

S T U D Y G U I D E

LM

ENVIRONMENTAL CONTROL SUBSYSTEM

For Training Purposes Only



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For Training Purposes Only

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Prepared By:

Edward Ferner

LM Training

Preface

This document is designed to support
the Environmental Control Subsystem
Course Number 30515.

The text contained herein describes
the LM-4 hardware configuration.

List of References

LSP 470-2A, Master End Item Specification for Lunar Excursion Module
LSP 330-2A, Design Control Specification for the LM ECS
LMA 790-3-RM, Apollo Operation Handbook
LM ECS Support Manual - Hamilton Standard
LED 360-7, LM Vehicle Measurement List
LDW 330-54000, ECS Level 3 Schematic
LED 540-43, Modular Mission Data Handbook
MH01-05085-414, CSM/LM ECS Cabin Pressurization ICD
PE-TM-65-03, CO₂ Measurement System Instruction Manual
SID 66-1231, Spacecraft Sequence of Operation, VOL. III
LED 360-421, Water Quantity Measuring Device Operational Manual

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CHAPTER I

INTRODUCTION TO THE LM ENVIRONMENTAL CONTROL SUBSYSTEM (ECS)

General

In order to provide life support in the hostile environment of outer space, the LM will carry its own artificial environment. This environment is supplied by the ECS flight hardware.

Subsystem Description (Reference Figure 1 - LM ECS Block Diagram)

The LM ECS consists of the following five integrated sections:

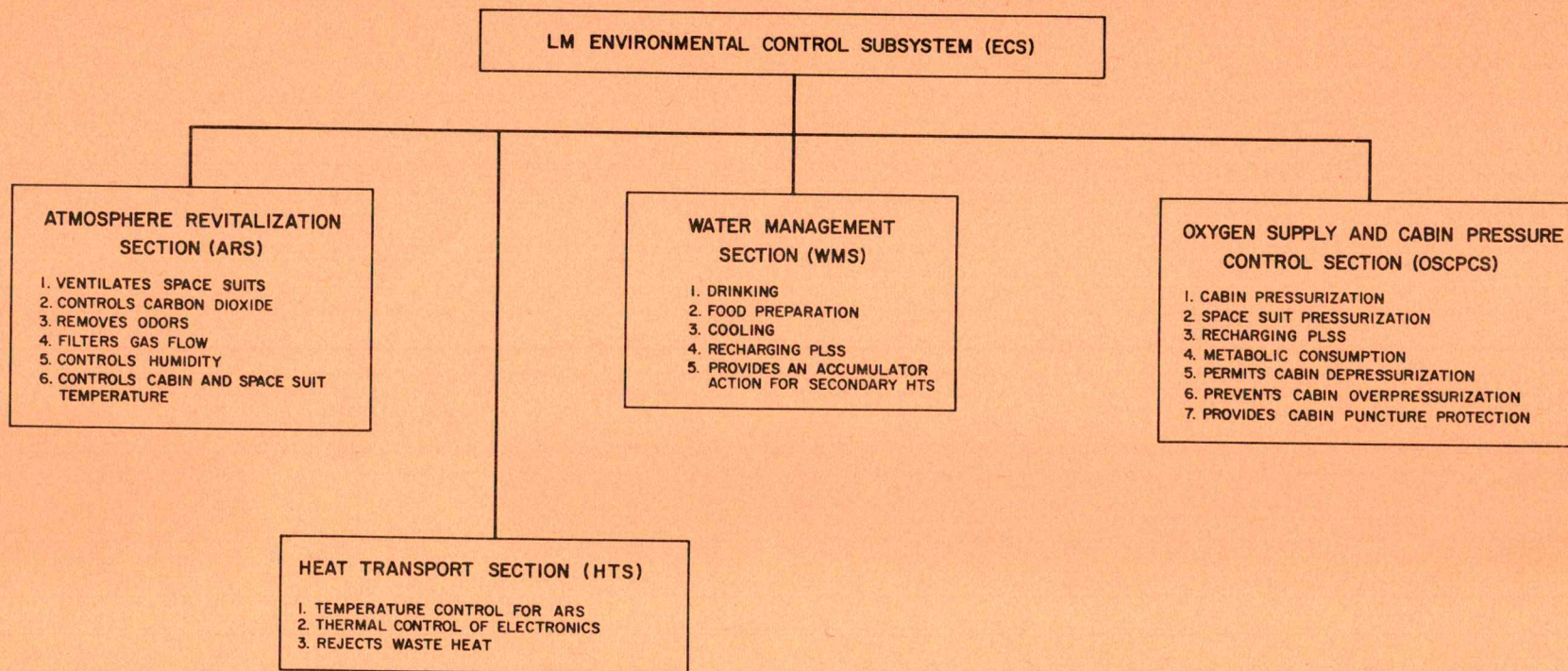
1. Atmosphere Revitalization Section (ARS)
2. Water Management Section (WMS)
3. Oxygen Supply and Cabin Pressure Control Section (OSCPCS)
4. Heat Transport Section (HTS)
5. Cold Plate Section (CPS)

Atmosphere Revitalization Section

This section provides ventilation and atmospheric conditioning for the cabin and space suits. Atmospheric conditioning consists of the removal of carbon dioxide, odors, particulate matter, and excess water vapor.

The ARS performs the following specific functions:

1. Ventilates the space suit assemblies (SSA) worn by the crew.
2. Controls the carbon dioxide (CO₂) level in the atmosphere breathed by the crew.
3. Removes odors and noxious gases from the atmosphere breathed by the crew.
4. Removes foreign objects originating within or entering the system which are capable of causing a malfunction of the ECS or impairment of crew performance.
5. Removes excess moisture from the space suit and cabin atmospheres.
6. Provides temperature control of the gas delivered to the SSA's and the cabin atmosphere.
7. Provides control of the gas flow through the SSA's and circulation of the cabin atmosphere.



LM ECS BLOCK DIAGRAM

T30505-36
DEC 66

Water Management Section

The WMS stores and distributes the water used in the LM for PLSS refilling, crew consumption, and evaporative cooling. In addition, this section provides for the utilization of the condensed water vapor removed from the ARS.

The WMS performs the following specific functions:

1. Provides storage for all drinking, food preparation, and cooling water required aboard the LM at earth launch.
2. Supplies water for use in the ARS and HTS evaporators.
3. Supplies refill water for the PLSS water tanks.
4. Provides an accumulator action for the secondary HTS.

Oxygen Supply and Cabin Pressure Control Section

This section stores, in gaseous form, all oxygen required by the ECS and maintains cabin and/or suit pressurization by supplying oxygen in sufficient quantities to replenish losses due to crew metabolic consumption and cabin or suit leakage. This section also protects the cabin pressure shell against overpressurization, enables the crew to intentionally depressurize and repressurize the cabin in addition to providing for PLSS oxygen refill. This section is capable of four cabin repressurizations.

The OSCPCS provides the following functions:

1. Supplies oxygen for metabolic consumption.
2. Pressurizes the cabin and/or SSA's.
3. Permits deliberate cabin depressurization.
4. Prevents overpressurization of the cabin.
5. Provides emergency pressurization during cabin puncture conditions.
6. Allows PLSS recharging.

Heat Transport Section

The HTS provides active thermal control of the electrical and electronic equipment in addition to the cabin and suit ventilating gases. Redundant active thermal control is also supplied for those electrical and electronic equipments required to effect a successful return to the Command Module (CM).

The HTS performs the following functions:

1. Provides cooling and/or heating as required for the ARS suit circuit.
2. Supplies cooling or heating as required for the cabin atmosphere.
3. Provides thermal control for the electronics equipment.
4. Provides a means for rejecting the vehicles waste heat.

Cold Plate Section

The CPS supplies the thermal coupling between the HTS and those electrical and electronic equipments which require active thermal control. Structural strip type and non-structural flat cold plate assemblies are used to accomplish this function.

Pressurized Areas for Life Support (Reference Figure 2 - LM Ascent Stage)

The ascent stage of the vehicle is capable of being pressurized from the front face of the vehicle aft to the rear pressure bulkhead. The confines of the pressurized area are outlined on Figure 2.

ECS Controls and Indicators (Reference Figure 3 and 4)

The ECS is controlled and monitored from two major areas of the vehicle, hand valves just aft of the SE position and the control and display panels directly in front of both the CDR and SE.

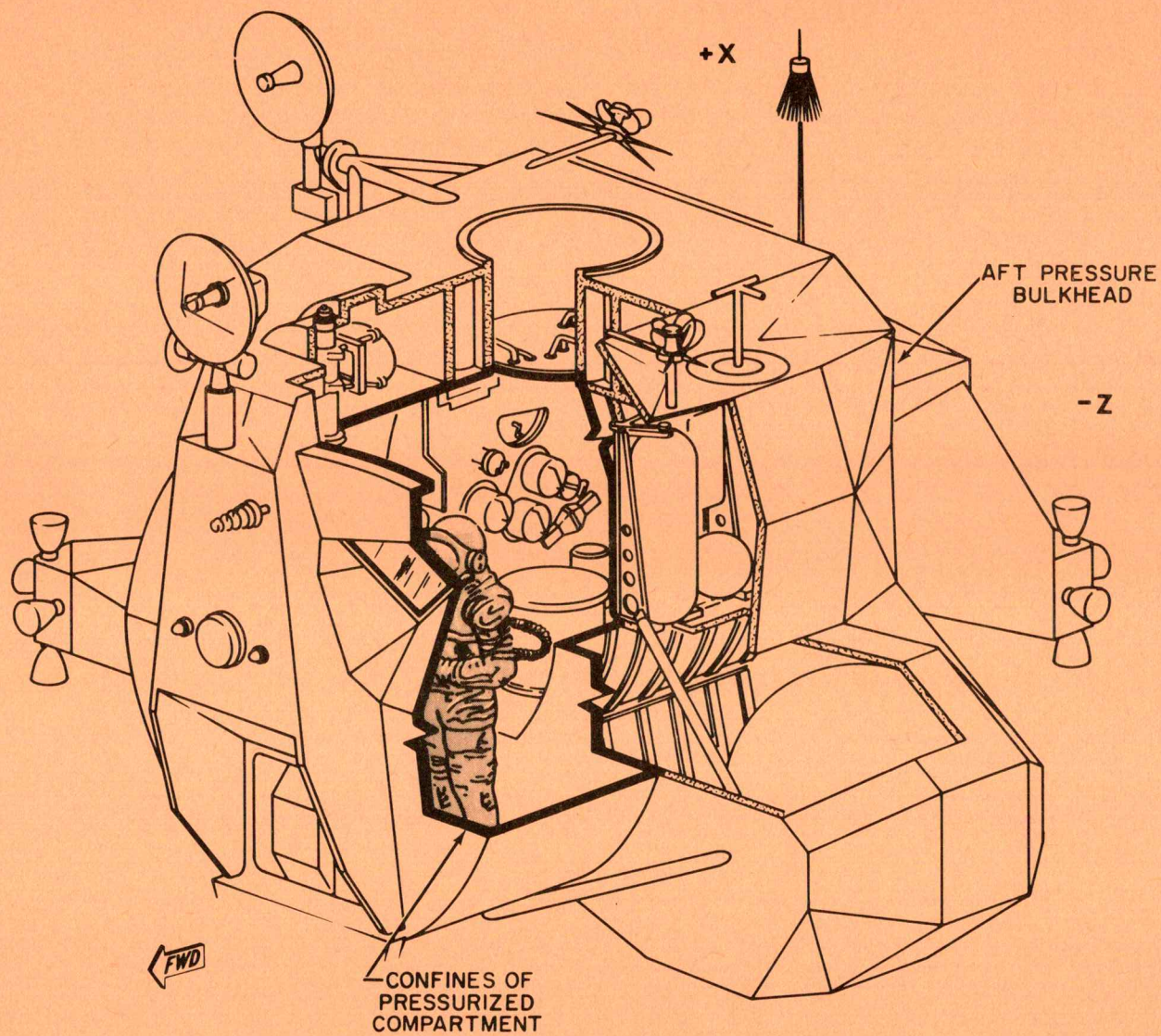
Aft of the SE (see Figure 3) the hand valves for controlling the ARS, WMS, OSCPCS, and the HTS are mounted in modular arrangement. This arrangement permits easy access by either crewman to the ECS controls.

Figure 4 depicts the general arrangement of the LM Display and Control panels in the vehicle. ECS controls and displays are located on panels I, II, XI and XVI.

Panel I (Reference Figure 5)

The following ECS controls and displays are mounted on panel No. 1:

1. Cabin Warning Light 6DS16
2. Suit/Fan Warning Light 6DS17

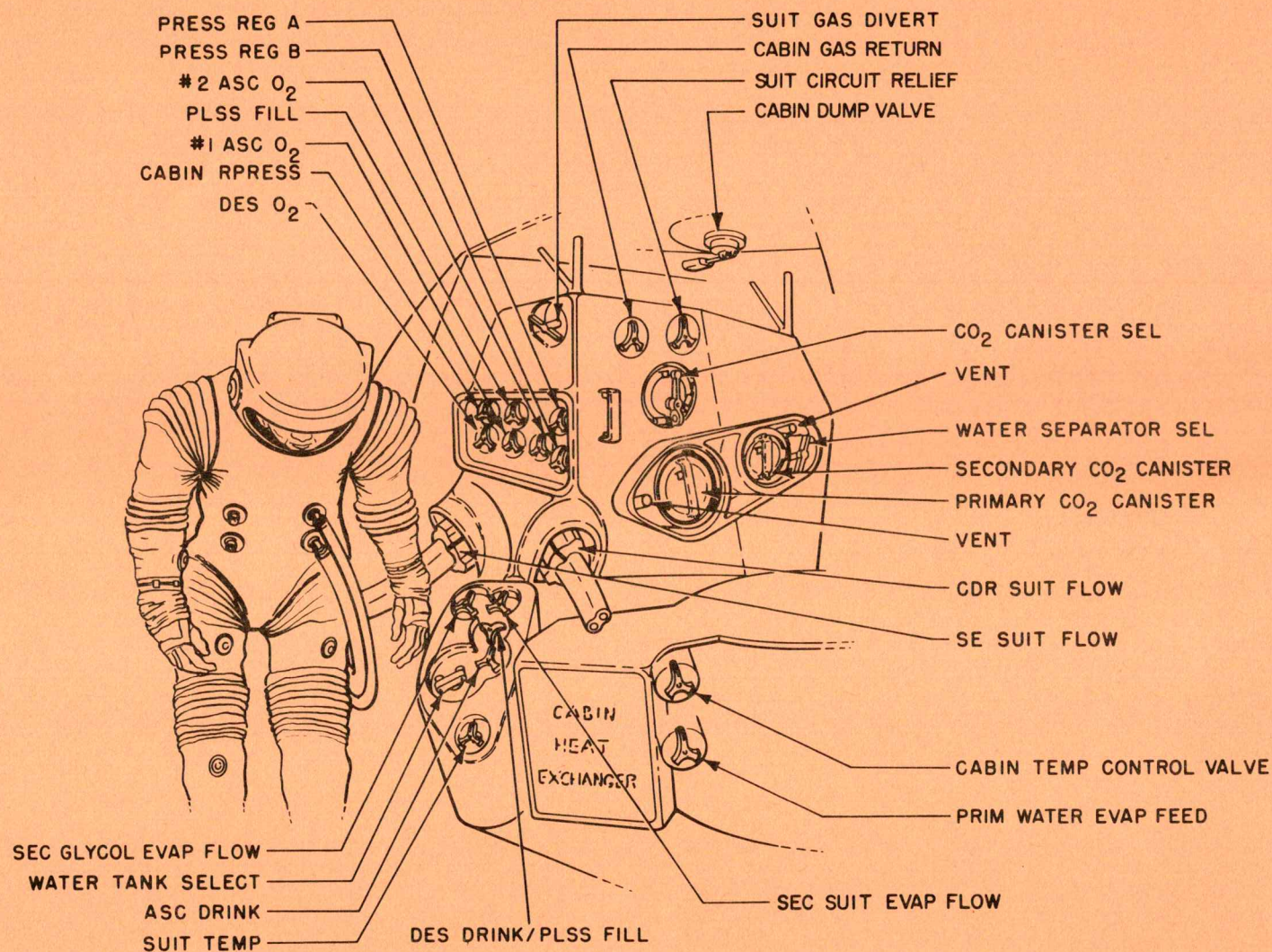


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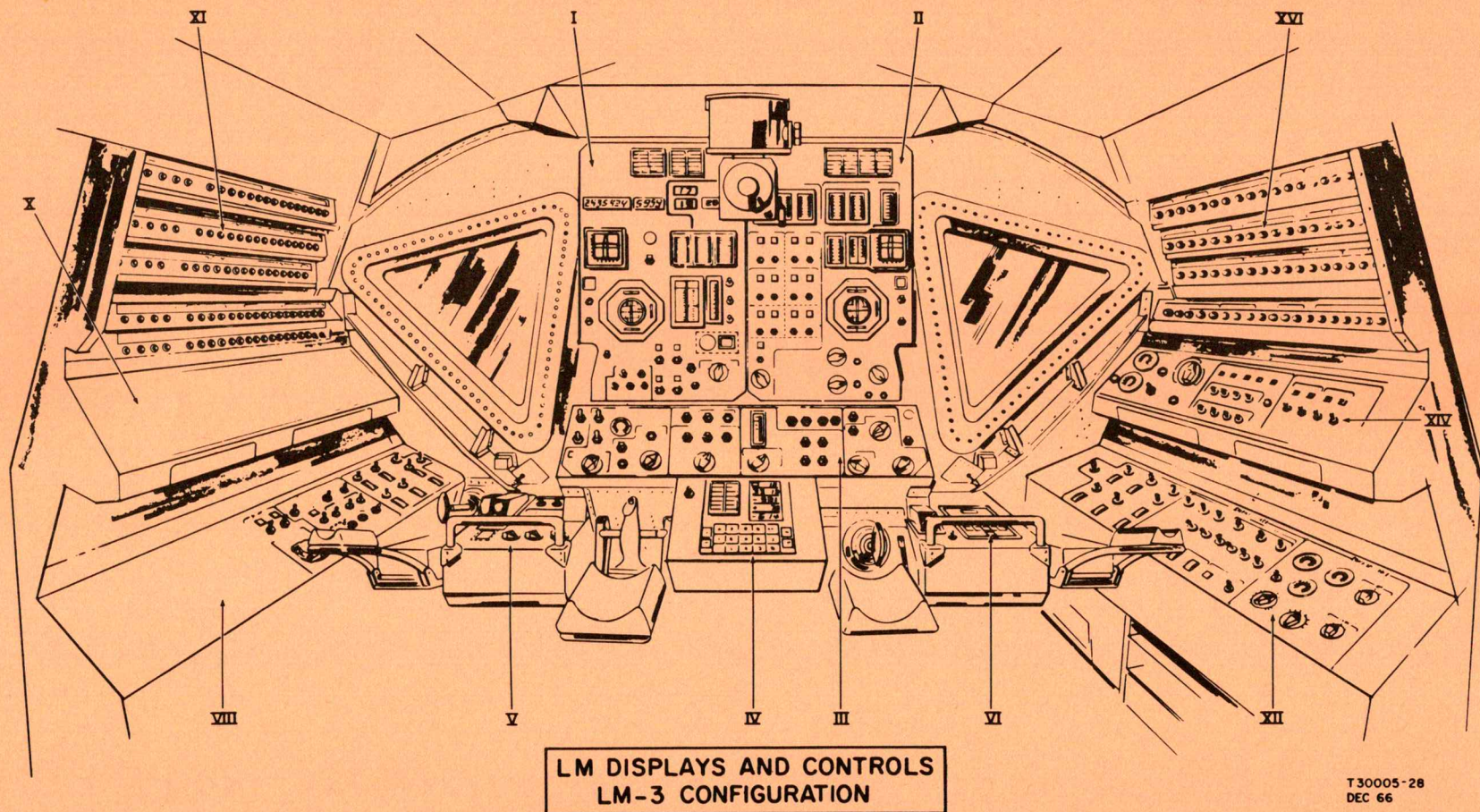
Figure 2

LM ASCENT STAGE

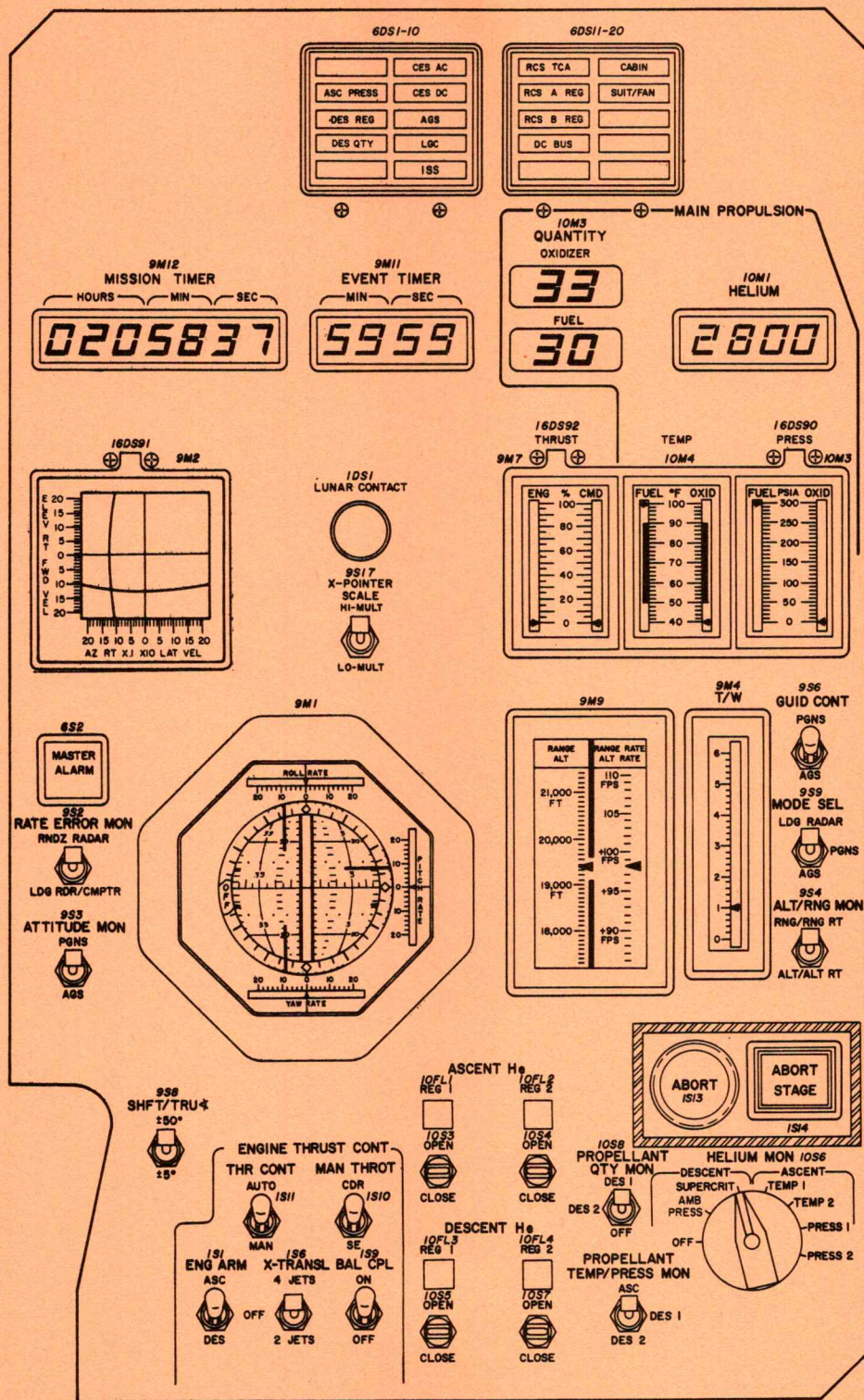
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ECS-SPACE SUIT INTERFACE



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PANEL I - LM 3 & SUB

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Panel II (Reference Figure 6)

The following ECS controls and displays are mounted on panel No. 2:

1. ECS caution annunciator 6DS36
2. O₂ Qty caution annunciator 6DS37
3. Glycol caution annunciator 6DS38
4. Water Qty caution annunciator 6DS39
5. Suit and Cab Temp gauge 7M3
6. Suit and Cab Press gauge 7M2
7. Part Press CO₂ gauge 7M1
8. Glycol Temp Press gauge 7M5
9. O₂ H₂O Quantity gauge 7M4
10. Glycol Pump switch 7S3
11. Glycol pump component caution light 7DS3
12. Suit Fan selector switch 7S1
13. Suit fan component caution light 7DS1
14. CO₂ component caution light 7DS6
15. H₂O Sep component caution light 7DS7
16. O₂/H₂O Qty Mon selector switch 7S2

Panel XI (Reference Figure 7)

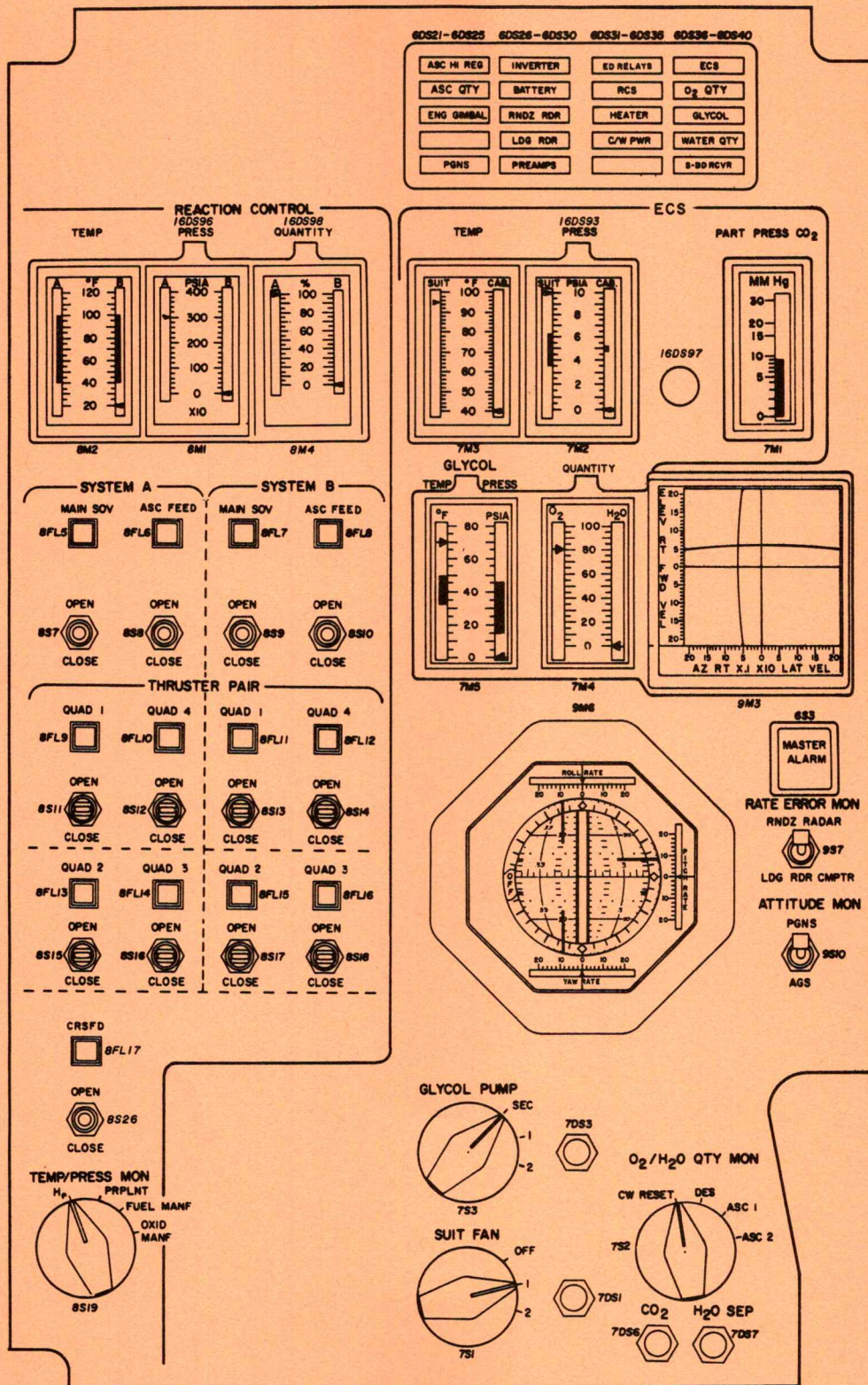
The following ECS circuit breakers are located on panel No. XI:

1. Suit Fan 1
2. Cabin Fan 1
3. Glycol Pump 2
4. Glycol Pump 1
5. Auto TRNFR

Panel XVI (Reference Figure 8)

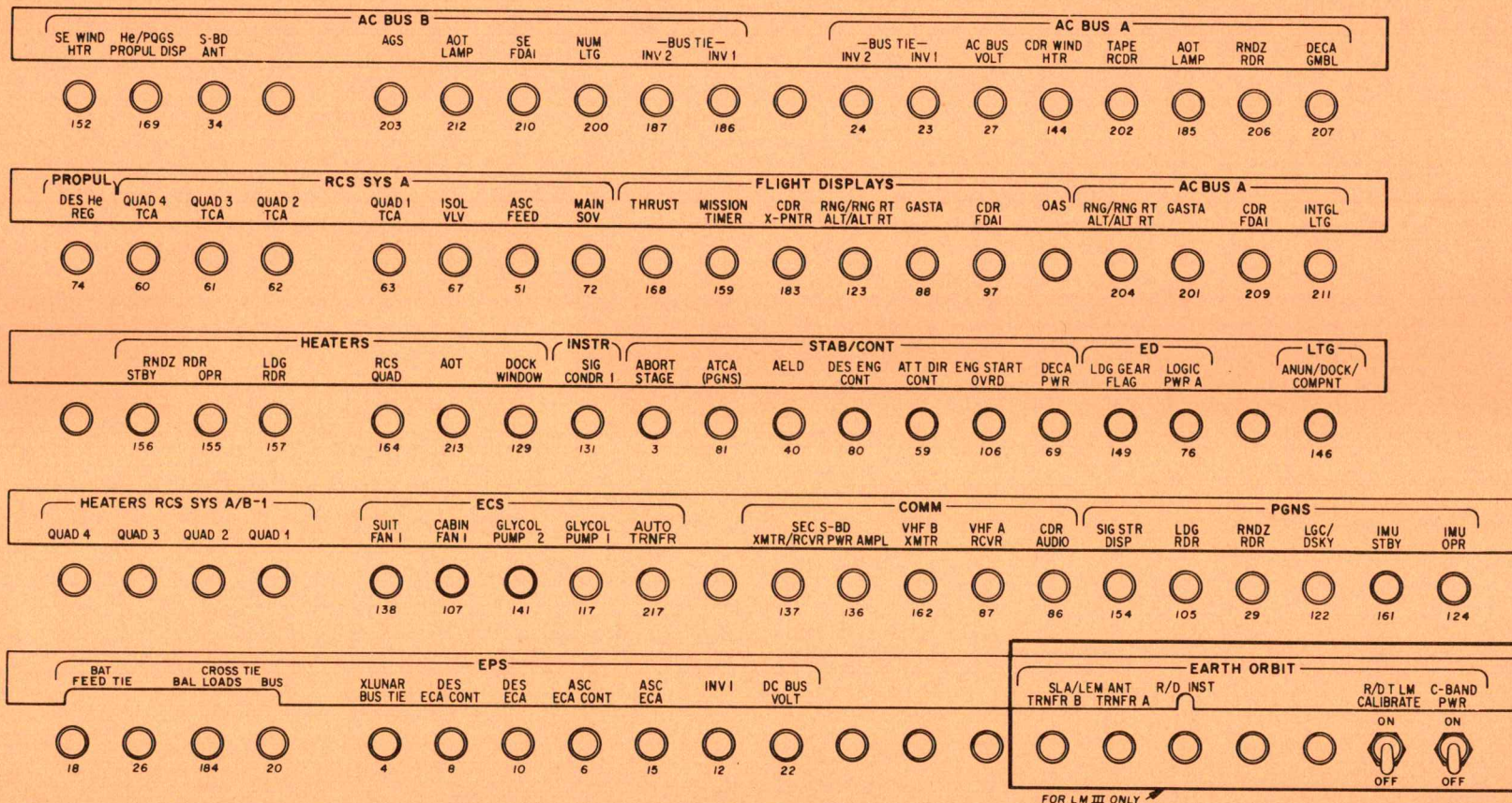
The following ECS circuit breakers are located on panel No. XVI:

1. Disp
2. Glycol Pump Sec
3. Cabin Fan 2
4. Cabin Fan Cont
5. Cabin Repress
6. Suit Fan 2
7. Suit Fan Δ P
8. Divert VLV
9. CO₂ Sensor



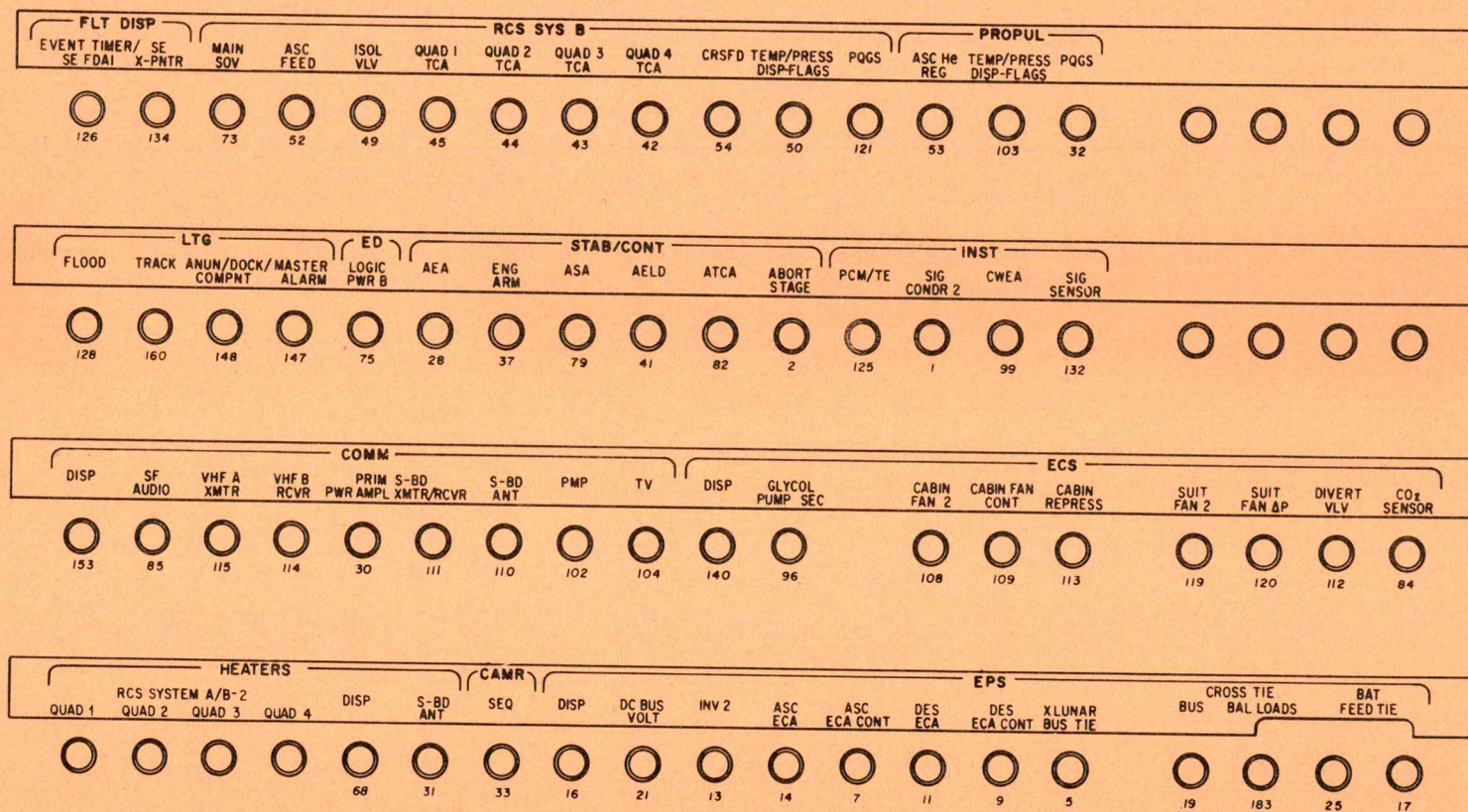
PANEL II - LM3 & SUB

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PANEL XI

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APR 67



PANEL XVI
LM 4

T30900-21
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Ascent Stage Equipment Locations (Reference Figure 9)

The following ECS equipment locations may be seen on Figure 9:

1. Right hand water tank
2. Suit circuit assembly
3. Cabin pressure switch
4. Steam duct
5. Coolant regenerative heat exchanger
6. Secondary heat transport section coolant filter
7. Coolant recirculation assembly
8. Cabin air recirculation assembly
9. Water hose assembly
10. Water module
11. Forward (ingress - egress) cabin dump valve
12. Commander's suit umbilical
13. Systems engineer's suit umbilical
14. Oxygen control module
15. Rate gyro assembly (RGA) cold plate
16. Abort sensor assembly (ASA) cold plate
17. Pulse torque assembly (PTA) cold plate

Aft Equipment Bay Area

The area of the vehicle extending from the aft pressure bulkhead to the aft thermal skin is an unpressurized area in the vehicle. This area is known as the AFT EQUIPMENT BAY and houses some of the ECS equipment.

A view from inside the aft equipment bay and looking forward (see Figure 10) will show the following ECS equipment:

1. Secondary HTS evaporator
2. Coolant accumulator
3. Primary HTS evaporator
4. Primary HTS (PRESSURE) disconnect
5. Primary HTS (SUCTION) disconnect
6. Secondary HTS (PRESSURE) disconnect
7. Secondary HTS (SUCTION) disconnect
8. Right hand water tank water fill disconnect
9. Right hand water tank nitrogen fill disconnect
10. Left hand water tank nitrogen fill disconnect
11. Left hand water tank fill disconnect
12. Water bacteria filter

RGA COLD PLATE
ASA COLD PLATE
O₂ CONT MODULE

SE UMBILICAL
H₂O HOSE

H₂O CONT MODULE
CDR
UMBILICAL

O₂ BACT FILTER
CAB DUMP VALVE

+X233.5
(REF)

+X215
(REF)

CAB RECIRC
ASSEMBLY

SUIT CIRCUIT ASSEMBLY
R/H H₂O TANK

+Z27(REF)
CAB TEMP CONT VALVE

PTA COLD PLATE
STEAM DUCT
CO₂ PARTIAL PRESS SENSOR
CABIN PRESS SW
PRI WATER EVAP FEED
VALVE

SEC HTS COOLANT
FILTER

COOLANT RECIRC
ASSEMBLY

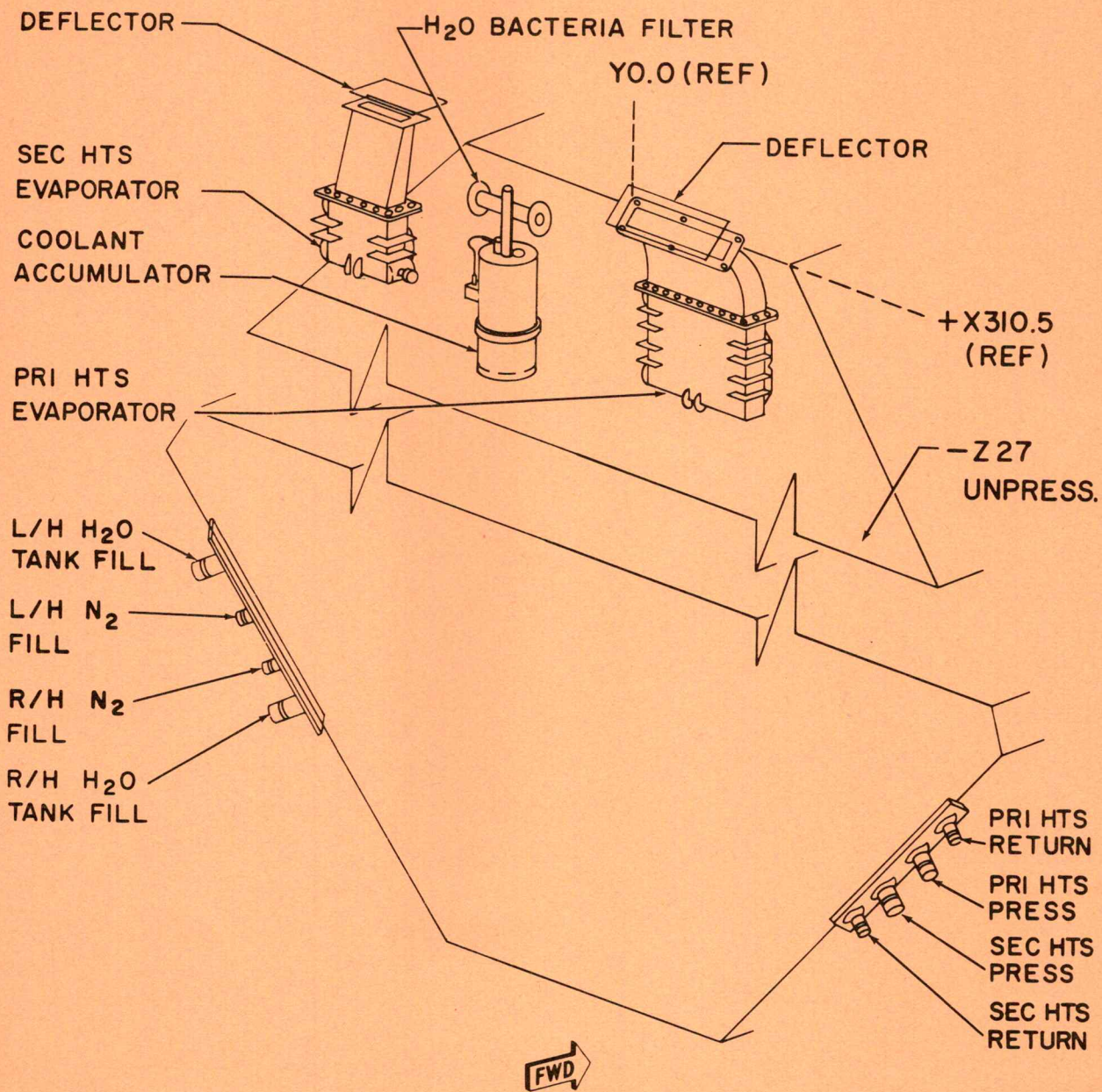
COOLANT REGEN H/X
SPARE PRIMARY L₁OH
CARTRIDGE

-Z27(REF)



ECS EQUIPMENT LOCATIONS ASCENT STAGE-R/H SIDE

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MAR 67



ECS EQUIPMENT LOCATIONS
AFT EQUIPMENT BAY
LOOKING FORWARD

T 30505-74
MAR 67

Looking aft in the aft equipment bay (reference Figure 11) we find the following ECS equipment:

1. No. 1 Ascent Oxygen tank.
2. No. 2 Ascent Oxygen tank.
3. Eleven cold rail assemblies to which various electronic equipments are mounted for thermal control.
4. Associated HTS plumbing for cold rails

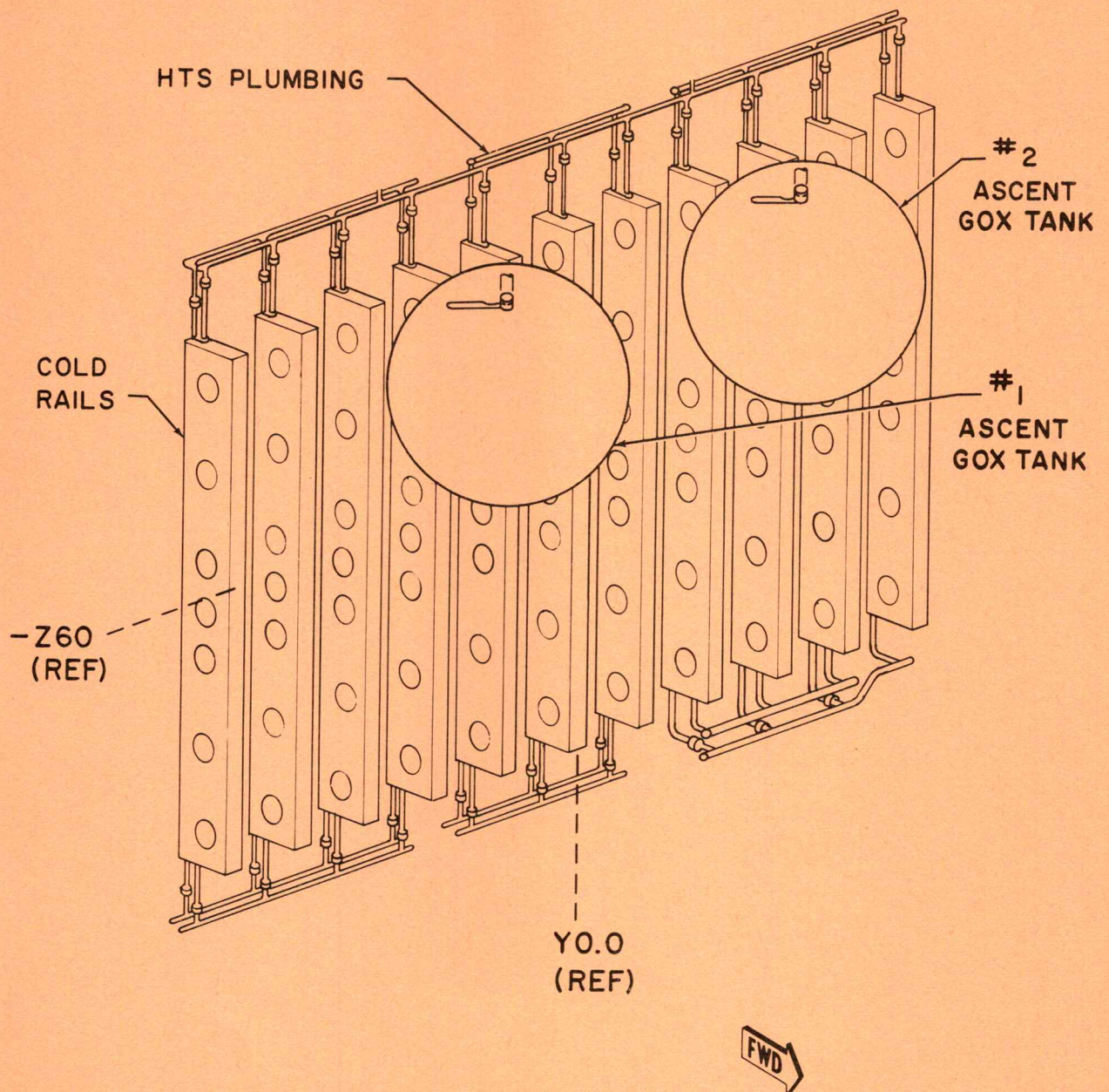
Figure 12 depicts the ECS equipment locations in the ascent stage on the left hand side of the vehicle. The equipment illustrated in this view consists of:

1. Cabin dump valve (top docking hatch)
2. Left hand water tank
3. Data Storage Electronics (DSE) cold plate
4. PLSS Oxygen service hose
5. Gimbal Angle Sequence Transformation Assembly (GASTA) cold plate
6. Tracking Light Electronics (TLE) cold plate
7. Lighting Control Assembly (LCA) cold plate
8. Oxygen interstage disconnect
9. Primary HTS interstage disconnects
10. Power Servo Assembly (PSA) cold plate
11. Coupling Display Units (CDU) cold plates
12. LM Guidance Computer (LGC) cold plates

Descent Stage ECS Equipment Locations (Reference Figure 13)

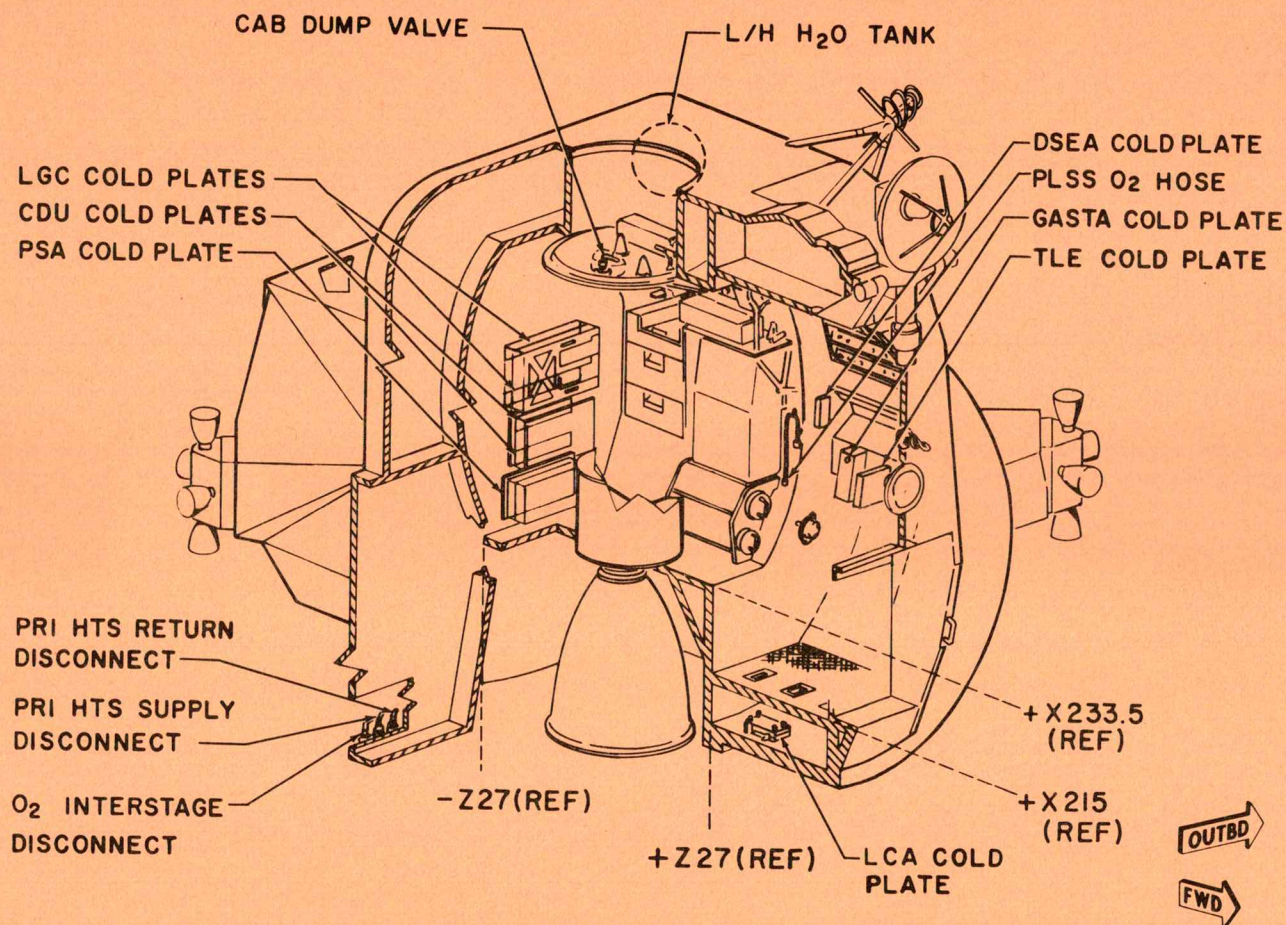
The ECS descent stage equipment is located in all four quads of the vehicle. This equipment is distributed as follows:

- Quad 1 - Two primary HTS cold rails
Two Electrical Power Subsystem (EPS) batteries
One EPS Electrical Control Assembly (ECA)
- Quad 2 - Descent stage water tank
Water tank water servicing disconnect
Water tank nitrogen servicing disconnect
- Quad 3 - Descent stage oxygen tank
High pressure oxygen control assembly
ECS interstage disconnects
- Quad 4 - Two primary HTS cold rails
Two EPS batteries
One EPS ECA



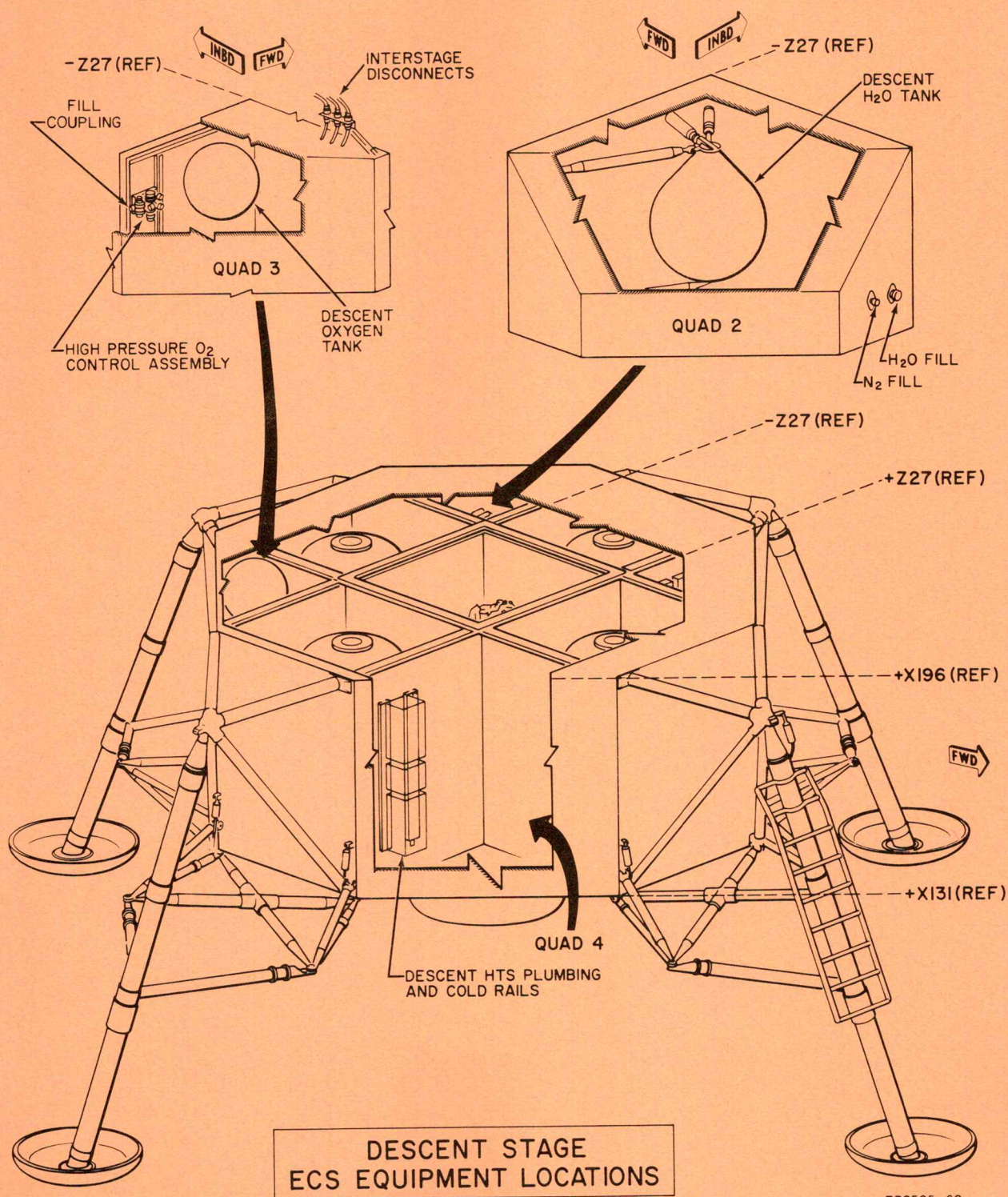
ECS EQUIPMENT LOCATIONS
AFT EQUIPMENT BAY
LOOKING AFT

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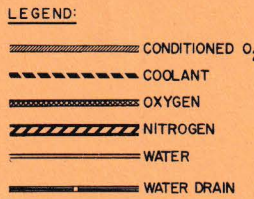


**ECS EQUIPMENT LOCATIONS
ASCENT STAGE-L/H SIDE**

T 30505-76
MAR 67



T30505-68
OCT 66



T30505-100
APR 67

CHAPTER II

OXYGEN SUPPLY AND CABIN PRESSURE CONTROL SECTION (OSCPCS)

Introduction

The OSCPCS stores, in gaseous form, all of the oxygen required by the ECS and maintains suit and/or cabin pressurization by supplying oxygen in sufficient quantities to replenish losses due to crew metabolic consumption and cabin or suit leakage. The section also protects the cabin pressure shell against overpressurization, and enables the crew to intentionally depressurize and repressurize the cabin. An interface is provided to refill the oxygen storage tank in the PLSS. A section capability of four repressurizations of the cabin has been supplied.

