

GRUMMAN



TRAINING
CENTER

**LEM
CREW
SYSTEMS
STUDY GUIDE**

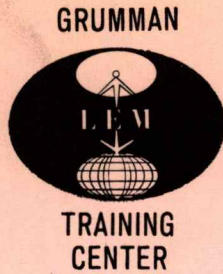
COURSE NO. 30815

FEBRUARY 1966

FOR TRAINING PURPOSES ONLY



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LEM CREW SYSTEMS STUDY GUIDE

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PREPARED BY
SERVICE AND PRODUCT SUPPORT DEPARTMENT

LEM
CREW SYSTEMS

S T U D Y G U I D E

FOR TRAINING PURPOSES ONLY

COURSE NUMBER 30815

DATE: FEBRUARY, 1966

Prepared by:

Joseph M. Jackson X1183

LEM Training

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PREFACE

THIS DOCUMENT IS DESIGNED TO SUPPORT
THE CREW SYSTEMS FAMILIARIZATION
COURSES 30815.

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SECTION ONE

CONTROLS AND DISPLAYS

1.1 Introduction and Description

The LEM, with its many subsystems, is a manned vehicle, designed to support two astronauts from lunar orbit until the rendezvous with the CSM when the lunar stay is completed. Since the LEM is manned, the crew must be furnished data relative to the status of the subsystems, be warned of malfunctions, be provided with guidance and navigational read-outs, and once supplied this information, be able to take the required action.

Many considerations and principals went into the layout and design of the controls and displays. Controls and displays relating to a particular function are generally grouped together. Thought was given to the 0 and 1/6 "G" environments to be encountered, as well as to space suit limitations. As details are discussed in more depth, the philosophy of design and placement will be better understood.

Displays may be described as devices used to exhibit information. Several types are used in the LEM. The exact purpose for each will be covered in detail. Most of the LEM displays are lights, however, certain specially designed devices are used and will be described in detail later in this Study Guide.

Controls are selected to suit their function. For instance, a common toggled switch may be found in various configurations. There are two and three position toggles. Each position may be a "Maintain" (MAIN), in which the toggle will stay in the position selected, a "Momentary" (MOM) where the lever is spring loaded to return to its original position, or a "LOCK", where a mechanical restraint must be released in order to move the lever. Also, specially designed devices are used to control specific functions, as will be seen later.

1.2 Alpha Numeric Designators

Every display and control is assigned an alpha numeric designator. These will indicate the related subsystem, the type of device, and a sequentially assigned number.

1.2.1 First Designator

1	-	ENGINE/THRUST CONTROLS
2	-	EXPLOSIVE DEVICE (PYROTECHNICS)
3	-	GUIDANCE AND NAVIGATION
4	-	ELECTRICAL POWER
5	-	TO BE DETERMINED
6	-	CAUTION/WARNING
7	-	ENVIRONMENTAL CONTROL
8	-	REACTION CONTROL
9	-	FLIGHT CONTROL
10	-	PROPULSION
11	-	STABILIZATION AND CONTROL
12	-	ABORT GUIDANCE
13	-	COMMUNICATIONS
14	-	COMMUNICATIONS ANTENNAS
15	-	AUDIO CONTROL
16	-	LIGHTING CONTROLS
17	-	RADAR CONTROLS
18	-	HEATER CONTROLS

NOTE: In the Audio Centers, the letter "A" suffixes the First Designator for the Commander's Controls, and the letter "B" for those of the Systems Engineer.

