- a. Supply from the water-glycol source.
- b. Return to the water-glycol source.
- c. Supply to the OWS Habitation Area Heat Exchanger.
- d. Return from the OWS Habitation Area Heat Exchanger.
- e. Supply to the DSV-4B-438A water-glycol/GN₂ cooling unit.
- f. Return from the DSV-4B-438A water-glycol/GN₂ cooling unit.

The four water-glycol supply valves consist of one solenoid valve and one hand valve in parallel to provide redundant supply of water-glycol to the OWS Habitation Area heat exchanger, and one solenoid valve and one hand valve in parallel to provide redundant supply of water-glycol to the DSV-4B-438A water-glycol/GN₂ cooling unit. Included is an electrical interlock to assure that when the solenoid valve supplying water-glycol to the Habitation Area heat exchanger is open, the solenoid valve for supplying the DSV-4B-438A water-glycol/GN₂ cooling unit is closed, and vice versa. Similarly, the electrical interlock shall assure that when the solenoid valve controlling return of water-glycol from the Habitation Area heat exchanger is open, the solenoid valve controlling return of water-glycol from the DSV-4B-438A water-glycol/GN₂ cooling unit is closed, and vice versa. The electrical interlock also assures that both solenoid valves (one supply and one return) allowing flow of water-glycol to and from the habitation area heat exchanger shall open and close simultaneously. Similarly, the electrical interlock shall assure that both solenoid valves (one supply and one return) allowing flow of water-glycol to and from the DSV-4B-438A water-glycol/GN₂ cooling unit shall open and close simultaneously.

The water-glycol control valve system also includes four additional hand valves (in the event of solenoid valve failure to close) to shut off.

- a. The coolant supply to the habitation area heat exchanger.
- b. The coolant supply to the new cooling unit in DSV-4B-438A.
- c. The coolant return from the habitation area heat exchanger.
- d. The coolant return from the new cooling unit in DSV-4B-438A.

4.2.1.2.2 On-Orbit Thermal Control Description

During habitation, the thermal control system (Figure 421-20) satisfies comfort criteria (Figure 421-21) for the heater power and heat removal design conditions shown in Table 421-2. Heat loads in excess of the design conditions, depending on the duration and magnitude of loads, can result in conditions not satisfying comfort criteria for portions of a given day at high beta angles. The design maintains local habitation area wall temperatures within the touch temperature range of 55° to 105°F by a combination active and passive thermal control.

Table 421-2
COMFORT PARAMETERS

| Condition | Beta Angle Range | Maximum Average Heater Power for Cold Case (Watts) | Minimum Electrical Heat Removal for Hot Case (Watts) |
|-----------|-----------------------|--|--|
| Nominal | -60° < β < +60° | 825 | 1350 |
| Nominal | -60° > β > +60° | 825 | 900 |
| 2 Sigma | -60° < β < +60° | 1170 | 1100 |
| 2 Sigma | -60° > β > +60° | 1170 | 600 |

The comfort conditions shall be met considering the above parameters.

Minimum electrical component power dissipated internally shall be 250 watts continuous.

Maximum total sensible metabolic range shall be 1000 Btu/hr.

ORBITAL WORKSHOP VCS/TCS SCHEMATIC

O/W-4628
6-15-70

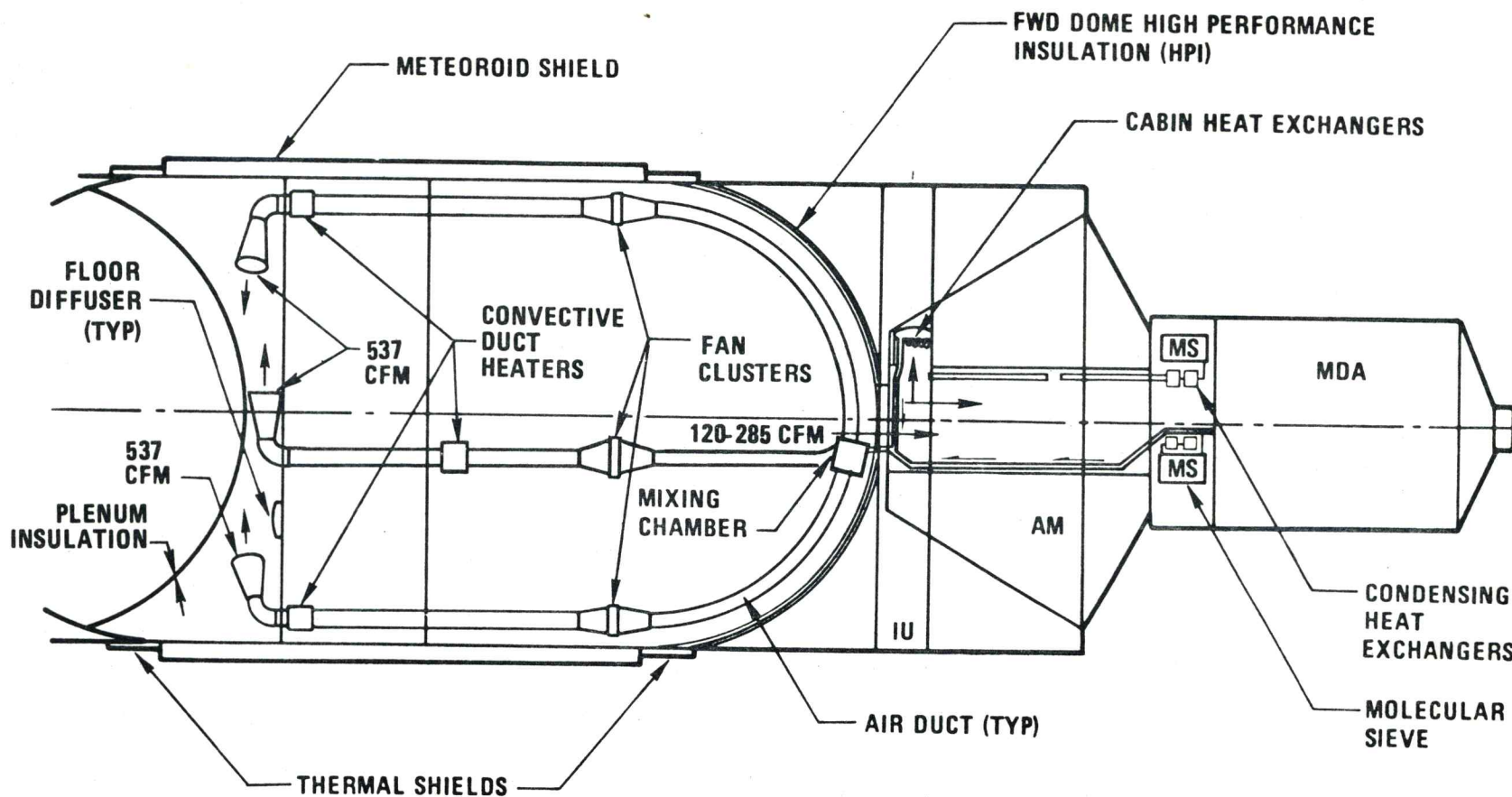


Figure 421-20. (Sheet 1 of 2)

ORBITAL WORKSHOP VCS/TCS SCHEMATIC

O/W-4759
5-27-70

4-74

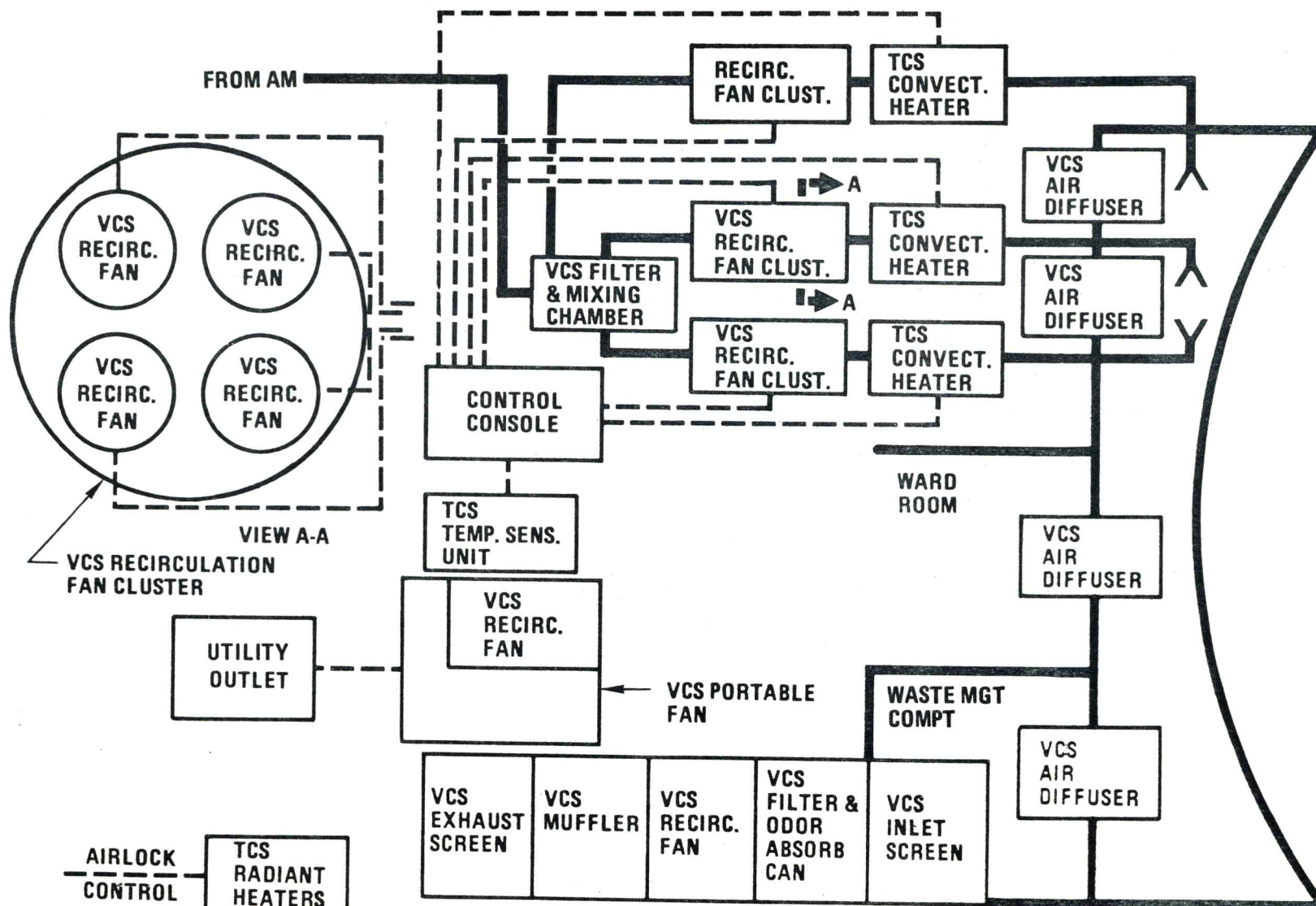


Figure 421-20. (Sheet 2 of 2)

SKYLAB "B" WORKSHOP THERMAL CONTROL SYSTEM ALL OPTIONS

O/W-7592
6-15-70

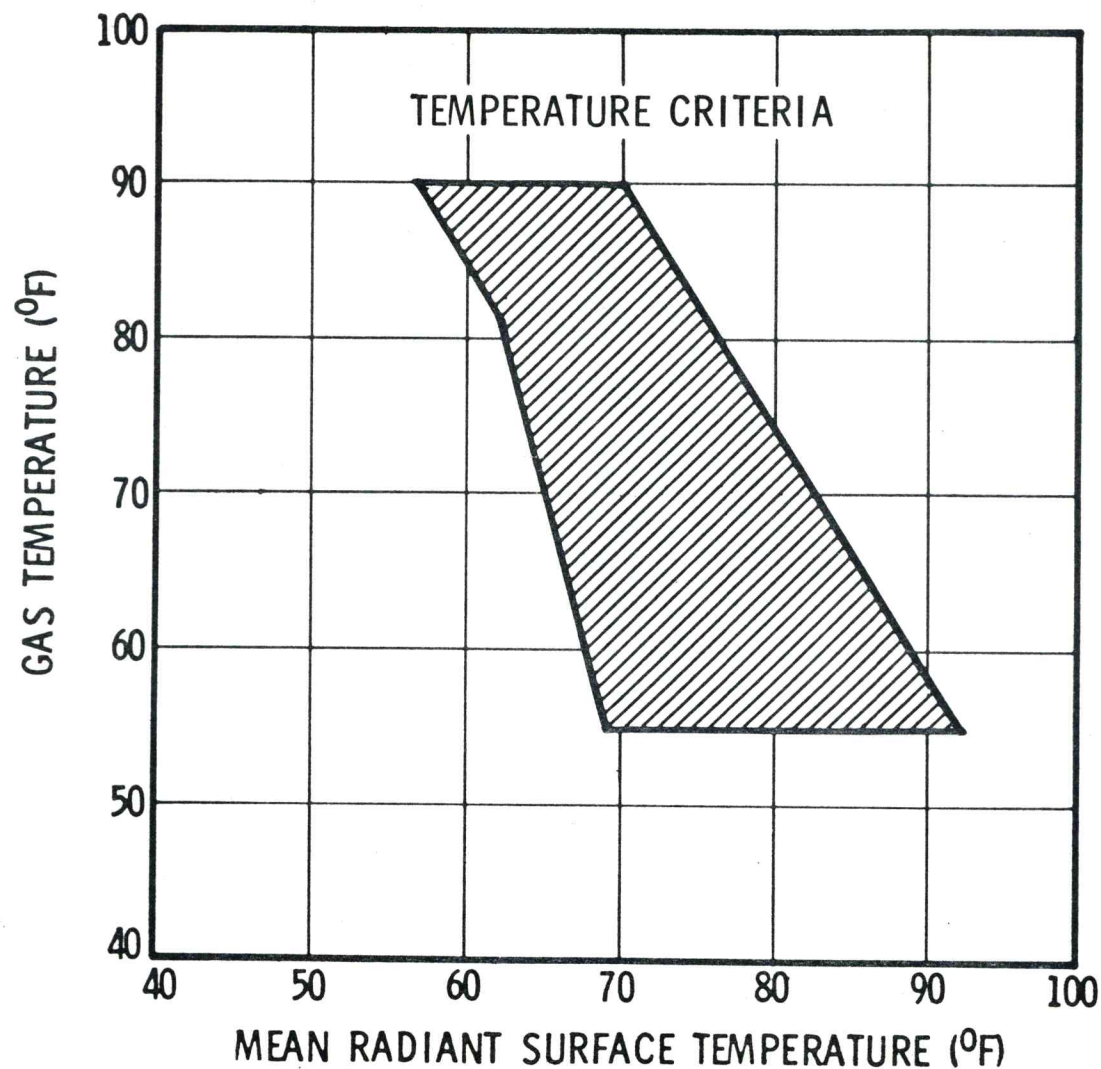


Figure 421-21.

4.2.1.2.2.1 Active Thermal Control

The active thermal control subsystem consists of convective heater assemblies located in the three VCS ducts, and four cabin gas heat exchangers located in the AM. Each of the three heater assemblies is capable of dissipating 500 watts at 24 volts (1500 watts total). The heaters in two of the ducts and the four cooling heat exchangers are controlled automatically or manually from Control and Display Panel No. 2. The heater in the third duct can only be manually controlled from Control and Display Panel No. 2.

Convective Heaters (1B77702)

Three 4-element convective heaters are installed, on each in the three VCS ducts (Figure 421-22). Each heater element is a 125 watt, 24 volt unit. The elements are thermostatically controlled for deactivation at a $260^{\circ} \pm 10^{\circ}\text{F}$ surface temperature.

Cabin Gas Heat Exchangers (AM)

The thermal control system utilizes four heat exchangers, located in the AM, as the source of cooling when required. Flow through the heat exchangers is controlled automatically (with manual override) by the thermal controller. The heat exchangers supply cooled air that is mixed with reconstituted air from the AM and recirculated air from the OWS. The AM heat exchanger performance characteristics are shown in Figure 421-23.

Temperature Control Subsystem

The temperature control subsystem (Figure 421-24) provides control of atmosphere heating and cooling. The subsystem is capable of automatic and manual operation.

The thermal control system controller unit is located on the Control and Display Console Panel No. 2. The controller displays gas temperature, pressure, and duct flow rates. It also houses the switches controlling the operation of the TCS. The temperature selector switch is set to the desired cabin gas temperature by the astronaut when the other switches controlling the duct heaters and AM heat exchanger fans are set in the automatic mode position. The fan and heater control switches may also be set to ON or OFF positions, thereby overriding the thermal controller commands.

Radiant Heaters (1B81046)

Eight radiant warmup heaters are provided to maintain the temperature of the OWS interior structure at a nominal 50°F prior to astronaut entry. The heaters dissipate a total of 1000 watts. Three heaters are located in the forward compartment, the remaining five are located in the crew quarters (Figure 421-25). The maximum surface temperature of the heaters is 160°F . The radiant heaters are not controlled within the OWS. The heaters are automatically controlled through the Digital Command System (DCS) and manually by switches in the AM (Figure 421-24).

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ORBITAL WORKSHOP CONVECTIVE HEATER

**O/W-4285
8-11-70**

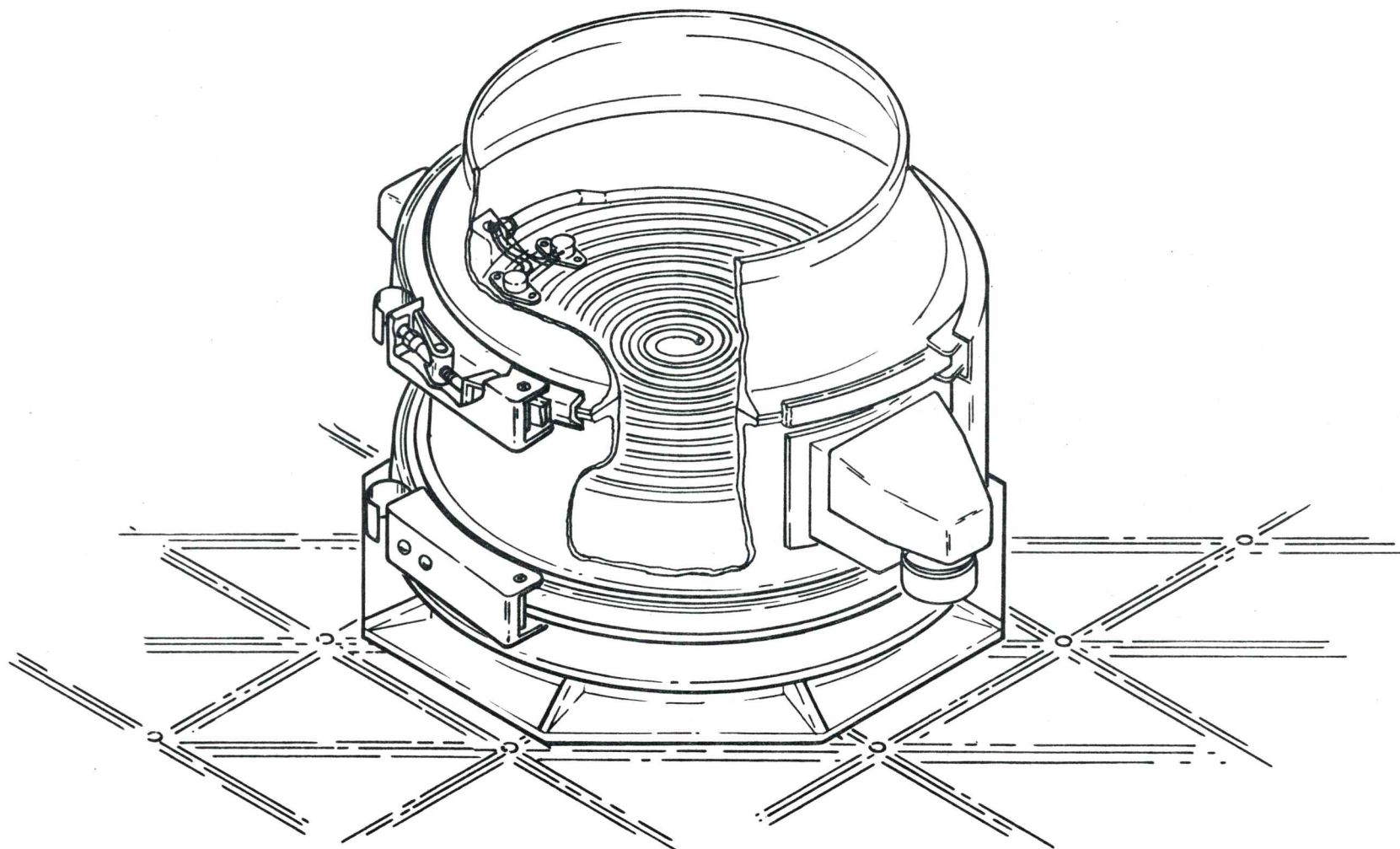


Figure 421-22.

ORBITAL WORKSHOP AIRLOCK HEAT EXCHANGER PERFORMANCE

O/W-8779
8-7-70

TOTAL SENSIBLE HEAT REMOVED
FROM OWS BY ACTIVE COMPONENTS - BTU/HR

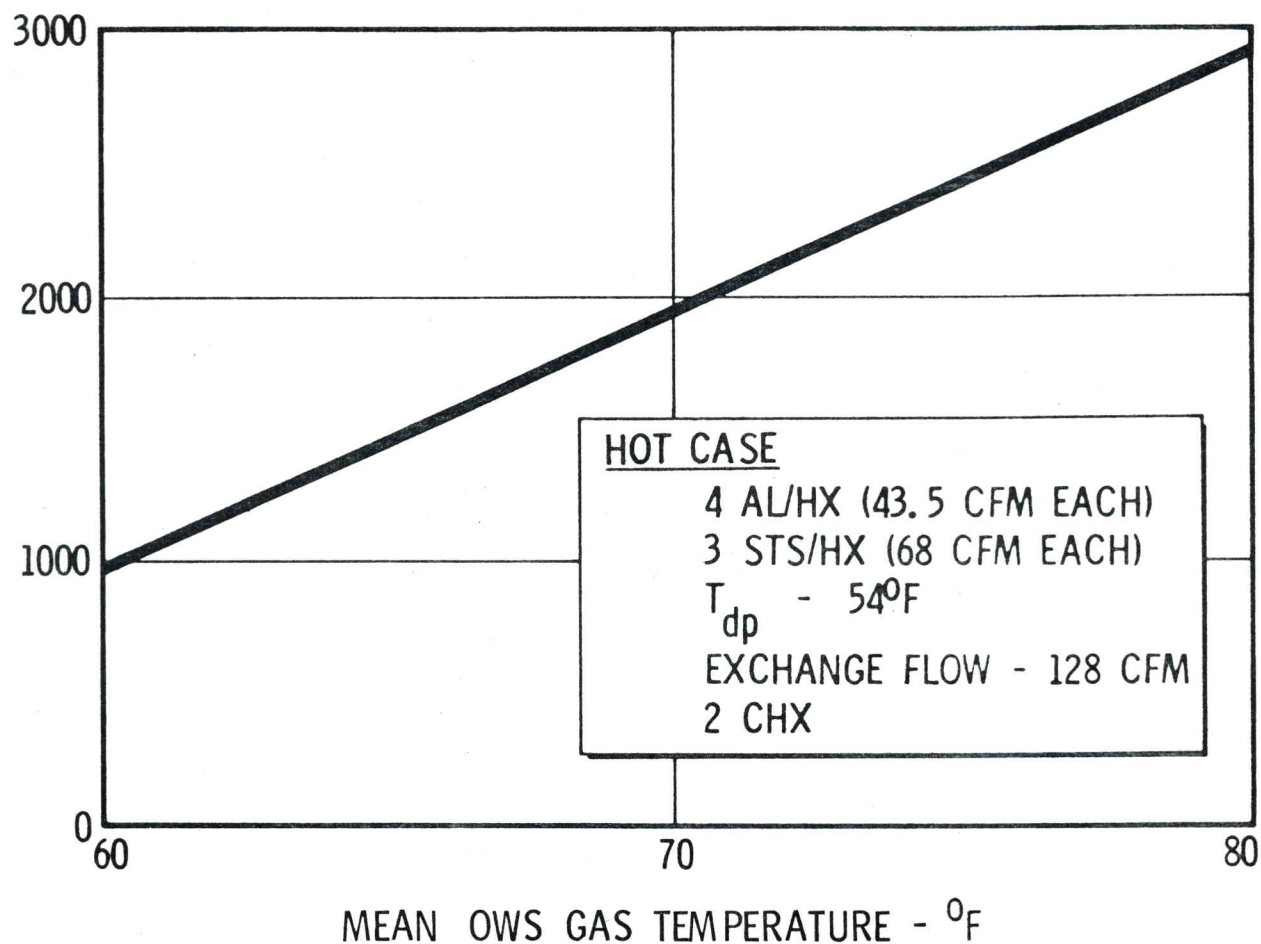


Figure 421-23.

ORBITAL WORKSHOP TEMPERATURE CONTROL SUBSYSTEM

O/W-4181
5-22-70

4-79

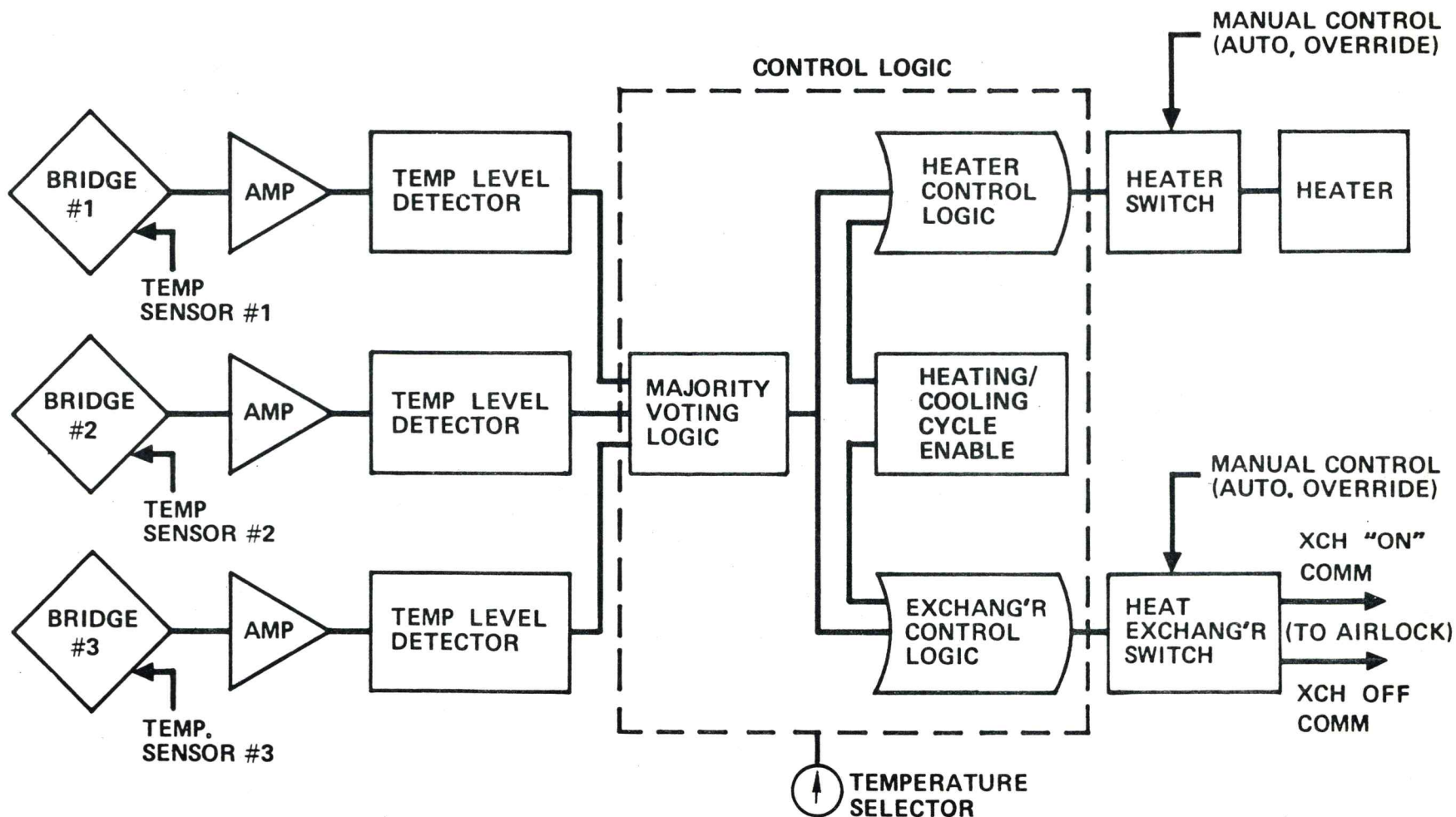


Figure 421-24. (Sheet 1 of 4)

ORBITAL WORKSHOP HEATER CONTROL

O/W-7771B
6-26-70

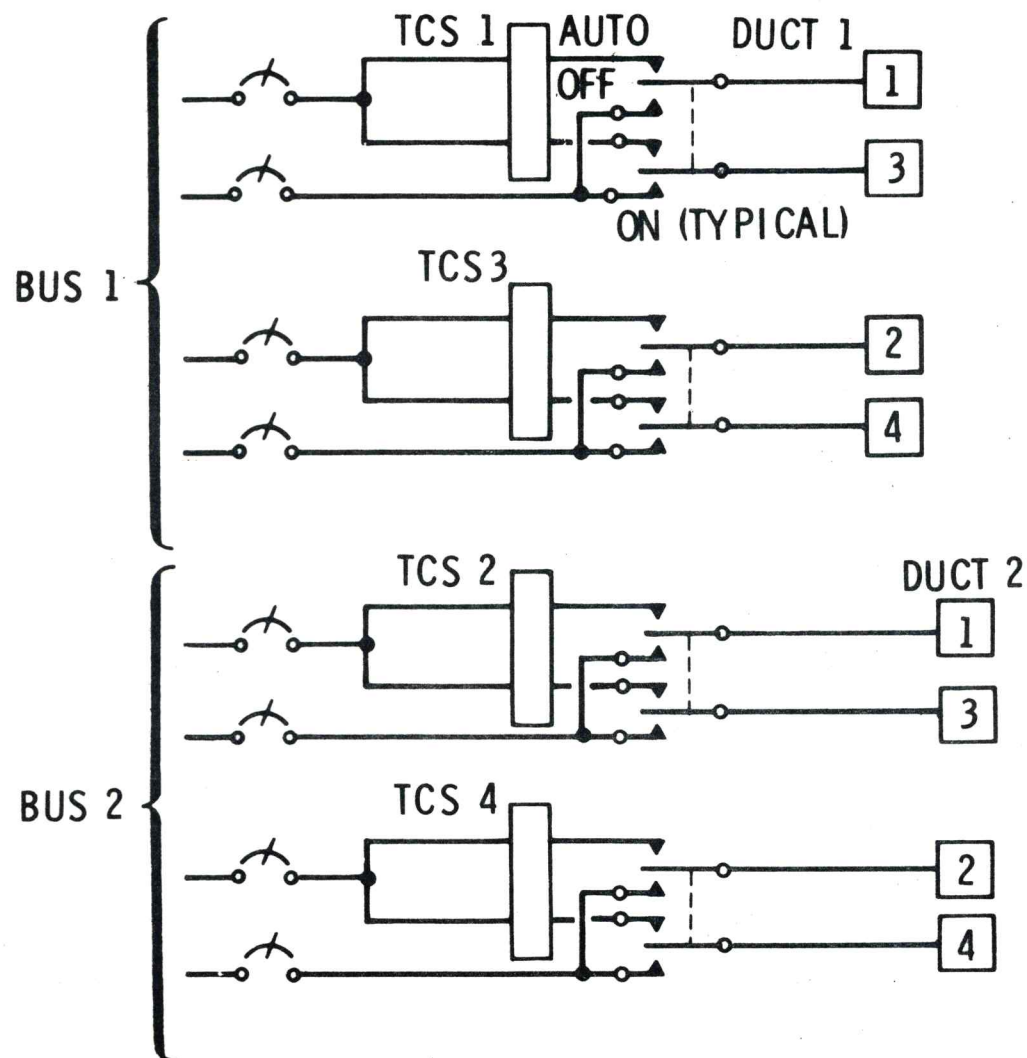


Figure 421-24. (Sheet 2 of 4)

ORBITAL WORKSHOP HEATER CONTROL DUCT 3

O/W-7771B-1
6-30-70

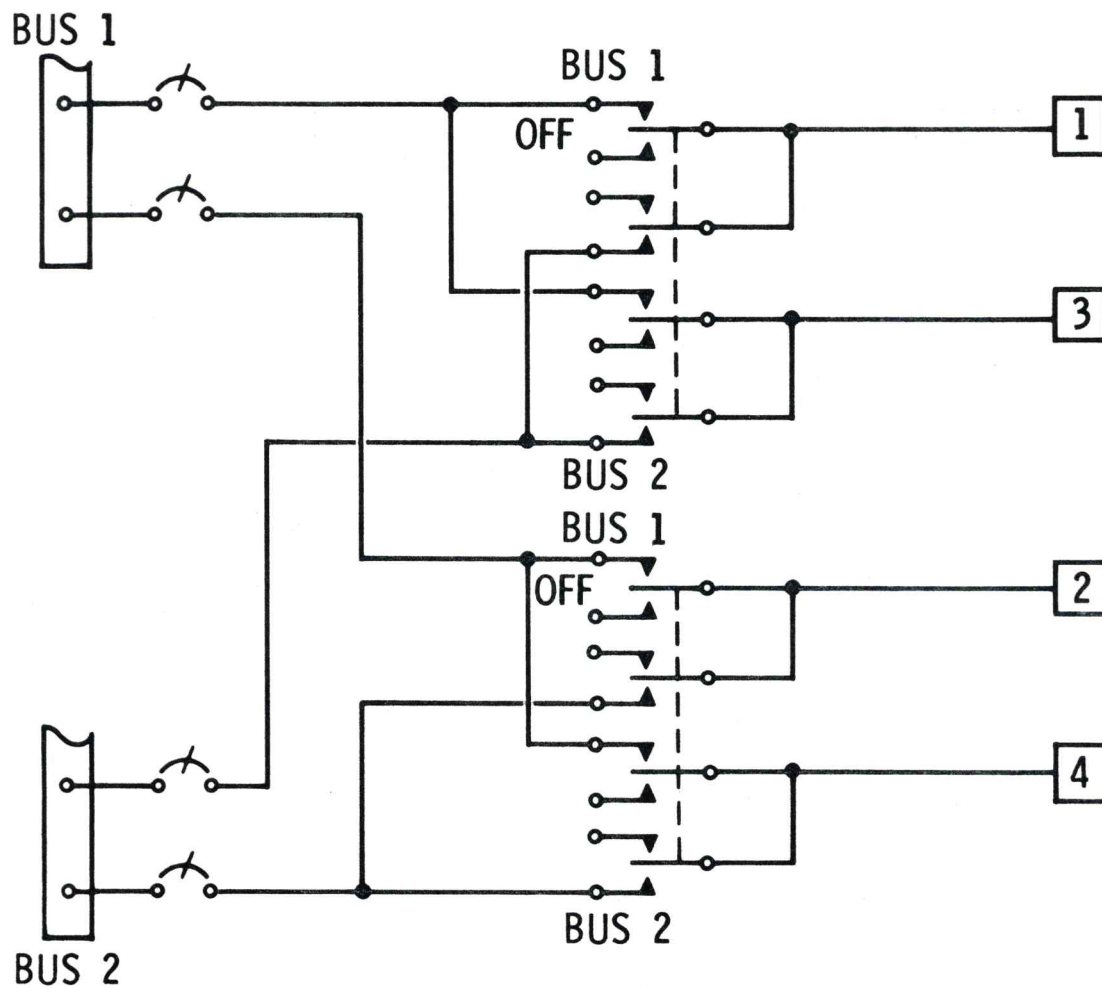
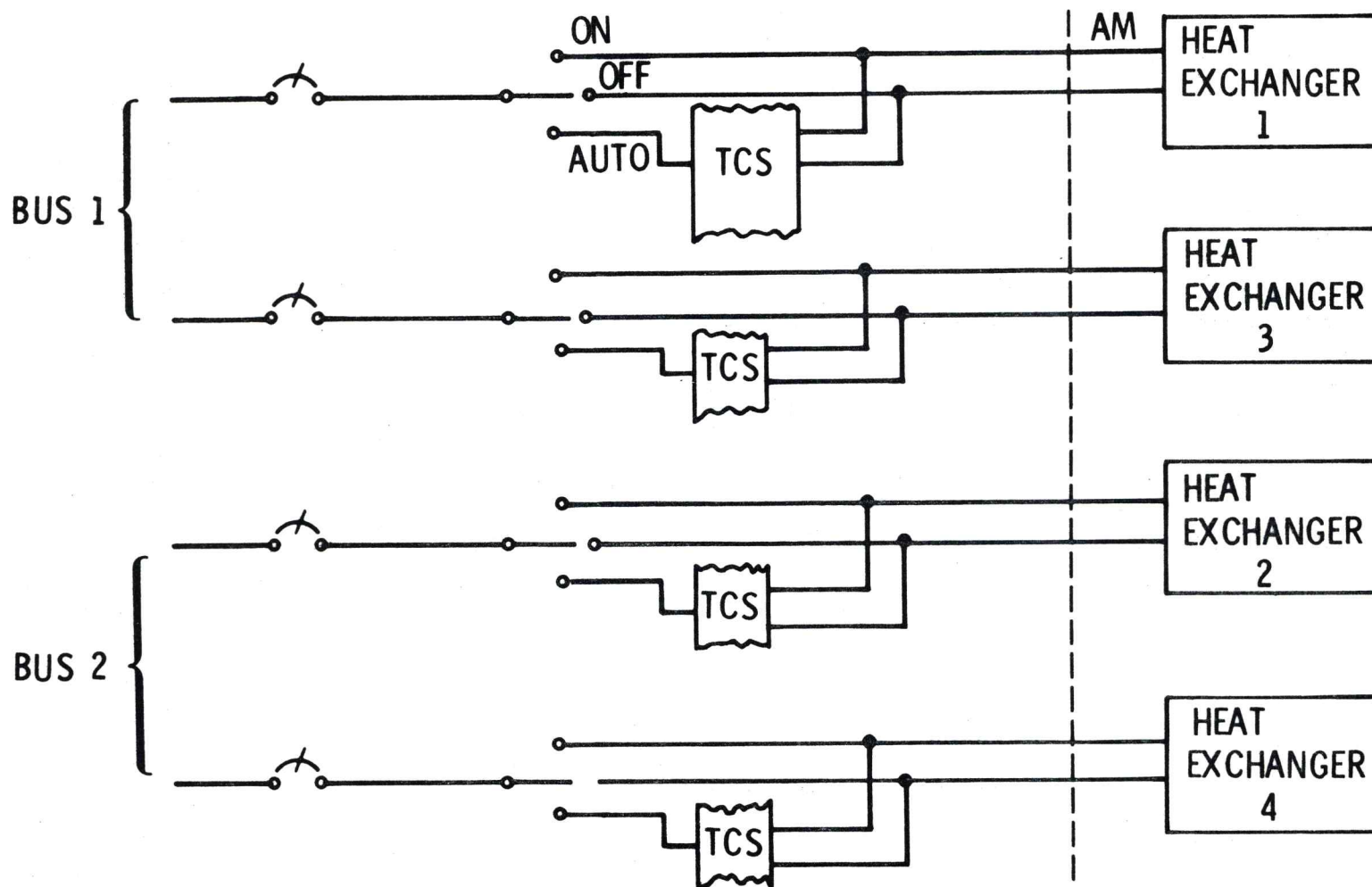


Figure 421-24. (Sheet 3 of 4)

ORBITAL WORKSHOP HEAT EXCHANGER CONTROL

O/W-8060
6-15-70



4-82

Figure 421-24. (Sheet 4 of 4)

ORBITAL WORKSHOP WARM-UP RADIANT HEATER/LOCATION

O/W-7477
5-26-70

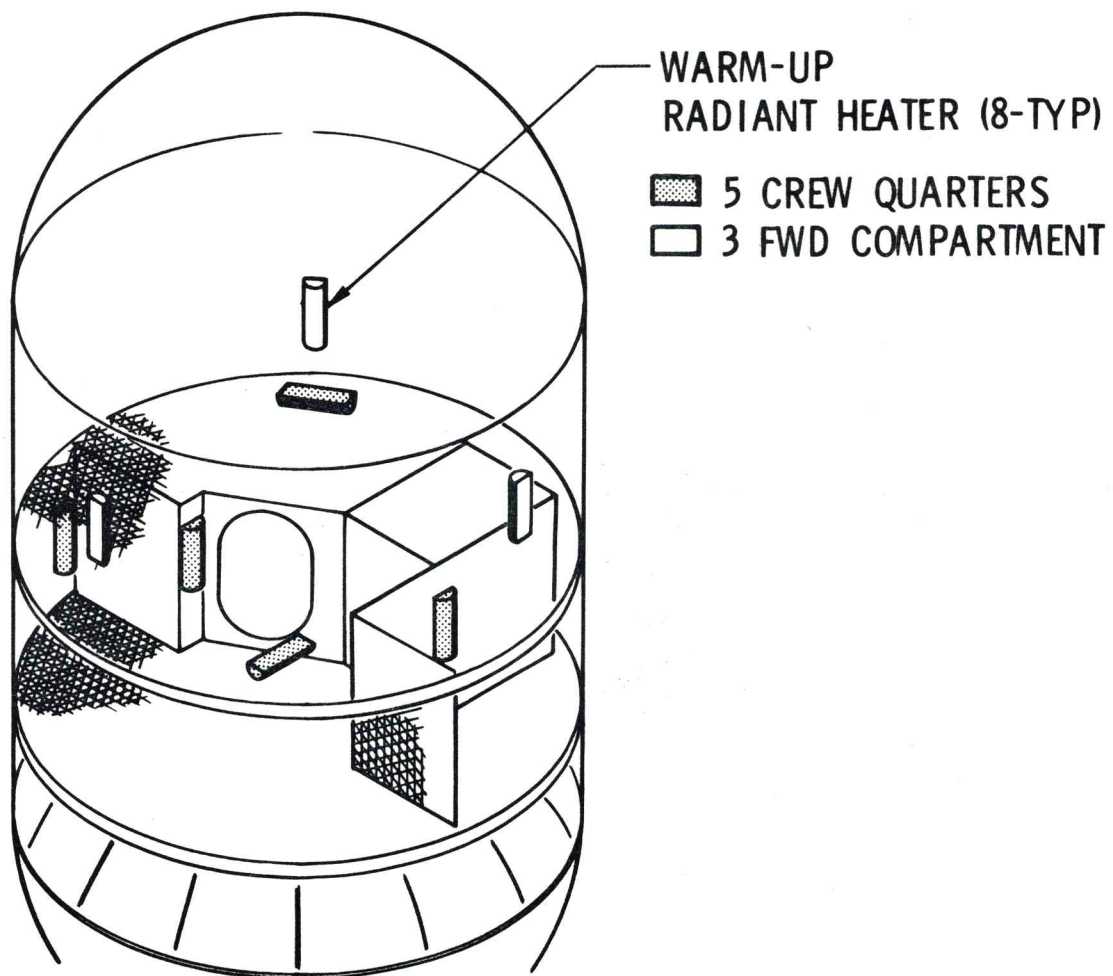


Figure 421-25. (Sheet 1 of 2)

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ORBITAL WORKSHOP WARM-UP RADIANT HEATER INSTALLATION (TYPICAL)

O/W-7266
5-18-70

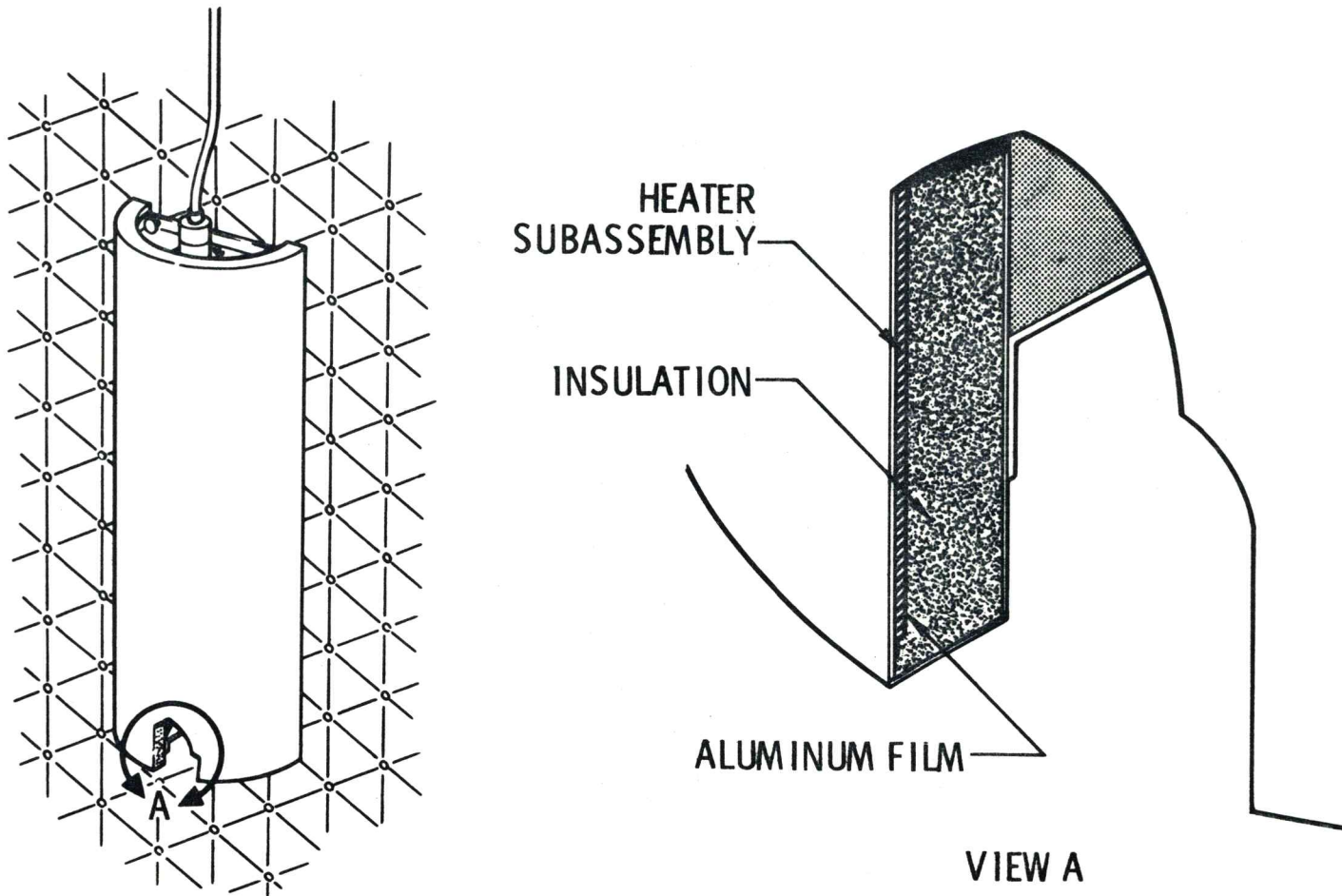


Figure 421-25. (Sheet 2 of 2)

4.2.1.2.2.2 Passive Thermal Control

The passive thermal control subsystem consists of polyurethane foam insulation on the internal surfaces of the forward compartment, high performance insulation on the forward dome, and optical property control of critical interior and exterior surfaces of the OWS. Items contributing toward passive thermal control are discussed in the following paragraphs.

Meteoroid Shield

The deployed meteoroid shields aids in heat balance control through use of a very low emissivity coating (goldized kapton) on one of the facing surfaces (outer habitation area wall, Figure 421-26).

Meteoroid Shield Boots (1B82677)

The meteoroid shield boot (Figure 421-27) minimizes the radiative heat loss from the forward and aft annulus formed by the deployed meteoroid shield and the habitation area.

Thermal Shields (1B76876)

Thermal shields cover portions of the forward and aft skirts, protecting a desired emissivity surface (Figure 421-28). They extend from the forward and aft habitation area joints to the first frame of the forward or aft skirt at stations 585.927 and 252.650, respectively. The primary function of the shield is to prevent excessive heat losses from the habitation area due to conduction and radiation. The heat loss results from conduction through the habitation area joints into the skirts, providing a large area from which heat is radiated into space. The most critical area for heat loss is at the joints, therefore, covering them is of prime importance.

High Performance Insulation (1B75752)

The forward dome heat loss without insulation would be detrimental to the habitable environment within the OWS. A high performance insulation (HPI) system with an overall heat transfer conductance value of $0.02 \text{ Btu/hr-ft}^2 \text{ } ^\circ\text{F}$ or less, consisting of multiple layers of double aluminized Mylar (0.00015-inch) separated by Dacron net spacers (0.008-inch) is provided. The layers are held together by intermittently spaced nylon fasteners (buttons) which penetrate the multilayer insulation and retain the system at a constant thickness (0.5-inch).

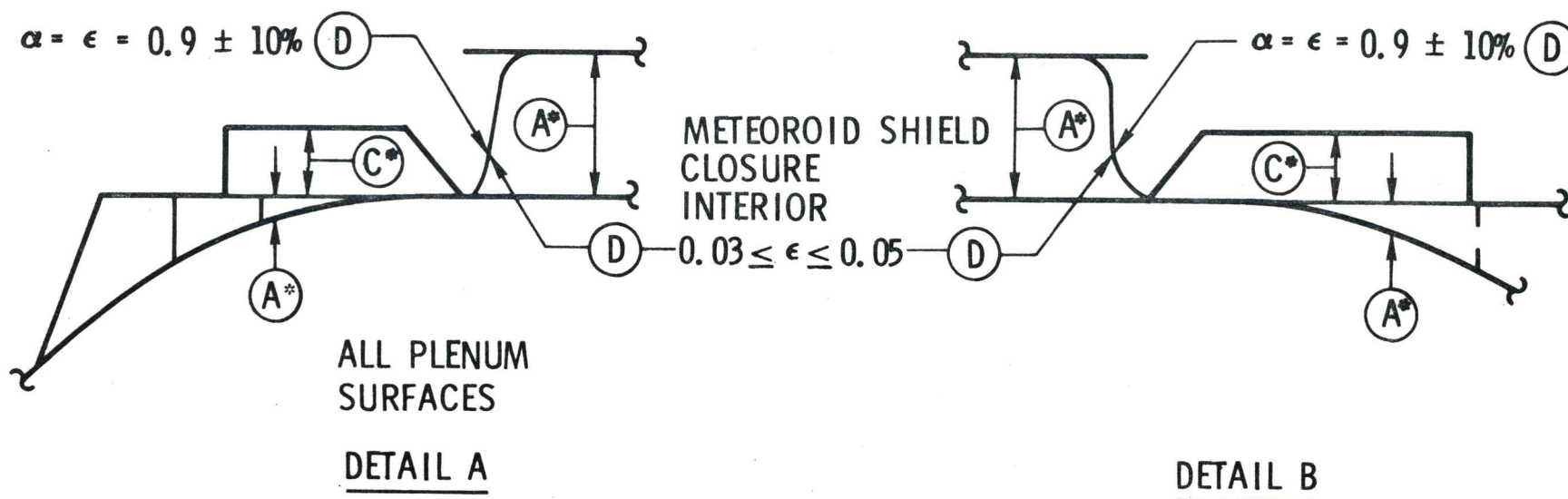
There are 18 panels (20 degree gore sections) to cover the forward dome area (Figure 421-29). Each panel consists of 48 layers of double, aluminized Mylar and 47 layers of Dacron net spacer material. The panels are approximately 160 inches long by 48 inches wide at the aft end, and 12 inches wide at the forward end.

The 18 panels are identical except for the cutouts required at the three electrical feed-through fittings. Special skull cap shaped HPI is used to cover the fittings and tie to the panel insulation.

ORBITAL WORKSHOP SURFACE OPTICAL PROPERTIES

O/W-4630-1
11-22-69

4-86



NOTES:

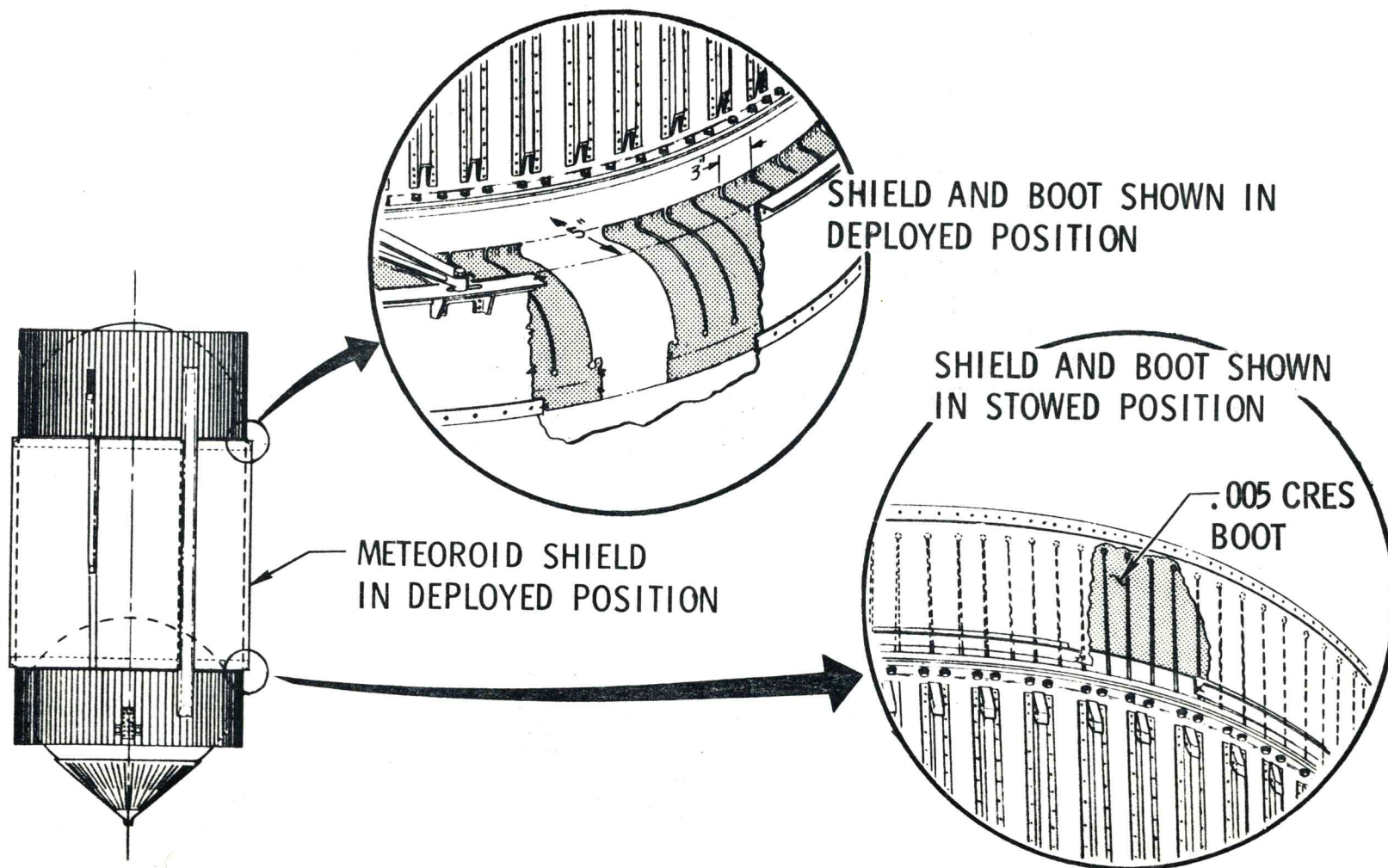
* INDICATES $\epsilon_{\text{eff}} \leq 0.05$

CIRCLED LETTERS REFER TO CHART OW-4632.

Figure 421-26.

ORBITAL WORKSHOP METEOROID SHIELD BOOT

O/W-1377
6-16-70

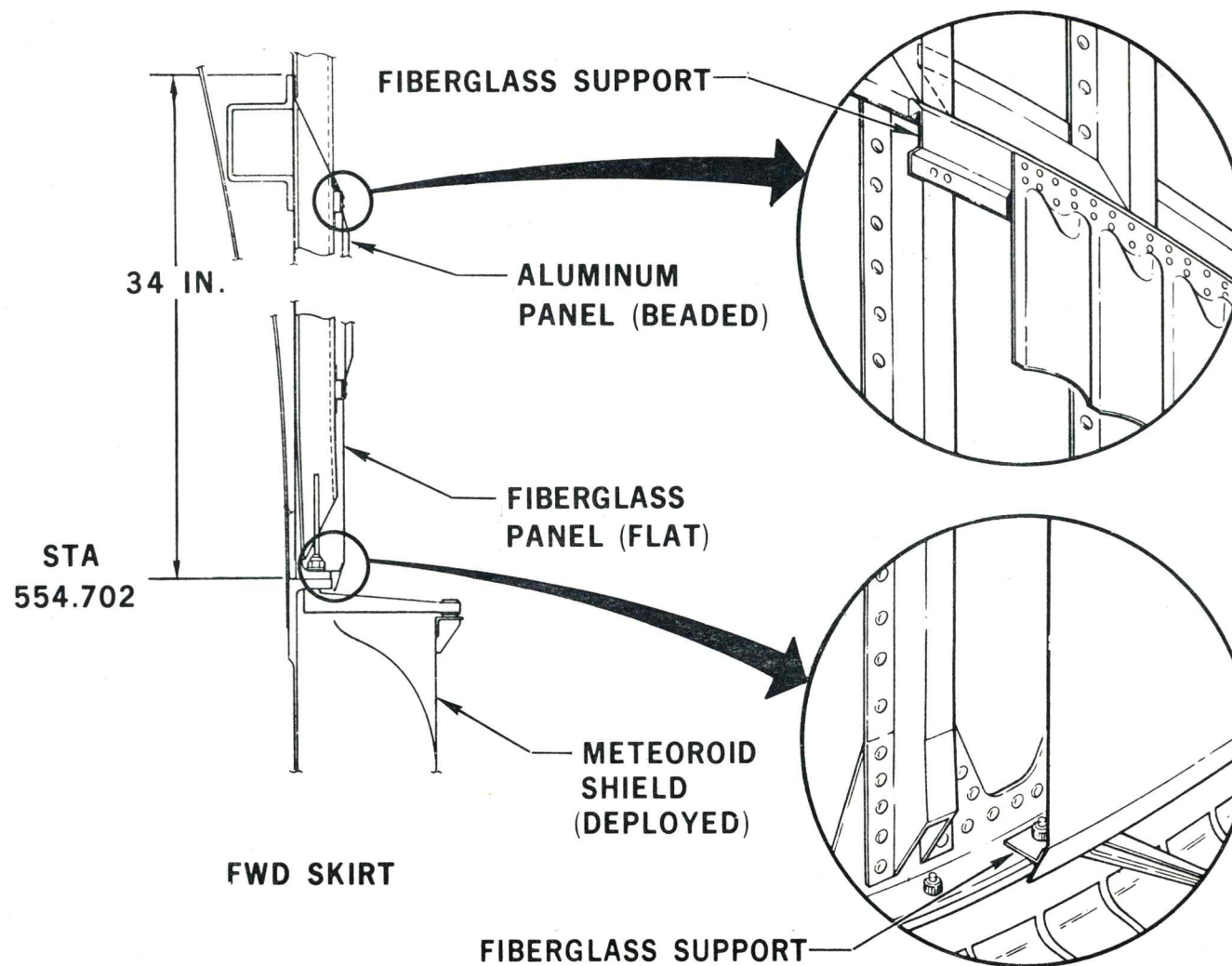


4-87

Figure 421-27.

ORBITAL WORKSHOP FORWARD THERMAL SHIELD

O/W-1774
11-21-69



4-88

Figure 421-28. (Sheet 1 of 2)

ORBITAL WORKSHOP AFT THERMAL SHIELD

O/W-1775
5-18-70

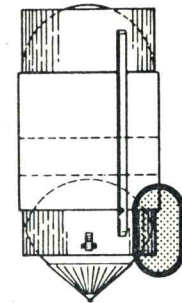
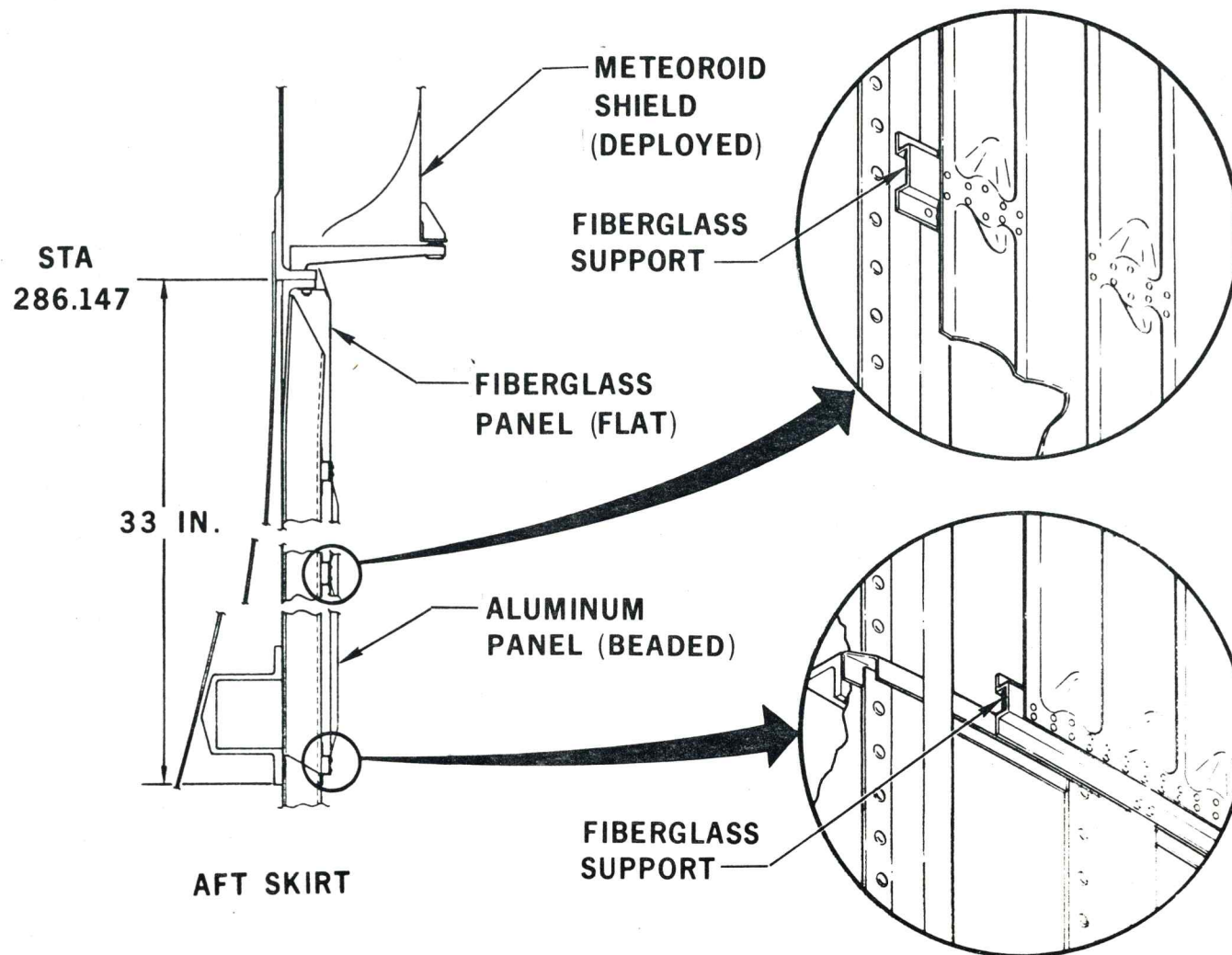


Figure 421-28. (Sheet 2 of 2)

ORBITAL WORKSHOP FORWARD DOME HPI SYSTEM

O/W-4622
11-22-69

WIRING BREAK
THRU (TYP)

ELECTRICAL FEED THRU

OWS HATCH

TYPICAL HPI
SEGMENT (18 TOTAL)
VIEW LOOKING AFT

HABITATION AREA
VENT SYSTEM

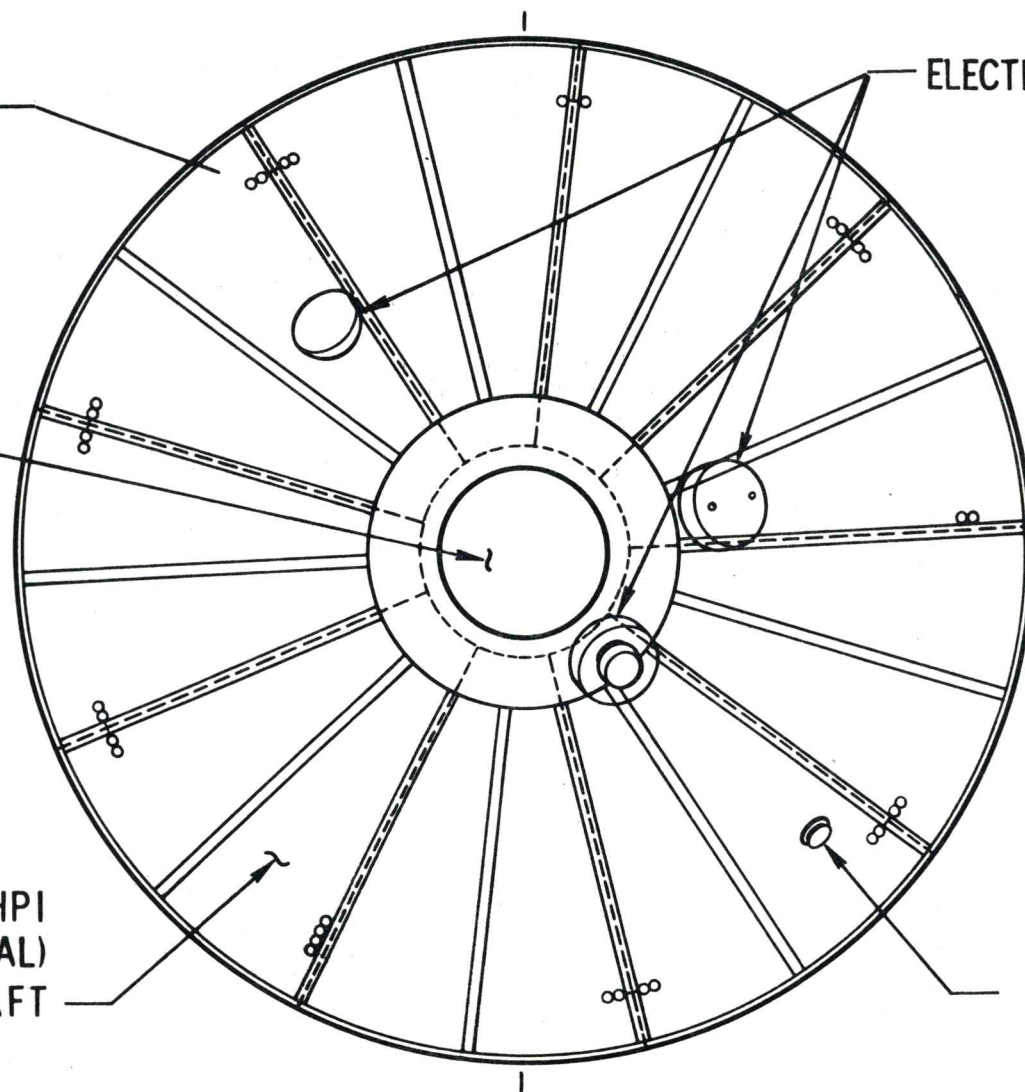


Figure 421-29.

The forward end of the HPI has a structural attachment to the electrical support panels. The aft end of the HPI consists of a wedge shaped flexible foam fitting which wedges between the skirt hat section frame and the dome skin.

The panels are installed at Kennedy Space Center as close to liftoff time as is practical.

Polyurethane Foam Insulation

To reduce heat transfer rates and eliminate potential condensation problems, various thicknesses of polyurethane foam are utilized to insulate specific areas of the OWS. The habitation area sidewall is insulated with one-inch of foam and the forward dome with one-half-inch. The common bulkhead, aft dome, and sidewall to aft dome joint are insulated with three inches of foam (Figure 421-30). All foam exposed to the cabin atmosphere is covered with aluminum foil to preclude any potential fire hazard, and to meet MSFC imposed flammability criteria.

Surface Finishes

The control of the OWS exterior surface finish regulates the energy balance between the OWS and its orbital environment. The OWS is black, except for white paint on the aft 36 inches of the aft skirt for visual sighting purposes, and a 20 degree by 180 degree white "T" pattern on the meteoroid shield for temperature control purposes (Figure 421-31). The stripe pattern was sized and shaped to satisfy the astronaut comfort criteria for a 2-sigma minimum heating orbit with 1170 watts of available heater power. For higher heating orbits, the white pattern assists the active thermal control system in rejecting internally generated heat. A list of parameters which determine the ± 2 -sigma tolerances is presented in Figure 421-32.

The control of the interior surface finish of the OWS provides more uniform internal surface temperatures by promoting thermal radiation interchange between all walls and partitions.

A complete summary of interior and exterior optical property requirements is presented in Figure 421-33.

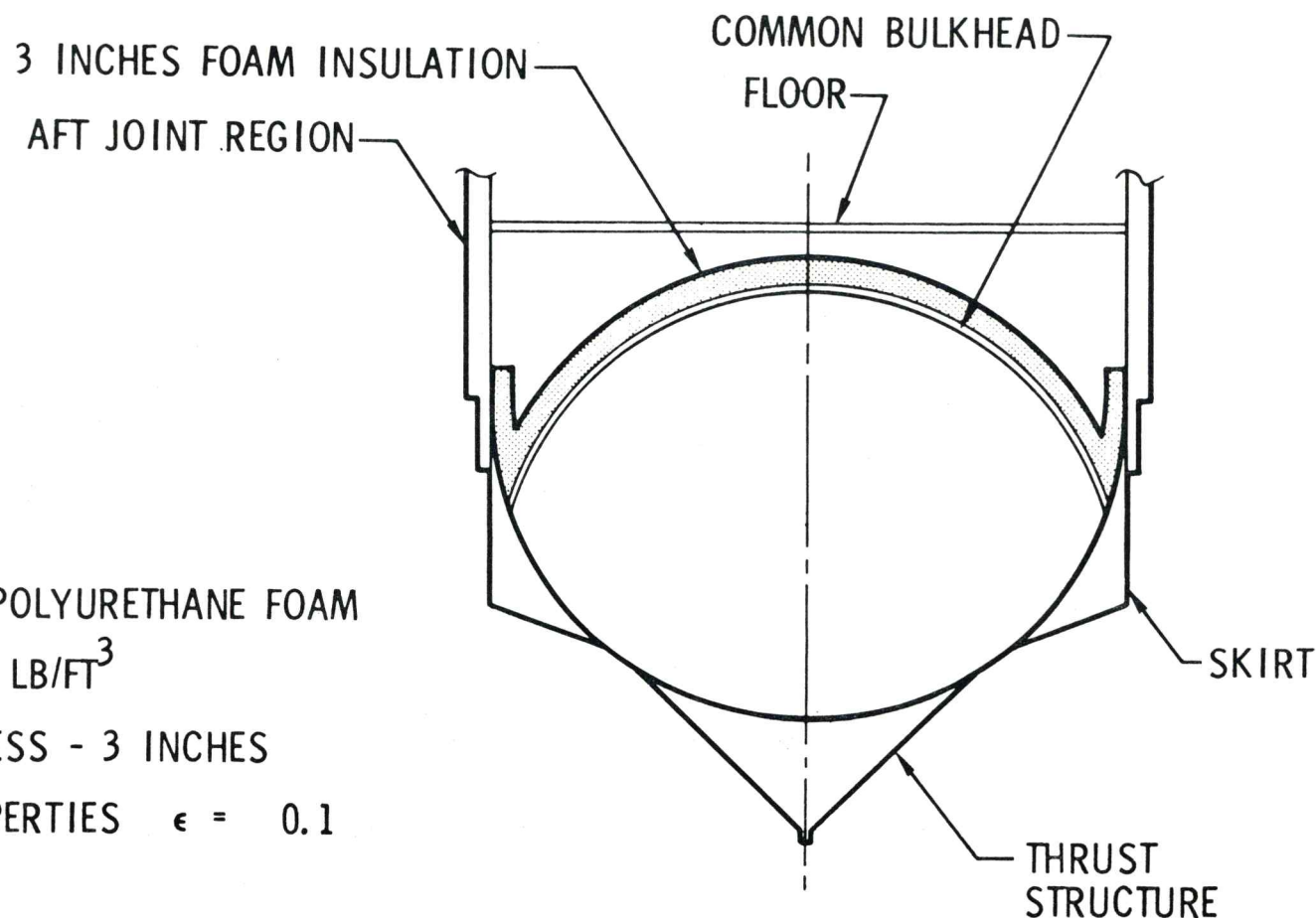
4.2.1.2.3 Ground Thermal Control Prior to Launch

The Ground Thermal Control System has the following operational aspects which are included in the following paragraphs:

- a. Operational aspects
- b. Performance prediction
- c. Constraints

ORBITAL WORKSHOP FOAM INSULATION BELOW CREW QUARTERS

O/W-8778
8-3-70



- MATERIALS - POLYURETHANE FOAM
- DENSITY - $\sim 5 \text{ LB/FT}^3$
- TOTAL THICKNESS - 3 INCHES
- SURFACE PROPERTIES $\epsilon = 0.1$

Figure 421-30.

ORBITAL WORKSHOP PARAMETERS AFFECTING TWO SIGMA CONDITIONS

O/W-8780
8-7-70

| SOURCE | PARAMETER | NOMINAL VALUE | 2σ TOLERANCE |
|--|--|----------------------------------|------------------------|
| INCIDENT HEAT FLUX | ALBEDO | 0.30 | ± 0.12 |
| | EARTH IR | 75 BTU/HR-FT ² | ± 13 |
| | SOLAR CONSTANT | 429 BTU/HR-FT ² | ± 19 |
| EXTERIOR SURFACE OPTICAL PROPERTIES | METEOROID SHIELD, THERMAL SHIELDS, SKIRTS, SLA, IU BLACK PAINT | $\alpha = \epsilon = 0.90$ | ± 0.05 |
| | WHITE PAINT | $\alpha = 0.25, \epsilon = 0.90$ | $\pm 0.06, \pm 0.05$ |
| INTERNAL SURFACE EMISSION | METEOROID SHIELD TO TANK SIDEWALL | 0.04 | $\pm 25\%$ |
| | WASTE TANK | 0.65 | ± 0.15 |
| | FIRE RETARDANT WALLS, CREW QUARTERS PARTITIONS | 0.80 | $\pm 10\%$ |
| | THERMAL SHIELDS TO SKIRTS | 0.04 | $\pm 25\%$ |

ORBITAL WORKSHOP PARAMETERS AFFECTING TWO SIGMA CONDITIONS

O/W-8780-1
8-3-70

| SOURCE | PARAMETER | NOMINAL VALUE | 2σ TOLERANCE |
|---|-------------------------------------|----------------------------------|------------------------|
| MATERIAL CONDUCTANCE | U OF HIGH PERFORMANCE INSULATION | 0.012 BTU/HR-FT ² -°F | +100%, -50% |
| | U ACROSS COMMON BULKHEAD | 0.35 BUT/HR-FT ² -°F | ±0.048 |
| | K OF INTERNAL INSULATION | 0.02 BTU/HR-FT-°F | +200%, -50% |
| INTERNAL CONVECTIVE HEAT TRANSFER COEFFICIENTS | ABOVE CREW QUARTERS | 0.07 | ±50% |
| | CREW QUARTERS | 0.14 | ±50% |
| | BELOW CREW QUARTERS | 0.25 | ±50% |

ORBITAL WORKSHOP OPTICAL COATINGS ALL OPTIONS

O/W-4632
8-7-70

4-96

| | <u>LOCATIONS</u> | <u>NOMINAL VALUE</u> | <u>COATING</u> |
|----|--|--------------------------------|--|
| A. | LH ₂ TANK EXTERIOR | | |
| | 1. BETWEEN METEROID SHIELD AND TANK WALL | $\epsilon_{\text{eff}} = 0.04$ | GOLDIZED KAPTON ON TANK |
| | 2. BETWEEN FORWARD DOME (AFT OF DEBRIS SHIELD) AND SKIRT | $\epsilon_{\text{eff}} = 0.05$ | GREEN TEFLON ON M/S GOLDIZED KAPTON (BOTH SURFACES) |
| | 3. BETWEEN AFT DOME AND SKIRT | $\epsilon_{\text{eff}} = 0.05$ | GOLDIZED KAPTON (BOTH SURFACES) |
| B. | METEROID SHIELD | | |
| | 1. EXTERIOR (EXCEPT LOCALLY) | $\alpha = \epsilon = 0.9$ | CAT-A-LAC FLAT BLACK ENAMEL |
| | 2. α LOCALLY ON SUN SIDE | $\alpha = 0.25$ | S-13G WHITE PAINT |
| C. | SKIRT THERMAL SHIELDS | | |
| | 1. BETWEEN SHIELD AND SKIRT | $\epsilon_{\text{eff}} = 0.05$ | GOLDIZED KAPTON ON SHIELD |
| | 2. EXTERIOR | $\alpha = \epsilon = 0.9$ | CAT-A-LAC FLAT BLACK ON SKIRT CAT-A-LAC FLAT BLACK ENAMEL |
| D. | METEROID SHIELD CLOSURES | | |
| | 1. INTERIOR | $\epsilon = 0.8$ | GREEN TEFLON |
| | 2. EXTERIOR | $\alpha = \epsilon = 0.9$ | CAT-A-LAC FLAT BLACK ENAMEL |

ORBITAL WORKSHOP OPTICAL COATINGS ALL OPTIONS

O/W-4632-1
8-7-70

| | <u>LOCATIONS</u> | <u>NOMINAL VALUE</u> | <u>COATING</u> |
|----|----------------------------------|---------------------------|-----------------------------|
| E. | FORWARD SKIRT 1. EXTERIOR | $\alpha = \epsilon = 0.9$ | CAT-A-LAC FLAT BLACK ENAMEL |
| F. | AFT SKIRT EXTERIOR 1. AFT 36" | $\alpha/\epsilon = 0.3$ | S-13G WHITE PAINT |
| | 2. STA. 236.6 TO 253.1 | $\alpha = \epsilon = 0.9$ | CAT-A-LAC FLAT BLACK ENAMEL |
| G. | THRUST STRUCTURE EXTERIOR | $\alpha = \epsilon = 0.9$ | CAT-A-LAC FLAT BLACK ENAMEL |
| H. | CREW QUARTERS VERTICAL WALLS | $\epsilon = 0.75$ | COLORLED ANODIZE |
| I. | FIRE RETARDANT LINER | $\epsilon = 0.7$ | COLORLED TEFLON |
| J. | CREW QUARTERS FLOOR | $\epsilon = 0.7$ | YELLOW ANODIZE |
| K. | CREW QUARTERS CEILING | $\epsilon = 0.7$ | YELLOW ANODIZE |

4-97

4.2.1.2.3.1 Operational Aspects

The system is manually controlled by ground crewmen who keep the habitation area within 40° to 80°F during the prelaunch phase, and at approximately 50°F immediately prior to launch (50°F is the optimum launch temperature).

4.2.1.2.3.2 Performance Prediction

The habitation area will be maintained with the 40° to 80°F temperature range from "Button-up" in the VAB until immediately before launch when approximately 50°F will be maintained.

4.2.1.2.3.3 Constraints of Habitation Area Purging, Pressurization, and Venting

The system shall meet the general requirements while purging, pressurization, leak checking, and venting in the Kennedy Space Center VAB and launch pad. Should contingency access be necessary after initial OWS "Button-up" in the VAB, provisions and/or procedures shall be included to meet the requirements.

4.2.1.2.4 Orbital Warmup Operations Prior to Astronaut Entry

4.2.1.2.4.1 Operational Procedures

Radiant heaters are to be used to warm the habitation area prior to crew entry. The heater control schematic is shown in Figure 421-34. The thermal control system panel is illustrated in Figure 421-35. The minimum habitation area surface temperature, as a function of time after the radiant heaters are turned on in a 2-sigma cold environment and in a nominal environment, is shown in Figure 421-36. The radiant heaters are turned on by ground command at the first ground command opportunity following SAS deployment.

4.2.1.2.4.2 System Performance

The radiant heaters are capable of warming the coldest compartment to 44°F before crew entry at 34 hours (Figure 421-36).

4.2.1.2.4.3 Limitations and Constraints

Radiant heaters should be turned off (TBS) minutes prior to crew entry so that the touch temperature limits (105°F) specified in the CEI specification are not exceeded.

4.2.1.2.5 Habitation Thermal Control

4.2.1.2.5.1 Operational Procedures

The TCS is not operational prior to habitation nor during the storage phases of the mission. The TCS is turned on by the astronaut after entry into the OWS. The mode of operation (manual or automatic) during TCS activation is not presently defined. After activation by the astronauts, the normal mode of TCS operation is the automatic mode.

ORBITAL WORKSHOP RADIANT HEATER CONTROL

O/W-8375
8-7-70

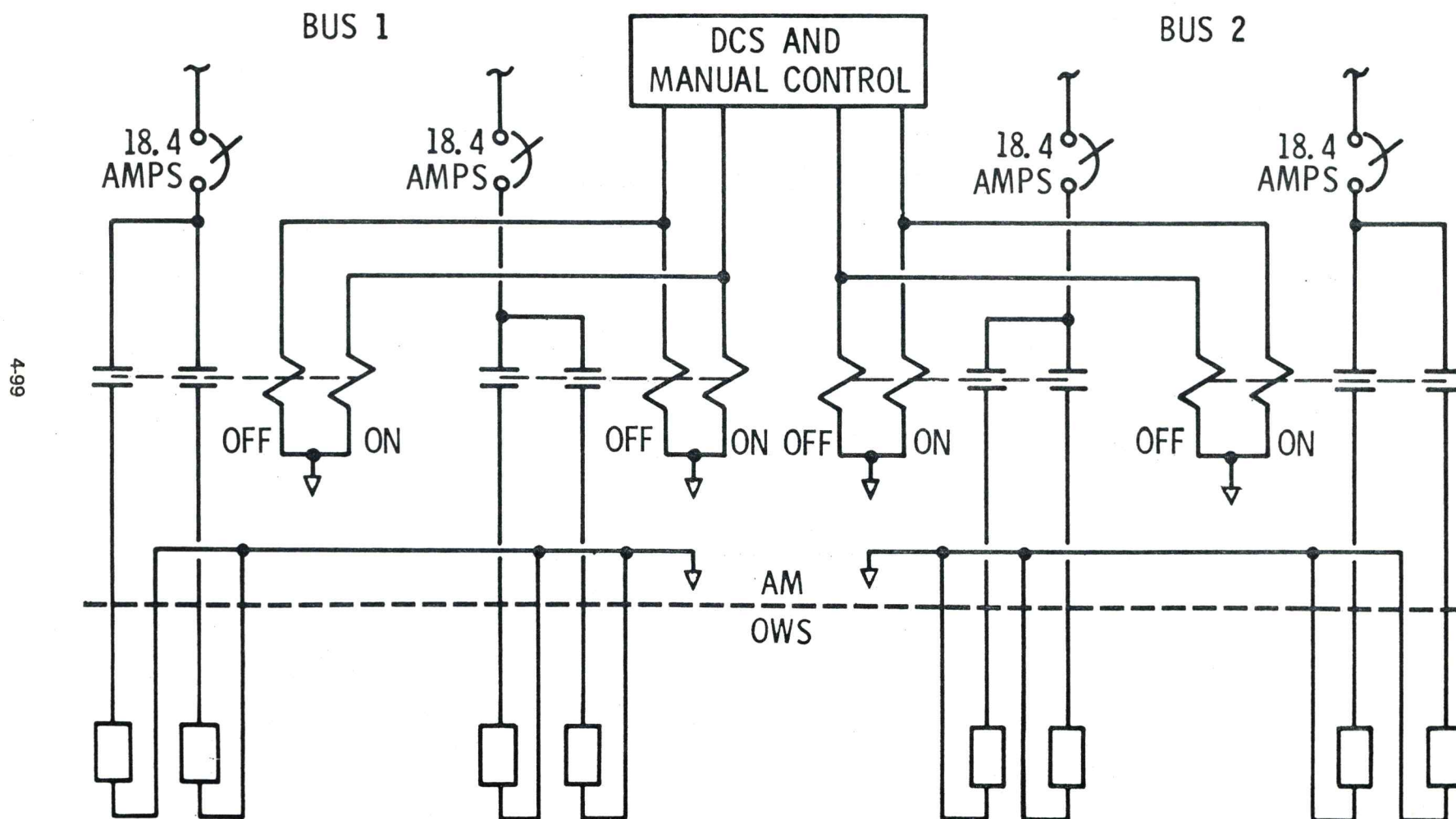
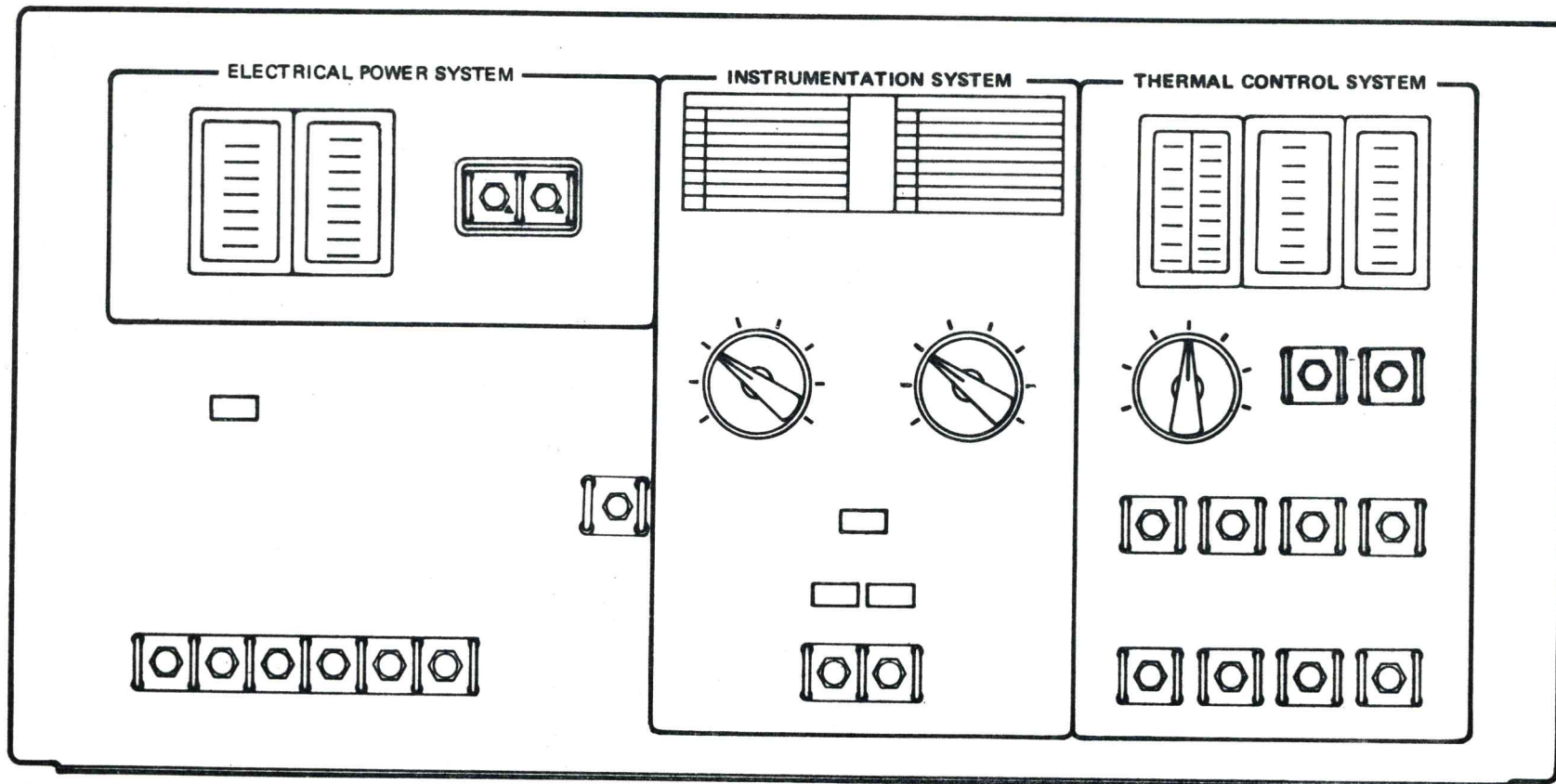


Figure 421-34.

ORBITAL WORKSHOP CONTROL AND DISPLAY PANEL NO. 2

O/W-3970A
6-8-70



4-100

Figure 421-35. (Sheet 1 of 2)

ORBITAL WORKSHOP CONTROL AND DISPLAY PANEL NO. 2 THERMAL CONTROL SYSTEM

O/W-5296A
8-8-70

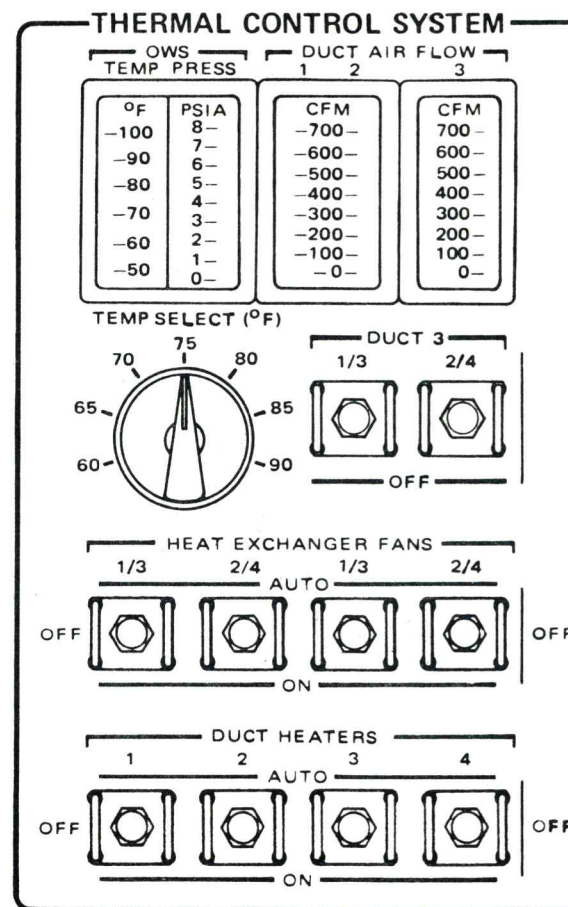
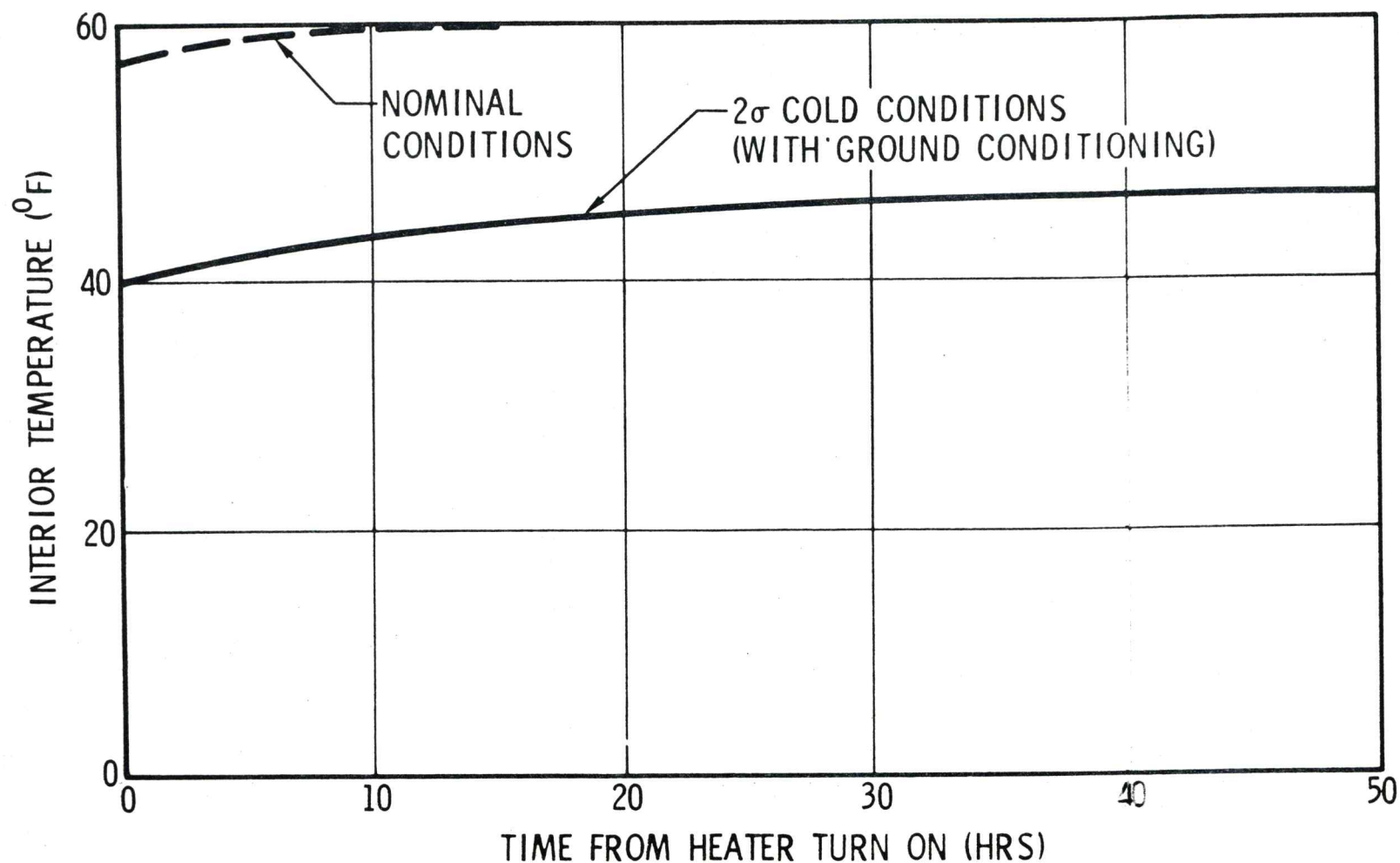


Figure 421-35. (Sheet 2 of 2)

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ORBITAL WORKSHOP WARMUP TEMPERATURE HISTORY 1000 WATTS HEATER POWER

O/W-8782
8-7-70



4-102

Figure 421-36.

When operating automatically, the thermal control system compares the selected thermostat temperature setting to the actual cabin gas temperature which is sensed by three transducers located in one of the experiment compartment floor diffuser outlets (Figure 421-24, Sheet 1). A majority voting logic is applied to temperatures sensed by these three transducers. The thermal controller activates the heaters or heat exchangers as required to stabilize the cabin gas temperature at the selected temperature. The allowable temperature deviation is $+4^{\circ}\text{F}$ from the temperature set point. Should the temperature increase by 4°F , the thermal control system enters a cooling cycle and all four heat exchangers are turned on. When the temperature decreases 2°F below the temperature set point, all four heat exchangers are turned off. Then, if the temperature increases to 1°F above the set point, one heat exchanger is turned on. If the temperature increases to 2°F above the set point, two heat exchangers are turned on. The same action results for 3°F and 4°F increases.

When the temperature drops below the set point by 2°F , the heat exchanger(s) is turned off and the thermal control system remains in the cooling cycle until the cabin gas temperature drops 4°F below the temperature set point. Then the system enters the heating cycle and the converse of the cooling cycle is performed.

For operation of the thermal control system in the manual mode, ON-OFF-MANUAL switches are provided for the control of each thermal element by the crewmen. These switches may be turned on or off at any time during either the heating or cooling cycle, overriding the action of the automatic system.

Instrumentation circuits are provided to inform the crewmen and the ground monitoring stations of performance and malfunctions of the thermal control system. The instrumentation includes current monitors, flow meters, and temperature sensors.

For additional local circulation, a portable fan can be connected to a utility outlet. Three portable fans are provided.

The temperature control subsystem design provides the following functions:

- a. Cabin gas temperature monitoring for display and telemetry.
- b. Heater current monitoring for TM.
- c. Duct flow monitoring and display.
- d. Cabin gas temperature regulation by selectively operating heaters or heat exchangers.
- e. Temperature selection control over a range of 60° to 90°F .

TCS instrumentation is defined by drawing 1B68467.

The sequence of operation for automatic temperature regulation is listed, and illustrated in Figure 421-37. The following definitions apply to the description of this operation sequence.

- T_A = Actual cabin gas temperature in degrees F.
- T_O = Selected cabin temperature, adjustable from +60° to +90°F
- T_1 = $T_O - 1^\circ\text{F}$
- T_2 = $T_O - 2^\circ\text{F}$
- T_3 = $T_O - 3^\circ\text{F}$
- T_4 = $T_O - 4^\circ\text{F}$
- T_5 = $T_O + 1^\circ\text{F}$
- T_6 = $T_O + 2^\circ\text{F}$
- T_7 = $T_O + 3^\circ\text{F}$
- T_8 = $T_O + 4^\circ\text{F}$
- T_9 = $T_O - 5^\circ\text{F}$
- T_{10} = $T_O + 5^\circ\text{F}$

The item "heater" used in this sequence description means a 250-watt element located in one of the three OWS ducts.

Initially, both the AM heat exchanger fans and the OWS duct heaters will be deenergized.

- a. If the controller is in the heating cycle and T_A is initially equal to, or subsequently drops to, a temperature of T_1 or lower, turn on one heater. Remain in this mode until T_A is equal to T_6 or T_2 .
- b. If the controller is in the heating cycle and T_A is initially equal to, or subsequently drops to, a temperature of T_2 or lower, turn on one more heater. Remain in this mode until T_A is equal to T_6 or T_3 .
- c. If the controller is in the heating cycle and T_A is initially equal to, or subsequently drops to a temperature of T_3 or lower, turn on one more heater. Remain in this mode until T_A is equal to T_6 or T_4 .
- d. If the controller is in the heating cycle and T_A is initially equal to, or subsequently drops to a temperature of T_4 or lower, turn on one more heater. Remain in this mode until T_A is equal to T_6 .
- e. If the controller is in the heating cycle, and T_A subsequently rises to a temperature of T_6 or greater, turn off all heaters. Remain in this mode until T_A is equal to T_8 .

ORBITAL WORKSHOP AUTOMATIC TEMPERATURE CONTROL SYSTEM LOGIC

O/W-3360
8-3-70

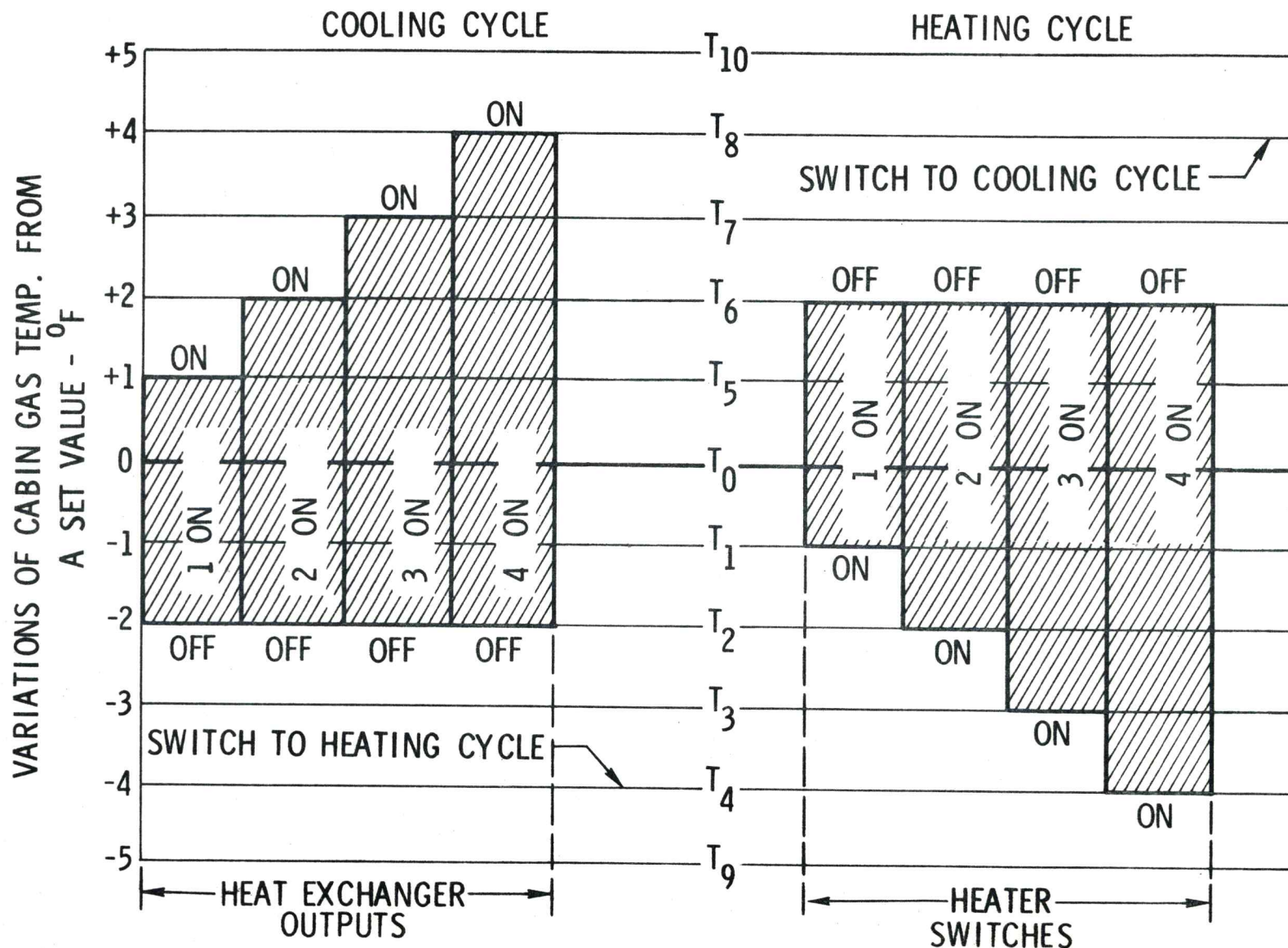


Figure 421-37.

- f. If the controller is in the heating cycle, and T_A rises to a temperature greater than T_8 , the controller will switch to the cooling cycle and energize four heat exchangers.
- g. If the controller is in the cooling cycle, and T_A is initially equal to, or subsequently rises to, a temperature of T_5 or greater, turn on one heat exchanger. Remain in this mode until T_A is equal to T_2 or T_6 .
- h. If the controller is in the cooling cycle, and T_A is initially equal to, or subsequently rises to a temperature of T_6 or greater, turn on one more heat exchanger. Remain in this mode until T_A is equal to T_2 or T_7 .
- i. If the controller is in the cooling cycle, and T_A is initially equal to, or subsequently rises to a temperature of T_7 or greater, turn on one more heat exchanger. Remain in this mode until T_A is equal to T_2 or T_8 .
- j. If the controller is in the cooling cycle, and T_A is initially equal to, or subsequently rises to a temperature of T_8 or greater, turn on one more heat exchanger. Remain in this mode until T_A is equal to T_2 .
- k. If the controller is in the cooling cycle, and T_A is equal to, or subsequently drops to a temperature of T_2 or lower, turn off all heat exchangers. Remain in this mode until T_A is equal to T_4 .
- l. If the controller is in the cooling cycle, and T_A drops to a temperature less than T_4 , the controller will switch to the heating cycle and cut turn four heaters.

4.2.1.2.5.2 System Performance

During habitation, the TCS maintains the internal structure and gas at temperatures that satisfy the comfort-criteria for the heater power and steady state heat removal design requirements. The system performance (Figure 421-38) shows that the system capability for dissipating component generated heat exceeds the design requirements by 250 and 390 watts for nominal and 2-sigma environments, respectively. The OWS temperature distributions satisfying comfort criteria for extreme hot and cold case conditions are shown in Figure 421-39.

The effect of dissipating 500 watts continuously in excess of the design requirements (a total of 1,100 watts) for 2-sigma conditions at a beta angle of 73.5 degrees, results in temperatures that do not satisfy the comfort criteria (Figure 421-40). But by adjusting the thermal controller temperature setting so that the four AM heat exchangers supplying cooling to the OWS operate continuously, this effect can be mitigated.

ORBITAL WORKSHOP
THERMAL CONTROL SYSTEM PERFORMANCE

O/W-7620
8-8-70

| | MINIMUM CONDITIONS REQUIRED HEATER POWER $\beta = 0^{\circ}$ (WATTS) | MAXIMUM CONDITIONS COMPONENT WASTE HEAT DISSIPATION CAPABILITY (WATTS)* | |
|------------------------|---|--|------------------------|
| | | $\beta = 60^{\circ}$ | $\beta = 73.5^{\circ}$ |
| NOMINAL ENVIRONMENT | 825 | 1700 | 1150 |
| 2 σ ENVIRONMENT | 1170 | 1490 | 900 |

*TO SATISFY COMFORT CRITERIA

Figure 421-38.

ORBITAL WORKSHOP
THERMAL CONTROL SYSTEM
OWS INTERNAL TEMPERATURES
(DEG. F)

O/W-7598-1
7-14-70

20/180 WHITE STRIPE

CREW QUARTERS

| CONDITION | EXP. | COMPT | WARDROOM | | SLEEP COMPT | | WMC | | FWD COMPT | | BULKHEAD | |
|--|-------|-------------|----------|-------------|-------------|-------------|-------|-------------|-----------|-------------|----------|-----|
| | T_g | \bar{T}_w | T_g | \bar{T}_w | T_g | \bar{T}_w | T_g | \bar{T}_w | T_g | \bar{T}_w | MAX | MIN |
| 4-108 NOMINAL $\beta = 0^\circ$ 825 WATT HEATER | 71 | 68 | 70 | 67 | 70 | 68 | 70 | 67 | 69 | 66 | 70 | 67 |
| NOMINAL $\beta = 73.5^\circ$ MAX COMPONENT POWER 1150 WATTS | 74 | 77 | 74 | 76 | 74 | 77 | 75 | 77 | 75 | 78 | 75 | 71 |

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ORBITAL WORKSHOP
THERMAL CONTROL SYSTEM
OWS INTERNAL TEMPERATURES
(DEG. F)

O/W-7598
7-14-70

20/180 WHITE STRIPE

CREW QUARTERS

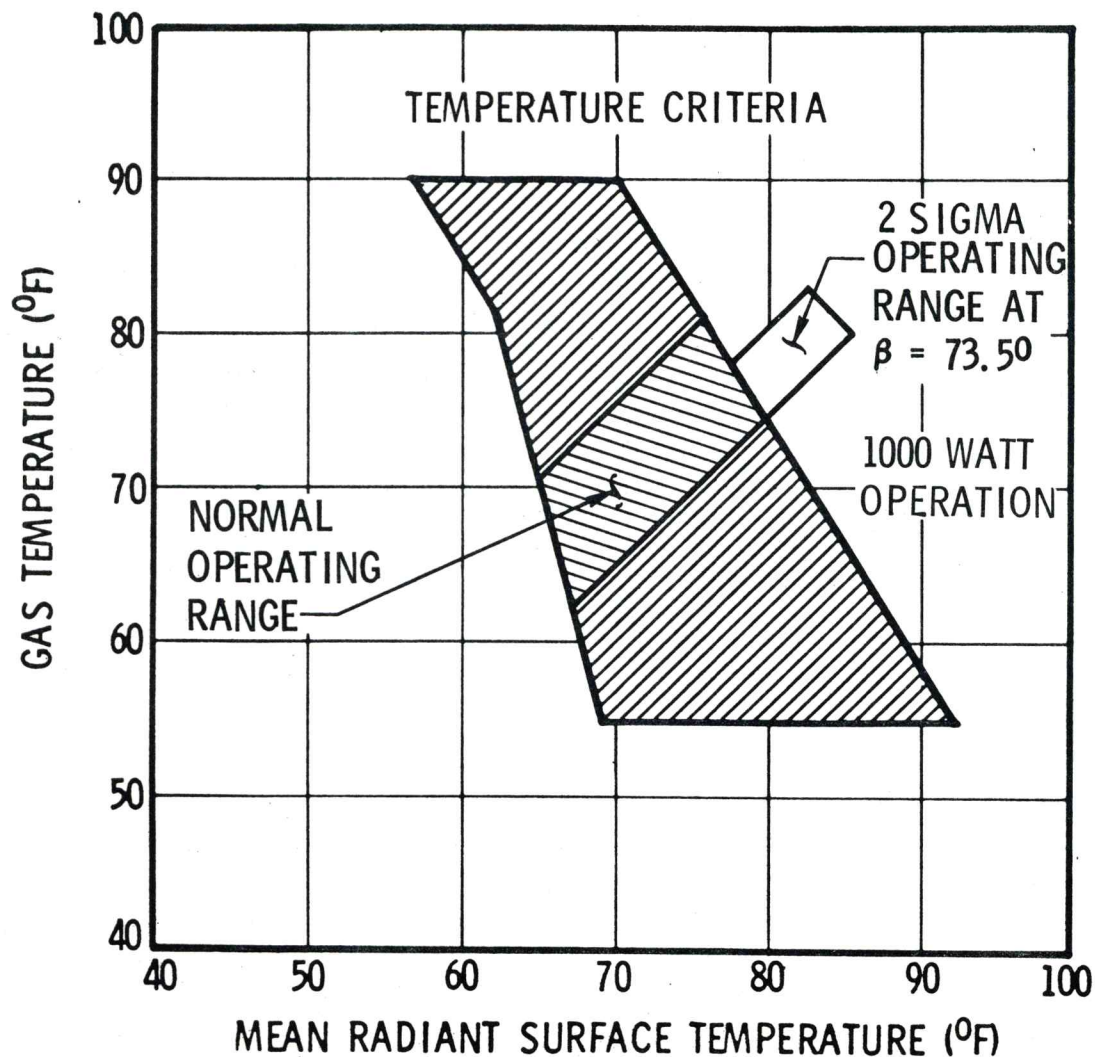
| CONDITION | EXP. | COMPT | WARDROOM | | SLEEP COMPT | | WMC | | FWD COMPT | | BULKHEAD | |
|--|-------|-------------|----------|-------------|-------------|-------------|-------|-------------|-----------|-------------|----------|-----|
| | T_g | \bar{T}_w | T_g | \bar{T}_w | T_g | \bar{T}_w | T_g | \bar{T}_w | T_g | \bar{T}_w | MAX | MIN |
| -2 σ $\beta = 0^\circ$ 1170 WATT HEATER | 72 | 69 | 72 | 68 | 72 | 68 | 71 | 68 | 70 | 65 | 70 | 68 |
| +2 σ $\beta = 73.5^\circ$ 910 WATTS COMPONENT POWER | 74 | 76 | 73 | 75 | 74 | 76 | 75 | 76 | 75 | 78 | 75 | 71 |

4-109

Figure 421-39. (Sheet 2 of 2)

ORBITAL WORKSHOP THERMAL CONTROL SYSTEM

O/W-7592-1
8-8-70



| PARAMETERS |
|-----------------------------------|
| VELOCITY, 15-100 FPM |
| CLO, 0.35-1.0 |
| METABOLIC RATE, 300-600 BTU/HR |

Figure 421-40.

A power failure mode (one bus out) analysis indicates that the TCS still has sufficient heating capacity to satisfy the comfort criteria for nominal conditions and will be only 3°F cold (outside the comfort box) for 2-sigma minimum conditions as shown in Table 421-3. The temperature response of the OWS to a step increase in the internal heat dissipation rate is presented in Figure 421-41.

Table 421-3
POWER DISSIPATION TO OWS ENVIRONMENT
(WATTS)

| | Power Required | Power Available (One Bus Out) | | Power Deficit | |
|---------------|-------------------|----------------------------------|------------|---------------|-------------|
| | | 24 Volts | 26.5 Volts | 24 Volts | 26.5 Volts |
| <hr/> | | | | | |
| Nominal | | | | | |
| Heaters: | 825 | 1000 | 1208 | (175) | (383) |
| Housekeeping: | <u>250</u> | <u>240</u> | <u>285</u> | <u>10</u> | <u>(35)</u> |
| | 1075 | 1240 | 1493 | (165) | (418) |
| 2-Sigma | | | | | |
| Heaters: | 1170 | 1000 | 1208 | 170 | (38) |
| Housekeeping: | <u>250</u> | <u>240</u> | <u>285</u> | <u>10</u> | <u>(35)</u> |
| | 1240 | 1420 | 1493 | 180* | (73) |

*180 watt deficit results in OWS temperature 3°F outside the comfort box (67°F gas temperature 62°F wall temperature)

Parentheses indicate positive margin

Limitations and Constraints

The thermal control system can satisfy the specified comfort criteria only if the OWS steady internal heat generation rate (combined heater power, electrical power dissipation, and metabolic load) is within the limits specified in Figure 421-42 for various beta angles. If the steady state heat dissipation rate is greater than the noted limits, internal temperatures will be too warm to satisfy the comfort criteria. Conversely, if the heat dissipation rate is less than the lower limit, internal temperatures will be below those required for comfort.

The effect of short and long duration step increases in power on out-of-comfort box operation can be estimated from Figure 421-41. For example, assuming initial conditions are the hot temperature extremes satisfying comfort criteria, it can be seen that up to a 600 watt step increase in power will result in a maximum temperature increase of 2°F if limited to a maximum duration of 0.5-hour.

OWS INTERNAL STRUCTURAL TEMPERATURE TRANSIENT RESPONSE

O/W-7599
6-4-70

TEMPERATURE RESPONSE TO STEP INCREASE IN POWER *
(MAXIMUM CONDITIONS)

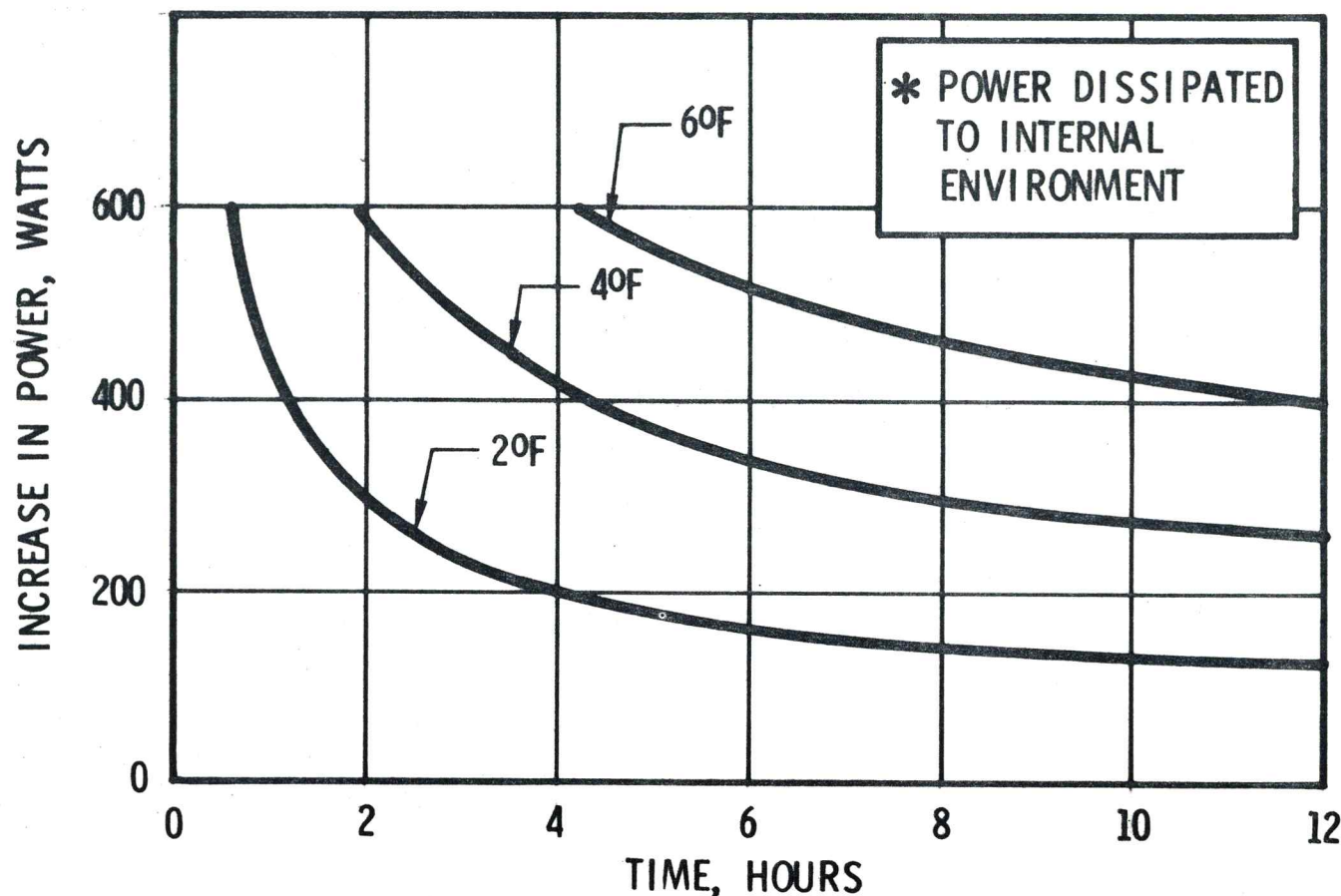


Figure 421-41.

ORBITAL WORKSHOP TCS-AVAILABLE COMPONENT HEAT DISSIPATION

O/W-7850
6-4-70

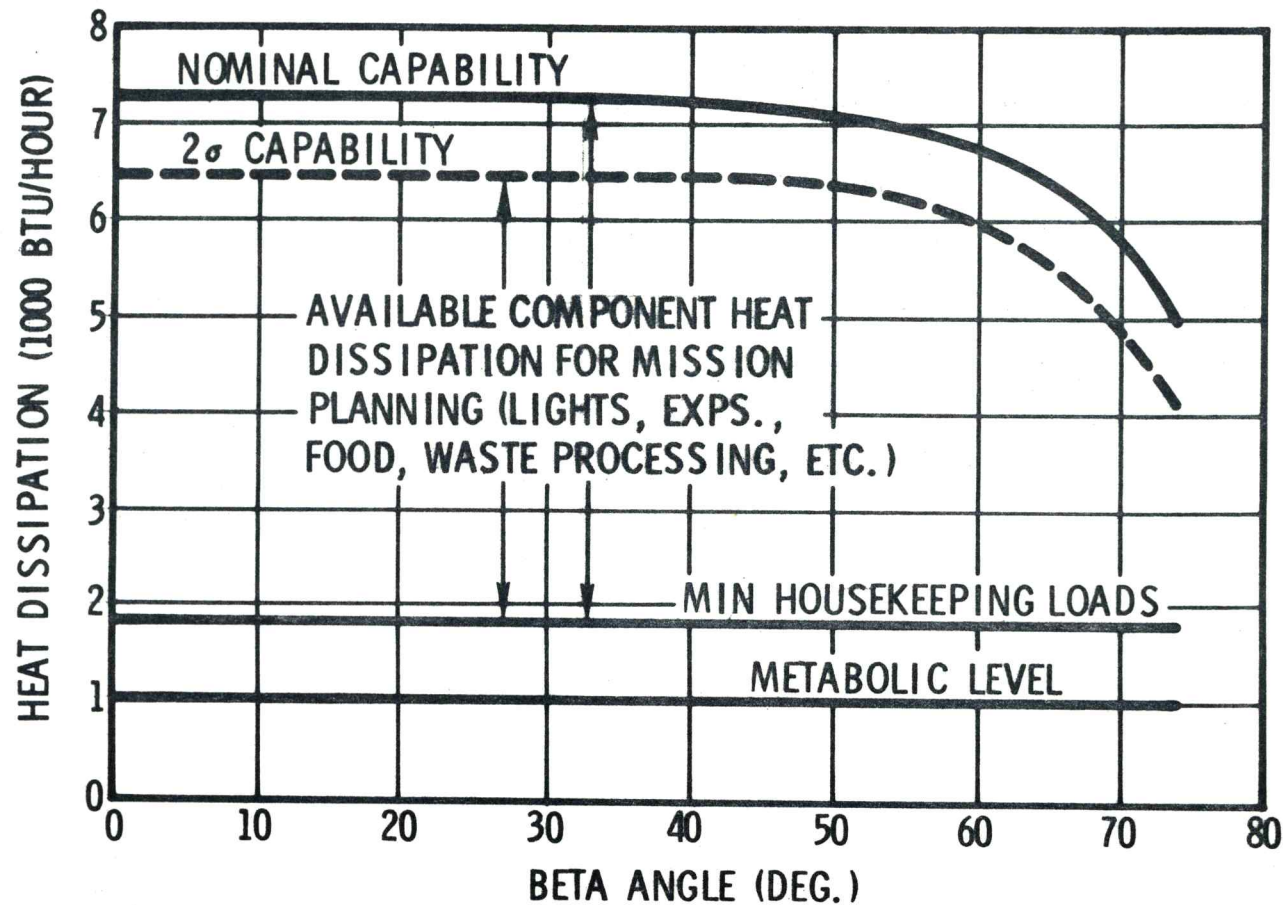


Figure 421-42.

4.2.1.2.6 Storage Thermal Control

4.2.1.2.6.1 Operational Procedures

The radiant heaters are turned on or off by ground command (DCS) prior to and after the habitation periods. Astronaut operation of the radiant heaters from the AM is possible. Normally, the heaters would be left on during the storage periods for $\beta \leq 50$ degrees condition. OWS temperatures during storage are monitored from the ground.

4.2.1.2.6.2 Performance

The minimum temperature during storage with the radiant heaters on is 45°F.

4.2.1.2.6.3 Limitations and Constraints

If the interior surface temperatures exceed TBD°F during storage, the radiant heaters should be turned off.

4.2.1.3 Ventilation Control System

The ventilation control system (VCS) (Figure 421-43) transports revitalized atmosphere (purified and dehumidified) from the AM and mixes it with the OWS thermally conditioned atmosphere, then circulates the mixture at below 100 FPM through the crew quarters. The system also provides for controlled atmosphere circulation within the head, as well as particulate filtration and odor removal of the discharged atmosphere.

4.2.1.3.1 Atmosphere Supply Subsystem

The atmosphere supply subsystem comprises:

- a. Reconditioned air supply duct.
- b. Mixing chamber.

4.2.1.3.1.1 Supply Duct

The supply duct carries revitalized air from the AM/Environmental Control System (ECS) to the VCS mixing chamber.

The duct is eight inches in diameter and has a maximum flow of 2.6 pounds per minute. The maximum pressure differential across the duct is 0.05 inches of water at the maximum internal flow.

4.2.1.3.1.2 Mixing Chamber

The revitalized atmosphere from the AM and the recirculated air from the OWS are mixed in the mixing chamber (Figure 421-44) and pulled into the ducts.

ORBITAL WORKSHOP VENTILATION

O/W-3961
8-5-70

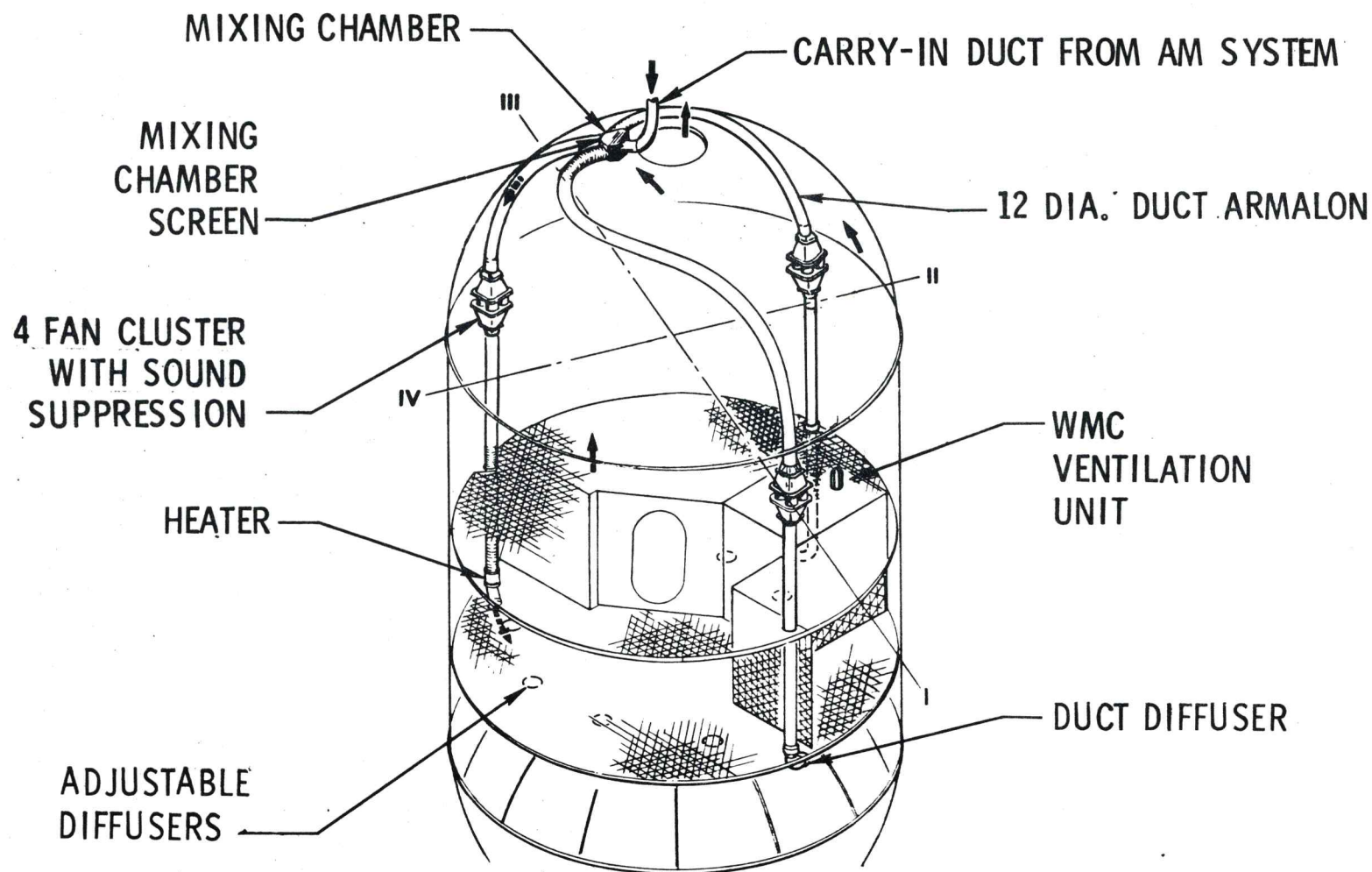


Figure 421-43.

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ORBITAL WORKSHOP AIRLOCK TO WORKSHOP INTERFACE AND MIXING CHAMBER

O/W-1770B
5-20-70

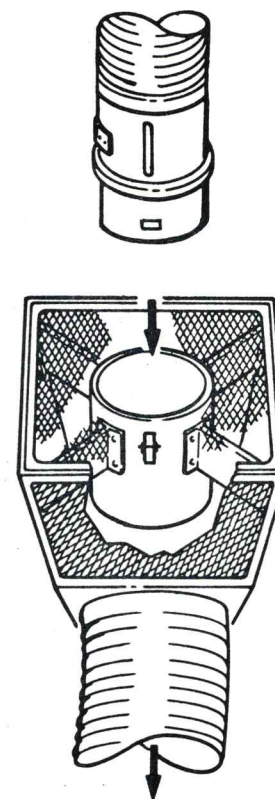
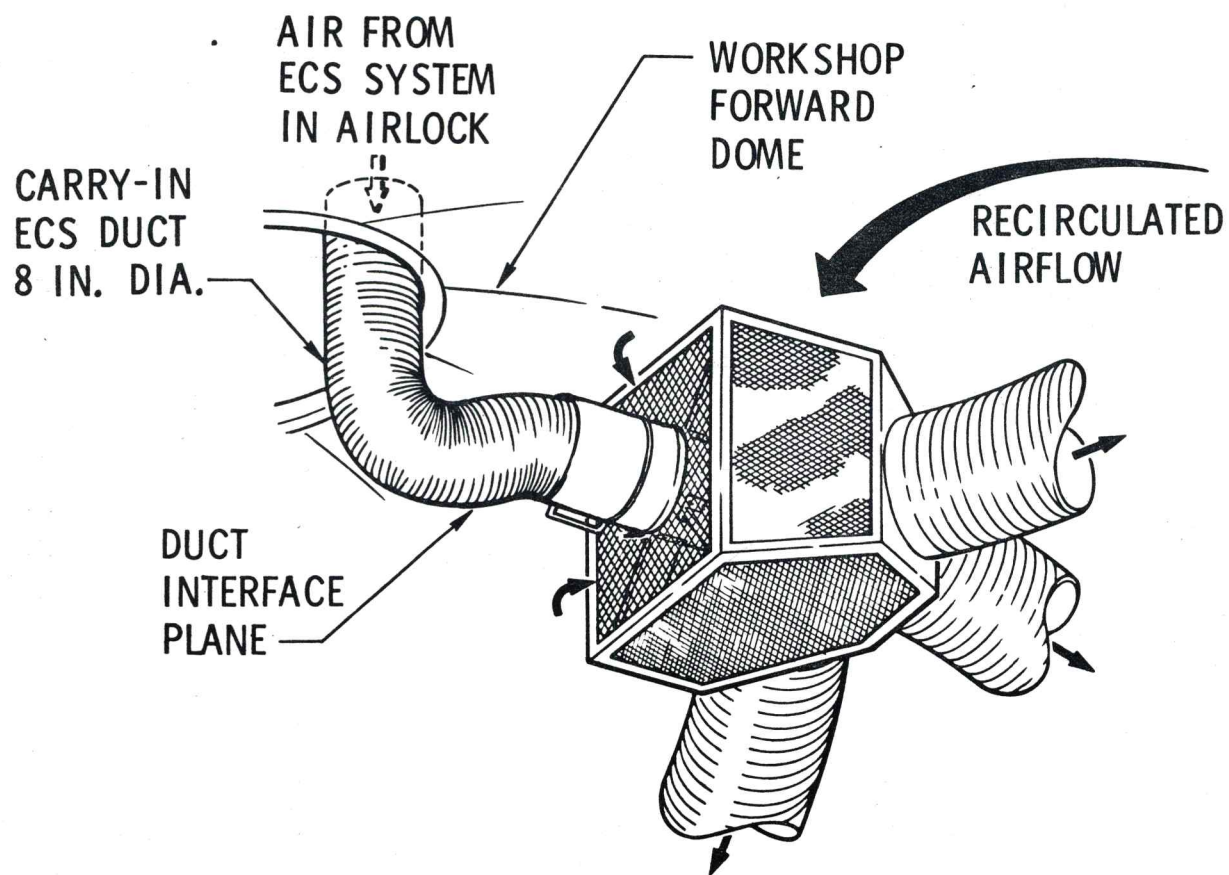


Figure 421-44.

4.2.1.3.2 Atmosphere Recirculation Subsystem

The atmosphere recirculation subsystem comprises the following hardware:

- a. Ducts (1B75464).
- b. Fan clusters (1B77900).
- c. Circular diffusers (1B78224).
- d. Rectangular diffusers (1B78223).
- e. Portable fan (1B2557).

4.2.1.3.2.1 Ducts (1B75464)

Each of the ducts (Figure 421-45) supplies airflow to the fan cluster through the crew quarters convective heater, and into the plenum chamber between the floor and common bulkhead. The fan cluster inlet duct is a wire-reinforced, dual-ply Armalon cloth construction. The discharge duct is a single-ply Armalon cloth construction.

4.2.1.3.2.2 Fan Cluster (1B77900)

The fan cluster (Figure 421-46) consists of a preinstalled, porous-wall baffled resonant chamber, inlet and outlet muffler, and four GFE fans to deliver the reconstituted and recirculated atmosphere to the plenum chamber. Each continuously operating fan cluster delivers air to the plenum.

4.2.1.3.2.3 Duct Diffuser (1B78426)

The duct outlet will turn, diffuse, and direct the air into the plenum area between the floor and common bulkhead to maximize distribution to the diffusers and minimize velocity profiles and heat loss to the bulkhead.

4.2.1.3.2.4 Diffusers (1B78223 and 1B78224)

A typical installation of the two types of adjustable velocity-profile, diffusers is shown in Figure 421-47. The Waste Management Compartment (WMC), wardroom, and main experiment area use a circular vane diffuser while the sleep compartment has two-dimensional-diffusing rectangular diffusers. The diffusers give velocities from 15 ft/min to 100 ft/min.

4.2.1.3.3 Waste Management Compartment Ventilation Subsystem

The WMC ventilation subsystem consists of the following hardware:

- a. Floor diffuser (1B78224)
- b. WMC ventilation unit (1B78833).

ORBITAL WORKSHOP INLET DUCT

O/W-1980
8-5-70

4-118

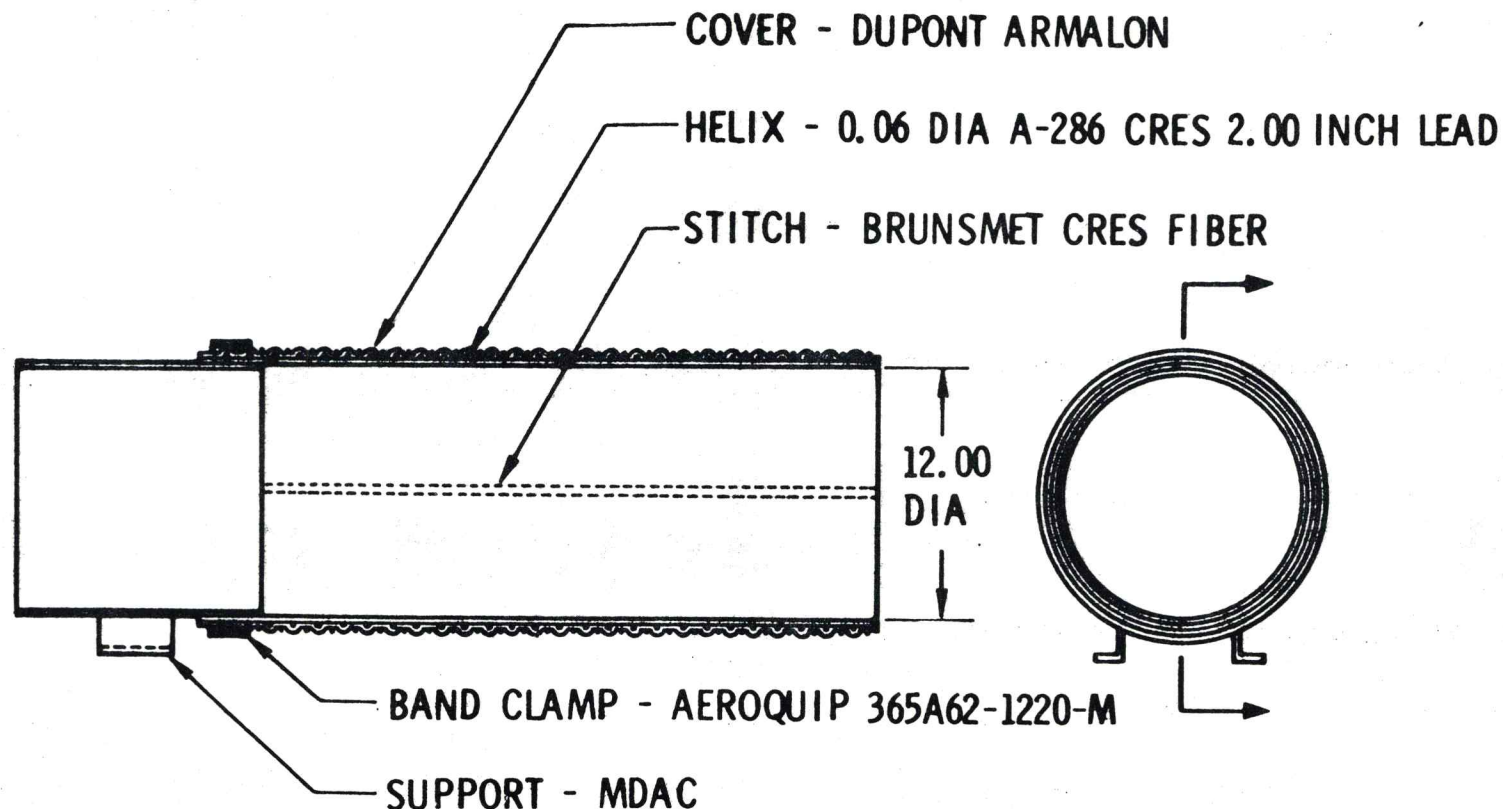
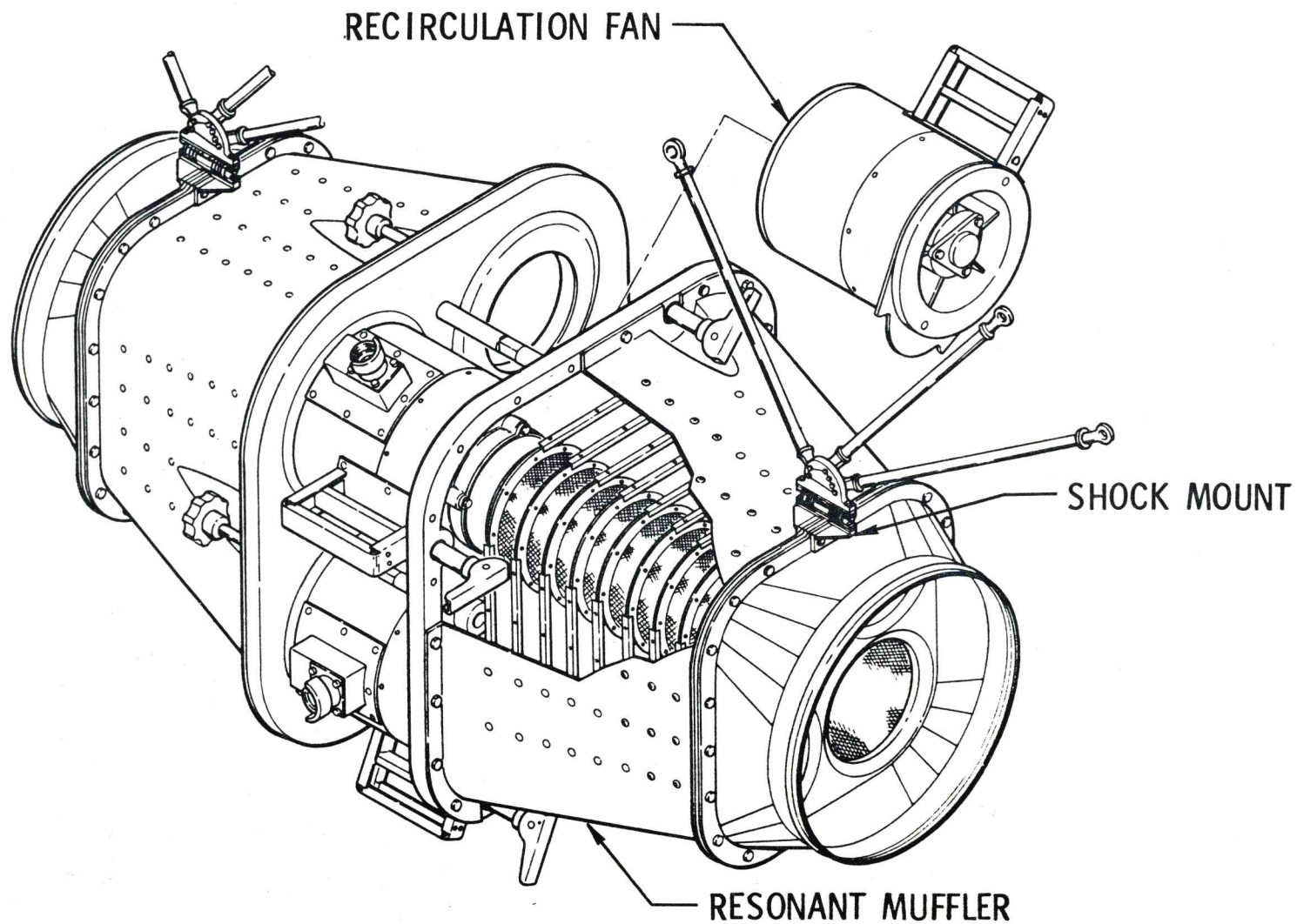


Figure 421-45.

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ORBITAL WORKSHOP FAN CLUSTER AND MUFFLER ASSEMBLY

O/W-3279
8-11-70



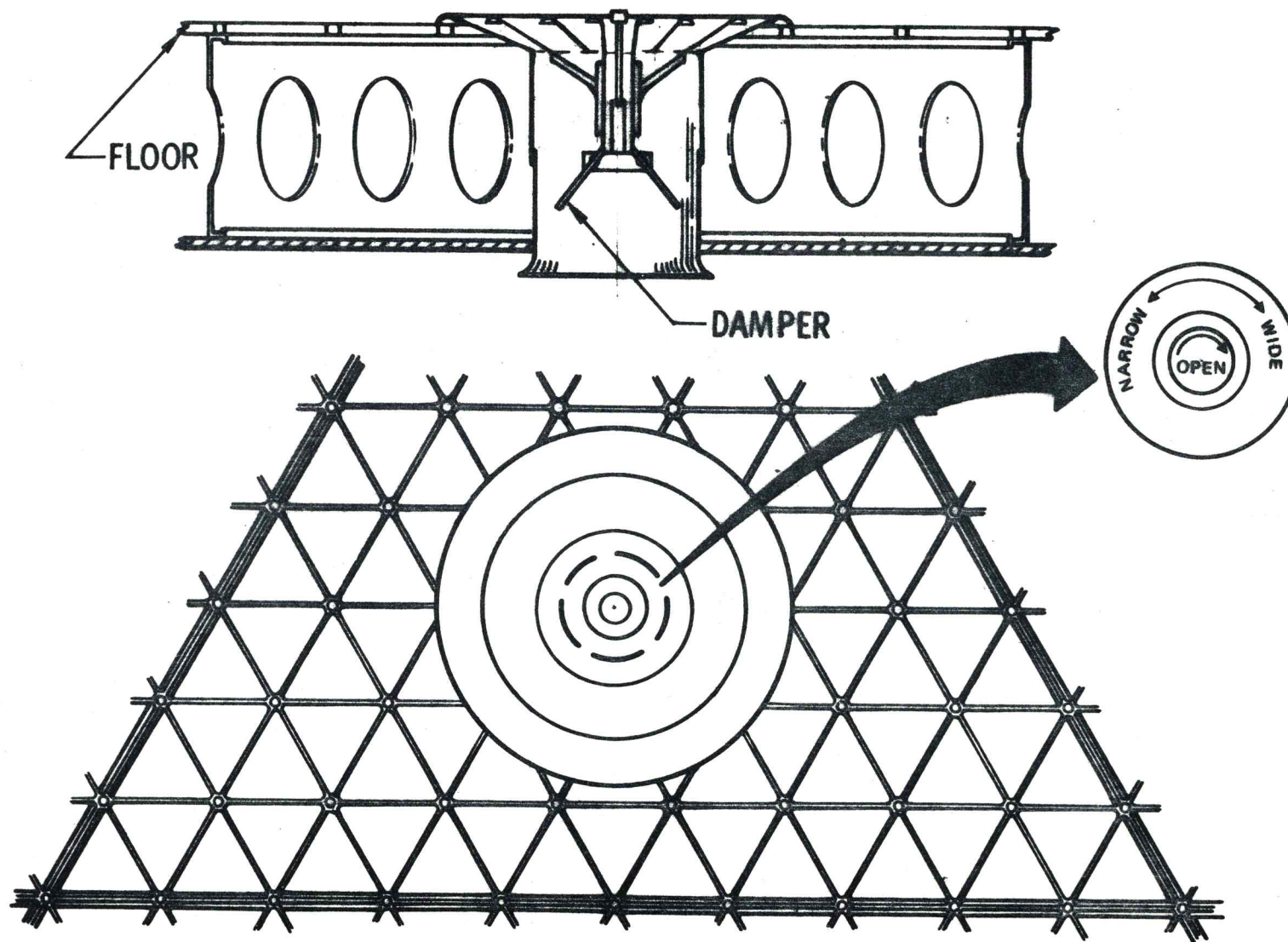
4-119

Figure 421-46.

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ORBITAL WORKSHOP FLOOR/AIR DIFFUSER ARRANGEMENT

O/W-4508
7-1-70



4-120

Figure 421-47.

The system pulls 120 cfm of air through the compartment and through a filter/odor-removal canister and discharges it into the forward OWS compartment. This system is an intermittently operated system controlled by the astronaut when entering or leaving the compartment.

4.2.1.3.3.1 Filter/Odor Removal Canister

The filter/odor removal canister (Figure 421-48) consists of two 1-inch deep annular concentric, activated-charcoal deodorizer beds with inlet filtration. One-hundred percent of the 120 cfm of air is scrubbed.

4.2.1.3.3.2 Fan

The fan is the basic GFE fan used in all OWS applications. This fan when operating on 28 vdc supplies 120 cfm of air at 0.22 inches of water.

4.2.1.3.3.3 Muffler

The exit muffler is a six inch long, porous-wall baffled, resonant-chamber device.

4.2.1.3.3.4 Portable Fans

The portable fan (Figure 421-49) utilizes the fan in a portable support that can be located on any of the OWS structural grids, the central pole or the hand rails and connected to any three amp utility outlet. This portable support incorporates sound suppression and hemispherical inlet and outlet screens to protect the fan from debris. The fan operates from a three-way switch giving a high, low, and off position.

Three portable fans allow the astronaut extra ventilation velocity at selected locations in the OWS.

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ORBITAL WORKSHOP WMC VENTILATION UNIT

O/W-3280
5-22-70

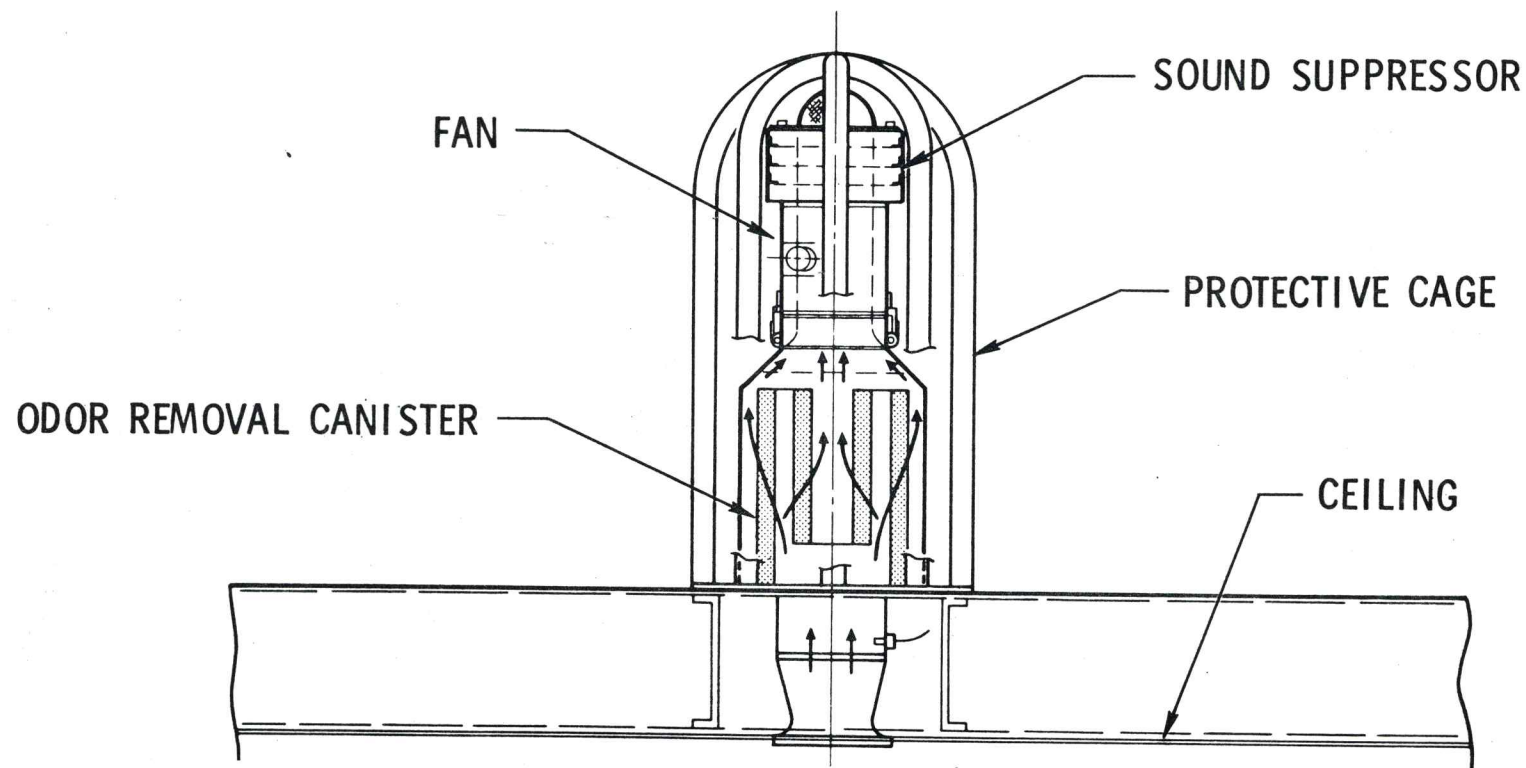
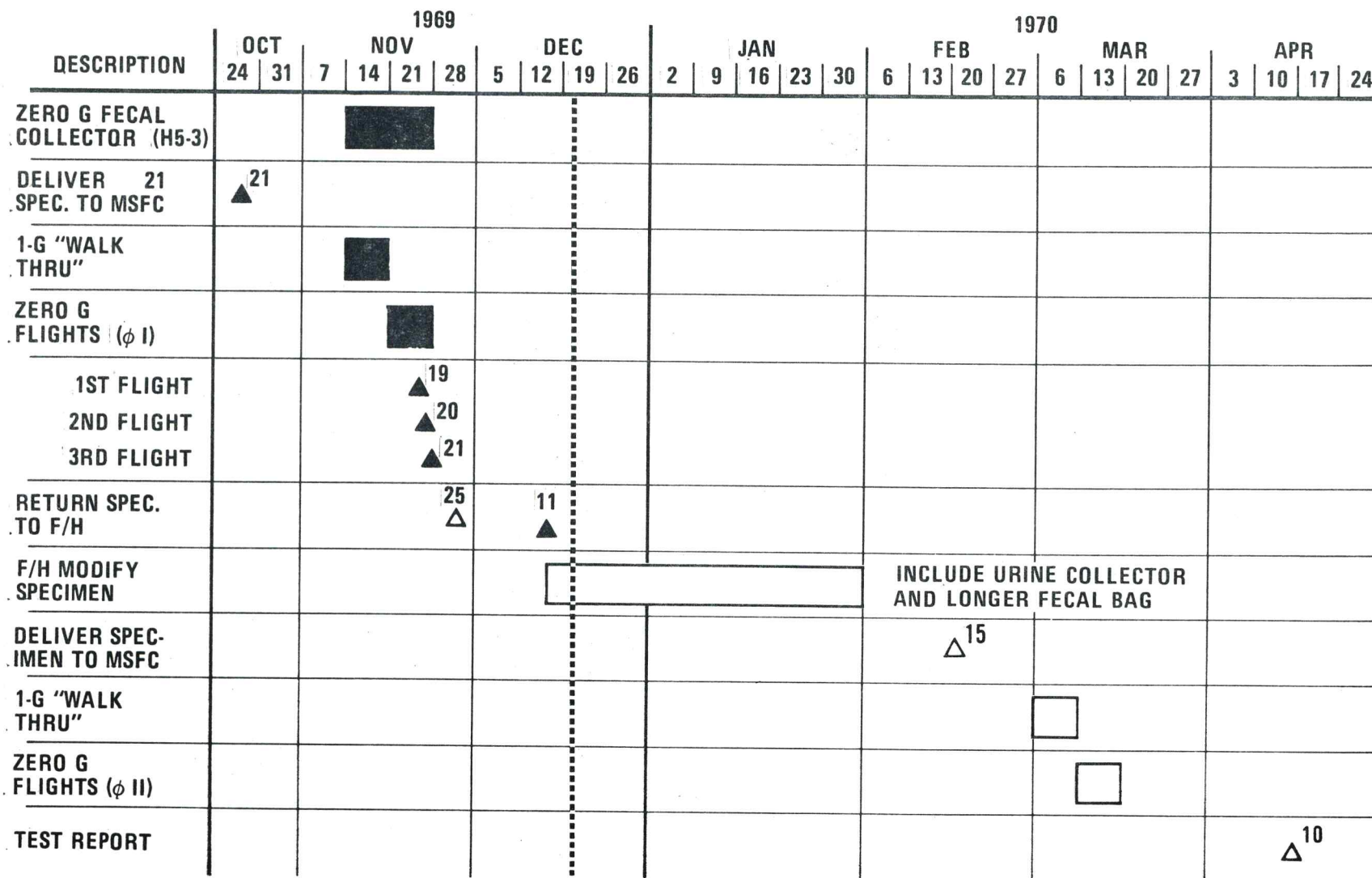


Figure 421-48.

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ORBITAL WORKSHOP WASTE MANAGEMENT SUBSYSTEM ACTIVE TESTS

O/W-4848
12-16-69



4-123

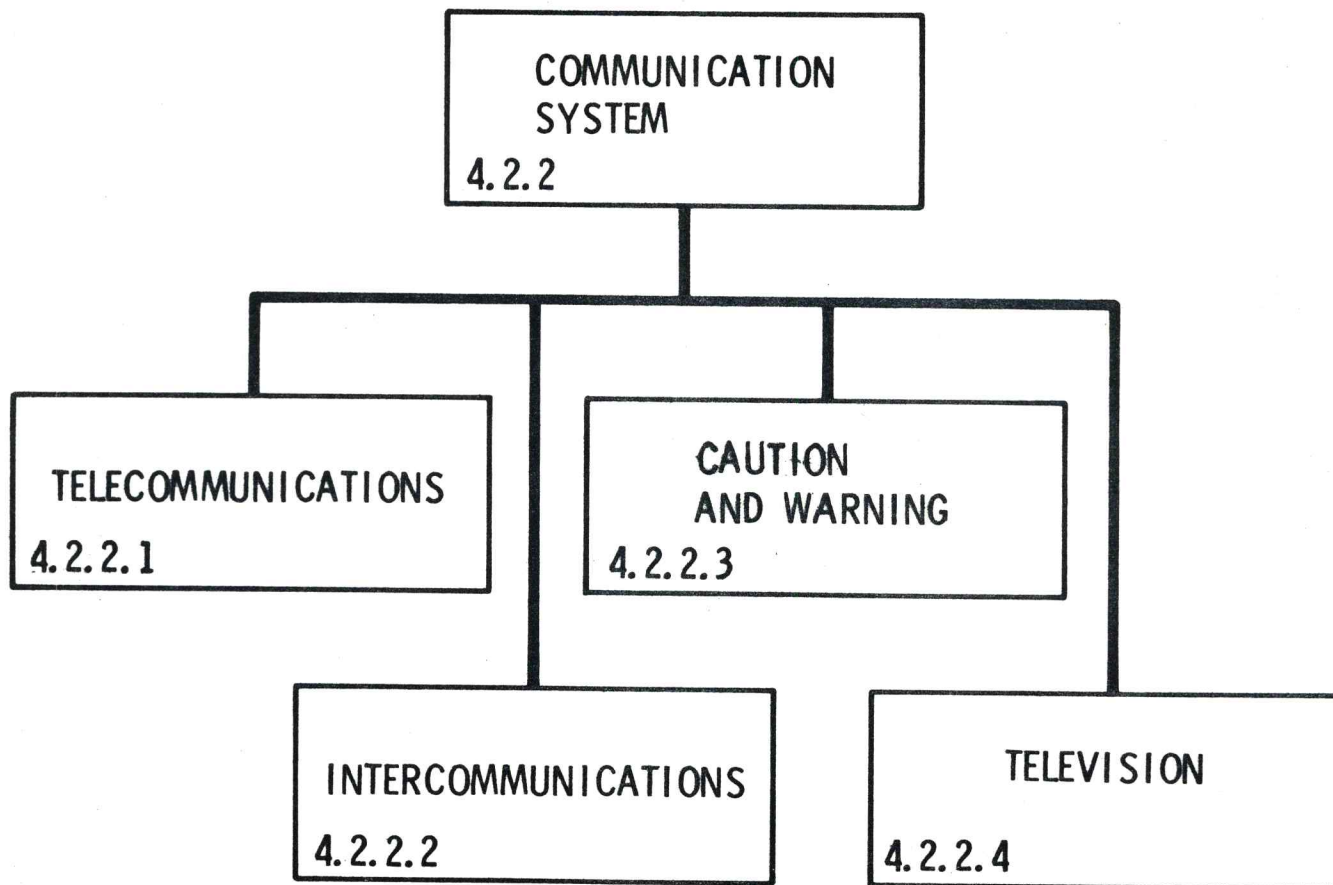
Figure 421-49.

COMMUNICATION SYSTEM

COMMUNICATION SYSTEM

ORBITAL WORKSHOP

O/W-7491
6-11-70



4.2.2 Communication System

The OWS Communication System is composed of the Telecommunication System Intercommunication System, Caution and Warning System, and Television. The Communication System provides the following capability:

- a. Interface with the Cluster Audio System, providing a direct voice link between the OWS and the Manned Space Flight Network (MSFN).
- b. Interface the astronaut in the OWS with the AM Telemetry System, providing a direct biomedical data link with MSFN.
- c. Allow intercommunication within the OWS and throughout the Cluster.
- d. Sense, receive, and display Caution and Warning alarm signals.
- e. Provide a television link between the OWS and CSM for transmission of video originating from the OWS.

4.2.2.1 Telecommunication System

The OWS Telecommunication is an extension of the Cluster Communications System via speaker intercom assemblies (Figure 422-1). The CSM Communication system via S-Band provides the voice communication link between the OWS crewman and the MSFN.