The hardware to implement the OSCPCS is located in both stages of the vehicle (reference Figure 1). The components in the section are identified by both their placarded nomenclature and item number, which in the case of the OSCPCS is a three-digit number beginning with either a 3 or a 5. Descent stage hardware consists of:

1. Descent tank (319)
2. GSE disconnect (321)
3. High Pressure Oxygen Control Assembly (392) containing:
 - a. Oxygen bypass valve (322)
 - b. Tank pressure regulator (320)
 - c. Overboard relief valve (503)
 - d. Burst diaphragm (324)
4. Interstage flex line (507)
5. Descent stage disconnect (505)
6. Descent tank pressure transducer (7MT10)

Ascent stage hardware consists of:

1. Ascent stage disconnect (505)
2. Interstage flex line (507)
3. Oxygen module (390) containing:
 - a. Three tank feed filters (315)
 - b. Three tank shut-off valves (304)
 - c. PLSS FILL valve (304)
 - d. PLSS filter (315)
 - e. Two oxygen demand regulators (306)
 - f. Cabin repressurization valve (309)
4. Two ascent stage tanks (318)
5. Two ascent stage tank pressure transducers (7MT5 and 7MT6)

390 MODULE

FILTER 3/4 - (4)

DEMAND REGULATOR O₂ (2)

CABIN PRESSURE VALVE 309 (1)

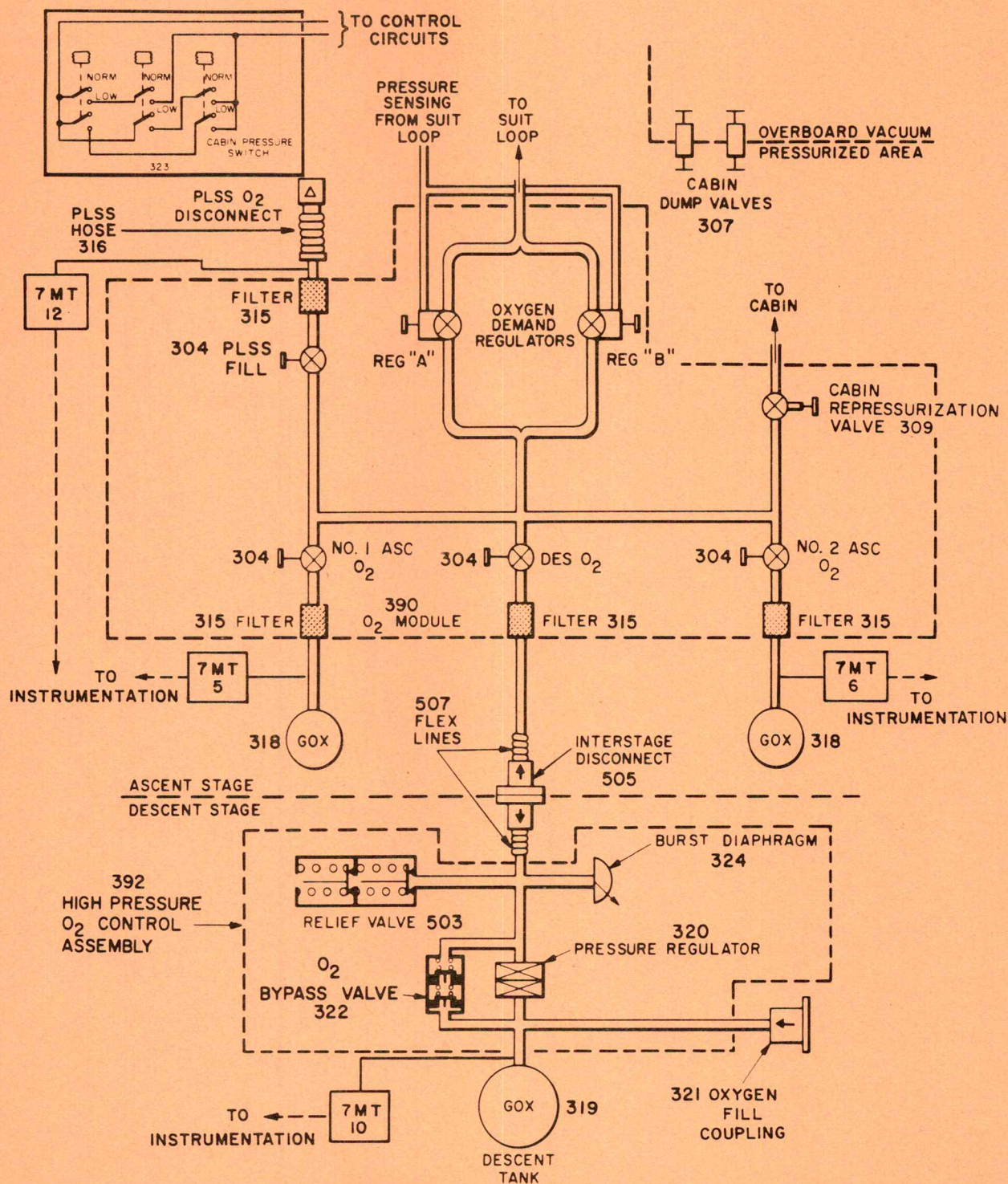
ASCENT VALVE } 304 (7)
PLSS FILL
DES O₂

392 HIGH PRESS O₂ CONTROL

BURST DIAPHRAM — 324 (1)

PRESSURE REG — 320 (1)

O₂ BYPASS — 322



OXYGEN SUPPLY AND CABIN PRESSURE
CONTROL SECTION SCHEMATIC

T30505-3
NOV 66

6. Selected O₂ supply pressure transducer (7MT12)
7. PLSS hose (316)
8. PLSS O₂ disconnect (GFE)
9. Two cabin dump valves (307)
10. Cabin pressure switch (323)

Descent Stage Oxygen Tank - Item 319

The descent stage oxygen tank is located in Quad 3 of the descent stage (see Figure 13; Chapter I), and is secured to primary structure by five support struts; two at the top and three at the bottom of the tank. The tank is manufactured by the Airite Division of Electrada Corp., Los Angeles, California, and is sized to store all the gaseous oxygen (GOX), required for metabolic consumption, cabin and/or suit circuit leakage, oxygen component leakage, six (6) PLSS refills at .9# each, four (4) cabin repressurization at 6.61# each, and cabin puncture protection, from earth launch to switchover to ascent tank No. 1. The tank will not be put on the line until the crew transfers into the vehicle in lunar orbit.

Descent Tank Design Criteria

Minimum internal tank volume = 2.985 ft.³
Maximum design pressure = 3000 P.S.I.
Total oxygen capacity at 2693 P.S.I.A. and 70°F = 48.01#
GSE fill gaging error allowance = .72# (1.5%)
Residual oxygen at 50 P.S.I.A. and 0°F = .97#
Total usable oxygen = 46.32#

High Pressure Oxygen Fill Coupling - Item 321

This disconnect (reference Figure 13, Chapter I), is provided for servicing the descent tank. During S/C servicing, this disconnect is interfaced with the Gaseous Oxygen Transfer Unit, 430-54200, and permits evacuation and filling of the descent tank. A self-sealing disconnect feature is incorporated in the disconnect in addition to a cap which provides a redundant seal.

Descent Tank Pressure Transducer - 7MT10

7MT10 is plumbed into the descent tank feed line and generates an electrical output which reflects tank pressure. This electrical output is fed to the Instrumentation Subsystem where it is used for:

1. Telemetry transmission to earth.
2. S/C display purposes.
3. Caution and Warning (C&W) signals.

Descent Tank Pressure Telemetry Signal Flow - GF3584P

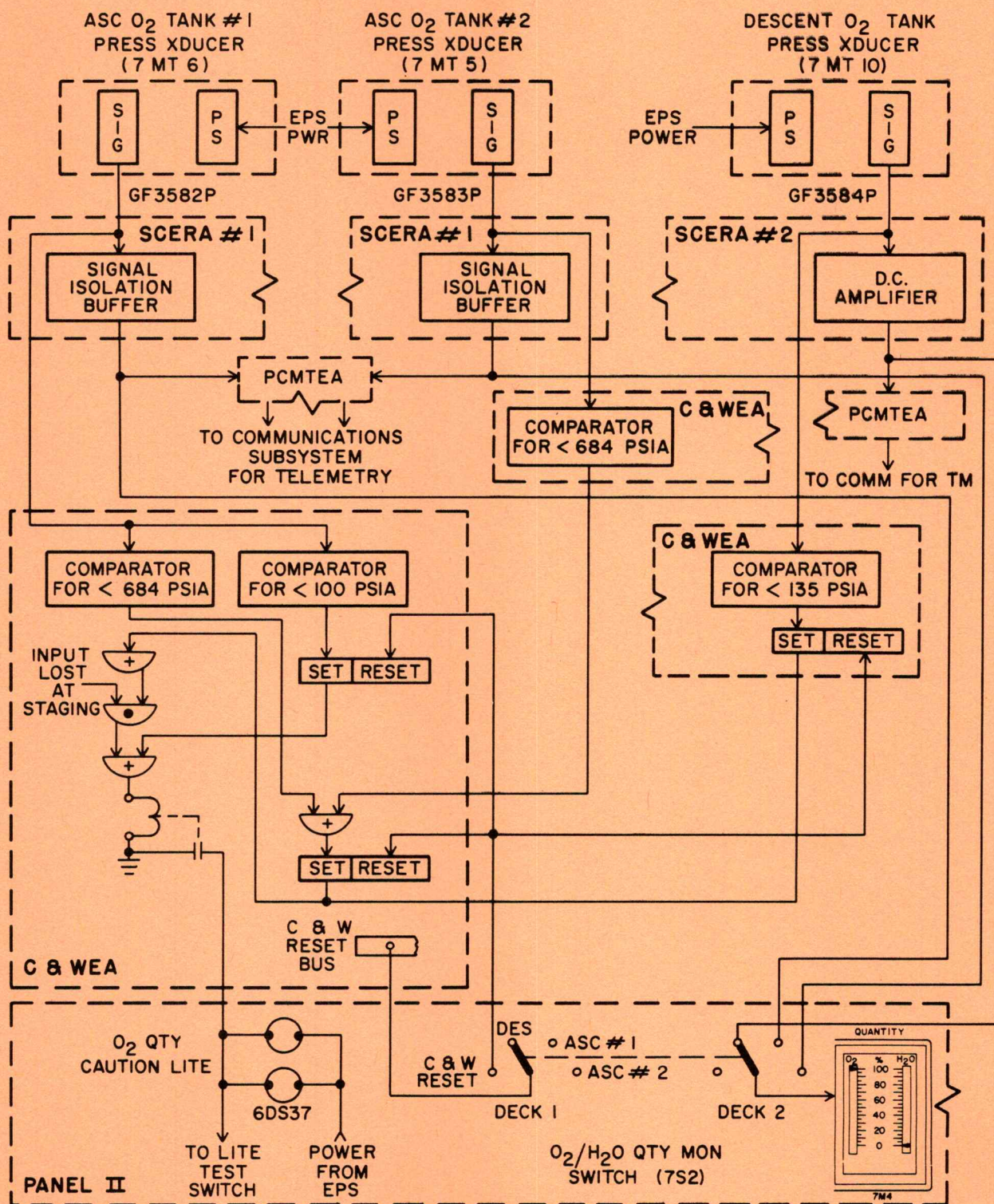
7MT10 is excited by power (reference Figure 2), from the LM Electrical Power Subsystem (EPS). The transducer senses tank pressure and generates an electrical output, which is proportional to the existing pressure. This signal (GF3584P), is routed to Signal Conditioning Electronics Replaceable Assembly (SCERA) No. 2. After passing through a DC amplifier in SCERA No. 2, the signal is fed into the Pulse Code Modulation Timing Electronics Assembly (PCMTEA). The PCMTEA output is routed to the Communications Subsystem for transmission to the Manned Space Flight Network (MSFN) tracking stations on earth.

Descent Tank Quantity Display Circuitry

The DC amplifier output of SCERA No. 2 is also paralleled off and fed to deck 2 of the O₂/H₂O QTY MON switch (7S2), on Panel II in the S/C. When the DES position is selected, the O₂ QUANTITY gage 7M4 will indicate the percent of oxygen remaining in that tank.

Descent Tank Caution and Warning Light Circuitry

Prior to GF3584P being fed into the DC amplifier in SCERA No. 2, a parallel signal is tapped off and fed to a comparator circuit in the C&WEA. When this voltage falls to a level that represents less than 135 P.S.I.A. ($\approx 5\%$), a set signal is developed and routed to the O₂ QTY caution light logic circuitry. Providing the vehicle has not been staged, this signal will energize the master alarm system causing the O₂ QTY caution light, 6DS37, to be illuminated. 6DS37 can be extinguished by the crew placing 7S2 to the C&W RESET position which will route a reset signal from the C&W reset bus to the comparator circuit removing the input from the logic circuitry.



**OXYGEN QUANTITY MONITORING
AND TELEMETRY CIRCUITRY**

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High Pressure Oxygen Regulator - Item 320

The high pressure oxygen regulator (see Figure 3), is provided to reduce the pressure of the oxygen stored in the descent oxygen tank to a level that is compatible with the components in the oxygen control module, item 390. The regulator is internally series redundant, and in addition to regulating discharge pressure from 875 to 960 P.S.I.G. at 75°F acts as a flow limiter. In the event of a failure of the upstream regulator sensor, the valve is designed to fail open permitting the downstream regulator to control outlet pressure.

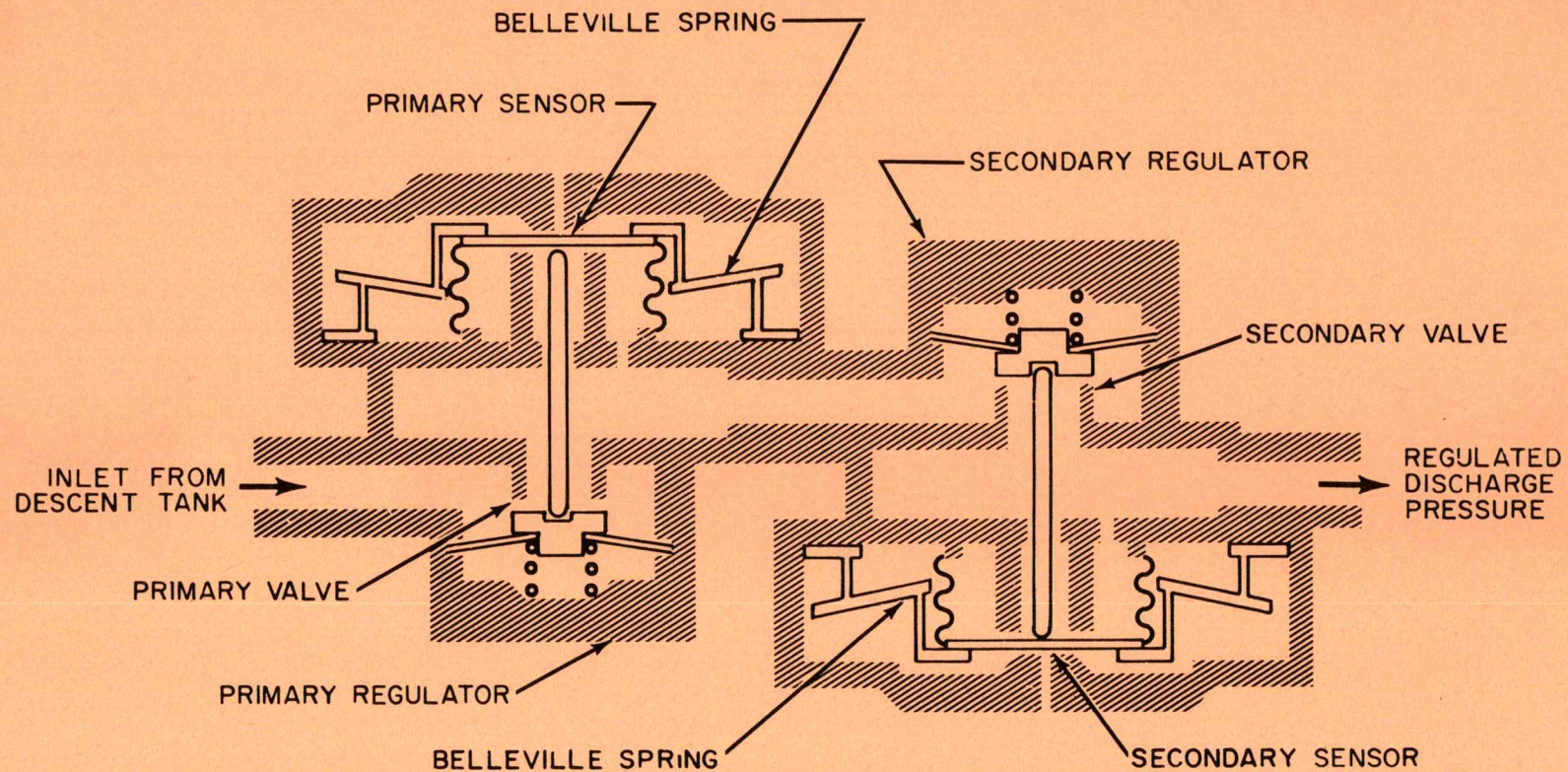
Oxygen from the descent tank enters the regulator and is sensed by the primary sensor. As the pressure builds up inside the sensor it expands and allows the primary valve to move toward its seat regulating the primary regulator discharge pressure. This oxygen then flows into the secondary regulator which is identical in operation to the primary. The primary regulator discharge is fed out and into plumbing to be used in the O.S.S.

Oxygen Bypass Valve - Item 322

A bypass relief valve is provided to protect the ascent oxygen tank against overpressurization conditions. The relief valve has two series redundant elements which crack open at 2875 P.S.I.G., are full open at 3030 P.S.I.G., and reseal at 2850 with 75°F oxygen. If tank pressures exceed acceptable values, 322 will open allowing the tank to vent to the downstream side of the 320 pressure regulator.

Oxygen Relief Valve - Item 503

A series redundant overboard relief valve is provided to protect the oxygen control module (item 390), from excessive pressure caused by either leakage through the high pressure oxygen regulator, or by relief flow or leakage through the oxygen bypass valve. This valve vents oxygen to ambient when the pressure downstream of the 320 pressure regulator reaches 1025 P.S.I.G. The valve is full open at 1090 P.S.I.G., and reseats at 985 when the temperature is 75°F.



HIGH PRESSURE OXYGEN REGULATOR
ITEM 320

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System pressure (see Figure 4), is present at the first stage relief valve but is prevented from relieving overboard due to the force of the poppet load spring. System pressure is also fed to both capsule sensing elements. When system pressure reaches 1025 P.S.I.G., the capsule sensing elements expand, displacing the fail safe pistons and exerting a force on the belleville lever springs. Belleville lever spring motion about the fulcrum points result in the opening of the main poppet valves.

The relief valve incorporates a fail safe open feature. Should a leak develop in the capsule sensing element, oxygen will be dumped into the leakage chamber. This leakage oxygen is allowed to bleed overboard, however, its flow rate is restricted by a bleed orifice in the piston. This allows leakage chamber pressure to build up and force the poppet valve open. As the piston is displaced to its full travel the proof pressure stops and seal is made preventing any further loss of oxygen overboard.

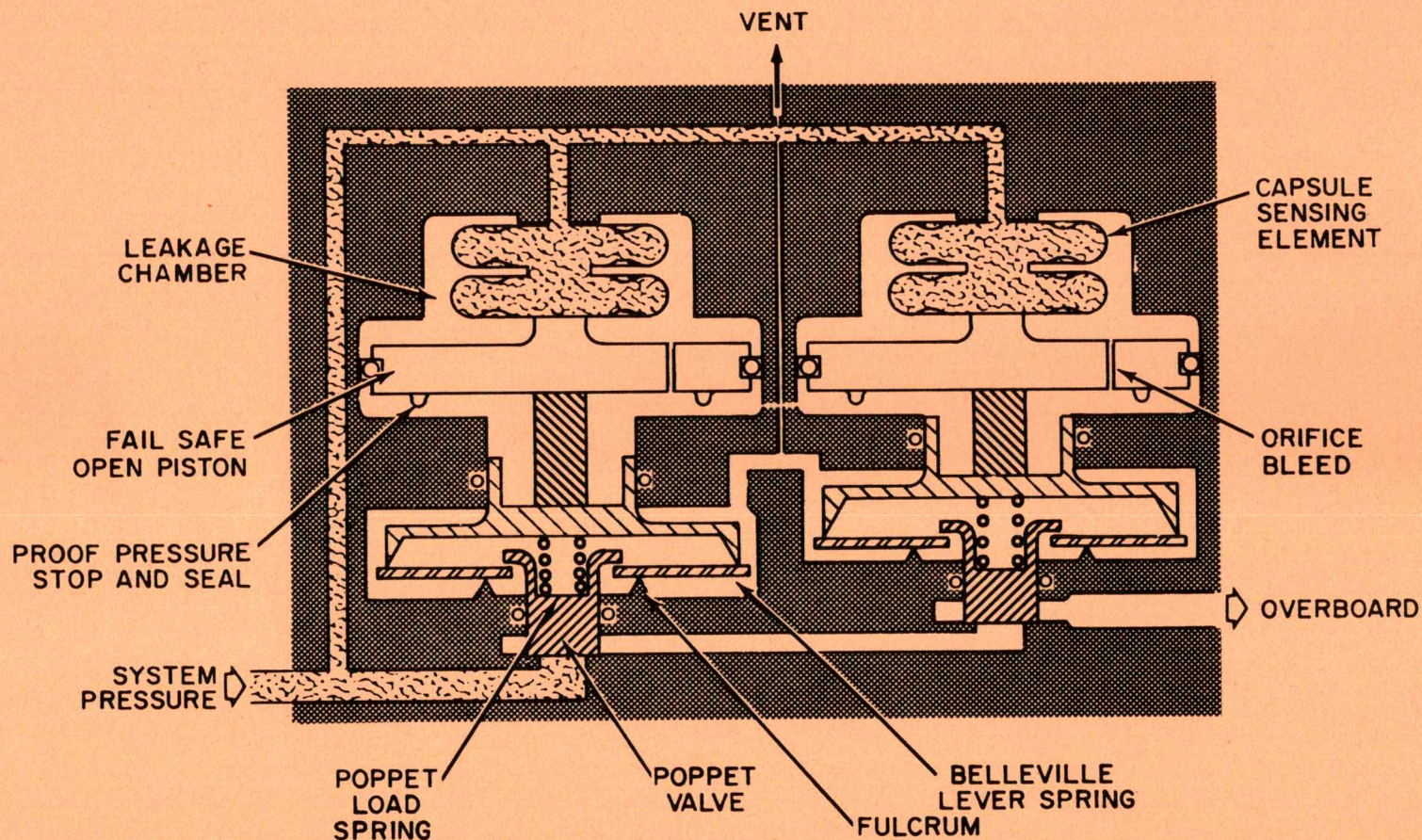
Item 503 has the capability of flowing from 0 to 50 P.P.H., at an inlet pressure of 1100 P.S.I.G.

Burst Diaphragm - Item 324

In the event a malfunction resulting in a rise of the regulated pressure to a dangerous level, a burst diaphragm is provided to vent the descent tank overboard.

Manifold pressure present at the inlet port acts on an aluminum diaphragm and exerts a force on a belleville spring assembly. At 1350 \pm 50 P.S.I.G., the belleville spring assembly snaps downward, withdrawing a diaphragm support and allowing pressure to rupture the diaphragm. A clean circular opening is created, and the sheared out section of diaphragm remains a single piece and clings to the support plate.

The spring system incorporates a temperature compensator to adjust the valve preload with respect to temperature changes in order to provide stability to pressure relief settings. When the valve operates, it has a flow capability of 10 P.P.M. at 150°F and 1300 P.S.I.A. As manifold pressure decays to some minimum value (approximately 300-400 P.S.I.) spring action will return the sheared out section to its original position prior to rupture. Gas will continue to flow overboard at a minimal rate until descent tank pressure is dissipated.



OXYGEN RELIEF VALVE SCHEMATIC
ITEM 503

High Pressure Oxygen Control Assembly - Item 392

The high pressure oxygen control assembly is located (see Figure 5), in quad 3 of the descent stage. The assembly is manufactured by the Parker Co., and contains the following components:

1. High Pressure Oxygen Regulator - Item 320
2. Oxygen By-Pass Relief Valve - Item 322
3. Overboard Relief Valve - Item 503
4. Burst Diaphragm - Item 324

Flexible Metal Hose Assembly - Item 507

Two identical flexible metal hose assemblies (see Figure 12, Chapter I), are provided to allow for relative motion between the interstage disconnects, item 505's, and the adjacent hard lines of the oxygen plumbing. The hose assembly consists of a convoluted flexible inner section with an outer flexible reinforcement braid.

Oxygen Interstage Disconnect - Item 505

The oxygen interstage disconnect is a gimbal mounted disconnect to provide for the interconnection of the ascent and descent stage oxygen lines, (see Figure 12, Chapter I), and allow the parting of these lines at stage separation of the vehicle. The disconnect assembly consists of two parts, a female coupling and a male coupling, mounted in the vehicle interstage area.

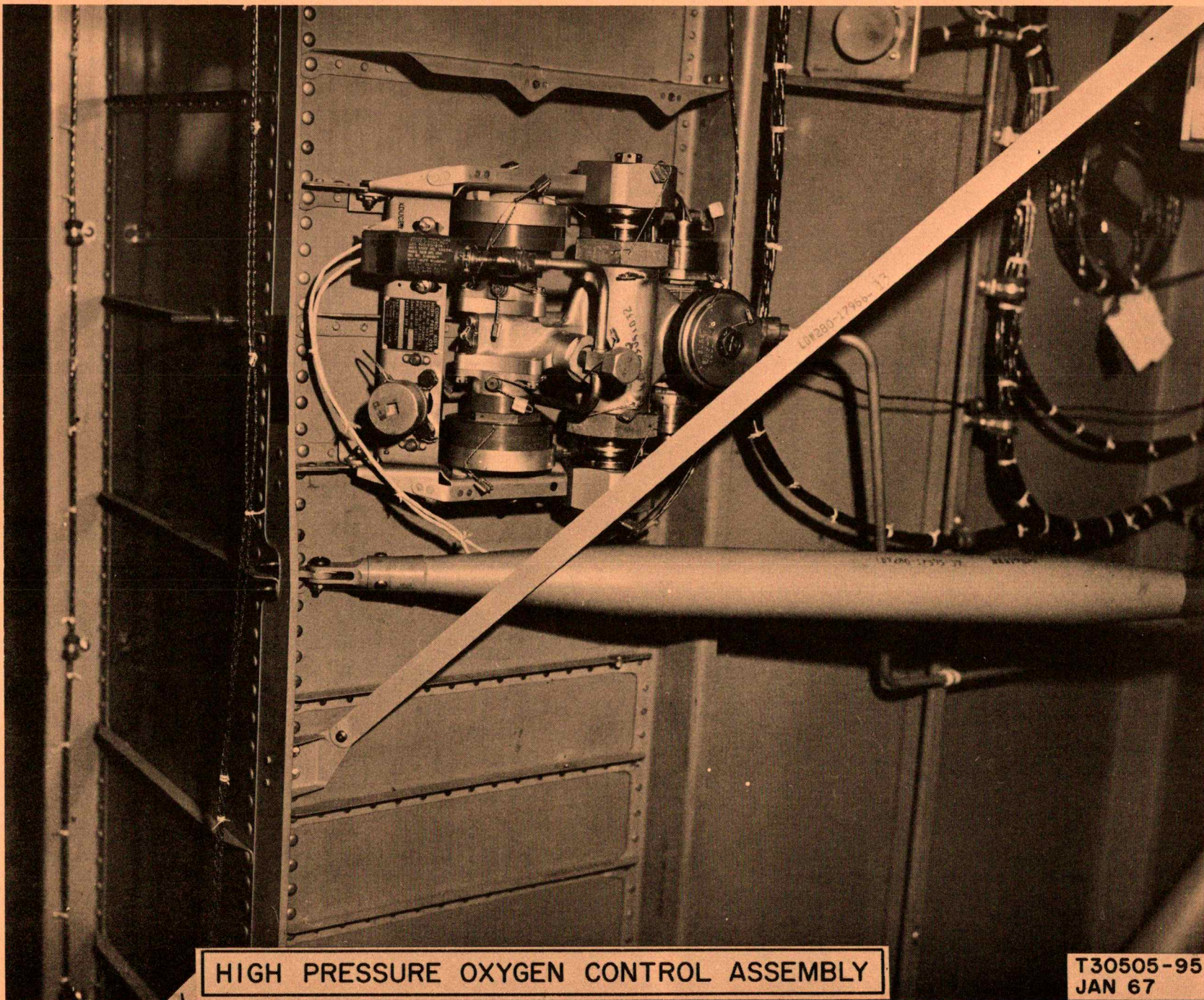
When the vehicle is staged, and the ascent and descent stages physically part, the disconnects will mechanically separate and both disconnect halves will automatically seal off the interconnecting oxygen plumbing.

Ascent Stage Oxygen Tanks - Item 318

Two identical gaseous oxygen storage tanks are provided to supply all the oxygen required for metabolic consumption, cabin and/or suit circuit leakage, oxygen component leakage, and cabin puncture protection subsequent to switchover to ascent consumables. Both tanks are located in the aft equipment bay (see Figure 11, Chapter I), which is an unpressurized region of the vehicle. Oxygen flow from both tanks is controlled by individually selectable tank shut-off valves on the oxygen control module.

2-11

Figure 5



HIGH PRESSURE OXYGEN CONTROL ASSEMBLY

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During a normal lunar landing mission, ascent tank No. 1 will be turned on during lunar pre-launch checkout, and is sized to provide adequate oxygen for return to the orbiting CSM. If an orbital contingency results, or if the worst case launch time is used, ascent tank No. 2 will be used in addition to tank No. 1 for successful return to the CSM.

Ascent Tank Design Criteria

Minimum internal tank volume = 0.495 ft.³

Maximum design pressure - 1000 P.S.I.

Total oxygen capacity at 80°F and 855 P.S.I. A. = 2.41#

Residual oxygen at 75 P.S.I.A. and 0°F = 0.24#

Total usable oxygen = 2.17#

Both ascent oxygen tanks are serviced during pre-launch activity through the PLSS oxygen disconnect using the Gaseous Oxygen Transfer Unit, 430-54200.

Ascent Tank Pressure Transducers - 7MT5 and 7MT6

Two absolute pressure transducers are plumbed into the tank feed lines from the ascent oxygen tanks. These transducers are physically located in the aft equipment bay. 7MT6 is used to sense No. 1 tank pressure and 7MT5 for No. 2 tank pressure.

Ascent Tank No. 1 Pressure Telemetry Signal Flow - GF3582P

The output of 7MT6 is fed into SCERA No. 1 (reference Figure 2), and into a signal isolation buffer. The buffer output, whose voltage level represents quantity remaining in the tank, is routed into PCMTEA where it is put in the proper format for transmission to earth via the Communication Subsystem.

Ascent Tank No. 1 Quantity Display

The output of the signal isolation buffer in SCERA No. 1 is also paralleled off and fed to deck 2 of the O₂/H₂O QTY MON Switch (7S2) on Panel II in the S/C. When the ASC No. 1 position is selected, the O₂ QUANTITY gage 7M4 will display the percent of oxygen remaining in that tank.

Ascent Tank No. 1 Caution and Warning Circuitry

GF3582P is also paralleled off and fed into comparator circuits in the C&WEA. Prior to staging the vehicle, if ascent No. 1 pressure falls to 684 P.S.I.A. (approximately 80%), logic circuitry will be set to energize the C&WEA alarm relay. This relay provides a ground for the O₂ QTY caution light (6DS37), on Panel II in the S/C. If the C&W RESET position on 7S2 is selected, 6DS37 may be extinguished.

After staging the vehicle, the "and" gate of the < 684 P.S.I.A. logic train is lost, thereby preventing this fault from triggering 6DS37. The philosophy of this circuit is that after staging, tank No. 1 will be turned on for use and we expect its pressure to decay as the mission progresses. Since this is normal system operation, it is not desirable to light 6DS37 when this occurs. During this phase of the mission, it is now desirable to notify the flight crew when the quantity of tank No. 1 is reaching a low level, consequently, a 100 P.S.I.A. comparator circuit is provided. When tank No. 1 pressure falls to 100 P.S.I.A., the C&WEA logic circuitry again originates a set pulse which energizes appropriate circuitry to again turn on 6DS37. This signal would alert the flight crew to change over to ascent No. 2 consumables. 6DS37 may be extinguished by using 7S2.

Ascent Tank No. 2 Telemetry Signal Flow - GF3583P

This signal flow is similar to GF3582P, previously described.

Ascent Tank No. 2 Caution and Warning Circuitry

The output of 7MT5 is paralleled off and fed into a comparator circuit in the C&WEA. Prior to vehicle staging, this circuit will generate a set pulse for the C&WEA logic circuitry to light the O₂ QTY caution light whenever tank pressure falls below 684 P.S. I.A. After vehicle staging this logic circuitry is disabled.

Oxygen Control Module - Item 390

This item is mounted on the ARS suit circuit assembly package, which is located to the right rear of the SE position (see Figure 3, Chapter I). It consists of a cast housing which contains the following components that make up the oxygen control module:

- 4 - Item 315 filters
- 4 - Item 304 shut-off valves
- 2 - Item 306 demand regulators
- 1 - cabin repressurization valve

In addition, an interlock is provided such that the item 304's controlling flow from the ascent oxygen tanks cannot be opened until the descent oxygen valve is shut off. An override to this interlock is also provided. A view of the oxygen module control panel is illustrated on Figure 6.

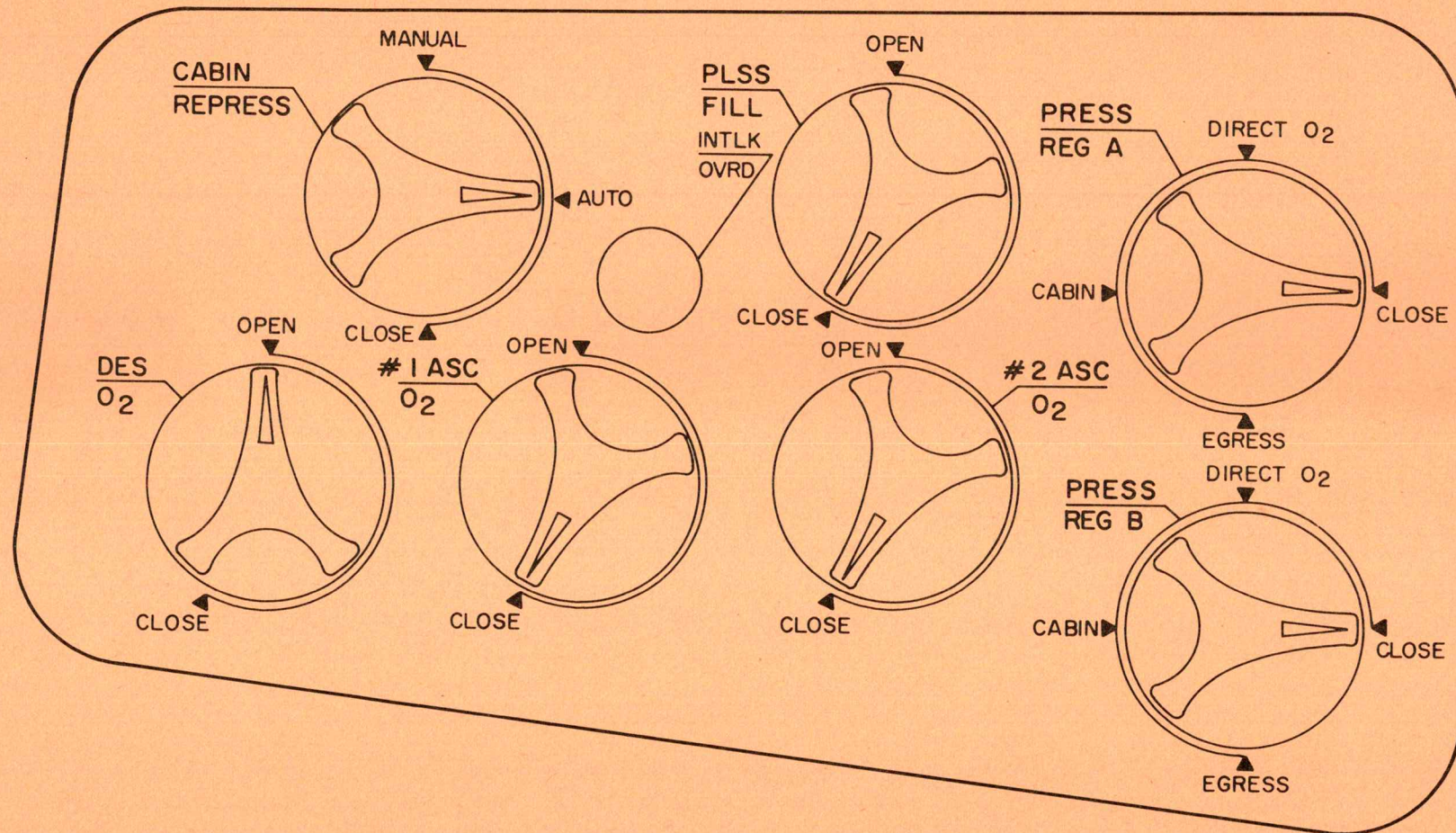
Oxygen Filters - Item 315

Oxygen filters are provided at each inlet to the oxygen control module to remove all particulate matter from the oxygen supply which could cause a malfunction of a component within the ECS. In addition, oxygen supplied to the PLSS disconnect is also routed through a filter. These filters have a 18 micron nominal and a 40 micron absolute filtering capability.

Oxygen Shut-Off Valves - Item 304's

Four manually operated shut-off valves are provided; one for each of the O.S.S. oxygen tanks, and one to control the flow of oxygen to the PLSS O₂ disconnect.

A mechanical interlock is provided to prevent an ascent feed valve from being opened prior to closing of the descent feed valve. This interlock will preclude the possibility of transferring ascent oxygen to the descent tank prior to staging, and also ensures that the descent feed valve is closed prior to staging so it may act as a redundant seal on the inter-stage disconnect preventing the loss of oxygen overboard. This interlock may be overridden by the crewmen depressing the INTLK OVRD button (see Figure 6), on the oxygen control module panel.



OXYGEN MODULE CONTROL NOMENCLATURE
ITEM 390

Oxygen Demand Regulators - Item 306's

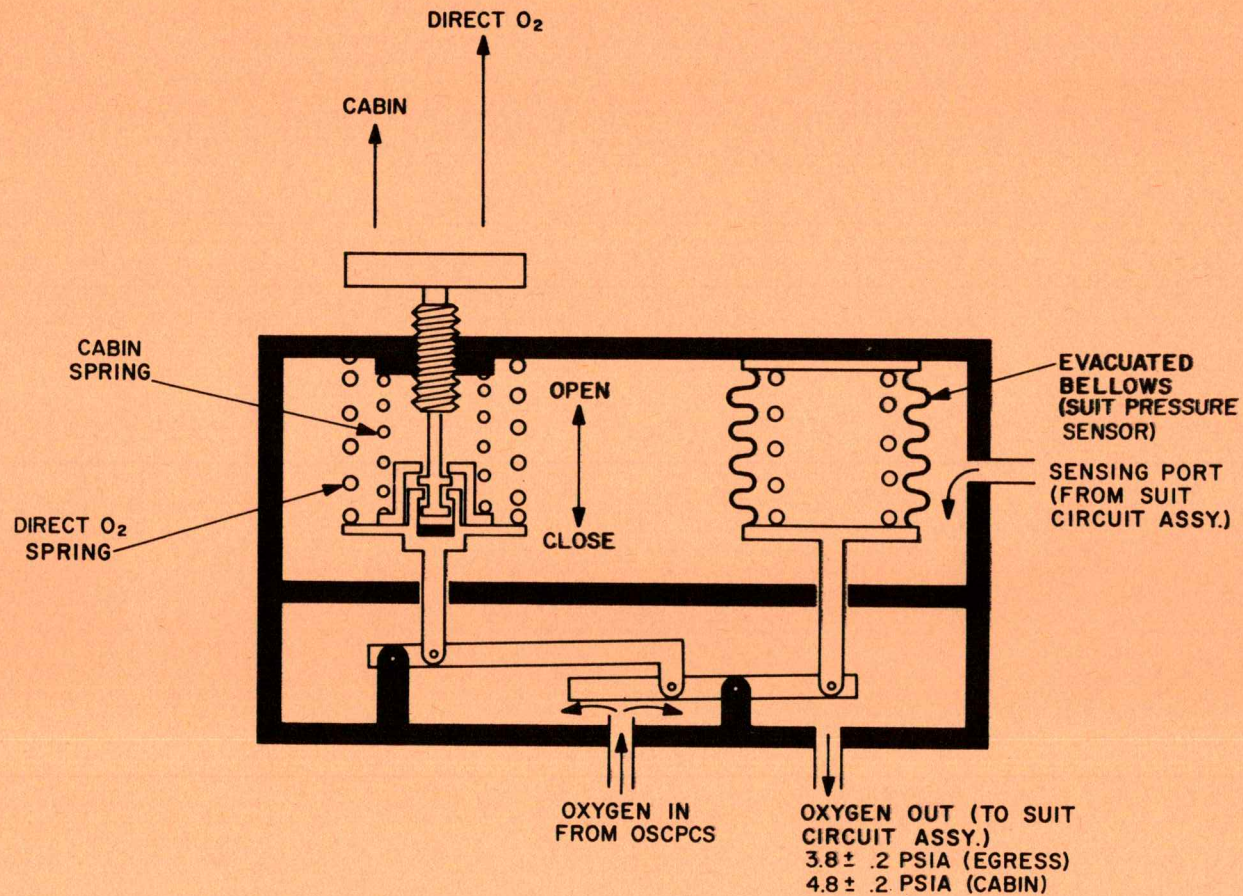
Two item 306 demand regulators, arranged in parallel, are used to meter oxygen from the supply tanks to the ARS. Both regulators are manually controlled by individual four-position selector handles which are placarded "CLOSE - DIRECT O₂ - CABIN - EGRESS". One regulator is referred to as a "PRESS REG A" and the other as a "PRESS REG B".

Schematic operation of the demand regulator is illustrated on Figure 7. Suit loop pressure is sensed by an aneroid bellows which actuates a balanced lever system. The levers actuate a valve metering poppet which is biased by spring force. By actuating the selector handle, the spring rates acting on the lever system may be changed, thereby resulting in different pressure levels being established in the suit loop.

The aneroid bellows is evacuated, but kept from collapsing by an internal spring. One end of the bellows is anchored to the regulator housing and the other to the lever systems which actuates the poppet valve. When the selector handle is placed to the "EGRESS" position, the forces exerted on the lever systems by the cabin, direct O₂, and the bellows springs are such that the metering poppet is opened and a flow of oxygen is established into the suit loop. As suit loop pressure rises, a tap downstream of the suits in the ARS feeds a reference pressure back into item 306 to the bellows area. This pressure buildup squeezes the bellows and moves the poppet toward its closed position throttling the flow to the ARS.

When the "CABIN" mode is selected, the selector shaft lifts the bottom spring seat retainer of the cabin spring, removing its force from the lever system. This action results in the valve poppet opening and allowing the suit pressure to build up from the previously selected level to $4.8 \pm .2$ P.S.I.A. As suit pressure rises, the sensed pressure once again acts on the bellows and when the proper pressure level is attained will regulate at that schedule.

A "DIRECT O₂" selection results in the spring seat retainer of the direct O₂ spring being lifted off the lever system causing the poppet to be driven full open. With an upstream pressure of 900 P.S.I.A. and a 70° fluid temperature, one 306 regulator is capable of flowing 7.1 P.P.H. into the ARS. Direct O₂ will be used during the ECS checkout in lunar orbit to determine suit circuitry integrity.



**OXYGEN REGULATOR ITEM 306
(SCHEMATIC)**

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A "CLOSE" selection results in the selector handle shaft bottoming on the lever system which physically drives the poppet valve onto its seat, terminating all flow to the ARS from that regulator. Both regulators will be launched from earth in the closed selection and this selection may also be used by the crew in isolating a malfunctioning regulator in flight.

Each regulator incorporates four micro switches which are actuated by the manual positioning of the regulator valve handle. Two of these switches are valve position indicator (VPI) switches, while the other two are functional switches which control electrical circuits in the ECS.

One VPI switch on each regulator (see Figure 8), provides a contact closure when the "CLOSE" selection has been made. This signal (GF3071X on reg. A and GF3073X on reg. B), is routed to the Instrumentation Subsystem for telemetry purposes. A second VPI switch on each regulator provides a contact closure when the "DIRECT O₂" position is selected. This signal (GF3072X on reg. A and GF3074X on reg. B), is also used for telemetry purposes.

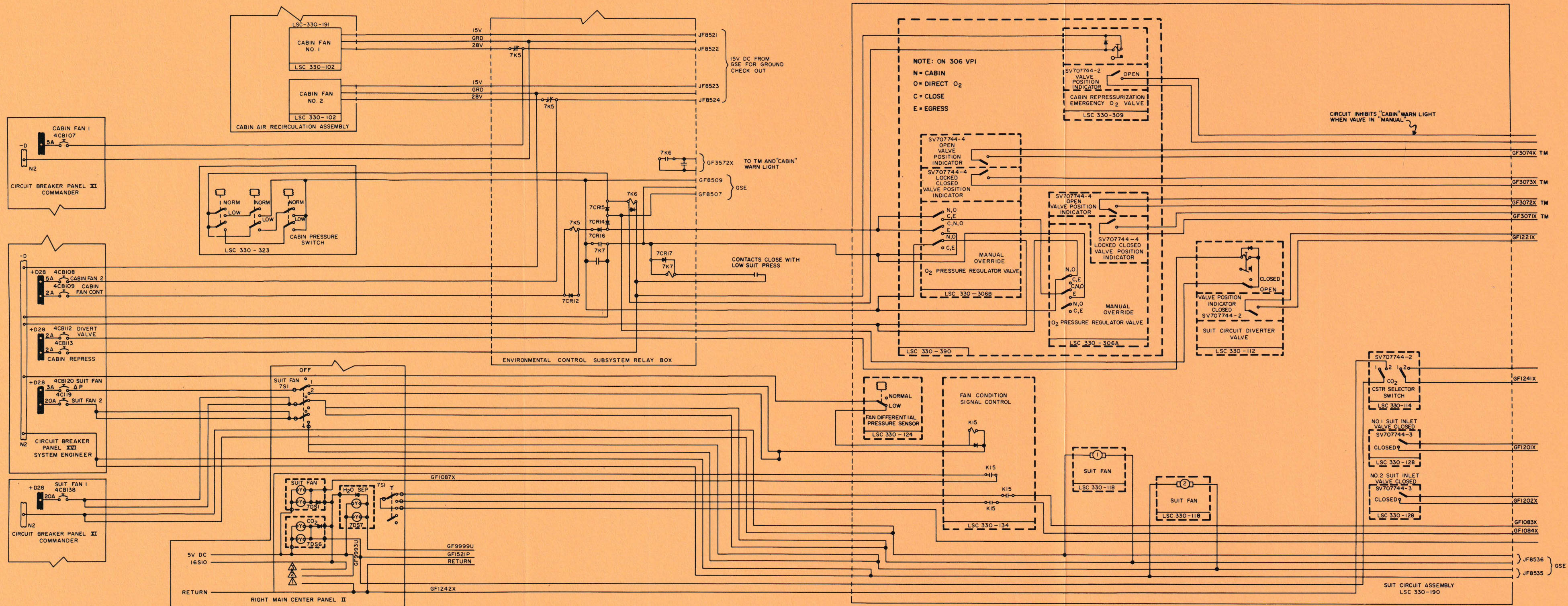
Each regulator mounts two functional switches. One functional switch is actuated to the closed position when "EGRESS" is selected. The second functional switch, a double-pole double-throw switch, has one set of contacts closed at the "CLOSE" and "EGRESS" positions and the second set of contacts is closed in the "CABIN" and "DIRECT O₂" positions. The functional switches provide circuitry for the control of the cabin re-pressurization valve and the suit circuit diverter valve.

PLSS Fill Valve

The PLSS fill valve is mounted on the oxygen control module and serves two in-flight functions:

1. Servicing of the PLSS oxygen tank.
2. Pressurizing 7MT12 transducer for telemetry indication.

This valve is identical in construction to the three oxygen tank feed valves.



ECS ELECTRICAL SCHEMATIC SHEET I

Oxygen Manifold Pressure Transducer - 7MT12

7MT12 is a 0 to 1400 P.S.I.A. pressure transducer which senses the oxygen pressure downstream of the PLSS fill valve. This transducer output is used for telemetry purposes only and will indicate the pressure available in the oxygen manifold. The manifold pressure will be used for monitoring section performance, in addition to providing a cross check capability on tank pressure transducers 7MT5, 6, and 10. In order for 7MT12 to produce useful data, the crew must open the PLSS fill valve.

PLSS Servicing Hose - Item 316

A flexible servicing hose is provided for routing oxygen from the OSCPCS to the PLSS oxygen tank. This hose is located on the left-hand side of the vehicle (see Figure 12, Chapter I), aft of the CDR position.

PLSS Oxygen Disconnect

The PLSS oxygen disconnect is a GFE item that is attached to the item 316 hose and allows mechanical connection of the assembly to a disconnect half on the PLSS. A check valve in the disconnect is opened when a positive mechanical force is applied during connection to its mating half. This check valve automatically closes upon uncoupling the disconnect from its mating half. In addition to being used for filling the PLSS oxygen tank, this disconnect allows GSE servicing of the two ascent oxygen tanks.

Cabin Repressurization and Emergency Oxygen Valve - Item 309

The cabin repressurization and emergency oxygen valve provides for the delivery of oxygen directly to the cabin for cabin pressurization, and to delay the decay of cabin pressure following a puncture of the cabin pressure shell. The valve automatically responds to signals from the cabin pressure switch during pressurized cabin operation, and to the suit pressure sensor during unpressurized cabin operation. Manual override provisions for opening and closing the valve are provided.

Item 309 is a solenoid operated valve which incorporates a manual override feature. It is used to repressurize the cabin after a deliberate decompression has been made and provides an emergency flow of oxygen should a cabin puncture occur. If a cabin puncture occurs, and the hole does not exceed an effective diameter of 0.5 inches, 309 is capable of maintaining a cabin pressure of 3.5 P.S.I.A., for a minimum of two minutes. This time interval is adequate for the flight crew to replace their gloves and helmets and revert to closed suit loop mode of operation isolating them from the decompressing cabin.

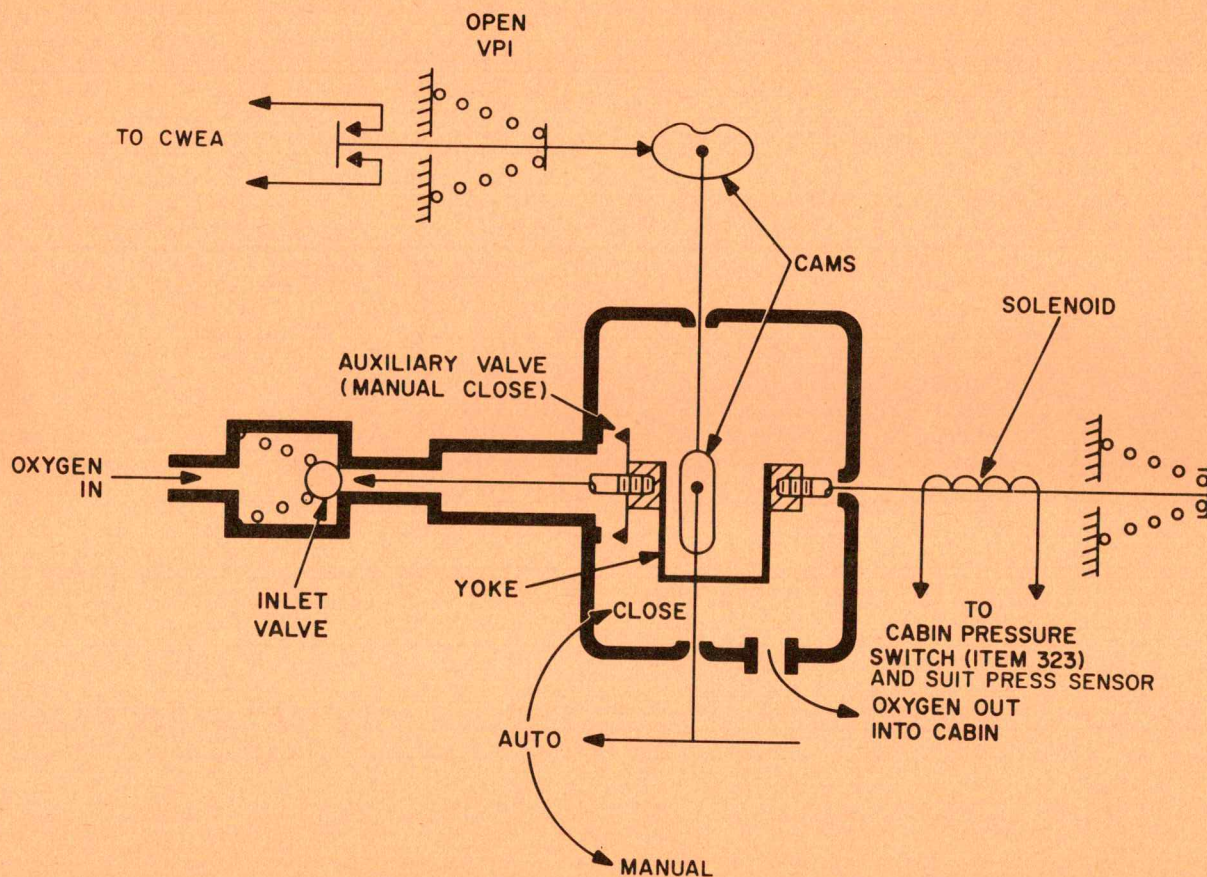
The valve, reference Figure 9, is controlled by a three-position (MANUAL - AUTO - CLOSE) selector handle on the oxygen control module. When "AUTO" has been selected, valve operation is controlled by the solenoid, which receives its signals from the cabin pressure switch. If oxygen regulator valve A or B have been selected to either "CABIN" or "DIRECT O₂", and the cabin pressure falls below $4.15 \pm .15$, power is supplied to the 309 solenoid. This results in the solenoid moving the valve yoke assembly in a direction such that the inlet valve is unseated allowing oxygen from the manifold to flow through the valve and out into the cabin area. Should the cabin pressure rise to $4.45 \pm .15$, the cabin pressure switch removes the power from the solenoid and the valve will close due to return spring action. Placing both of the demand regulators to either "CLOSE" or "EGRESS" will disable the circuitry to the 309 solenoid through the cabin pressure switch provided suit pressure does not fall below 3.12. During periods when the cabin is decompressed, the suit pressure sensor will energize (see Figure 8), relay 7K7 in the ECS relay box. A set of contacts on 7K7 will energize the cabin repressurization valve provided it is in the "AUTO" selection. This circuitry affords crew protection against catastrophic failures of the suit circuit while exposed to a decompressed cabin.