1.2.2 Second Designator

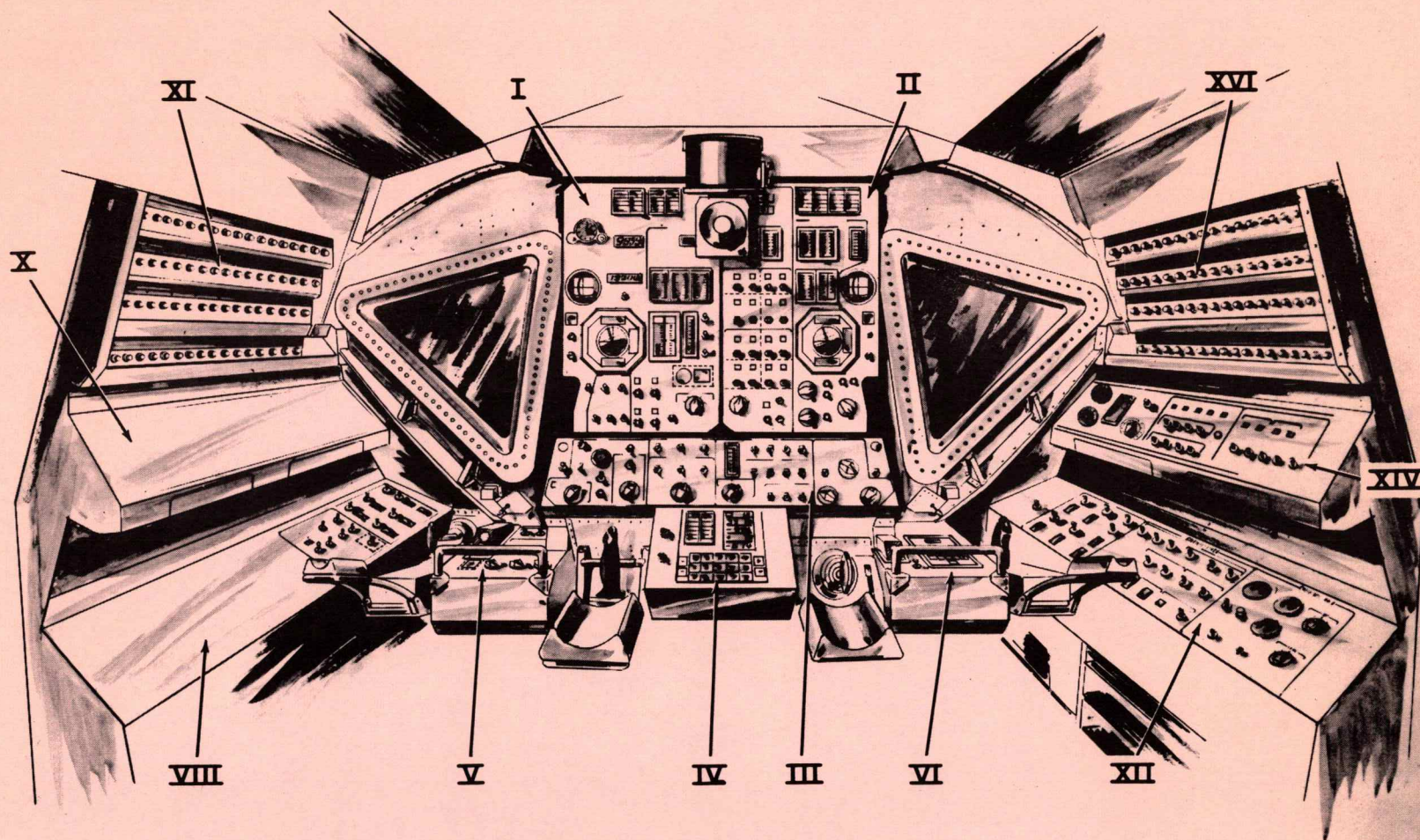
- S - SWITCH
- M - DISPLAY (METER-DIGITAL DISPLAY-FLIGHT INDICATOR, ETC)
- DS - CAUTION/WARNING, COMPONENT CAUTION INDICATOR, OR LUNAR CONTACT LIGHT
- B - SYNCHRO
- R - THUMBWHEEL OR CONTINUOUS ROTARY SWITCH
- CB - CIRCUIT BREAKER
- FL - STATUS FLAG
- T - AUDIBLE WARNING TONE
- H - MANUAL CONTROL

1.2.3 Third Designator

The Third Designator is a numeral which has been sequentially assigned.

EXAMPLE: Systems Engineer's Intercom Volume Control Thumbwheel

	_____	Audio Control
	_____	Systems Engineer
15B-R-7	_____	Sequential Designator
	_____	Thumbwheel



LEM DISPLAYS AND CONTROLS

1.3 Cabin Panel Layout

The LEM Displays and Controls are primarily located on panels in the forward section of the crew compartment. These panels are designated with Roman Numerals. The panel views shown in this section are for position and function reference only and may not reflect the latest design changes. See panel reference section for the most up-to-date configuration.