4.2.2.2 Intercommunication System

The Intercommunication System is comprised of ten GFE Speaker Intercom Assemblies (SIA) (Figure 422-2) and associated wiring. The SIA has dual-channel capability. The dual-channel operation enables astronauts to use separate channels, providing the capability for two astronauts to transmit voice and/or biomedical data across the OWS/AM interface for relaying to the MSFN. The astronauts may converse by using headsets, which are wired through the same connector as the biomedical data, or the speaker/microphone at any SIA. Each channel is wired in parallel (Figure 422-3) which allows the astronauts to connect into the same channel at another SIA station for voice communications. The biomedical data are relayed across the OWS/AM interface and channeled into the AM Data Acquisition System for Telemetry transmission (Figure 422-4).

In summarizing, the OWS Intercommunication System includes the following design features:

- a. Provides ten SIA at the locations as tabulated (Figure 422-5):

| <u>Location</u> | <u>Quantity</u> |
|------------------------------|-----------------|
| Sleep Compartment | 3 |
| Waste Management Compartment | 1 |
| Experiment Compartment | 2 |
| Forward Compartment | 3 |
| Wardroom | <u>1</u> |
| TOTAL | 10 |

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ORBITAL WORKSHOP TELECOMMUNICATIONS AUDIO

O/W-4349
5-6-70

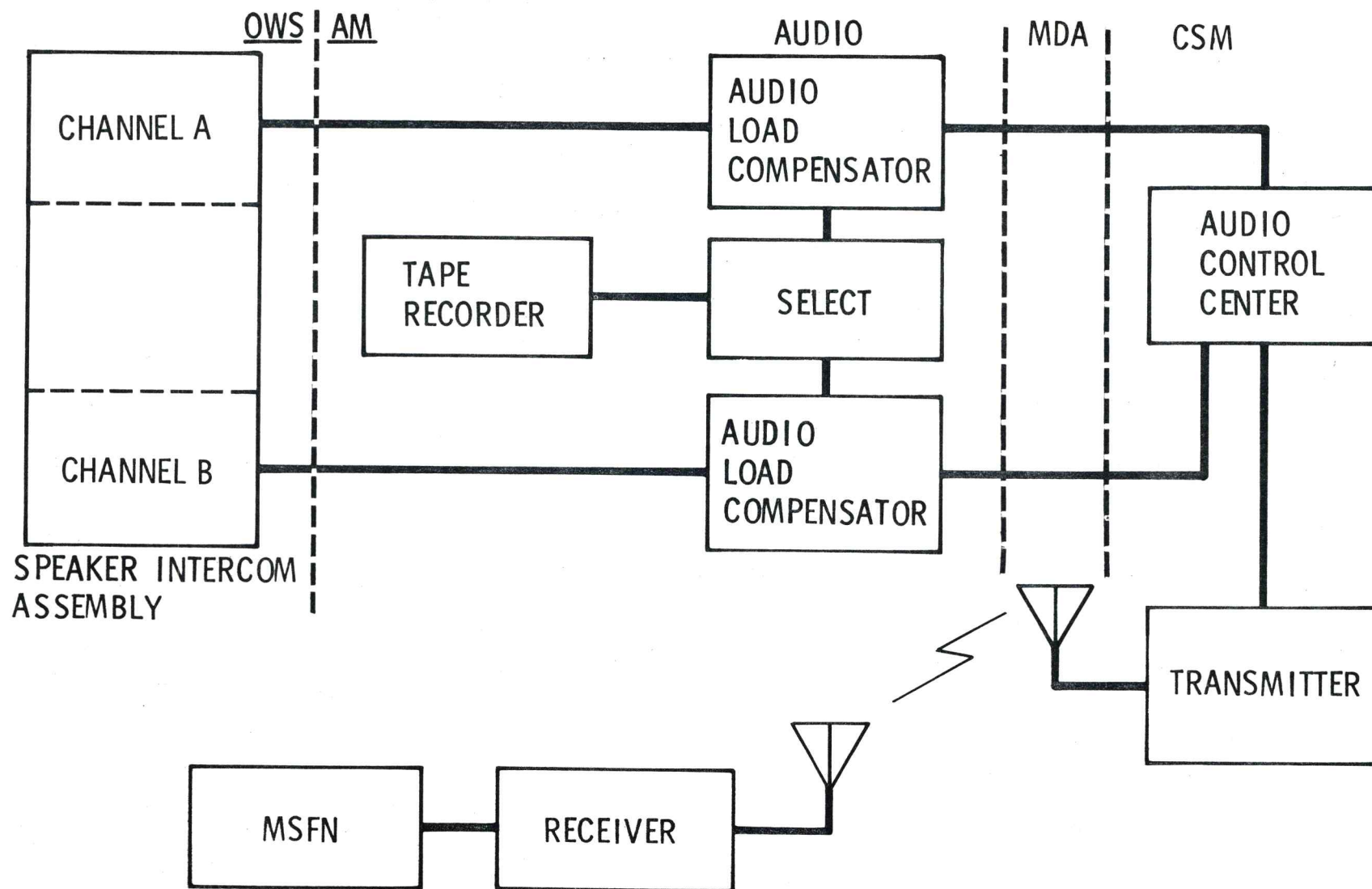


Figure 422-1.

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ORBITAL WORKSHOP SPEAKER INTERCOM ASSEMBLY

O/W-1151
5-8-70

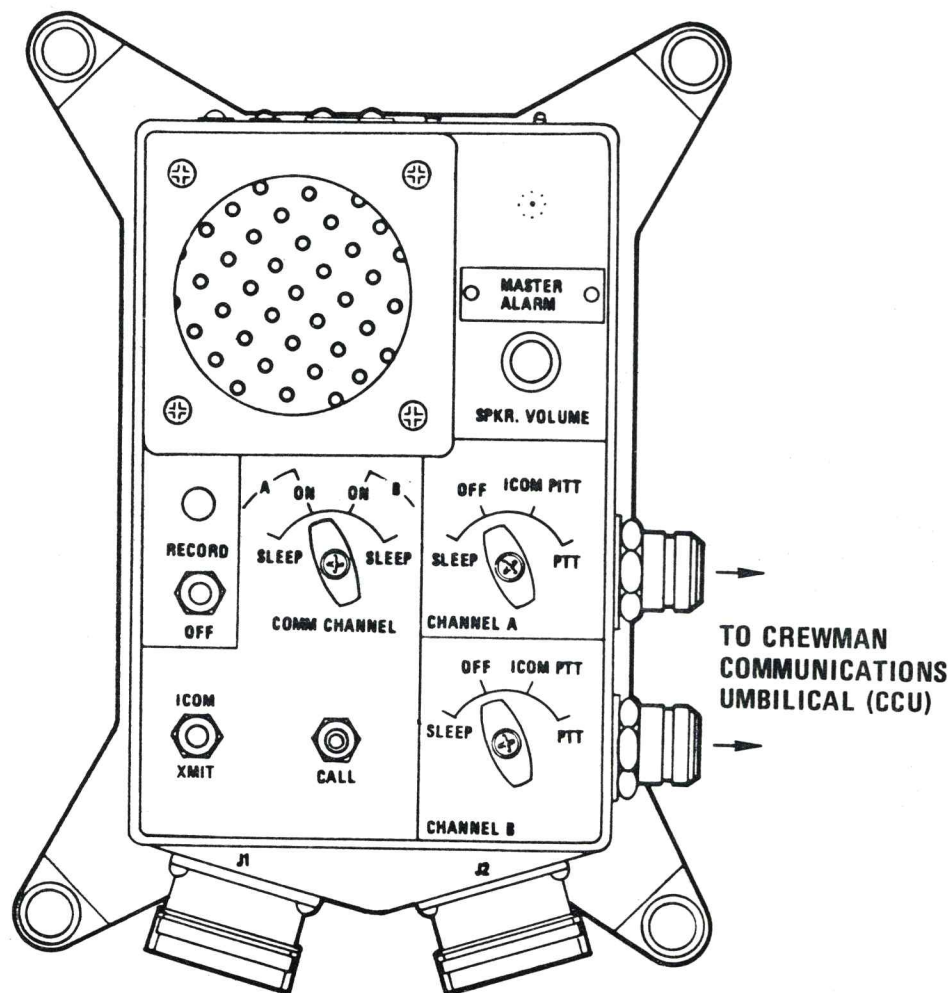


Figure 422-2. (Sheet 1 of 2)

ORBITAL WORKSHOP
SPEAKER INTERCOM ASSEMBLY

O/W-7444
5-12-70

| <u>ITEM</u> | <u>FUNCTION</u> |
|-----------------------------|--|
| S PEAKER | PROVIDES AUDIO OUTPUT |
| MICROPHONE | PROVIDES AUDIO INPUT |
| S PEAKER VOLUME CONTROL | PROVIDES AUDIO OUTPUT VOLUME CONTROL |
| MASTER ALARM LIGHT | PROVIDES C&W INDICATION |
| RECORD SWITCH | ACTUATE VOICE TAPE RECORDER |
| RECORD LIGHT | PROVIDES TAPE RECORDER "ON" INFORMATION |
| COMM CHANNEL SWITCH | SELECT CHANNEL A, CHANNEL B, ON SLEEP MODE |
| INTERCOM/TRANSMITTER SWITCH | SELECT PUSH -TO -TALK OR PUSH-TO -TRANSMIT |
| CALL SWITCH | OVERRIDES OTHER SLEEP MODE SWITCHES |
| CHANNEL A SWITCH | MODE SELECT SWITCH FOR CCU A RECEPTACLE |
| CHANNEL B SWITCH | MODE SELECT SWITCH FOR CCU B RECEPTACLE |
| CCU RECEPTACLES | FOR CREWMEN'S COMMUNICATIONS UMBILICAL (CCU) |

Figure 422-2. (Sheet 2 of 2)

ORBITAL WORKSHOP INTERCOMMUNICATION SYSTEM

The diagram illustrates a parallel closed loop system for a workshop. At the top, a horizontal line represents the main power supply, labeled "SIGNAL", "SIGNAL RETURN", and "AM WORKSHOP". Below this, the system is divided into two main sections: a left section with three stations and a right section with two stations. Each station is represented by a rectangular box containing a speaker icon and the label "SIA". The stations are connected to the main supply line via a series of switches and relays. The left section shows three stations connected in parallel, with the top station having a switch that can be moved to the "SIGNAL" or "SIGNAL RETURN" line. The right section shows two stations connected in parallel, with the top station having a switch that can be moved to the "SIGNAL" or "SIGNAL RETURN" line. The bottom station in the right section is connected to the "SIGNAL RETURN" line via a dashed line, indicating a connection to the common return. A legend on the right side of the diagram states: "STATIONS IN PARALLEL CLOSED LOOP (ONLY ONE CHANNEL SHOWN)" and "SIA = SPEAKER INTERCOM ASSEMBLY".

Figure 422-3.

ORBITAL WORKSHOP BIOMED DATA

O/W-4348
8-7-70

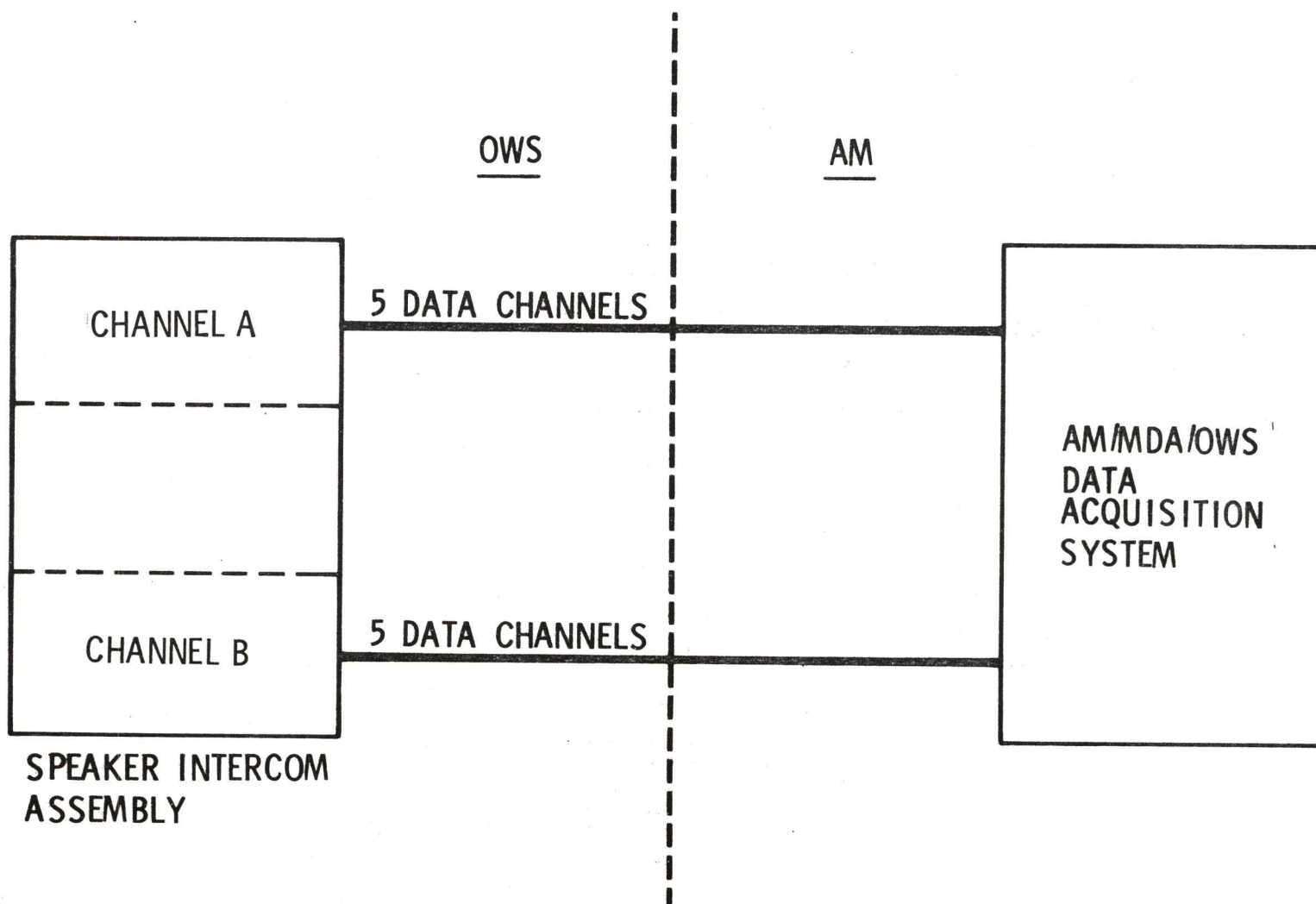


Figure 422-4.

ORBITAL WORKSHOP INTERCOMMUNICATION STATIONS

O/W-1374
8-8-70

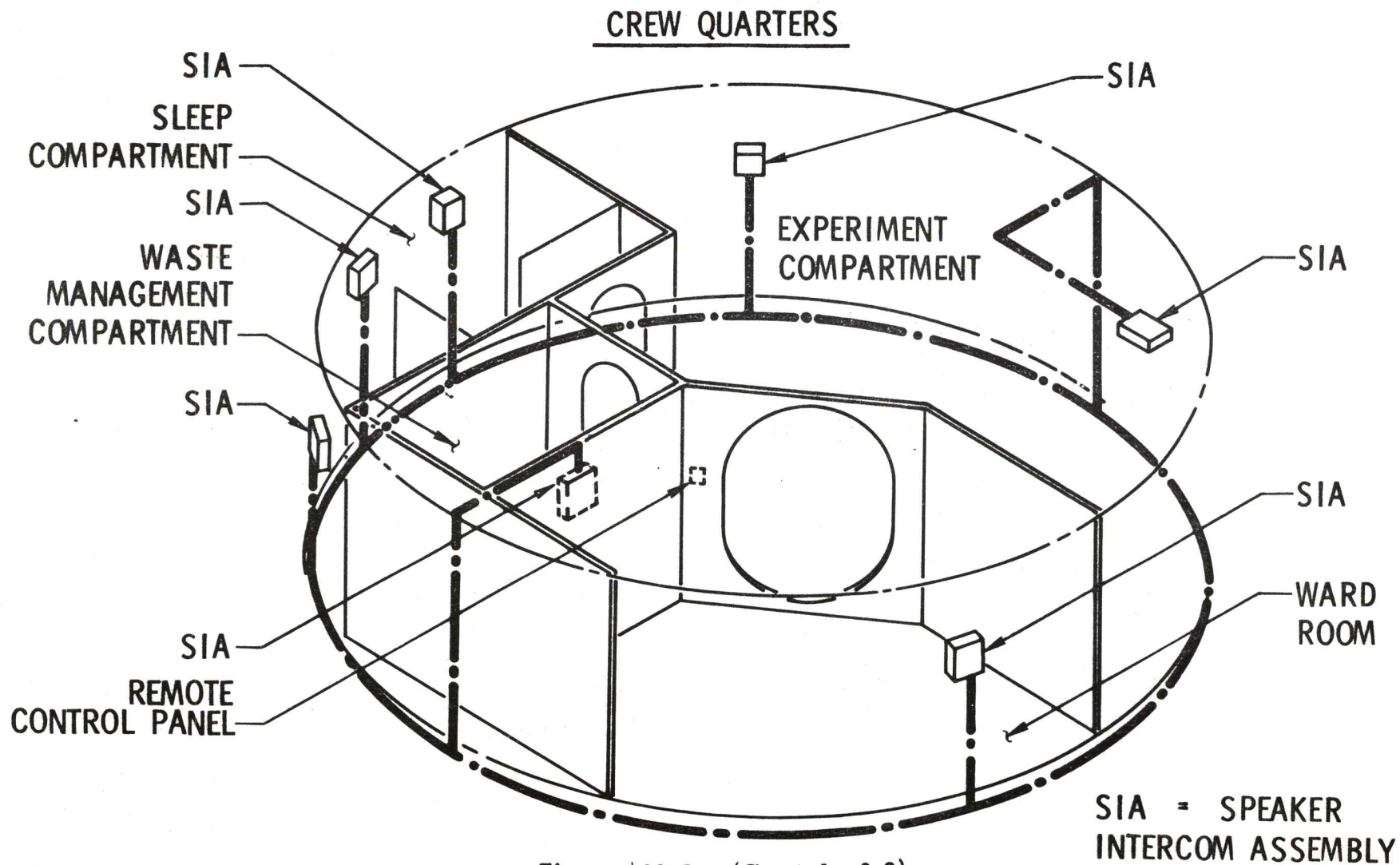


Figure 422-5. (Sheet 1 of 2)

ORBITAL WORKSHOP INTERCOMMUNICATIONS STATIONS

O/W-1375B
8-7-70

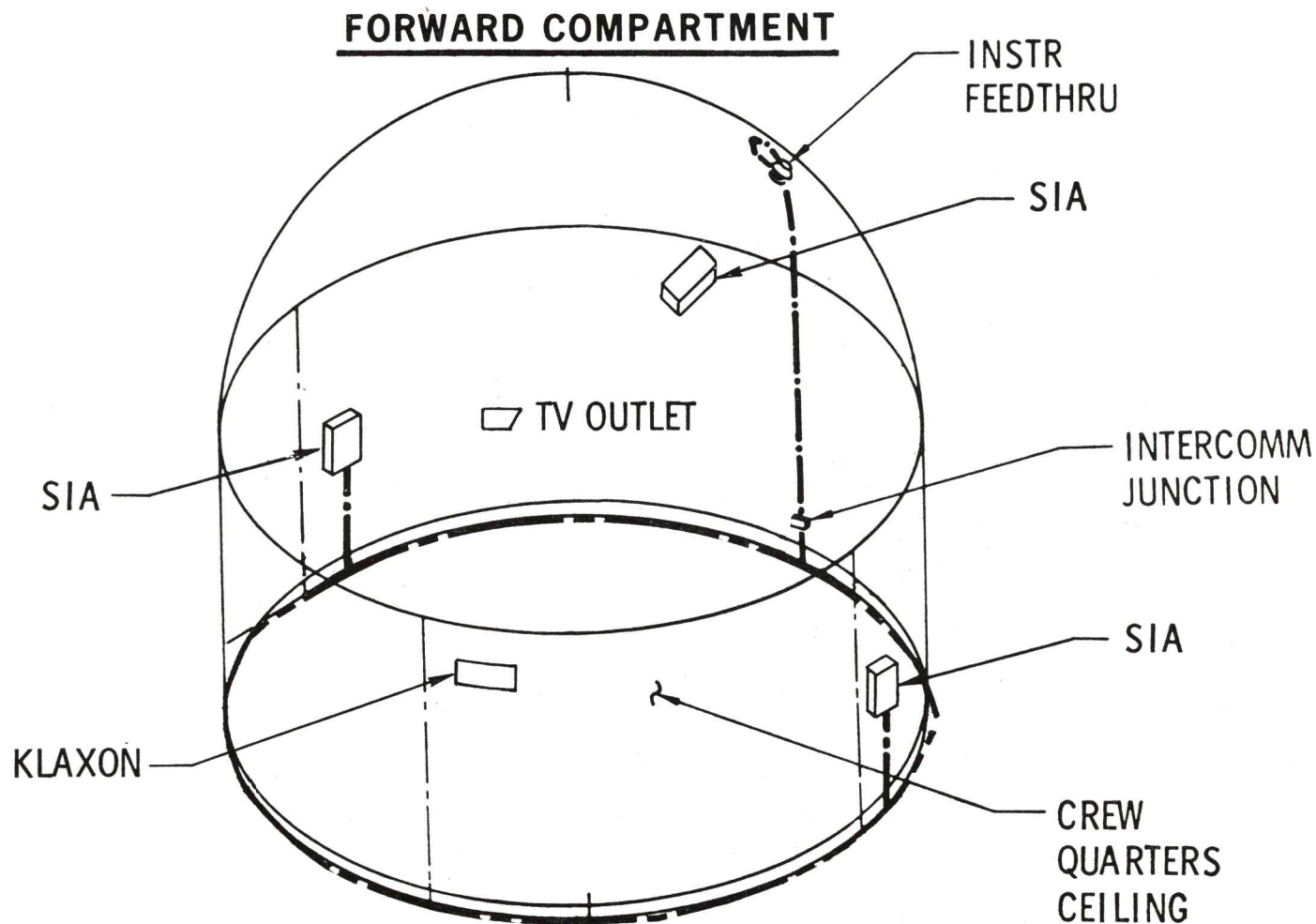


Figure 422-5. (Sheet 2 of 2)

- b. Provides parallel, closed loop, wiring to each SIA.
- c. Provides two input connectors at each SIA.
 - 1. Input channel A
 - 2. Input channel B
- d. Provides two crew communication umbilical (CCU) connectors at each SIA.
- e. Provides dual channel system to permit crewman intercommunication through headsets or SIA.
- f. Accommodates caution and warning tone signals and Master Alarm light from AM.
- g. Provides the OWS voice communications to the MSFN.
- h. Provides the interface to transmit biomedical data.

4.2.2.3 Caution and Warning System

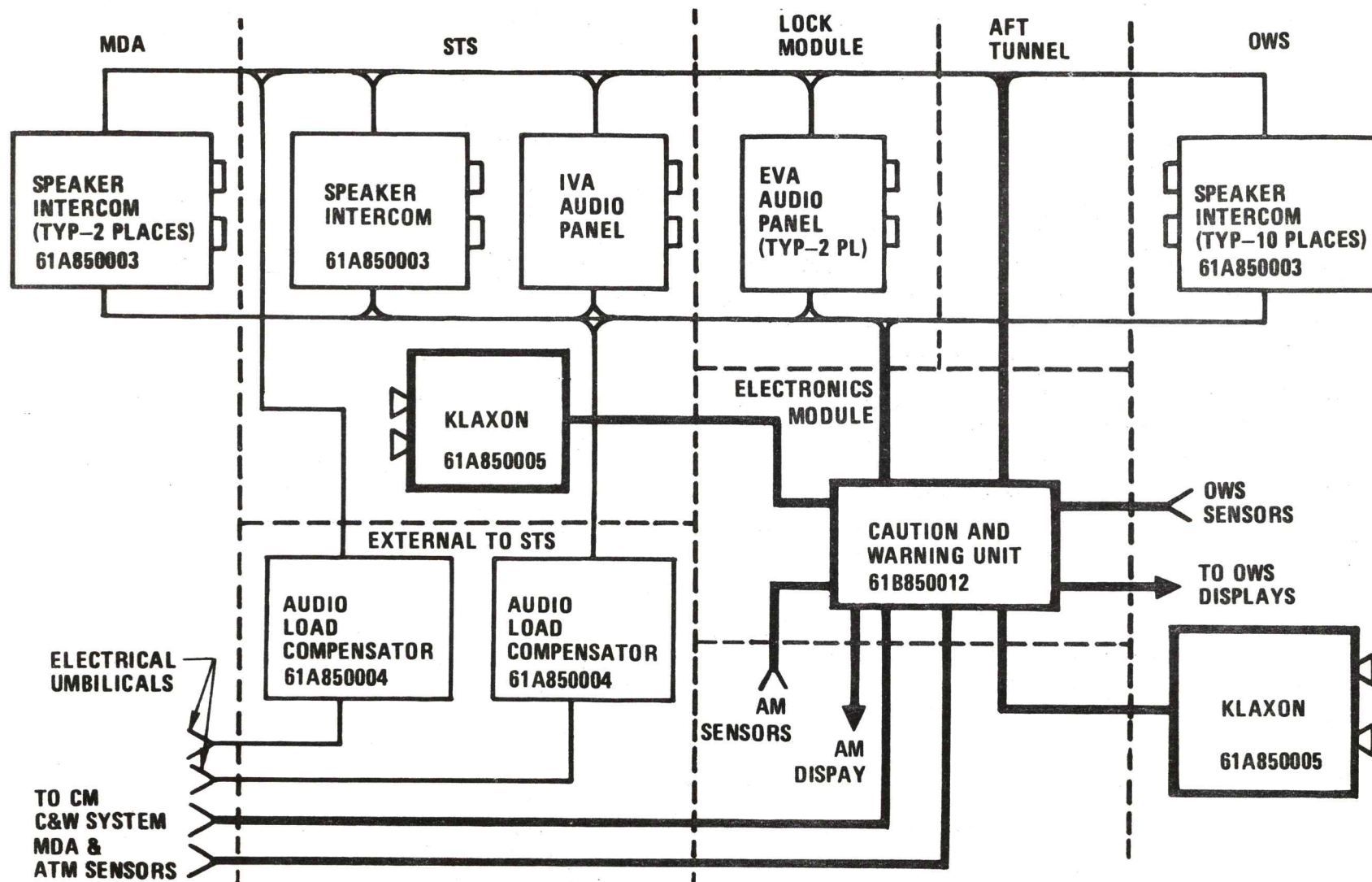
The Caution and Warning System (CWS) alerts the crew to an impending or existing condition that is potentially hazardous to the life of the crew or completion of the mission. The OWS CWS is an extension of the AM CWS (Figure 422-6) and consists of the repeater CWS Control and Display panel, alarm devices (Klaxon and SIA's) and associated wirings.

The repeater control and display panel (Figure 422-7), controlled entirely from the AM CWS, provides the annunciations of the selected parameters. Each annunciator on the panel has redundant lamps. Annunciators are provided with the designated lens coloring for the following parameters:

- a. Master Alarm (Red lens)
- b. Emergencies (Red lens)
 - 1. OWS Forward Fire
 - 2. AM Fire
 - 3. Rapid ΔP
 - 4. MDA/STS Fire
 - 5. OWS Crew Qtrs Fire
 - 6. Spare
- c. Warning (Red lens)
 - 1. OWS Bus 1 Low
 - 2. OWS Bus 2 Low
 - 3. Crew Alert

ORBITAL WORKSHOP CAUTION AND WARNING SYSTEM

O/W-7381
8-7-70



4-134

Figure 422-6.

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ORBITAL WORKSHOP CONTROL AND DISPLAY PANEL NO. 1 CAUTION/WARNING SYSTEM

O/W-5291
8-7-70

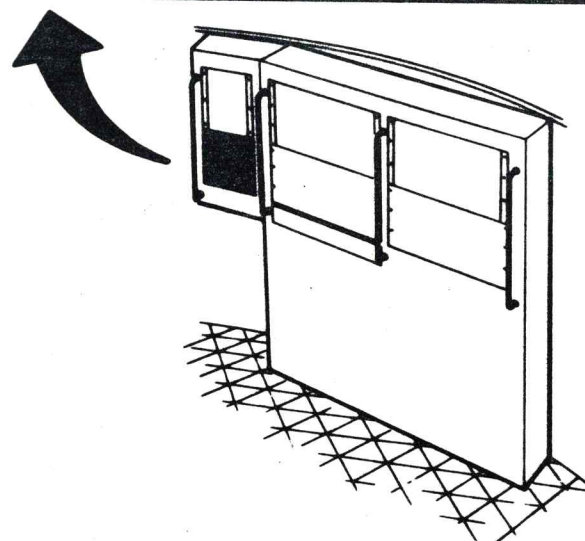
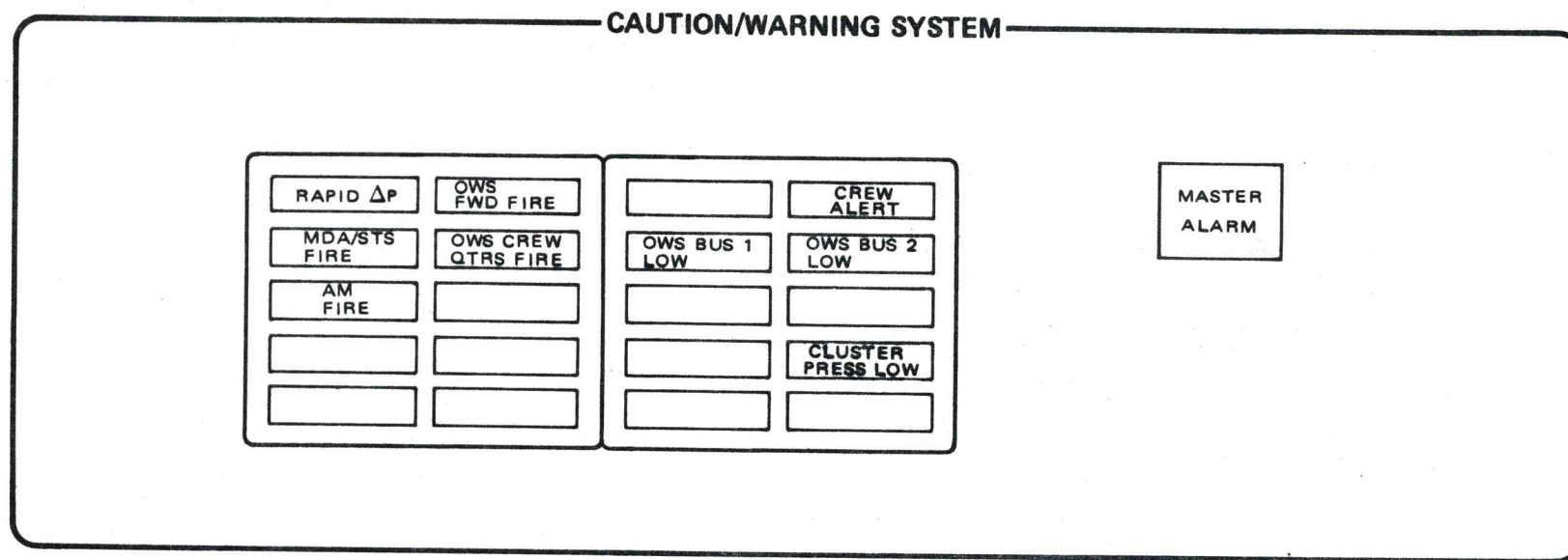


Figure 422-7.

d. Caution (Yellow lens)

1. Cluster Pressure Low
2. Spare
3. Spare

Spare annunciator circuits are included and completely wired to the OWS/AM interface. The two OWS bus low voltages are sensed at the OWS Bus through circuit breaker protection and routed to the AM CWS where a low voltage detector initiates the alarm signal.

A master alarm reset is provided at the control and display panel, which sends redundant reset commands to the AM CWS when depressed. These commands turn off the master alarm indicator lights and alarm tone, and place the system in a ready state to accept another alarm signal. The malfunction light that identifies the cause of the alarm signal remains illuminated.

A GFE klaxon is located in the forward compartment (Figure 422-5) to assure maximum coverage within the OWS. The klaxon has redundant speakers separately wired to disseminate the emergency tones.

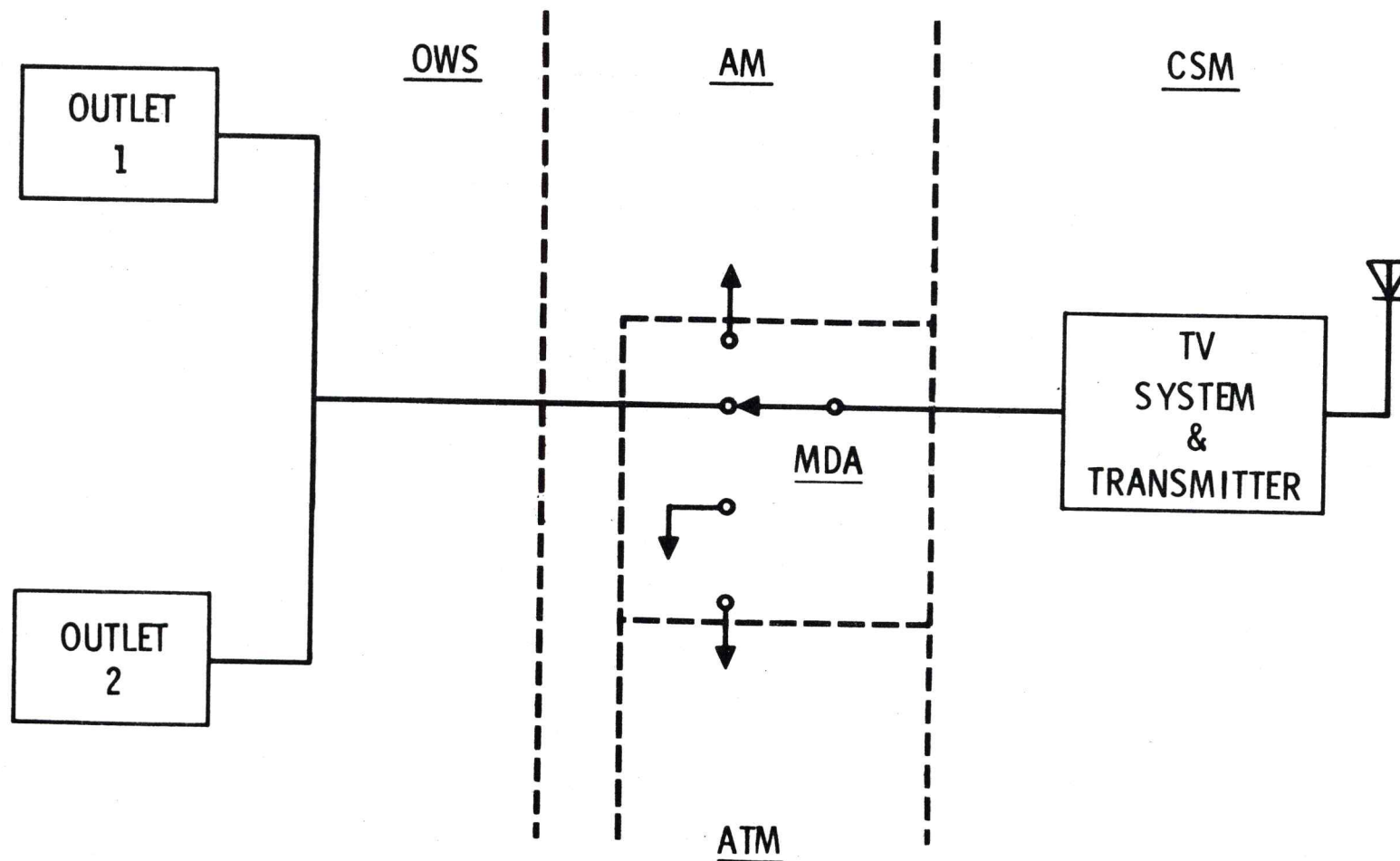
The routing from the AM (Figure 422-6) of caution and warning tones into the Intercommunication System is provided when a caution, warning or emergency condition exists. The headsets or speaker intercom assemblies respond with audible sound provided they are in the ON mode of operation. A crew alert ground command will override the SIA OFF or SLEEP modes of operation.

4.2.2.4 Television

The Television System (Figure 422-8) is an extension of the cluster television system into the OWS for video coverage of crew activities, equipment operation, and experimentation. The OWS television accommodations provide the capability for operation with an Apollo color TV camera and a monitor unit. Provisions are made in the OWS habitation area to permit mounting of the monitor unit, to provide operation power (23 watts at 28 vdc) for both the camera and monitor units, and to handle video transmissions (2 MHz on 75 ohm coax). The coaxial cable is routed separately to the AM interface for transmission via CSM S-Band. A TV outlet is provided in the crew quarters area with a second outlet located in the forward compartment. The camera and monitor units are GFE.

ORBITAL WORKSHOP TELEVISION

O/W-4350
8-7-70



4-137

Figure 422-8.

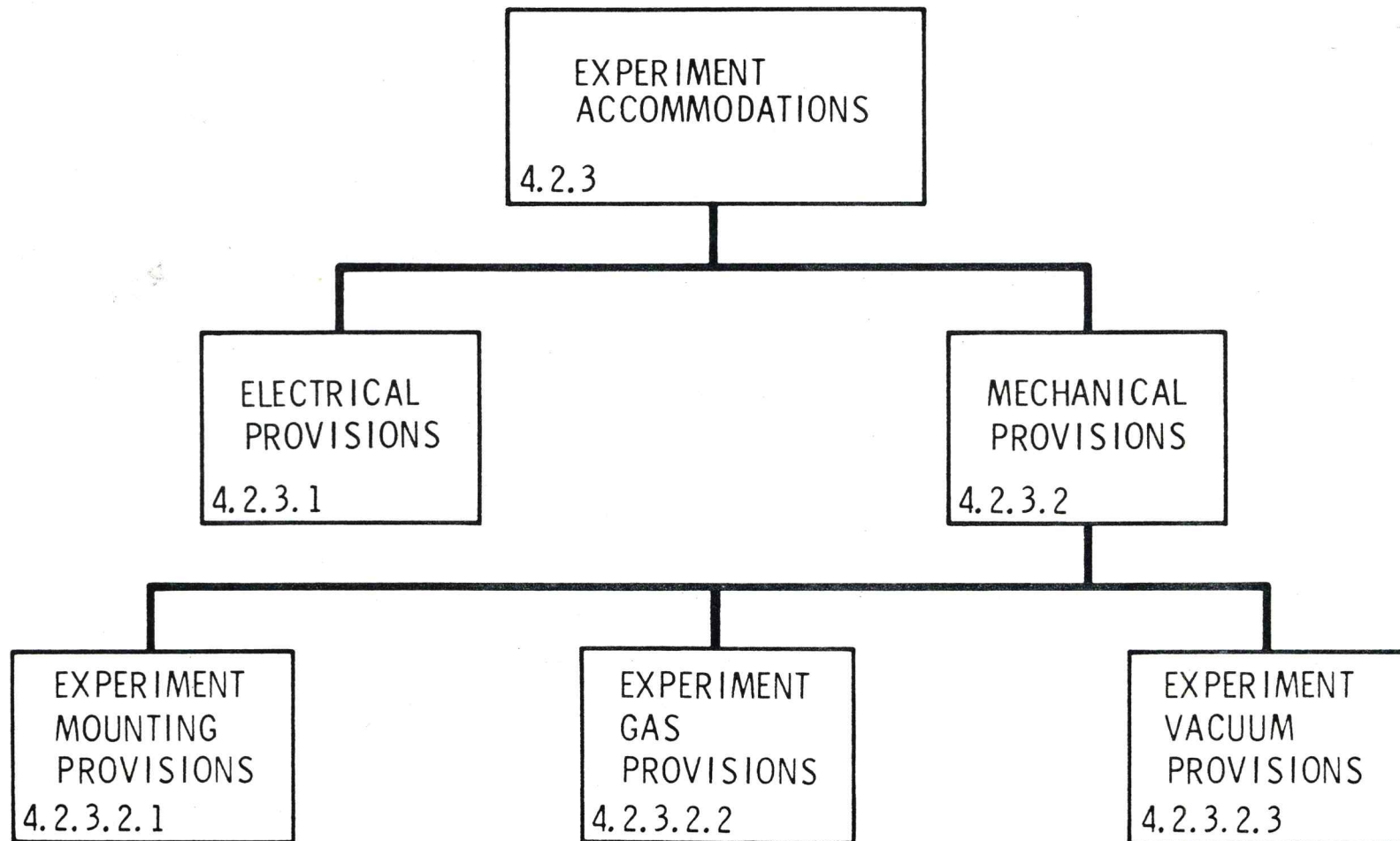
EXPERIMENT
ACCOMMODATIONS

IONS
2.2

EXPERIMENT
VACUUM
PROVISIONS
4.2.3.2.3

ORBITAL WORKSHOP

O/W-5045
8-6-70



4.2.3 Experiment Accommodations

The OWS experiment accommodations are outlined in Figure 423-1.

4.2.3.1 Electrical Provisions

The OWS contains all of the necessary electrical provisions for operation of the following experiments (Figure 423-2).

| | |
|-------|---|
| ESS | Experiment Support System. |
| M074 | Specimen Mass Measurement. |
| *M092 | In-Flight Lower Body Negative Pressure. |
| *M093 | Vectorcardiogram. |
| M131 | Human Vestibular Function. |
| *M171 | Metabolic Activity. |
| M172 | Body Mass Measurement. |
| M507 | Gravity Substitute Workbench. |
| M509 | Astronaut Maneuvering Equipment. |
| T013 | Crew/Vehicle Disturbance. |
| T027 | ATM Contamination Measurement. |
| | *From ESS |

4.2.3.2 Mechanical Provisions

4.2.3.2.1 Experiment Mounting Provisions

Accommodations are provided throughout the OWS for mounting experiments (Figure 423-3).

4.2.3.2.2 Experiment Gas Provisions

Nitrogen is provided to experiments M171 and ESS from the OWS water pressurization system.

4.2.3.2.3 Experiment Vacuum Provisions

4.2.3.2.3.1 Scientific Airlock

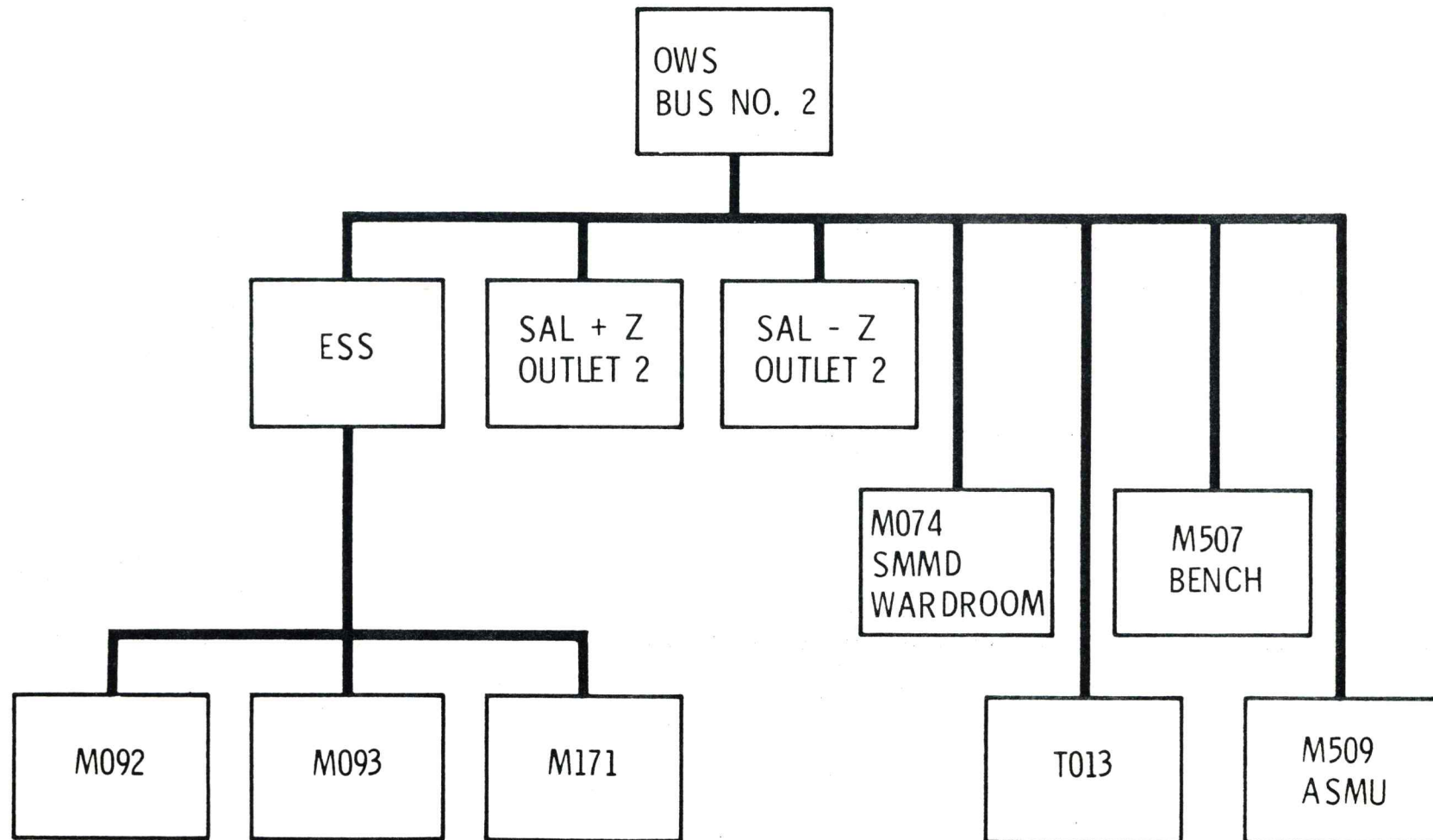
Vacuum provisions for SAL experiments S019, S020 and T027 are shown in Figure 423-4.

4.2.3.2.3.2 M092 and M171

Vacuum provisions for the lower body negative pressure device (M092) and the metabolic analyzer (M171) are supplied by the OWS (Figure 423-5). These vents are ducted directly overboard through the tank wall in the crew compartment experiment area. Each vent consists of a one-inch duct and a hand-operated shutoff valve (Figure 423-6).

ORBITAL WORKSHOP ELECTRICAL POWER DISTRIBUTION SYSTEM EXPERIMENT ACCOMMODATIONS BUS NO. 2

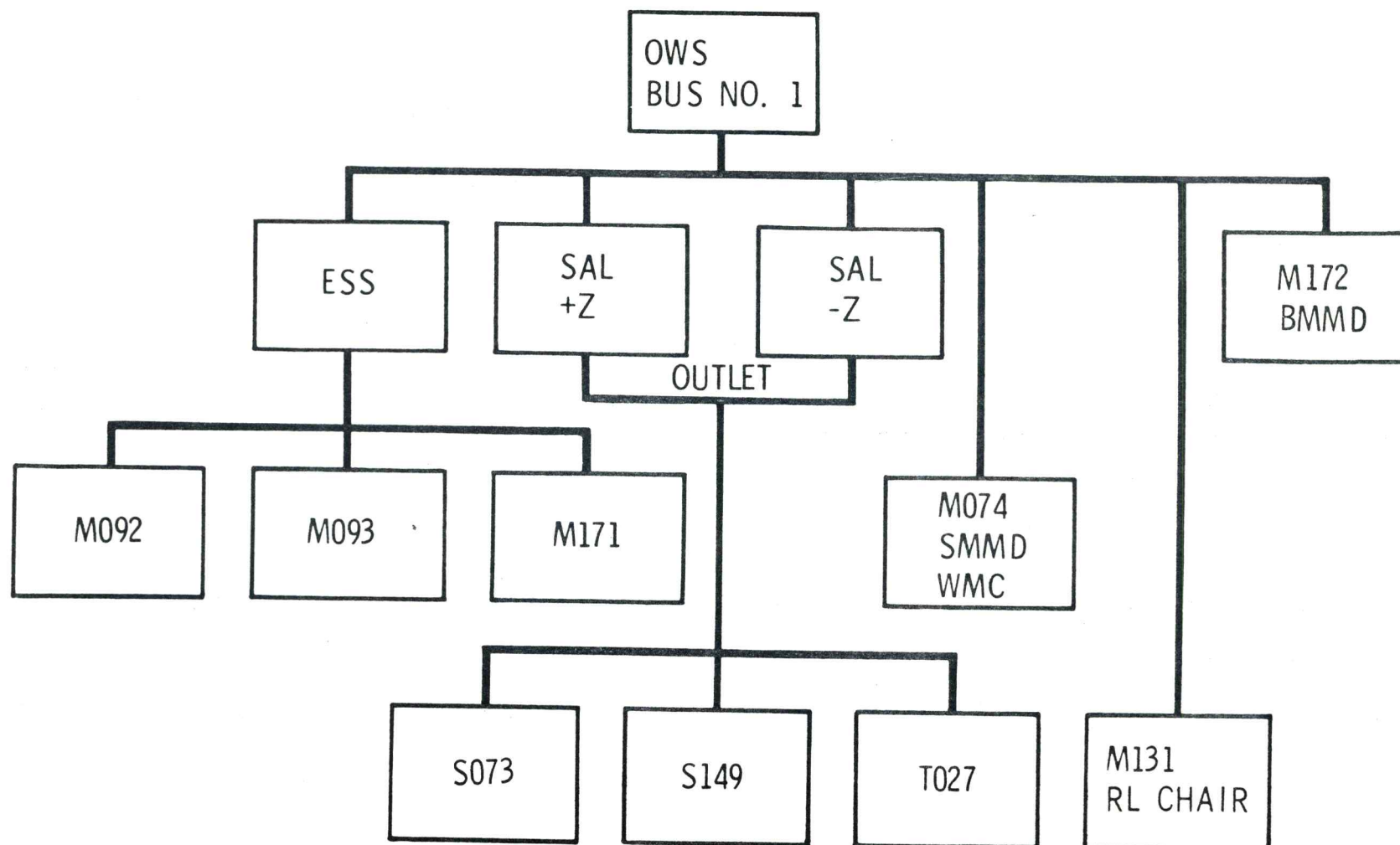
O/W-8844
8-6-70



4-142

ORBITAL WORKSHOP ELECTRICAL POWER DISTRIBUTION SYSTEM EXPERIMENT ACCOMMODATIONS BUS NO. 1

O/W-8845
8-6-70



4-143

Figure 423-2. (Sheet 2 of 7)

ORBITAL WORKSHOP EXPERIMENT SUPPORT SYSTEM INTERFACE

O/W-4314
8-6-70

4-144

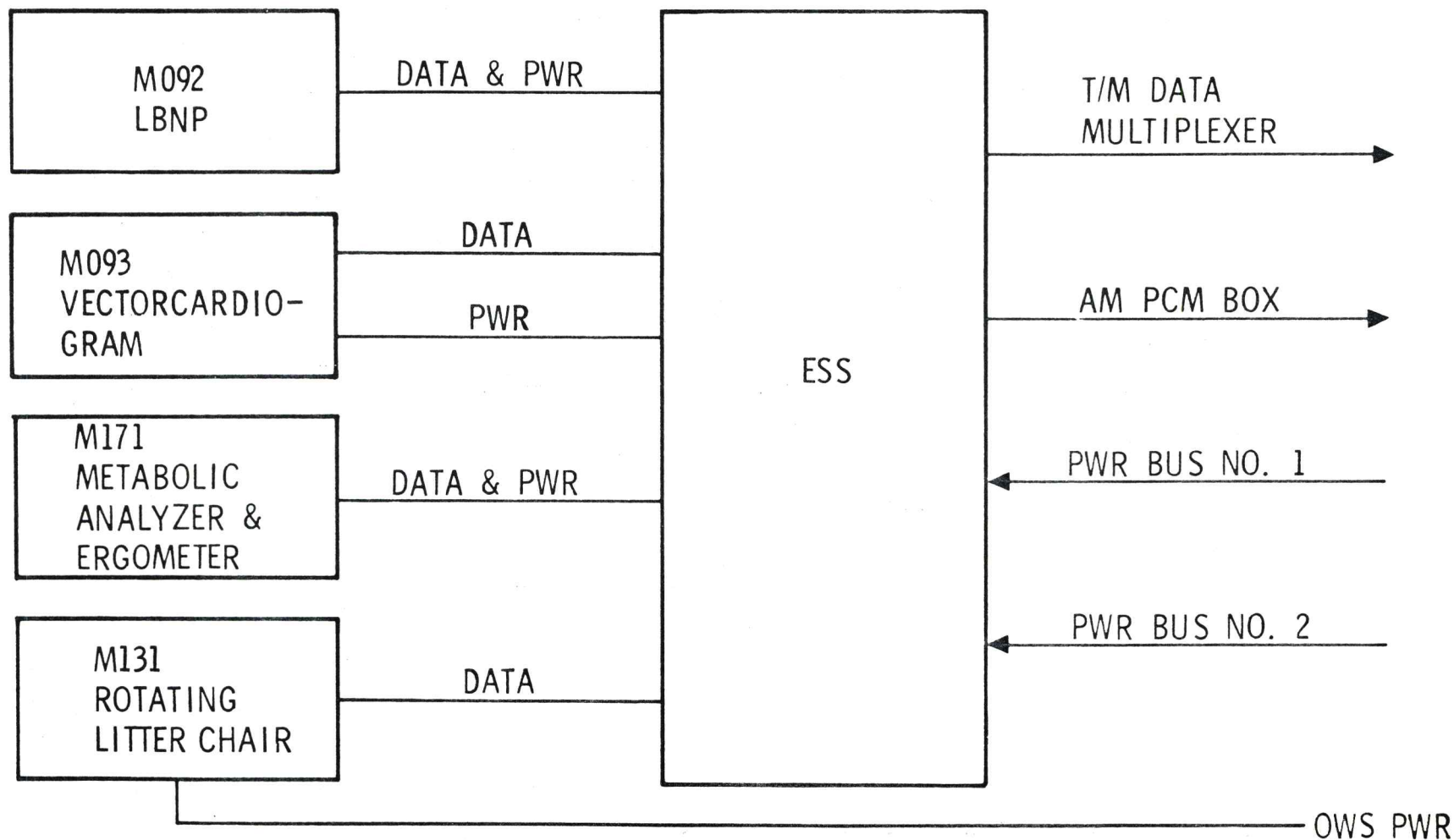


Figure 423-2. (Sheet 3 of 7)

ORBITAL WORKSHOP EXPERIMENTS M509 & T013 TELECOMMUNICATIONS

O/W-4315
8-6-70

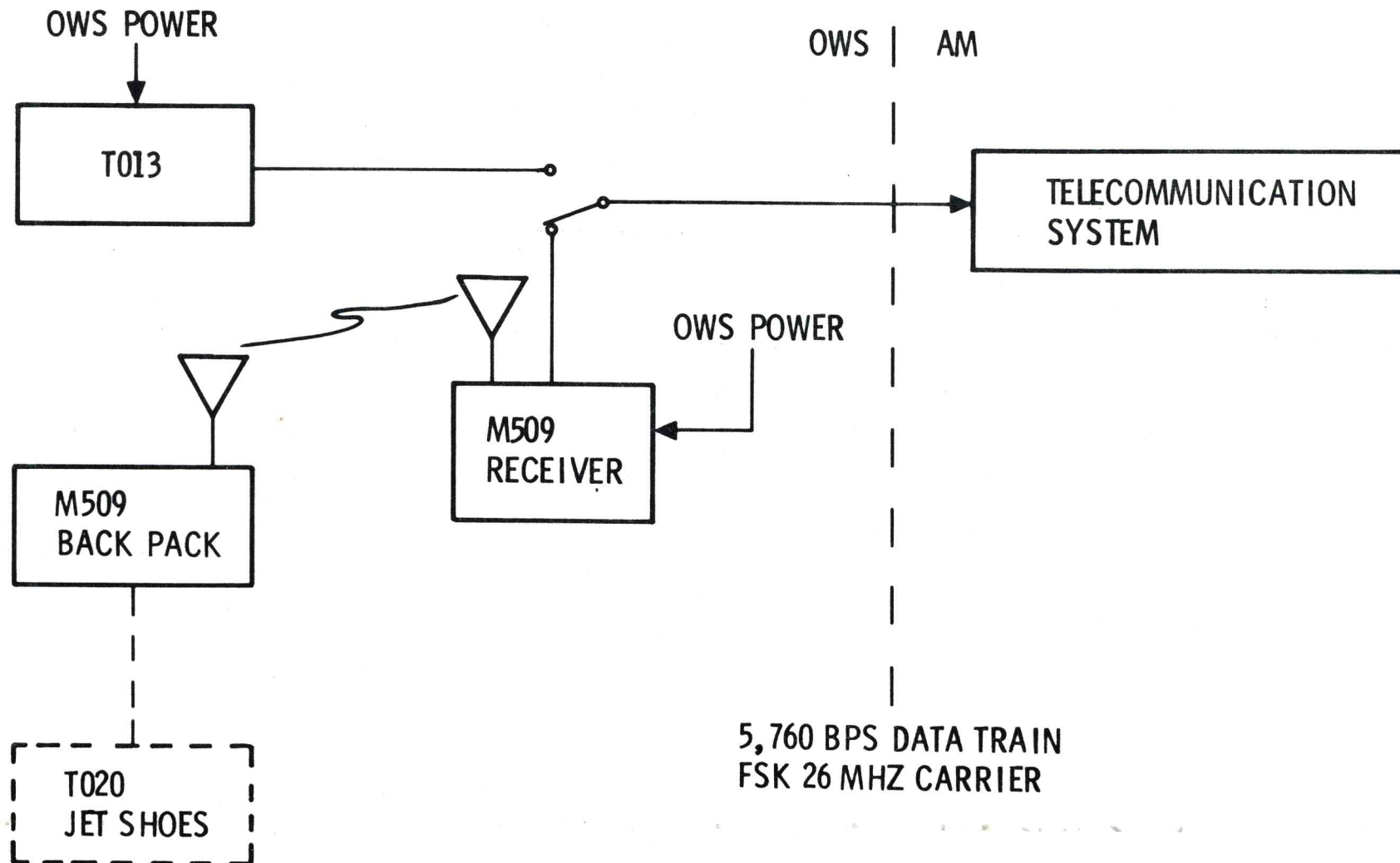
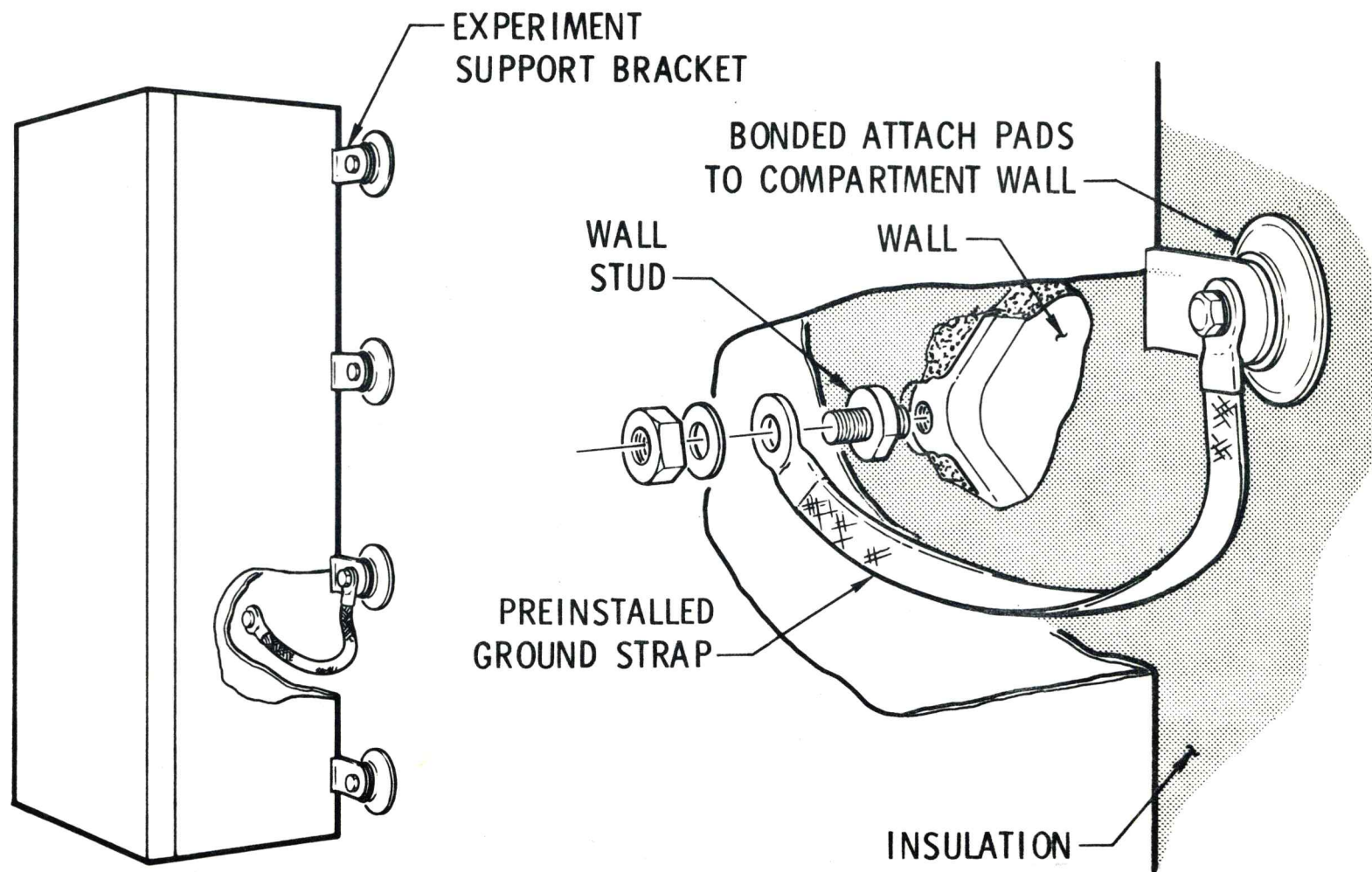


Figure 423-2. (Sheet 4 of 7)

ORBITAL WORKSHOP TYPICAL FORWARD COMPARTMENT WALL MOUNTING STATIC BONDING PROVISIONS

O/W-4549
8-6-70

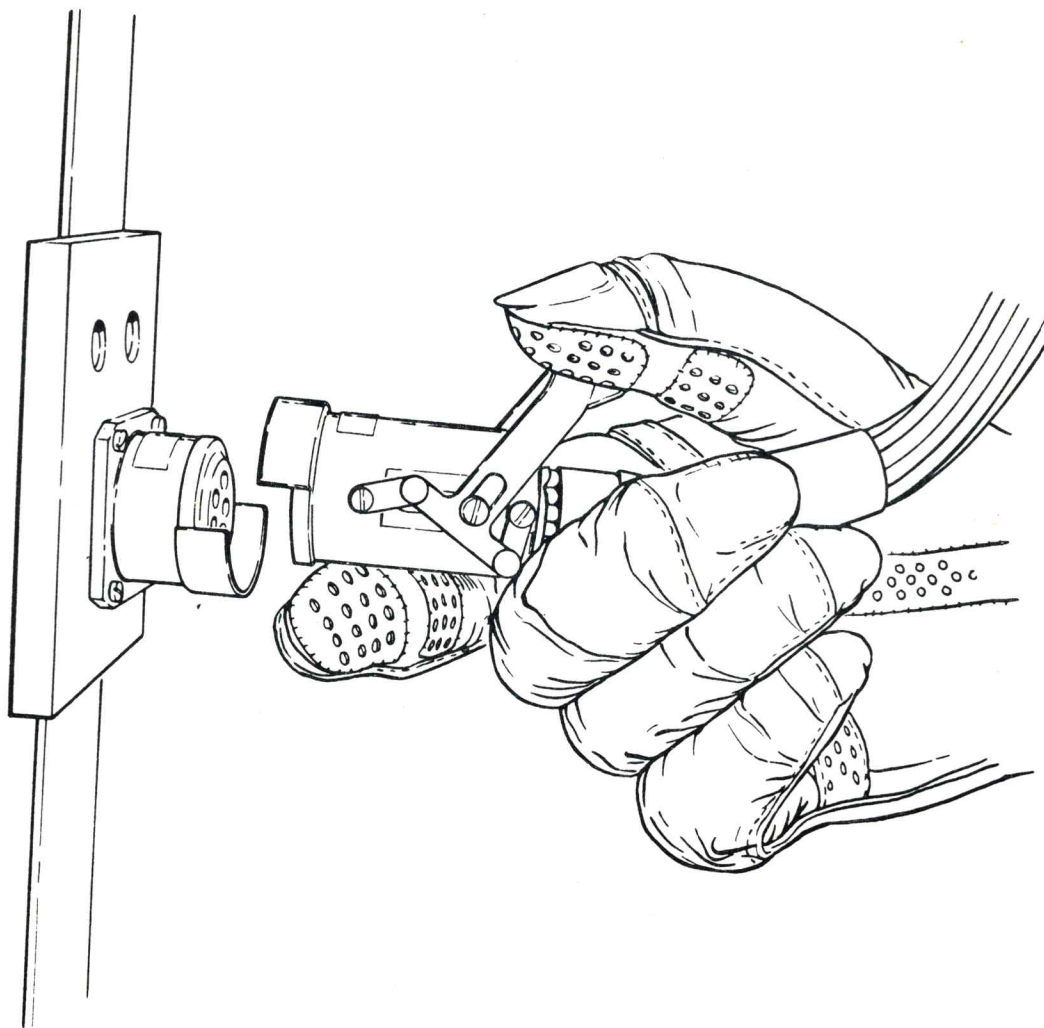


4-146

Figure 423-2. (Sheet 5 of 7)

ORBITAL WORKSHOP ZERO G CONNECTOR - DISENGAGED

O/W-4178
5-12-70



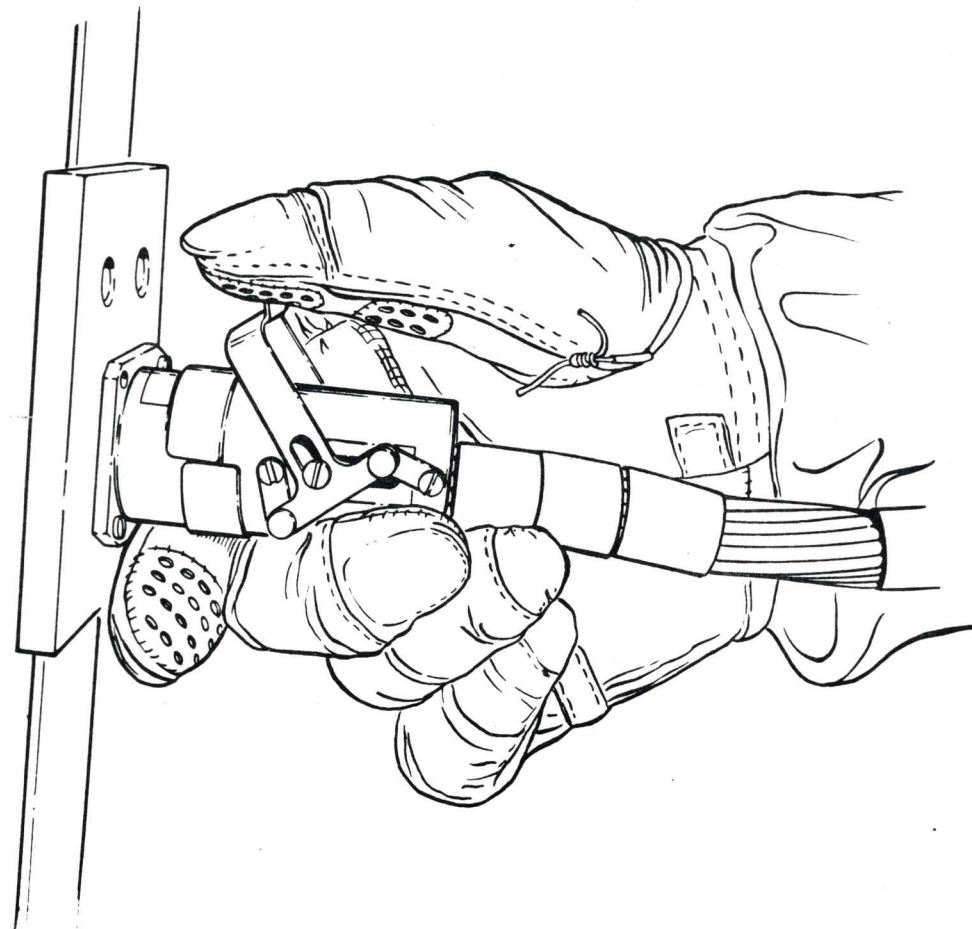
4-147

Figure 423-2. (Sheet 6 of 7)

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ORBITAL WORKSHOP ZERO G CONNECTOR - ENGAGED

O/W-4177
5-12-70

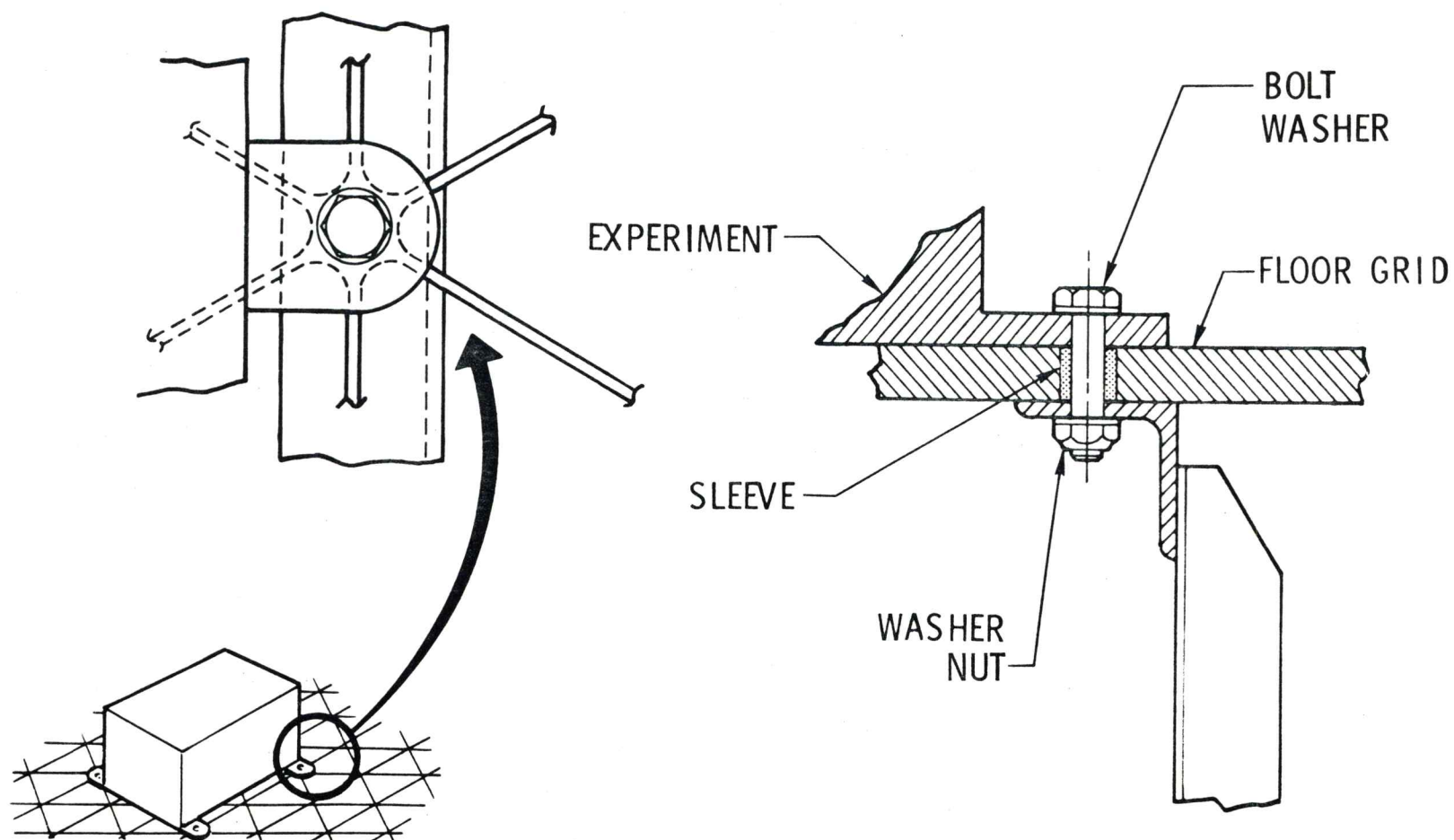


4-148

Figure 423-2. (Sheet 7 of 7)

ORBITAL WORKSHOP TYPICAL FLOOR MOUNTING PROVISIONS

O/W-4699-2
5-26-70



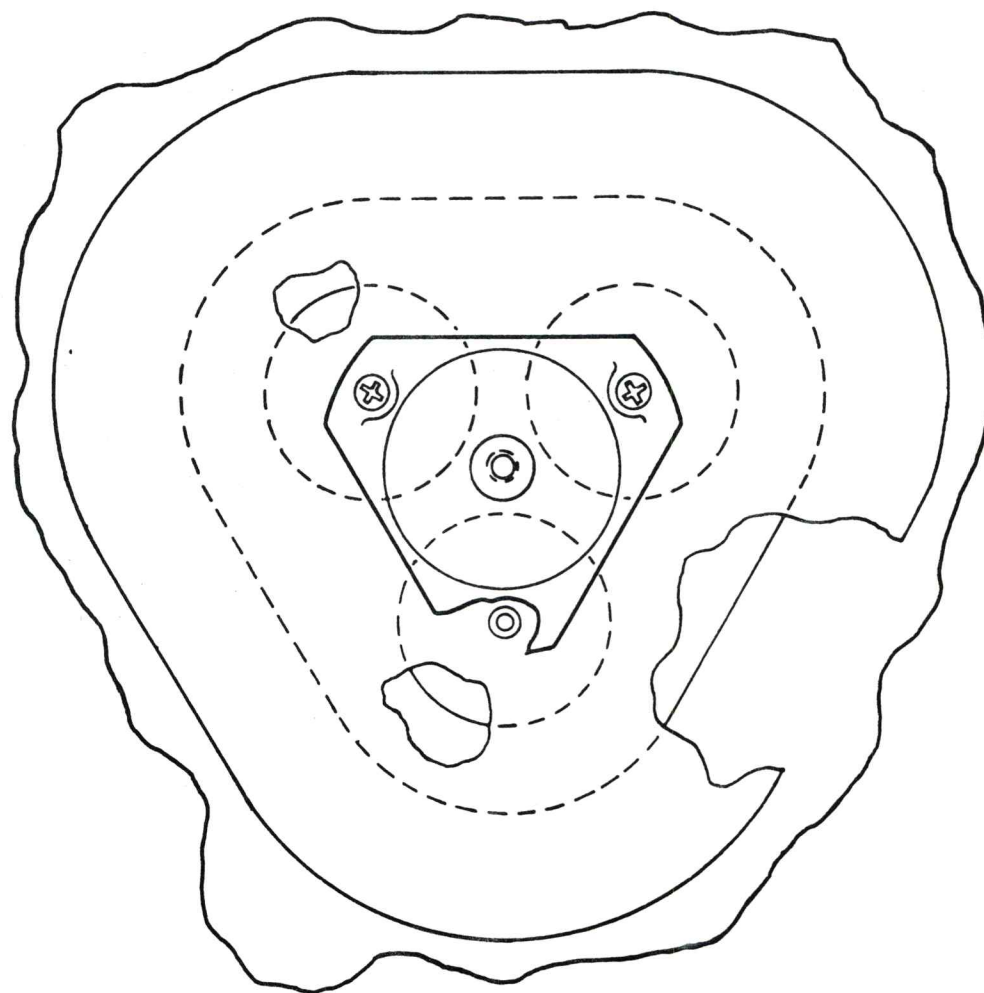
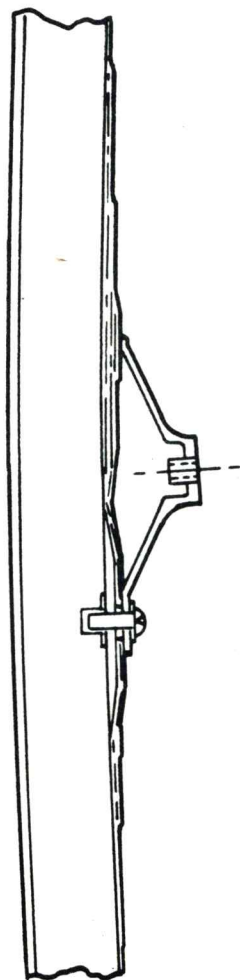
4-149

Figure 423-3. (Sheet 1 of 2)

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ORBITAL WORKSHOP TYPICAL EXPERIMENT OWS WALL ATTACHMENT

O/W-4548-1
8-6-70

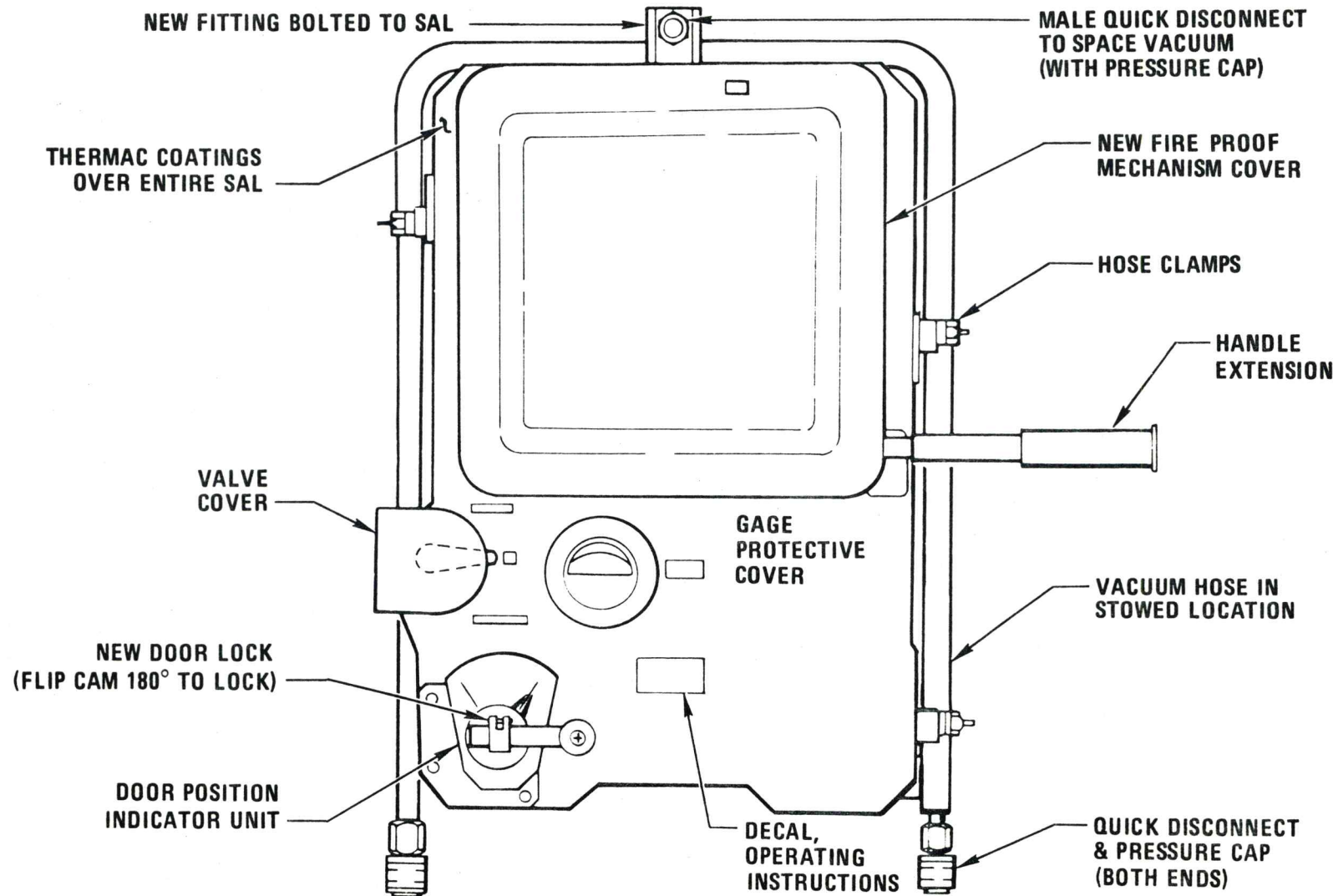


4-150

Figure 423-3. (Sheet 2 of 2)

ORBITAL WORKSHOP REVISED SCIENTIFIC AIRLOCK

O/W-7812
8-6-70



4-151

Figure 423-4. (Sheet 1 of 2)

ORBITAL WORKSHOP SCIENTIFIC AIRLOCK INSTALLATION

O/W-5866A
8-6-70

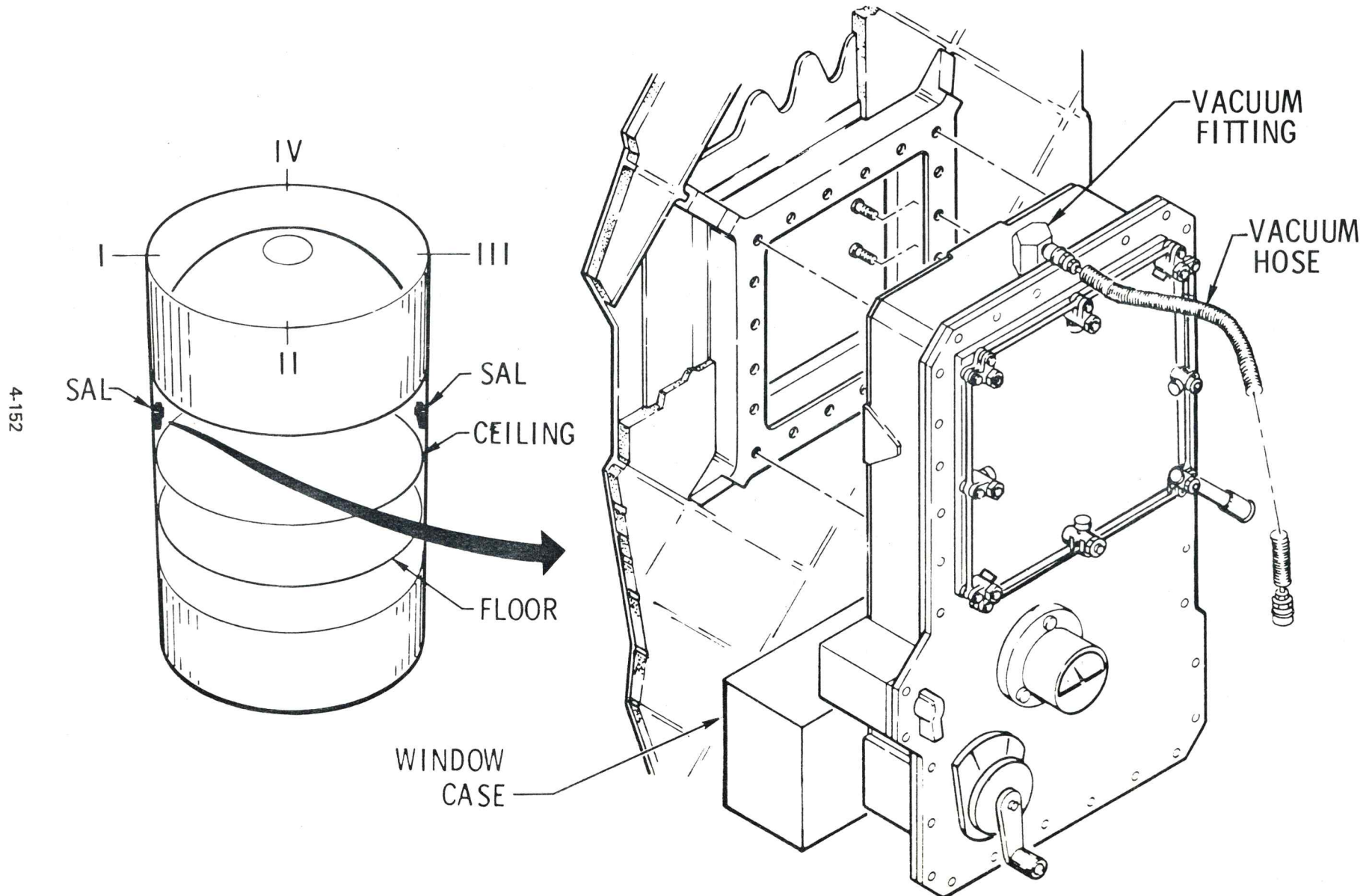


Figure 423-4. (Sheet 2 of 2)

ORBITAL WORKSHOP VACUUM PROVISIONS-SCHEMATIC

O/W-4393
8-6-70

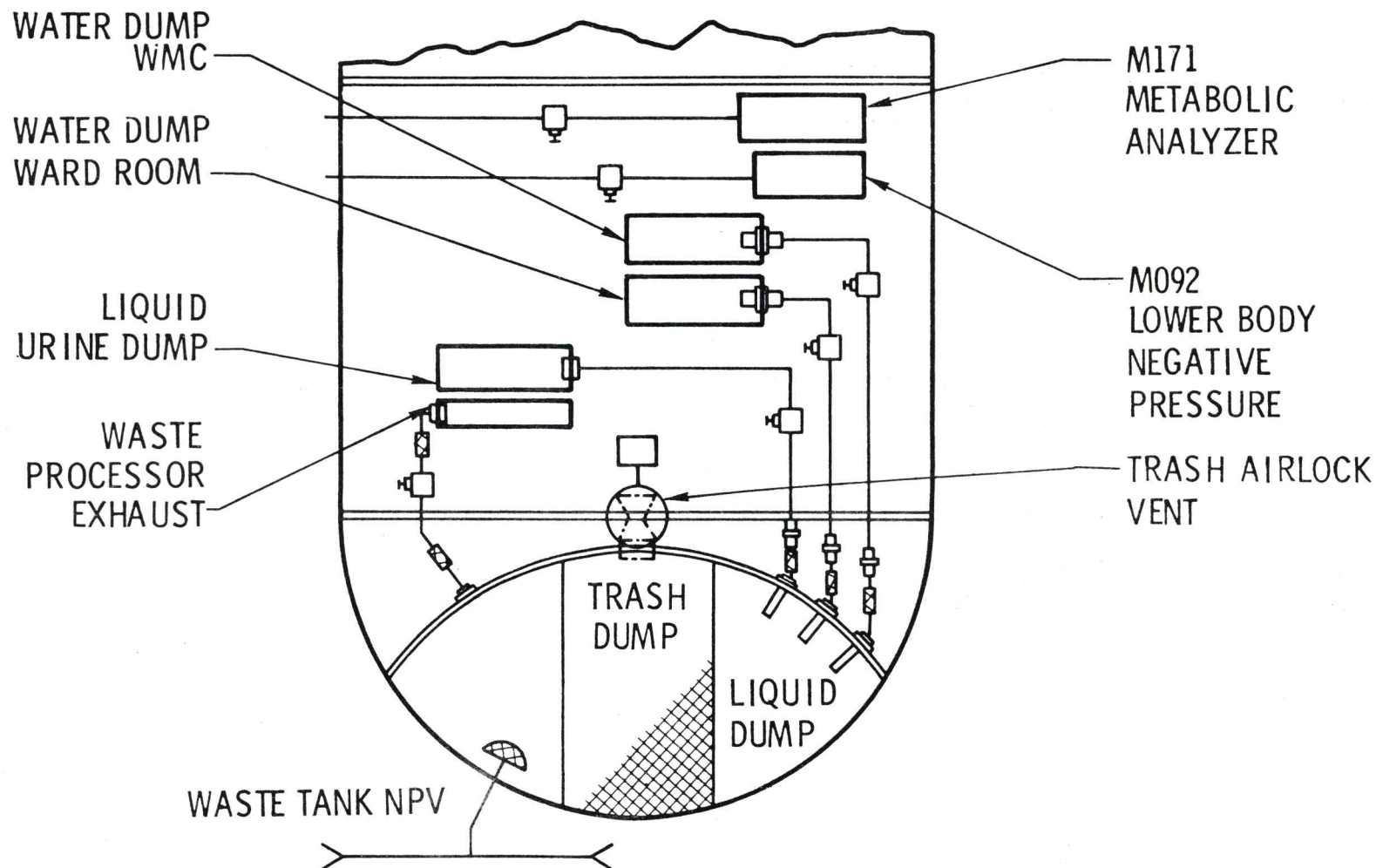


Figure 423-5.

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ORBITAL WORKSHOP LOWER BODY NEGATIVE PRESSURE OUTLET METABOLIC ANALYZER OUTLET

O/W-8767
8-7-70

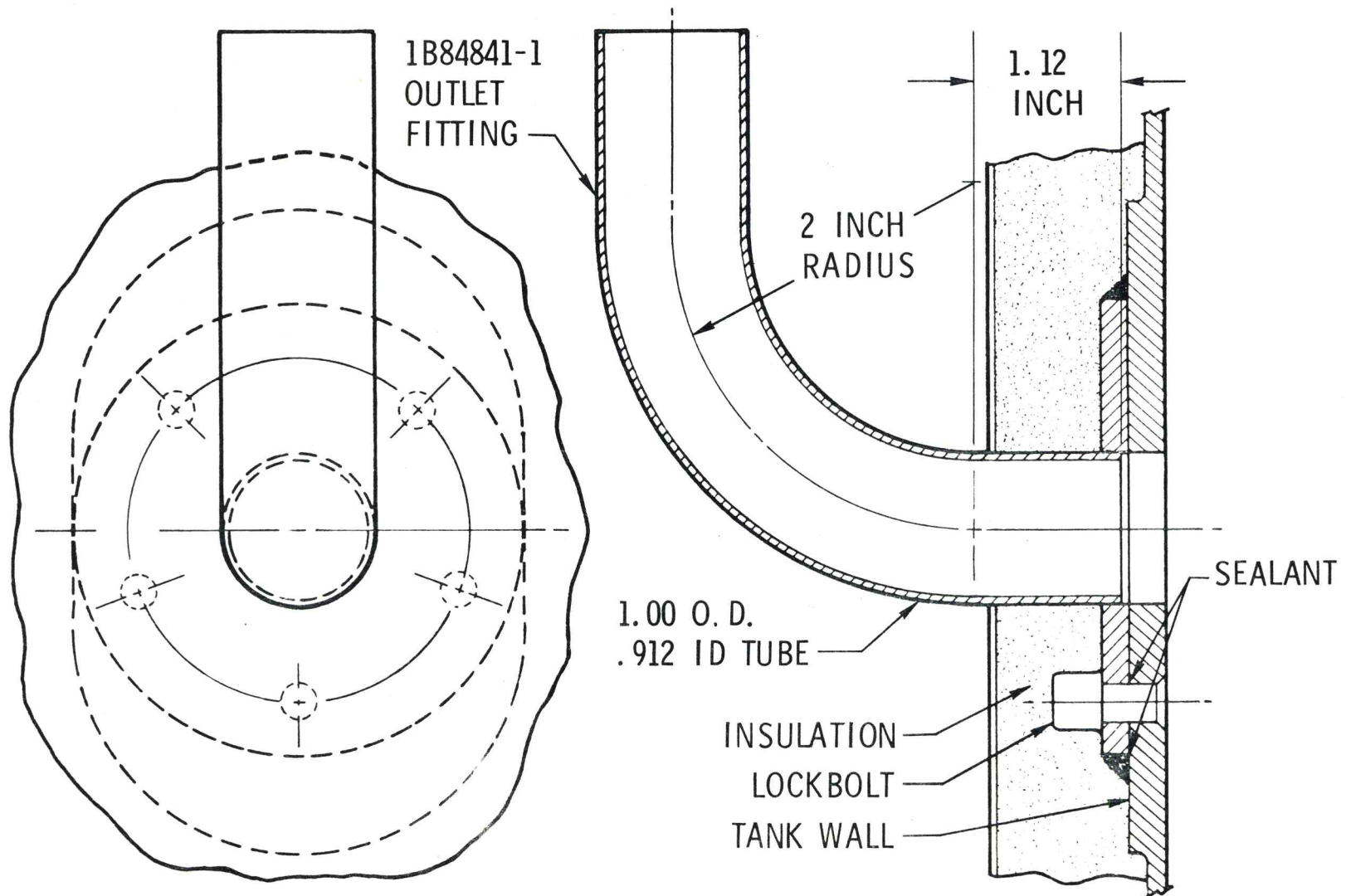


Figure 423-6. (Sheet 1 of 2)

ORBITAL WORKSHOP VACUUM HAND VALVE (ONE INCH)

O/W-6620
8-7-70

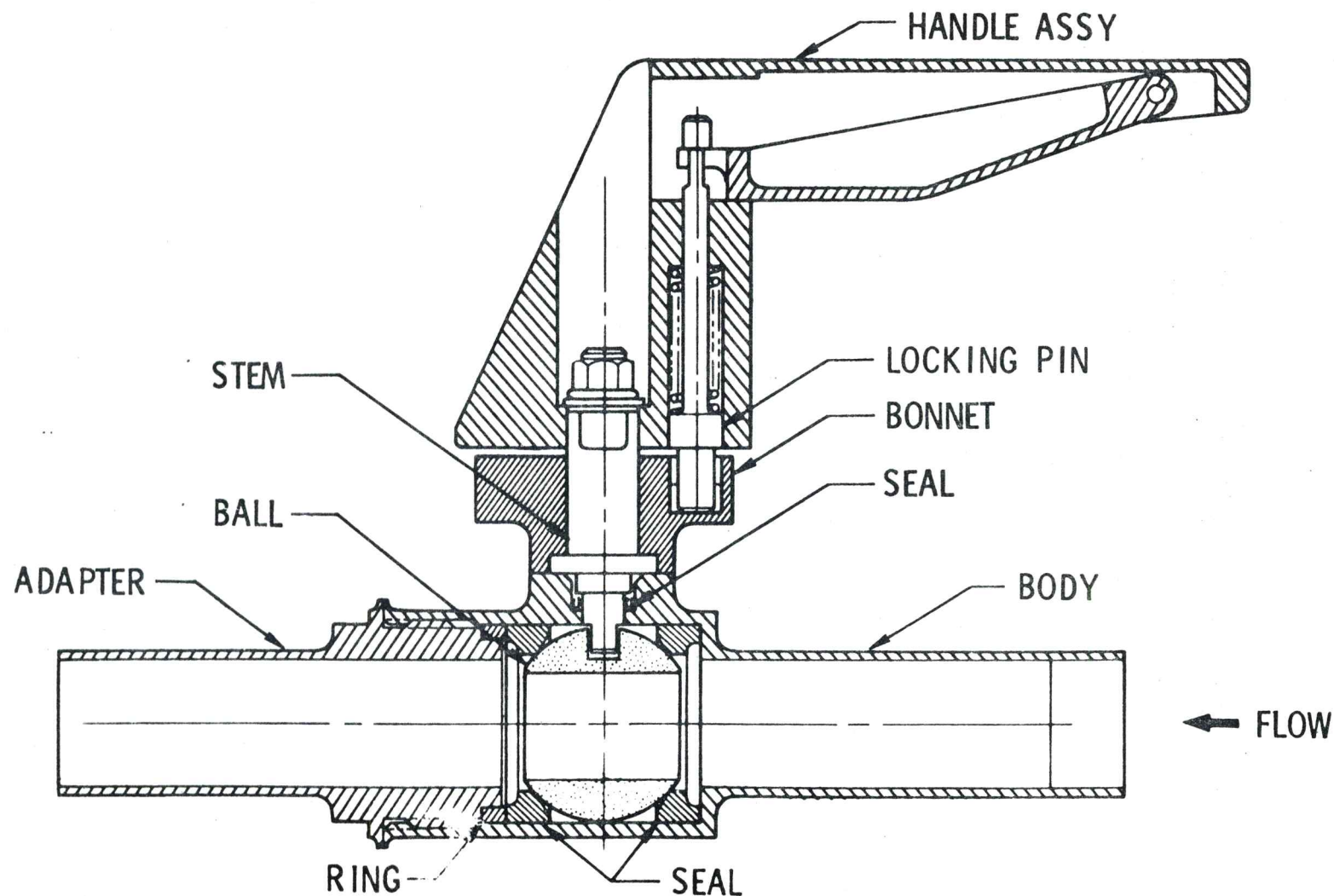


Figure 423-6. (Sheet 2 of 2)

OWS EXPERIMENT ACCOMMODATIONS

| Exp. No. | Title | Experiment Equipment Installed in OWS | Experiment Equipment Location | Method of Attachment | Gas & Fluid Rqmts. | | | Power Rqmts. | Elect. Connector | Data Signal Rqmts. |
|----------|---------------------------------------|--|---|--|--------------------|----------|--------------------------|--------------------------------|--|--------------------------------------|
| | | | | | Oxygen | Vacuum | Nitrogen | | | |
| ✓ M071 | Mineral Balance | None | None | None | None | None | None | None | None | None |
| M073 | Bioassay of Body Fluids | None | None | None | None | None | None | None | None | None |
| ✓ M074 | Specimen Mass Measurement | SMMD (Food) SMMD (Waste) | Wardroom Interior Wall Head Back Wall | Hardmount to Cabinet Hardmount to Cabinet | None | None | None | 28VDC (OWS) | Type ZG per 40M39580 | Voice Recording |
| ✓ M092 | Inflight Lower Body Negative Pressure | LBNP Device Leg Volume Plethysmographs(2) Blood Pressure Assembly | Crew Quarters Exp. Compt. Floor Stored in ESS Cont. Stored in ESS Cont. | Bolted to Floor None None | None | From OWS | None | From ESS | None | Data from ESS to AM; Voice Recording |
| M093 | Vectorcardiogram | Vest and Harness (3) Electrode Application Kit | Stored in ESS Cont. Stored in ESS Cont. | None None | None | None | None | From ESS | None | Data from ESS to AM; Voice Recording |
| ✓ M131 | Human Vestibular Function | Rotating Litter Chair and Motor Base Control Console Equipment Storage Container | Crew Quarters Exp. Compt. Floor Crew Quarters Exp. Compt. Int. Wall Crew Quarters Exp. Compt. Int. Wall | Bolted to Floor Bolted to Wall Bolted to Wall | None | None | None | 28VDC (OWS) to Control Console | NB Type per 40M39569 | Data from ESS to AM; Voice Recording |
| M151 | Time and Motion Study | None | None | None | None | None | None | None | None | None |
| ✓ M171 | Metabolic Activity | Metabolic Analyzer Ergometer Helmet Storage Container | Crew Quarters Exp. Compt. Crew Quarters Exp. Compt. Floor Crew Quarters Exp. Compt. Floor | Floor to Ceiling Rails Bolted to Floor Bolted to Floor | None | From OWS | From H2O Pressure | From ESS | None | Data from ESS to AM; Voice Recording |
| ✓ M172 | Body Mass Measurement | Body Mass Meas. Device | Fwd. Section Floor | Bolted to Floor | None | None | None | 28VDC (OWS) | Type ZG per 40M39580 | Voice |
| ✓ M507 | Gravity Substitute Workbench | Gravity Workbench Ion Source Shield Power Supply Speed Control Unit | Crew Quarters Exp. Compt. Int. Wall Crew Quarters Exp. Compt. Int. Wall | Bolted to Wall Bolted to Wall | None None | None | None | 28VDC (OWS) 28VDC (OWS) | Type ZG per 40M39580 Type ZG per 40M39580 | Voice |
| 7 M508 | EVA Hardware Evaluation | None | None | None | None | None | None | None | None | None |
| ✓ M509 | Astronaut Maneuvering Equipment | Auto. Stab. Maneuv. Unit Antennas Stowage Station | Fwd. Section Floor Fwd. Section Dome Area Fwd. Section Floor | Bolted to Floor Attached to Water Bottle Ring | From AM (PGU) | None | From AM Recharge Station | 28VDC (OWS) | NB Type per 40M39569 | PCM Data; Voice |

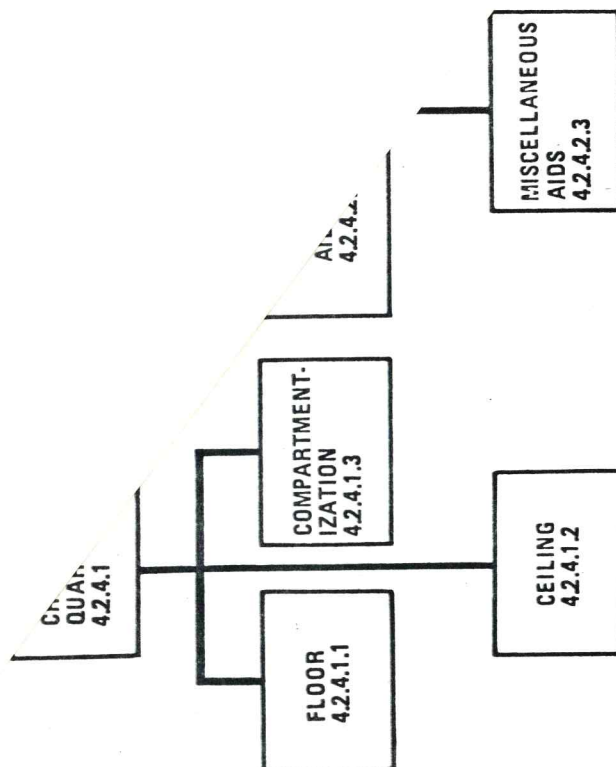
Figure 423-1. (Sheet 1 of 2)

OVS EXPERIMENT ACCOMMODATIONS (Cont'd)

| Exp. No. | Title | Experiment Equipment Installed in OWS | Experiment Equipment Location | Method of Attachment | Gas & Fluid Rqmts. | | | Power Rqmts. | Elect. Connector | Data Signal Rqmts. |
|----------|---------------------------------------|---------------------------------------|-------------------------------|--------------------------------|--------------------|----------|---------------------------|--------------|--------------------------|--------------------|
| | | | | | Oxygen | Vacuum | Nitrogen | | | |
| S019 | UV Stellar Astronomy | UV Spectrograph Mirror System | Fwd. Section Floor | Bolted to Floor | None | From SAL | None | None | None | Voice |
| S020 | UV/X-Ray Solar Photography | Canister Assembly | Fwd. Section Floor | Bolted to Floor | None | From SAL | None | None | None | Voice |
| S073 | Gegenschein/Zodiacal Light | Photographic Unit | Stored with T027 | None | None | None | None | None | None | PCM Data; Voice |
| S149 | Micrometeorite Collection | Detector Assembly | Fwd. Section Floor | Bolted to Floor | None | None | None | None | None | PCM Data; Voice |
| T003 | Inflight Nephelometer | Nephelometer Assembly | Crew Quarters Interior Wall | Bolted to Wall | None | None | None | None | None | Voice |
| T013 | Crew/Vehicle Disturbance | Force Measurement Units | Fwd. Section Tank Wall | Cantilever Mounting Structure | None | None | None | 28VDC (OWS) | Type NB per 40M39569 | PCM Data; Timing |
| | | LIMS Container | Fwd. Section Tank Wall | Bonded Nut Plates | | | | | | |
| | | Data System Unit | Fwd. Section Floor | Bolted to Floor | From AM | | | | | |
| T020 | Foot Controlled Maneuvering | Thruster Unit | Fwd. Section Floor | Bolted to Floor | (PGU) | None | From M509 | None | None | None |
| T025 | Coronagraph Contamination Measurement | Coronagraph Container | Fwd. Section Tank Wall | Nut Plates Bonded to Tank Wall | None | None | None | None | None | Voice |
| T027 | ATM Contamination Measurement | Photometer Assembly | Fwd. Section Floor | Bolted to Floor | None | From SAL | None | 28VDC (OWS) | Type ZG per 40M39580 | PCM Data; Voice |
| | | Sample Array System Container | Fwd. Section Floor | Bolted to Floor | | | | | | |
| ESS | Experiment Support System | ESS Console | Crew Quarters Exp. Compt. | Floor to Ceiling Rails | None | None | H ₂ O Pressure | 28VDC (OWS) | Type NB per 40M39580 | PCM Data; Voice |
| | | Equipment Stowage Container | Crew Quarters Exp. Compt. | Floor to Ceiling Rails | | | | | | |
| S183 | UV Panorama | Instrument Container | Fwd. Section Floor | Bolted to Floor | None | None | None | 28VDC (OWS) | Type ZG per 40M39580 | PCM Data; Voice |
| S063 | UV Airglow Horizon Photography | Experiment Container | Fwd. Section Floor | Bolted to Floor | None | None | None | None | (2) Type ZG per 40M39580 | Voice |

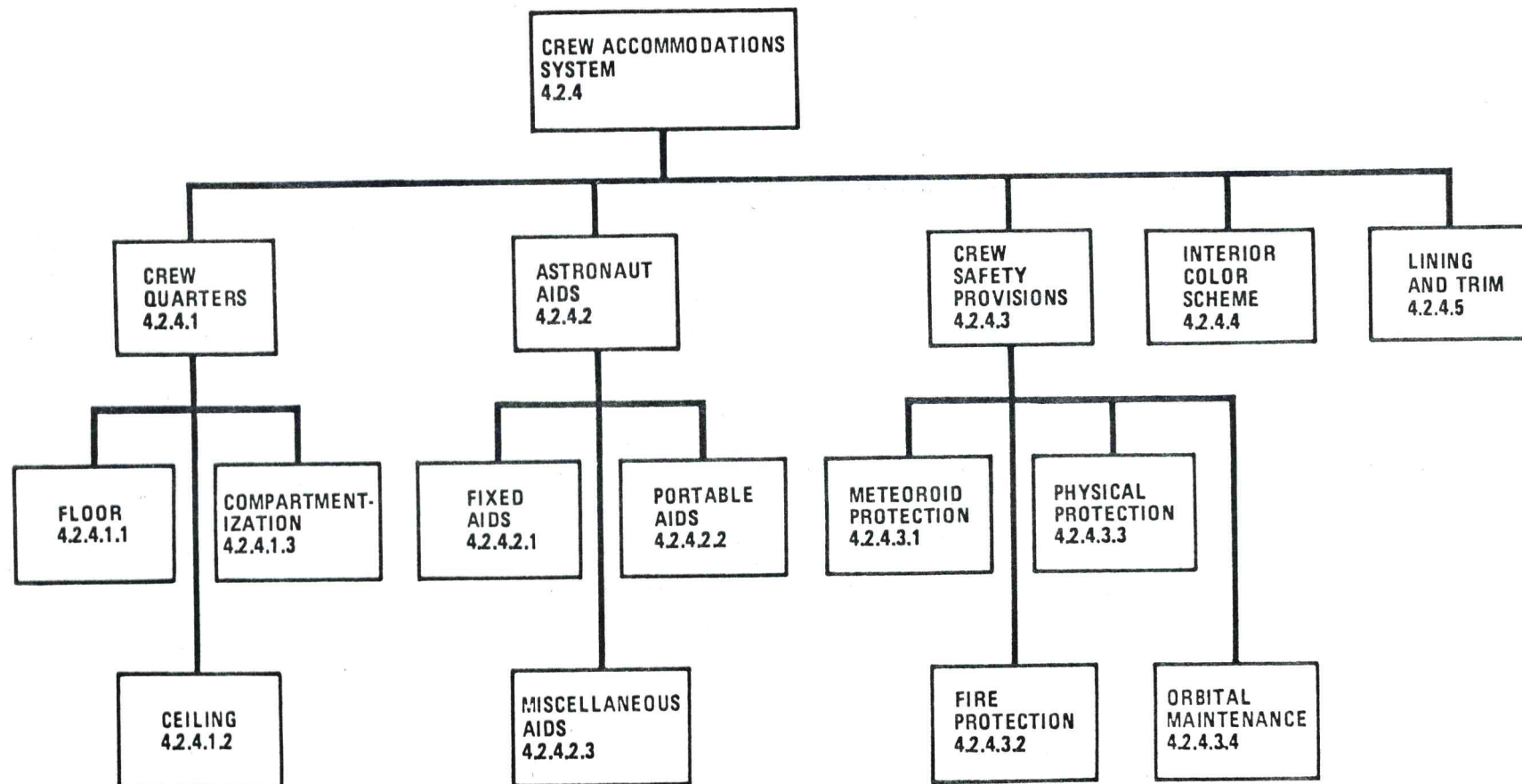
Figure 423-1. (Sheet 2 of 2)

CREW ACCOMMODATIONS
SYSTEM



ORBITAL WORKSHOP

O/W-8082
8-5-70



4.2.4 Crew Accommodations System

The crew accommodations system consists of equipment which (1) provides compartments for crew habitation and operational activities, (2) aids crew mobility and restraint and (3) supports crew safety.

4.2.4.1 Crew Quarters

4.2.4.1.1 Lower Floor System

The lower floor assembly (Figure 424-1) is composed of main structural beams and intermediate beams (intercostals) with a standard grid on the upper surface and an aluminum sheet diaphragm on the lower surface. See MDAC Drawing 1B79042 for the Lower Floor assembly structure.

The floor main structural beams (Figure 424-2) are 8-inch deep assemblies of aluminum caps and shear webs. They are arranged and joined together to form a network of equilateral triangles 42 inches on a side.

Intermediate beams (intercostals) are installed where equipment and experiments mounting does not occur on the main beams. They transmit longitudinal loads to the main beams. These intermediate beams are also 8-inch deep assemblies of aluminum caps and shear webs.

The standard grid is machined from 0.400-inch thick aluminum plate to make an open grid network of equilateral triangles measuring 4.2 inches per side. The grid is manufactured in panels and spliced together at the main beams. A standard hole is drilled at the apex of every triangle to provide a universal "peg-board" attach pattern (Figure 424-3).

The diaphragm on the lower surface of the floor assembly closes off the lower end of the OWS to form the ventilation control system plenum chamber, and also stabilizes the floor beams. The floor is attached to the tank wall by a conical sheet metal ring assembly (Figure 424-4). The ring assembly is mechanically attached to the edge of the floor and to the tank wall at waffle intersections. See MDAC Drawing 1B79177 for the lower floor installation.

4.2.4.1.2 Upper Floor System

The upper floor assembly is composed of 8-inch deep main and intermediate beams identical to those in the lower floor assembly. It has standard grid (see lower floor) on both the upper and lower surfaces. See MDAC Drawing 1B79183 for the upper floor assembly.

In the geometric center of the upper floor, as well as in the sleep compartment and wardroom, hexagonal openings provide egress into the forward tank area.

The upper floor is supported in the tank the same as the lower floor (see Drawing 1B77172).

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ORBITAL WORKSHOP CREWS ACCOMMODATIONS STRUCTURAL ARRANGEMENT

O/W-69-3
5-14-70

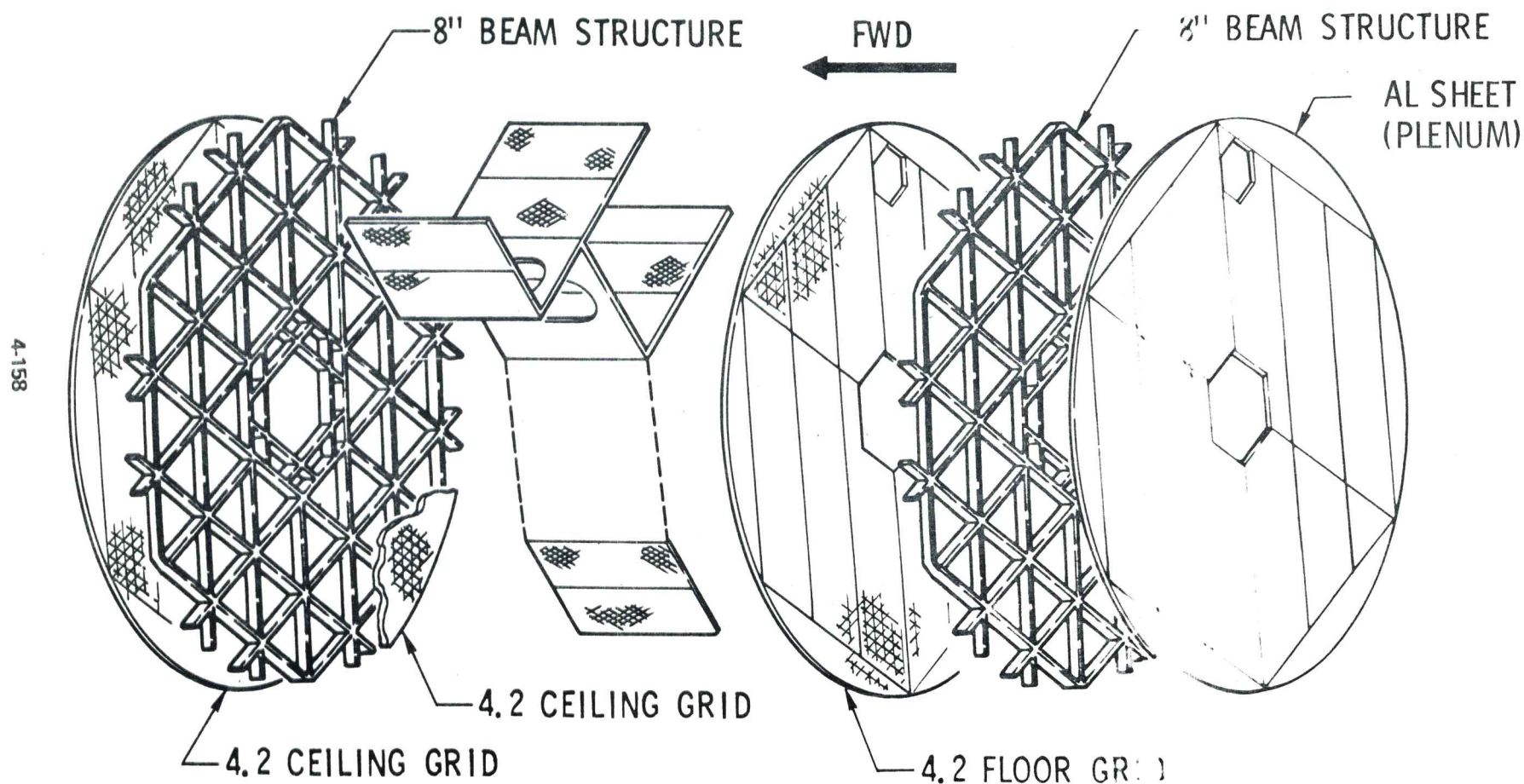
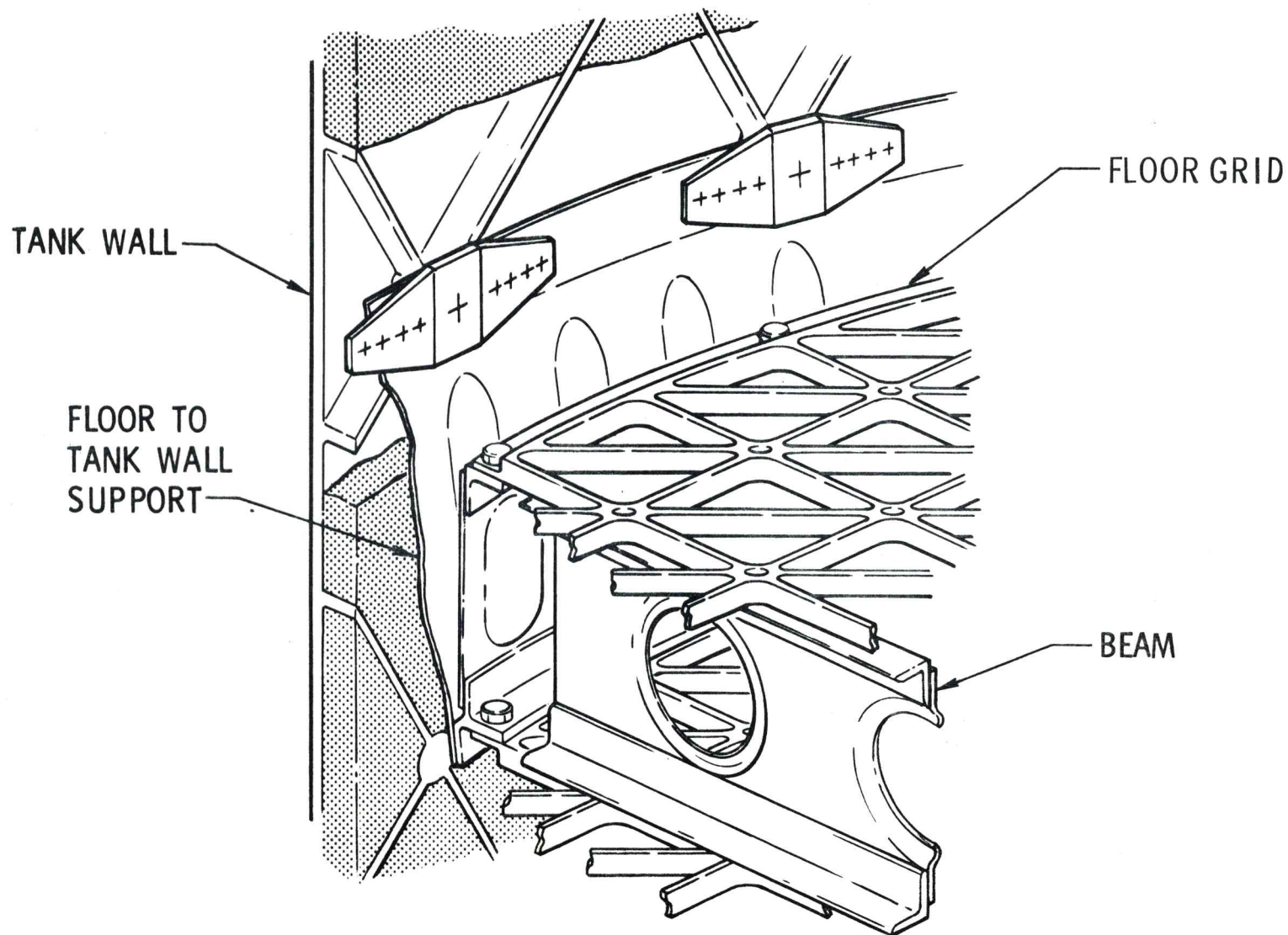


Figure 424-1.

ORBITAL WORKSHOP FLOOR/CEILING STRUCTURE

O/W-4342
6-16-70



4-159

Figure 424-2.

ORBITAL WORKSHOP STANDARD GRID

O/W-401A
10-29-69

FLOOR

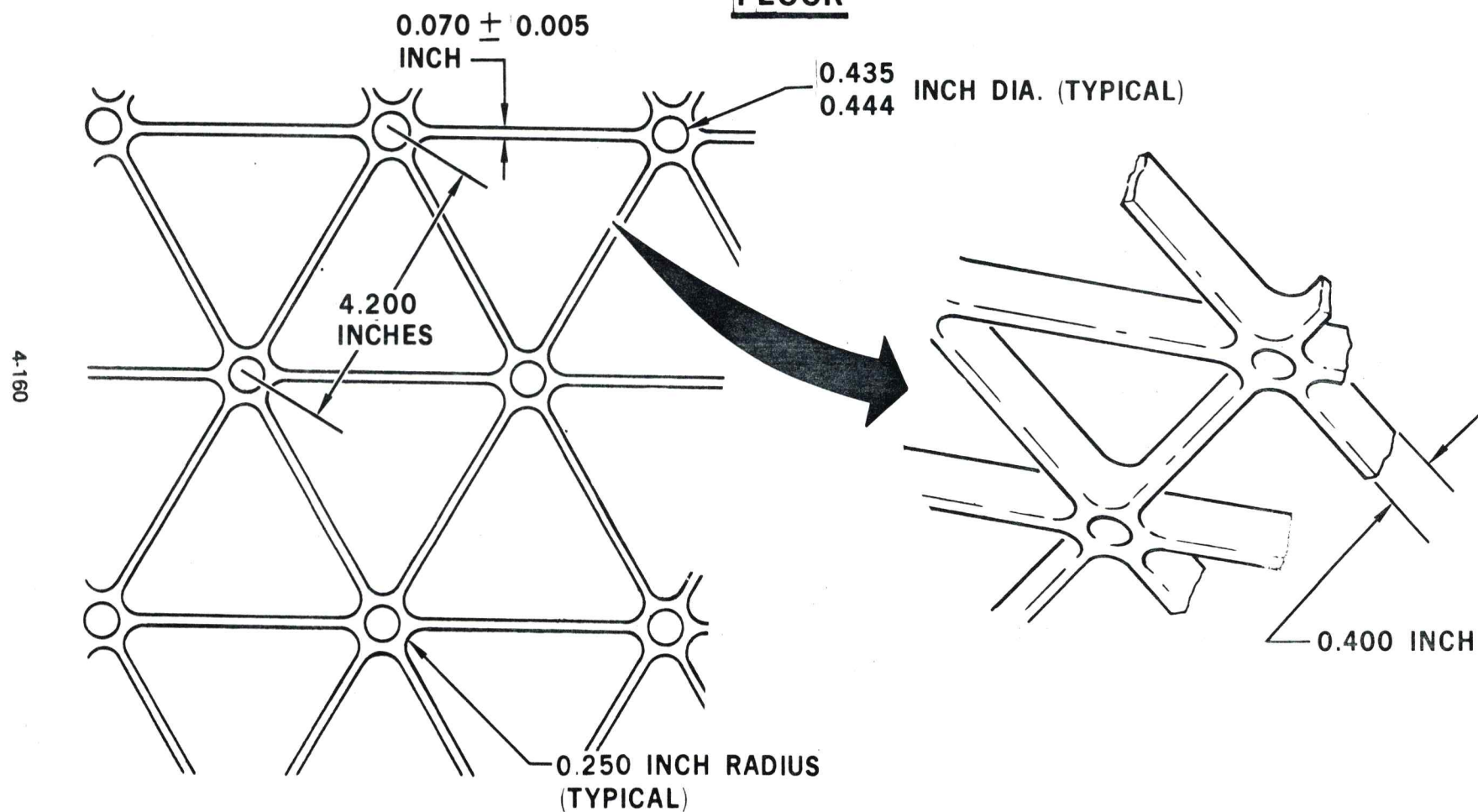


Figure 424-3.

ORBITAL WORKSHOP FLOOR/CEILING TO TANK WALL SUPPORT

O/W-4343
5-14-70

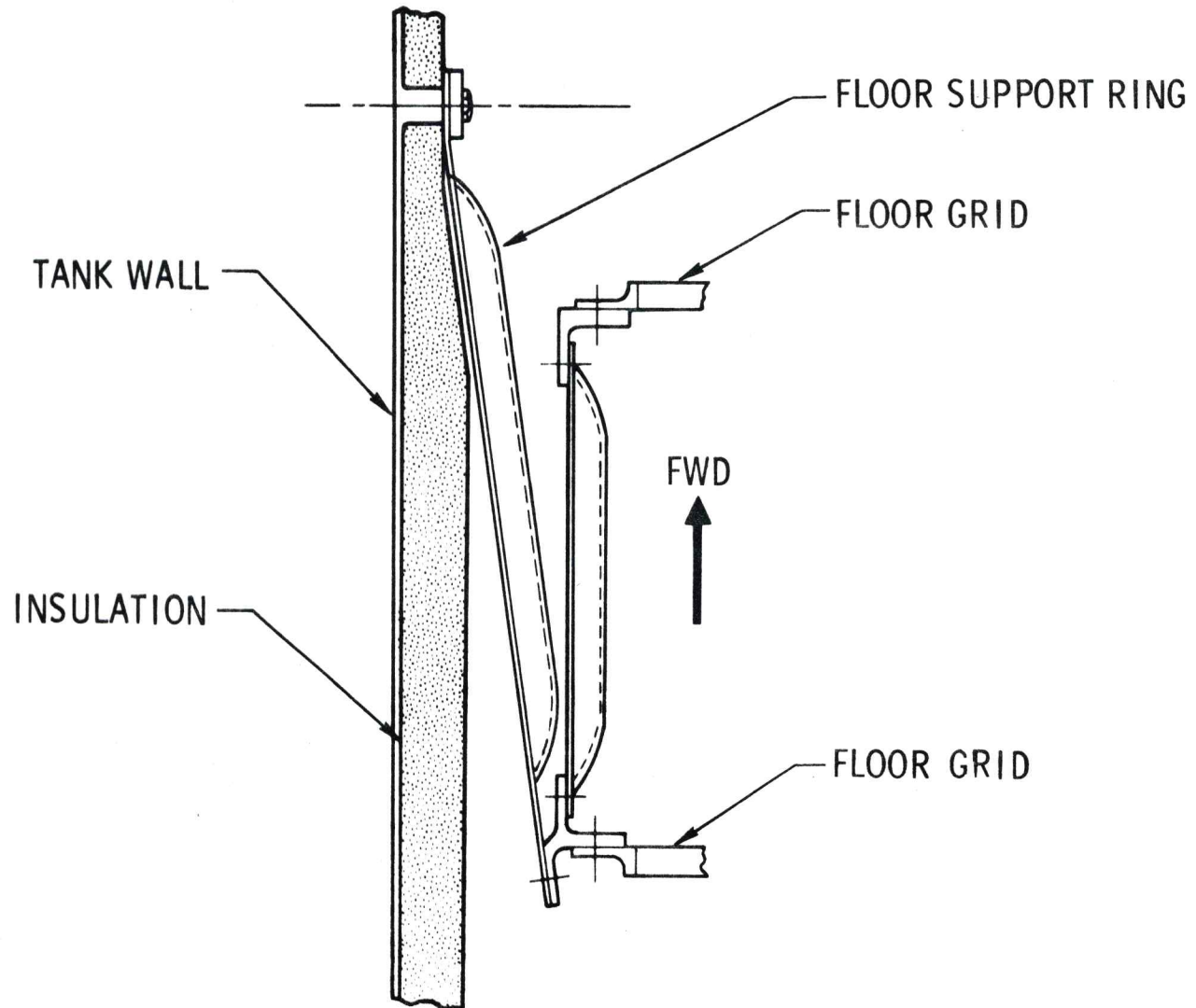


Figure 424-4.

4.2.4.1.3 Compartmentization

The crew quarters is divided into four compartments: sleep compartment, waste management compartment, wardroom, and experiment compartment (Figure 424-5).

The compartment partitions are lap-jointed panels which are attached to the lower and upper floor assemblies through channels and angles. The panels are machined to the same grid pattern as the floor grid with an integral thin skin on one surface (Figure 424-6). Because of high structural loads double wall panels are installed for all partitions except at the entrances to the sleep compartment, waste management compartment, and wardroom (Figure 424-7). The panels are stiffened by vertical and horizontal members. For details of crew quarters wall installation see MDAC Drawing 1B79041.

Within the waste management compartment the floor and ceiling grid is covered by aluminum sheets to control particle migration and odor.

Access to each compartment is provided by openings to the experiment compartment. A door is preinstalled for the waste management compartment only. This is a telephone-booth type door constructed of integrally machined aluminum grid and incorporates a breakaway feature for emergency egress. The details of the WMC door are shown in Drawing 1B74295.

A folded curtain is provided at the wardroom entrance. The curtain is constructed of aluminum coated mylar, between two layers of armalon fabric. It is guided by tracks located at the top and bottom of the curtain (Figure 424-8). During launch, it is restrained in an open position, secured by a strap and turnbutton. The curtain incorporates a breakaway feature, consisting of velcro tape along the top and one side, for emergency egress. A strap in the corner at the intersection of the velcro strips is utilized to actuate the breakaway feature.

4.2.4.2 Astronaut Aids

4.2.4.2.1 Fixed Astronaut Aids

Fixed astronaut aids consist of handrails, handholds, and the central handrail. The fixed astronaut aids are:

- a. WMC ceiling handrail.
- b. Forward compartment vertical handrails.
- c. Forward compartment circumferential handrails.
- d. Forward dome circumferential handrails.
- e. Forward dome vertical handrails.
- f. Access hatch circular handrail.
- g. Aft compartment handrail.

ORBITAL WORKSHOP CREW QUARTERS CONFIGURATION

O/W-88-2
6-16-70

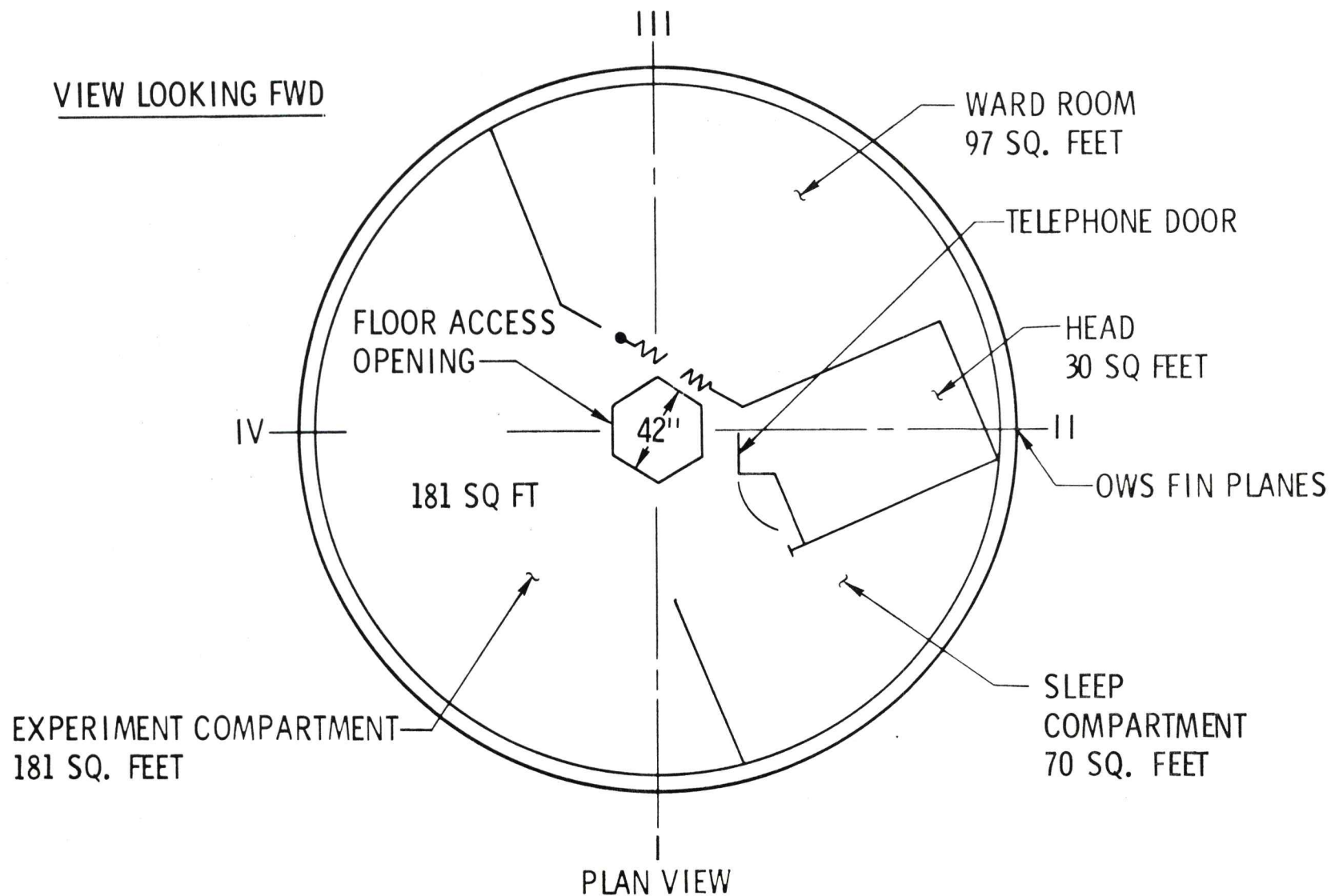


Figure 424-5.

ORBITAL WORKSHOP STANDARD INTEGRAL SKIN GRID

O/W-401B
6-16-70

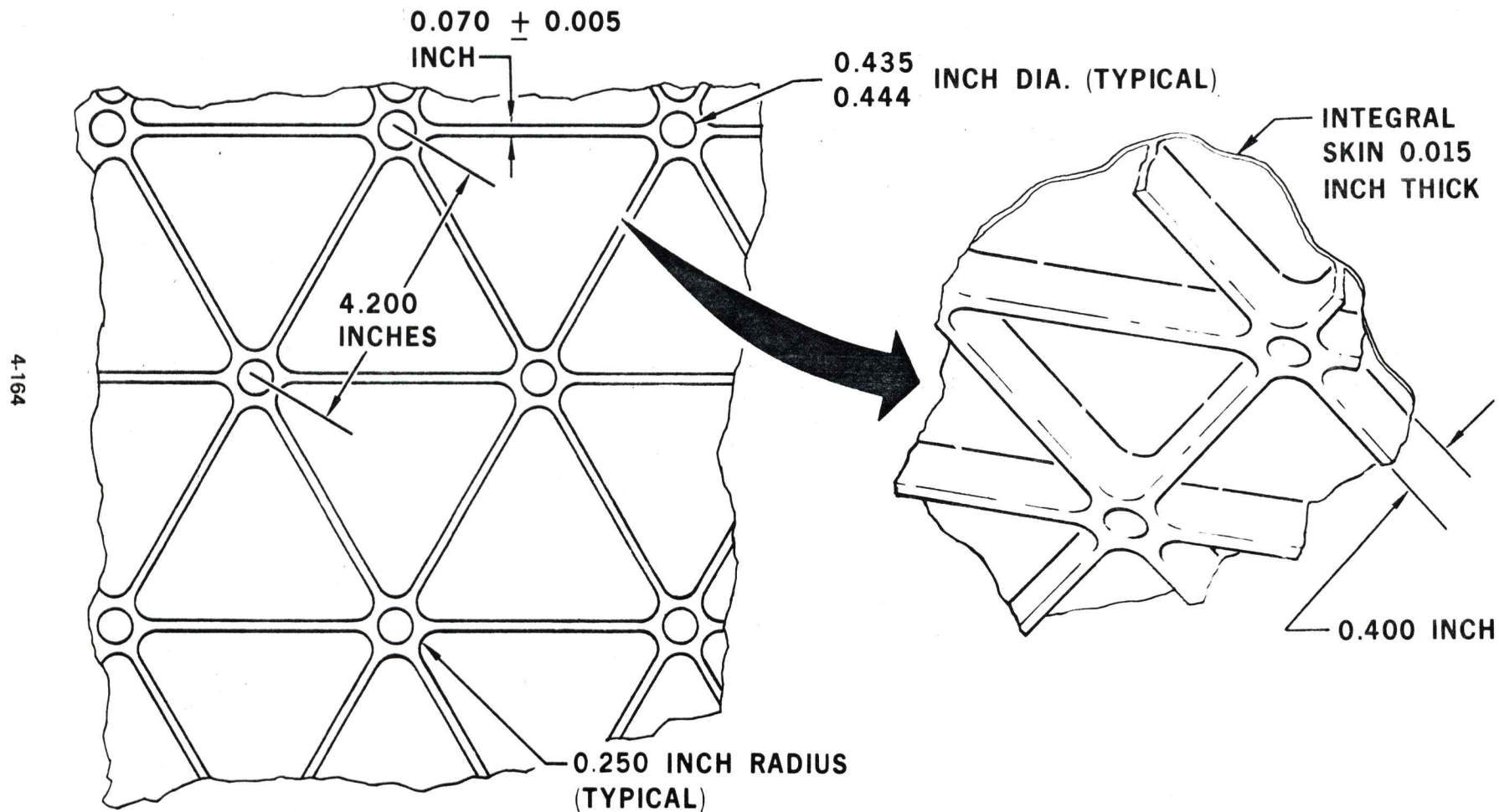
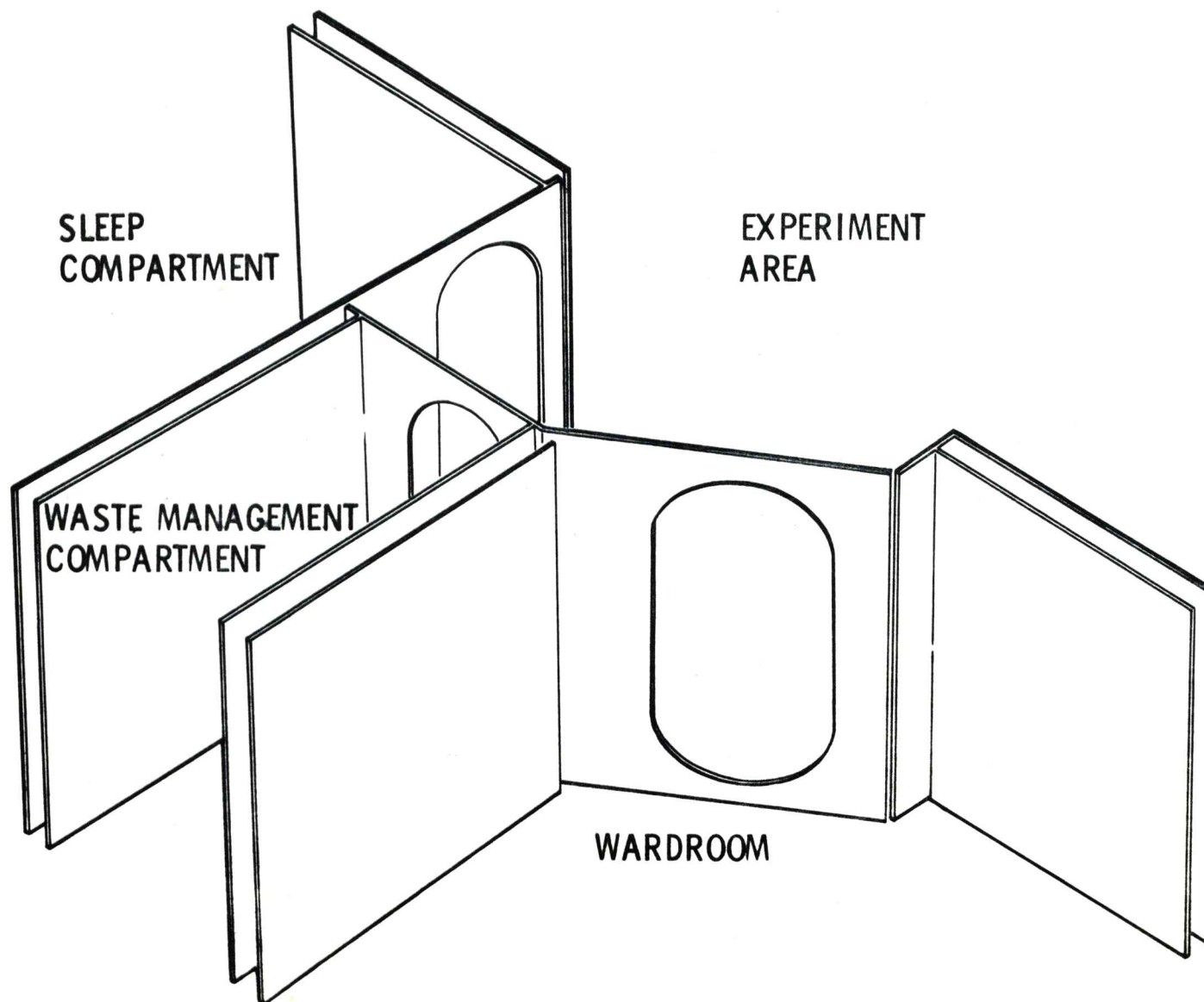


Figure 424-6.

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ORBITAL WORKSHOP CREW QUARTERS WALL ARRANGEMENT

**O/W-8100
6-16-70**



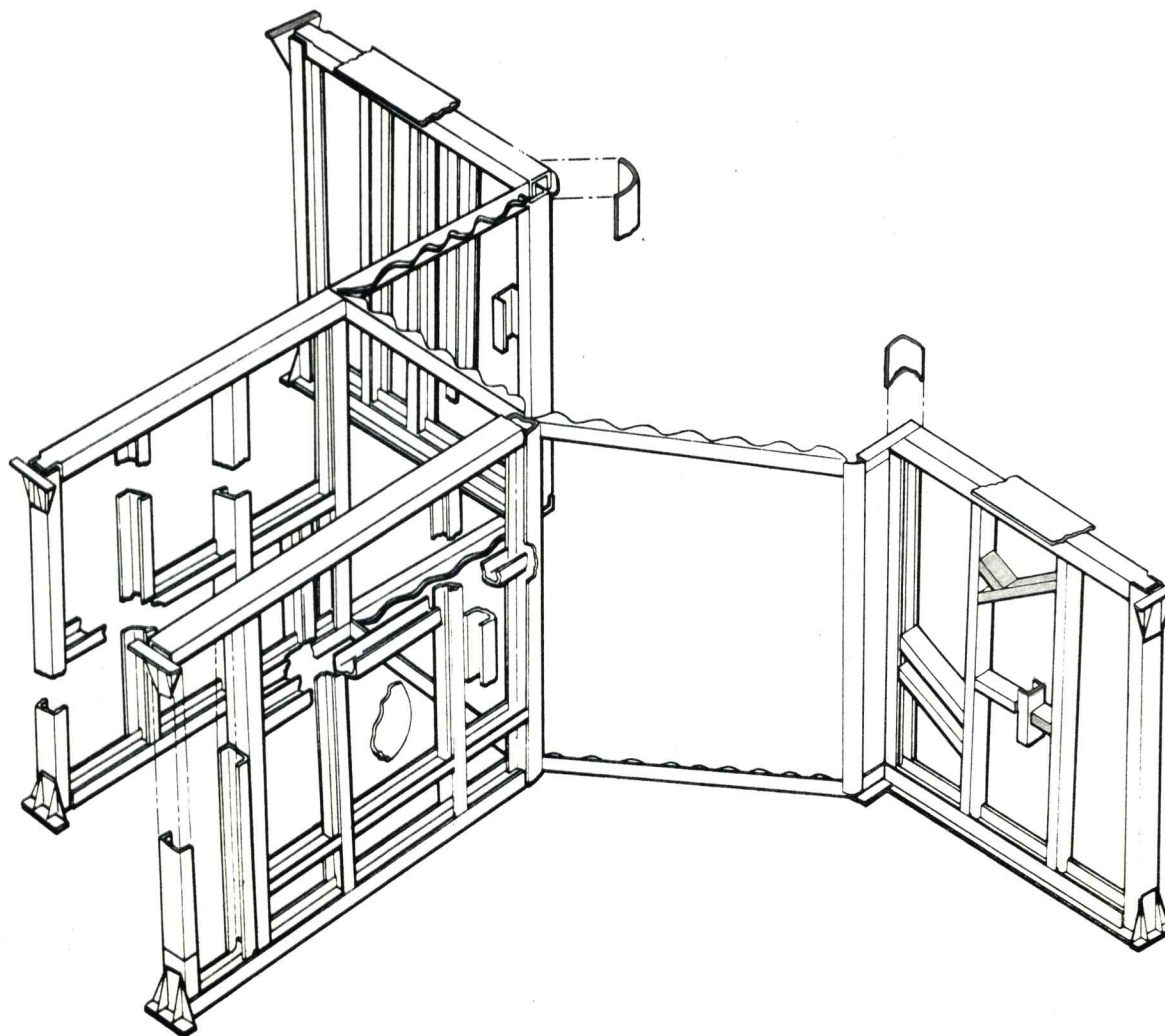
4-165

Figure 424-7. (Sheet 1 of 2)

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ORBITAL WORKSHOP CREW QUARTERS WALL FRAMING

**O/W-8101
6-16-70**



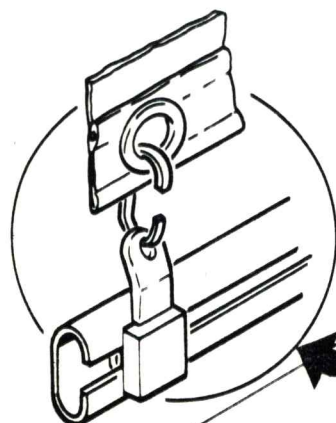
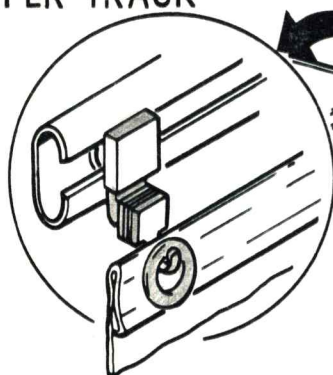
4-166

Figure 424-7. (Sheet 2 of 2)

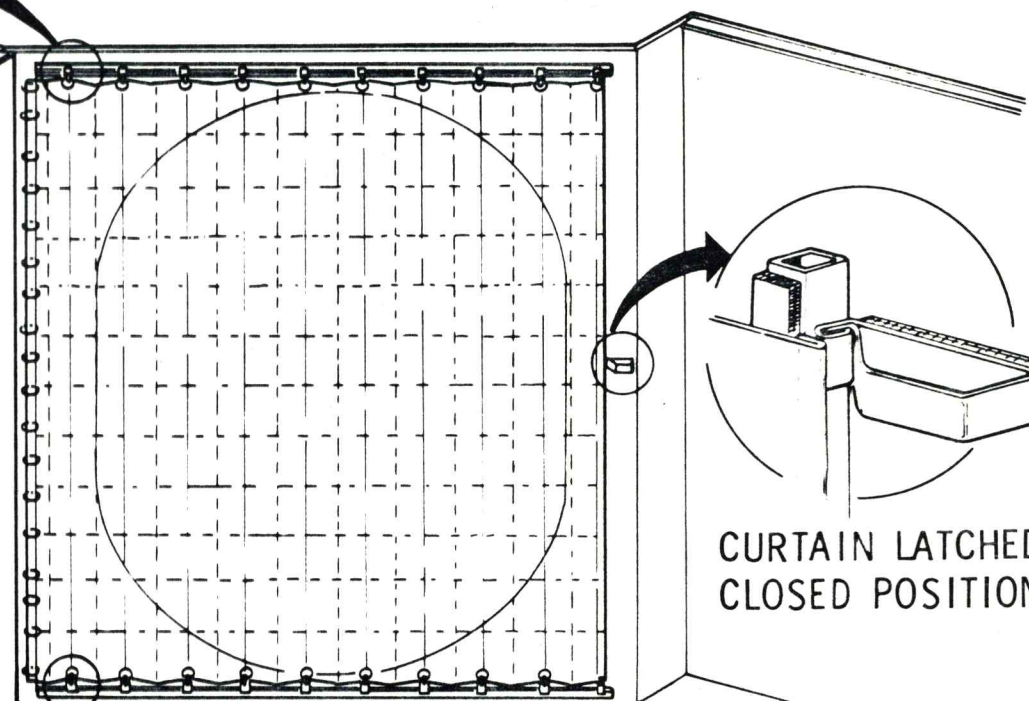
ORBITAL WORKSHOP WARDROOM ENTRY CURTAIN

O/W-6942
8-12-70

CURTAIN INSTALLATION
UPPER TRACK



CURTAIN INSTALLATION
LOWER TRACK



CURTAIN LATCHED
CLOSED POSITION

Figure 424-8.

- h. Hatch stabilization handholds.
- i. Central handrail.

The location of the fixed astronaut aids is shown in Figure 424-9.

4.2.4.2.1.1 Handrails

Typical methods of attachment of OWS handrails are shown in Figure 424-10.

Waste Management Compartment Ceiling Handrail

The Waste Management Compartment Ceiling Handrail is attached to the ceiling structure in the Waste Management Compartment. It is 56 inches long and extends from the doorway to the outboard wall of the compartment. It is located approximately 14 inches to the right of the centerline of the doorway (facing outboard). The detail design and installation of the WMC ceiling handrail is shown in Drawing 1B81229.

Forward Compartment Vertical Handrails

The Forward Compartment Vertical Handrails consist of a series of six handrails of various lengths which extend vertically in the forward compartment. The approximate handrail sizes and locations are as follows:

- a. Handrail 26 inches long with midpoint 40 inches from floor; located 14 inches from Pos. I toward Pos. IV.
- b. Handrail 26 inches long with midpoint 49 inches from floor; located 61 inches from Pos. I toward Pos. IV.
- c. Handrail 26 inches long with midpoint 40 inches from floor; located 24 inches from Pos. III toward Pos. IV.
- d. Handrail 26 inches long with midpoint 40 inches from floor; located 9 inches from Pos. III toward Pos. II.
- e. Handrail 47 inches long with midpoint 30 inches from floor; located 32 inches from Pos. III toward Pos. II.
- f. Handrail 34 inches long with midpoint 78 inches from floor; located 32 inches from Pos. III toward Pos. II.

The detail design and installation of the forward compartment vertical handrails is shown in Drawing 1B80529.

Forward Compartment Circumferential Handrails

The Forward Compartment Circumferential Handrails consist of a series of three handrails of various lengths which extend circumferentially around the forward compartment 60 inches forward of the crew quarters floor.

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ORBITAL WORKSHOP CREW ACCOMMODATIONS FIXED HANDRAILS

O/W-7636-1
8-7-70

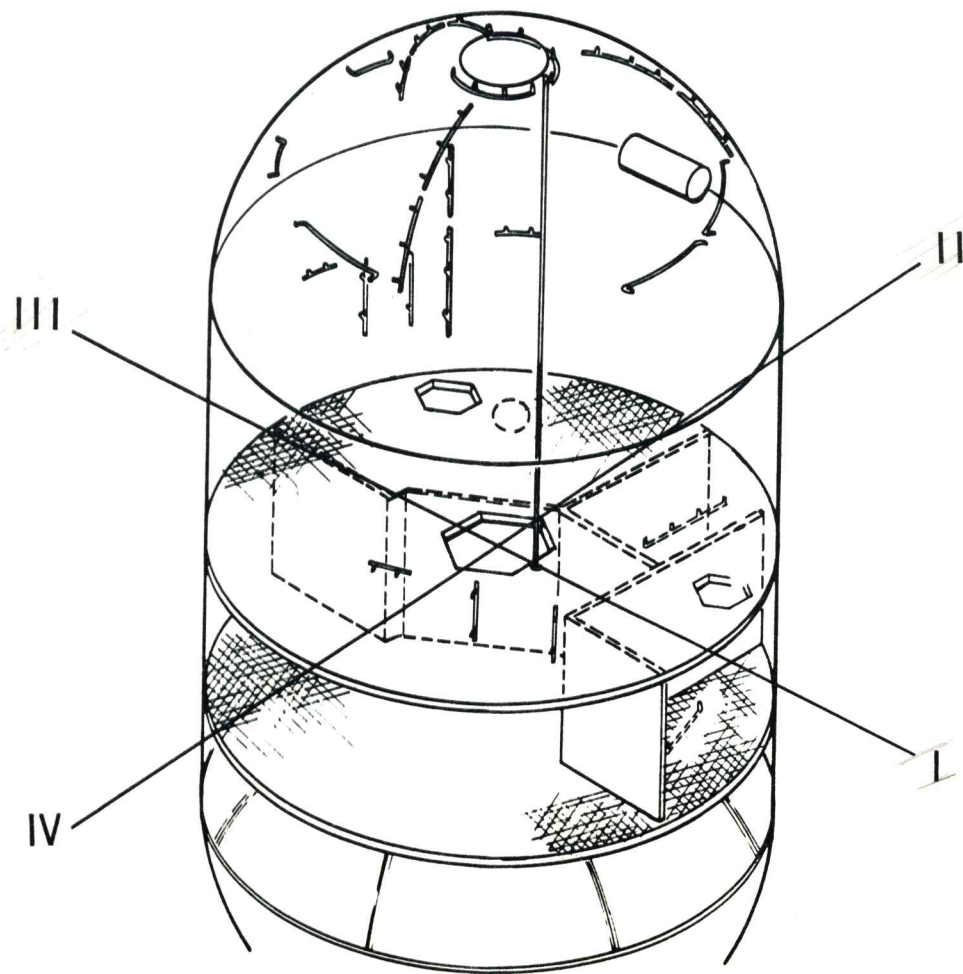


Figure 424-9.

ORBITAL WORKSHOP TYPICAL METHOD OF ATTACHMENT

O/W-5468
11-26-69

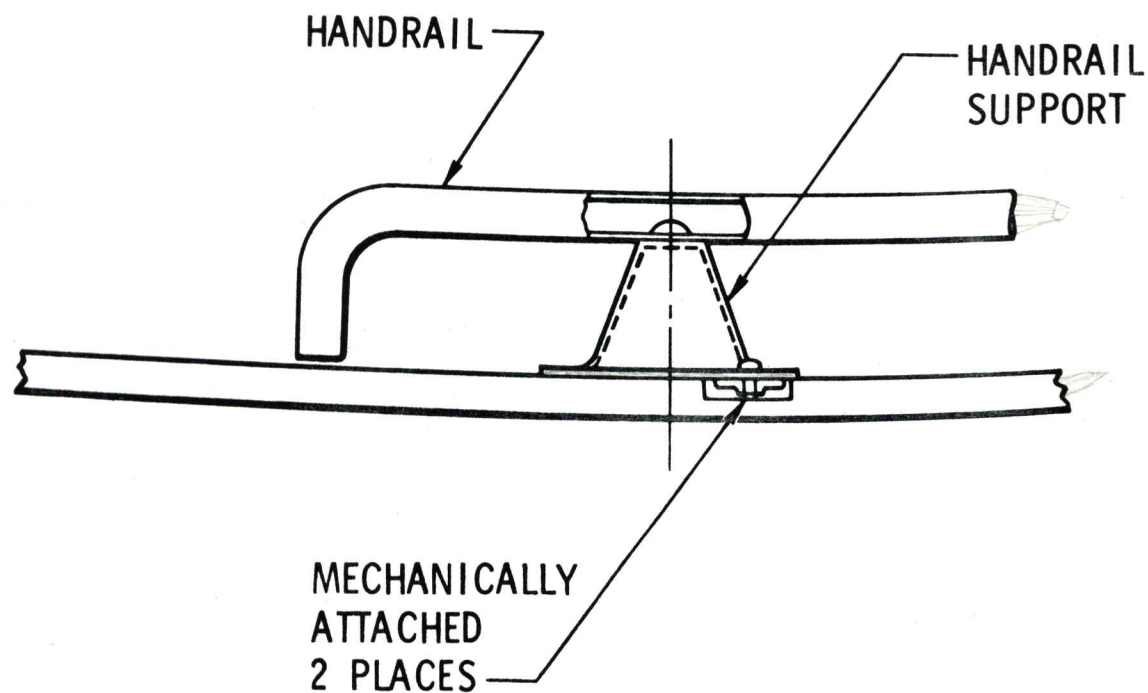


Figure 424-10.

The approximate handrail sizes and locations are as follows:

- a. Handrail 20 inches long with midpoint located 107 inches from Pos. I toward Pos. IV.
- b. Handrail 14 inches long with midpoint located 48 inches from Pos. III toward Pos. IV.
- c. Handrail 14 inches long with midpoint located 62 inches from Pos. III toward Pos. II.

The detail design and installation of the forward compartment circumferential handrail is shown in Drawing 1B80529.

Forward Dome Circumferential Handrails

The Forward Dome Circumferential Handrails consist of a series of five handrails of various lengths which extend circumferentially around the inside of the forward dome. The approximate sizes and locations are as follows:

- a. Handrail 9 inches long with midpoint 5° from Pos. III toward Pos. IV; located on the forward dome 50° forward of the intersection of the forward dome and the cylindrical section of the forward compartment.
- b. Handrail 9 inches long with midpoint 85° from Pos. III toward Pos. IV; located on the forward dome 45° forward of the intersection of the forward dome and the cylindrical section of the forward compartment.
- c. Handrail 42 inches long with midpoint 24° from Pos. IV toward Pos. I; located on the forward dome 45° forward of the intersection of the forward dome and the cylindrical section of the forward compartment.
- d. Handrail 42 inches long with midpoint 21° from Pos. I toward Pos. II; located on the forward dome 50° forward of the intersection of the forward dome and the cylindrical section of the forward compartment.
- e. Handrail 42 inches long with midpoint 61° from Pos. I toward Pos. II; located on the forward dome 50° forward of the intersection of the forward dome and the cylindrical section of the forward compartment.

The detail design and installation of the forward dome circumferential handrails is shown in Drawing 1B74594.

Forward Dome Vertical Handrails

The Forward Dome Vertical Handrails consist of three segmented vertical handrails on the forward dome which extend from the proximity of the access hatch handrail to the forward circumferential wire cover above the water container support structure. The approximate locations are as follows:

- a. Handrail located 85° from Pos. I toward Pos. II.
- b. Handrail located 75° from Pos. II toward Pos. III.

- c. Handrail located 42° from Pos. IV toward Pos. I.

The detail design and installation of the forward dome vertical handrails is shown in Drawing 1B74594.

Access Hatch Circular Handrail

The access hatch circular handrail consists of a series of two handrails which are preinstalled on the forward dome around the circumference of the access hatch jamb. The handrails are used, primarily, to aid in translation through the hatch opening.

The detail and installation of the handrail are shown in Drawing 1B74589.

Aft Compartment Handrail

The Aft Compartment Handrail is attached to the aft side of the crew quarters floor, in the aft compartment. The handrail provides restraint for the replacement of waste tank dump probes. It is a straight handrail approximately 50 inches long and is located nominally 5 inches inboard of the three probes.

The detail design and installation of the aft compartment handrail is shown in Drawing 1B83138.

4.2.4.2.1.2 Access Hatch Stabilization Handholds

Two access hatch stabilization handholds are provided on the workshop access hatch to provide crewman restraint during hatch opening activities. The location of the stabilization handholds on the access hatch is shown in Drawing 1B67998.

4.2.4.2.1.3 Central Handrail

The central handrail consists of a hexagonal cross-section handrail which extends from the access hatch to the crew quarters ceiling. The handrail is capable of detachment for stowage out of the way when certain experiments are performed in the forward compartment.

The details and installation of the central handrail are shown in Drawing 1B80631.

4.2.4.2.2 Portable Astronaut Aids

Portable astronaut aids consist of portable handholds, portable tether-attachment assemblies, portable foot restraint assemblies, portable pressure suit foot restraint assemblies, and detachable tethers. The portable astronaut aids attach to the standard open grid pattern and can be utilized wherever open grid is located within the OWS.