When the "MANUAL" position is selected, the handle shaft actuates a cam which displaces the yoke in the same direction as the previous solenoid action in the auto mode. A rod attached to the yoke unseats the inlet valve and a flow is established to the cabin. When the valve is full open it is capable of flowing 8 P.P.M at 500 P.S.I.A., and 160°F. The valve is capable of repressurizing a decompressed cabin in 60 ± 10 seconds.

The manual "CLOSE" selector operates similar to the previously described open selection with the exception that shaft motion in this direction results from the high cam striking the yoke with a corresponding increase in displacement of the assembly. This causes the inlet valve to open, and in addition, an auxiliary valve downstream of the inlet valve to be forced onto its seat. In this configuration the inlet valve is open; however, no flow is present to the cabin due to the auxiliary valve being seated. A physical cross-sectional cutaway of the valve is illustrated in Figure 11.

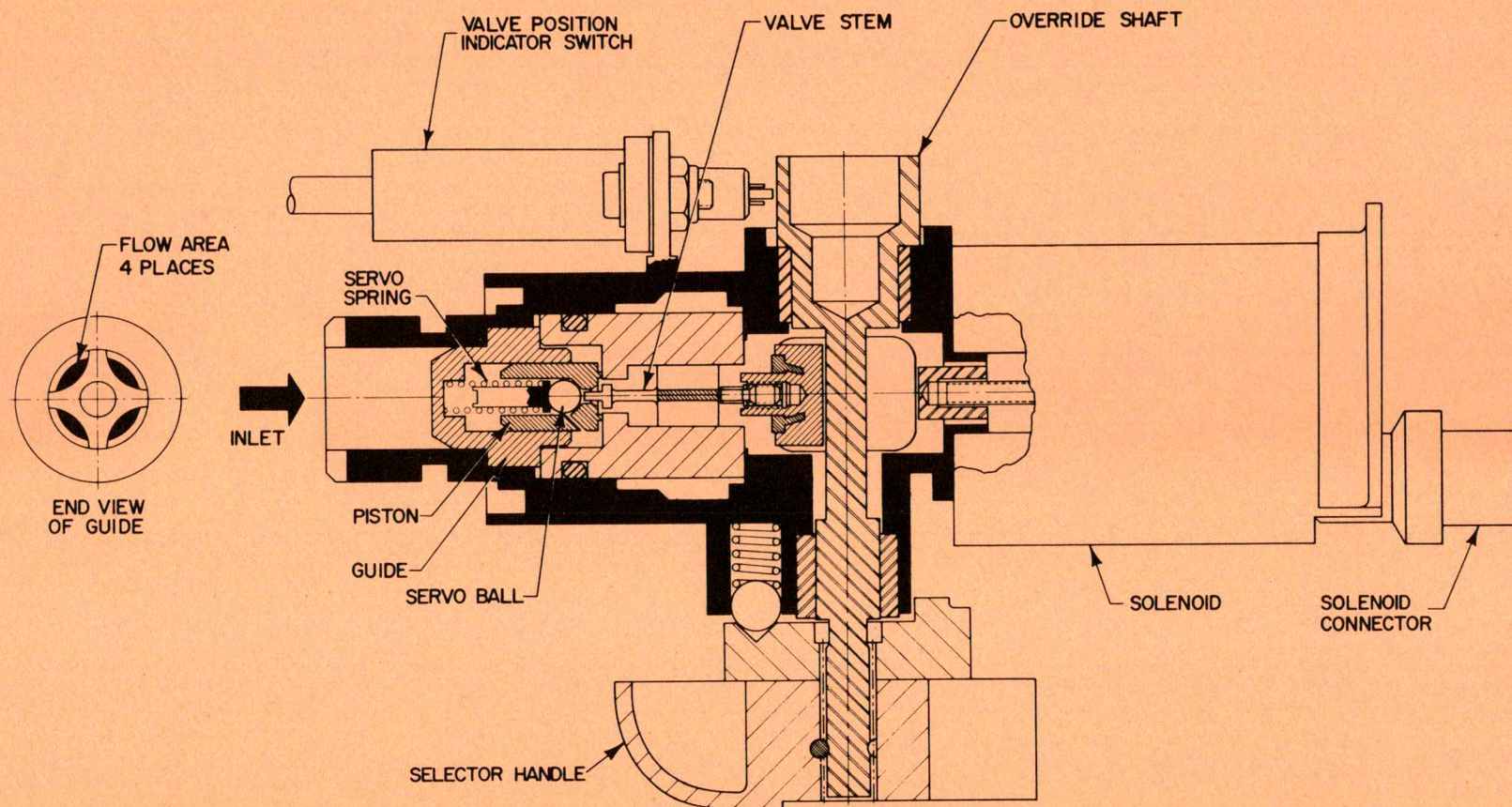
Cabin Dump Valves - Item 307

Two pneumatically operated dump valves are used to prevent excessive cabin overpressurization and to permit deliberate cabin decompression. Both valves are identical in construction and operation. One valve is located on the forward ingress-egress hatch and the other on the overhead docking hatch.



**CABIN REPRESSURIZATION AND EMERGENCY
OXYGEN VALVE (ITEM 309) SCHEMATIC**

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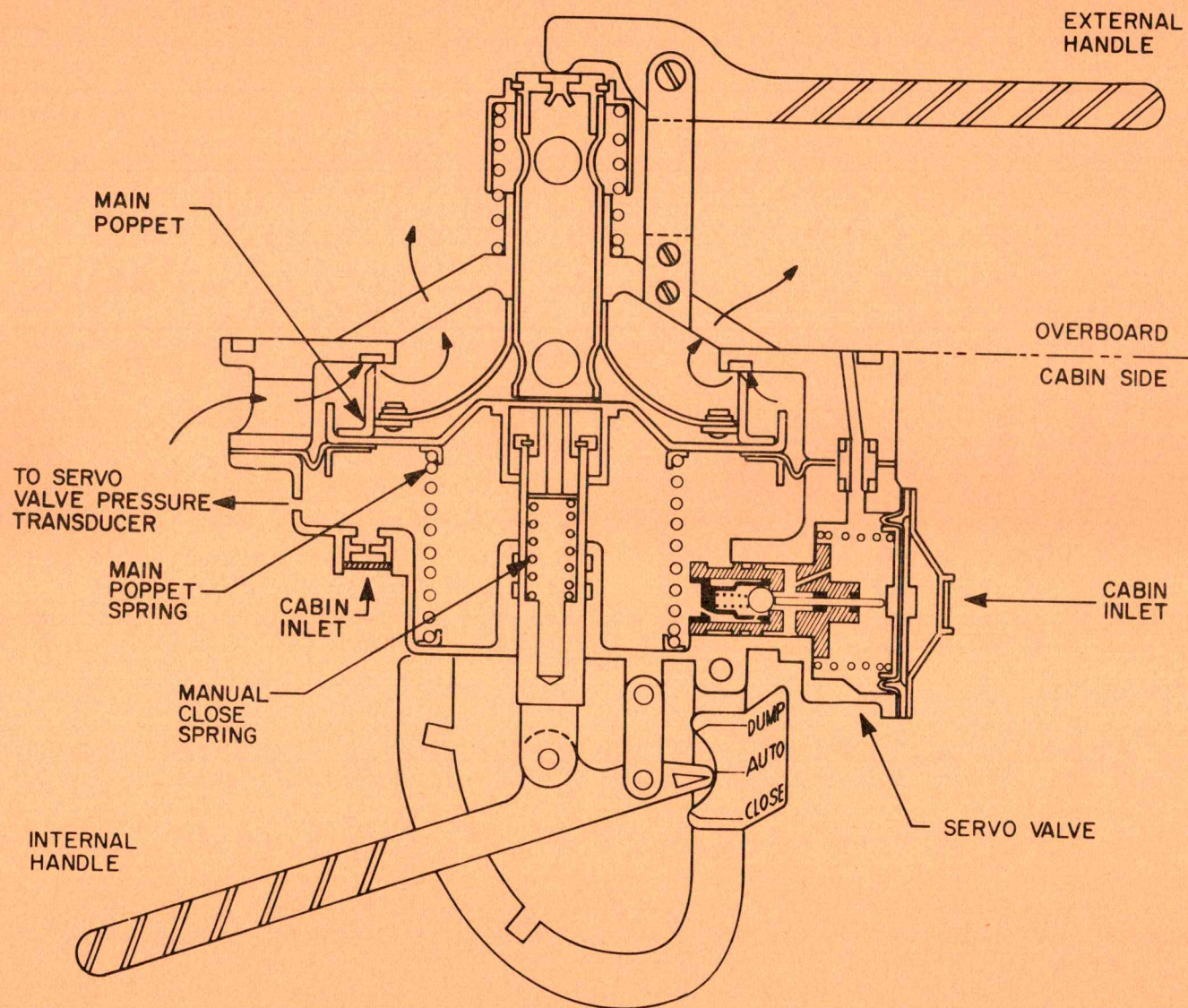


CABIN REPRESSURIZATION AND EMERGENCY OXYGEN VALVE

Two manual handles (see Figure 11), are provided for each 307 valve, one inside the vehicle and one externally. The internal handle is a three-position (DUMP-AUTO-CLOSE) handle which is detent locked in all three selections. When the "AUTO" selection is made, operation of the valve is by means of the external handle or the action of the servo valve. The servo valve consists of a metering valve whose position is controlled by the deflection of the servo valve diaphragm. One side of this diaphragm is exposed to cabin pressure, while its spring side is vented overboard to ambient. When the cabin-to-ambient pressure differential reaches approximately 5.4 P.S.I.D. the servo valve diaphragm will overcome the servo spring and unseat the servo valve. This action will vent the spring side of the main poppet to ambient causing a pressure drop in this chamber. Since cabin pressure is still present on the bottom surface of the main poppet, it will overcome the force of the main poppet spring and open the valve. Cabin pressure will now dump overboard reducing it to acceptable values. At a pressure differential of 6 P.S.I.D., one 307 valve is capable of flowing 11.1 PPM of oxygen overboard. When the internal handle is in "AUTO", the valve may be manually opened by using the external handle. Force exerted on the external handle is transmitted to the main poppet and it will be driven off its seat regardless of the cabin pressure differential at that moment.

Moving the internal handle to the "DUMP" position results in a shaft motion which will pull the poppet off its seat. One 307 valve without a bacteria filter can dump the cabin from 5.0 to 0.08 P.S.I.A., in 180 seconds with no cabin inflow. Dumping the cabin gas through the O₂ bacteria filter increased the dump time to 240 seconds. A close selection moves the manual actuation rod toward the main poppet increasing the load on the manual close spring. This selection will be used in isolating a leaky dump valve in flight.

In addition to positive pressure relief, the cabin dump valves will relieve cabin negative pressure. If ambient pressures exceed cabin pressure the main poppet will open and equalize the pressure differential. This condition could occur during docking when oxygen is supplied to the LM from the CM ECS through the tunnel area.



CABIN DUMP VALVE-ITEM 307

Oxygen Bacteria Filter

A filter is provided on the cabin side of the forward ingress-egress hatch cabin dump valve to allow for bacteria filtration of the cabin gas when dumping cabin pressure. The filter is capable of being installed on the dump valve by the crew after lunar descent and removed prior to lunar ascent. This filter will remove 95% of all bacteria particles greater than 0.5 microns and will minimize lunar environment contamination.

Cabin Pressure Switch - Item 323

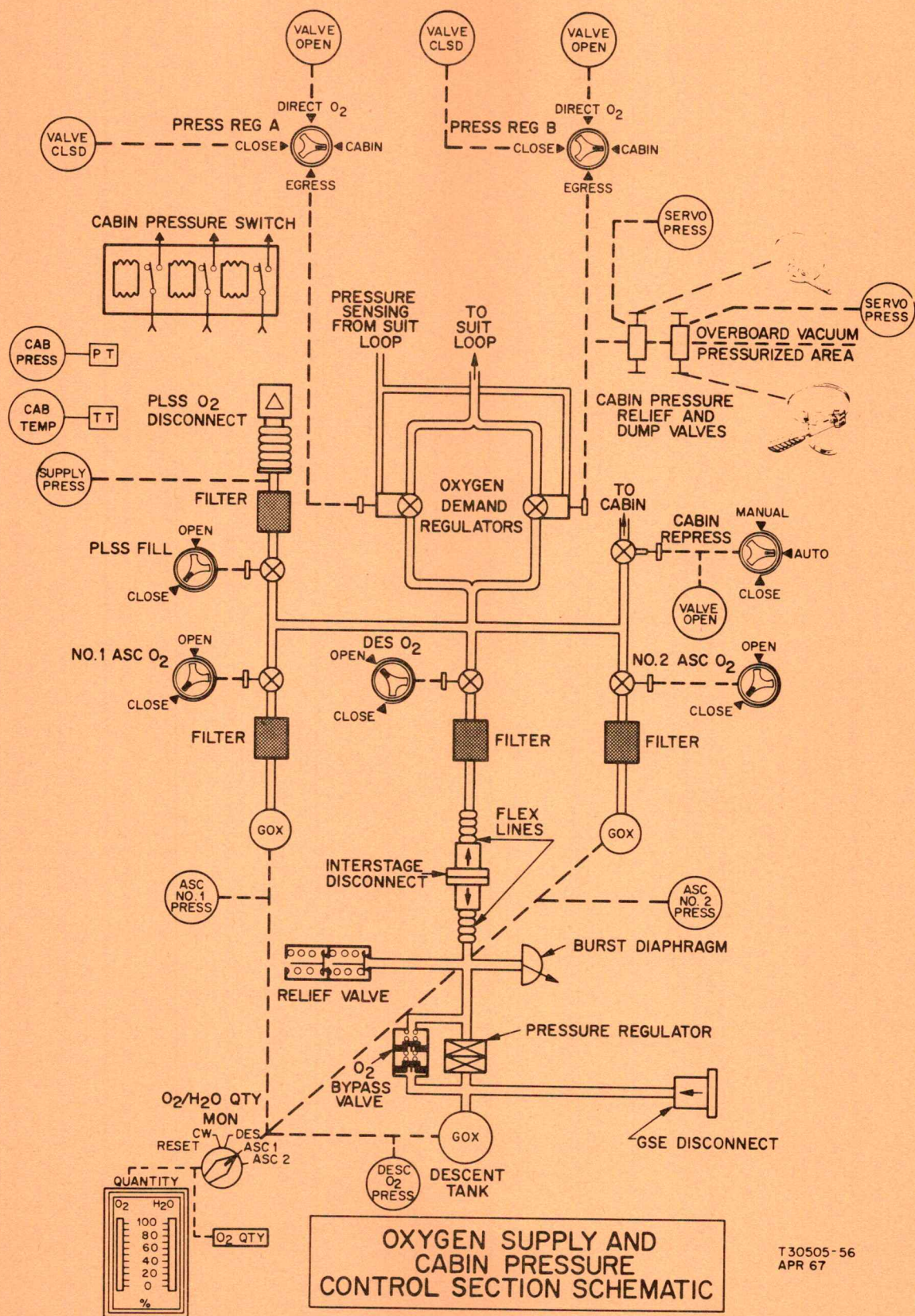
A cabin pressure switch is provided in the vehicle to monitor the cabin pressure level and initiate electrical signals for controlling various ECS functions. The switch consists of a housing, which houses three absolute pressure bellows assemblies. Each of the bellows are mechanically linked to a double pole microswitch, whose functions are to provide a readout of three voting circuits to implement various ECS electrical functions. All three bellows are set to provide a switch closure at a decreasing pressure of $4.15 \pm .15$ P.S.I.A. Any two out of the three microswitches being actuated will result in the following ECS reactions provided the "CABIN" mode has been selected by the crew:

1. Suit circuit gas diverter valve closes.
2. Cabin repressurization valve opens.
3. Master alarm lights on panels I and II are activated.
 - a. A 3000 cps tone is generated in the flight crew headsets.
 - b. The "CABIN" red warning light on panel I is illuminated.

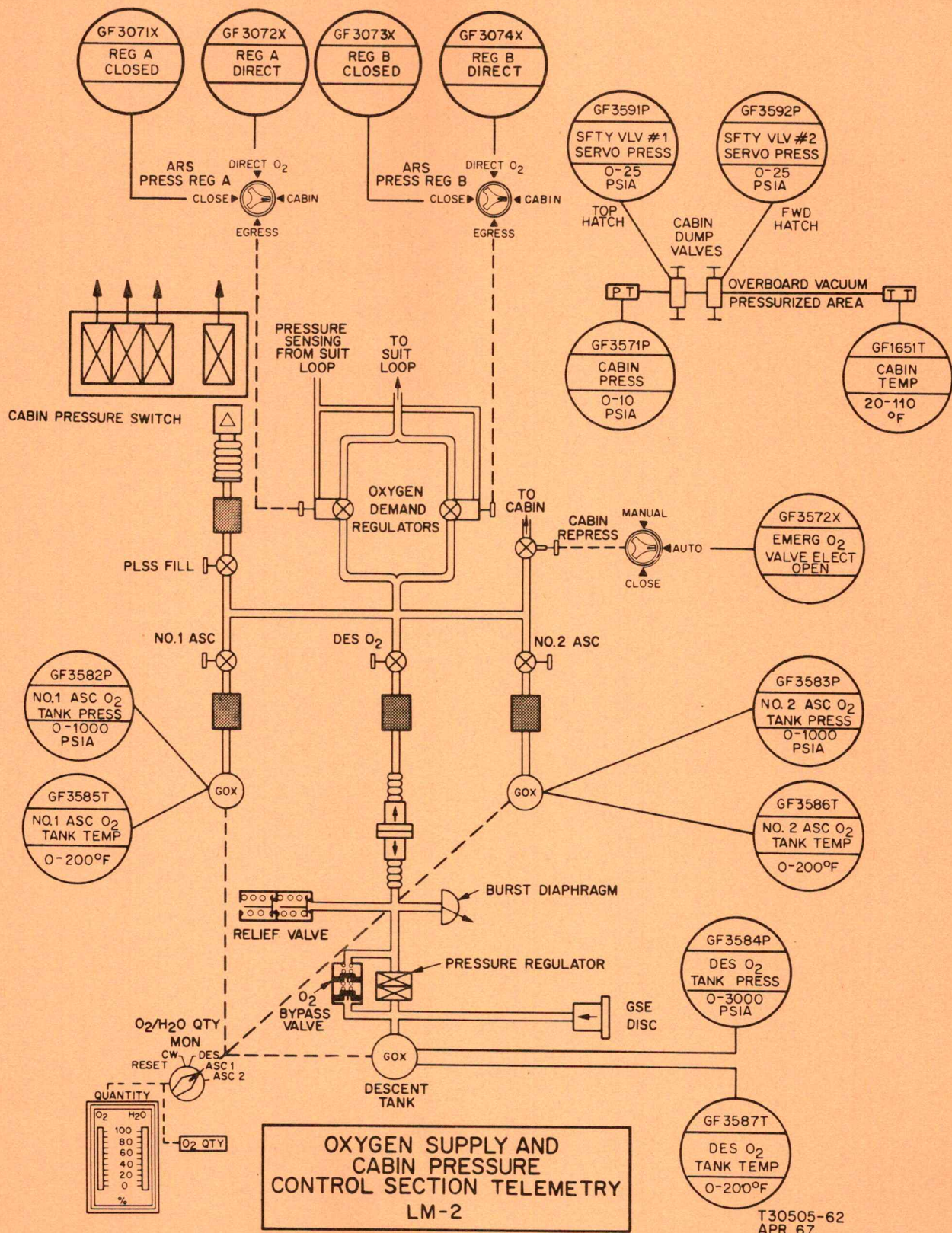
With an increasing pressure in the cabin, the cabin pressure switch circuits will be opened at $4.45 \pm .15$ P.S.I.A.

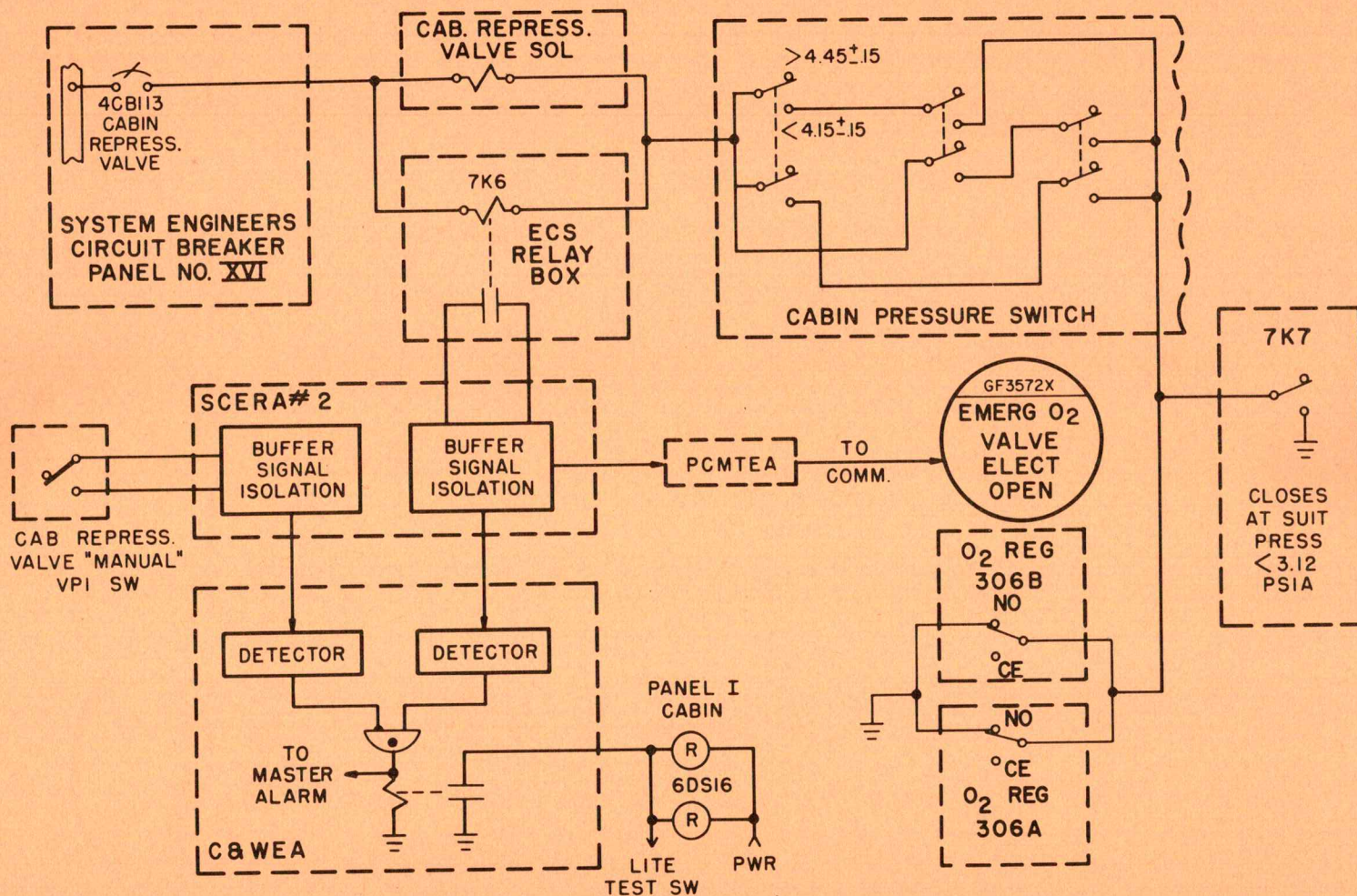
Oxygen Section Performance Criteria

1. Cabin leak rate = 0.2 P.P.H. at 5.0 P.S.I.A. and 75°F.
2. Suit circuit leak rate = 0.01 P.P.H. maximum at 3.8 P.S.I.A. and 70°F.
3. Suit leak rate = 0.035 P.P.H. each 3.9 P.S.I.A. and 50°F.
4. Cabin volume = 235 ft³.
5. 6 P.L.S.S. refills at 0.92 lbs. each.
6. 4 cabin repressurizations at 6.618 lbs. each.

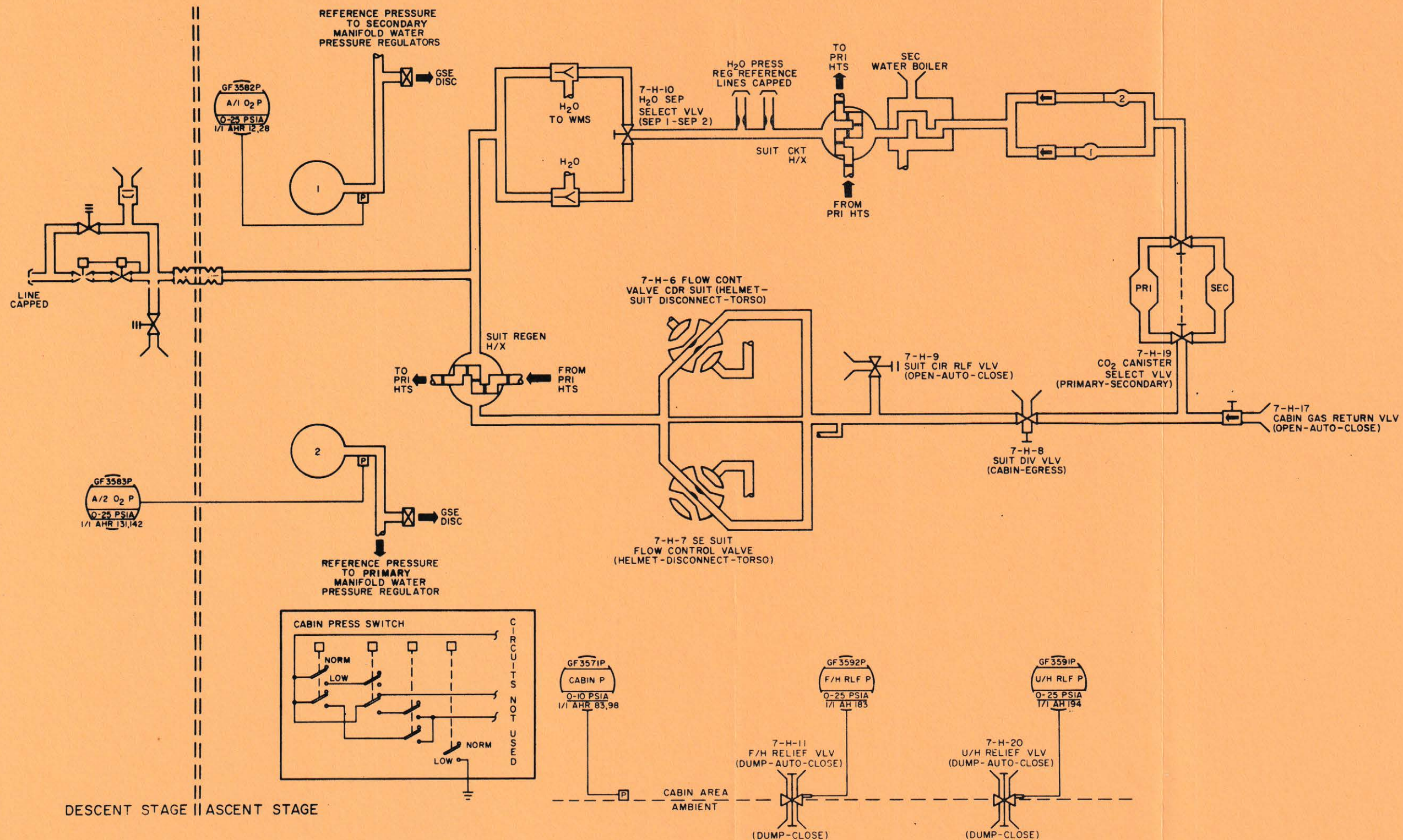


T30505-56
APR 67





**CABIN REPRESSURIZATION VALVE
CONTROL AND INDICATION CIRCUITRY**



OXYGEN SUPPLY AND ATMOSPHERE REVITALIZATION SECTIONS LM-1

T30505-92
APR 67

CHAPTER III

ATMOSPHERE REVITALIZATION SECTION (ARS)

General Operation - Reference Figure 1

The ARS consists of three major assemblies; the suit circuit assembly (Item 190), cabin recirculation assembly (Item 191), and a steam flex duct (Item 129). The section basically is a closed loop recirculating system with provisions for bringing in makeup oxygen to maintain the pressure level. Circulation of the atmosphere is provided by electrically driven fans. Heating and cooling is accomplished by flowing the gas through heat exchangers where heat is either surrendered to, or picked up from, the HTS coolant solution. Mechanical water separators are utilized to remove moisture which condenses during the cooling phase of the loop. CO₂ and odor removal is achieved in the CO₂ and odor removal canisters by using lithium hydroxide and activated charcoal.

Suit Umbilical Hose Assembly - Item 160

A suit umbilical hose assembly is provided for each crewman to carry ventilating gas to and from the crewman's space suit and the suit circuit assembly. The hose assembly is sufficiently flexible to provide the required crew mobility in both the pressurized and unpressurized modes of suit operation.

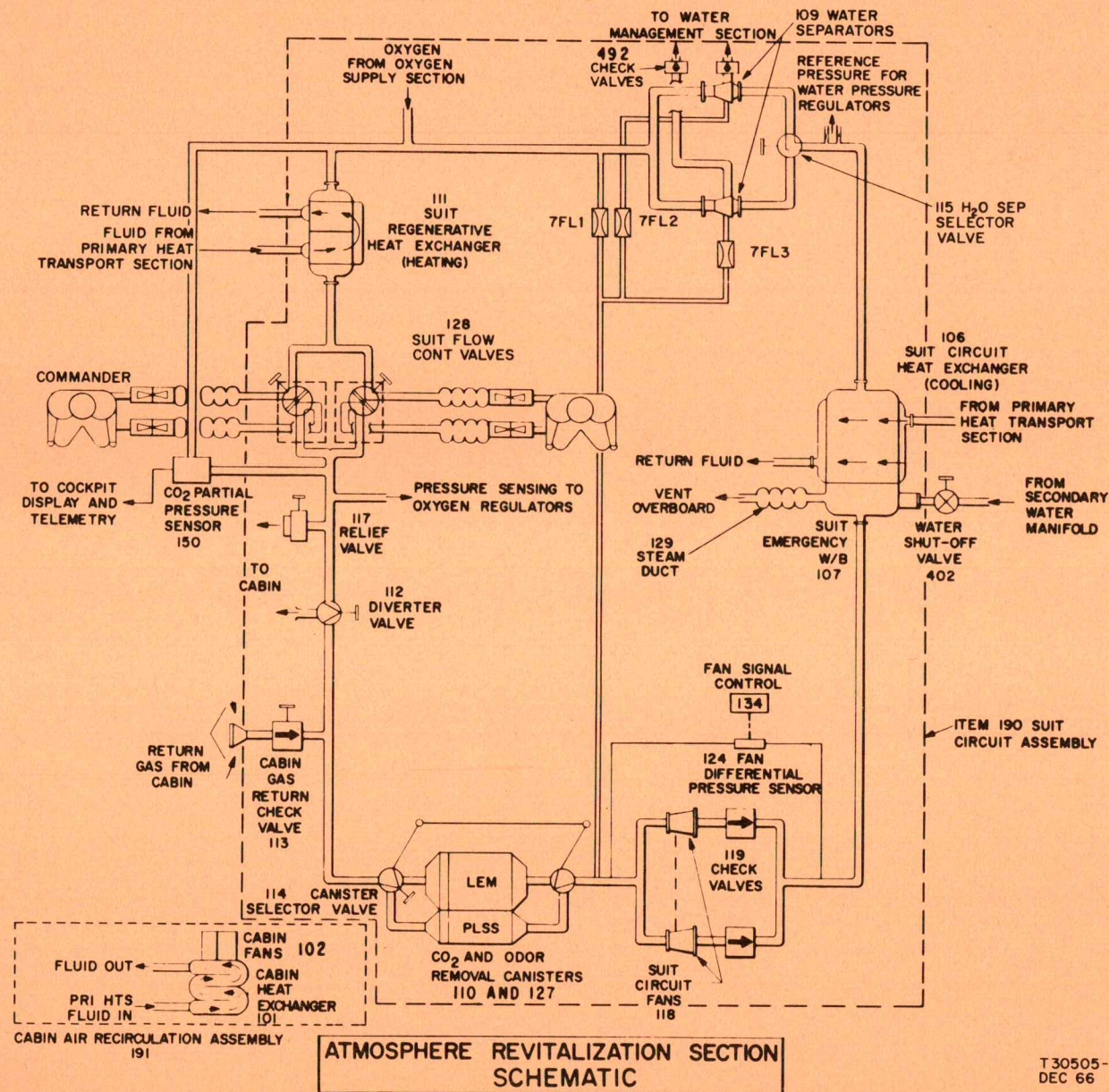
Suit Circuit Assembly - Item 190

The suit circuit assembly consists of items 106, 107, 109 (2), 110, 111, 112, 113, 114, 115, 117, 118 (2), 119 (2), 122, 124, 127, 128 (2), 134 and 492 (2), plus all interconnecting plumbing couplings. This assembly also includes all instrumentation, wiring and bracketry required to mount and support the foregoing components plus item 150 and 390.

Suit Circuit Heat Exchanger - Item 106

This heat exchanger (H/X) is located downstream of the secondary suit evaporator (107) and is used to reject waste heat from the suit circuit to the cooler HTS water-glycol coolant being supplied to the H/X by the primary HTS. The rejected heat basically consists of:

1. Heat generated by the crew members (sensible and latent).
2. Electrical and chemical reaction heat generated within the suit circuit.
3. Heat transferred from the cabin atmosphere to the suit loop.



The H/X is a plate-fin type, made of aluminum, with a single pass for both the W/G and suit atmosphere flow. It is the primary heat sink for the cooling of the ARS. Warm gas entering the H/X gives up heat to the cooler W/G solution causing a decrease in the ARS gas temperature and condensation of water vapor. This entrained moisture is removed by the mechanical water separators in the section.

Secondary Suit Evaporator - Item 107

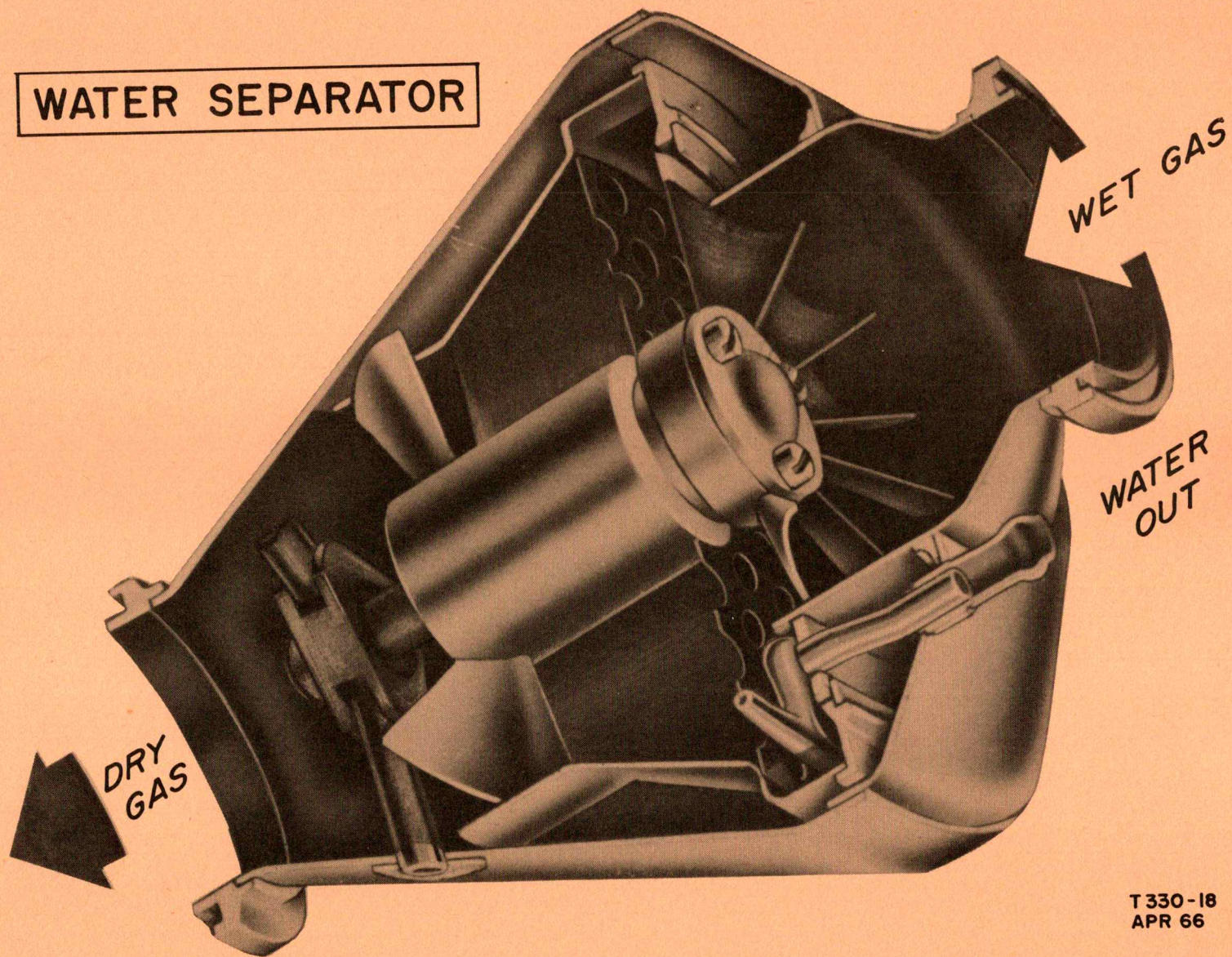
This unit is a porous plate sublimator located downstream of the fan check valves. It provides a means for rejecting suit circuit heat by sublimating ice into the vacuum of space should the suit circuit H/X (106) become inoperative.

Water Separators - Item 109 - Reference Figure 2 and 3

Two water separators are located downstream of the water separator selector valve. These units are ducted in parallel, however, only one unit operates at a time as determined by the positioning of the water separator selector valve. Saturated gas and free moisture which has been condensed in item 106 or 107 is fed into the unit and comes in contact with the inlet stator blades which are used to direct the flow onto the rotor at the proper angle. The majority of the entrained moisture collects on the rotating perforated plate which centrifuges the water into the rotating water trough. A stationary pitot device, that is placed tangentially to the rotating trough, picks up the removed water and discharges it from the unit through plumbing attached to the WMS. The pitot pumping action creates a dynamic head of pressure which is sufficient to ensure a positive flow from the water separator to the WMS. Any water passing through the perforated plate will collect on the rotating conical drum and be fed into the water trough. The rotor extracts the necessary energy from the gas stream to drive the rotating parts of the unit.

Each water separator incorporates a mounting boss for an angular velocity transducer which is a self-generating magnetic pickup that senses the rotation of a square toothed gear located on the separator shaft. The transducer develops a frequency signal, which is converted to a voltage level with respect to separator RPM in a signal conditioner unit. This signal is telemetered to earth and lights the ECS caution light as well as the water separator component light in the spacecraft when the speed drops to 800 RPM.

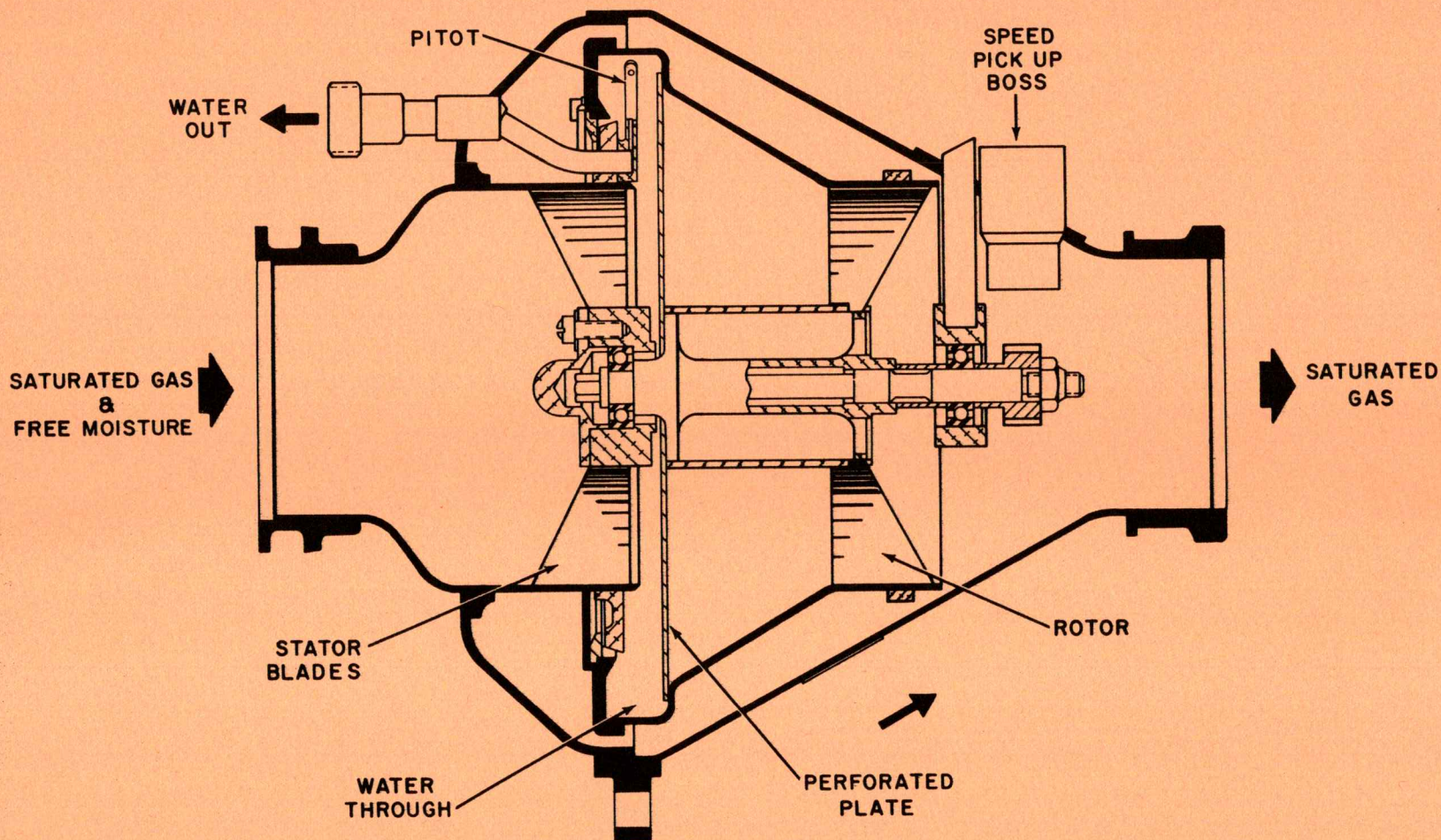
WATER SEPARATOR



3-4

Figure 2

T 330-18
APR 66



**CENTRIFUGAL WATER SEPARATOR
ITEM 109**

T30505-84
DEC 66

A water drain boss is provided on each separator to act as a drain for the cavity between the rotating drum and the outer shell of the unit. Attached to the drain boss of each separator is plumbing, which will carry away any water from this area, feed it through flow limiters 7FL2 or 7FL3, and dump it into the inlet side of the operating suit circuit fan.

Water Separator Selector Valve - Item 115

This valve is a two position flapper type diverter valve located at the inlet of the two water separators. An internal flapper assembly, which floats on a carrier allowing a certain degree of flexibility for alignment purposes, is manually positioned by an external handle to route the suit circuit gas flow through a particular water separator. A two position push-pull "T" handle placarded WATER SEP SEL - PUSH: SEP 1; PULL: SEP 2 is provided to control valve position.

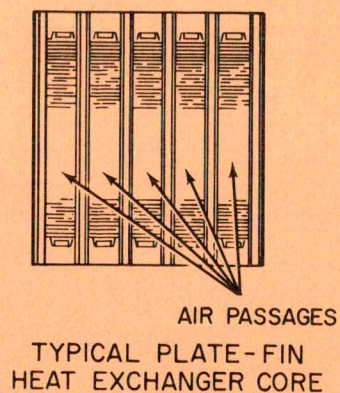
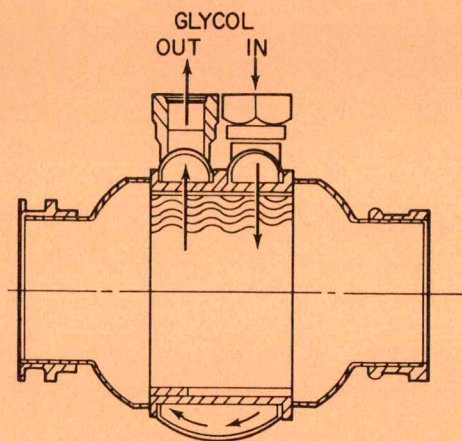
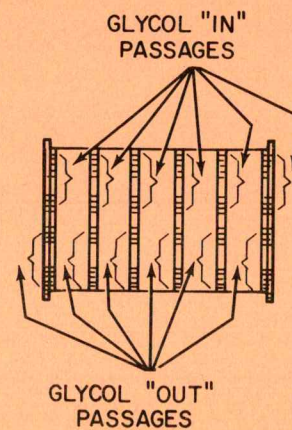
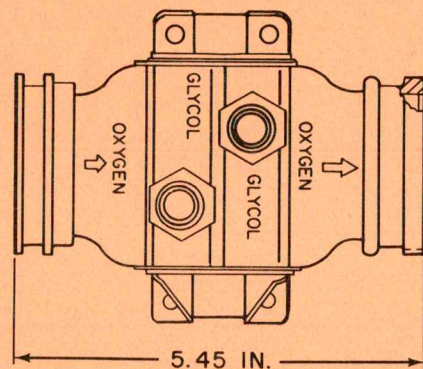
Water Pressure Regulator Reference Tap

Downstream of the suit circuit H/X, suit loop pressure is tapped off and fed to the two primary water pressure regulators (Item 415) and the single secondary pressure regulator of the WMS. This feed acts as a reference pressure which will determine the discharge pressure from the units. Sense line orificing is incorporated to control the loss of suit loop gas should a sense line malfunction occur.

Suit Circuit Regenerative H/X - Item 111 - Reference Figure 4

The suit circuit regenerative H/X provides a means of heating the suit loop gas, as required, by transferring heat from the HTS to the suit gas flow. ARS gas makes a single pass through the unit while the HTS fluid makes two passes. The H/X is an aluminum plate and fin type.

Item 208 Suit Temperature Control Valve is used to control the flow of hot water-glycol (W/G) through the H/X over a range of 0 to approximately 1.5#/MIN. This W/G solution surrenders heat to the ARS gas flow resulting in a decrease of the W/G temperature and an increase of ARS gas temperature. Gas temperature rise is determined by the setting of the suit temperature control valve.



REGENERATIVE SUIT CIRCUIT
HEAT EXCHANGER ITEM III

Suit Circuit Gas Diverter Valve - Item 112 - Reference Figure 5

Item 112 is a manually operated two way valve, (1 inlet and 2 outlet ports), with a solenoid override in one direction. The valve is manually controlled by a push-pull two position T bar handle labeled "PUSH CABIN" and "PULL EGRESS".

When the control handle is placed to the cabin selection, suit circuit gas flow is directed from the suit loop into the cabin. This position is used during helmet off operations to ensure that the suit circuit will circulate sufficient cabin gas to maintain the CO₂ and humidity level of the cabin atmosphere at the desired values. A solenoid latch maintains the valve in the cabin position against the force of the main valve spring. When the handle is pulled toward the closed selection the solenoid latch is overridden and allows the valve to be repositioned to its upper seat. This action terminates the suit loop communication with the cabin and is used when on closed suit loop operation.

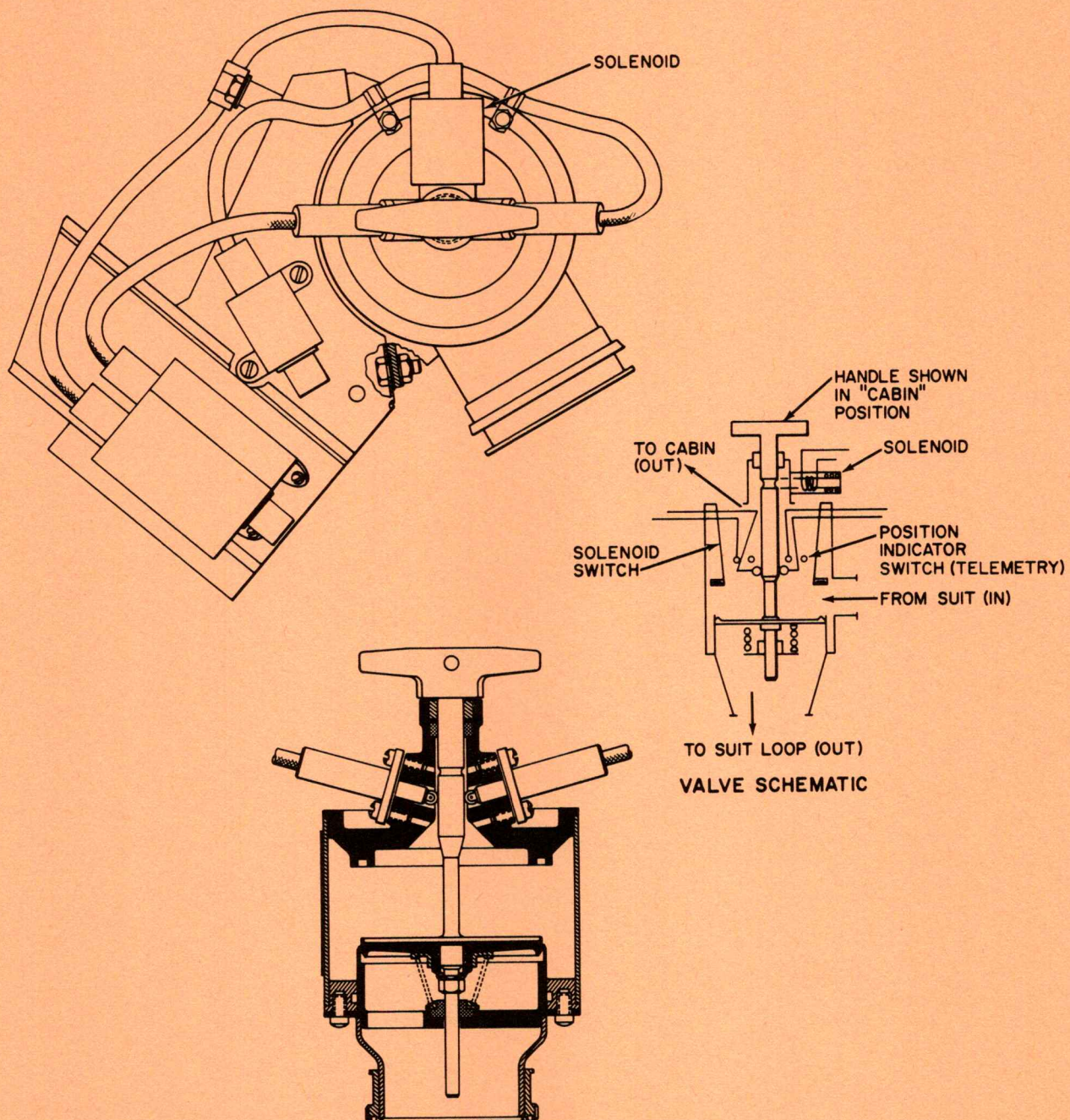
In addition to the manual operation of the valve, an automatic return to egress feature is provided. If the valve has been positioned to the cabin selection and the cabin pressure decays to $4.15 \pm .15$ PSIA the Cabin Pressure Switch (Item 323) will provide power to energize the solenoid latch allowing the main valve spring to reposition the valve to the "PULL EGRESS" position.

Electrical power is also supplied to the valve when the "EGRESS" position is selected on the Oxygen Demand Regulators (Item 306).

Suit Circuit Relief Valve - Item 117 - Reference Figure 6 and 7

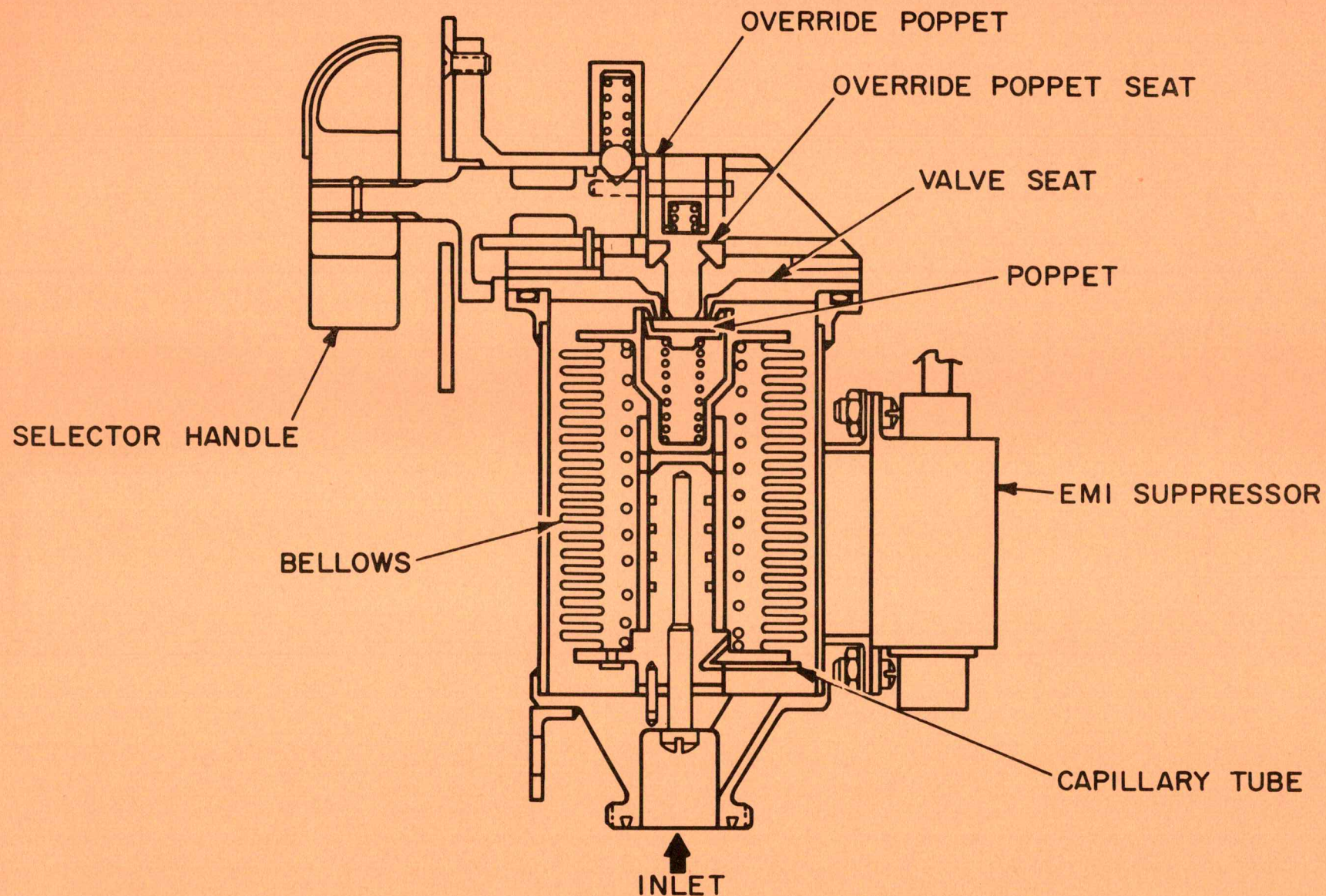
The suit circuit relief valve is an aneroid operated poppet type valve that protects the suit loop against overpressurization. A three position (AUTO-OPEN-CLOSED) selector handle is provided to control valve operation.