1.3.1 COMMANDER'S CENTER CONSOLE (I)

Flight Control

Warning Lights

Main Propulsion

Engine Thrust Control

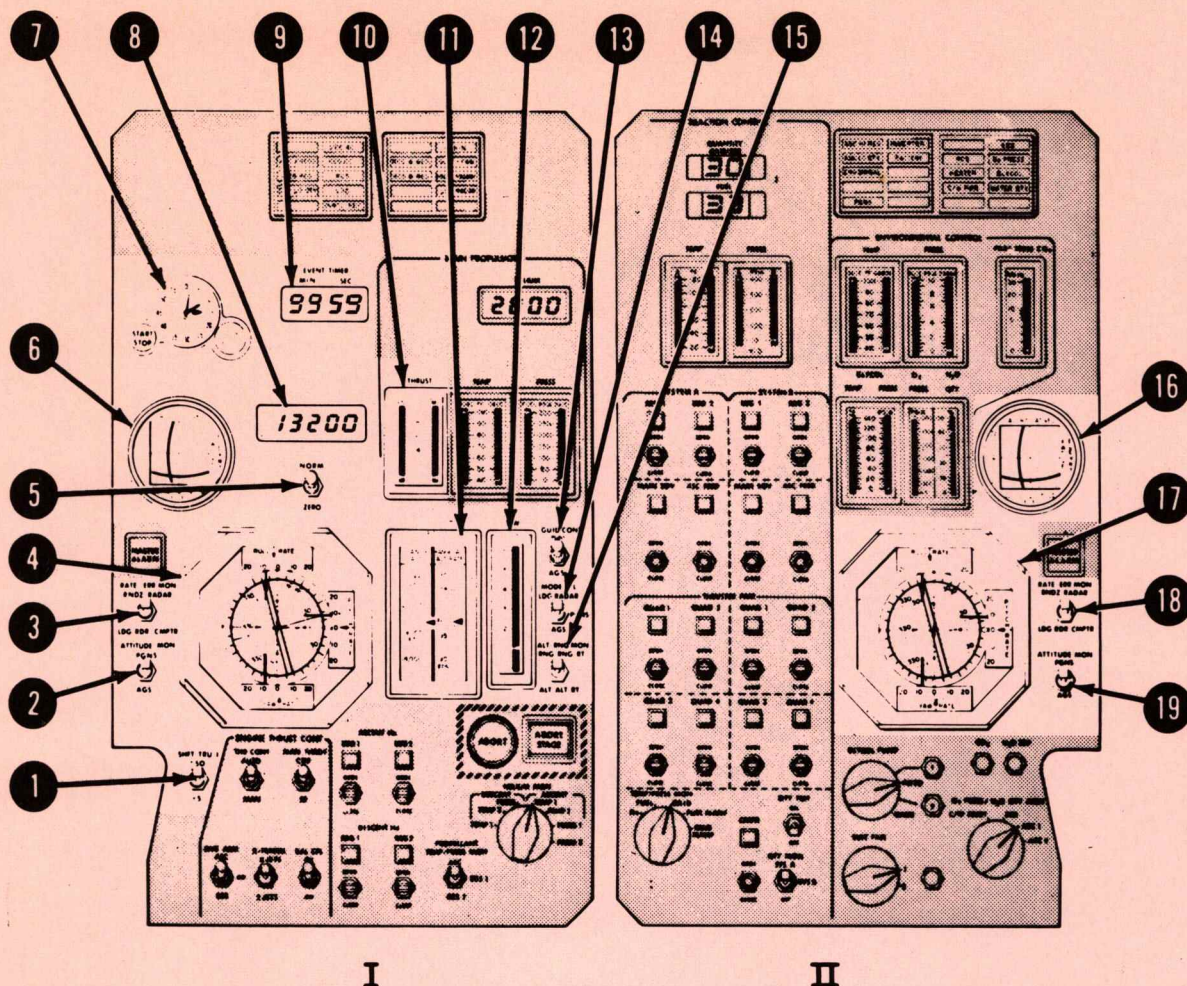
1.3.2 SYSTEMS ENGINEER'S CENTER CONSOLE (II)