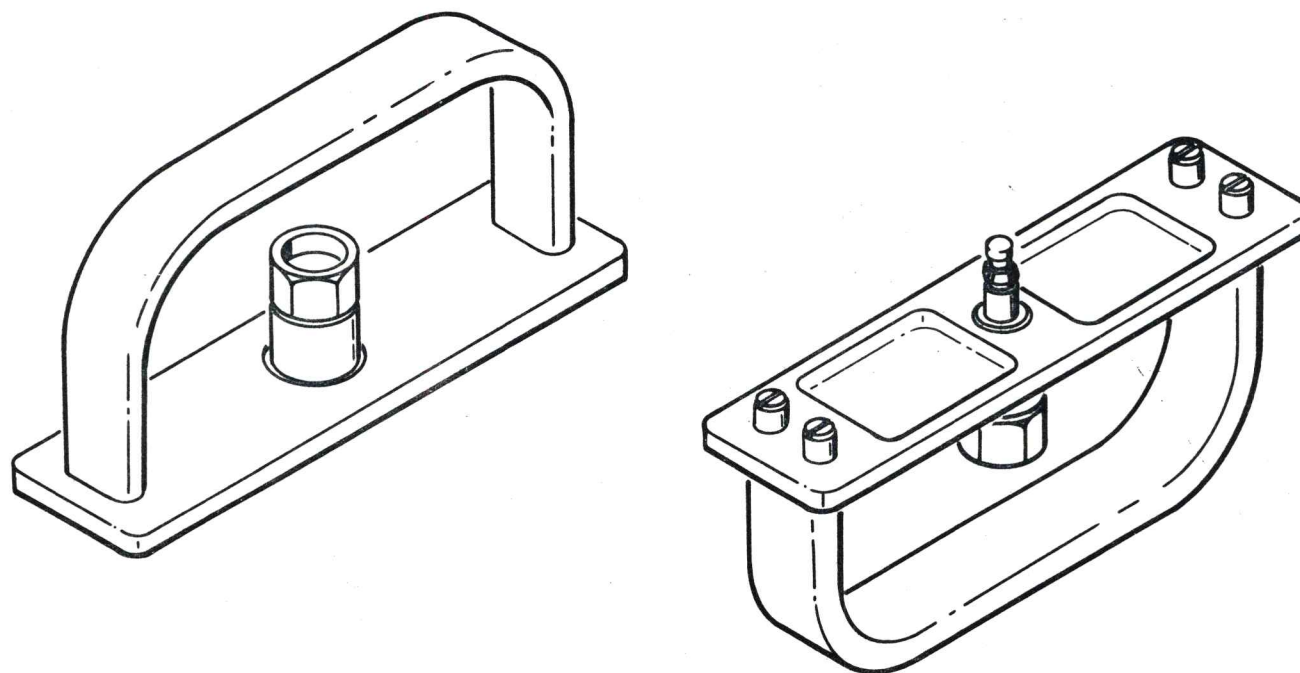
4.2.4.2.2.1 Portable Handholds

The portable handholds can be attached by the crew to any open grid surfaces to provide restraint as required. The handhold is compatible with the bare hand or pressure suit glove. A quick release fastener with a visual lock indication is utilized. The portable handholds are shown in Figure 424-11. The detail design of the portable handholds is shown on Drawing 1B77067.

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ORBITAL WORKSHOP PORTABLE HANDHOLD

**O/W-75
5-11-70**



4-173

Figure 424-11.

4.2.4.2.2.2 Portable Tether Attachment Assemblies

The portable tether attachment assemblies provide a tether attach ring which can be fastened anywhere on the open grid surfaces as required by the crew. The tether attachment assembly is compatible with the Apollo tether belt. A quick release fastener with visual lock indication is utilized. The portable tether attachment assembly is shown in Figure 424-12. The detail design of the portable tether attachment assembly is shown in Drawing 1B79534.

4.2.4.2.2.3 Fixed Foot Restraint Assembly

The fixed foot restraint assembly provides foot restraint in the WMC. The fixed foot restraint assembly is compatible with portable foot restraints, bare feet, or stocking feet (Figure 424-13). The detail design of the fixed foot restraint is shown in Drawing 1B79337.

4.2.4.2.2.4 Portable Foot Restraint Assemblies

The portable foot restraints (Figure 424-14) are devices with sole attachments which can index into standard open grid, and are compatible with the constant wear garment. They provide body restraint, leaving both hands free for task performance. One pair of restraints is provided for each astronaut. The detail design of the fixed foot restraint is shown in Drawing 1B80638.

4.2.4.2.2.5 Portable Pressure Suit Foot Restraint Assembly

The portable pressure suit foot restraint assembly (Figure 424-15) is secured to the standard open grid pattern with two grid cleats at the forward end and a quick release fastener at the aft end of the assembly. It is adjustable to accommodate a range of pressure suit boot lengths, is compatible with the Pressure Suit Assembly, and provides body restraint, leaving both hands free for task performance. Three portable pressure suit foot restraint assemblies are provided. The detail design of the portable pressure suit foot restraint assembly is shown in Drawing 1B79535.

4.2.4.2.2.6 Detachable Tether Straps

Two detachable tether straps are provided for translation from the forward dome to the forward floor. The tethers are attached between the forward dome handrails and the forward floor.

4.2.4.2.3 Miscellaneous Aids

4.2.4.2.3.1 Sleep Restraints

Sleep restraints are discussed in paragraph 4.2.7.5.1.

4.2.4.2.3.2 Wardroom Restraint Assemblies

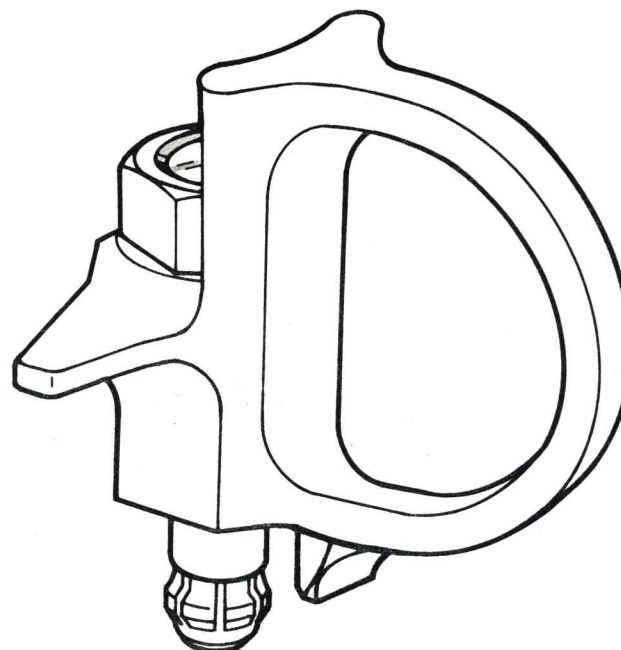
Thigh Restraints and table foot restraints are discussed in paragraph 4.2.7.4.5.

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ORBITAL WORKSHOP OWS ASTRONAUT AIDS

O/W-108-1
8-7-70

PORTABLE TETHER ATTACHMENT ASSEMBLY



ATTACH TO GRID HOLES

- PUSH TO ENGAGE
- DEPRESS BUTTON TO RELEASE

Figure 424-12.

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ORBITAL WORKSHOP FIXED FOOT RESTRAINT ASSEMBLY

O/W-4494
7-15-70

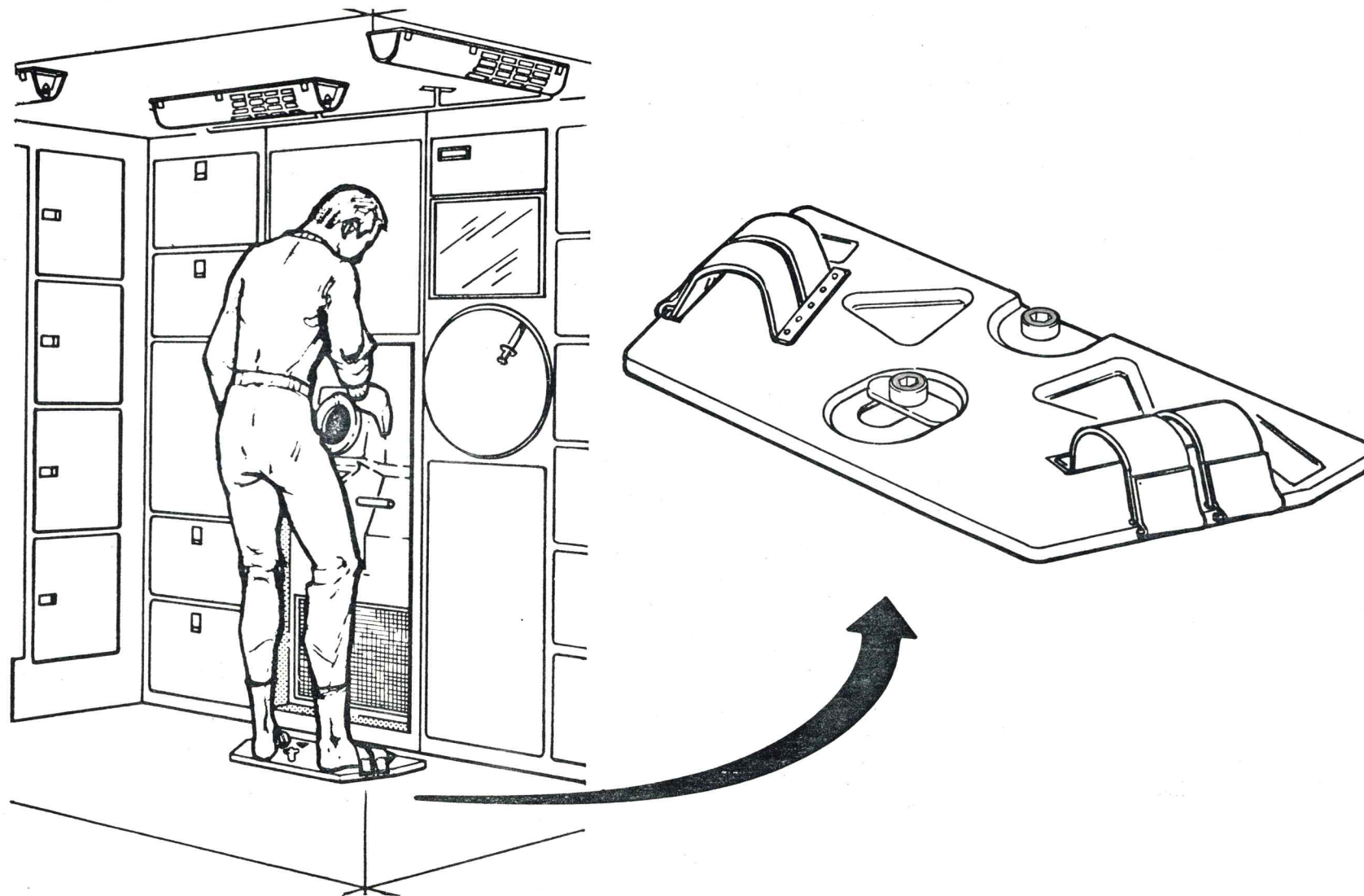


Figure 424-13.

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ORBITAL WORKSHOP PORTABLE FOOT RESTRAINT ASSEMBLY

OW-426
2-19-70

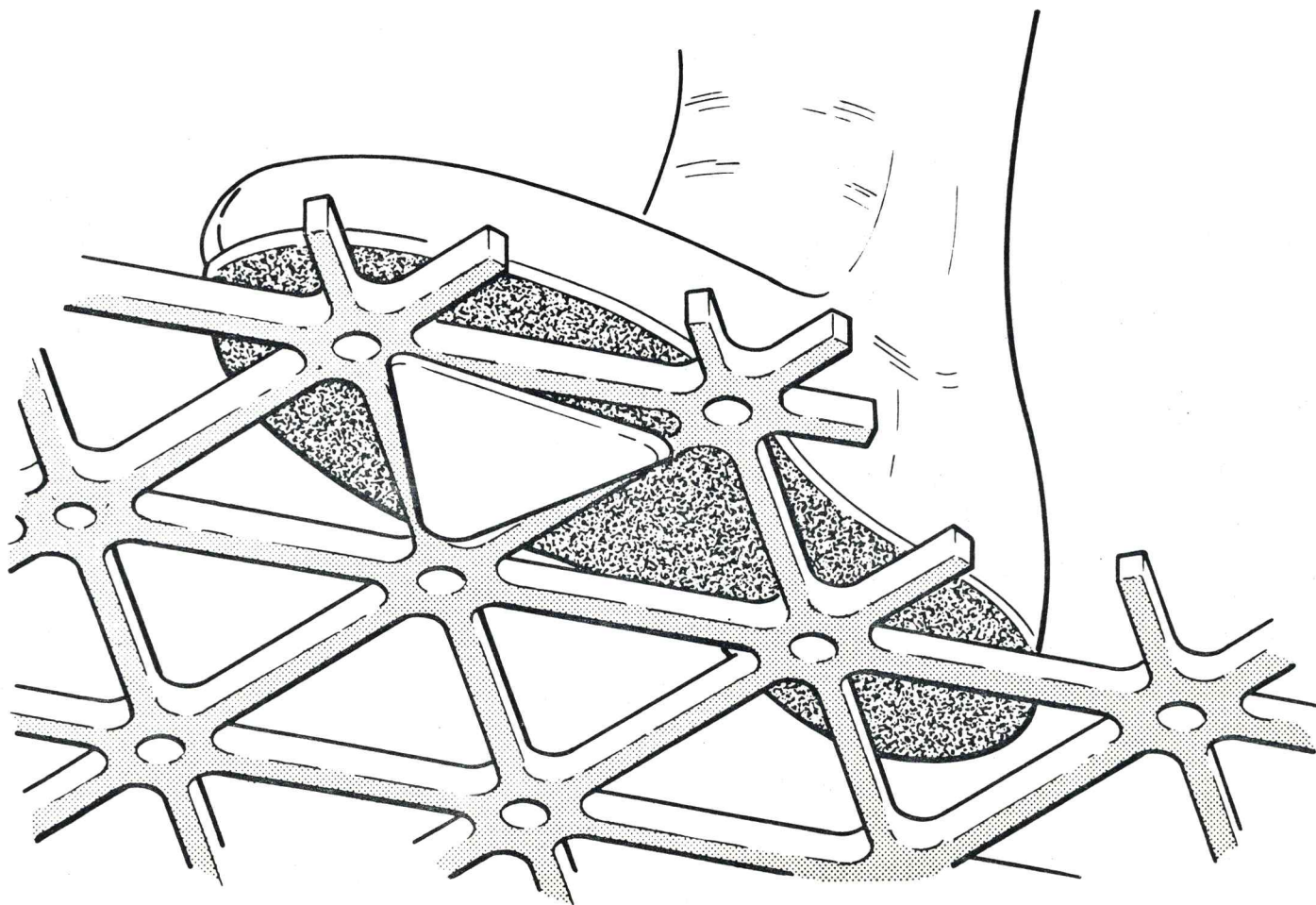


Figure 424-14.

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ORBITAL WORKSHOP CREW ACCOMMODATIONS PORTABLE PRESSURE SUIT FOOT RESTRAINT ASSEMBLY

O/W-4192
5-11-70

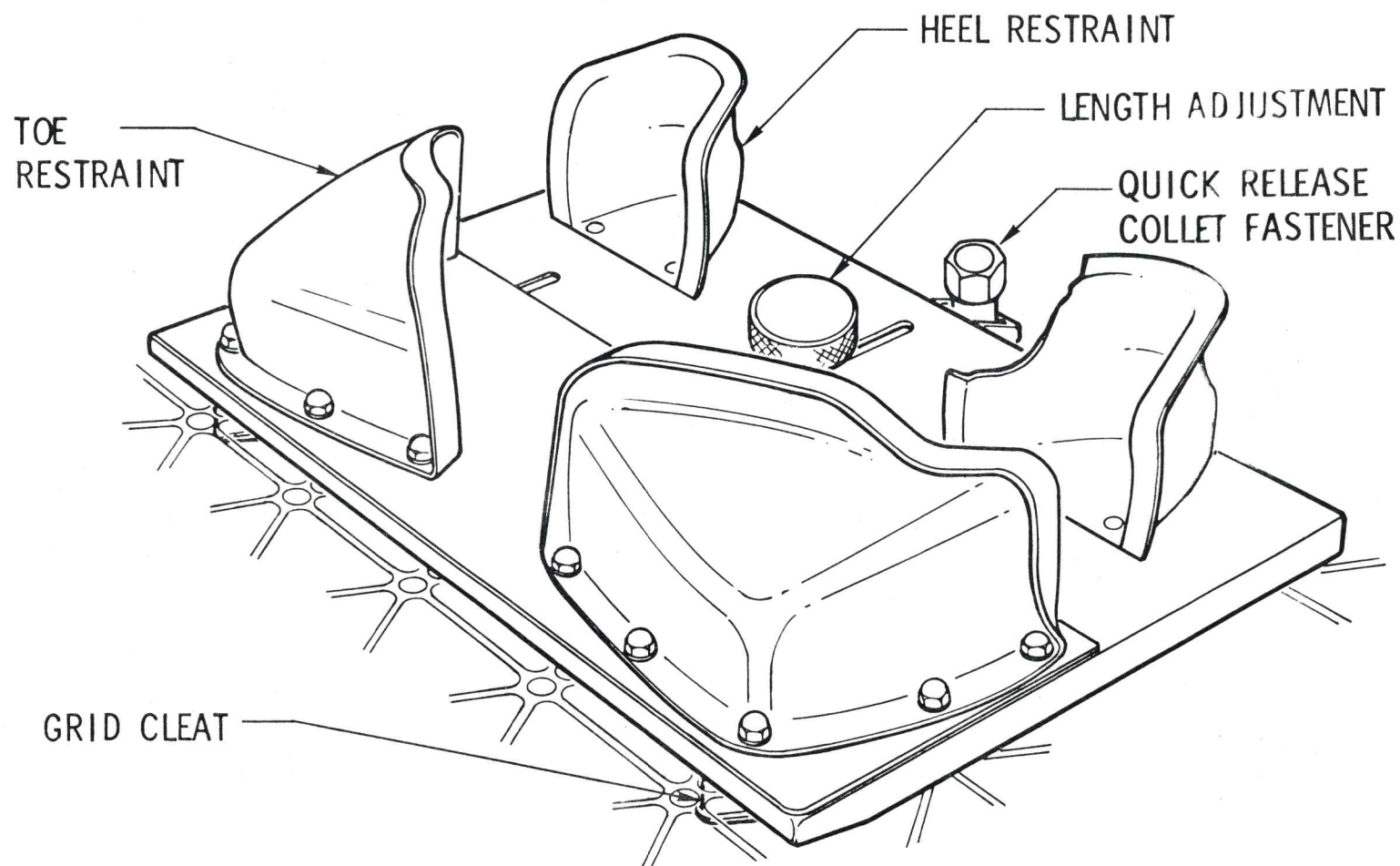


Figure 424-15.

4.2.4.2.3.3 Power Control Panel Handrails

Three vertical handrails are provided on the workshop electrical power console. The handrails extend vertically along the front face of the panel and are used for restraint while operating the console controls.

4.2.4.3 Crew Safety Provisions

4.2.4.3.1 Meteoroid Protection

4.2.4.3.1.1 Meteoroid Shield

The meteoroid shield decreases the probability of penetration of the OWS by meteoroids during a typical mission. The meteoroid shield is a 0.025-inch, Teflon coated, 2014-T6 aluminum sheet which encompasses the exterior of the OWS over the length of the habitation area cylindrical section. When deployed (Figure 424-16), it forms a cylinder that is concentric with and spaced approximately 5 inches off the outer shell. During ground handling and boost, the shield is retracted and held firmly against the OWS. The excess shield material is retained in hinged panels which fold on themselves permitting proper retraction to the smaller diameter. The links are pinned to the forward and aft skirt attach angles. Deployment forces are produced by preloaded torsion bars which drive the links.

The shield is preloaded by trunnion assemblies.

Tunnel straps are shown in Figure 424-17.

A closure is provided at either end of the shield (Figure 424-18).

4.2.4.3.1.2 Meteoroid Shield Deployment System

Meteoroid shield deployment is initiated by redundant EBW detonators and electronic firing units, located on a panel in the forward skirt. A redundant fuse train, consisting of the confined detonating fuse, extends between the detonators in a detonator block and the expandable tubes, which when initiated allow deployment of the shield.

The expandable tubes consist of two flattened 1/2-inch-diameter steel tubes extending the full length of the shield. Each tube contains a mild detonating fuse. The tubes are encased in a tension strap which is ruptured its entire length by expansion of a tube when either tube of the redundant system is fired (Figure 424-19).

Each explosive train is detonated using an EBW system containing an electronic firing unit which is commanded by charging and triggering one of the firing units. The other system remains available as a backup system.

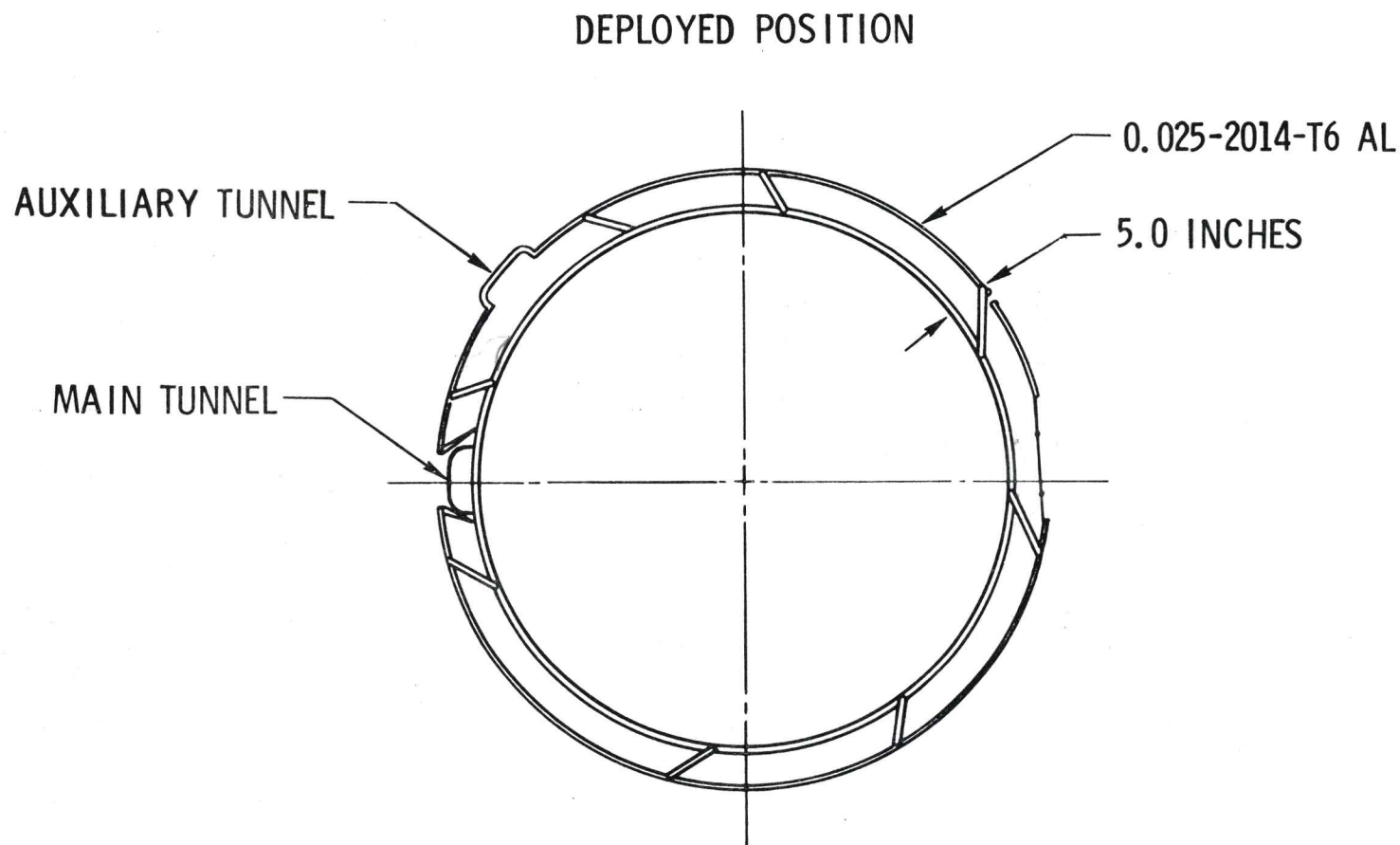
The electrical design provides for a firing command from the IU with an identical AM DCS firing circuit as a backup (Figure 424-20).

The following instrumentation is provided to verify system operation (1) EBW firing unit voltages, (2) breakwires to indicate the shield in the stowed position, and (3) position switches to indicate shield deployment.

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ORBITAL WORKSHOP DEPLOYABLE METEOROID SHIELD

O/W-323B
5-19-70



4-180

Figure 424-16.

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ORBITAL WORKSHOP DEPLOYABLE METEOROID SHIELD

O/W-617B
11-22-69

HINGED TENSION STRAP UNDER MAIN TUNNEL (TYP)

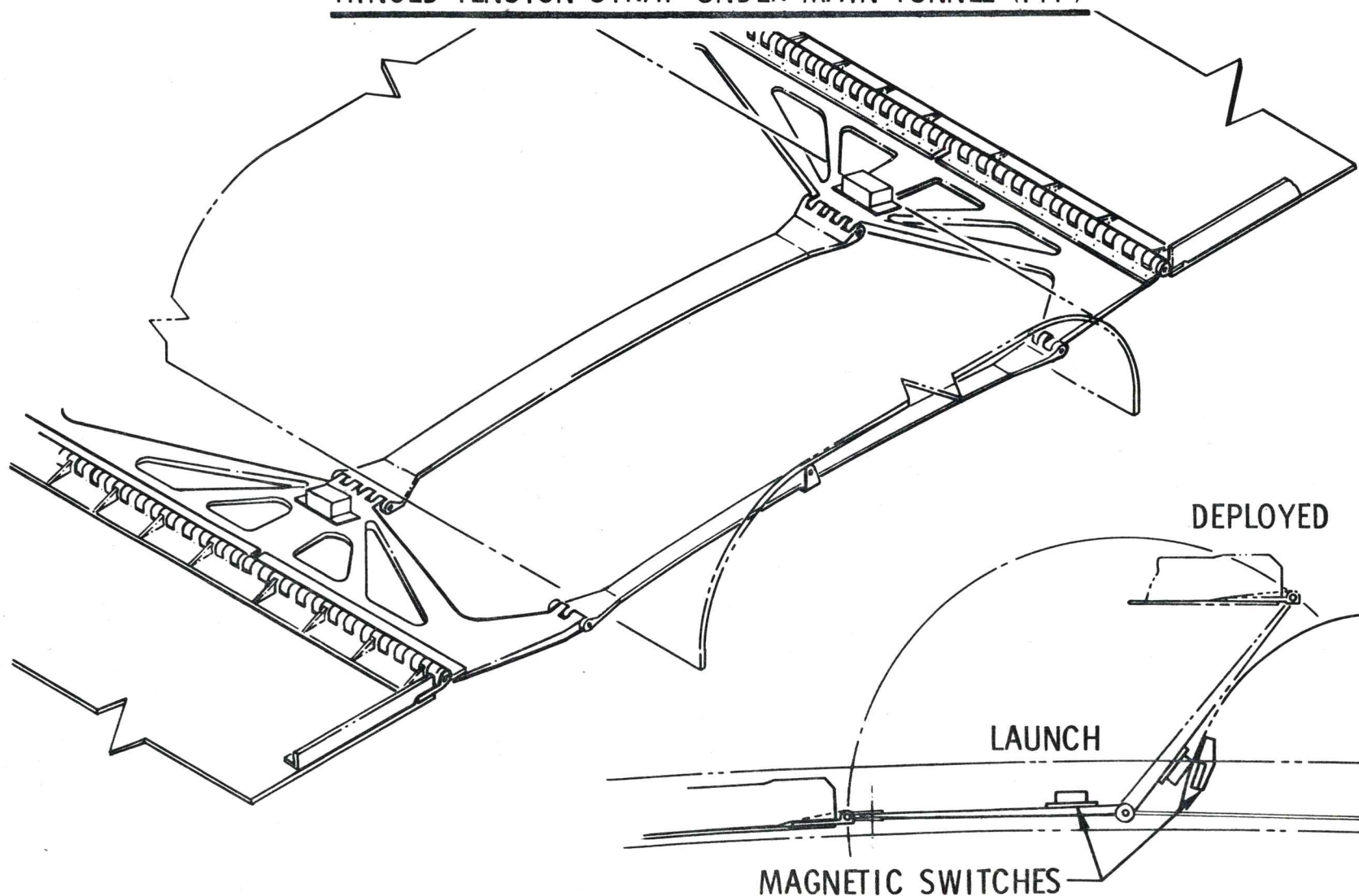


Figure 424-17.

ORBITAL WORKSHOP METEOROID SHIELD BOOT

O/W-1377
6-16-70

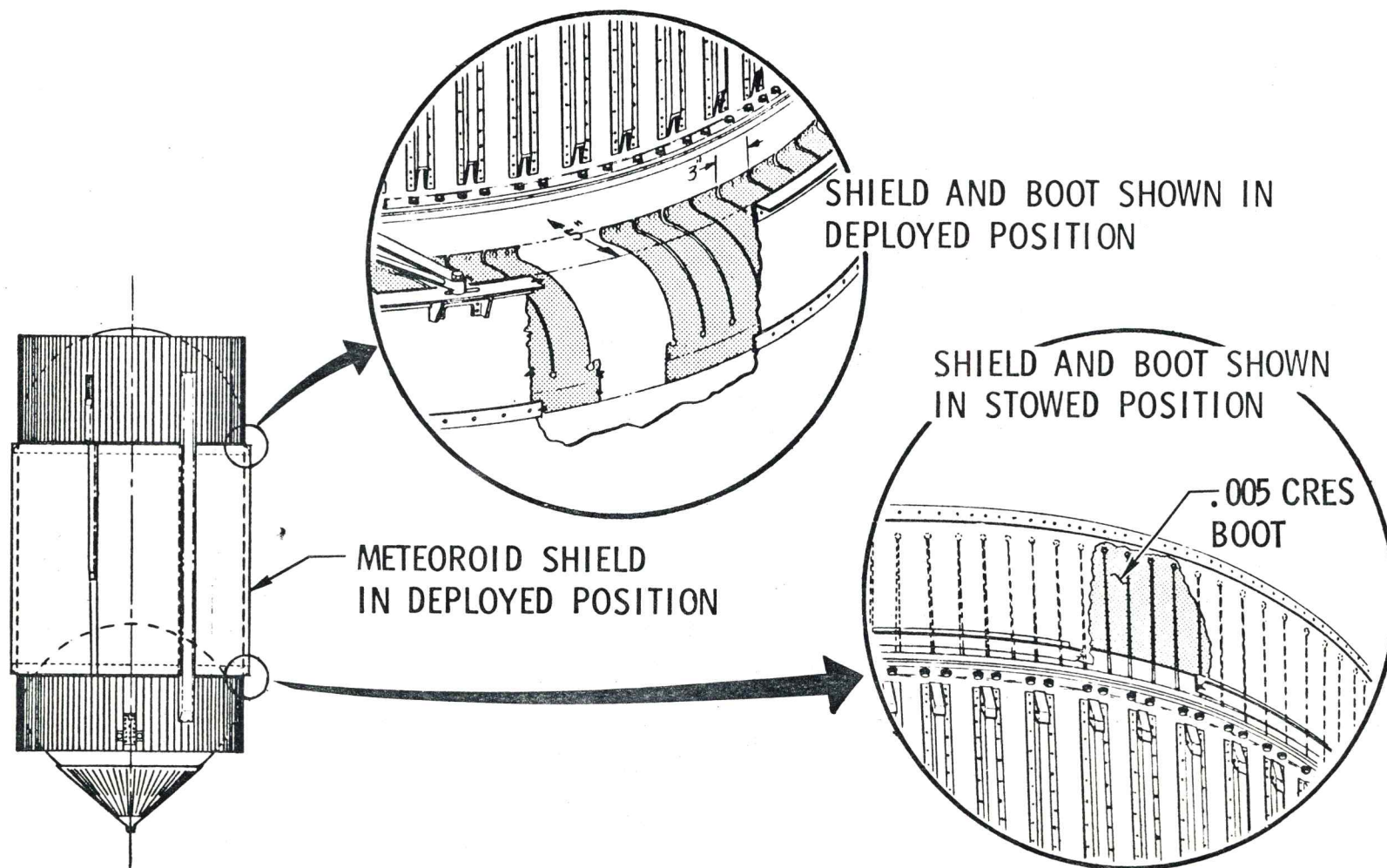


Figure 424-18.

ORBITAL WORKSHOP METEOROID SHIELD DEPLOYMENT ORDNANCE SYSTEM

O/W-60D
7-14-70

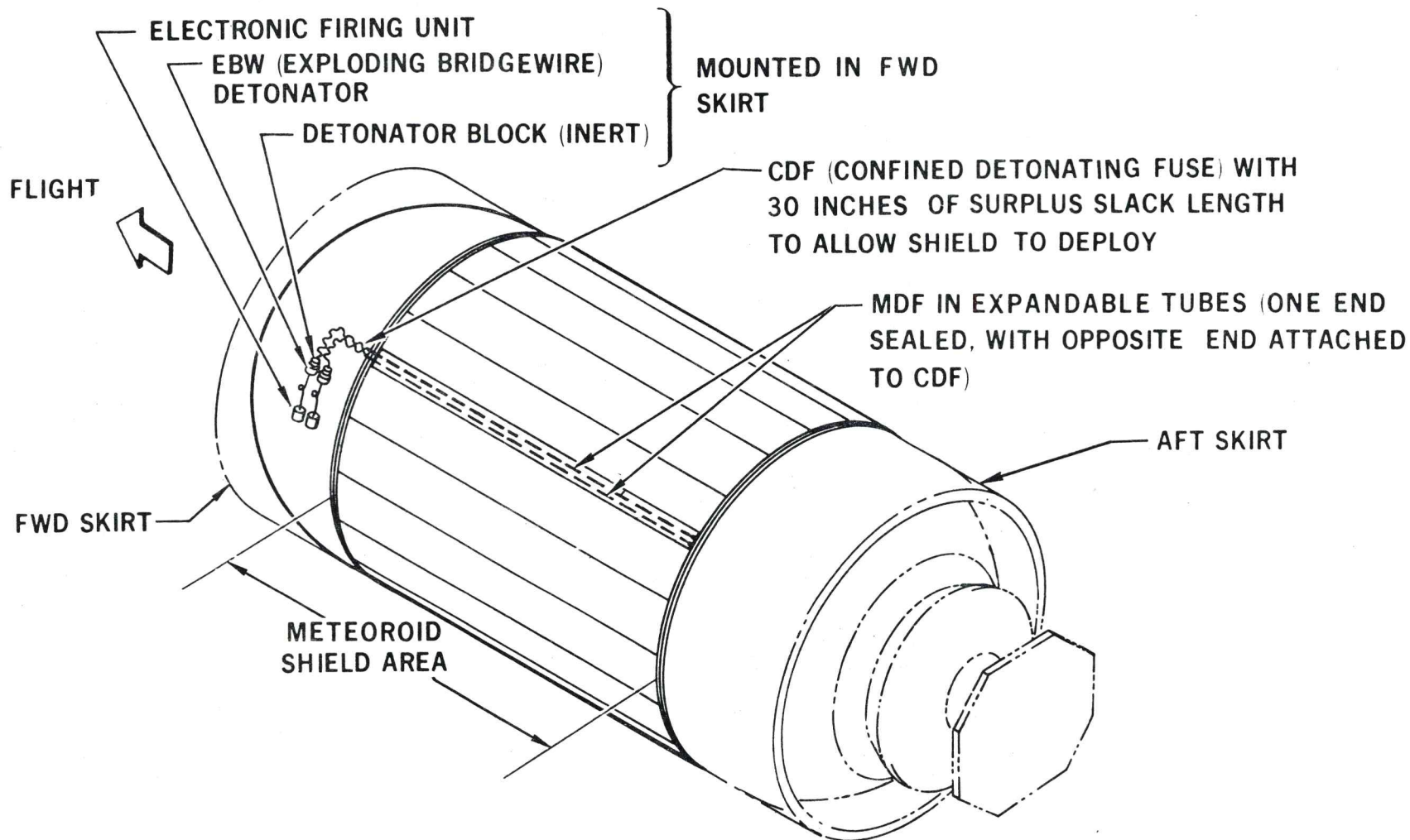
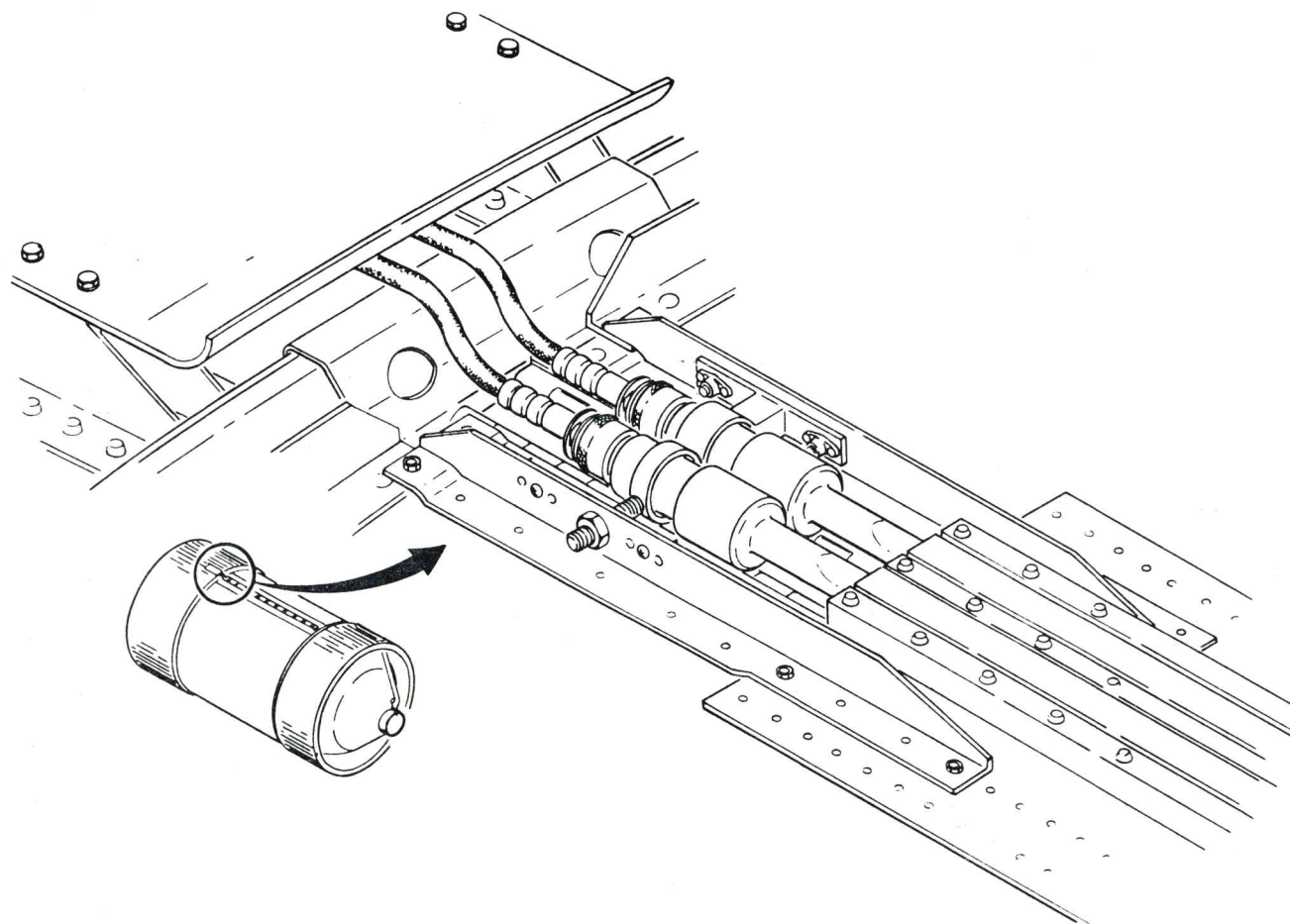


Figure 424-19. (Sheet 1 of 5)

ORBITAL WORKSHOP METEOROID SHIELD RELEASE MECHANISM

O/W-1295
10-29-69



VIEW B-B

ORBITAL WORKSHOP METEOROID SHIELD PARTIALLY DEPLOYED

O/W-1294
5-19-70

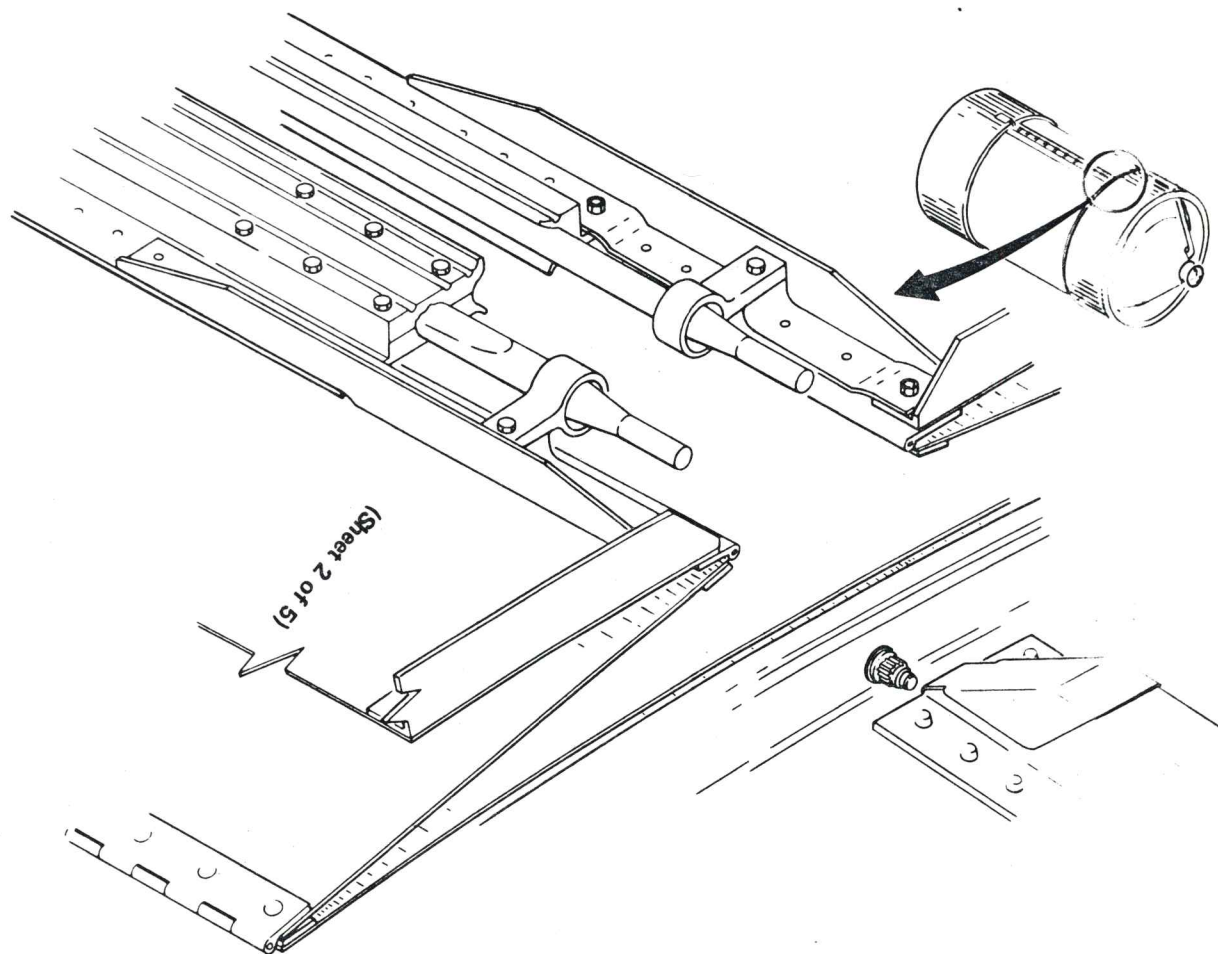
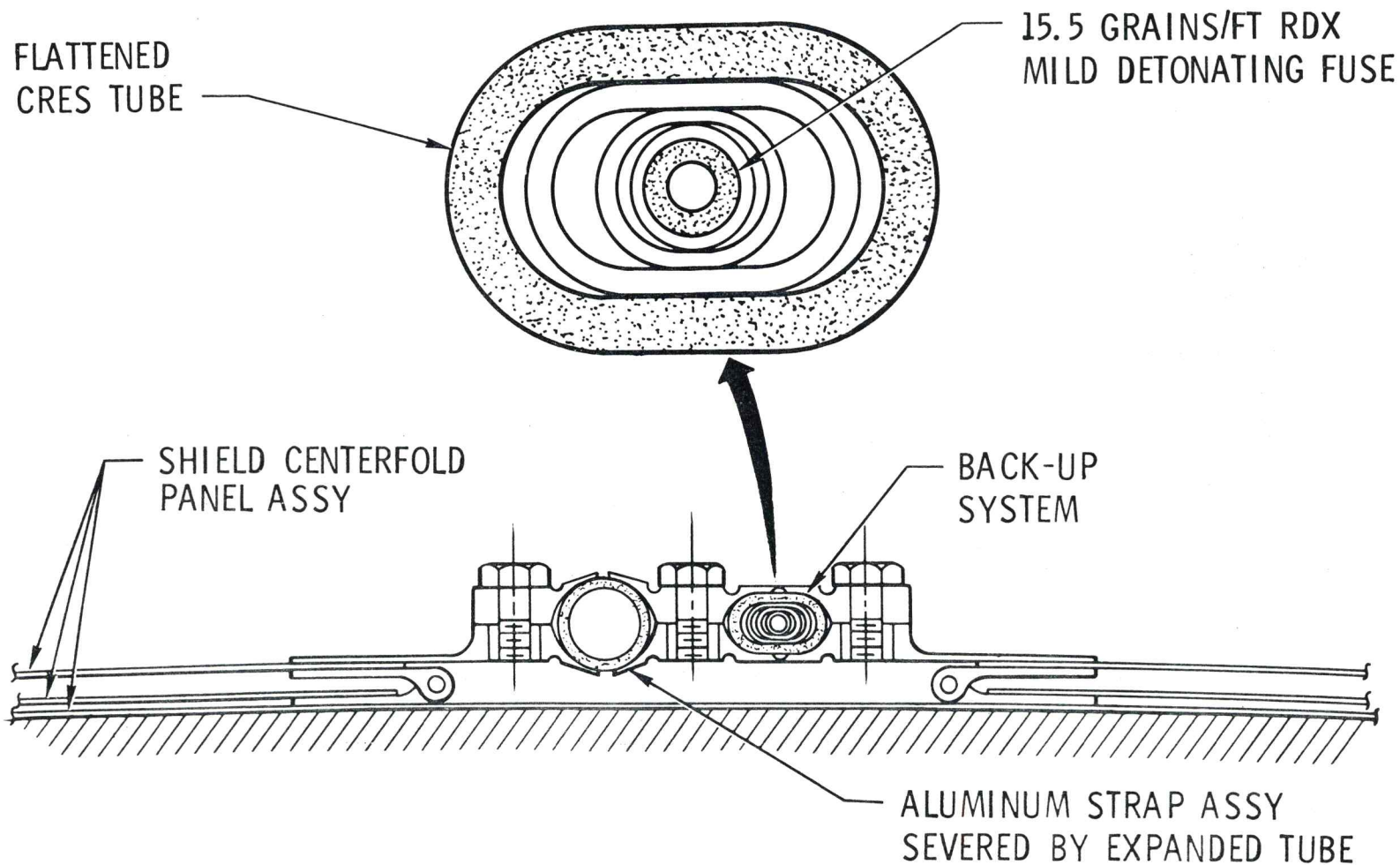


Figure 424-19. (Sheet 3 of 5)

ORBITAL WORKSHOP SHIELD RELEASE DEVICE

O/W-3273
5-19-70

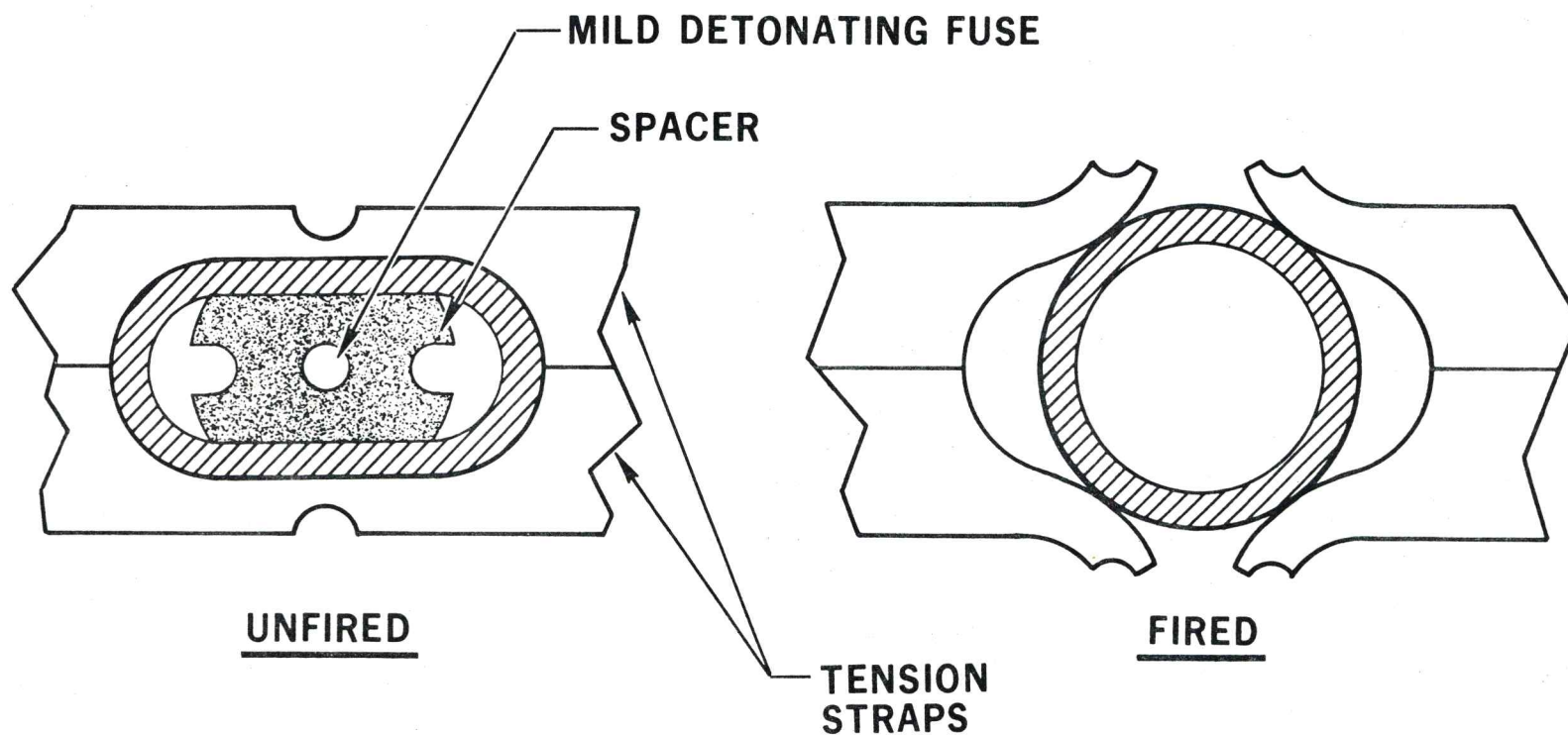


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ORBITAL WORKSHOP METEOROID SHIELD RELEASE SYSTEM

O/W-640 B
2-9-68

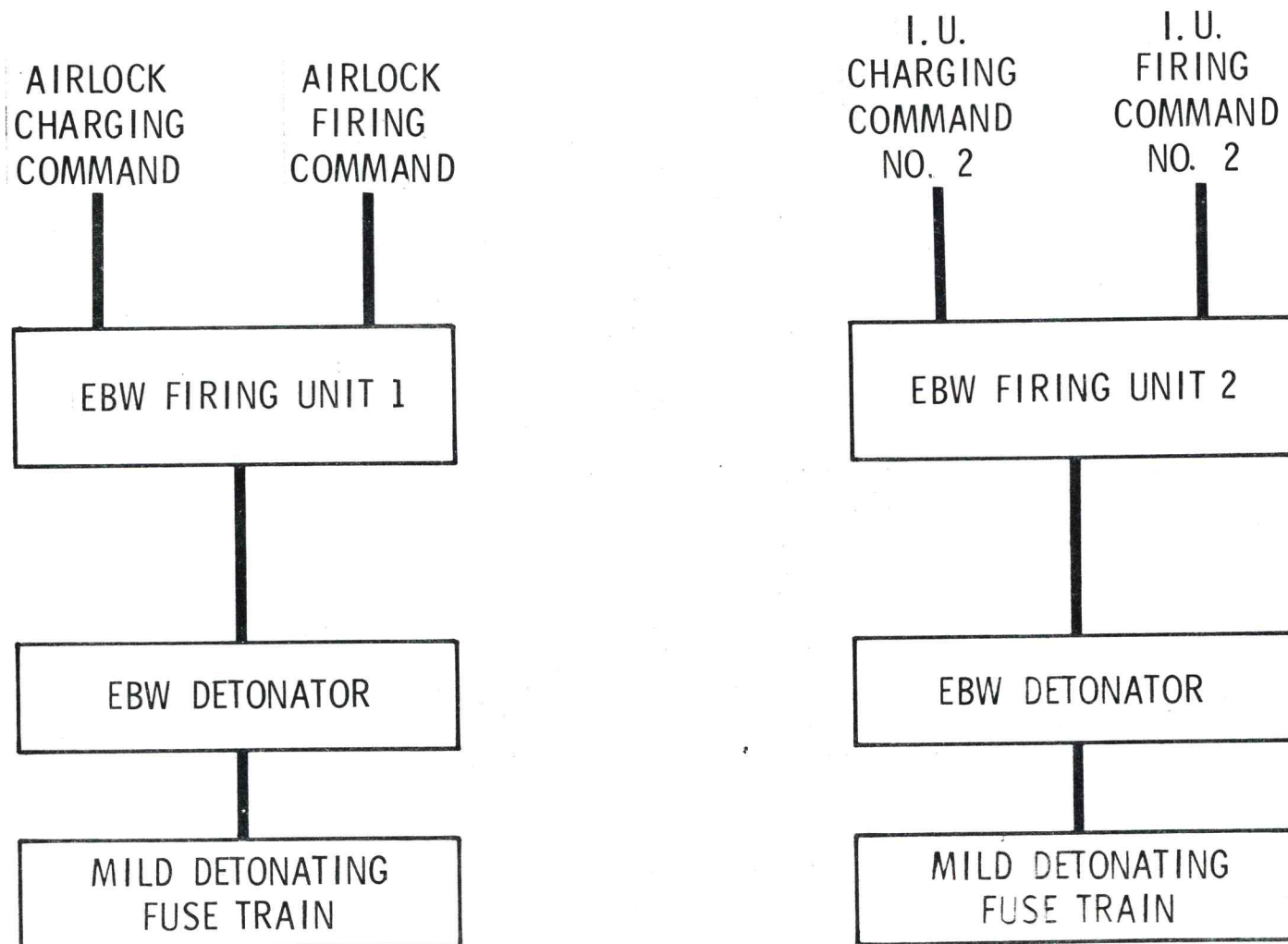
EXPANDABLE TUBE CONCEPT



4-187

ORBITAL WORKSHOP METEOROID SHIELD DEPLOYMENT CIRCUIT

O/W-133A
6-18-70



4-188

Figure 424-20.

4.2.4.3.2 Fire Protection

4.2.4.3.2.1 Flame-Retardant Liner

The habitation area internal insulation is covered with a 0.003-inch Teflon coated aluminum foil to inhibit flame propagation. The foil is bonded to the glass-fiber liner with polyurethane adhesive. Emissivity in selected areas is altered by an MDC-MD-19 surface treatment, light green in color, to increase the emissivity from 0.5 to 0.72.

4.2.4.3.2.2 Fire Extinguisher Mounting Provisions

Mounting provisions for three Apollo fire extinguishers are provided in the workshop - one on the forward dome and two in the experiment compartment.

4.2.4.3.2.3 Material Selection

Materials are selected in accordance with the flammability acceptance criteria specified in MFSC-Spec-101A, Flammability, Odor and Toxicity Requirements and Test Procedures for Materials in Gaseous Oxygen Environments.

Replacement of Fiberglass Brackets

All fiberglass brackets within the habitation area are removed and replaced with metallic parts to eliminate exposed flammable materials.

4.2.4.3.3 Physical Protection

4.2.4.3.3.1 Mechanical Design Provisions

The following mechanical design provisions are provided to prevent astronaut injury and damage to astronaut equipment:

- a. Rounding of all exposed edges and recessing of bolts within the OWS.
- b. Hard covers are preinstalled on wires and wire supports within the OWS.

Emergency egress openings, consisting of one hexagonal opening in the sleep compartment, and one in the wardroom, provide the astronauts with the capability of immediate emergency egress through the compartment grid ceiling.

4.2.4.3.3.2 Electrical Design Provisions

The basic design of the OWS electrical system incorporates general safety provisions, i.e., bonding, circuit protection, etc., as well as specific safety provisions, i.e., emergency lighting, caution and warning, etc. The design includes provisions that in case of a malfunction within the system that portion becomes automatically inert. In addition the system monitors itself and other systems which could endanger the safety of the crew.

The emergency lighting system is designed to provide illumination automatically in case of a total OWS power failure.

The Caution and Warning System (CWS) is designed to detect malfunctions in the OWS and provide audio/visual displays in addition to providing audio/visual displays of malfunctions in other SWS modules.

Electrical bonding is incorporated into the basic design to protect personnel and equipment from shock hazards and explosions that might result from accumulation of static charges.

The distribution system is designed with the following safety characteristics:

- a. All wiring using AM power is protected by circuit breakers.
- b. Power-return circuits are isolated from OWS structure ground.
- c. The internal LH₂ tank power wiring is protected in such a manner as to prevent physical damage by the crew, but is capable of being visually inspected after the stage acceptance firing.
- d. All wire harnesses carrying different AM bus power are physically separated.
- e. Procedural means for removing power from the OWS receptacles are employed.
- f. The OWS connectors are designed to preclude the occurrence of a hazardous condition, due to electrical arcing, when the crew is mating and unmating electrical equipment.

4.2.4.3.3.3 Material Selection For Contamination Control

Materials are selected in accordance with the odor and toxicity acceptance criteria specified in MSFC-Spec-101A, Flammability, Odor and Toxicity Requirements and Test Procedures for Materials in Gaseous Oxygen Environments.

All cadmium-plated components within the habitation area, such as bolts and nuts are replaced to avoid contaminating the OWS atmosphere.

4.2.4.3.4 Orbital Maintenance Provisions

Orbital maintenance provisions consist of orbital spares, an orbital tool kit and a repair kit.

4.2.4.3.4.1 Orbital Spares

A projected list of orbital spares is presented in Table 424-1.

Table 424-1

| Page Number | Part Number | Nomenclature | On-Board Recom Qty Spares | Backup Recom Qty Spares |
|----------------|-------------|---|---------------------------------|-------------------------------|
| 1 | 1B74832-1 | Sealing Device, Habitation Area Vent Outlet | 1 | 0 |
| 2 | 1B69364-1 | Floodlight, General Illumination | 6 | 6 |
| 3 | 61A850003-5 | Intercommunication Box (GFE) | 2 | 2 |
| 4 | 1B77902-1 | Heater Assembly, Thermal Control | 1 | 1 |
| 5 | 20M42270-1 | Post Landing Ventilation Fan (GFE) | 5 | 0 |
| 8 | 1B77645-1 | Probe Assembly - Heated | 1 | 0 |
| 9 | 1B75334-505 | O-Ring | 6 | 0 |
| 10 | 115D406002 | Power Module, Collection | 1 | 0 |
| 11 | 1B78850-1 | Valve Assembly, Water Dispenser | 1 | 0 |
| 12 | TBD | Plug, Trash Airlock Assembly | 1 | 0 |
| 13 | 1B80661-1 | Cartridge, Filter and Charcoal | 1 | 0 |
| 14 | 1B78612-1 | Dispenser Assembly, Drinking Water | 1 | 0 |
| 15 | 1B81445-1 | Dispenser Valve, Hot Water | 1 | 0 |
| 16 | AA5417-1 | Seal, Inboard Hatch | 6 | 0 |
| 17 | 1B81423-1 | Indexing Cleat Assembly, LH | 1 | 0 |

Table 424-1 (Cont)

| Page Number | Part Number | Nomenclature | On-Board Recom Qty Spares | Backup Recom Qty Spares |
|-------------|-------------|--|---------------------------------|-------------------------------|
| 18 | 1B81423-2 | Indexing Cleat Assembly, RH | 1 | 0 |
| 19 | 1B78542-1 | Switch Assembly, Control Panel | 1 | 1 |
| 20 | 1B78542-501 | Switch Assembly, Control Panel | 1 | 1 |
| 21 | 1B78542-503 | Switch Assembly, Control Panel | 1 | 1 |
| 22 | 1B78542-505 | Switch Assembly, Control Panel | 1 | 1 |
| 23 | 1B78542-507 | Switch Assembly, Control Panel | 1 | 1 |
| 24 | 1B78542-509 | Switch Assembly, Control Panel | 1 | 1 |
| 25 | 1B78542-511 | Switch Assembly, Control Panel | 1 | 1 |
| 26 | 1B78543-1 | Circuit Breaker Assembly, Power Distribution | 1 | 1 |
| 27 | 1B78543-501 | Circuit Breaker Assembly, Power Distribution | 1 | 1 |
| 28 | 1B78543-503 | Circuit Breaker Assembly, Power Distribution | 1 | 1 |
| 29 | 1B78543-505 | Circuit Breaker Assembly, Power Distribution | 1 | 1 |
| 30 | 1B75334-509 | O-Ring | 6 | 0 |

4.2.4.3.4.2 Orbital Tool Kit

The orbital tool kit provides a set of hand tools for spares replacement and general maintenance. The tool kit consists of a teflon coated beta cloth pouch with pockets to contain the tools. The pockets have retention flaps with velcro tabs to securely restrain the tools. The tool kit is shown in Figure 424-21.

The multipurpose tools provided by the orbital tool kit are presented in Table 424-2. Each tool has a tether ring to secure it to the crewman, and is capable of being used with an ungloved or PSA gloved hand. Each individual bit has a piece of velcro hook attached which enables the crewman to apply it to exposed pile instead of replacing it in the pouch. Each tool will be identified with letters or combination letter/number for ease of identification.

There is also a utility transfer assembly which consists of a waist tether and two utility pouches which may be attached to the waist tether. There are also two straps attached to waist tether which are used to transfer items too large to be accommodated by either pouch. The utility transfer assembly is shown in Figure 424-22. This assembly will interface with the Apollo utility pouch.

4.2.4.3.4.3 OWS Repair Kit

An OWS repair kit is provided for the repair of air ducts, curtains, filters and the repair of tank walls resulting from meteoroid penetrations. The OWS repair kit is shown in Figure 424-23.

A list of the projected repair kit items is presented in Table 424-3.

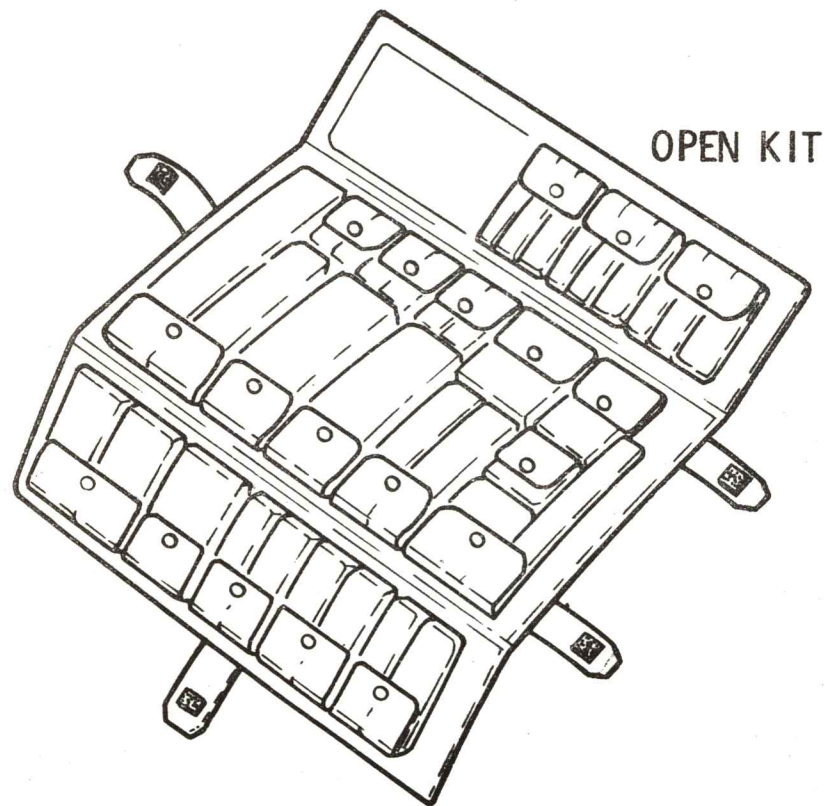
4.2.4.4 Interior Color Scheme

The interior of the OWS and equipment surfaces normally exposed to the crew are finished in a harmonious color scheme designed to enhance crew comfort and interior illumination. Details are given in Appendix B, 1B79289, Design Requirements Drawing.

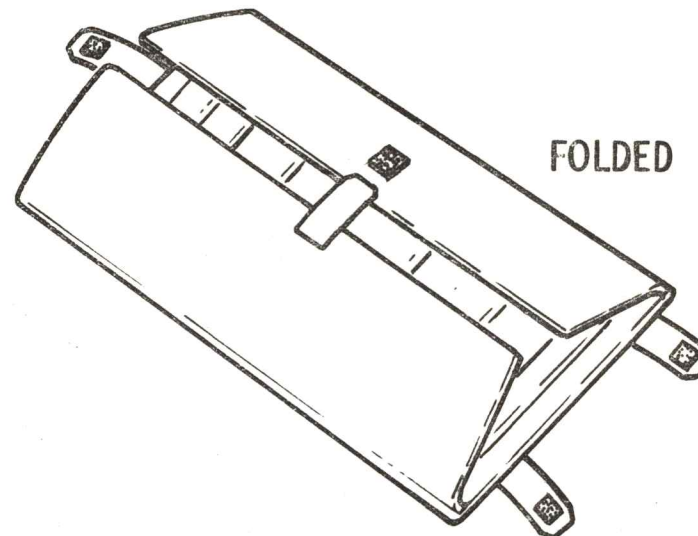
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ORBITAL WORKSHOP TOOL KIT

O/W-5835
8-3-70



OPEN KIT



FOLDED

ROLLED FOR
STOWAGE

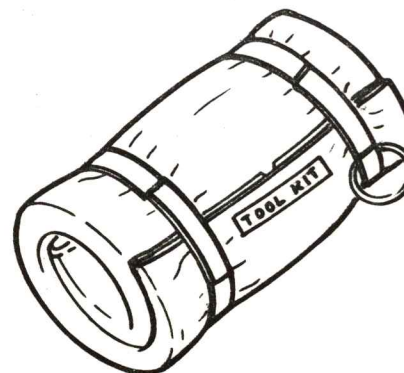


Table 424-2

TOOLS

| Part Number | Nomenclature | Qty |
|-------------|--------------------------------------|-----|
| 3162 | <u>Screwdriver Handle</u> | 1 |
| 3158 | Screwdriver, 3/16 Scoffed Bit | 1 |
| 3161 | Allen Wrench, 3/16 x 2 Bit 90° | 1 |
| 3154-078 | Allen Wrench, 5/64 x 2 Bit | 1 |
| 3163 | Allen Wrench, 5/32 x 2 Bit | 1 |
| 3154-093 | Allen Wrench, 3/32 x 2 Bit | 1 |
| 3171 | Extractor, O-Ring | 1 |
| 3155 | <u>Torque Wrench</u> | 1 |
| 3165 | 3/8 Socket | 1 |
| 3166 | 9/16 Socket | 1 |
| 3164 | 3/8 Ratchet, 3/8 Drive | 1 |
| 3152-OE12 | 3/4 Open End, 3/8 Drive | 1 |
| 3152-OE5 | 5/16 Open End, 3/8 Drive | 1 |
| 3152-OE9 | 9/16 Open End, 3/8 Drive | 1 |
| 3153 | 9/16 Box End, 3/8 Drive | 1 |
| 1B83629 | <u>Wrist Tether (Tools)</u> | 6 |
| 1B83593 | <u>Utility Transfer Assembly</u> | 3 |
| | No. 20 Insertion/Removal Tool | 3 |
| | No. 16 Insertion/Removal Tool | 3 |
| | No. 12 Insertion/Removal Tool | 3 |
| 3156 | <u>Latch Release Tool</u> | 8 |
| 3160 | <u>Tool, Pin Straightener</u> | 1 |
| 3159 | <u>Pliers, General</u> | 1 |
| TBD | <u>Leak Detector</u> | 1 |
| 1B83592 | <u>Manual Atmosphere Monitor Kit</u> | 1 |

ORBITAL WORKSHOP UTILITY TRANSFER ASSEMBLY

O/W-8765
8-3-70

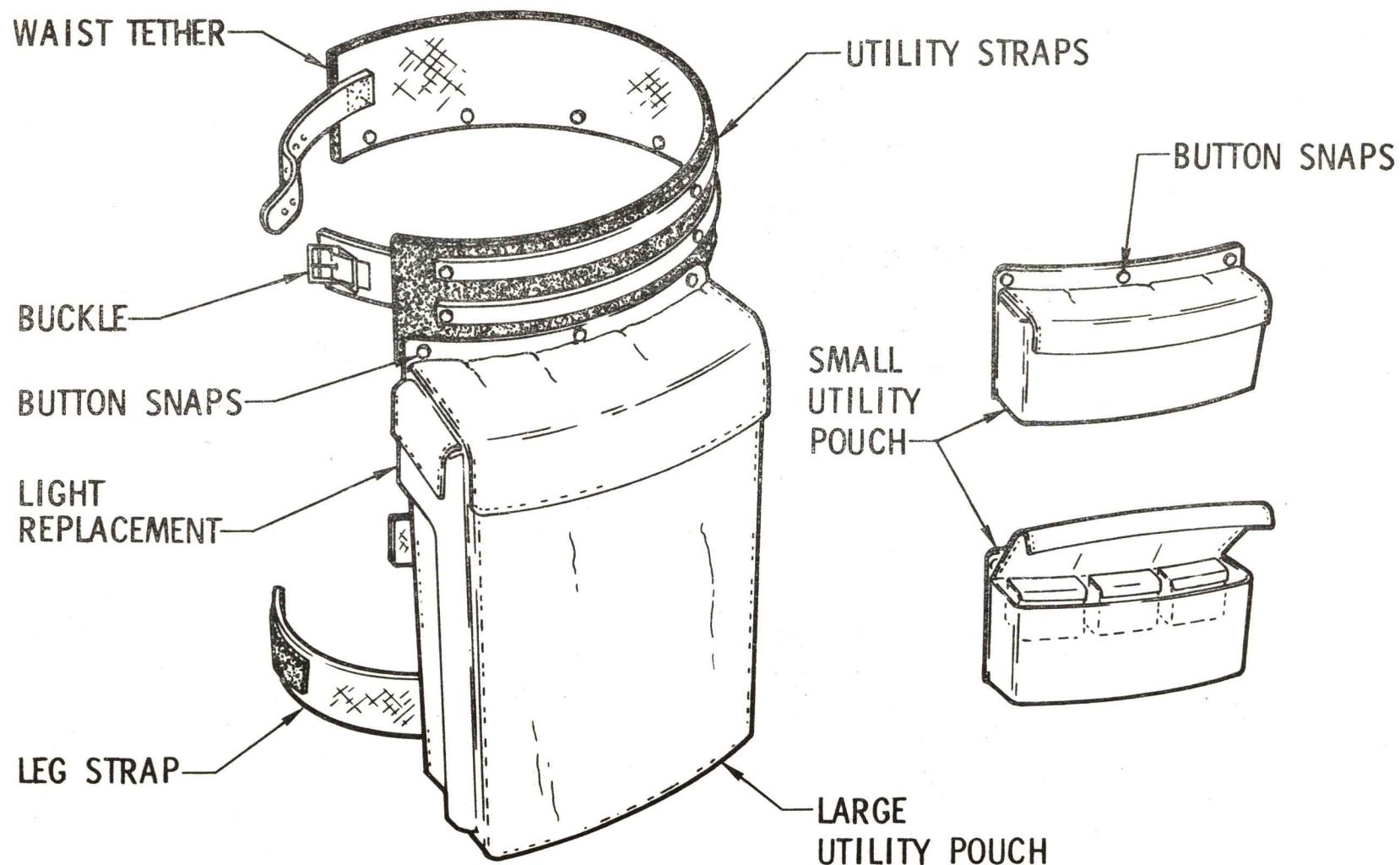


Figure 424-22.

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ORBITAL WORKSHOP REPAIR KIT

O/W-5836
8-3-70

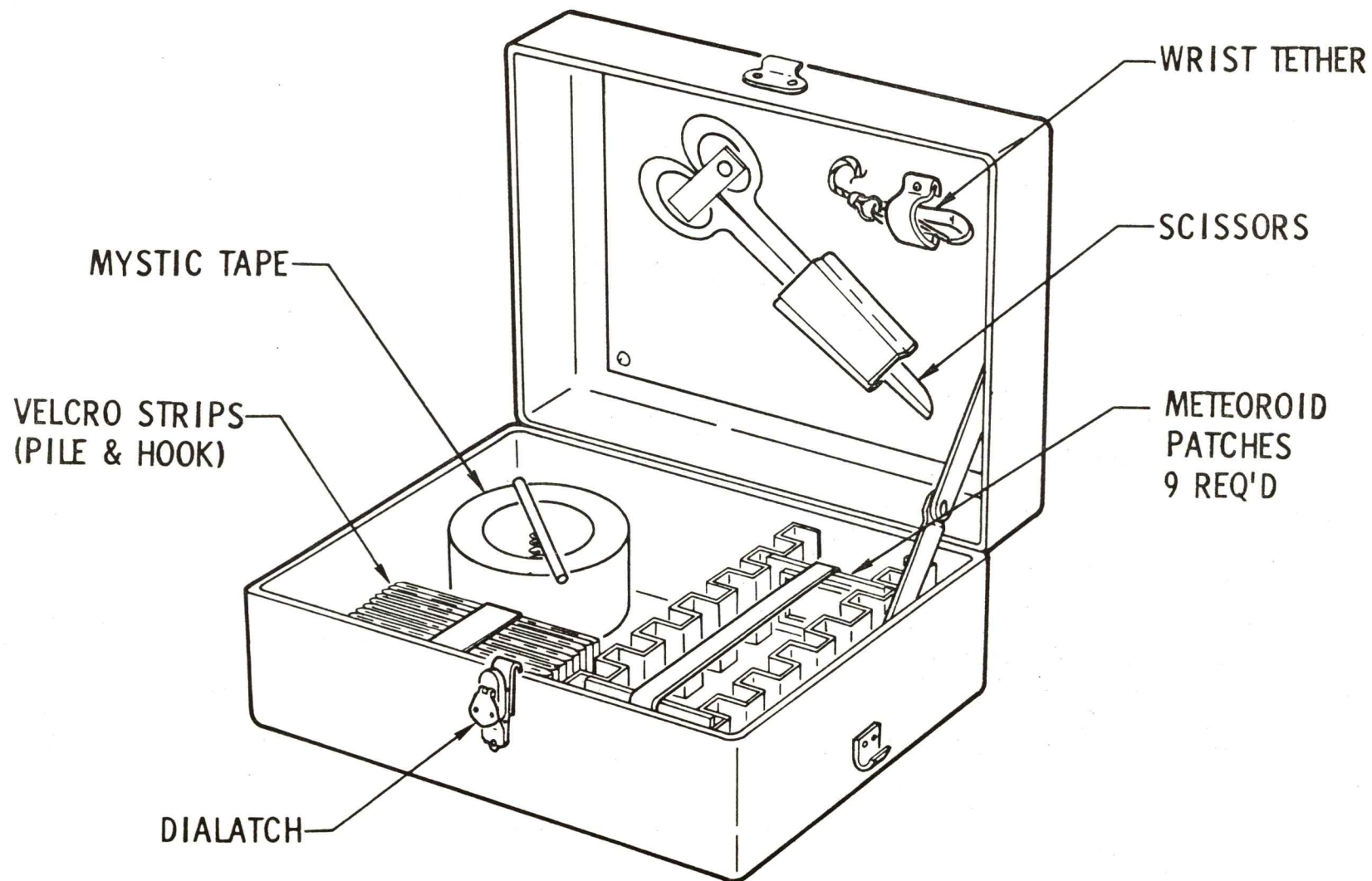


Figure 424-23.

Table 424-3
OWS REPAIR KIT

| Nomenclature | Qty |
|-------------------------|---------|
| Scissors | 1 |
| Tether, Wrist | 1 |
| Tape (Mystic 7453) | 1 roll |
| Patch, Meteoroid Repair | 9 |
| Velcro Tape, Hook | 10 feet |
| Velcro Tape, Pile | 10 feet |

4.2.4.5 Lining and Trim

4.2.4.5.1 Locations

The following locations are provided with close-outs to prevent loose articles (paper, pencils, debris, etc.) from floating into inaccessible areas:

a. Sleep Compartment

1. Exposed perimeter at the top and bottom of stowage lockers (between lockers and the ceiling/floor).
2. Area between stowage lockers and the tank wall/compartment wall.
3. Area under stowage lockers between the two floor grids.
4. Area between the compartment walls/partition and the tank wall.

b. Wardroom

1. Exposed perimeter at the top and bottom of stowage lockers, entertainment center, galley, and freezer/chiller (between equipment and the ceiling/floor).
2. Area between stowage lockers and other wardroom equipment, and the tank wall/compartment wall.
3. Area under stowage lockers, freezer/chiller, data file, galley, entertainment center, and food table between the two floor grids.
4. Crevices between the front of stowage lockers and other wardroom equipment.
5. Area between the food freezer/chiller and adjacent lockers.
6. A window fairing panel with sliding window shade is provided. It extends between the two lockers adjacent to the window and from the data file to the ceiling.

c. Waste Management Compartment

1. Exposed perimeter at the top and bottom of stowage lockers, the waste processor, the fecal/urine collector, etc. (between equipment and the floor/ceiling).
2. Area between stowage lockers/waste processor and compartment walls.
3. Crevices between the front of stowage lockers and other WMC equipment.

d. Experiment Compartment

1. Exposed perimeter at the top of the stowage locker, the control console, and the power console (between the equipment and the ceiling).
2. Area between the tank wall and the stowage locker, the control console, the power console, the gas analyzer, and the experiment support system.
3. Area under the stowage locker, the control console, and the power console between the two floor grids.
4. Area under floor mounted experiments (greater than one square foot) between the two floor grids.
5. Area between the wardroom compartment wall and the tank wall.

e. Forward Compartment

1. Area between the water containers and the support structure.
2. Area between the stowage ring containers and the support structure.
3. Area between the upper floor and the tank wall, as required.
4. Area between food containers/freezers and tank wall/water ring.
5. Area between film vault/3-compartment cabinet/return container rack/5-compartment stowage locker, and tank wall/water ring.
6. Between the water ring structure and the tank wall.
7. Upper floor between the two floor grids in areas of common footprints for equipment mounted on the forward and aft sides of the floor. This condition occurs under food containers, freezers, film vault, 3-compartment cabinet, 8-compartment stowage locker, and seven experiment units.

4.2.4.5.2 Hardware Description

Hardware items comprising lining and trim are:

- a. Elastomer sheet strips attached to the top, bottom, and sides of the lockers, freezers, etc.
- b. Teflon-coated beta fabric mounted on the forward and aft floors, oriented vertically and attached to the two facing grids.
- c. Teflon-coated beta fabric netting mounted where air flow through the closure is required.

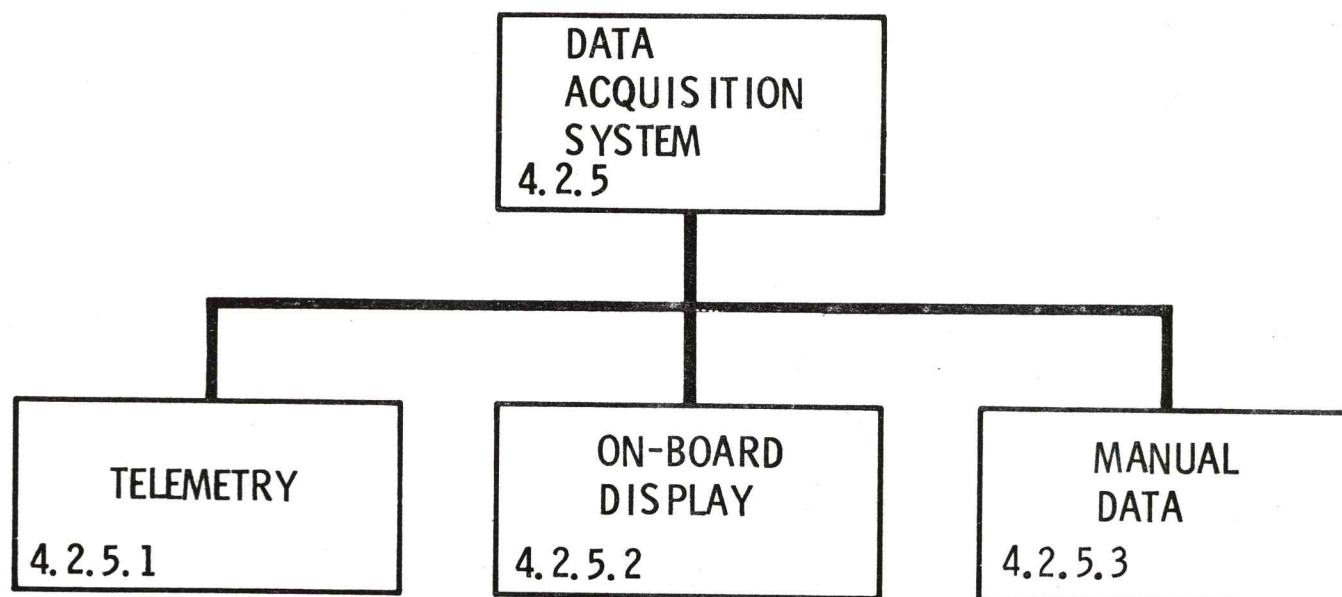
- d. Teflon-coated beta fabric attached to lockers, cabinets, containers, walls, and partitions.
- e. Sheet metal lining panels mounted to lockers and freezers.
- f. Elastomer mouldings bonded to lockers, etc., to close local areas.
- g. Aluminum screen mounted to floor, lockers, etc., where fabric netting is not feasible.

DATA ACQUISITION SYSTEM

DATA ACQUISITION SYSTEM

ORBITAL WORKSHOP

O/W-8205
6-17-70



4.2.5 Data Acquisition System

4.2.5.1 Telemetry

The OWS Telemetry System (Figure 425-1) consists of multiplexers, instrumentation, and a remote calibration system. The control signals and power requirements for the multiplexers are supplied by the AM.

4.2.5.1.1 Multiplexers

There are 12 multiplexers in the OWS, five high-level and seven low-level (Figure 425-2). Each multiplexer is equipped with a heater and temperature control device to maintain the minimum operating temperature. The maximum measurement capability of the OWS Telemetry System is as follows:

- a. 158 - 0 to 5v channels at 1.25 samples per second.
- b. 5 - 0 to 5v channels at 320 samples per second.
- c. 2 - 0 to 5v channels at 80 samples per second.
- d. 1 - 0 to 5v channels at 40 samples per second.
- e. 56 - 0 to 20Mv channels at 1.25 samples per second.
- f. 1 - 0 to 5v channels at 20 samples per second.
- g. 168 - 0 to 20Mv channels at .416 samples per second.
- h. 2 - 0 to 5v channels at 10 samples per second.
- i. 72 - bilevel channels at 10 samples per second.
- j. 74 - bilevel pulse channels at 10 samples per second.
- k. 1 - 5, 76KB serial digital data.

The bilevel channel with an input signal of less than 5vdc indicates an off response, and an input signal greater than 15vdc indicates an on response. The bilevel pulse channel with an input signal of 5vdc or less for ten or more milliseconds indicates an on response, and an input signal of 15vdc or more indicates an off response.

The high sample rate channels of the OWS (greater than 10 sps for bilevel and greater than 1.25 sps for analog channels) are interfaced directly to the AM PCM interface box.

4.2.5.1.2 Instrumentation

The instrumentation for the OWS consists of transducers, signal conditioning modules, and transducer power supplies. The transducers convert the physical measurement (temperature, pressure, etc.) into electrical outputs that are routed either to multiplexers, or to signal conditioning modules which convert transducer outputs to the required signal level for multiplexing. Transducer power supply modules receive 28 ± 2.0 , -2.5vdc from the AM and provide either 5 ± 0.04 vdc or 20 ± 0.05 vdc, as required, to the measurement transducer. All 28vdc instrumentation power is distributed through fuse modules in the OWS for bus protection.

All measurements on the OWS are listed in and controlled by the MDAC Orbital Workshop Instrumentation Program and Components List (1B68467). The

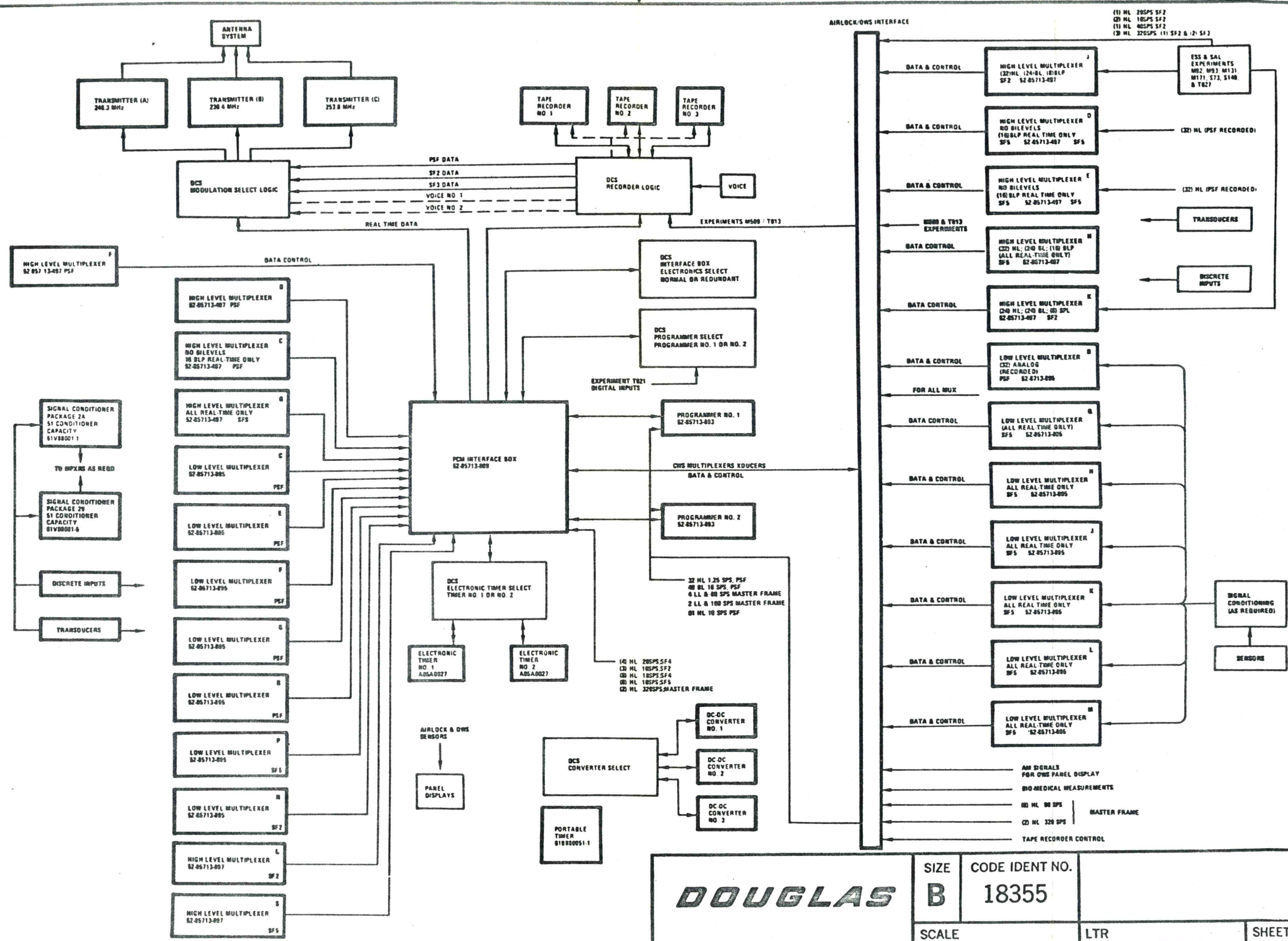


Figure 425-1.

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ORBITAL WORKSHOP MEASUREMENTS

O/W-6973
8-8-70

| DESCRIPTION | T/M | ON-BOARD DISPLAY | UMBILICAL |
|-------------------|-----|------------------|-----------|
| TEMPERATURE | 119 | 1 | 8 |
| PRESSURE | 28 | 2 | 3 |
| EVENT | 43 | 2 | 16 |
| VOLTAGE | 27 | 2 | 2 |
| FLOW | 3 | 3 | 0 |
| CURRENT | 6 | 2 | 0 |
| POSITION | 7 | 0 | 0 |
| LEVEL | 10 | 0 | 0 |
| CAUTION & WARNING | 0 | 8 | 0 |
| TOTAL | 231 | 20 | 29 |

GRAND TOTAL 280

4-205

Figure 425-2.

transducers are located throughout the OWS and include the following types of measurements:

- a. Corollary experiment accommodations.
- b. Temperature.
- c. Pressure.
- d. Events.
- e. Voltage.
- f. Current.
- h. Position.
- i. Level.
- j. Strain.
- k. Acceleration.

Figure 425-2 provides a summary of the measurements used in the OWS not including the experiment measurements. The instrumentation used for telemetry, on-board displays and umbilical measurements utilize separate transducers and signal conditioning assemblies. Typical measurement systems are illustrated in Figure 425-3.

4.2.5.1.3 Remote Automatic Calibration System

The Remote Automatic Calibration System (RACS) is designed to allow remote calibration of the signal conditioning modules during OWS ground checkout operations (Figure 425-4). In-flight calibration is not provided. The system provides a 28vdc signal to a selected channel. This signal initiates a relay closure which applies a fixed stimuli into the electronics, producing an output of 0 percent, 20 percent or 80 percent full scale of the specific channel selected for verification.

4.2.5.2 On-Board Data Display

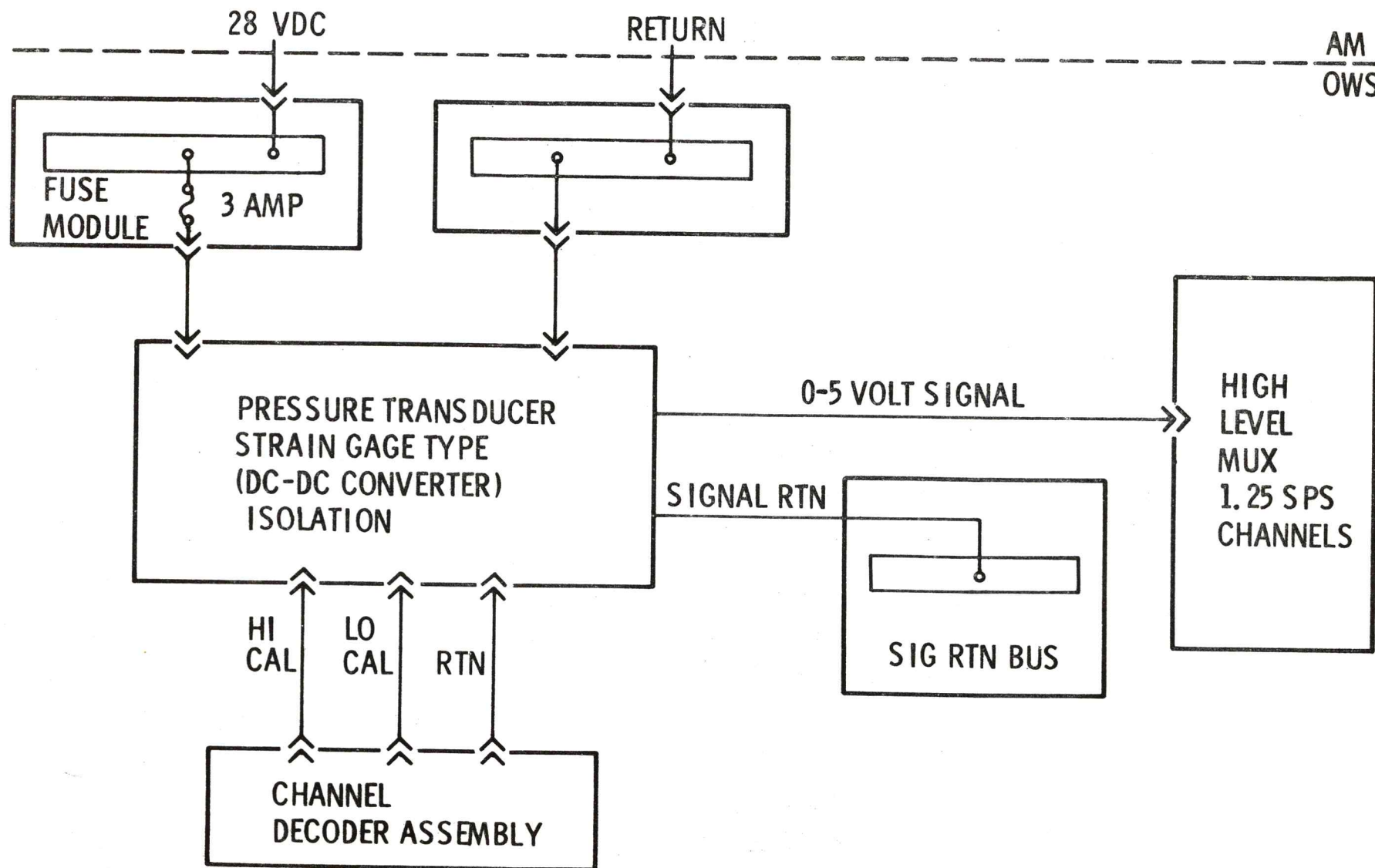
The OWS Data Acquisition System includes on-board displays which provide the crew members with selected system status and caution and warning information. These data are displayed to the crew on various panels and consoles located in the forward compartment, Experiment Compartment, Wardroom and waste management compartment (Figures 425-5 through 425-12). The OWS on-board displays and their locations are listed in Table 425-1. The instrumentation required for the meters and annunciators are separate from the instrumentation provided for the telemetry system.

4.2.5.3 Manual Data

The Manual Data System provides the capability to record the HSS data. This system consists of log books as well as voice, photographic, and television recording. Log books are provided as a part of the system. Photographic (still and motion pictures) and television data utilize existing mission and experiment equipment accommodations.

ORBITAL WORKSHOP INSTRUMENTATION - PRESSURE

O/W-4324
5-19-70

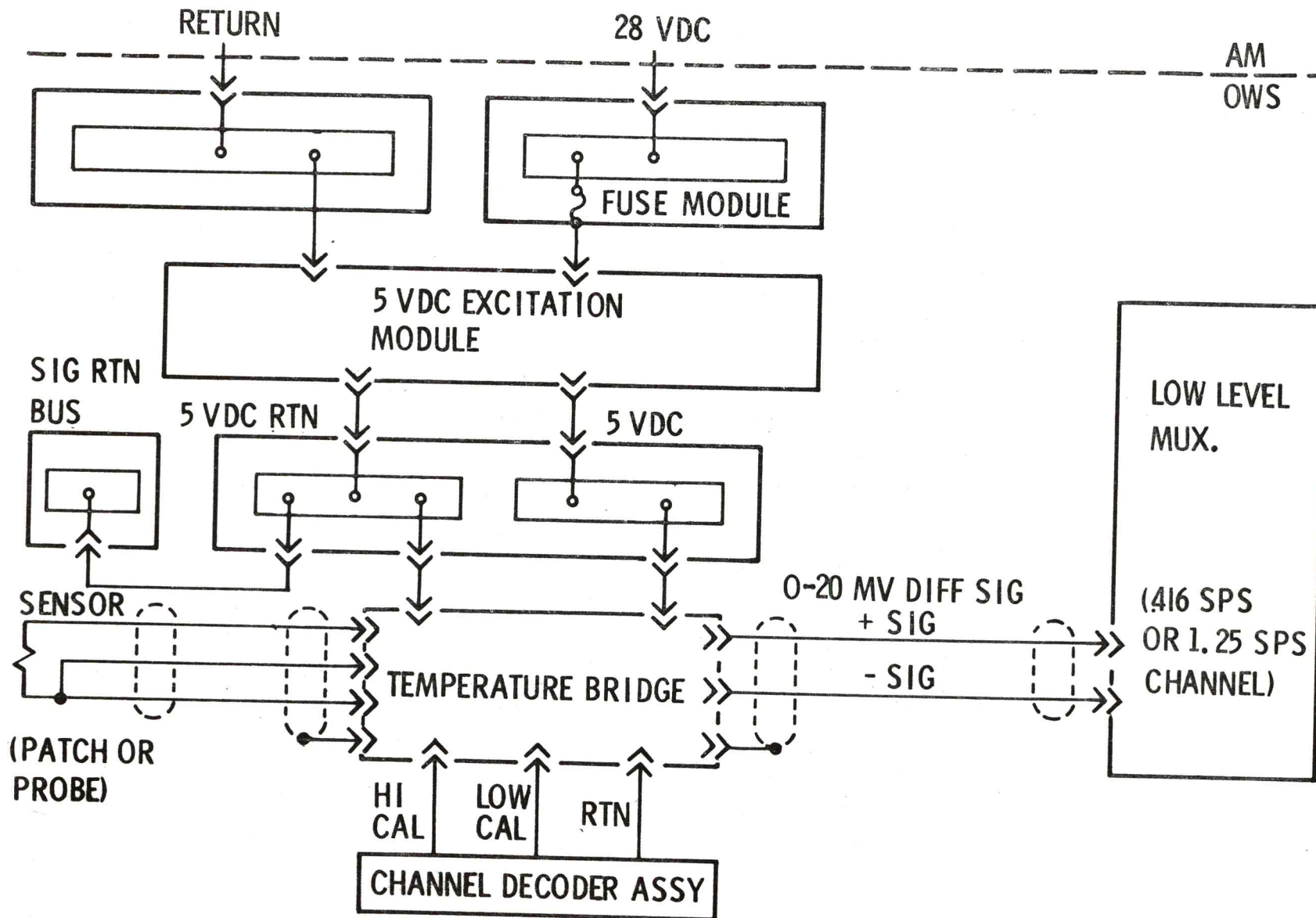


4-207

Figure 425-3. (Sheet 1 of 3)

ORBITAL WORKSHOP INSTRUMENTATION-TEMPERATURE

O/W-4325
5-26-70

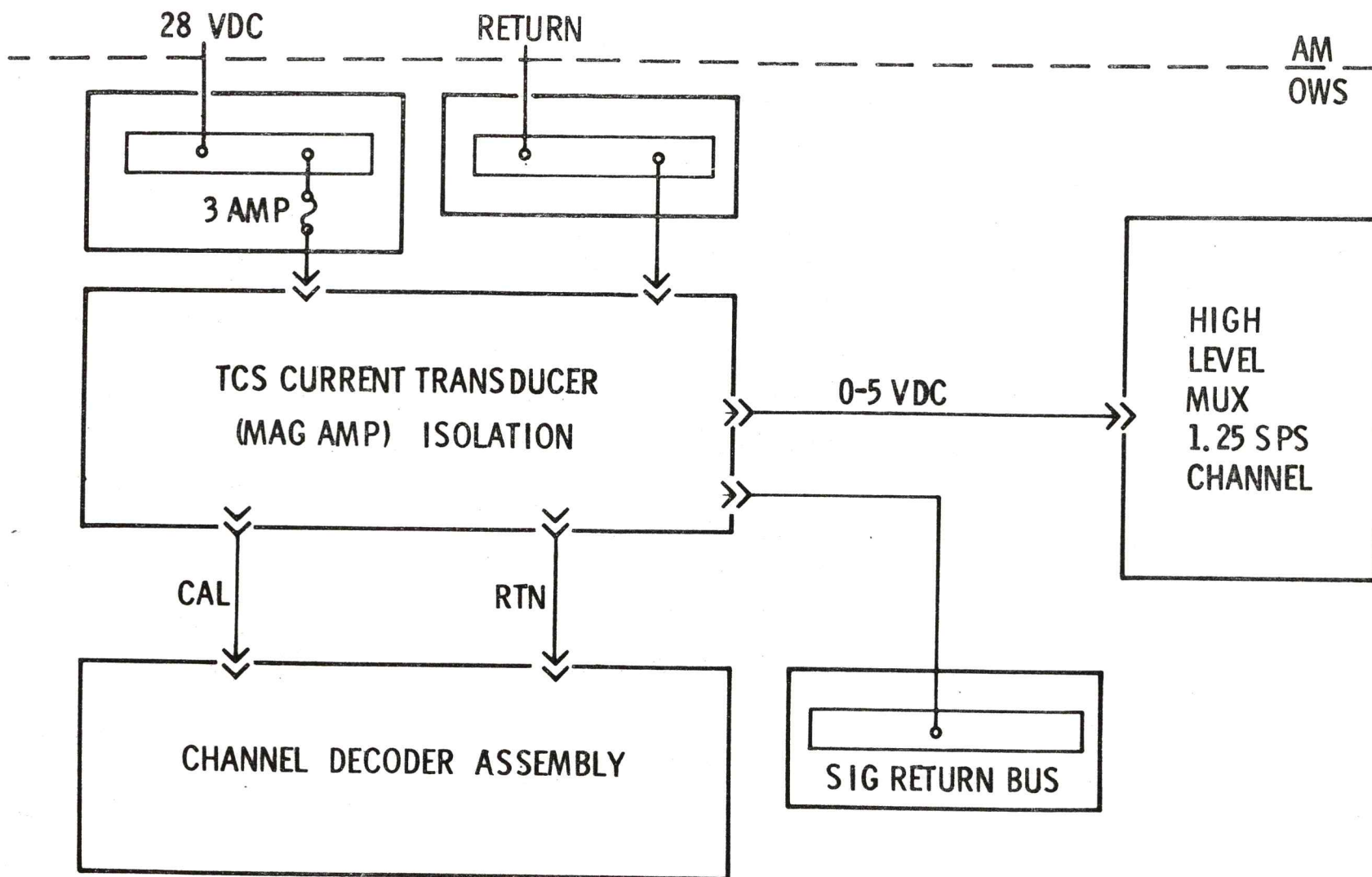


4-208

Figure 425-3. (Sheet 2 of 3)

ORBITAL WORKSHOP INSTRUMENTATION - CURRENT MEASUREMENT

O/W-4321
5-19-70



4-209

Figure 425-3. (Sheet 3 of 3)

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ORBITAL WORKSHOP REMOTE AUTOMATIC CALIBRATION SYS (RACS)

O/W-4327
6-18-70

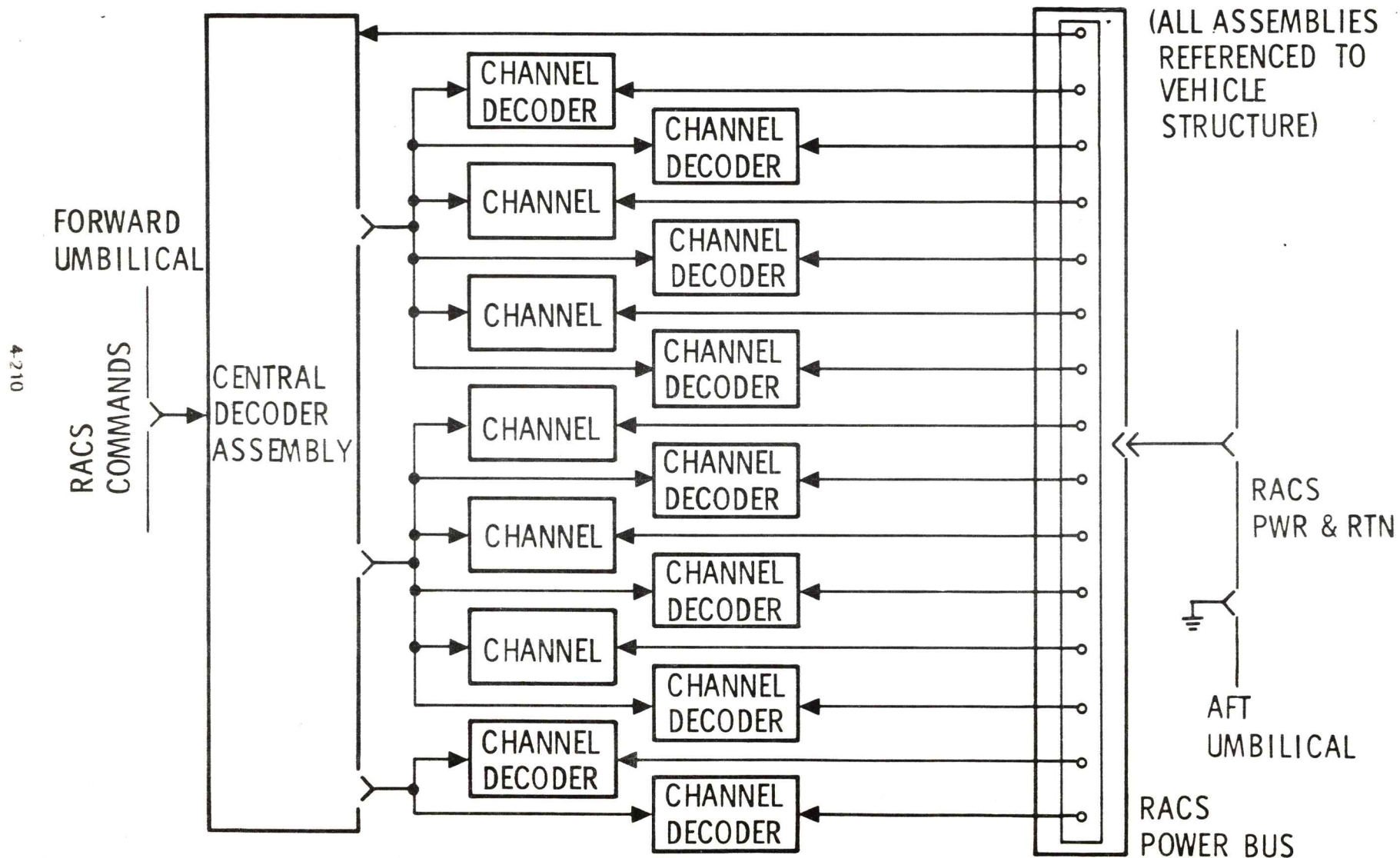


Figure 425-4.

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ORBITAL WORKSHOP CONTROL AND DISPLAY PANEL NO. 1 CAUTION/WARNING SYSTEM

O/W-5291
8-7-70

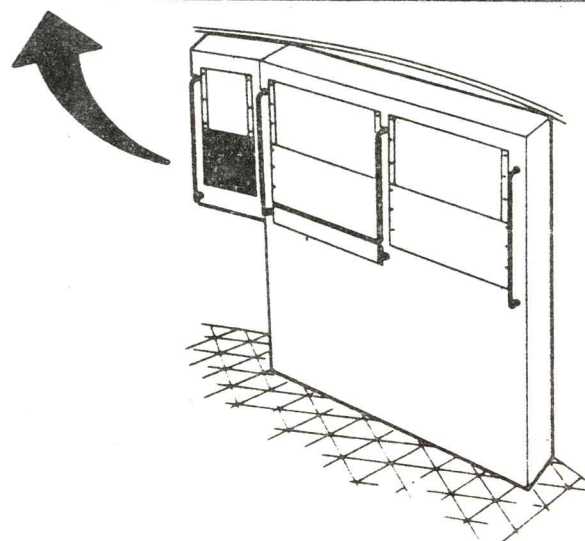
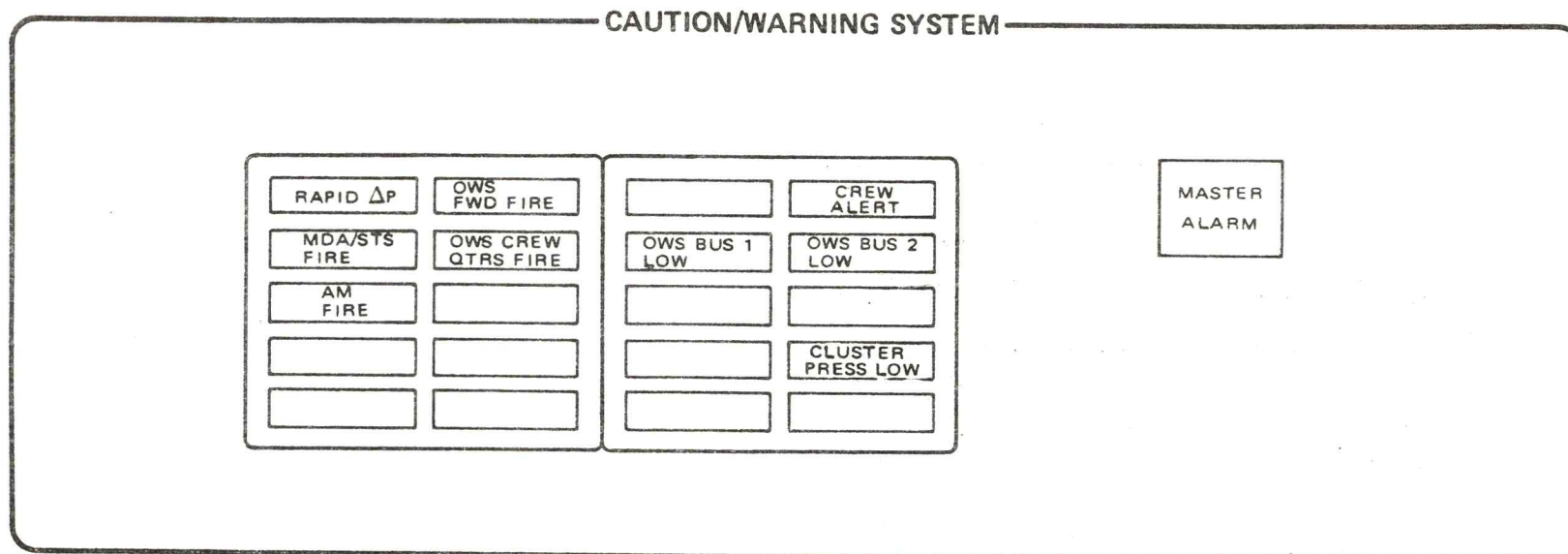


Figure 425-5.

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ORBITAL WORKSHOP CONTROL AND DISPLAY PANEL NO. 1 REFRIGERATION SYSTEM

O/W-7748
8-8-70

4-212

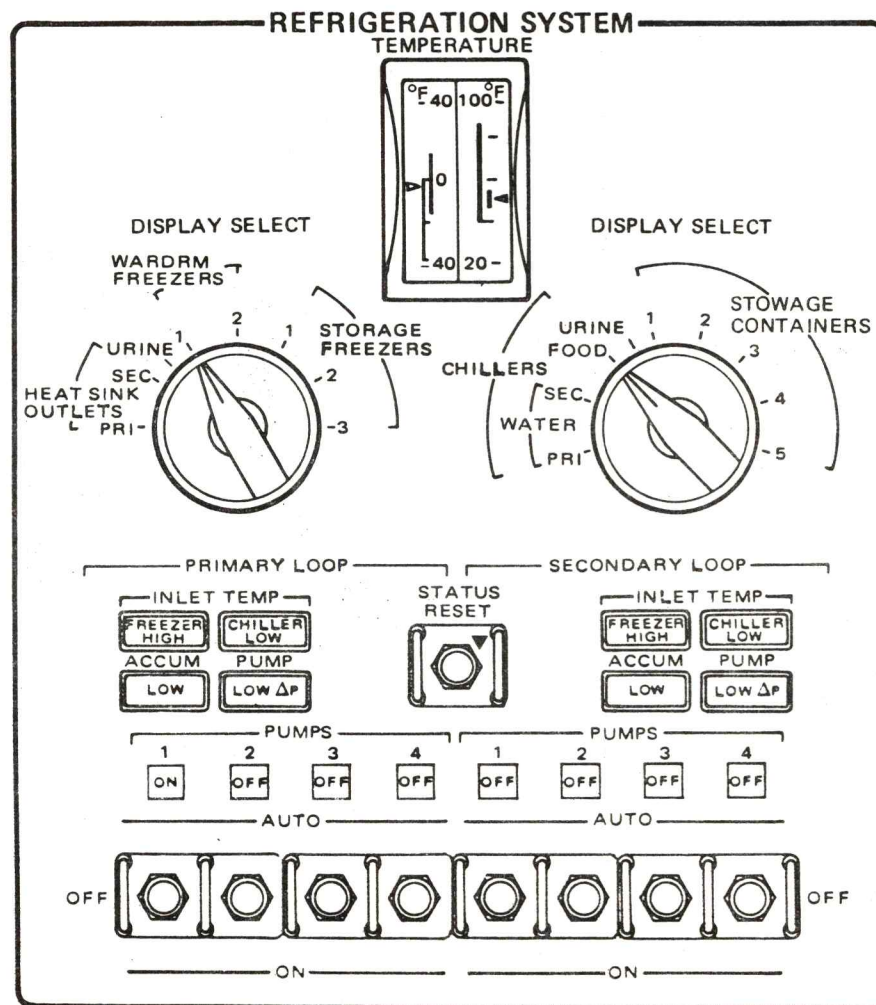
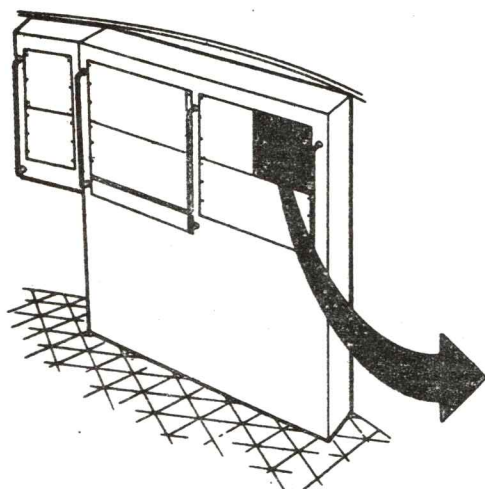


Figure 425-6.

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ORBITAL WORKSHOP CONTROL AND DISPLAY PANEL NO. 2 POWER

O/W-5298A
8-8-70

4-213

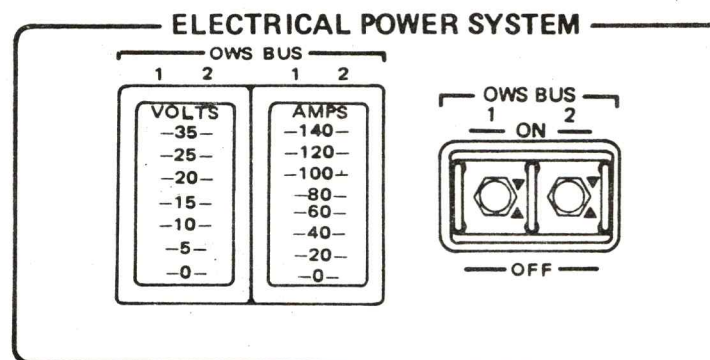
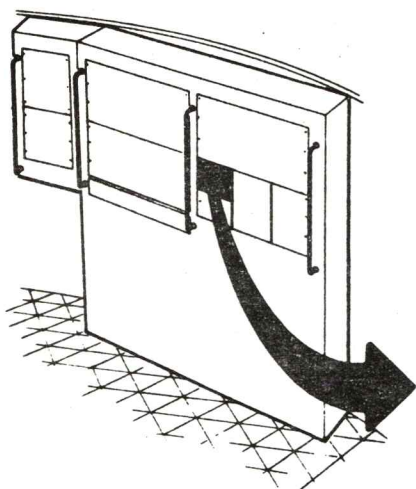


Figure 425-7.

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ORBITAL WORKSHOP CONTROL AND DISPLAY PANEL NO. 2 INSTRUMENTATION SYSTEM

O/W-5297A
8-8-70

4-214

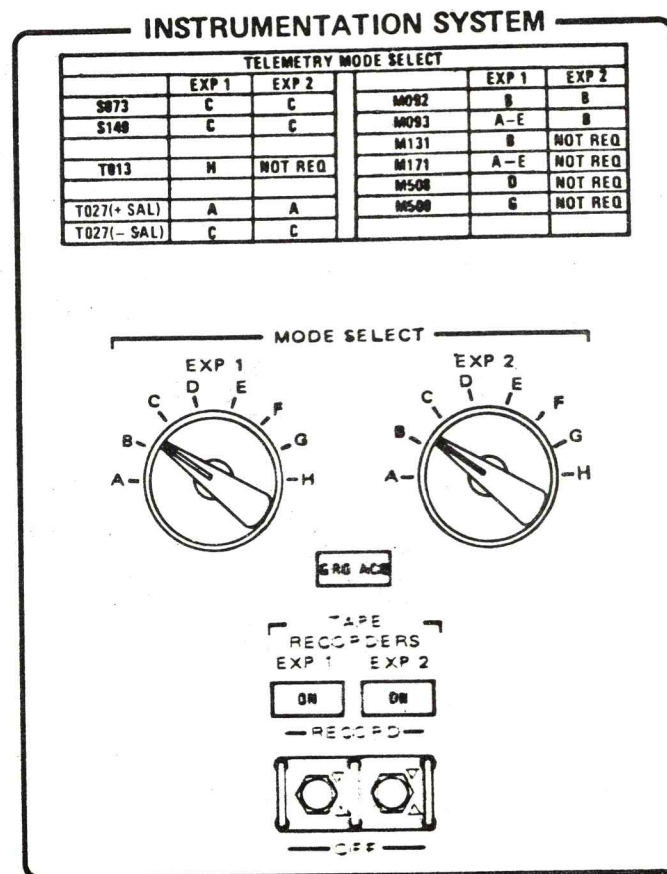
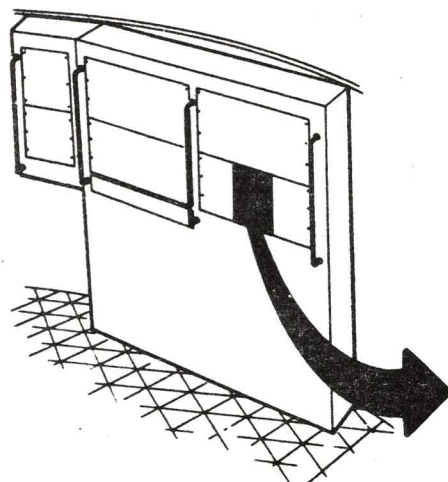
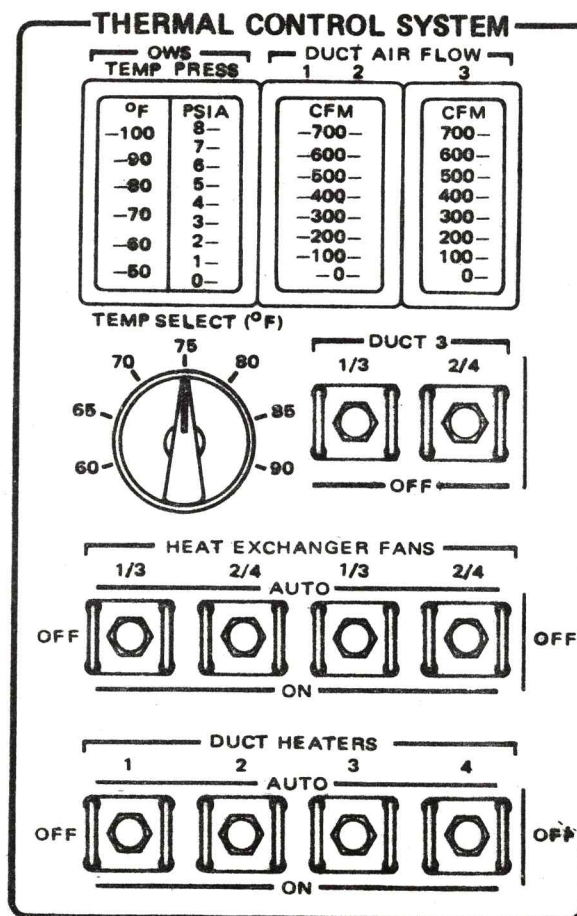


Figure 425-8.

**MCDONNELL
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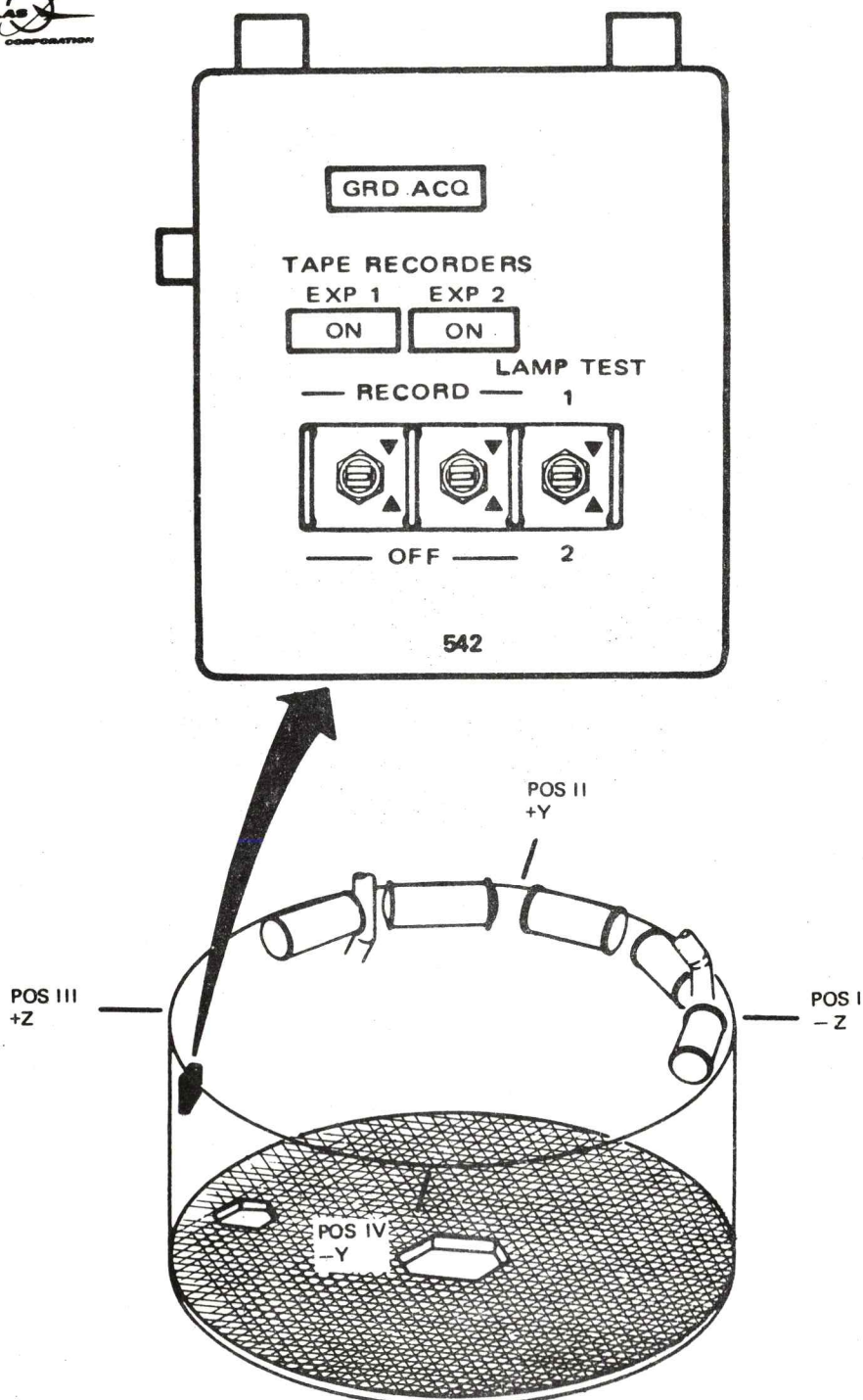
ORBITAL WORKSHOP CONTROL AND DISPLAY PANEL NO. 2 THERMAL CONTROL SYSTEM

**O/W-5296A
6-23-70**

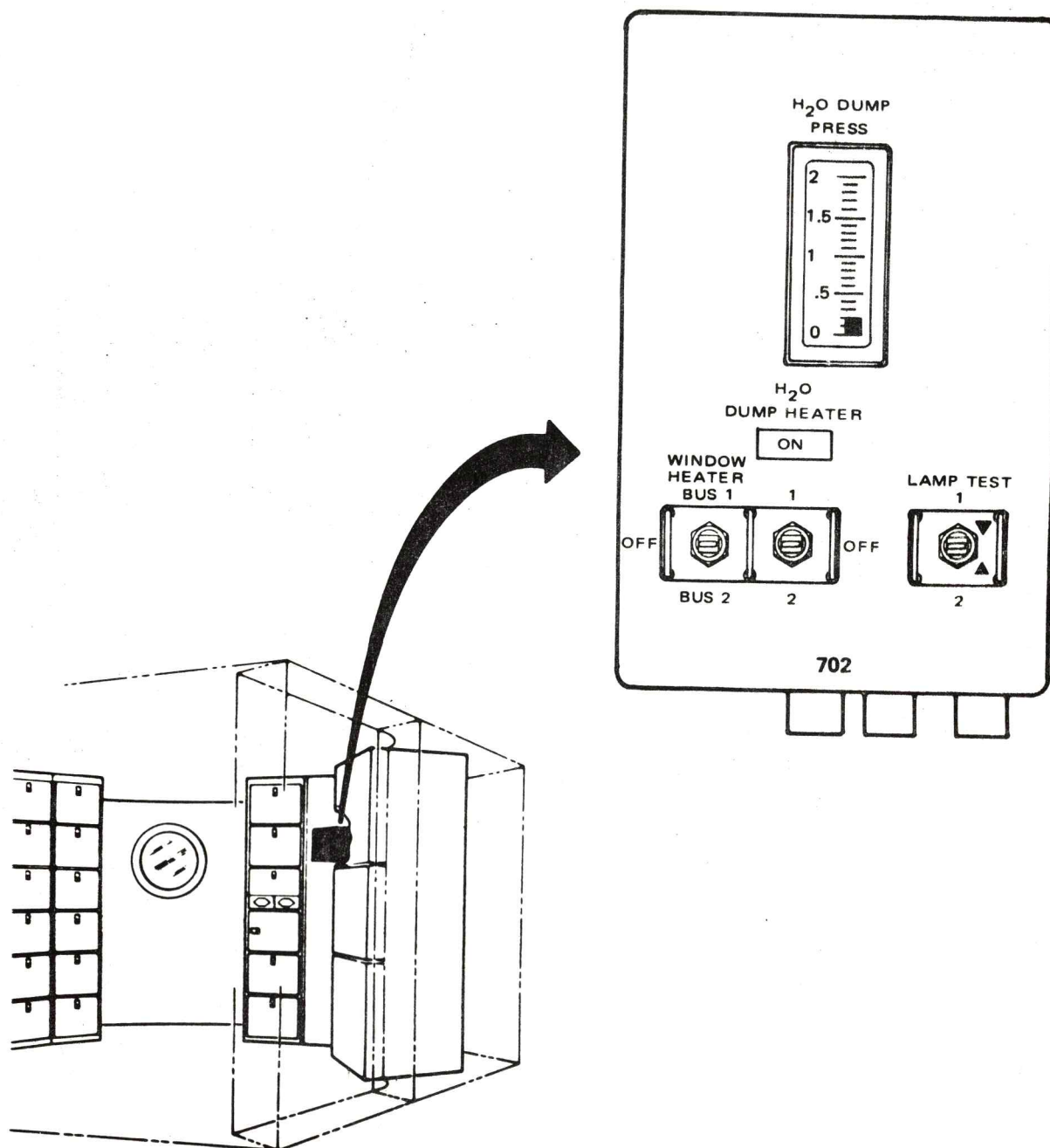


4-215

Figure 425-9.

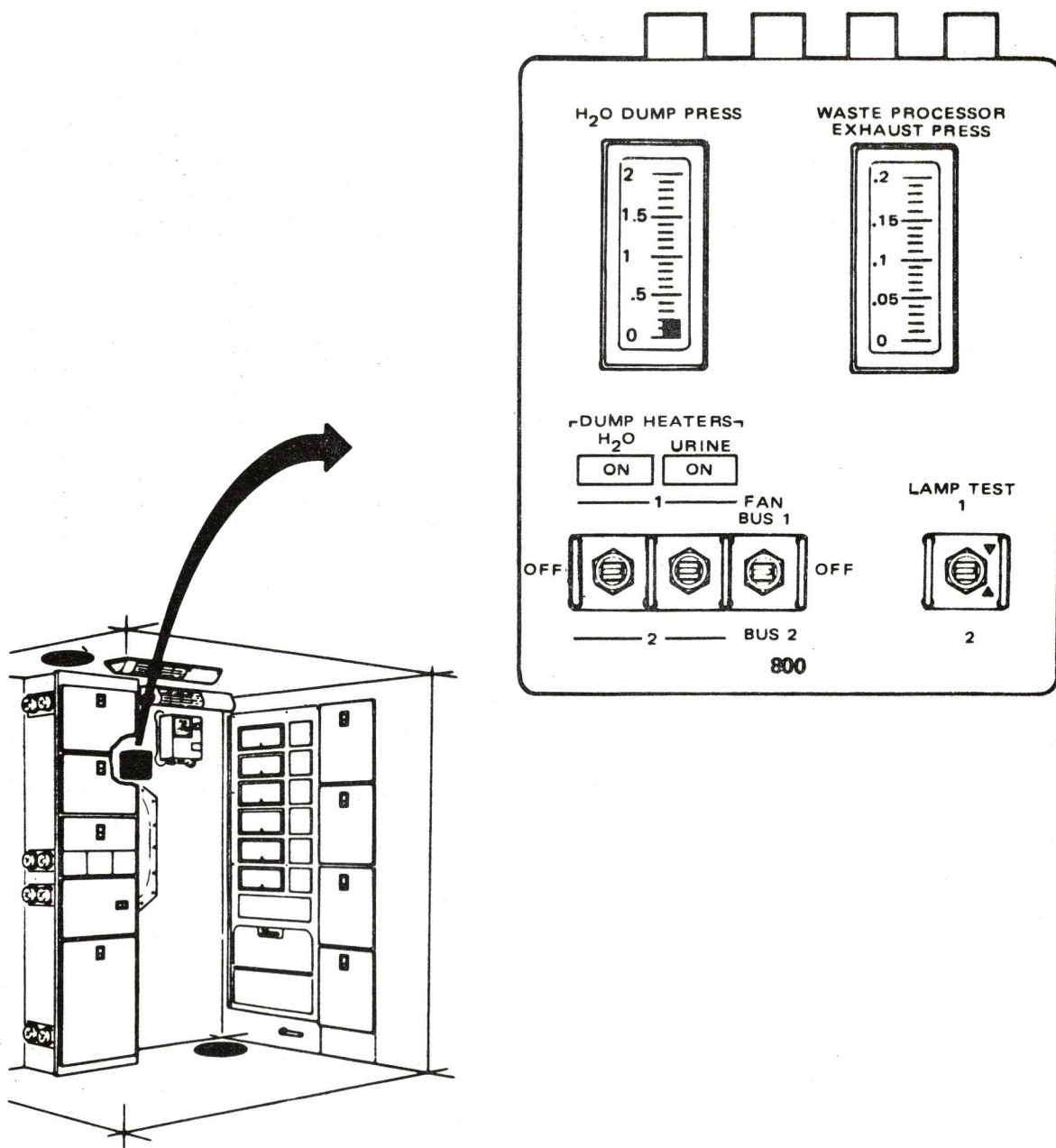


Forward Compartment Instrumentation Panel - 542



Wardroom Control and Display Panel - 702

Figure 425-11.



Waste Management Compartment Control and Display Panel - 800

Figure 425-12.

Table 425-1

Orbital Workshop On-Board Displays

| Title | Display Type | Location | Fig. No. |
|----------------------------------|-------------------|-----------------|----------|
| Emergency-Fire OWS Crew Quarters | Annunciator Light | C&D Panel No. 1 | 425-5 |
| Emergency-Fire OWS Fwd | Annunciator Light | C&D Panel No. 1 | 425-5 |
| Emergency-Fire AM | Annunciator Light | C&D Panel No. 1 | 425-5 |
| Emergency-Fire AM/STS | Annunciator Light | C&D Panel No. 1 | 425-5 |
| Emergency-Rapid P | Annunciator Light | C&D Panel No. 1 | 425-5 |
| Warning - Crew Alert | Annunciator Light | C&D Panel No. 1 | 425-5 |
| Caution - OWS Bus No. 1 Low | Annunciator Light | C&D Panel No. 1 | 425-5 |
| Caution - OWS Bus No. 2 Low | Annunciator Light | C&D Panel No. 1 | 425-5 |
| Caution - Cluster Pressure Low | Annunciator Light | C&D Panel No. 1 | 425-5 |
| Temp - Pri Loop Ht. Sink Outlet | Meter-Shared | C&D Panel No. 1 | 425-5 |
| Temp - Sec. Loop Ht. Sink Outlet | Meter-Shared | C&D Panel No. 1 | 425-6 |
| Temp - Wardroom Freezer No. 1 | Meter-Shared | C&D Panel No. 1 | 425-6 |
| Temp - Wardroom Freezer No. 2 | Meter-Shared | C&D Panel No. 1 | 425-6 |
| Temp - Stowage Freezer No. 1 | Meter-Shared | C&D Panel No. 1 | 425-6 |
| Temp - Stowage Freezer No. 2 | Meter-Shared | C&D Panel No. 1 | 425-6 |
| Temp - Stowage Freezer No. 3 | Meter-Shared | C&D Panel No. 1 | 425-6 |
| Temp - Pri Water Chiller | Meter-Shared | C&D Panel No. 1 | 425-6 |
| Temp - Sec. Water Chiller | Meter-Shared | C&D Panel No. 1 | 425-6 |
| Temp - Food Chiller | Meter-Shared | C&D Panel No. 1 | 425-6 |

Table 425-1

Orbital Workshop On-Board Displays (Continued)

| Title | Display Type | Location | Fig. No. |
|---------------------------------------|-------------------|-----------------|----------|
| Temp - Stowage Container No. 1 | Meter-Shared | C&D Panel No. 1 | 425-6 |
| Temp - Stowage Container No. 2 | Meter-Shared | C&D Panel No. 1 | 425-6 |
| Temp - Stowage Container No. 3 | Meter-Shared | C&D Panel No. 1 | 425-6 |
| Temp - Stowage Container No. 4 | Meter-Shared | C&D Panel No. 1 | 425-6 |
| Temp - Stowage Container No. 5 | Meter-Shared | C&D Panel No. 1 | 425-6 |
| Event - Pri - Freezer High Inlet Temp | Annunciator Light | C&D Panel No. 1 | 425-6 |
| Event - Sec. Freezer High Inlet Temp | Annunciator Light | C&D Panel No. 1 | 425-6 |
| Event - Pri - Chiller Low Inlet Temp | Annunciator Light | C&D Panel No. 1 | 425-6 |
| Event - Sec. - Chiller Low Inlet Temp | Annunciator Light | C&D Panel No. 1 | 425-6 |
| Event - Pri - Low Accum. Press. | Annunciator Light | C&D Panel No. 1 | 425-6 |
| Event - Sec. Low Accum. Press. | Annunciator Light | C&D Panel No. 1 | 425-6 |
| Event - Pri-RS Pump Low P | Annunciator Light | C&D Panel No. 1 | 425-6 |
| Event - Sec-RS Pump Low P | Annunciator Light | C&D Panel No. 1 | 425-6 |
| Voltage - OWS Bus No. 1 | Meter-Shared | C&D Panel No. 2 | 425-7 |
| Voltage - OWS Bus No. 2 | Meter-Shared | C&D Panel No. 2 | 425-7 |
| Current - OWS Bus No. 1 | Meter-Shared | C&D Panel No. 2 | 425-7 |
| Current - OWS Bus No. 2 | Meter-Shared | C&D Panel No. 2 | 425-7 |
| Event - Exp. No. 1 Tape Rec. ON | Annunciator Light | C&D Panel No. 2 | 425-8 |

Table 425-1

Orbital Workshop On-Board Displays (Continued)

| Title | Display Type | Location | Fig. No. |
|---------------------------------------|-------------------|----------------------------|----------|
| Event - Exp. No. 2 Tape Rec. ON | Annunciator | C&D Panel No. 2 | 425-9 |
| Flow - TCS Duct No. 1 | Meter | C&D Panel No. 2 | 425-9 |
| Flow - TCS Duct No. 2 | Meter | C&D Panel No. 2 | 425-9 |
| Flow - TCS Duct No. 3 | Meter | C&D Panel No. 2 | 425-9 |
| Pressure - OWS | Meter | C&D Panel No. 2 | 425-9 |
| Temperature - Crew Quarters | Meter | C&D Panel No. 2 | 425-9 |
| Event - Ground Acquisition | Annunciator Light | Fwd Compt. Instr. Panel | 425-10 |
| Event - Exp. No. 1 Tape Rec. ON | Annunciator Light | Fwd Compt. Instr. Panel | 425-10 |
| Event - Exp. No. 2 Tape Rec. ON | Annunciator Light | Fwd Compt. Instr. Panel | 425-10 |
| Pressure - H ₂ O Dump | Meter | Wardroom C&D Pnl. | 425-11 |
| Event - H ₂ O Dump Htr. ON | Annunciator Light | Wardroom C&D Pnl. | 425-11 |
| Pressure - H ₂ O Dump | Meter | Waste Mgt C&D Pnl. | 425-12 |
| Pressure - Waste Proc. Exhaust | Meter | Waste Mgt C&D Pnl. | 425-12 |
| Event - H ₂ O Dump Htr. ON | Annunciator Light | Waste Mgt C&D Pnl. | 425-12 |
| Event - Urine Dump Htr. ON | Annunciator | Waste Mgt C&D Pnl. | 425-12 |

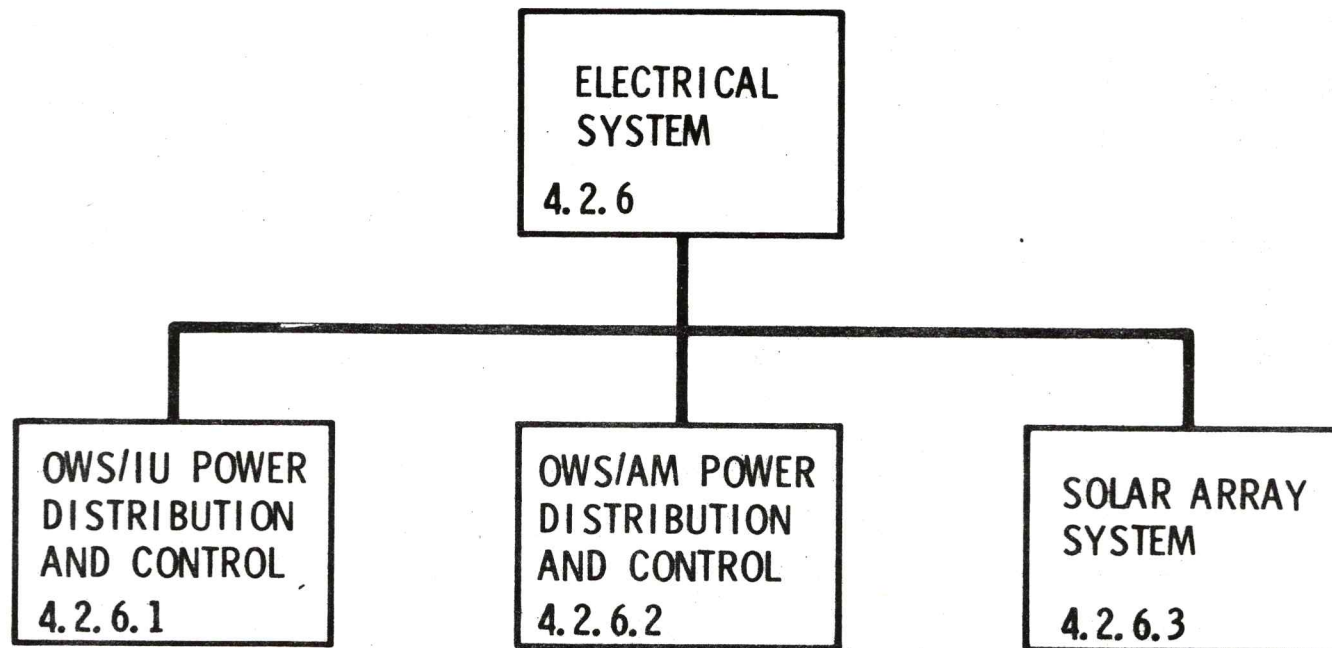
SOLAR ARRAY
SYSTEM

4.2.6.3

ELECTRICAL SYSTEM

ORBITAL WORKSHOP

O/W-7492
6-11-70



4-2222

4.2.6 Electrical System

The Electrical System provides the primary OWS power source and the distribution and control of IU/AM power and commands to OWS equipment and experiments. Electrical System inboard equipment locations are as shown in Figure 426-1. Electrical System outboard equipment locations are as shown in Figure 426-2.

4.2.6.1 OWS/IU Power Distribution and Control

This system provides power and control for OWS functions interfacing with the Instrument Unit (IU). These functions are as follows:

- Meteoroid Shield Deployment
- Solar Array Deployment
- TACS Control
- Atmosphere Control System
- Refrigeration System

This system is peculiar to the launch, ascent and early mission phase and has no function after IU shutdown (approximately 7.5 hours after liftoff).

The IU computer supplies digital information in parallel to the OWS Switch Selector, consisting of five address bits and eight data bits. The Switch Selector sends the data word it has received back to the computer for verification. If valid, the computer sends execute; if invalid, the computer sends the compliment which the Switch Selector interprets as a valid word and the computer follows with execute. The OWS Switch Selector is powered from AM Bus 2.

The electrical interface between the OWS and the IU is contained in Drawing 40M30597.

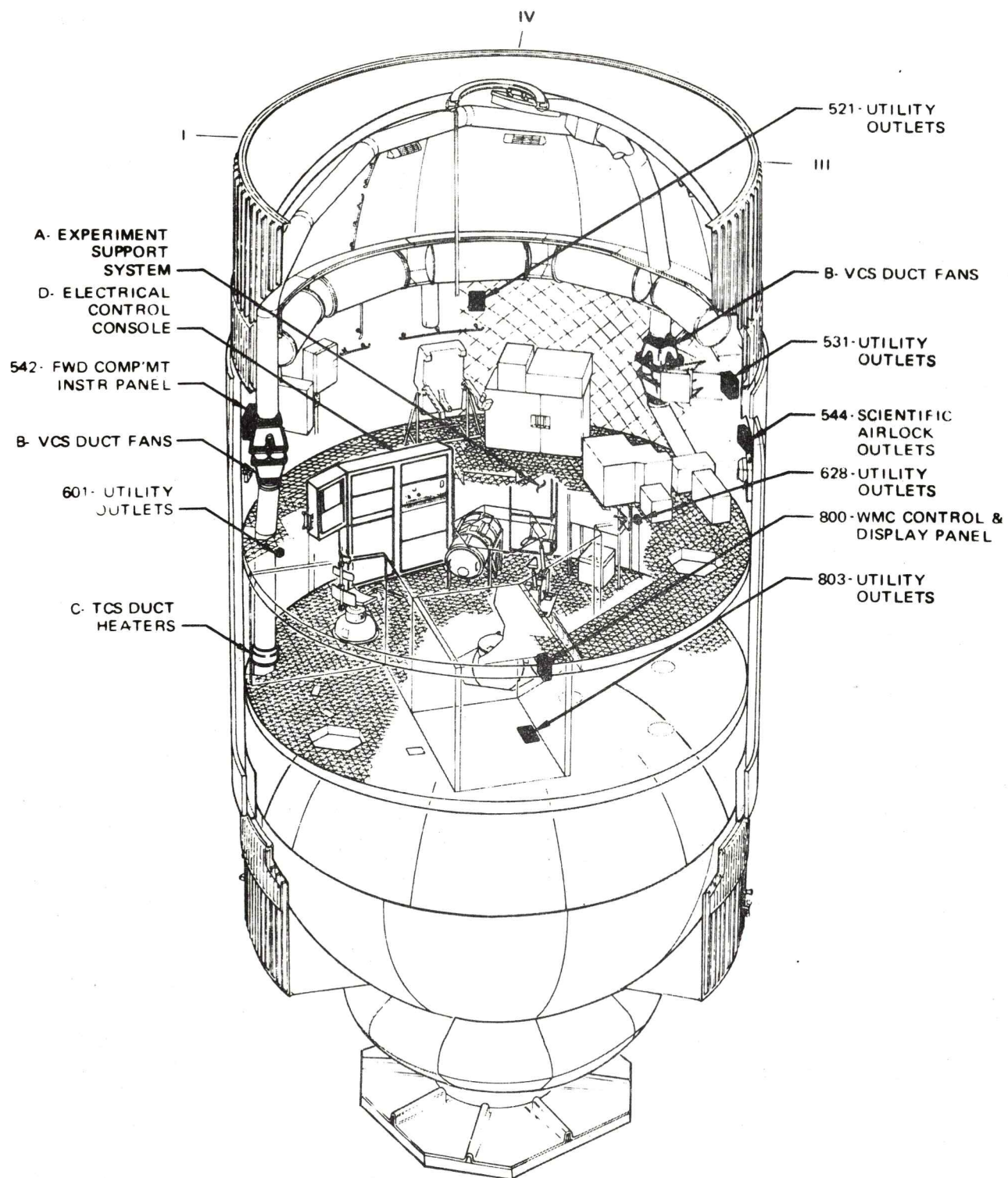
Electrical isolation is maintained between this system and the OWS/AM system. (Figure 426-3). AM power is used for all OWS loads. Isolation is accomplished via the Switch Selector or Control Switching Assembly.

4.2.6.2 OWS/AM Electrical Power Distribution and Control

This section delineates the electrical design and equipment within the OWS, which provides the electrical power and control to support crew accommodations, habitability support, illumination, atmosphere control, communications, data, refrigeration, and corollary experiment systems.

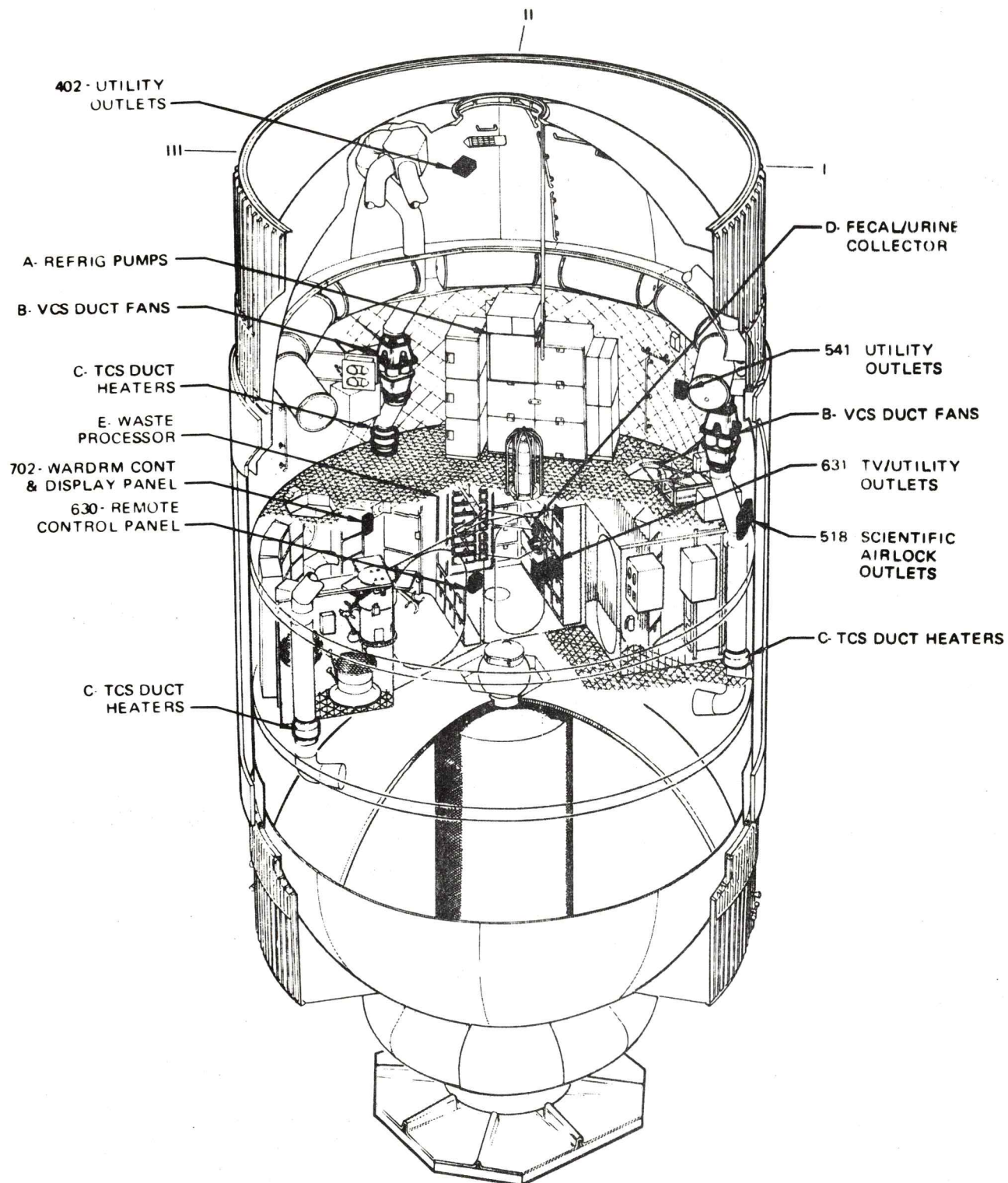
Electrical power distribution for the thruster attitude control, solar array, and data systems, which are external, are also covered.

The Electrical Power Distribution System receives control power and instrumentation power from the cluster electrical power system via the AM (Figure 426-4). The AM provides power to the AM/OWS interface in accordance with CP2080J1C. When supplied with 25.5 volts at the AM interface, the OWS buses distribute 108 amperes at 24 volts to the loads. Each bus is capable of delivering 76 amperes to the loads in a one-bus-out contingency mode. Power to the OWS buses from the AM is controlled by the DCS and by manually operated switches



Orbital Workshop - Electrical Equipment Inboard Locations

Figure 426-1. (Sheet 1 of 2)



Orbital Workshop - Electrical Equipment Inboard Locations

Figure 426-1. (Sheet 2 of 2)

ORBITAL WORKSHOP ELECTRICAL EQUIPMENT LOCATIONS - FWD SKIRT

O/W-8878
8-6-70

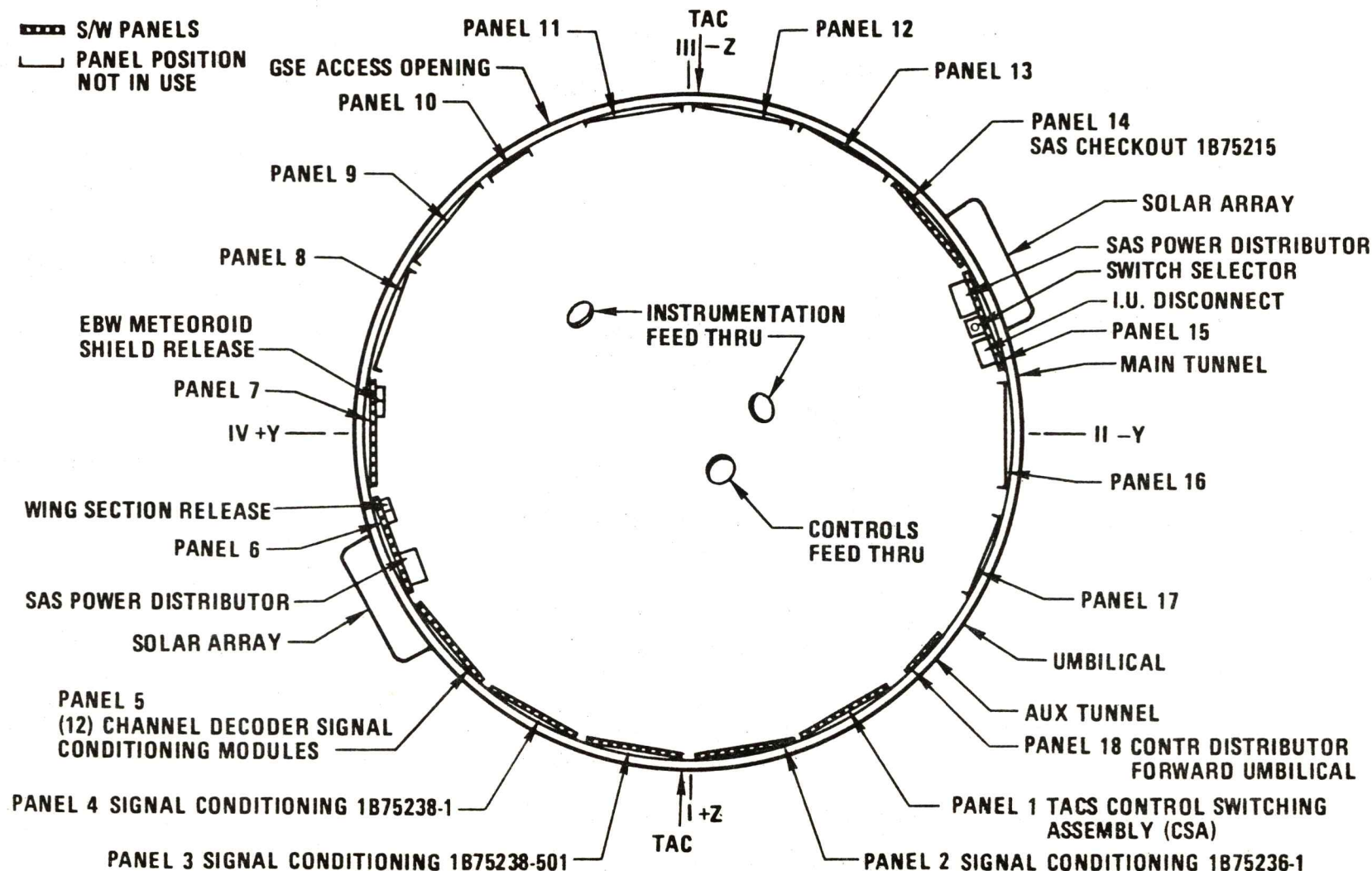


Figure 426-2. (Sheet 1 of 2)

ORBITAL WORKSHOP ELECTRICAL EQUIPMENT LOCATIONS - AFT SKIRT

O/W-8879
8-6-70

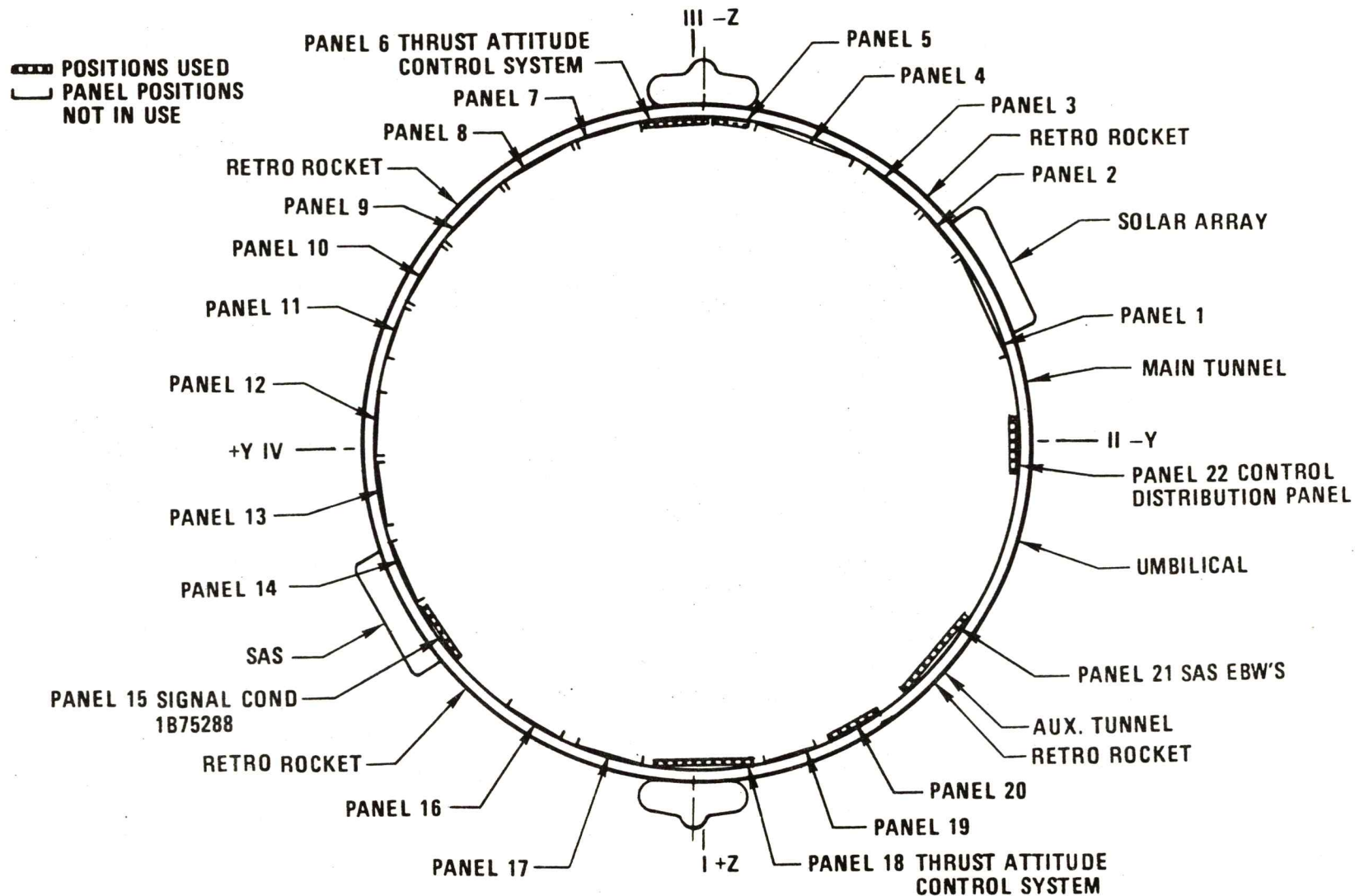


Figure 426-2. (Sheet 2 of 2)

ORBITAL WORKSHOP OWS/IU POWER DISTRIBUTION AND CONTROL SYSTEM

O/W-8876
8-6-70

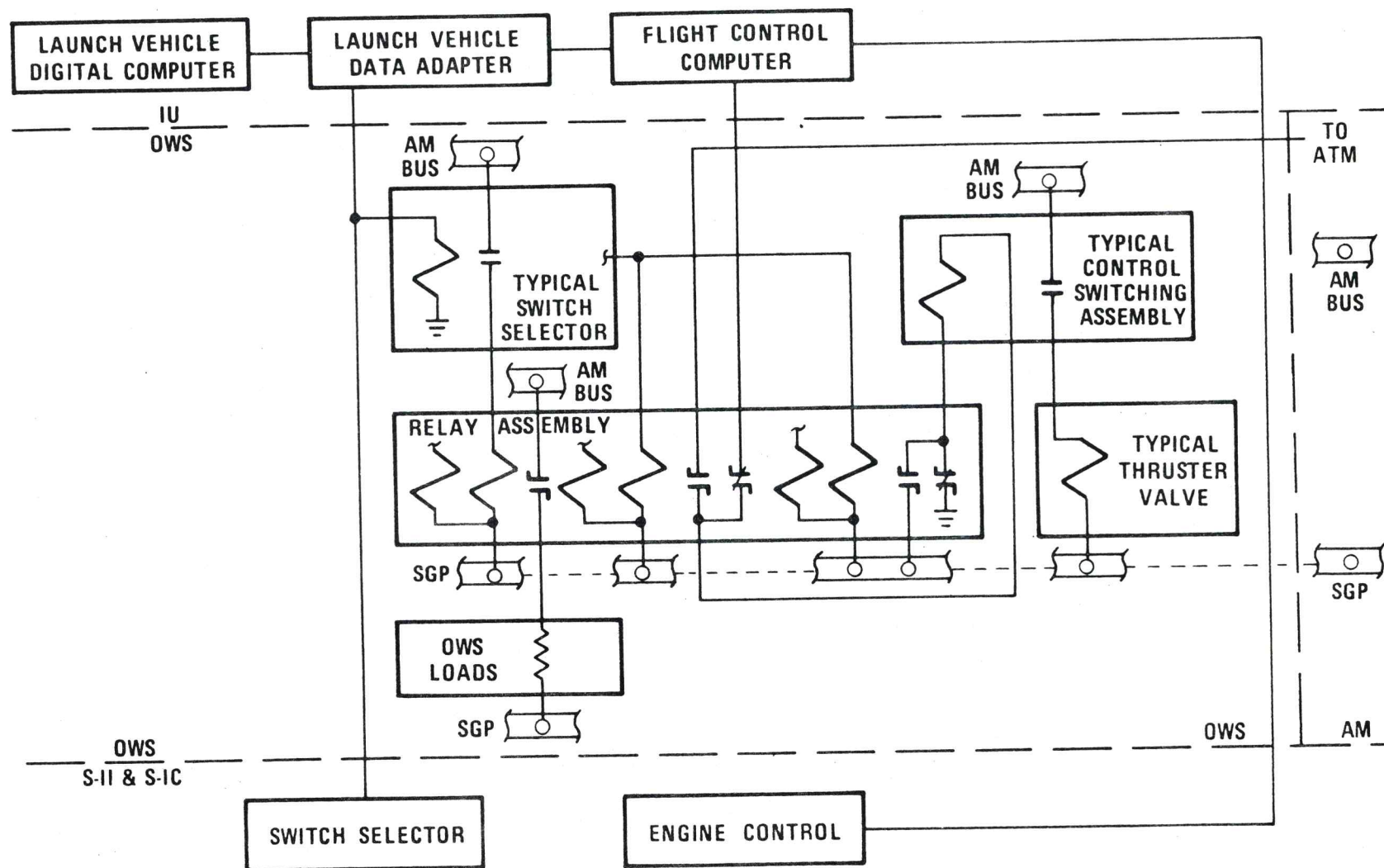


Figure 426-3.