AUTO - In the auto selection the valve acts as an absolute pressure relief valve. Suit loop pressure is sensed by the aneroid and the valve will crack open relieving suit pressure to the cabin at 4.3 to 4.45 pounds per square inch absolute (PSIA). At a pressure of 4.7 PSIA the valve is full open and will flow 7.8 pounds per hour (PPH) at 90°F. The valve reseats at approximately 4.3.

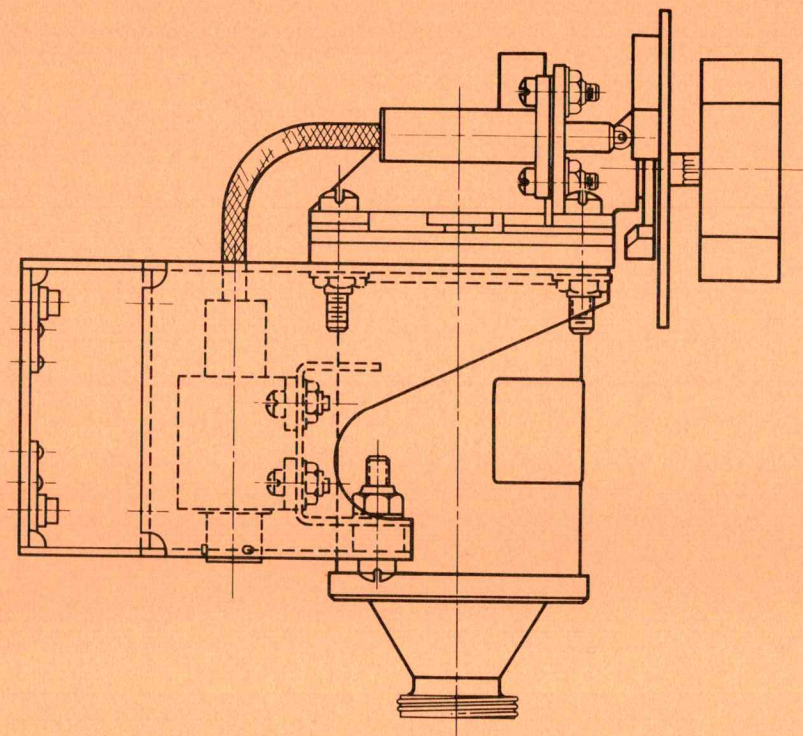


SUIT GAS DIVERTER VALVE ITEM 112

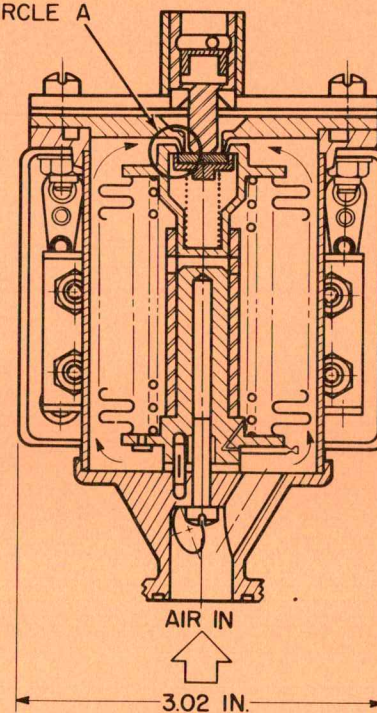
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APR 67



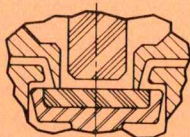
SUIT CIRCUIT RELIEF VALVE (ITEM 117)



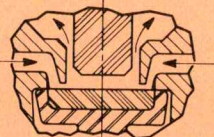
SEE CIRCLE A



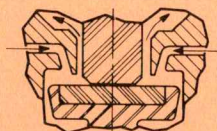
HANDLE IN THE NORMAL-
POSITION, POPPET CLOSED



HANDLE IN THE NORMAL-
POSITION, POPPET OPEN

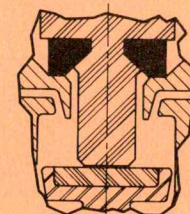


HANDLE IN THE OPEN POSITION



CIRCLE A

HANDLE IN THE CLOSED
POSITION



SUIT CIRCUIT RELIEF VALVE ITEM 117

OPEN - When the handle is rotated to this position, it manually displaces the poppet off its seat, opening the valve, regardless of suit loop pressure.

CLOSED - The manual closed function is accomplished by a seat that contacts the opposite side of the normal valve seat. Seating action takes place when the control handle is rotated past the full open position resulting in the normal poppet being open but the auxiliary seat being closed. This feature ensures the ability to maintain suit pressure should the relief valve fail in the open position.

Two externally mounted microswitches are provided to supply telemetry information to the Instrumentation Subsystem when either the manual open or close positions of the valve are selected.

Cabin Gas Return Check Valve - Item 113

This unit (reference Figure 8) consists of a spring loaded flapper type check valve with a means for manual override to the closed and open positions. During normal operation the valve flapper functions automatically to permit gas flow to return to the suit circuit from the cabin. In the event of a cabin decompression it prevents the loss of suit pressure.

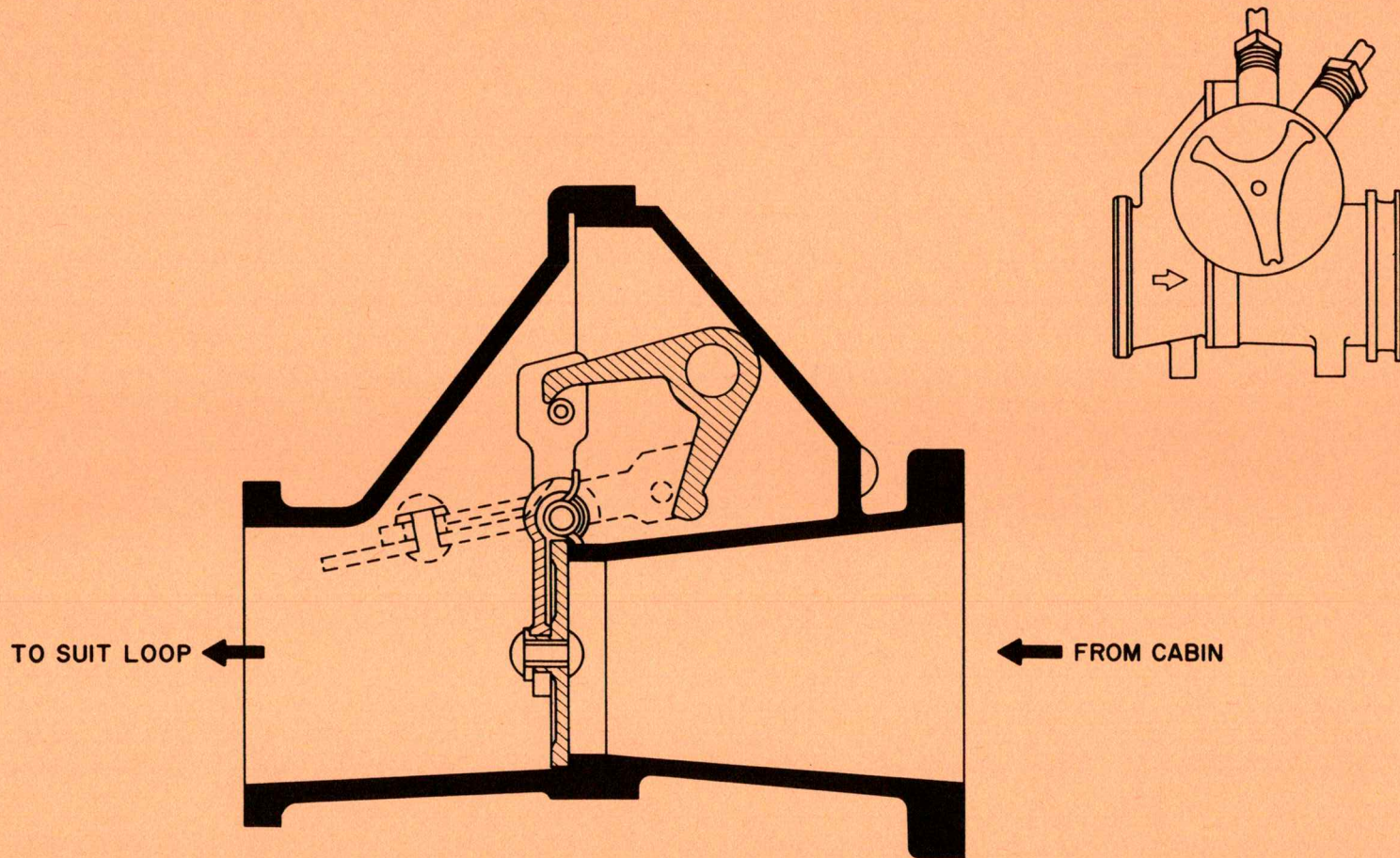
Two microswitches are provided to supply valve position indicator (VPI) information to the Instrumentation Subsystem for telemetry transmission. These switches are actuated when the manual open or manual close (EGRESS) selections have been made.

PLSS Carbon Dioxide and Odor Removal Cartridge - Reference Figure 9

The carbon dioxide level in the LM atmosphere is controlled by passing the gas flow across a bed of lithium hydroxide (LiOH). Odors are removed from the atmosphere by absorption in activated charcoal which is packaged together with the LiOH in replaceable cartridges. Filtering provisions are provided to prevent the escape of LiOH and/or activated charcoal. This filter is capable of retaining all particles 28 microns or greater in size.

3-13

Figure 8

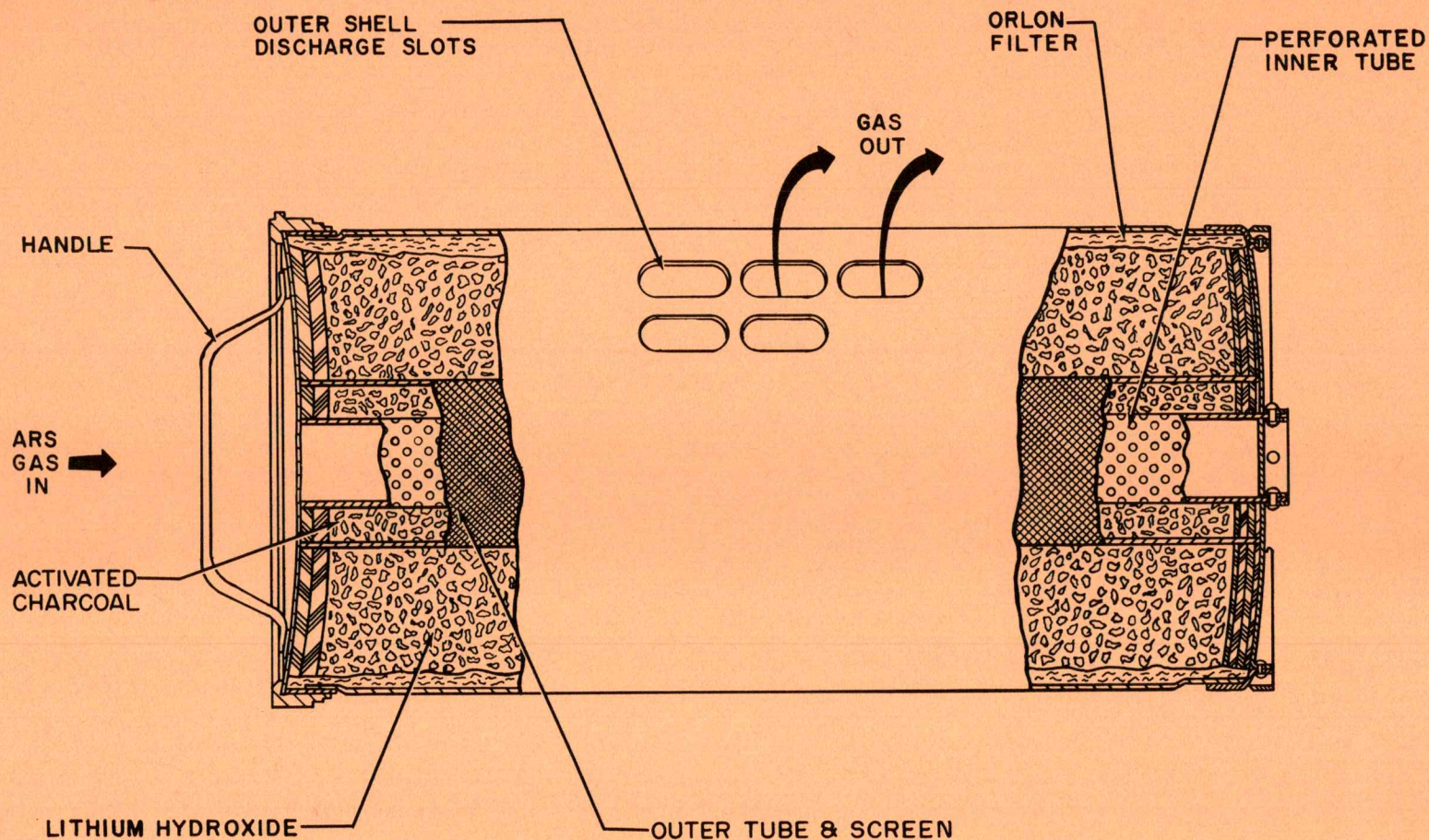


CABIN GAS RETURN CHECK VALVE
ITEM 113

T30505-78
NOV 66

3-14

Figure 9



PLSS L10H CARTRIDGE

The radial flow cartridge consists of a perforated inner tube, surrounded by concentric layers of activated charcoal, screening, lithium hydroxide and orlon felt. The ARS gas enters the cartridge at the end of the perforated tube which passes through the center of the cartridge. The gas flows radially through the holes in the tube, passes over the bed of activated charcoal, through a screen, the lithium hydroxide, orlon filter, and out of the assembly via elongated slots cut in the outer shell. The tubes and screens are attached to the end caps of the cartridge. A handle is provided to assist the crew in removal and replacement of spent cartridges.

The cartridge contains approximately .3 lb. of activated charcoal and 2.5 lbs. of lithium hydroxide. The cartridge has a maximum endurance of 4 man hours. One cartridge will be installed in the secondary carbon dioxide and odor removal canister at earth launch, and five spare cartridges will be stowed in horizontal tubes on the L/H side of the vehicle aft of the CDR's position.

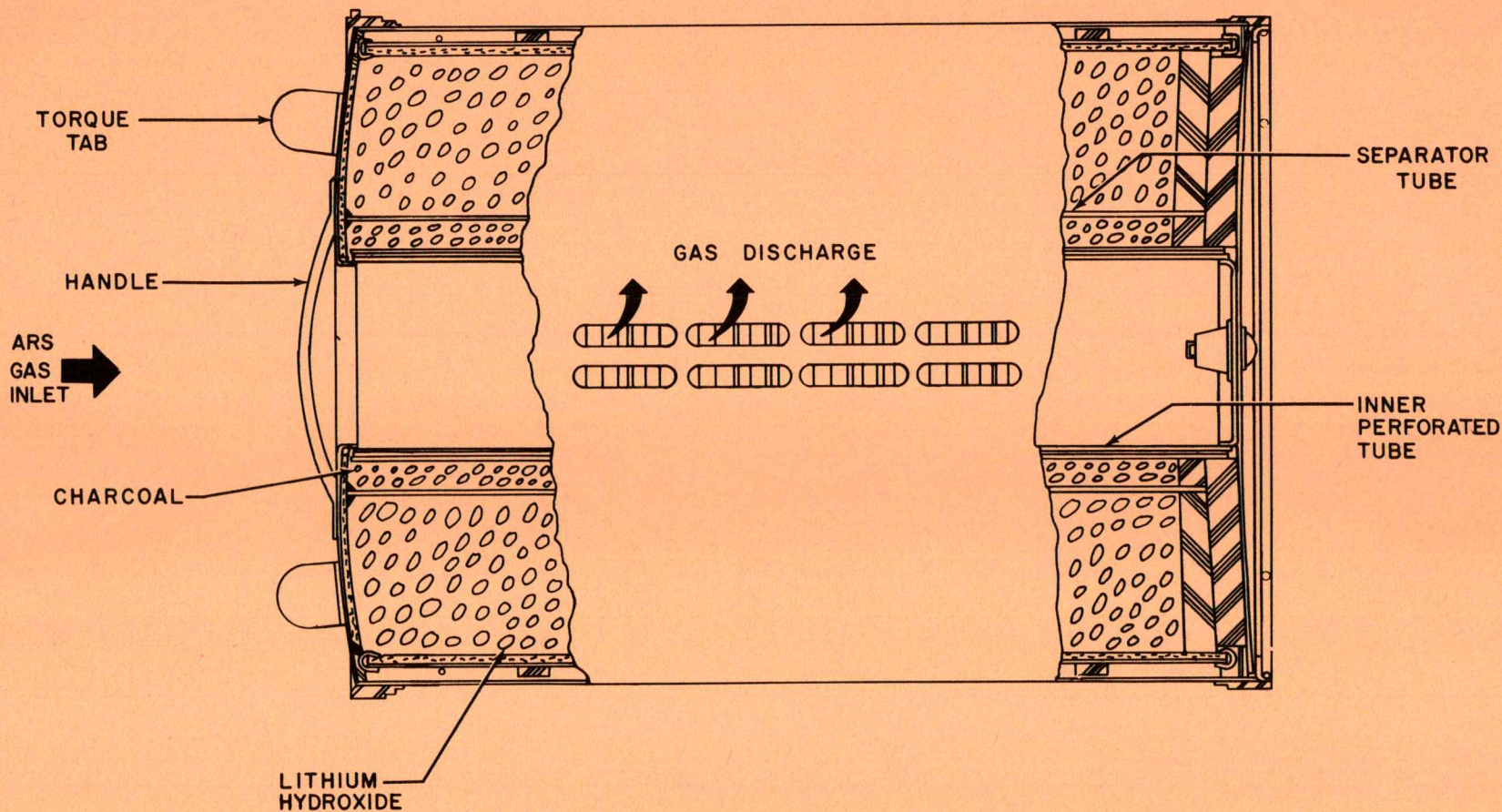
Primary Carbon Dioxide and Odor Removal Cartridge - Item 122

The 122 cartridge (see Figure 10) is similar in construction and operation to the PLSS cartridge with the exception that it is physically larger in size.

The 122 cartridge contains approximately 5.2 pounds of LiOH and .5 lbs. of charcoal providing a maximum endurance of 42 man hours before requiring replacement. Two Item 122 cartridges are provided, one cartridge being installed in the primary carbon dioxide and odor removal canister (Item 110), and the second cartridge being stowed in a holder attached to the ascent engine cover.

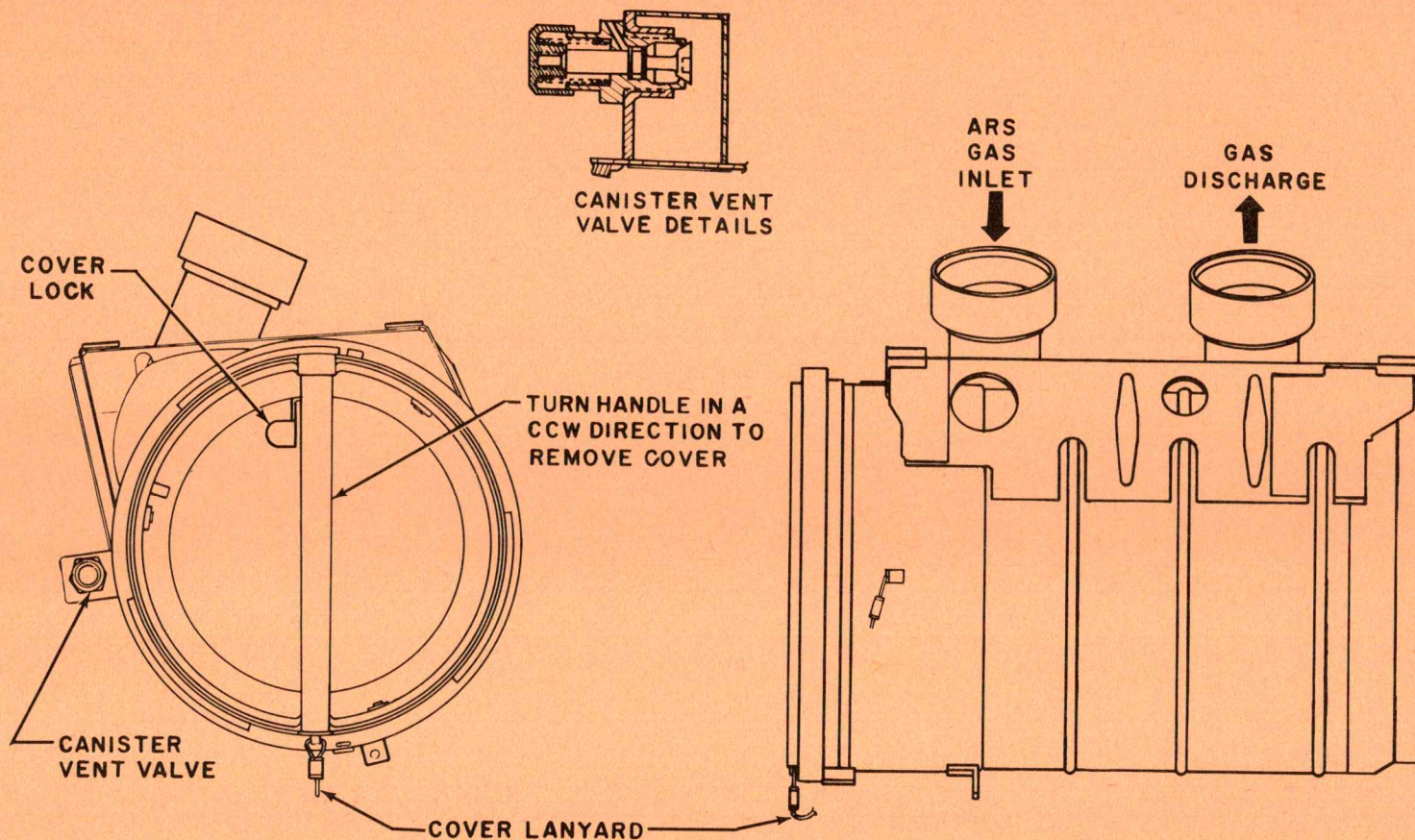
Primary Carbon Dioxide and Odor Removal Canister - Item 110

The 110 canister consists of a tubular assembly containing an inlet and outlet port (see Figure 11) and a single 122 cartridge. The canister is designed so that removal and replacement of spent cartridges may be made with a decompressed cabin.



PRIMARY CARTRIDGE
ITEM 122

T30505-85
DEC 66



PRIMARY CANISTER
ITEM 110

To remove the canister cover the canister selector valve must first be placed to the "SEC" position to withdraw a push-pull cable that locks the primary canister cover while it is selected on the gas stream. To equalize the pressure across the canister cover, the canister vent valve will be depressed. This action vents the internal canister cavity to cabin removing any ΔP existing across the cover. The tab type lock on the cover adjacent to the handle must now be depressed to unlock the cover from the canister and allow it to rotate. By rotating the cover in a CCW direction approximately 98° tangs on the cover will line up with grooves in the canister and allow the cover to be withdrawn. A lanyard secures the cover to the canister during the cartridge replacement operation.

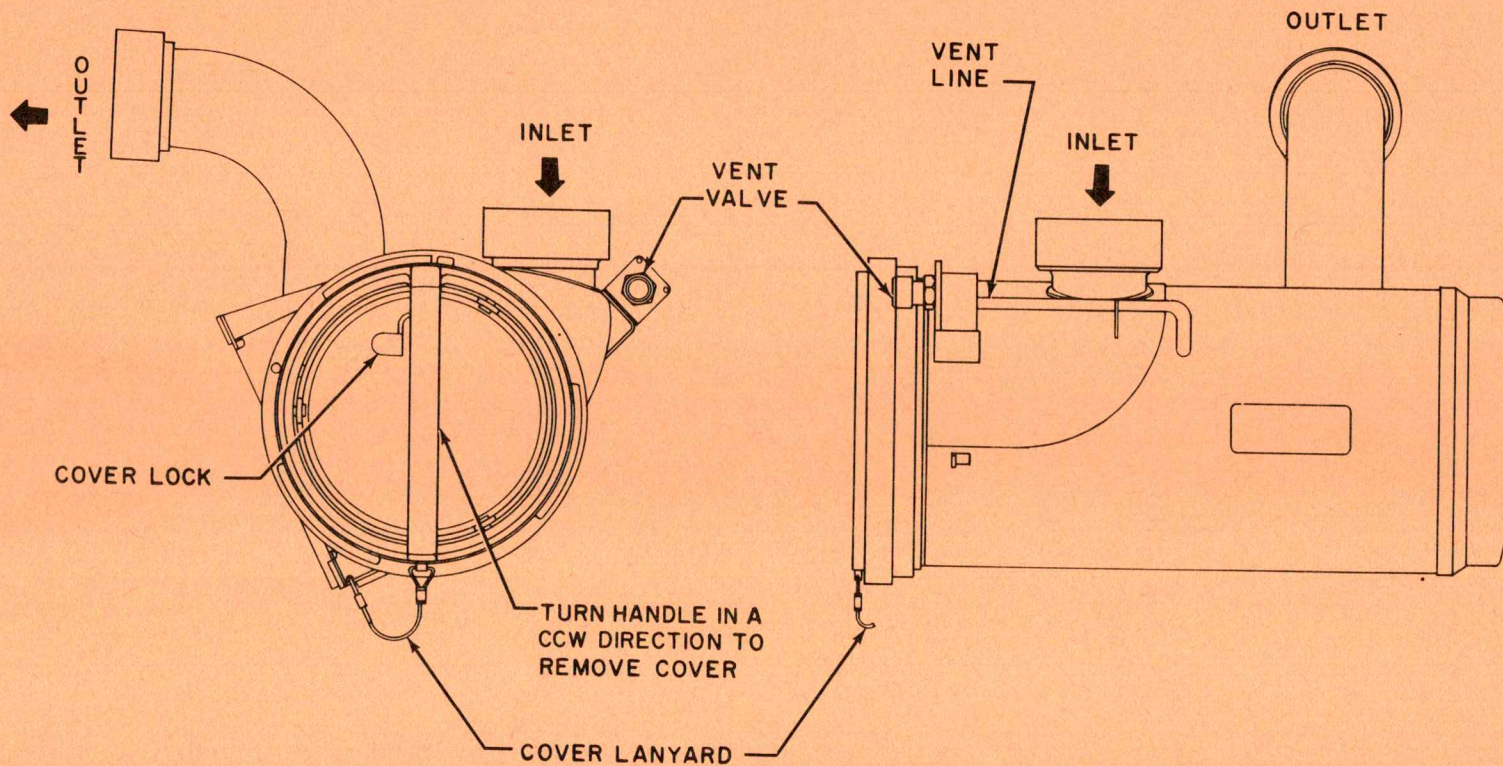
A debris trap, in the form of a mesh screen is incorporated in the canister cover to prevent particulate matter from entering the cartridge. A relief valve permits bypass flow around this unit in the event it becomes clogged cutting off circulation in the suit loop.

Secondary Carbon Dioxide and Odor Removal Canister - Item 127 - Reference Figure 12

This carbon dioxide and odor removal canister is installed in parallel with the primary carbon dioxide and odor removal canister (Item 110) and is similar in operation to the larger 110 unit except that it is smaller in physical dimensions and does not have a debris trap or bypass valve. It is designed to house a single GFE PLSS cartridge. The canister provides for removal and replacement of spent cartridges with a decompressed cabin.

Canister Selector Valve - Item 114

This valve is a two position (Primary-Secondary) dual flapper type diverter valve. The flapper assembly floats on a carrier which is connected to the control handle and allows a degree of flexibility for proper alignment. One flapper is located at the inlet to the CO_2 and odor removal canisters and the other at the outlet. When actuated, gas flow is directed through either the primary or the secondary canister assemblies while completely isolating the off stream canister from the loop. This arrangement permits the replacement of spent cartridges. The valve also actuates cables which interlock the canister covers preventing the opening of an on stream canister. A spring loaded latch is also supplied to prevent inadvertent operation of the selector valve handle.



3-19

Figure 12

SECONDARY CANISTER
ITEM 127

T30505-86
DEC 66

Replacement cartridges are stowed in the S/C for inflight replacement as required. One spare 122 cartridge and five (5) spare PLSS GFE cartridges are aboard the LM at Earth Launch. A spent cartridge will be indicated by:

1. A reading of 7.6 mm Hg or above on the CO₂ partial pressure indicator 7M1.
2. Activation of the master alarm lights 6S2 and 6S3.
3. Illumination of the "ECS" light 6DS36 on the caution array panel.
4. The "CO₂" advisory light 7DS6 comes on.

The canister selector valve will then be positioned to the "SEC" selection. This action will lower the CO₂ partial pressure and extinguish 6DS36. 7DS6 will remain illuminated by a ground being supplied by a microswitch on the selector valve as long as it remains in the "SEC" position. The selection of "SEC" unlocks the canister cover on the primary canister. A manual relief valve, placarded "VENT PUSH", adjacent to the canister cover allows equalization of pressure between the cabin and the internal canister cavity prior to cover removal. A finger latch integral with the cover must also be released prior to rotation of the cover assembly.

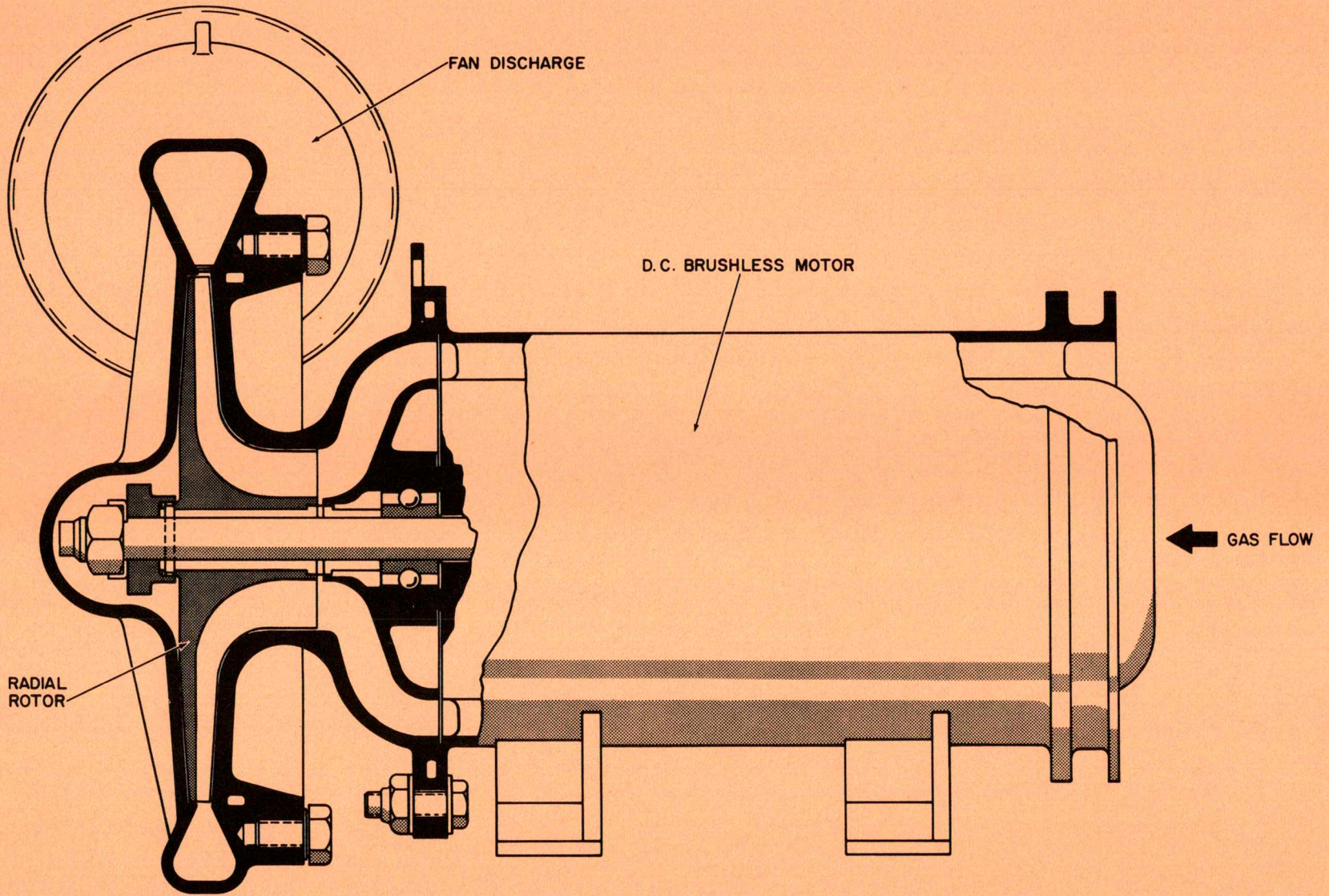
After replacement of the 122 cartridge and replacement of the canister cover the selector valve is repositioned to the "PRI" selection placing the 110 canister back on the gas stream. It is this action that removes the ground from 7DS6 and extinguishes the light.

Suit Circuit Fans - Item 118 - Reference Figure 13

The suit circuit fans are driven by 28V DC brushless motors. A parallel fan arrangement is provided for recirculation of the gas through the suit loop, however, only one fan will operate at any one time. A radial type rotor is used and results in a recirculation of approximately 24 cubic feet per minute at $25,000 \pm 500$ RPM. Operation at sea level pressures and above must be conducted using a reduced voltage of 12-15V DC to prevent damage to the units. Fan operation is controlled by selector switch 7S1 located on the systems engineer main right hand center panel.

Fan Backflow Check Valves - Item 119

Each of the suit circuit fans discharge through a flapper type check valve to prevent reverse flow through the non-operating fan.



SUIT CIRCUIT FAN

T330-37
MAY 65

Suit Fan Differential Pressure Sensor - Item 124

The fan differential pressure (ΔP) sensor, see Figure 14, is a hermetically sealed unit consisting of a diaphragm type pressure sensor within a housing which incorporates a high and a low pressure port and an electrical receptacle. A single pole double throw electrical switch is housed in the unit. The pressure sensor monitors the fan ΔP and provides a closed electrical circuit when ΔP decreases to 6" H₂O. This circuit is broken at an increasing ΔP of approximately 8" H₂O. Signals from the ΔP switch are routed to the Fan Signal Control, Item 134.

Fan Condition Signal Control - Item 134

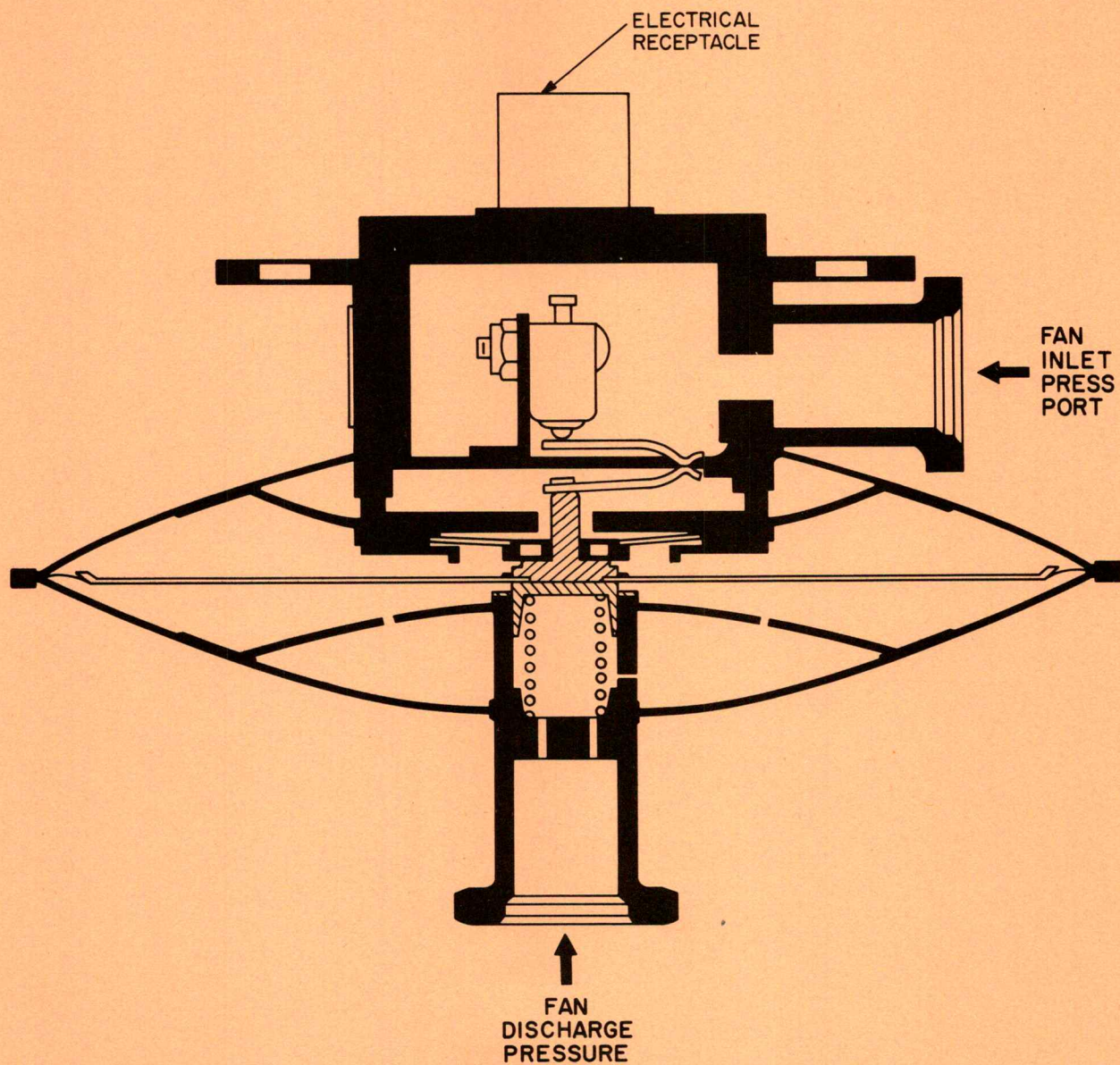
This control contains an electro-mechanical switching device in a hermetically sealed container. Electrical connections and appropriate mounting provisions are an integral part of the container. The control contains circuitry which permits the S/C caution lights to be actuated when a signal is received from the fan ΔP sensor, Item 124, indicating that a drop in ΔP has occurred across the suit circuit fan, Item 118.

Suit Flow Control Valves - Item 128 - Reference Figure 15

These valves are located at the interface of the suit umbilicals and the suit circuit assembly. A three position (TORSO-SUIT DISC-HELMET) rotatable collar is provided for controlling valve position.

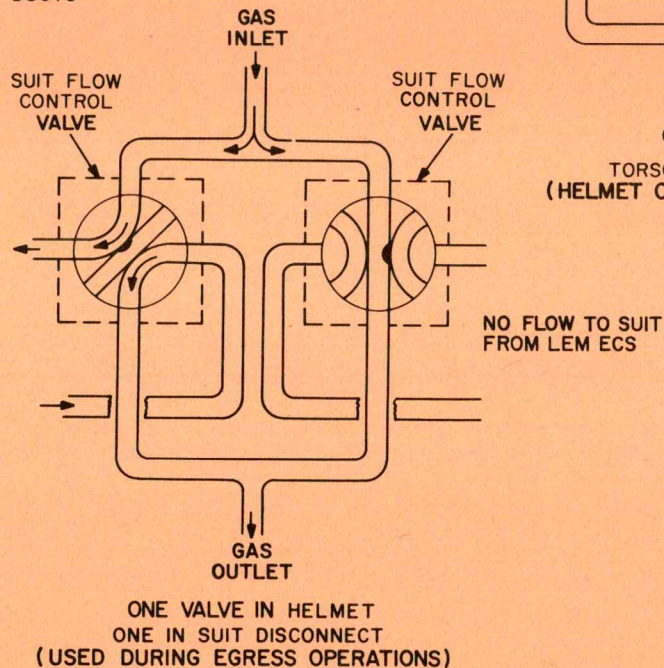
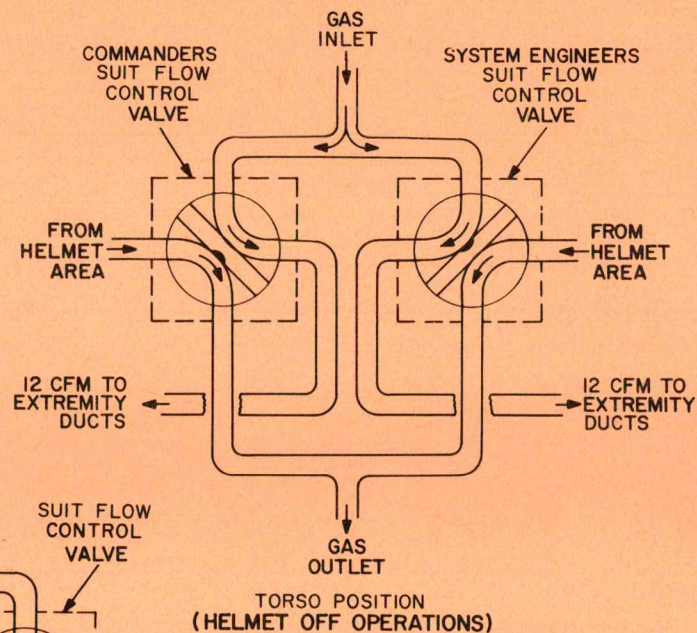
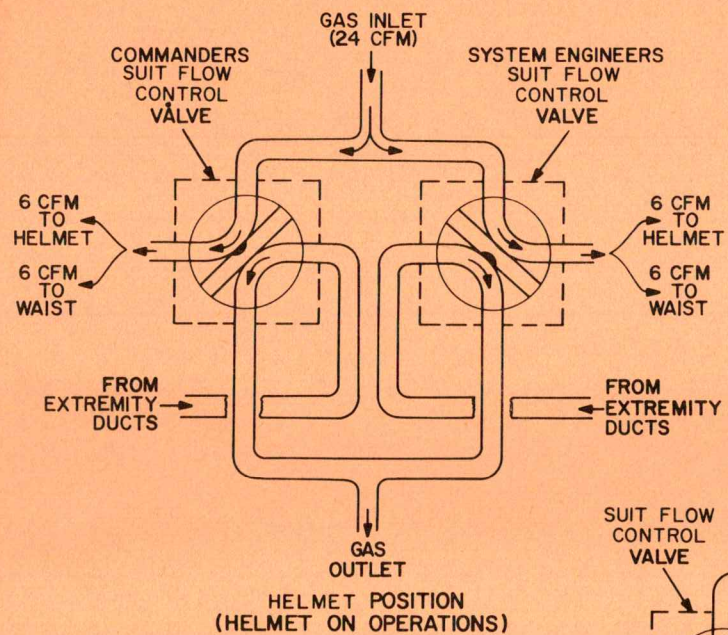
HELMET - In the HELMET position half of the 12 CFM suit circuit oxygen flow will pass directly into the body of the SSA at the waist and half of the flow will pass into the helmet, then down over the astronaut's body surface and into ducts at the four extremities. From here, the oxygen will flow through the extremity ducts to the exhaust umbilicals. (For flow distribution through suit, see Figure 16)

TORSO - In the TORSO selection, the 12 CFM suit circuit gas flow will pass through the four extremity ducts and out into the SSA. Part of the gas then flows over the astronaut's body surface and out the neck ring into the cabin, and part out the suit exhaust umbilical.

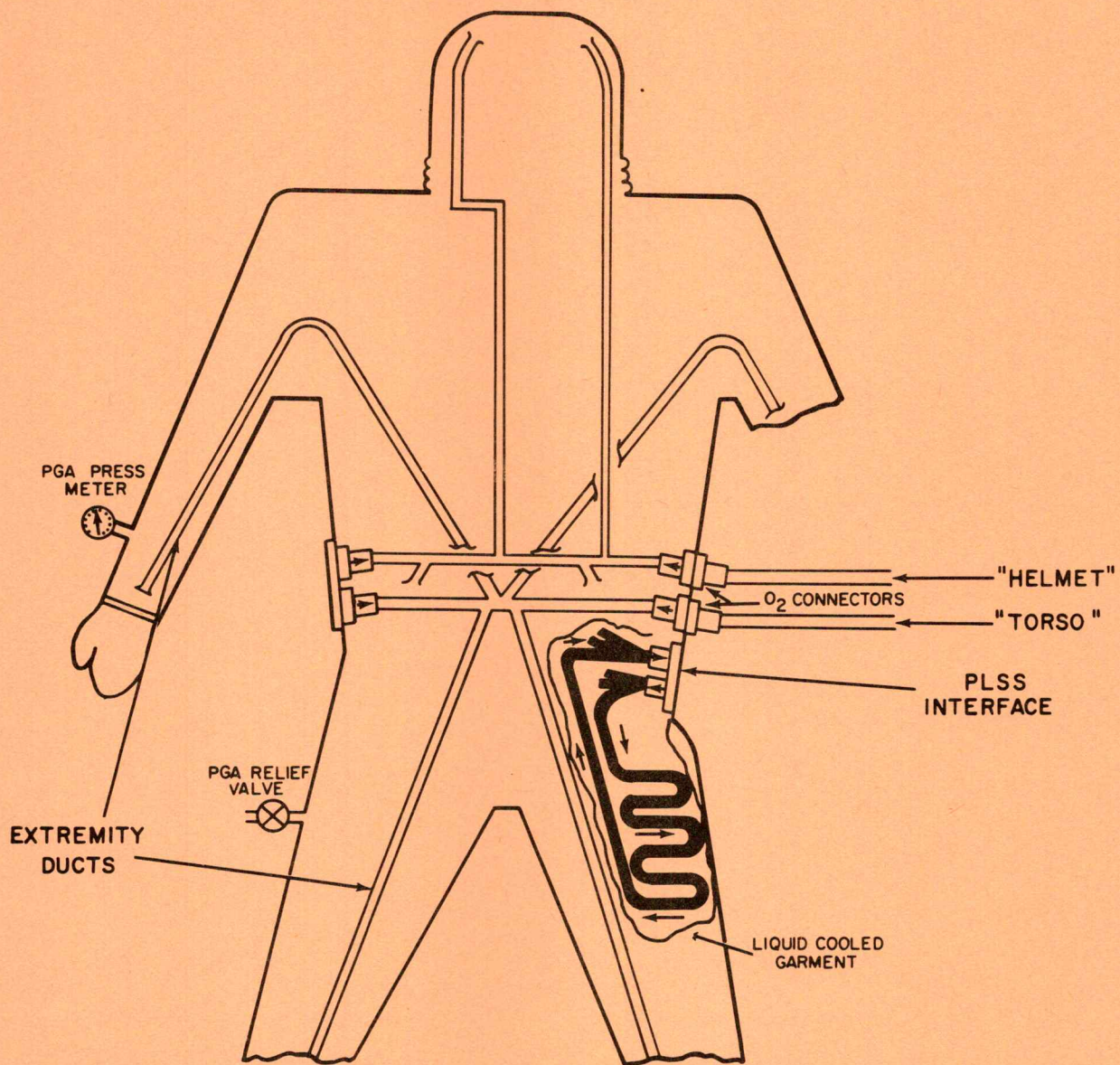


SUIT FAN ΔP SWITCH
ITEM I24

T30505-77
NOV 66



SUIT FLOW CONTROL VALVE SCHEMATIC OPERATION



SPACE SUIT INTERNAL FLOW

T30505-15
MAR 67

SUIT DISCONNECT - This position completely seals the umbilical hose assembly from the suit circuit assembly (Item 190) while by-passing suit circuit flow around the sealed umbilical hose assembly. The pressure drop of the bypass path is equal to that of an umbilical hose assembly plus a suit operating in the HELMET mode. When the PLSS is operating the "SUIT DISCONNECT" mode will be selected. This will allow the 6 CFM from the PLSS to pass entirely to the helmet and then down over the astronaut's body surface and into the ducts at the extremities. There will be no flow directly into the waist as before, due to the body flow valve on the space suit being closed.

Pressure Sensing Tap to Oxygen Demand Regulators

Upstream of the suit circuit relief valve a reference pressure tap is taken off the suit loop and fed to the OSCPCS to be used as control pressure in the two oxygen demand regulators.

Oxygen Make Up Tap

Downstream of the water separators, provisions are made for bringing oxygen from the OSCPCS into the suit loop. This permits the ARS to be maintained at a preselected pressure level by the action of the demand regulators in the OSCPCS.

CO₂ Partial Pressure Sensor - Item 150

This unit samples the gas flow entering the SSA's and provides an electrical signal to the spacecraft CO₂ partial pressure indicator and telemetry to indicate the CO₂ level in the atmosphere being supplied to the crew.

If the sensed CO₂ partial pressure should reach 7.6 mm HG the following spacecraft (S/C) indications are actuated:

1. The master alarm lights come on.
2. The "ECS" caution light illuminates.
3. The "CO₂" advisory light on the systems engineer main R/H center instrument panel will light.

To correct a high CO₂ partial pressure, the crew will select the secondary CO₂ and odor removal canister, replace the spent primary cartridge and re-select the primary unit back onstream. This last selector valve positioning will extinguish the CO₂ advisory light.

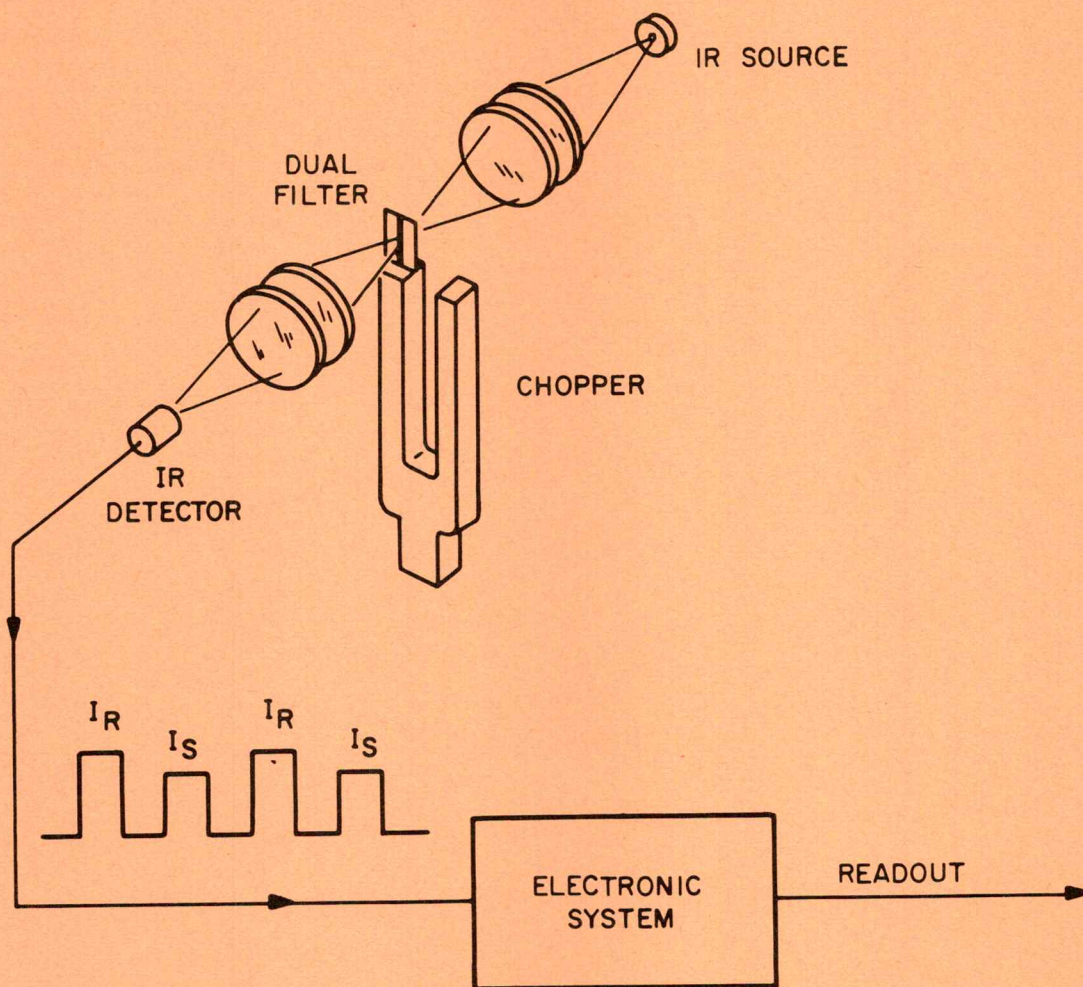
The CO₂ Sensor is a single-beam, dual-wavelength, filter photometer with ratio readout as shown schematically in Figure 17. The dual filter, which has the characteristics shown in Figure 18, is mounted on one tine of a vibrating tuning fork and located at a point in the optical system where a small image of the source is formed in space. As the fork vibrates, the dual filter is moved back and forth across the light beam, alternately transmitting energy at the sample and reference wavelengths. Since there is also an opaque area in the center of the dual filter through which no energy passes, the detector signal has the appearance shown in Figure 17. I_R is a measure of the energy received by the detector at the reference wavelength (4.0 microns) where CO₂ does not absorb, and I_S is a measure of the energy received at the sample wavelength (4.3 microns) where CO₂ does absorb.