Flight Control

Caution Lights

Environmental Control

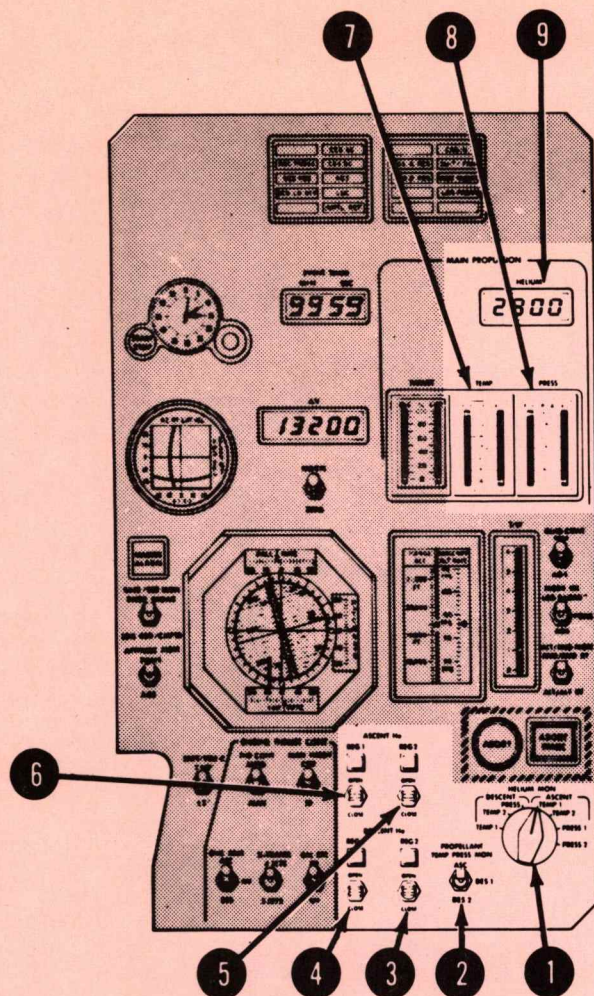
Reaction Control



FLIGHT CONTROL

1. SHAFT/TRUNION SWITCH
2. COMMANDER'S ATTITUDE MONITOR SWITCH
3. COMMANDER'S RATE/ERROR MONITOR SWITCH
4. COMMANDER'S FLIGHT DIRECTOR ATTITUDE INDICATOR
5. ΔV RESET SWITCH
6. COMMANDER'S FORWARD VELOCITY/LATERAL VELOCITY—LOS AZIMUTH RATE/LOS ELEVATION RATE INDICATOR
7. ELAPSED TIMER
8. ΔV INDICATOR
9. EVENT TIMER INDICATOR
10. THRUST INDICATOR
11. ALTITUDE/RANGE INDICATOR
12. THRUST/WEIGHT INDICATOR
13. GUIDANCE CONTROL SWITCH
14. MODE SELECT SWITCH
15. ALTITUDE/RANGE MONITOR SWITCH
16. SYSTEMS ENGINEER'S FORWARD VELOCITY/LATERAL VELOCITY—LOS AZIMUTH RATE/LOS ELEVATION RATE INDICATOR
17. SYSTEMS ENGINEER'S FLIGHT DIRECTOR ATTITUDE INDICATOR
18. SYSTEMS ENGINEER'S RATE/ERROR MONITOR SWITCH
19. SYSTEMS ENGINEER'S ATTITUDE MONITOR SWITCH