ORBITAL WORKSHOP AIRLOCK MODULE ELECTRICAL POWER INTERFACES

O/W-7371
5-7-70

4-229

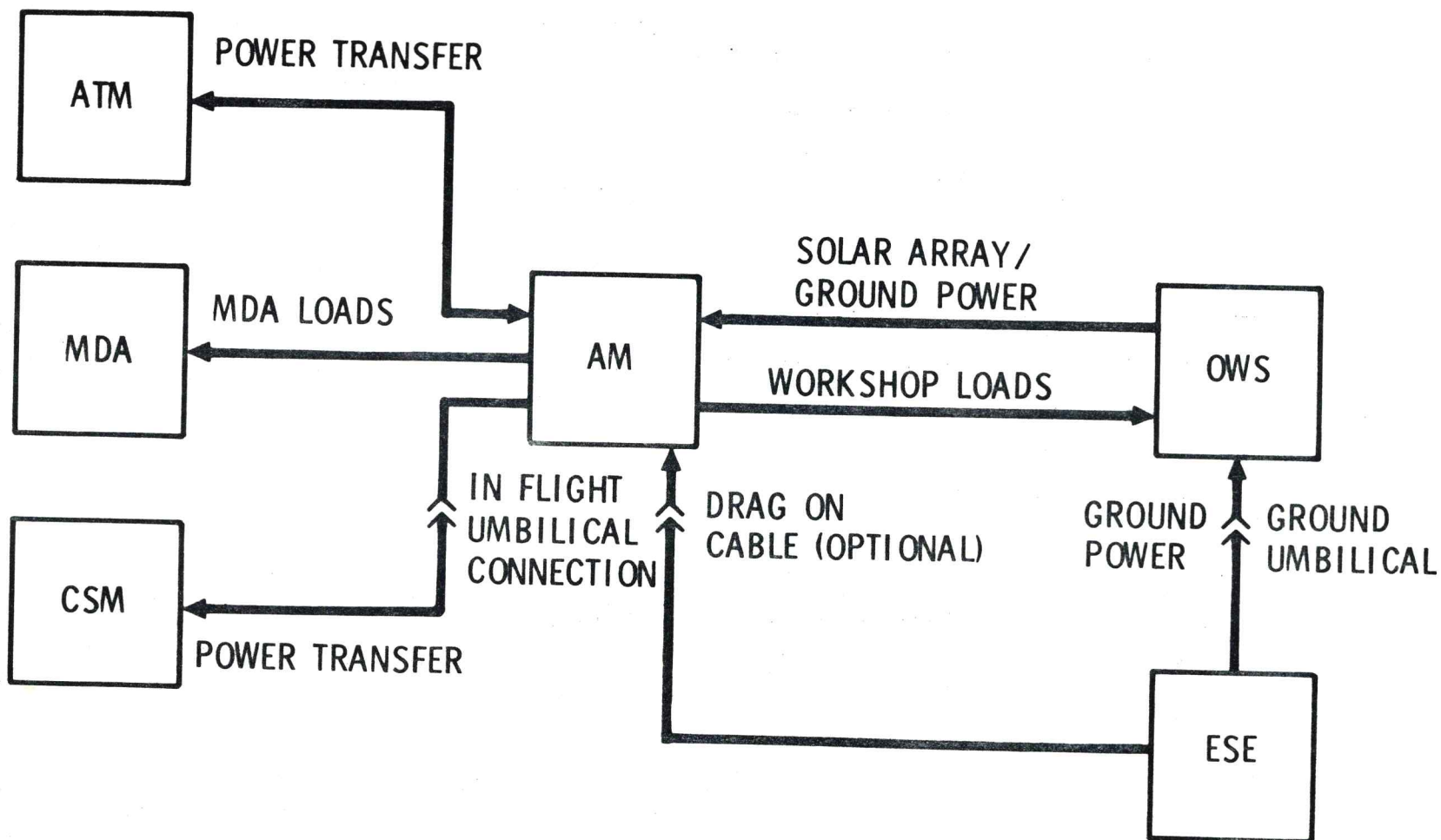


Figure 426-4. (Sheet 1 of 3)

ORBITAL WORKSHOP ELECTRICAL POWER DISTRIBUTION SYSTEM CLUSTER

O/W-7372
8-6-70

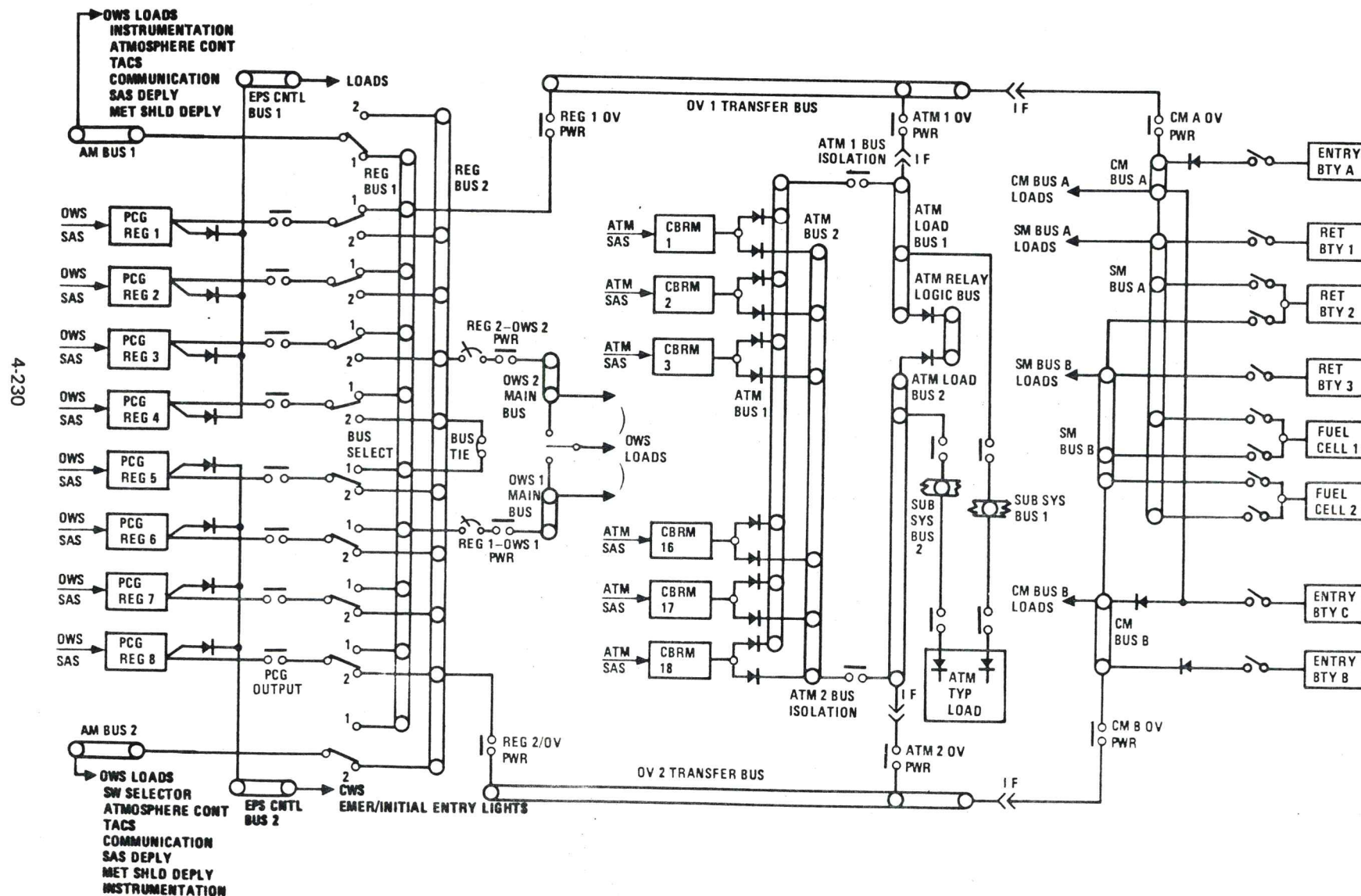


Figure 426-4. (Sheet 2 of 3)

ORBITAL WORKSHOP ELECTRICAL POWER DISTRIBUTION SYSTEM

O/W-7766
7-14-70

4-231

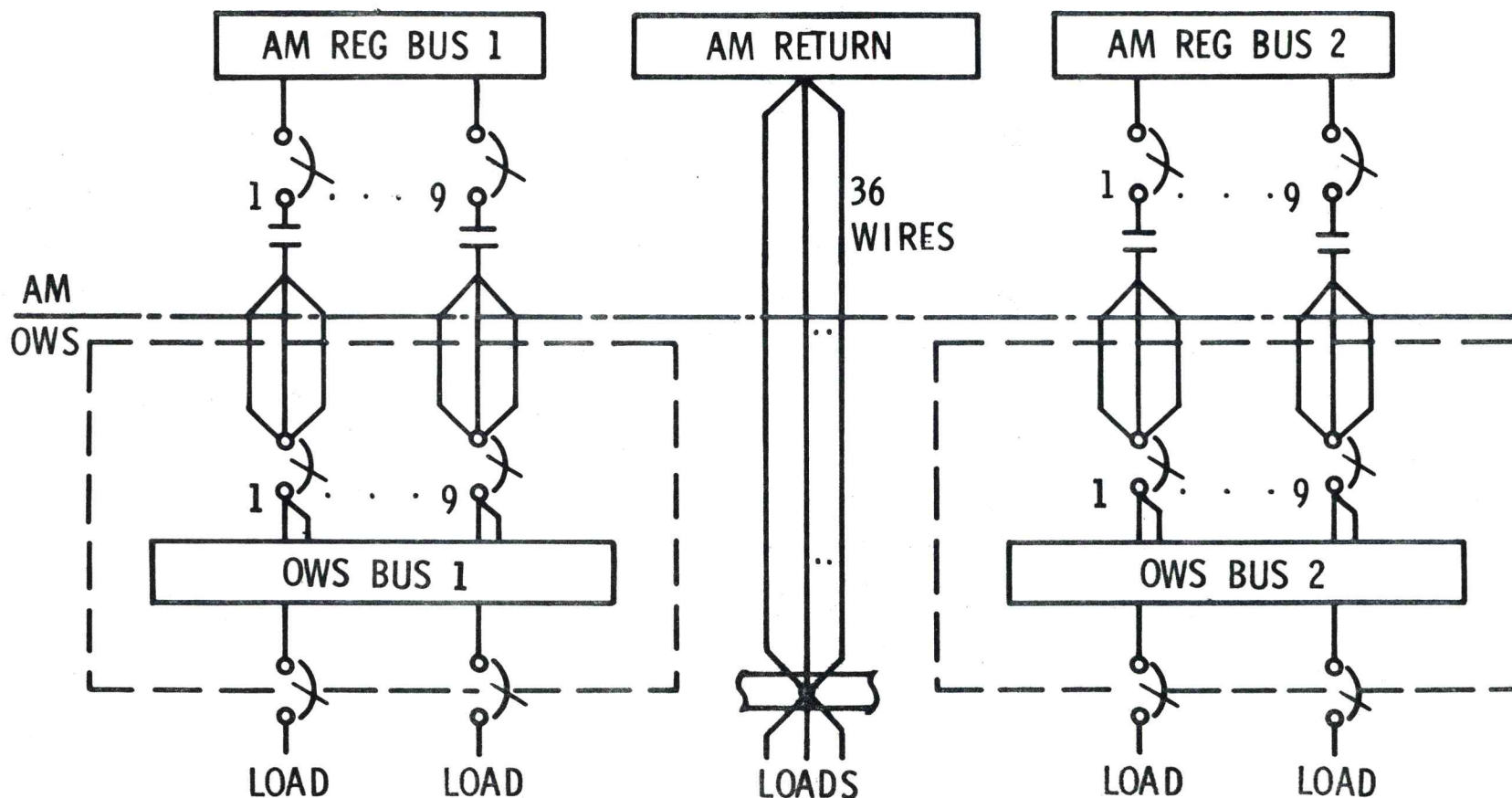


Figure 426-4. (Sheet 3 of 3)

on the STS Instrumentation Panel and the OWS Control and Display Panel. This power is distributed throughout the OWS to allow operation of the OWS Systems. Typical schematics are shown in Figure 426-5. The main control console (Figure 426-6) is located in the experiment compartment. This console contains all necessary switches, circuit breakers and indicators to allow crew control of the OWS Electrical Power and Control Systems. There is no crew interface with the Instrumentation Power System. Remote control panels for illumination, (Figure 426-7), habitability support (Figure 426-8 and 426-9) and recorders (Figure 426-10) are also provided at convenient locations.

A listing of the OWS components receiving power from the different AM buses and not from the OWS electrical control console is contained in Table 426-1.

A listing of the OWS components receiving power from the OWS buses and distributed from the electrical control console is contained in Table 426-2.

All power wiring is protected by circuit breakers. The distribution system is designed with the following characteristics:

- a. The voltage drop within the OWS does not exceed 1.5 volts.
- b. All wiring using AM power is protected by circuit breakers.
- c. Power-return circuits are isolated from OWS structure ground.
- d. Two-wire circuits are employed.
- e. The single-point ground is in the AM or Command and Service Module (CSM).
- f. Utility outlets are provided for fans, lights, heaters, cameras, experiments, etc.
- g. The utility receptacles are of a common design to allow for interchangeability of equipment, i.e., fans, lights, and cameras.
- h. The internal OWS power wiring is protected to prevent physical damage by the crew.
- i. All wire harnesses carrying different AM bus power are physically and electrically isolated.
- j. Procedural means for removing power from the OWS receptacles is employed.
- k. The OWS connectors are designed to preclude the occurrence of electrical arcing when the crew is mating and unmating electrical equipment.

ORBITAL WORKSHOP POWER BUSES AND TYPICAL LOADS

O/W-8877
8-6-70

4-233

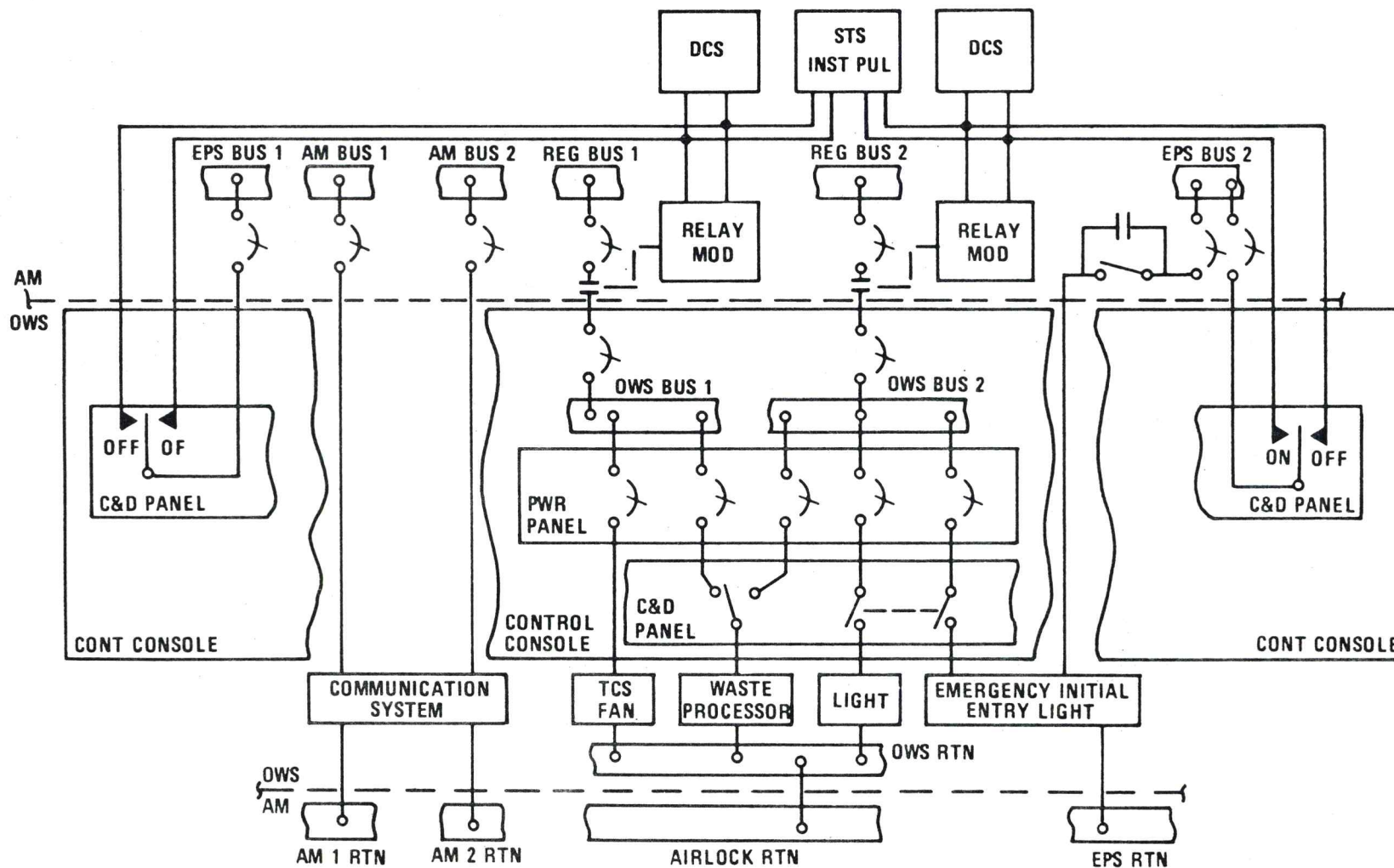
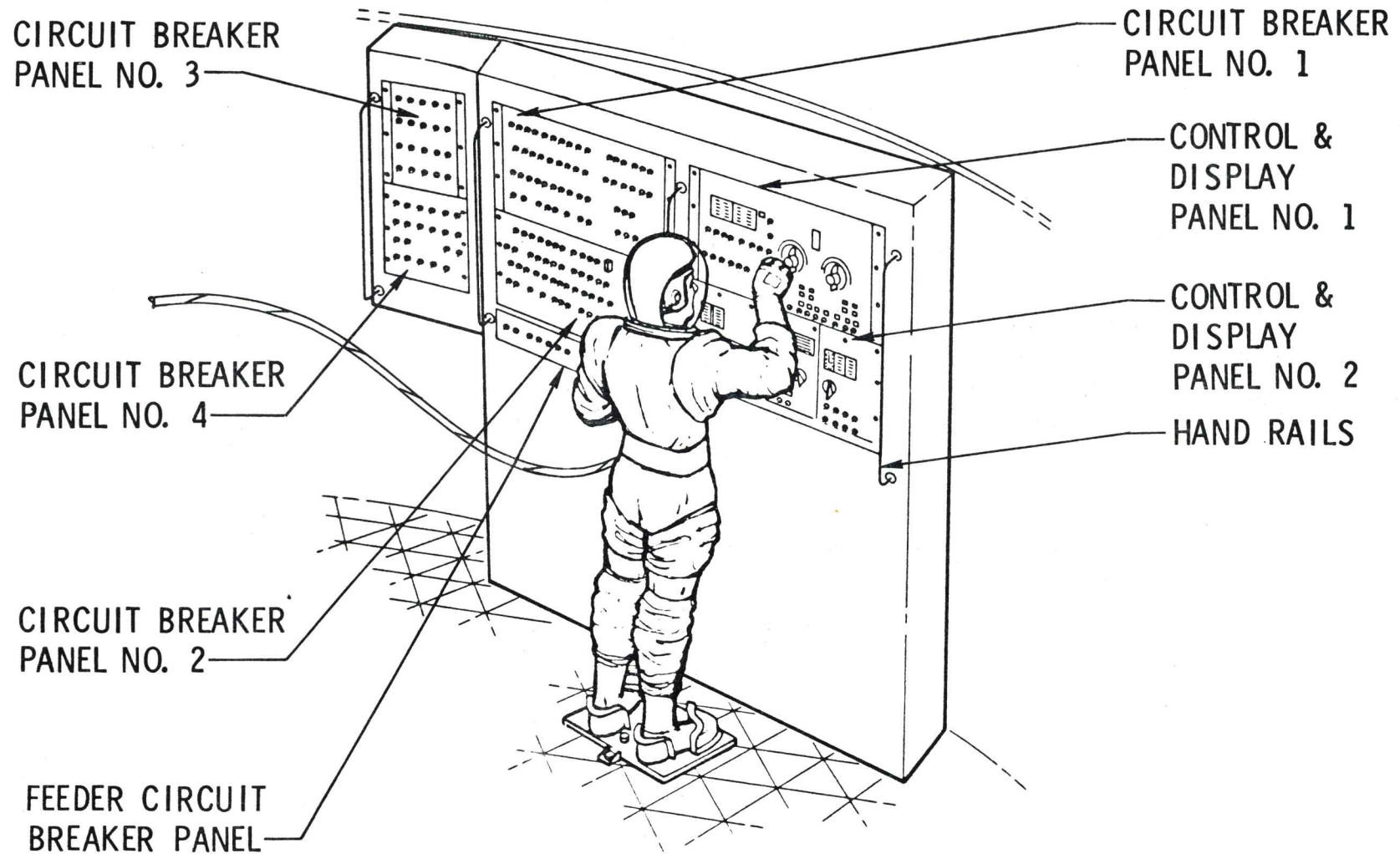


Figure 426-5.

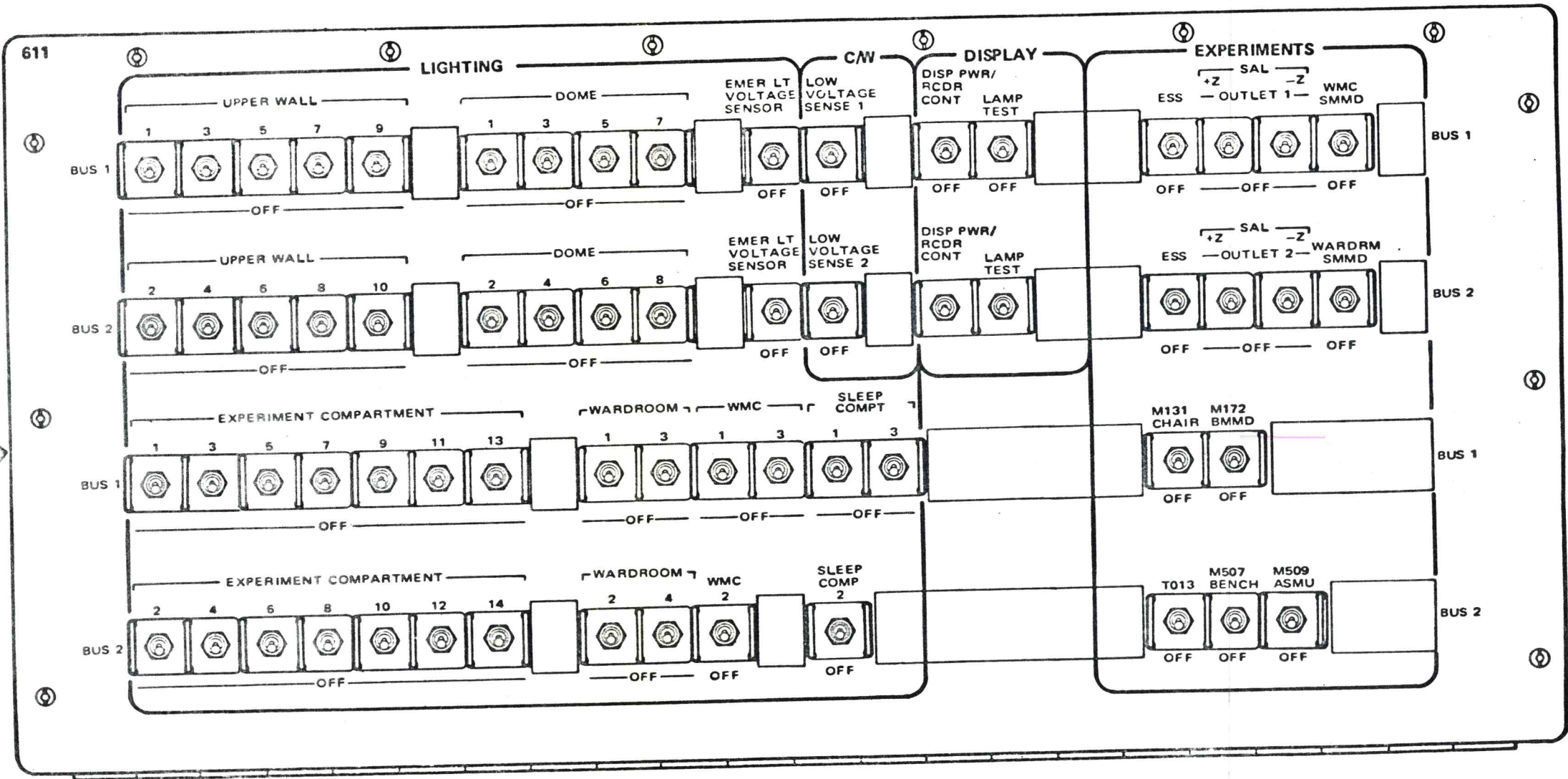
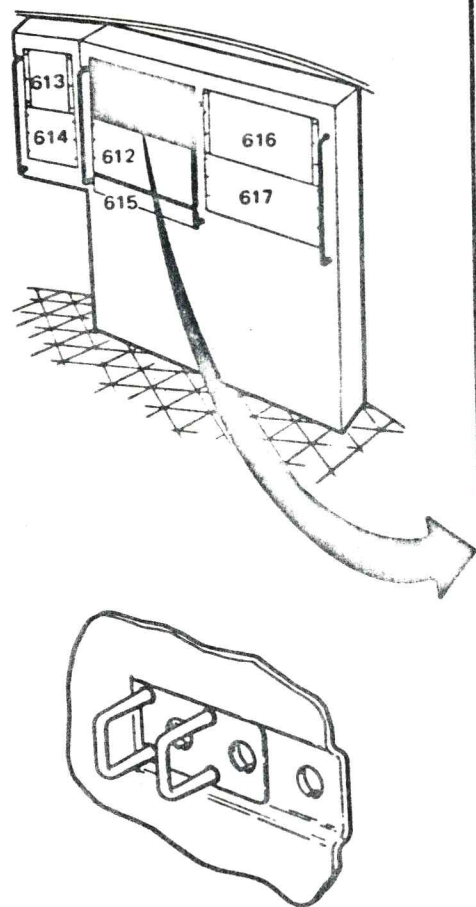
ORBITAL WORKSHOP ELECTRICAL CONTROL CONSOLE

O/W-4241
8-8-70



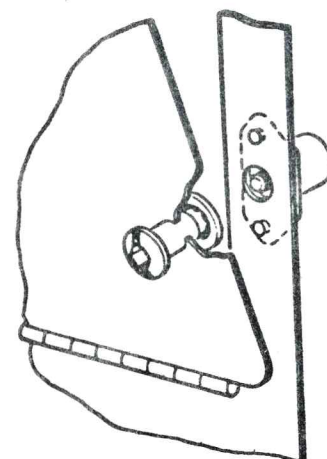
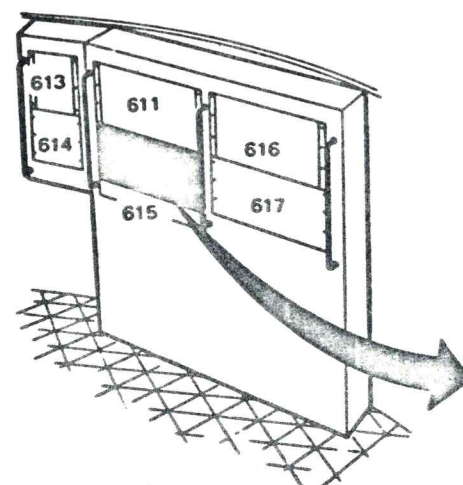
4-234

Figure 426-6. (Sheet 1 of 8)

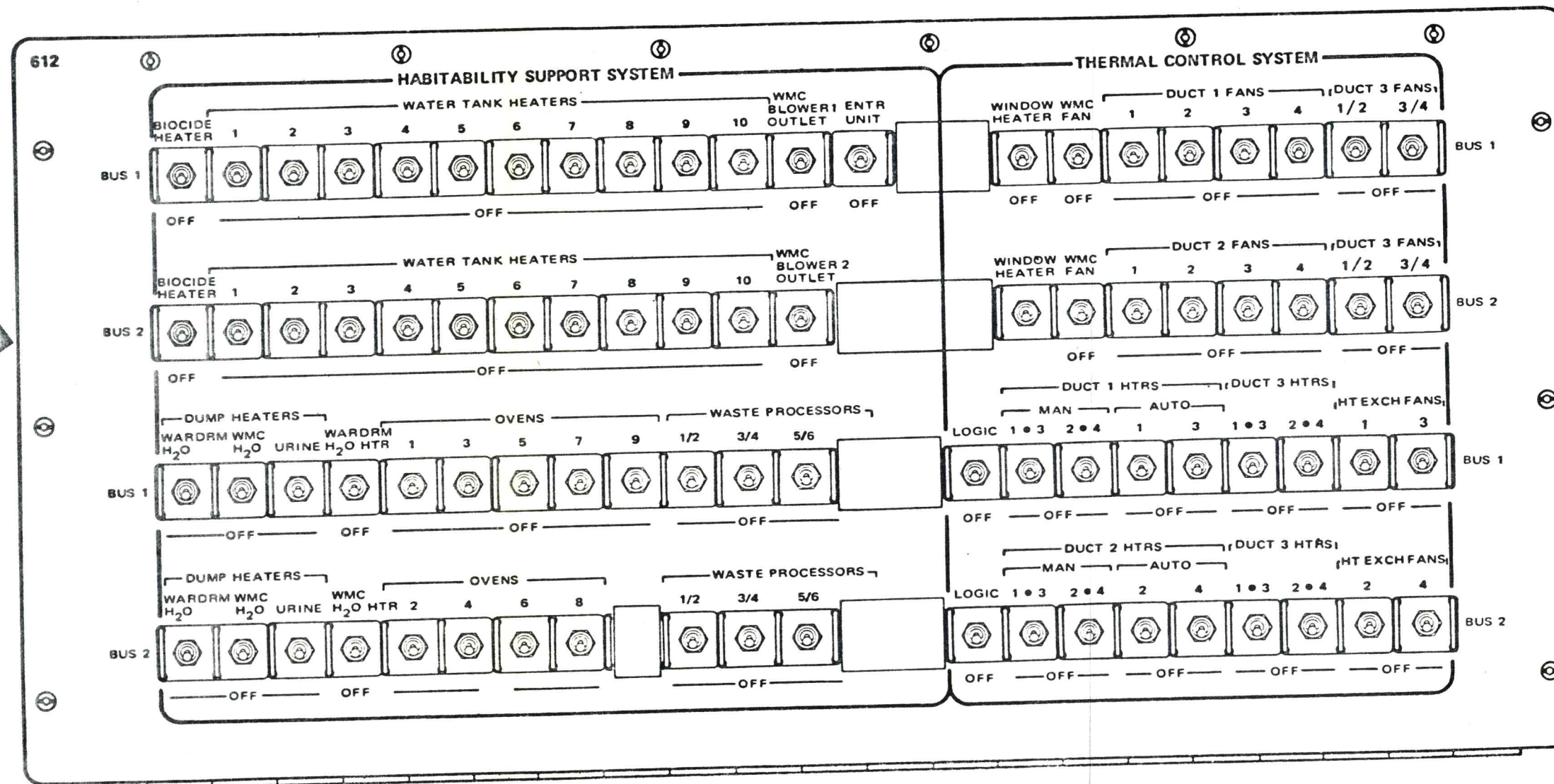


Circuit Breaker Panel No. 1 - 611

Figure 426-6. (Sheet 2 of 8)

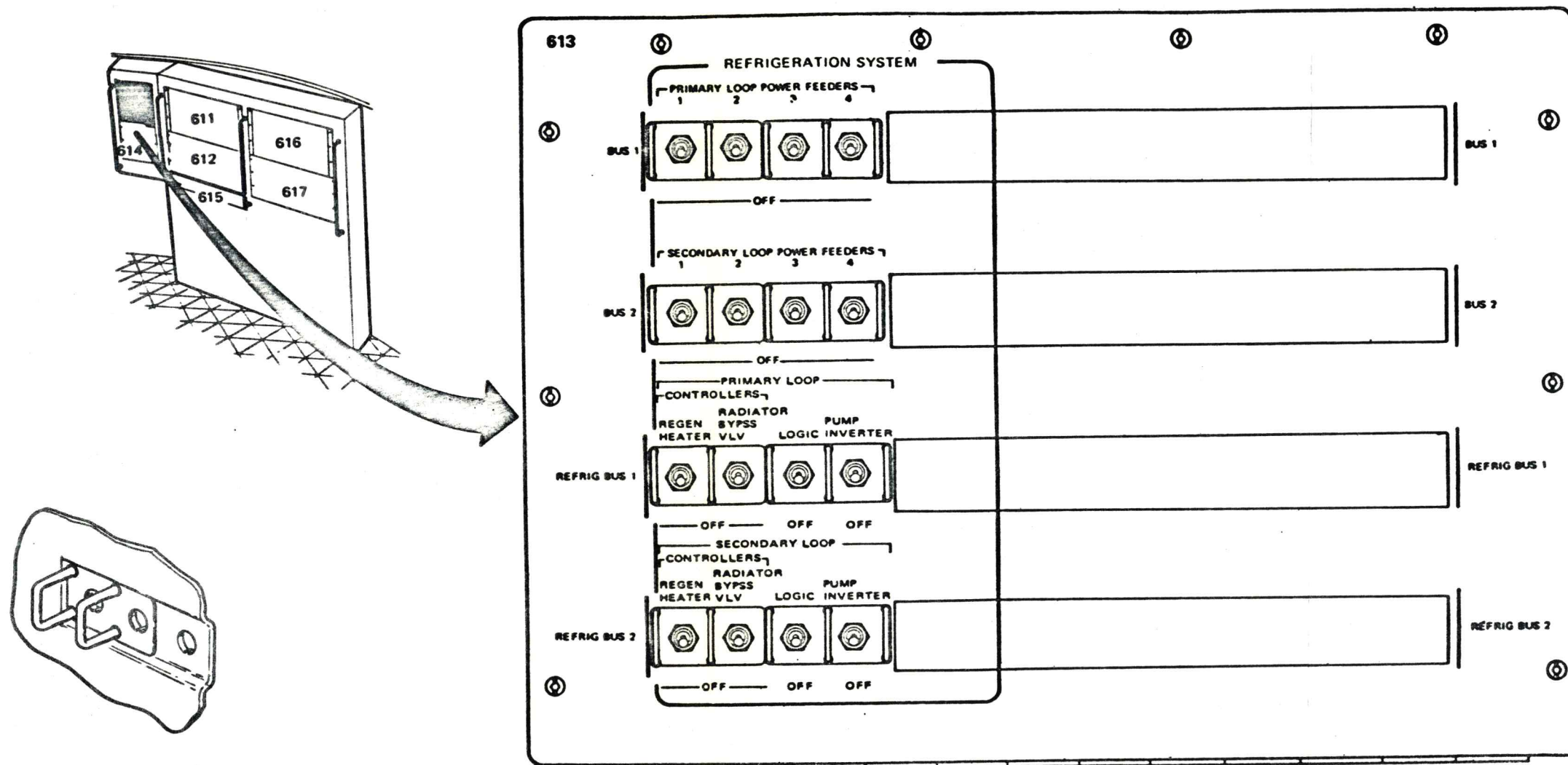


CAPTIVE FASTENER



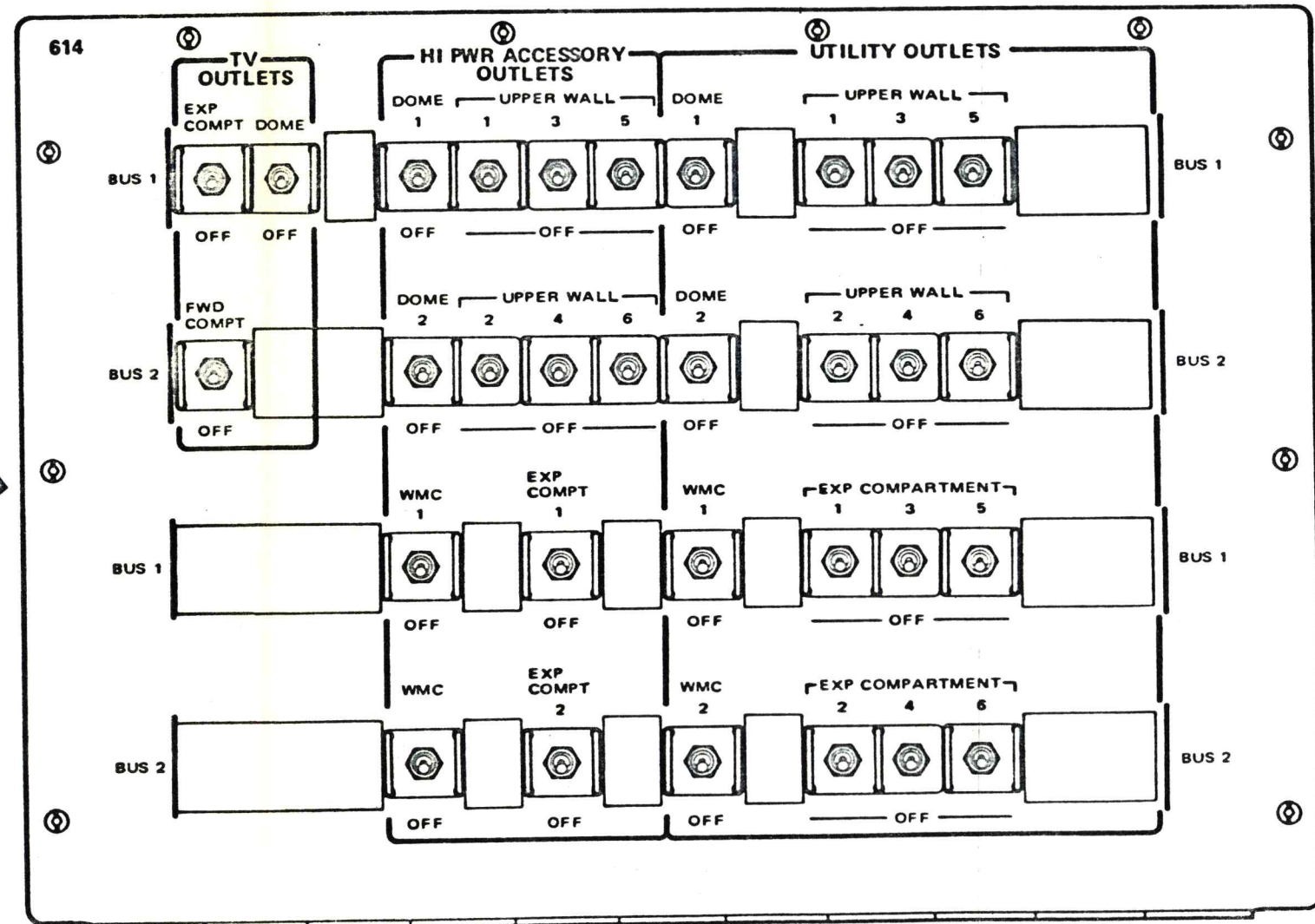
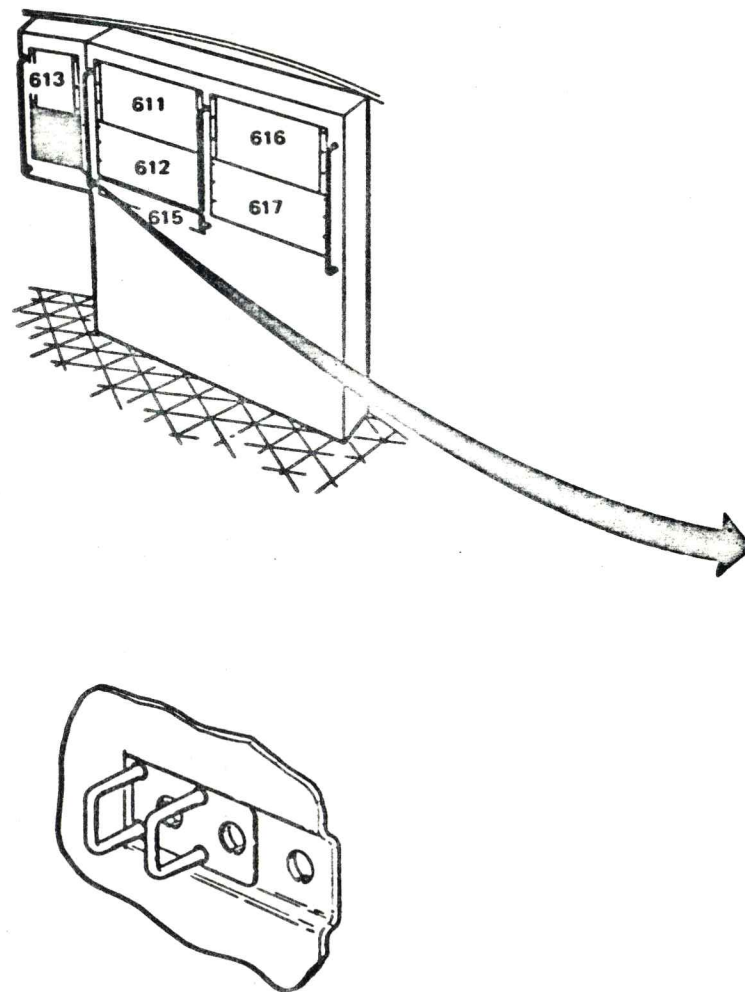
Circuit Breaker Panel No. 2 - 612

Figure 426-6. (Sheet 3 of 8)

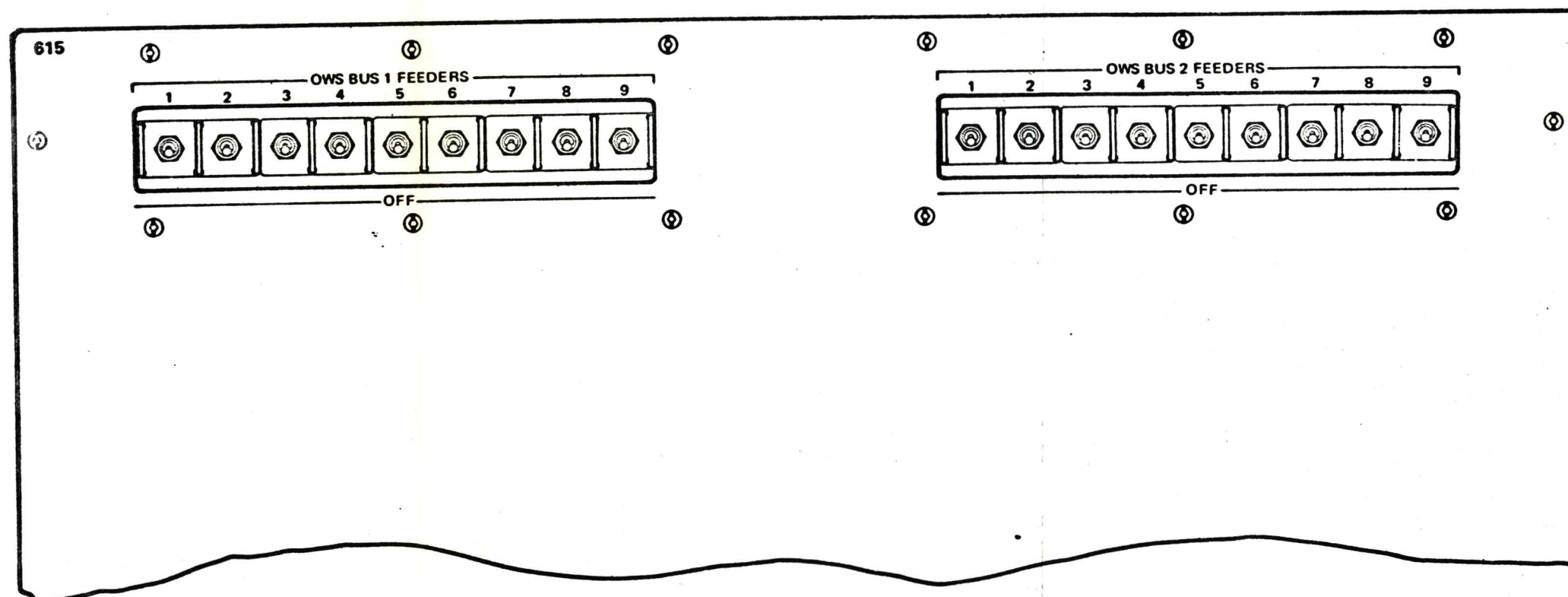
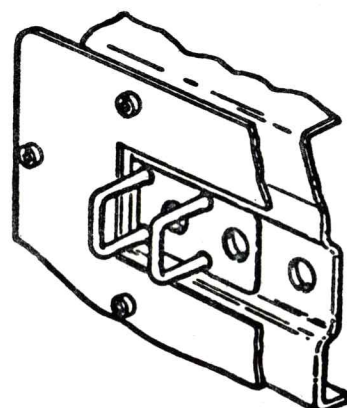
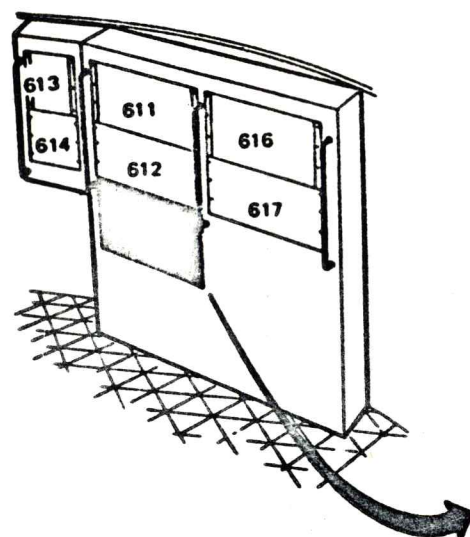


Circuit Breaker Panel No. 3 - 613

McDONNELL DOUGLAS

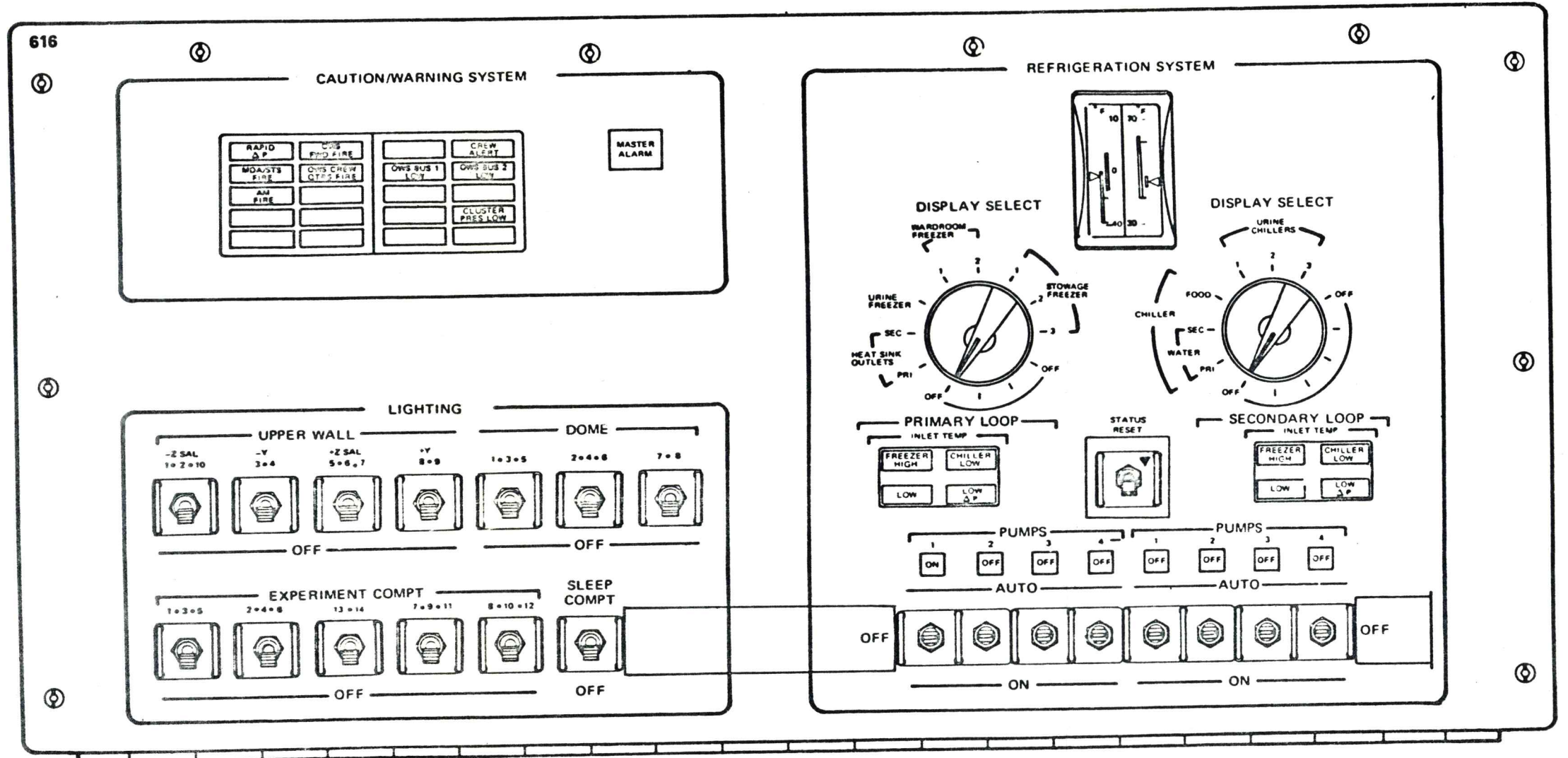
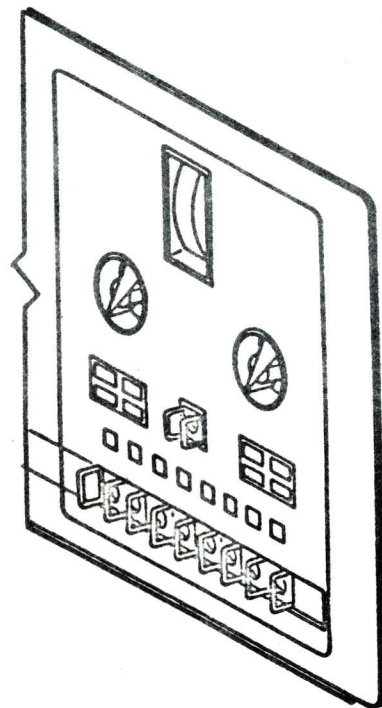
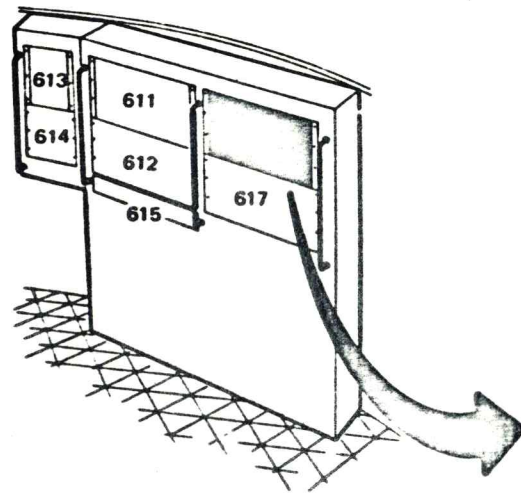


Circuit Breaker Panel No. 4 - 614



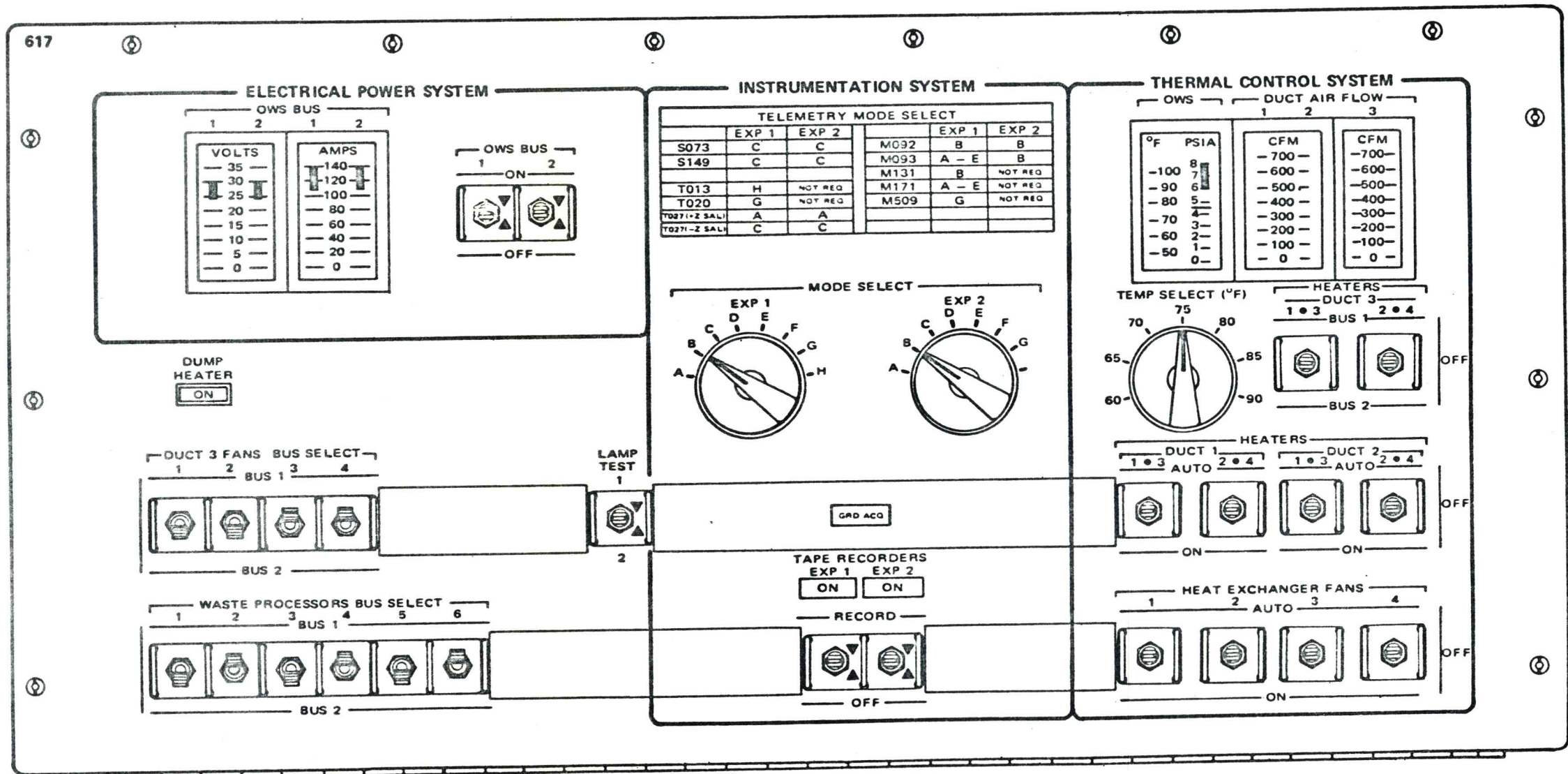
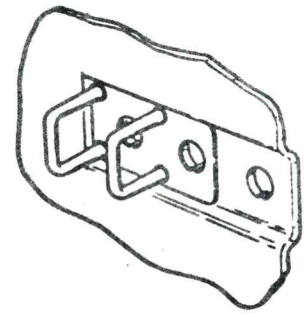
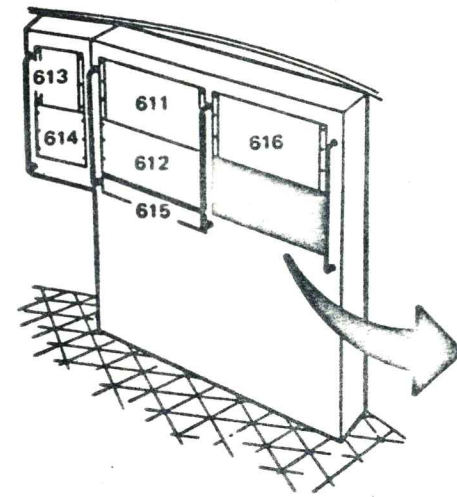
Feeder Circuit Breaker Panel - 615

MCDONNELL DOUGLAS CORPORATION



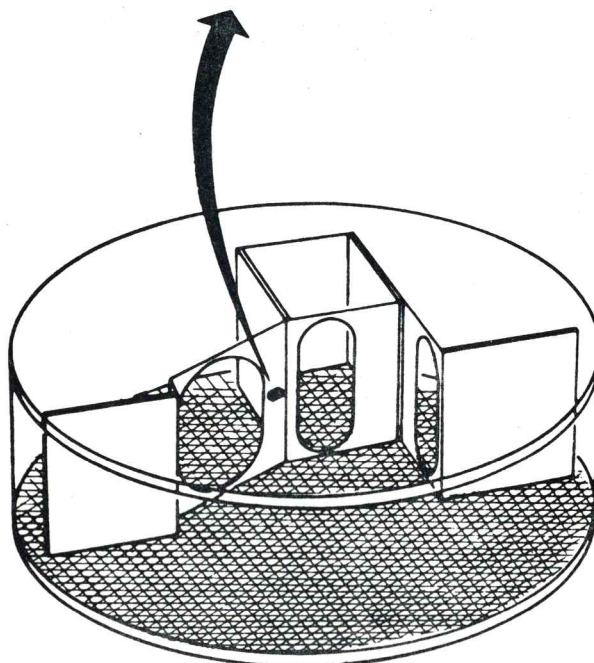
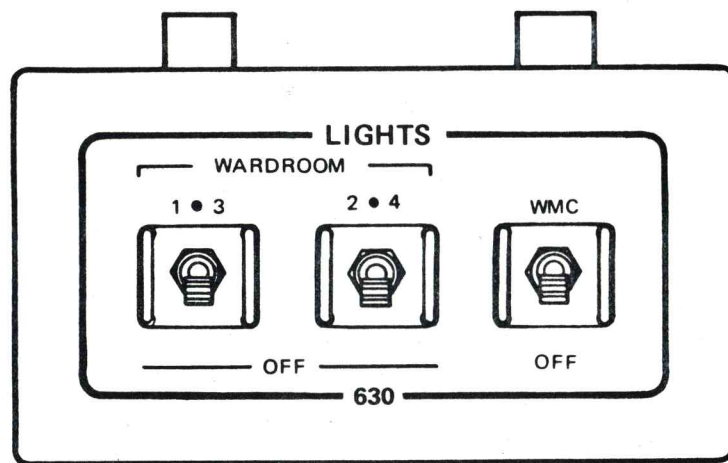
Control & Display Panel No. 1 - 616

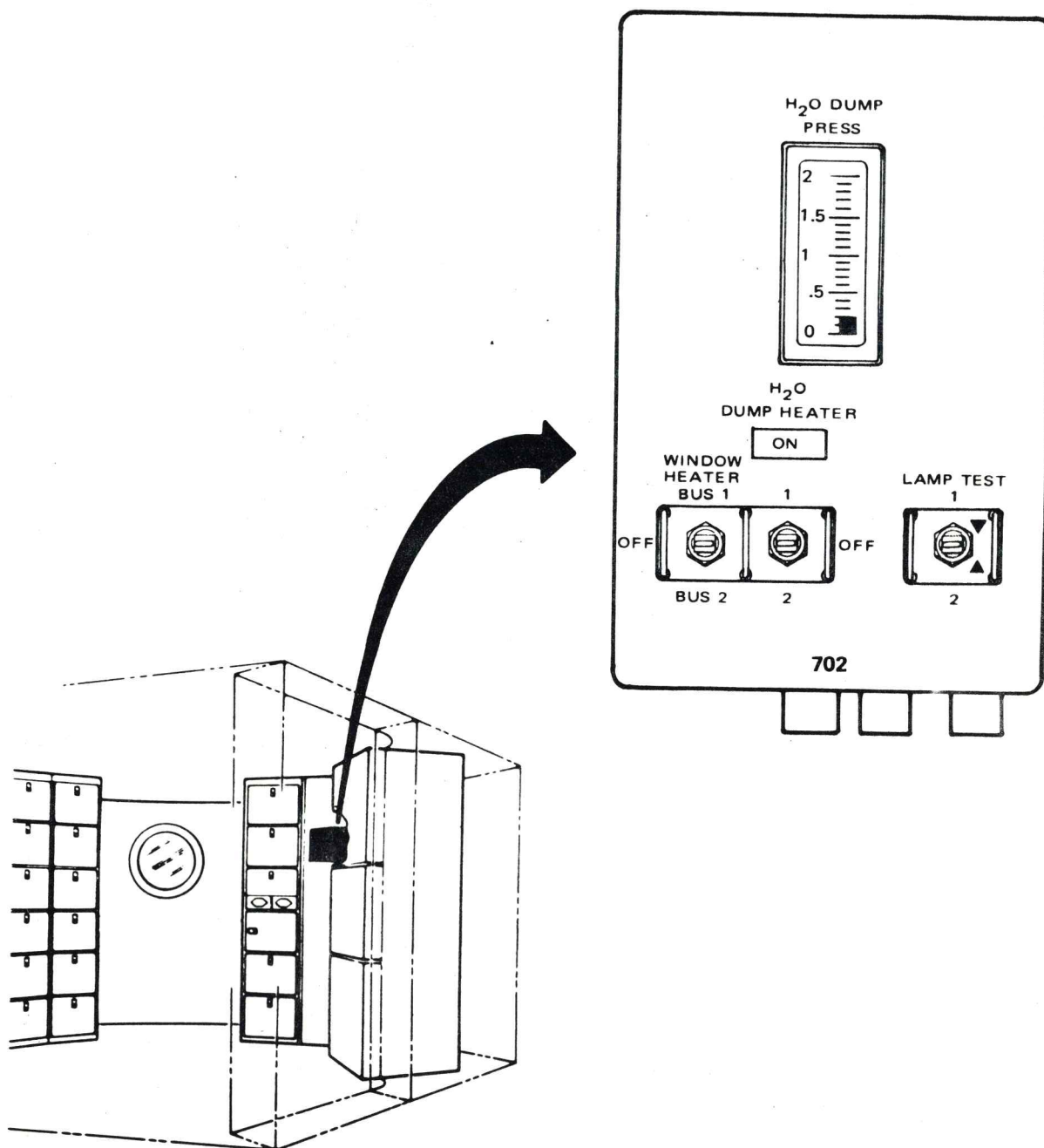
Figure 426-6. (Sheet 7 of 8)



Control and Display Panel No. 2 - 617

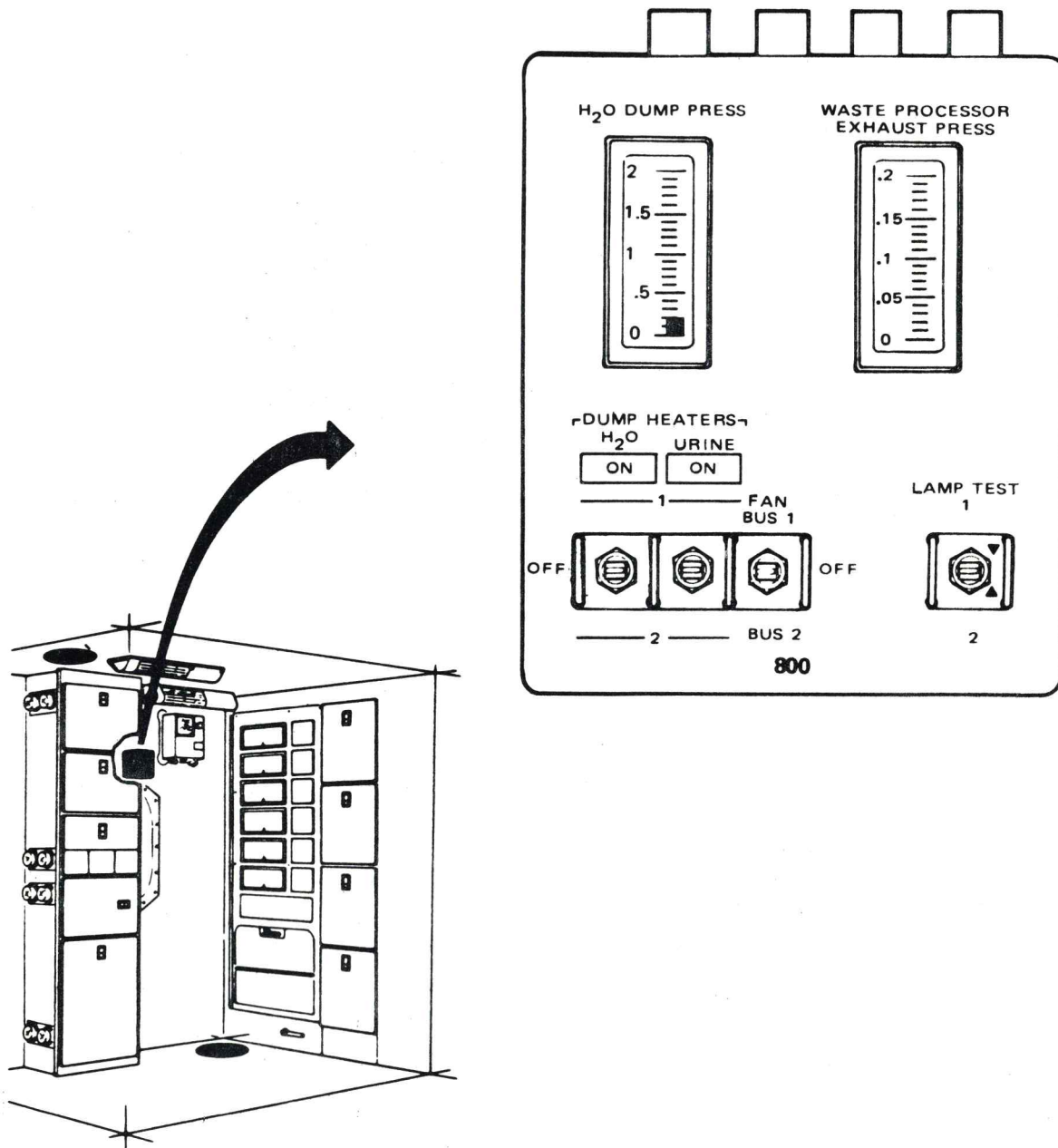
Figure 426-6. (Sheet 8 of 8)





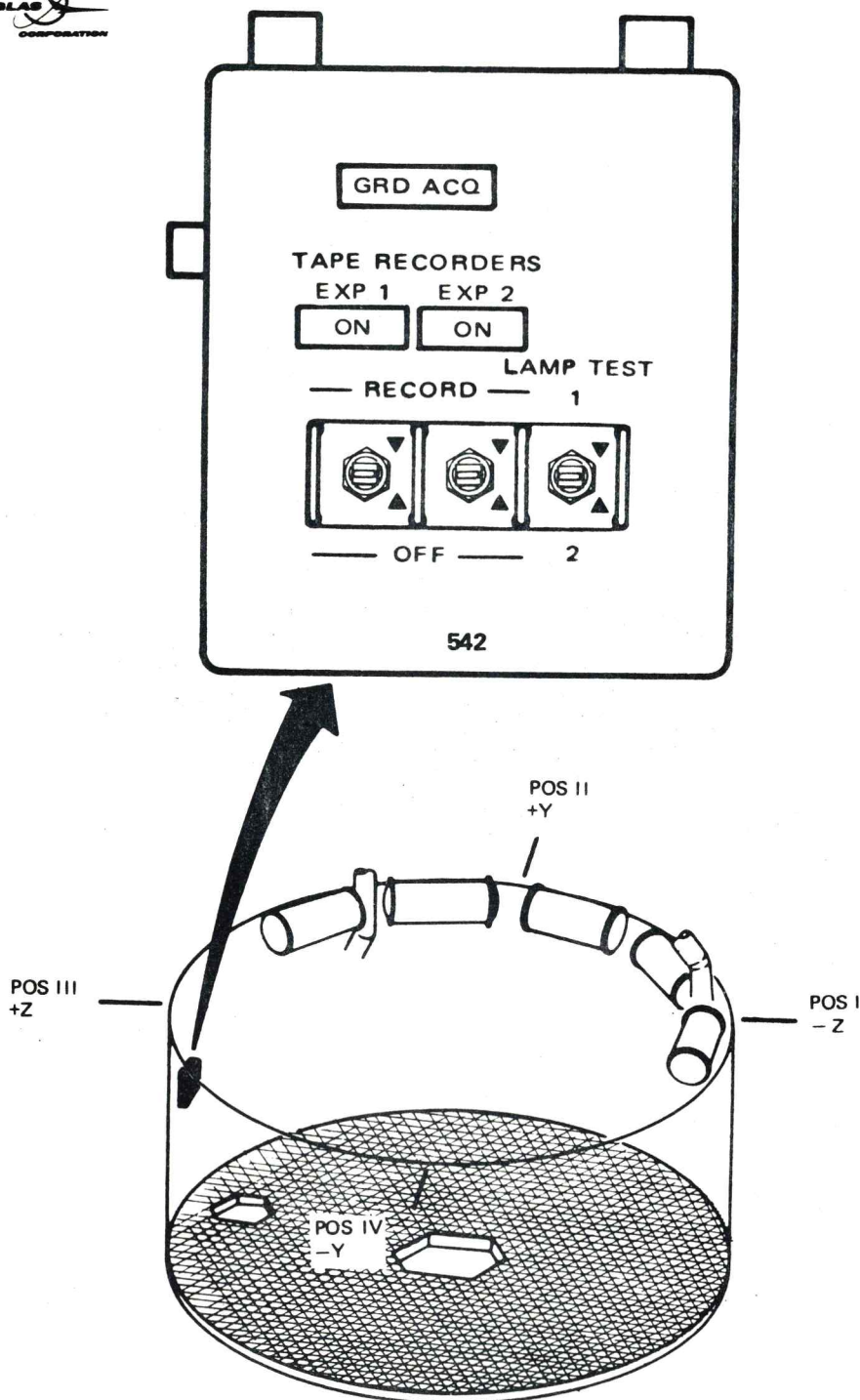
Wardroom Control and Display Panel — 702

Figure 426-8.



Waste Management Compartment Control and Display Panel - 800

Figure 426-9.



Forward Compartment Instrumentation Panel - 542

Table 426-1

AM Buses Power

| | <u>REG.</u> <u>BUS 1</u> | <u>REG.</u> <u>BUS 2</u> | <u>EPS</u> <u>CNTL</u> <u>BUS 1</u> | <u>EPS</u> <u>CNTL</u> <u>BUS 2</u> | <u>AM</u> <u>BUS 1</u> | <u>AM</u> <u>BUS 2</u> |
|---|-----------------------------|-----------------------------|---|---|---------------------------|---------------------------|
| Instrumentation: | | | | | | |
| Hi Level Mux Heaters | | | | | 2 of 6 | 3 of 6 |
| Low Level Mux Heaters | | | | | 4 of 7 | 3 of 7 |
| Sig Cond/Transducers | | | | | 88 of 175 | 87 of 175 |
| Switch Selector | | | | | -- | 1 of 1 |
| Thruster Attitude Control Valves | | | | | 12 of 24 | 12 of 24 |
| Meteoroid Shield Deployment | | | | | 1 of 2 | 1 of 2 |
| Solar Array System: | | | | | | |
| Solar Array Fairing Deployment | | | | | 1 of 2 | 1 of 2 |
| Solar Array Wing Section Deployment | | | | | 1 of 2 | 1 of 2 |
| Atmosphere Control System: | | | | | | |
| Waste Tank Latching Vent Valves | | | | | 1 of 2 | 1 of 2 |
| Habitation Area Latching Vent Valves | | | | | 1 of 1 | -- |
| Habitation Area Vent Valve | | | | | -- | 1 of 1 |
| Pneumatic Dump Valve | | | | | -- | 1 of 1 |
| Habitation Area Sole- noid Vent Valves | | | | | 2 of 4 | 2 of 4 |
| Radiant Heaters | | | | | 4 of 8 | 4 of 8 |

Table 426-1 (Continued)

AM Buses Power

| | <u>REG.</u> <u>BUS 1</u> | <u>REG.</u> <u>BUS 2</u> | <u>EPS</u> <u>CNTL</u> <u>BUS 1</u> | <u>EPS</u> <u>CNTL</u> <u>BUS 2</u> | <u>AM</u> <u>BUS 1</u> | <u>AM</u> <u>BUS 2</u> |
|--------------------------|-----------------------------|-----------------------------|---|---|---------------------------|---------------------------|
| *Initial Entry Lights | | | 4 of 8 | 4 of 8 | | |
| *Emergency Lights | | | 4 of 8 | 4 of 8 | | |
| OWS Bus 1 | 1 of 1 | | | | | |
| OWS Bus 2 | | 1 of 1 | | | | |
| Communication System | | | | | 10 of 10 | 10 of 10 |
| Caution & Warning System | | | 1 of 2 | 1 of 2 | | |

*Eight of the OWS general illumination lights are also utilized for initial entry and emergency egress. These lights are normally powered from the OWS Control Console and can also be powered from the AM for initial entry and emergency egress.

Table 426-2

OWS BUSES POWER

| <u>Component</u> | <u>OWS Bus</u> | | <u>Transferrable (Bus 1/Bus 2)</u> |
|--|----------------|--------------|--|
| | <u>Bus 1</u> | <u>Bus 2</u> | |
| Duct Recirculation Fans | 4 of 12 | 4 of 12 | 4 of 12 |
| Duct Convective Heaters | 4 of 12 | 4 of 12 | 4 of 12 |
| Temperature Control Module | 1 of 2 | 1 of 2 | 2 of 2 |
| OWS Temperature Display | -- | 1 of 1 | -- |
| OWS Pressure Display | -- | 1 of 1 | -- |
| *Floodlight, General Illumination | 22 of 42 | 20 of 42 | -- |
| Outlets, Utility | 8 of 16 | 8 of 16 | -- |
| Outlets, High Power Accessory | 6 of 12 | 6 of 12 | -- |
| TV Outlet, Crew Quarters | 1 of 1 | -- | -- |
| TV Outlet, Forward Compartment | -- | 1 of 1 | -- |
| Stowage Freezer Temperature Display | 2 of 3 | 1 of 3 | -- |
| Stowage Containers Temperature Display | 2 of 5 | 3 of 5 | -- |
| Refrigeration System | 1 of 2 | 1 of 2 | |
| Refrigeration System Displays | 2 of 4 | 2 of 4 | -- |
| Food Chiller Temperature Display | -- | 1 of 1 | -- |
| Wardroom Freezer Temperature Display | 1 of 2 | 1 of 2 | -- |
| Heater, Wardroom Food | -- | -- | 3 of 3 |
| Heater, Wardroom Viewing Window | -- | -- | 1 of 1 |
| Heater, Wardroom Water | 1 of 1 | -- | -- |

*Eight of the OWS general illumination lights are also utilized for initial entry and emergency egress. These lights are normally powered from the OWS Control Console and can also be powered from the AM for initial entry and emergency egress.

Table 426-2 (Continued)

OWS BUSES POWER

| <u>Component</u> | <u>OWS Bus</u> | | <u>Transferrable (Bus 1/Bus 2)</u> |
|--|----------------|--------------|--|
| | <u>Bus 1</u> | <u>Bus 2</u> | |
| Heater, Wardroom Dump Line | 1 of 2 | 1 of 2 | -- |
| Wardroom Water Dump Pressure | 1 of 1 | -- | -- |
| Blower Motor, Fecal/Urine Collection | -- | -- | 1 of 1 |
| Waste Processor | -- | -- | 6 of 6 |
| Waste Processor Exhaust Pressure Display | 1 of 1 | -- | -- |
| WMC Filter/Odor Removal Canister | -- | -- | 1 of 1 |
| Heater, WMC Urine Dump Line | 1 of 2 | 1 of 2 | -- |
| Heater, WMC Water | -- | 1 of 1 | -- |
| Heater, Water Storage Container | 10 of 20 | 10 of 20 | -- |
| Heater, Iodine Storage Container | 1 of 2 | 1 of 2 | -- |
| Heater, WMC Water Dump Line | 1 of 2 | 1 of 2 | -- |
| Water Dump Pressure Display | 1 of 1 | -- | -- |

Wiring for power distribution and control of all electrical end items, such as fans, lights, and experiments, is routed from the OWS/AM electrical interface through the OWS power feed-through and control console to end items in the OWS.

The main power feeders are routed through separate connectors on the OWS/AM interface and enter the OWS through separate connectors in the OWS power feed-through on the forward dome. These wires route through separate wire-attach supports inside the feed-through and, upon entering the OWS, are routed down the forward dome and along walls to the control console in the crew quarters.

Wiring internal to the OWS is routed through a closed-trough system (Figure 426-11) for flammability and physical damage protection. The closed trough system consists of rigid troughs, flex troughs, interchange boxes, convoluted tubing, and connector boots (Figures 426-12 and 426-13). Barriers within these devices prevent flame propagation and cause the flame to self-extinguish. The control console is compartmented similar to the interchange boxes.

The OWS power distribution wiring schematic is shown in Drawing No. 1B78707. The wire routing is shown in Drawing No.'s 1B74947 and 1B75214.

The electrical interface between the OWS and the AM is contained in NASA Document 40M35594, AAP Interface Document.

The electrical power allocation for each of the components in the OWS is contained in NASA Drawing Number 40M35631, Orbital Workshop Power Allocation Document. The power profile requirements are contained in NASA Documents MSC-KM-D-68-4B1 and 25M00005.

Zero-G Connector

The zero-g connector (Figure 426-14) is designed to easily and safely facilitate electrical connection and disconnection of equipment. The design utilizes a bail handle, rather than twist-lock or screw-on, to accommodate one-handed operation by a pressure-suited astronaut. This connector is explosion-proof. Deadfacing is performed by procedural means and is not part of the connector.

Bonding Provisions

Electrical bonding is provided in accordance with MIL-B-5087 to protect personnel from shock hazards and equipment from electromagnetic interference.

4.2.6.2.1 Crew Accommodations

Electrical power for crew accommodations is distributed and controlled from the control console in the experiment compartment, and from four remote control panels provided at convenient locations (Figure 426-6 through 426-10).

Electrical outlets are provided at convenient locations throughout the forward compartment and crew compartment (Figures 426-15 through 426-18). Utility outlets capable of delivering six amperes are provided for additional lighting,

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COMPANY

ORBITAL WORKSHOP CLOSED TROUGH SYSTEM (GENERAL CONCEPT)

O/W 7153
5-21-70

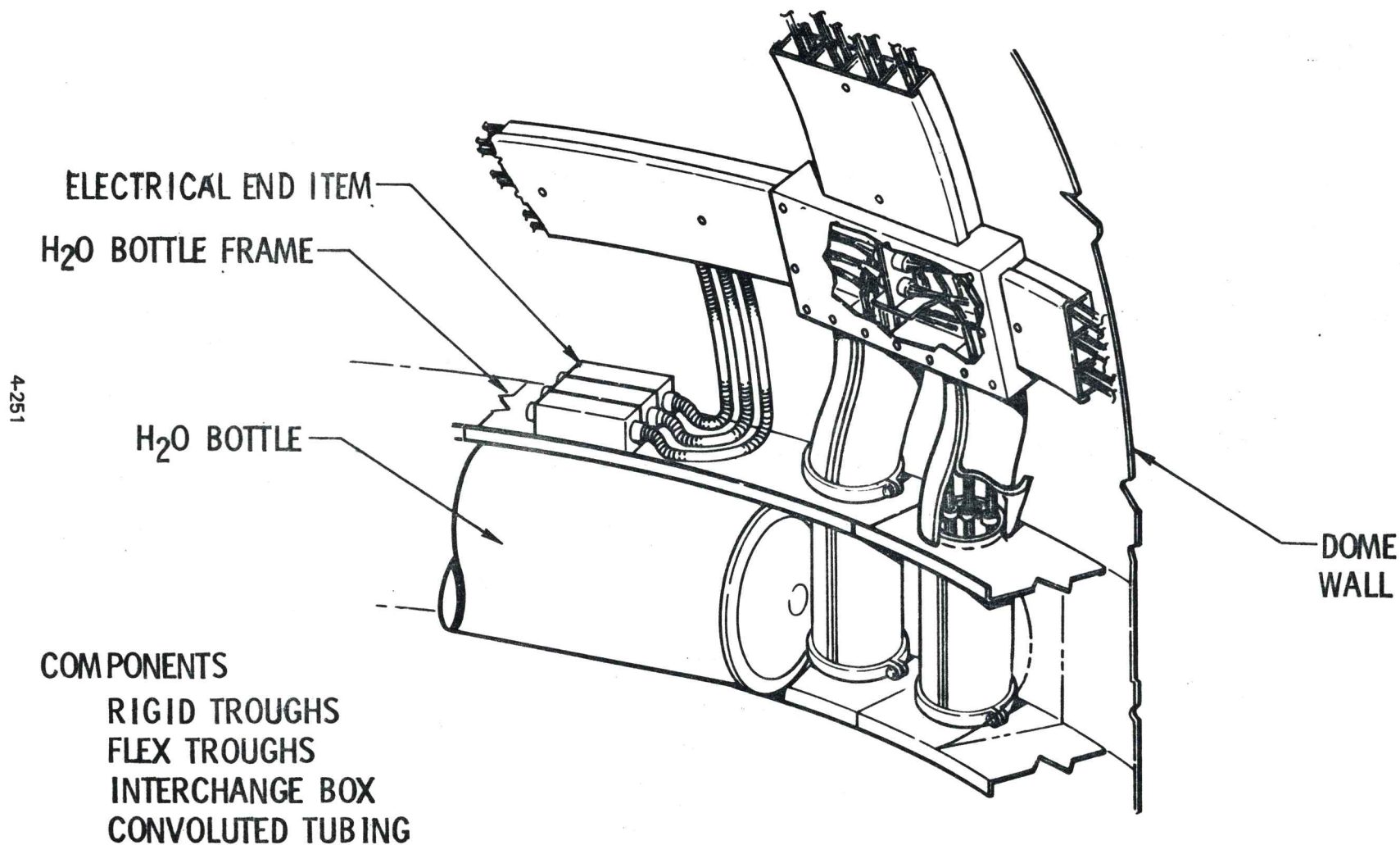
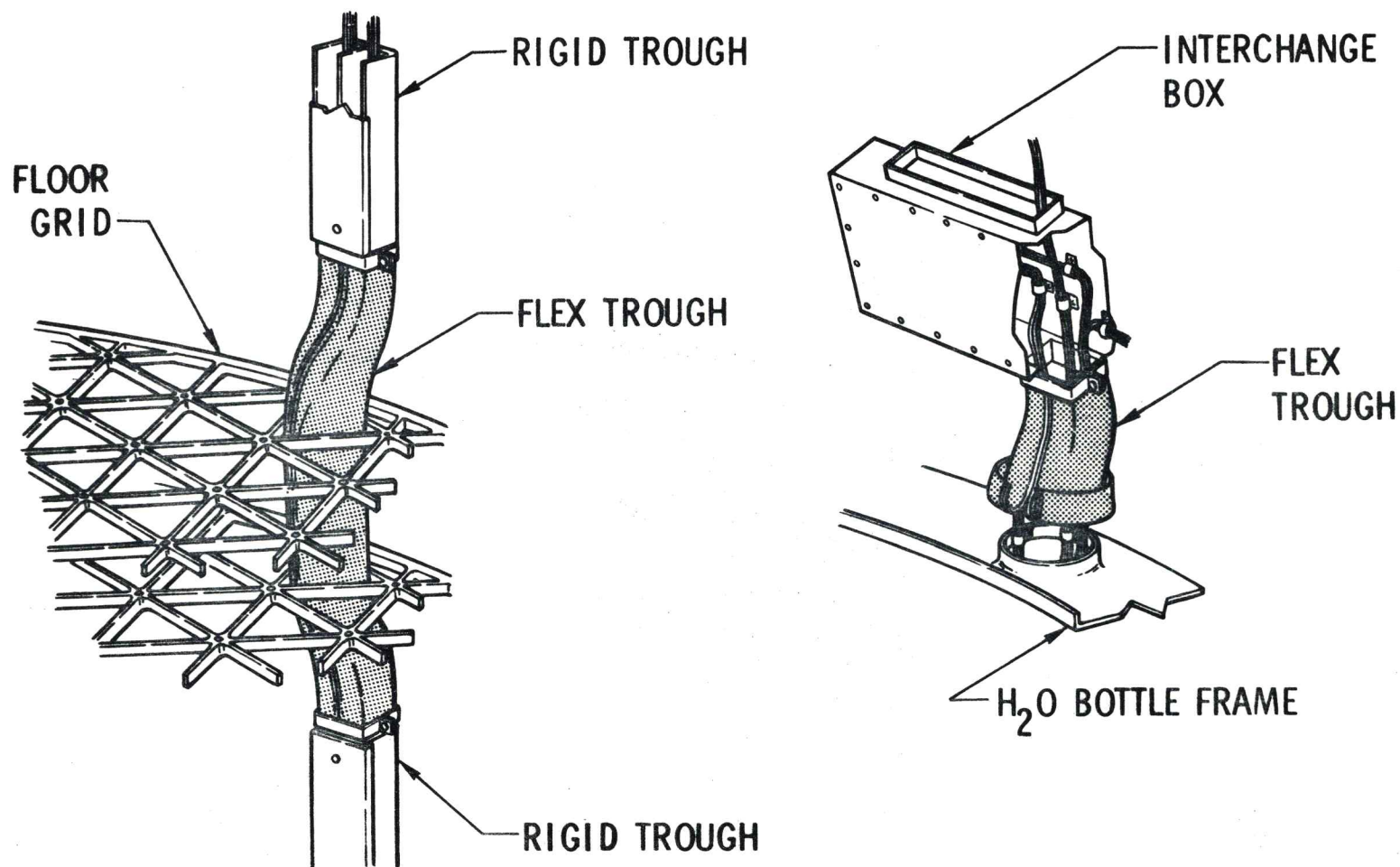


Figure 426-11.

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COMPANY

ORBITAL WORKSHOP FLEX TROUGH USAGE (GENERAL CONCEPT)

O/W-7154
4-28-70



4-252

Figure 426-12.

ORBITAL WORKSHOP RIGID TROUGH

O/W-7566
8-6-70.

4-253

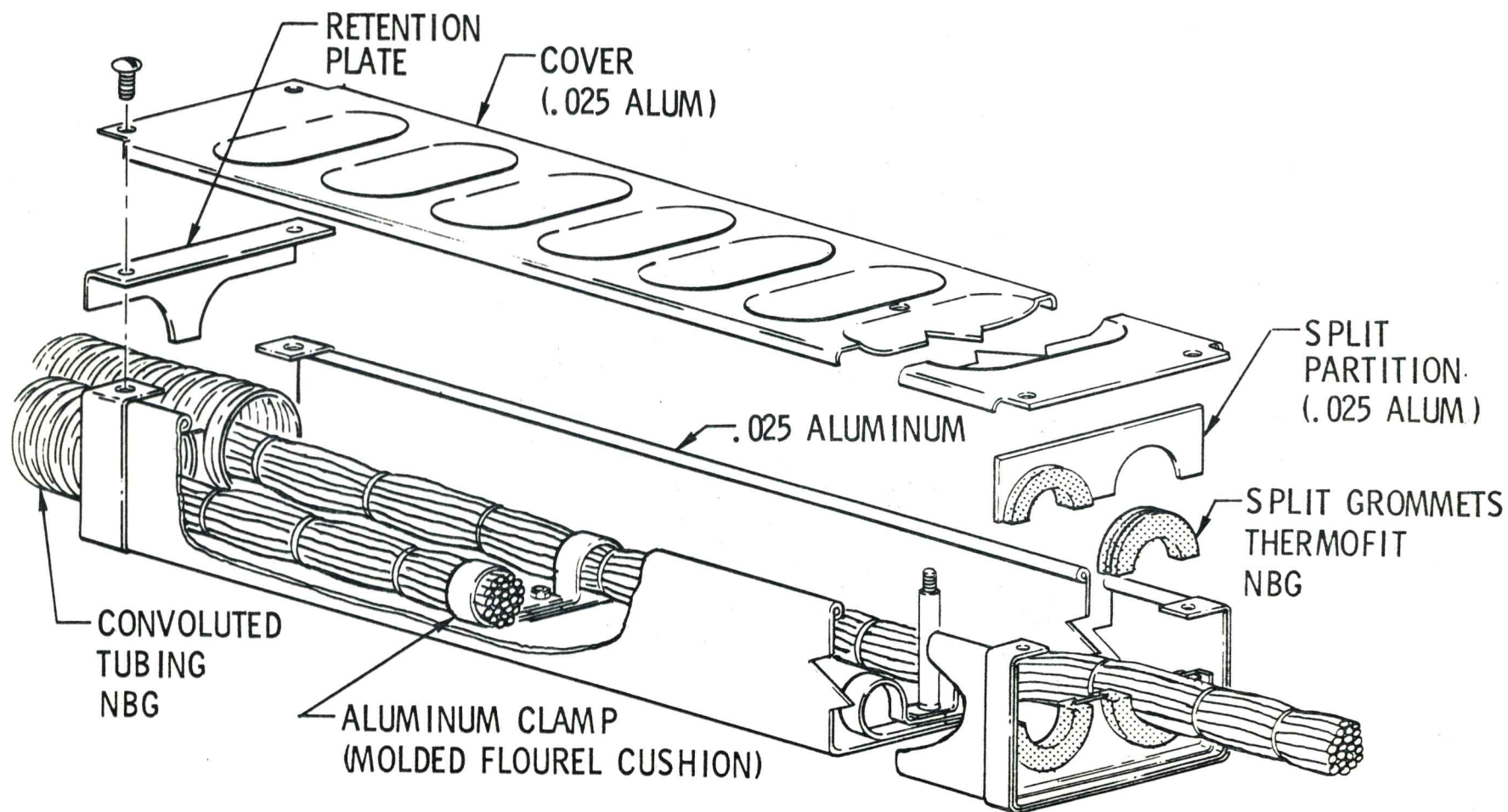


Figure 426-13.

MCDONNELL
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COMPANY

ORBITAL WORKSHOP ZERO G CONNECTOR - ENGAGED

O/W-4177
5-12-70

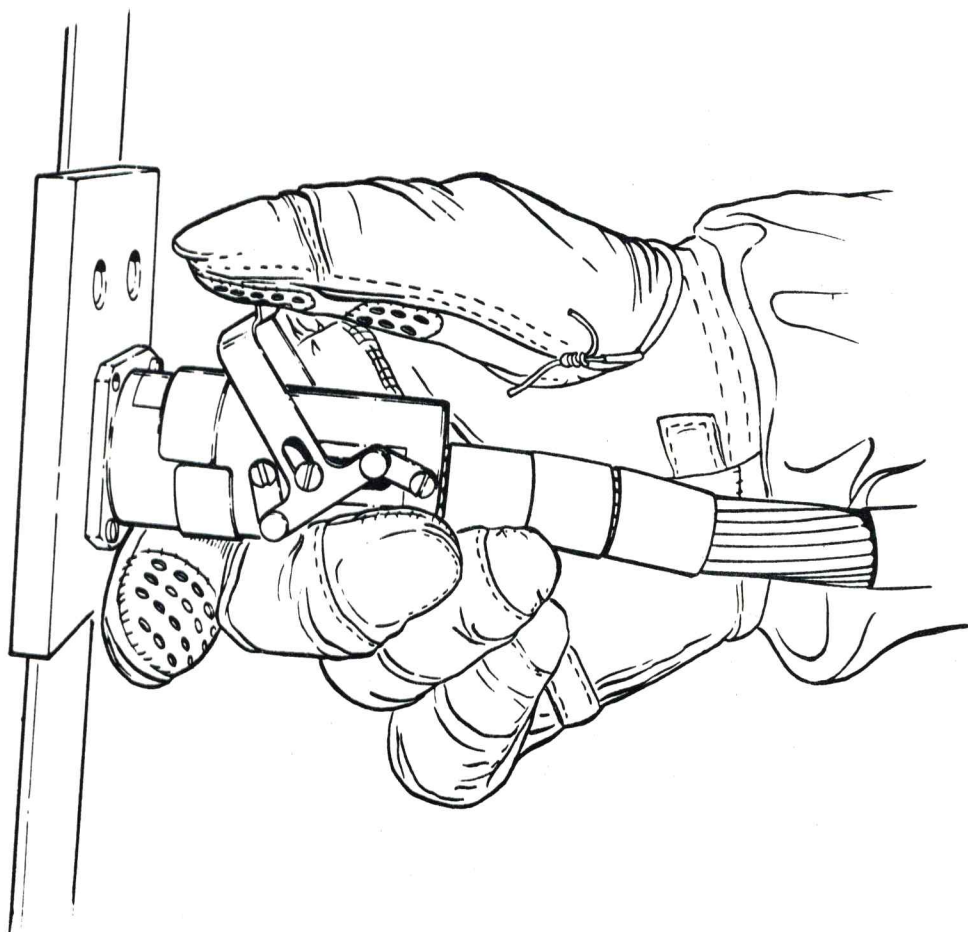


Figure 426-14. (Sheet 1 of 2)

ORBITAL WORKSHOP ZERO G CONNECTOR - DISENGAGED

O/W-4178
5-12-70

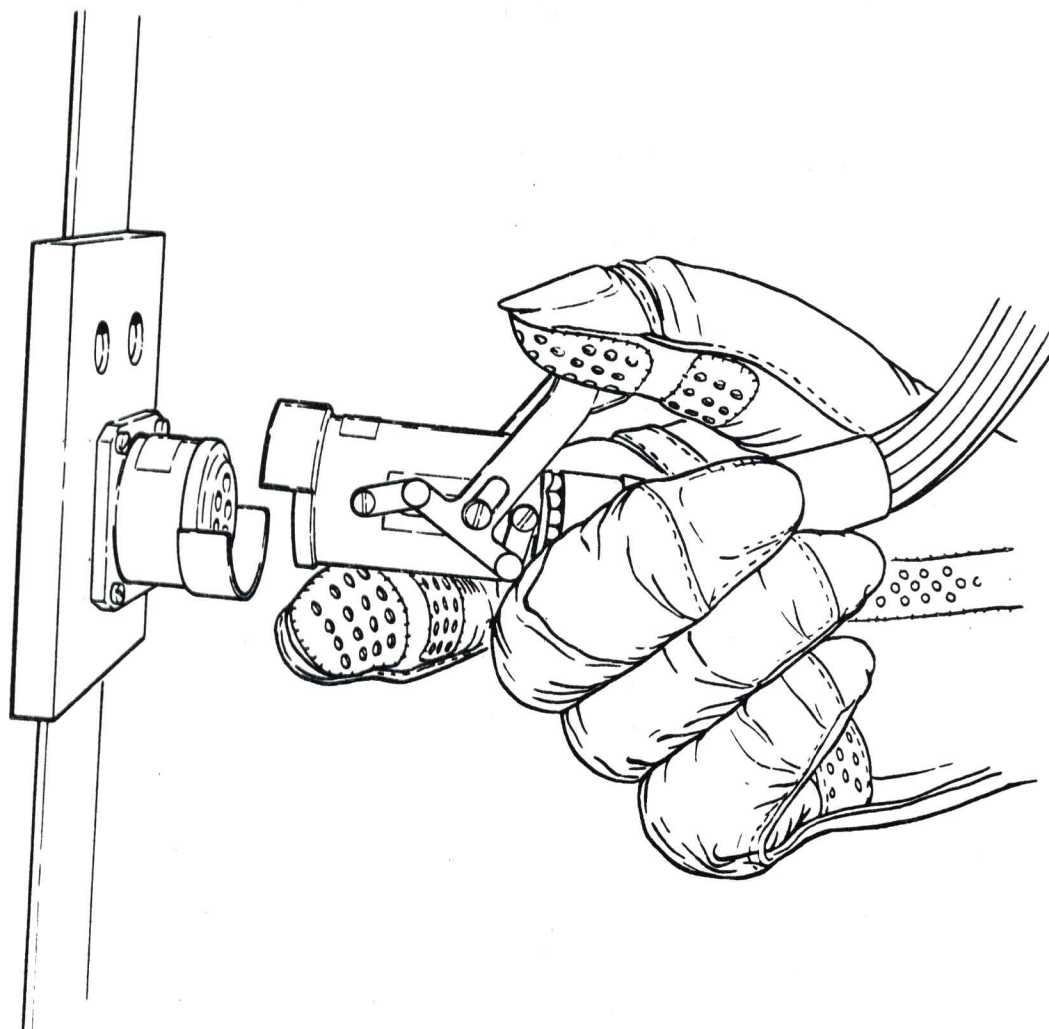
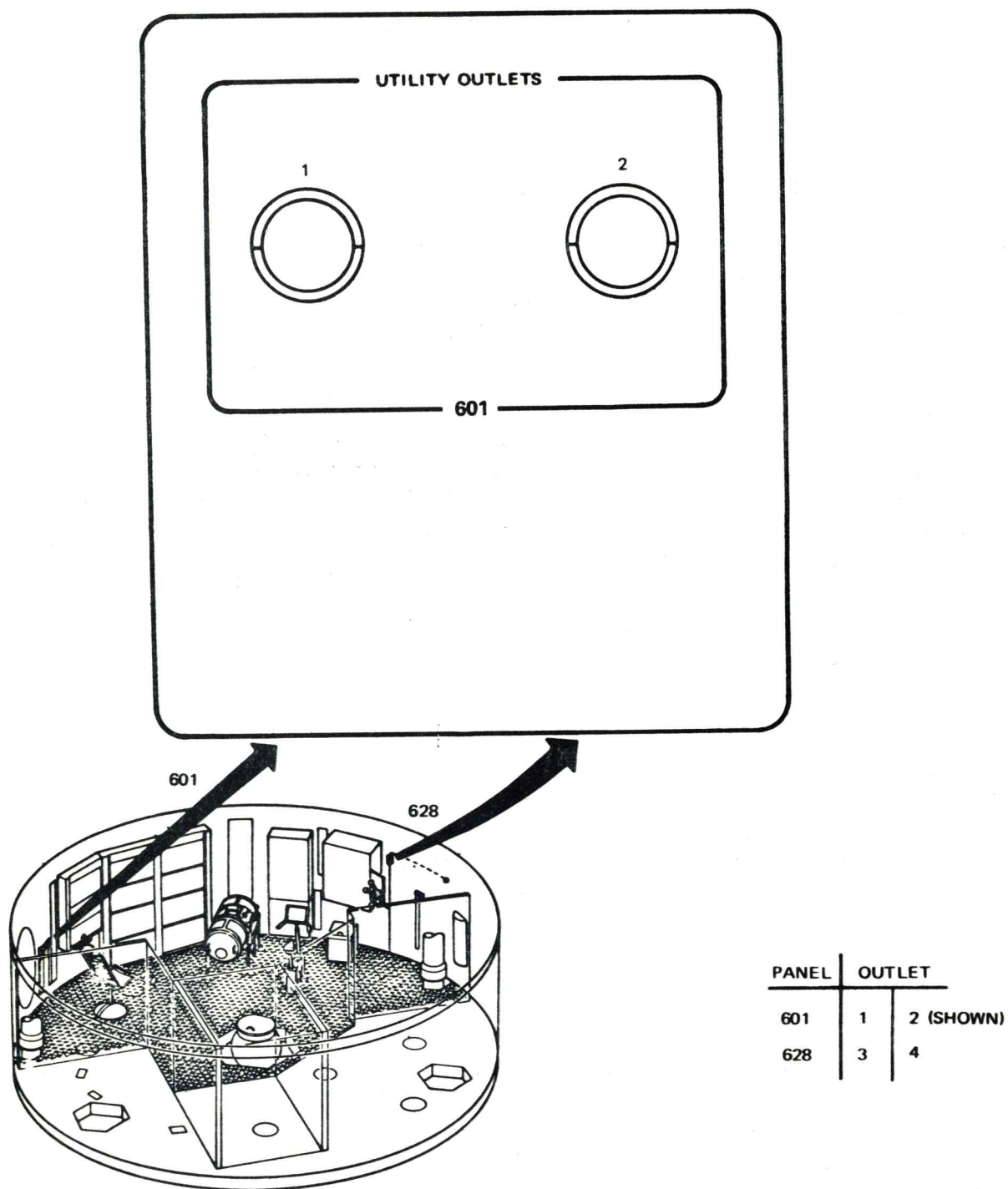


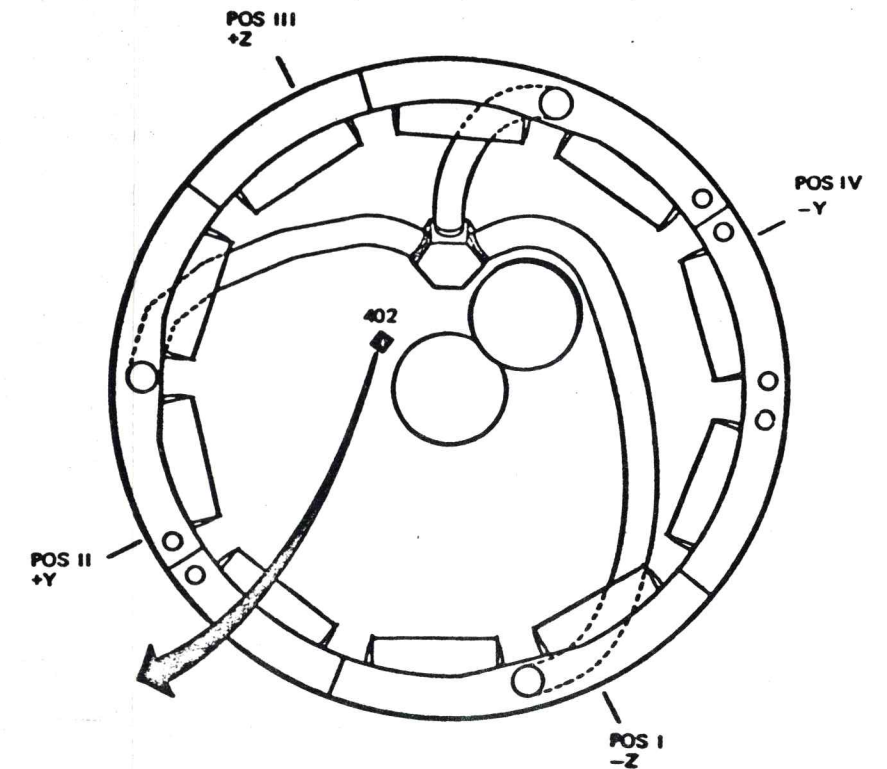
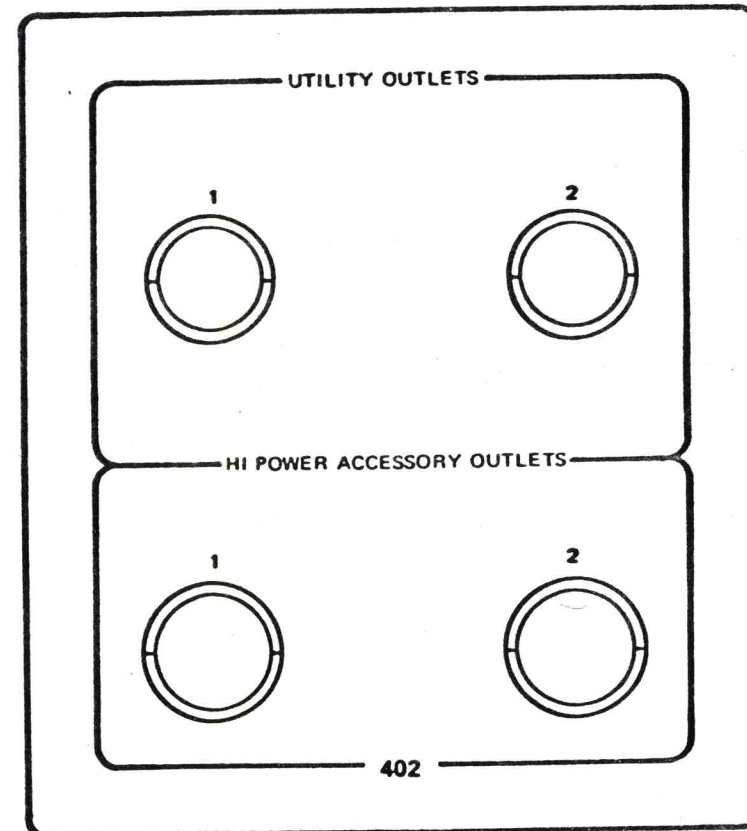
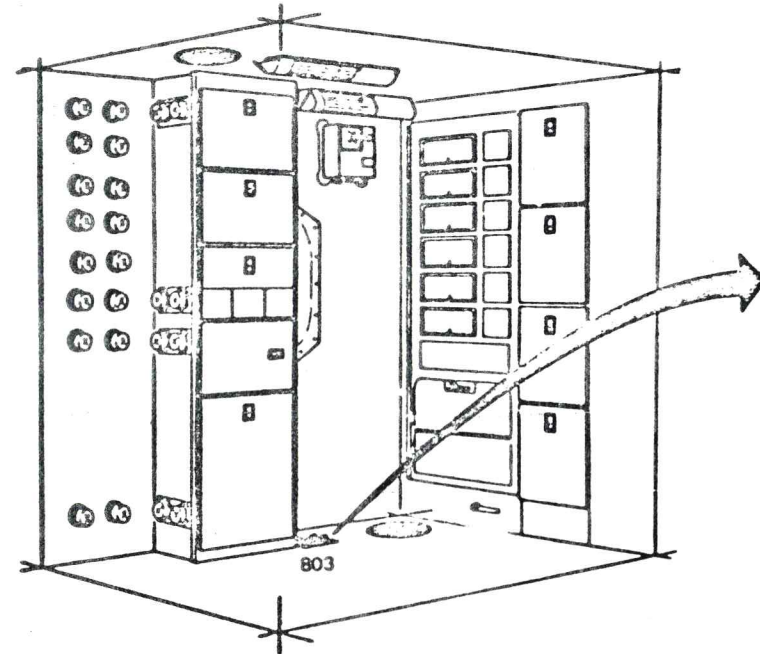
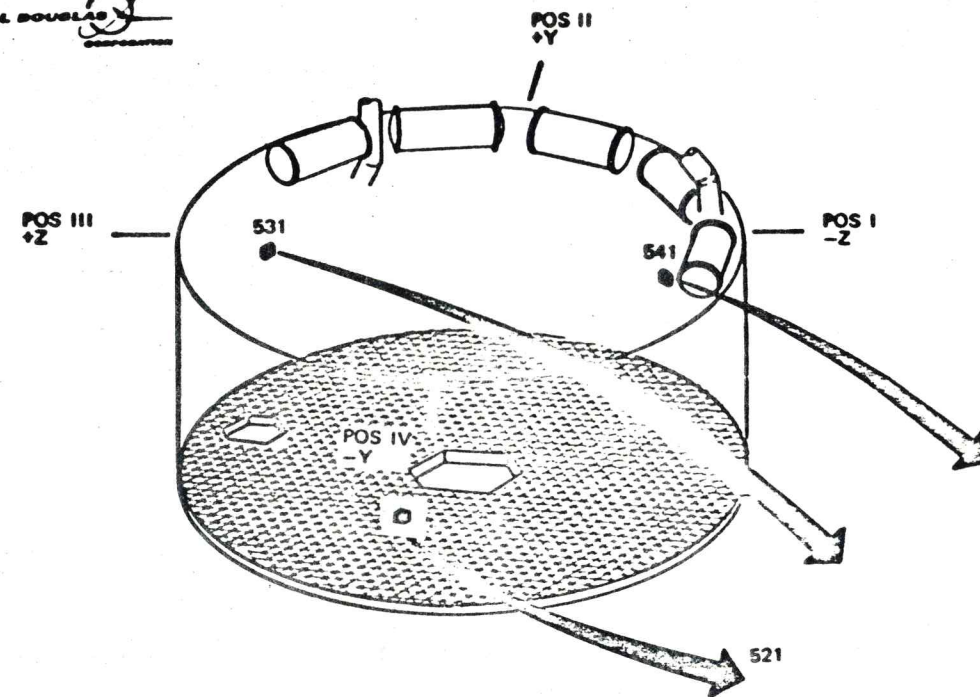
Figure 426-14. (Sheet 2 of 2)



Utility Outlets -601,-628

Figure 426-15.

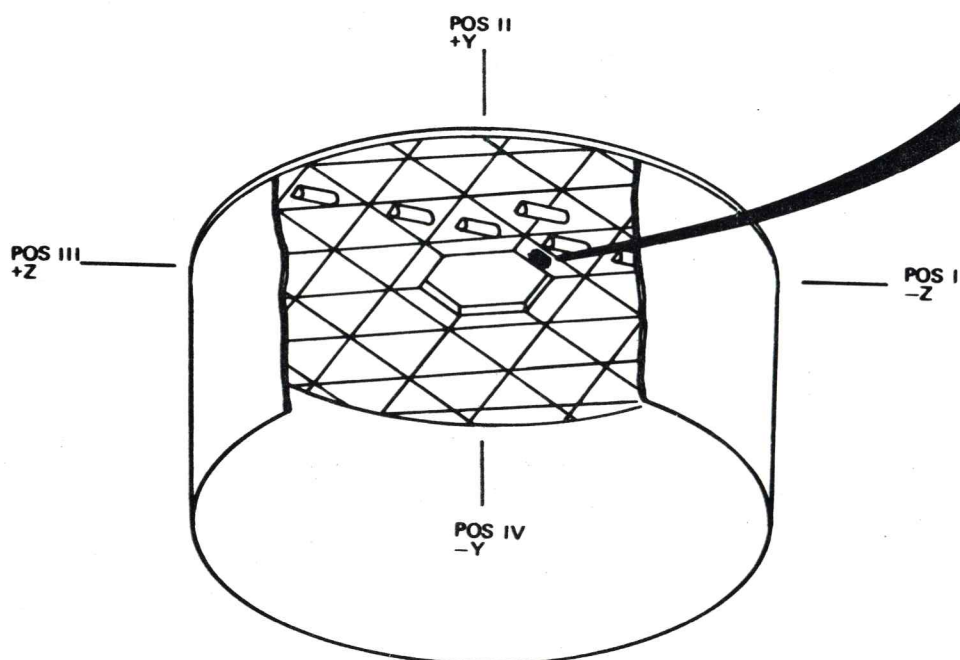
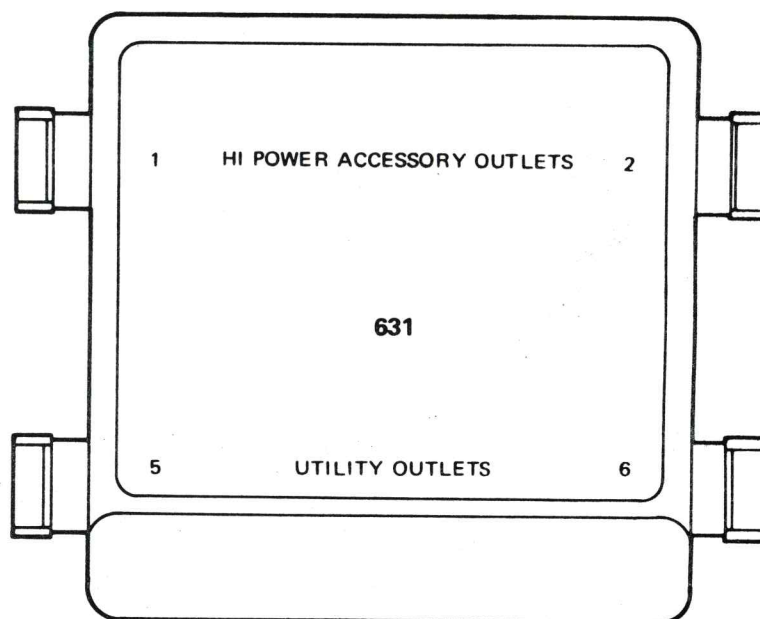
McDONNELL DOUGLAS
CORPORATION



| PANEL | OUTLET | | | |
|-------|---------|---|--------|-----------|
| | UTILITY | | HI PWR | |
| 402 | 1 | 2 | 1 | 2 (SHOWN) |
| 521 | 1 | 2 | 1 | 2 |
| 531 | 3 | 4 | 3 | 4 |
| 541 | 5 | 6 | 5 | 6 |
| 803 | 1 | 2 | 1 | 2 |

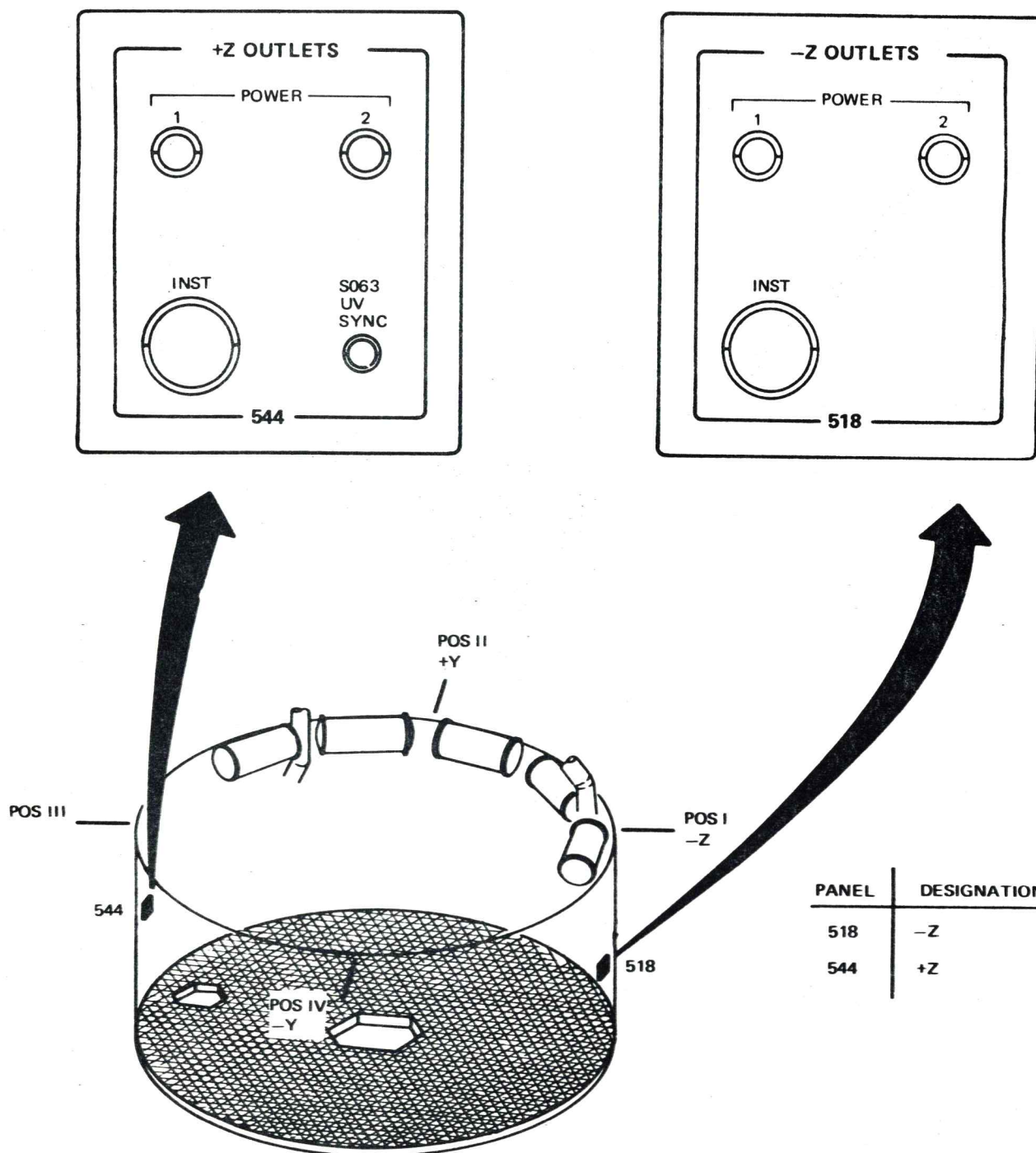
Power Outlets -402, -521, -531, -541, -803

Figure 426-16.



Power Outlet - 631

Figure 426-17.



Scientific Airlock Outlets -518,-544

Figure 426-18.

camera, area circulation fans, etc. They are divided into two circuits and distributed to allow loads to be connected to either bus 1 or bus 2 in a contingency mode.

All wiring to the utility outlets is individually protected by circuit breakers in the power distribution panel. High power accessory outlets capable of delivering 12 amperes are provided for camera lights and vacuum cleaner. These outlets are divided into two circuits and protected in the same way as the utility outlets. Television outlets provide power and signal routing for the TV cameras. The power circuits are also individually protected. Scientific airlock outlets provide power for experiments (20 amperes) and signal routing for experiment instrumentation. Instrumentation circuits are not equipped with circuit breakers. The types of outlets (utility, high power, TV, power and instrumentation) are mutually noninterchangeable.

The portable lights and portable fans are provided with manual switches for local control.

4.2.6.2.2 Habitability Support

Electrical power for operation of equipment within the HSS is provided from the control console located in the crew quarters experiment compartment.

The MSS equipment provided electrical power includes:

- a. The waste collector blower motor, vacuum cleaner blower motor, waste processors, water heaters, and shaver in the waste management compartment.
- b. The freezer, food heaters, and water heaters in the wardroom.
- c. The water heaters for the water containers in the forward compartment.
- d. The water dump and urine dump line heaters in the waste tank.

4.2.6.2.3 Illumination

Electrical power distribution and control of the illumination system is derived from the control console (Figure 426-6) located in the experiment compartment. The emergency/initial entry lights are also controlled from the AM. A remote control panel containing switches for lights in the WMC and wardroom is located in the experiment compartment (Figure 426-7).

Illumination within the OWS is provided by fluorescent lights. Control functions for the lights are in groups on the control console. Individual circuit protection is provided at the power panel for each of the lights. A switch is provided on the lamp assembly for OFF-LOW-HIGH control of each light, independently.

4.2.6.2.4 Communications

Wiring is provided for the OWS Communication System including C and W. This wiring is run directly from the OWS/AM electrical interface to the 10 intercommunication stations.

4.2.6.2.5 Data Acquisition

Electrical power for the OWS portion of the cluster Data Acquisition System is supplied from the AM buses 1 and 2. This power is routed external from the AM, across the AM/OWS electrical interface on the octagonal ring, to the OWS instrumentation panels in both the forward and aft skirts. The power is brought across the interface on 16 gage wires to fuse modules. The power is then distributed from these fuse modules to various locations for signal conditioning, transducer excitation, and component heaters. The fuse modules protect the power distribution from a short circuit by removing power off that portion of the circuit. This is true both in the instrumentation power and the auxiliary component heater power circuit. Figure 426-19 illustrates this.

4.2.6.2.6 Atmosphere Control

Electrical power distribution and control of the atmosphere control system (electronic control package, fans, and heaters) is from the control console.

Pressure System Valves

Power for the pressure control system is supplied from the AM. Control by the IU via the switch selector is provided for the waste tank latching vent valves, the habitation area latching vent valves, the habitation area vent valve, and the pneumatic dump valve. Control by the AM DCS is provided for the habitation area solenoid vent valves.

Fan Circuits

Power for the ventilation control system fans within the OWS is distributed from the control console. Control of the area circulation fans and of the exhaust fan is local and manual. Individual circuit protection is provided at the control console for each fan.

Heater Circuits

Power for the TCS heaters is also distributed from the control console. The thermal control system provides the control for these heaters. Circuit protection for each heater is provided at the control console.

4.2.6.2.7 Corollary Experiments

Electrical power is distributed from the Electrical Control Console to the various experiments located throughout the crew quarters and forward compartment. Power is routed from the control console to the Experiment Support System (ESS) and then distributed to the three experiments (M092, M093, and M171). Three other experiments (S073, S149, and T027), utilize the power outlets located by the Scientific Airlocks (SALS) in the forward compartment.

Experiment T020 receives power from M509. The rest of the experiments receive power directly from the control console.

The experiments utilizing power are listed in Table 426-3.

ORBITAL WORKSHOP DATA ACQUISITION SYSTEM INSTRUMENTATION POWER

O/W-4317
5-20-70

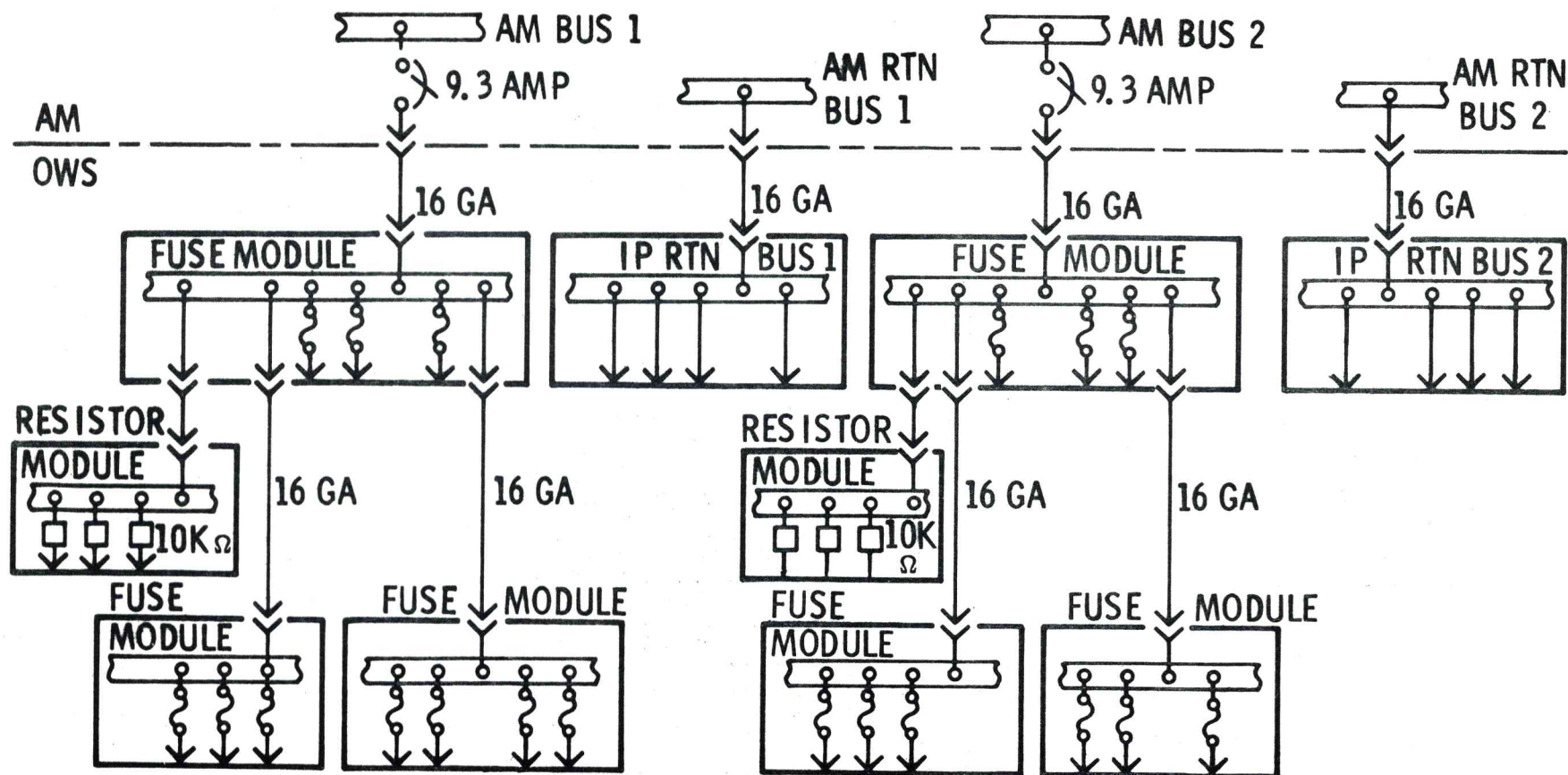
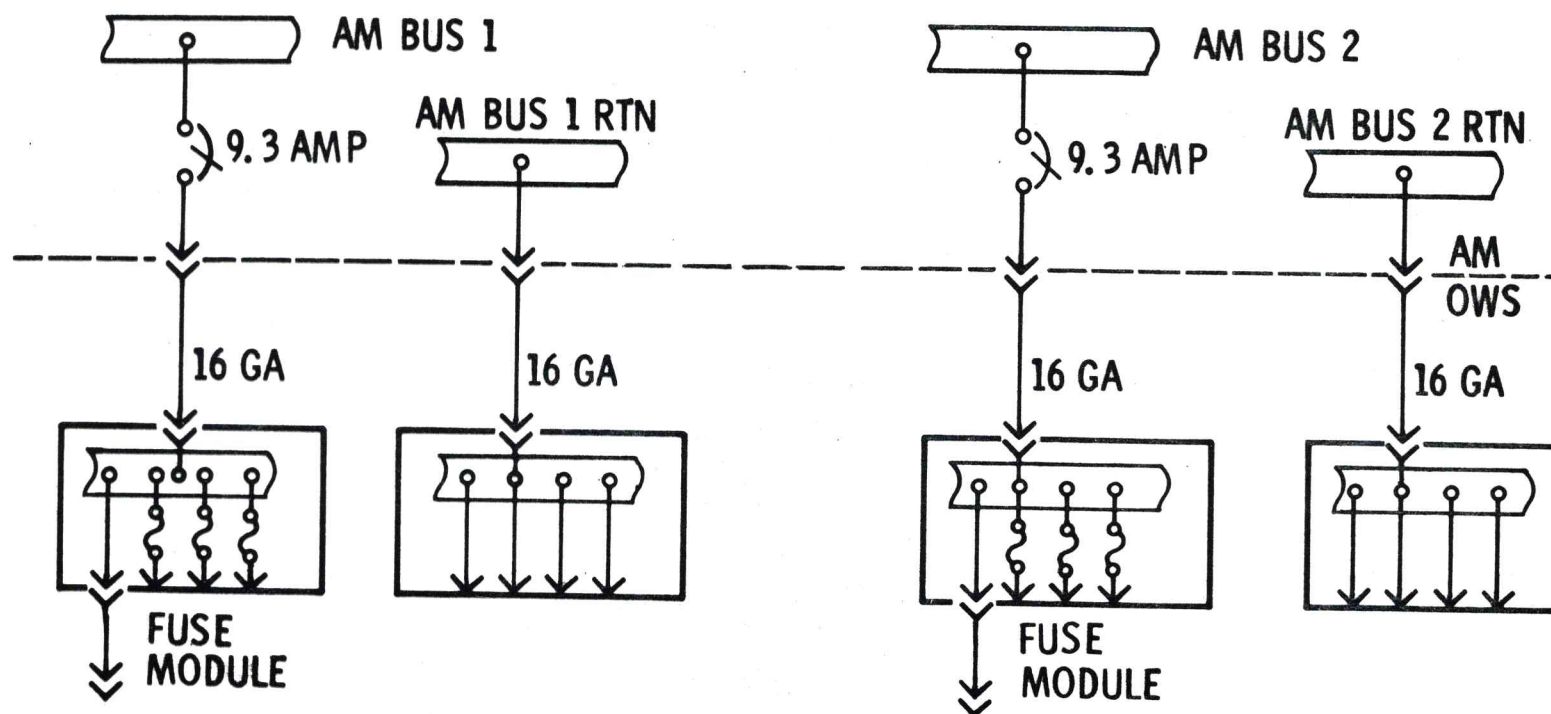


Figure 426-19. (Sheet 1 of 2)

ORBITAL WORKSHOP DATA ACQUISITION SYSTEM HEATER POWER

O/W-4328
5-19-70



4-263

Figure 426-19. (Sheet 2 of 2)

Table 426-3

EXPERIMENT POWER UTILIZATION

| Experiment No. | Title | Power Bus |
|----------------|--|-----------|
| M074 | Specimen Mass Measurement | -- |
| | Wardroom Location | 2 |
| | Waste Management Compartment Location | 1 |
| M131 | Human Vestibular Function | 1 |
| M172 | Body Mass Measurement | 1 |
| M507 | Gravity Substitute Workbench | 2 |
| M508 | EVA Hardware Evaluation | 1 |
| M509 | Astronaut Maneuvering Equipment | 2 |
| T020 | One Foot-Controlled Maneuvering Unit | -- |
| T013 | Crew/Vehicle Disturbance | 2 |
| ESS | Experiment Support System | 1 & 2 |
| M092 | In-Flight Lower Body Negative Pressure | -- |
| M093 | Vector Cardiogram | -- |
| M171 | Metabolic Activity | -- |
| SALS | Scientific Airlocks | 1 & 2 |
| S073 | Gegenschein/Zodiacal Light | -- |
| S149 | Micrometeorite Collection | -- |
| T027 | ATM Contamination Measurement | -- |

4.2.6.2.8 Thruster Attitude Control

Power for the OWS Thruster Attitude Control Systems (TACS) is supplied from the AM and routed to the thrusters in the aft skirt via the Control Switching Assembly (CSA). The power is utilized by the CSA for actuating the TACS nitrogen thruster valves.

4.2.6.3 Solar Array System

The Solar Array System (SAS) converts solar energy into dc electrical power and supplies it to the AM. From there it is conditioned and distributed to various SWS loads (OWS, AM, MDA, ATM, CSM).

The SAS consists of two deployable wing assemblies externally mounted (Figure 426-20), approximately 28 degrees off Position Planes II and IV (Figure 426-21), and their associated electronics and instrumentation. When deployed, the arrays are parallel to the SWS X-Y plane with the active side facing toward the +Z axis. Acquisition and maintenance of the SAS in a solar orientation is accomplished by controlling the SWS attitude rather than SAS articulation. With the exception of the earth resources experiment and the rendezvous maneuver the SWS is oriented in a solar inertial attitude throughout the mission duration.

Each wing assembly consists of:

- a. A forward fairing assembly, permanently attached to the forward skirt, which houses the hinge and actuating mechanism.
- b. A fairing assembly extending from the hinge to the aft skirt.
- c. Three wing section assemblies, containing the solar cells, which store inside the fairing assembly.
- d. Mechanical and ordnance systems for deploying the SAS in orbit.
- e. Stabilizing beams which restrain the wing section in the deployed position.

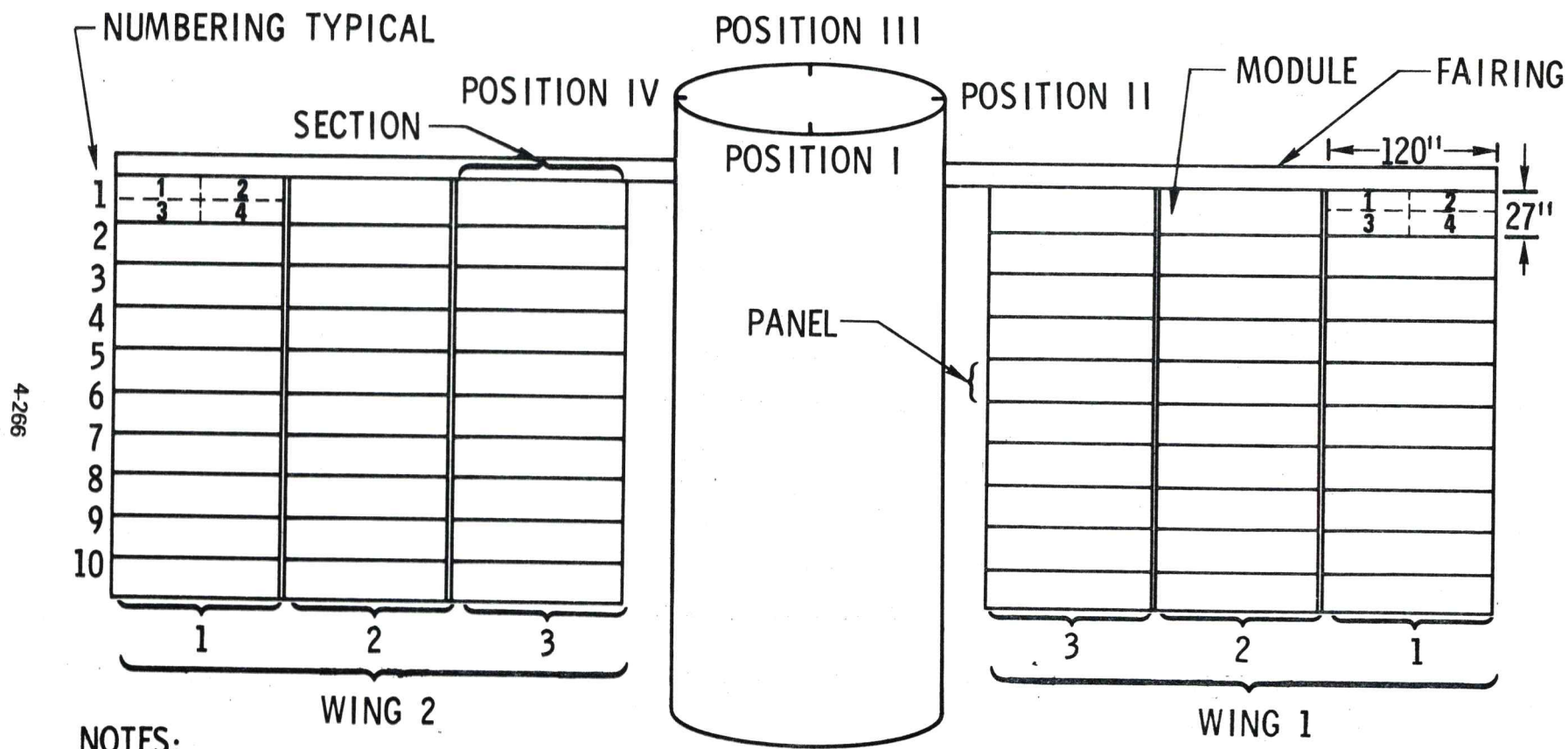
Each fairing assembly is held in the stowed position at two points on the forward skirt and four points on the aft skirt.

The fairings provide:

- a. Protection for the wing section assemblies during launch and ascent.
- b. Controlled venting on the ground of purge gases.
- c. Pressure venting during ascent.
- d. Housing for instrumentation and power collection.

ORBITAL WORKSHOP SOLAR ARRAY SYSTEM

O/W-4004-1
5-20-70



NOTES:

1. (616) SOLAR CELLS MAKE UP A MODULE
2. (4) MODULES MAKE UP A PANEL
3. (10) PANELS MAKE UP A WING SECTION
4. (3) WING SECTIONS PLUS BEAM FAIRING MAKE UP A WING

Figure 426-20.

ORBITAL WORKSHOP SAS-ARRAY DEPLOYMENT AND ORIENTATION

O/W-4171
5-20-70

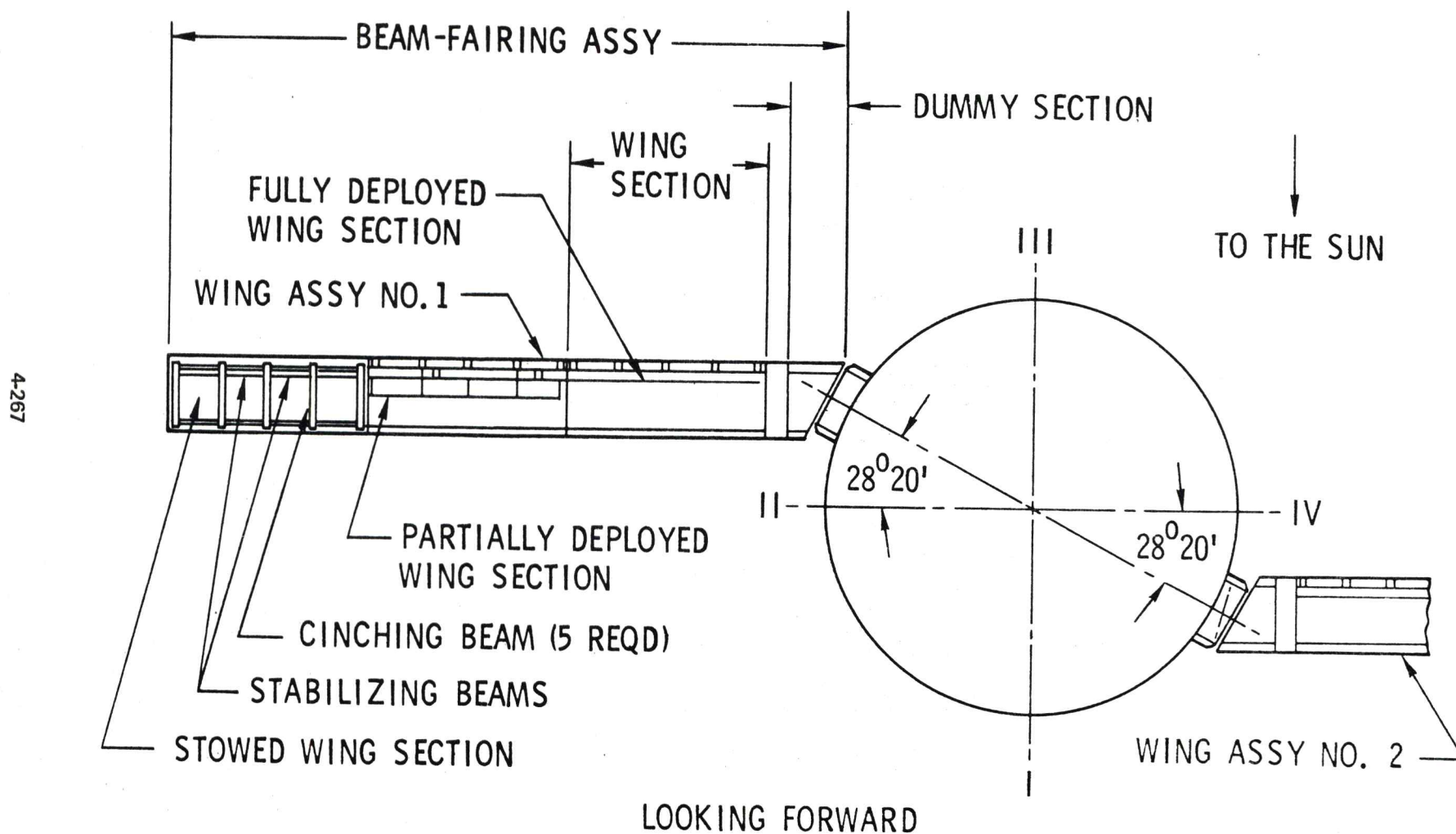


Figure 426-21.

The fairing assemblies when deployed are rotated 90 degrees to the OWS XZ plane by actuators which apply torque about the hinge lines and are held in the deployed position by mechanical latches.

The actuators are self-contained, preloaded energy sources.

The wing sections are also deployed by preloaded, self-contained energy source mechanisms.

SAS instrumentation provides the following telemetered data:

- a. Temperature at 20 locations (analog).
- b. Deployment position of the six wing sections relative to the fairing structure (analog).
- c. Deployment signals showing fairing secured to the side of the OWS (event).
- d. Deployment signals showing the fairings fully extended from the OWS (events).
- e. Voltage measurements on EBW firing units.

In addition, checkout test points are provided to monitor voltage at the positive terminals of each solar array module between the solar cells and their associated blocking diodes with respect to returns for each power group.

The electrical support equipment for the SAS consists of:

- a. Cabling from the modules to the SAS Power Unit (Figure 426-22).
- b. The SAS power unit containing the isolation diodes, bussing devices, and GSE connectors in the forward skirt (Figure 426-23).
- c. The SAS instrumentation signal conditioning unit in the forward skirt.
- d. Cabling from the SAS power unit to the AM (Figure 426-24).
- e. Fairing jettison and SAS deployment electronics.

4.2.6.3.1 Solar Array Grouping

The solar array wing sections are made up of 240 modules (120 per wing), divided into eight electrically isolated power groups of 30 parallel-connected modules each (Figure 426-25). This concept of arranging the modules into electrically isolated module groups minimizes the output power difference among the groups for the various shadowing conditions expected to be encountered.

ORBITAL WORKSHOP SAS - POWER WIRE ROUTING

O/W-4201-1
8-7-70

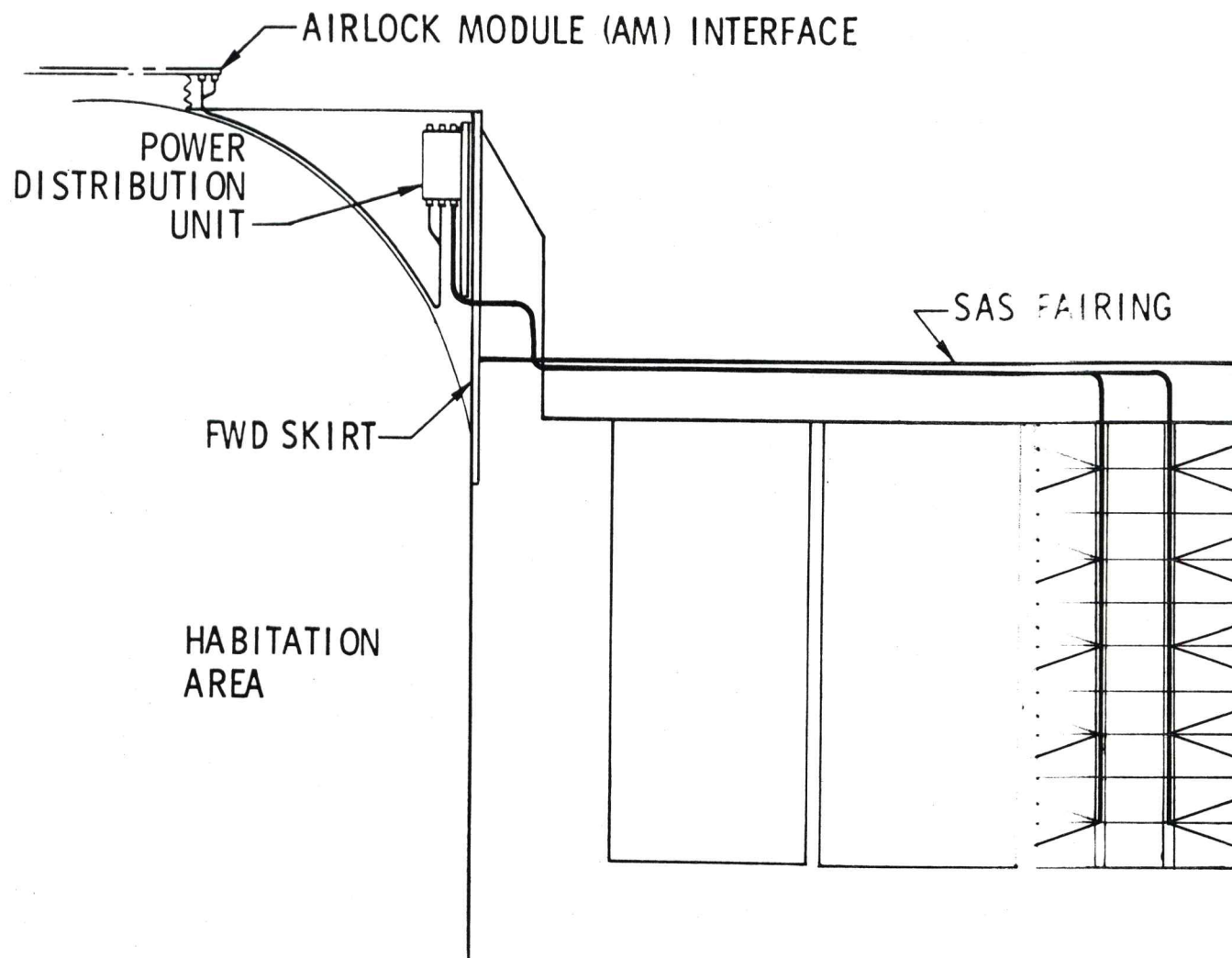
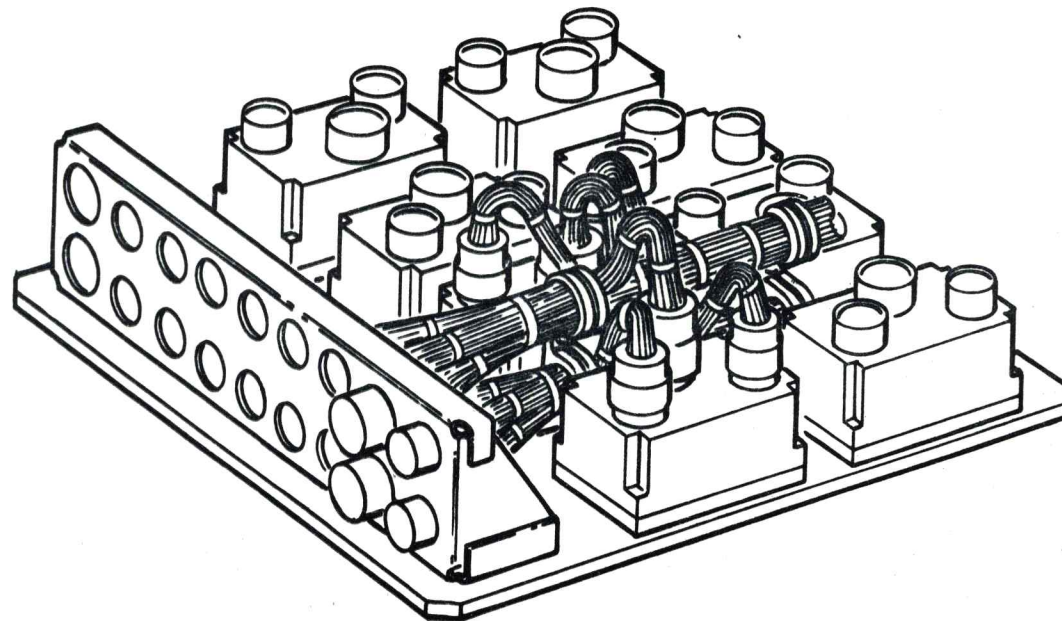


Figure 426-22.

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ORBITAL WORKSHOP SAS POWER UNIT

**O/W-7779
8-8-70**



4-270

Figure 426-23.

ORBITAL WORKSHOP SOLAR ARRAY SYSTEM

O/W-4537
8-6-70

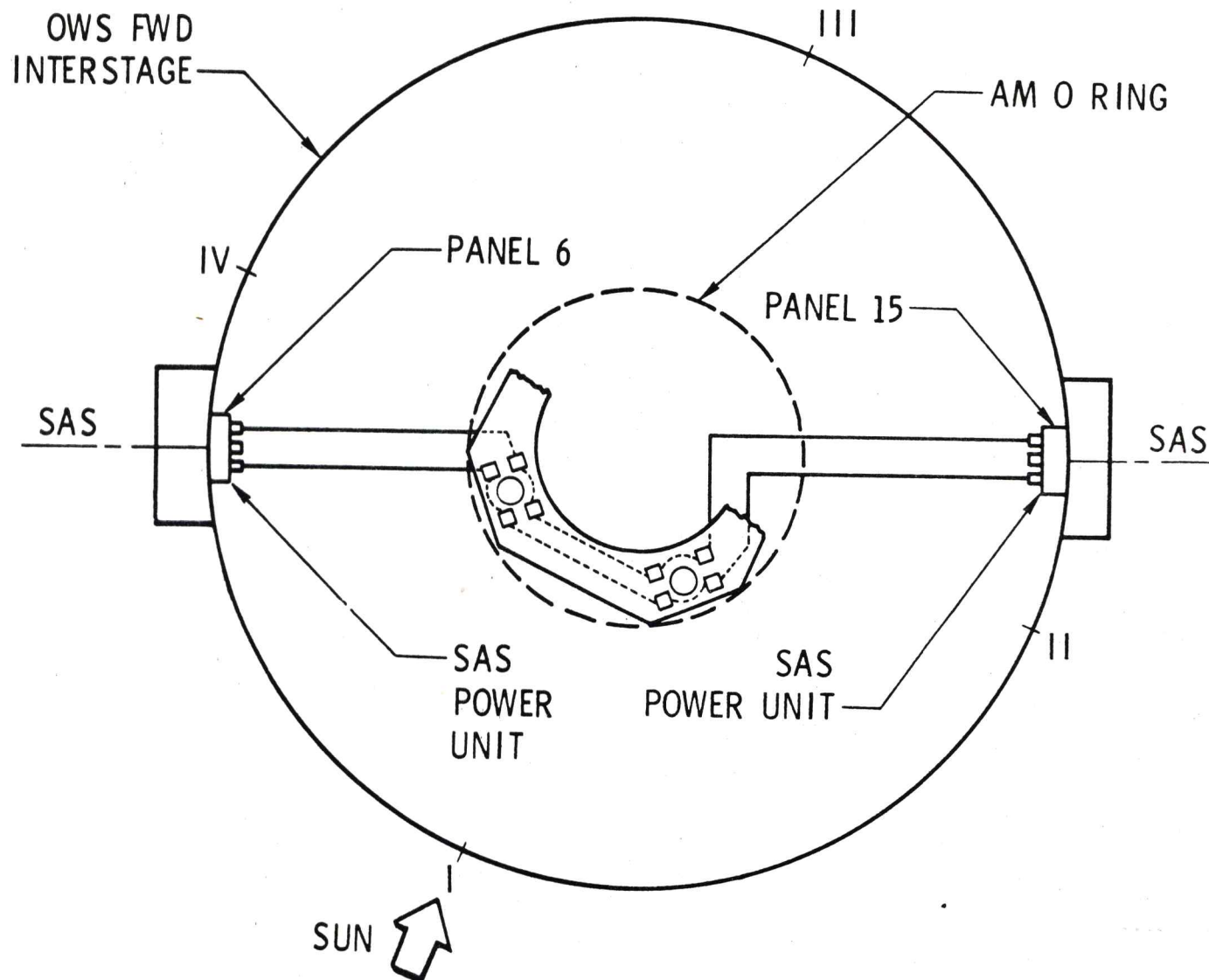


Figure 426-24.

ORBITAL WORKSHOP SAS-ELECTRICAL POWER

O/W-4190
6-2-70

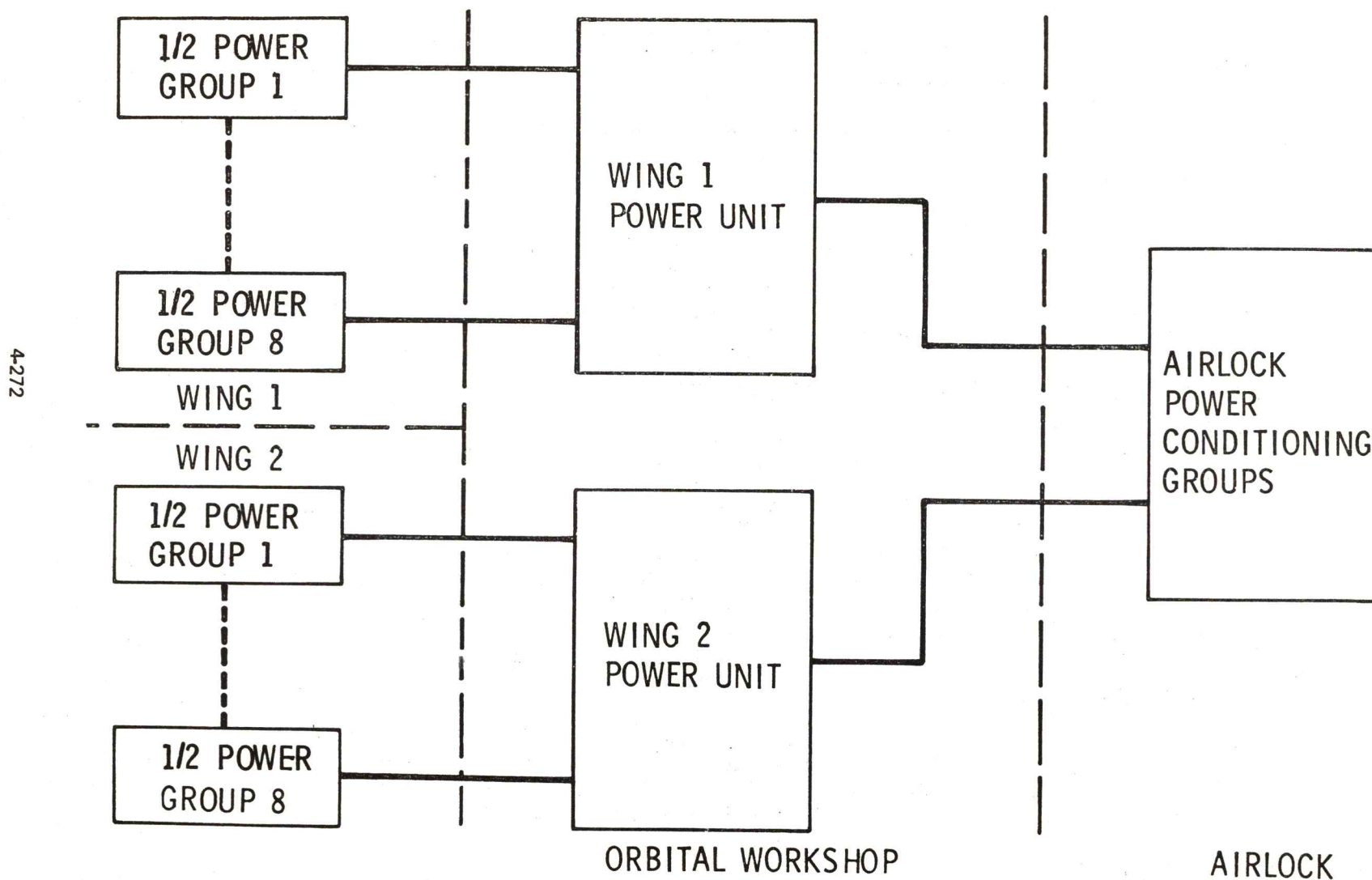


Figure 426-25. (Sheet 1 of 2)

ORBITAL WORKSHOP SAS - ELECTRICAL POWER

O/W-4190-1
5-20-70

4-273

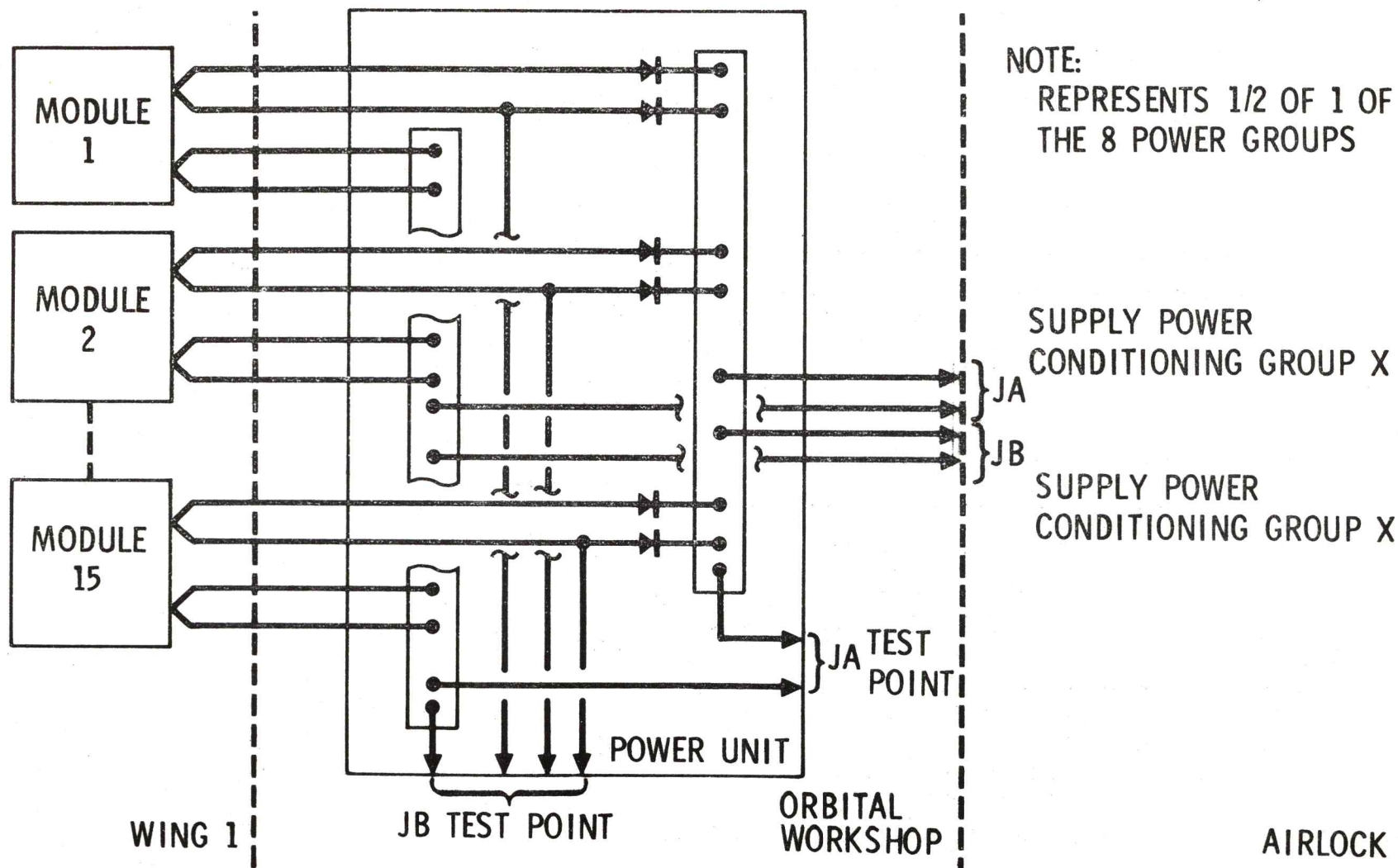


Figure 426-25. (Sheet 2 of 2)

The power output of the array, specified in CEI Specification CP2080J1C, shall not be less than 11,200 watts at the fairing interface at a temperature of 130°F at an intensity of 140 nm/cm² at the beginning of the SL-1 mission. Expected electrical characteristics are shown in Figures 426-26 and 426-27, as measured at the OWS/AM interface. Figure 426-26 shows expected performance for start of the mission, with no array misorientation. This represents a condition where the highest average voltages will be encountered. Figure 426-27 shows performance for the end of the mission, with 8 degrees misorientation. This represents the condition at which the lowest average voltages will be generated. It should be emphasized that Figures 426-26 and 426-27 represent expected or nominal values. Actual performance will vary above and below because of a measure of variability between solar cells and their modules. The standard deviation of voltage for a single solar cell module is approximately 0.7 volt.