With no CO₂ in the sample, I_S will be the same as I_R . With an increasing amount of CO₂ in the sample, I_S will decrease in amplitude relative to I_R . Thus, the essential information, for selectively and quantitatively measuring the amount of CO₂ in the sample, is present in the detector signal. An electronic system "decodes" the detector signal, computes the ratio of I_S to I_R , and reads out a continuous DC voltage proportional to the partial pressure of CO₂ in the sample gas.

The optical system (Figure 17) consists of a source (a small, tungsten lamp), collimating lens, another lens which re-images the source on the dual filter, and finally another lens which re-images the chopped and filtered source image onto the detector target.

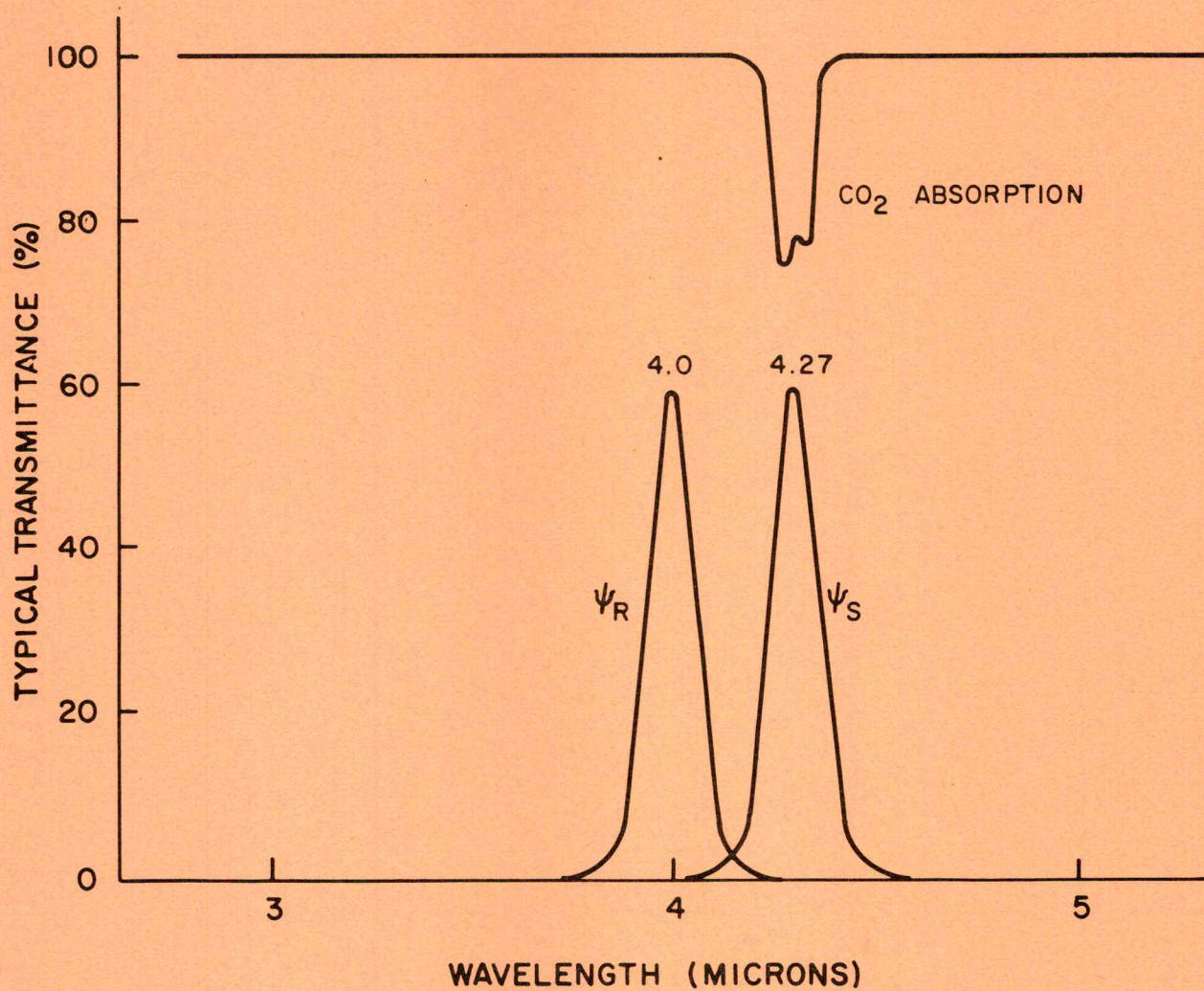
Sample gas enters through the gas fitting at the center of the unit, fills the entire gas-tight chamber containing the optical system, and passes out through the other fitting in the unit.

The tuning fork chopper has associated driving and pick-up coils. The dual filter is a small object, mounted on the lower tine of the tuning fork. This filter is the functional heart of the instrument. The tuning fork vibrates the filter across the light beam at 600 cycles-per-second, with a peak-to-peak amplitude of 0.050 inch.



CO₂ SENSOR
SIMPLIFIED SYSTEM DIAGRAM

T30505-87
DEC 66



CARBON DIOXIDE SENSOR
DUAL WAVELENGTH FILTER CHARACTERISTICS
(TYPICAL)

T30505-88
DEC 66

Cabin Recirculation Assembly - Item 191

The cabin recirculation assembly consists of the cabin H/X, item 101, two cabin fans, items 102, plus an interconnecting duct. The assembly also includes all braketery required to mount and support the foregoing components and to mount the assembly itself. Fan inlet screens capable of filtering out particulate matter which might impair the performance of 101 or 102's are incorporated. These screens are replaceable prior to, but not during, flight.

The assembly is mounted on the floor of the ascent stage directly behind the systems engineer. During pressurized cabin operation the assembly functions to control the cabin atmosphere temperature at $75 \pm 5^{\circ}\text{F}$.

Cabin Heat Exchanger - Item 101

The cabin H/X is an aluminum plate and fin type unit containing a single pass for the recirculated cabin atmosphere and four passes for the W/G HTS solution. Cabin temperature is controlled by regulating the inlet temperature of the W/G being supplied to the unit at a constant flow rate.

A self contained wick filled condensate tray for storing moisture condensed by the H/X is provided. Wicking is also provided on the discharge face of the H/X to collect condensed moisture and deliver it to the condensate tray. The wicking also provides for re-evaporation of water from the tray during those mission phases when the H/X discharge gas is not saturated.

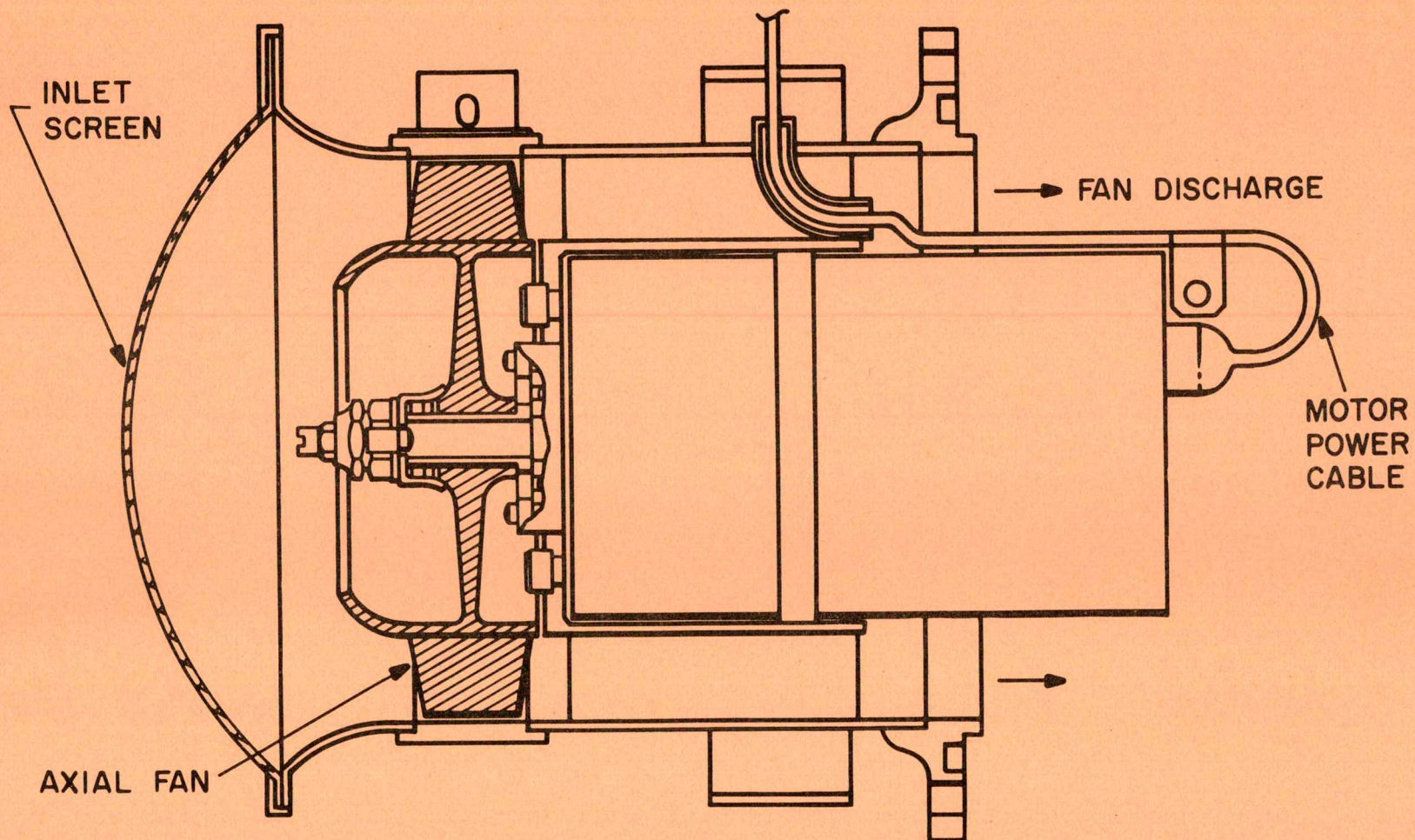
Cabin Fans - Item 102 - Reference Figure 19

Two axial flow fans are mounted to the cabin H/X to circulate the cabin atmosphere. Each fan is capable of moving approximately 5#MIN of air weight flow at 13,000 RPM. Brushless 28V DC motors are used to drive each fan. The fans may be shut down by selecting "EGRESS" on the oxygen demand regulators or by circuit breaker manipulation.

To prevent damage to the fan motors during earth ambient operation their input voltage must be reduced to 12-15V DC.

Steam Flex Duct - Item 129

A flexible duct is provided to carry the steam discharged from the secondary suit evaporator (Item 107) overboard. The duct is sufficiently flexible to accommodate the relative motion between the 107 unit and the -Z29 bulk-head of the ascent stage midsection.

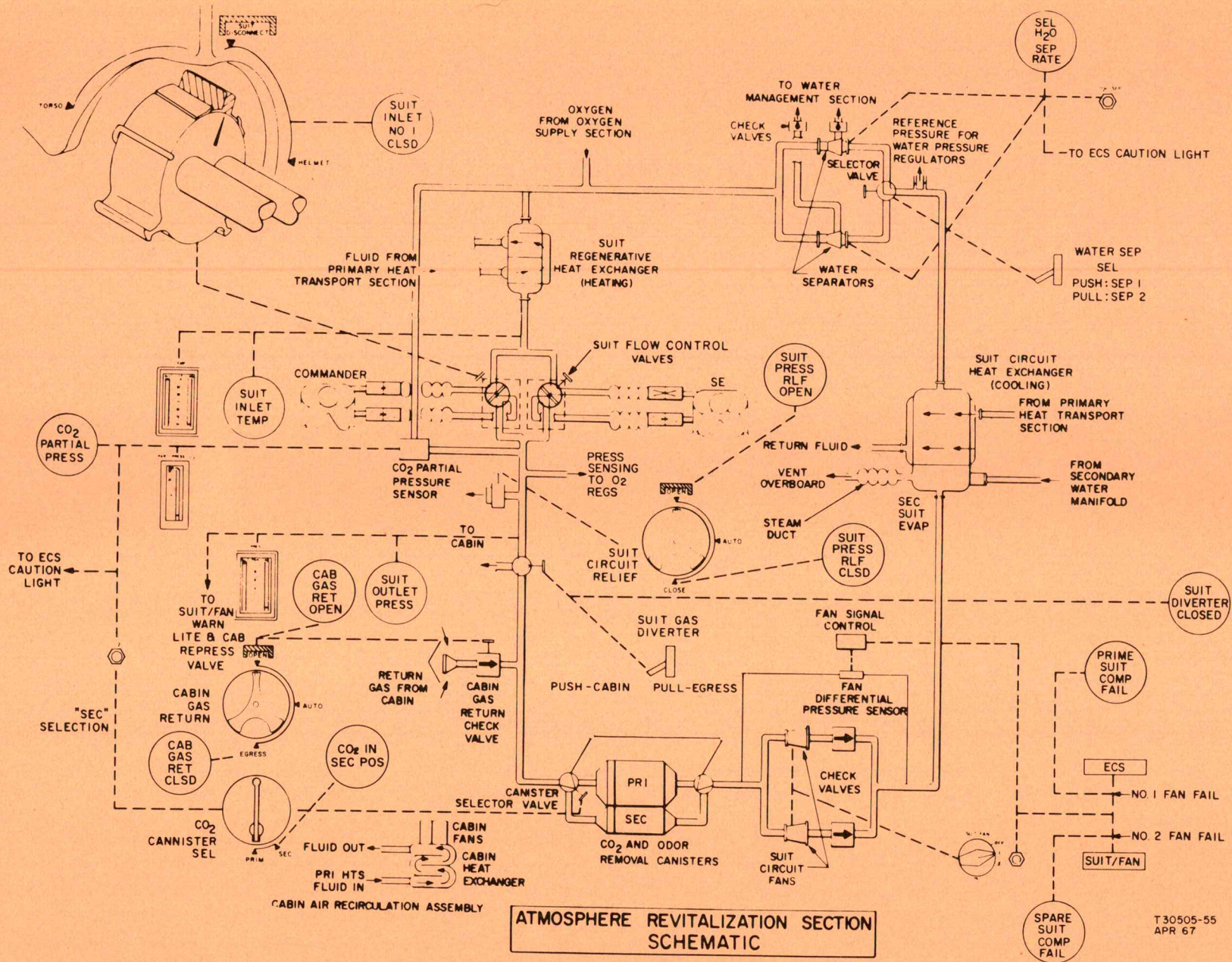


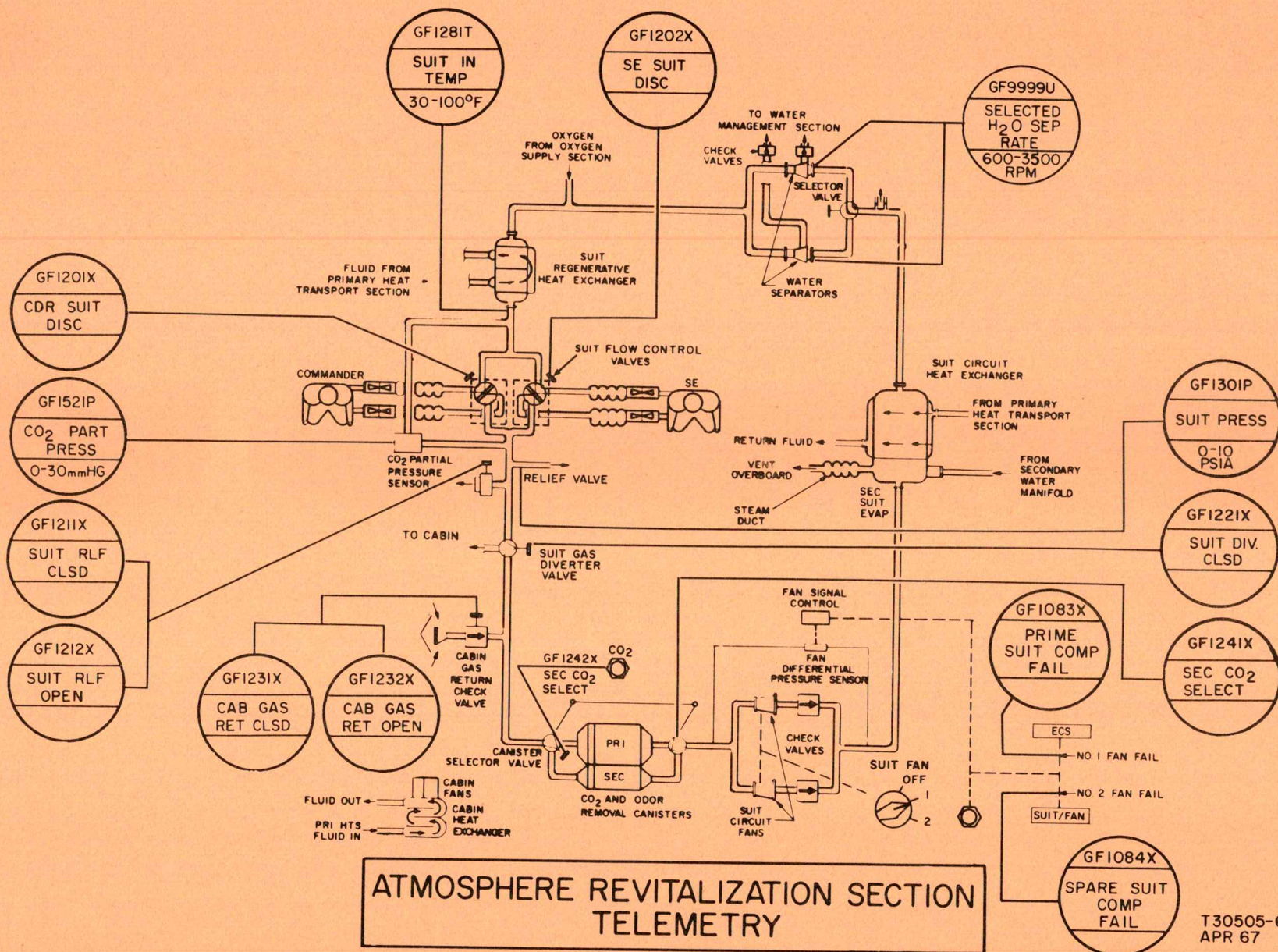
3-31

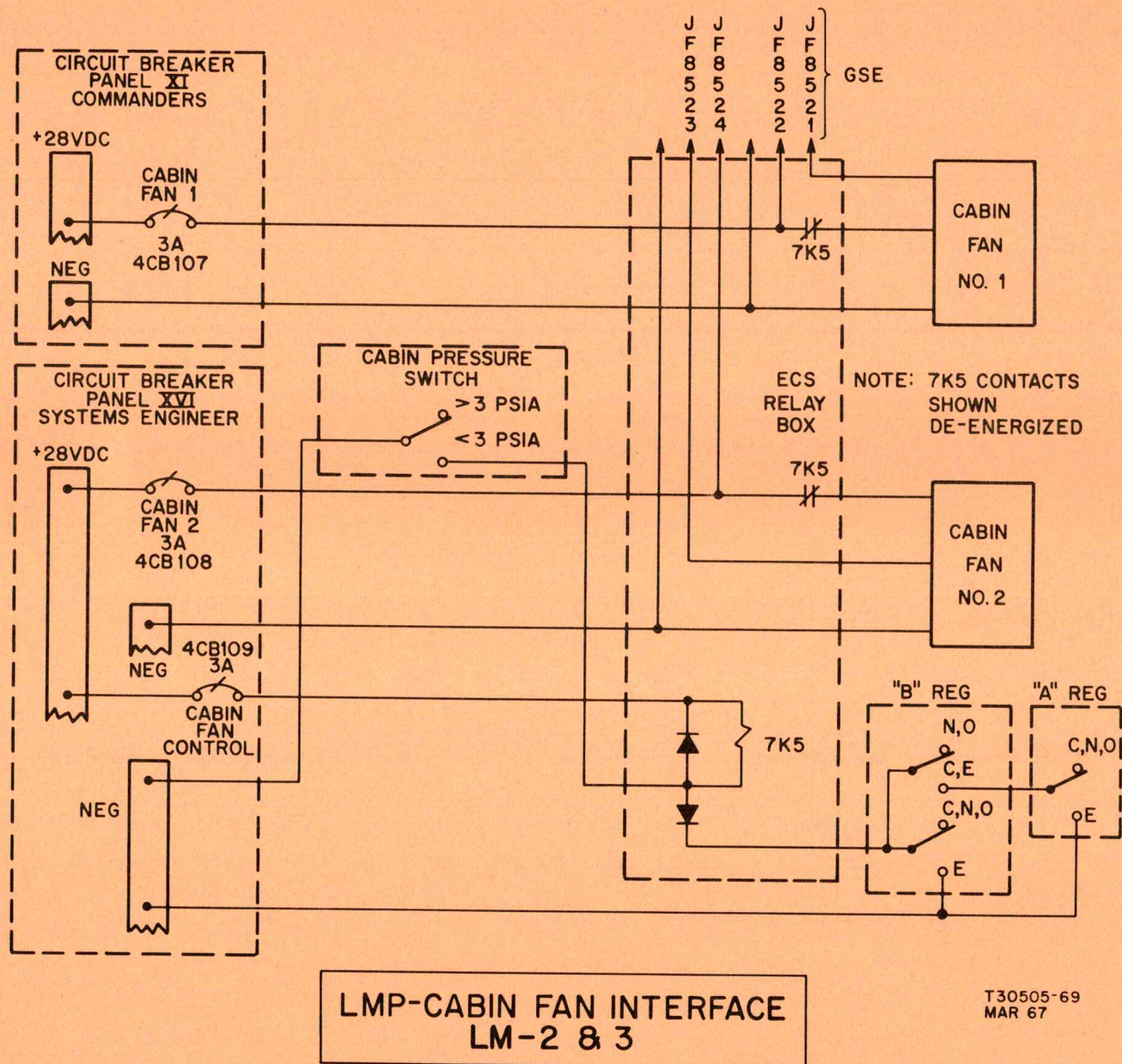
Figure 19

CABIN FAN (ITEM 102)

T30505-38
MAR 67







CHAPTER IV

WATER MANAGEMENT SECTION (WMS)

Operation . Reference Figure 1

The WMS stores water for metabolic consumption, evaporative cooling, and PLSS water tank refill. It also controls the distribution of this stored water as well as the water reclaimed from the ARS by the water separators. Reclaimed water is used only for evaporative cooling in the various ECS water evaporators.

Water is stored in a multiple tank configuration with a single large tank in the descent stage and two identical smaller tanks in the upper mid-section of the ascent stage. All three tanks are bladder type vessels which are prepressurized with nitrogen prior to earth launch.

The controls for the WMS are grouped together on the water control module which is located to the right rear of the systems engineer. The module consists of a cast manifold in which the various water control valves and pressure regulators are mounted.

Descent Water Tank - Item 404

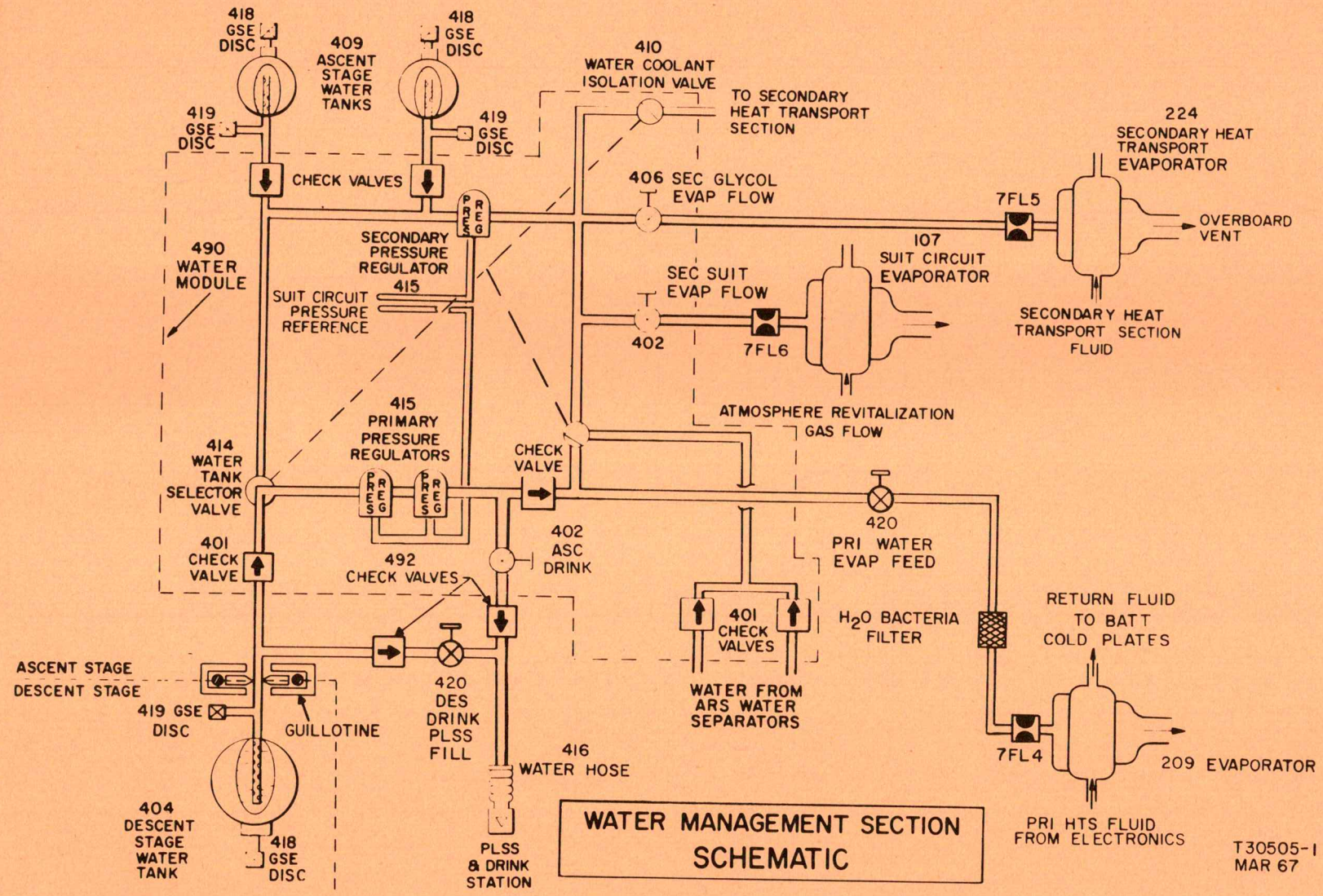
The descent stage water tank is located in quad 2 of the vehicle (see Figure 13, Chapter I). This tank stores the water necessary for HTS cooling, crew consumption and PLSS servicing, during both the descent to the lunar surface and during the lunar stay time.

The tank (see Figure 2) consists of an outer aluminum shell, a standpipe, and a silicone rubber S9711 bladder. The bladder cavity is used to contain the water while the outer shell to bladder volume is charged with gaseous nitrogen for expulsion purposes.

A total of 332# of water is serviced into the descent stage tank 325.4 of which is useable water. An initial nitrogen precharge of 50 P.S.I.A. at 100°F is used to squeeze the bladder and force the water through holes in the tank standpipe and out into the section plumbing.

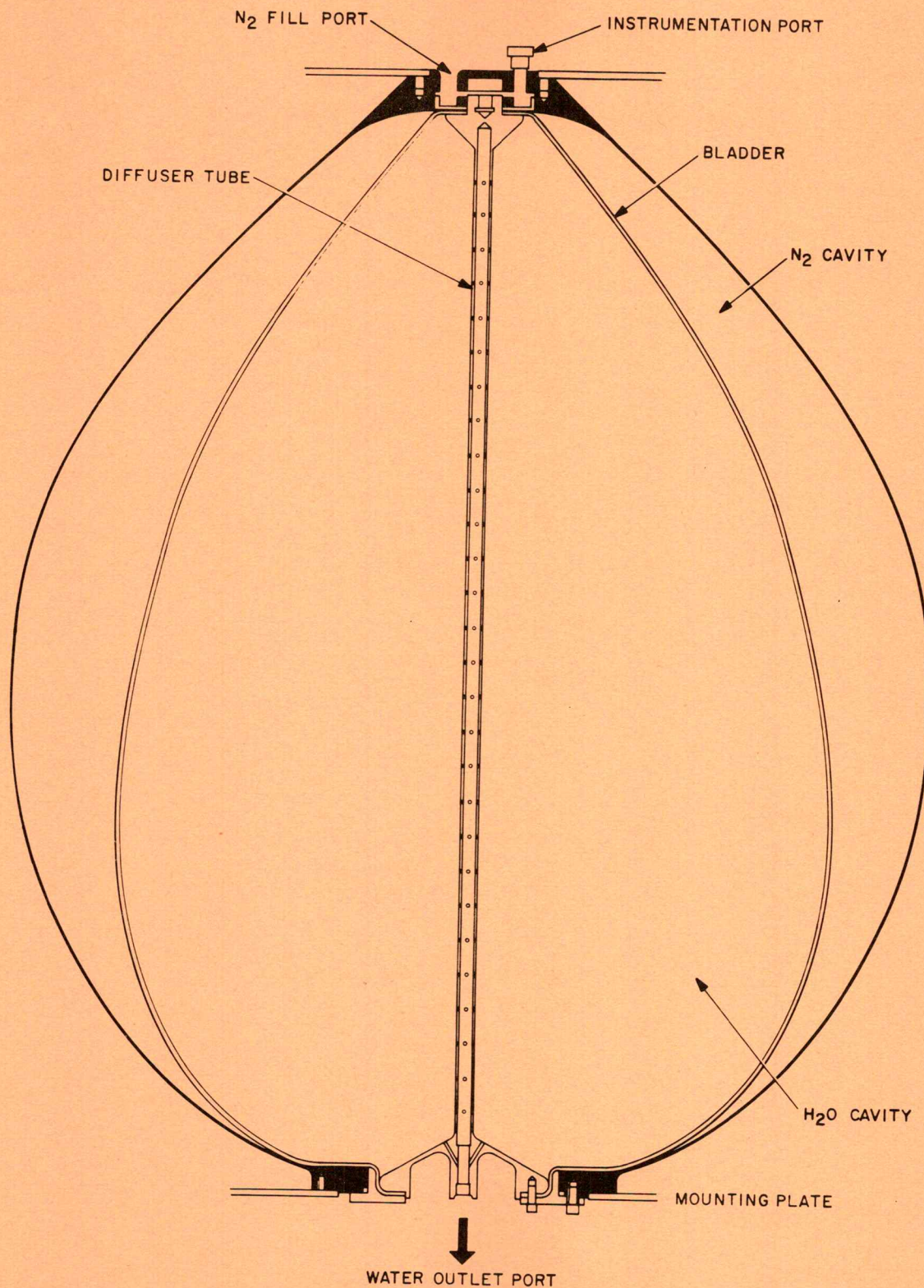
Three ports are used on the descent tanks, a nitrogen fill port, an instrumentation port, and a water outlet port.

The nitrogen fill port interfaces with plumbing that in turn is routed to the GSE servicing disconnect, Item 418. This disconnect will permit evacuation and gas servicing access to the nitrogen cavity.



WATER MANAGEMENT SECTION SCHEMATIC

T30505-1
MAR 67



DESCENT WATER TANK ITEM 404

T30505-32
FEB. 66

The tank instrumentation port receives the Water Quantity Measuring Device (WQMD) pressure-temperature transducer which is used for generating water quantity indication signals for S/C display and telemetry use.

Ascent Water Tanks - Item 409 - Reference Figure 3

The ascent tanks are similar in construction to the descent tank. Both ascent tanks have a capacity of 42.5# each, 41.65# of which is useable. An initial nitrogen charge of 50 P.S.I.A. at 100°F is used in both tanks. For the location of ascent stage water tanks, see Chapter I, Figures 9 and 12.

GSE Water Disconnect - Item 419

A female, self-sealing quick disconnect half is provided for each of the 404 and 409 water tanks. These quick disconnect halves are used in conjunction with WMS GSE equipment for section servicing purposes. The disconnect half also includes provisions for mechanical capping after disconnect to protect against leakage due to failure of the self-sealing feature.

GSE Water Tank Pressurization Quick Disconnect - Item 418

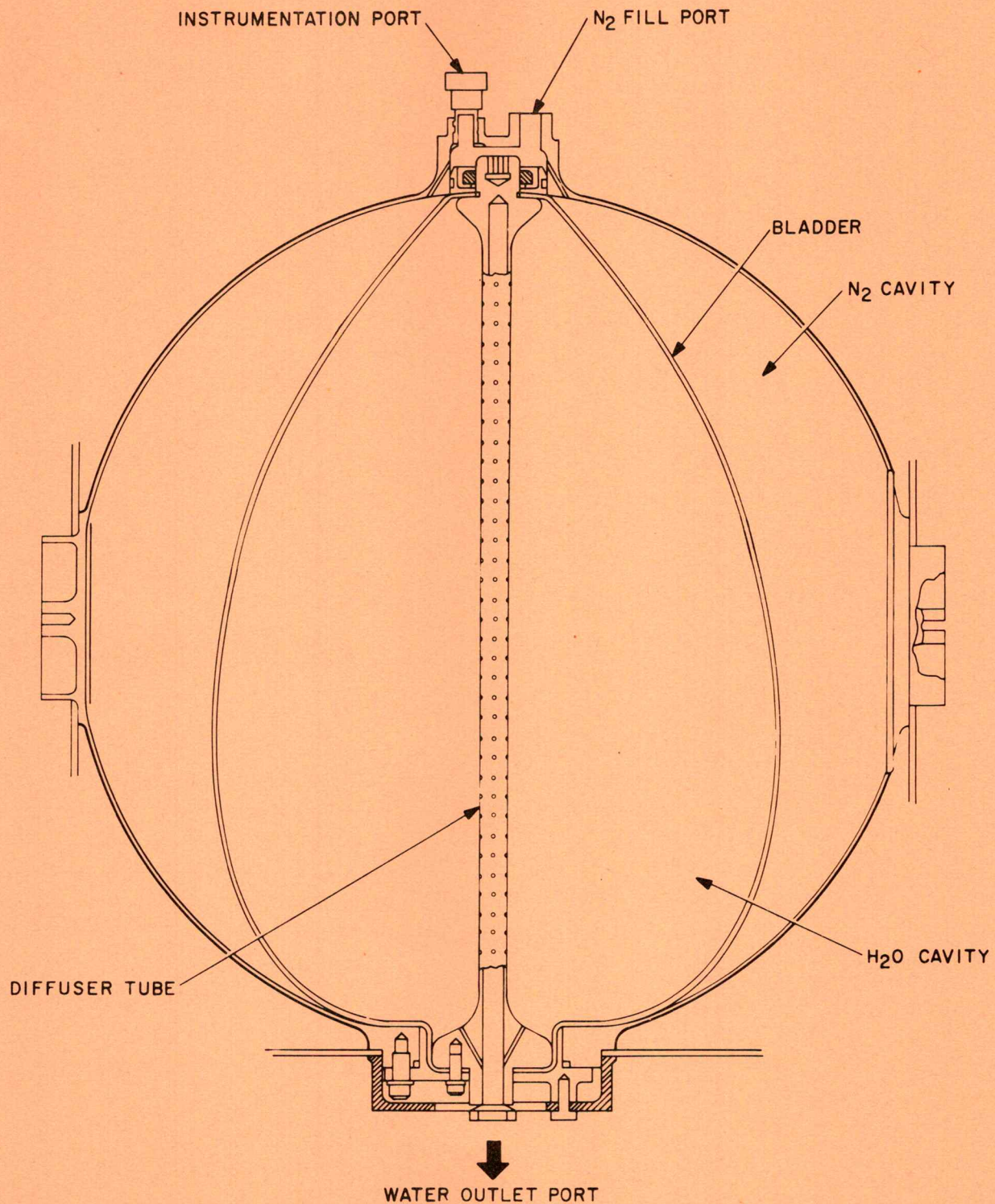
A male, self-sealing, quick disconnect half is provided for pressurizing each of the 404 and 409 water tanks. These quick disconnect halves are used in conjunction with the WMS GSE to evacuate and pressurize the tanks. These disconnects incorporate a mechanical capping feature similar to the 419's.

Water Control Module - Item 490 - Reference Figure 4

The water control module consists of six 401 check valves, two 402 shut off valves, items 406, 410, 414, three 415's, in addition to all inter-connecting plumbing and couplings. This assembly also includes all bracketry required to mount and support the foregoing components and to mount the assembly itself. An artist view of the water module control is illustrated in Figure 5.

Water Check Valves - Item 401 - Reference Figure 6

Six 401 check valves are used in the WMS, one in each of the tank feed lines, one downstream of the ascent drink valve, and one in each of the discharge lines from the ARS water separators. These check valves serve the following purposes:

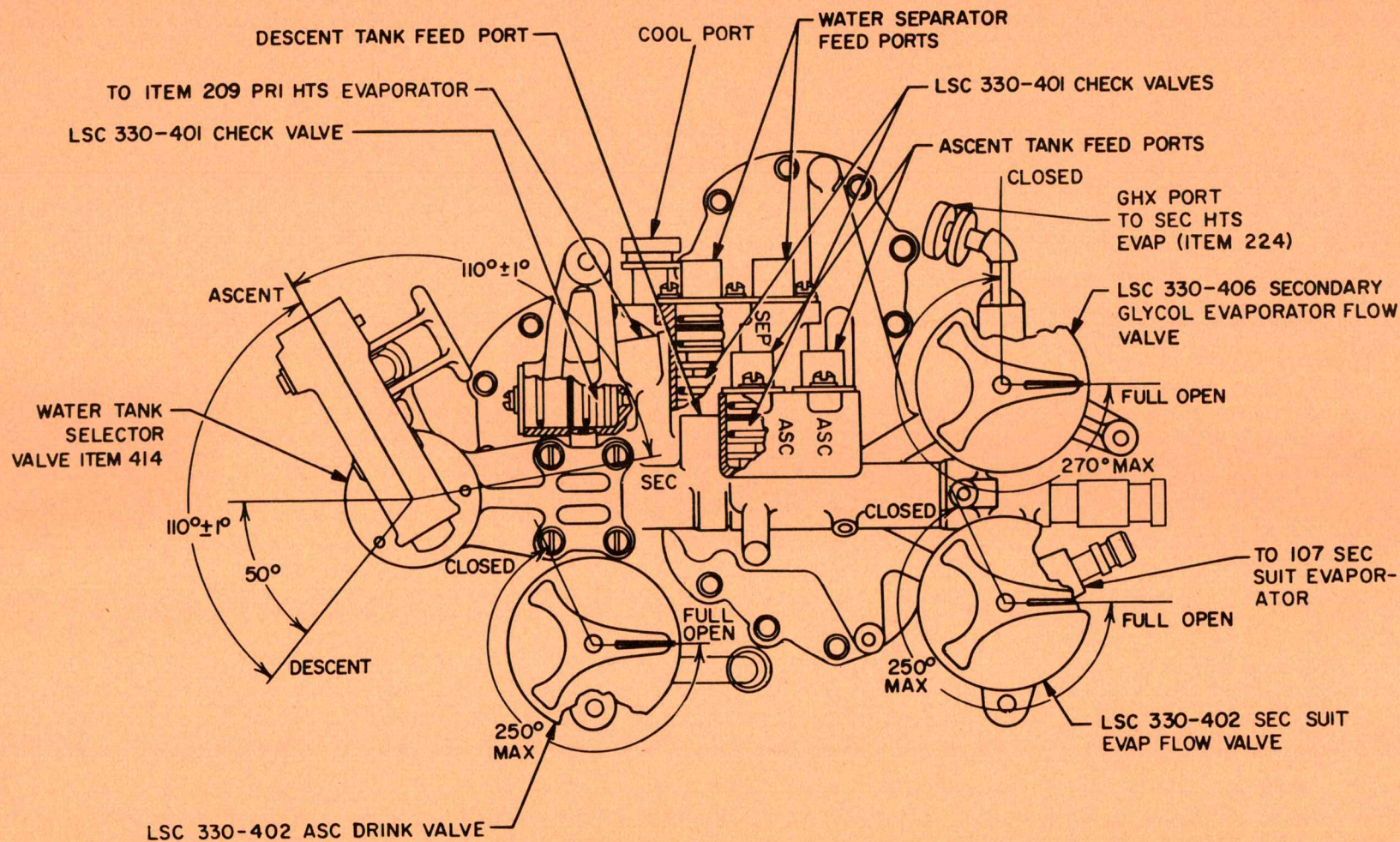


ASCENT WATER TANK ITEM 409

T30505-33
FEB. 66

4-6

Figure 4

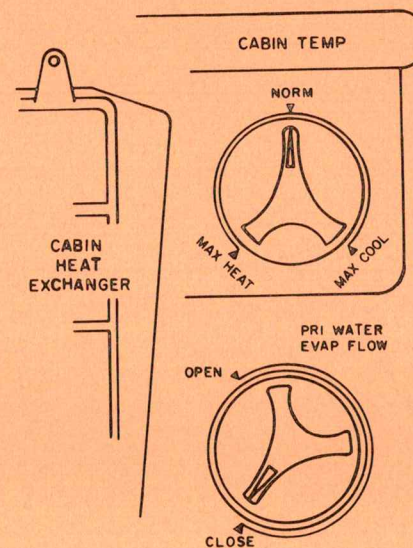
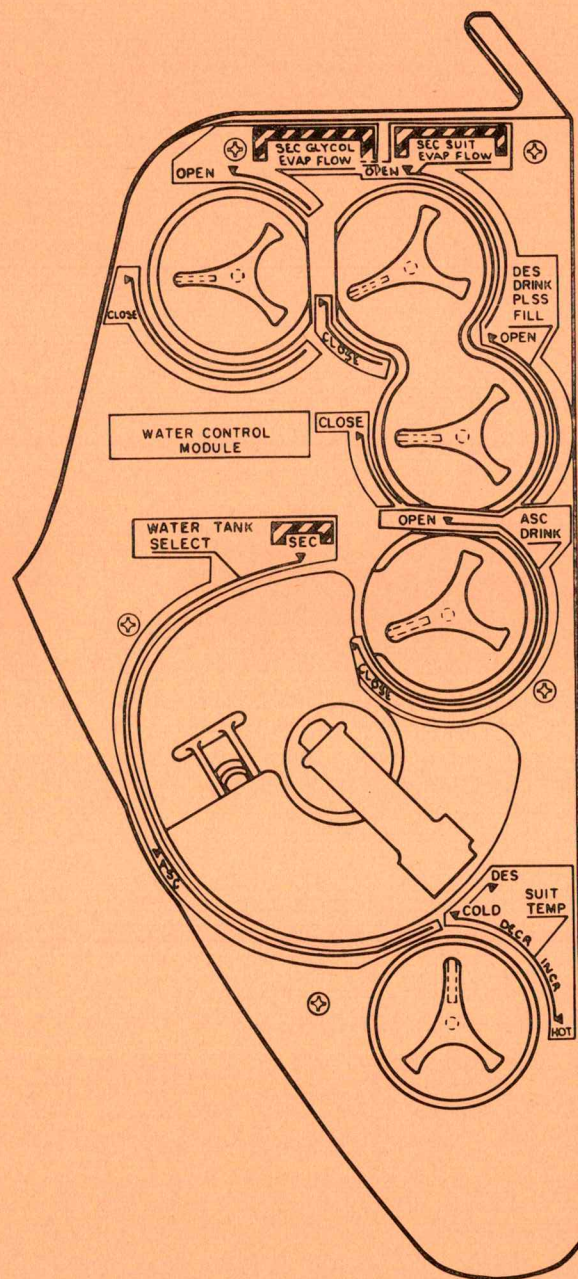


WATER CONTROL MODULE ITEM 490

T30505-31
MAR 67

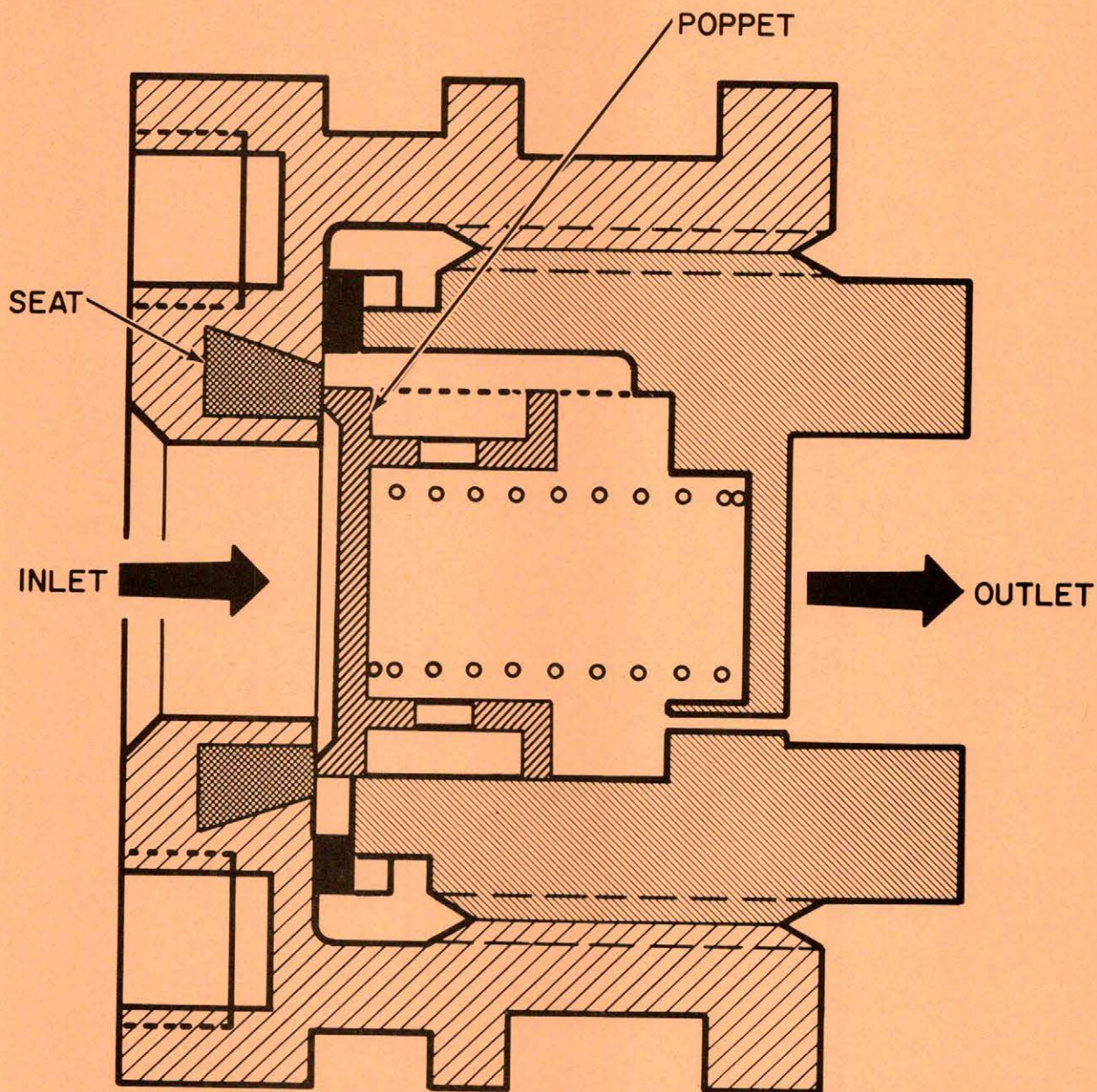
4-7

Figure 5



WATER MANAGEMENT CABIN/SUIT TEMP CONTROLS

T30505-7
MAR 67



WATER CHECK VALVE
ITEM 401

T30505-13
APR 67

1. Prevent water flow from the water control module to the water separators.
2. Prevent water flow from the water control module to the water storage tanks.
3. Prevent flow of water from the water separators to the drinking/PLSS tap.

ASC Drink Valve - Item 402 - Reference Figure 7

A manually operated water shut-off valve is provided to control the flow of water from the water control module to the water hose assembly (Item 491). This control (OPEN-CLOSE) is used to control water flow for drinking purposes during the ascent phase of the mission.

Secondary Suit Evaporator Flow Control Valve - Item 402

This valve is a manually operated poppet type shut-off valve that is normally maintained in the closed position. When back up cooling for the suit loop becomes necessary the valve is opened allowing water to flow to the secondary suit evaporator, Item 107.

Secondary Glycol Evaporator Flow Control Valve - Item 406

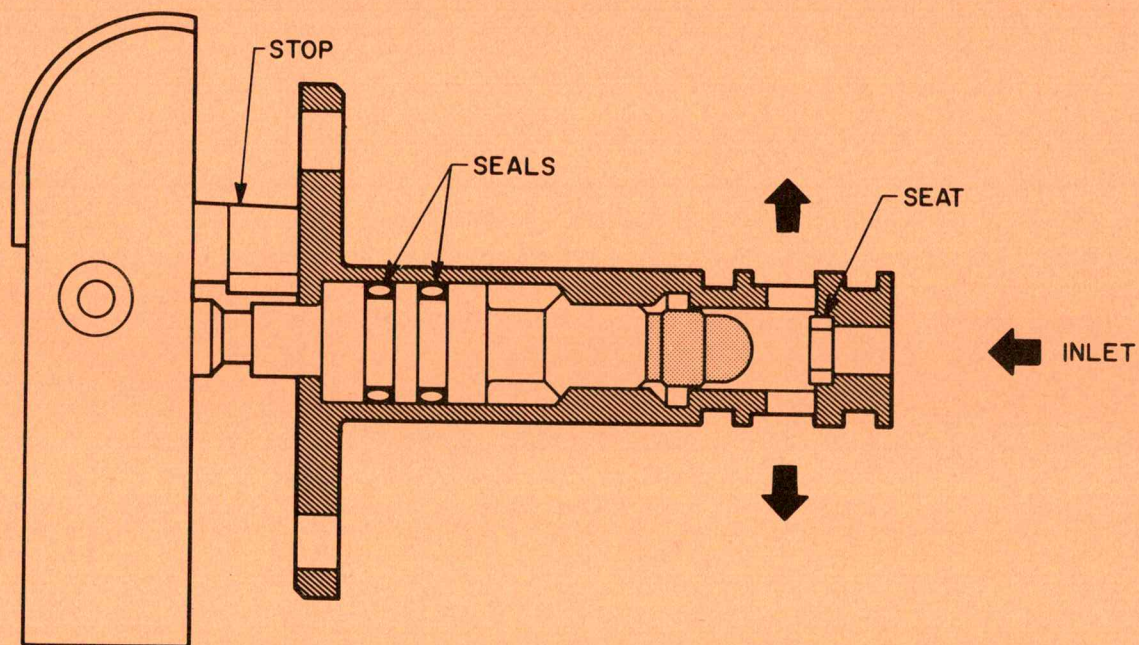
This valve is a manually operated valve to control the flow of water to the secondary heat transport water evaporator. When the secondary loop is activated this valve must be opened to provide the necessary evaporative cooling to reject the loops waste heat.

Water Coolant Isolation Valve - Item 410

A valve is provided to isolate the WMS from the secondary loop of the HTS. The valve consists of an aluminum diaphragm machined into an aluminum housing. It is physically mounted on the water tank selector valve and when this valve is actuated to the secondary position the secondary spool spike will pierce the diaphragm establishing a flow path between the WMS and the secondary heat transport loop. When punctured, the valve permits the WMS to serve as an accumulator for the secondary loop.

Water Tank Selector Valve - Reference Figure 8 - Item 414

The water tank selector valve is a manually operated three position (DESCENT -ASCENT-SECONDARY) spool valve. Two spools (a primary and a secondary) linked to a selector handle are used to rearrange the internal valve porting such that proper water flow paths may be established. A fold-out hand crank is provided to control the valve position.

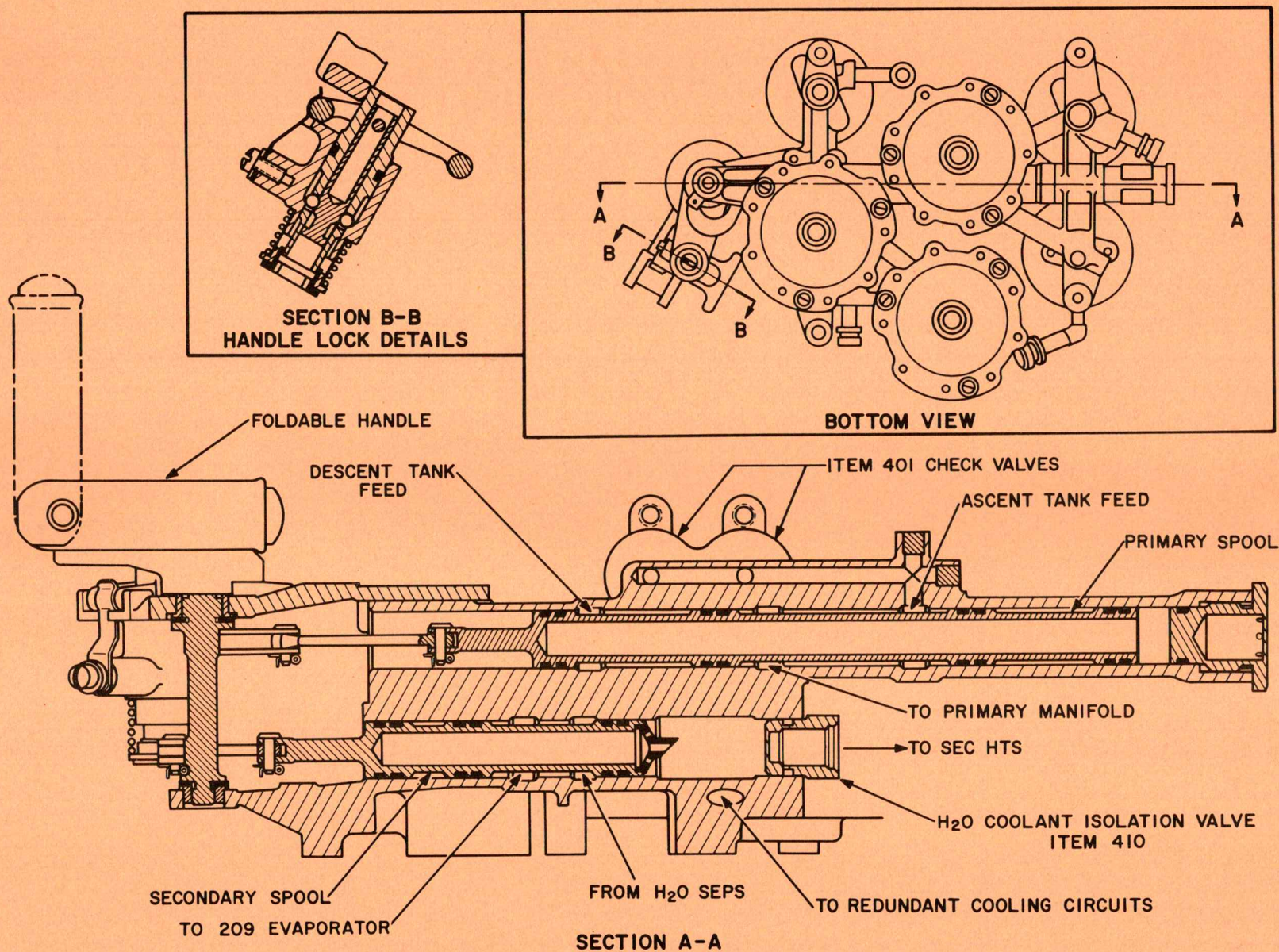


WATER SHUTOFF VALVE
ITEM 402

T30505-30
FEB 66

4-11

Figure 8



DESCENT - In the descent position the primary spool is moved to the extreme left establishing a flow path between the descent stage tank and the primary manifold. The secondary spool provides porting to allow the ARS water separator discharge to feed the primary HTS evaporator.