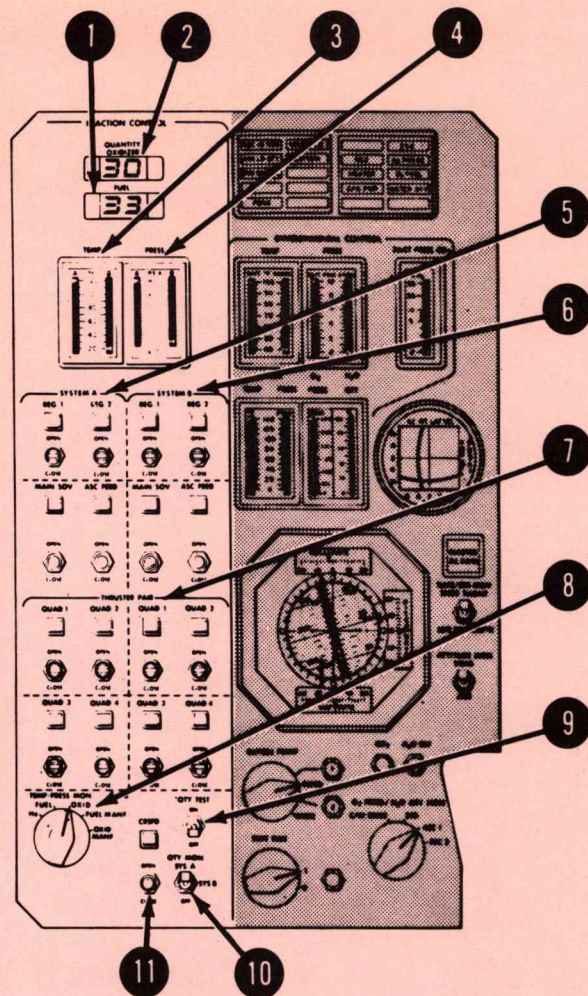
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MAIN PROPULSION

I

1. HELIUM MONITOR SELECT SWITCH
2. PROPELLANT TEMPERATURE/PRESSURE MONITOR SWITCH
3. DESCENT HELIUM REGULATOR #2 SWITCH
4. DESCENT HELIUM REGULATOR #1 SWITCH
5. ASCENT HELIUM REGULATOR #2 SWITCH
6. ASCENT HELIUM REGULATOR #1 SWITCH
7. PROPELLANT TEMPERATURE INDICATOR
8. PROPELLANT PRESSURE INDICATOR
9. HELIUM INDICATOR