4.2.6.3.2 Solar Array Deployment

The solar arrays are nominally deployed within 10 minutes prior to orbital sunrise and 30 minutes prior to orbital sunset to avoid excessive temperature extremes. Deployment is automatic via IU command with group backup via the AM and must be accomplished within TBD hours. The solar arrays can be deployed in any stable vehicle attitude.

Ordnance systems are used to release the fairings and solar array panels. The fairings, subsequent to release, are mechanically driven to and locked in an erected position normal to the OWS centerline. After the fairings are erected and locked in position, solar panel release from both fairings is simultaneously initiated. The completely redundant ordnance systems consist of exploding bridgewire (EBW) firing units and detonators and common ordnance type confined detonating fuse (CDF) assemblies.

4.2.6.3.2.1 Fairing Release

Solar array fairing release is accomplished by means of an automatic command through the IU and backup commands through the airlock module (Figure 426-28). Two independent ordnance systems are used to achieve redundancy. Ordnance systems consist of expandable tubes and frangible tension straps at each fairing tiedown point. Expandable tubes are initiated by confined detonating fuse (CDF) assemblies which are routed to CDF manifolds in the forward and aft skirts (Figure 426-29). One expandable tube in each tension strap expands to sever the tension strap when the primary command is issued through the IU. The other tube and its mating ordnance train remains unfired as a backup release system. This backup system is capable of being isolated electrically by opening circuit breakers in the airlock module.

The fairing hinge which completes deployment following ordnance release is shown in Figure 426-30.

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ORBITAL WORKSHOP SOLAR ARRAY ELECTRICAL CHARACTERISTICS START OF MISSION

O/W-8880
8-6-70

ELECTRICAL CHARACTERISTICS
AT OWS/AM INTERFACE
30-MODULE ARRAY GROUP

START OF MISSION
0° MISORIENTATION

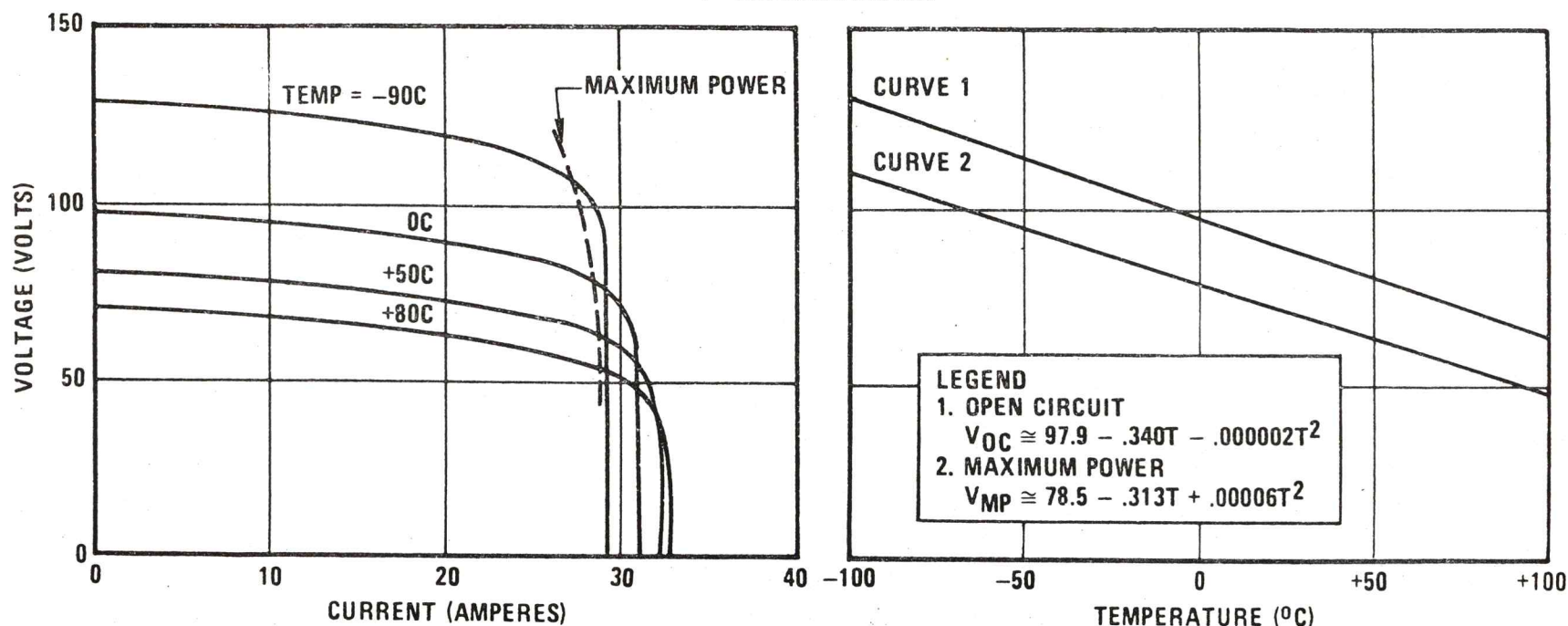


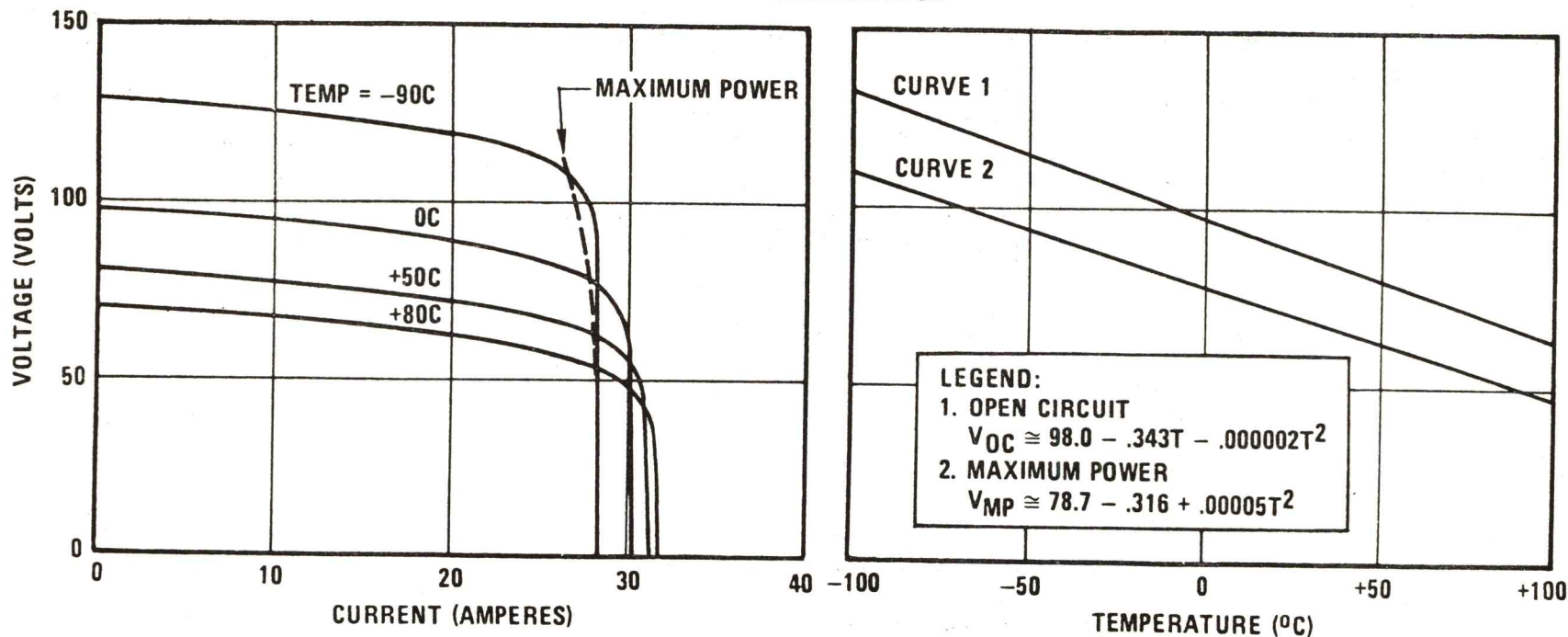
Figure 426-26.

ORBITAL WORKSHOP SOLAR ARRAY ELECTRICAL CHARACTERISTICS END OF MISSION

O/W-8881
8-6-70

VOLTAGE CHARACTERISTICS
AT OWS/AM INTERFACE
30-MODULE ARRAY GROUP

END OF MISSION
8° MISORIENTATION

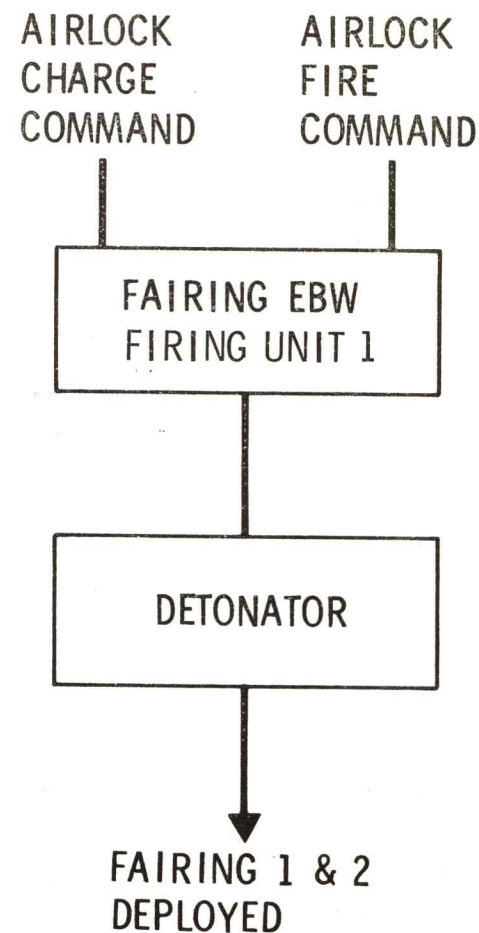
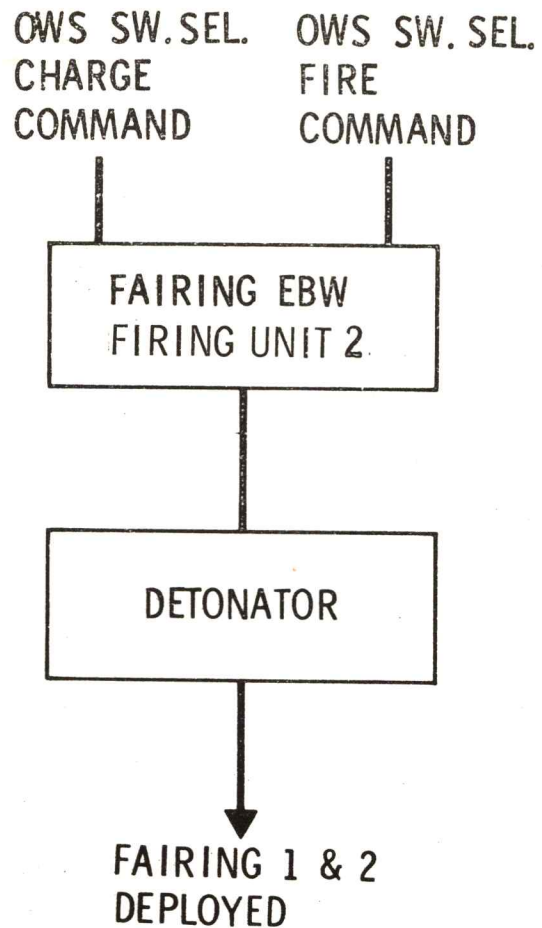


4-276

Figure 426-27.

ORBITAL WORKSHOP SAS - FAIRING DEPLOYMENT

OW-4188-1
8-7-70



ORBITAL WORKSHOP SAS-FAIRING DEPLOYMENT

O/W-4188
8-7-70

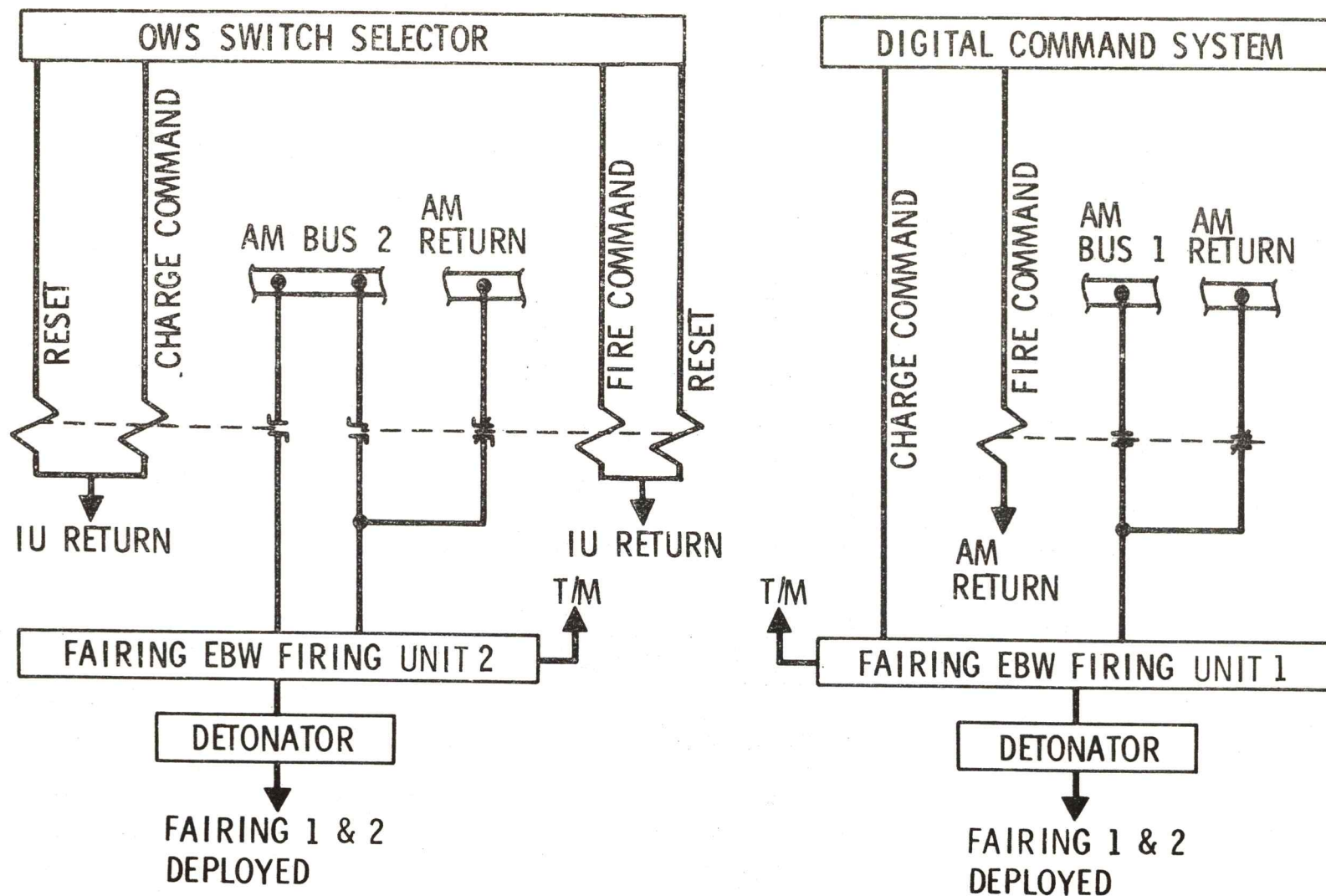


Figure 426-28. (Sheet 2 of 2)

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ORBITAL WORKSHOP SAS BEAM/FAIRING ORDNANCE RELEASE SYSTEM SCHEMATIC

O/W-8368
8-8-70

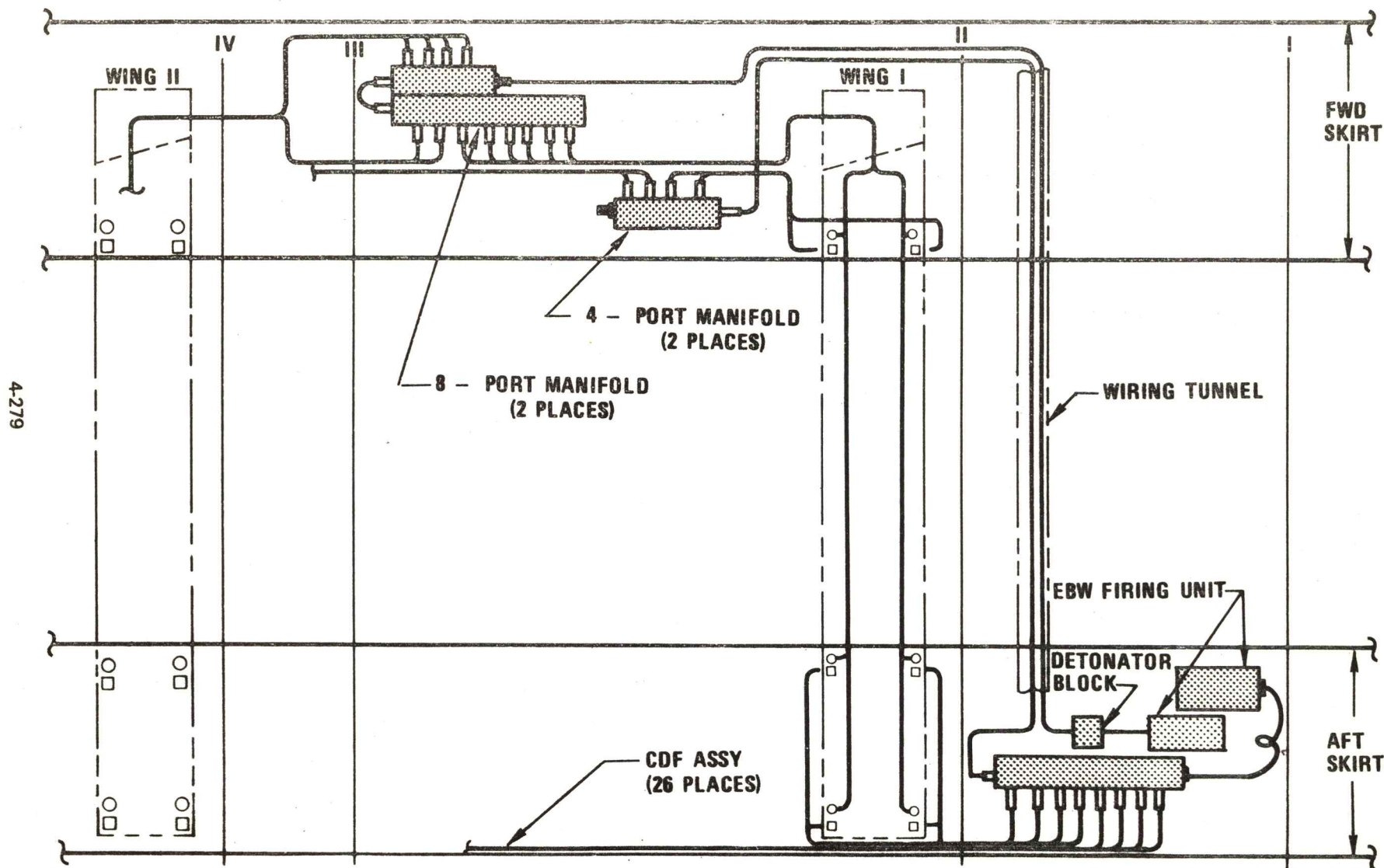
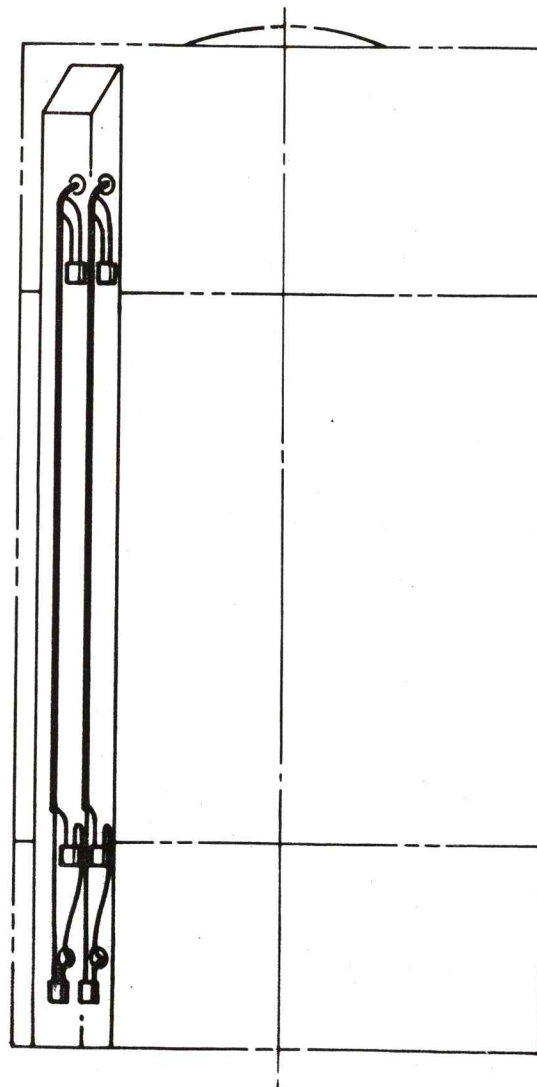


Figure 426-29. (Sheet 1 of 3)

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ORBITAL WORKSHOP SOLAR ARRAY SYSTEM BEAM FAIRING RELEASE

O/W-8369
6-30-70



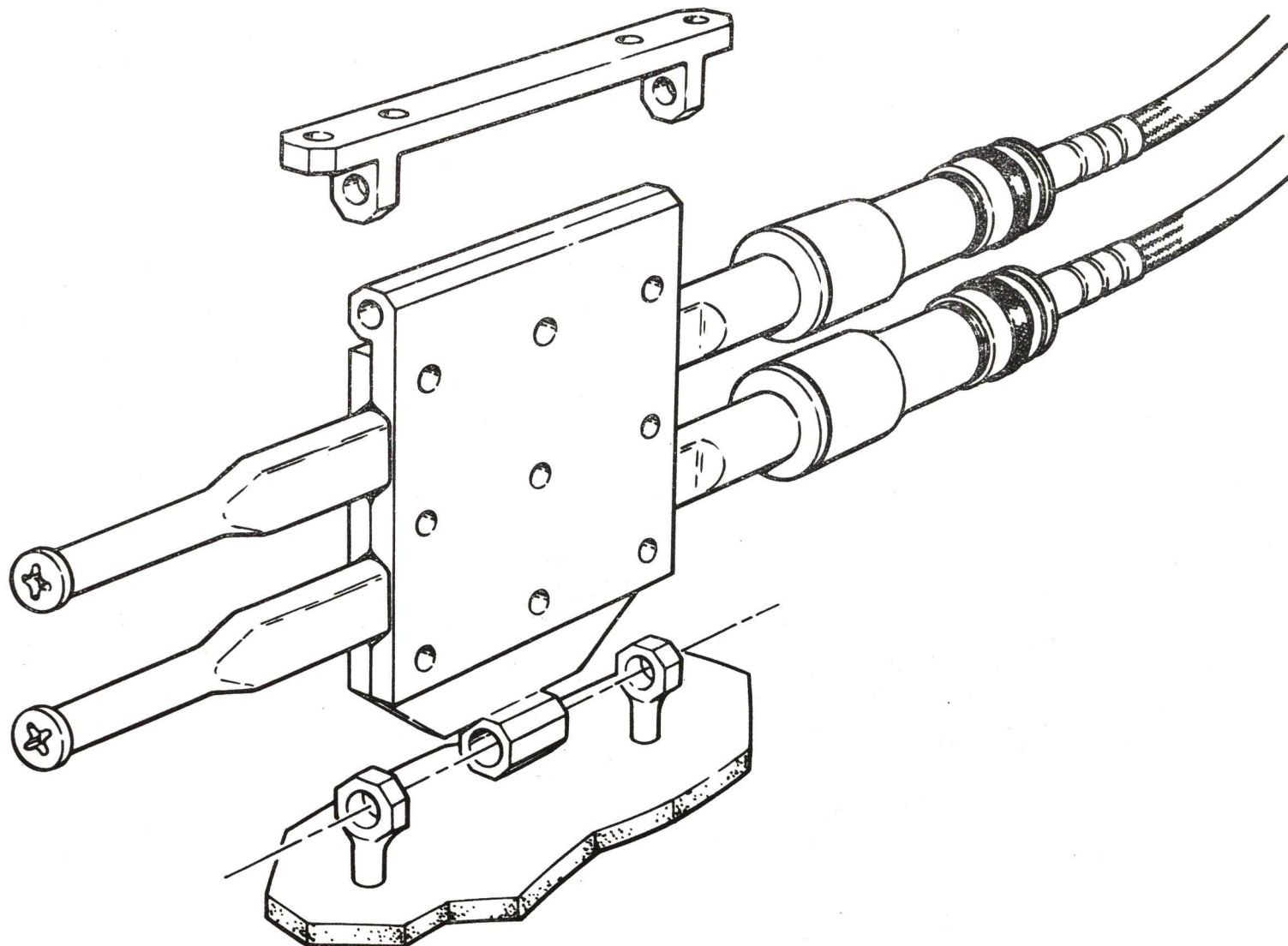
4-280

Figure 426-29. (Sheet 2 of 3)

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ORBITAL WORKSHOP SOLAR ARRAY SYSTEM BEAM FAIRING RELEASE

O/W-8369-1
6-30-70



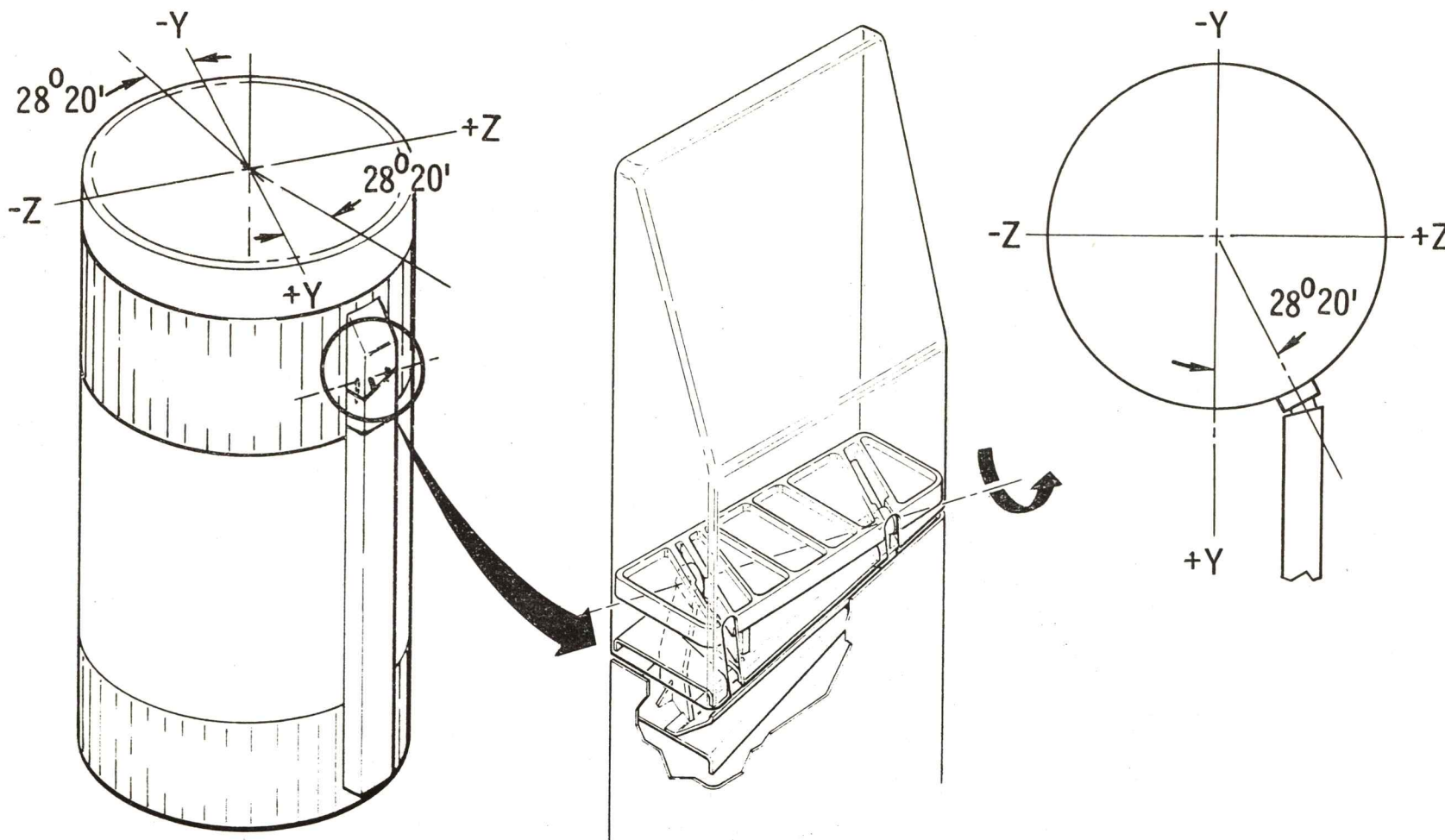
4-281

Figure 426-29. (Sheet 3 of 3)

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ORBITAL WORKSHOP SAS - BEAM FAIRING HINGE

O/W-4175
5-20-70



4-282

Figure 426-30. (Sheet 1 of 3)

ORBITAL WORKSHOP ACTUATION/ROTATION MECHANISM STOWED POSITION

O/W-1078
7-14-70

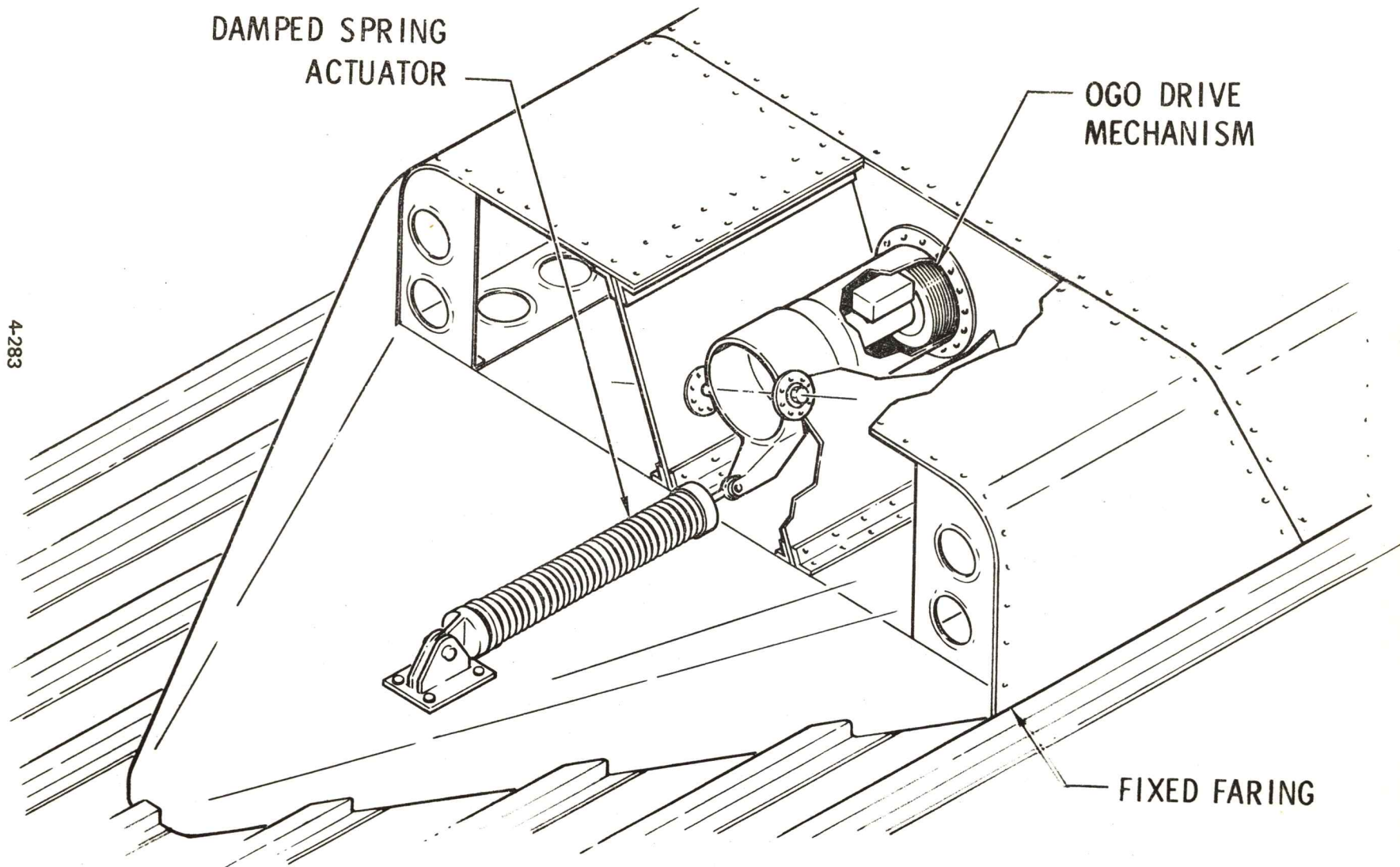
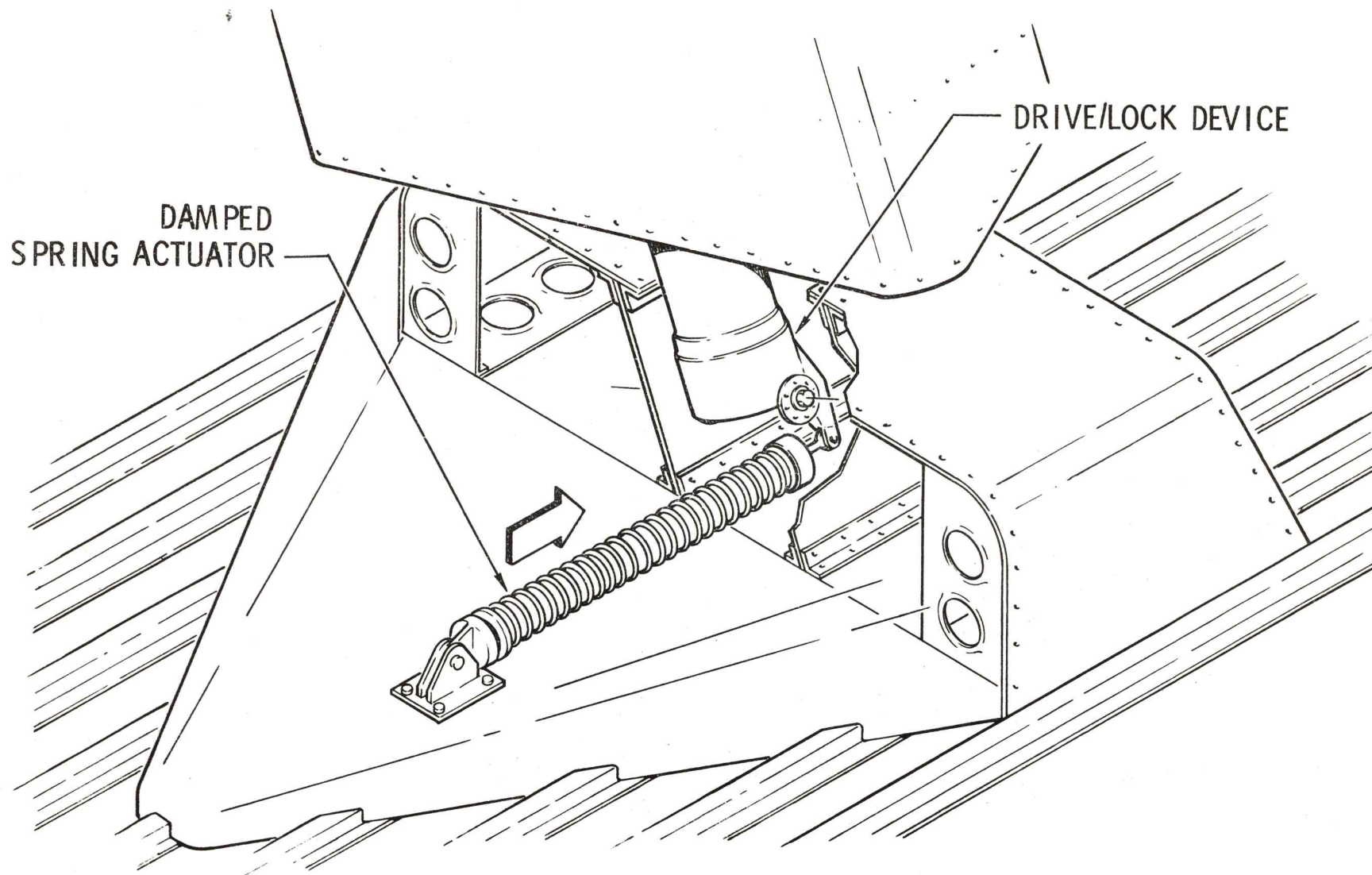


Figure 426-30. (Sheet 2 of 3)

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ORBITAL WORKSHOP ACTUATION/ROTATION MECHANISM DEPLOYED POSITION

O/W-1077
7-14-70



4-284

Figure 426-30. (Sheet 3 of 3)

4.2.6.3.2.2 Wing Section Release

Release of the wing system is accomplished by a completely redundant system consisting of dual (CDF contained) expandable tube assemblies adjacently mounted within each fairing and extending the full length of the fairing.

Functioning of either expandable tube assembly, which is designed identical to those used for meteoroid shield release, simultaneously releases the 15 cinching bars which retain the panels in each fairing. Once released, panel deployment is accomplished by spring force.

The dual CDF assemblies, routed from the detonator blocks through the skirt structure to the forward end of the SAS modules, which provide the energy to expand the tubes are initiated by redundant EBW firing units and detonators located in the forward skirt.

Primary wing section release commands are from the IU with back via the AM DCS (Figure 426-31).

ORBITAL WORKSHOP SAS-WING SECTION DEPLOYMENT

O/W-4189
3-23-70

OWS SW. SEL. OWS SW. SEL.
CHARGE FIRE
COMMAND COMMAND

SECTION EBW
FIRING UNIT 2

DETONATOR

ALL SECTIONS
DEPLOYED

AIRLOCK
CHARGE
COMMAND

AIRLOCK
FIRE
COMMAND

SECTION EBW
FIRING UNIT 1

DETONATOR

ALL SECTIONS
DEPLOYED

Figure 426-31. (Sheet 1 of 2)

ORBITAL WORKSHOP SAS-WING SECTION DEPLOYMENT

O/W-4189-1
6-2-70

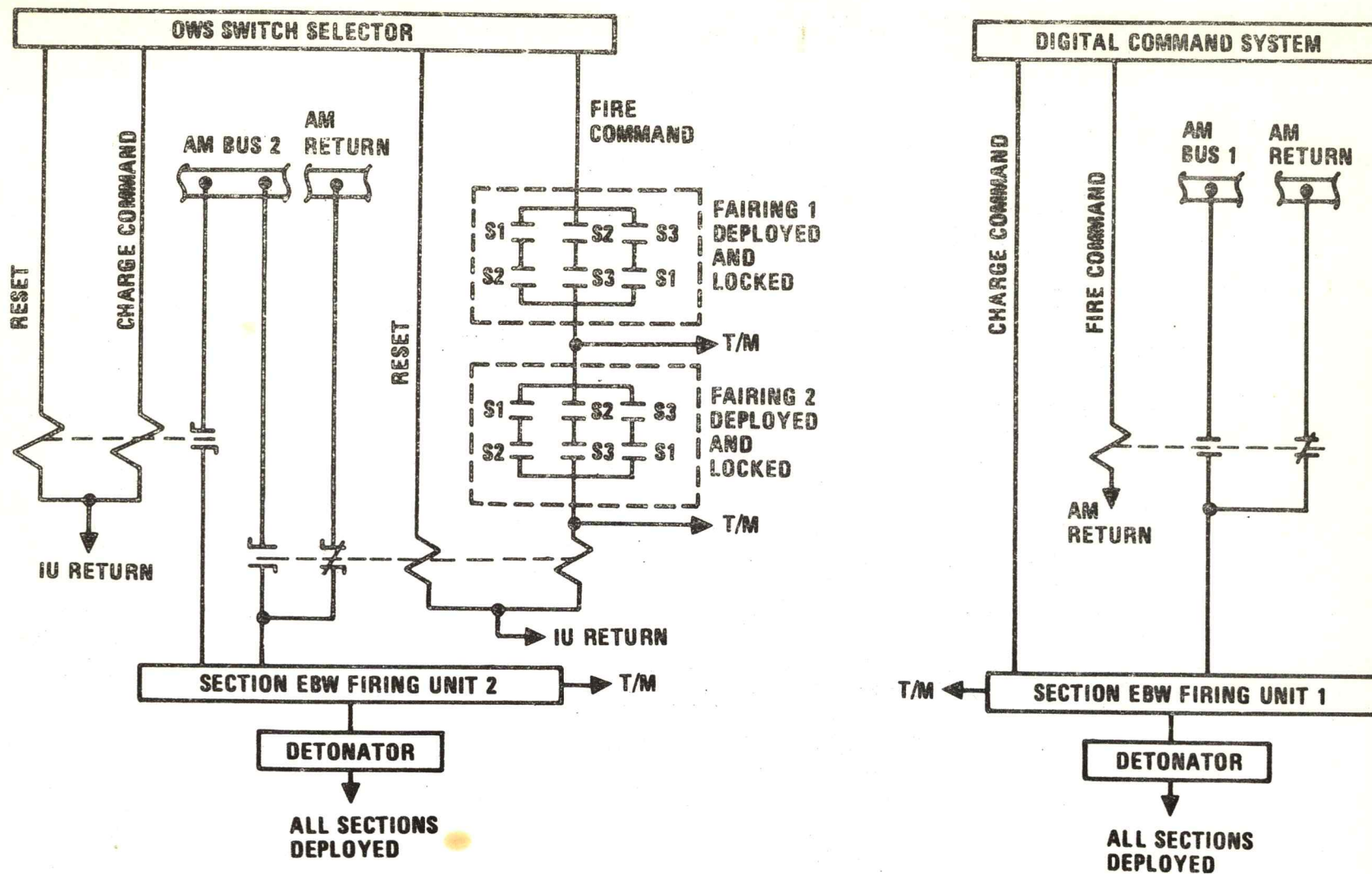


Figure 426-31. (Sheet 2 of 2)

HABITABILITY SUPPORT
SYSTEM

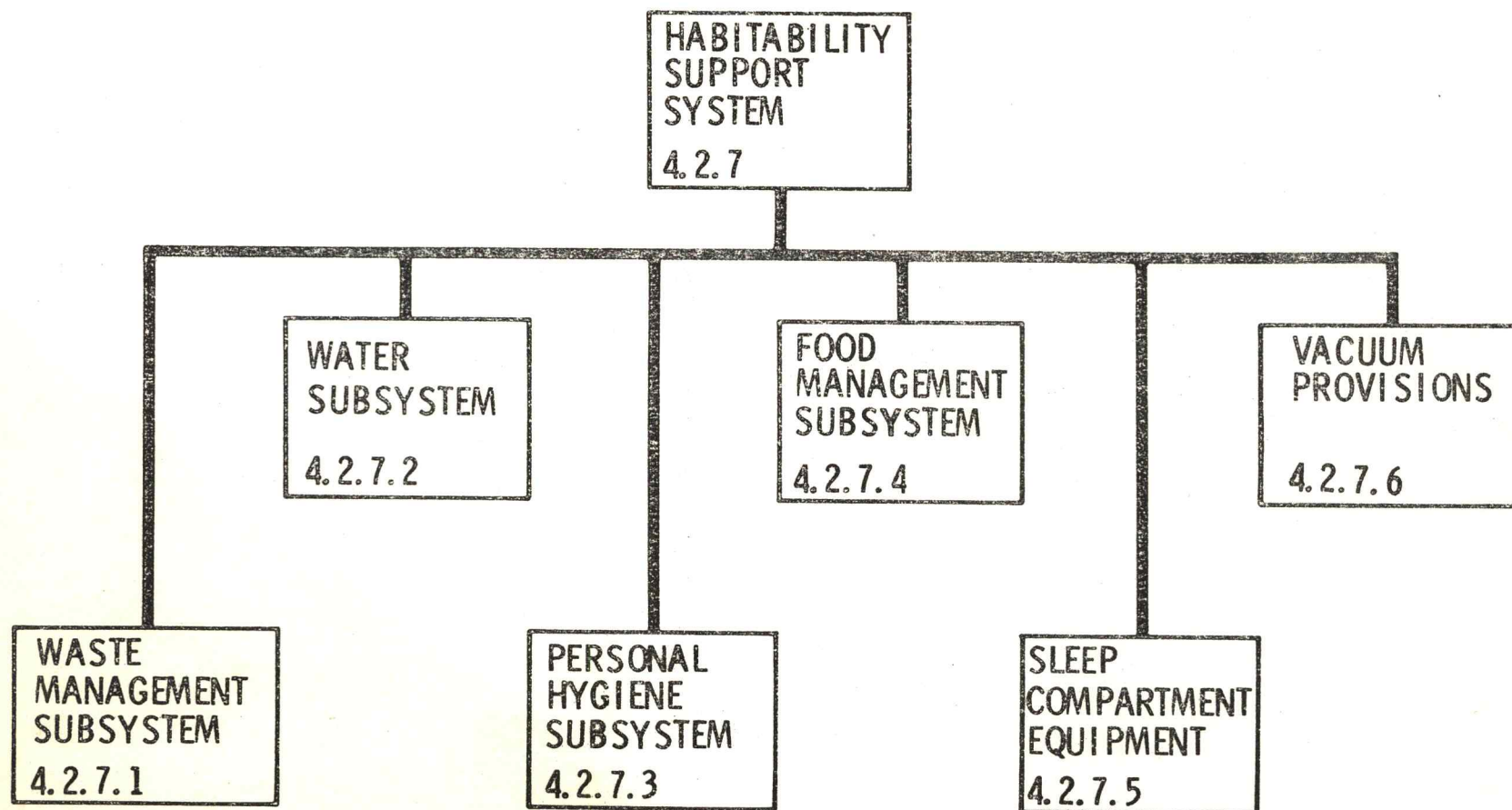
WASTE
MANAGEMENT
SUBSYSTEM

4.2.7.1

THE HABITABILITY SUPPORT SYSTEM (HSS) IS A SUBSYSTEM WHICH MANAGE METABOLIC WASTES FOR SUSTENANCE, HEALTH, PERSONAL HYGIENE,

ORBITAL WORKSHOP HABITABILITY SUPPORT SYSTEM

O/W-2047
6-12-70



THE HABITABILITY SUPPORT SYSTEM (HSS) CONSISTS OF SUBSYSTEMS AND EQUIPMENT WHICH MANAGE METABOLIC WASTES AND ACCOMMODATE THE CREWMEN FOR SUSTENANCE, HEALTH, PERSONAL HYGIENE, SLEEP AND COMFORT.

4.2.7 Habitability Support System

The Habitability Support System (HSS) consists of subsystems and equipment which manage metabolic wastes and accommodate the crewmen for sustenance, health, personal hygiene, sleep, and comfort.

The HSS provides equipment which will be used for one 28-day mission and two 56-day missions. HSS expendables for the 28-day mission and both 56-day missions will be launch-stored on SL-1.

The HSS includes the following:

- a. Waste Management.
- b. Water Subsystem.
- c. Personal Hygiene Subsystem.
- d. Food Management subsystem.
- e. Sleep Compartment Equipment.
- g. Vacuum Provisions.

The location of the HSS equipment in the OWS is shown in Figure 427-1.

ORBITAL WORKSHOP HABITABILITY SUPPORT SYSTEM EQUIPMENT LOCATION

O/W-1714
8-8-70

4-290

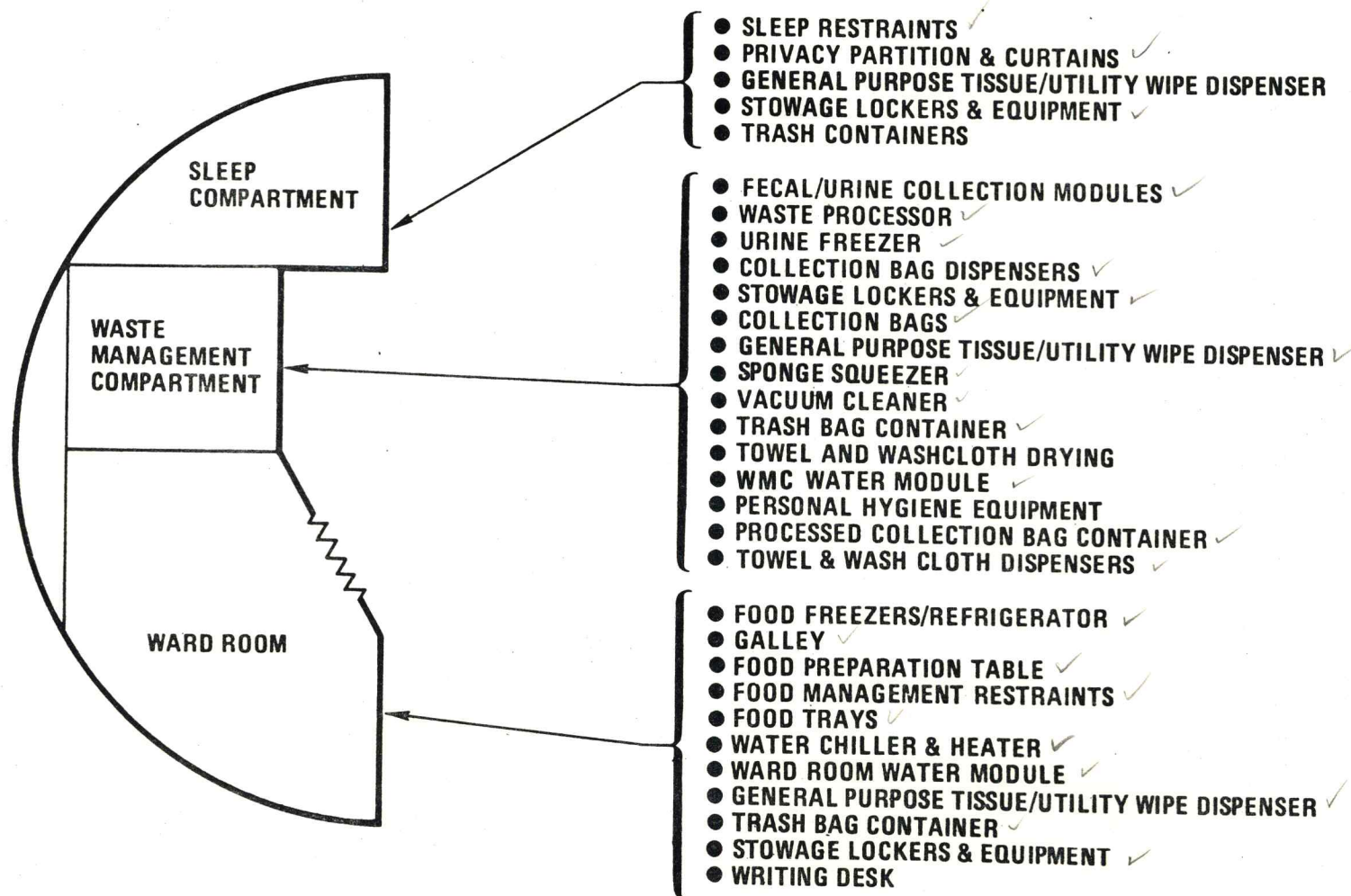
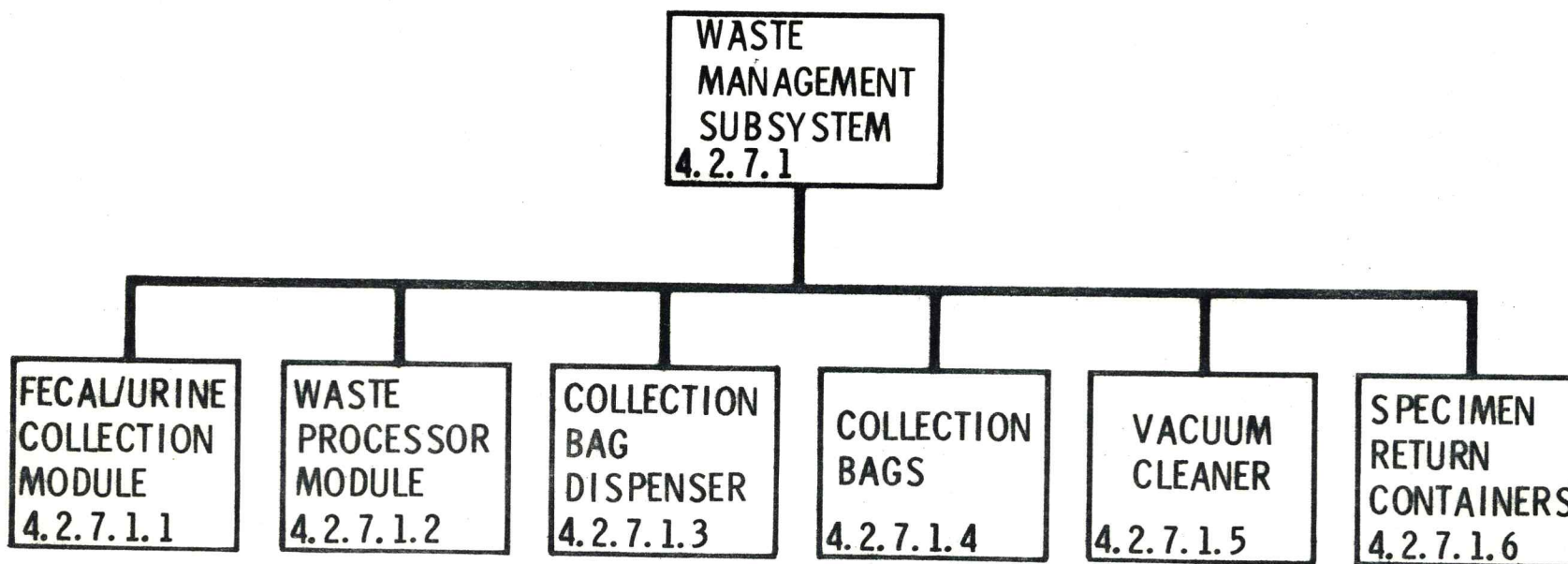


Figure 427-1.

ORBITAL WORKSHOP HSS WASTE MANAGEMENT SUBSYSTEM

O/W-2091B
6-19-70



THE WASTE MANAGEMENT SUBSYSTEM PROVIDES THE HARDWARE ITEMS NECESSARY FOR SAFE, EFFECTIVE, AND HYGIENIC COLLECTION, PROCESSING, STORAGE, RETURN, AND/OR DISPOSAL OF WASTE PRODUCTS (FECES, URINE, VOMIT AND DEBRIS) FOR THREE CREWMEN.

4.2.7.1 Waste Management Subsystem

The Waste Management Subsystem (WMS) provides the hardware items necessary for safe, effective, and hygienic collection, processing, storage, return and/or disposal of feces, urine and vomitus waste products for three OWS crewmen. The WMS also provides for collection and disposal of debris and free water from the atmosphere.

The modular components of the WMS are arranged in the OWS Waste Management Compartment (WMC) as shown in Figure 427-2. A schematic of the WMS is shown in Figure 427-3.

Urine from each crewmember is collected using individual receivers, tubing and collection bags in order to avoid cross-contamination. The total daily accumulation of urine from each crewmember is pooled and chilled in his bag for a 24-hour period. At the end of the pooling period volume determination of the collected urine is accomplished. Each pooled specimen is thoroughly mixed and a minimum urine sample of 120 ml is transferred to an attached sample container. The above operations are all performed without removing the urine bags from the collection module.

The three sample bags are separated from their respective collection bags, automatically sealed, and stored in the urine freezer. Waste urine is disposed of by depositing the urine and bags in the waste tank through the trash airlock. An alternate method of dumping waste urine is through the OWS urine dump system into the waste tank. Three fresh urine collection/sample bags and receiver assemblies are then installed in the collection module and the system prepared for the ensuing 24-hour period.

Each defecation and each vomitus deposit by each crewmember is collected in an individual collection bag. A hand held collection bag is used for the collection of vomitus. Each collected feces and vomitus specimen is then mass measured in its respective bag using a government furnished (GFE) specimen mass measurement device (SMMD) and then installed in a processor unit to be vacuum dried without any sample withdrawal.

All processed fecal and vomitus specimens and frozen urine samples, having been bacteriologically deactivated, are stored for return to earth in the Command Module for laboratory analysis.

Vacuum drying of all fecal and vomitus specimens, and freezing of the urine samples is accomplished without degradation of the organic or inorganic constituents of interest.

Provisions are also made for the collection of debris and free water particles from the OWS atmosphere into a collection bag by the use of a hand held vacuum cleaner. The debris bag is sealed and disposed of in the waste tank.

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ORBITAL WORKSHOP HSS WASTE MANAGEMENT COMPARTMENT

O/W-3890-2A
6-22-70

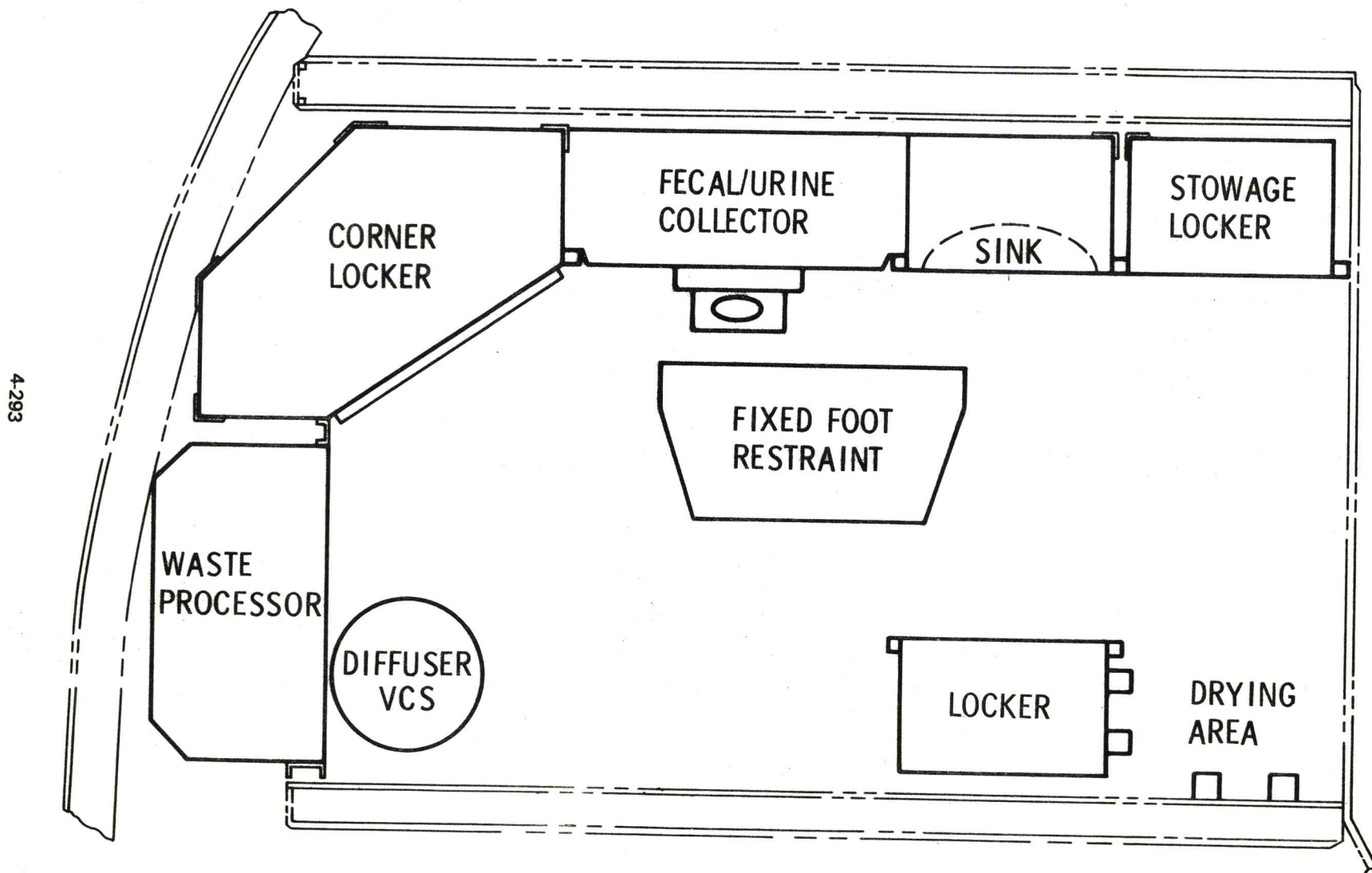
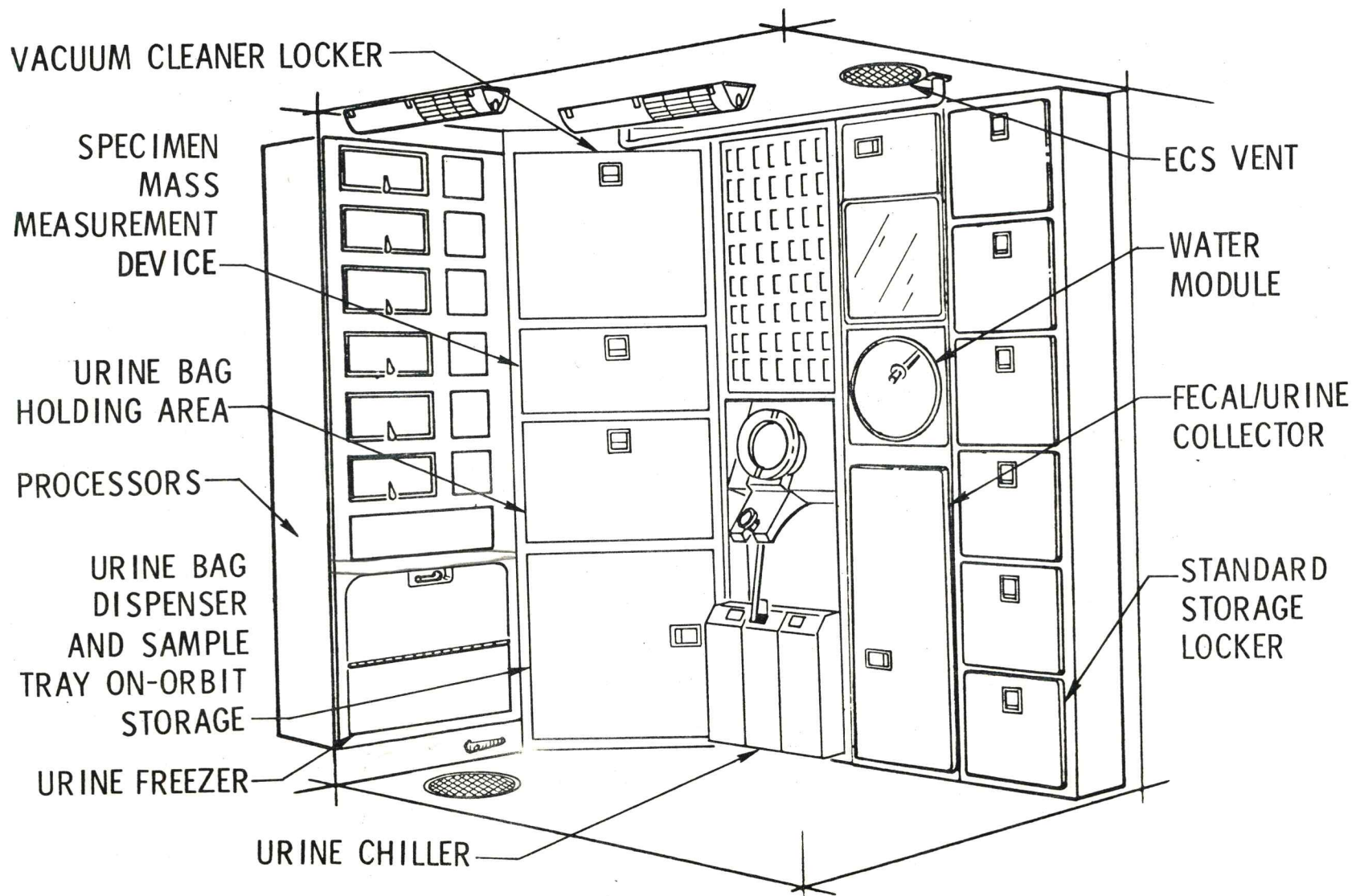


Figure 427-2. (Sheet 1 of 3)

ORBITAL WORKSHOP HSS WASTE MANAGEMENT COMPARTMENT

O/W-2183B-1
8-8-70

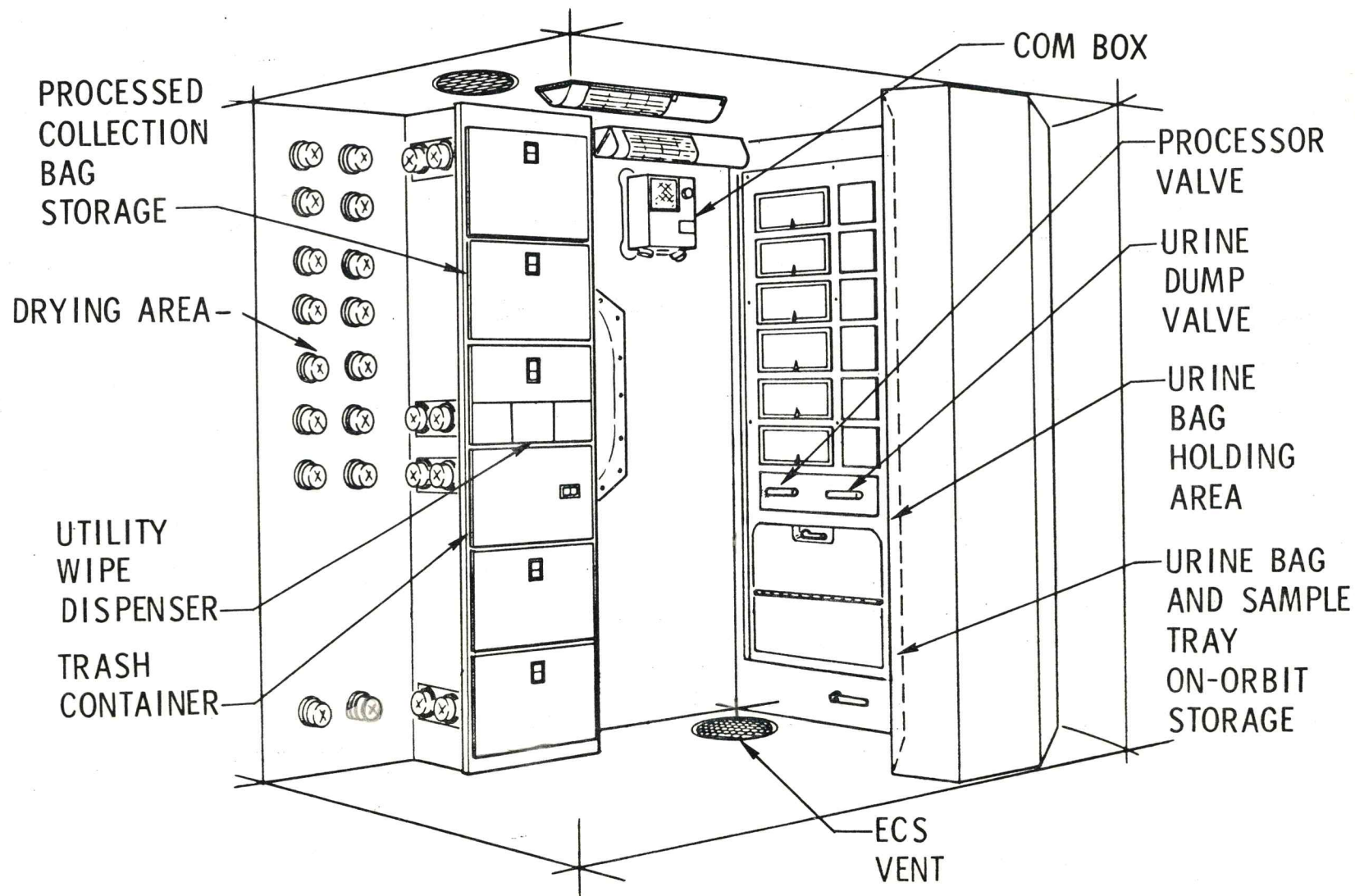


4-294

Figure 427-2. (Sheet 2 of 3)

ORBITAL WORKSHOP WASTE MANAGEMENT COMPARTMENT

O/W-2183A-1
8-3-70



4-295

Figure 427-2. (Sheet 3 of 3)

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ORBITAL WORKSHOP HSS WASTE MANAGEMENT SUBSYSTEM SCHEMATIC BASELINE DESIGN

O/W-4211
8-5-70

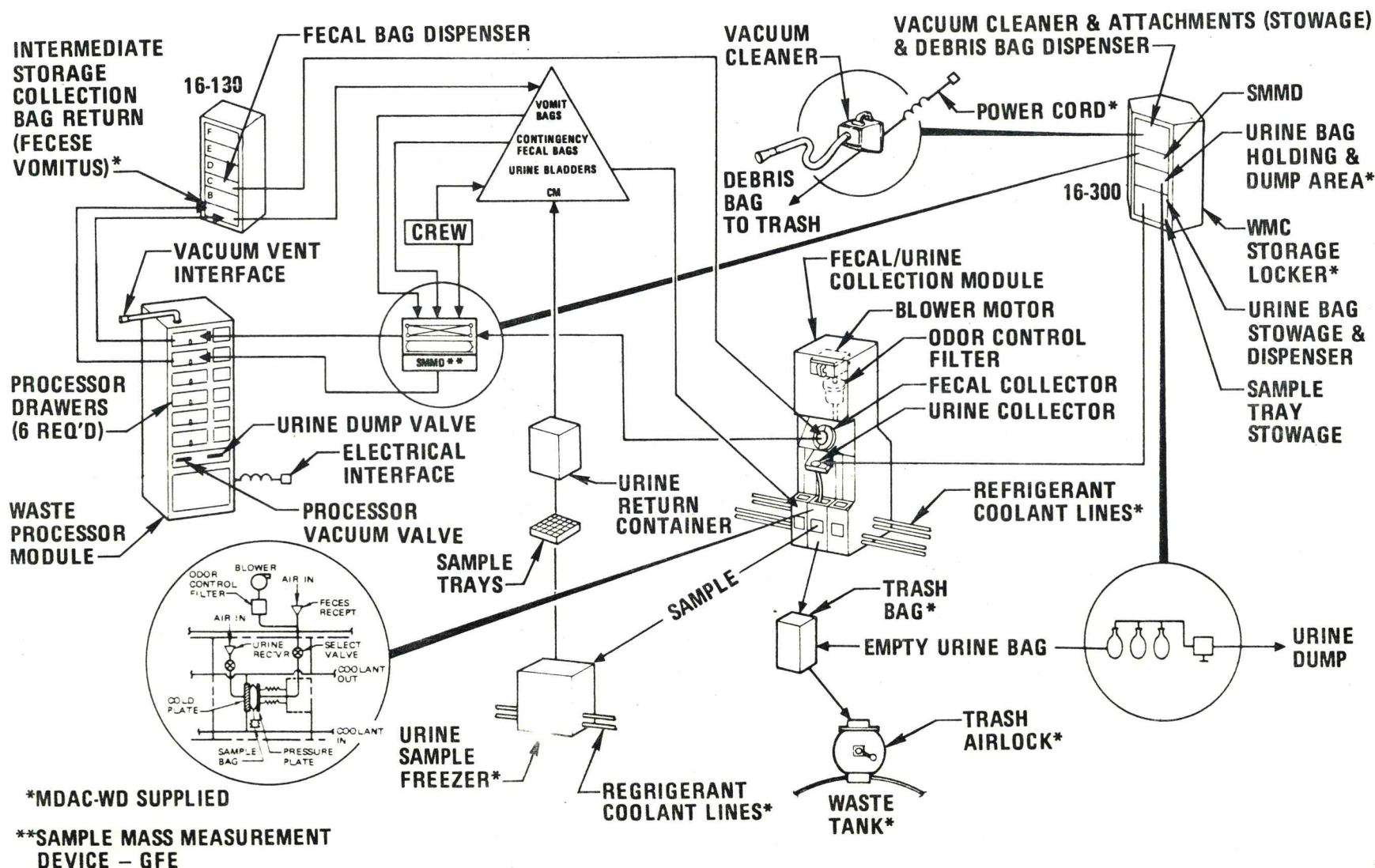


Figure 427-3.

4.2.7.1.1 Fecal/Urine Collection Module

The Fecal/Urine Collection Module is a rigid, wall-mounted unit which provides the hardware items necessary to collect the feces and urine. The Fecal/Urine Collection Module is designed so that a crewmember may defecate and urinate simultaneously while seated with restraints on the Fecal/Urine Collection Module. The module is designed to also accommodate a crewman urinating while in the standing position. To overcome the effect of zero gravity, a blower motor pulls cabin air through the fecal and uring bags to assist in separation and collection of all urine and feces deposits. The air flow passes through an odor control filter before exhausting back to the cabin atmosphere.

4.2.7.1.2 Waste Processor Module

The Waste Processor Module preserves those organic and inorganic constituents of the vomitus and feces required to support the medical experiments. The processor module vacuum dries the vomit and feces so that the residue may be safely stored in the OWS for the total mission duration and returned to earth by CM for Medical Laboratory Analysis.

The processor module is a wall-mounted unit consisting of a structural assembly and processing units (Figure 427-4). Each processing unit utilizes electric heating elements and space vacuum to accomplish drying of vomitus and feces. Each processing unit includes a timer. The timer is manually set by the crewman to start the drying cycle; it automatically shuts off each processing unit at the completion of the drying cycle.

In operation, a collection bag containing waste material is placed in an open processing chamber. When the door to the processing chamber is closed, it will, through mechanical linkage, open the chamber to space vacuum. A pressure plate, operated by the collection bag pressure differential, will open or close the bag filter saver valve as necessary to prevent overpressurization of the bag. The heater element is thermostatically controlled at 140°F. This temperature is sufficient, with the reduced pressure in the chamber, to cause the water in either the vomit or feces to evaporate and dump overboard through the vacuum valve.

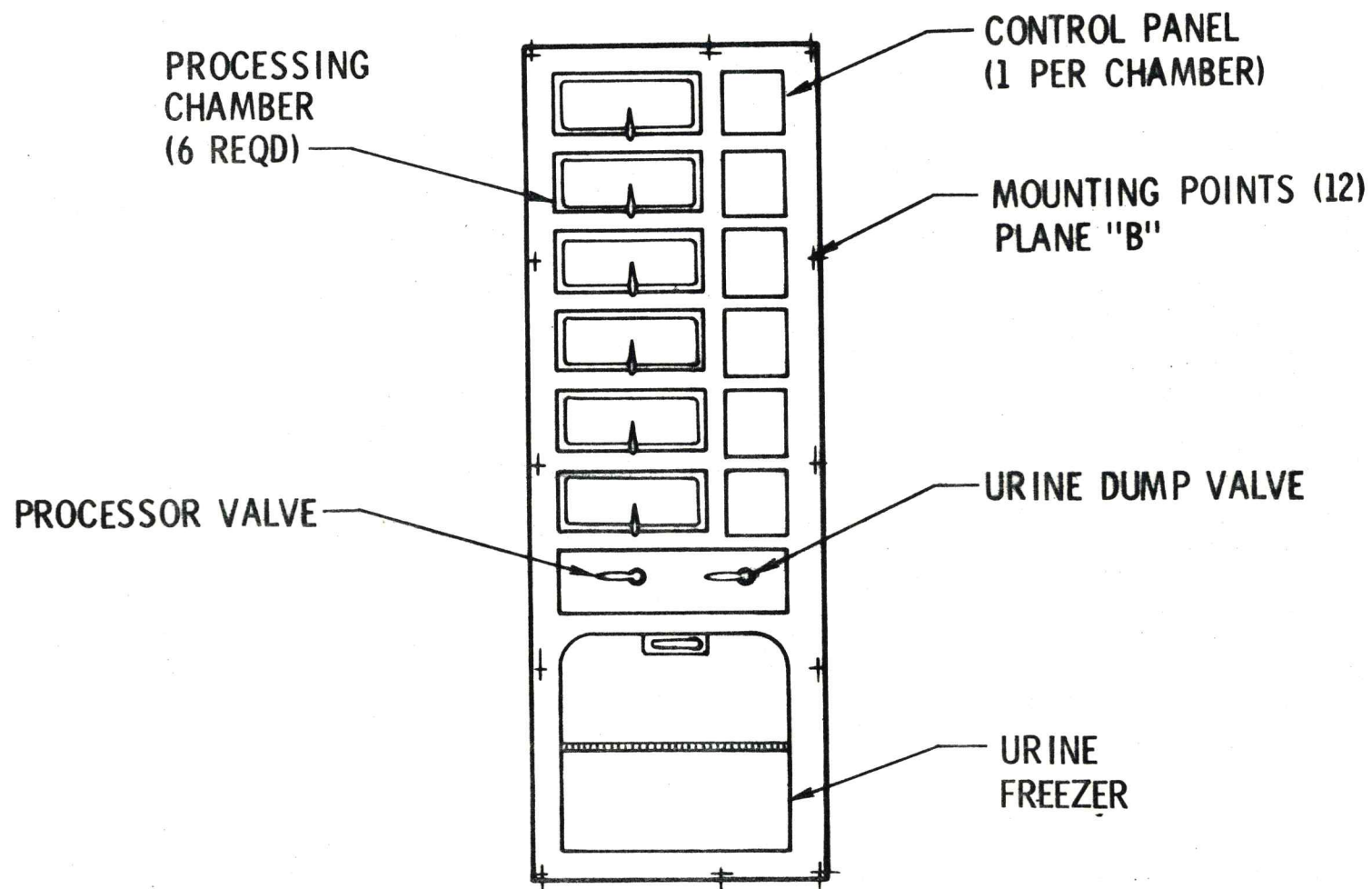
4.2.7.1.3 Collection Bag Dispenser

The Collection Bag Dispenser provides the crewmen with a convenient method of obtaining fecal and urine bags as required. The dispenser is mounted on the waste management compartment wall adjacent to the Fecal/Urine Collection Module to provide easy access to the bags during waste management activities. The dispenser is resupplied with fecal and urine bags from the Waste Management Supply Cabinet.

The crewman obtains a bag by grasping it and extracting it from the dispenser. As a bag is removed, a replacement bag is automatically moved into position by spring action, replacing the bag which was removed (Figure 427-5).

ORBITAL WORKSHOP WASTE PROCESSOR MODULE

**O/W-2205-1
8-6-70**



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Figure 427-4. (Sheet 1 of 2)

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ORBITAL WORKSHOP HSS WASTE PROCESSOR UNIT

O/W-1092
5-8-70

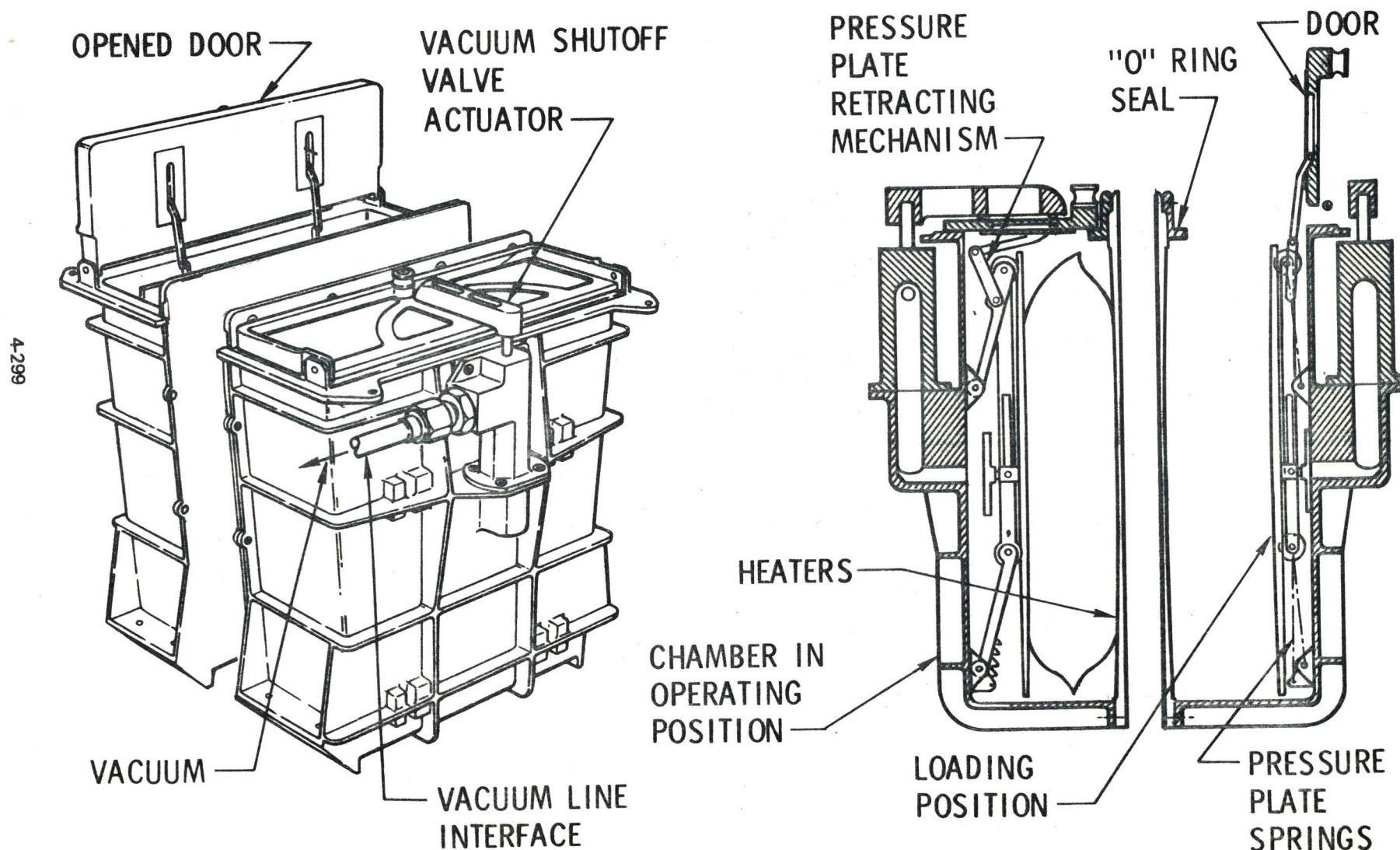
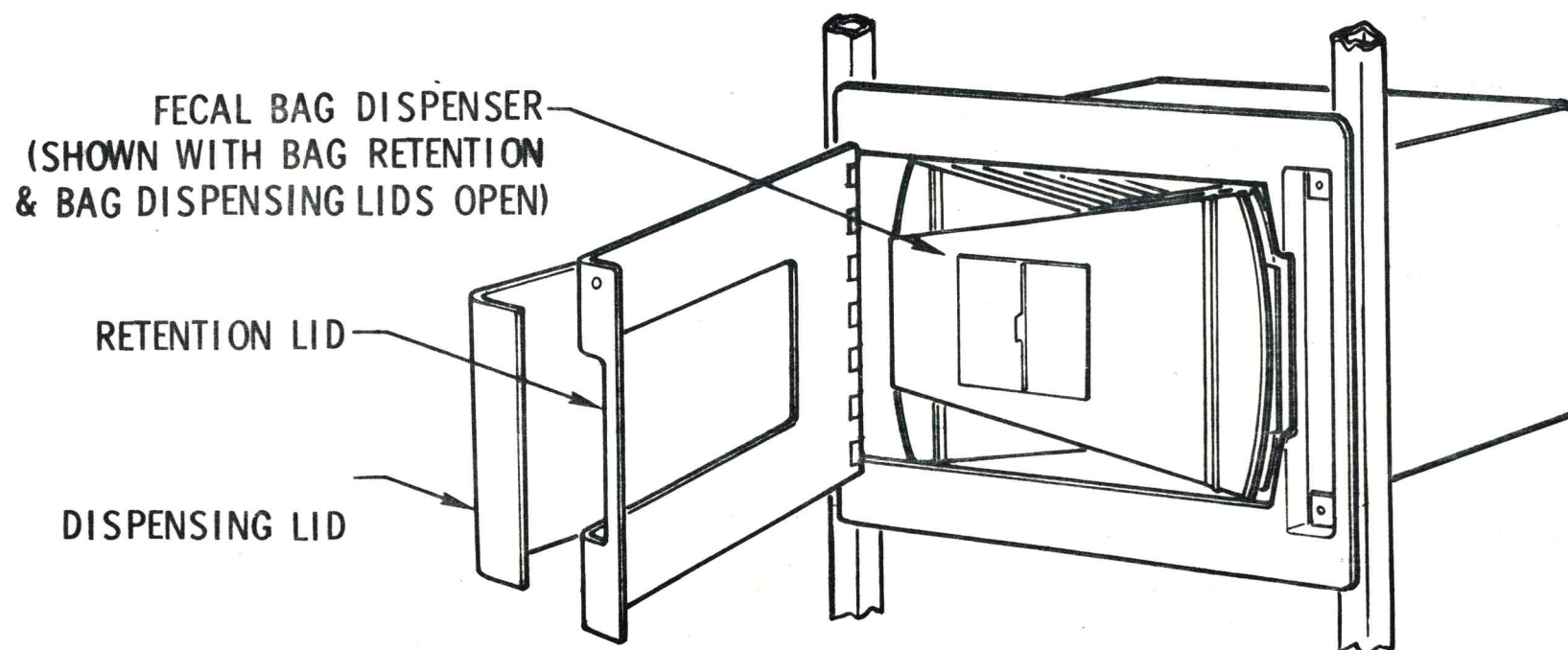


Figure 427-4. (Sheet 2 of 2)

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ORBITAL WORKSHOP HSS FECAL BAG DISPENSER

O/W-2107
5-28-70



4-300

Figure 427-5.

4.2.7.1.4 Collection Bags

Collection Bags are used by the crew for the collection of urine, feces, vomit, body wash water, and vacuum cleaner debris.

For fecal and urine collection, bags are removed from the supply cabinets as required and are loaded into the Collection Bag Dispenser. Individual bags for vomit and vacuum cleaner debris collection are removed directly from the supply cabinets and are used as required.

Collection bags are constructed of an impermeable outer material with an opening of sufficient size to allow waste material and air to enter. A vapor port in the collection bag allows air and vapors to pass through and exit the bag.

Water and solid material cannot exit through the port. The vapor port contains a millipore filter with a hydrophobic surface. Liquid waste material in the bag is repelled from the vapor port by the hydrophobic surface and is attracted to the side of the bag opposite the vapor port by a hydrophilic surface. The bag filter also serves to prevent the passage of bacteria from the bag into the OWS atmosphere. Collection bags also include a sealable closure and other features which make them compatible with the waste collection receptacles and the Waste Processor Module. A data entry tag is provided as an integral part of the urine, fecal, and vomit collection bags.

The various types of collection bags used in the Waste Management Subsystem are described in the following paragraphs.

Urine Bags

Urine bags (Figure 427-6) with sample bag attached are obtained from the Collection Bag Dispenser and inserted into the urine collector receptacle. The bag is designed with a transfer port to allow transfer of urine to an attached sample bag and to facilitate overboard dumping. The total daily accumulation of urine from each crewmember is pooled and chilled in his bag for a 24-hour period. At the end of the pooling period a volume determination is taken of the collected urine. The pooled urine is thoroughly mixed and a minimum urine sample of 120 ml will be transferred to the attached sample bag.

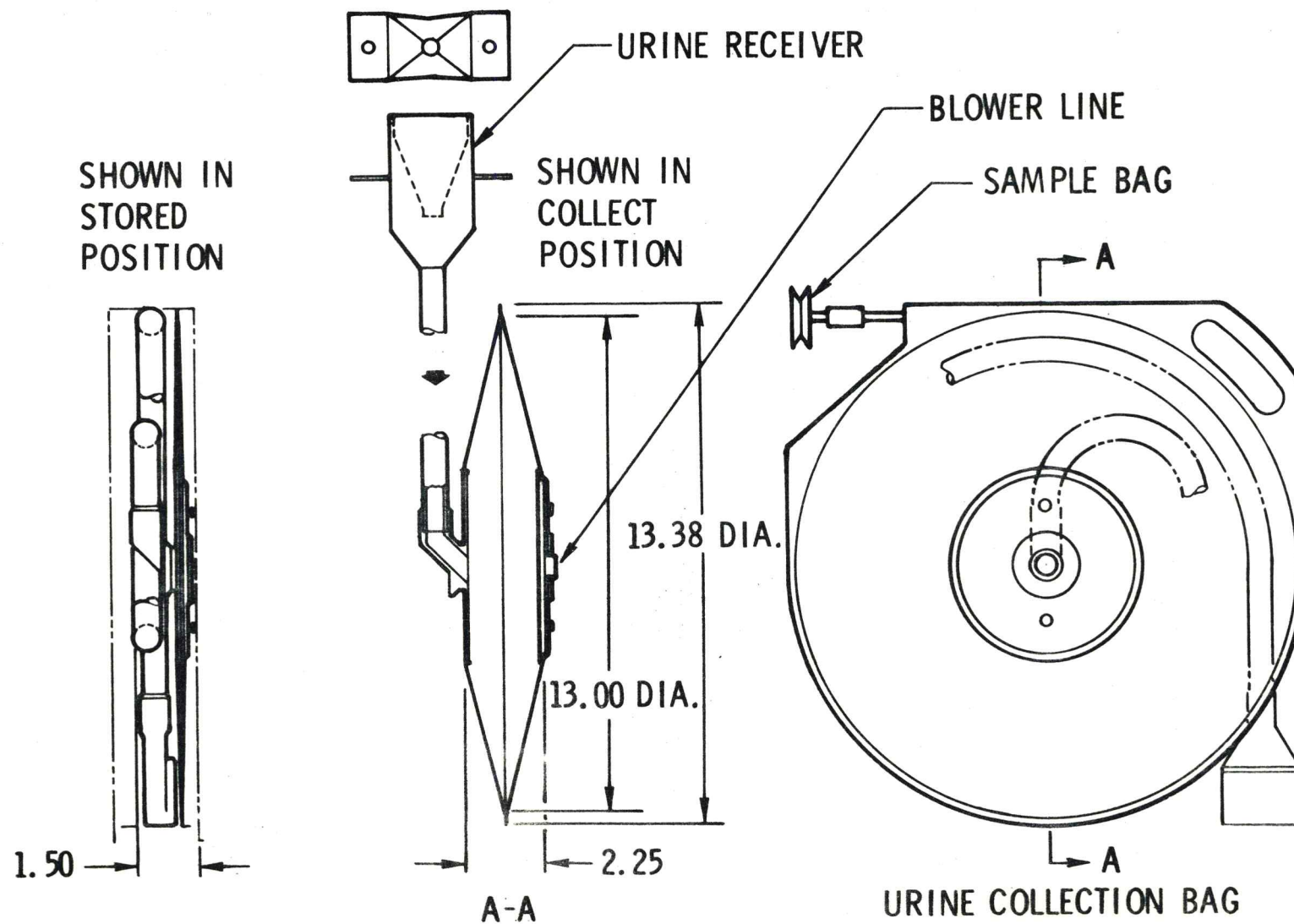
Urine Sample Bag

Sample bags are provided to obtain a urine sample from the urine collection bag. The sample bag is designed so it can be folded and stored flat prior to use. It is connected to the collection bag by a transfer line and self-sealing valve so that the sample volume can be transferred without removing the bag from the urine collector. The bags are designed as follows:

- a. Sample bag for a minimum of 120 ml of urine.
- b. Designed for minimum return volume and weight.

ORBITAL WORKSHOP URINE COLLECTION BAG

O/W-7438
5-28-70



- c. Capability for push-lever separation of the sample bag from the collection bag with automatic positive sealing of each bag.
- d. Capable of storage and freezing in the urine freezer. The bag containing frozen urine is 2 x 2 x 2-3/8 inches.
- e. Compatible for freezing at -2.5° to -14°F.

When the transfer valve is opened the required quantity of urine is forced into the sample bag. The valve is then closed and the bags separated. The sample bag is then placed in the urine freezer for preservation by freezing.

Fecal Bags

Fecal bags (Figure 427-7) are obtained from the Collection Bag Dispenser and are inserted into the fecal collector receptacle. After use, the bag is removed from the receptacle and placed on the SMMD to determine its mass. The bag is then placed in the Waste Processor Module. After processing is completed, the bag is transferred to the Specimen Return Container for return to earth in the CM.

Vacuum Cleaner Debris Bags

Vacuum cleaner debris bags (Figure 427-8) are obtained individually from the Waste Management Supply Cabinet and a single bag is installed in the vacuum cleaner bag receptacle. After use, the bag is removed from the vacuum cleaner, sealed, and eventually deposited in the waste tank through the trash airlock.

Vomit Bags

Vomit bags (Figure 427-9) are obtained from the Waste Management Supply Cabinet. Vomit bags are obtained as needed or are carried on the crewman's person. The bags are used manually and do not require blower motor air flow.

After use, the mass of the bag containing vomit is determined and the bag is placed into the Waste Processor Module. After processing, the bag is transferred to the Specimen Return Container for return to earth in the CM.

CM Contingency Fecal Collection Bag

Contingency Fecal Collection Bags (Figure 427-10) are provided for interim use in the Command Module. These bags are capable of collecting feces without a receptacle and without airflow by attaching the bag to the buttocks during defecation utilizing a device for separating the bolus from the anus. The collection bag is capable of subsequent inactivation in the Waste Processor Module.

4.2.7.1.5 Vacuum Cleaner

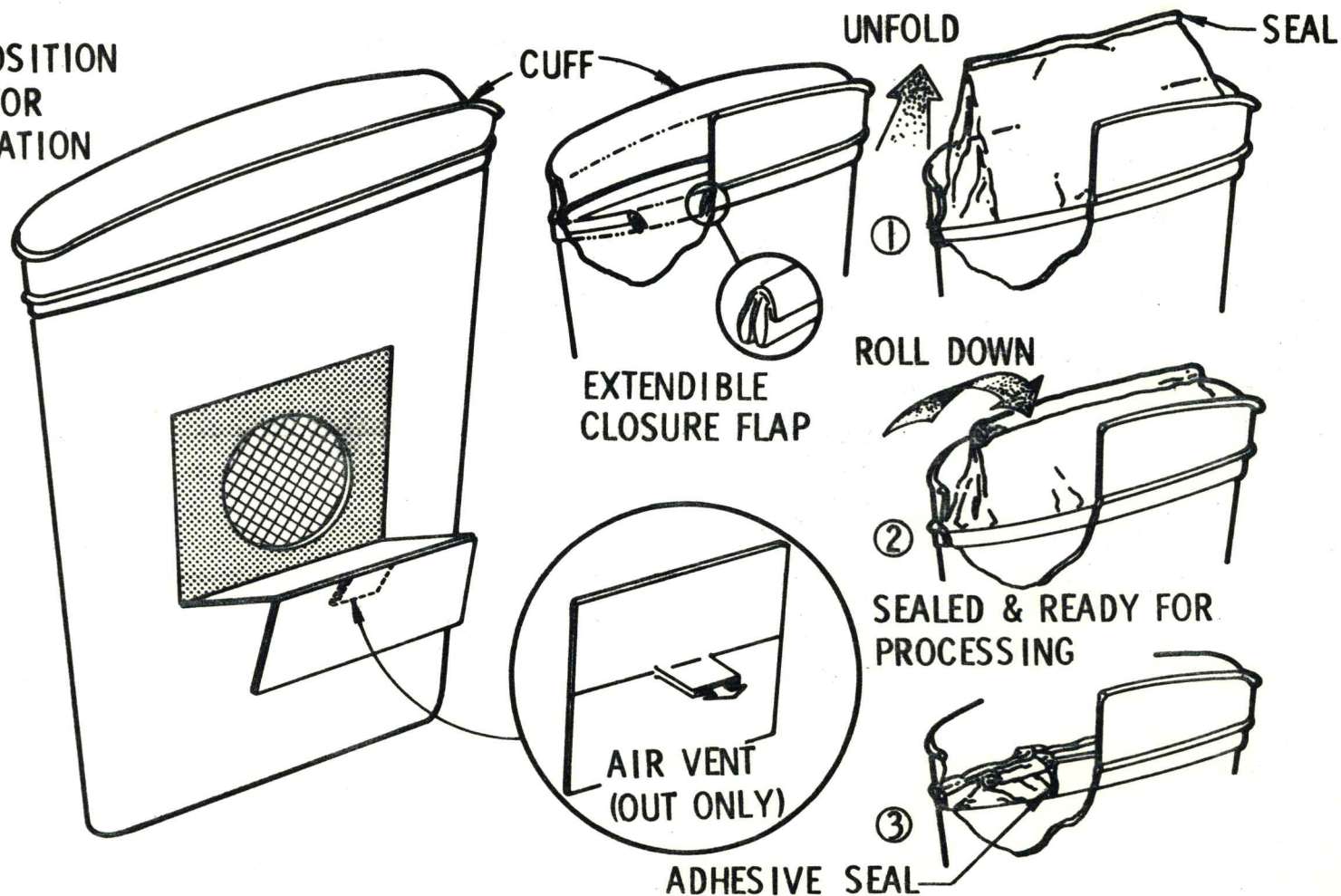
The vacuum cleaner (Figure 427-11) is used to collect and retain particulate matter, water droplets, and debris, utilizing the air flow provided by a blower motor. All areas of the OWS are accessible to the unit. It is a

ORBITAL WORKSHOP WASTE MANAGEMENT SUBSYSTEM FECAL COLLECTION BAG

O/W-1070
5-18-70

OPEN POSITION
READY FOR
INSTALLATION

SEALING OPERATION

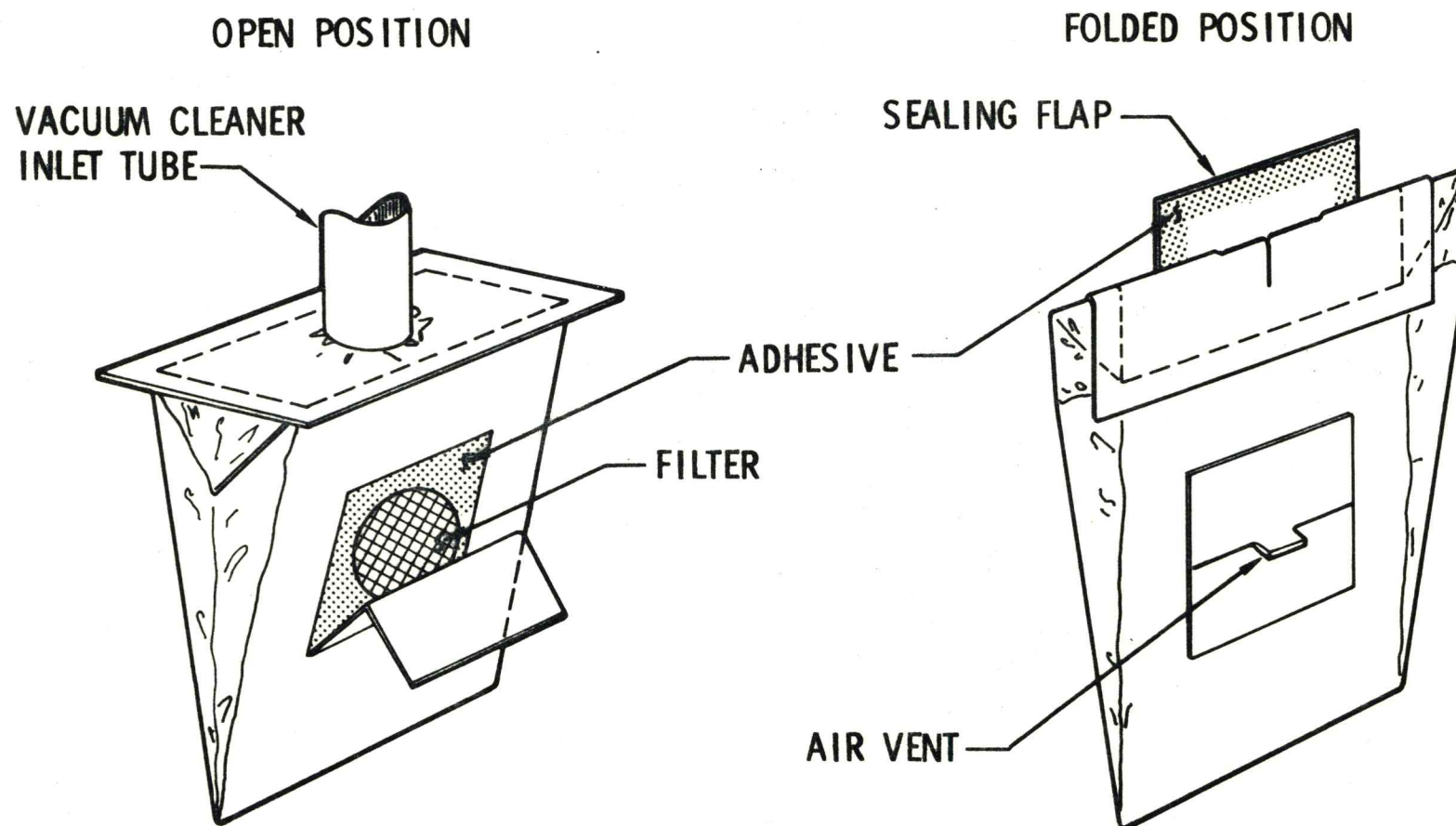


4-304

Figure 427-7.

ORBITAL WORKSHOP WASTE MANAGEMENT SUBSYSTEM VACUUM CLEANER / DEBRIS BAG

O/W-3505
5-8-70



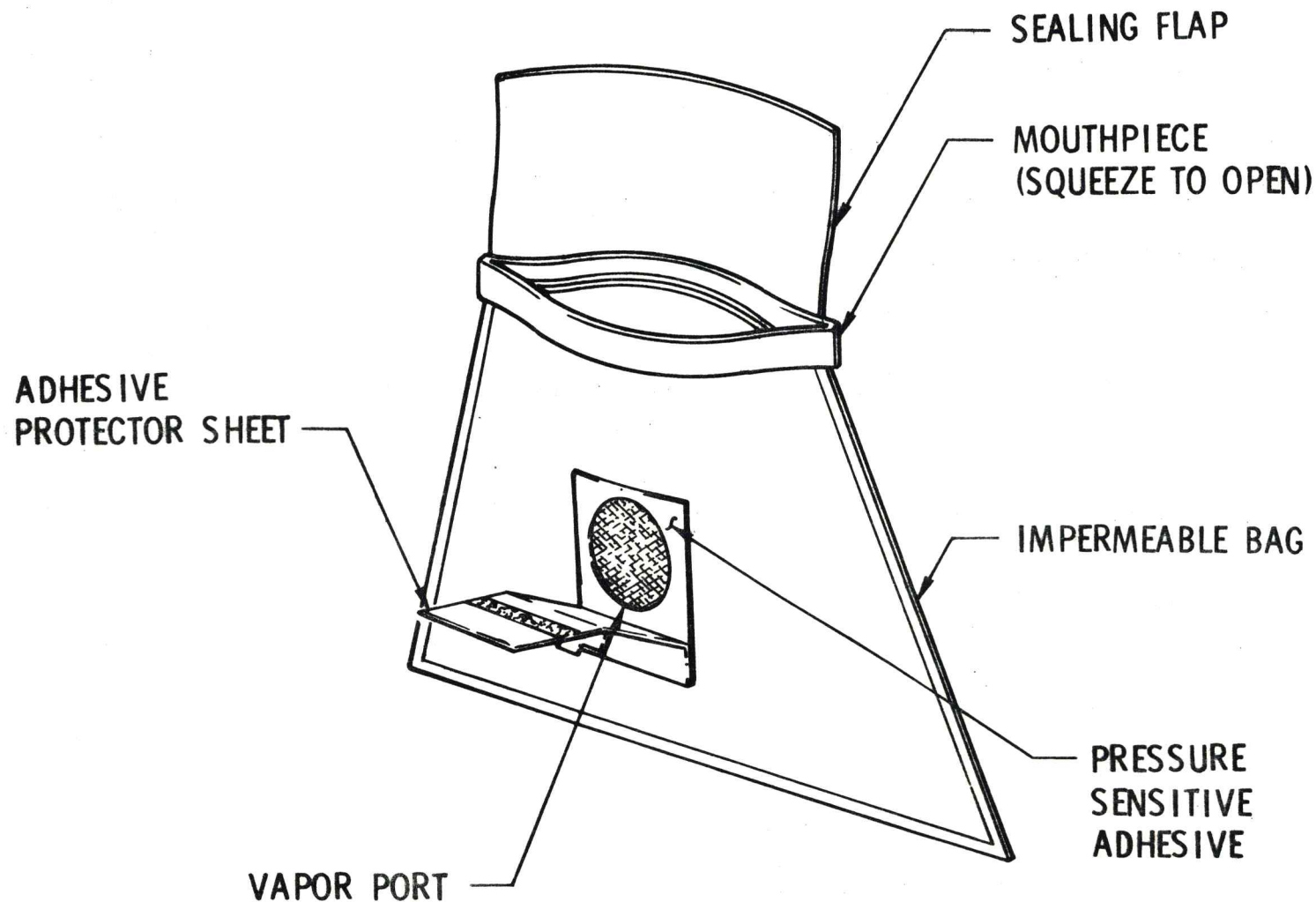
4-305

Figure 427-8.

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ORBITAL WORKSHOP HSS WASTE MANAGEMENT SUBSYSTEM VOMITUS BAG

O/W-3448
5-14-70



4-306

Figure 427-9.

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ORBITAL WORKSHOP HSS CONTINGENCY FECAL BAG

O/W-2209
5-14-70

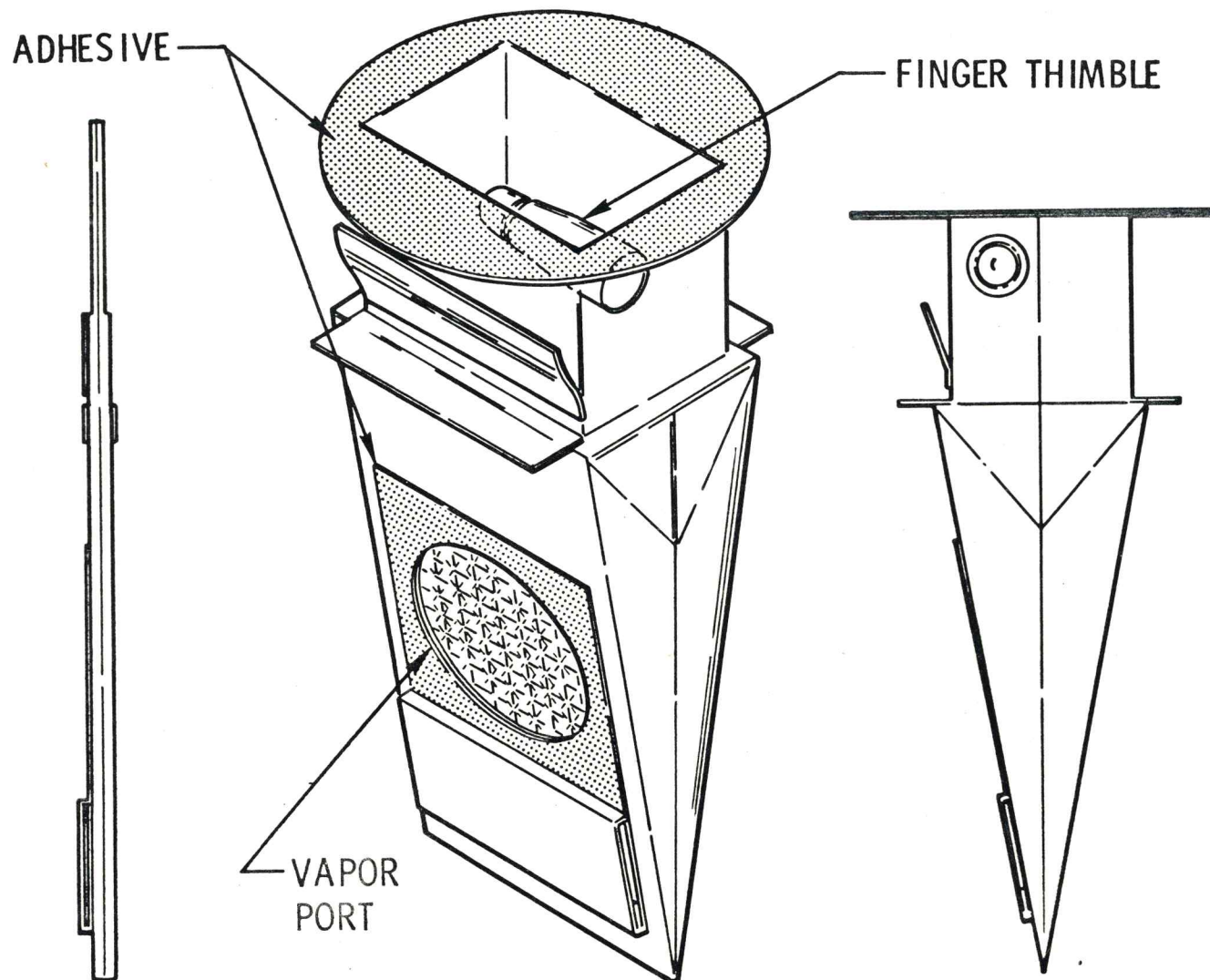
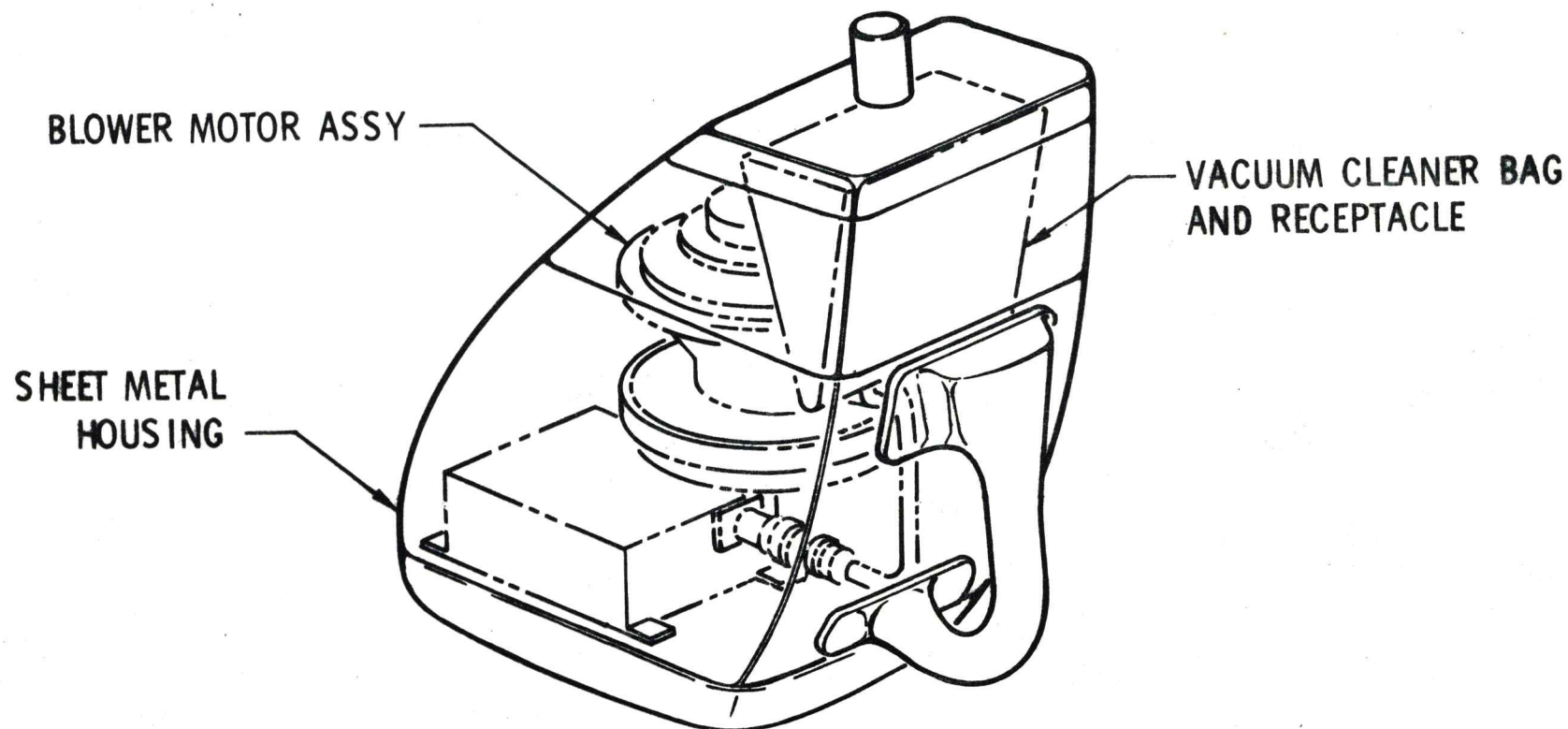


Figure 427-10.

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ORBITAL WORKSHOP HSS VACUUM CLEANER

O/W-3430
5-8-70



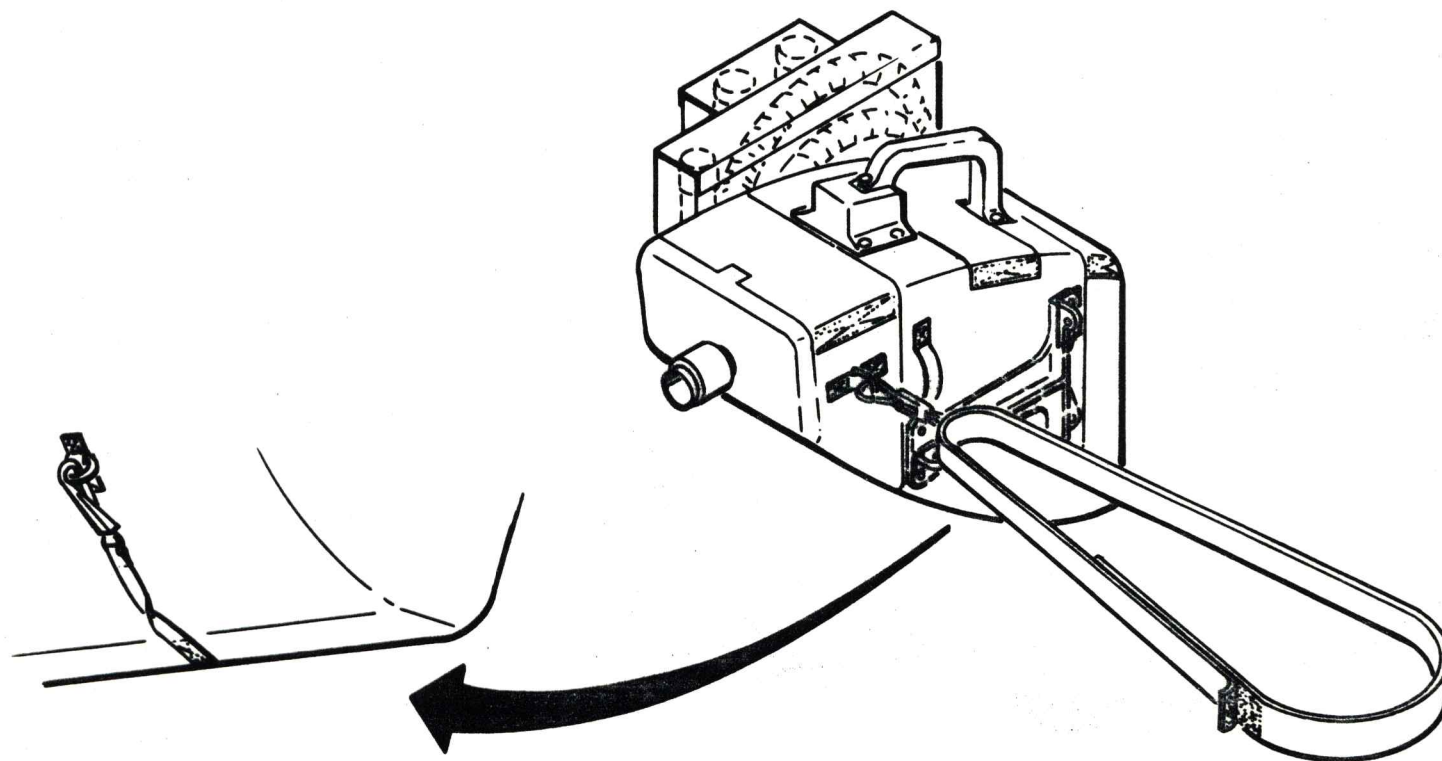
4-308

Figure 427-11. (Sheet 1 of 2)

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ORBITAL WORKSHOP VACUUM CLEANER AND ATTACHMENTS

**O/W-8773
8-3-70**



4-309

Figure 427-11. (Sheet 2 of 2)

portable, self-contained unit powered by 28 vdc from any utility outlet. The vacuum cleaner utilizes a vacuum cleaner debris bag which retains the debris for storage or processing, as required.

The bag is replaced by removing the forward housing of the vacuum cleaner.

The vacuum cleaner blower motor is identical to the blower motor in the Fecal/ Urine Collection Module. The vacuum cleaner blower motor can be used as a backup in the event of a malfunction of the other blower motor.

4.2.7.1.6 Specimen Return Containers

The specimen return containers are used for storage of processed collection bags which are required to support the medical experiments. The specimen return containers are returned to earth in the CM.

Intermediate Storage

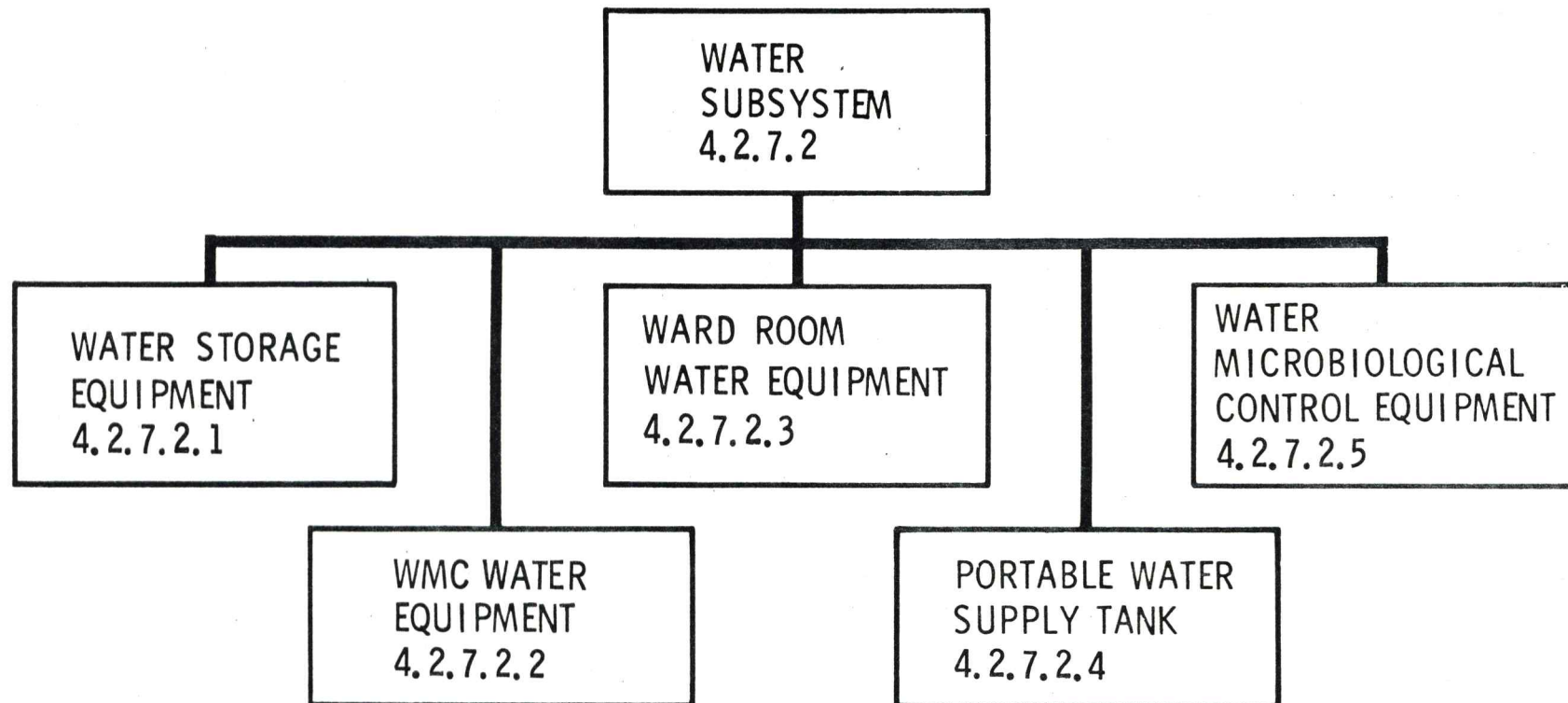
Intermediate storage in a locker in the Waste Management Compartment is required for the processed collection bags. The processed collection bags are bundled in stacks 9-1/2 inches high before transferring to the specimen return container for return to the earth in the CM.

Urine Freezer

The Urine Freezer provides intermediate low temperature (-5°F) storage for urine specimens as required to support the medical experiments. The low temperature is provided by heat transfer from the urine samples through the freezer specimen box to the refrigeration system (Section 4.2.9) fluid circuit.

ORBITAL WORKSHOP HSS WATER SUBSYSTEM

O/W-2041A
6-12-70



THE HSS WATER SUBSYSTEM PROVIDES FOR THE LAUNCH STORAGE OF THE TOTAL MISSION WATER REQUIREMENTS USING TWO SEPARATE DISPENSING SYSTEMS. ONE FOR THE WARD ROOM AND ONE FOR THE WMC. IT PROVIDES THE CAPABILITY TO SUPPLY AND DISPENSE WATER FOR FOOD AND BEVERAGE PREPARATION, DRINKING, AND BODY CLEANSING ACTIVITIES. THE SUBSYSTEM INCLUDES BIOCIDES DISPENSING AND MONITORING EQUIPMENT FOR MAINTAINING MICROBIAL CONTROL.

4.2.7.2 Water Subsystem (1B79571)

The OWS Water Subsystem (Figure 427-12) supplies potable water to the OWS crew quarters (WMC and wardroom) for metabolic, personal hygiene, and general housekeeping cleansing purposes (Figure 427-13). The subsystem also utilizes a portable water container to transfer water from the water containers to areas and systems vital to accomplishing mission objectives that are not covered by the OWS hard line water distribution system. To accomplish mission objectives of the water subsystem, the following hardware items are provided:

- a. Water pressurization equipment.
- b. Water storage containers and agitator pump.
- c. Waste Management Compartment water distribution equipment.
- d. Wardroom water distribution equipment.
- e. Portable water container.
- f. Water microbiological control equipment.
- g. Water dump equipment.
- h. Volume indicator transducer.
- i. Interfaces.
 1. Water pressurization supply system.
 2. LH₂ tank wall.
 3. Electrical power.
 4. Ground service equipment.
 5. TM link.
 6. Waste Management Compartment water distribution lines.
 7. Wardroom water distribution lines.

The hardware items of the Water Subsystem are launched-stored in the OWS (Figure 427-14). The Water Subsystem provides two separate water systems for HSS usage; one for the waste management compartment and one for the wardroom.

Electrical heater blankets are provided to prevent freezing of water during orbital storage.

ORBITAL WORKSHOP WATER SYSTEM SCHEMATIC

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8-6-70

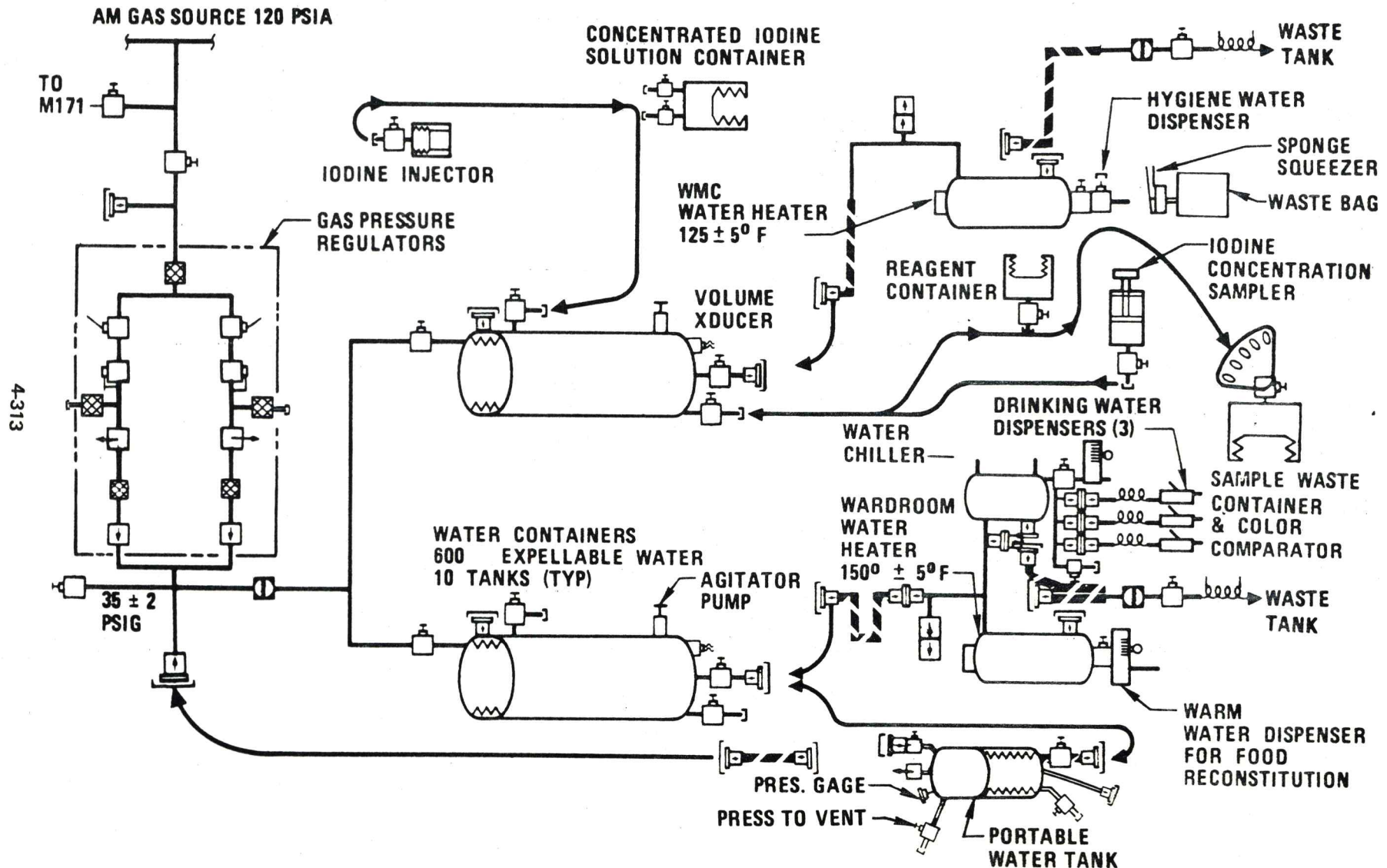


Figure 427-12.

ORBITAL WORKSHOP
HSS WATER SUBSYSTEM

O/W-2179
5-27-70

• WARDROOM DAILY WATER USAGE

USAGE FOR 3 CREWMEN

| | |
|-------------|----------|
| • METABOLIC | 24.0 LBS |
| | <hr/> |
| TOTAL | 24.0 LBS |

• WMC DAILY WATER USAGE

USAGE FOR 3 CREWMEN FOR

| | |
|--------------------|----------|
| • CLEAN-UP | 4.0 LBS |
| • PERSONAL HYGIENE | 3.0 LBS |
| | <hr/> |
| TOTAL | 7.0 LBS |
| | <hr/> |
| GRAND TOTAL | 31.0 LBS |

Figure 427-13.

ORBITAL WORKSHOP WATER SYSTEM

O/W-4224
8-6-70

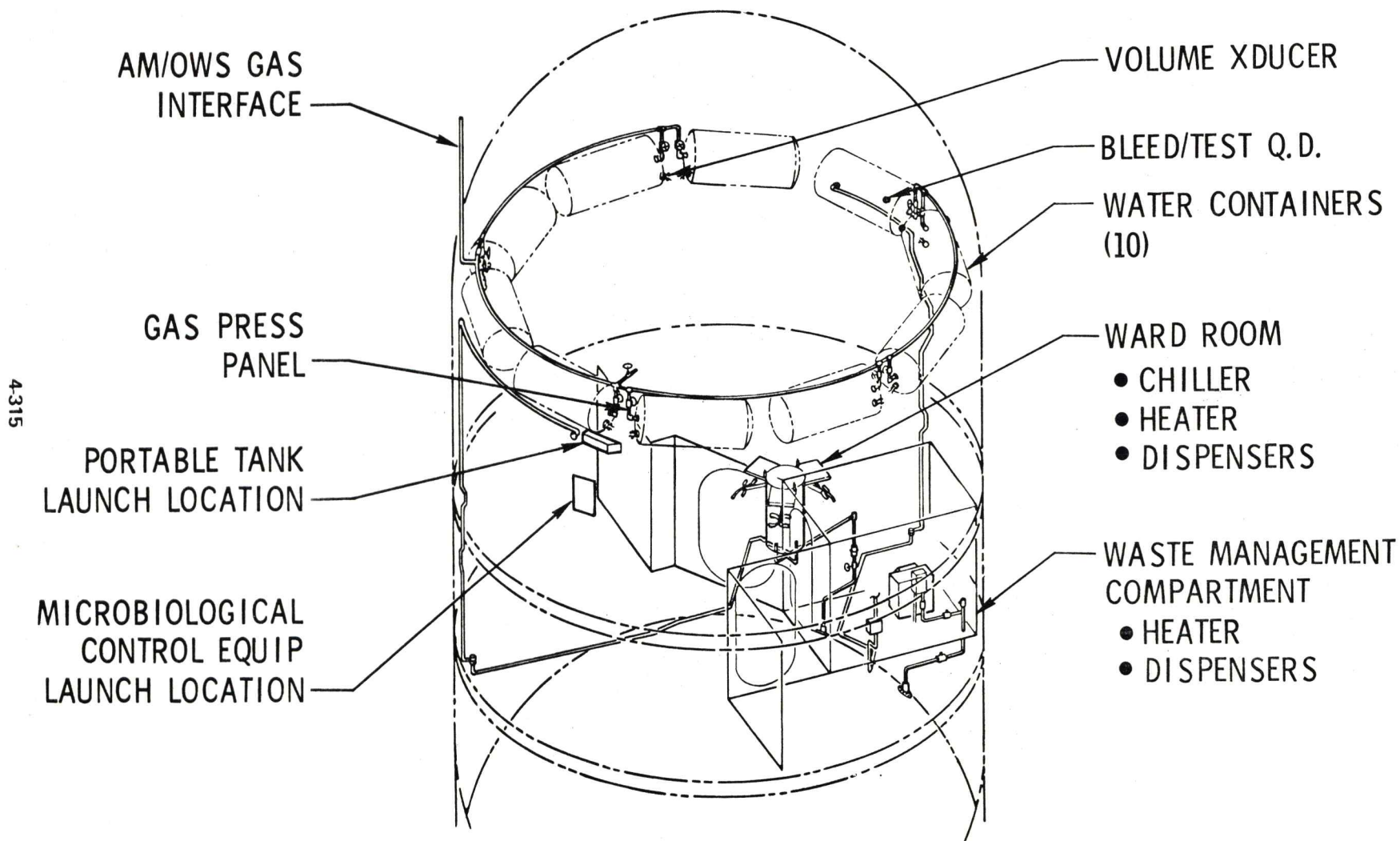


Figure 427-14.

4.2.7.2.1 Water Storage Equipment

Ten stainless steel water containers (Figure 427-15) are provided to launch-store 6,000 pounds of useable water. The containers are located in the forward end of the cylindrical section of the OWS and bolted at each end to bulkheads within the water container support structure. The support structure consists of two circular ring assemblies separated vertically by a shear web and bulkheads. The support structure is attached to the OWS tank wall by a conical sheet metal ring assembly (same as the floors). For details of the water container and support structure installation see MDAC Drawing 1B77174.

Each water container has a stainless steel bellows enclosed in a stainless steel shell. The bellows are pressurized from a common manifold connecting all ten water containers.

The following hardware items are enclosed as part of each water container (1B79098):

- a. Stainless steel bellows.
- b. Stainless steel shell.
- c. Electrical heater blankets.
- d. Flush and bleed port.
- e. Supply port.
- f. Gas pressure port.
- g. Hand valves (2 required).
- h. Quick-disconnects (2 required).
- i. Iodine injection port (in-orbit).
- j. Water sampling port (in-orbit).
- k. Water agitator pump.

Positive expulsion of water for the OWS is accomplished by pressurizing the pneumatic side of the water containers with GO_2 . The oxygen supply is furnished from the AM. Approximately 23 pounds of oxygen will be required for water expulsion for SL-1/2, SL-3, and SL-4 missions. An interface has been initiated with the AM which will provide oxygen at 120 ± 10 psi to the water system pressurization module. The following hardware items are included in the water pressurization equipment (1B80410):

- a. Ground gas supply connection (2 required)
- b. 10 μ filters (5 required).

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ORBITAL WORKSHOP WATER CONTAINER

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8-6-70

4-317

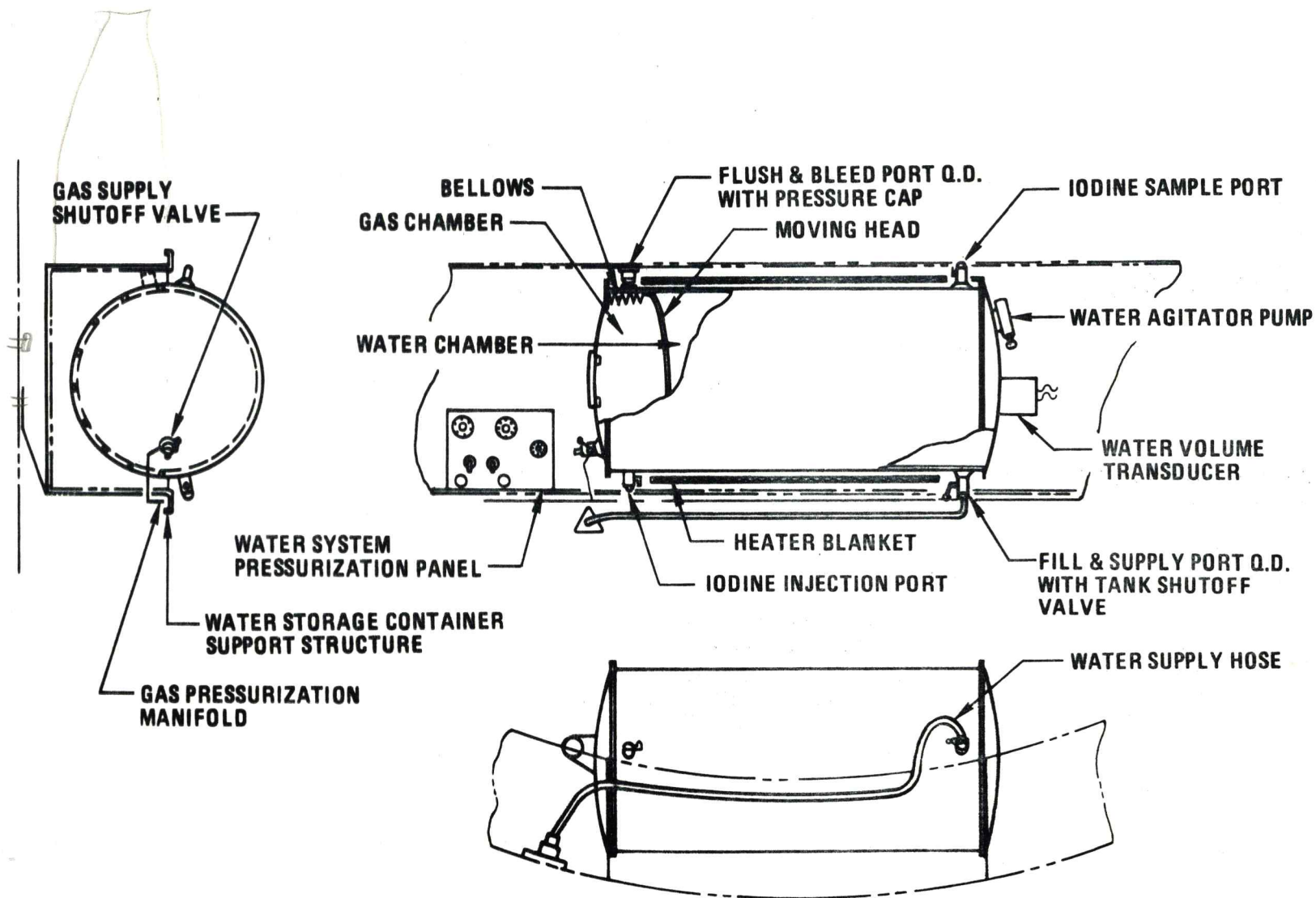


Figure 427-15. (Sheet 1 of 2)

ORBITAL WORKSHOP WATER SYSTEM WORK AREA

O/W-7356
5-27-70

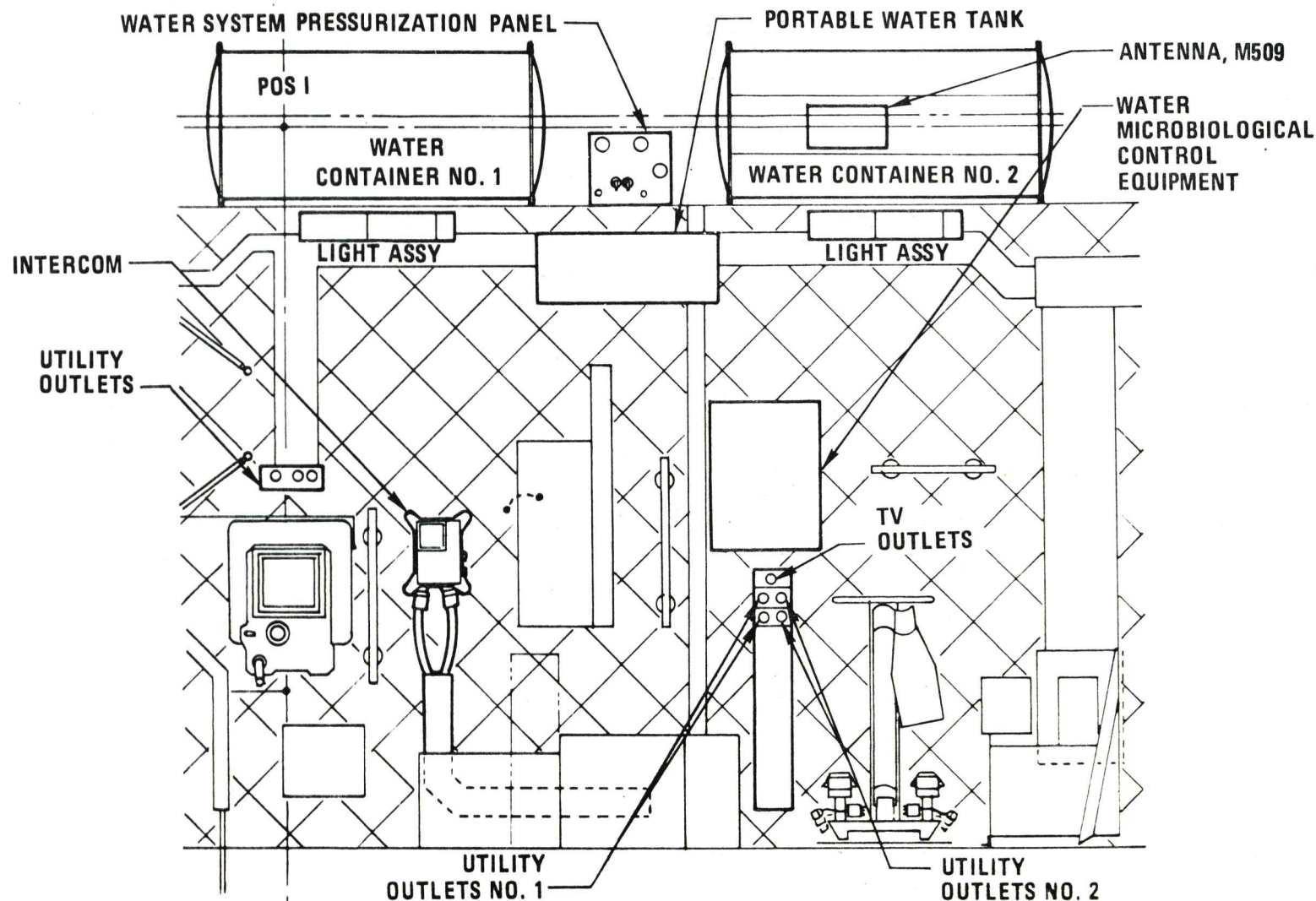


Figure 427-15. (Sheet 2 of 2)

- c. Dual regulators.
- d. Dual pressure relief valve.
- e. Check valves (2 required).
- f. Manual vent valve.
- g. Manual shutoff valve.
- h. Common manifold.
- i. Quick-disconnects (2 required).
- j. Interfaces.
 - 1. AM GO_2 supply.
 - 2. TM link.
 - 3. Pressure transducer
 - 4. Portable water container.
 - 5. Water container.
 - 6. GSE Equipment

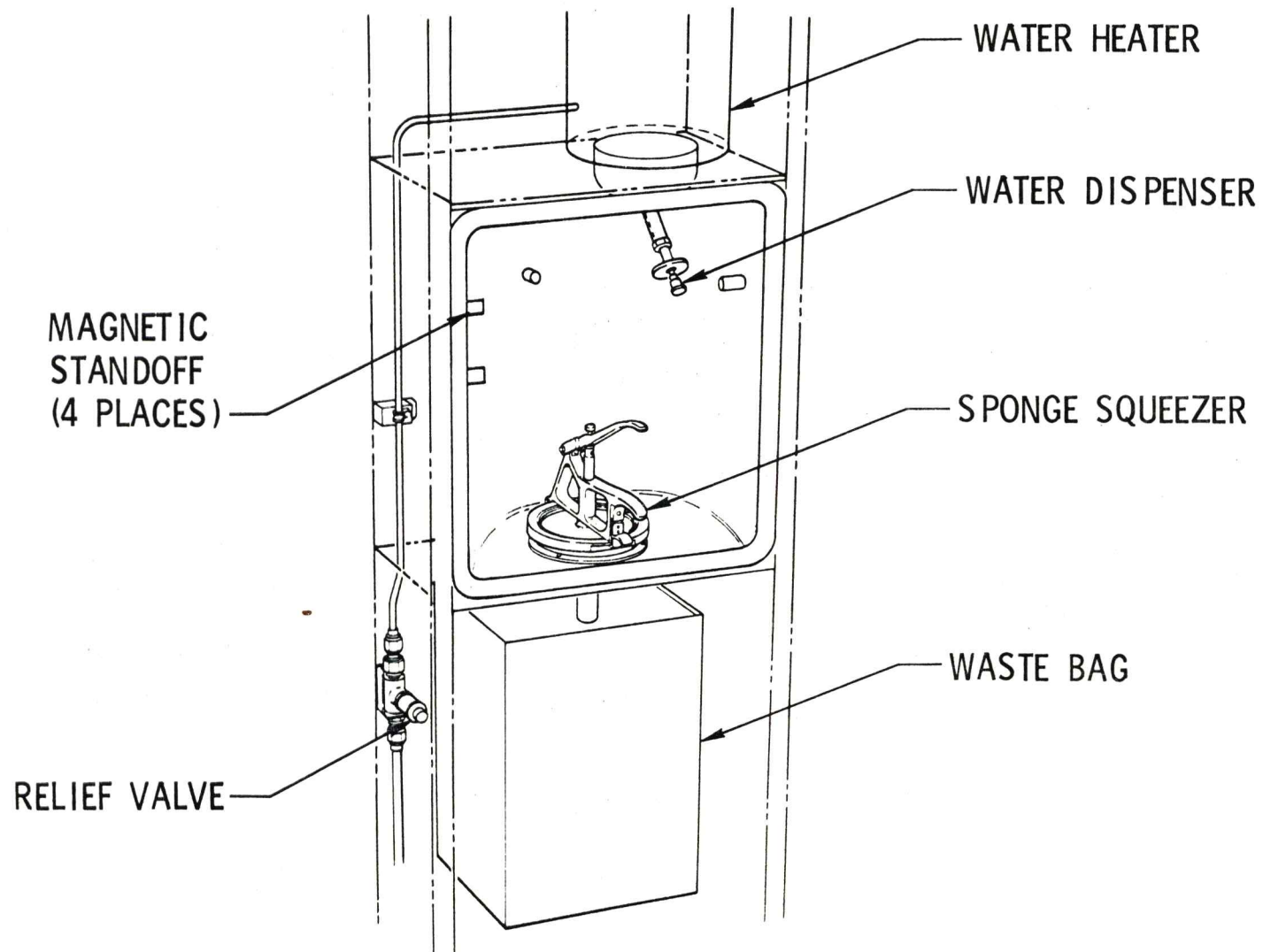
4.2.7.2.2 Waste Management Compartment Water Equipment (1B81397)

The WMC water equipment consists of a module which conditions and distributes water within the WMC for body cleansing and general housekeeping purposes (Figure 427-16). The requirement for WMC water is seven pounds per day (three pounds for body cleansing and four pounds for housekeeping). The following items of hardware comprise the WMC water equipment:

- a. Flex hose.
- b. Interconnecting plumbing.
- c. Pressure relief valves.
- d. WMC Water heater ($125 \pm 5^\circ\text{F}$) (Figure 427-17).
- e. Hygiene water dispenser.
- f. Hand washer (sink).

ORBITAL WORKSHOP WMC WATER MODULE SPONGE/SQUEEZER

O/W-8456
8-5-70

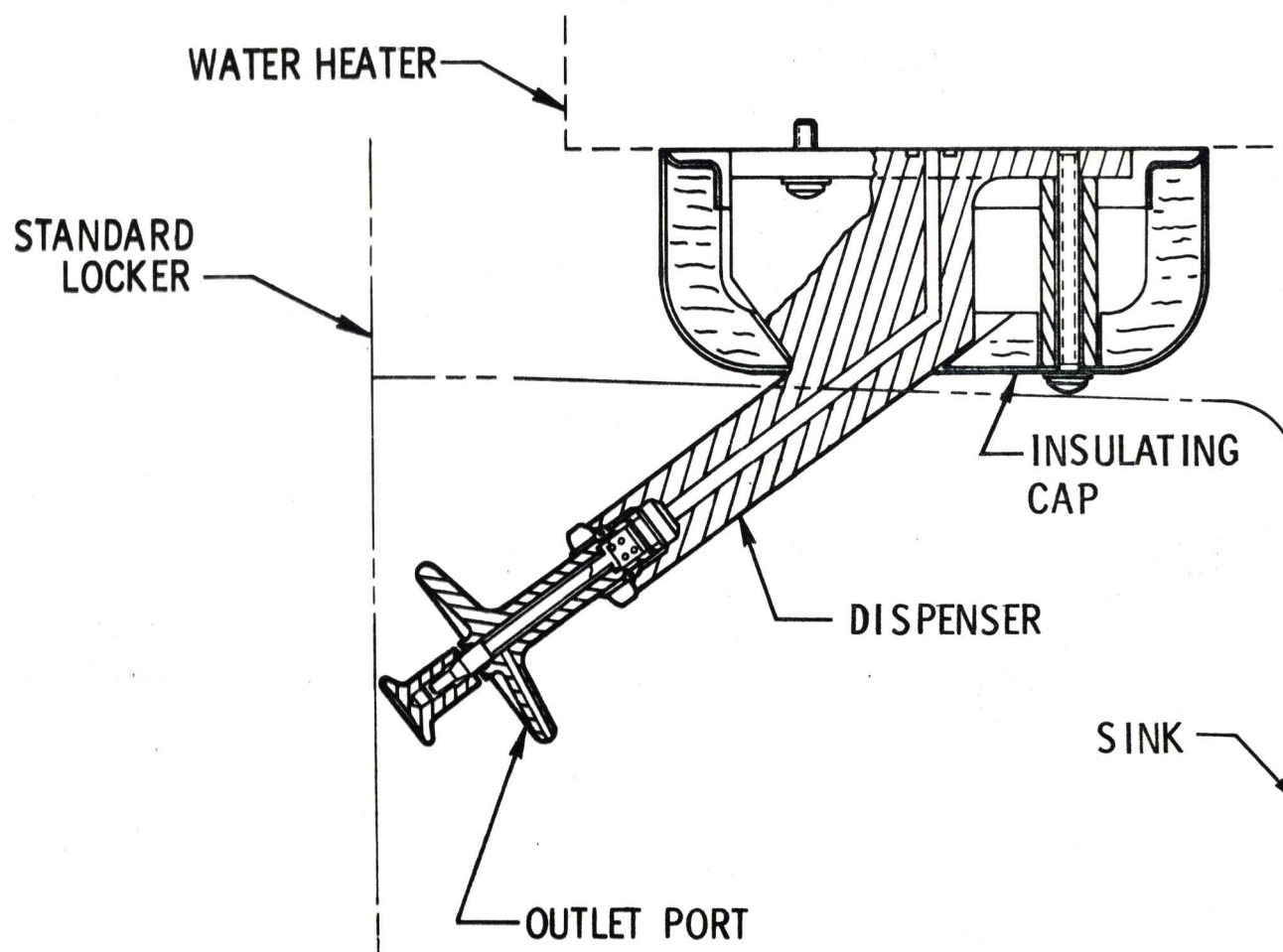


4-320

Figure 427-16. (Sheet 1 of 2)

ORBITAL WORKSHOP PERSONAL HYGIENE WATER DISPENSER

O/W-5774
8-5-70



4-321

Figure 427-16. (Sheet 2 of 2)

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ORBITAL WORKSHOP HSS WMC AND WARDROOM WATER HEATER

O/W-2211
8-6-70

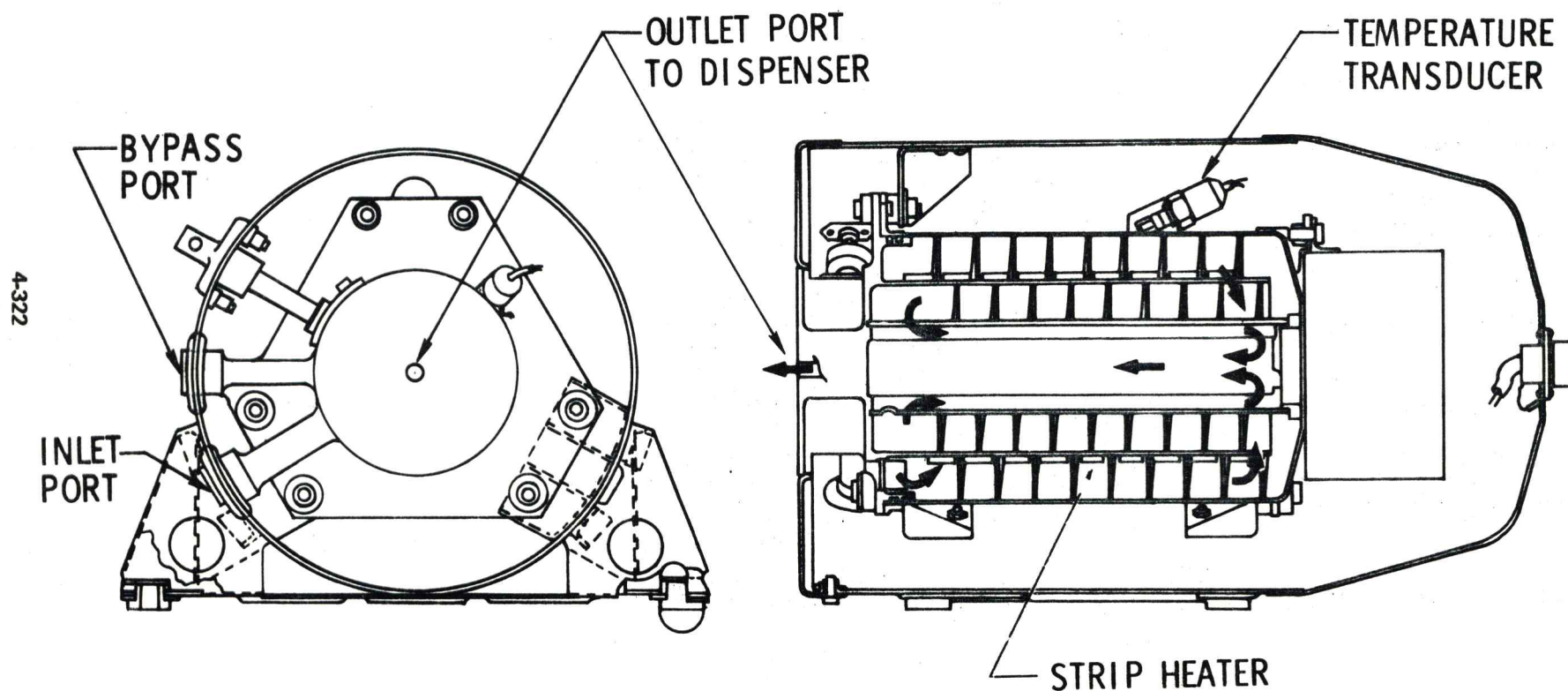


Figure 427-17.

g. Interfaces.

1. Water container.
2. Electrical power.
3. Water dump system.
4. Portable water container.
5. OWS structure.

4.2.7.2.3 Wardroom Water Equipment (1B78836)

The wardroom water equipment provides for the conditioning and distribution of water within the wardroom for metabolic purposes (Figure 427-18). The water required for a 140-day orbital mission is eight pounds per man-day. A total requirement for the wardroom is 3,360 pounds. The following items of hardware are provided for metabolic consumption:

- a. Flex hoses (3 required).
- b. Pressure relief valve (2 in line).
- c. Interconnecting plumbing.
- d. Water heater.
- e. Water chiller.
- f. Drinking water dispensers (3 required) (Figure 427-19).
- g. Food reconstitution dispensers (2 required) (Figure 427-20).
- h. Quick-disconnects (5 required).
- i. Interfaces.
 1. Water containers.
 2. Electrical power.
 3. Water dump system.
 4. Portable water container.
 5. OWS structure.