ASCENT - The ascent selection is illustrated in Figure 8. In this selection the primary spool establishes a flow path between the ascent tanks and the primary manifold while the secondary spool allows water separator discharge to feed the primary HTS evaporator.

SECONDARY - Secondary may not be selected unless the mechanical handle lock is released. To release the lock the finger latch is lifted unlatching the ball locks. If the lifting force is now removed the return spring will slide the lock pin to the unlocked position and the control handle may be moved to the "SEC" position. This action will move the secondary spool to the right causing the water coolant isolation valve to be punctured and the water separator discharge to be routed to the secondary manifold. The secondary selection will be made when the secondary HTS is activated in flight.

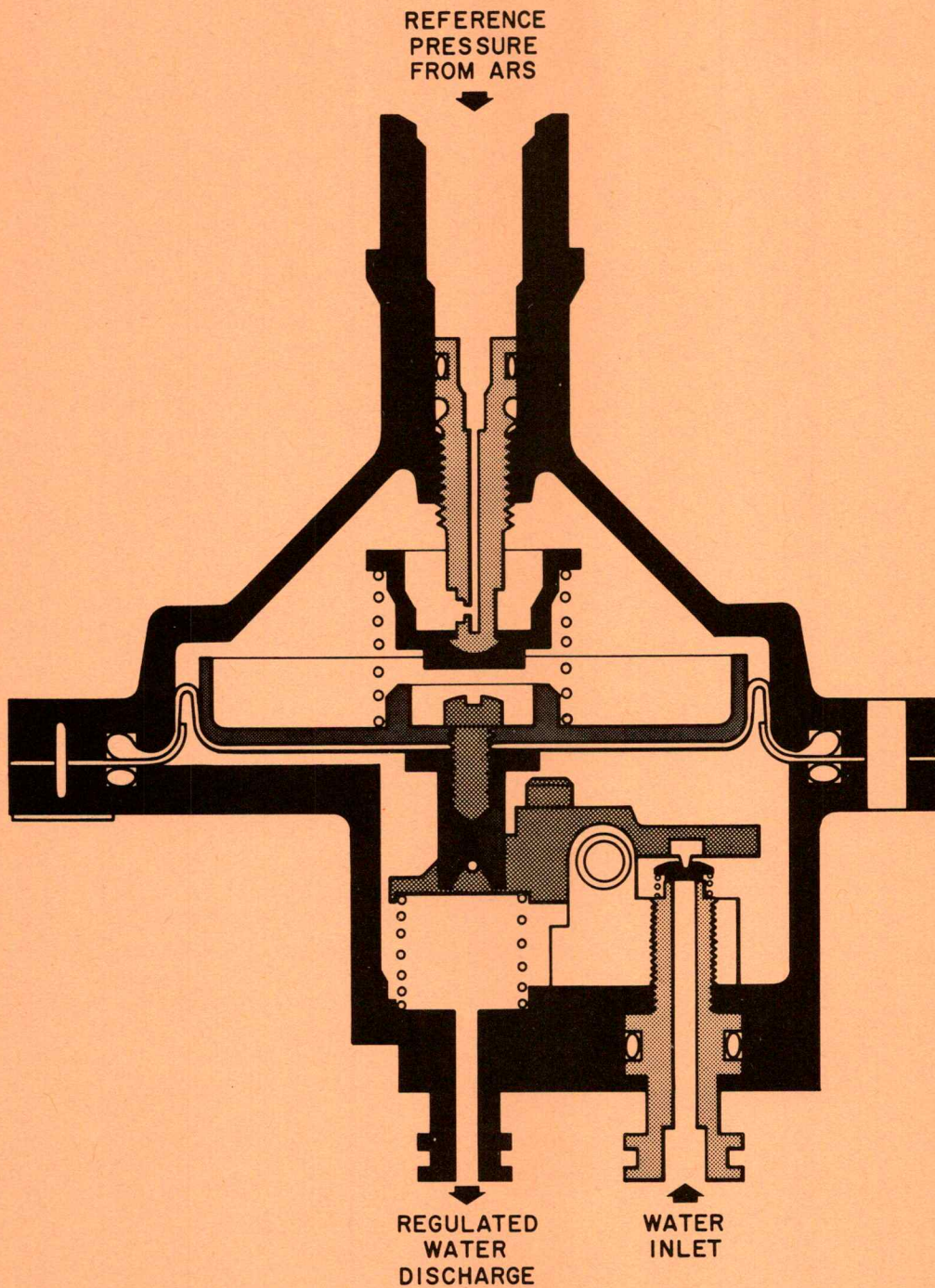
Water Pressure Regulators - Reference Figure 9 - Item 415

Three water pressure regulators are used in the WMS; one in the secondary manifold, and two in series in the primary manifold. The regulators control the water pressure in response to suit circuit gas reference pressure.

Under normal operating conditions, the section feeds water from either the descent or ascent tankage (depending upon selector valve positioning) through the series pressure regulators to the primary HTS evaporator and the ascent drink valve.

A redundant water circuit is provided for use should either the primary water manifold or the primary heat transport loop fail. When this mode (secondary) is selected, the water coolant isolation valve is opened to provide an accumulator action for the secondary heat transport loop. Water from the ascent tanks is fed through the single pressure regulator and is routed to the redundant cooling circuits.

The water pressure regulators contain a spring loaded diaphragm that senses the pressure difference between suit loop gas pressure and the downstream water pressure. The diaphragm actuates a balanced lever which is attached to the metering poppet. Water discharge pressure is maintained at .5 to 1.0 P.S.I. above ARS gas pressure.



WATER PRESSURE REGULATOR
ITEM 415

T30505-9
OCT. 65

A small orifice in the suit loop pressure sensing port prevents excessive leakage of water to the suit loop in the event of a diaphragm failure.

Primary Water Evaporator Flow Valve - Item 420

Item 420, primary glycol evaporator flow valve, is used to control the flow of water to the primary HTS evaporator, Item 209.

Water Hose - Item 416

A flexible water hose is provided of sufficient length and flexibility to permit refilling of the PLSS water tank.

Water Disconnect

The water disconnect is a GFE supplied, female ball locking zero-air-entrapment disconnect, containing a self-sealing check valve which is positively displaced upon coupling of the two disconnect valves. Uncoupling of the disconnect is achieved with a pulling action on the sleeve attached to the female end. Coupling occurs when the male and female connectors are pushed together. The water disconnect provides a means of manually detaching or attaching one end of the water hose to the PLSS, water dispenser, and Item 421 protective cap without the use of tools.

Water Check Valves - Item 492 - Reference Figure 10

Two Item 492 check valves are used in the WMS. Each valve basically consists of a 401 check valve and a valve housing. One 492 valve is located in the DES DRINK PLSS FILL high pressure servicing line and the other in the low pressure ASC DRINK line.

The 492 in the DES DRINK PLSS FILL servicing line prevents flow of water from the water hose assembly to the descent water tank, item 404, through the water shut-off valve 420.

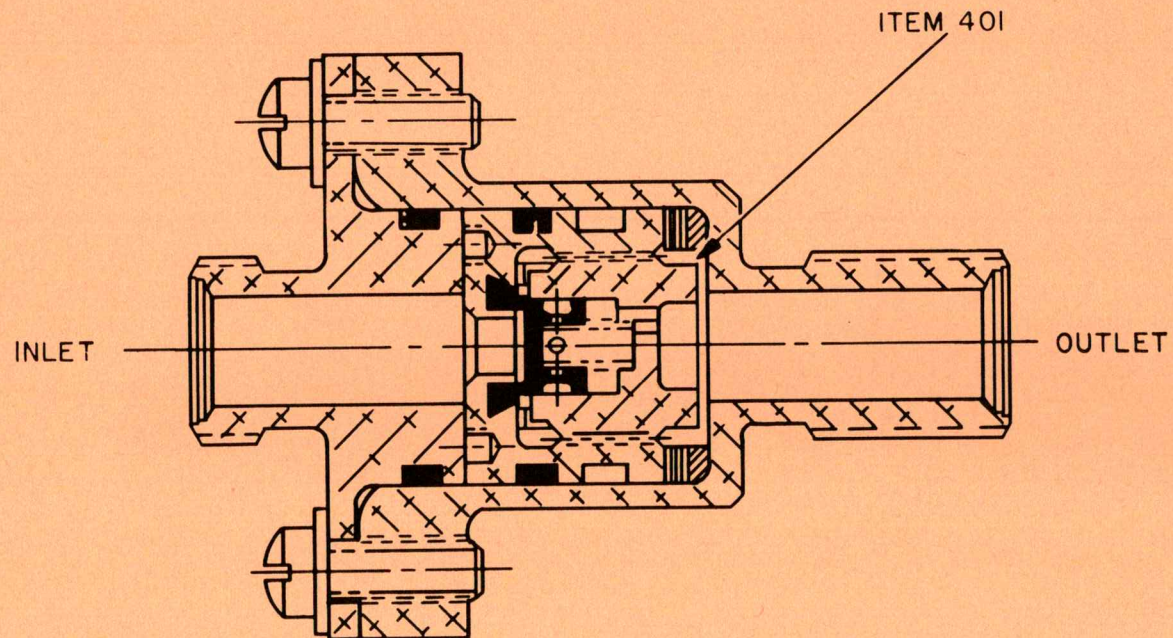
The 492 in the ASC DRINK feed line prevents water flow from the descent water tank through the water shut-off valves 420 and 402 to the primary HTS evaporator 209.

Interstage Guillotine Cutter Assembly - Reference Figure 11

The LM Electroexplosive Devices System utilizes a cutter assembly to sever the interstage water feed line from the Item 404 water tank. The cutter assembly has two cutting blades, each blade being driven by a separate detonator. Operation of either blade will result in severing the water feed line.

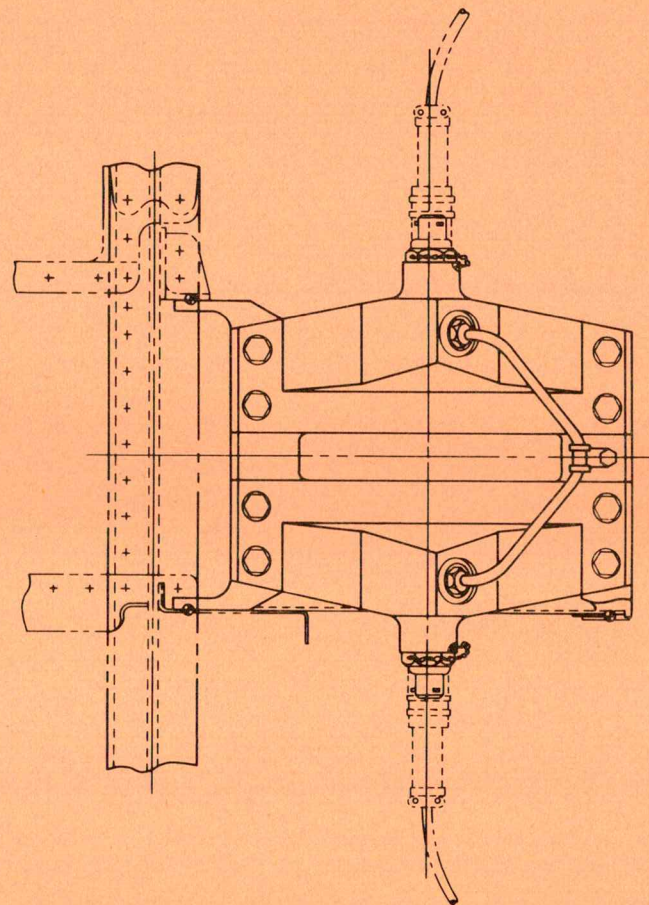
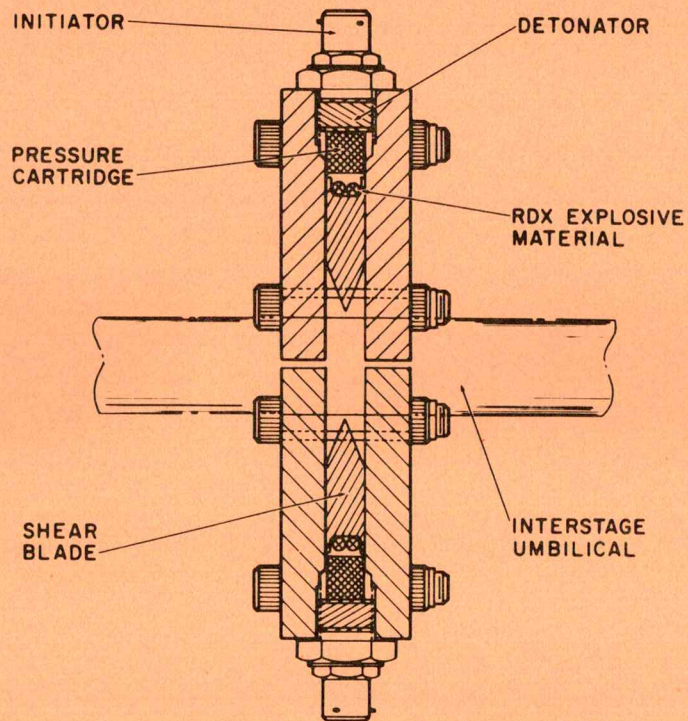
4-15

Figure 10



WATER CHECK VALVE
ITEM 492

T30505-96
MAR 67



CABLE CUTTER ASSEMBLY

T30905-53
FEB 67

The blades of the cutter assembly are maintained in the "safe" position with shear pins. The application of shear pins assures that the cutter will not interfere with WMS operation without a positive "fire" signal to the cutter assemblies control circuit.

When the initiators are fired, the gas generated drives the cutter blades completely severing the water line and the interstage wire bundle.

Water Bacteria Filter - Item 423

A bacteria filter is provided in the water feed line from the water control module to the primary HTS evaporator. The filter will remove 95% of the bacteria of 0.15 micron size and incorporates a differential pressure bypass having a bacteria loading capacity of 1×10^{10} micro-organisms before bypass activation.

Water Quantity Measuring Device (WQMD)

The Water Quantity Measuring Device is designed to measure the quantity of water in the water storage tanks of the Environmental Control Subsystem. Three units are used on the vehicle - one on the descent tank and one on each of two ascent tanks.

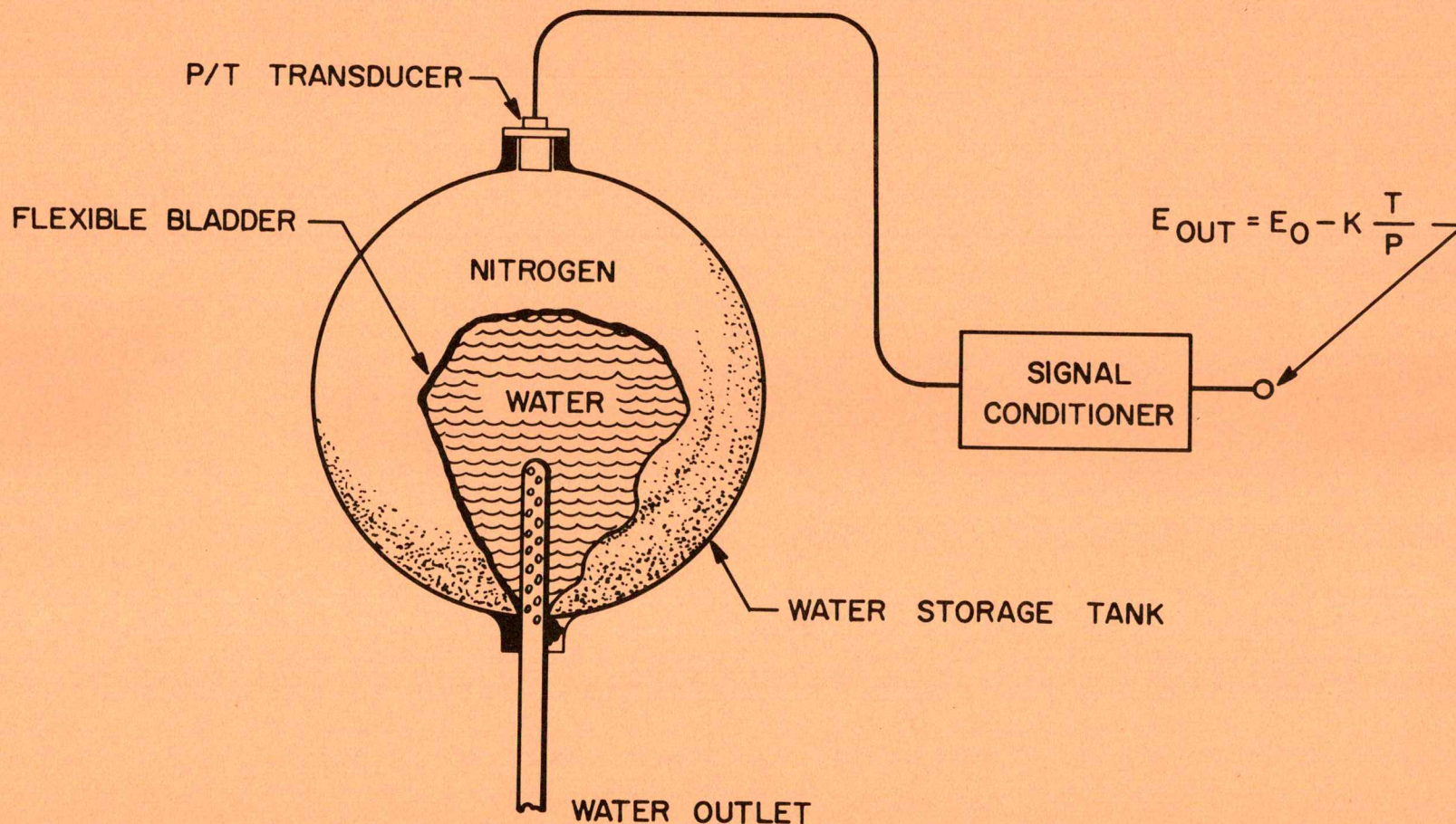
The basic concept of the Water Quantity Measuring Device as applied to an ECS water storage tank is shown in Figure 12. The quantity of water remaining in the tank is measured by sensing the pressure and temperature of the nitrogen gas and computing the water volume by the application of the ideal gas law.

The Water Quantity Measuring Device consists of two basic elements, the transducer, and the signal conditioner. The transducer is mounted on a flange on the water storage tanks and held in place by a clamping nut and seal ring. The output of the transducer is fed to the remotely mounted signal conditioner by an interconnecting cable.

The system provides an output signal which is directly proportional to the amount of water in the storage tanks. The way in which this is accomplished may be readily understood by applying the ideal gas law to the system shown in Figure 12. This law states that the volume of the gas in a container is given by

$$V_g = WRT/P \quad (1)$$

where V_g = gas volume
W = mass of gas
R = specific gas constant
T = absolute temperature
P = absolute pressure



WATER QUANTITY MEASURING DEVICE
SIMPLIFIED SCHEMATIC

The volume of water remaining in the tank is the difference between the tank volume and the gas volume, or

$$V_w = V_o - V_g \quad (2)$$

where V_w = water volume

V_o = tank volume

The water volume can be expressed in terms of pressure and temperature by combining Eqs. 1 and 2:

$$V_w = V_o - WRT/P \quad (3)$$

To provide an output proportional to the water remaining in the tank, the WQMD senses the gas pressure and temperature and produces an output given by Eq. 4:

$$E_{out} = E_o - KT/P \quad (4)$$

where E_{out} = device output voltage

E_o = tank volume constant

K = gas mass constant

The output of the Water Quantity Measuring Device is proportional to the water volume because Eq. 3 and 4 have the same form.

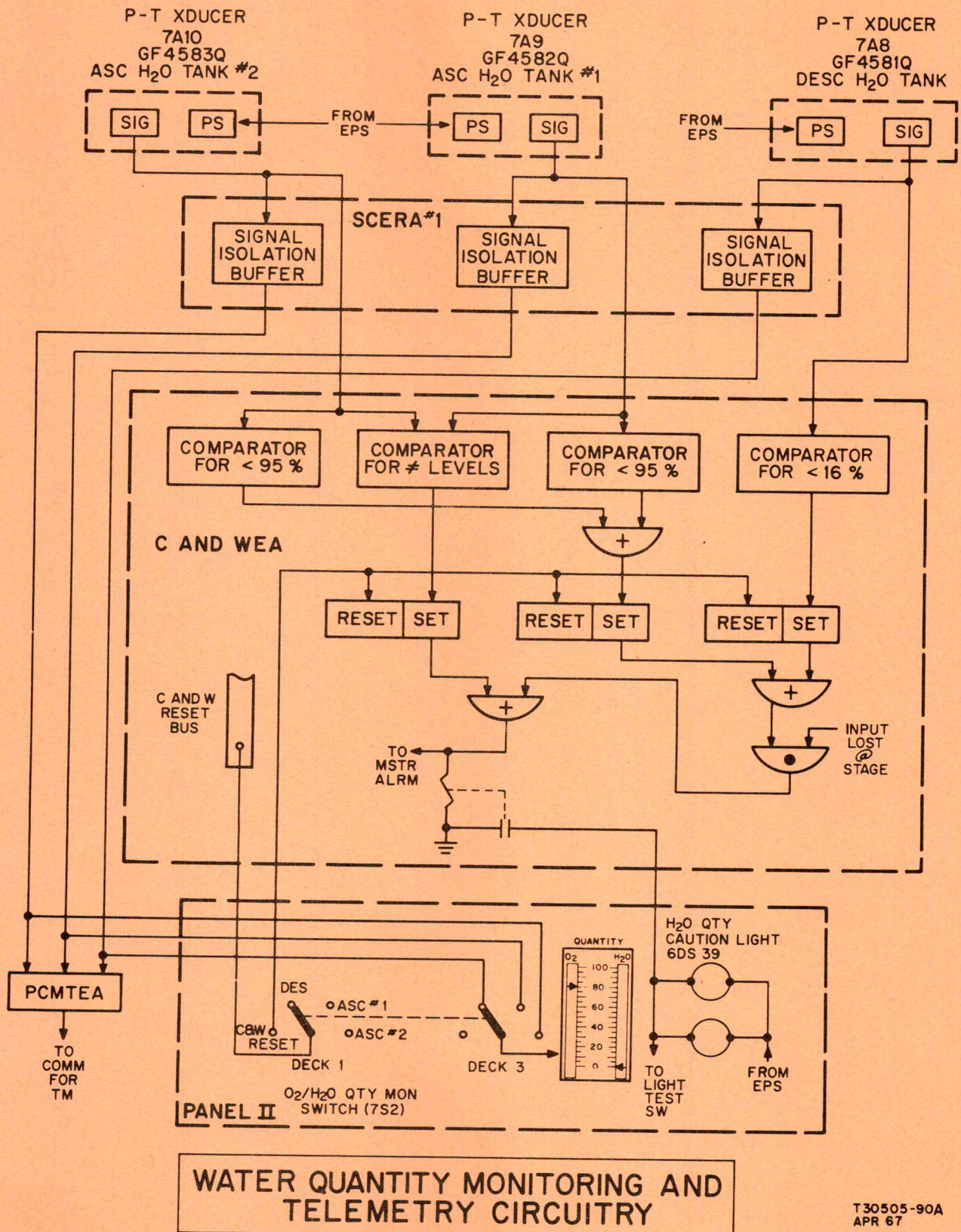
Water Quantity Display and Telemetry - Reference Figure 13

The output of each WQMD is fed into SCERA #1 for signal isolation purposes. Outputs from all three tanks are routed to PCMTEA for telemetry transmission and also to the O_2/H_2O QTY MON switch 7S2 on panel II of the S/C. By proper positioning² of 7S2 the three water tank quantities may be displayed one at a time on the H_2O quantity gage.

All three channels are also fed to the CWEA for constant monitoring of tank water levels. The following conditions will result in triggering the master alarm system and illumination of the H_2O QTY caution light 6DS39.

Prior to vehicle staging:

1. Descent tank level less than 16%
2. Ascent tank #1 level less than 95%
3. Ascent tank #2 level less than 95%

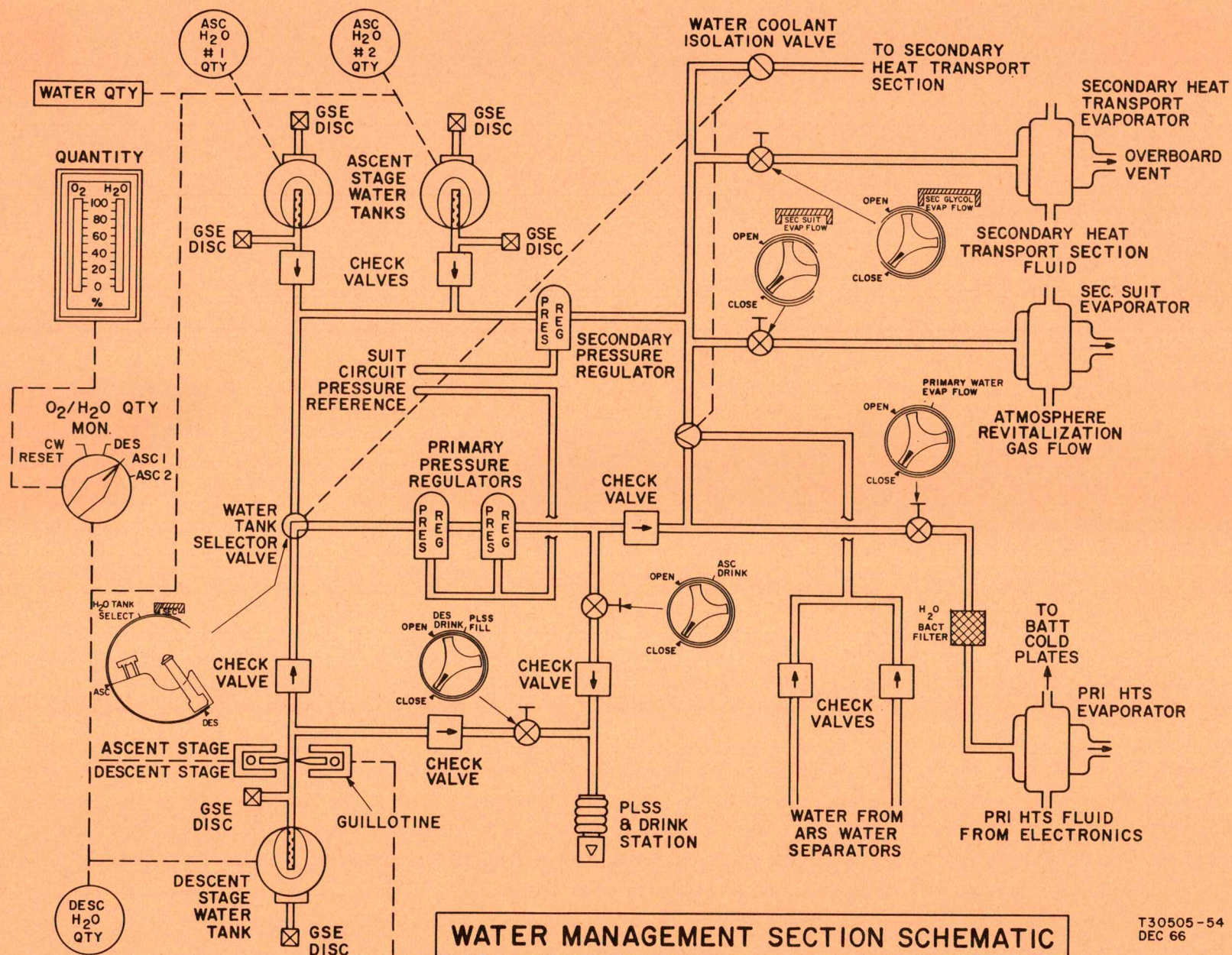


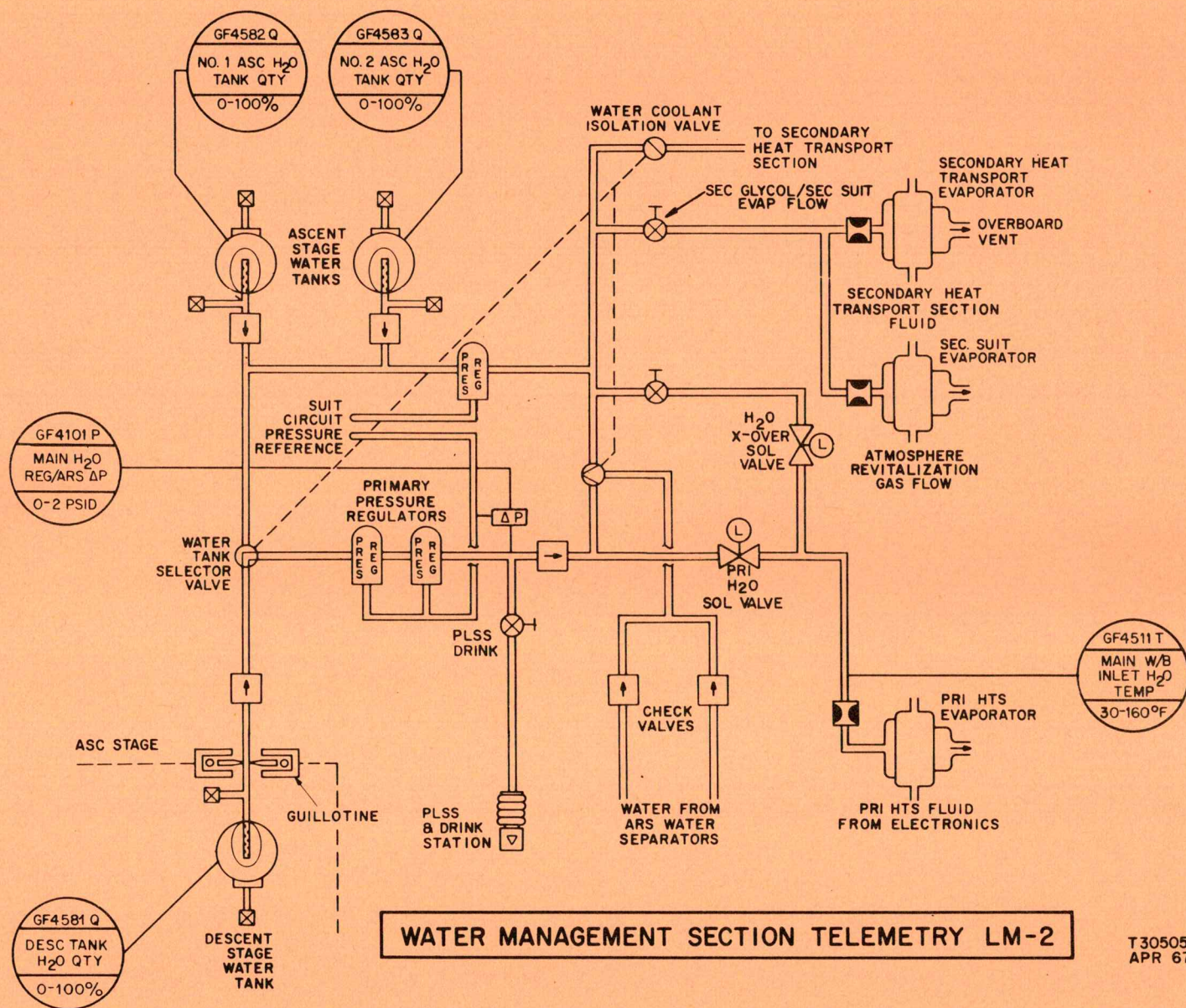
T30505-90A
APR 67

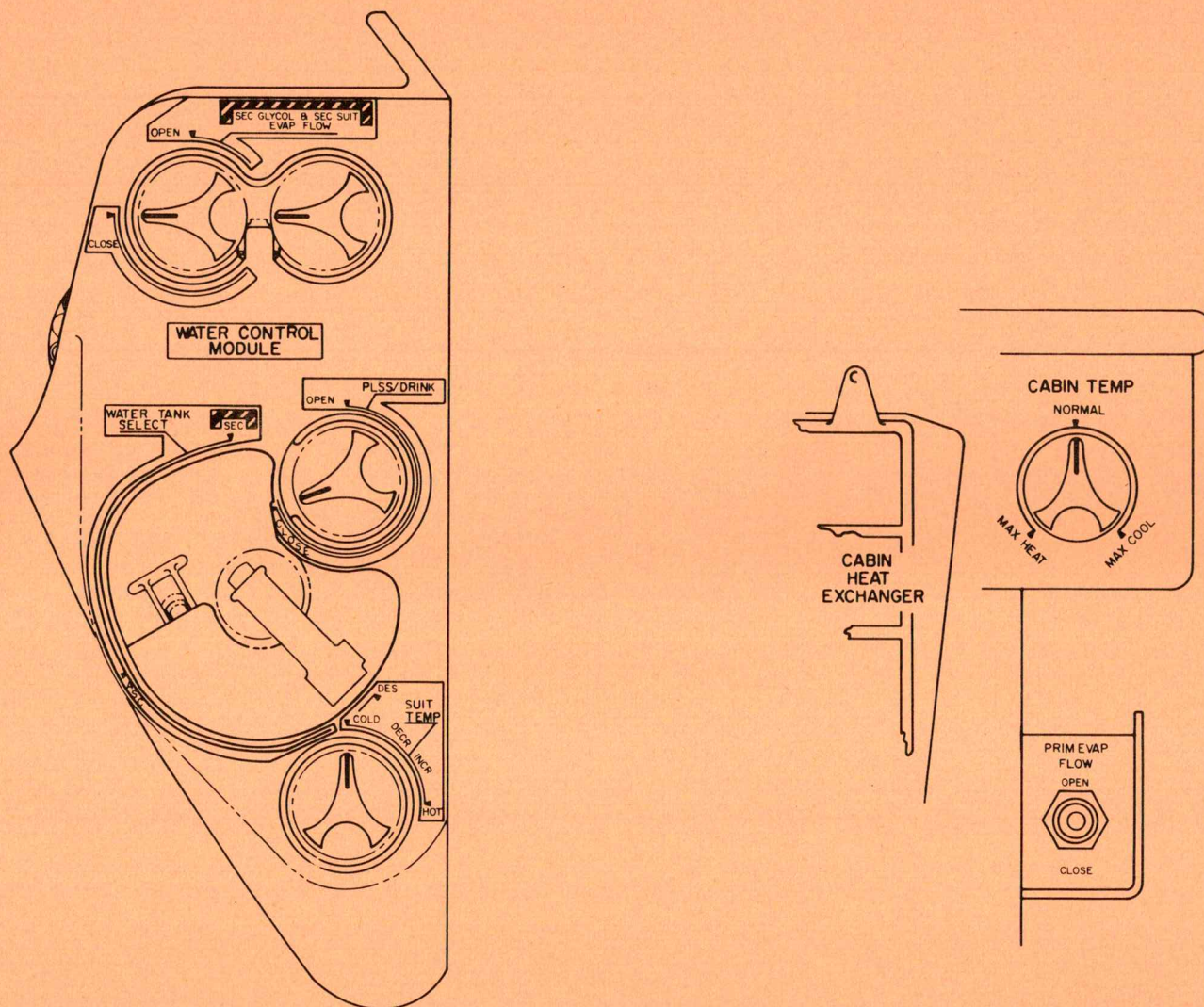
After staging the vehicle:

1. Unequal levels (approximately 15% or .75 VOLTS) existing between the two ascent tanks.

All of the above faults may be reset by placing 7S2 to the C&W RESET position.

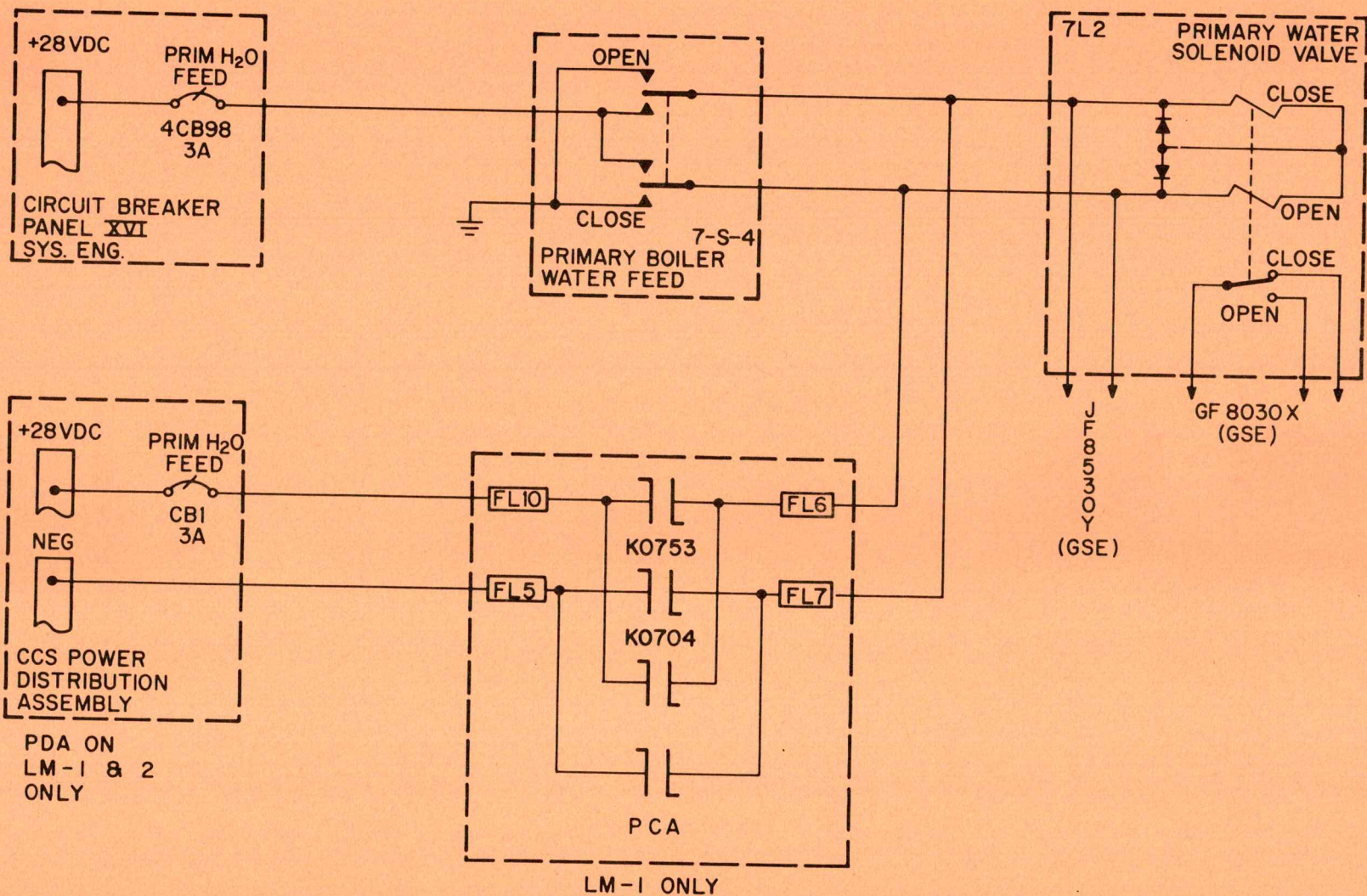


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APR 67



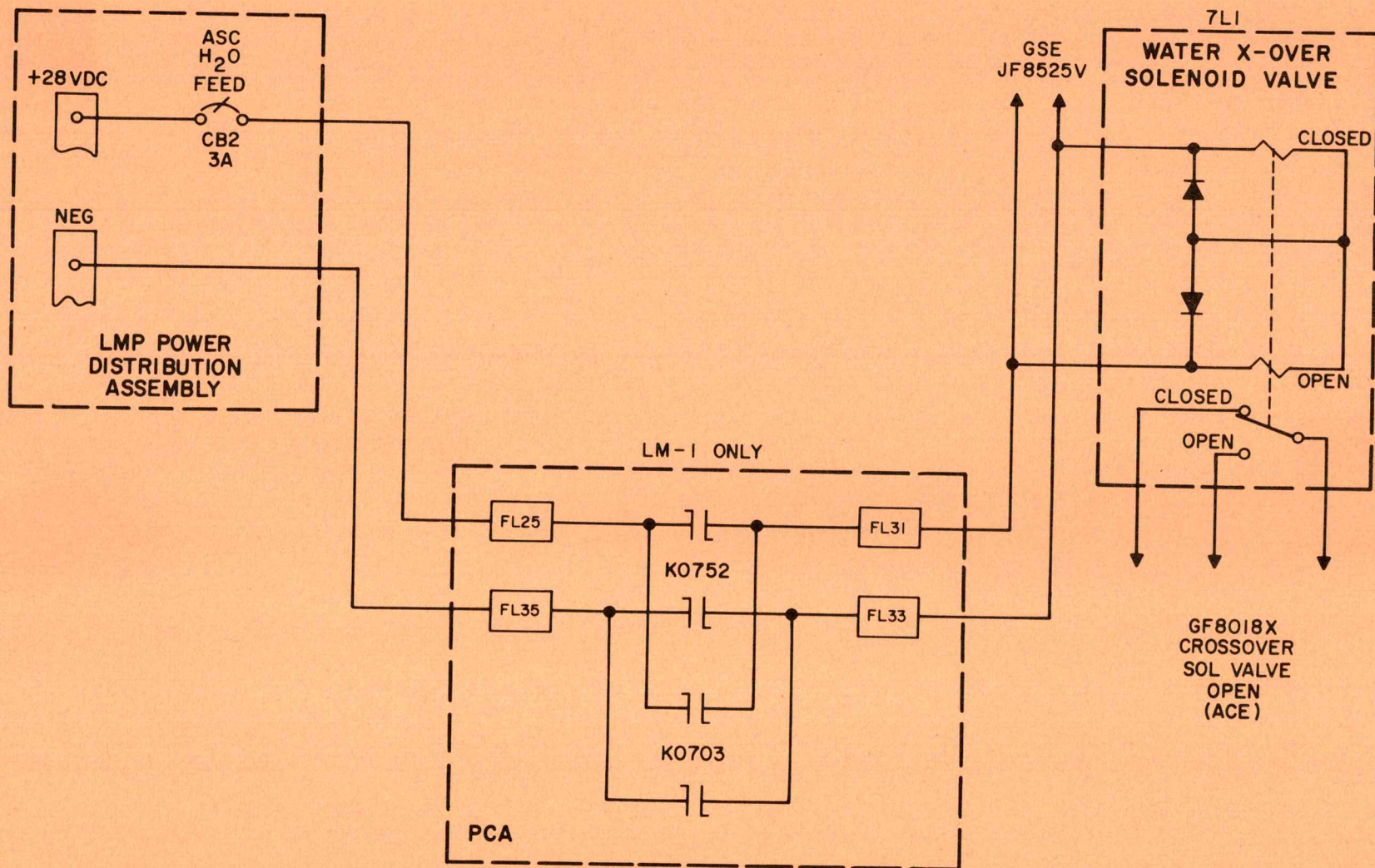
WATER MANAGEMENT AND CABIN/SUIT TEMP CONTROLS
LM-2

T30505-90
MAR 67



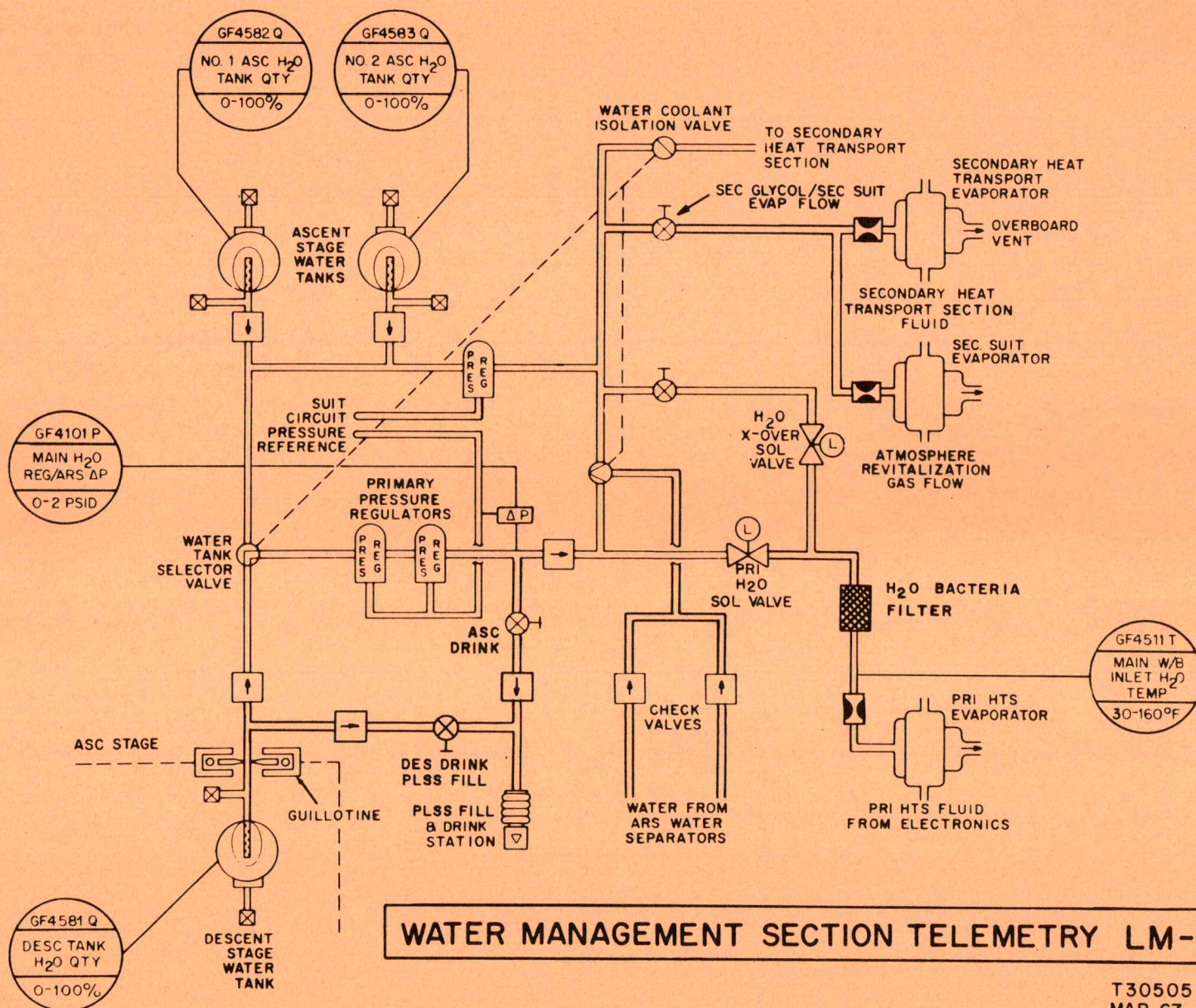
LMP PRIMARY WATER FLOW IMPLEMENTATION
LM-1 THROUGH 3

T30505-70
MAR 67



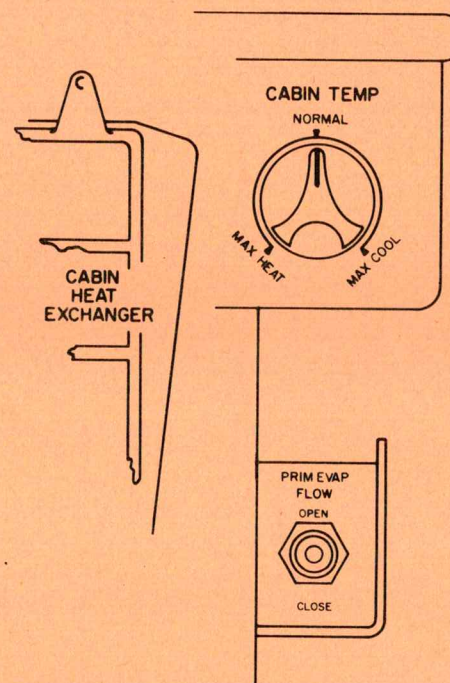
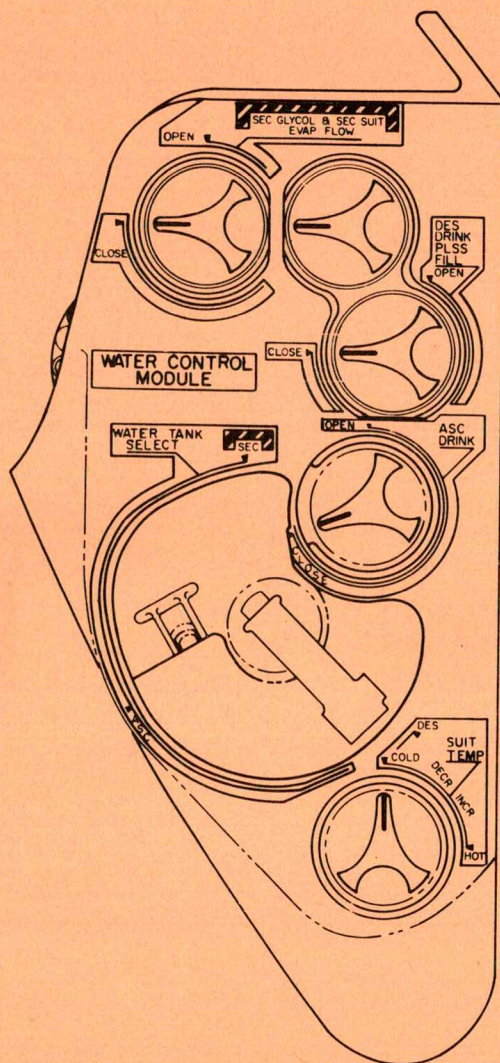
LMP CONTROL OF WATER CROSSOVER VALVE
LM-1 AND 2

T30505-71
MAR 67



WATER MANAGEMENT SECTION TELEMTRY LM-3

T30505-97
MAR 67



**WATER MANAGEMENT AND CABIN/SUIT TEMP CONTROLS
LM-3**

T30505-91
MAR 67

CHAPTER V

HEAT TRANSPORT SECTION (HTS)

Operation - Reference Figure 1

The HTS circulates a coolant fluid consisting of 35% ethylene glycol and 65% water, by weight, to the LM equipment requiring active thermal control and provides the heat sinks to which the coolant rejects any waste heat. The function of active thermal control includes cooling of electronics which cannot dissipate their heat passively and heating and/or cooling of the suit circuit and cabin oxygen as required.

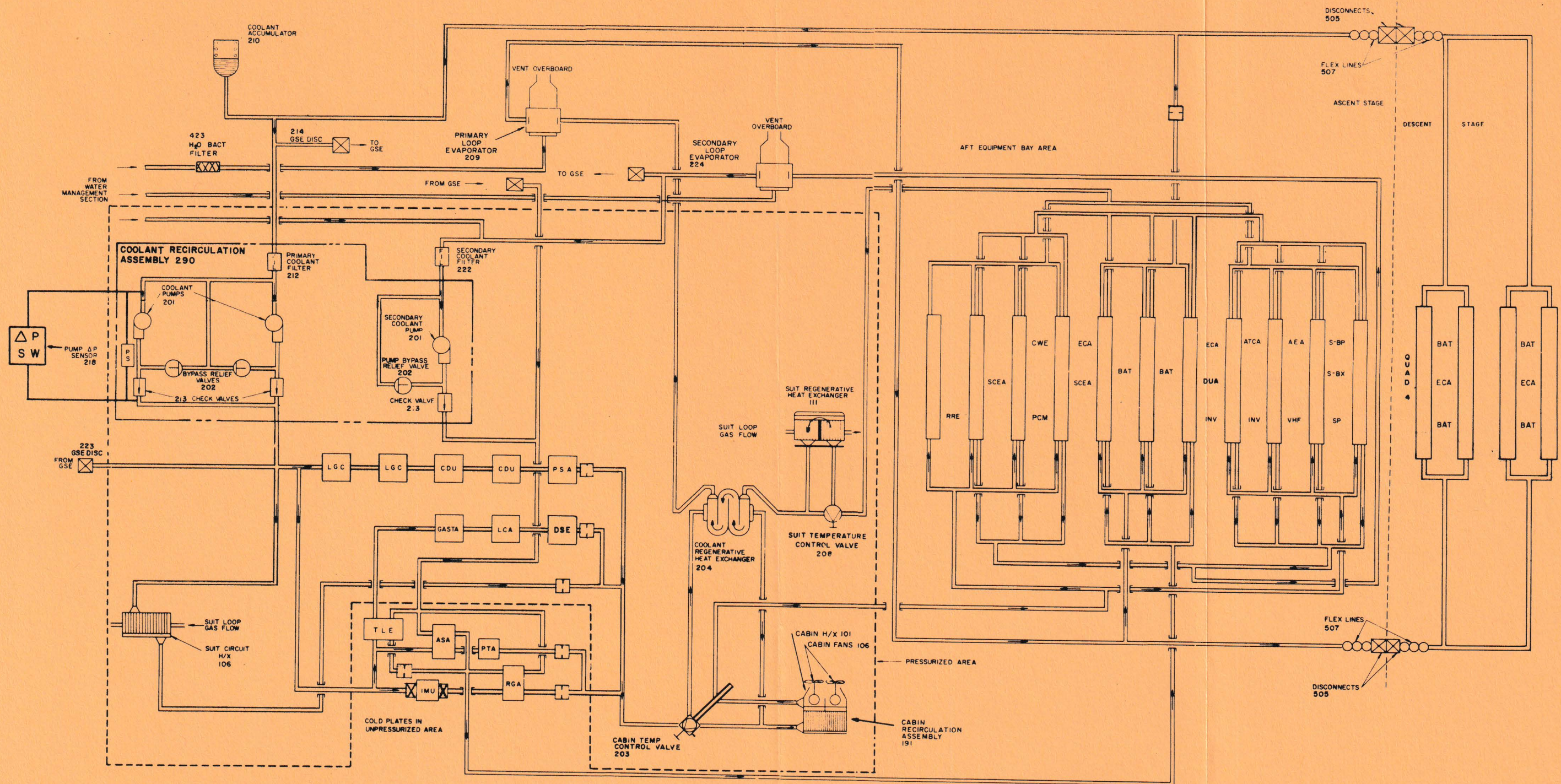
The HTS includes two separate independent coolant loops, a primary and a secondary. The primary loop provides all of the functions previously mentioned above. Electronic thermal control is effected via the cold plate section of the ECS. Heating and cooling of suit circuit and cabin atmosphere is accomplished in the suit circuit and cabin recirculation assemblies described in chapter three. In-flight waste heat rejection from the primary loop is provided by a primary water evaporator. ECS evaporators are located in the aft equipment bay and vent steam overboard through a cutout in the LM thermal skins.

Primary loop filling, draining, and heat rejection during ground operation is accomplished with Ground Support Equipment (GSE), connections for which are located on the right hand side of the aft equipment bay bulkhead inside the thermal skin. A coolant accumulator is also located in the aft equipment bay.

The secondary coolant loop provides only thermal control for those electronics whose performance is necessary in effecting a safe return to the command and service module (CSM). In-flight heat rejection from the secondary loop is provided by the secondary water evaporator. This evaporator is located in the aft equipment bay and vents its steam overboard through a cutout in the LM thermal skin. Secondary loop filling, draining and heat rejection during ground check out is accomplished with GSE, connections for which are located on the right side of the aft equipment bay bulkhead inside the thermal skin.