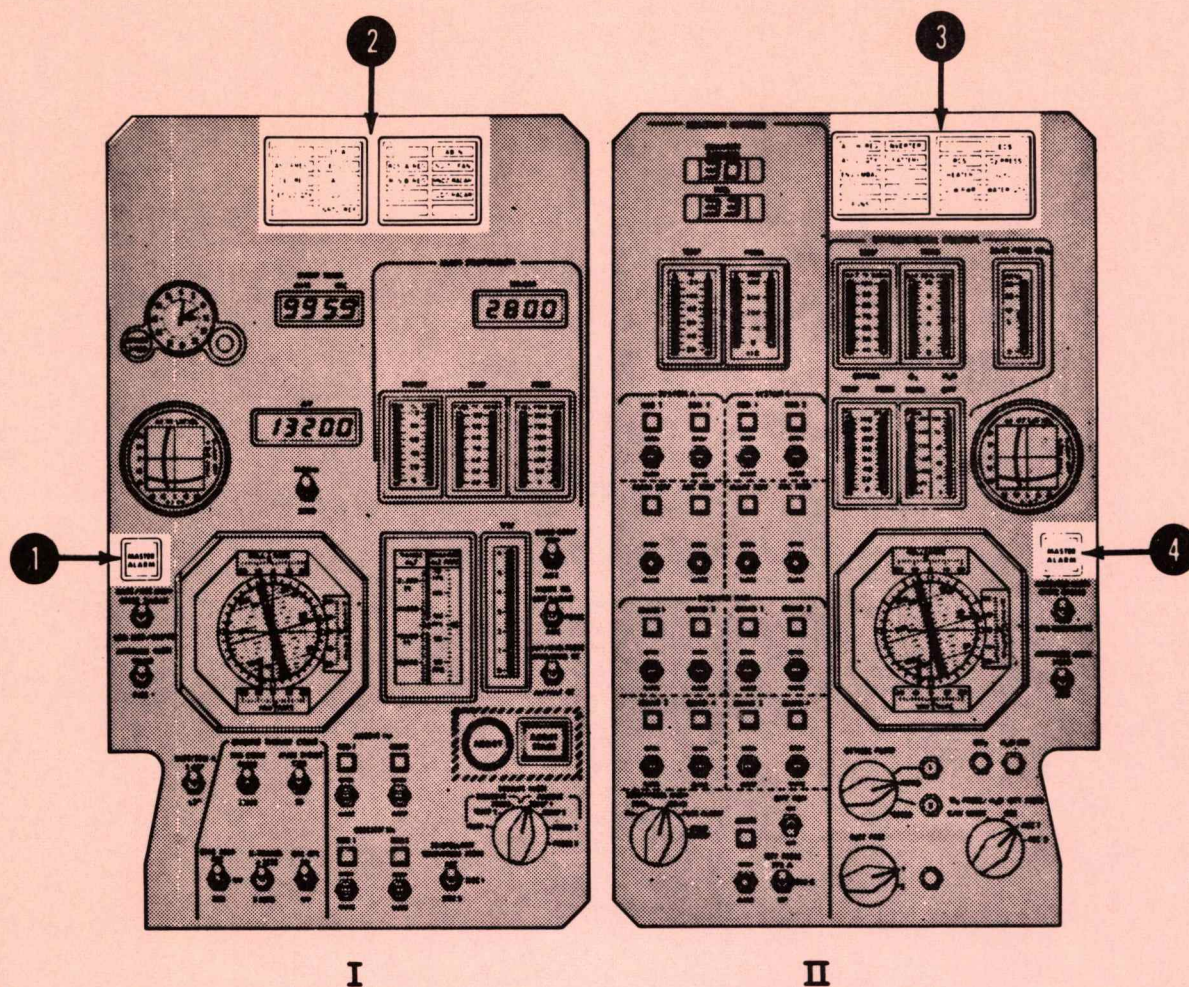


REACTION CONTROL

II

1. FUEL QUANTITY INDICATOR
2. OXIDIZER QUANTITY INDICATOR
3. TEMPERATURE INDICATOR
4. PRESSURE INDICATOR
5. SYSTEM A SWITCHES AND STATUS FLAGS
6. SYSTEM B SWITCHES AND STATUS FLAGS
7. THRUSTER PAIR SWITCHES AND STATUS FLAGS
8. TEMPERATURE/PRESSURE MONITOR SELECT SWITCH
9. QUANTITY TEST SWITCH
10. QUANTITY MONITOR SWITCH
11. CROSSFEED SWITCH AND STATUS FLAG

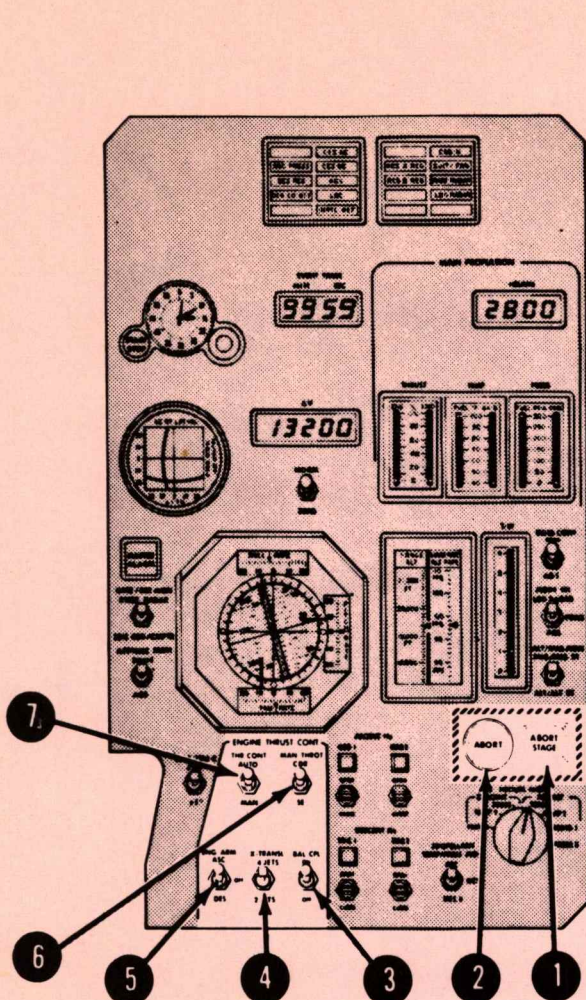
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CAUTION and WARNING LIGHTS