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ORBITAL WORKSHOP TABLE TOP ARRANGEMENT (OPTIONAL RECESSED TABLE TOP)

O/W-7760
6-5-70

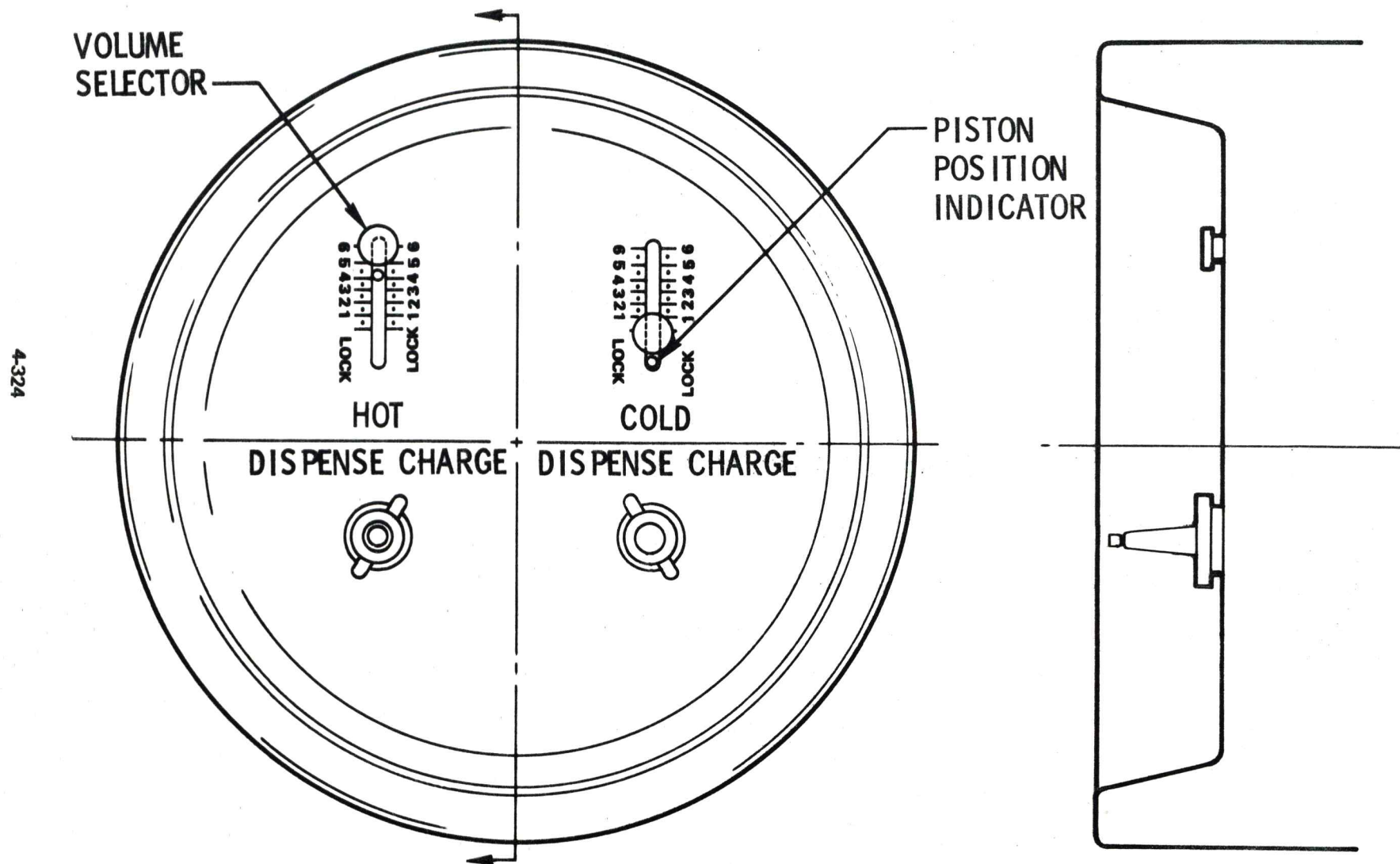


Figure 427-18.

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ORBITAL WORKSHOP HSS WATER SUBSYSTEM DRINKING WATER DISPENSERS

O/W-3510
8-6-70

4-325

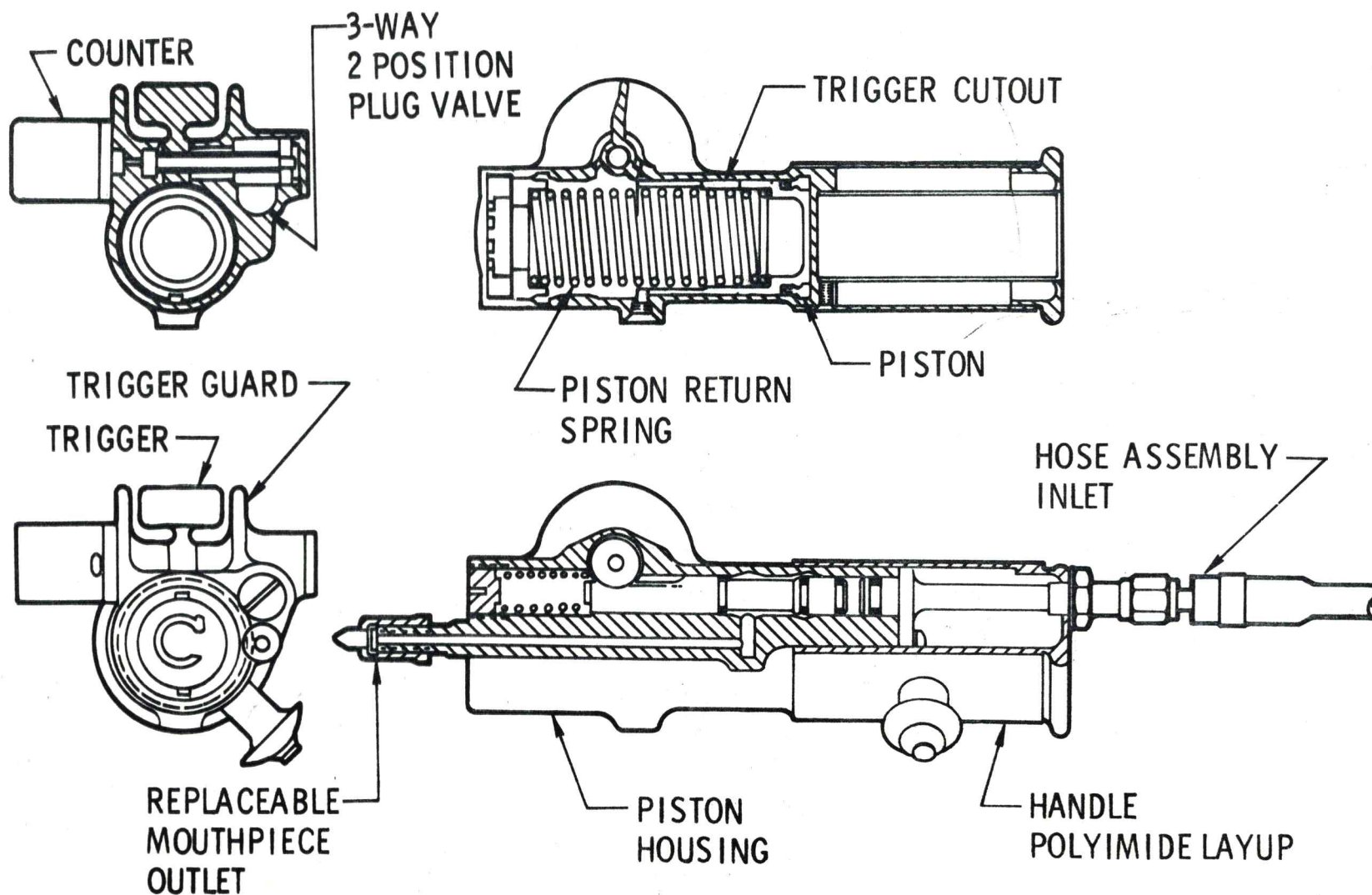
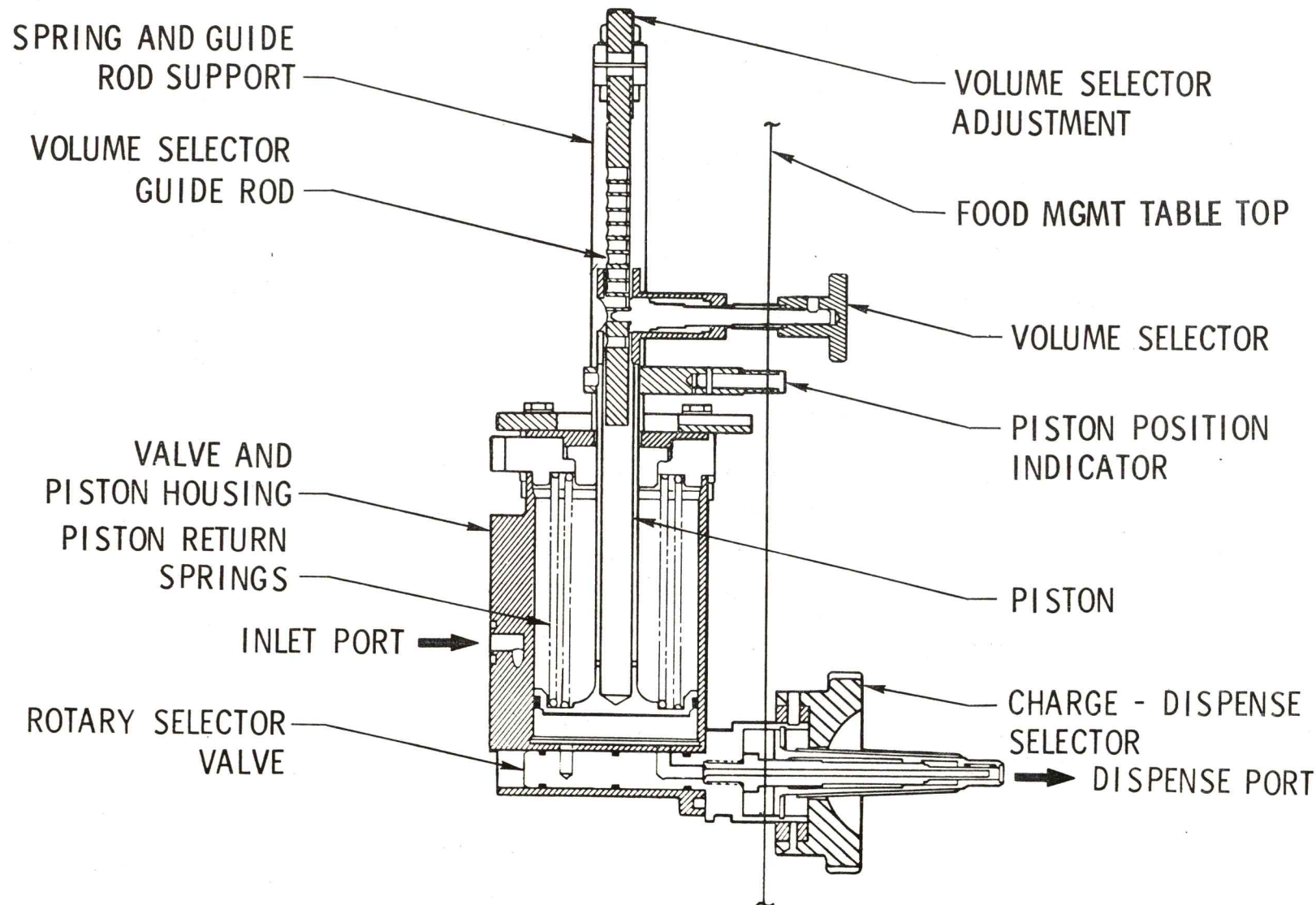


Figure 427-19.

ORBITAL WORKSHOP HSS FOOD RECONSTITUTION WATER DISPENSER

O/W-3493
5-27-70



4-326

Figure 427-20.

4.2.7.2.3.1 Water Chiller (1B79914)

A water chiller is provided to satisfy the requirement for chilled drinking water at $40^{\circ} \pm 5^{\circ}\text{F}$. The unit is constructed of stainless steel with an outer layer of foam insulation. The cooling refrigerant and the drinking water pass through adjacent annular helical passages.

Five pounds of chilled drinking water will be contained in the unit. Upon extracting the maximum demand of five pounds of chilled water, approximately one hour is required to rechart the incoming water. The refrigerant is controlled to an inlet temperature of $36^{\circ} \pm 3^{\circ}\text{F}$.

4.2.7.2.4 Portable Water Tank (1B81575)

The portable water tank (Figure 427-21) is used as a container of 100 ppm iodine solution for microbial decontamination of the water distribution system, and as a container of potable water for contingency usage by the crewmen in the wardroom and WMC. The container has a capacity of 26 pounds of water and an operating range of 15 to 40 psig. The tank includes the following components:

- a. Stainless steel bellows (for a water container).
- b. Stainless steel cylindrical inside shell with one end welded to the bellows. A ring is welded at the other end of the cylinder for attachment (by screws) of an aluminum dome/manifold assembly (item c).
- c. Aluminum dome/manifold assembly. The manifold is welded to the dome and provides ports for installation of components listed in items d through h.
- d. Gas pressure gage.
- e. Gas charging quick-disconnect with cap.
- f. Gas safety relief valve.
- g. Gas supply shutoff valve.
- h. Gas vent valve (manual).
- i. A quick-release fastener (for orbital usage only).
- j. Aluminum carrying handle. Part of the handle forms a protective cover around items d through h.
- k. Two manifold fittings attached to conoseal flanges protruding from the bellows fixed end dome.
 - l. One of the manifold fittings provides ports for installation of water fill/supply quick-disconnect (with plug) and leak check plug. In addition, an iodine injector fitting (with an integral shutoff valve and cap) is welded to this manifold.

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ORBITAL WORKSHOP HSS PORTABLE WATER SUPPLY TANK

O/W-2146
8-4-70

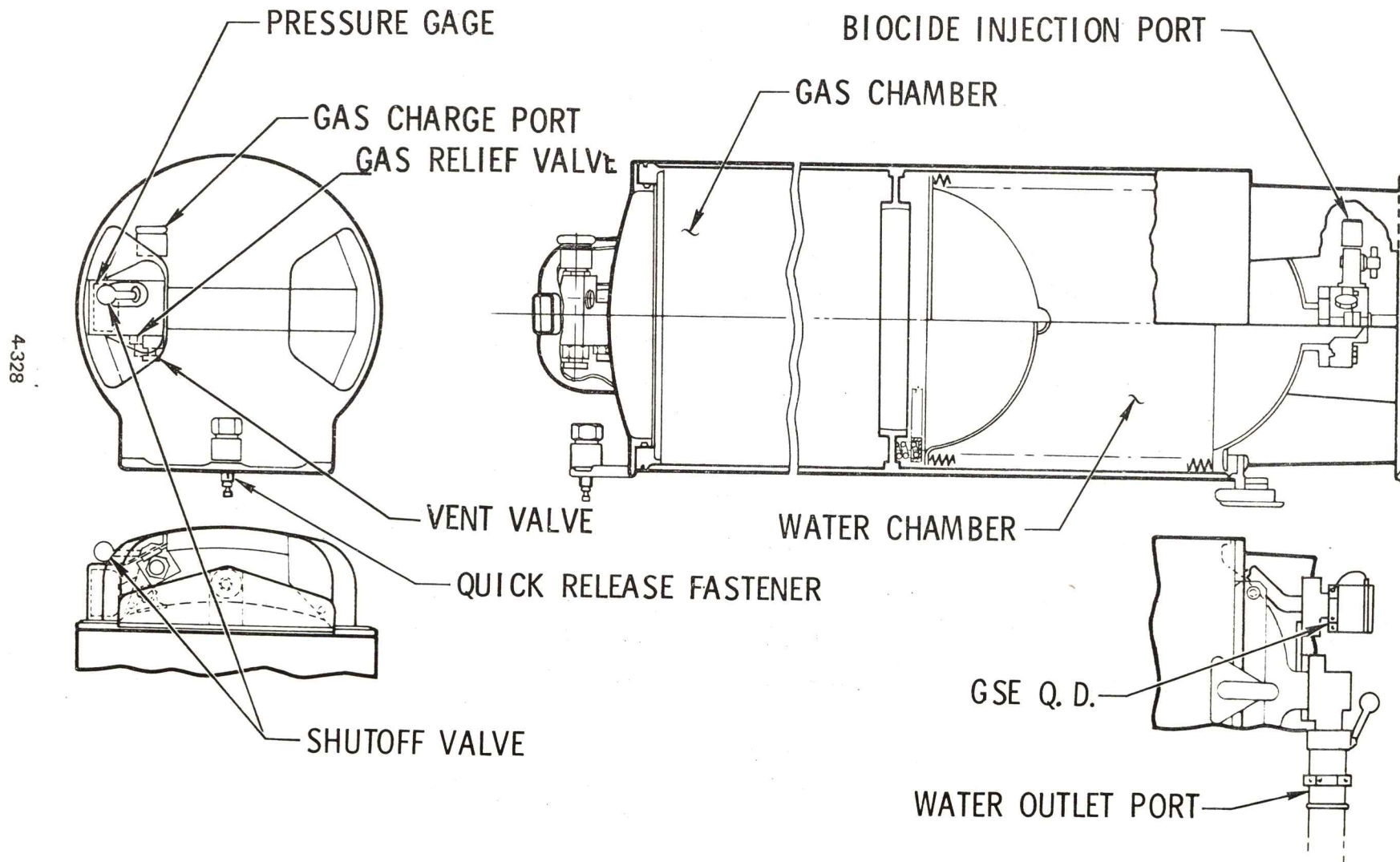


Figure 427-21.

2. The other manifold provides ports for installation of a quick-disconnect and a leak check plug (identical to those listed in item k, 1). This quick-disconnect is intended for usage during ground servicing only.
1. A soft stop (ring with springs) for the bellows movable end dome. This soft stop is provided to preclude over-pressurization of the water-filled bellows in case of water thermal expansion.
- m. An outer protective shell assembly, consisting of:
 1. Cylindrical shell.
 2. A ring welded to the shell (for attachment).
 3. Protective water end cover assembly, consisting of four leas and a tabular ring welded to the ring (item m, 2).

The portable water container could be used after mission termination to fill the WMC and wardroom water distribution equipment with a high iodine concentration to sterilize the system after usage. Also, this procedure may be used prior to water usage to sterilize the distribution equipment for use.

4.2.7.2.5 Water Microbiological Control Equipment (1B81201)

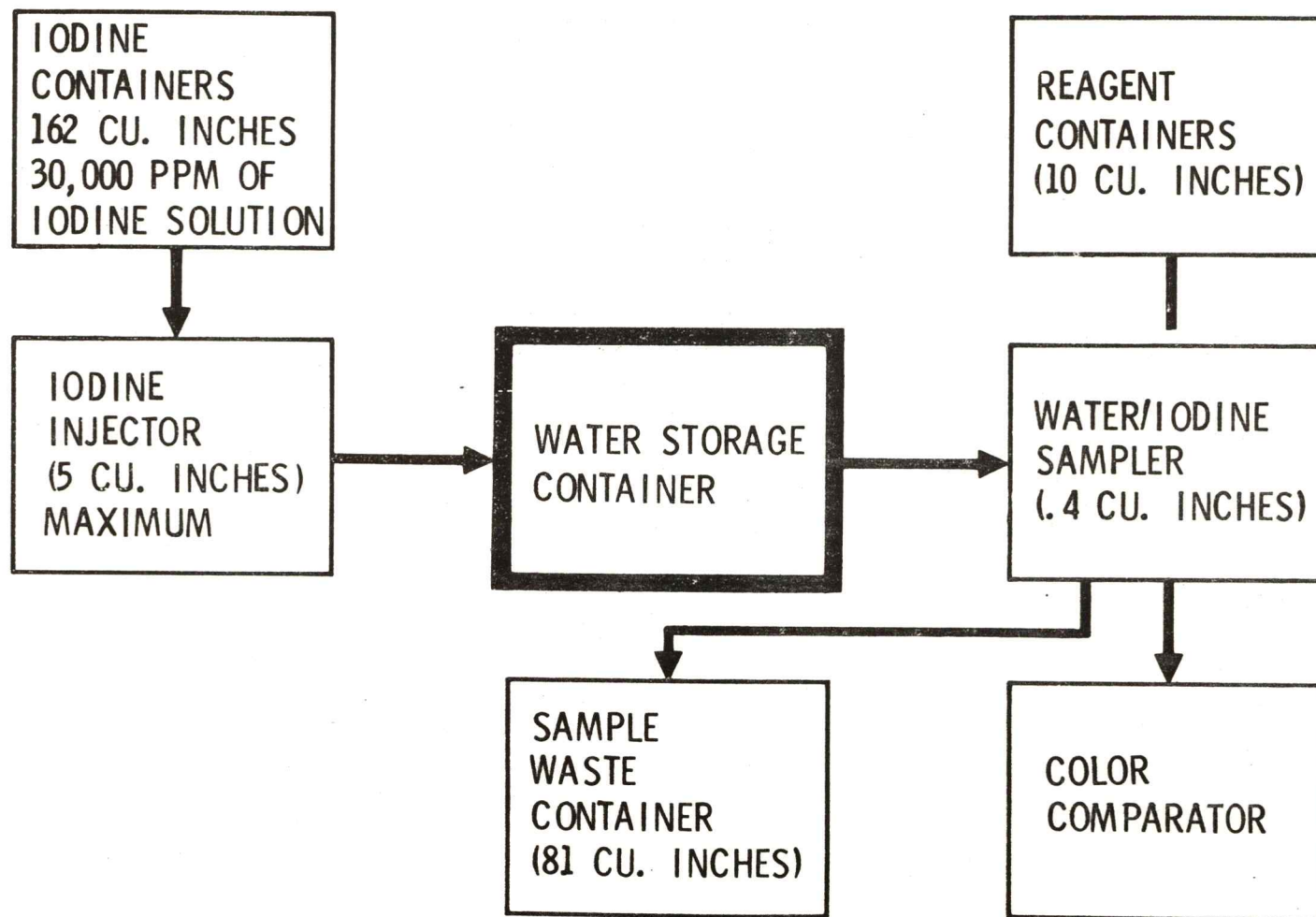
Microbiological control of the OWS water system is accomplished by ground servicing the complete water system with processed water that has been "polished" to meet MSC SPEC-PF-1A and then maintaining this water purity during orbital life. An iodine solution is added during ground servicing to provide initial microbiological control for early mission duration. During orbital operations, the iodine concentration depletion rate will be monitored periodically to determine if additional iodine should be added (Figure 427-22). When the iodine concentration reaches 0.5 mg/l in the water storage containers, the iodine concentration will be increased by adding a concentrated potassium iodide solution to the water.

The microbiological control equipment (Figure 427-23), for on-orbit maintenance of water purity, consists of the following items:

- a. Water sampler.
- b. Reagent solution container.
- c. Color comparator.
- d. Iodine injector.
- e. Iodine storage container.
- f. Sample waste container.

ORBITAL WORKSHOP HSS WATER SUBSYSTEM

O/W-4302
5-27-70



4-330

Figure 427-22.

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ORBITAL WORKSHOP HSS WATER SUBSYSTEM BIOCIDE MONITORING AND INJECTING EQUIPMENT

O/W-4301
8-5-70

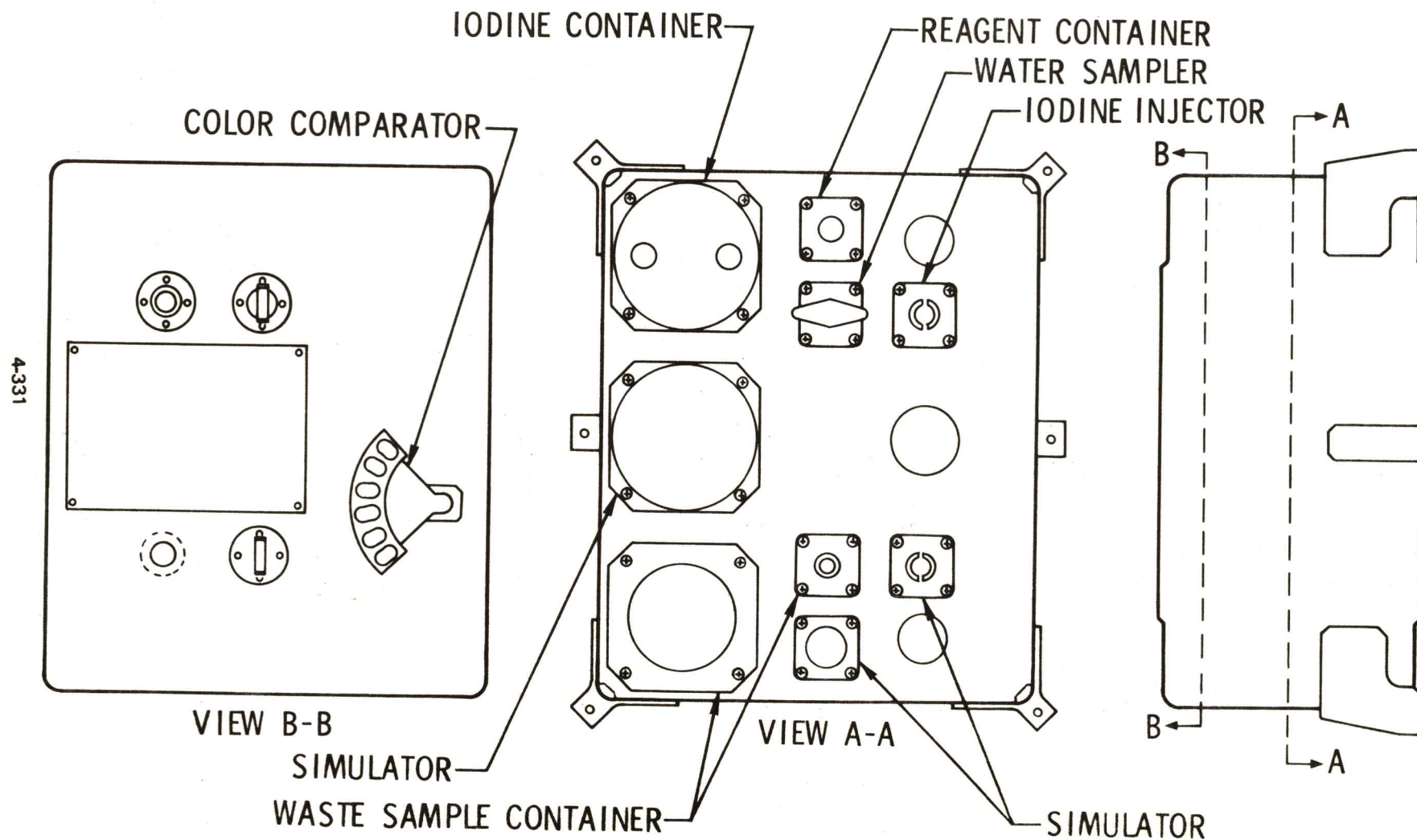


Figure 427-23. (Sheet 1 of 7)

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ORBITAL WORKSHOP HSS WATER SUBSYSTEM WATER/IODINE CONCENTRATION SAMPLER

O/W-4291
8-5-70

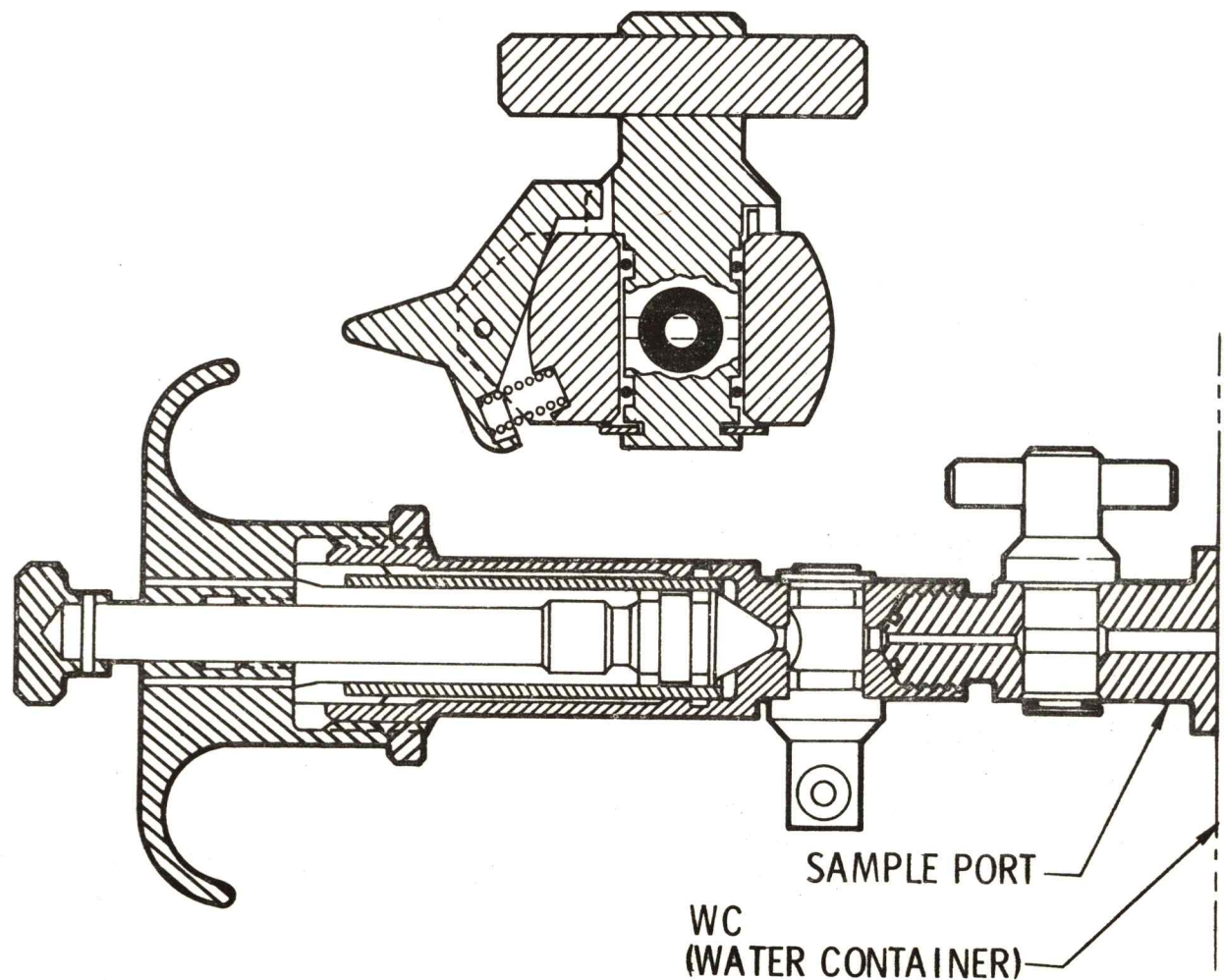
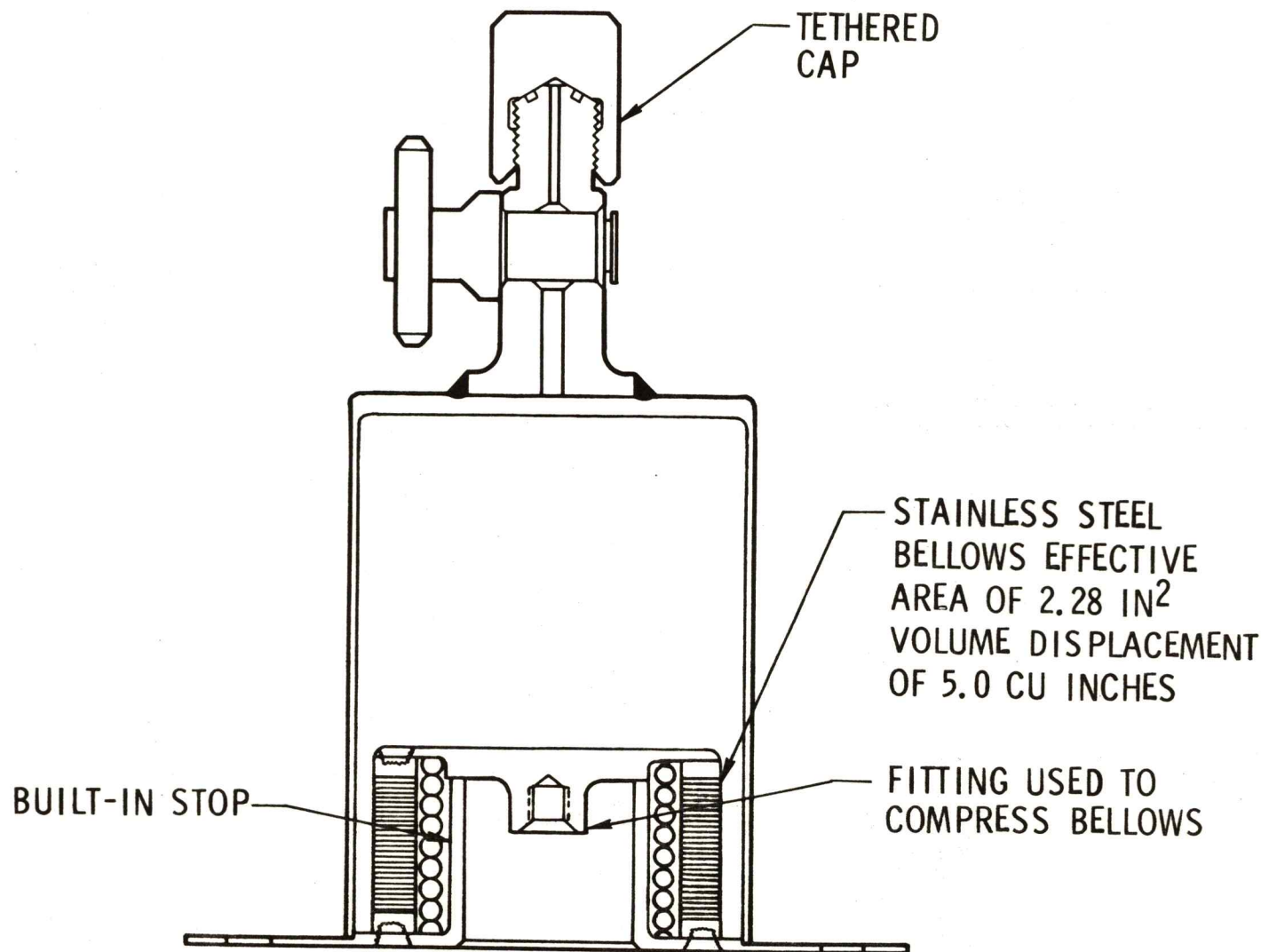


Figure 427-23. (Sheet 2 of 7)

ORBITAL WORKSHOP HSS WATER SUBSYSTEM REAGENT CONTAINER ASSEMBLY

O/W-4295
8-5-70



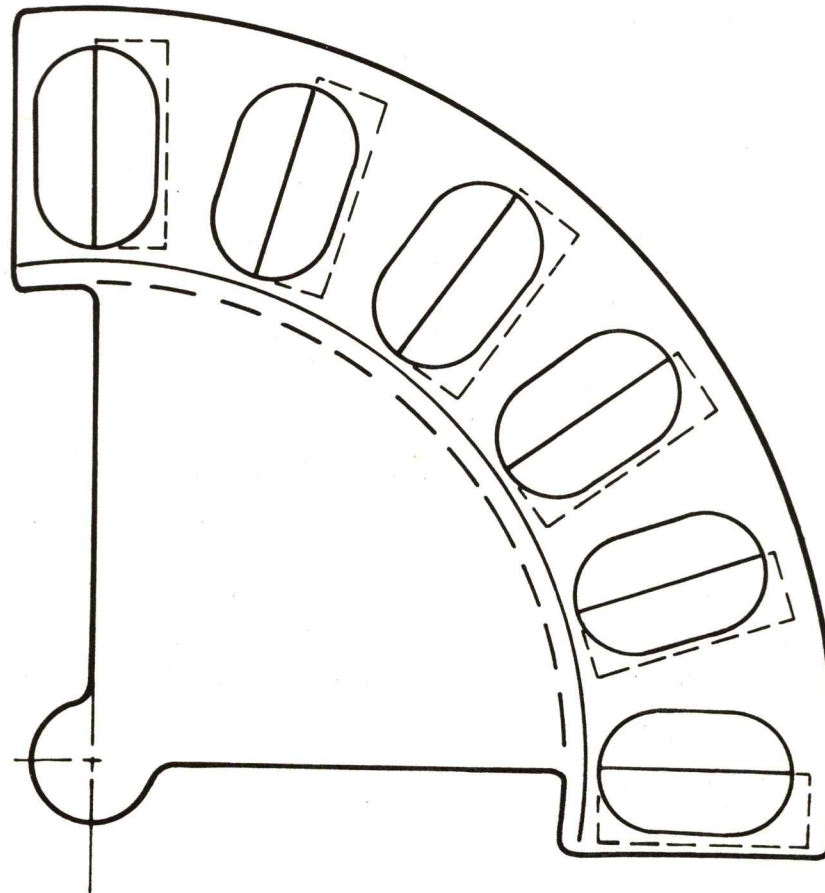
4-333

Figure 427-23. (Sheet 3 of 7)

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ORBITAL WORKSHOP HSS WATER SUBSYSTEM COLOR COMPARATOR

O/W-4299
5-7-70



4-334

Figure 427-23. (Sheet 4 of 7)

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ORBITAL WORKSHOP HSS WATER SUBSYSTEM IODINE INJECTOR

O/W-3366
5-12-70

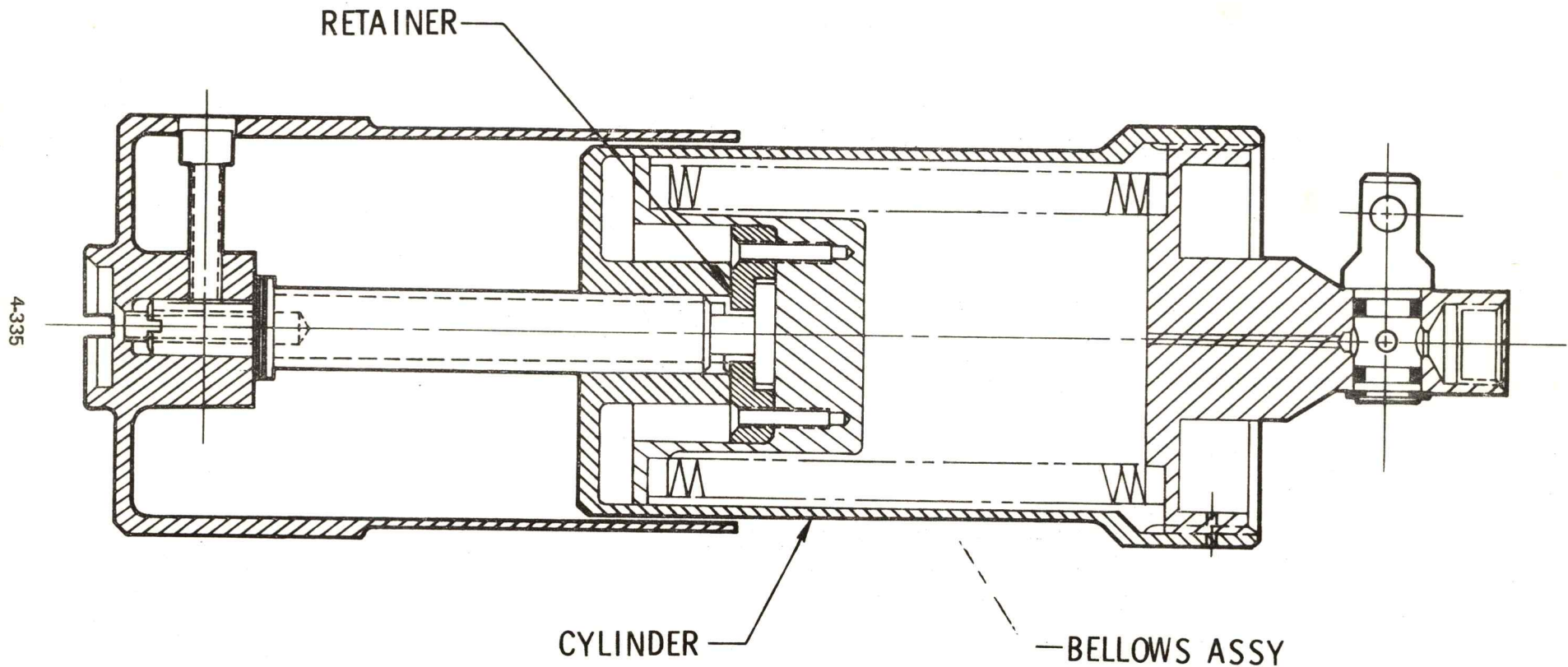


Figure 427-23. (Sheet 5 of 7)

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ORBITAL WORKSHOP HSS WATER SUBSYSTEM IODINE CONTAINER

O/W-4293
8-5-70

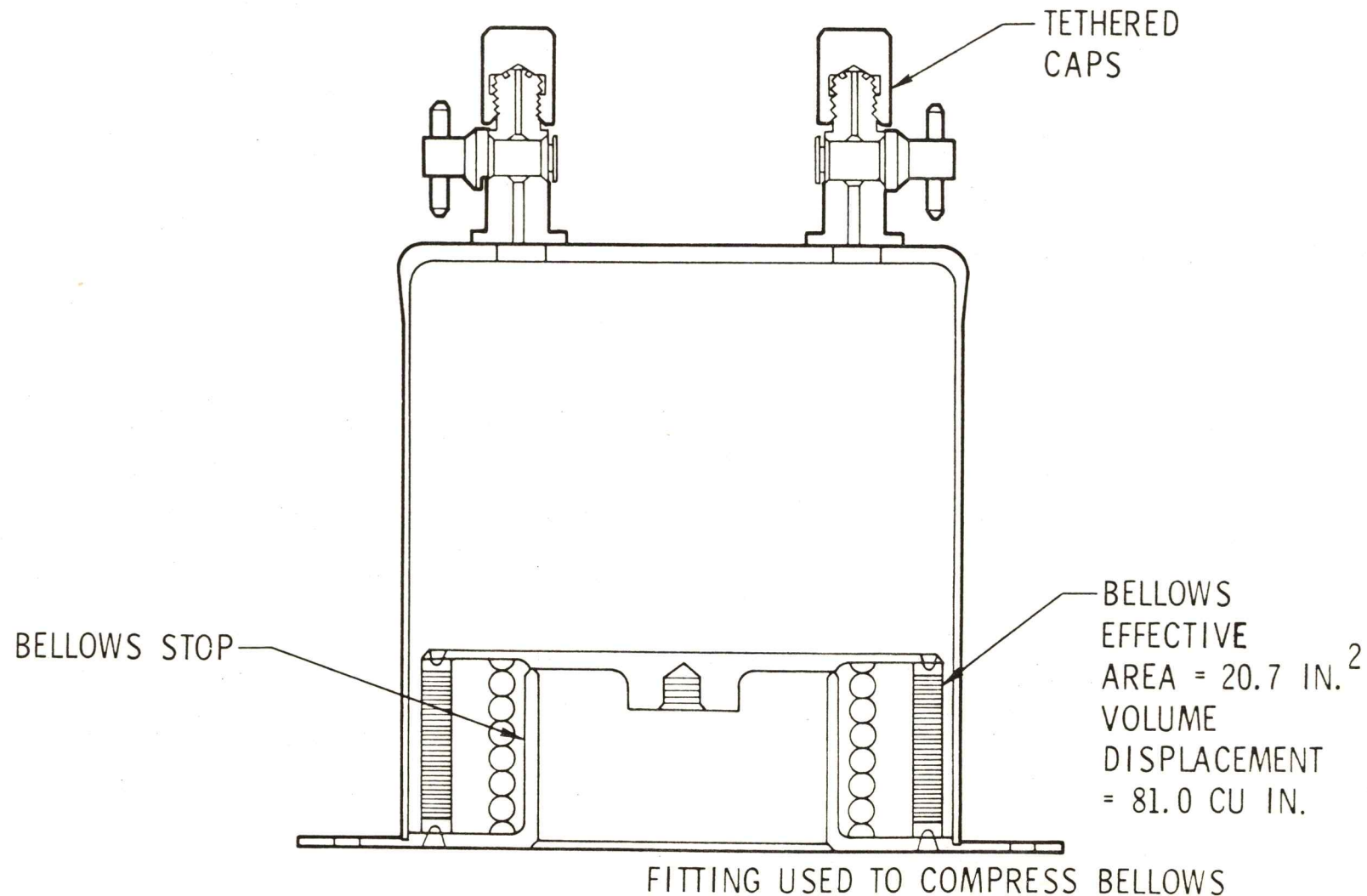


Figure 427-23. (Sheet 6 of 7)

ORBITAL WORKSHOP
HSS WATER SUBSYSTEM
WATER/IODINE WASTE SAMPLE CONTAINER

O/W-4297
8-5-70

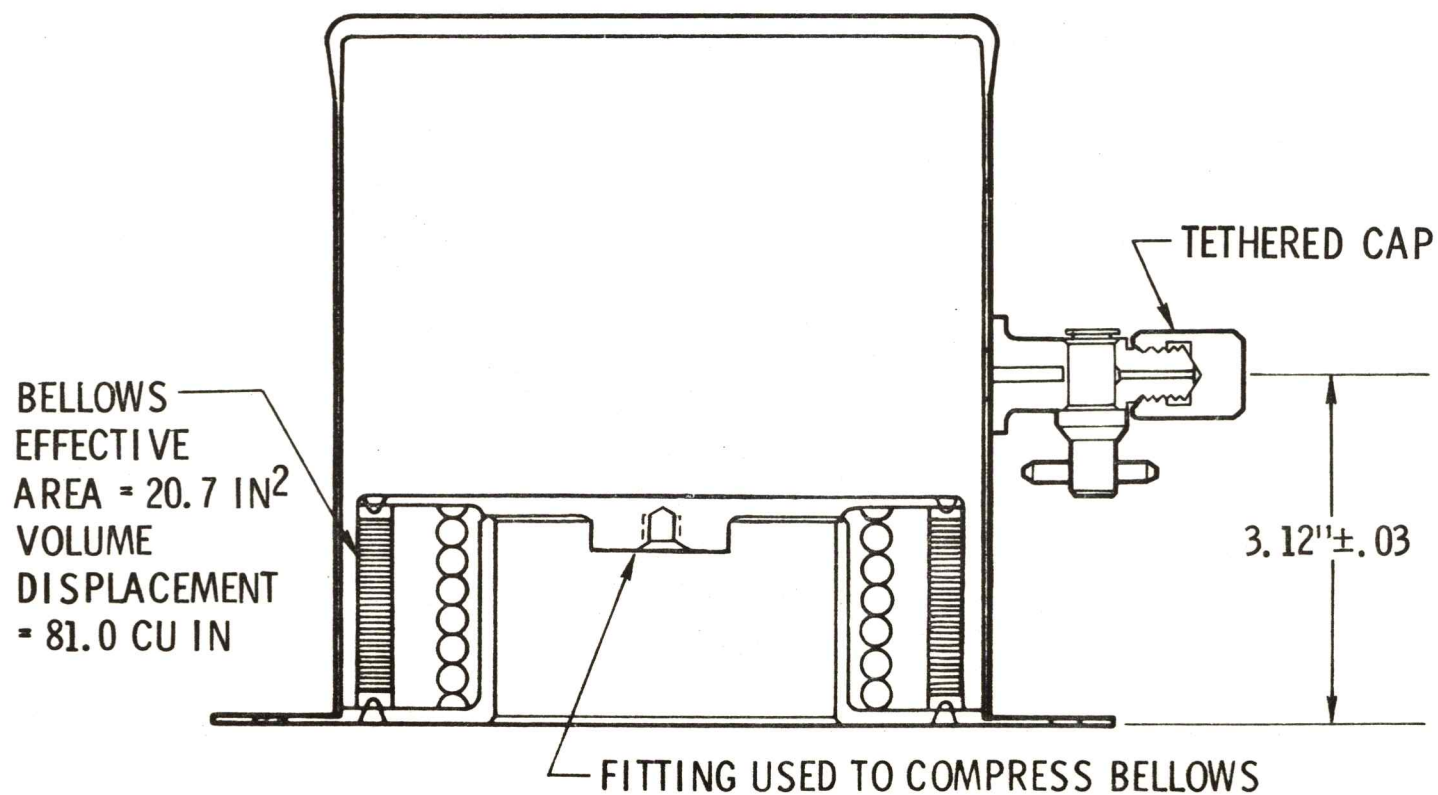
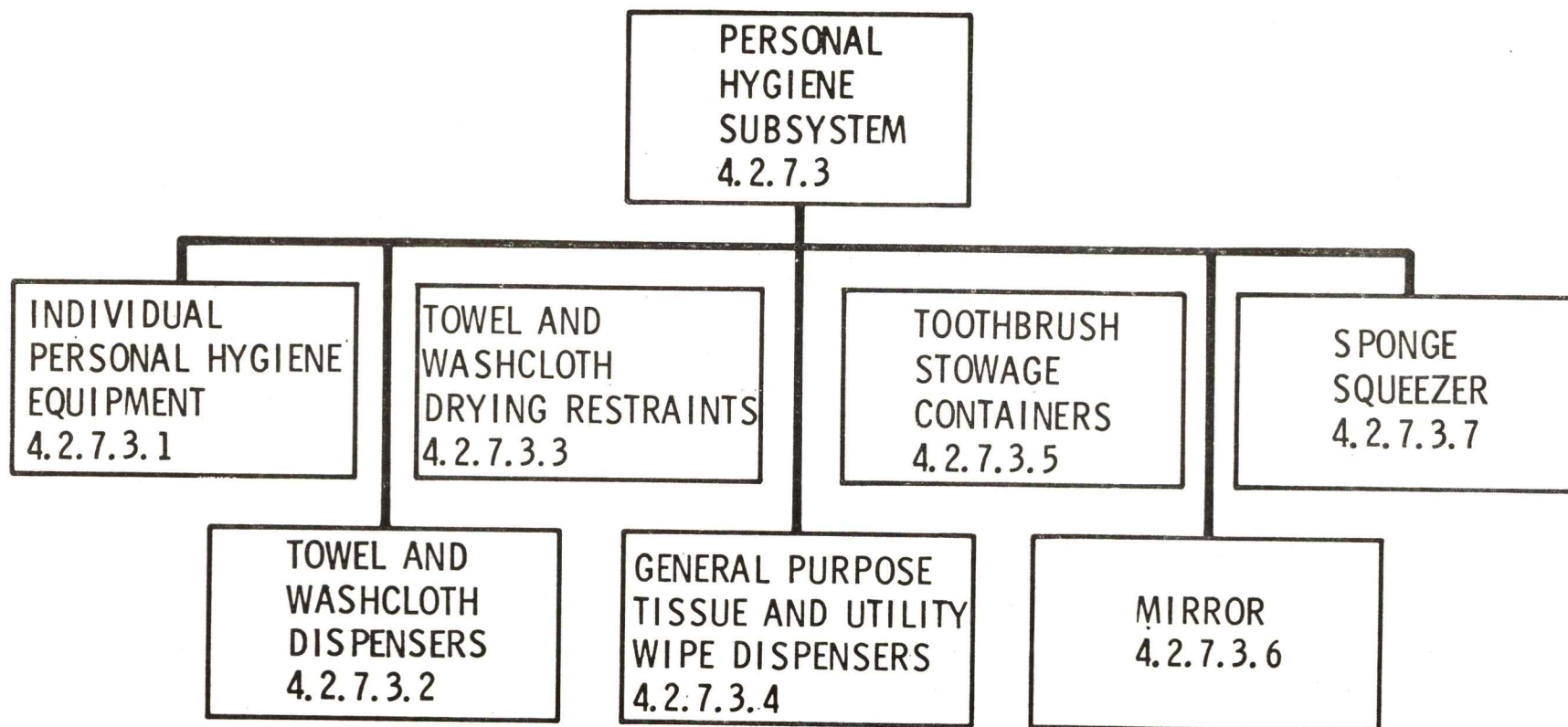


Figure 427-23. (Sheet 7 of 7)

ORBITAL WORKSHOP HSS PERSONAL HYGIENE SUBSYSTEM

O/W-2048
8-5-70

4-338



THE PERSONAL HYGIENE SUBSYSTEM PROVIDES
FOR MAINTENANCE OF SKIN HEALTH, PERSONAL
CLEANLINESS AND GROOMING

4.2.7.3 Personal Hygiene Subsystem

The Personal Hygiene Subsystem in conjunction with the WMC water equipment provides for maintenance of skin health, personal cleanliness, and grooming. Specific personal hygiene activities include body cleansing, brushing of teeth, shaving, and nail and hair clipping.

The Personal Hygiene Subsystem consists of the following items:

- a. Individual personal hygiene equipment.
- b. Towel and washcloth dispensers.
- c. Towel and washcloth drying restraints.
- d. General purpose tissue and utility wipe dispensers.
- e. Toothbrush stowage container.
- f. Mirror.
- g. Sponge squeezer.

Personal Hygiene Subsystem expendables are presented in Table 27-1.

4.2.7.3.1 Individual Personal Hygiene Equipment

The individual personal hygiene equipment is contained in fifteen identical containers (one per crewman per 28 days) and consists of items which are used individually, e.g., hair brush, fingernail clippers, toothbrush. The individual personal hygiene contents are Government Furnished Equipment. The container is supplied by MDAC. The dimensions of the units are TBD. Five units are stowed in each of three locker compartments.

4.2.7.3.2 Towel and Washcloth Dispensers

A total of five towel dispensers and 30 washcloth dispensers are provided in the personal hygiene subsystem. Each towel dispenser contains 24 towels and each washcloth dispenser contains 28 washcloths. One towel and six washcloth dispensers is a 28-day supply for three men. One towel and three washcloth dispensers occupy one locker compartment (Figure 427-24).

The towel dispenser is comprised of a six pigeon hole welded aluminum container. Four towels are stowed in each pigeon hole. Two web straps with velcro fasteners are used to restrain the towels within the unit. For on-orbit restraint, the towel unit itself is restrained within a locker compartment by a velcro strip on the back of the unit, mating with a velcro strip on the inside rear of the locker compartment.

The washcloth dispenser is a sheet metal, welded aluminum box which is spring-loaded to advance the washcloths to the front of the dispenser. Twenty-eight washcloths are stowed in each dispenser. For on-orbit restraint, the dispenser is restrained within a locker compartment by a velcro strip on the back of the unit, mating with a velcro strip on the inside rear of the locker compartment.

TABLE 27-1

Personal Hygiene Subsystem
Expendables

| Expendable Item | Usage Rate | 28-Day Supply | Total Required |
|-------------------------|-------------------------------------|---------------|----------------|
| Towels | 2/man/week | 24 | 120 |
| Washcloths | 2/man/day | 168 | 840 |
| Sponges | 1/man/3 day (body cleansing) | 28 | 140 |
| Soap Bars | 1/man/2 weeks (body cleansing) | 6 | 55 |
| | 1/2 weeks (WMC cleansing) | 2 | |
| | 1/2 weeks (Wardroom cleansing) | 2 | |
| | 1/28 days (Trash lock cleansing) | 1 | |
| General Purpose Tissues | 10/man/day | 840 | 4,200 |
| Utility Wipes | 6/man/day (personal) | 504 | 3,500 |
| | 7/day (compartment cleansing) | 196 | |

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ORBITAL WORKSHOP COMMON PERSONAL HYGIENE STOWAGE TOWEL AND WASHCLOTH DISPENSERS

O/W-6943
7-14-70

4-341

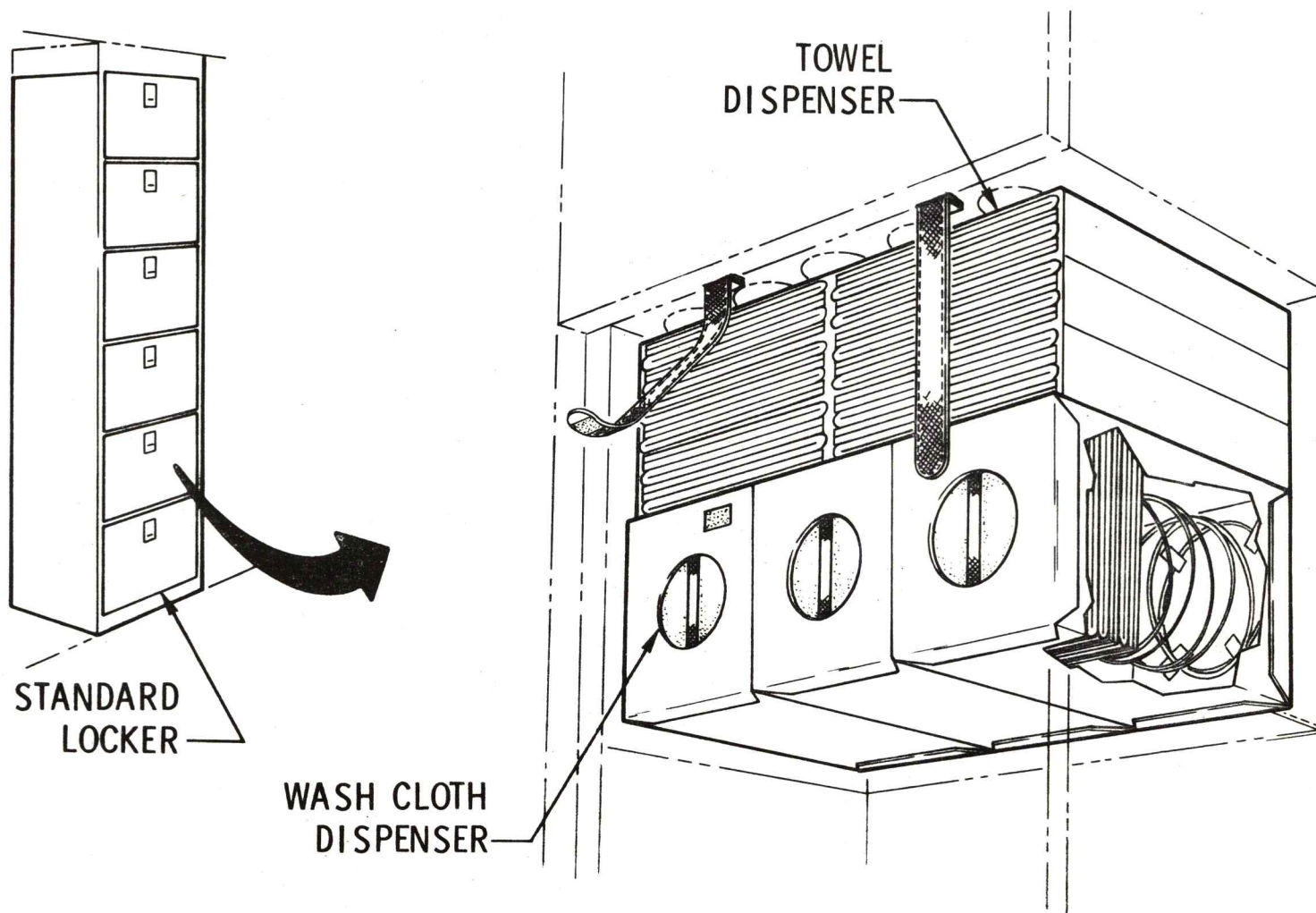


Figure 427-24.

Three washcloth dispensers and one towel dispenser are located in the WMC. The balance of the dispensers are stored as resupply in the wardroom.

A total of five towel and washcloth assembly installations are provided in the personal hygiene subsystem, two assembly installations in the WMC and three resupply assembly installations in the wardroom. Fifteen additional resupply washcloth dispensers are also provided.

4.2.7.3.3 Towel and Washcloth Drying Restraints

Three drying restraints are provided for towels (one per crewman) and nine for washcloths (three per crewman). Each towel restraint consists of four fluorocarbon rubber cups with a cross-cut on the front face and installed in the WMC (Figure 427-25). The molded cups are located so the corners of the towels can be inserted into and restrained by the cross-cuts. Each washcloth restraint consists of one cup as previously described, but located so the center of the cloth is restrained.

4.2.7.3.4 General Purpose Tissue/Utility Wipe Dispensers

Three general purpose tissue/utility wipe dispensers (Figure 427-26) are installed in the bottom one-third part of each of the five locker compartments - one in the WMC, one in the wardroom, and one in each of the three sleep areas. The dispensers are an integral part of these compartments. A metal shelf and two dividers within the compartment form an envelope for the three dispensers. A spring feed for the tissues and wipes is also integral with the compartment. Tissues and wipes are spring-loaded within each dispenser to advance the items to the front of the unit by removing the tissue/wipe cartridge back and impinging the spring directly on the items. Each three-dispenser complement contains two tissue cartridges and one cartridge of wipes. Three individually hinged doors are provided on the locker compartment door for access to the general purpose tissues and utility wipes.

Cartridges of tissues and wipes are launched in the dispensers. Cartridges of 196 wipes or 392 tissues are resupplied by opening the entire locker door, removing the expended cartridge and inserting the replacement cartridge. Eighteen cartridges of utility wipes are provided (five launched in dispensers and 13 resupply) and 11 cartridges of general purpose tissues (10 launched in dispensers and one resupply), for a total of 3528 wipes and 4312 tissues.

General purpose tissues of 3-ply construction are 5.0 inches wide and 8.43 inches long, folded to approximately 5.0 inches by 4-1/4 inches. The tissues are packaged in cartridges of 392 for resupply of the general purpose tissue dispensers. Utility wipes are also 3-ply tissue, 5.0 inches wide and 16-7/8 inches long, folded to approximately 5.0 inches by 4-1/4 inches. Utility wipes are packaged in cartridges of 196 for resupply of the utility wipe dispenser.

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ORBITAL WORKSHOP TOWEL AND WASHCLOTH DRYING RESTRAINT

O/W-7998
6-12-70

4-343

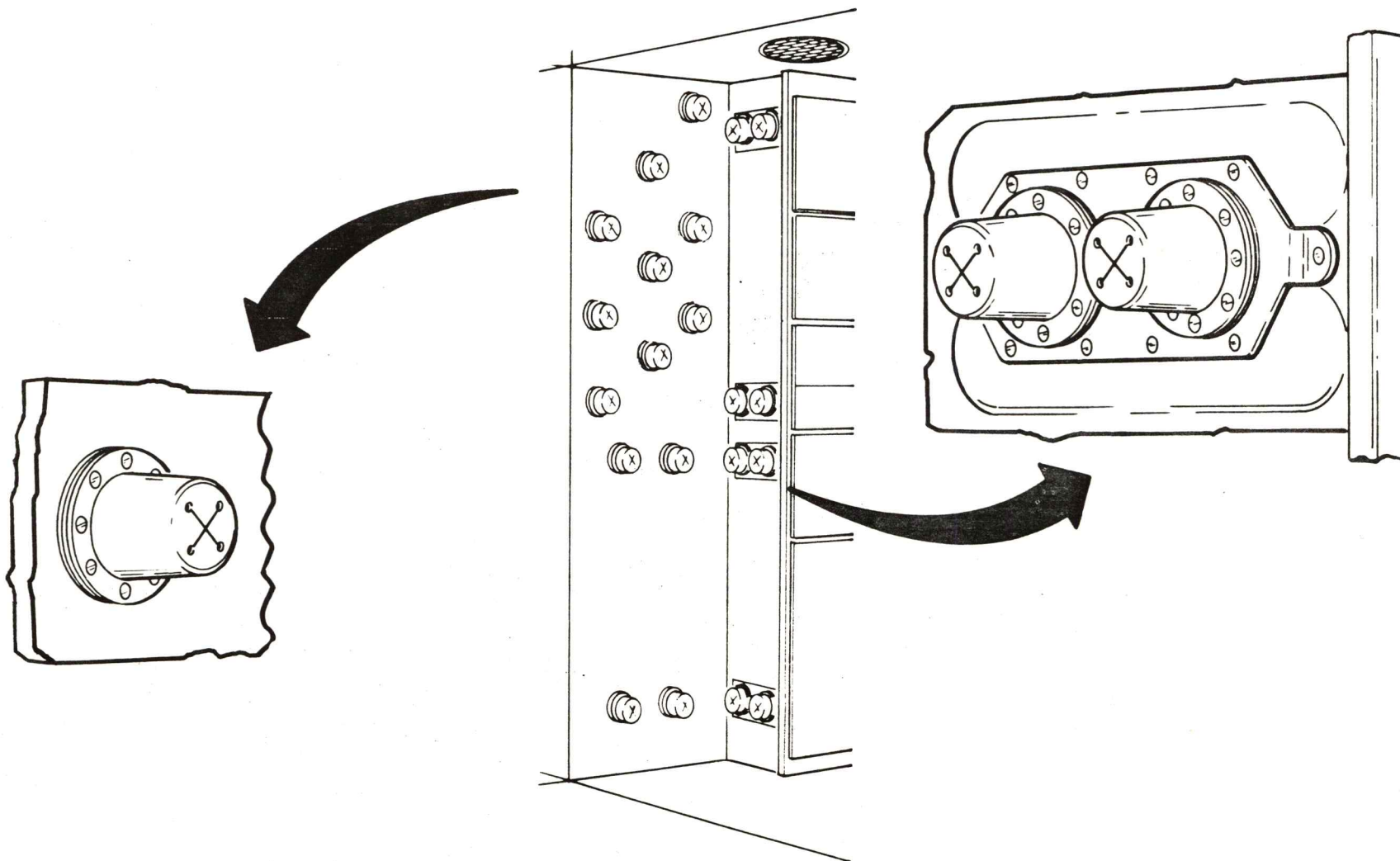


Figure 427-25.

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ORBITAL WORKSHOP GENERAL PURPOSE TISSUE/UTILITY WIPE DISPENSER

O/W-4693
8-6-70

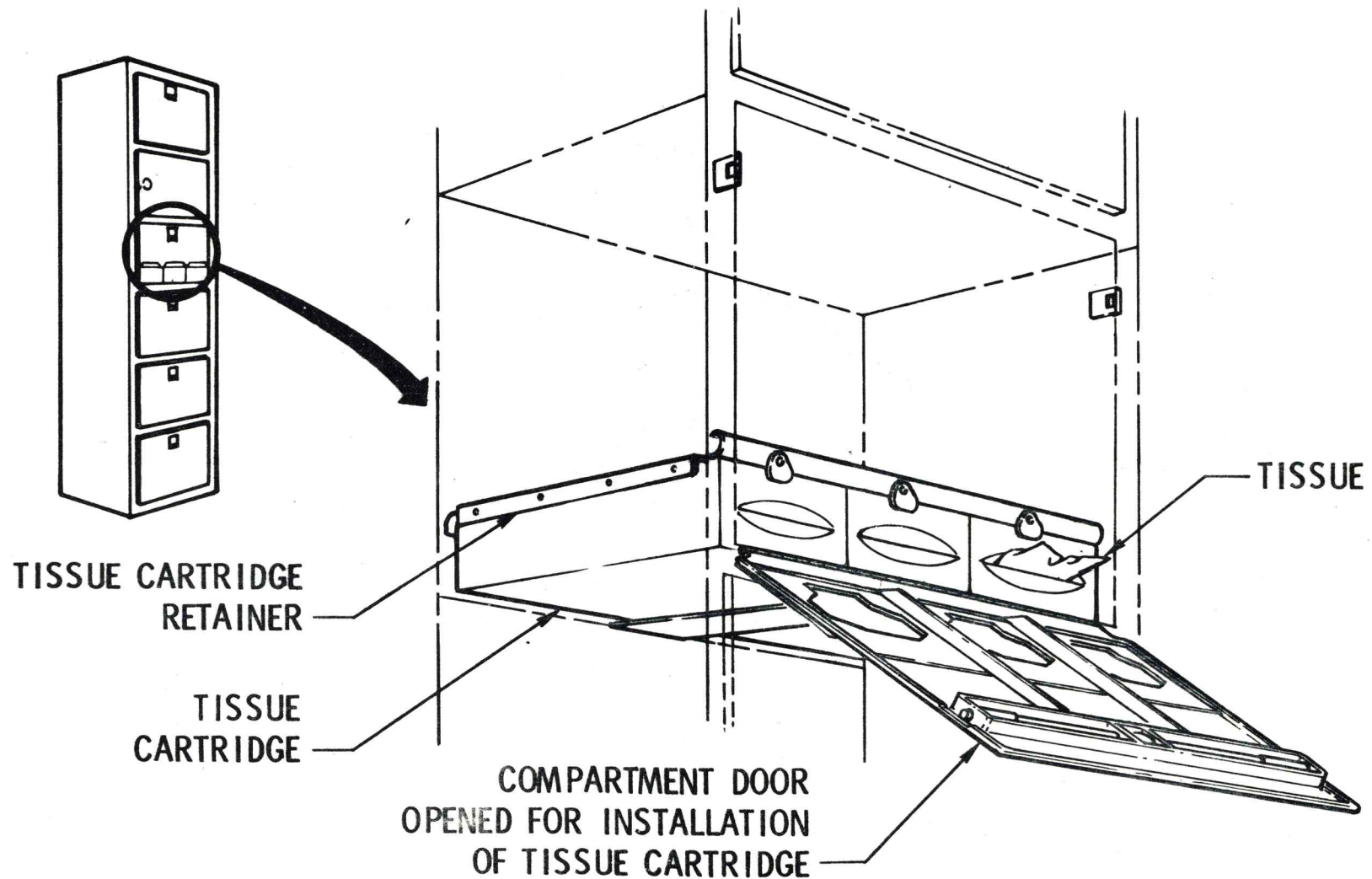


Figure 427-26.

4.2.7.3.5 Toothbrush Stowage Containers

Three toothbrush stowage containers are provided for stowing the individual crewman's toothbrush and dental cream. The containers are fastened to the wardroom table pedestal (Figure 427-27). The toothbrush stowage containers consist of a small box with a hinged lid. The box is perforated to provide airflow for toothbrush drying.

4.2.7.3.6 Mirror

A polished stainless steel mirror is bonded to the locker compartment door located above the WMC water module. The mirror is 16.0 inches wide and 12.0 inches high.

4.2.7.3.7 Sponge Squeezer

The sponge squeezer (Figures 427-28 and 427-29) provides the capability to remove soapy water from sponges during body cleansing. The natural sponges are one inch thick and five inches in diameter. The squeezer is mounted on the WMC water module. The squeezer can be rotated to the use position during body washing and rotated out of the way when not in use. The top portion of the squeezer is hinged to allow insertion of the sponge into the sponge receptacle.

The sponge squeezer is operated by (1) inserting a sponge into the receptacle and (2) activating a piston by means of a hand lever. Water is pressed from the sponge into a water collection bag containing a one-way check valve.

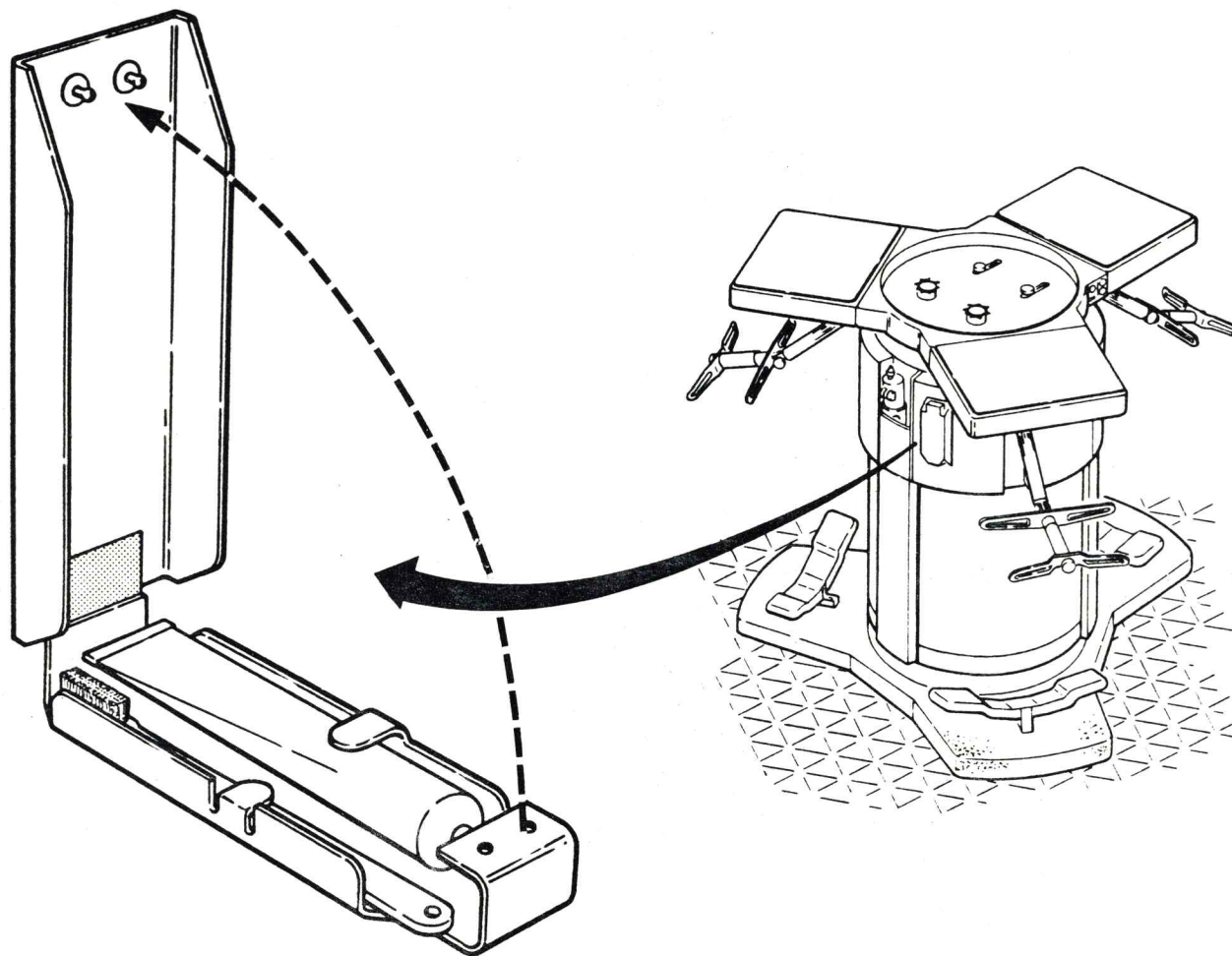
Hardware items comprising the sponge squeezer are:

- a. Hand lever.
- b. Sponge receptacle.
- c. Piston.
- d. Collection bags with one-way check valves.
- e. Hinge.
- f. Latch.

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ORBITAL WORKSHOP TOOTHBRUSH STOWAGE CONTAINER

O/W-8000
6-12-70

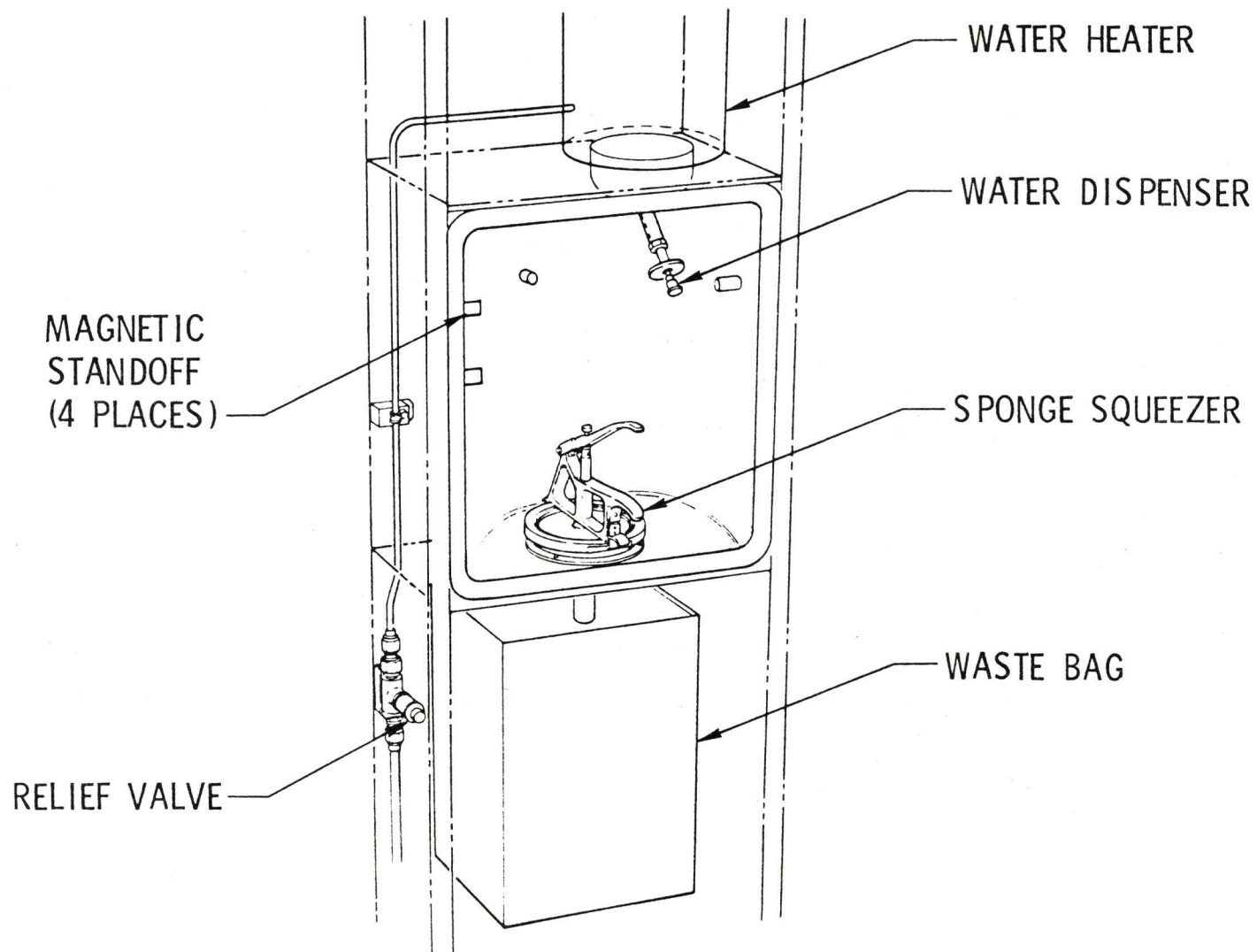


4-346

Figure 427-27.

ORBITAL WORKSHOP WMC WATER MODULE SPONGE/SQUEEZER

O/W-8456
8-5-70



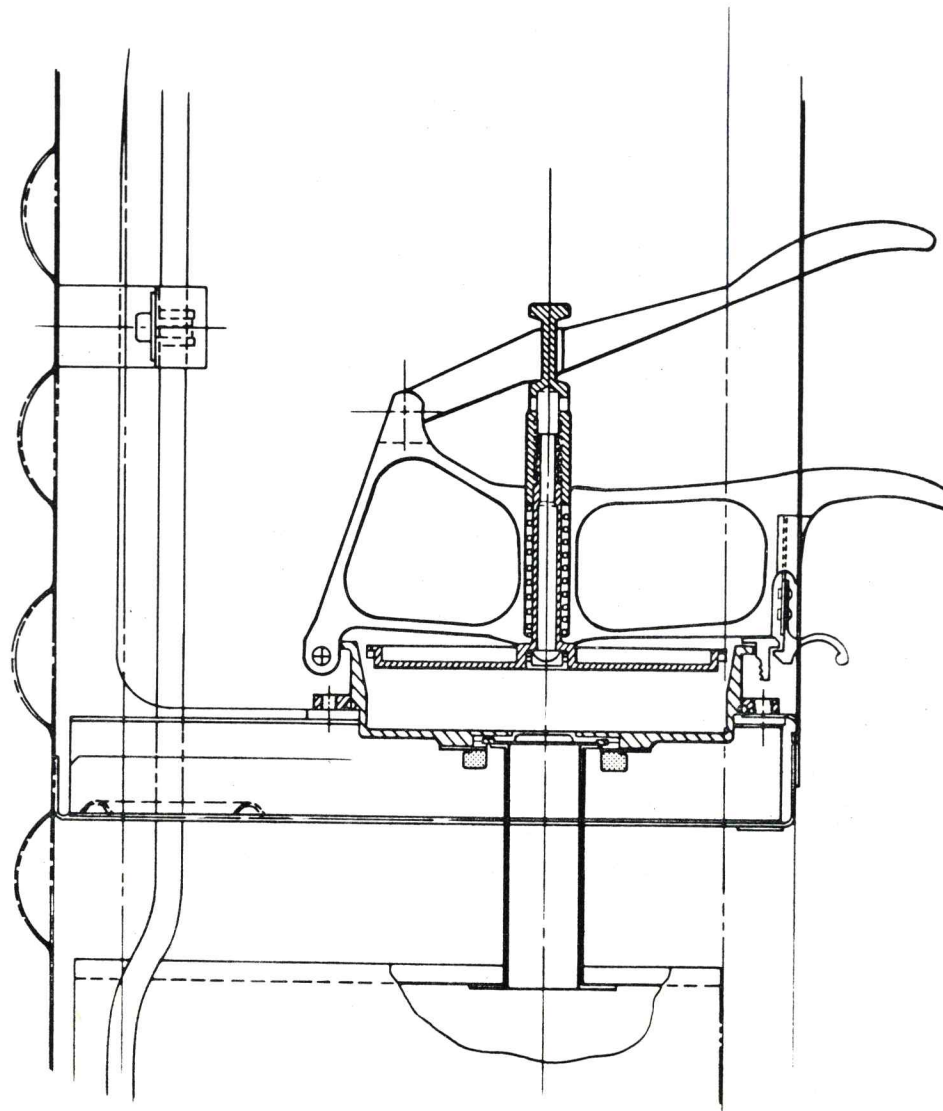
4-347

Figure 427-28.

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ORBITAL WORKSHOP WMC WATER MODULE SPONGE/SQUEEZER

**O/W-8456A
7-8-70**

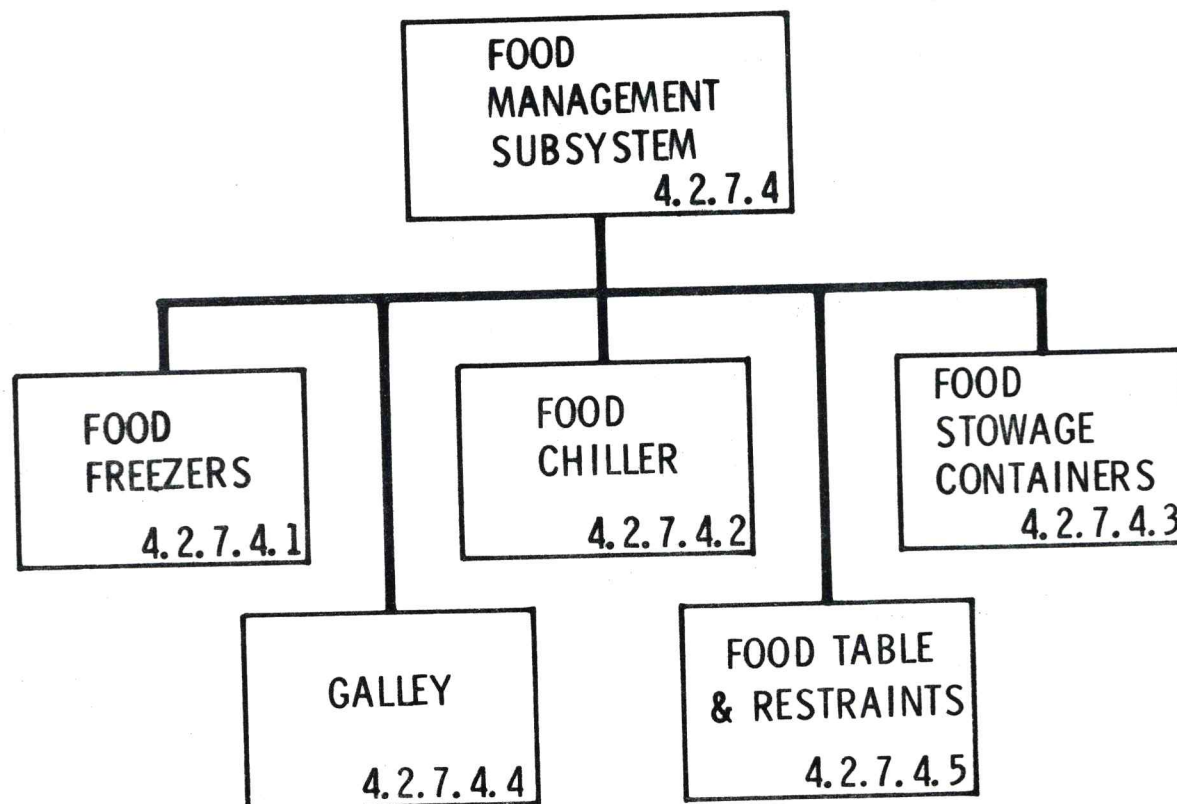


4-348

Figure 427-29.

ORBITAL WORKSHOP HSS FOOD MANAGEMENT SUBSYSTEM

O/W-4700A
8-6-70



4.2.7.4 Food Management Subsystem

The Food Management Subsystem provides the equipment and supplies required for food storage, preparation, and consumption. It also provides the three crewmen with an 140-day supply of food and beverages.

Basic food requirements for the Habitability Support System Food Management Subsystem are shown in Figure 427-28.

The FMC arrangement is shown in Figure 427-29.

The food management subsystem consists of the following items:

- a. Food freezers.
- b. Food chiller.
- c. Food stowage containers.
- d. Galley.
- e. Food table and restraints.

4.2.7.4.1 Food Freezers

The Food Management System provides two food freezer assemblies: (1) a wardroom food freezer (Figure 427-30) consisting of two freezer compartments and one food chiller compartment, and (2) a forward compartment food freezer consisting of three food freezer compartments. Both freezer assemblies utilize the same basic design.

Each of the five freezer compartments provide for stowage of 100 pounds of frozen food, for a total capability of 500 pounds. Each freezer compartment has inside dimensions of 13 x 16.5 x 17 inches for a useable volume of 2.1 cubic feet. The freezers provide a stowage temperature of $-10 \pm 10^{\circ}\text{F}$ maximum. Required temperatures are provided by heat rejection to the Refrigeration System fluid circuit (Section 4.2.9). Instrumentation is provided for temperature readout.

Each freezer compartment has a foam-filled door. The annulus between the food compartments and the outer freezer shell is also filled with foam insulation.

4.2.7.4.2 Food Chiller

The food chiller provides $45 \pm 12^{\circ}\text{F}$ storage temperature for up to 100 pounds of perishable food. The food chiller is the top compartment of the wardroom food freezer assembly. The food chiller maintains the required temperature in the chiller by rejecting heat to the refrigeration fluid circuit downstream of the chiller control valve where the fluid temperature is controlled. The chiller compartment structure and insulation is identical to the freezer compartments which make up the remainder of the wardroom freezer assembly.

ORBITAL WORKSHOP
HSS FOOD MANAGEMENT SUBSYSTEM
STOWAGE REQUIREMENTS

O/W-4701
8-6-70

| OWS STOWAGE REQUIREMENT | DEHYDRATED | INTERMEDIATE MOISTURE AND WET PACK | PERISHABLE | FROZEN |
|-------------------------------|---------------------------|--|--|---------------------------|
| WEIGHT | 252 LB | 393.5 LB | 52.4 LB | 252 LB |
| VOLUME | 8.75 FT ³ | 13.125 FT ³ | 1.75 FT ³ | 8.75 FT ³ |
| TEMPERATURE | 40 TO 85 ⁰ F | 40 TO 85 ⁰ F | 45 + 0 ⁰ - 12 ⁰ F | -10 ± 10 ⁰ F |
| LAUNCH STOWAGE | TOTAL FOR ALL MISSIONS | TOTAL FOR ALL MISSIONS | MISSION #1 (26.2 LB/0.875 FT ³) | TOTAL FOR ALL MISSIONS |
| PACKAGED UNITS | 3 CREWMEN FOR 7 DAYS | 3 CREWMEN FOR 7 DAYS | --- | --- |

4-351

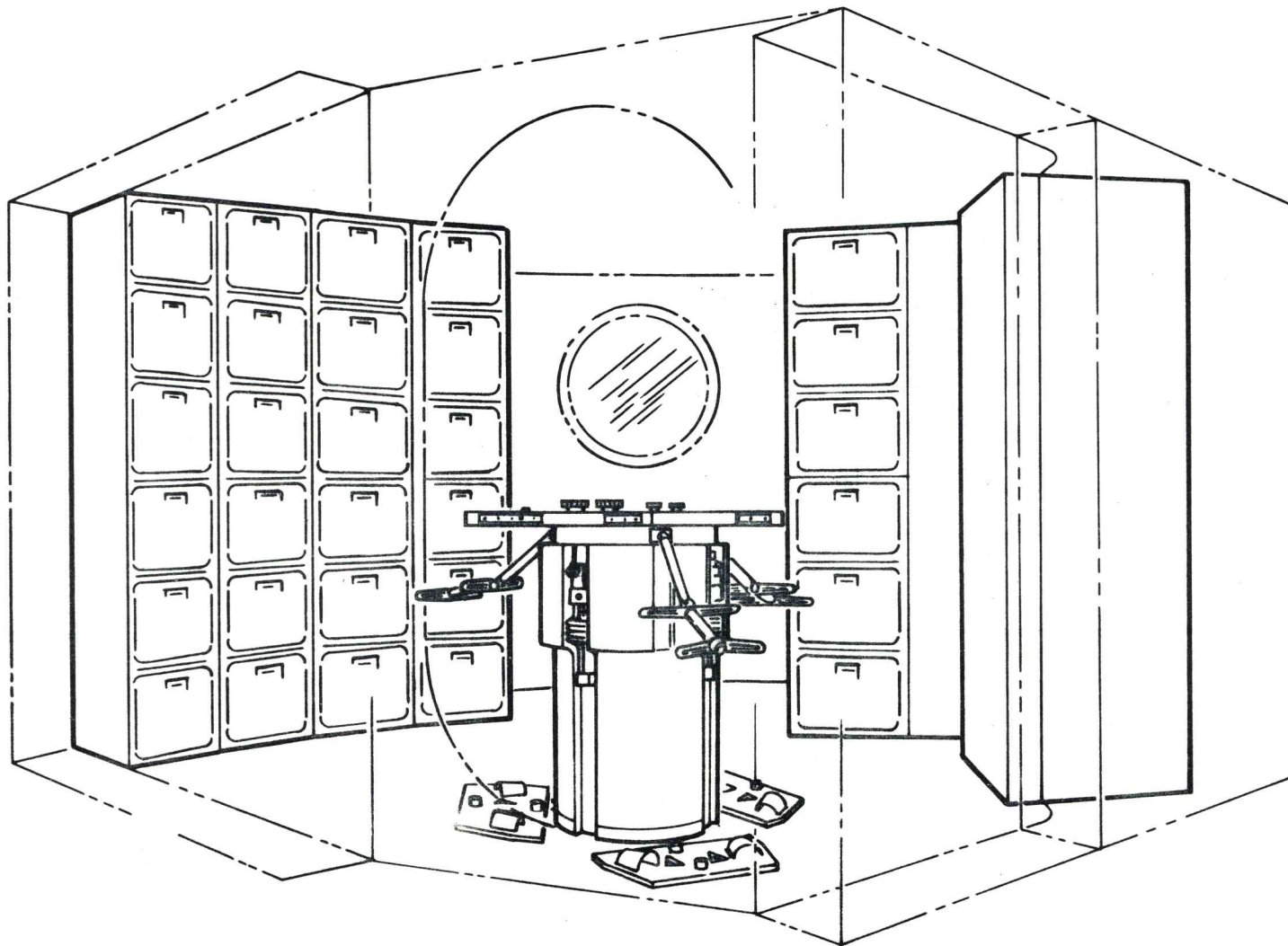
Figure 427-28.

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ORBITAL WORKSHOP

UTILIZE FOOD PREPARATION TABLE, FOOD MGT RESTRAINTS & FOOD HEATERS

O/W-4280 A
4-20-70



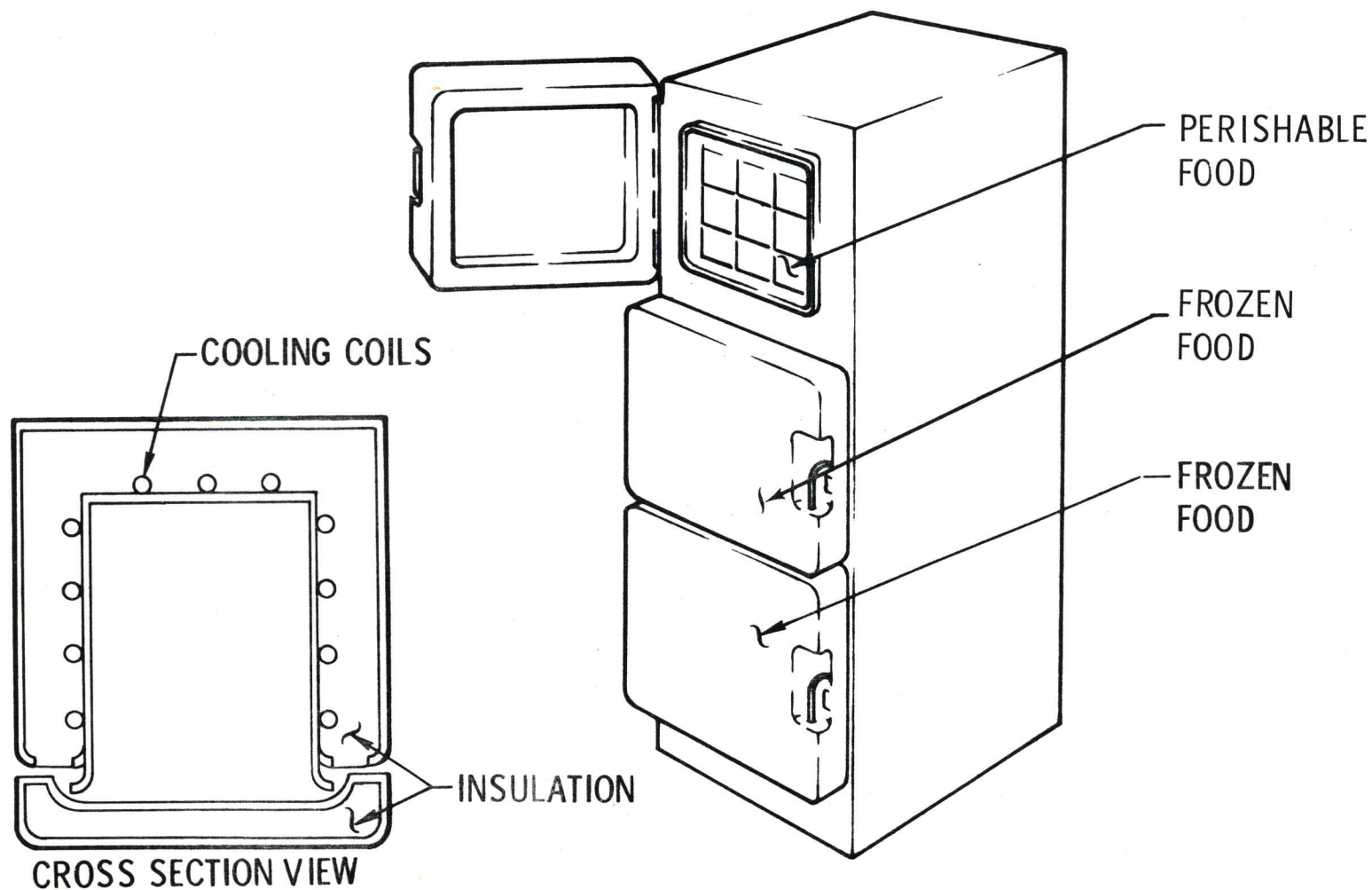
4-352

Figure 427-29.

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ORBITAL WORKSHOP WARDROOM FREEZER FROZEN FOOD COMPARTMENT

O/W-4694
6-12-70



4-353

Figure 427-30.

4.2.7.4.3 Food Stowage Containers

The food stowage containers consist of noninsulated sheet metal containers sized for the stowage of unrefrigerated food (dehydrated, intermediate moisture, and wet pack). Eleven of these containers are required for the stowage of approximately 84 cubic feet of food. Each container will have inside dimensions of 20 inches high, 22 inches wide by 32 inches deep and a placard weight of 200 pounds. Access to the containers is provided by a hinged door which utilizes a latch identical to that of the standard locker compartments. The construction of these containers permit packing of the food external to the OWS and installation of the fully loaded container into the OWS for launch. For weight distribution during the launch phase, five of these containers will be launched in their on-orbit positions. The other six containers will be arranged on the forward compartment floor to distribute the g loads (Figure 427-31). During workshop actuation, these six containers will be relocated to the on-orbit locations (Figure 427-32).

Hardware items comprising the food containers are:

- a. Beaded sheet metal construction.
- b. Access door with latch.
- c. Piano hinges.
- d. Tie-down cleats for launch restraint.
- e. Disposable clamps for launch restraint.

4.2.7.4.4 Galley

The galley is located adjacent to the wardroom freezer. The galley is of modular construction, designed to contain the following (Figure 427-33):

- a. Two stowage compartments capable of accommodating a seven day supply of food canisters of two sizes. The canisters are restrained internally and the stowage compartment doors have positive latching coupled with the door handle.
- b. A recessed area containing stowage restraints for empty food canisters (canister tops will be utilized as closures when the canisters are used for waste), a bulkhead-mounted can opener and general purpose restraints.
- c. Open stowage slots are provided to contain three food tray covers which are restrained with a friction spring.
- d. A slide tray will restrain three sets of utensils. Six additional utensil sets are stored in the galley for crew change.

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ORBITAL WORKSHOP FORWARD AREA STOWAGE (LAUNCH)

O/W-8267
8-8-70

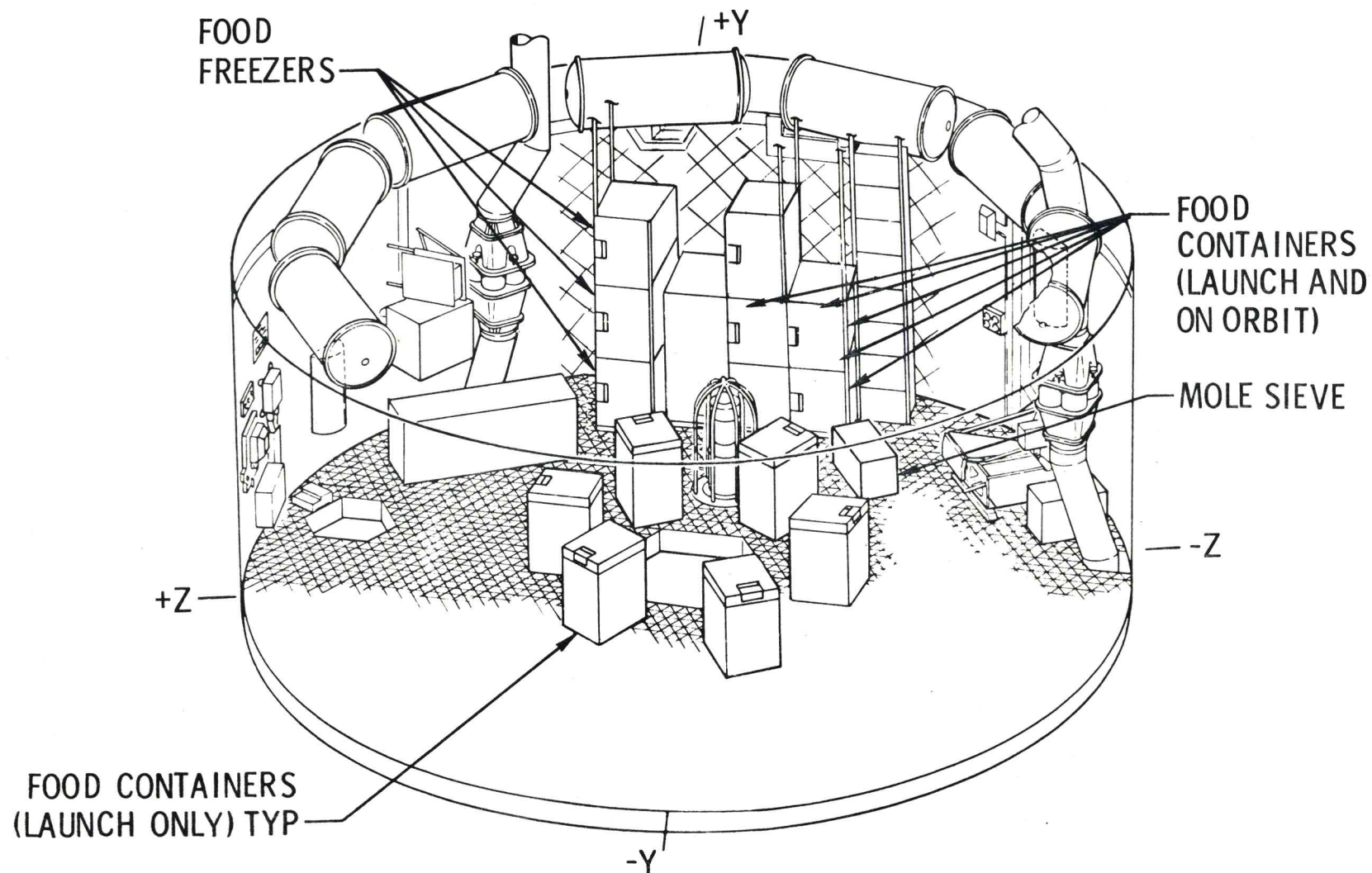


Figure 427-31.

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ORBITAL WORKSHOP FORWARD COMPARTMENT ON-ORBIT STOWAGE

O/W-5393A
8-10-70

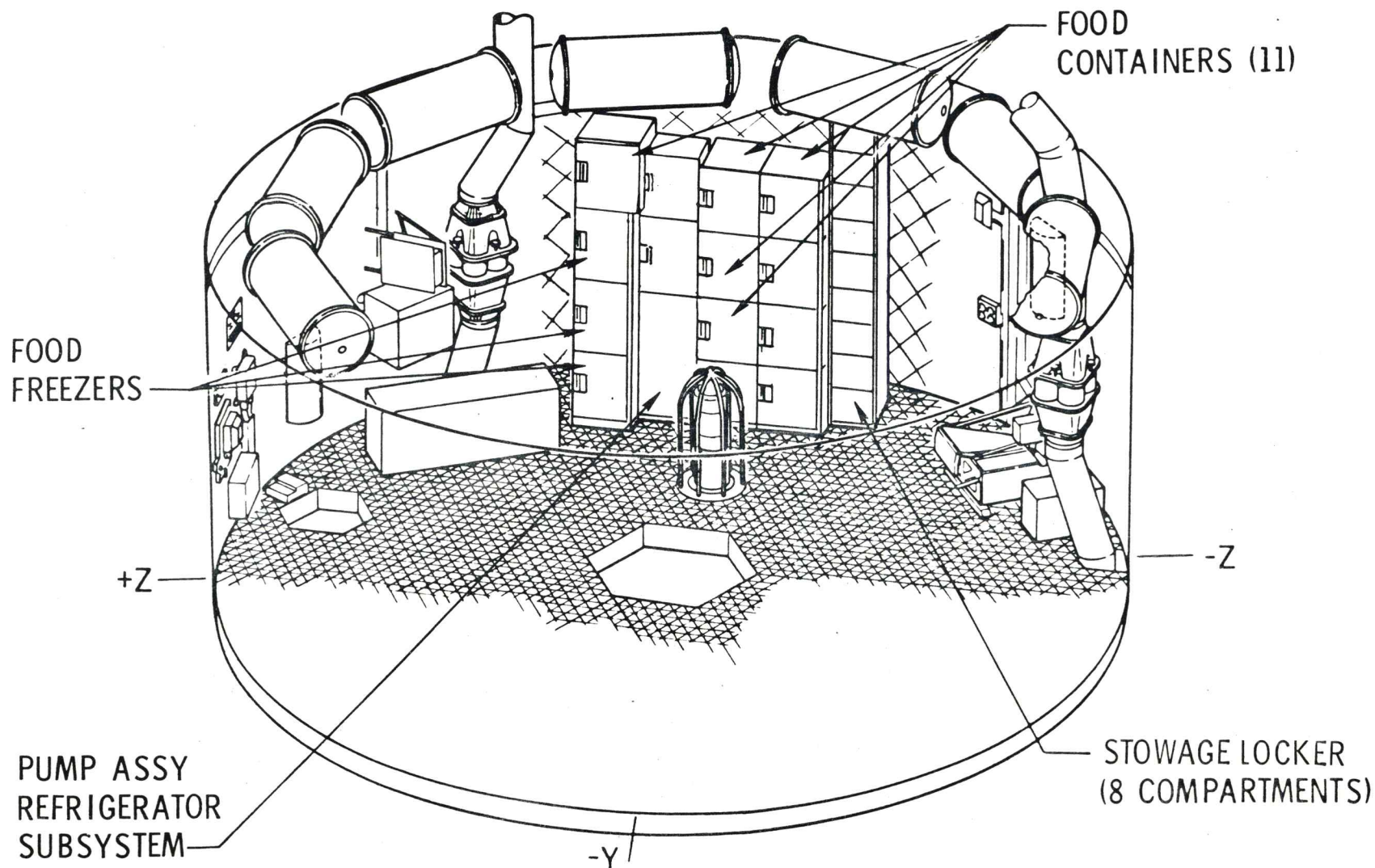
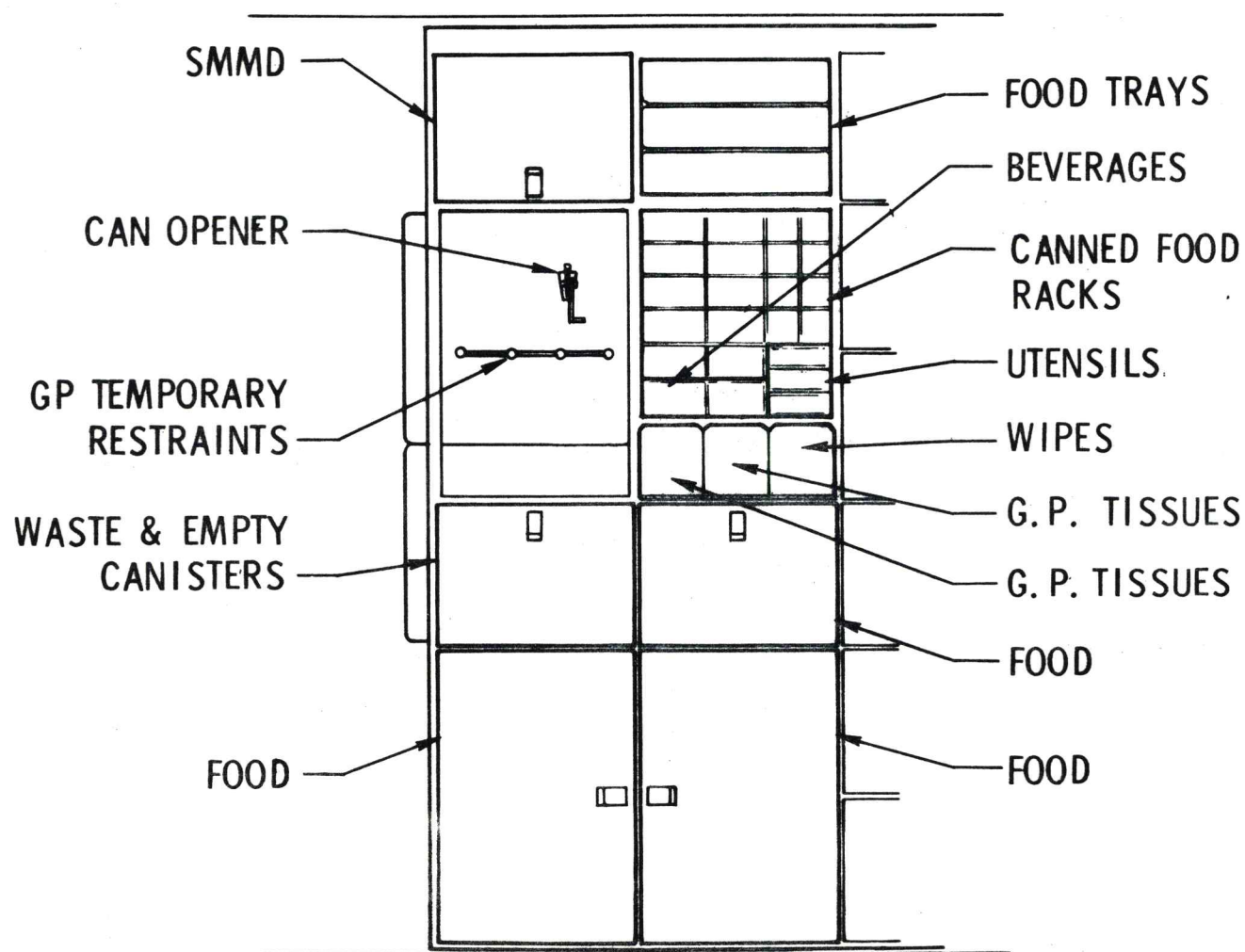


Figure 427-32.

ORBITAL WORKSHOP GALLEY CONCEPT

O/W-8312
8-6-70



4-357

Figure 427-33.

- e. Trays are provided for stowage of a two-day supply (approximately) of food cans and a one-day supply of beverage containers. The trays and contents will utilize pressure and friction type spring restraints.
- f. Three general purpose tissue/utility wipe dispensers (paragraph 4.2.7.3.4) are provided. Empty tissue/wipe cartridges are removed and replaced by releasing the dispenser restraint cover latch.

4.2.7.4.5 Food Table and Restraints

The food table and thigh restraints (Figure 427-34) provide the means for three crewmen to simultaneously consume food in an efficient and comfortable manner. The food table also supports components of the water subsystem.

The food table provides a means to restrain the food tray during food consumption. The table also provides a base for the water heater, water chiller, water dispensers and thigh restraints. It is provided with a cover equipped with gameboard markings.

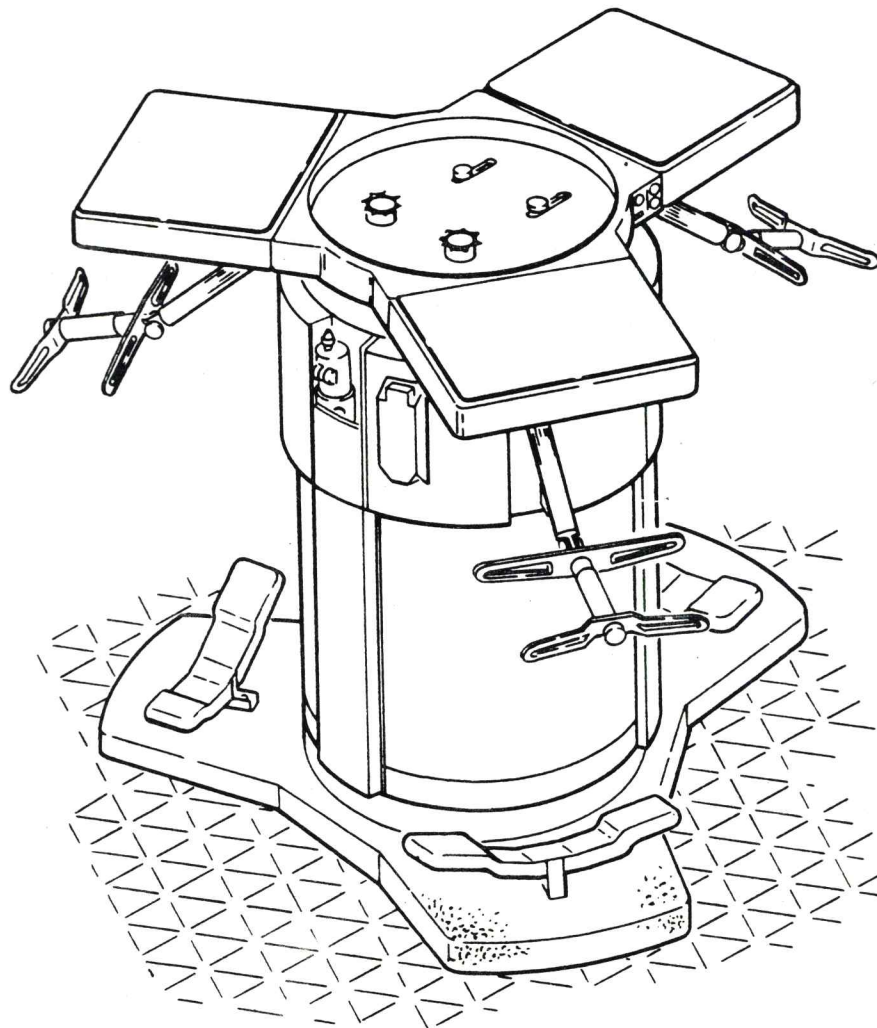
The food is restrained on three detachable trays. The trays can be detached to increase crew space in the wardroom. Each tray is provided with a removable cover which can be used as a writing surface.

Three thigh restraints are used in conjunction with the table foot restraints to provide a comfortable and efficient means of stabilizing the crewman at the table. The thigh restraints are adjustable for various-sized crewmen and can be folded against the food table when not in use. The table foot restraints can be removed to facilitate access into the table.

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ORBITAL WORKSHOP WARDROOM TABLE

O/W-8319
8-6-70

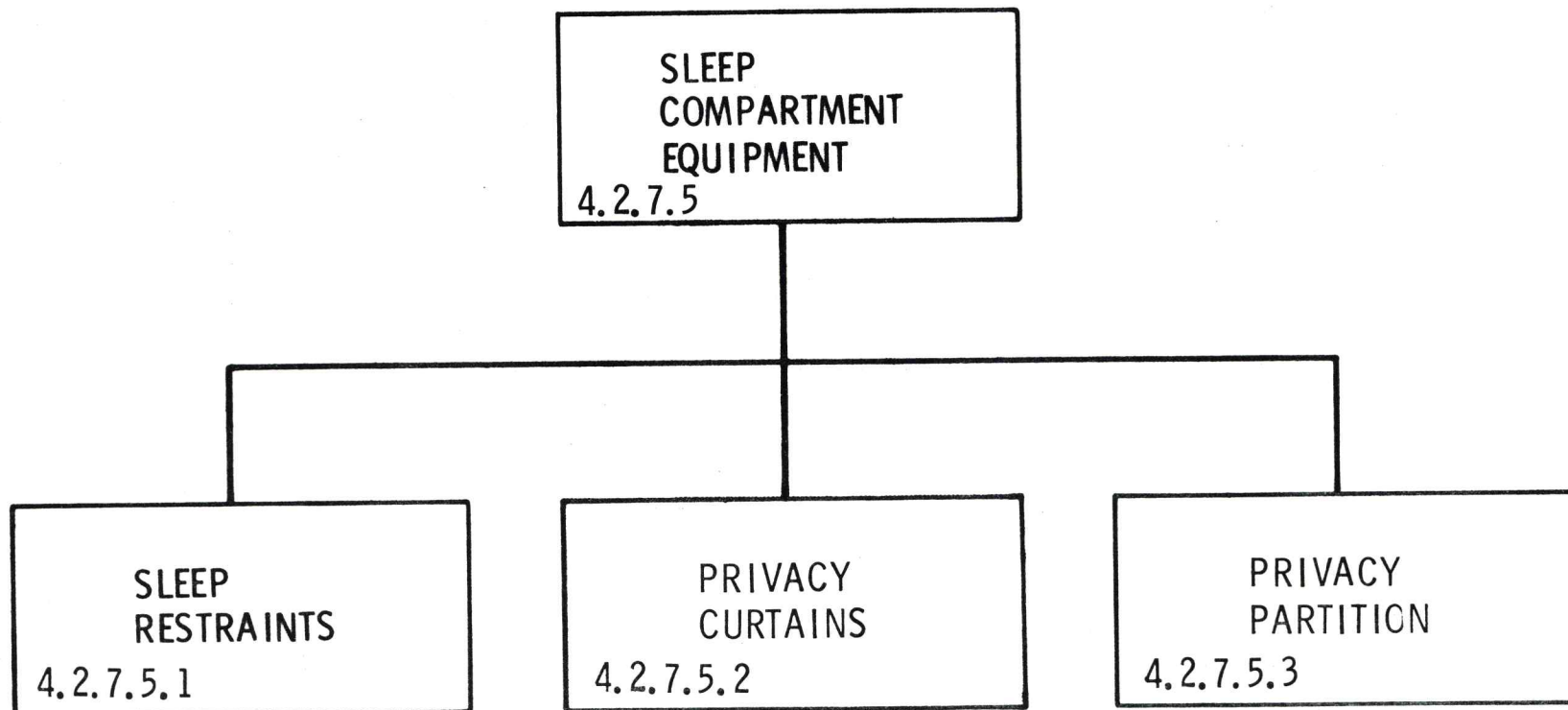


4-359

Figure 427-34.

ORBITAL WORKSHOP SLEEP COMPARTMENT EQUIPMENT

O/W-2068
6-12-70



THE SLEEP COMPARTMENT EQUIPMENT CONSISTS OF THE ITEMS NECESSARY
TO PROVIDE SLEEPING ACCOMMODATIONS FOR THREE CREWMEN

4.2.7.5 Sleep Compartment Equipment

The sleep compartment equipment consists of sleep restraints for three crewmen, a privacy partition and privacy curtains which provide sleeping privacy (Figure 427-35).

4.2.7.5.1 Sleep Restraints

The sleep restraints (Figure 427-36) provide positive restraint of the crewmen's bodies while sleeping. The restraints allow choice of sleeping positions, including the fetal position.

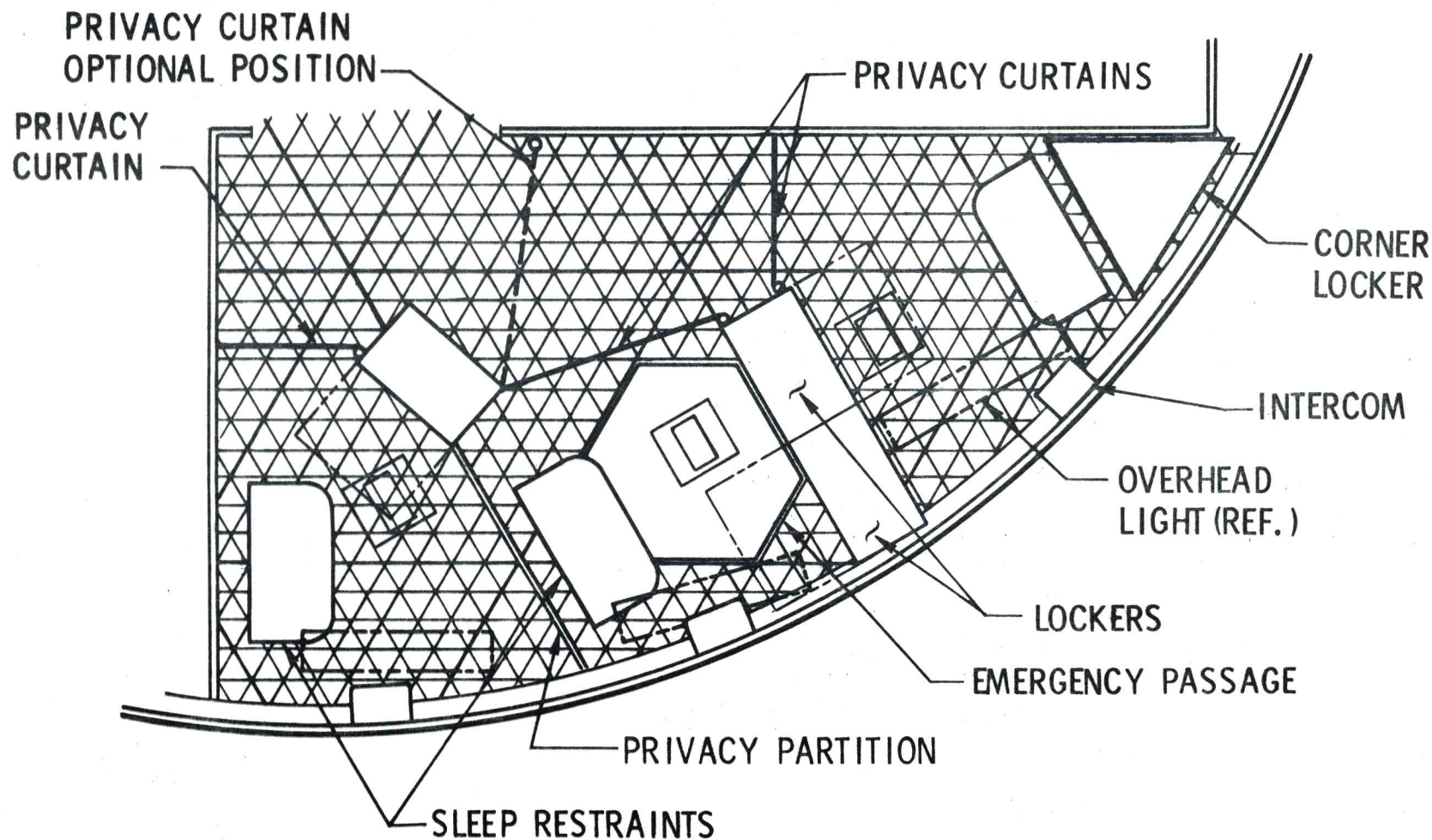
Thirty restraints will be supplied for the three missions. Three restraints are installed in the Sleep Compartment for launch. The remaining restraints are stored in lockers and are deployed as required.

Hardware items comprising the sleep restraint are:

- a. TBD material assembly.
 - 1. Arm access holes (closed by zipper operated from inside).
 - 2. Adjustable ventilation holes.
 - 3. Shoulder straps.
 - 4. Inflatable air pillow (removable).
- b. Center zipper.
 - 1. Zipper length - zips down past knees to provide ease of ingress and egress.
 - 2. Zipper operation from inside or outside the restraint.
- c. Attaching provisions.
 - 1. Two straps, each attached at floor and ceiling levels, prevent rotation and gyration of the restraint.
 - 2. Straps provide standoff from OWS wall.
 - 3. Straps maintain restraint orientation to Crew Quarters frame of reference.
 - 4. Straps adjustable to enable restraint to become taut as desired.
- d. Interfaces.
 - 1. Sleep compartment structure.
 - 2. Stowage locker compartments.

ORBITAL WORKSHOP SLEEP COMPARTMENT ARRANGEMENT

O/W-3892-1
8-5-70



4-362

Figure 427-35. (Sheet 1 of 2)

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ORBITAL WORKSHOP SLEEP COMPARTMENT

O/W-3340
8-6-70

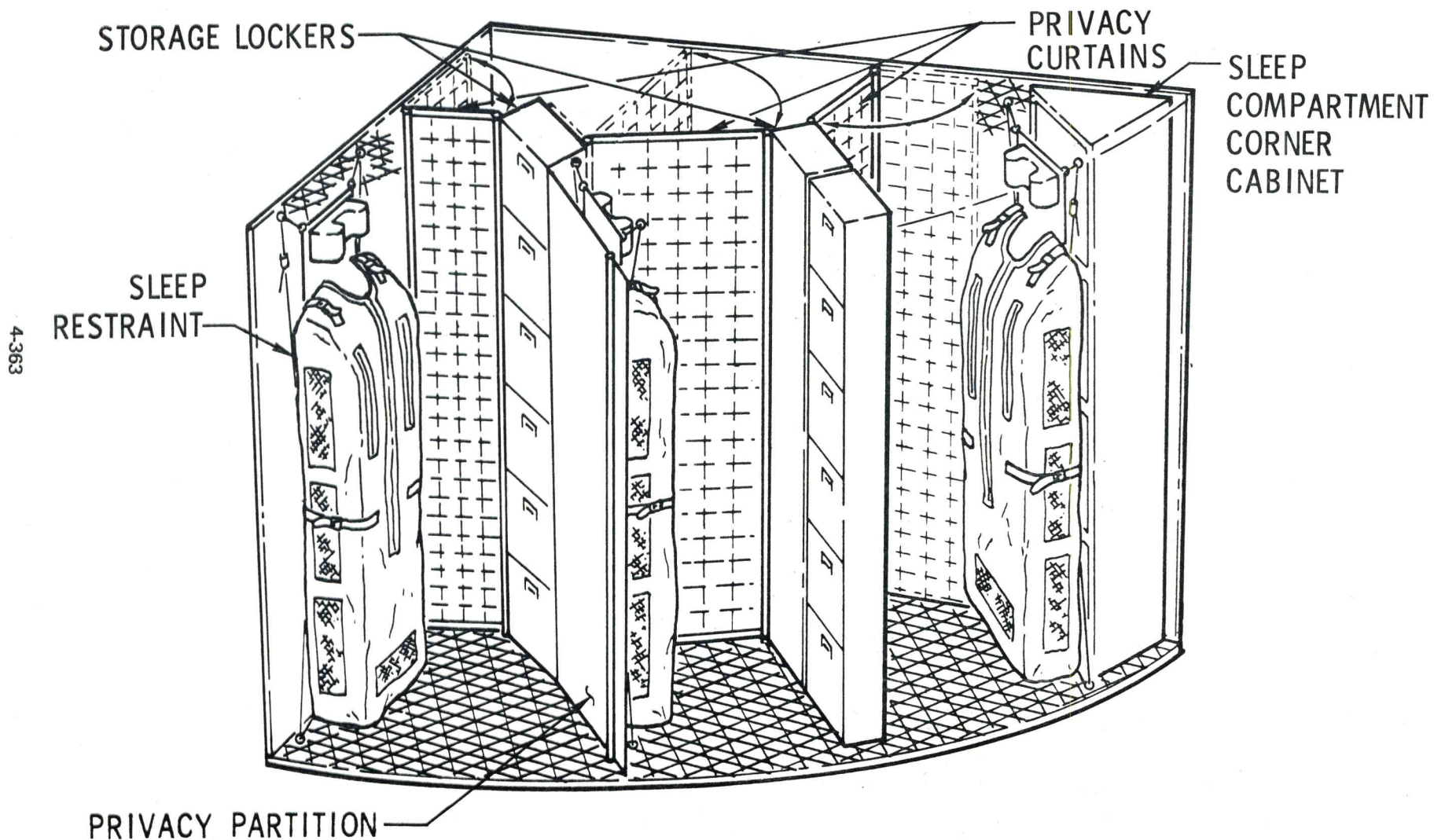


Figure 427-35. (Sheet 2 of 2)

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ORBITAL WORKSHOP HSS SLEEP RESTRAINT

O/W-2197B
8-5-70

4-364

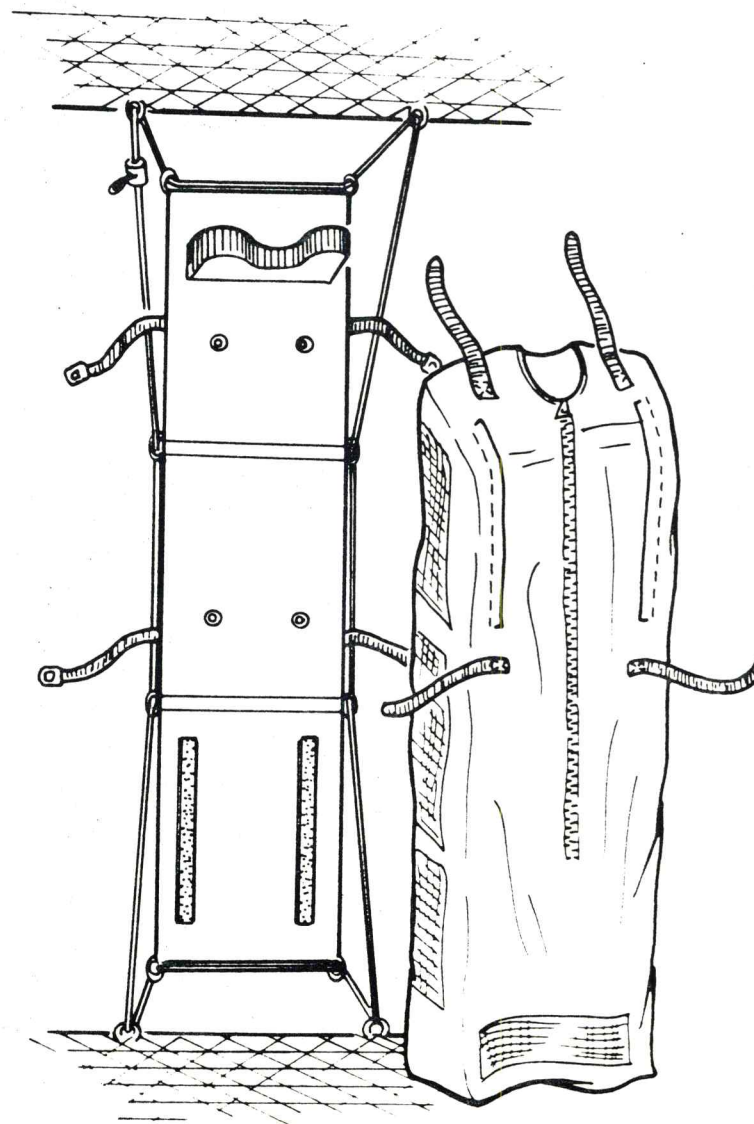


Figure 427-36.

4.2.7.5.2 Privacy Curtains

One privacy curtain is provided for each of the three individual sleep areas. The curtains provide visual separation and light control. They are constructed of teflon coated beta fabric. The curtains are operated by a handle attached to an operating tube, assembled into the vertical edge of each curtain. A slit in the curtain permits operation from either side of the curtain with a flap over the slit for light control. The privacy curtains are restrained in the open position for launch by turn buttons and during orbital operations by means of a velcro strip. They are held in the closed position by a velcro strip which restrains the operating tube. The design of the privacy curtains is shown in Drawing 1B81228.

4.2.7.5.3 Privacy Partition

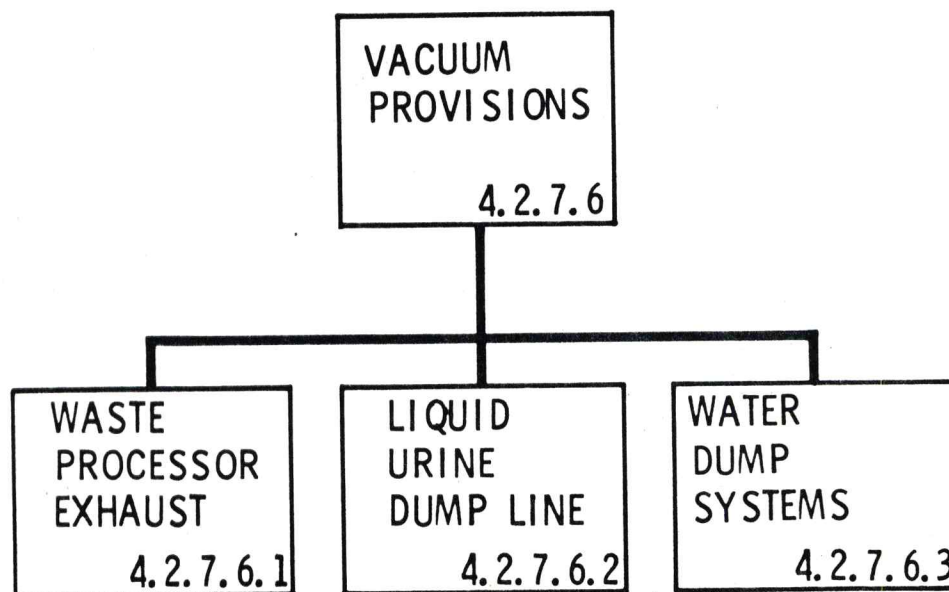
The privacy partition is a divider which separates two sleep areas in the sleep compartment. A third sleep area is separated by two lockers. The privacy partition provides visual separation and acts as a light barrier between two sleep areas.

Hardware items comprising the privacy partition are:

- a. Panel constructed of aluminum sheet metal.
- b. Aluminum angle frame.
- c. Interfaces.
 1. Sleep compartment structure.
 2. Locker.

ORBITAL WORKSHOP VACUUM PROVISIONS

O/W-4511B
6-15-70



4.2.7.6 Vacuum Provisions

The vacuum provisions for the HSS (Figure 427-37) consist of the hardware items necessary to vent the waste processor, the liquid urine dump, and two water system drainage lines into the waste tank through fittings in the habitation-area/waste-tank common bulkhead. Each vacuum line incorporates a shutoff valve to isolate the system from the waste tank and to control the dump procedures.

After orbital insertion, the waste tank vent valves will be permanently latched open to vent the waste tank to space. When water or urine is dumped into the waste tank, where the pressure will be below the triple point of water, the liquid will flash. Approximately 15 percent of the liquid will vaporize and the remainder will freeze. The vapor will be vented immediately through the non-propulsive vent (NPV) system, but the frozen residue will be trapped by screens in the waste tank and will sublime gradually.

4.2.7.6.1 Waste Processor Exhaust

Gases are vented from the waste processor through a manifold to a one-inch hand operated ball valve (Figure 427-38) located on a panel in the WMC. A 1 and 1/2-inch stainless steel line runs from the valve to the floor and then to a boss on the common bulkhead, venting into the waste tank. The vent line is sized to keep the manifold pressure below 0.15 psia at maximum flowrate.

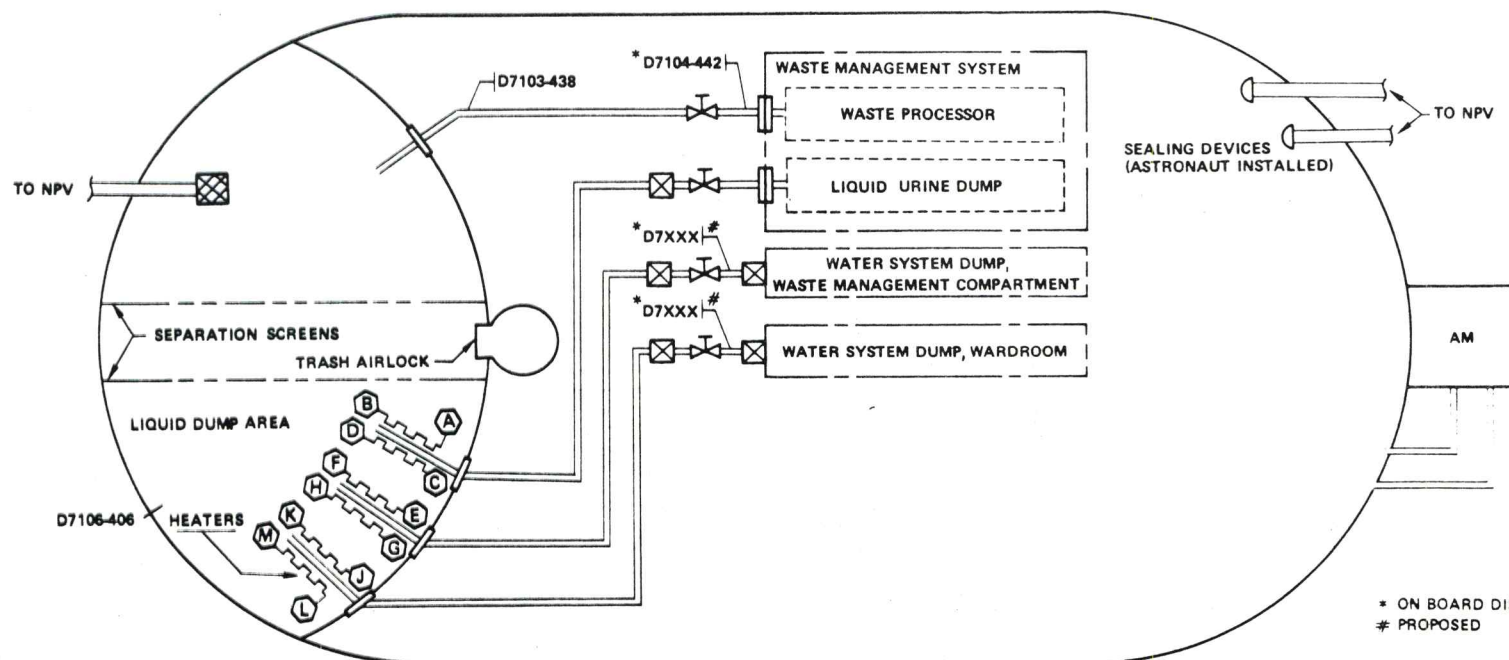
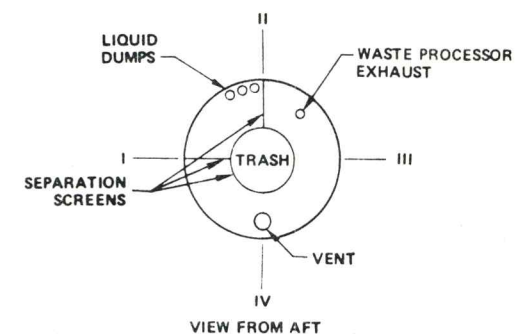
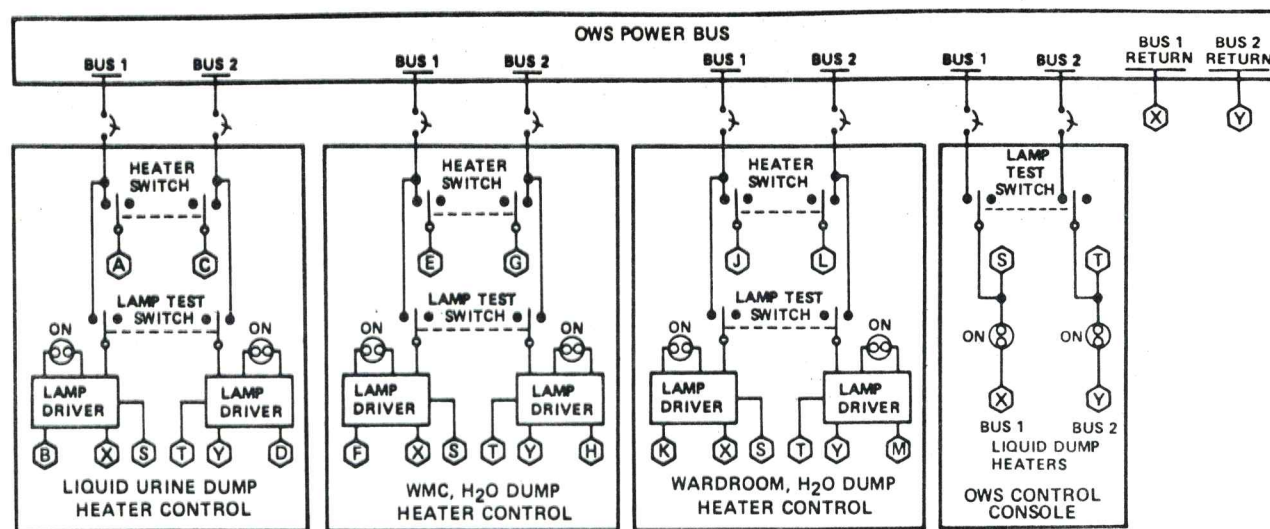
4.2.7.6.2 Liquid Urine Dump

The liquid urine dump is connected to the liquid dump compartment of the waste tank through a separable connector in the waste management compartment, a 1/2-inch shutoff valve (Figure 427-39) on the WMS panel, and a 1/4-inch stainless steel line to a separable connector beneath the compartment floor. A replaceable probe assembly (Figure 427-40) with separable connectors, Teflon hose, silver converging nozzle, and a dual element heater runs from the floor connector to a flange on the waste tank bulkhead. The heater elements on the probe assembly will keep the probe free of ice formation and resultant blockage. The probe heater is made of silver for good heat conduction. The converging nozzle will keep the pressure inside the dump line above the triple point of water during a dump. The entire probe assembly is designed to be removable for replacement in the event the heater elements fail or the probe assembly becomes plugged. The system will flow about 1 lb/min. of urine.

4.2.7.6.3 Water Dump Systems

The two water dump systems are used to evacuate the fresh water supply lines in the wardroom and the waste management compartment during flushing and filling operations, and to drain the lines prior to the orbital storage periods. The water supply lines are evacuated during storage (when the OWS thermal control system is inactive) so they will not be subjected to the high expansion stresses of freezing. The two water dump lines consist of the same basic components as the liquid urine dump line. The water dump lines are disconnected from the water supply lines during the mission except during the fill, flush, and drain operations at the beginning of SL-3 and SL-4 and at the end of SL-2 and SL-3; consequently, the probe heaters are used only during these operations.

O/W-8134
8-7-70



VACUUM SYSTEM SCHEMATIC
ORBITAL WORKSHOP

Figure 427-37.

8 JUNE 1970

4-368

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COMPANY

ORBITAL WORKSHOP VACUUM HAND VALVE (HALF-INCH)

O/W-6971
8-7-70

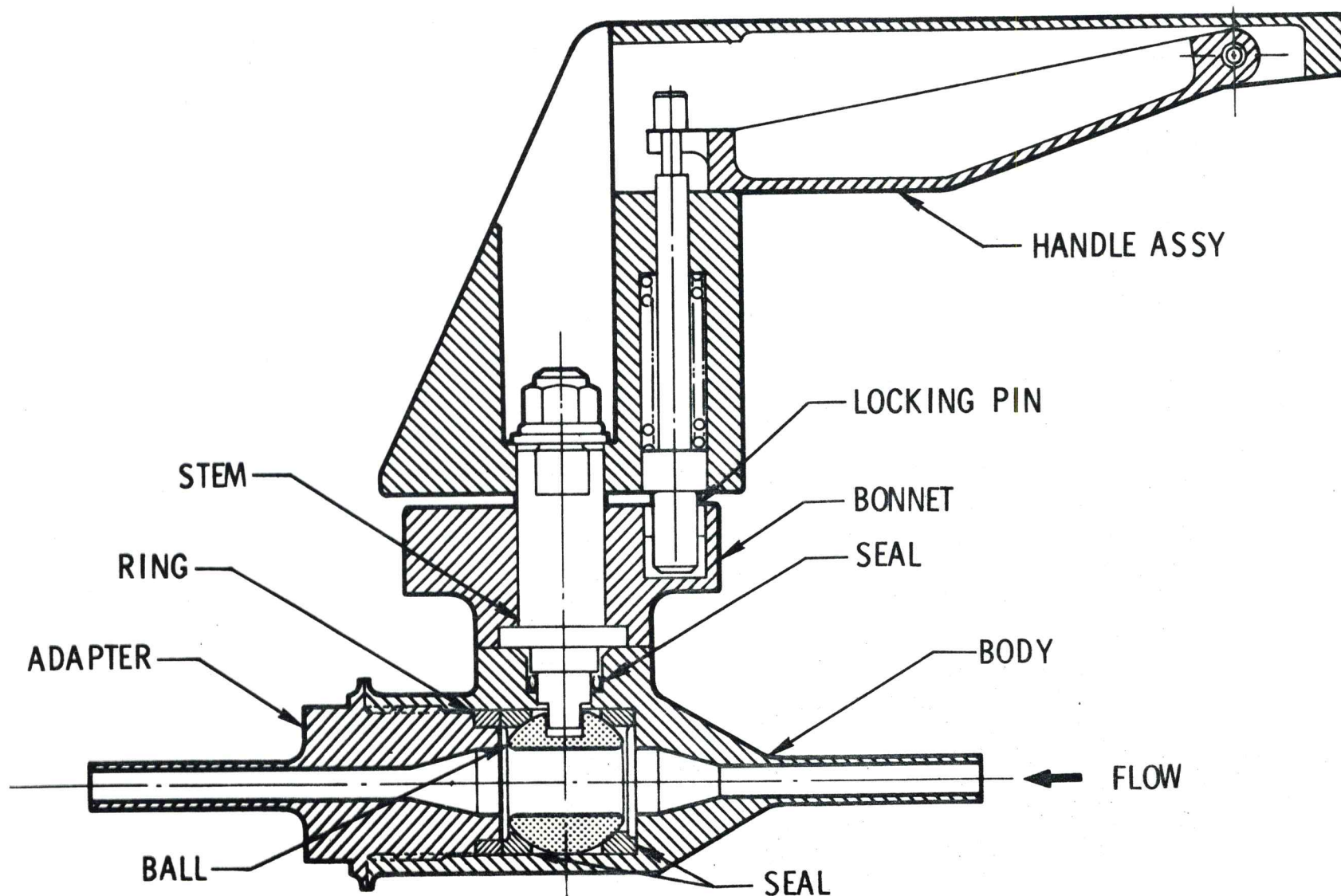
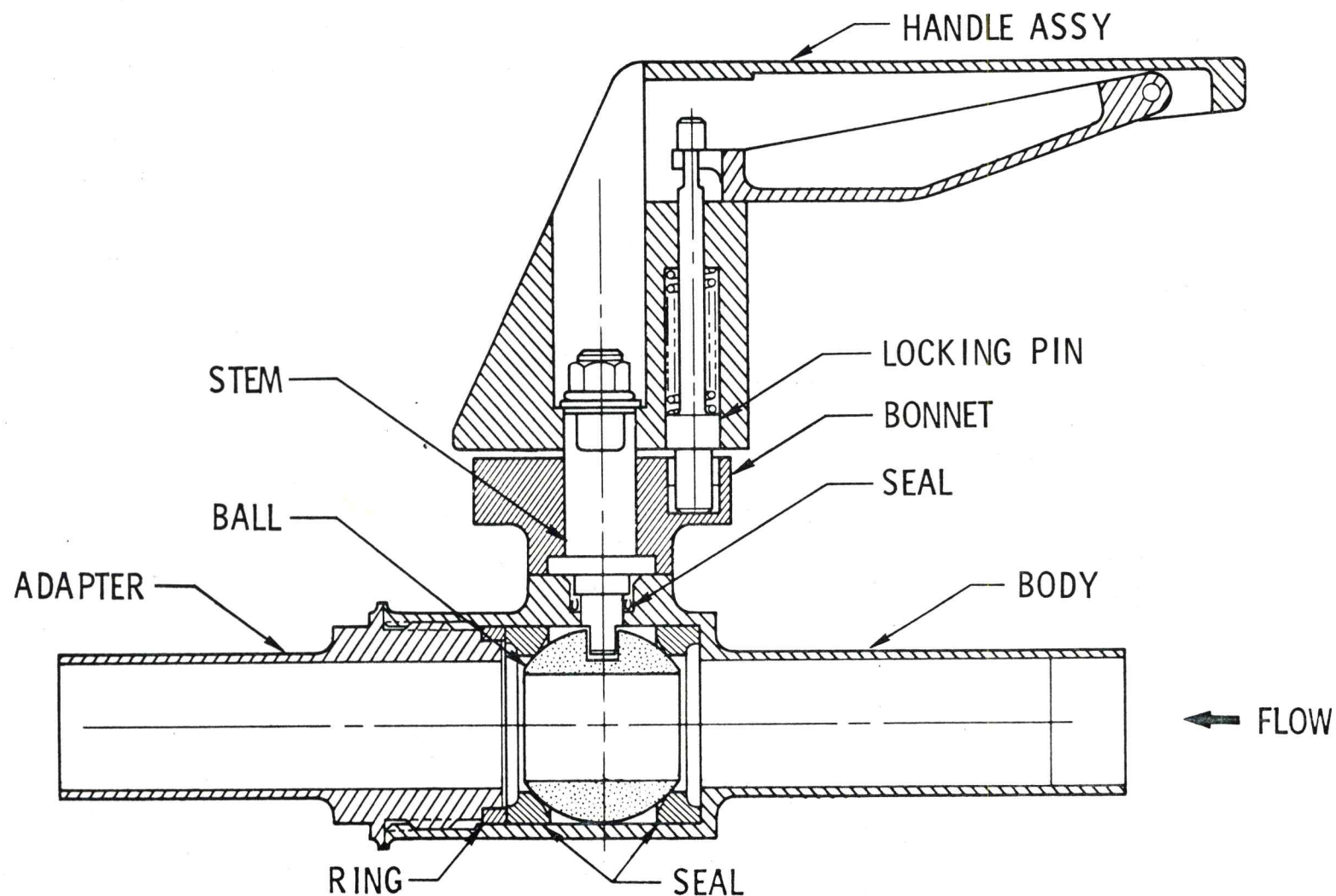


Figure 427-38.

MCDONNELL
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ORBITAL WORKSHOP VACUUM HAND VALVE (ONE INCH)

O/W-6620
8-7-70



4-370

Figure 427-39.

ORBITAL WORKSHOP DUMP PROBE ASSEMBLY

O/W-5044
6-16-70

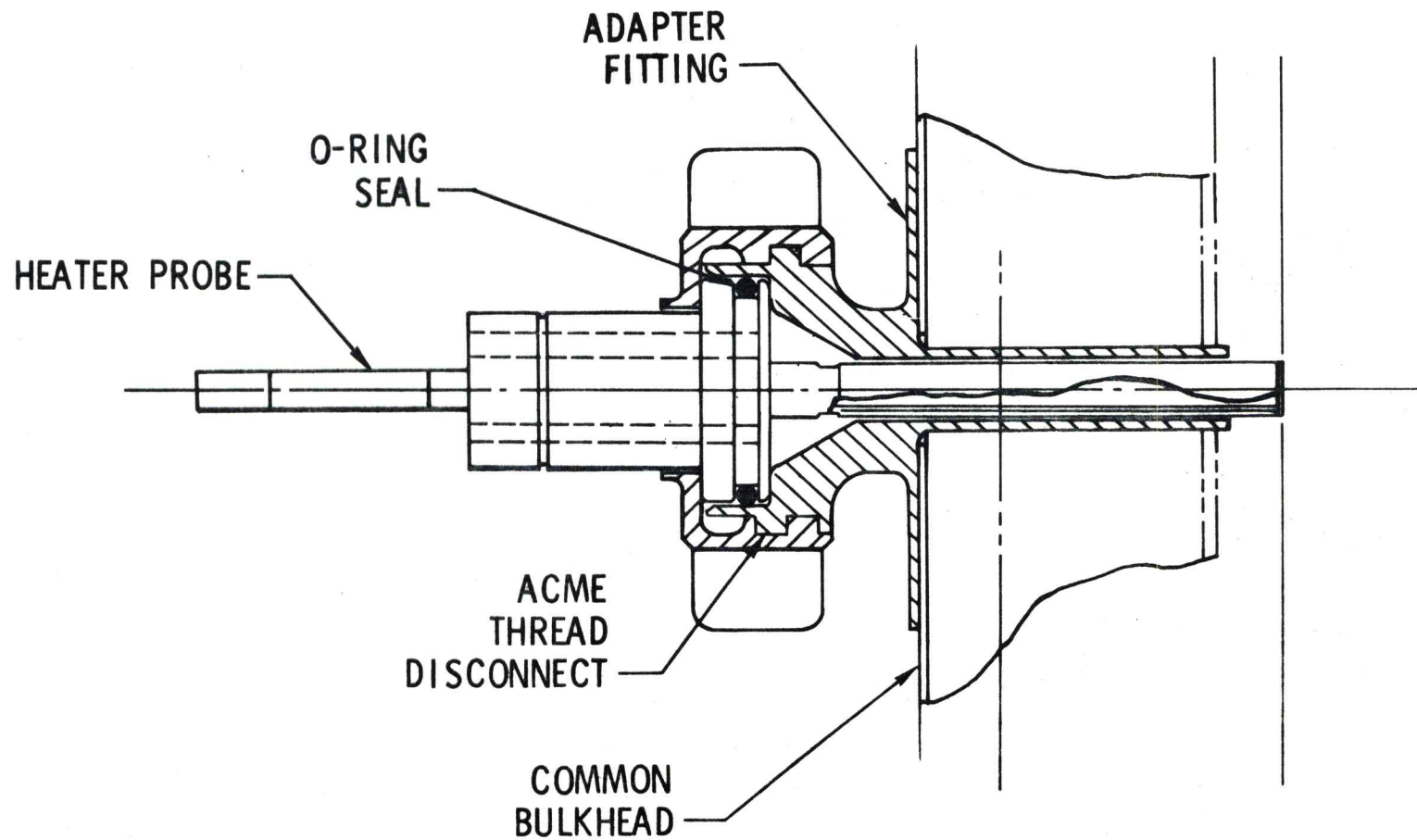
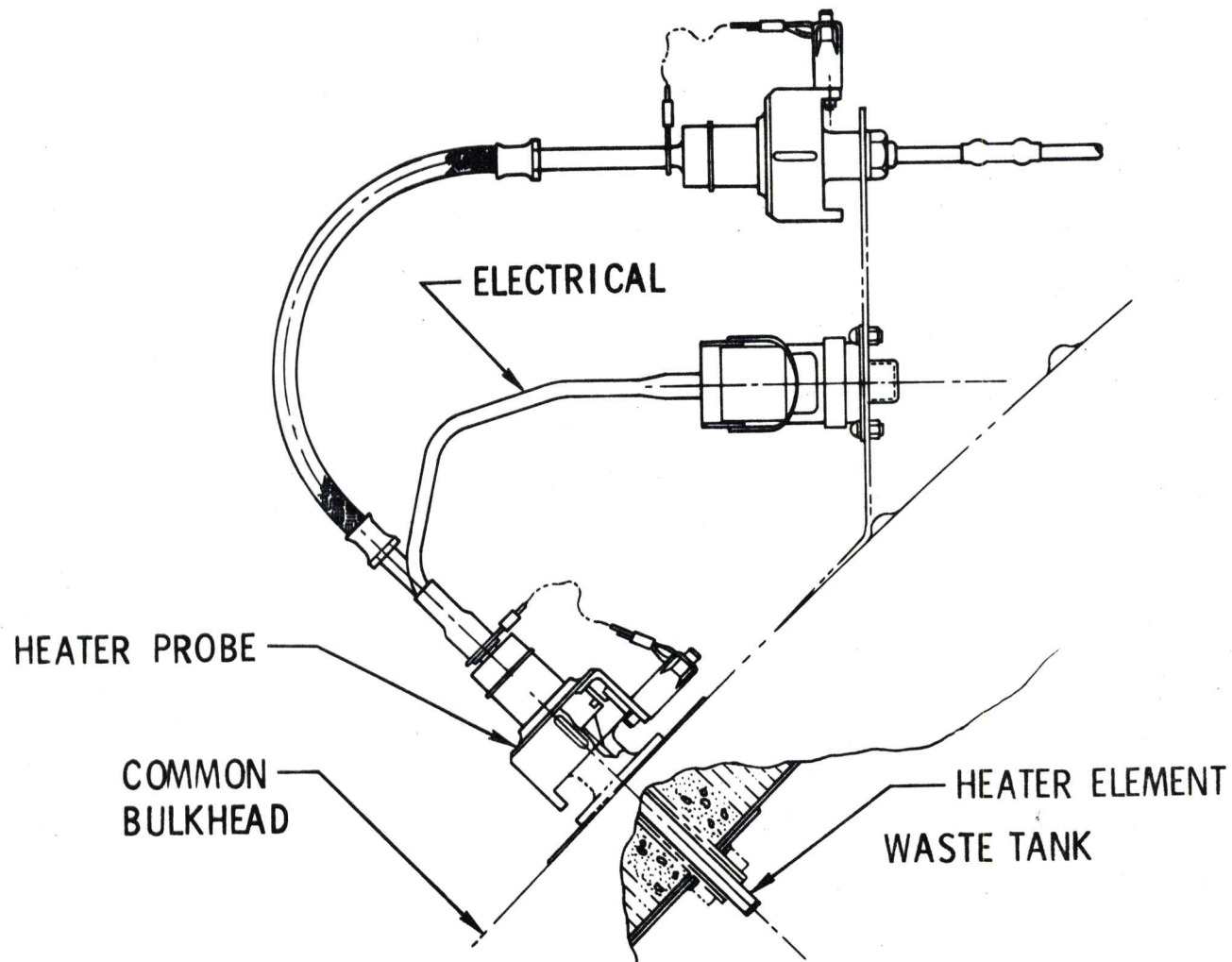


Figure 427-40. (Sheet 1 of 2)

ORBITAL WORKSHOP HEATER PROBE INSTALLATION

O/W-6974
8-7-70



4-372

Figure 427-40. (Sheet 2 of 2)

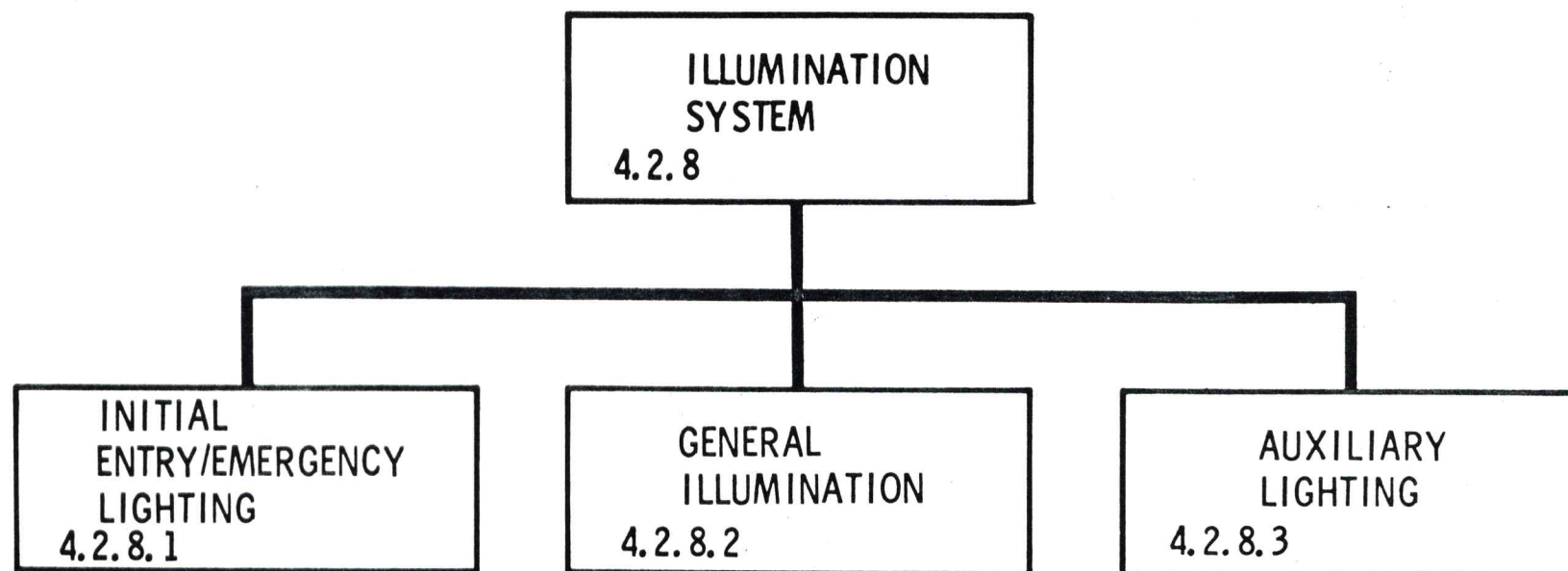
ILLUMINATION SYSTEM

ILLUMINATION SYSTEM

L.
4.2.8.

ORBITAL WORKSHOP

O/W-7493
8-6-70



4.2.8 Illumination System

The illumination system consists of the equipment and means to manually and/or automatically control interior lighting and illumination levels for initial entry and emergency conditions. Also, during habitation periods and special operations.

4.2.8.1 Initial Entry/Emergency Lighting

Initial entry and emergency lighting is provided by four general illumination dome and forward compartment lights and four general illumination crew quarters lights. Two located above the power distribution and control panel and two located at the primary exit in the experiment compartment. For both of these functions these lights are directly powered and controlled from the AM.

In the initial entry mode the system is designed to allow the crew to illuminate the OWS prior to opening the access hatch from the AM control panel.

In the emergency mode the system is designed to provide automatic illumination of the OWS in the event of a total OWS power system failure.

4.2.8.2 General Illumination

Lights are provided to illuminate the habitation area (forward compartment and crew quarters) (Figure 428-1). Refer to Drawing No. 1B76406 for exact locations and designations.