Coolant Recirculation Assembly - Item 290

This assembly includes all HTS coolant pumps as well as their associated check valves, pump relief valves, instrumentation, and the primary loop filter.



HEAT TRANSPORT SECTION

T30505-4
APR 67

Figure 1

Glycol Pumps - Item 201

Three glycol pumps are used in the HTS, two in the primary loop and a single pump in the secondary. These pumps are of the sliding vane positive displacement type and are used to circulate the coolant solution through the plumbing. All pumps are driven by 28 V.D.C. brushless motors which supply a recirculation rate of approximately 3.7 #/minute at 40°F and a 7 P.S.I.A. pump inlet pressure. The pumps provide a nominal pressure rise of 16 P.S.I. to the coolant solution and operate at approximately 5200 R.P.M.

Pump Bypass Relief Valves - Item 202

To prevent damage due to excessive back pressure, a pump bypass relief valve is installed downstream of each coolant pump. These valves provide pump relief of excessive back pressure by routing a portion, or the entire pump output if necessary, directly to the inlet side of the pump. The valves crack open at 33 and are full open at 39 P.S.I.D. and reset at 32.

Pump Discharge Check Valves - Item 213

A spring loaded poppet type check valve is located at the discharge side of each coolant pump. In the primary loop, these valves prevent fluid from feeding back through an inoperative pump. In both the primary and secondary loops the valves prevent coolant flow from by-passing the section while on GSE operation.

Coolant Pump Differential Pressure (ΔP) Sensor - Item 218

The pump ΔP sensor senses the differential across the primary coolant pumps and provides a signal for the Instrumentation Subsystem. This signal is used for activating the following circuits:

1. ECS caution annunciator light
2. Glycol pump component caution light
3. Automatic pump changeover if armed

At an increasing pressure of 7 ± 1 P.S.I.D. the sensor opens the electrical circuits and is an indication of normal pump operation. A switch closure occurs at a ΔP between the open value and a minimum of 3 P.S.I.D.

Manual HTS Pump Control

The HTS controls and indicators are located on panel II. Glycol pump operation may be controlled manually by monitoring panel indications or automatically by closing the AUTO TRNFR circuit breaker 4CB217 on panel XI.

If manual operation is selected, the following control settings will be initially selected:

1. Glycol pump switch 7S3-#1
2. Glycol pump 1 CB closed
3. Glycol pump 2 CB closed

When pump #1 ΔP rises through 7+1 P.S.I.D. the ECS caution annunciator 6DS36 and the glycol pump component caution light 7DS3 will be extinguished.

If pump #1 subsequently fails the following panel indications will occur:

1. Master alarm
2. ECS caution annunciator 6DS36
3. Glycol pump component caution 7DS3

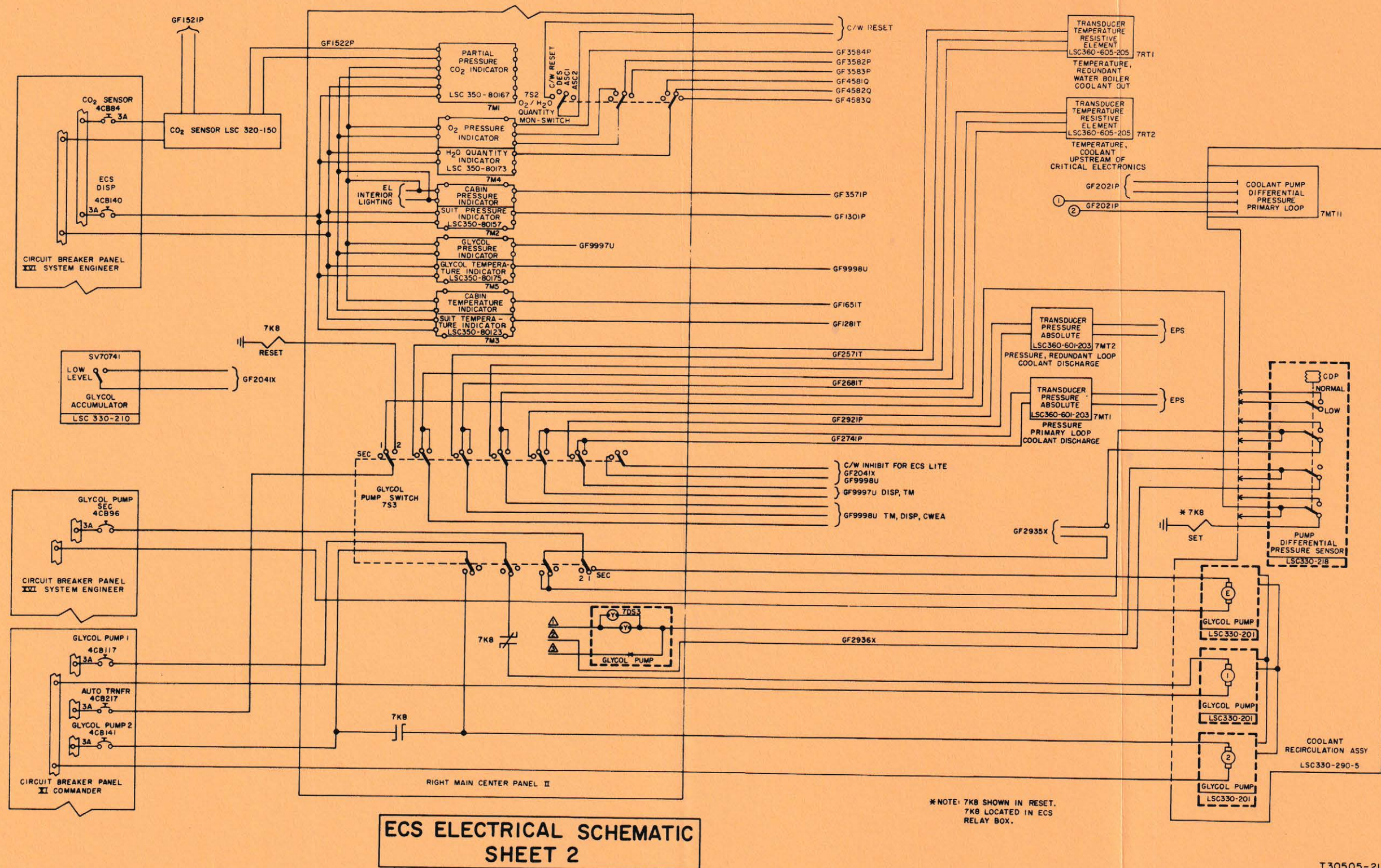
Selection of #2 pump will disconnect power from #1 and activate #2. When #2 pump ΔP rises through 7+1 items 2 and 3 above will be extinguished. A failure of #2 pump results in the same panel indications as described for pump #1.

When secondary glycol loop operation is selected the ECS caution annunciator does not monitor glycol pump operation. The glycol pump component caution light 7DS3 will remain illuminated at all times when 7S3 is in the SEC position. When this selection is made the water tank selector valve in the WMS must also be placed to the SEC position and the secondary glycol evaporator flow valve must be opened.

Automatic Pump Operation - Reference Figure 2

Automatic pump control is required during two man Extravehicular Activity (EVA). Assuming pump #1 is in operation, auto transfer is armed by closing 4CB217 - AUTO TRNFR on the CDR bus.

If pump #1 fails with 4CB217 closed the following sequence takes place:



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Figure 2

1. Master alarm is activated
2. ECS caution annunciator and glycol pump caution lights illuminate
3. 7K8 Set in the ECS relay box is energized. This action will open circuit #1 pump and automatically activate #2. As #2 pump ΔP recovers the ECS and glycol pump lights will be extinguished.

Glycol Pressure Indication

Glycol pressure gage 7M5 provides a continuous readout of absolute pump discharge pressure as derived from 7MT1 or 7MT2. The information being routed to the meter is controlled by the glycol pump switch. If 7S3 is selected to the #1 or #2 position primary loop pressure from 7MT1 is displayed. When SEC is selected, the output of 7MT2 is fed to the meter.

Glycol Temperature Indication

Glycol temperature gage 7M5 provides a continuous readout of the W/G solution prior to entering the glycol pump for recirculation. This information is derived from 7RT1 in the secondary loop and 7RT2 in the primary loop. Switching to the indicator is controlled similar to the glycol pressure as explained previously.

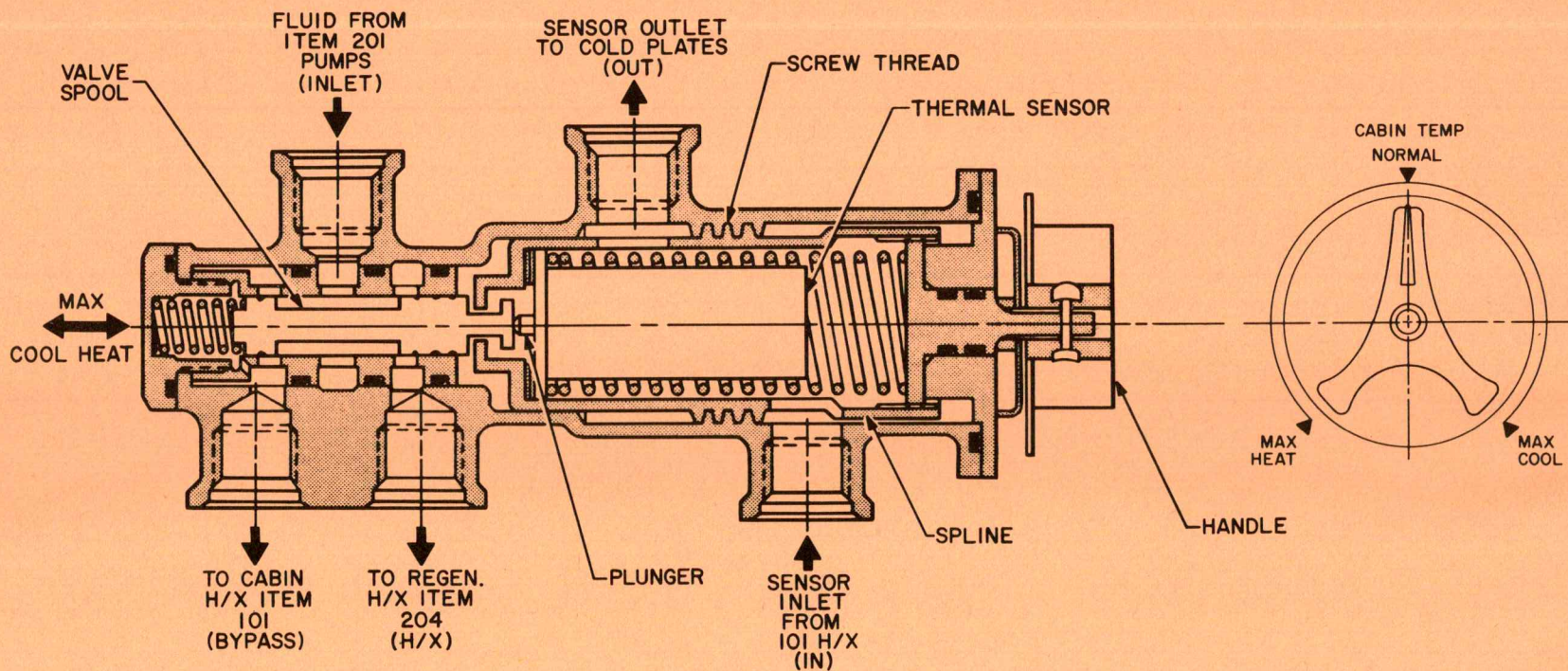
During primary loop operation, should the temperature rise to 50°F the GLYCOL caution annunciator will be illuminated. This light is inhibited during secondary loop operation.

Cabin Temperature Control Valve - Item 203 - Reference Figure 3

The cabin temperature control valve is a sliding spool type valve which is used to vary the flow rate to the coolant regenerative H/X so that the temperature of the fluid leaving the cabin H/X, and consequently the cabin gas temperature, is maintained at the desired level.

A manual handle, located adjacent to the cabin H/X, is used to select the desired cabin gas temperature. When the control handle is placed to the "MAX COOL" position the spool valve is driven to the left allowing all of the fluid entering the valve inlet port to be fed directly to the cabin H/X, Item 101. This action results in a maximum flow of cool pump discharge fluid to bring about a maximum cooling effect in the H/X.

When "MAX HEAT" is selected the valve spool is repositioned to close off the cabin H/X feed port and to open the feed to the Item 204 where it will pick up heat from the hot fluid being returned to the pump inlet from the aft equipment bay cold plates. The fluid that has now been warmed is fed via external plumbing to the cabin H/X where it may now accomplish its task of heating up the cabin gas atmosphere.



**CABIN TEMPERATURE CONTROL VALVE
ITEM 203**

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In the intermediate positions between "MAX COOL" and "MAX HEAT" an infinite number of water-glycol temperatures may be selected. When the control handle is placed in this range, the spool valve position is controlled automatically by the WAX filled thermal sensor. All fluid being discharged from the cabin H/X is fed across the sensor before being routed to the aft equipment and descent stage cold plates. The sensor will expand and contract in response to fluid temperature changes and by means of the plunger and spool return spring reposition the valve spool to obtain the selected water - glycol, and consequently cabin gas temperature. In these intermediate positions the pump feed to the valve inlet will be split, part going directly to the cabin H/X and part going to the coolant regenerative H/X. The characteristics of this flow diversion is determined by proper assembly technique. The valve is calibrated such that a 70°F sensed temperature will result in a 50-50 split in coolant flow. This condition occurs when the handle is in the 12 o'clock position and operation of the sensor and spool assembly from this point may be illustrated using the characteristic curve of figure 4. This plot depicts the flow pattern through the valve under various sensed W/G temperatures. As the handle is rotated this curve moves to the left and right maintaining a constant slope until the spool is manually engaged by the handle mechanism.

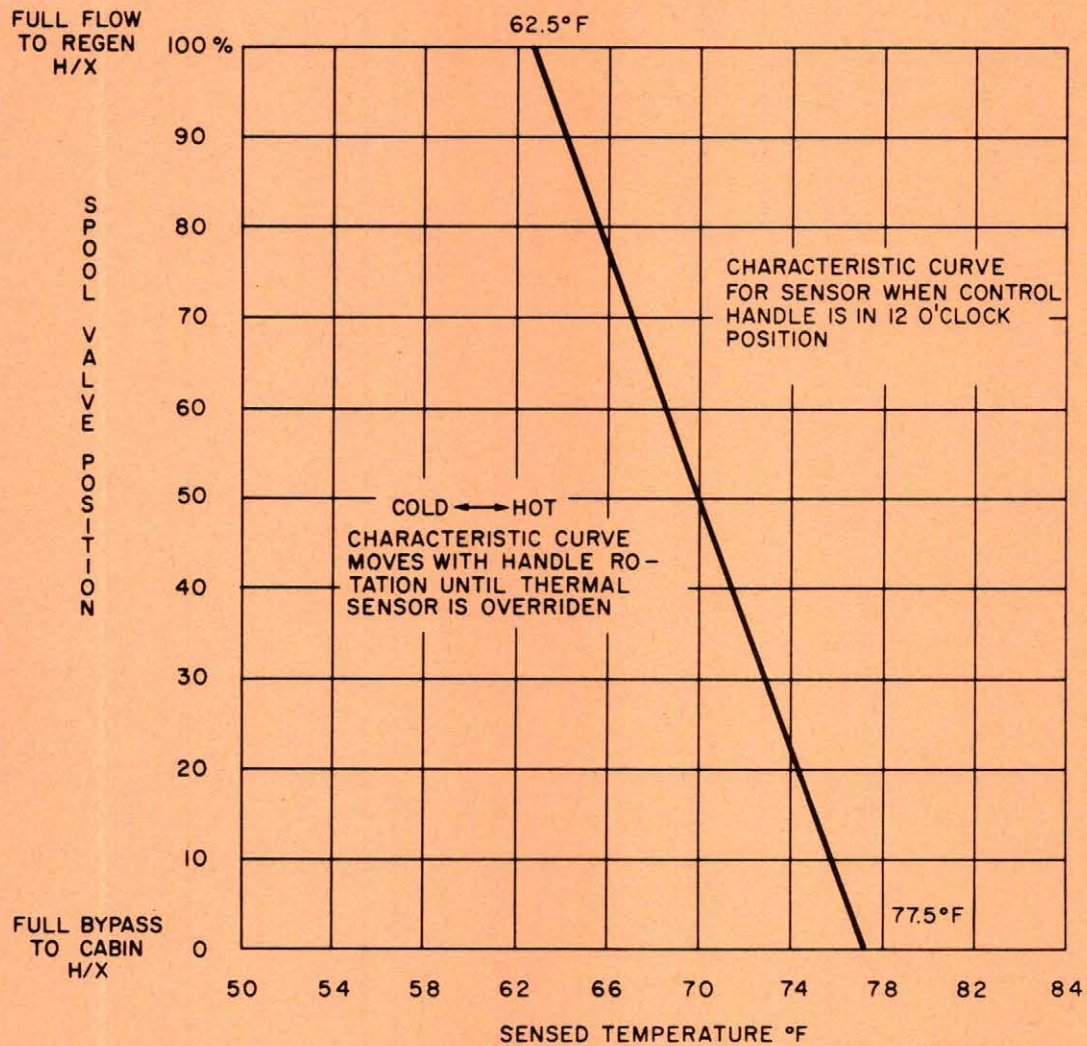
Coolant Regenerative Heat Exchanger - Item 204

When the cabin temperature control valve has been positioned to divert flow to the 204 H/X, Item 204 will transfer heat, which was removed from the electronic equipment, to the coolant flow on its way to the cabin H/X.

The unit is physically a plate-fin type H/X using a single fluid pass on the cold side and four passes on its hot side.

Primary Water Evaporator - Item 209

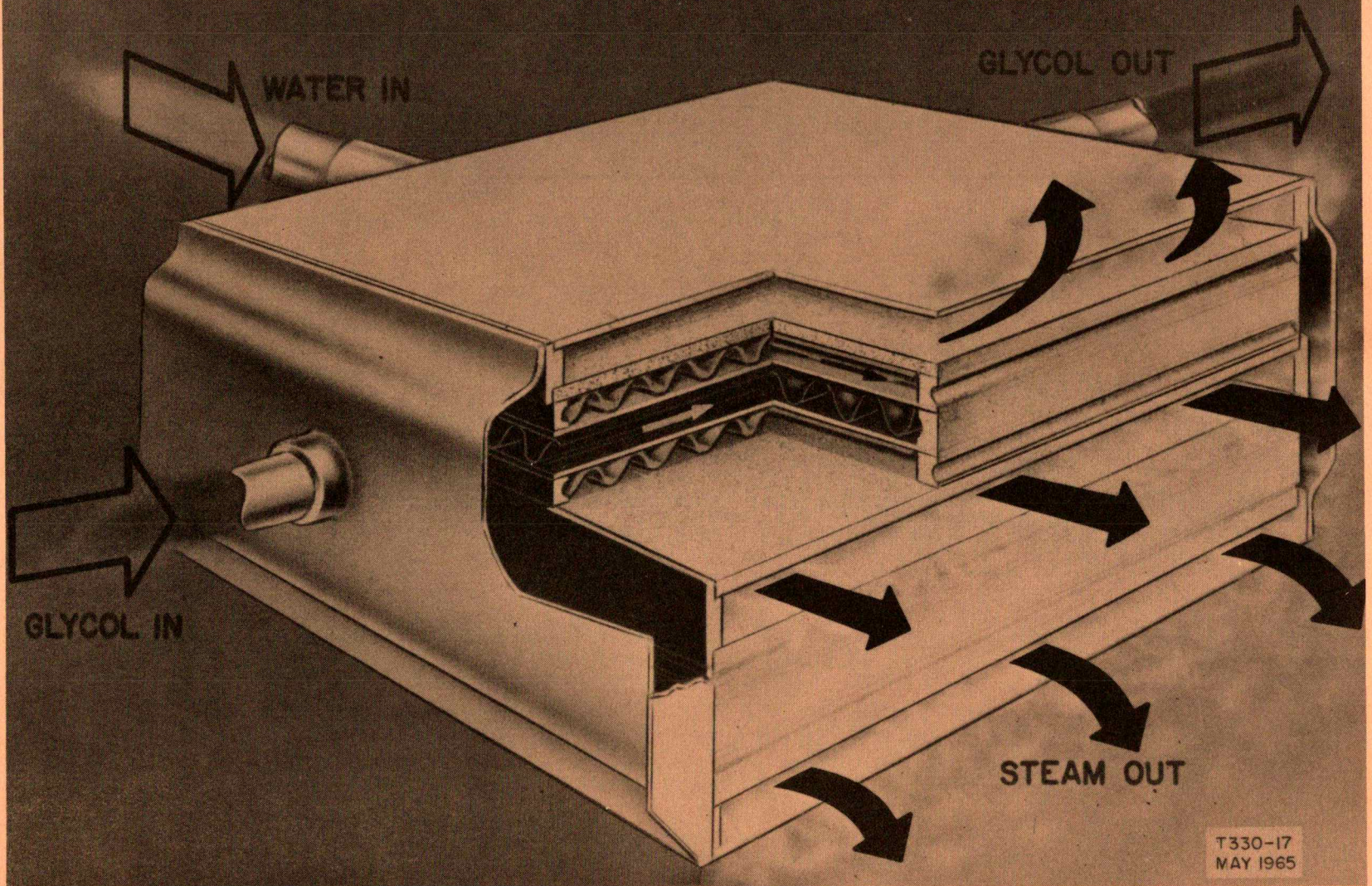
The primary water evaporator provides a means for rejecting waste heat from the primary loop prior to feeding the fluid back into the loop for cooling the ascent and descent batteries. The unit is a porous plate sublimator (see Figure 5) which rejects heat to the vacuum of space at the expense of water from WMS and the ARS. A flow control or valve is not needed to modulate the flow of water to the assembly as it is a self-regulating device. The unit is made up basically of nickel sintered porous plates, finned fluid passages and the necessary leaders and inlet-outlet connections.



CABIN TEMPERATURE CONTROL VALVE CHARACTERISTICS

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POROUS PLATE WATER BOILER



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The function of the porous plate evaporator is to provide cooling by expending water at a suitable temperature level. The water used is discharged to the surrounding ambient as a vapor, at a temperature level determined by the saturation pressure characteristics of the water.

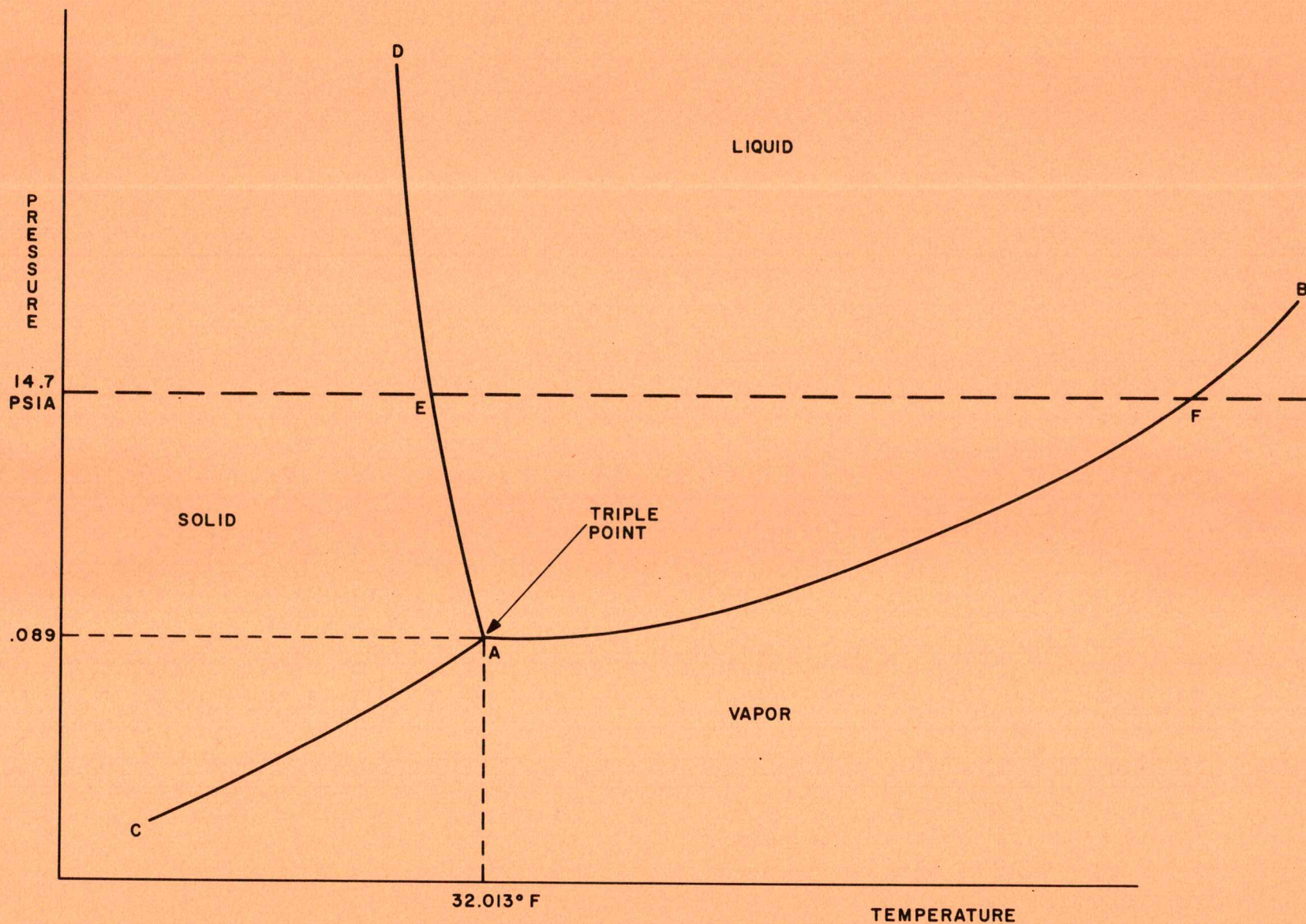
There are two basic modes by which evaporative cooling can occur when a porous plate cooling device is used. The two modes are the evaporative and sublimative which correspond to the types of phase change involved. The characteristics of each mode is highly dependent upon the pore size of the nickel plates. Since the pore size is not uniform it is possible to have the unit operating under both modes of operation simultaneously, and this is referred to as the mixed mode.

The sublimation mode is characterized by a layer of ice on the inside face of the porous plate, which prevents liquid from passing into the plate and escaping to ambient. The existence of this ice layer is determined by a combination of the vapor pressure drop characteristics of the porous plate and the heat flux or vapor flow rate. When the vapor pressure drop of the porous plate is less than the triple point pressure indicated by the water phase diagram in Figure 6, the phase change must be from the solid directly to the vapor phase by sublimation of the ice layer. The thickness of the ice is governed by the rate of heat transfer and the sublimation temperature corresponding to the local vapor pressure at the inlet face of the porous plate. Under normal operating pressure differentials across the porous plate the pressure is insufficient to extrude the ice into the pores and therefore the ice forms a barrier to liquid flow into the pores. In order to accomplish the necessary heat transfer the ice sublimates at the porous plate face and freezes at a corresponding rate at the liquid interface. The ice therefore flows somewhat in the manner of a glacier toward the porous plate, but at an extremely slow rate while serving as a heat conduction media.

If the input heat flux is increased, the vapor pressure drop across the porous plate increases causing the sublimation temperature to rise accordingly. This results in a reduction in the ice layer thickness in order to satisfy the heat rejection requirements. Eventually the ice layer will disappear completely when the heat flux is sufficient to cause the vapor pressure at the inlet face of the porous plate to be greater than the triple point pressure. It is at this point that the evaporative mode begins to occur. However, if the pore size distribution is non-uniform the heat flux at which this transition occurs will vary with location on the plate due to differences in vapor pressure drop, resulting in mixed mode of operation.

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Figure 6



WATER PHASE DIAGRAM

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In the evaporative mode, the phase change occurs at pressure levels above the triple point. The absence of a solid ice layer to prevent liquid from passing through the porous plate requires that some other mechanism retain the liquid if supply pressure to ambient pressure differentials are to be greater than the vapor pressure drop. Surface tension supplies the necessary restraining force for preventing liquid from passing through the porous plate.

Increasing input heat flux will cause a direct transition from the sublimation mode to the evaporative mode if the pores are regular and uniform and sufficiently small for surface tension to prevent liquid breakthrough. However, porous plates contain a random distribution of pores with respect to both size and shape causing an operating region known as mixed mode. In the mixed mode of cooling, phase change occurs at local temperatures above and below the triple point depending on the local pore geometry.

Coolant Accumulator - Item 210 - Reference Figure 7

The coolant accumulator has the capacity necessary to accommodate volumetric changes caused by temperature variation in the primary HTS. The cylindrical aluminum tank is divided into two cavities by a piston and diaphragm. The fluid side contains approximately 46 cubic inches of fluid under pressure which maintains a head on the pump inlets to prevent cavitation and also provide a small make-up supply. Spring pressure will vary, depending upon fluid level between 5.5 to 8.6 P.S.I.

A low level switch (LSC 360-616) located on the accumulator is actuated by the piston rod when a level of 10%+5 remains. This signal is telemetered to earth in addition to tripping the master alarm and lighting the "GLYCOL" caution annunciator in the S/C.

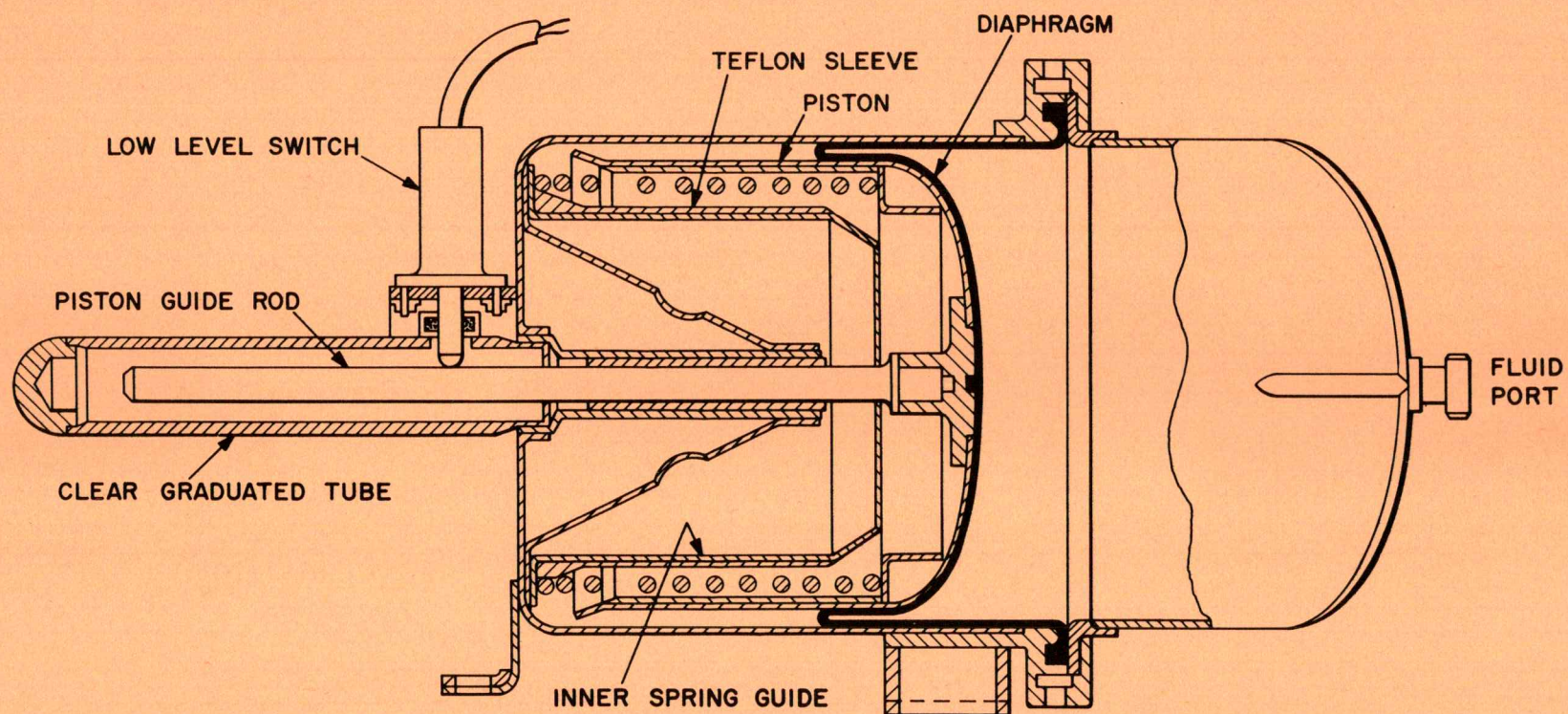
GSE Disconnects - Items 214 and 223 - Reference Figure 8

These disconnects are provided for use when GSE is used for flushing, purging, evacuating, servicing, and ground cooling the section. When the GSE is disconnected the disconnects are self sealing and a cap is provided to act as a back up seal and contaminant barrier.

Two disconnects are employed, the only difference being the location of the mounting ears. The 214 or suction disconnect has the ears mounted to the male half of the disconnect. The 223 unit is used for the pressure disconnect and has the ears mounted on the female half. This arrangement precludes the possibility of incorrect hook up of the GSE.

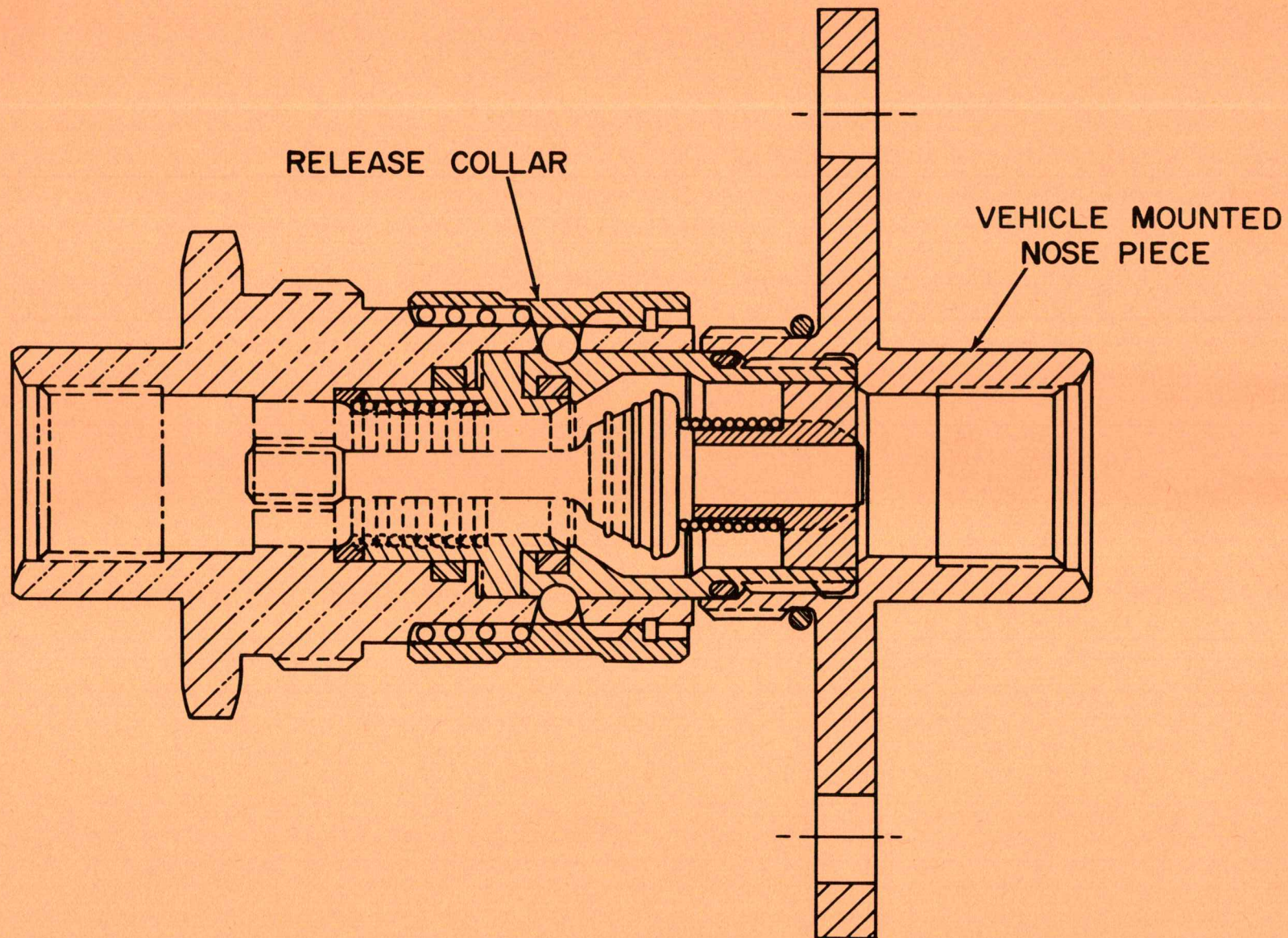
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Figure 7



ITEM 210 COOLANT ACCUMULATOR

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SEPT 65



G.S.E. DISCONNECT - ITEM 214 (SUCTION)

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SEPT 65

Primary Loop Coolant Filter - Item 212

The primary coolant loop filter is designed to remove particles that are large enough to possibly cause a malfunction of the HTS components. The 35 micron filter element is replaceable prior to but not during flight. An integral pressure relief by-pass feature is incorporated to maintain coolant flow in the event the filter element becomes clogged. This by-pass valve operates at .4 P.S.I.D.

Secondary Loop Evaporator - Item 224

An Item 224 evaporator is utilized in the secondary loop of the HTS. This unit is similar in construction and operation to the item 209 evaporator.

The 224 unit is used to reject all waste heat picked up by the HTS fluid during secondary loop operation.

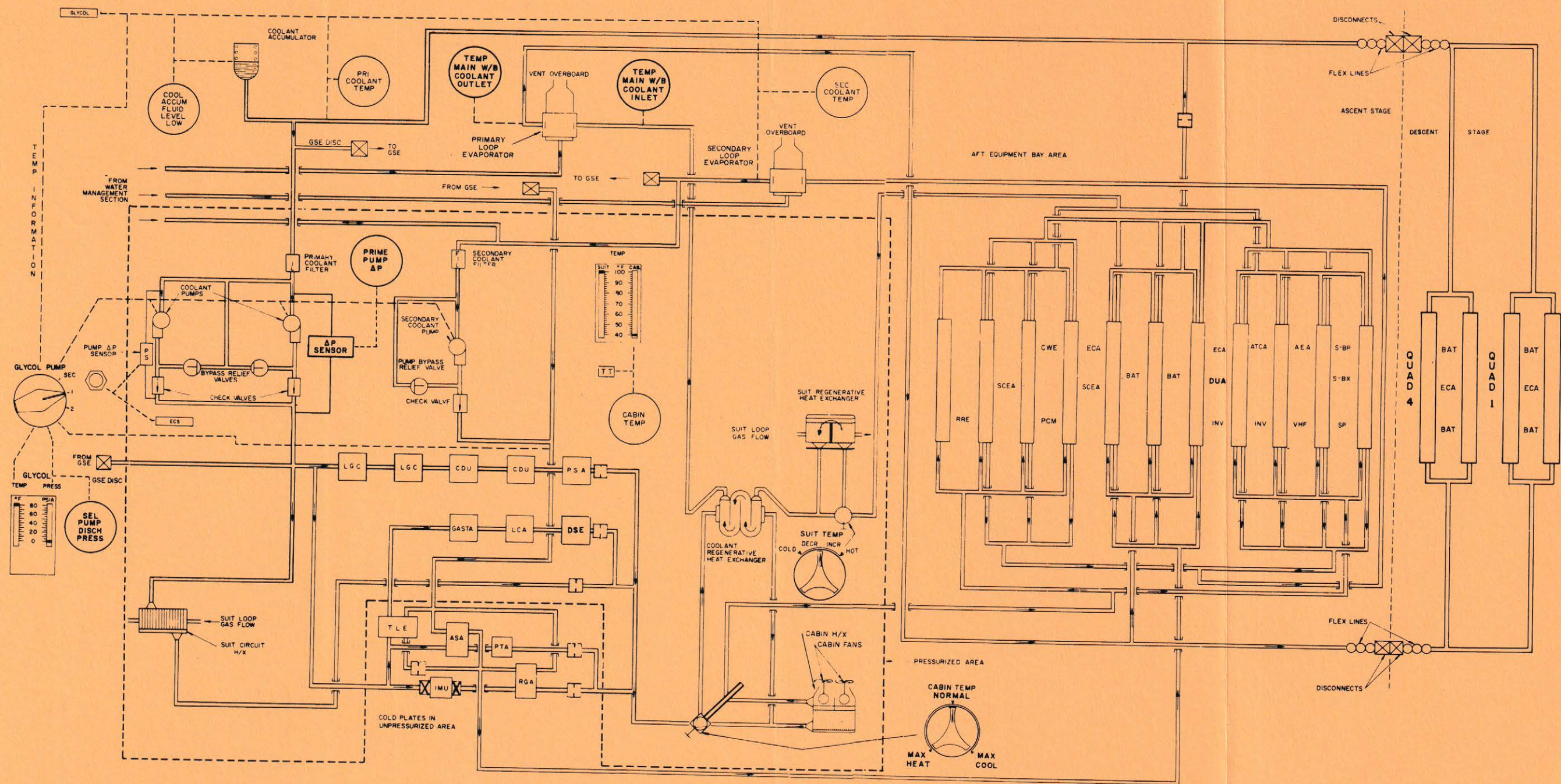
Secondary Loop Coolant Filter - Item 222

The secondary coolant filter provides the same basic functions as the Item 212 previously described with the exception that it filters to 45 microns absolute and does not incorporate a by-pass feature.

Suit Temperature Control Valve - Item 208

The Item 208 temperature control valve is used to modulate the W/G flow rate through the Item 111 suit regenerative H/X. Hot W/G solution from the cold plates may be diverted by the valve and made to flow through 111 increasing the ARS gas temperature.

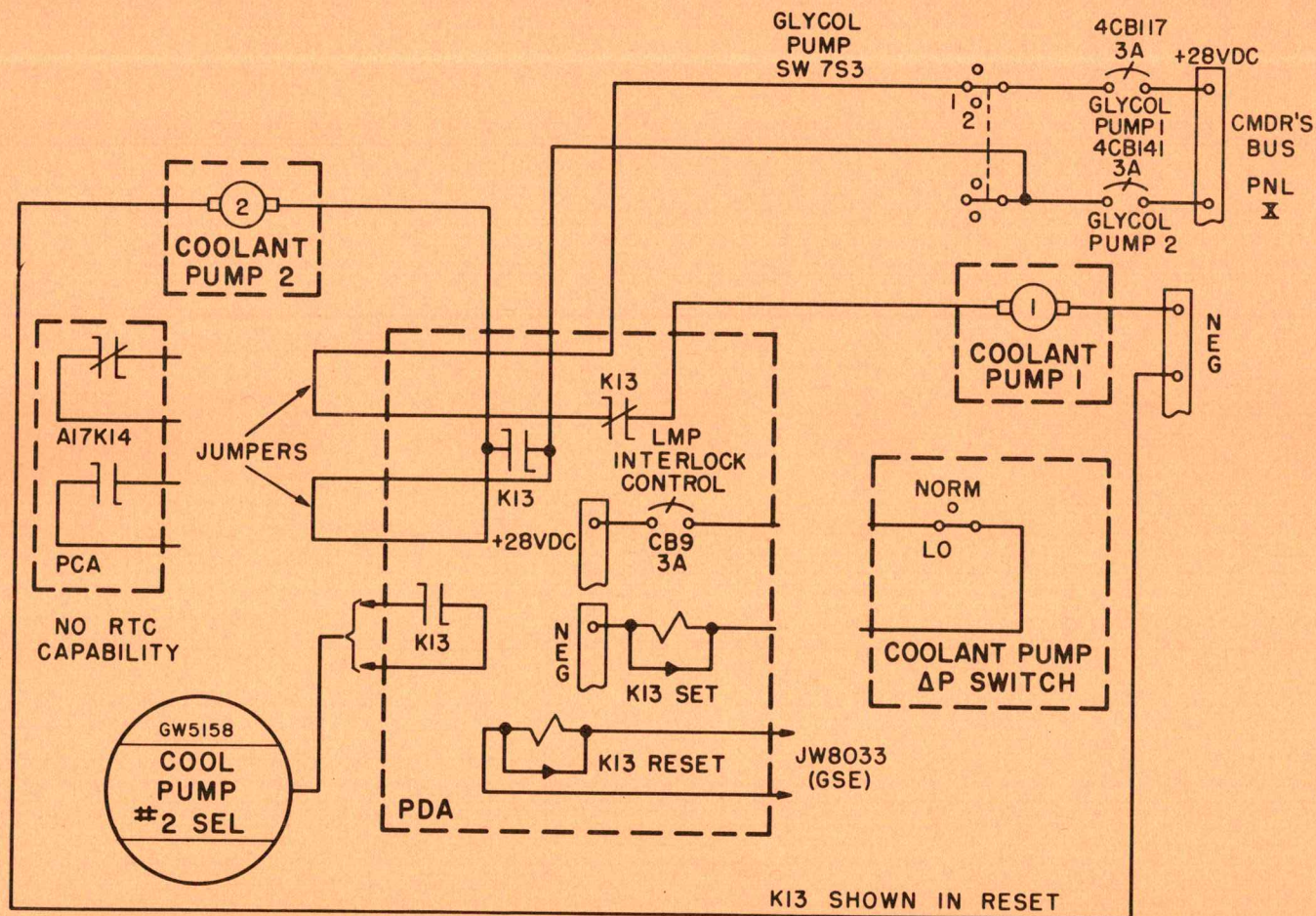
Item 208 is a barrel type valve, which varies coolant flow through non-linear ports cut into a cylindrical spool. Rotation of the spool past fixed orifices in the valve housing results in a predetermined non-linear output from 0 to approximately 1.5 #/MIN.



HEAT TRANSPORT SECTION

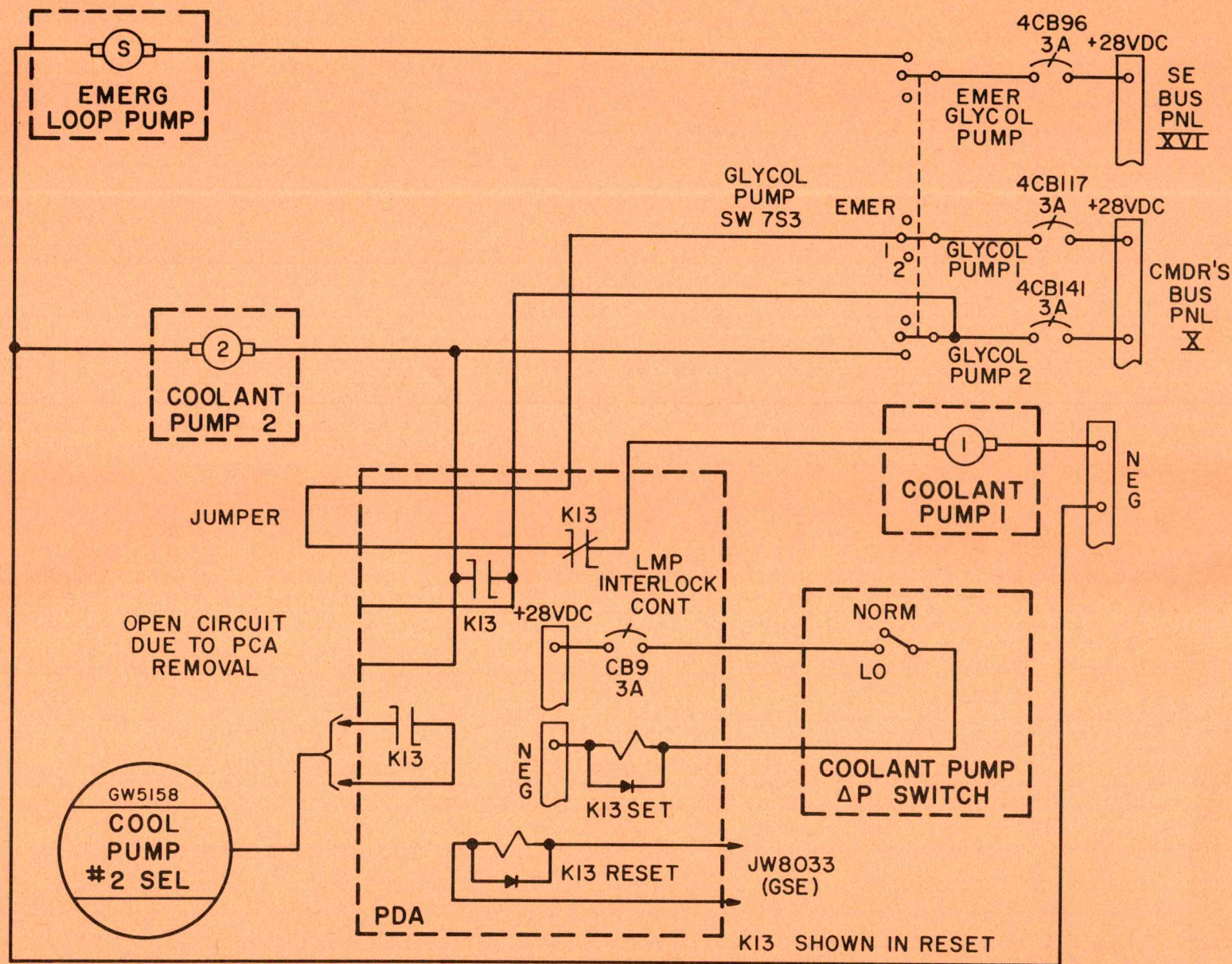
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Figure 9

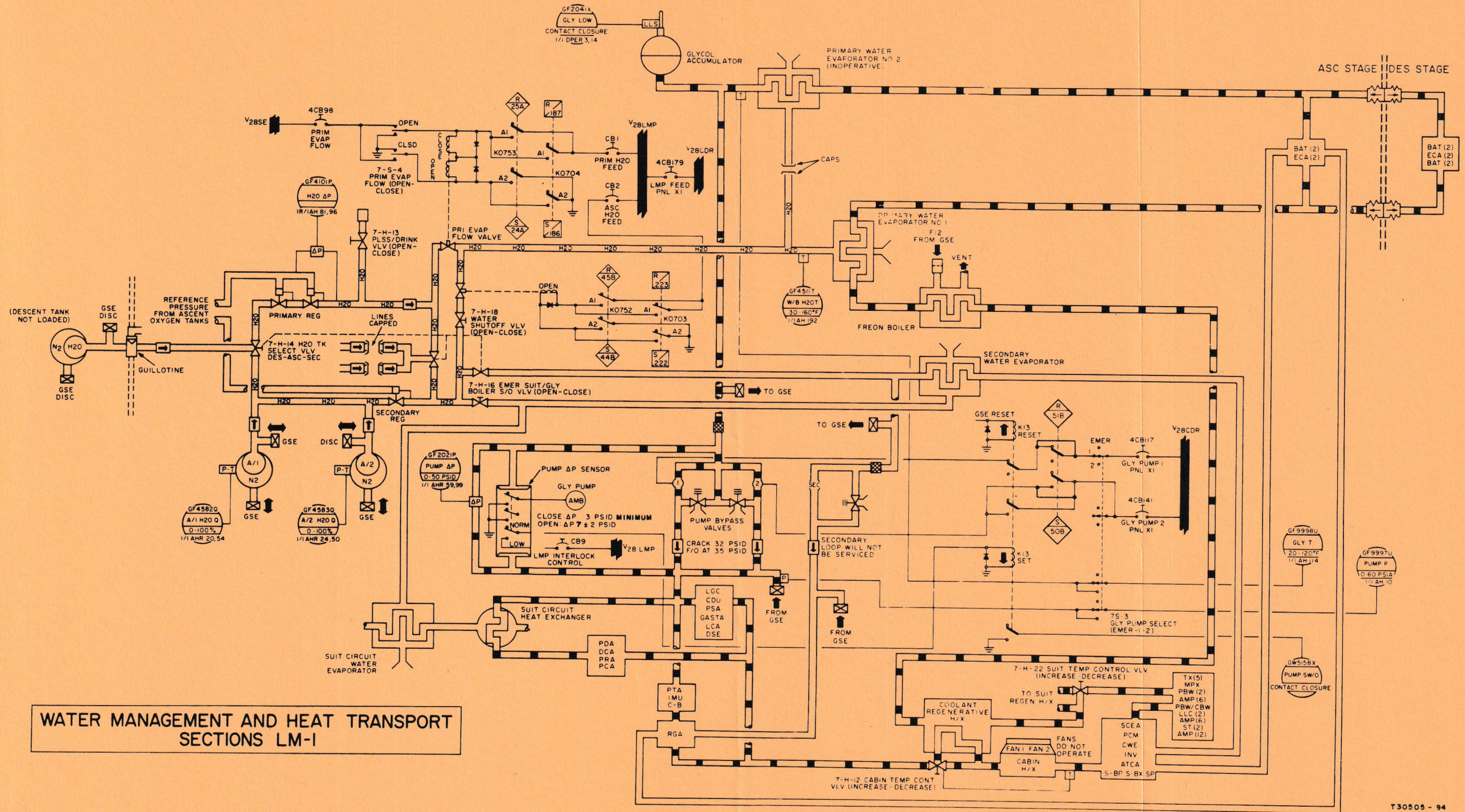


LM-1 HTS PUMP CIRCUITRY

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LM-2 HTS PUMP CONTROL



CHAPTER VI

COLD PLATE SECTION (CPS)

Section Description

The CPS consists of:

1. Structural strip type cold plates.
2. Non-structural flat type cold plates.

All cold plates are designed to permit the removal of equipment for which they provide thermal control without disconnecting the cold plates from the HTS plumbing.