4.2.8.2.1 Forward Compartment

The Forward Compartment includes the volume between the forward dome and the crew quarters. Eight lights are located on the dome approximately 45 degrees apart near the handrails and 45 degrees up from the tangent point of the cylindrical section; and ten lights in the forward compartment approximately 36 degrees apart and located near the tangent point of the cylindrical section and the dome below the water bottles (Figure 428-2).

4.2.8.2.2 Crew Quarters

The crew quarters includes the waste management compartment, wardroom, sleep compartment, and experiment compartment. The lights are installed as follows: (1) four lights in the wardroom, (2) three lights in the waste management, (3) three lights in the crew sleep compartment, and (4) fourteen lights in the experiment compartment (Figure 428-3).

The light housings (Figure 428-4) are permanently installed and lights are designed for crew replacement with spare lamps. The lights can be controlled from either the light assembly or the control panel. In addition, provision for two airlock-controlled lights are installed above the power distribution console and two lights at the exit. These lights are included among the initial-entry lights used during initial operations entry and emergency lighting conditions. A switch is provided on each lamp assembly for OFF-LOW-HIGH control of each light, independently. The end of the preinstalled light housing assembly is indexed to the switch on the light bulb. The bulb has an attached pigtail with a zero-g connector which allows a one handed replacement operation. A hinged cover on the housing assembly protects the pigtail after installation and supports the lamp.

ORBITAL WORKSHOP LIGHTING LOCATIONS

O'W-433A
8-8-70

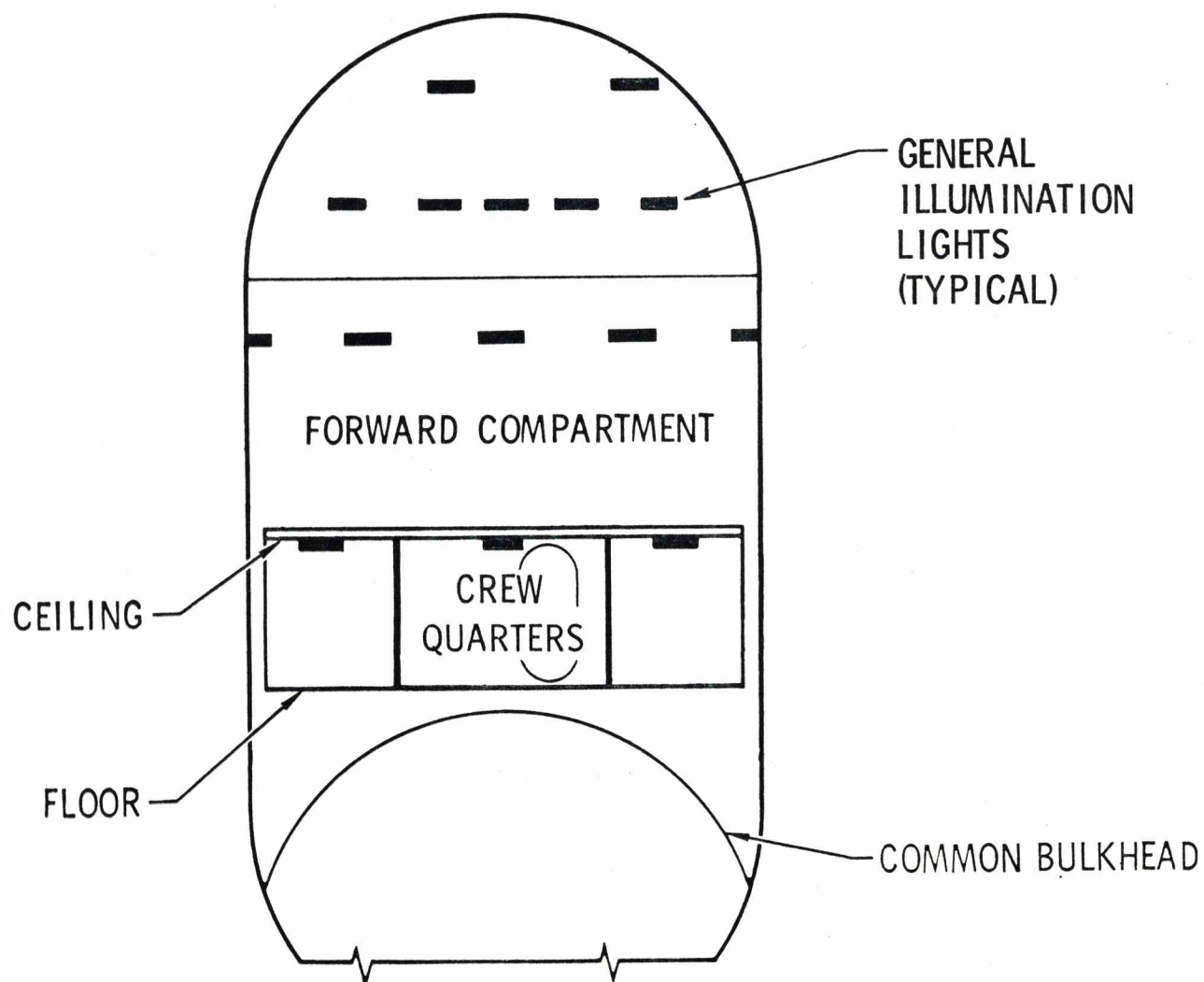


Figure 428-1.

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ORBITAL WORKSHOP FORWARD DOME

O/W-7833-1
8-4-70

4-376

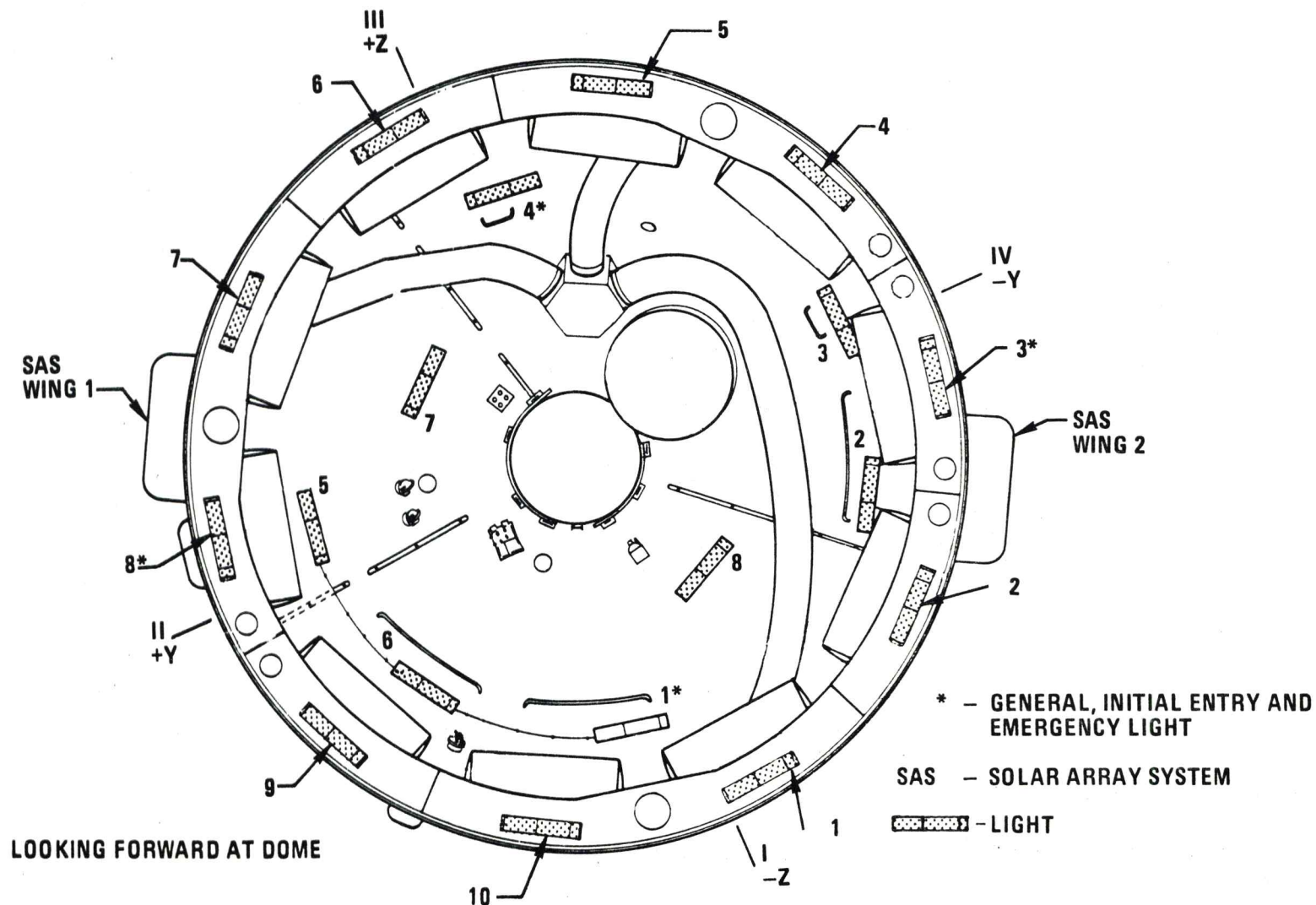
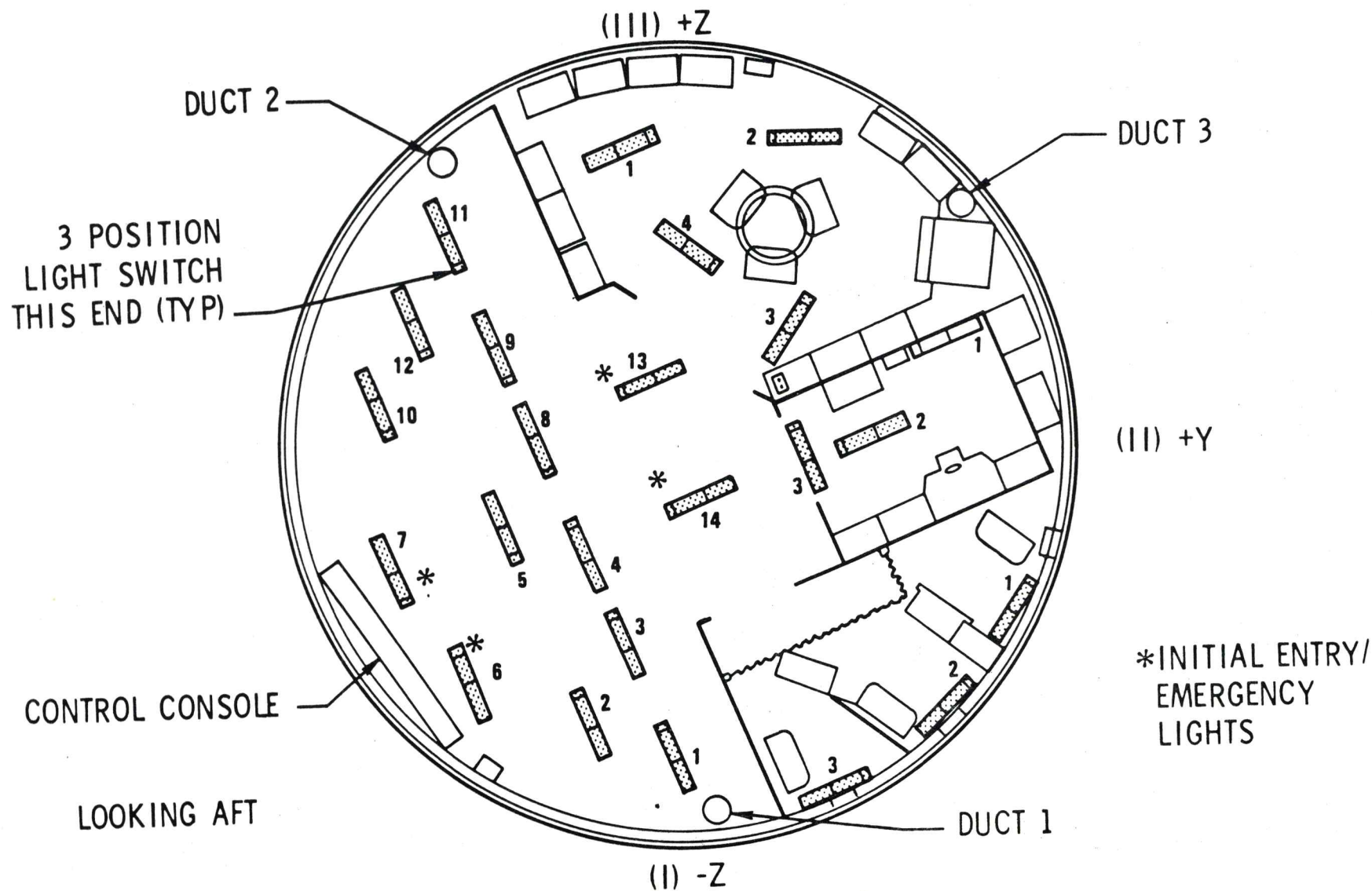


Figure 428-2.

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ORBITAL WORKSHOP CREW QUARTER SLIGHTING

O/W-3965B
8-4-70



4-377

Figure 428-3.

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ASTRONAUTICS
COMPANY

ORBITAL WORKSHOP GENERAL ILLUMINATION FLOODLIGHT

O/W-432-1
6-1-70

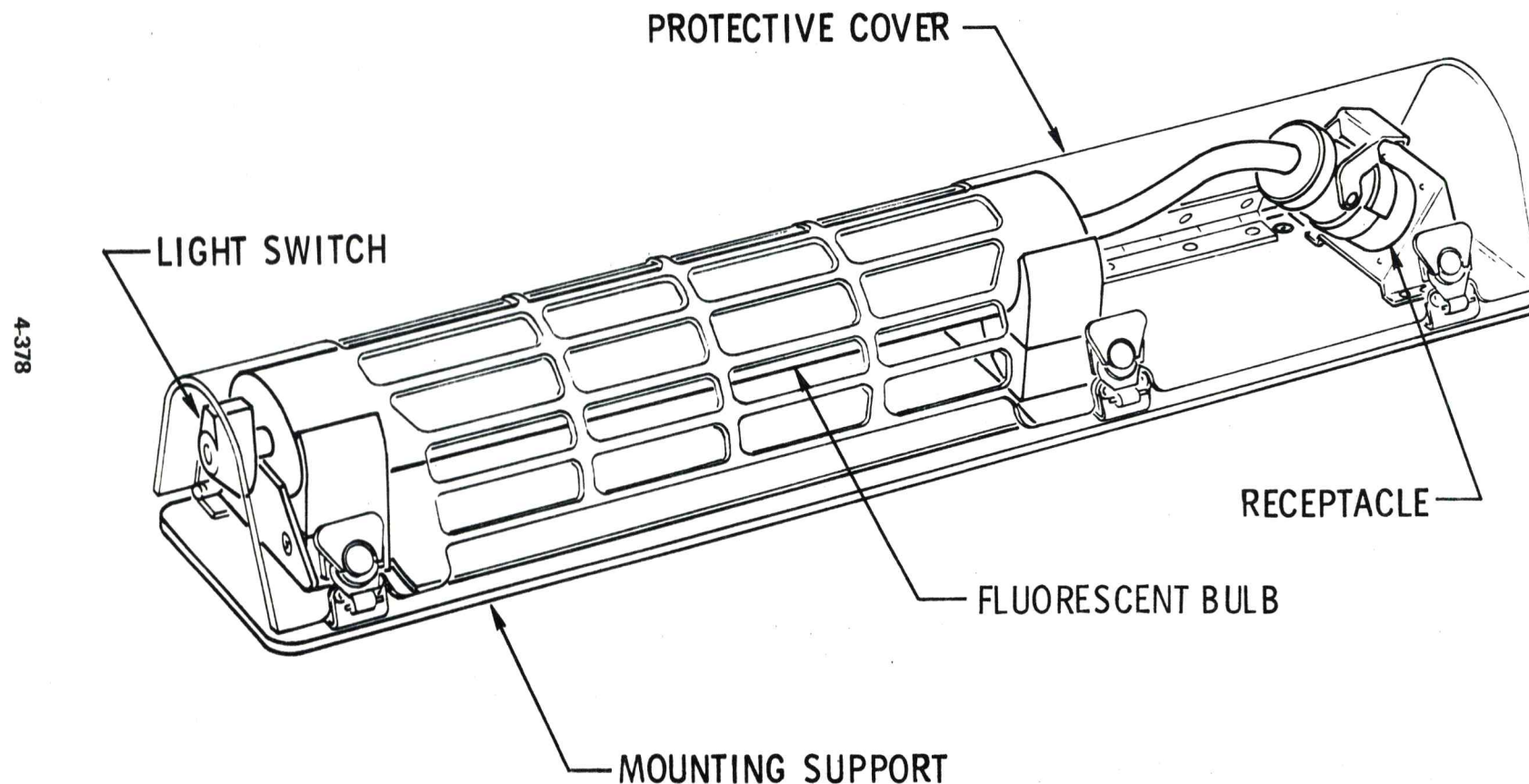


Figure 428-4. (Sheet 1 of 2)

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ASTRONAUTICS
COMPANY**

ORBITAL WORKSHOP GENERAL ILLUMINATION FLUORESCENT BULB

**O/W-3779
5-20-70**

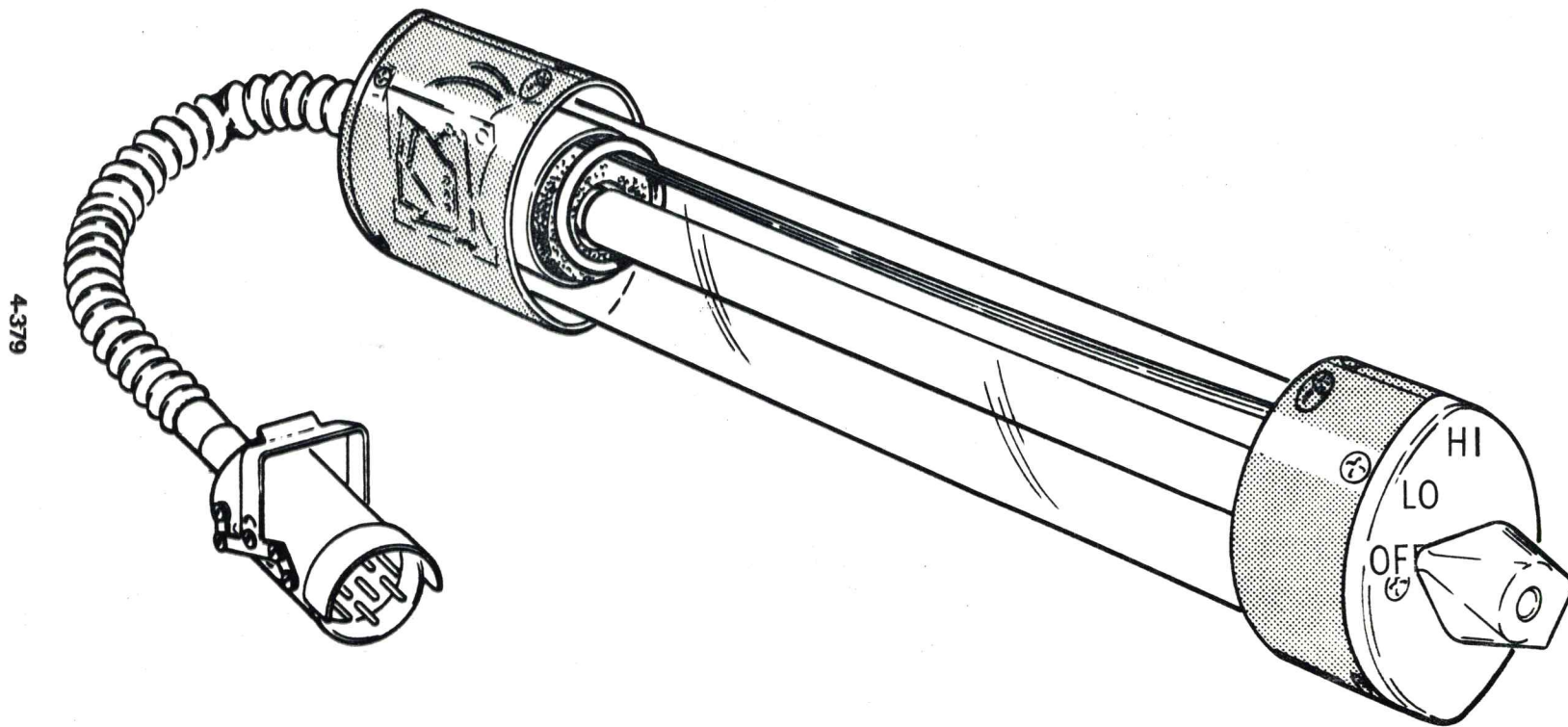


Figure 428-4. (Sheet 2 of 2)

The lights provide the following average illumination levels:

| <u>Area</u> | <u>Footcandles (Minimum)</u> |
|---------------------------------|----------------------------------|
| a. NASA Sleep Compartment | 4.5 |
| b. DOD Sleep Compartment | 5.0 |
| c. Food Management Compartment | 5.0 |
| d. Waste Management Compartment | 9.0 |
| e. Experiment Compartment | 5.5 |
| f. Forward Compartment | 1.0 |

The footcandles, specified for the forward compartment, are an average illumination level three feet from the light source. In the crew quarters, the footcandles are an average illumination level three feet from the ceiling, with the experiments installed in the operating mode.

Brightness ratios do not exceed:

- a. 10:1 Between task areas and remote surfaces.
- b. 20:1 Between light source and immediately adjacent surfaces.
- c. 3:1 Between task areas and immediate surroundings.

Electrical power for the OWS lighting system is controlled and distributed from the control console (Figure 428-5). The lights are divided into twelve main groups. Eleven of the groups are controlled from the console. The twelfth group is wired directly to, and controlled from, the AM.

Control is also provided at each light to allow switching the light to HIGH or LOW intensity or to OFF. The remote control switch on the control console must be in the ON position before the local control is effective.

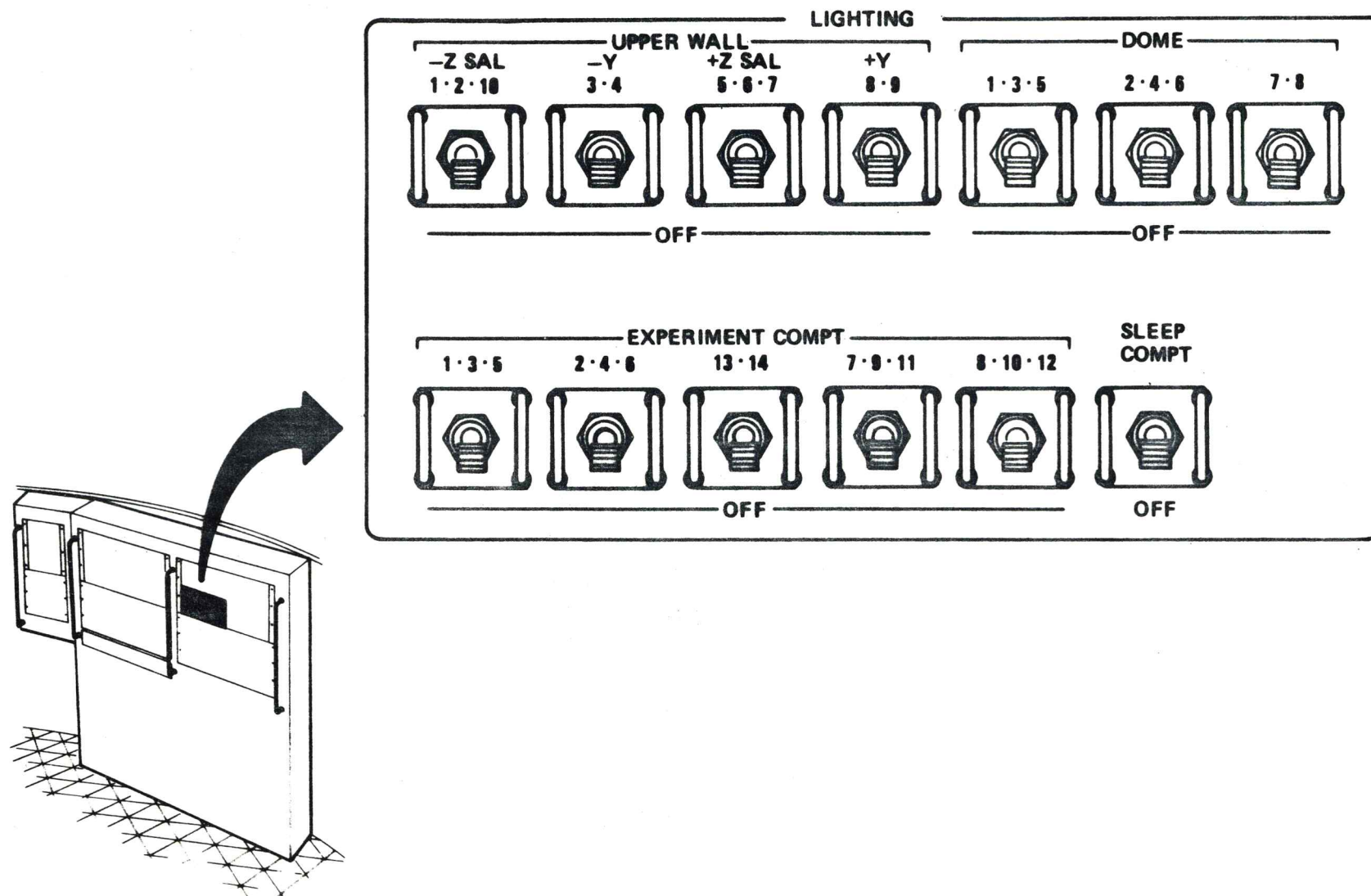
All light circuits are individually protected. Forty-two general illumination lights are provided with a total maximum power of 525 watts. All power-returns from the lights are bussed together and, in turn, bussed to the power-returns of the other electrical end items so that all power-returns to the OWS/AM interface are shared (Figure 428-6).

4.2.8.3 Auxiliary Lighting

Portable lights (Figure 428-7) are used to supplement the general illumination lights for reading, writing, and experimental tasks. These lights are capable of being connected to any OWS utility outlet.

ORBITAL WORKSHOP CONTROL AND DISPLAY PANEL NO. 1 LIGHTING

O/W-5292A
8-4-70



4-381

Figure 428-5. (Sheet 1 of 2)

ORBITAL WORKSHOP REMOTE ELECTRICAL CONTROL PANEL

O/W-7109
8-4-70

4-382

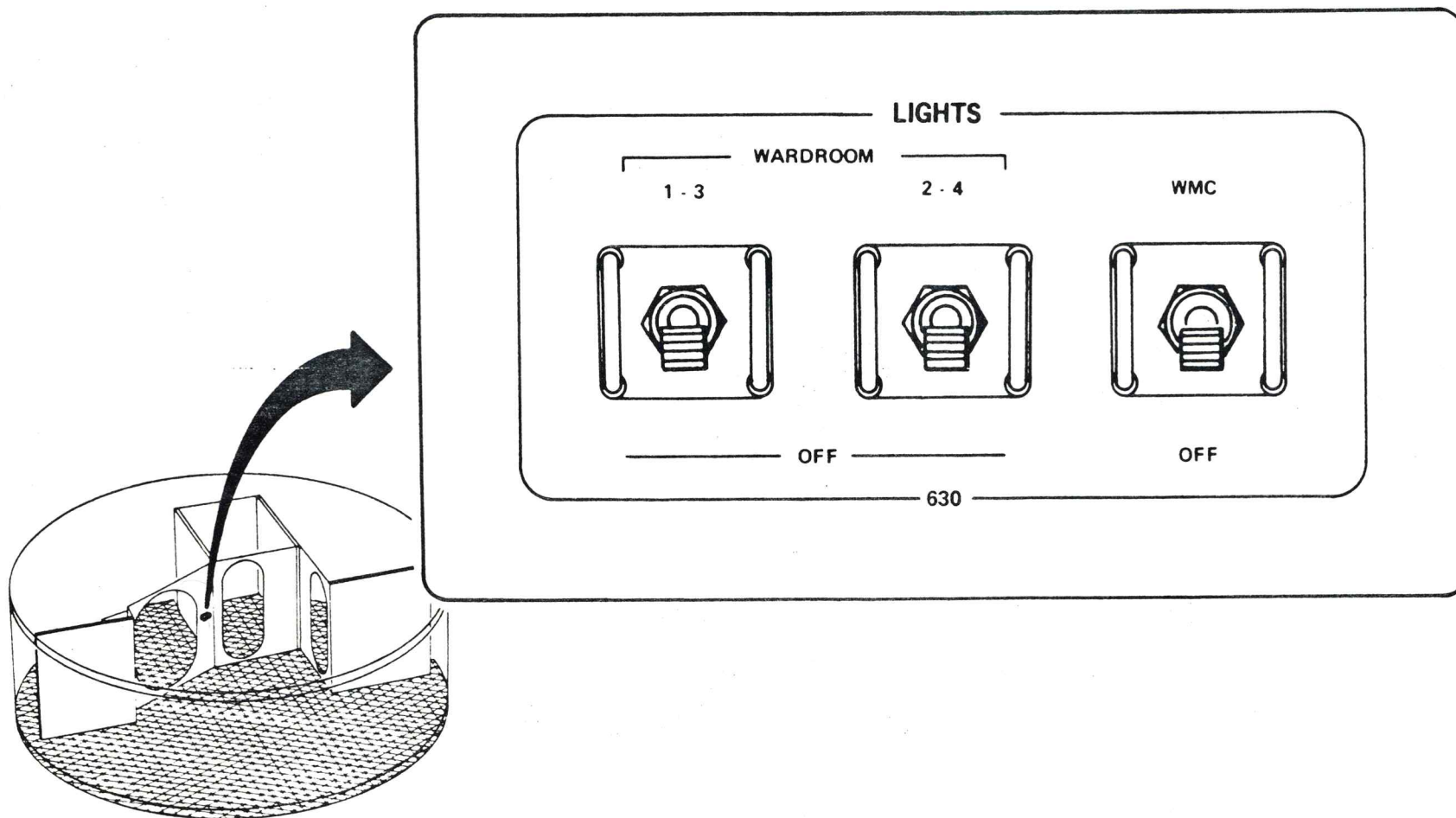
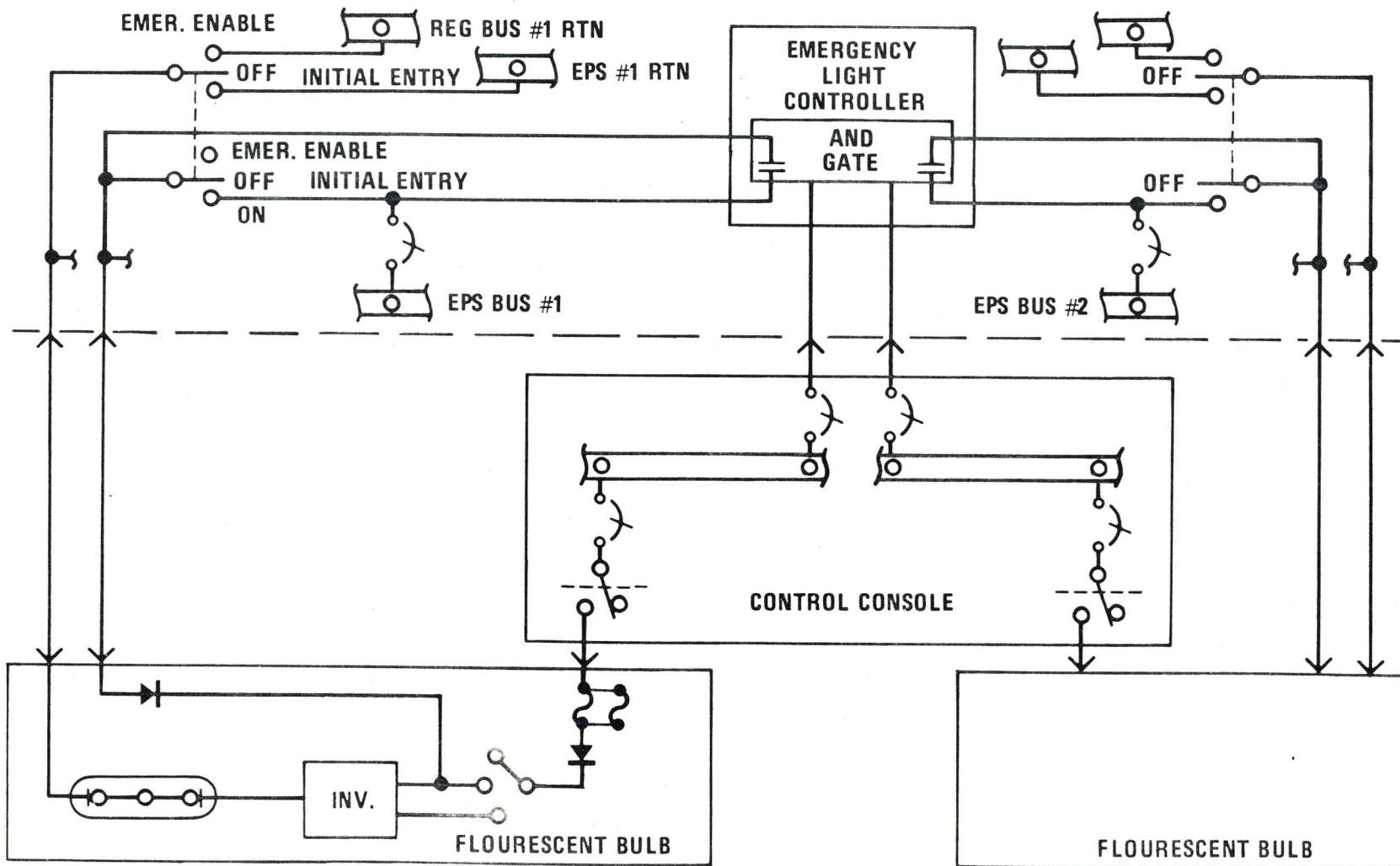


Figure 428-5. (Sheet 2 of 2)

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ORBITAL WORKSHOP ILLUMINATION SYSTEM SCHEMATIC

O/W-5430A-1
8-8-70

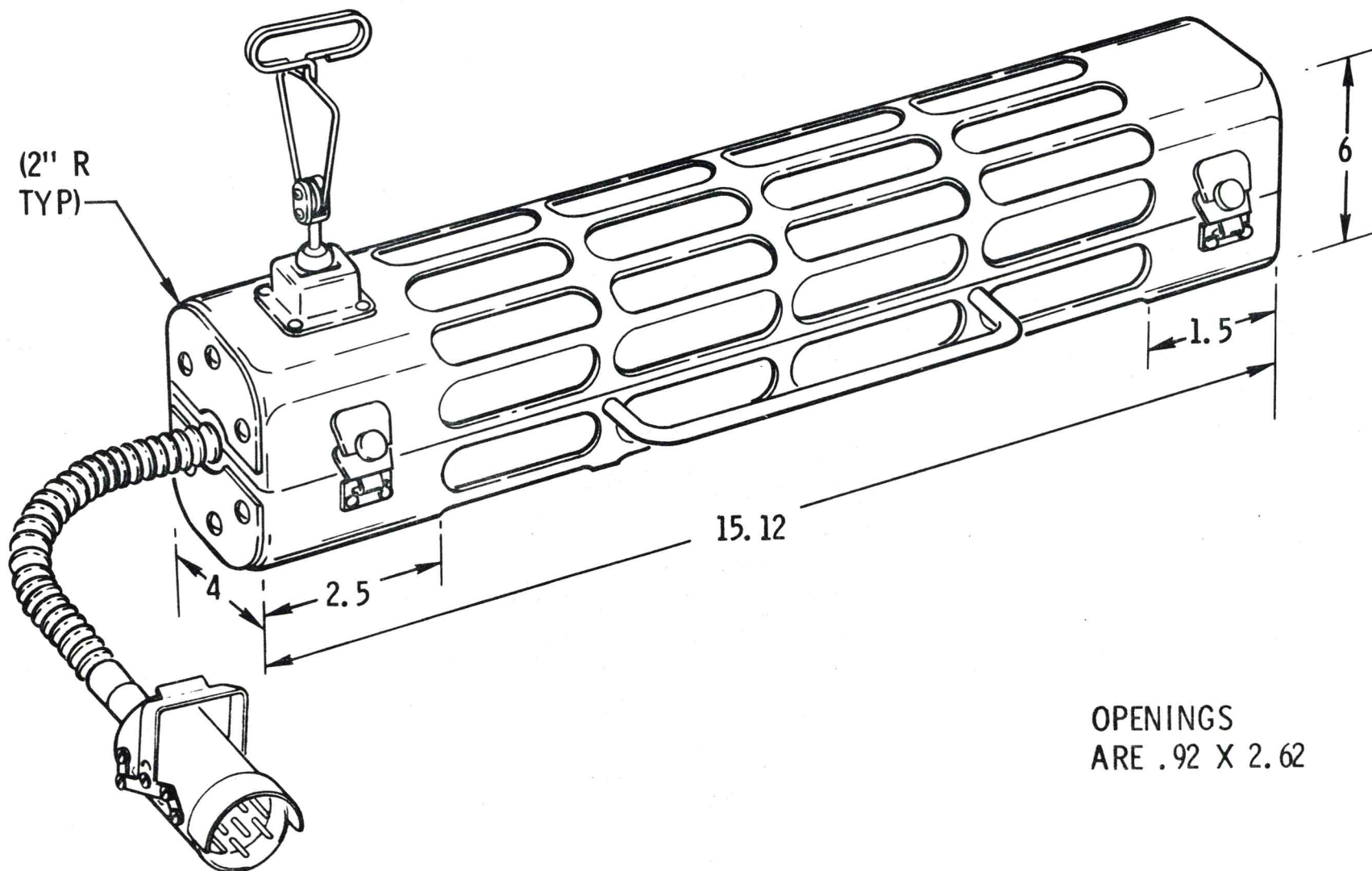


4-383

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ORBITAL WORKSHOP ILLUMINATION SYSTEM PORTABLE LIGHT

O/W-7643
8-6-70



OPENINGS
ARE .92 X 2.62

Figure 428-7.

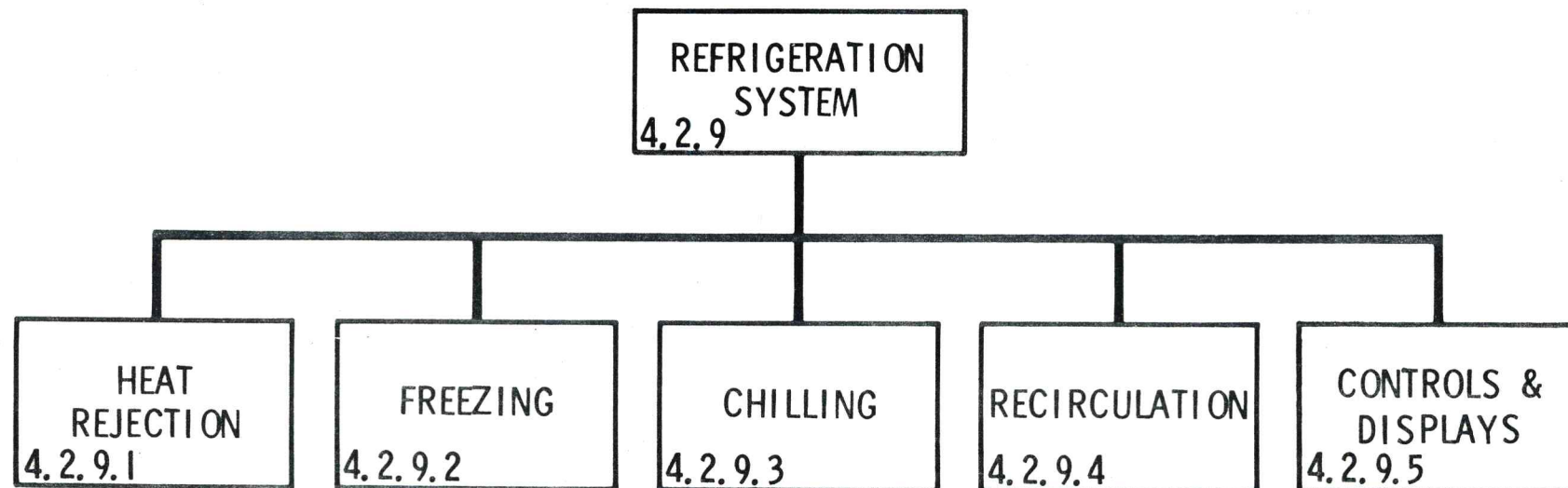
CONTROLS &
DISPLAYS
4.2.9.5

EQUIPMENT FOR THE HEAT
CONTROL FOR: 1) FREEZING URINE
NE, AND WATER.

REFRIGERATION SYSTEM

ORBITAL WORKSHOP REFRIGERATION SYSTEM

OW-7519A
7-31-70



DEFINITION:

THE REFRIGERATION SYSTEM PROVIDES THE EQUIPMENT FOR THE HEAT REMOVAL AND LOW TEMPERATURE CONTROL FOR: 1) FREEZING URINE AND FOOD, 2) CHILLING FOOD, URINE, AND WATER.

4.2.9 Refrigeration System

The Refrigeration System (RS) provides a closely controlled temperature environment for food refrigeration, potable water chilling, food freezing, and urine sample freezing in the OWS. The RS has the capability to supply coolant fluid temperatures for refrigeration and thermoconditioning in the range of -14°F to $+39^{\circ}\text{F}$. A schematic of the RS is shown in Figure 429-1.

Dual refrigerant circuits, operationally defined as the primary and secondary circuits, are employed in order to achieve a high order of reliability. The primary circuit functions operationally to meet the cooling requirements for the Skylab mission. The secondary system serves as a backup in the event of a primary circuit failure. Each coolant circuit contains four pumps; and each coolant circuit has sufficient pump life to last the entire mission plus a 30% design margin. The secondary circuit also contains four pumps.

4.2.9.1 Description and Operation of Basic Coolant Loop Heat Rejection

The Refrigeration System utilizes a single phase liquid refrigerant, Coolanol-15, which is circulated through the temperature controlled storage units absorbing heat. The absorbed heat is in turn delivered to one of the following:

- a. External Space Radiator.
- b. Thermal Capacitor.
- c. Ground Cooling Heat Exchanger.

for heat rejection.

Temperature control for refrigeration and thermoconditioning is maintained by utilizing a radiator control valve (controls to $-14 \pm 3^{\circ}\text{F}$), and a regenerative loop which limits the supply to the chillers to $36 \pm 3^{\circ}\text{F}$.

The radiator, an irregular octagon, is located on the aft thrust structure below the J-2 engine thrust casting (Figure 429-2).

The radiator peripheral dimensions are limited by the envelope defined by the separation clearance path between the S-II stage and the SWS. The separation clearance design criteria used include the assumption of one inoperative retrorocket coupled with the adverse condition of 2-sigma performance parameters related to the separation problem.

The envelope with the one retro-rocket inoperative condition and 2-sigma performance is shown in Figure 429-3. This envelope was used to size the radiator and determine its shape. As can be noted, maximum relative motion occurs in the plane of the retro-rockets, and minimum relative motion occurs in a plane 45 degrees from the motor. Determination of shape of the clearance envelope at the station of the radiator allowed maximizing the effective radiator area.

ORBITAL WORKSHOP REFRIGERATION SUBSYSTEM SCHEMATIC

O/W-7520
8-8-70

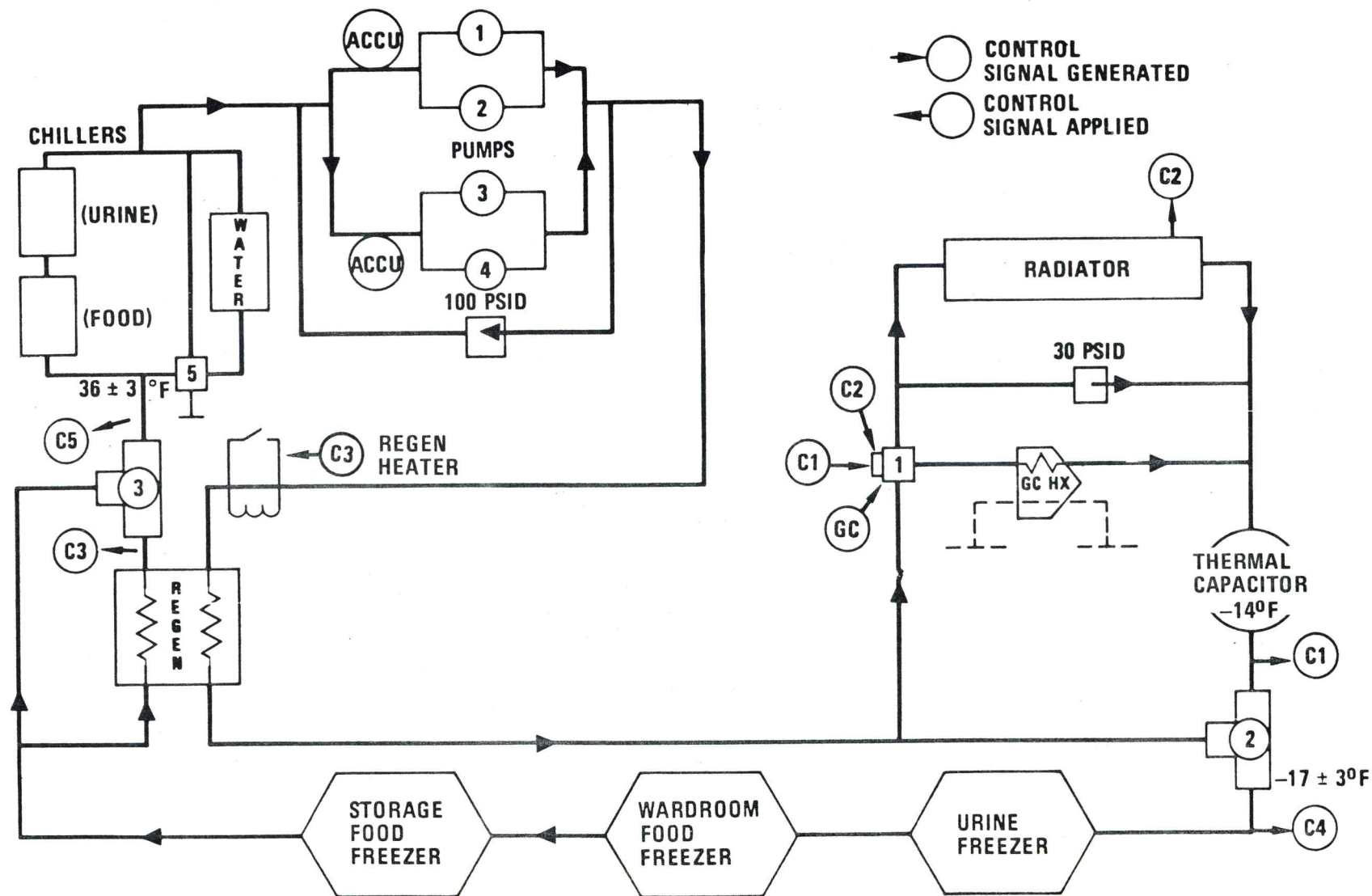


Figure 429-1.

**MCDONNELL
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ORBITAL WORKSHOP REFRIGERATION SYSTEM RADIATOR

**O/W-3787
7-9-70**

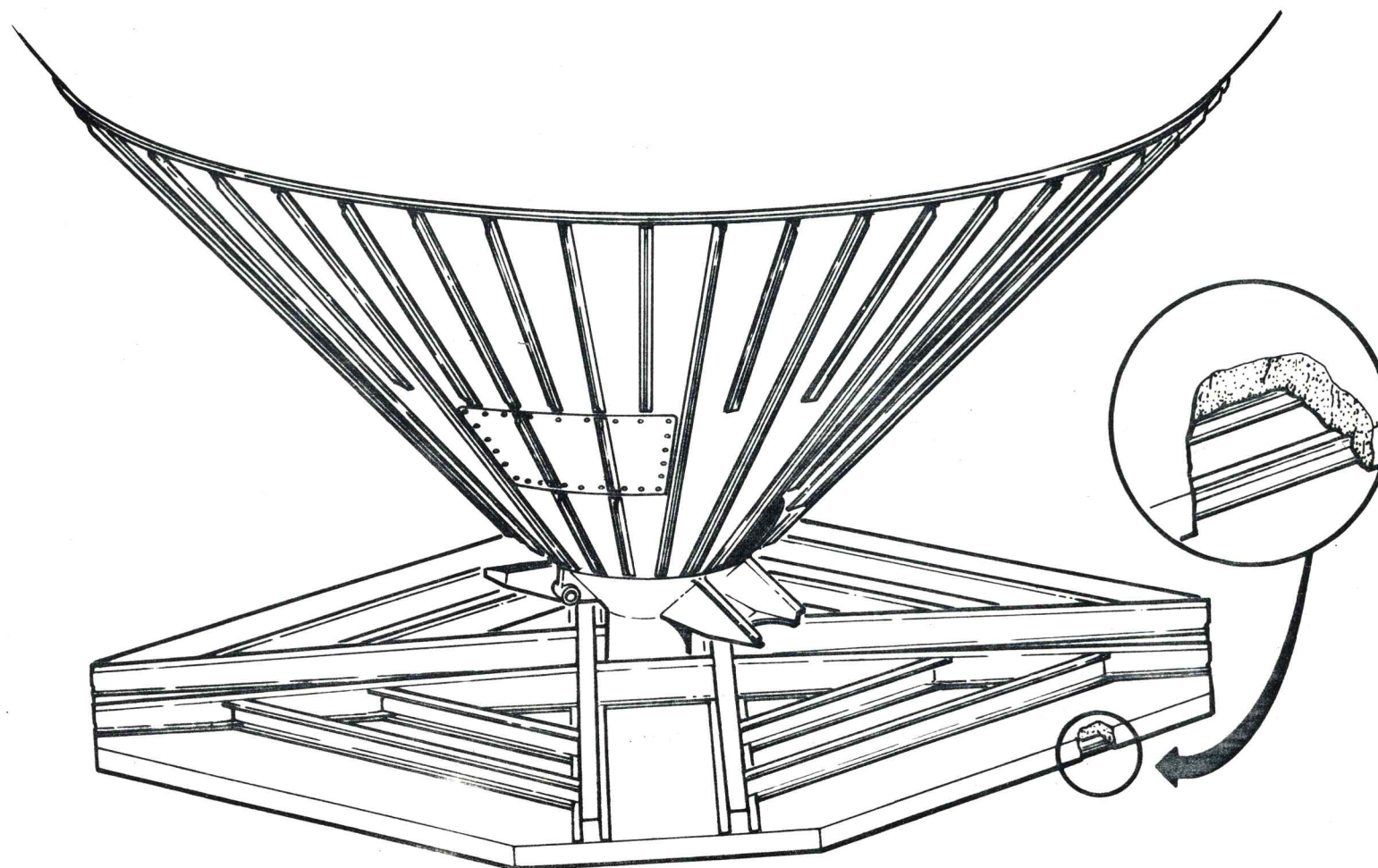


Figure 429-2.

ORBITAL WORKSHOP SEPARATION CLEARANCE ENVELOPE NEAR RADIATOR POSITION

O/W-8798
8-7-70

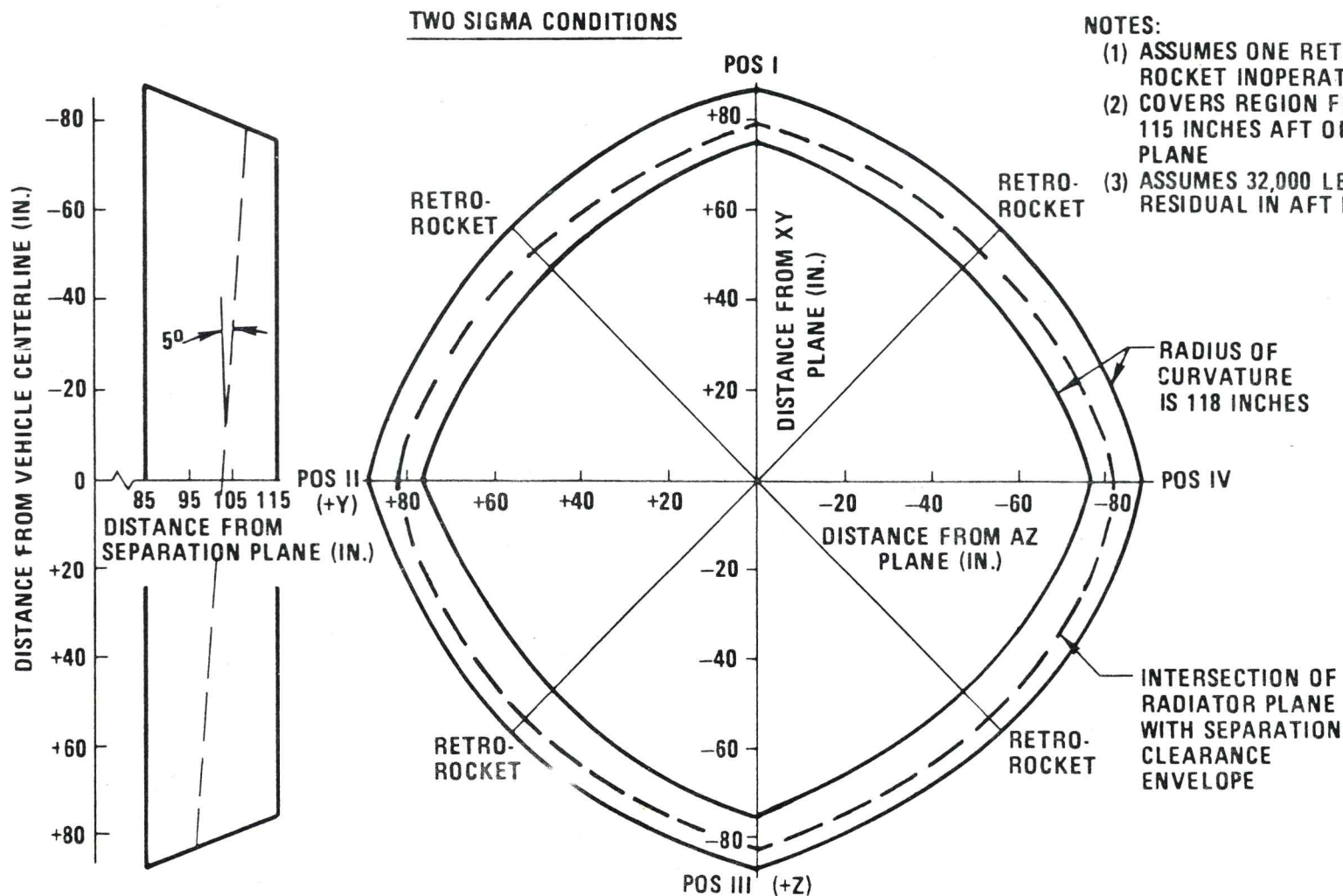


Figure 429-3.

Approximately 84 ft² of area is available for heat rejection. Fluid is circulated through "T bulb" extrusions with a 0.193 inch I.D. The extrusions are stitch welded to the 0.025 inch thick aluminum radiator surface. SL3G thermal control coating is used to provide an efficient radiation conductance.

The radiator is redundantly plumbed (i.e., each fluid circuit traces a separate path across the effective radiator area). The active face of the radiator points aft and is tilted five degrees aft of fin plane I to prevent direct solar energy impingement for five degree misalignment of the Orbiting Assembly in the + ZLV X - IOP orbit attitude.

The back face (or inactive radiator face) is insulated from the OWS thrust structure by utilizing series resistance barriers of polyurethane foam and High Performance Insulation to minimize heat leak from the OWS.

The active surface of the radiator is protected from retrorocket plume impingement by providing a removeable protective cover that is removed after S-II/OWS interstage separation.

4.2.9.1.2 Thermal Capacitor

A thermal capacitor, which consists of a phase change heat sink (UNDECANE, C₁₁H₂₄), is used to absorb RS heat during periods the space radiator cannot be used for heat rejection. This condition occurs initially during ascent and subsequently for a portion of each orbit when heat influx due to solar effects is maximum. During the periods of high radiator surface temperature, refrigerant flow to the radiator is shut off by valve No. 1, and the main coolant flow is directed through the thermal capacitor. The heat transfer from the refrigerant to the phase changing wax compound occurs at essentially constant temperature (-14°F).

When the radiator surface temperature drops below the control setting, flow through the radiator resumes as directed by valve No. 1. The cold fluid from the radiator outlet passes through the thermal capacitor which regenerates the phase change media in preparation for the next warm cycle. During this period a constant temperature of -14°F. (phase change temperature of UNDECANE) is maintained at the heat sink discharge.

When all of the stored heat has been absorbed from the thermal capacitor, the exit temperature of the refrigerant from the thermal capacitor will drop below the phase change temperature of -14°F. Valve No. 2 will respond to the lower inlet temperature by mixing warmer fluid from the hot side of the regenerator to achieve the desired control outlet temperature of -17 ± 3°F.

During orbit storage the refrigeration system heat loads drop to a point where the radiator is no longer needed for heat rejection.

This point is indicated when the fluid outlet temperature of the thermal capacitor has dropped below -35°F. At this temperature, the radiator is bypassed by valve No. 1 and flow is resumed when the thermal capacitor coolant outlet temperature is greater than -20°F.

4.2.9.1.3 Ground Cooling Heat Exchanger

Ground cooling heat exchangers are provided for cooling of the RS on the ground from the time the system is first operable (before food loading) until launch. The heat exchanger is of CRES plate fin construction. Two identical heat exchangers are plumbed in series on the vehicle side and in parallel on the GSE side in order to provide the required cooling capacity. The heat exchangers are plumbed redundantly on the vehicle side (enabling either primary or secondary loops to operate) and plumbed to the single ground side loop.

Temperature control is maintained during the ground hold situation, until launch, by a ground conditioning unit which circulates liquid coolant (water glycol) through ground cooling heat exchangers in the flight system. At liftoff the GSE coolant is disconnected and the ground side coolant lines are purged with N₂ gas.

4.2.9.2 Freezing

The -17°F coolant controlled by valve No. 2 services the urine freezer (Figure 429-4), wardroom food freezer (Figure 429-5), food freezer and the food storage freezer. All freezer boxes are basically the same in thermodynamic construction. Each freezer incorporates the following features:

- a. A high thermal conductivity (aluminum) internal liner wrapped with coolant tubes is used to absorb external heat flux and maintain a uniform internal box wall temperature.
- b. Polyurethane foam insulation is used to limit the environmental heat flux, form a moisture barrier between Workshop moist gas and cold internal walls, and provide structural integrity for the box by transferring internal loads to the external box skin.
- c. Aluminum external shells with a high emissivity coating are used to encase the foam and provide uniform exterior box temperatures above the dewpoint (55°F). On the food boxes an aluminum inner door is provided to maintain uniform internal box temperatures.
- d. Insulated doors are provided with a gasket to minimize moisture migration and; hence, condensation on the cold internal parts of the freezer.

4.2.9.3 Chilling

Chilling (temperatures > 33°F) is provided by the RS regeneration loop to the water and urine chillers. The main regeneration loop components are:

- a. Thermal Control Valve (36 ± 3°F).
- b. 3 Regenerative Heat Exchangers plumbed in series.
- c. A 100 watt Regenerative Heater.

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ORBITAL WORKSHOP URINE FREEZER

O/W-7548
5-28-70

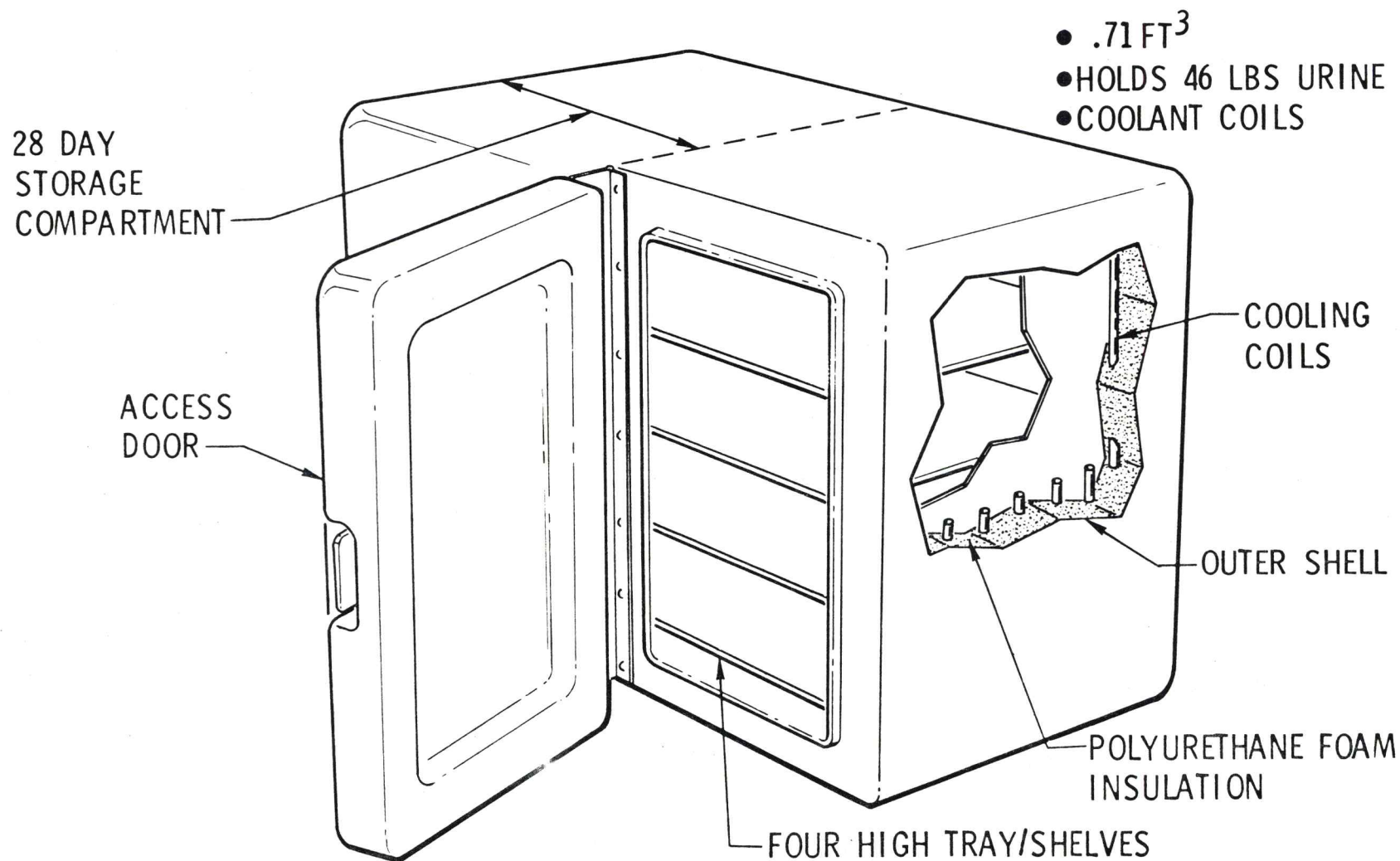


Figure 429-4.

MCDONNELL
DOUGLAS
ASTRONAUTICS
COMPANY

ORBITAL WORKSHOP WARDROOM FREEZER PERISHABLE FOOD COMPARTMENT

O/W-7522
5-18-70

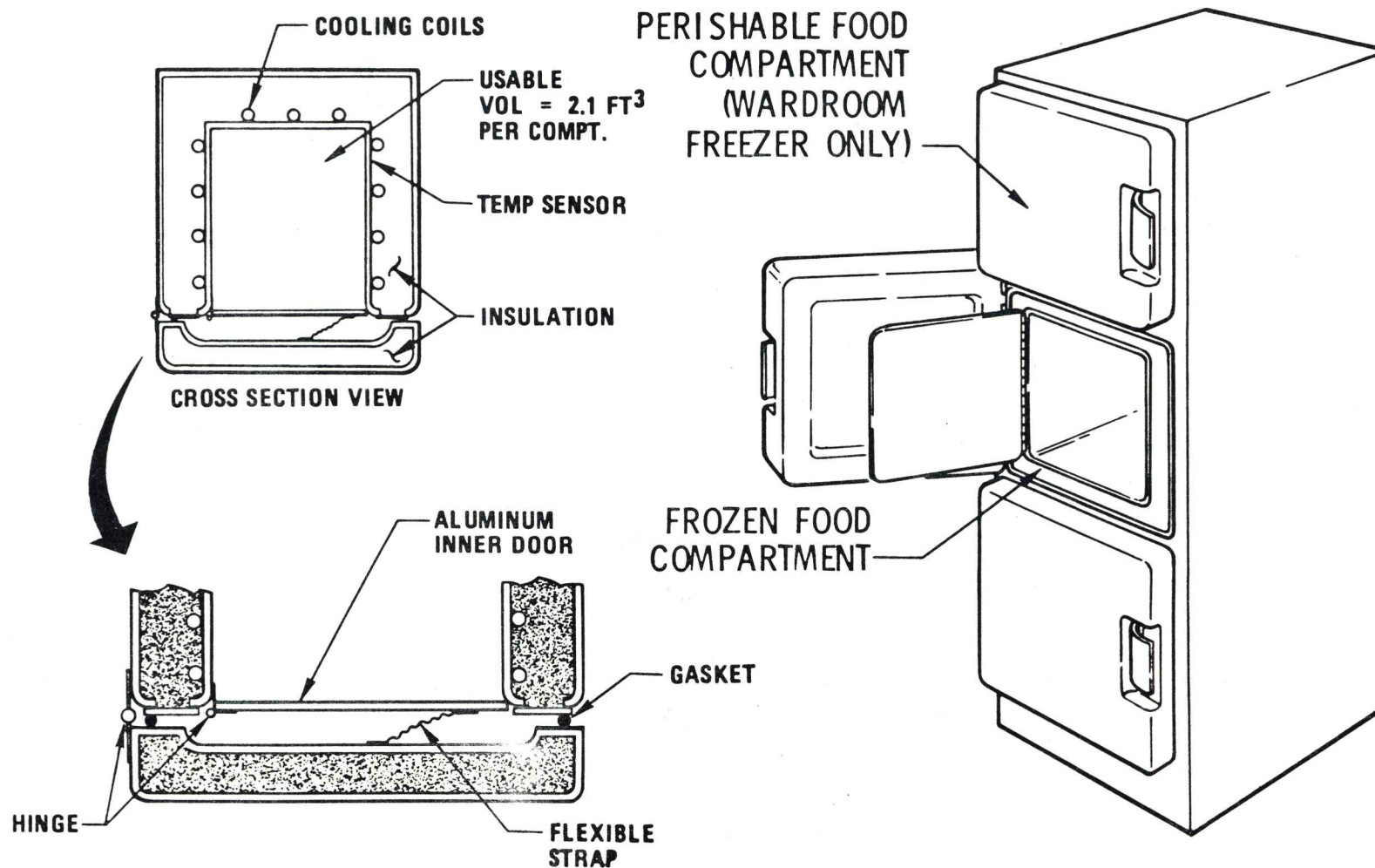


Figure 429-5.

The coolant discharge temperature of the freezer loop will be below 33°F. Fluid temperature into the chillers is attained by proportioned flow mixing of the regenerator and bypass flow by valve No. 3. The 100 watt heater is activated when energy addition to the chiller loop is not sufficient to maintain regeneration. On leaving the chillers, the coolant passes through the pumps, the pump box, the regenerative heater then through the hot side of the regenerative heat exchangers and finally to either the radiator, heat sink, or ground heat exchanger for heat removal.

A manual bypass valve, valve No. 5, can be used to isolate the water chiller from the coolant loop.

The food storage temperature requirements for the dry and moist food modules is 40° to 85°F. The addition of ground cooling (PDR on 6-26-70) which maintains 40° to 85°F prior to launch, and the operation of the radiant heaters during orbital storage, ensure that the food storage temperature limitations are not exceeded.

4.2.9.4 Recirculation

Four positive displacement gear pumps are used in each circuit. The pumps maintain coolant flow at 125 ± 11 lb/hr during all mission operations. The pumps are manually sequenced off before the manufacturer guaranteed life of 2,200 hours is exceeded.

The pumping and chiller thermal control (t/c) assemblies contain approximately 80 percent of the potential leak paths (b-nuts and O rings) for the coolanol 15 coolant within the OWS. To minimize the possibility of coolant leakage within the OWS, the pumping and chiller t/c assemblies are combined within a pressure tight container and vented overboard (to vacuum) via the waste tank. A hand shut-off valve is located in the vent line to permit on-orbit access to these assemblies (Figure 429-6).

The pumps are automatically turned off at launch to prevent exceeding the working pressure of the heat sink and are turned on again by IU command at 30 seconds after S-II outboard engine cutoff (Figure 429-7).

4.2.9.5 Controls and Displays

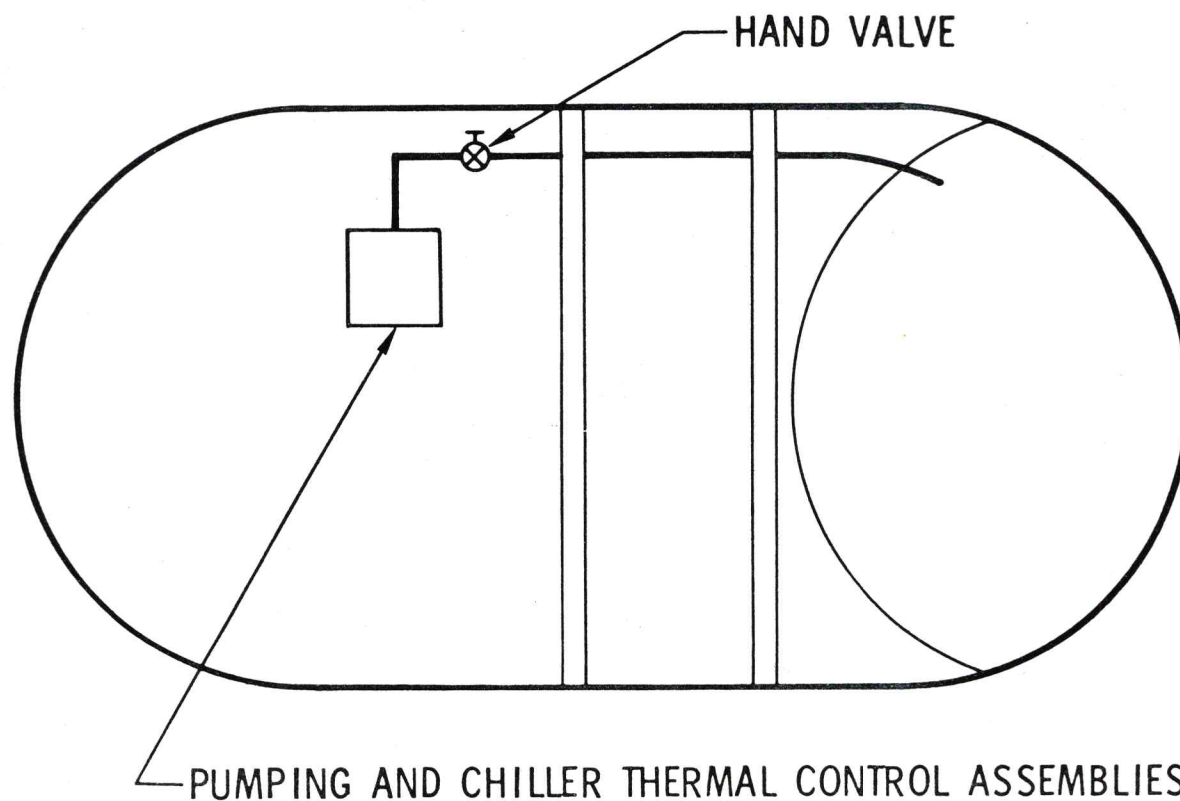
The RS is provided with the following major electrical components to control, monitor, and display its operation.

- a. Coolant Pump Inverters (two required).
- b. Control Logic Unit (two required).
- c. Radiator Bypass Valve Controller (two required).
- d. Regenerator Heater Controller (two required).
- e. Display and Control Panel (Part of Power Console).
- f. Instrumentation.
- g. Control Sensors.

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ORBITAL WORKSHOP REFRIGERATION SYSTEM

O/W-8803
8-4-70



METHOD FOR VENTING PUMPING AND CHILLER THERMAL
CONTROL ASSEMBLIES OVERBOARD (TO VACUUM)

4-395

Figure 429-6.

ORBITAL WORKSHOP RS COMMAND TIME LINE

O/W-7526
8-8-70

4-396

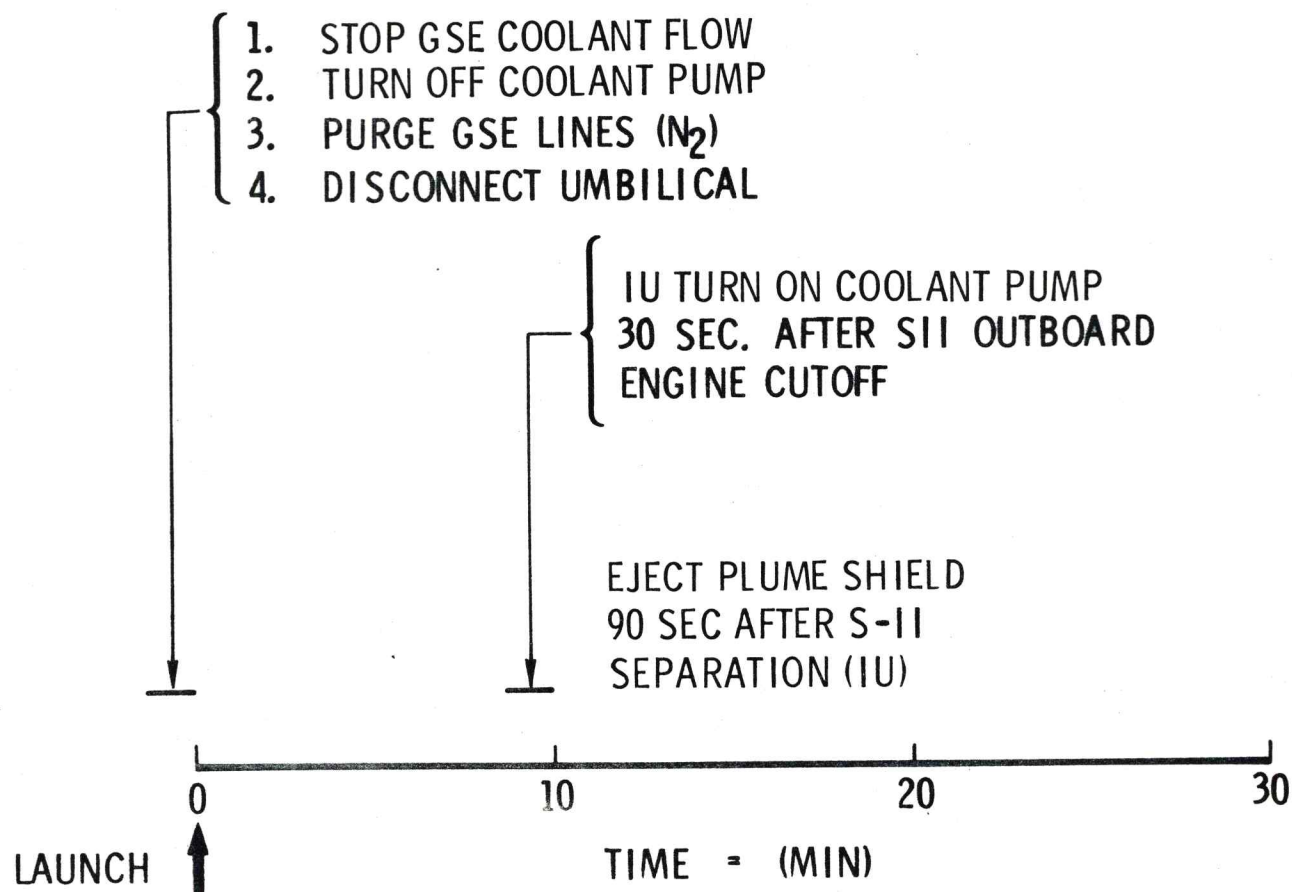


Figure 429-7. (Sheet 1 of 2)

ORBITAL WORKSHOP PUMP SEQUENCE

O/W-7525
6-30-70

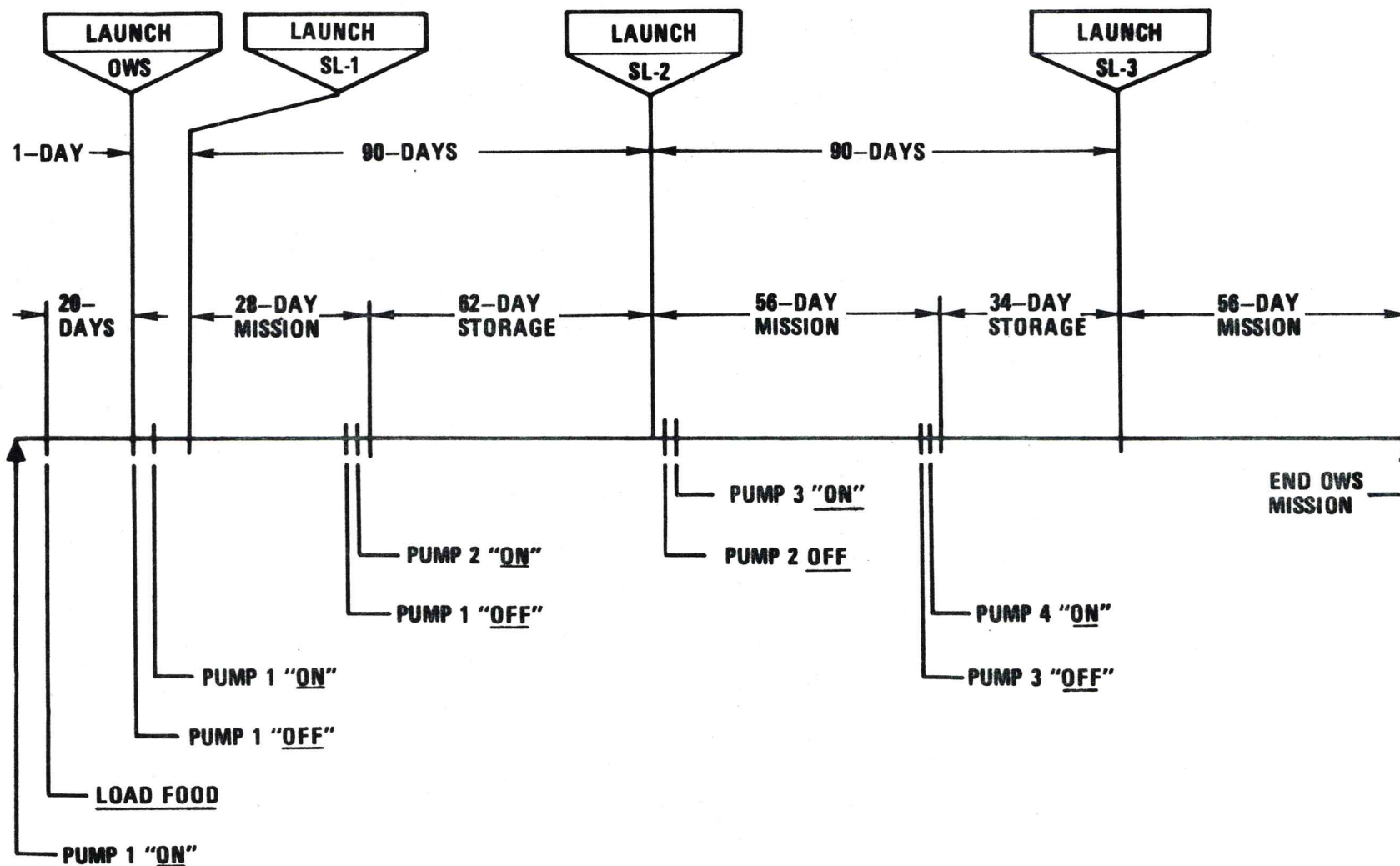


Figure 429-7. (Sheet 2 of 2)

The electrical functions of the subsystem are fully redundant and isolated from each other with the exception of loop switching capabilities. Ground power is supplied through the umbilical interface for prelaunch operation and from OWS Bus 1 and 2, via the Electrical Control and Display Console, for flight operation. All refrigeration electrical components of the primary coolant loop are supplied from OWS Bus 1 and all electrical components of the secondary coolant loop are supplied from Bus 2 (Figure 429-8). The electrical design of the subsystem are described in the subsequent paragraphs.

4.2.9.5.1 Coolant Pump Inverters

The RS utilizes eight coolant pumps, four in the primary coolant loop and four in the secondary coolant loop. Coolant pump inverters are designed to convert the 28vdc power to three phase, quasi-square wave, 8.5v RMS power necessary to drive the pump motors. One inverter is provided for each loop to sequentially drive the coolant pumps. A simplified diagram of the coolant pump inverter operational interface is shown in Figure 429-9.

4.2.9.5.2 Control Logic Unit

Two control logic units provide the necessary logic and control to operate the four coolant pumps in each loop, the controllers for the radiator bypass valve and the regenerator heater for each loop. System control parameters requiring displays are also derived from the control logic units.

The interfaces with the central logic units are depicted in Figure 429-10. The various control/monitoring functions are:

- a. Pump package differential pressure.
- b. Pump package accumulator liquid level.
- c. High freezer inlet temperature.
- d. Low chiller inlet temperature.
- e. Digital Command System (DCS) commands.
 1. ENABLE, primary loop.
 2. DISABLE, primary loop.
 3. ENABLE, secondary loop.
 4. DISABLE, secondary loop.
- f. Ground support equipment (GSE) commands.
 1. Command RS primary loop radiator bypass valve bypass.
 2. Command RS secondary loop radiator bypass valve bypass.
 3. DISABLE, primary loop.
 4. DISABLE, secondary loop.

ORBITAL WORKSHOP REFRIGERATION SYSTEM POWER DISTRIBUTION

O/W-7877
7-31-70

4-399

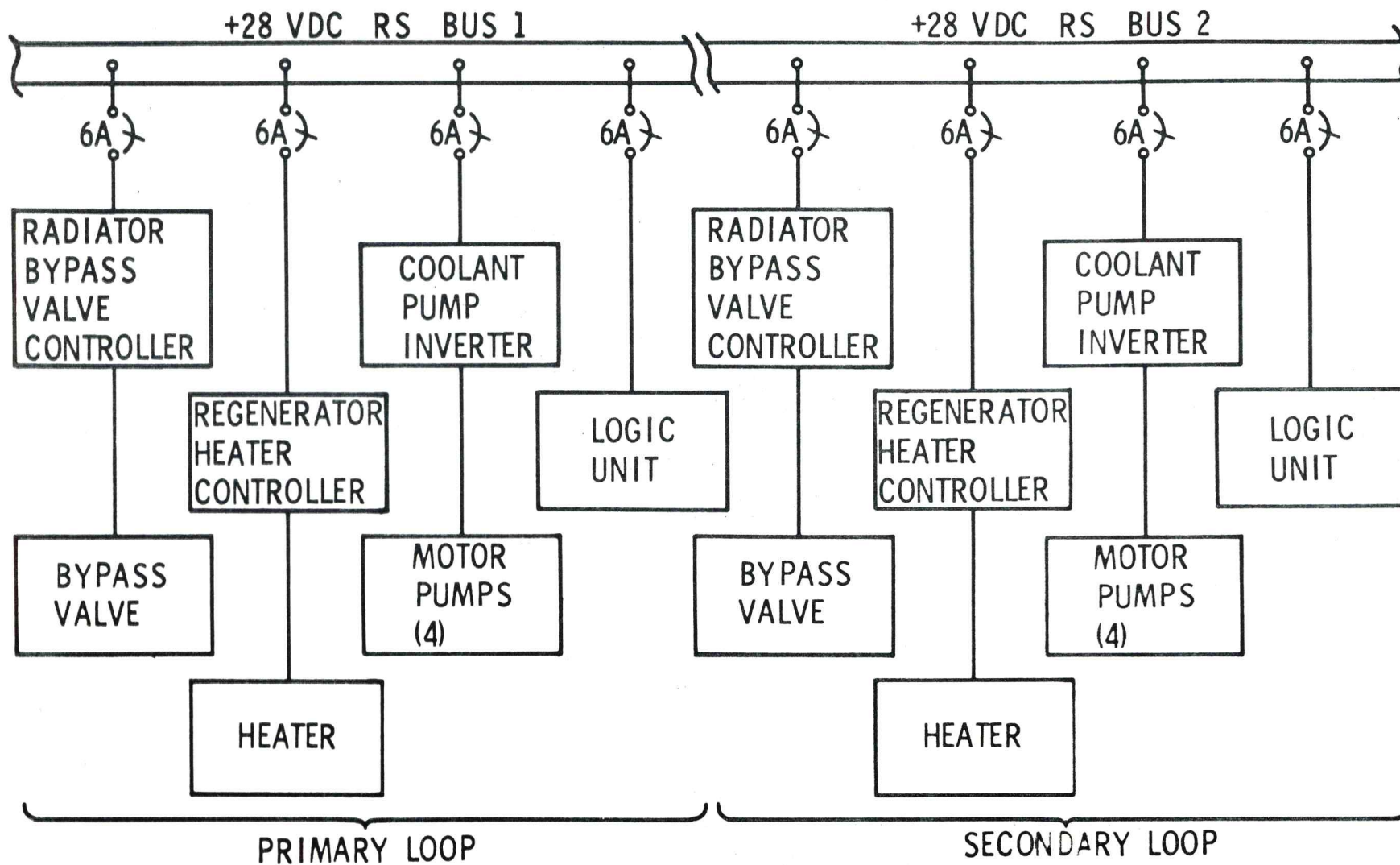


Figure 429-8.

ORBITAL WORKSHOP REFRIGERATION SYSTEM COOLANT PUMP INVERTER INTERFACES

O/W-7876
7-9-70

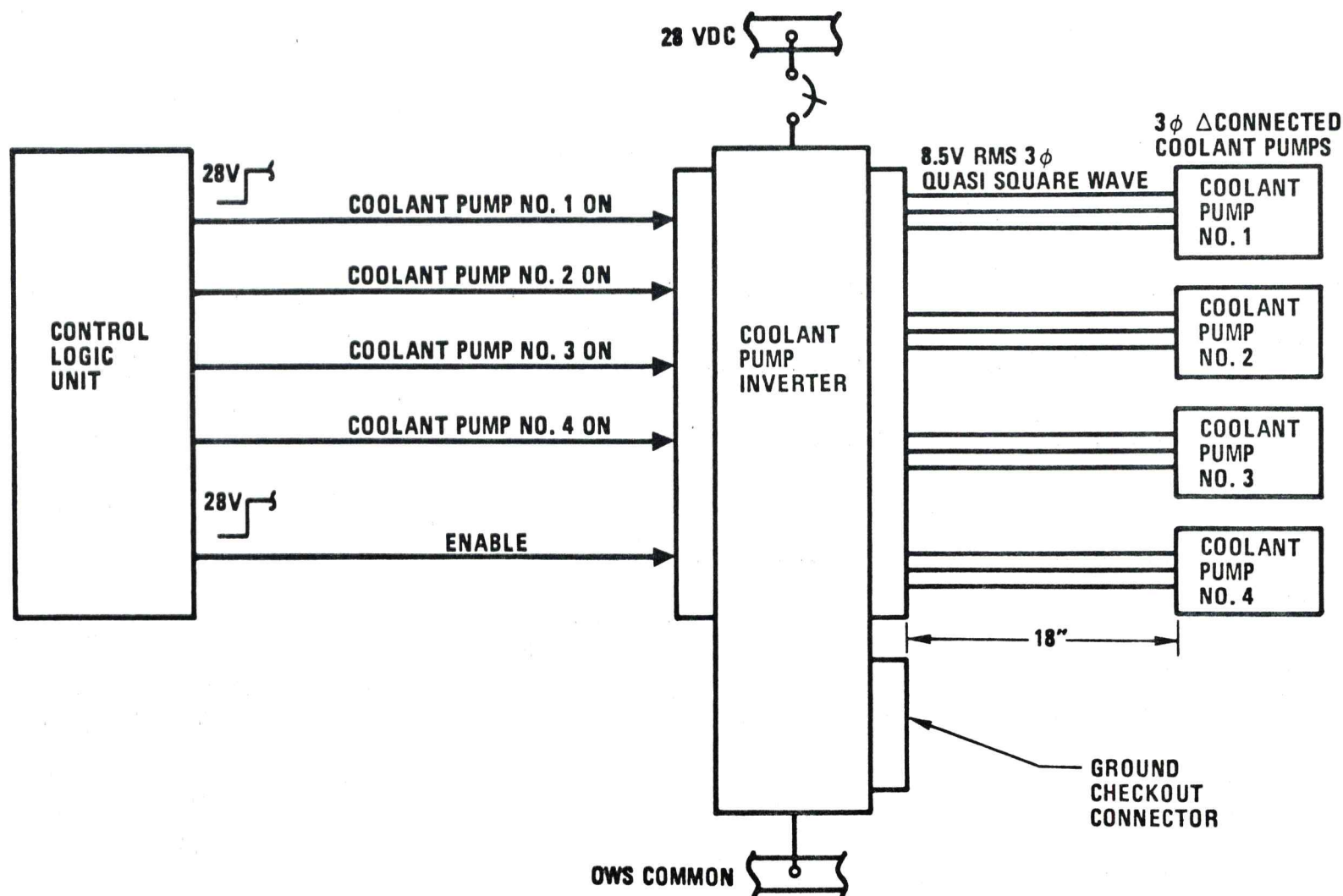


Figure 429-9.

ORBITAL WORKSHOP REFRIGERATION SYSTEM LOGIC UNIT INTERFACE

O/W-7538
8-3-70

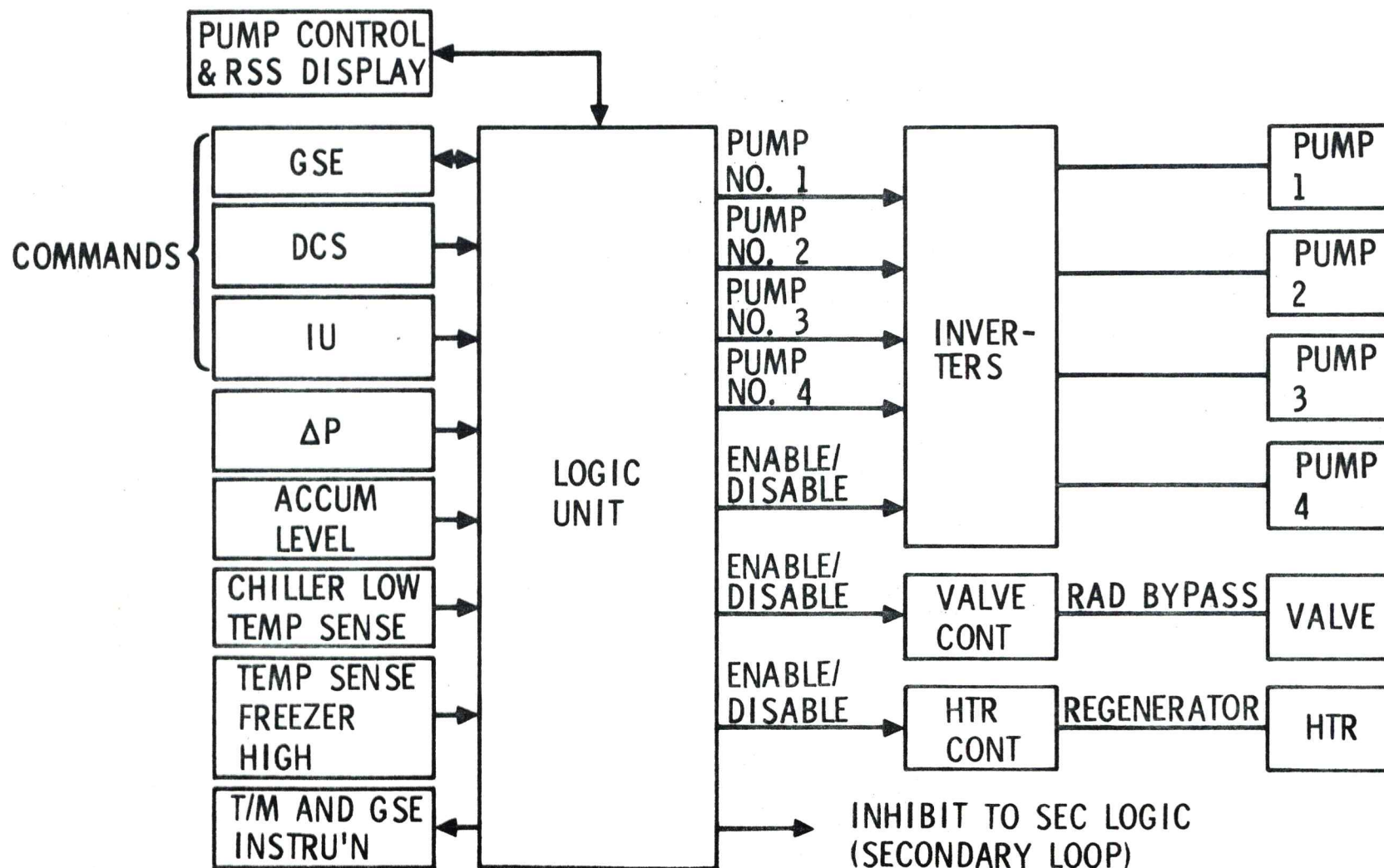


Figure 429-10.

- g. Instrumentation Unit (IU) commands.
 - 1. ENABLE, primary loop.
 - 2. ENABLE, secondary loop.
- h. Thermal capacitor outlet temperature.
- i. Radiator outlet temperature.
- j. Freezer inlet temperature.
- k. Chiller inlet temperature.

4.2.9.5.3 Radiator Bypass Valve Controllers

Valve controllers are provided in each loop to control the bypass valves, allowing radiator bypass when it does not provide adequate conditioning of the coolant (Figure 429-11).

The coolant is cooled in the radiator during normal orbital operations. During ground operation, the coolant is routed through a heat exchanger cooled by ground support equipment. During the first 27 minutes after launch, or until the radiator reaches the proper cooling temperature, the coolant bypasses the radiator. The thermal capacitor provides cooling during the 27 minutes after launch and when the radiator does not provide adequate cooling.

During orbital operations, the controller senses abnormal radiator temperatures and switches the bypass valve to the bypass position and back to the radiator position when the radiator temperature returns to normal.

Power is provided to the controllers through circuit breakers on the control and display console.

A signal from the IU enables the controller to switch the bypass valve to the radiator position when the radiator reaches the proper cooling temperature. The bypass valve can be switched to either position from the GSE.

4.2.9.5.4 Regenerator Heater Controller

An electrical heater blanket is provided to maintain the temperature of the coolant into the heat exchanger within a selected control range. Each coolant loop is provided with a separate controller to its respective heater blanket. The regenerator heater controller receives signals from the Control Logic Unit and provides ON-OFF control of the power to the heater blankets.

A simplified diagram of the Regenerator Heater Controller is shown in Figure 429-12.

ORBITAL WORKSHOP REFRIGERATION SYSTEM BYPASS VALVE CONTROL

O/W-7536
8-8-70

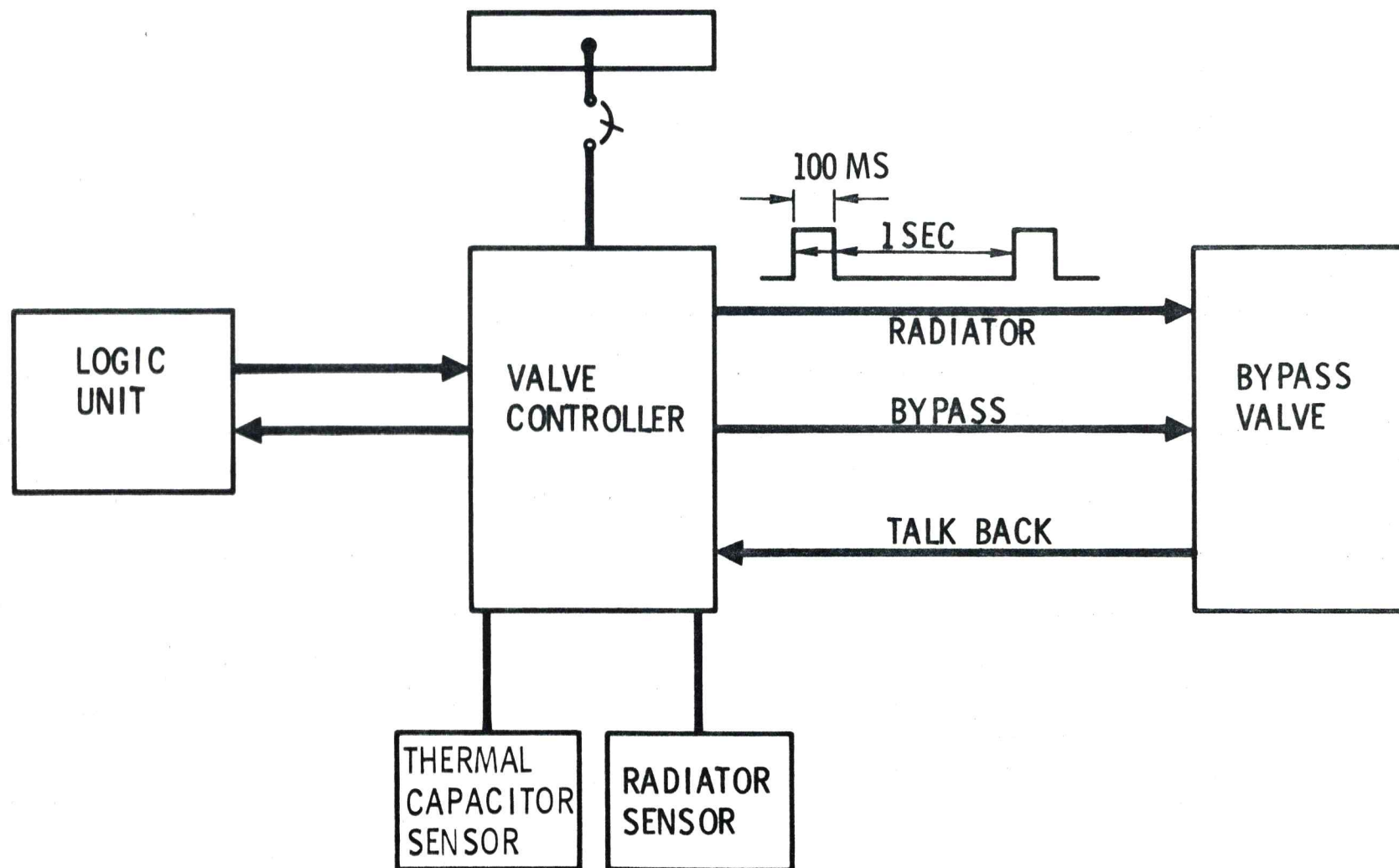
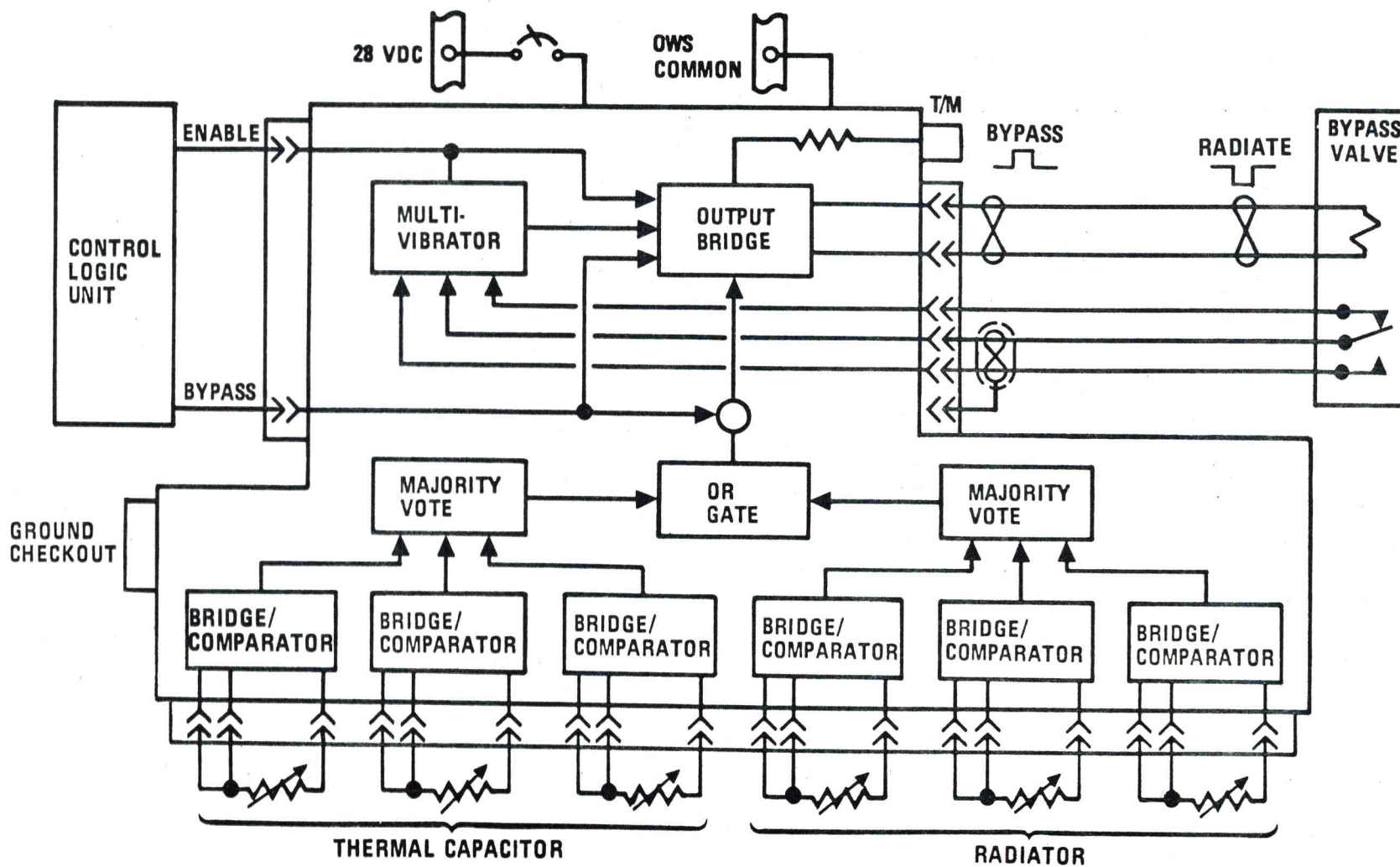


Figure 429-11. (Sheet 1 of 2)

ORBITAL WORKSHOP REFRIGERATION SYSTEM BYPASS VALVE CONTROLLER

O/W-7878
8-8-70



4-404

Figure 429-11. (Sheet 2 of 2)

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ORBITAL WORKSHOP REFRIGERATION SYSTEM HEATER CONTROLLER

O/W-7879
7-9-70

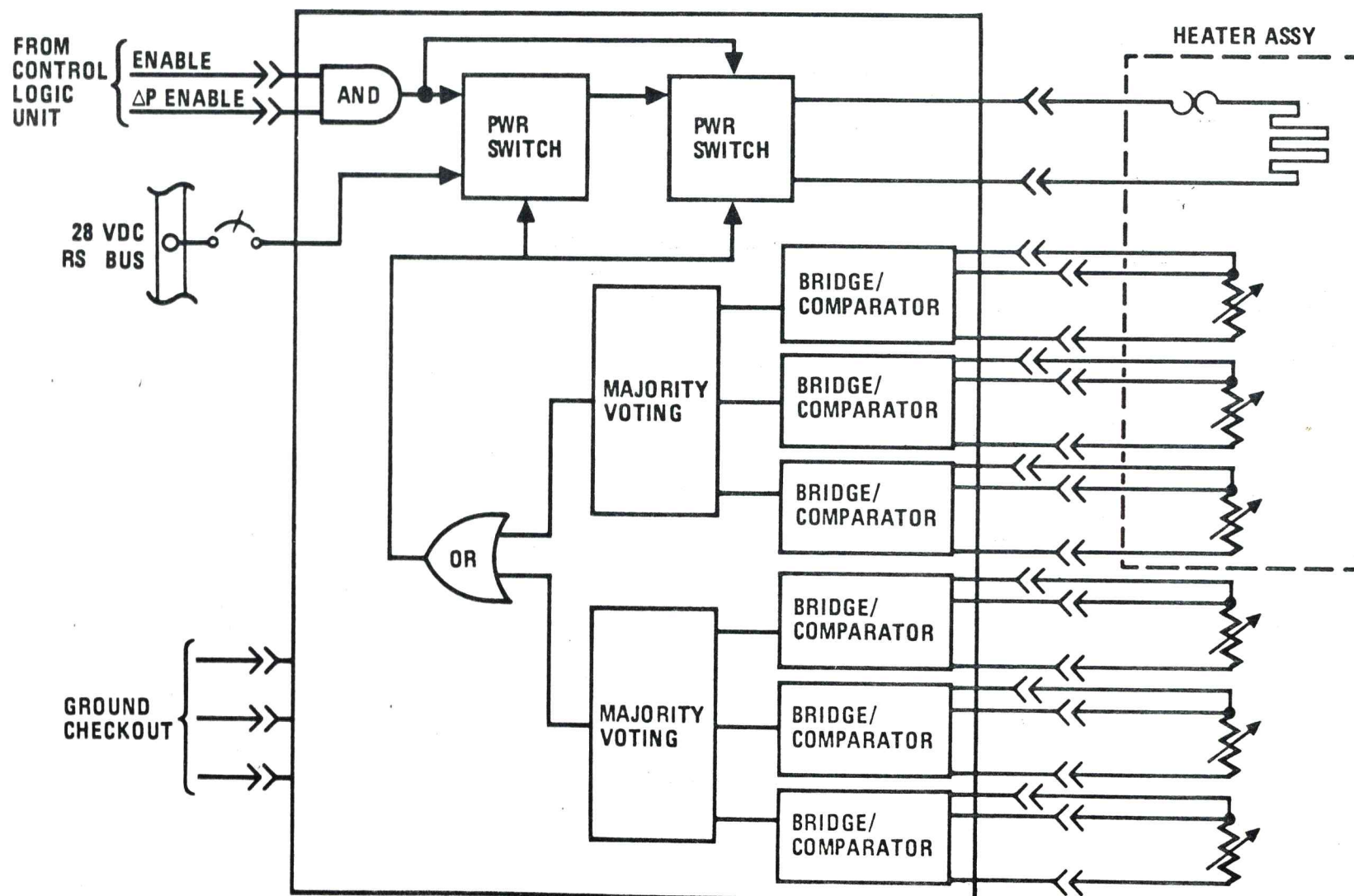


Figure 429-12.

4.2.9.5.5 Control and Display Panel

The Control and Display Panel (Figure 429-13) for the RS is part of the Electrical Control and Display Console located in the Experiment Compartment. It provides for crew monitoring of the operational system and allows for manual control of the system.

ORBITAL WORKSHOP CONTROL AND DISPLAY PANEL NO. 1 REFRIGERATION SYSTEM

O/W-7748
6-23-70

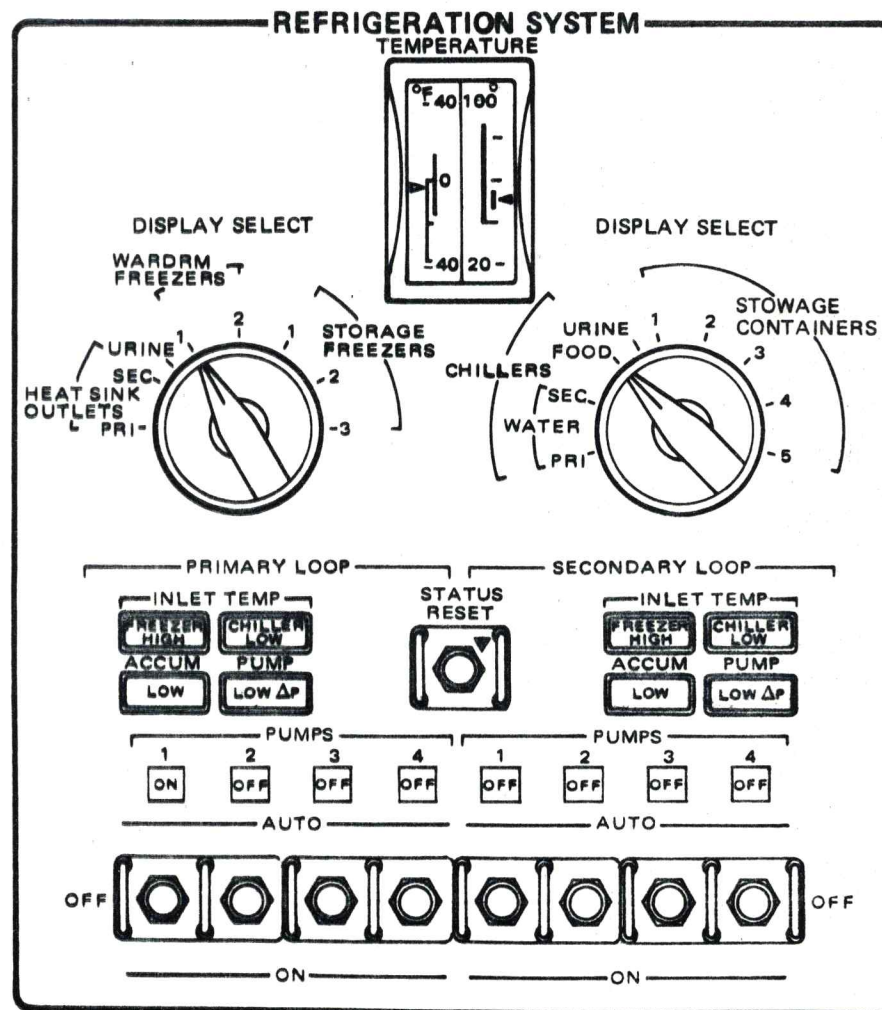


Figure 429-13.

STOWAGE
PROVISIONS

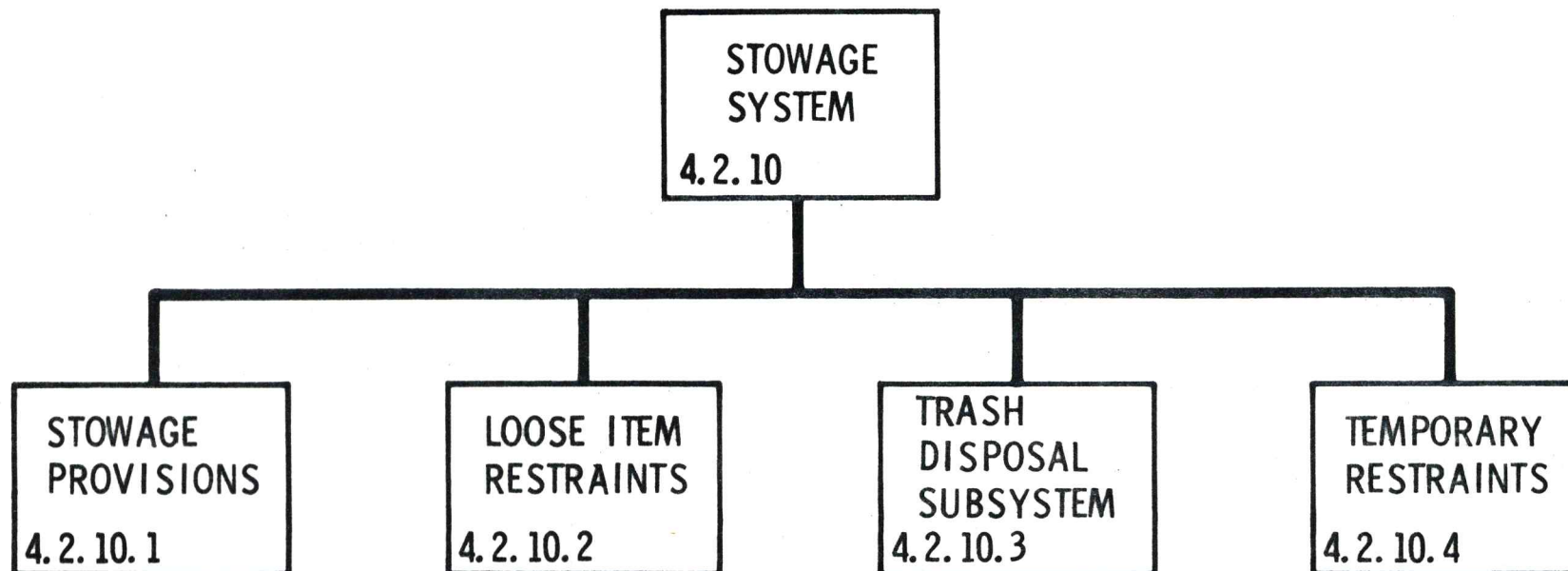
4.2.10.1

STOWAGE SYSTEMS

THE STOWAGE
THE CONTAINMENT
EQUIPMENT IN THE
HANDLING AND DISPOS,

ORBITAL WORKSHOP STOWAGE SYSTEM

O/W-8882
8-6-70

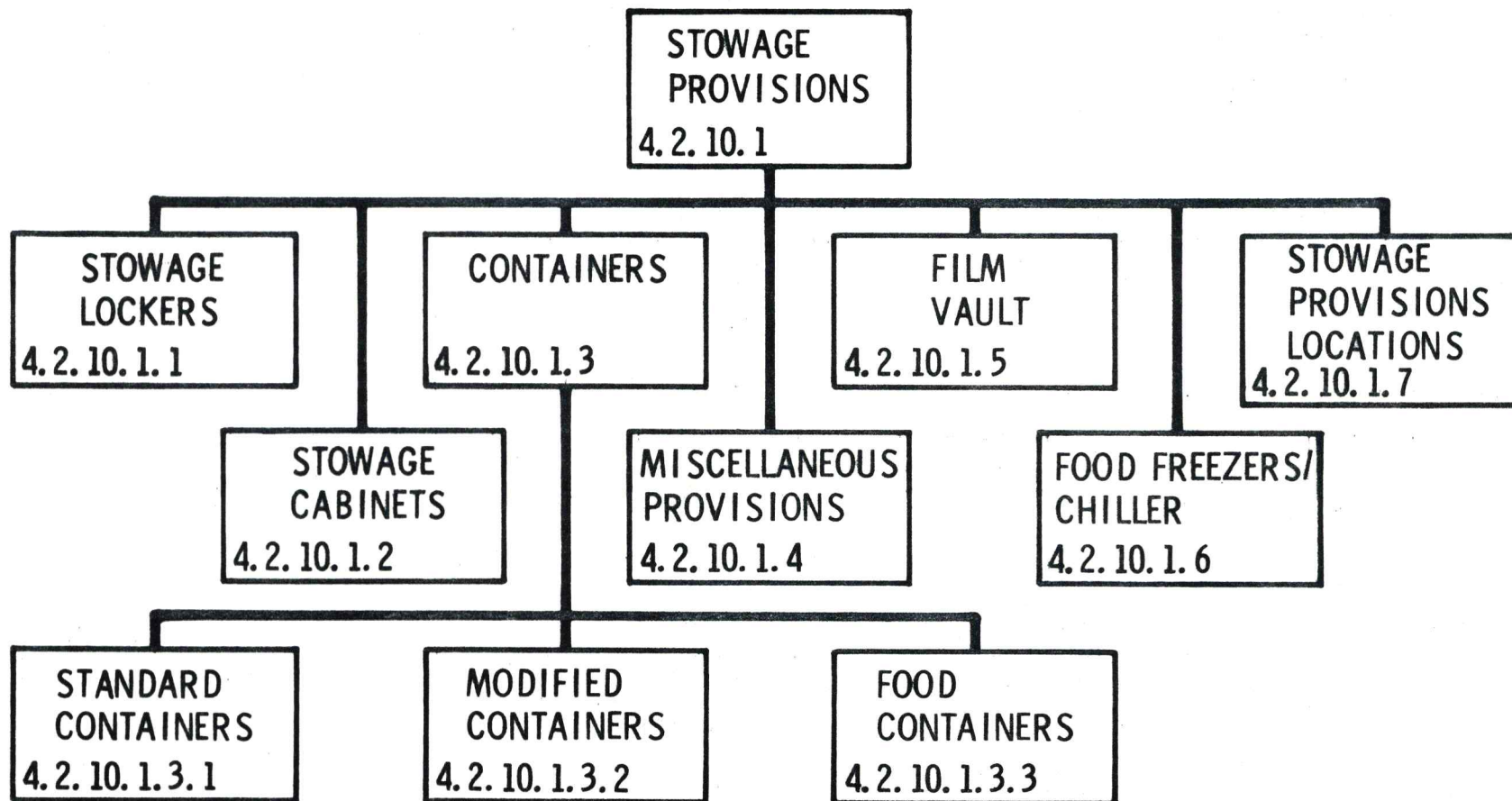


4-408

THE STOWAGE SYSTEM CONSISTS OF PROVISIONS FOR THE CONTAINMENT/RESTRAINT AND ACCESS OF LOOSE EQUIPMENT IN THE OWS AND PROVISIONS FOR TRASH HANDLING AND DISPOSAL

ORBITAL WORKSHOP STOWAGE PROVISIONS

O/W-8883
8-6-70



STOWAGE PROVISIONS CONSIST OF THE CONTAINERS, LOCKERS, FOOD FREEZERS, ETC. REQUIRED FOR THE STOWAGE OF LOOSE EQUIPMENT IN THE OWS.

4.2.10 Stowage System

The stowage system consists of provisions for the containment/restraint and access of loose equipment in the OWS, and for trash handling and disposal. This section provides a description of stowage system hardware. A complete identification of loose equipment items to be stowed and their launch locations in the OWS is presented in MDC G0350, Orbital Workshop Stowage List.

4.2.10.1 Stowage Provisions

Stowage provisions consist of the following items of equipment required for the stowage of loose equipment in the OWS:

- a. Stowage lockers.
- b. Stowage cabinets.
- c. Containers.
- d. Miscellaneous provisions.
- e. Film vault.
- f. Food freezers/chiller.

4.2.10.1.1 Stowage Lockers

Stowage lockers (Figures 4210-1 through 4210-3) consist of preinstalled general stowage provisions divided into standard sized compartments approximately 10 x 11.4 x 16 inches. There are 16 stowage lockers containing 90 standard compartments available for general stowage. They are located in the OWS as follows:

| <u>Compartment</u> | <u>No. of Lockers</u> | <u>No. of Compartments</u> |
|------------------------|---------------------------|--------------------------------|
| Forward Compartment | 2* | 12 |
| Experiment Compartment | 1 | 5 |
| Sleep Compartment | 3 | 15 |
| Waste Mgmt Compartment | 2 | 10 |
| Wardroom | <u>8</u> | <u>48</u> |
| Totals | 16 | 90 |

*One of these lockers has two oversized compartments (approximately 11.4 x 10.0 x 19.75 inches).

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ORBITAL WORKSHOP STANDARD STORAGE LOCKER

O/W-3759
4-2-70

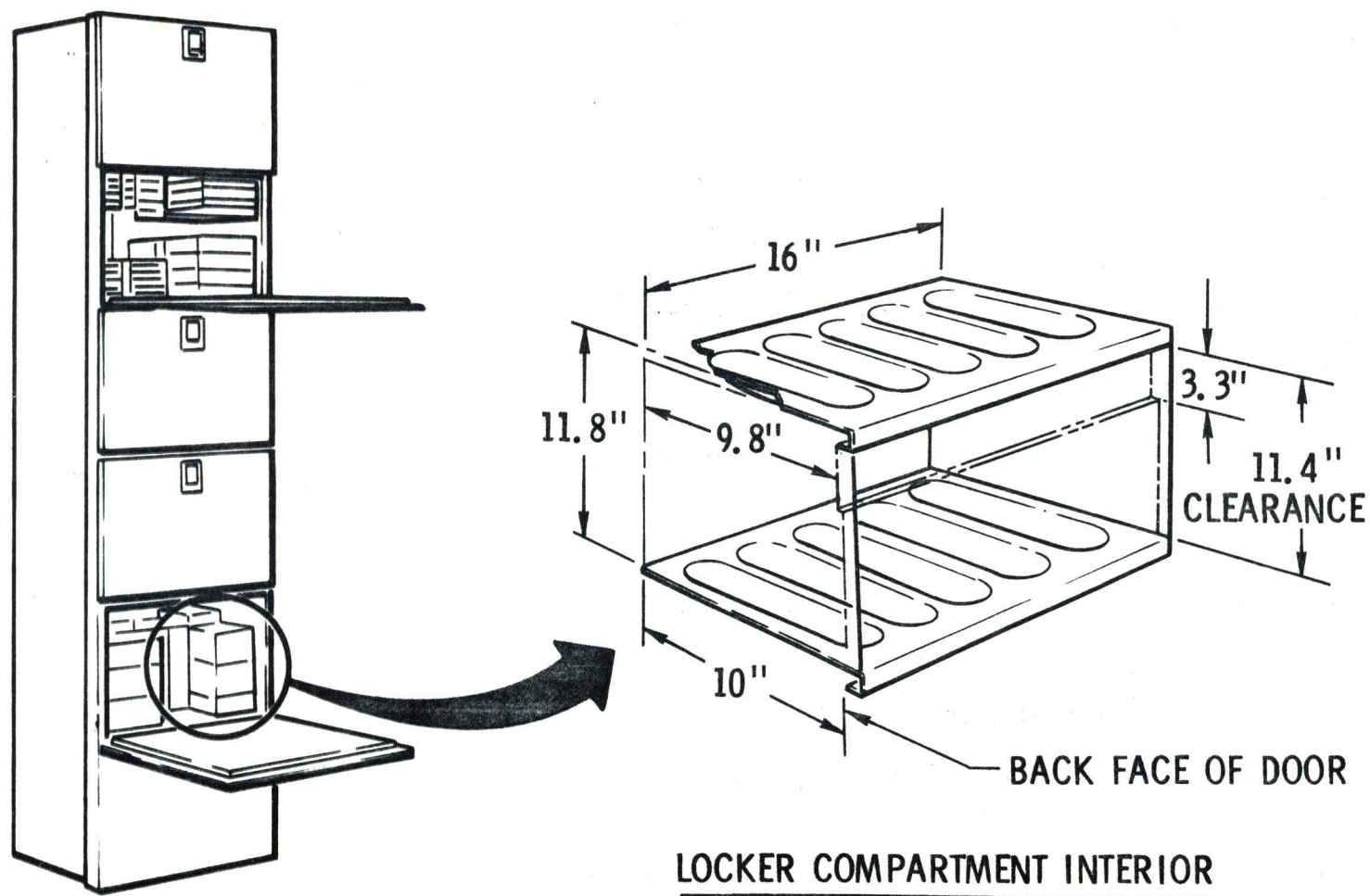
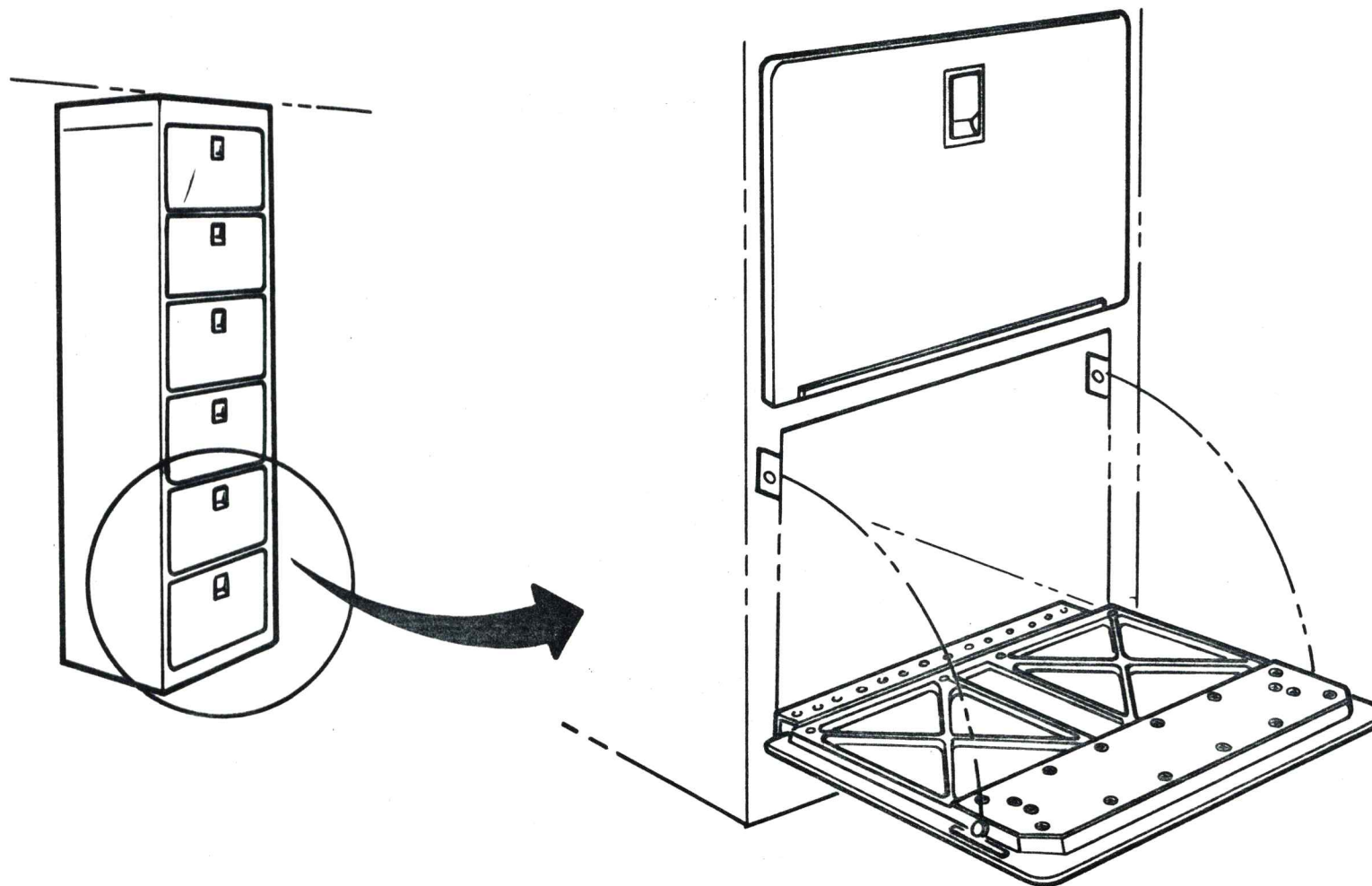


Figure 4210-1.

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ORBITAL WORKSHOP STANDARD LOCKER DOOR

O/W-6969
4-20-70



4412

Figure 4210-2.

**ORBITAL WORKSHOP
STORAGE LOCKER COMPARTMENT
NOMINAL CLEAR OPENING
(PRODUCTION)**

[illegible]

4-413

Hardware items comprising the stowage locker are:

- a. Beaded aluminum construction.
- b. Access door with latch.
- c. Piano hinge.
- d. Shear pins.
- e. Hole for latch inspection/emergency access.
- f. Standard hole pattern for multiple internal restraint attachment.
- g. Attachment provisions:
 1. Mounting pallet at locker base for loads in all vectors.
 2. Pivoting linkage at forward end of locker for lateral and torsional stability.

The detail design of the stowage locker is shown in drawing 1B80775.

4.2.10.1.2 Stowage Cabinets

Stowage cabinets consist of preinstalled, general stowage provisions of nonstandard sized compartments. There are five stowage cabinets containing 16 compartments of varying size. They provide maximum space utilization and stowage versatility due to their shape and size. They are located in the OWS as follows:

| <u>Compartment</u> | <u>No. of Cabinets</u> | <u>No. of Compartments</u> | <u>Approximate Volume</u> |
|------------------------|----------------------------|--------------------------------|-------------------------------|
| Forward Compartment | 1 | 3 | 6.39 |
| Sleep Compartment | 1 | 4 | 10.00 |
| Waste Mgmt Compartment | 1 | 4 | 13.54 |
| Wardroom | <u>2</u> | <u>5</u> | <u>12.17</u> |
| Totals | 5 | 16 | 42.10 |

The five stowage cabinets are defined as:

- a. Forward compartment stowage cabinet.
- b. Sleep compartment corner cabinet.
- c. WMC corner cabinet
- d. Data file stowage cabinet (wardroom).
- e. Entertainment center stowage cabinet (wardroom).

Hardware items comprising each of the stowage cabinets are:

- a. Sheet metal construction.
- b. Access door.
- c. Standard locker compartment latch.
- d. Piano hinge.
- e. Shear pins.
- f. Attachment provisions.

4.2.10.1.2.1 Forward Compartment Stowage Cabinet

The access openings of the three compartments in the forward compartment stowage cabinet are identical to that of a standard locker compartment. However, the cabinet depth is increased to provide approximately 2.13 cubic feet of stowage space per compartment. In addition, a frame extends from the cabinet to the water ring for stowage of the three urine specimen return containers. An illustration and location of the forward compartment stowage cabinet are provided in paragraph 4.2.10.1.7.

4.2.10.1.2.2 Sleep Compartment Corner Cabinet

The sleep compartment corner cabinet incorporates double doors on each of the four compartments to provide maximum access to the triangular-shaped storage area. Access to the stowage cabinet requires removal of the adjacent sleep restraint. Therefore, equipment stowed in this cabinet will be restricted to those items which require access only at the scheduled time of sleep restraint replacement (14-day intervals). An illustration and location of the sleep compartment corner cabinet are provided in paragraph 4.2.10.1.7.

4.2.10.1.2.3 WMC Corner Cabinet

The WMC corner cabinet consists of four compartments. In addition to providing for general stowage, the cabinet incorporates the urine pooling bag dispenser, a urine holding area, and the mounting provisions for a specimen mass measurement device. An illustration and location of the WMC corner cabinet are provided in paragraph 4.2.10.1.7.

4.2.10.1.2.4 Data File Stowage Cabinet

The data file stowage cabinet consists of a two-compartment unit located beneath the window in the wardroom. The cabinet provides stowage and access to the OWS data file. Shelves and dividers are sized to provide adequate restraint and access to the various elements of the file. An illustration and location of the data file stowage cabinet are provided in paragraph 4.2.10.1.7.

4.2.10.1.2.5 Entertainment Center Stowage Cabinet

The entertainment center stowage cabinet is a corner cabinet located in the wardroom. It houses the heat exchangers and ducting for the OWS ground

conditioning system, the preinstalled entertainment equipment, and one compartment for general stowage. An illustration and location of the entertainment center stowage cabinet are shown in paragraph 4.2.10.1.7.

4.2.10.1.3 Containers

Stowage containers consist of removable stowage provisions which permit packing of contents external to the vehicle, allowing fully loaded containers to be installed in the OWS. There are provisions for the installation of 25 containers forward of the water ring. Twenty-one of these containers are standard containers, four are modified containers. In addition, 11 food containers are provided for the stowage of dehydrated, intermediate moisture and, wet pack food. There are provisions for installation of the food containers in the forward compartment.

4.2.10.1.3.1 Standard Stowage Ring Containers

The Standard Stowage Ring container (Figure 4210-4) provides for approximately 6 cubic feet of general stowage. The inside dimensions of 16 x 23 x 30 inches permit modular stowage equivalent to six standard locker compartments (Figure 4210-5). The hinge and latch arrangement permit the restraint of loose equipment in both the base and cover, enabling ease of access to the stowed equipment. The placard weight of the container is 160 pounds. Hardware items comprising the stowage locker are:

- a. Sheet metal construction.
- b. Hinged cover with latch.
- c. Piano hinge.
- d. Attach provisions.

4.2.10.1.3.2 Modified Stowage Ring Containers

The modified stowage ring containers are constructed in the same manner as the standard containers. The 23-inch and 30-inch inside dimensions are the same as those of the standard container, with the 16-inch dimension (depth) modified as required for duct and wiring clearance. Four of these containers are installed forward of the water ring.

4.2.10.1.3.3 Food Containers

The food stowage containers are discussed in paragraph 4.2.7.4.4.

4.2.10.1.4 Miscellaneous Stowage Provisions

Miscellaneous stowage provisions consist of the mounting hardware and restraint provisions for those items on the stowage list that are stowed individually in the OWS (not in lockers, cabinets, or containers). A list of the items presently stowed in this manner and their general locations is given in Figure 4210-6.

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ORBITAL WORKSHOP STOWAGE RING CONTAINER

O/W-8258
8-7-70

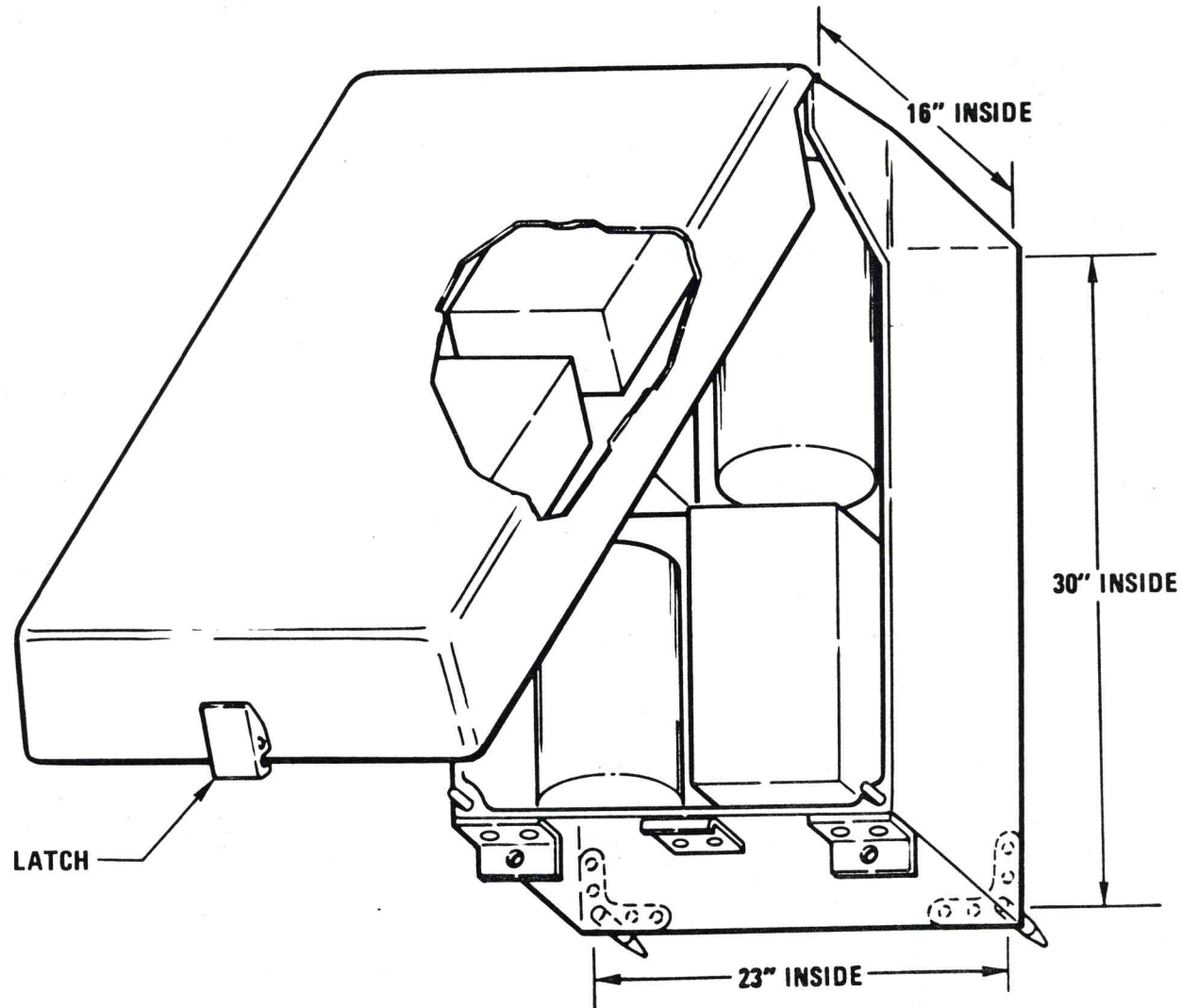


Figure 4210-4.

MCDONNELL
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ORBITAL WORKSHOP STOWAGE RING CONTAINER

O/W-8258A
8-7-70

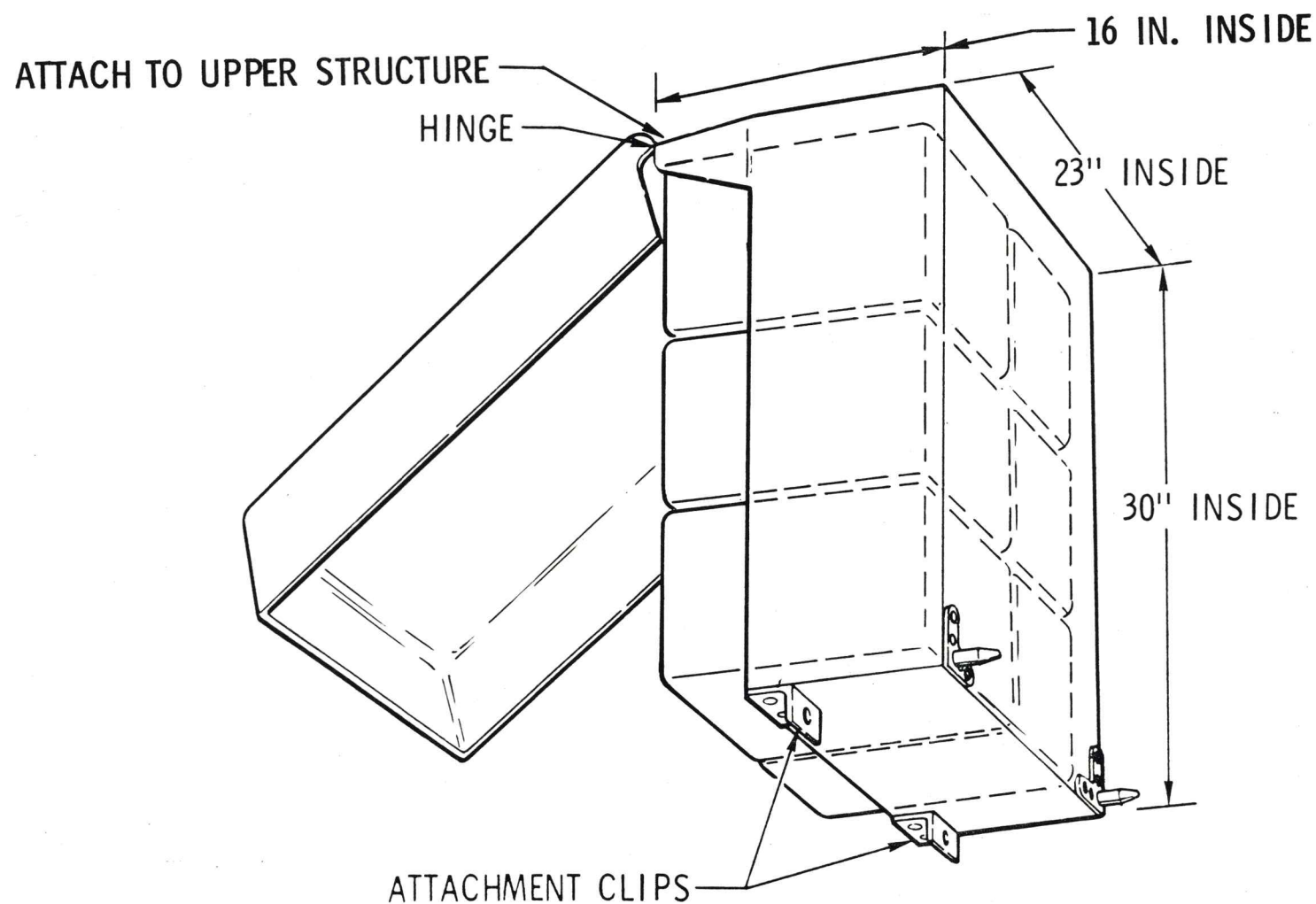


Figure 4210-5.

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ORBITAL WORKSHOP
STOWAGE VOLUME SUMMARY
MISCELLANEOUS PROVISIONS

O/W-8302
8-7-70

| <u>QUANTITY</u> | <u>ITEM</u> | <u>EST TOTAL VOLUME</u> | <u>LAUNCH STOWAGE LOCATION</u> |
|-----------------|---|-----------------------------|---|
| 6 | EVA / IVA UMBILICAL | 28.0 | MEZZANINE |
| 3 | PORTABLE FANS | 7.7 | EXPERIMENT COMPARTMENT FLOOR |
| 3 | FIRE EXTINGUISHERS | 1.2 | EXPERIMENT COMPARTMENT WALL (2 PLACES), DOME |
| 3 | RESTRAINT ASSY, PORTABLE PRESSURE SUIT FOOT | 3.7 | EXPERIMENT COMPARTMENT FLOOR |
| 1 | MOLE SIEVE, SPARE | 11.5 | FORWARD COMPARTMENT FLOOR |
| 1 | M509 N ₂ RECHARGE BOTTLE ASSEMBLY | 8.9 | FORWARD COMPARTMENT FLOOR |
| 9 | TETHER ATTACH BRACKET ASSY, PORTABLE | .14 | EXPERIMENT COMPARTMENT WALL |
| 6 | PORTABLE HANDHOLDS | .44 | EXPERIMENT COMPARTMENT WALL |
| 1 | RESTRAINT ASSY, FIXED FOOT | .13 | WMC FLOOR |
| | TOTAL | 61.51 | |

Figure 4210-6.

4.2.10.1.5 Film Vault

A film vault is provided to protect the photographic films from the expected radiation environment in the OWS. The 12 drawers of the vault will have four different thicknesses of aluminum for radiation protection. The following tabulates the thickness of aluminum radiation protection and the corresponding number of drawers.

| <u>Thicknesses</u> | <u>No. of Drawers</u> |
|--------------------|---------------------------|
| 0.25 inches | 2 |
| 1.90 inches | 5 |
| 2.90 inches | 1 |
| 3.40 inches | 4 |

The film to be carried and its drawer assignment is defined by Orbital Workshop Stowage List, GO35.

The film vault will be bolted to the floor utilizing the support beam structure. It will consist of three castings (the main body and two doors). Figure 4210-7 shows the three castings, the center hinge, and the fasteners required to secure the doors for launch. Figure 4210-8 shows one of the vault doors open and a film drawer extended. Each drawer, containing various film magazines, is capable of removal and can be used to transport the film magazines. At least one drawer in each of the vaults will be capable of on-orbit modification of magazine retention.

To assure that the films are not exposed to relative humidity in excess of 75 percent, two pockets in the door (Figure 4210-8) will be filled and sealed with silicagel. A pocket will be opened prior to each stowage period. When the temperature drops during the stowage period, the accompanying increase in relative humidity will be precluded because the silicagel will have absorbed the water vapor in the vault.

The hardware items comprising the film vault are:

- a. Three castings.
- b. Twelve drawers.
- c. Slide mechanisms.
- d. Center hinge.
- e. Silicagel compartments.
- f. Launch load fasteners.
- g. Door latches.

ORBITAL WORKSHOP FILM VAULT EXTERIOR

O/W-8111
6-23-70

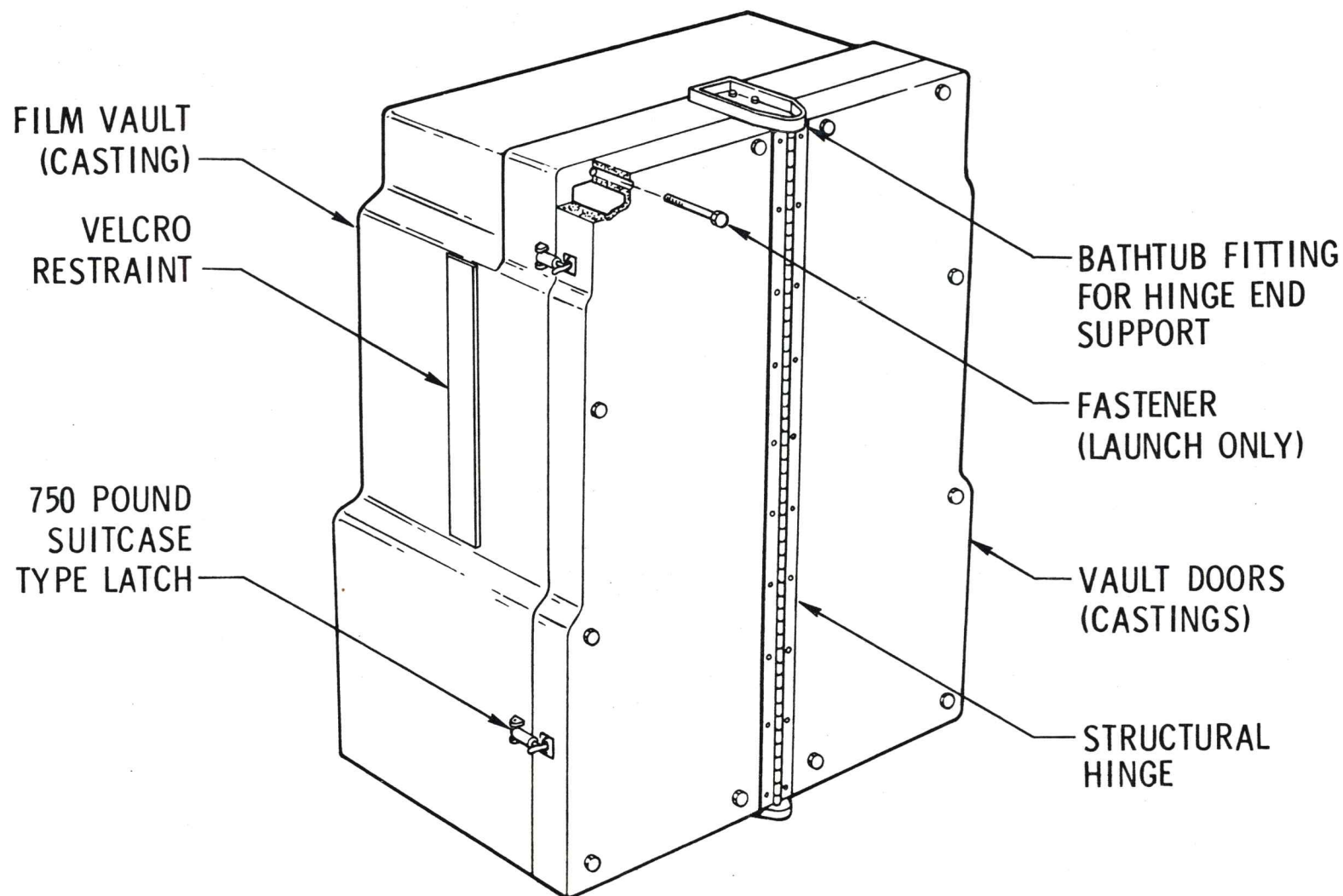


Figure 4210-7.

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ORBITAL WORKSHOP FILM VAULT INTERIOR

O/W-8110
8-8-70

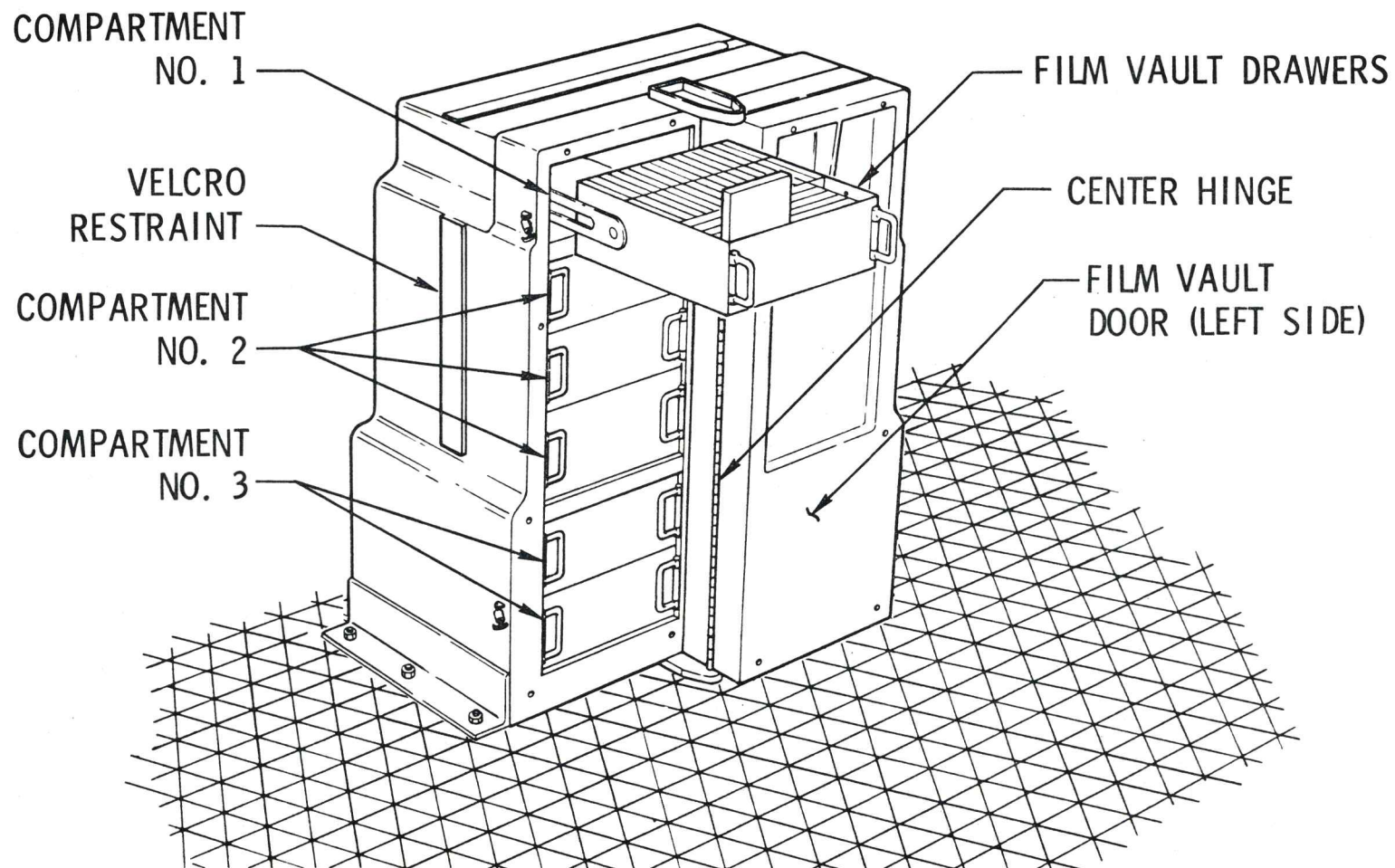


Figure 4210-8.

4.2.10.1.6 Food Freezers/Chiller

The food freezers/chiller is discussed in paragraphs 4.2.7.4.1 and 4.2.7.4.5.

4.2.10.1.7 Stowage Provisions Location

The locations of the stowage provisions discussed in the preceeding paragraphs are as follows:

- a. The arrangement of standard and modified containers on the stowage ring is shown in Figure 4210-9.
- b. The forward compartment stowage provisions, (lockers, cabinet, film vault, food containers, and food freezer), are shown in Figures 4210-10 through 4210-12.
- c. The experiment compartment locker is shown in Figure 4210-13.
- d. The sleep compartment stowage provisions arrangement is shown in Figures 4210-14 and -15.
- e. The waste management compartment stowage provisions arrangement is shown in Figures 4210-16 through -18.
- f. The wardroom stowage provisions arrangement is shown in Figures 4210-19 through -21.

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ORBITAL WORKSHOP STOWAGE RING

O/W-8251A
8-7-70

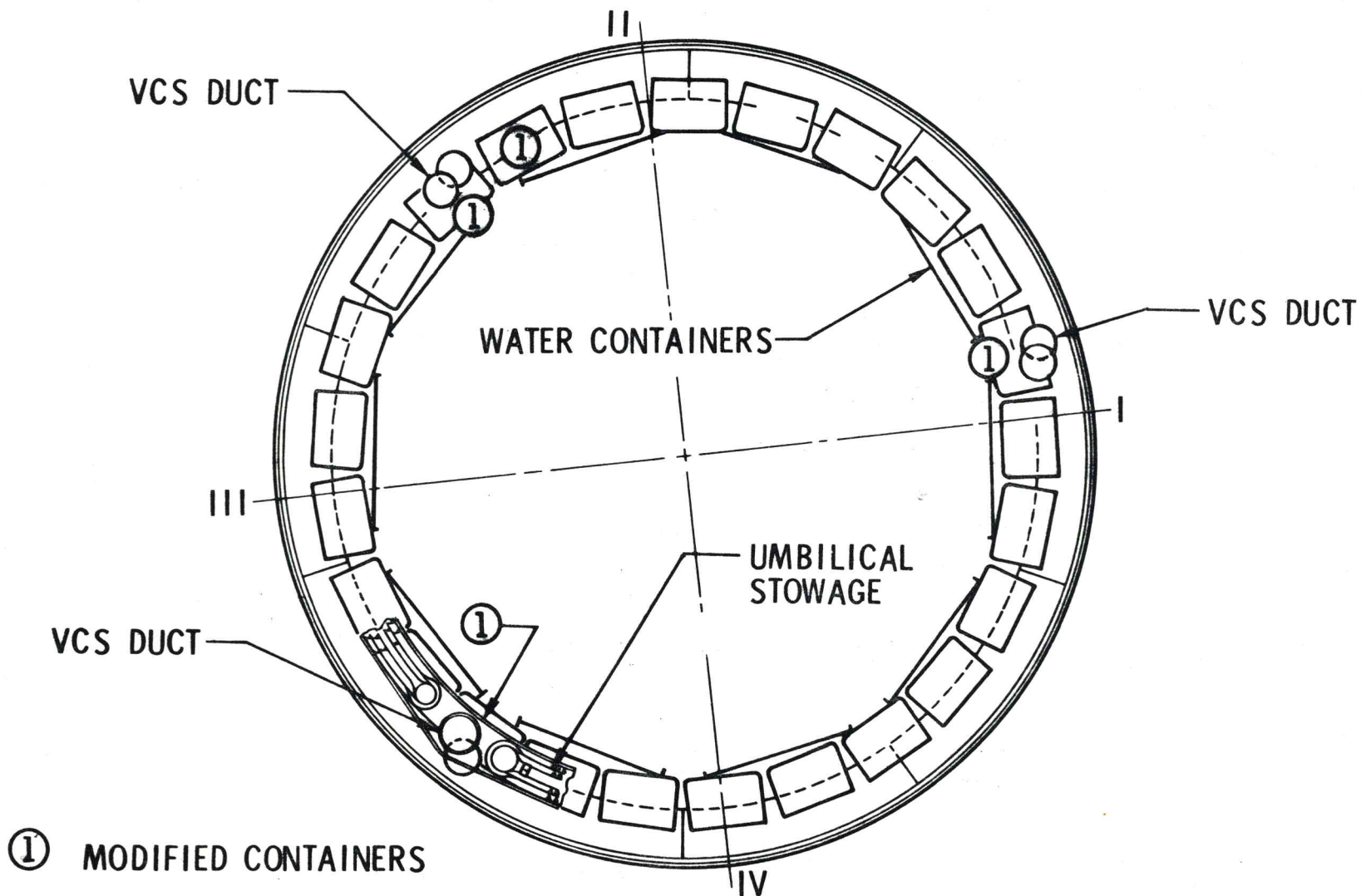
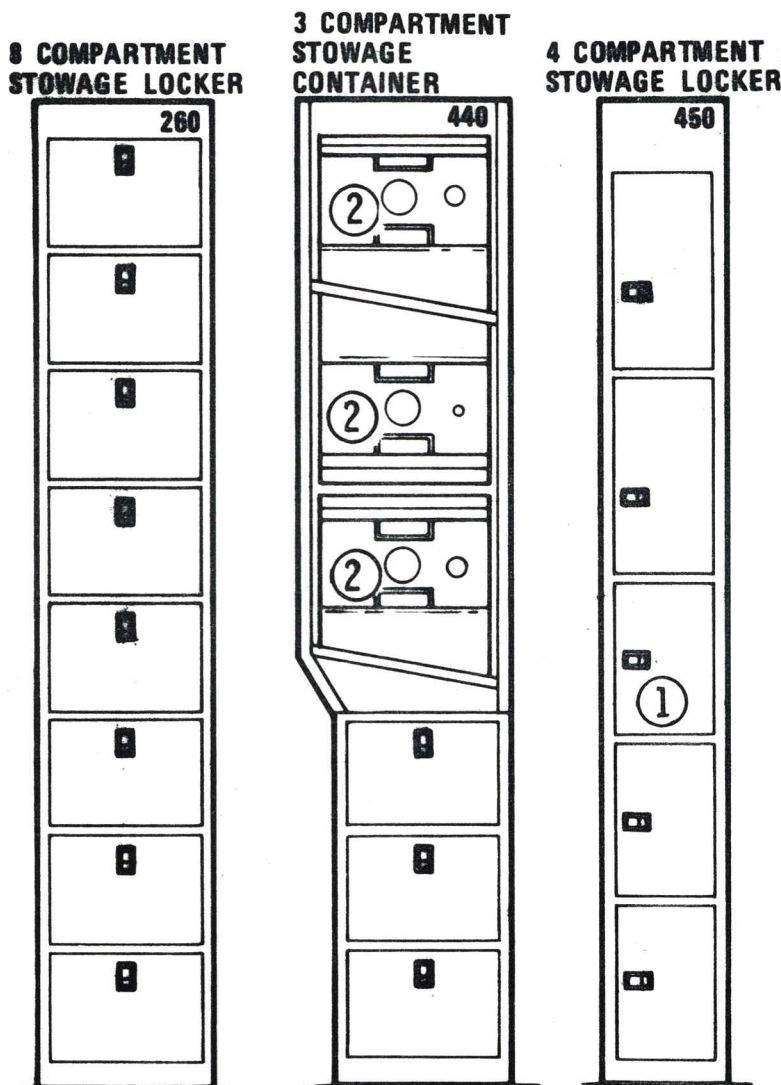


Figure 4210-9.