Strip Type Cold Plates

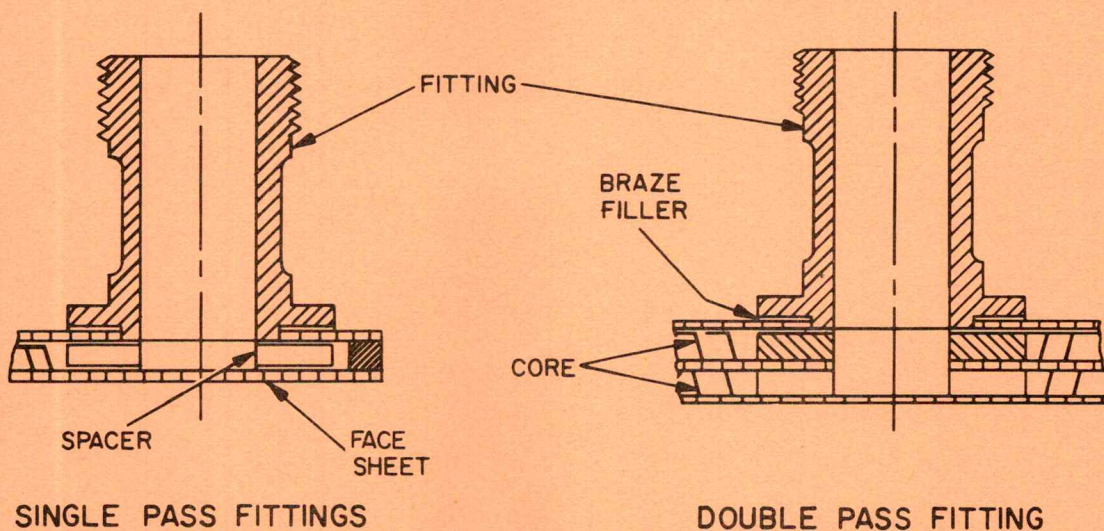
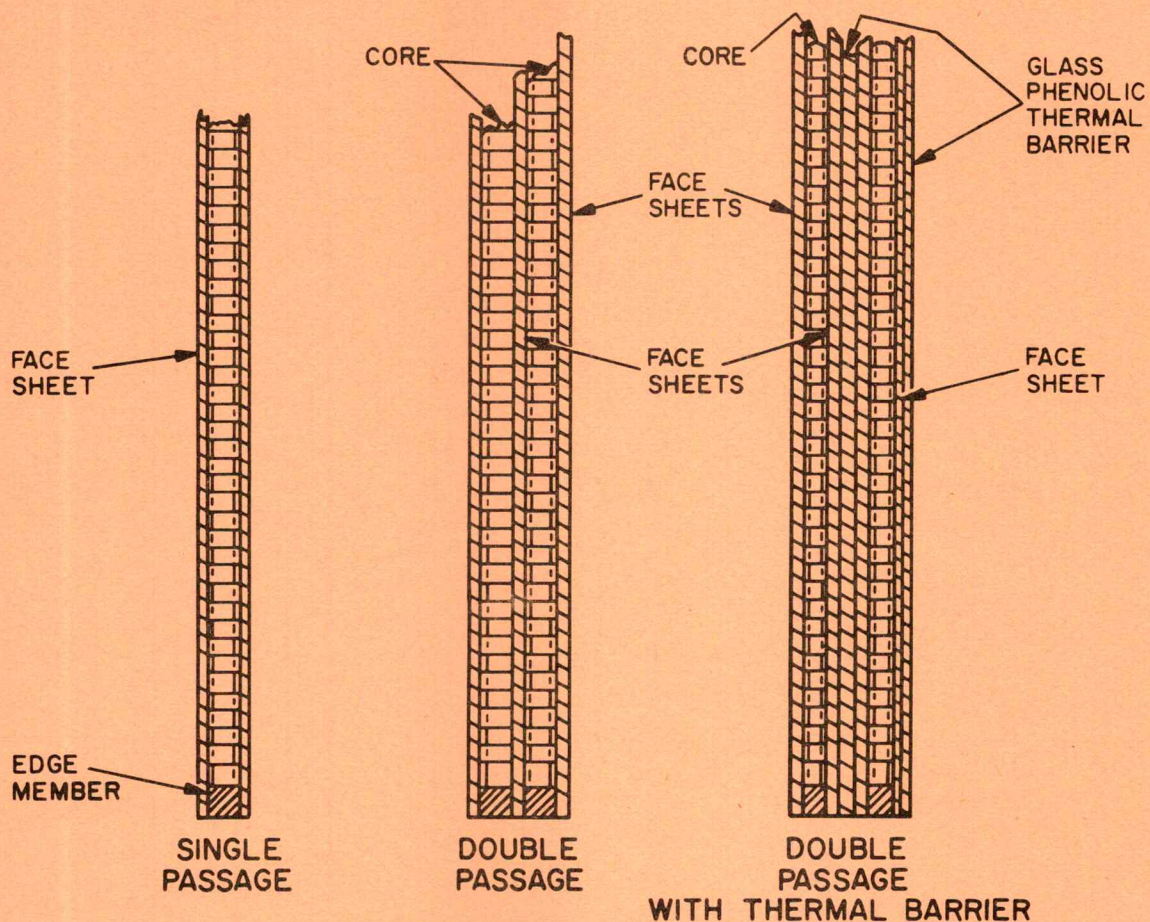
Strip cold plates provide both active thermal control and structural support for those electrical and electronic equipments which utilize the Electronics Replaceable Assembly (ERA) packaging concept. HTS primary loop coolant is circulated through one passage and secondary loop coolant through the other. Both passages contain fins required to provide adequate heat transfer surface area.

Flat Type Cold Plates

Flat cold plates provide active thermal control for those electrical and electronic equipments which utilize packaging concepts other than the ERA concept. The general construction details for both single and double passage flat cold plates and their fluid fittings are illustrated in Figure 1. The double passage unit with a thermal barrier is only applicable to the Abort Sensor Assembly (ASA). This scheme provides the proper heat transfer coefficient for proper thermal control of the ASA.

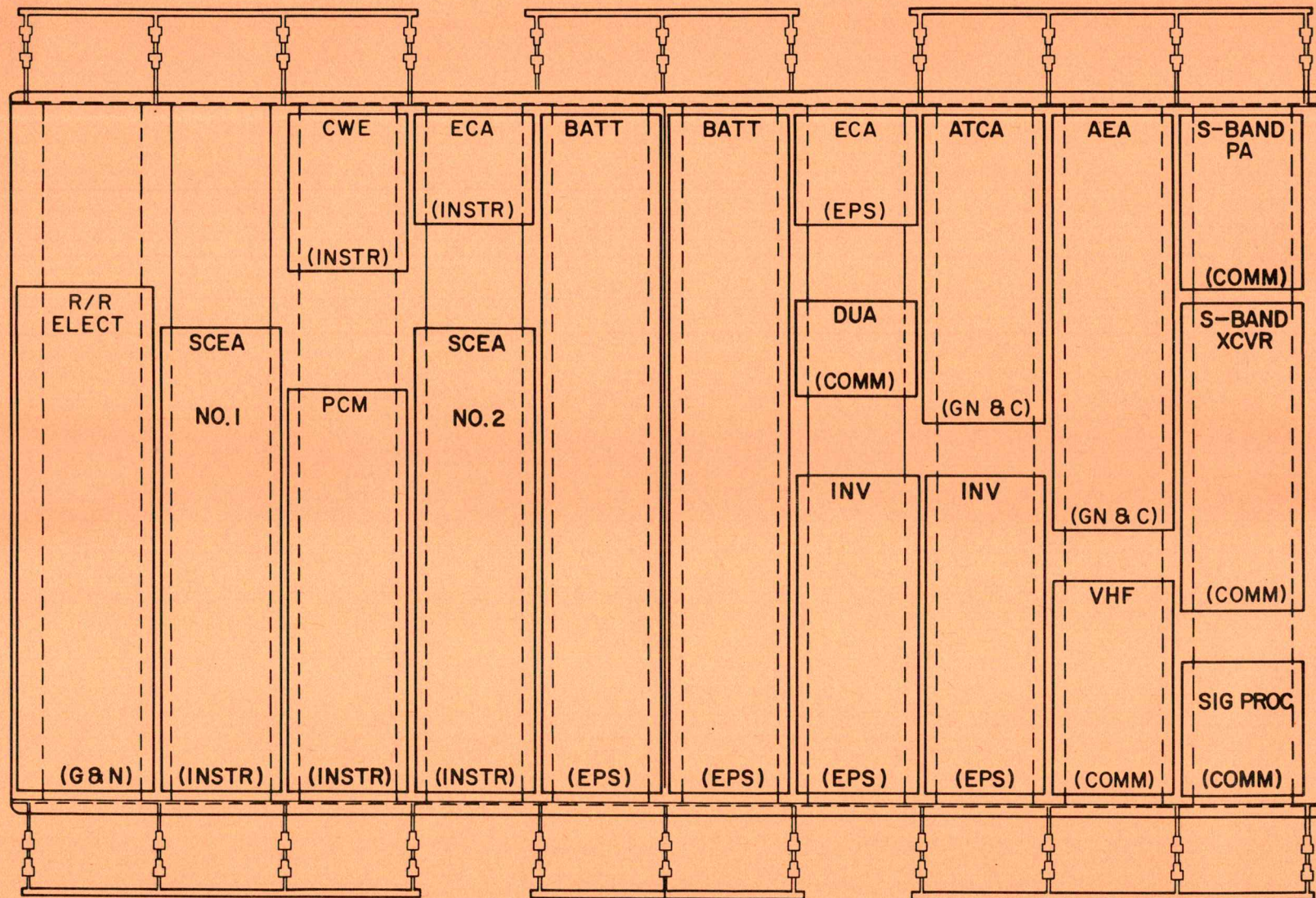
Aft Equipment Bay Cold Plates and Equipment Arrangement

The aft equipment bay houses eleven vertical cold rails which will mount, (see Figure 2), various ERA equipment. The ERA's are flange mounted to the cold rails after the flanges have been coated with a film of silicone rubber RT601 and aluminum oxide mixture. This thermal interface material insures proper heat transfer characteristics of the assembly.



FLAT COLD PLATE DETAILS

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VIEW LOOKING FWD

AFT EQUIPMENT BAY COLD PLATE AND ERA ARRANGEMENT

List of Abbreviations

ARS	- Atmosphere Revitalization Section
ASA	- Abort Sensor Assembly
CB	- Circuit Breaker
CM	- Command Module
CDR	- Commander
CDU	- Coupling Display Unit
CSM	- Command and Service Module
CO ₂	- Carbon Dioxide
C&W	- Caution and Warning
CPS	- Cold Plate Section
DSE	- Data Storage Electronics
ECS	- Environmental Control Subsystem
EPS	- Electrical Power Subsystem
ERA	- Electronic Replaceable Assemblies
EVA	- Extravehicular Activity
GASTA	- Gimbal Angle Sequence Transformation Assembly
GFE	- Government Furnished Equipment
GOX	- Gaseous Oxygen
GSE	- Ground Support Equipment
HTS	- Heat Transport Section
H/X	- Heat Exchanger
LCA	- Lighting Control Assembly
LGC	- Lunar Module Guidance Computer
LM	- Lunar Module
LiOH	- Lithium Hydroxide
MSFN	- Manned Space Flight Network
OSPCPS	- Oxygen Supply and Cabin Pressure Control Section
PCMTEA	- Pulse Code Modulation Timing Electronics Assembly
PLSS	- Portable Life Support System
PPH	- Pounds Per Hour
PSA	- Power Servo Assembly
PSIA	- Pounds Per Square Inch Absolute
PTA	- Pulse Torque Assembly ✓

List of Abbreviations (Continued)

RGA	- Rate Gyro Assembly
RPM	- Revolutions Per Minute
S/C	- Spacecraft
SCERA	- Signal Conditioning Electronics Replaceable Assembly
SE	- Systems Engineer
SSA	- Space Suit Assembly
TLE	- Tracking Light Electronics
VPI	- Valve Position Indicator
WMS	- Water Management Section
W/G	- Water-Glycol
WQMD	- Water Quantity Measuring Device

LSG 770-430-22 - LTA-8

ENVIRONMENTAL CONTROL SUBSYSTEM

STUDY GUIDE

LUNAR MODULE

LTA-8

CONTRACT NAS 9-1100

EXHIBIT E; PARAGRAPH 3.7.4

TYPE III DOCUMENT

FOR TRAINING PURPOSES ONLY; IN
SUPPORT OF LTA-8 SUBSYSTEM BRIEFINGS

REFERENCE CF22/T21-67-T471

LM TRAINING SECTION
PRODUCT SUPPORT DEPARTMENT
GRUMMAN AIRCRAFT ENGINEERING CORPORATION
BETHPAGE, NEW YORK

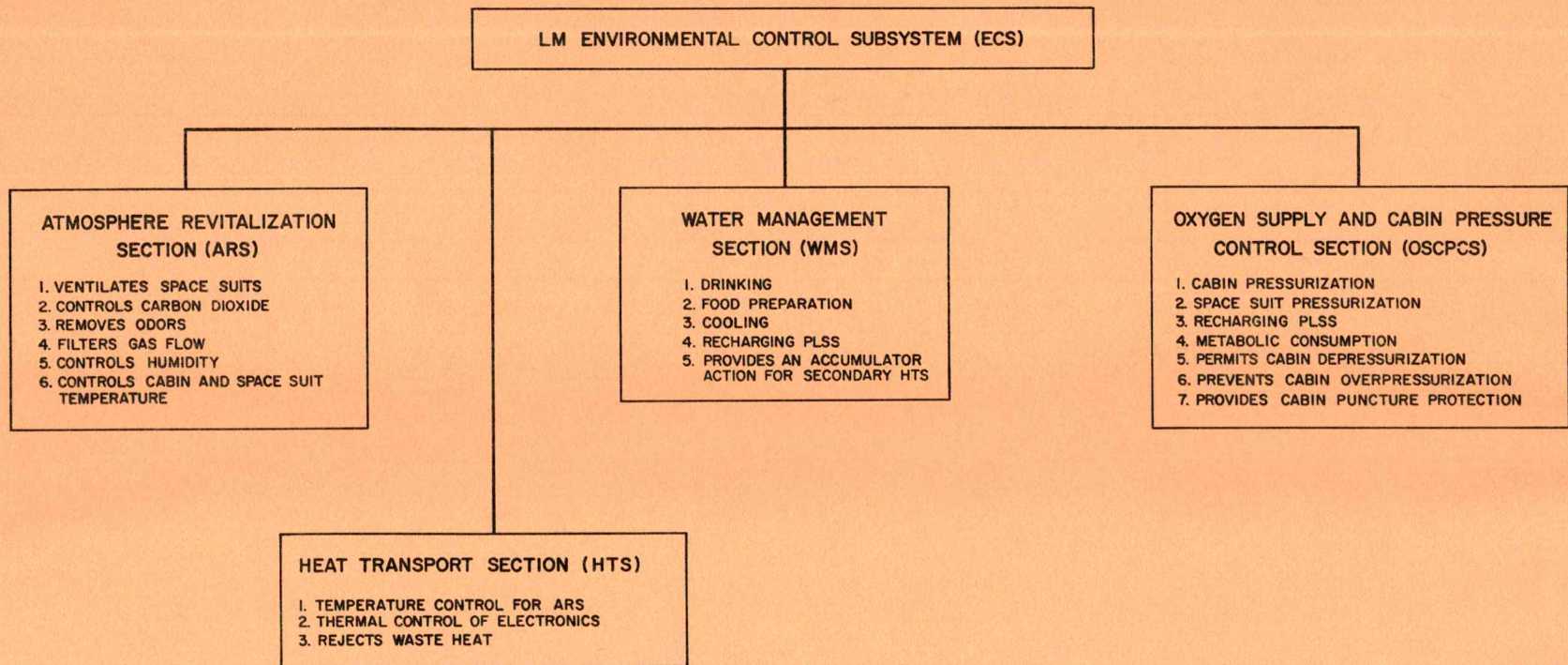
SEPTEMBER 1967

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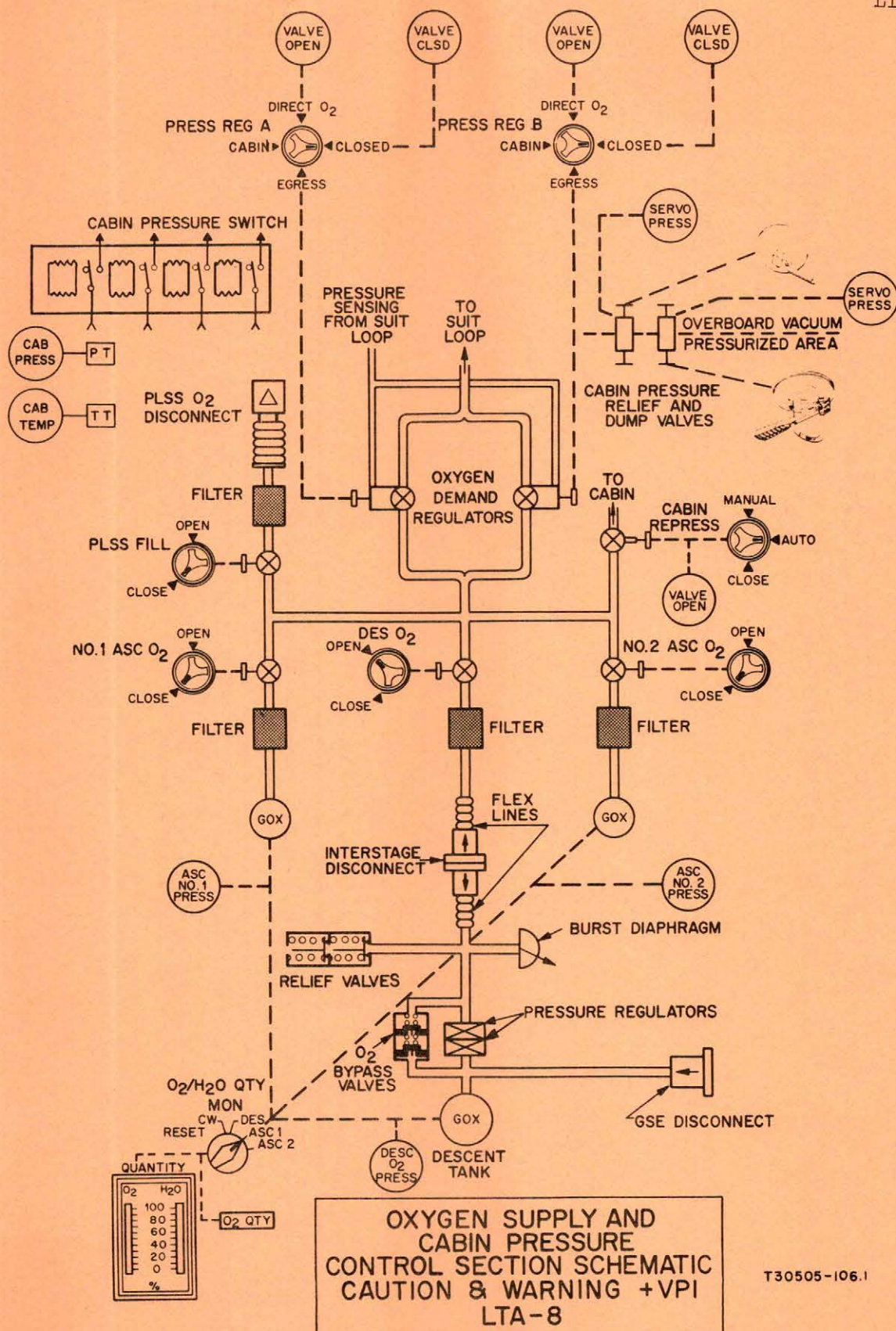
September 1967

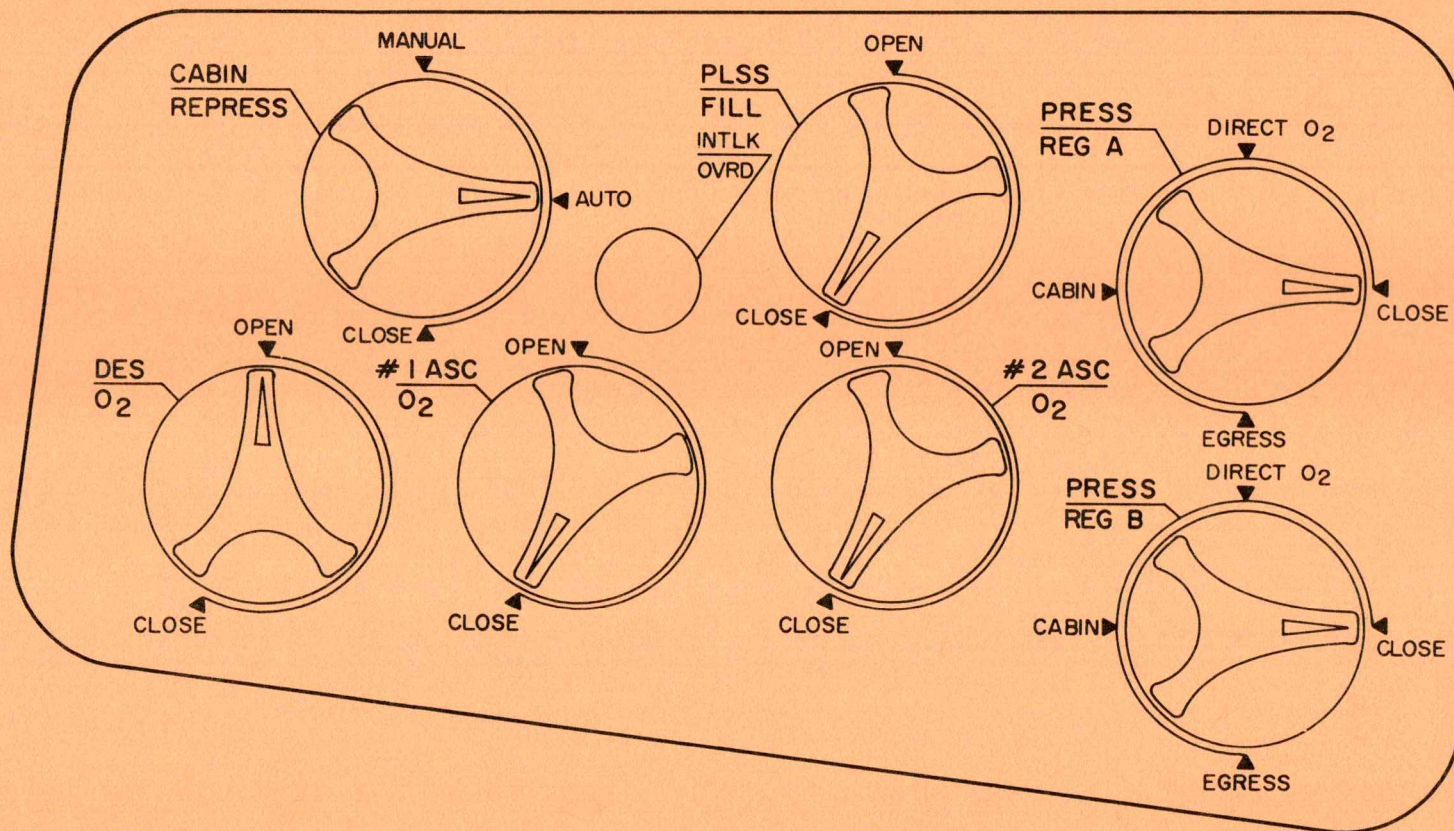
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LM ECS BLOCK DIAGRAM

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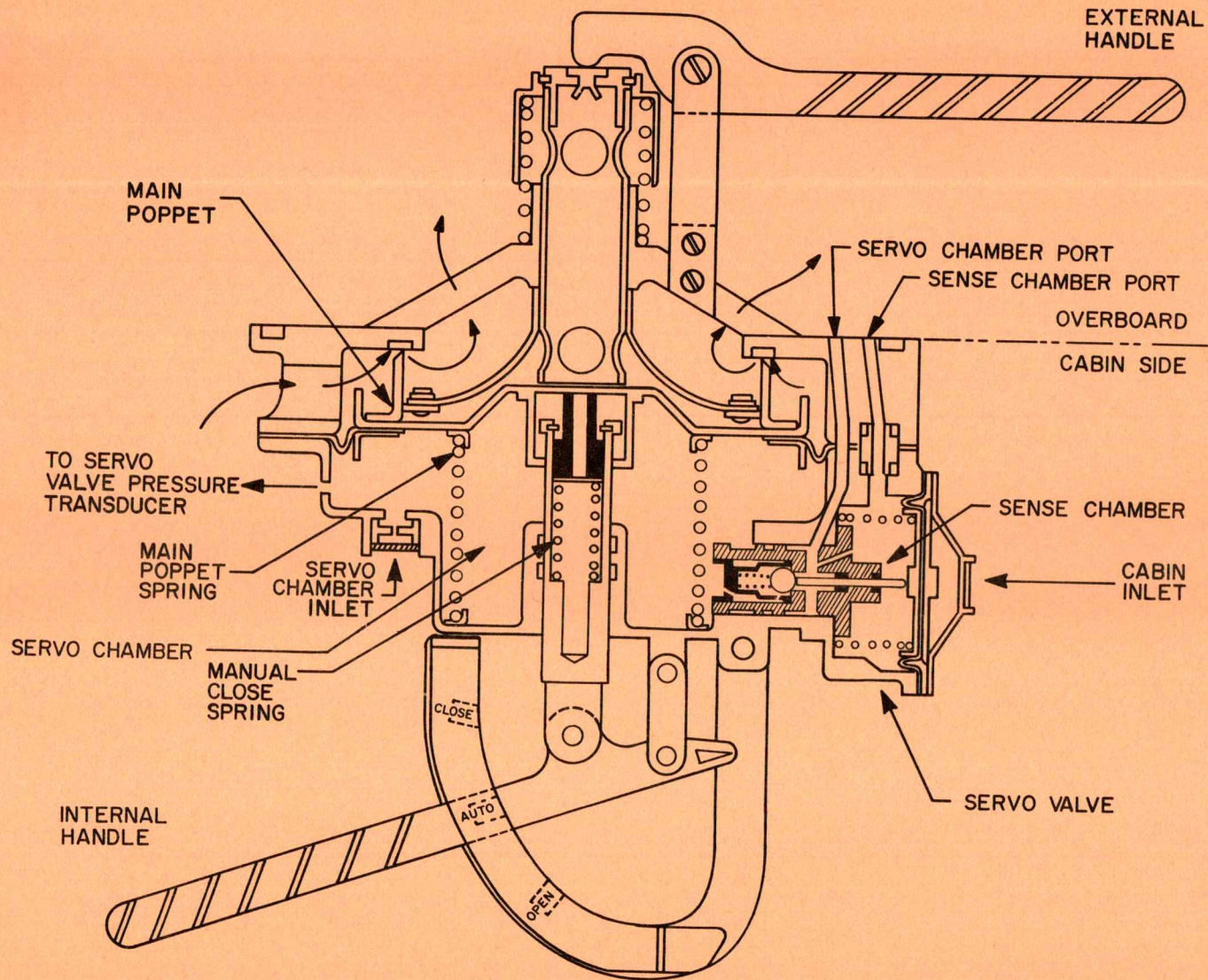




OXYGEN MODULE CONTROL NOMENCLATURE
ITEM 390 LTA-8

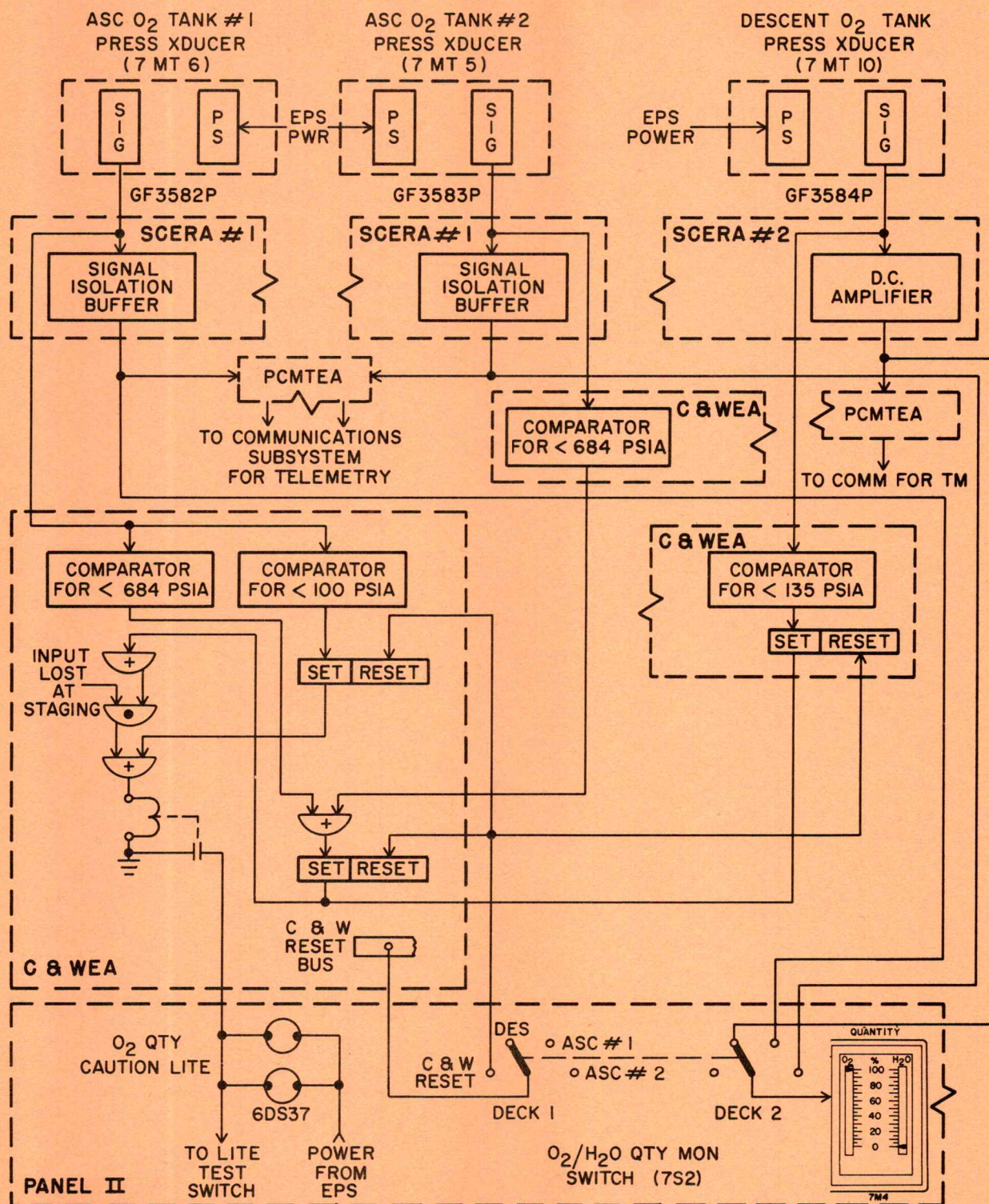
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CABIN DUMP VALVE-ITEM 307

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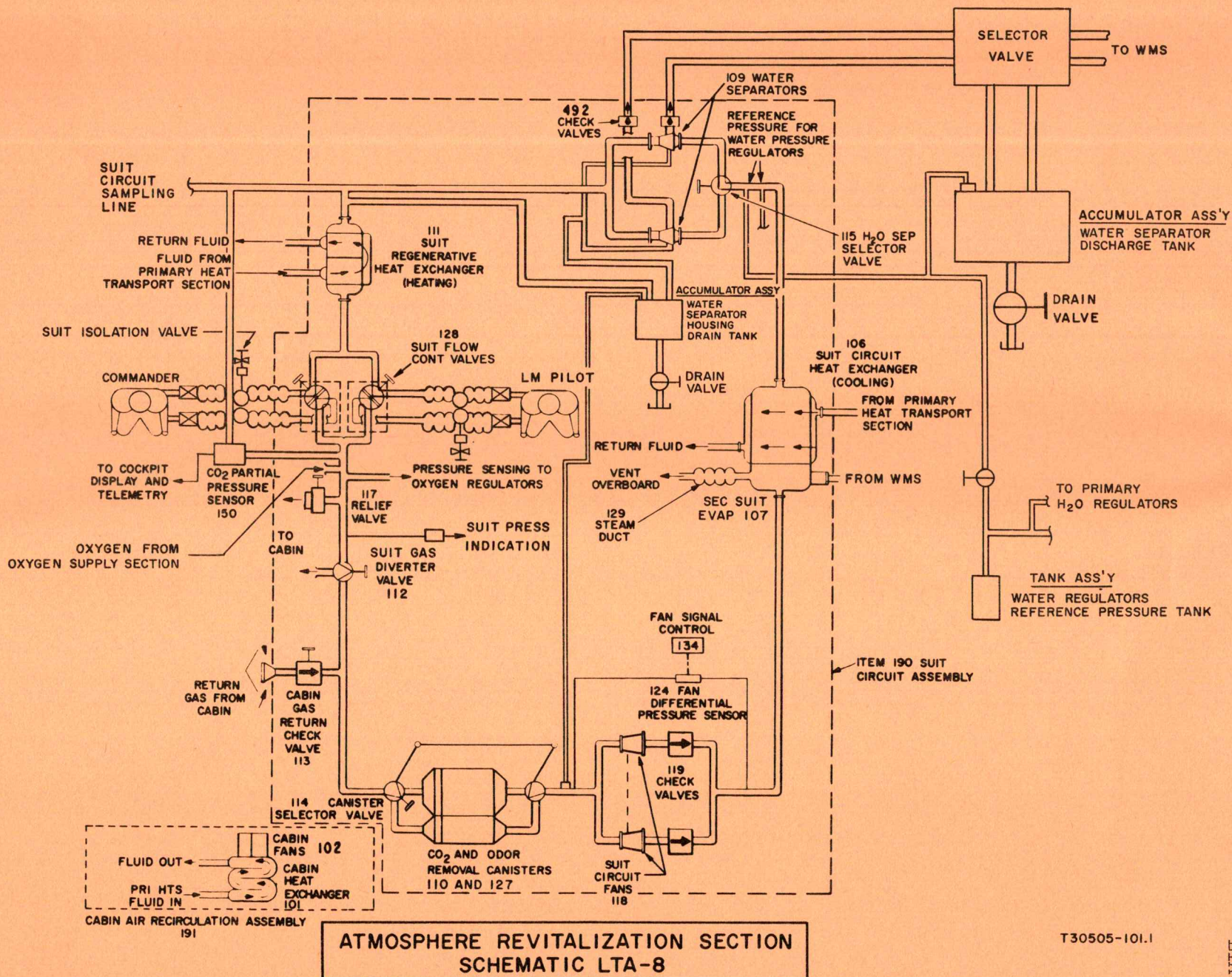


OXYGEN QUANTITY MONITORING AND TELEMTRY CIRCUITRY

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Date: September 1967

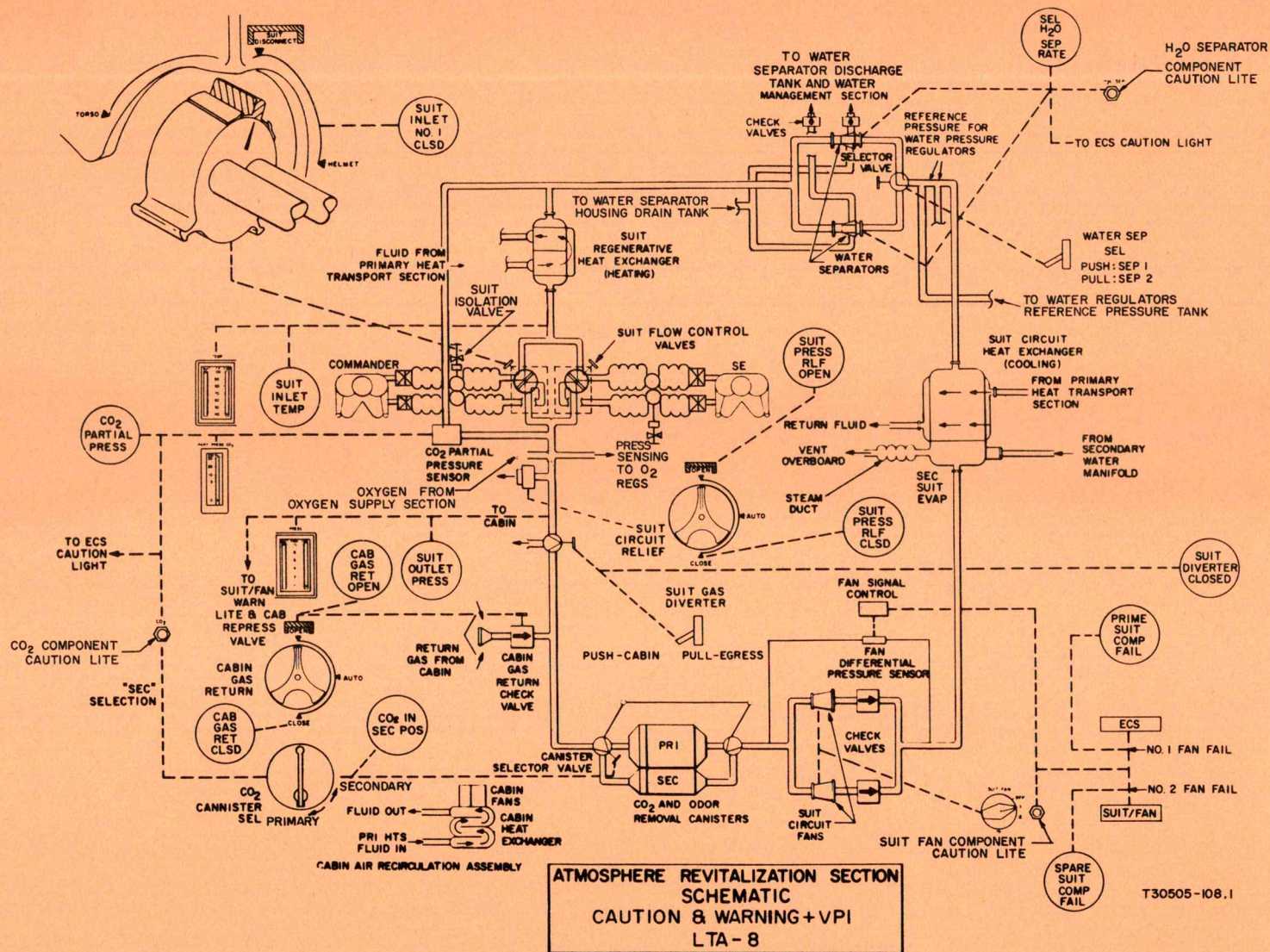
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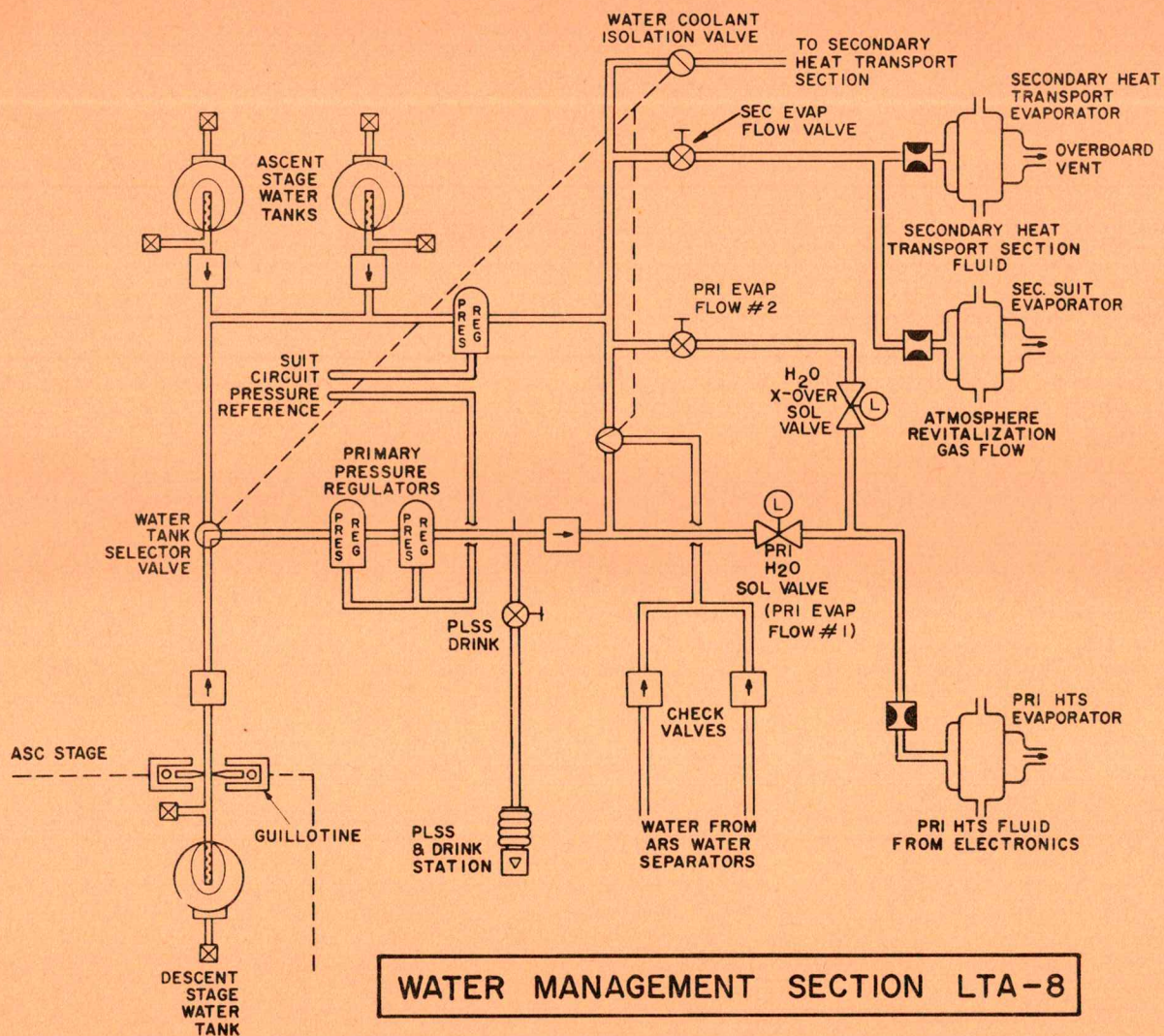
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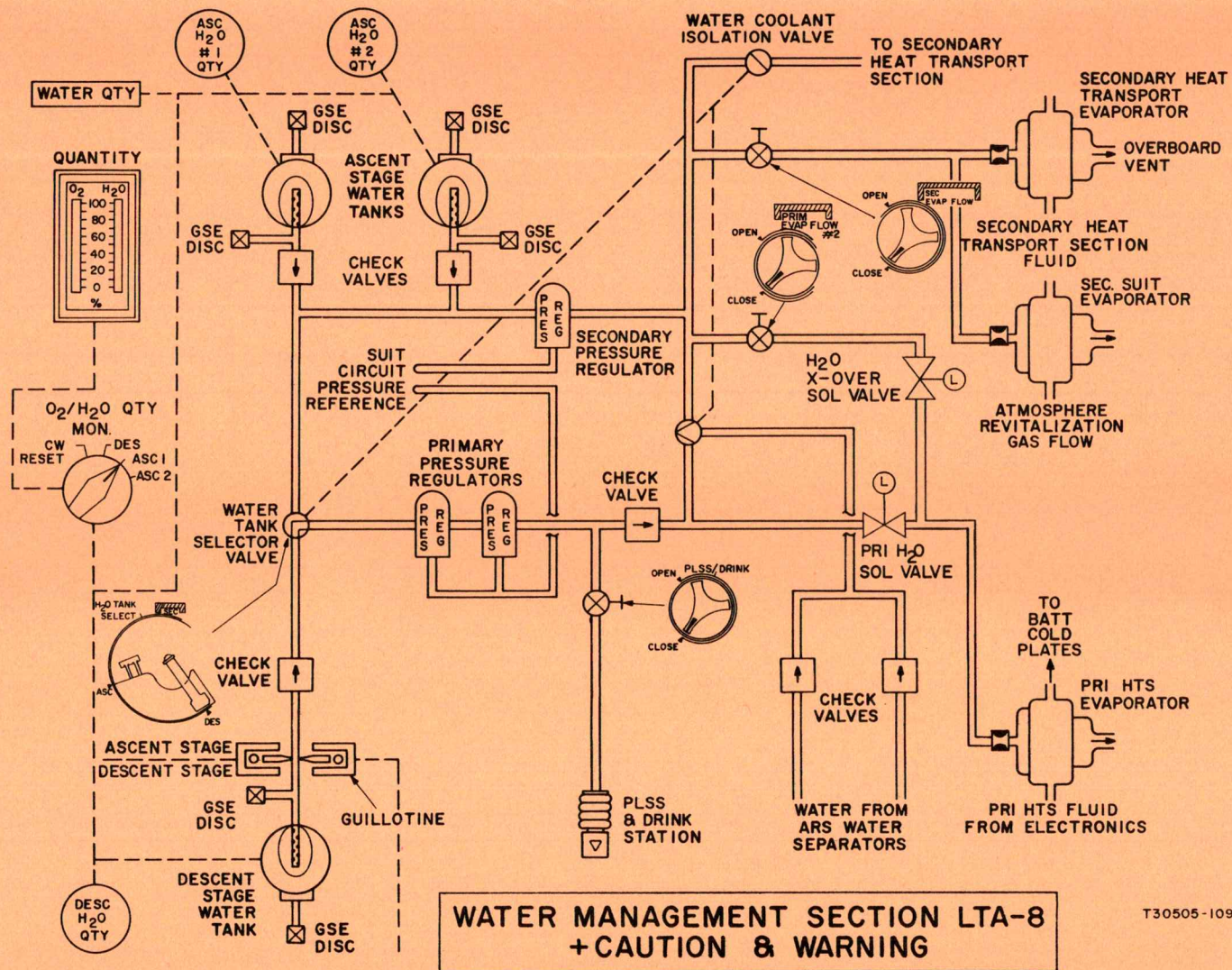
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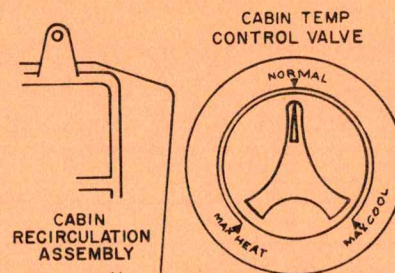
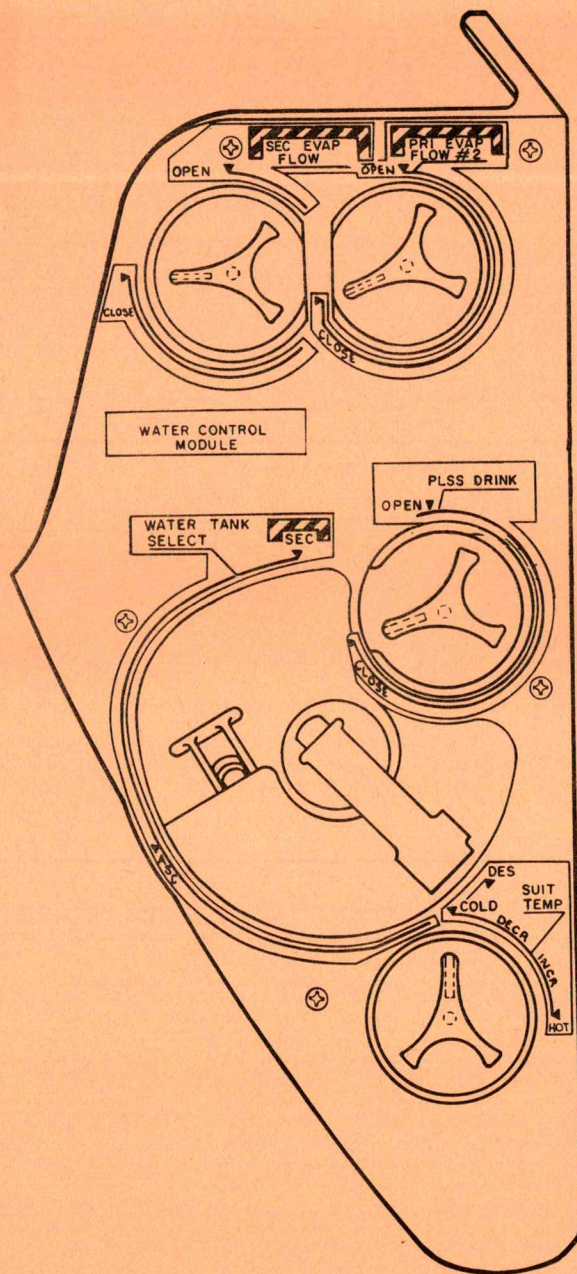
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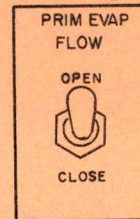
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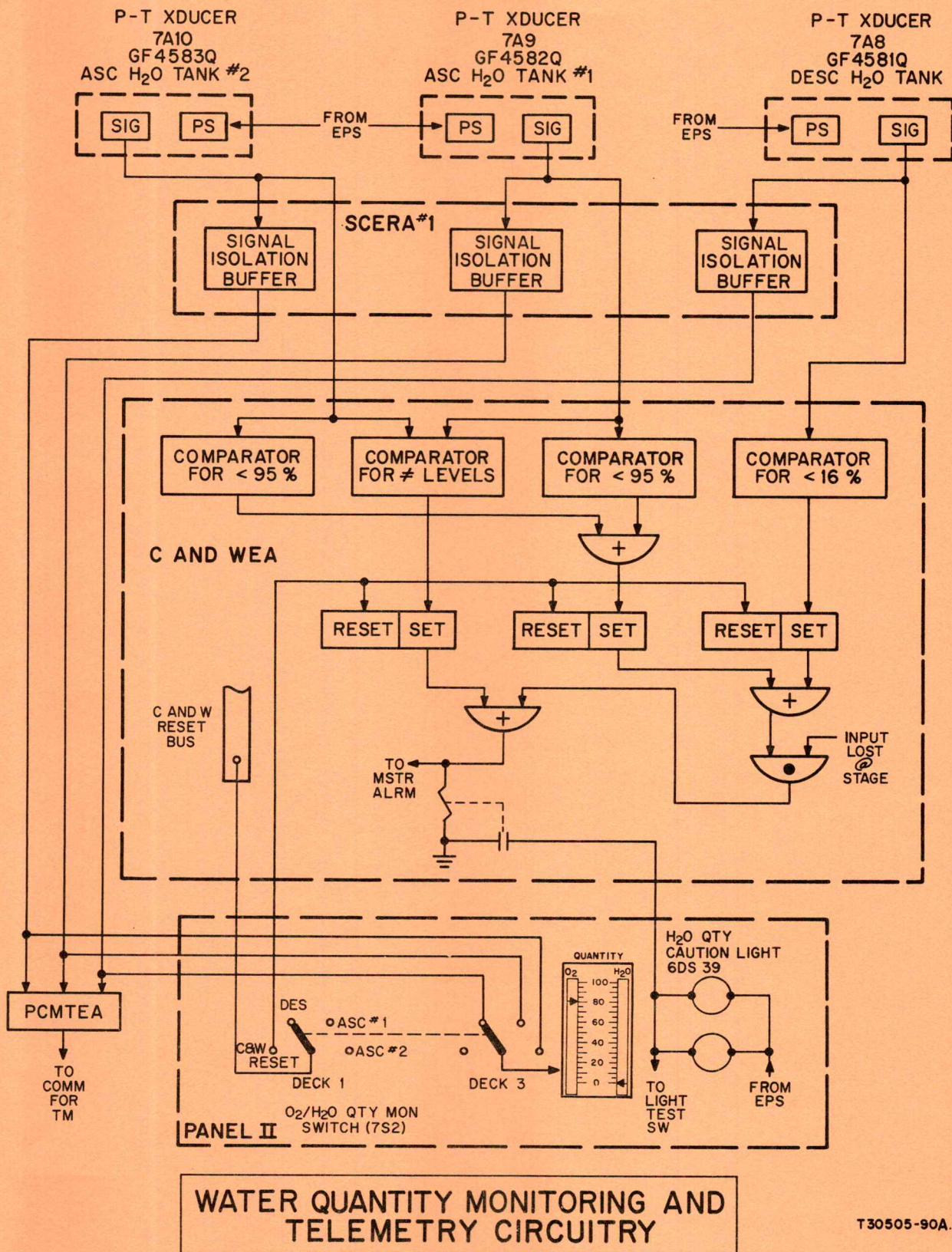


PRI EVAP FLOW #1 (TOGGLE SWITCH
(FOR PRIM H₂O SOL VLV))

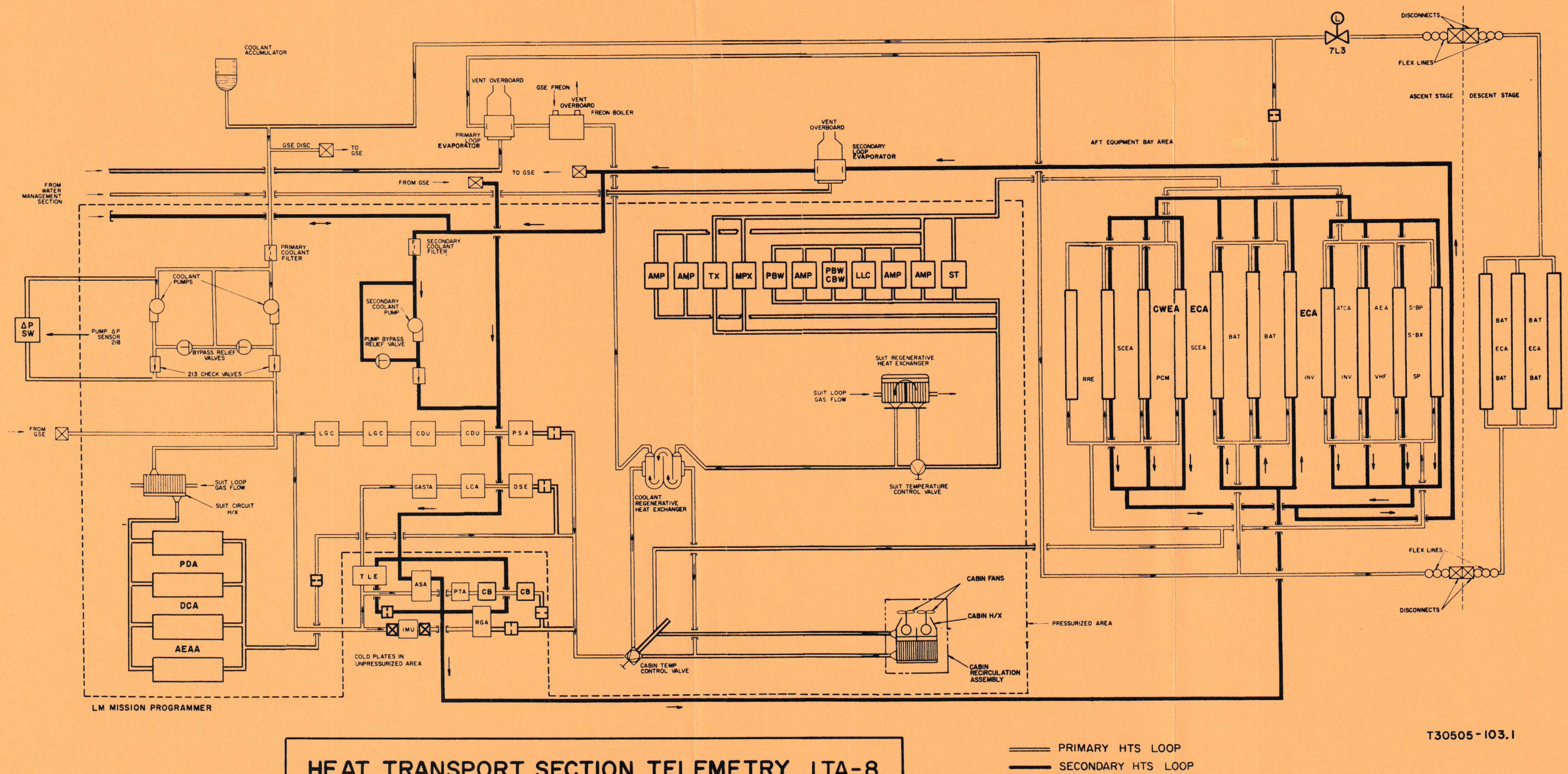


WATER MANAGEMENT CABIN/SUIT TEMP CONTROLS LTA-8

T30505-110.1



T30505-90A.1



T30505-103.1



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