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ORBITAL WORKSHOP FORWARD COMPARTMENT STOWAGE LOCATIONS

**O/W-7226
8-7-70**



- ① TRASH CONTAINER
- ② SPECIMEN RETURN CONTAINER PROVISIONS

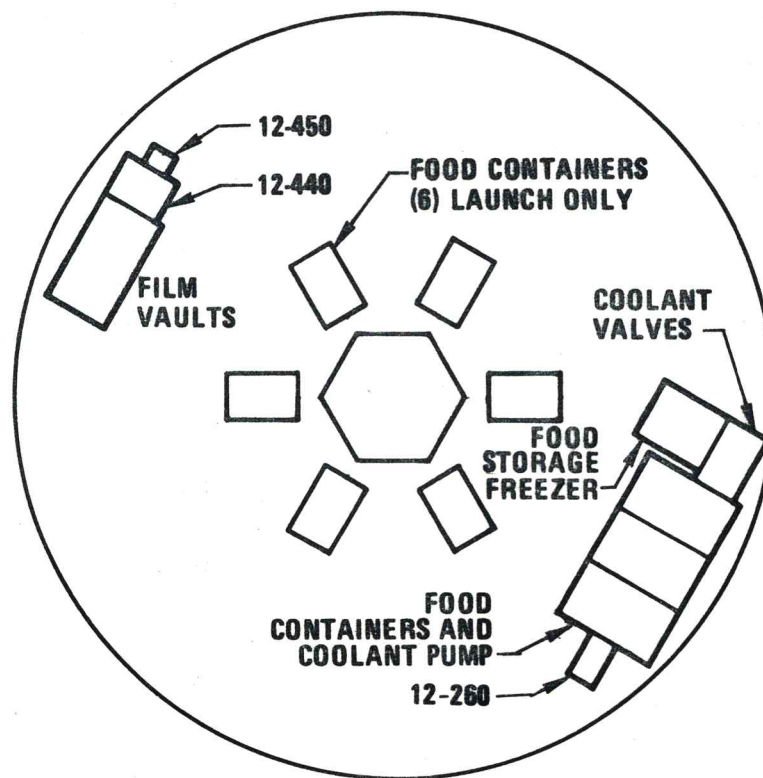


Figure 4210-10.

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ORBITAL WORKSHOP STORAGE AREA ON-ORBIT STOWAGE

O/W-7842
8-7-70

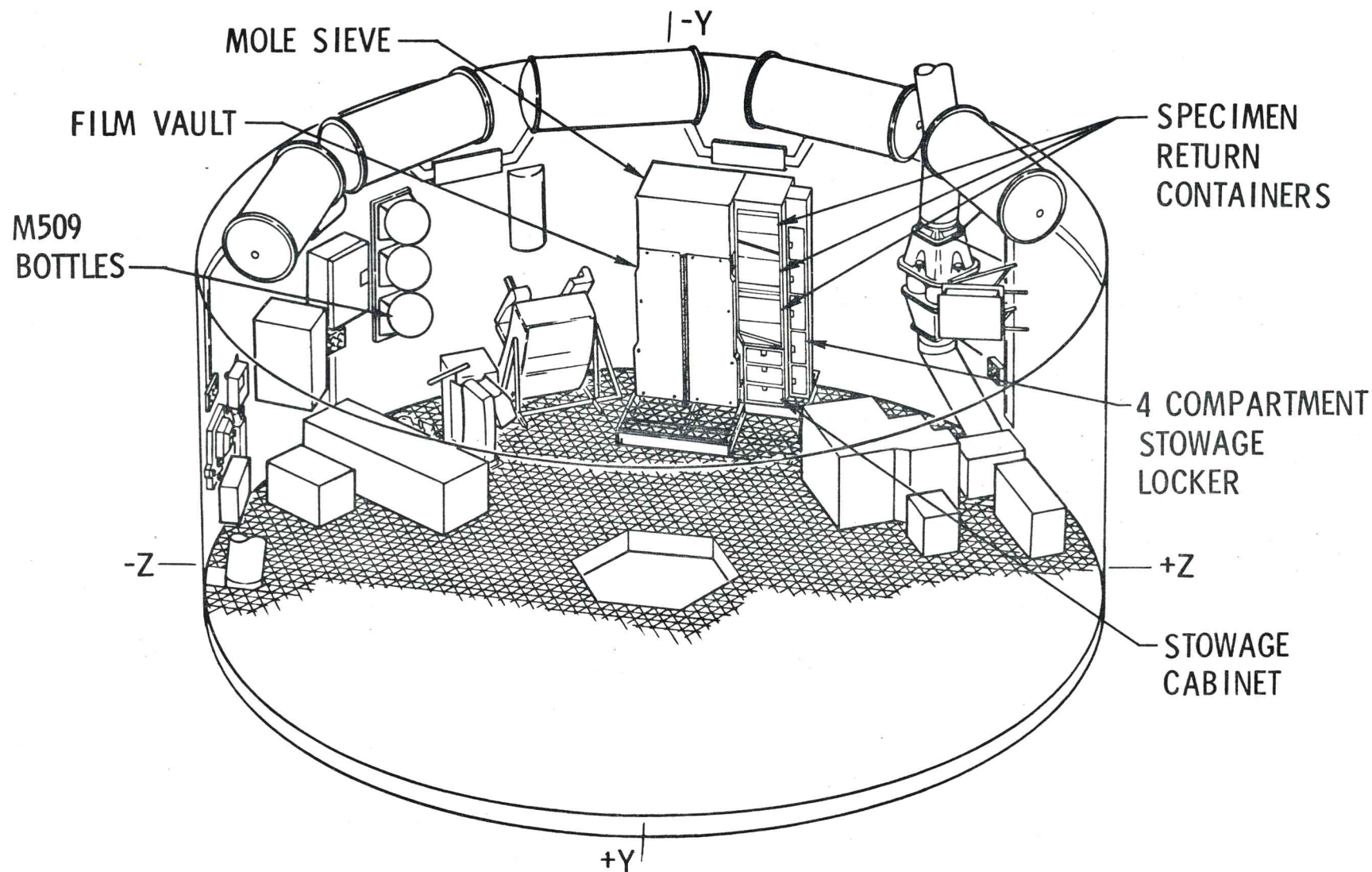


Figure 4210-12.

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ORBITAL WORKSHOP EXPERIMENT COMPARTMENT STOWAGE LOCATIONS

O/W-7228
8-8-70

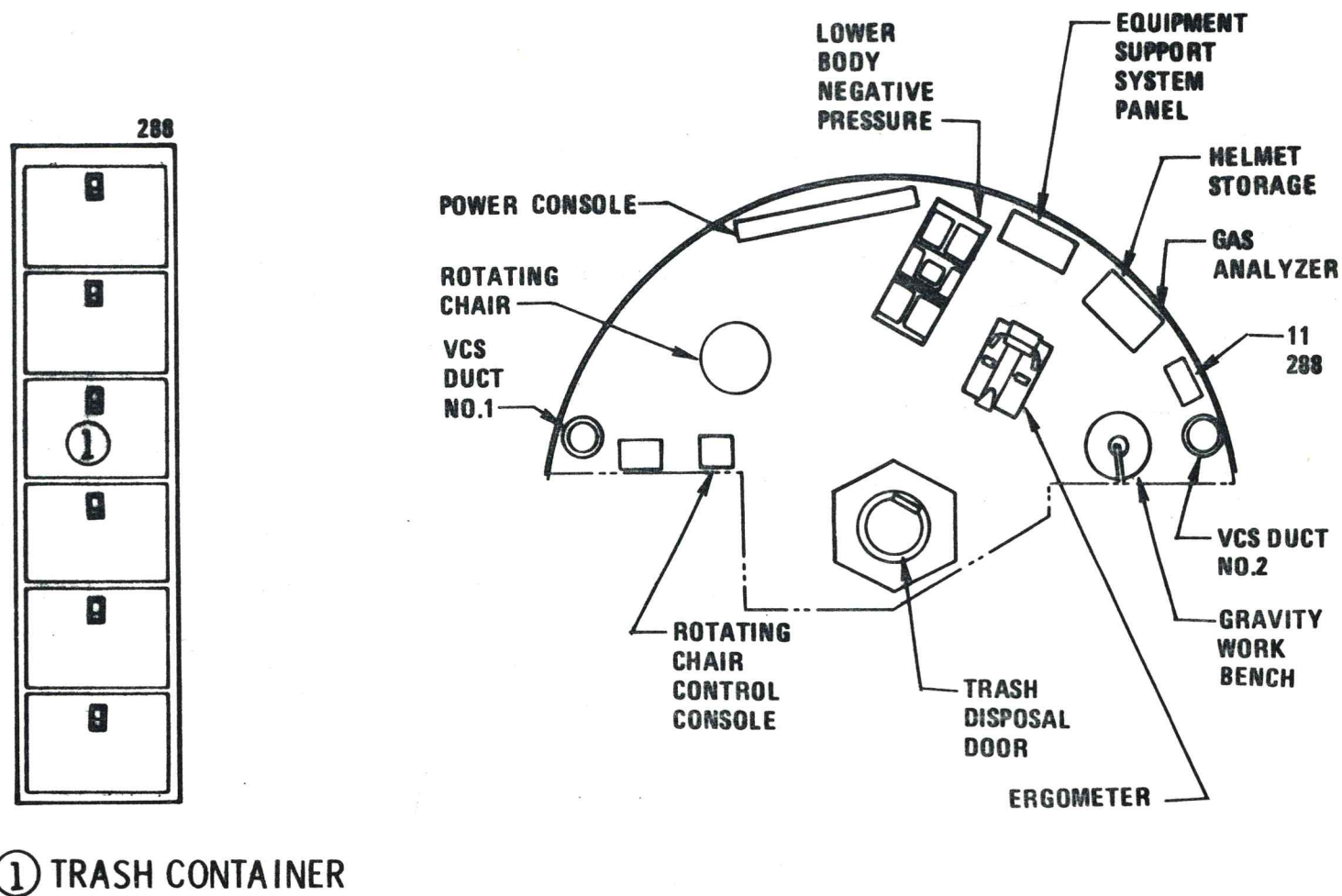
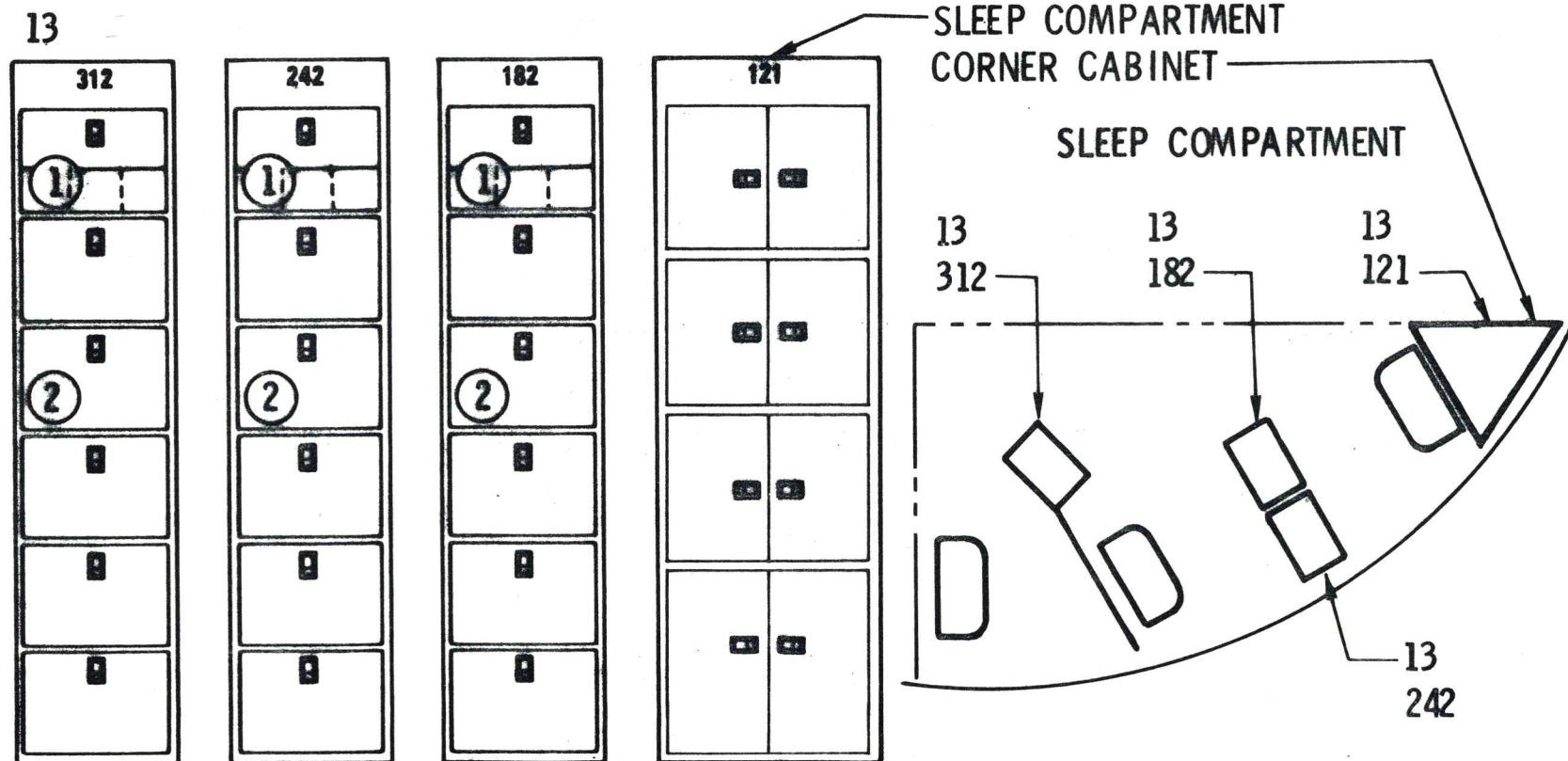


Figure 4210-13.

ORBITAL WORKSHOP SLEEP COMPARTMENT STOWAGE LOCATIONS

O/W-7227
8-7-70



- ① TISSUE DISPENSER
- ② TRASH CONTAINER

Figure 4210-14.

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ORBITAL WORKSHOP HSS WASTE MANAGEMENT COMPARTMENT

O/W-3890-2A
8-7-70

4431

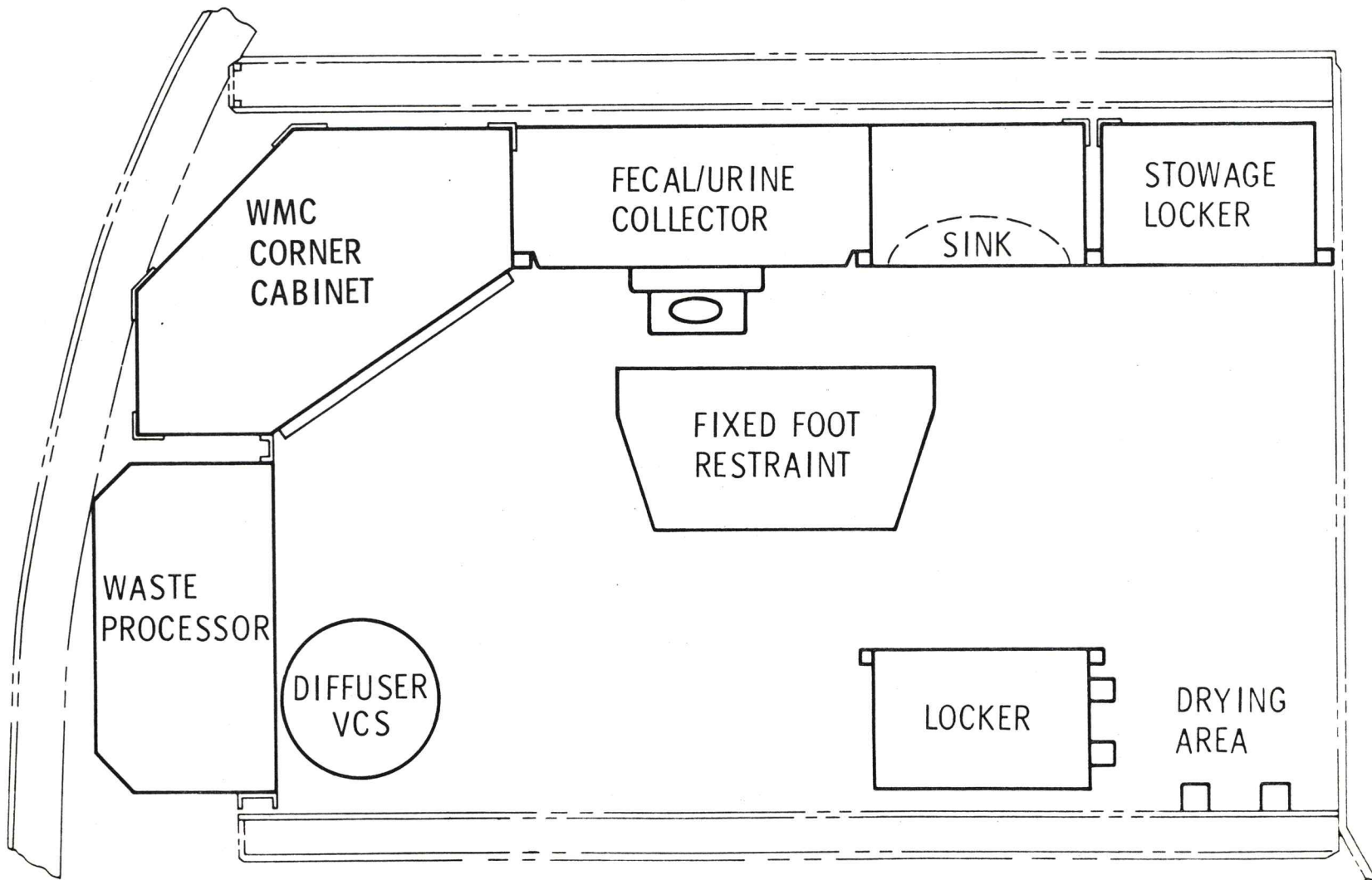


Figure 4210-16.

ORBITAL WORKSHOP HSS WASTE MANAGEMENT COMPARTMENT

O/W-2183B-1
8-8-70

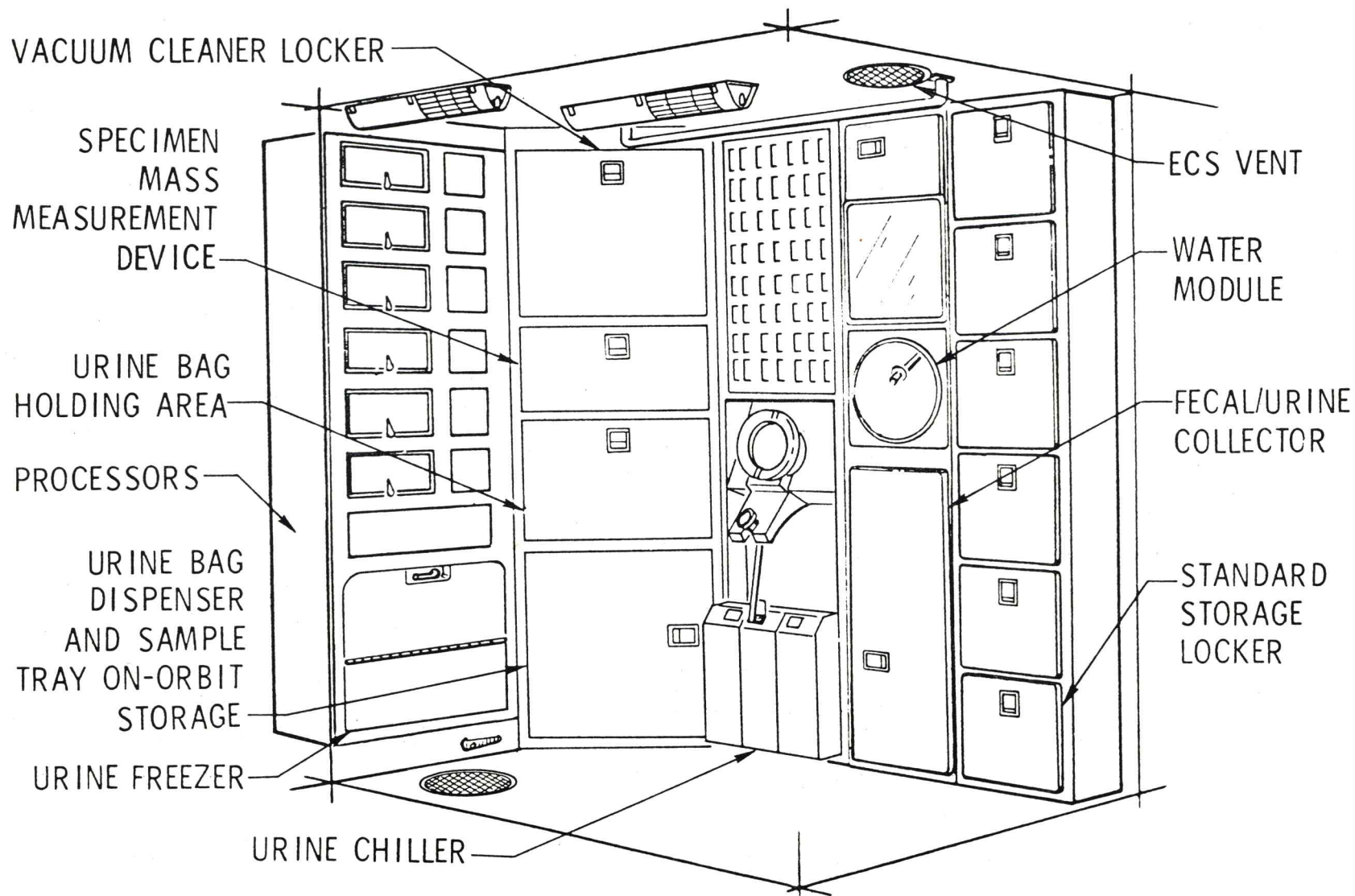


Figure 4210-17.

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ORBITAL WORKSHOP WMC ARRANGEMENT URINE BAG DISPENSER CONCEPT 1

O/W-8246
8-7-70

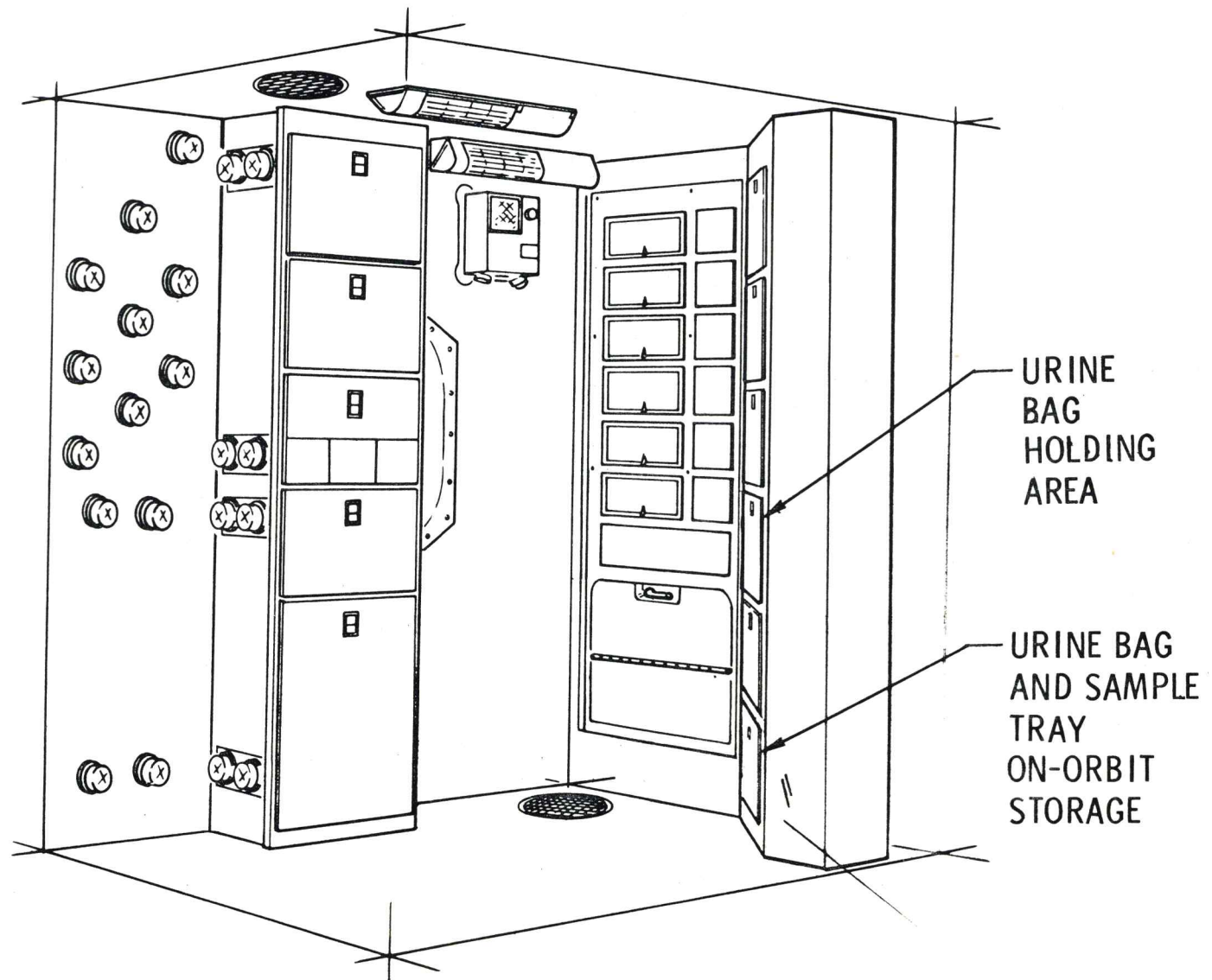


Figure 4210-18.

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ORBITAL WORKSHOP WARDROOM - PLAN VIEW

O/W-8309
8-7-70

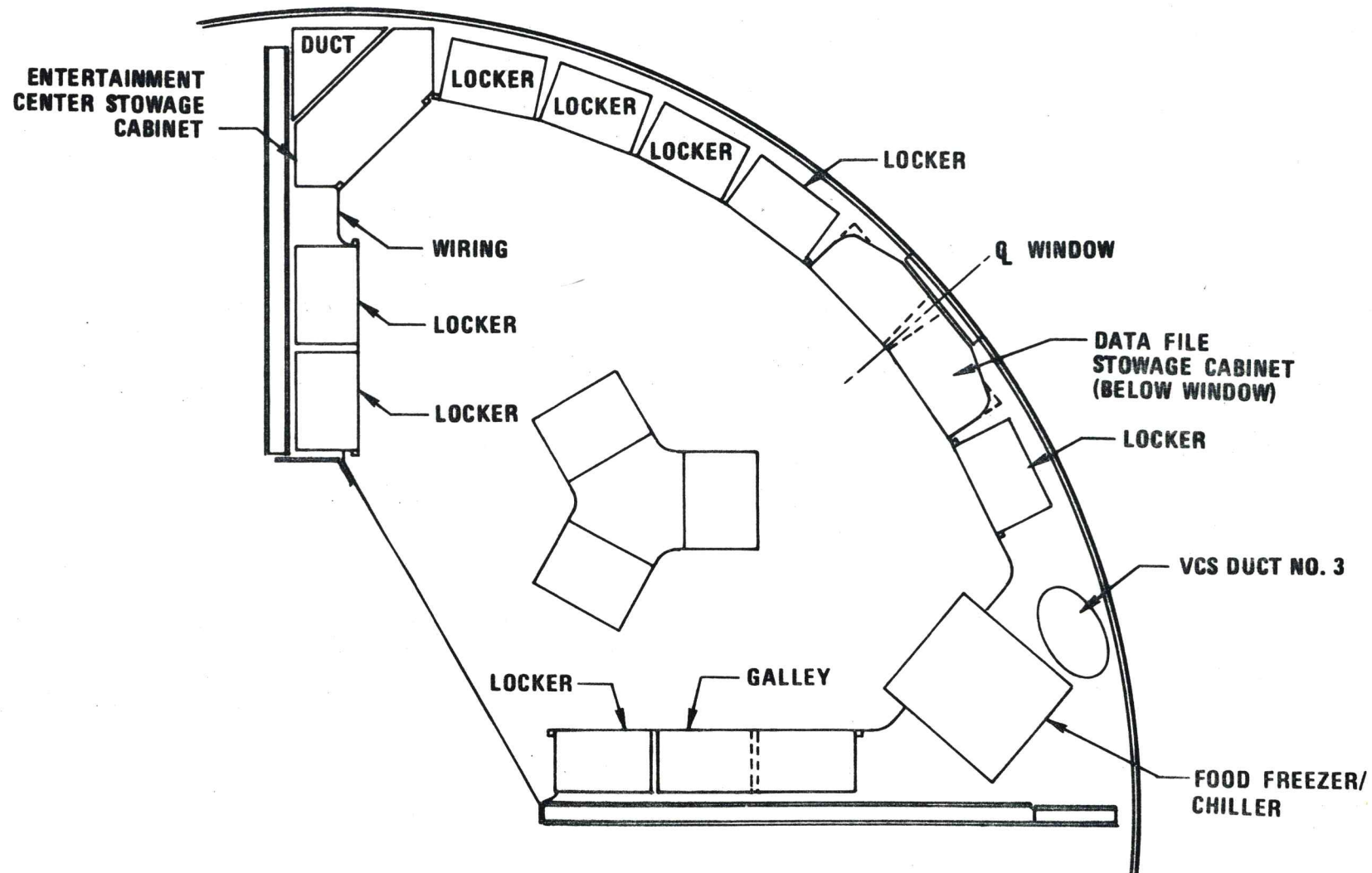
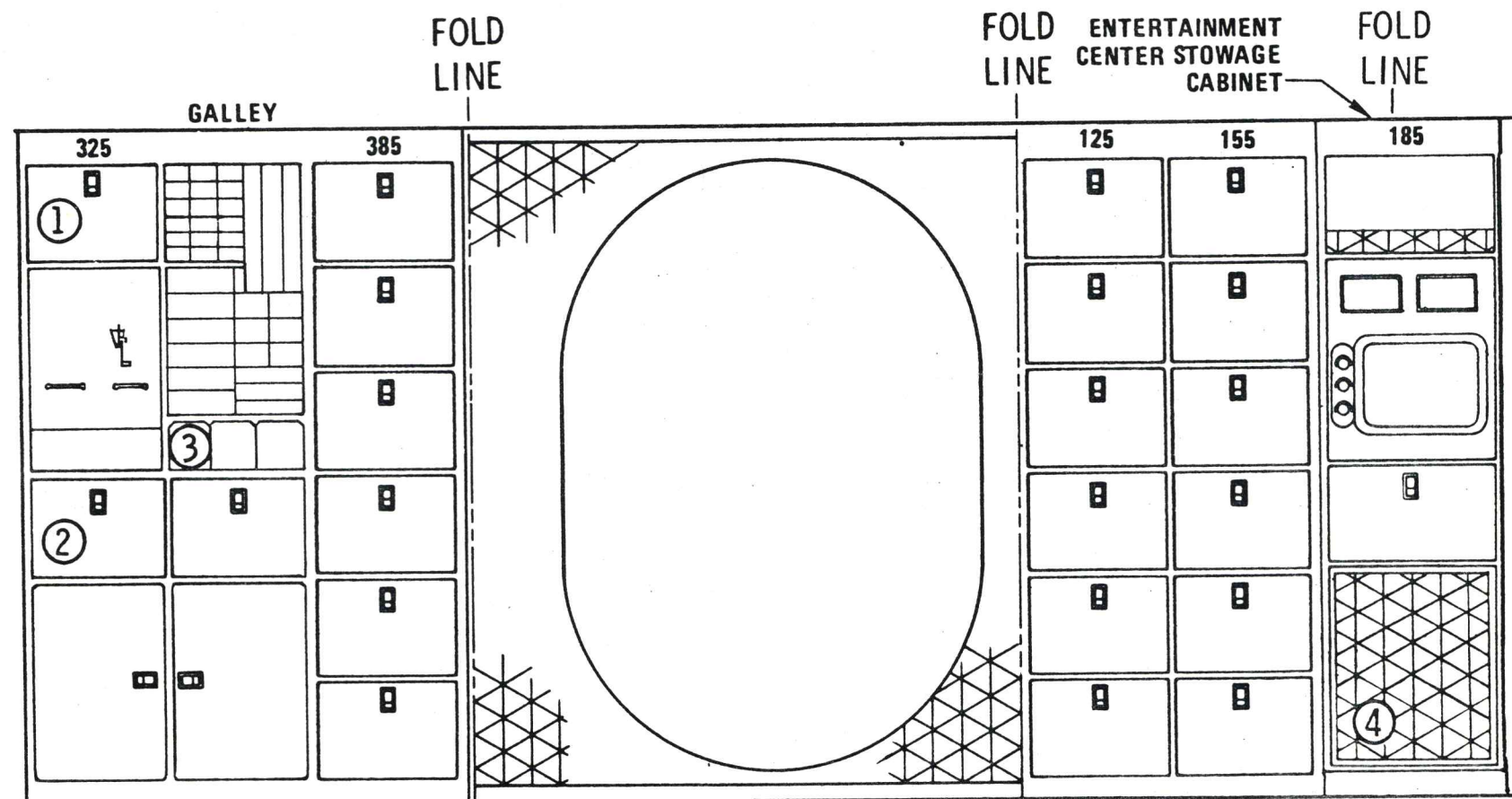


Figure 4210-19.

4434

ORBITAL WORKSHOP WARDROOM STOWAGE LOCATIONS

O/W-7224
8-8-70



① SMMD

② TRASH CONTAINER

③ TISSUEWIPES DISPENSER

④ OWS GROUND THERMAL CONDITIONING SYSTEM
COMPONENTS

Figure 4210-20.

ORBITAL WORKSHOP WARDROOM STOWAGE LOCATIONS

O/W-7224-1
8-7-70.

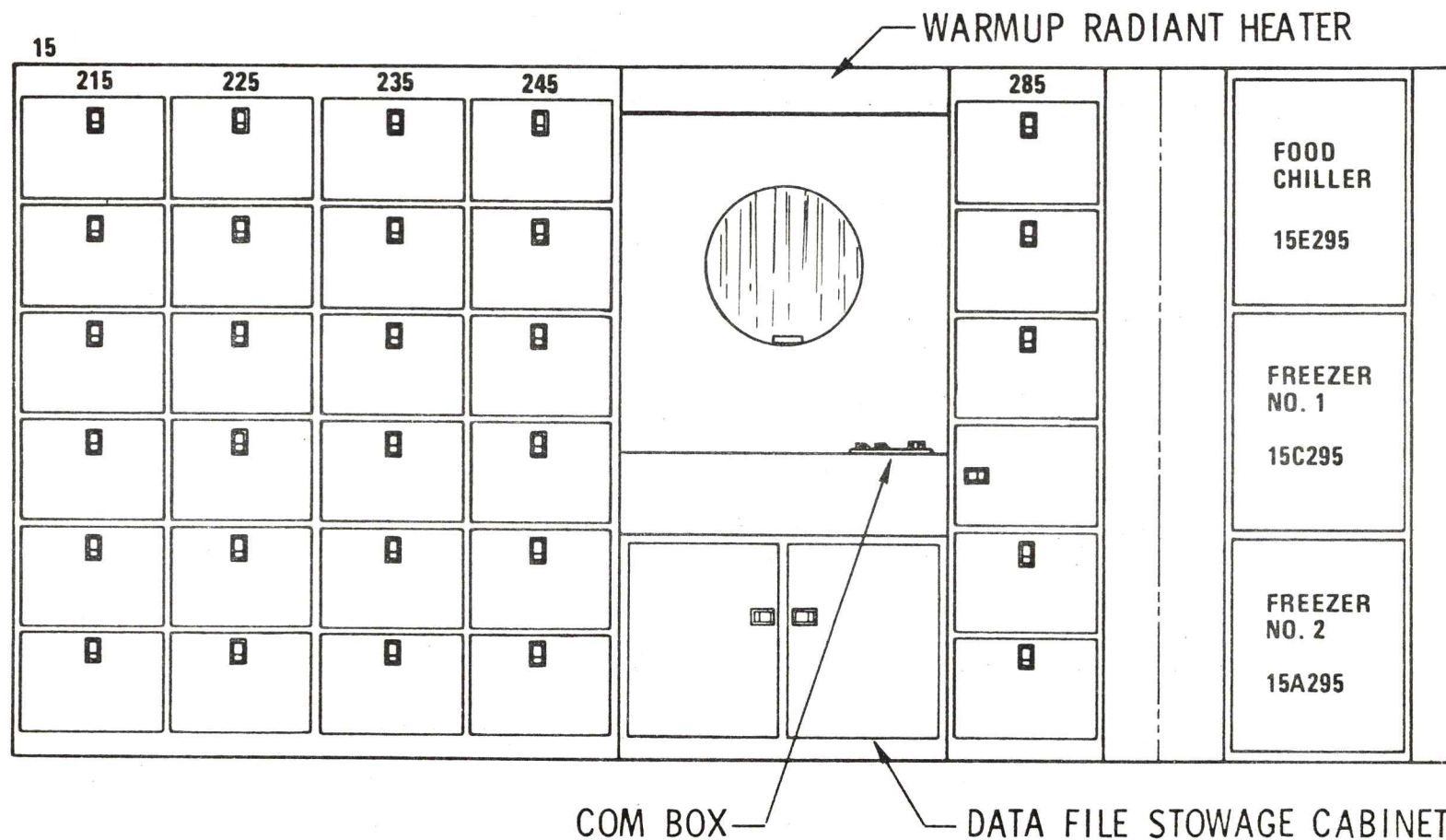
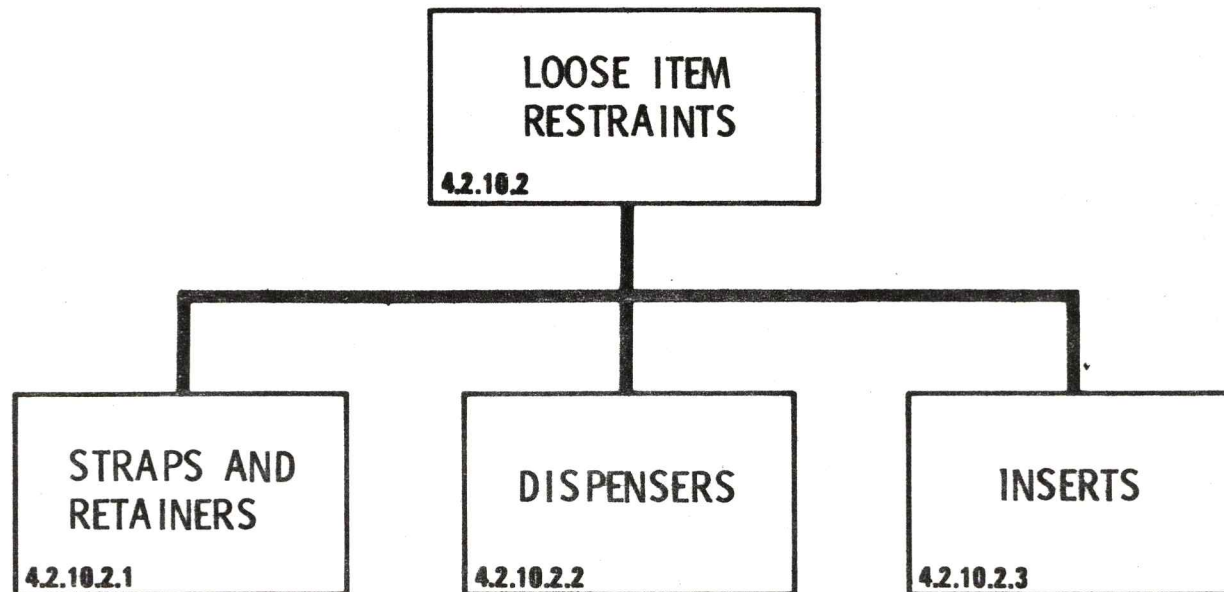


Figure 4210-21.

ORBITAL WORKSHOP LOOSE STEM RESTRAINTS

O/W-8924
8-8-70



LOOSE ITEM RESTRAINTS CONSIST OF THE HARDWARE
ITEMS NECESSARY FOR THE RESTRAINT AND PACKING
OF EQUIPMENT WITHIN THE STOWAGE PROVISIONS
(e.g., LOCKERS, CONTAINERS).

4.2.10.2 Loose Item Restraints

Loose item restraints consist of the following categories of equipment required for restraint and packing of loose equipment within the OWS:

- a. Straps and retainers.
- b. Dispensers.
- c. Inserts.

4.2.10.2.1 Straps and Retainers

Multi-length straps are provided for restraining items, such as resupply bundles, crew clothing, etc. within stowage compartments. One end of each strap is provided with a metal plate for attachment to the stowage compartment structure; the other end has a buckle, velcro, or a finished edge to accommodate particular stowage applications. All straps are constructed of flourel-coated beta webbing. Some of the straps are preinstalled as an integral part of packing inserts (reference paragraph 4.2.10.2.3).

Retainers are provided for retention of various items, such as film and dispenser hardware within stowage compartments. These retainers are constructed of either sheet metal clips or velcro patches.

4.2.10.2.2 Dispensers

There are two basic types of dispensers, (1) a dispenser integral with loose equipment item (reference paragraphs 4.2.7.3.2 and 4.2.7.3.4), and (2) a dispenser preinstalled in the stowage compartment. The dispenser which is integral with the loose equipment consists of a sheet metal enclosure with the back end completely closed and the front end partially open to allow access to the items to be dispensed. A coiled spring is attached to the inside, rear of the compartment to force the items to the front of the dispenser as the quantity is diminished. Another dispenser design integral with the stowed items consists of an adjustable strap capable of retaining the items in position as the quantity is diminished.

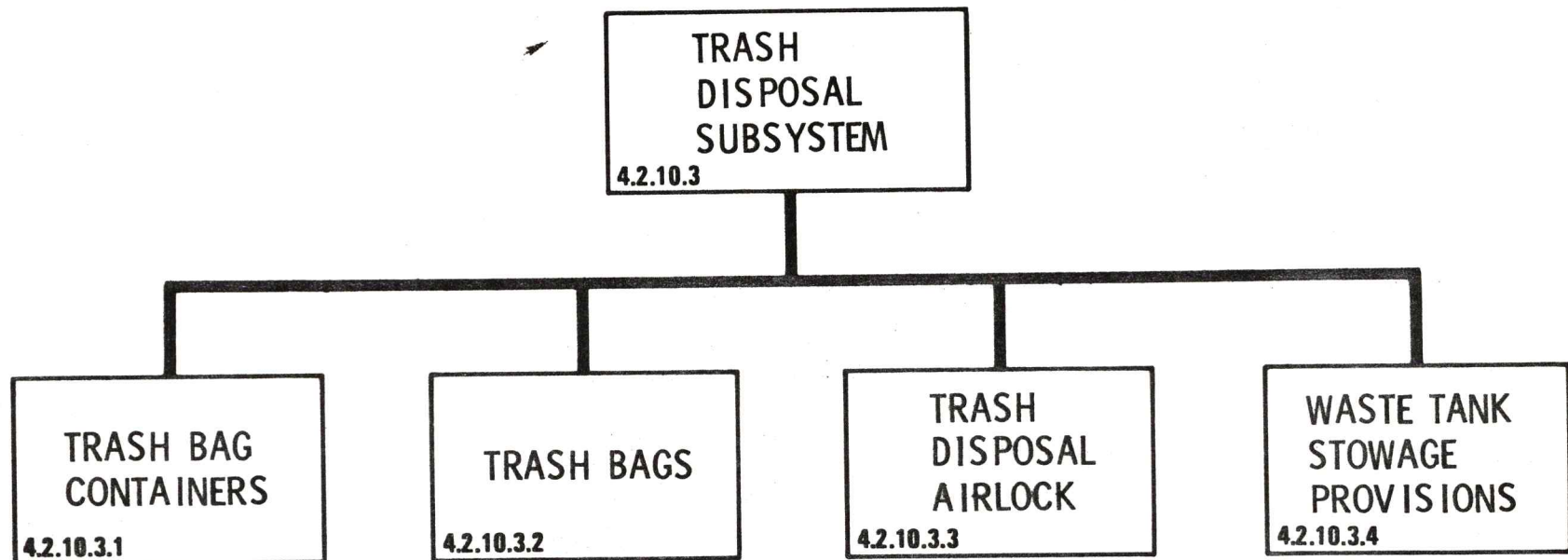
Preinstalled dispensers are permanently installed within the stowage compartments and provide spring-loaded dispensing, partitions, or strap dispensing.

4.2.10.2.3 Inserts

Inserts consist of items required to protect stowed equipment from damage during launch. Packing material and internal supports are examples of inserts.

ORBITAL WORKSHOP TRASH DISPOSAL SUBSYSTEM

O/W-4619
8-8-70



THE TRASH DISPOSAL SUBSYSTEM PROVIDES THE EQUIPMENT
REQUIRED FOR THE COLLECTION, CONTAINMENT AND DISPOSAL
OF TRASH GENERATED IN THE OWS.

4.2.10.3 Trash Disposal Subsystem

The trash disposal subsystem includes the equipment and supplies required to manage the trash generated by the three crewmen for a total of 140 mission days. This subsystem includes the following items:

- a. Trash bag containers.
- b. Trash bags.
- c. Trash disposal airlock.
- d. Waste tank stowage provisions.

4.2.10.3.1 Trash Bag Containers

Trash bag containers (Figure 4210-22) are modified standard locker compartments which are configured to contain and restrain one trash bag. Trash bag containers are located as follows in the OWS:

| <u>Location</u> | <u>No. of Trash Bag Containers</u> |
|------------------------|------------------------------------|
| WMC | 1 |
| Wardroom | 1 |
| Sleep Compartment | 3 |
| Experiment Compartment | 1 |
| Forward Compartment | <u>1</u> |
| Total | 7 |

4.2.10.3.2 Trash Bags

There are two sizes and designs of trash bags. The one type of bag consists of a vented teflon assembly approximately 11 inches in diameter and 15 inches long. An elastic, split diaphragm mounted in the cylindrical portion of the bag provides access into the bag. The diaphragm restraint also provides mounting provisions for the bag to the locker door. When a bag has been filled with trash or requires disposal, it is removed from the trash bag container, placed in the trash lock and transferred into the waste tank. An integral adhesive flap seals the split diaphragm to prevent trash escaping into the airlock during transfer. An unused trash bag is then removed from stowage and placed in the trash bag container.

Hardware items comprising this trash bag are:

- a. Vented teflon assembly.
- b. Integral elastic split diaphragm.
- c. Integral diaphragm cover flap.

ORBITAL WORKSHOP TRASH CONTAINER AND BAG

O/W-8685
8-5-70

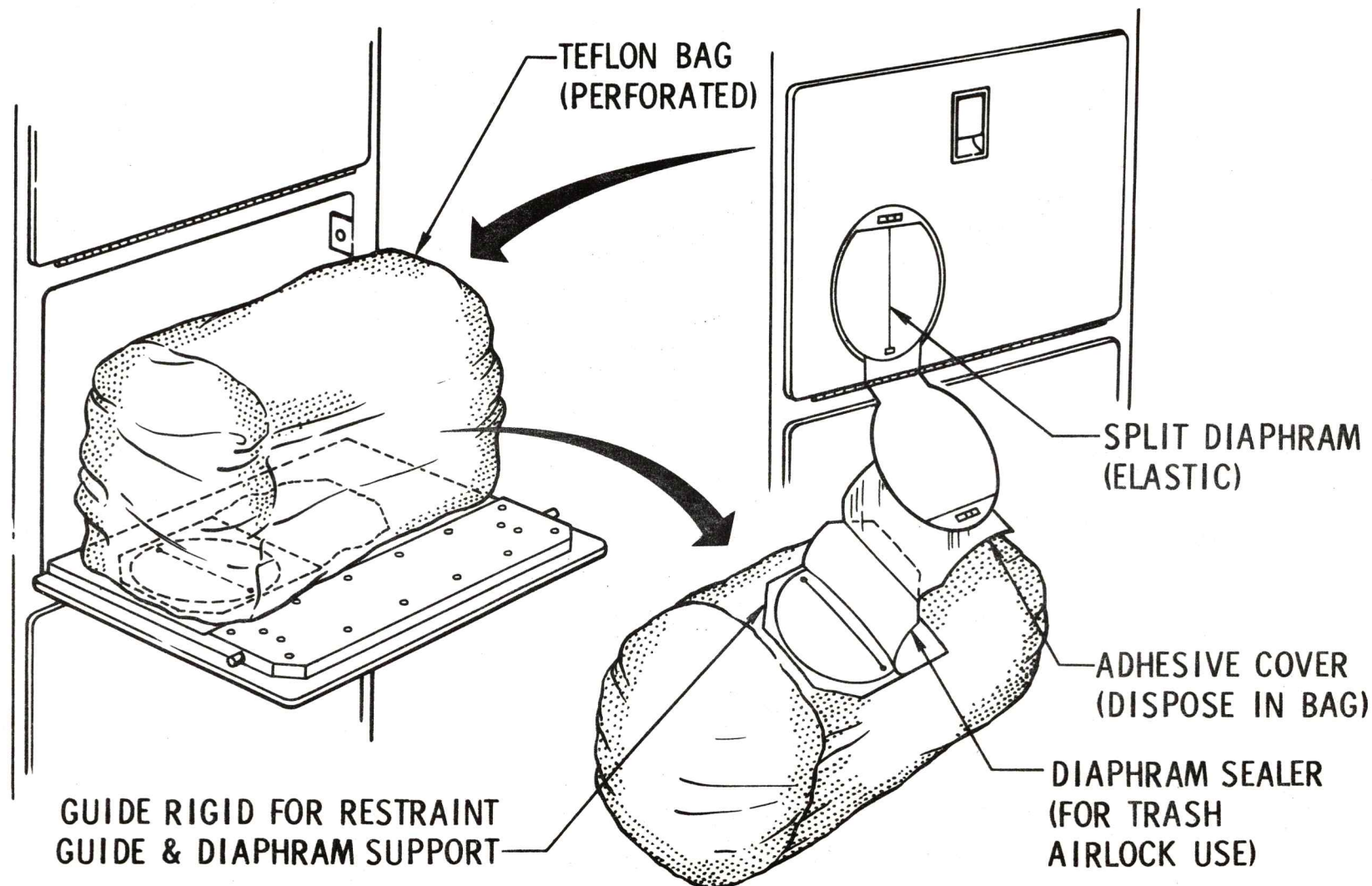


Figure 4210-22.

The second bag is a vented teflon assembly approximately 13.5 inches in diameter by 21 inches long (open). The bag is cylindrical and open at one end. The open end contains integral stiffeners which permit the bag to be closed, folded over on the stiffeners, and snapped to provide an effective seal. The bag is designed to accommodate, for disposal through the trash airlock, any objects too large to pass into the locker-contained trash bag. To load the bag, it is suspended from wall mounted clips located in the WMC and the wardroom. The method of disposal is identical to the first trash bag. The bag is removed from its storage compartment, loaded, and disposed of on an as-required basis.

Hardware items comprising this trash bag are:

- a. Vented teflon assembly.
- b. Integral stiffeners.
- c. Closure tab.

4.2.10.3.3 Trash Disposal Airlock

The trash disposal airlock (Figure 4210-23), consists of a chamber between the crew quarters experiment compartment and the waste tank. Pressure-tight hatches are located at the inboard and outboard ends of the airlock.

During use, the outboard hatch (eyelid) between the airlock and the waste tank is closed. The airlock pressure is equalized to that of the OWS. The inboard hatch between the airlock and the OWS is opened, and the trash bags to be disposed are inserted. The inboard hatch is closed and latched and the trash airlock is vented to vacuum (i.e., the waste tank). The outboard hatch is opened and the trash ejector forces the trash into the waste tank. After the trash has been ejected, the ejector is returned to the stowed position and the outboard hatch is closed (the airlock is left unpressurized).

Hardware items comprising the trash disposal airlock are:

- a. Chamber structure.
- b. Inboard hatch.
- c. Outboard hatch (eyelid).
- d. Trash ejector.
- e. Outboard hatch activation mechanism.
- f. Pressurization valve.
- g. Pressure gage.

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ORBITAL WORKSHOP TRASH LOCK VENT TO VACUUM

O/W-7824
8-11-70

INBOARD HATCH LATCH
LATCHED POSITION
INTERLOCK DISENGAGED

DE-PRESSURIZE
POSITION

TRASH EJECTOR
(RETRACTED)

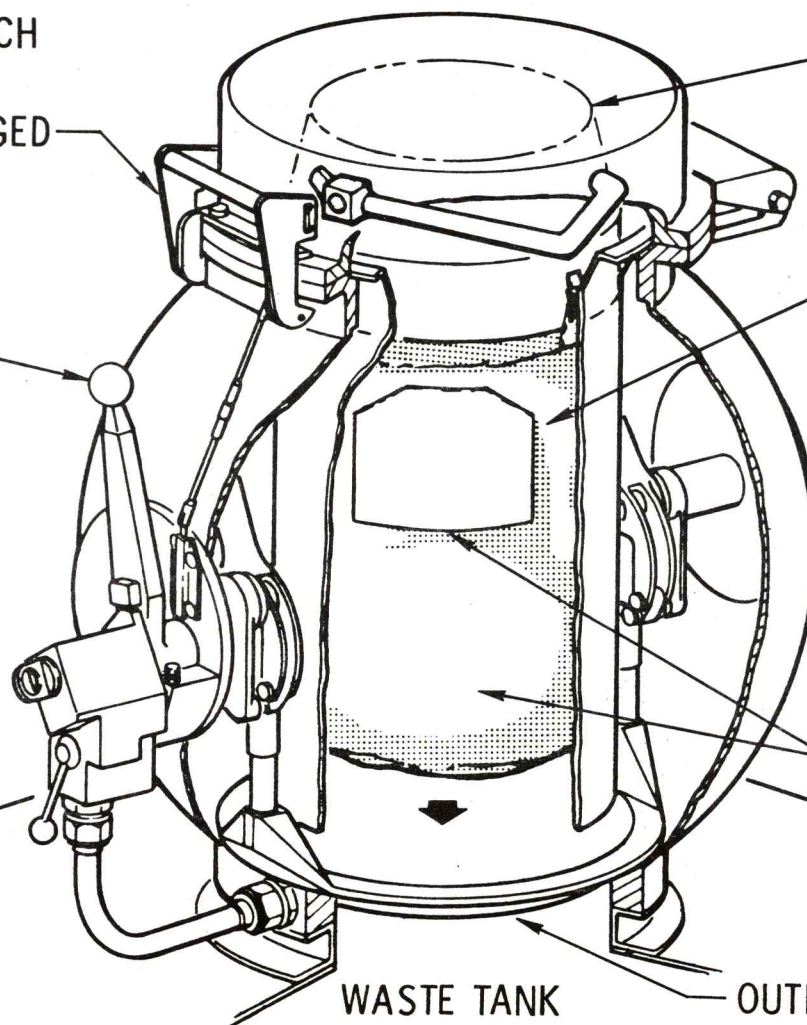
TRASH BAG
READY FOR EJECTION
RESTRAINED BY CLIPS

CREW QUARTERS

SHOW NEW BAG
IN UPPER POSITION

WASTE TANK

OUTBOARD HATCH CLOSED



4-443

Figure 4210-23. (Sheet 1 of 3)

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ORBITAL WORKSHOP TRASH LOCK TRASH BAG EJECT

O/W-7825
8-11-70

INBOARD HATCH LATCH
CLOSED, INTERLOCKED
POSITION

EJECTOR HANDLE
EJECT POSITION

TRASH
EJECTOR (DEPLOYED)

OUTBOARD HATCH
OPEN

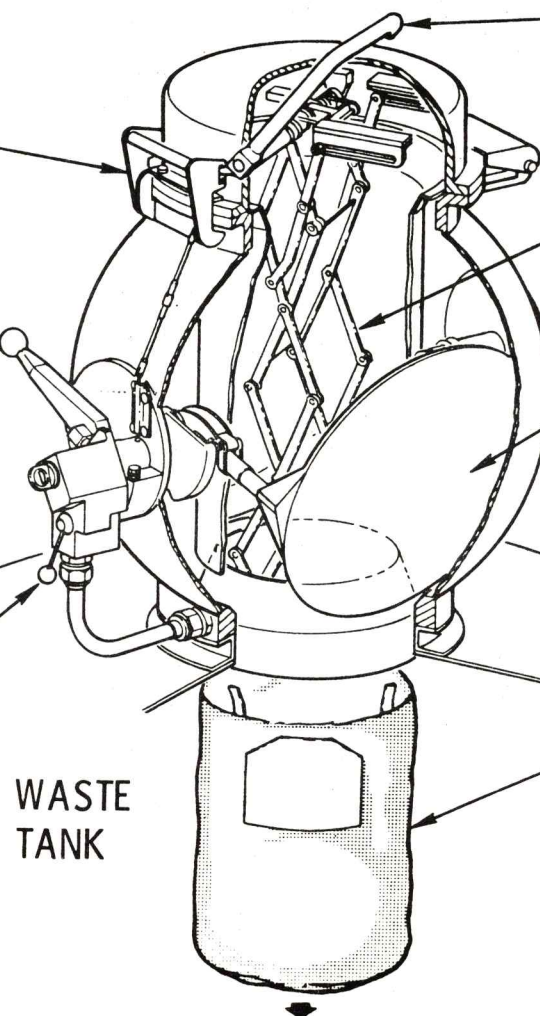
CREW QUARTERS

VALVE HANDLE
OUTBD HATCH
OPEN POSITION

EMERGENCY
VACUUM
SHUTOFF
VALVE OPEN
POSITION

WASTE
TANK

TRASH BAG EJECTED



4-444

ORBITAL WORKSHOP TRASH LOCK LOADING EQUALIZE PRESSURE

O/W-7826
8-11-70

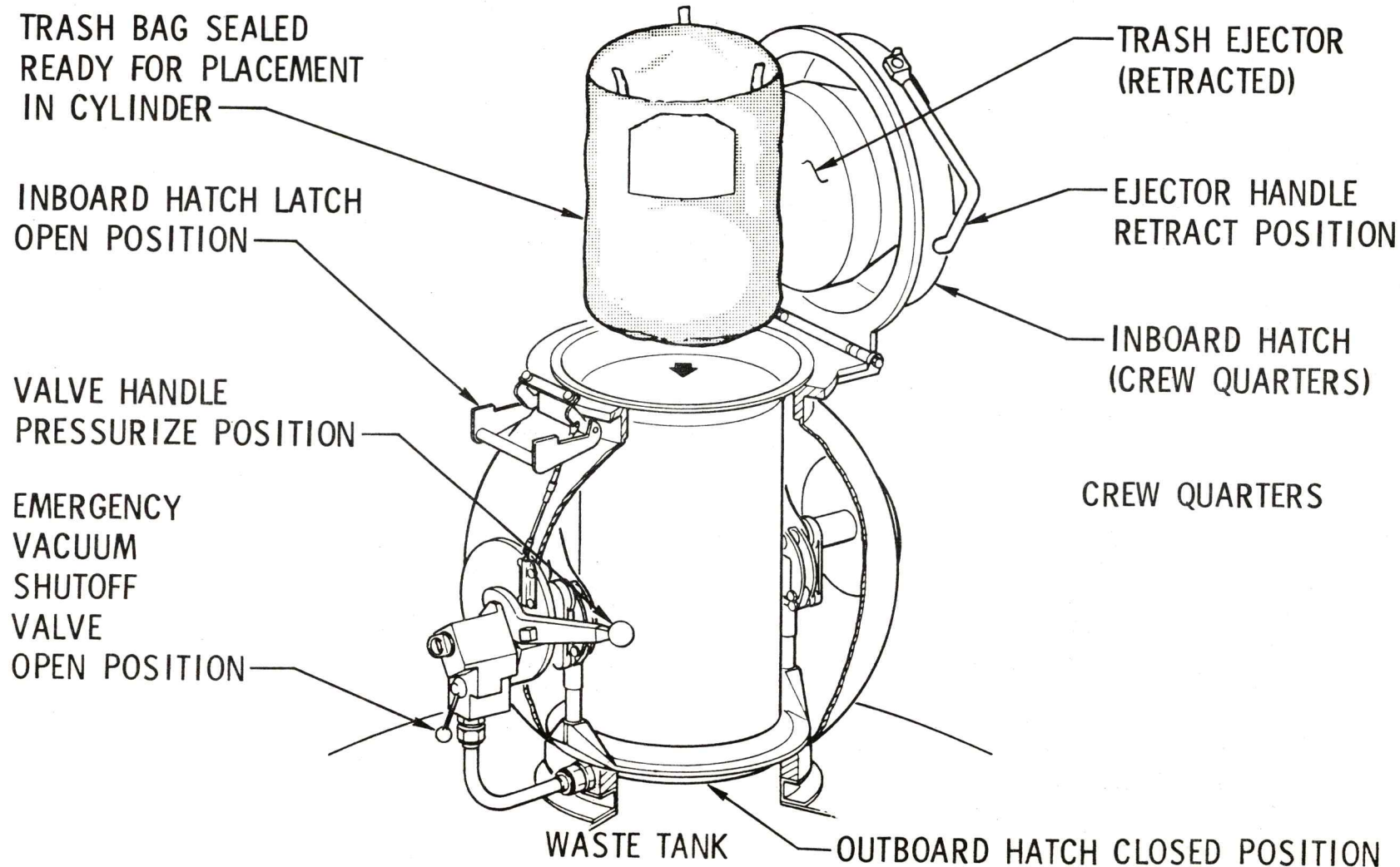


Figure 4210-23. (Sheet 3 of 3)

4.2.10.3.4 Waste Tank Stowage Provisions

The waste tank is separated into three areas by screens for trash disposal (Figure 4210-24). These three areas are:

- a. Dry waste (trash) disposal area.
- b. Liquid disposal area.
- c. Processor exhaust area.

The purpose of the waste tank screening is to prevent waste material from coming in contact with the waste tank nonpropulsive vent system, possibly clogging the vent.

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ORBITAL WORKSHOP WASTE TANK

O/W-7496
5-14-70

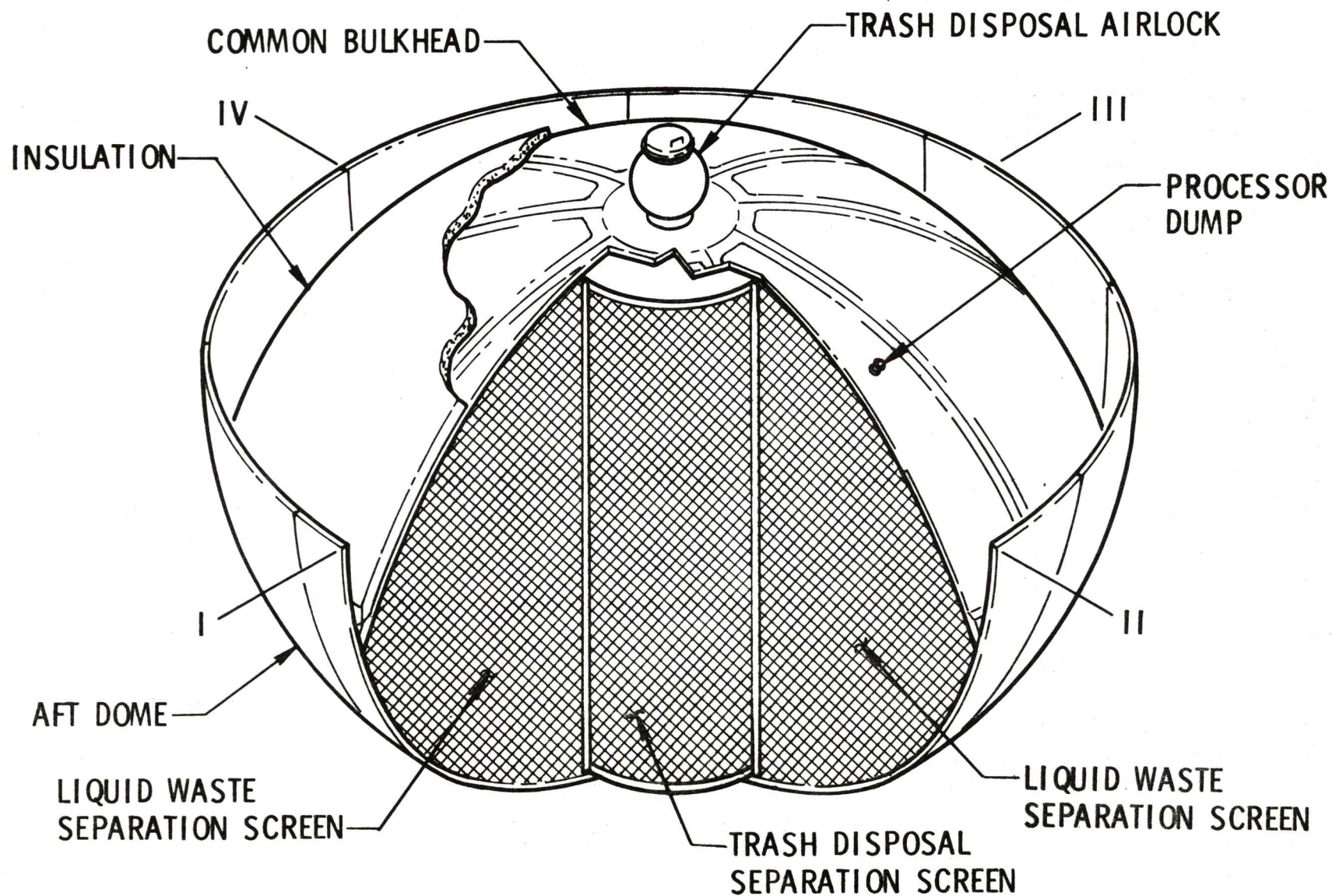
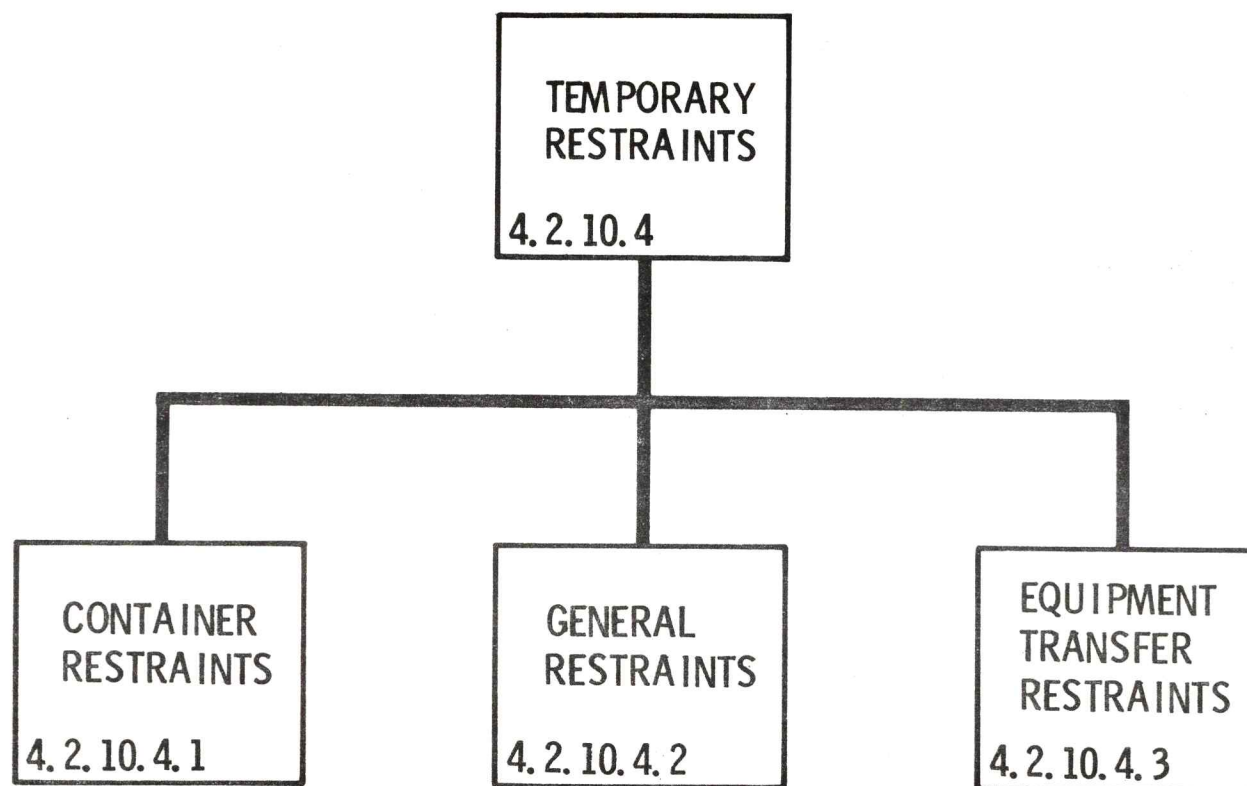


Figure 4210-24.

ORBITAL WORKSHOP TEMPORARY RESTRAINTS

O/W-8925
8-8-70



4.2.10.4 Temporary Restraints

Temporary restraints consist of the following types of equipment used for temporary stowage, retention, or transfer of equipment within the OWS:

- a. Container restraints.
- b. General restraints.
- c. Equipment transfer restraints.

4.2.10.4.1 Container Restraints

Container restraints consist of straps which restrain the container to the grid. They are constructed of flourel-coated beta webbing with snaps at each end to engage the grid, and a take-up buckle in the center.

4.2.10.4.2 General Restraints

There are two types of general restraints. One type is used to attach the Apollo temporary stowage bag to the grid or to the crewman's leg. It is also used to restrain cables to the grid or to any area where snaps are located.

These general restraints consist of flourel-coated beta webbing with snaps one one surface and velcro hook and pile on the other.

The other type of general restraint is a "bungee-type" consisting of a coiled spring center and webbing ends equipped with hooks and snaps (Figure 4210-25). The hooks and snaps engage the grid or locker compartment doors for restraint of loose items such as logbooks, crew clothing, etc. Two different lengths of each type of general restraint are provided.

4.2.10.4.3 Equipment Transfer Restraints

Equipment transfer restraints are used to transfer equipment, such as food cans, launch pins, etc., throughout the OWS. One type of equipment transfer restraint adapts the Apollo temporary stowage bag to the crewman's tether belt utilizing the general restraints. Another type of equipment transfer restraint consists of a separate bag which also attaches to the crewman's tether belt. This bag is used to collect items, such as launch pins that are removed during OWS activation. The bag consists of beta material and has straps and snaps for attachment to the grid.

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ORBITAL WORKSHOP STOWAGE SUBSYSTEM ON-ORBIT STOWAGE

O/W-4618
11-24-69

STOWAGE RESTRAINTS

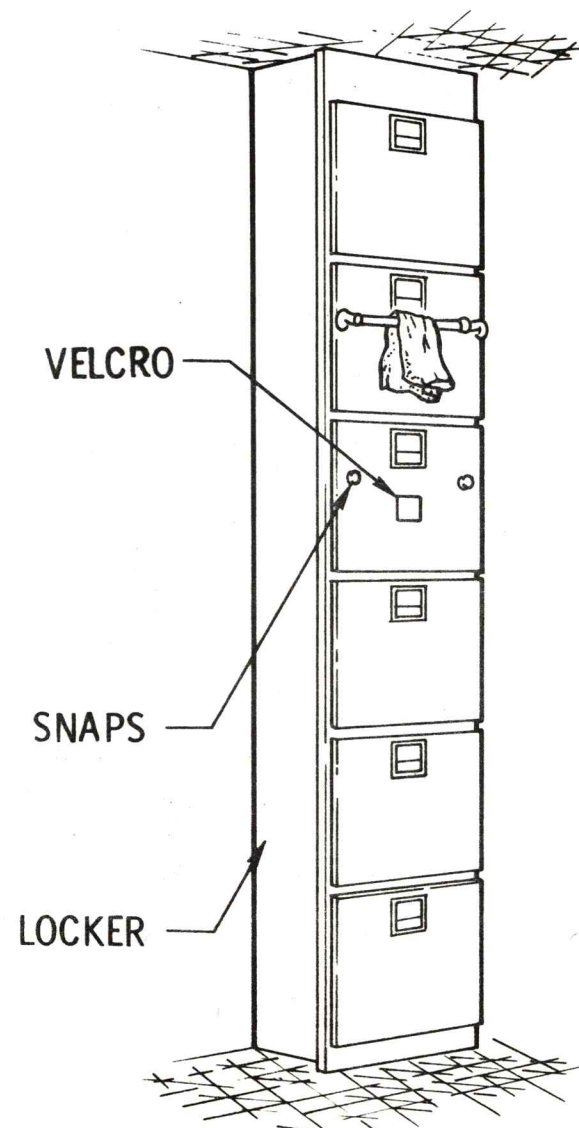
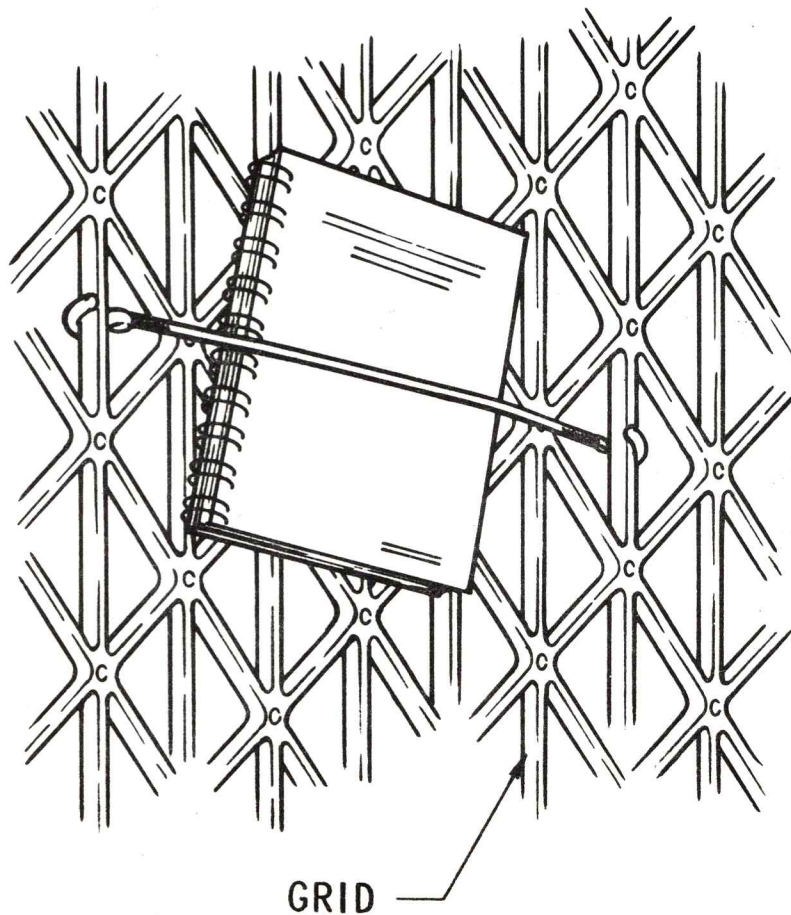


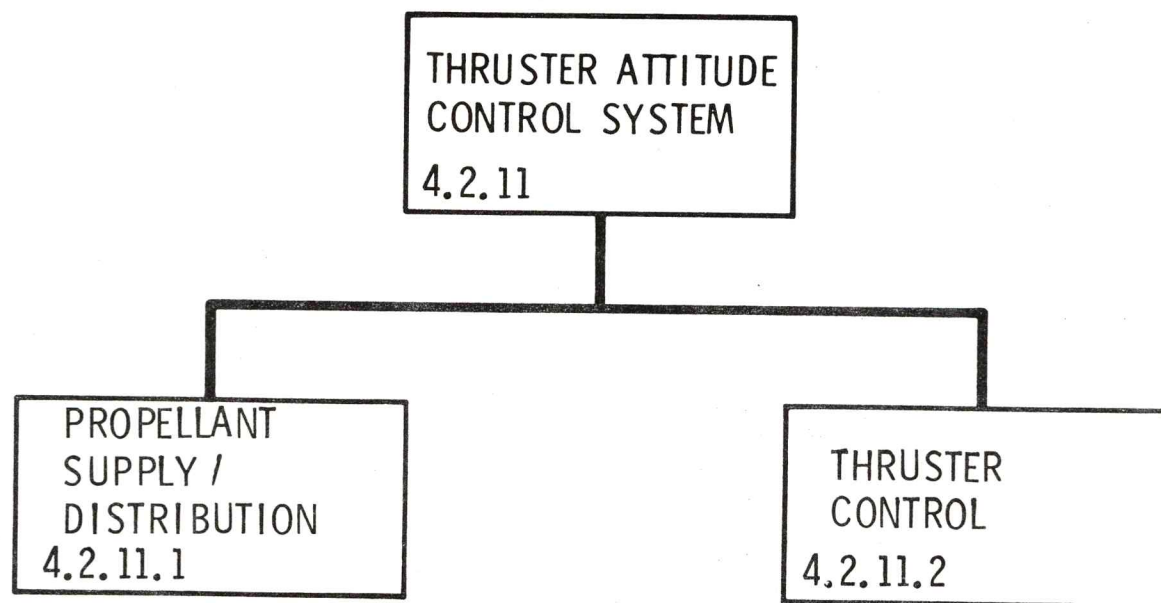
Figure 4210-25.

THRUSTOR ATTITUDE
CONTROL SYSTEM

THRUSTOR ATTITUDE CONTROL SYSTEM

ORBITAL WORKSHOP

O/W-5046
6-16-70



4.2.11 Thruster Attitude Control System

The OWS Thrust Attitude Control System (TACS) provides primary attitude control of the SWS following SII separation until the Control Moment Gyros (CMG) are sufficiently spun-up to allow transfer of attitude control from the TACS to a "nested" TACS/CMG mode of operation. The TACS is used during the following phases and conditions:

- a. During CMG spinup (the IU provides attitude control signals to the TACS up to a maximum time of 7.5 hours, guaranteed IU lifetime), the TACS is the primary control system.
- b. Whenever the TACS control system deads and is exceeded (± 1.0 degree attitude error and ± 0.1 degrees/second rate crossover) or the CMG momentum buildup exceeds TBD percent of maximum capability.
- c. Whenever the "TACS only" mode is selected by the crew.
- d. In the event of a CMG failure, as detected by the redundancy management scheme. The TACS will take over control of the SWS, and the CMG's will be commanded to a zero momentum configuration.

The performance characteristics of the TACS are:

- a. The minimum individual nozzle thrust at the start of the mission is 50 pounds.
- b. The individual thrusters respond to a 40-millisecond command pulse with an impulse bit no greater than 7.25 pound-seconds (at the maximum thrust level), and to a 110-millisecond command pulse with an impulse bit of no less than 0.5 pound-seconds at the minimum thrust level. The thrusters have the capability to respond to minimum command pulses of 36 milliseconds.
- c. The individual thrusters provide a minimum thrust of 20 pounds when no more than 47,000 pound-seconds of the total system impulse has been used, and provide a minimum thrust of 10 pounds when no more than 61,000 pound-seconds of the total system capability has been used.

Table 4211-1 presents a detailed breakdown of TACS impulse usage.

The TACS configuration (Figure 4211-1) features:

- a. Cold gas propellant (gaseous nitrogen blowdown system).
- b. Storage spheres located on the thrust structure protected by a meteoroid shield.
- c. Two thruster modules of three thrusters each, located on the aft skirt at Position Planes I and III.
- d. A control switching assembly.

Table 4211-1
TACS IMPULSE REQUIREMENTS

| Event | Impulse per Event (16-sec) | | Times | Total Impulse (16-sec) | |
|--|-------------------------------|--------------------------|-------|---------------------------|---------------------------|
| | Max Maneuver Rate | Max Maneuver Rate* | | Max Maneuver Rate | Max Maneuver Rate** |
| S-II/SWS Separation | 5,800 | 4,500+ | 1 | 5,800 | 4,500+ |
| Blowdown | 780 | | 1 | 780 | |
| Maneuver to Retrograde | 980 | | 1 | 980 | |
| Jettison Payload Shroud | 50 | | 1 | 50 | |
| Deploy ATM | 50 | | 1 | 50 | |
| Deploy ATM Solar Arrays | 50 | | 1 | 50 | |
| Deploy OWS Solar Array | 50 | | 1 | 50 | |
| Acquire Solar Inertial | 540 | | 1 | 540 | |
| Hold LHR (1/4 orbit) | 50 | | | | |
| Roll 180 \pm 8 deg | 450 | | | | |
| Remove Orbital Pitch Rate | 40 | | | | |
| CMG Spinup | 4,050 | | 1 | 4,050 | |
| Hold SI (6 orbits) | 3,780 | | | | |
| Absorb CMG Momentum | 270 | | | | |
| Z-LV Rendezvous | TBD | | 3 | TBD | |
| CSM Docking | 3,750 | 3,000 | 3 | 11,250 | 9,000 |
| Unsuccessful | 1,800 | 1,420 | | | |
| Successful | 1,450 | 1,130 | | | |
| CMG Gain Inefficiency | 500 | | | | |
| CSM Undocking (CMG Gain Inefficiency) | 500 | | 2 | 1,000 | |
| Z-LV ER (3 CMGs) | TBD | | 9 | TBD | |
| Z-LV ER (2 CMGs) | TBD | | 36 | TBD | |
| CMG Backup with CSM | 3,800 | 2,440 | 3 | 11,400 | 7,320 |
| Cage CMGs | 270 | | | | |
| Acquire SI | 2,040 | | | | |
| Hold SI (2 orbits) | 1,380 | | | | |
| Vent | 110 | | | | |
| CMG Backup without CSM | 2,800 | 1,780 | 2 | 5,600 | 3,560 |
| Cage CMGs | 270 | | | | |
| Acquire SI | 1,530 | 510 | | | |
| Hold SI (2 orbits) | 1,000 | | | | |
| Subtotal ² | | | | 41,600 | 31,930 |
| Contingency (10%) | | | | 4,160 | 3,190 |
| Total ² | | | | 45,760 | 35,120 |

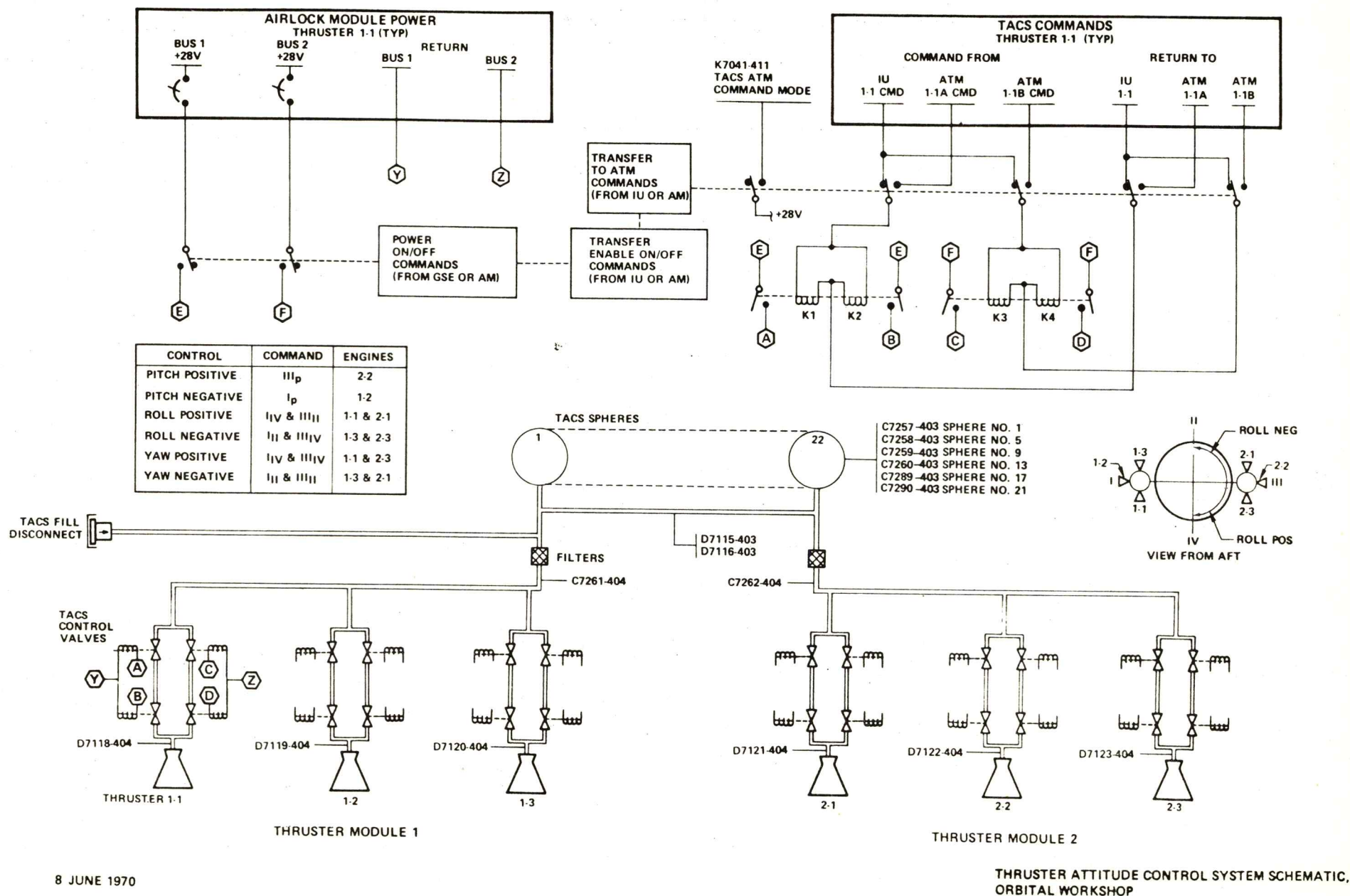
* Maximum possible maneuver rate is 0.3 deg/sec; minimum desirable maneuver rate is 0.1 deg/sec.

** Does not include impulse requirements for Z-LV Earth Resources Experiments and Rendezvous

+ This number is reduced by considering all four retrorockets operating rather than one retrorocket out, and is not a function of maneuver rate.

O/W-8135
6-17-70

4-454



8 JUNE 1970

Figure 4211-1. (Sheet 1 of 3)

ORBITAL WORKSHOP TACS-MANIFOLD INSTALLATION

O/W-4462
5-7-70

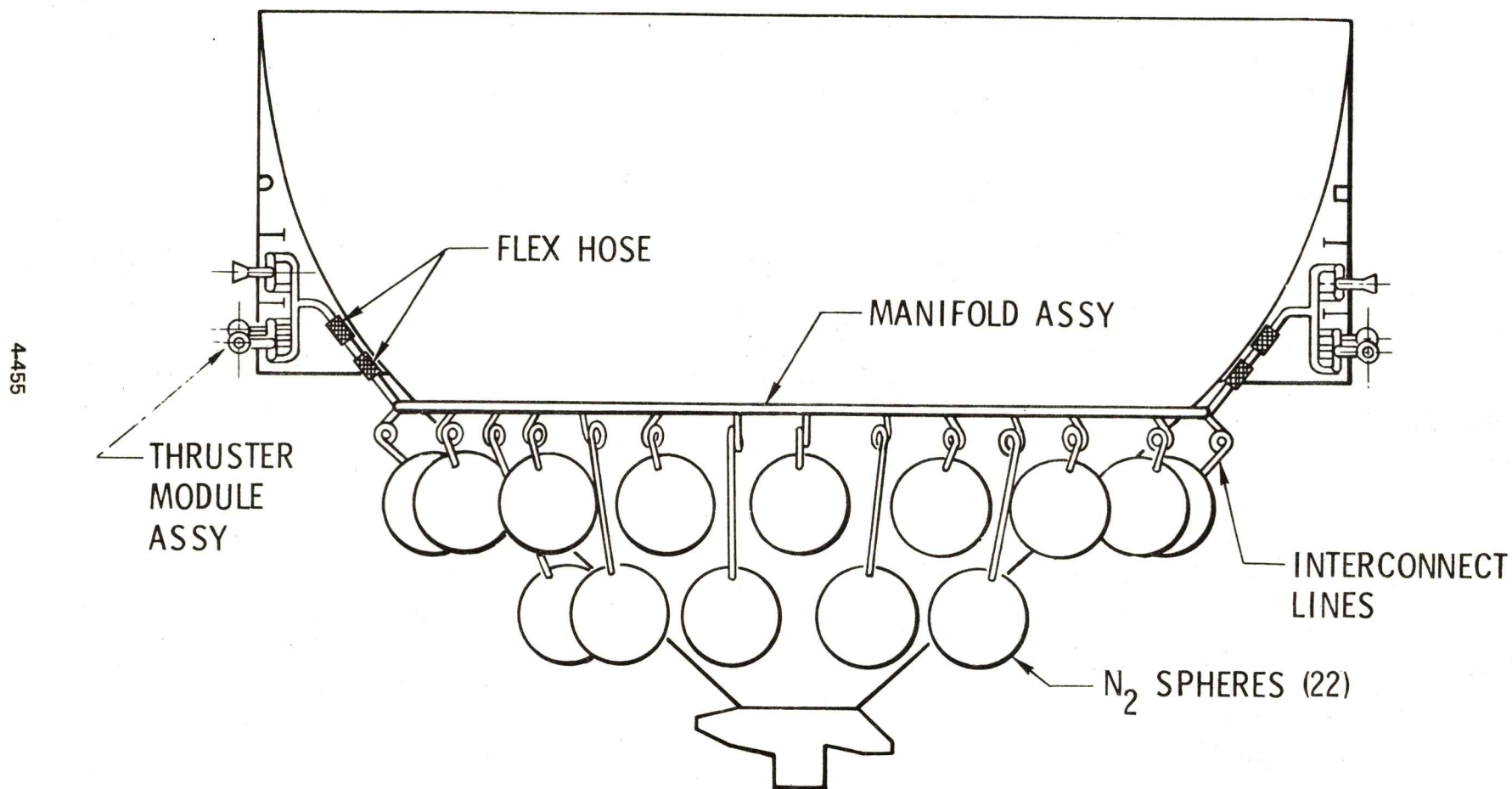


Figure 4211-1 (Sheet 2 of 3)

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ORBITAL WORKSHOP TACS CONFIGURATION

O/W-3982
8-8-70

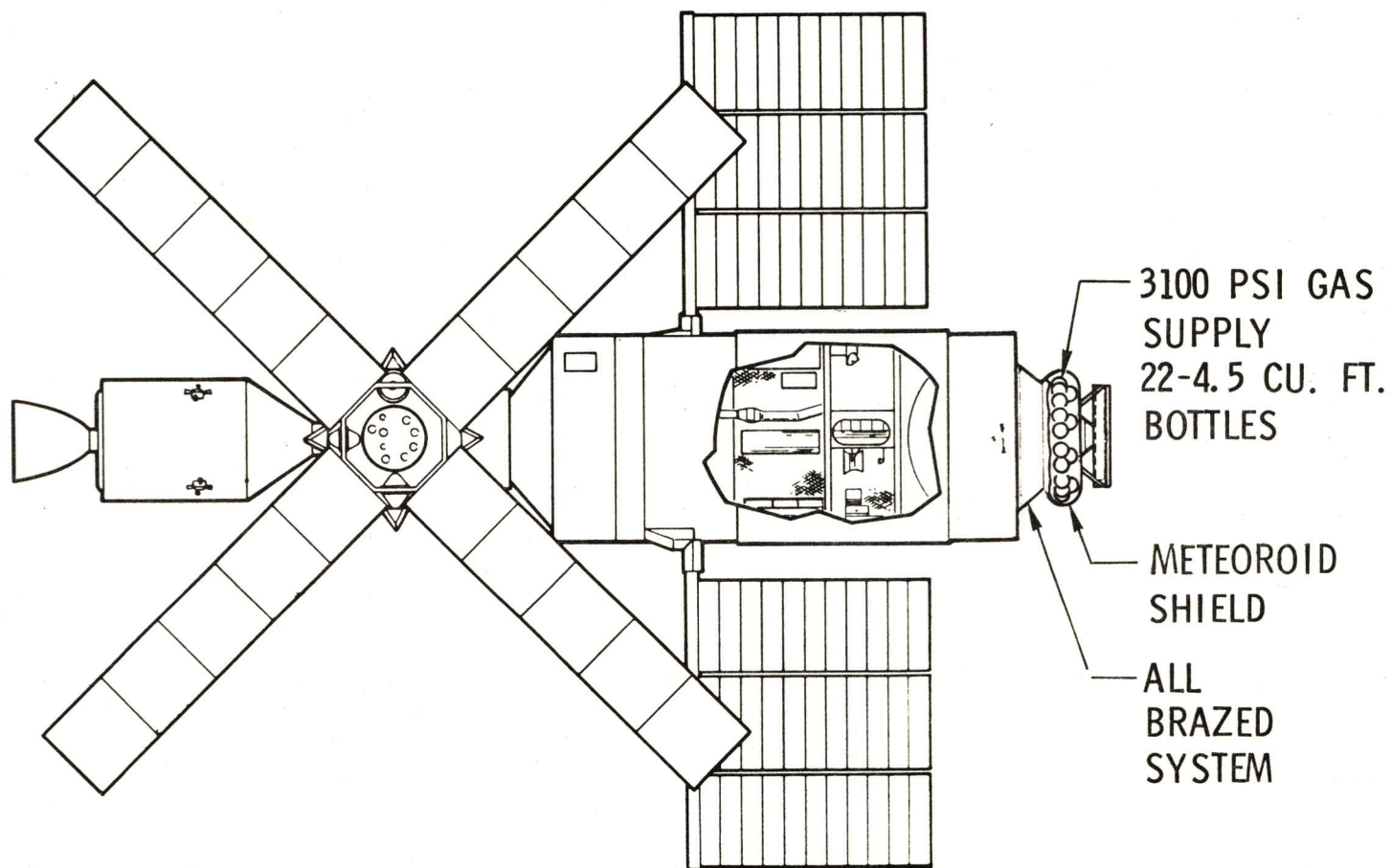


Figure 4211-1. (Sheet 3 of 3)

4.2.11.1 Propellant Supply/Distribution

The gaseous nitrogen propellant is stored at 3100 ± 100 psia in twenty-two (22), thrust structure mounted, 4.5 cubic foot spheres and distributed via a common manifold connecting the thruster modules. The propellant supply and distribution system is completely brazed to minimize leakage, shielded to preclude meteoroid penetration and passively protected from thermal extremes. The propellant supply includes sufficient reserve to compensate for anticipated system leakage. The minimum thrust (for one thruster) is shown in Figure 4211-2 as a function of total impulse consumed.

4.2.11.1.1 TACS Storage Spheres

The 4.5 cubic foot titanium sphere, Part No. 1B80321, currently used on S-IVB, meets all requirements. Twenty-two of the spheres are adequate for the required storage volume. A modification to the inlet fitting and addition of a bi-metal joint provides the capability of "in-place" brazing. The bi-metal joint, (Figure 4211-3) consisting of titanium and stainless steel (type 304L) fused together by extruding both thru a die, is welded into the sphere. This joint provides an interface between the titanium sphere and the stainless steel manifold tubing.

The spheres (Figure 4211-4) are mounted on the thrust structure using a "pan and straps" configuration. The 23 OWS spheres (22 TACS spheres plus one pneumatic control sphere) are mounted in the same manner requiring only a slight modification to the base of the pans due to the variation in stringer legs around the thrust structure. The addition of the 23 spheres requires reinforcing of the frames at Stations 171.50 and 155.94.

4.2.11.1.2 TACS Fill Disconnect

The nitrogen storage spheres are filled through a self sealing disconnect (Figure 4211-5) located at the vehicle skin. The disconnect is a manually operated, 1/4-inch tube size unit that is hard-capped prior to launch. Integral mounting provisions are provided as well as a 1/4-inch tube stub to permit "in-place" brazing to the sphere supply line. The maximum allowable leakage through the internal poppet with the disconnect capped less than 0.006 scim over the environmental temperature range of -150 to $+165^{\circ}\text{F}$ during exposure to space vacuum conditions for 237 days and during/after exposure to launch and boost environments. The design is identical to a disconnect used on the Command Service Module (CSM) except for changes in materials susceptible to stress corrosion.

4.2.11.1.3 TACS Filter

Two filters (Figure 4211-6) are utilized, one in each of the nitrogen transfer lines to the thruster modules. An existing S-IVB design, that utilizes a multilayer etched disc construction to provide in depth filtration, is modified to provide tube stubs at both inlet and outlet ports for "in-place" brazing.

ORBITAL WORKSHOP THRUSTER ATTITUDE CONTROL SYSTEM

O/W-4386-1
5-15-70

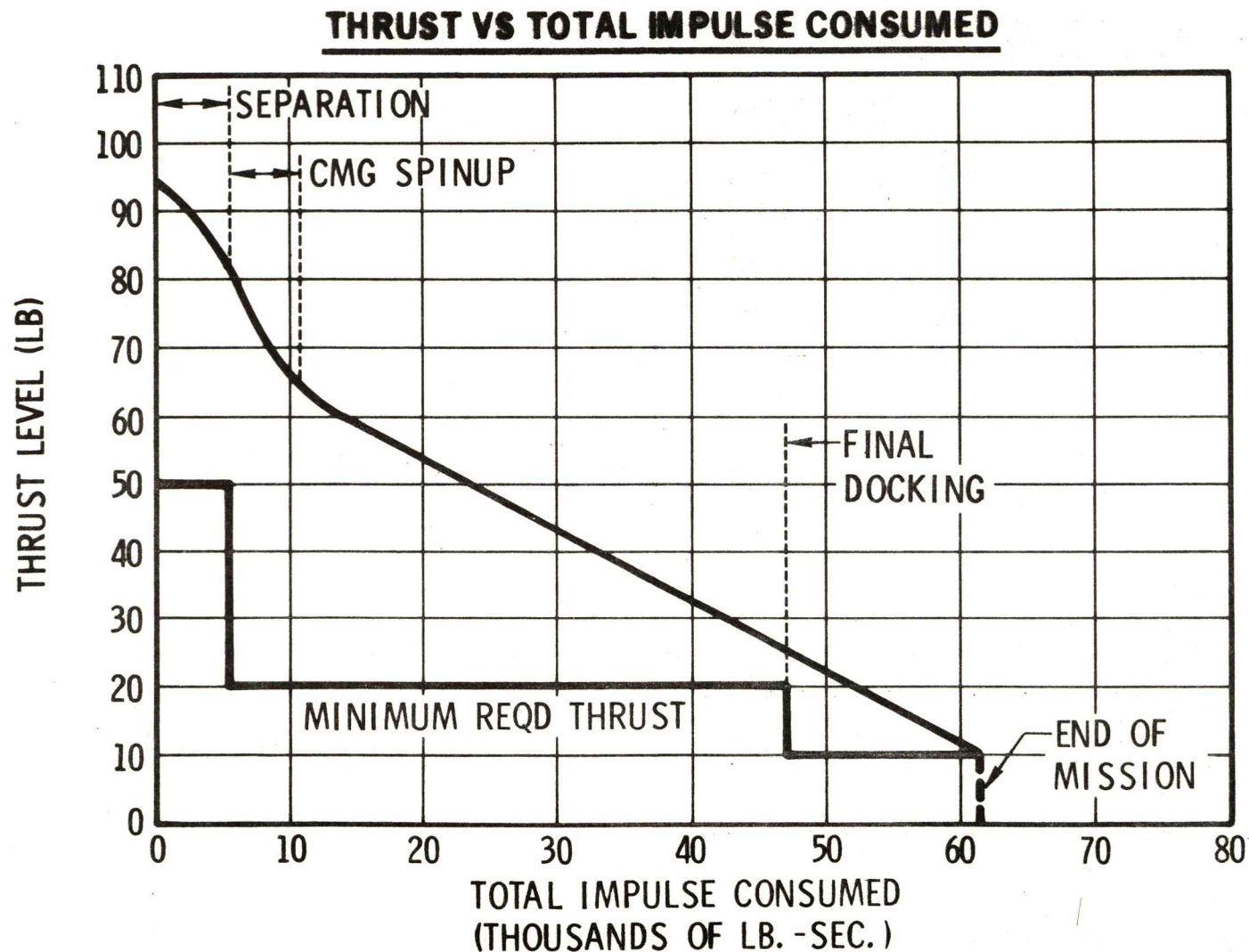
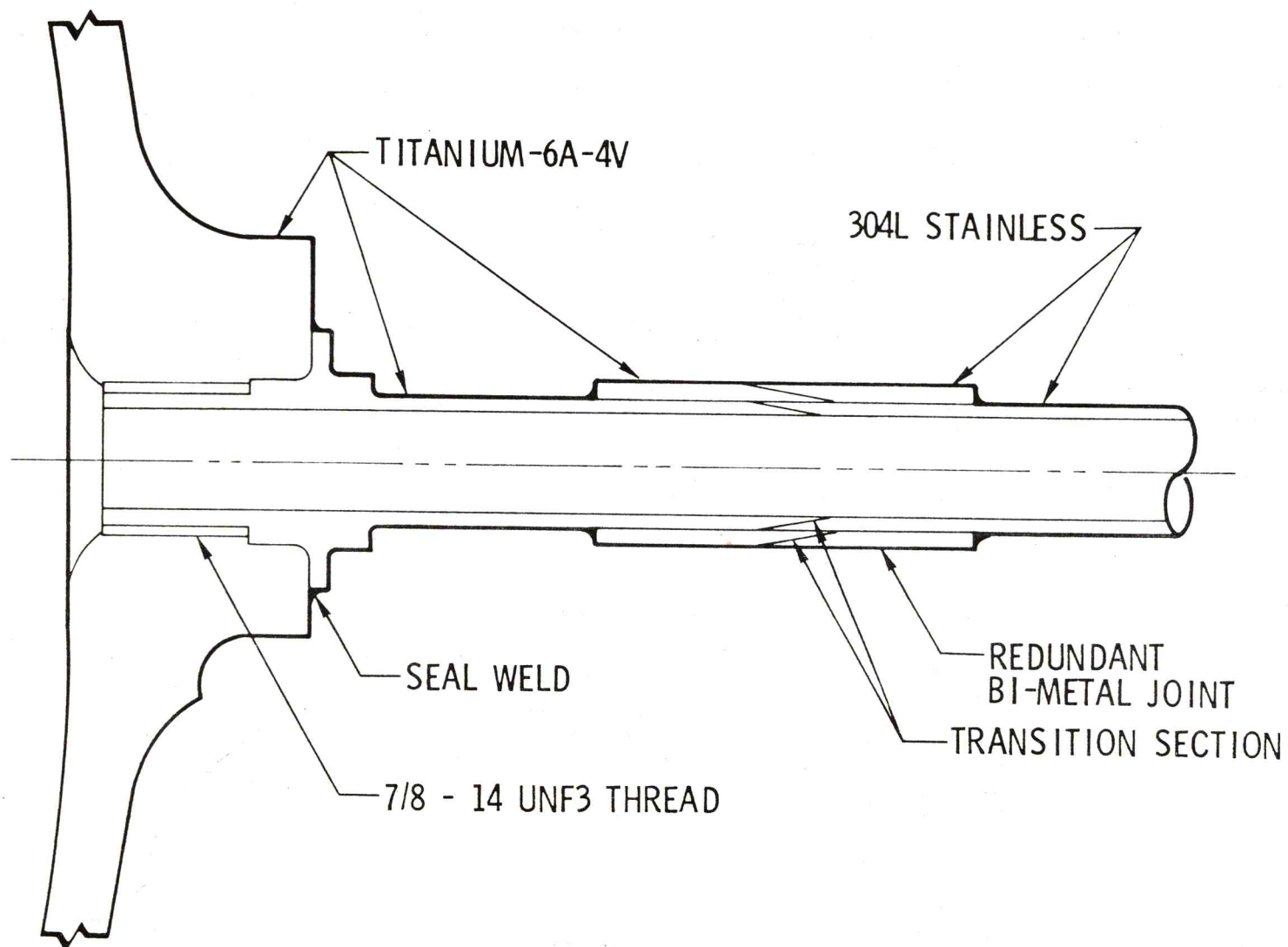


Figure 4211-2.

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ORBITAL WORKSHOP THRUSTER ATTITUDE CONTROL SYSTEM SPHERE

O/W-8913
8-8-70



4-459

Figure 4211-3.

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TACS SPHERES AND METEOROID SHIELD INSTALLATION

O/W-5730
8-6-70

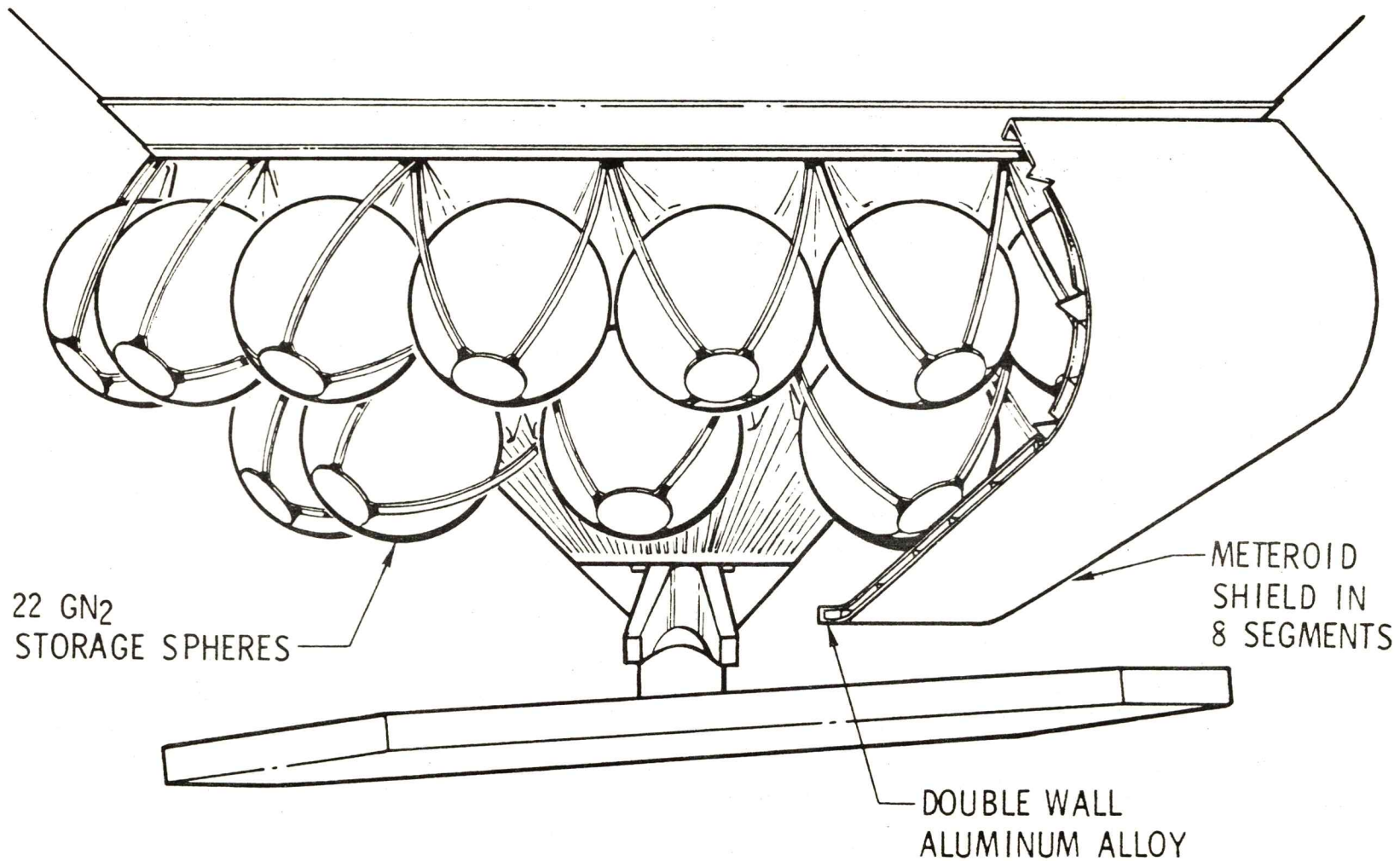
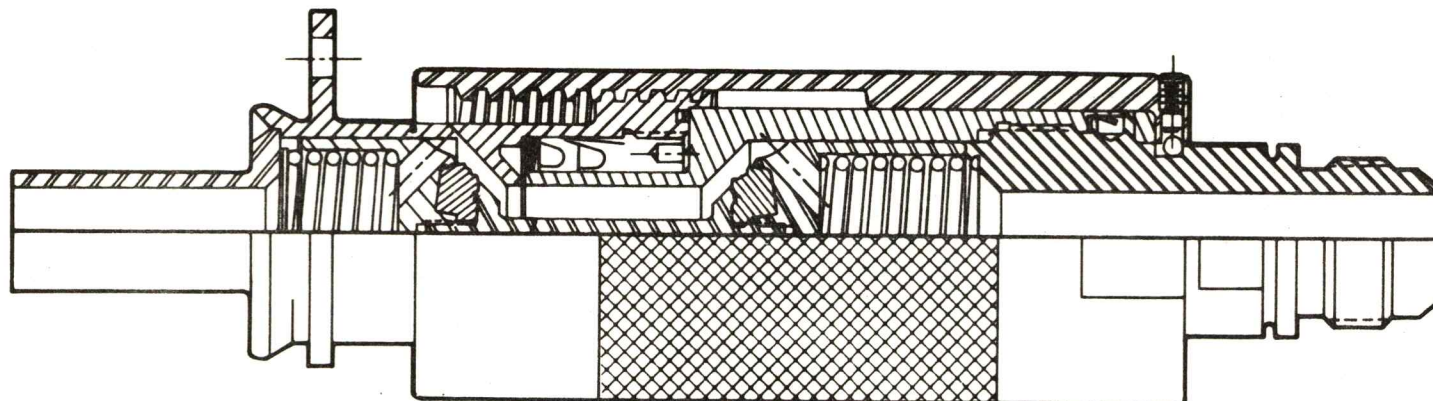


Figure 4211-4

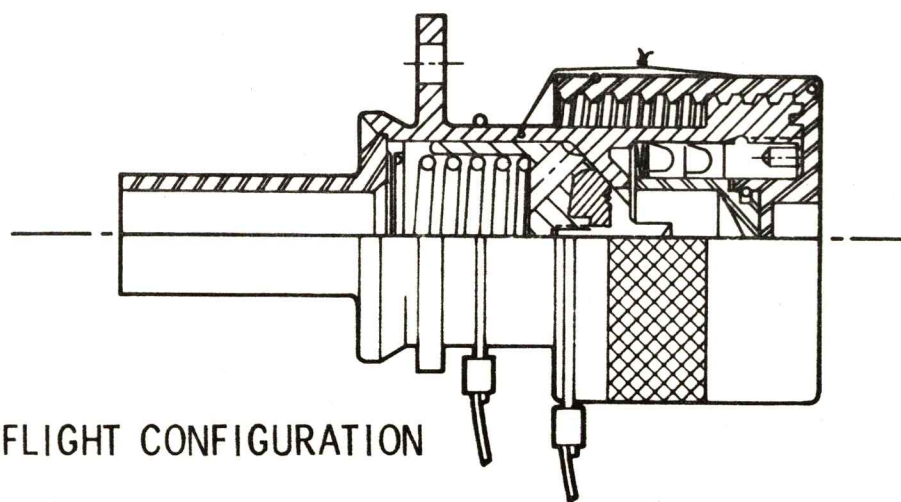
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ORBITAL WORKSHOP TACS DISCONNECT

O/W-6929
4-17-70



GROUND & V-HALF CONNECTED



FLIGHT CONFIGURATION

Figure 4211-5.

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ORBITAL WORKSHOP TACS FILTER

O/W-6928
4-20-70

4-462

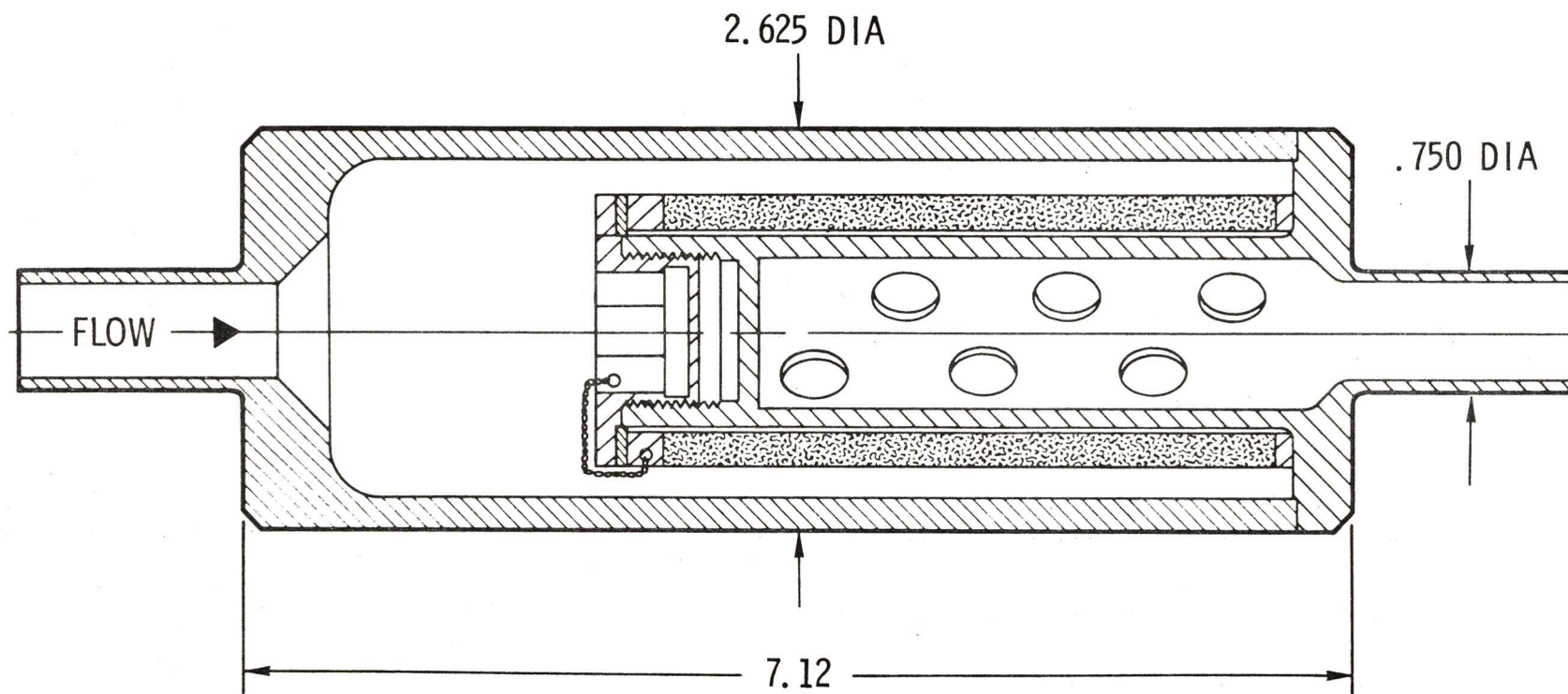


Figure 4211-6.

4.2.11.1.4 Meteoroid Shield

The pressure sphere meteoroid shield (Figure 4211-4) protects the spheres and the manifolding located on the thrust structure. The shield consists of an annular form fabricated from eight identical segments fastened together with screws. The assembled annulus is bolted to frames added around the thrust structure.

4.2.11.2 Thruster Control

Propellant is supplied to each of the six thrusters through quad-redundant control solenoid valves. A control switching assembly provides for valve actuation on command from either the IU or ATM. (Figure 4211-7)

4.2.11.2.1 Thrusters

Each of the six thrusters consists of a quad-redundant valve package and a converging-diverging nozzle section. The nozzle, fabricated from stainless steel, has a throat diameter of approximately 0.16 inch and an expansion ratio of 50:1.

4.2.11.2.2 TACS Control Valves

The control valve (Figure 4211-8) has a stainless steel body with integral mounting provisions and standard 1/2-inch O.D. tube stubs (for "in-place" brazing) at both inlet and outlet ports. All moving parts and assemblies have a minimum operating cycle life of 35,000 cycles. The valves are capable of operation when exposed to the environmental temperature range of -150° to +165°F, space vacuum conditions, and after exposure to the launch and boost environments. An integral filter of 100 micron absolute rating is provided at each valve inlet.

Other characteristics are:

- a. Electrical - 30 vdc, 3 amp at -150°F, continuous duty rated, with electrical connectors.
- b. Mechanical - Integral pilot operated/vented downstream, single unbalanced poppet, Vespel pilot seat, Vespel main poppet, maximum internal leakage of 6×10^{-2} scim.

4.2.11.2.3 Control Switching Assembly

The Control Switching Assembly (CSA), capable of accepting inputs from either the Saturn IU or the ATM, receives the TACS firing command and directs the appropriate thruster to fire (Figure 4211-9). The CSA is designed to take advantage of the redundant valve configuration by providing fault isolation for the predominant modes of switch failure. Adequate isolation to preclude failure of the TACS due to the malfunction of, or influence from the instrumentation, displays, data management system, or EMI transients is provided.

ORBITAL WORKSHOP TACS THRUSTER CONTROL

O/W-4609
6-20-70

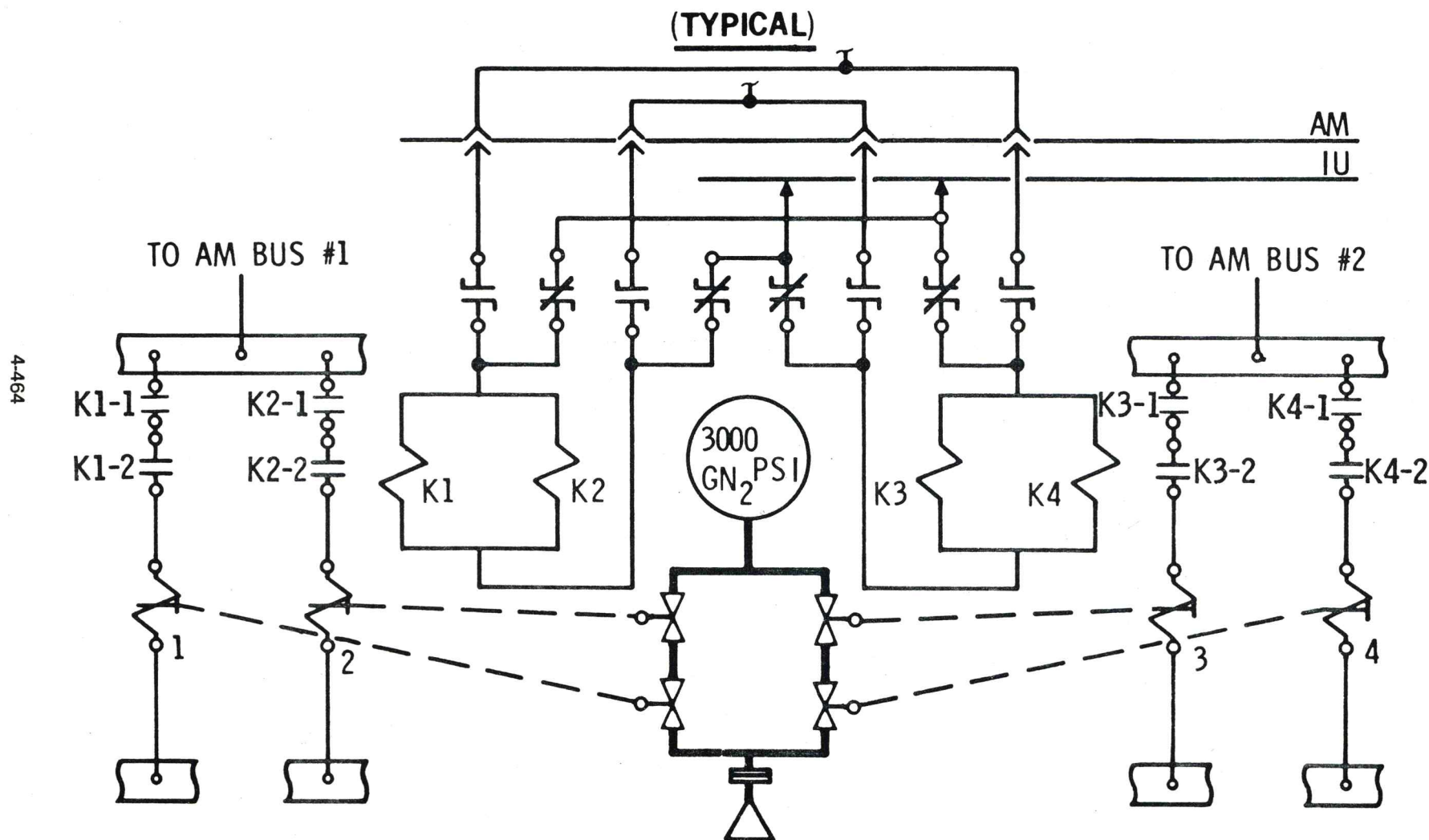


Figure 4211-7.

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ORBITAL WORKSHOP TACS VALVE

O/W-6930
8-8-70

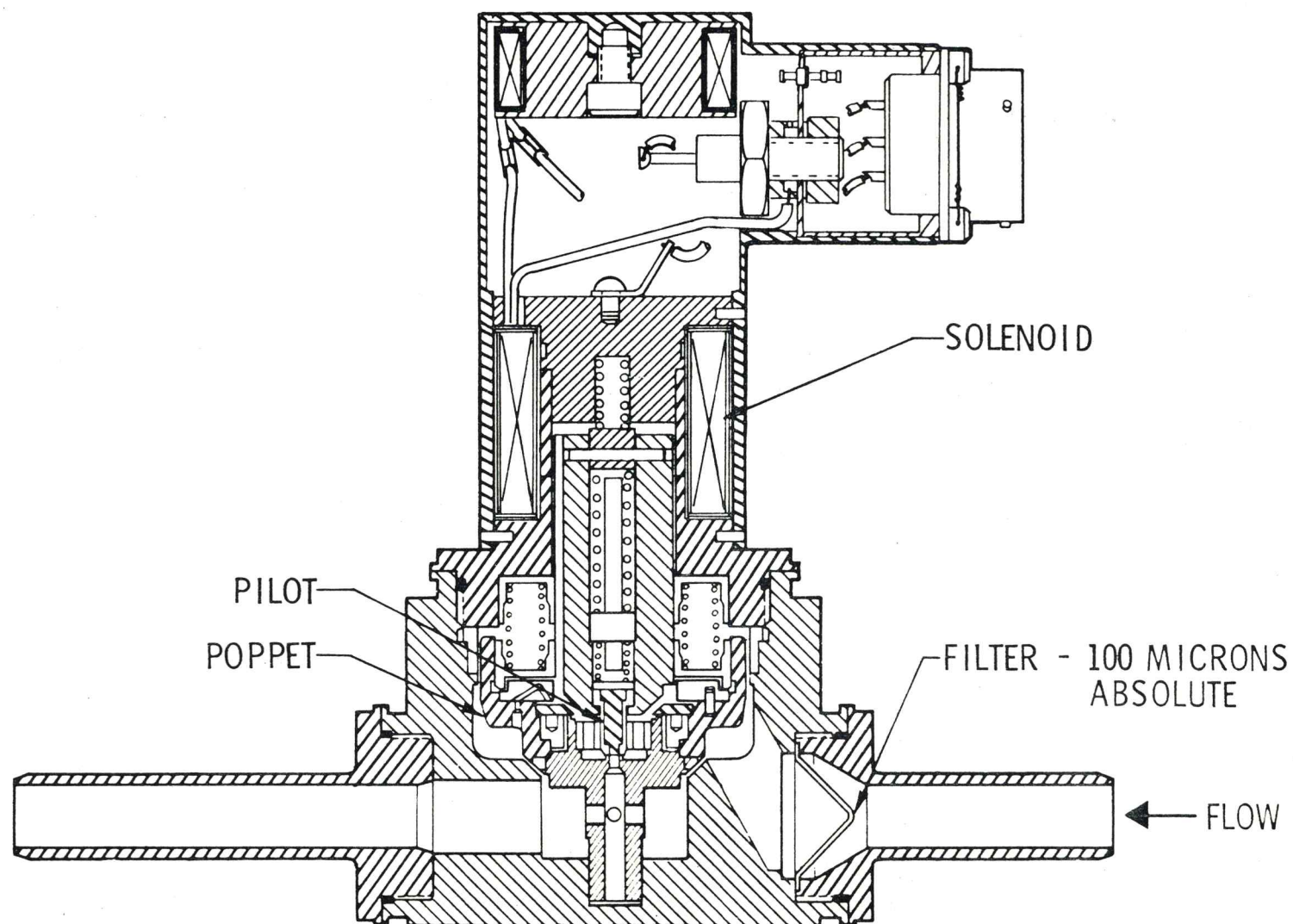


Figure 4211-8.

ORBITAL WORKSHOP THRUSTER ATTITUDE CONTROL SYSTEM

O/W-4608
5-15-70

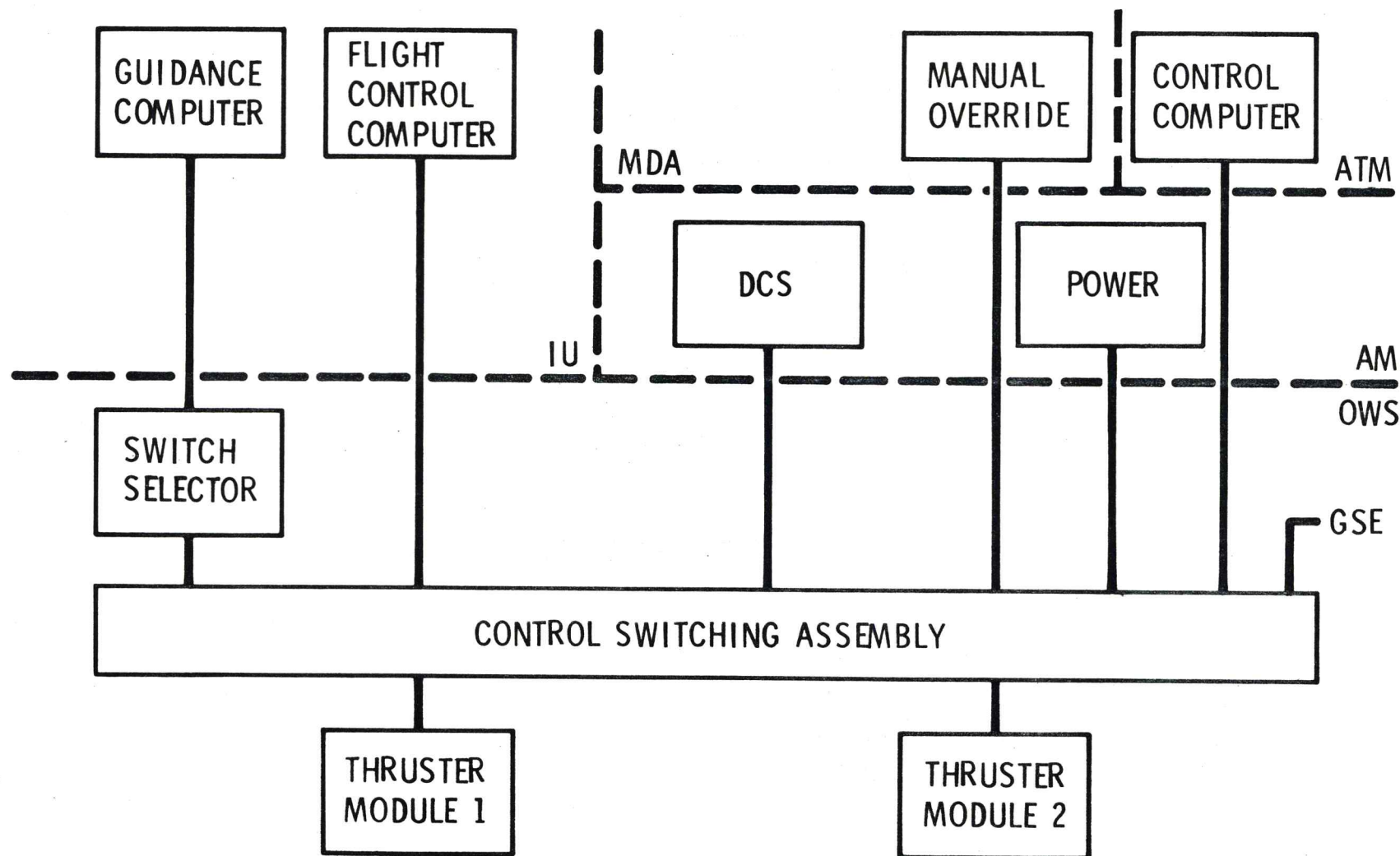


Figure 4211-9. (Sheet 1 of 3)

ORBITAL WORKSHOP TRANSFER CONTROL TACS

O/W-6965
6-16-70

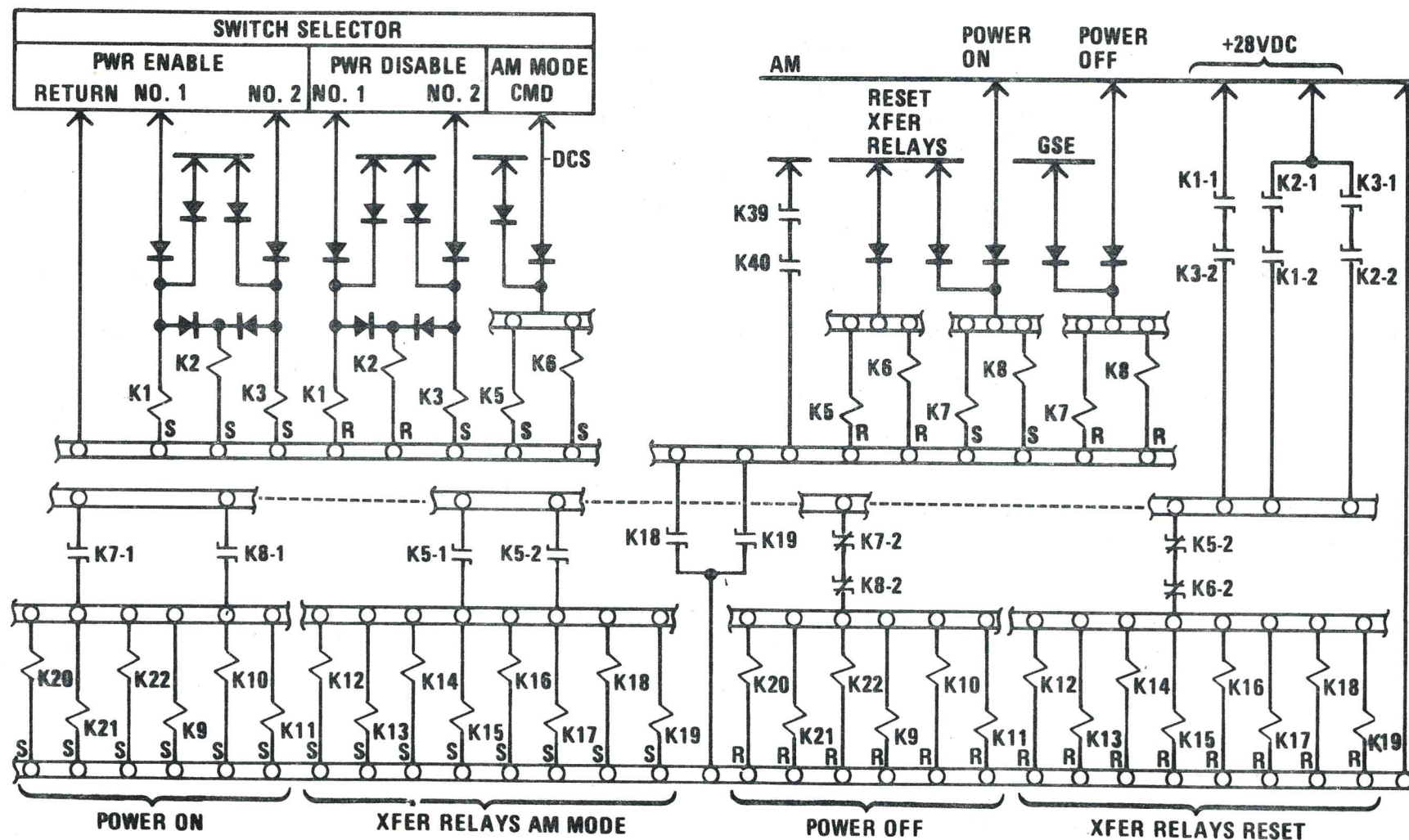


Figure 4211-2. (Sheet 2 of 3)

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ORBITAL WORKSHOP TACS POWER SYSTEM (TYPICAL X2)

O/W-5863
1-30-70

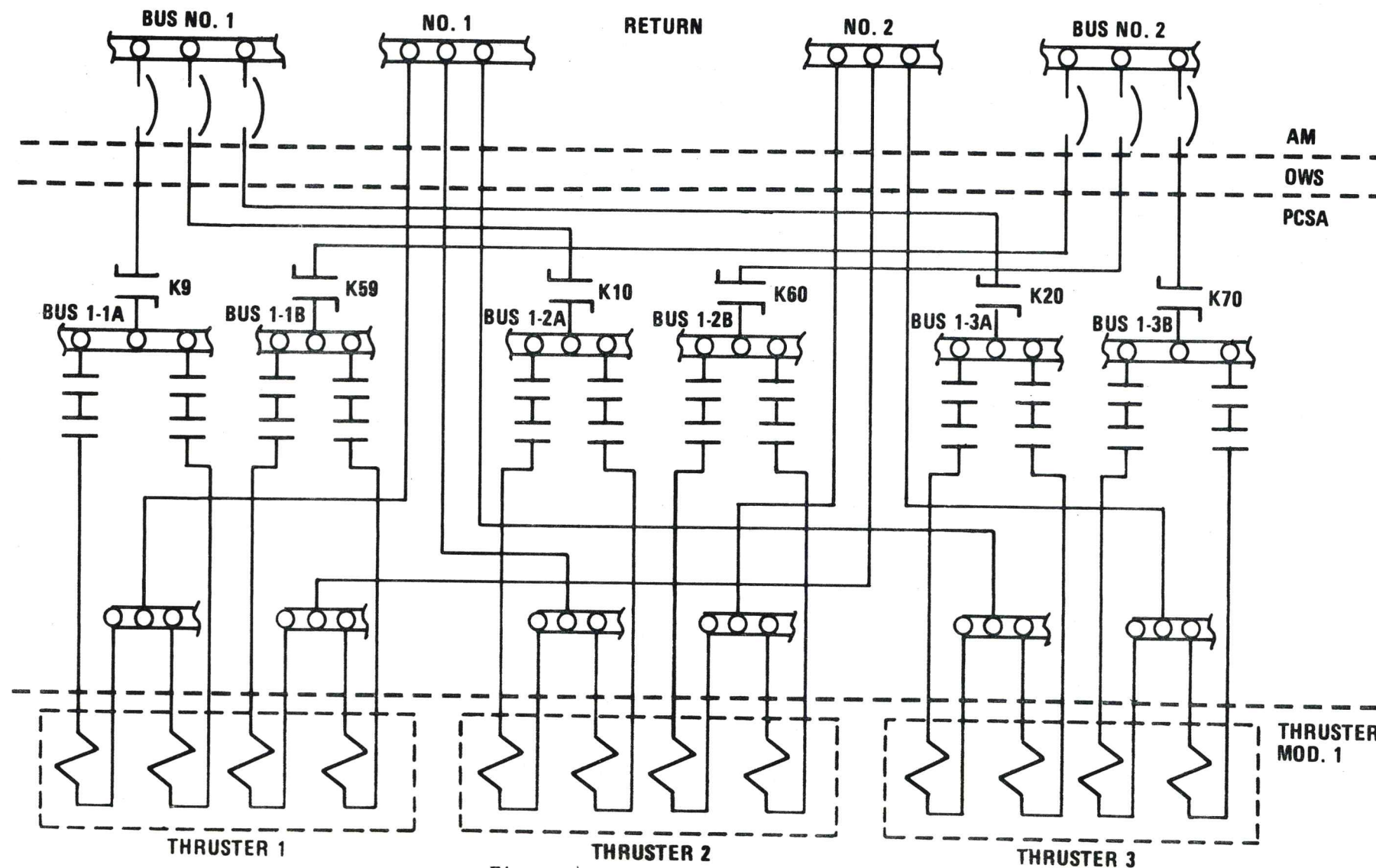


Figure 4211-1. (Sheet 2 of 3)

Appendix A

This section will be incorporated at a later date.

REVISIONS

| SYM | DESCRIPTION | DATE | APPROVED |
|-----|-------------|---------|--------------------|
| A | SEE E.O. | 2-13-70 | <i>[Signature]</i> |
| B | SEE E.O. | 3-26-70 | <i>[Signature]</i> |
| C | SEE E.O. | 5-1-70 | <i>[Signature]</i> |
| D | SEE E.O. | 8-6-70 | <i>[Signature]</i> |

PREPARED FOR NASA-MSFC

PART OR IDENTIFYING NO.

DASH NUMBERS OF THIS DRAWING
ODD DASH NUMBERS SHOWN
EVEN DASH NUMBERS OPPOSITE

UNLESS OTHERWISE SPECIFIED

DIMENSIONS ARE IN INCHES
TOLERANCES
FRACTIONS DECIMALS ANGLES
± — ± — ± —

MATERIAL

FINISH

SEE ENGINEERING RECORDS FOR USAGE DATA

ACTZ
ORIG
SECT.

REL
CODE

FIRST REL
OF PRINTS
ORIG DATE
OF DWG

5 NOV 1969

| | |
|----------|-----------------------------|
| MATL | |
| WT CHK | |
| STR CHK | |
| CHECK | |
| PR ENGR | |
| DES ENGR | <i>[Signature]</i> 12-2-69 |
| GR ENGR | |
| PREP BY | <i>[Signature]</i> 11-17-69 |

DOUGLAS
AIRCRAFT COMPANY, INC

SANTA MONICA, CALIFORNIA

INTERIOR COLOR USAGE - OWS

DESIGN REQUIREMENTS DRAWING

DESIGN ACTIVITY APPROVAL

CODE IDENT NO. SIZE
18355 A

1879289

CUSTOMER APPROVAL

SCALE

SHEET 1 OF 2

TABLE OF CONTENTS AND CHANGE LETTER RECORD

| TABLE OF CONTENTS | SHEET NO. | LETTER | | | | | | | | | | | | | | | |
|--------------------------------|-----------|--------|---|---|---|--|--|--|--|--|--|--|--|--|--|--|--|
| TITLE SHEET | 1 | A | B | C | D | | | | | | | | | | | | |
| TABLE OF CONTENTS | 2.0 | A | B | C | D | | | | | | | | | | | | |
| | 2.1 | A | B | C | D | | | | | | | | | | | | |
| SCOPE | 3.0 | A | B | C | D | | | | | | | | | | | | |
| APPLICABLE DOCUMENTS | . | | | | | | | | | | | | | | | | |
| GENERAL CONSIDERATIONS | 4.0 | | B | | D | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |
| WALLS - TANK | 5.0 | A | B | | D | | | | | | | | | | | | |
| WALLS - CREW QUARTERS | 5.1 | A | B | | | | | | | | | | | | | | |
| DOORS CURTAINS - CREW QUARTERS | 5.2 | A | B | C | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |
| FLOORS, CEILINGS | 6.0 | | B | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |
| STRUCTURAL COMPONENTS | 7.0 | A | B | | D | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |
| STORAGE FACILITIES | 8.0 | A | B | C | D | | | | | | | | | | | | |
| " | 8.1 | | | | D | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |
| ASTRO-AIDS, RESTRAINTS | 9.0 | A | B | C | D | | | | | | | | | | | | |
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| | | | | | | | | | | | | | | | | | |

DOUGLAS

SIZE

A

CODE IDENT NO.

18355**1B79289**

SCALE

LTR

D

SHEET 2.0

TABLE OF CONTENTS AND CHANGE LETTER RECORD

| TABLE OF CONTENTS | SHEET NO. | LETTER | | | | | | | | | | | | | | | |
|---------------------------|-----------|--------|---|---|---|--|--|--|--|--|--|--|--|--|--|--|--|
| VENTILATION COMPONENTS | 10.0 | B | C | D | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |
| ELECTRICAL COMPONENTS | 11.0 | A | B | C | D | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |
| FOOD MGMT COMPONENTS | 12.0 | A | B | C | D | | | | | | | | | | | | |
| | 12.1 | B | C | D | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |
| WATER MGMT COMPONENTS | 13.0 | A | B | C | D | | | | | | | | | | | | |
| | 13.1 | | | | D | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |
| WASTE MGMT COMPONENTS | 14.0 | B | | D | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |
| MISCELLANEOUS | 15.0 | A | B | C | D | | | | | | | | | | | | |
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DOUGLAS

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SCALE

LTR

D

SHEET 2.1

SCOPE:

This Design Requirements Drawing expands the requirements of Design Engineering Plan 665 to establish the color scheme for the interior of the Orbital Workshop. The color is called out for all hardware exposed to crewmen under normal operating conditions. Generally, colors are called out for groups or categories of hardware rather than specific items. Individual parts are identified only when necessary to identify a unique color requirement or when necessary to clarify the requirement.

There is no requirement for color aft of Sta. MDC-341.0 except that the finish should be selected to provide maximum light reflection for the benefit of on-orbit maintenance activities.

Any deviation from the colors called out herein requires prior approval of the Crew Systems Department, MM/RE, and the Project Office.

The information contained herein is for Douglas internal use only and is not to be considered as binding on the McDonnell Douglas Astronautics Company. If in the opinion of the McDonnell Douglas Company, the information contained herein is required to complete the technical requirements in a formally released document, the information shall be transferred from this drawing and shall be included as an integral part of the formally released document.

APPLICABLE DOCUMENTS:

The following documents, latest issue, form a part of this drawing to the extent specified herein:

1. DEP-665 Development Engineering Plan - Orbital Workshop Color Requirements
2. F-297 Finish Specification for Orbital Workshop and Associated Support Equipment.

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SCALE

REV

SHEET

3.0

1. PAINT SHALL NOT BE APPLIED TO SURFACES SUBJECT TO EXTREME ABRASION, WEAR OR IMPACT.
2. PAINT SHALL NOT BE APPLIED TO HINGE KNUCKLES.
3. ALL VISIBLE FASTENERS SHALL BE NATURAL METALLIC.
4. BRACKETS, SUPPORTS, WIRING SHROUDS, ETC. SHALL BE THE COLOR OF THE BACKGROUND WHERE THEY ARE MOUNTED.
5. ALUMINUM ATTACH ANGLES AND BRACKETS SHALL BE ANODIZED THE SAME COLOR AS THE COMPONENT WHICH THEY ACCOMPANY.

NOTE: THE GENERAL REQUIREMENTS OF THIS SECTION APPLY IN ALL CASES EXCEPT WHERE A SPECIFIC REQUIREMENT IS CALLED OUT ELSEWHERE IN THIS DRAWING.

GENERAL CONSIDERATIONS

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SCALE

REV

D

SHEET

1.0

THE INTERIOR OF THE OWS TANK FROM THE
FORWARD HATCH TO STA. MDC-341.0 SHALL BE
LIGHT YELLOW TEFLON.

THE INTERIOR OF THE TANK AFT OF STA. MDC-341.0
AND THE COMMON BULKHEAD MAY BE LIGHT YELLOW
TEFLON OR OTHER COLOR PROVIDING HIGH LIGHT
REFLECTANCE.

WALLS - TANK & FWD DOME

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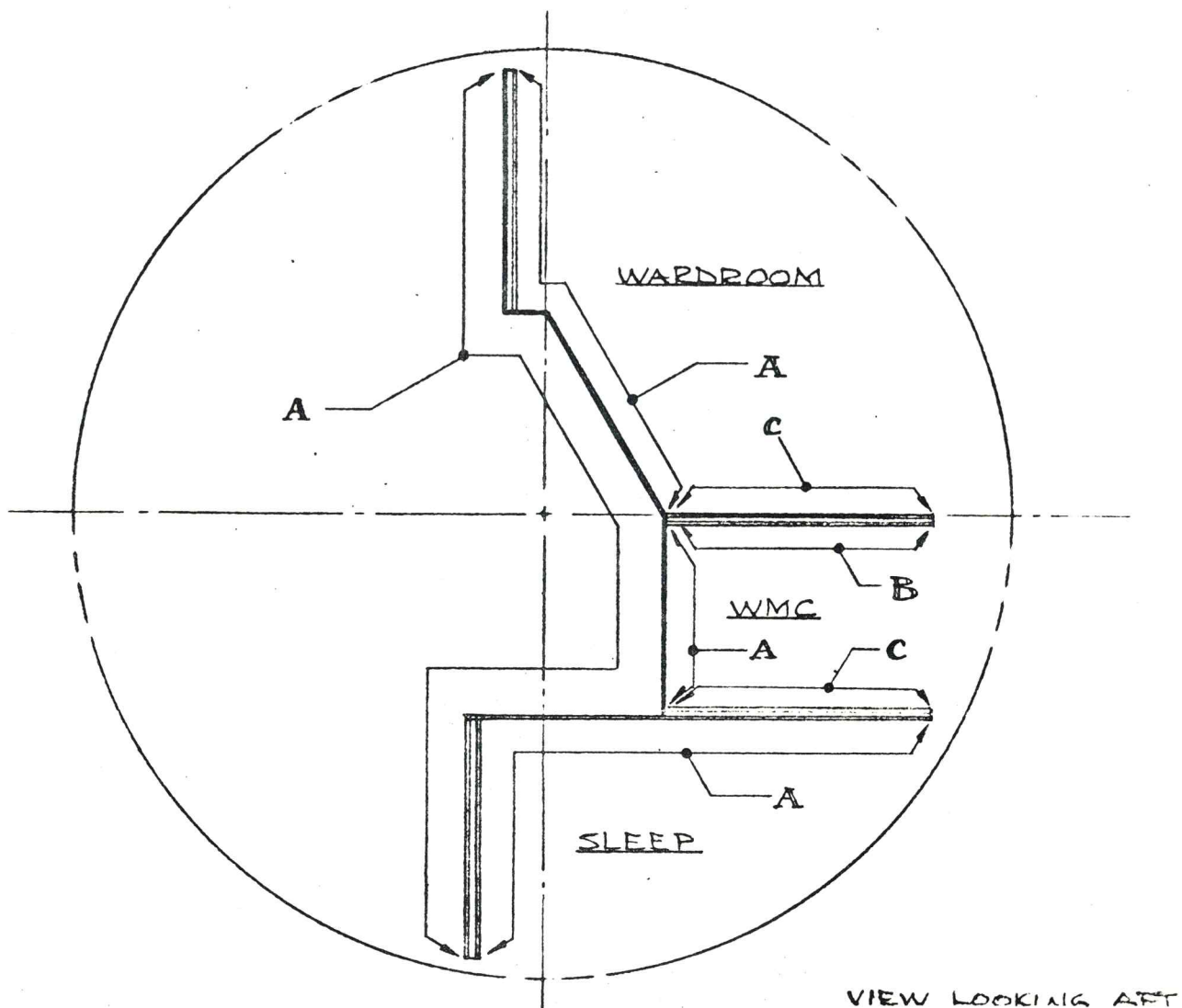
SCALE

REV

0

SHEET

50



- A** - WALL PANELS, ADJACENT ANGLES & BRACKETS, TRIM - GOLD
- B** - WALL PANELS, TOP & BOTTOM CHANNELS, TRIM - LIGHT BLUE
- C** - WALL PANELS, ADJACENT ANGLES, BRACKETS AND TRIM NOT COVERED ABOVE - CLEAR ANODIZE

WALLS - CREW QUARTERS

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SCALE 1/50

REV

B

SHEET

C1

WMC DOOR INSTALLATION -

| | |
|------------------|-----------|
| HANDLE | DARK BLUE |
| DOOR PANELS | GOLD |
| HINGES, BRACKETS | GOLD |
| ATTACH HARDWARE | GOLD |

SLEEP COMPARTMENT -

| | |
|-------------------|---------------|
| PRIVACY CURTAINS | WHITE ARMALON |
| PRIVACY PARTITION | GOLD |
| ATTACH HARDWARE | GOLD |

WARD ROOM -

| | |
|-----------------|---------------|
| DOOR CURTAIN | WHITE ARMALON |
| ATTACH HARDWARE | GOLD |

DOORS, CURTAINS - CREW QUARTERS

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SCALE

REV

C

SHEET

57

| | |
|--------------------------------------|--------|
| ALL GRID FLOORS | YELLOW |
| ALL GRID CEILINGS | YELLOW |
| FLOOR & CEILING BEAMS | YELLOW |
| ASSOCIATED FLOOR & CEILING STRUCTURE | YELLOW |
| PLENUM COVER | YELLOW |

| | |
|-------------|---------------|
| WMC FLOOR | RED-TAN |
| WMC CEILING | CLEAR ANODIZE |

FLOORS, CEILINGS

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SCALE

REV B

SHEET 6.0

EXPERIMENT MOUNTING
PROVISIONS

GOLD

FWD HATCH ASSY

GOLD

HATCH OPERATING HANDLES

DARK BLUE

MEZZANINE:

WATER TANK SUPPORT STRUCTURE

GOLD

INBOARD CAP ANGLES

DARK BLUE

STOWAGE CONTAINER SUPPORT STRUCTURE

GOLD

RESTRAINT RING

DARK BLUE

STRUCTURAL COMPONENTS

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SCALE

REV

D

SHEET

7.0

SLEEP COMPARTMENT

LOCKERS, CABINETS - BODY
 ATTACH COMPONENTS
 DOORS:
 TRASH CONTAINER
 TISSUE DISPENSER
 OTHERS
 LATCHES
 HINGES

GOLD
 GOLD
 GOLD
 GOLD
 GOLD
 NATURAL METALLIC
 GOLD

WMC

LOCKERS, CABINETS - BODY
 ATTACH HARDWARE

LIGHT BLUE
 CLEAR ANODIZE

DOORS:
 TRASH CONTAINER
 TISSUE DISPENSER
 OTHERS
 LATCHES
 HINGES

LIGHT BLUE
 LIGHT BLUE
 LIGHT BLUE
 NATURAL METALLIC
 LIGHT BLUE

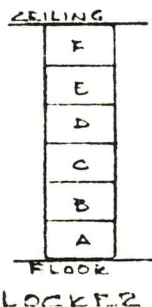
WARDROOM

LOCKERS, CABINETS - BODY
 ATTACH HARDWARE

GOLD
 GOLD

DOORS:
 TRASH CONTAINER
 TISSUE DISPENSER
 OTHER D & E LEVEL
 HINGES
 LATCHES

RED-TAN
 RED-TAN
 RED-TAN
 WHITE TEFLON FOLL OVERLAY
 RED-TAN
 NATURAL METALLIC

LOCKER

STORAGE FACILITIES

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SCALE

REV

D

SHEET

8.0

EXPERIMENT COMPARTMENT

LOCKER, CABINETS - BODY
ATTACH COMPONENTS

GOLD
GOLD

DOORS
HINGES
LATCHES

GOLD
GOLD
NATURAL METALLIC

FORWARD COMPARTMENT

LOCKERS, CABINETS - BODY
ATTACH COMPONENTS

GOLD
GOLD

DOORS
HINGES
LATCHES

GOLD
GOLD
NATURAL METALLIC

FILM VAULT, BODY & DOORS
HINGES
LATCHES
INTERIOR ALUMINUM PARTS

GOLD
GOLD
NATURAL METALLIC
GOLD

DOME AREA

STORAGE CONTAINERS, COMPLETE
LATCHES

RED TAN
NATURAL METALLIC

NEW
PAGE

STORAGE FACILITIES

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SCALE

REV

D

SHEET

8.1

FOOT RESTRAINT PLATFORM
 ALUMINUM PARTS
 FABRIC PARTS

CLEAR
 WHITE ARMALON

HAND RAILS & ATTACH BRACKETS

DARK BLUE

MISCELLANEOUS ASTRO-AIDS
 ALUMINUM PARTS
 FABRIC PARTS

DARK BLUE
 WHITE

DUTCH SHOES

ALUMINUM PARTS
 POLYIMIDE PARTS

DARK BLUE
 NATURAL

THIGH RESTRAINTS (FOOD TABLE)

NATURAL METALLIC

ASTRO-AIDS, RESTRAINTS

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SCALE

REV

D

SHEET

30

| | |
|-------------------------------------|------------------|
| DUCTS | WHITE ARMALON |
| MIXING CHAMBER COMPLETE | GOLD |
| FAN CLUSTER & MUFFLER EQUIP. | GOLD |
| SUPPORTING STRUTS | DARK BLUE |
| HEATER HOUSING & BRACKETRY | GOLD |
| FAN/FILTER ASSY (ODOR CONTROL, WMC) | GOLD |
| GUARD ASSY | DARK BLUE |
| DUCT ATTACH HARDWARE | GOLD |
| DIFFUSERS, ROUND | NATURAL METALLIC |
| " RECTANGULAR | YELLOW |
| PORTABLE FAN ASSEMBLY | GOLD |
| RADIANT HEATERS | GOLD |

VENTILATION COMPONENTS

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SCALE

REV ID

SHEET 10.0

REMOTE RECORDING PANEL, Box
PANELGOLD
OFF-WHITE MICATEXPOWER PANELSUPPORT FRAME & ATTACH HDWE
DISPLAY/CONTROL PANELS
MARKINGS
SWITCH GUARDSDARK BROWN
OFF-WHITE MICATEX
BLACK
NATURAL METALLICWARD ROOM D/C PANEL

OFF-WHITE

WMC D/C PANEL

OFF-WHITE

(NO COLOR COMT FOR BOXES FOR ABOVE)

KNOBS

BLACK

TOGGLE SWITCHES

NATURAL METALLIC

BEZELS

NAT. METALLIC OR CLEAR MODIZE

METERS: FACES

BLACK

MARKINGS

WHITE

VITON TUBING

NATURAL (TAN)

WIRE DUCTS, COVERS & ATTACH HDWE:

ON CREW QUARTERS WALLS

TO MATCH WALLS

ON GRID CEILING, FLOOR

YELLOW

ON TANK WALLS

GOLD

UTILITY OUTLETS

GOLD

CONNECTORS

SILVER GRAY

TIMER, FOOD HEATER

OFF-WHITE MICATEX

LIGHT HOUSING & ATTACH BRACKETS

CLEAR

REFLECTOR

OFF-WHITE TEFLON

ADAPTOR PLATE

YELLOW

ELECTRICAL COMPONENTS

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SCALE

REV D

SHEET 11.0

TABLE: TOP

OFF-WHITE TEFLON

PEDESTAL PANELS, DOORS

OFF-WHITE TEFLON

STRUCTURAL CHANNELS
& SKIRTS

CLEAR

TRAYS

OFF-WHITE TEFLON

ATTACH HDWE

NATURAL METALLIC

CARPET (FOOT RESTRAINT)

CLEAR

FOOD MANAGEMENT COMPONENTS

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SCALE

REV

D

SHEET 12.0

REFRIGERATOR / FREEZERFOOD STORAGE FREEZER

DOORS, POLYIMIDE PARTS
 DOORS, ALUMINUM PARTS, EXTERIOR
 DOORS, ALUMINUM PARTS, INTERIOR
 BOX, INTERIOR
 BOX, EXTERIOR
 LATCH
 HINGE

OFF-WHITE TEFLON
 GOLD
 NATURAL ALUMINUM
 NATURAL ALUMINUM
 GOLD
 CLEAR
 GOLD

FOOD STORAGE CONTAINERS

ALUMINUM PARTS
 POLYIMIDE PARTS
 LATCHES

GOLD
 OFF-WHITE TEFLON
 NATURAL METALLIC

REFRIGERATION LINES

GOLD

COOLANT PUMP: ENCLOSURE

CONTROL PANEL
 CONTROL KNOBS
 MARKINGS

GOLD
 OFF-WHITE MICATEX
 BLACK
 BLACK

FOOD MANAGEMENT COMPONENTS

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SCALE

REV

D

SHEET 12.1

WATER STORAGE TANKS
PORTABLE WATER TANK

NATURAL METALLIC
NATURAL METALLIC

SPACE SINK, S.S. PARTS
" " , ALUM PARTS

NATURAL METALLIC
LIGHT BLUE

WATER HEATERS
VALVE HANDLE
MARKINGS

BLACK
BLACK
BLACK ON SILVER

WATER CHILLER

TBD

WATER DISPENSERS:

• FOOD PREPARATION -
EXPOSED METAL PARTS
EXPOSED POLYIMIDE PARTS
CONTROL KNOBS
INDICATOR

NATURAL METALLIC
WHITE TEFLON
BROWN*
RED

• DRINKING
BODY ASSEMBLY
HANDLE (POLYIMIDE)
COUNTER CASE
COUNTER DIAL
MARKINGS
HOSE

NATURAL METALLIC
OFF-WHITE TEFLON
NATURAL METALLIC
WHITE
BLACK
BLACK

WATER SYSTEM CONTROL PANEL

SUPPORT FRAME & ATTACH HDWE
PANEL
MARKINGS
CONTROL KNOBS

GOLD
OFF-WHITE MICATEX
BLACK
BLACK

IODINE INJECTION EQUIPMENT
CASE

TBD
GOLD

* MAY BE ANODIZED ALUM. OR NATURAL POLYIMIDE

WATER MANAGEMENT COMPONENTS

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REV

D

SHEET 3.0

WATER PURIFICATION EQUIPMENT

CASE
HINGE
LATCH
ATTACH HARDWARE
FLOOR (INTERIOR), FRONT FACE
S.S. COMPONENTS
HEATER CONTROLLERS

GOLD
GOLD
NATURAL METALLIC
GOLD
OFF-WHITE MICATEX
NATURAL METALLIC
NATURAL ALUMINIUM
(PLASMA SPRAY)

WATER MANAGEMENT COMPONENTS

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SCALE

REV

D

SHEET

12.1

TRASH DISPOSAL AIR-LOCK

DARK BROWN

OPERATING LEVERS

NATURAL METALLIC

FECAL/URINE COLLECTOR

CLEAR ANODIZE

RESTRAINTS, HAND HOLDS

DARK BLUE

CONTROL KNOBS

BLACK

SWITCH LEVERS

NATURAL METALLIC

MARKINGS

BLACK

WASTE PROCESSOR

CLEAR ANODIZE

CONTROL KNOBS

BLACK

MARKINGS

BLACK

URINE FREEZER

CLEAR ANODIZE

PORTABLE VACUUM CLEANER

CLEAR ANODIZE

WASTE MANAGEMENT COMPONENTS

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SCALE

REV

D

SHEET 14.0

FIRE EXTINGUISHERS RED
 MOUNTING BRACKETS GOLD
 EMERGENCY REPAIR KITS RED
 IN-FLIGHT TOOL KIT GRAY
 EMERGENCY CONTROLS YELLOW & BLACK STRIPES

CREW EQUIPMENT
 COLOR CODING:

CREWMAN #1 RED
 CREWMAN #2 WHITE OR LIGHT BLUE
 CREWMAN #3 BLUE

VENT LINE SEALING DEVICE. BODY TOP YELLOW
 MARKINGS BLACK
 HANDLE & BODY EDGE BLACK & YELLOW STRIPES

SCIENTIFIC AIRLOCK WHITE &
 CLEAR ANODIZED

VACUUM LINES NATURAL METALLIC
 VACUUM VALVE HANDLES BLACK
 FACE PLATE & ATTACH. — WMC LIGHT BLUE
 — EXP. COMPT. GOLD

M 509 ANTENNA SUPPORT, ALUM PARTS GOLD
 POLYIMIDE PARTS OFF-WHITE TEFLON

MISCELLANEOUS

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SCALE

—

REV

D

SHEET

150

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