1. COMMANDER'S MASTER ALARM SWITCH LIGHT
2. WARNING LIGHTS
3. CAUTION LIGHTS
4. SYSTEMS ENGINEER'S MASTER ALARM SWITCH LIGHT

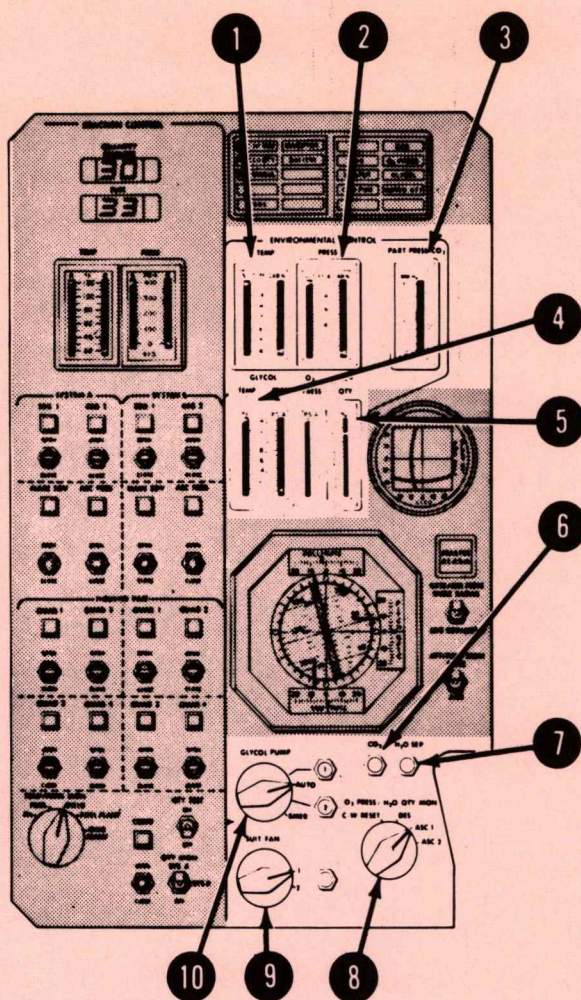
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ENGINE THRUST CONTROL

1. ABORT STAGE SWITCH
2. ABORT SWITCH
3. BALANCED COUPLES SWITCH
4. X-TRANSLATION SWITCH
5. ENGINE ARM SWITCH
6. MANUAL THROTTLE SWITCH
7. THRUST CONTROL SWITCH

I



ENVIRONMENTAL CONTROL

1. SUIT/CABIN TEMPERATURE INDICATOR
2. SUIT/CABIN PRESSURE INDICATOR
3. PARTIAL PRESSURE CO₂ INDICATOR
4. GLYCOL TEMPERATURE/PRESSURE INDICATOR
5. O₂ PRESSURE/H₂O QUANTITY INDICATOR
6. CO₂ PARTIAL PRESSURE LIGHT
7. H₂O SEPARATOR LIGHT
8. O₂ PRESSURE/H₂O QUANTITY MONITOR SELECT SWITCH
9. SUIT FAN SELECT SWITCH
10. GLYCOL PUMP SELECT SWITCH

II

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Fig. 1-5

1.3.3 COMMANDER'S UPPER SIDE CONSOLE (XI)

Circuit Breaker Panels

1.3.4 COMMANDER'S CENTER SIDE CONSOLE (X)

1.3.5 COMMANDER'S LOWER SIDE CONSOLE (VIII)

Explosive Devices Panel

Audio Panel

1.3.6 SYSTEMS ENGINEER'S UPPER SIDE CONSOLE (XVI)

Circuit Breaker Panels

1.3.7 SYSTEMS ENGINEER'S CENTER SIDE CONSOLE (XIV)

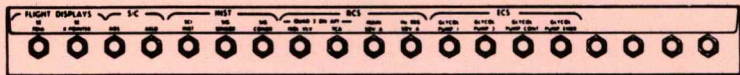
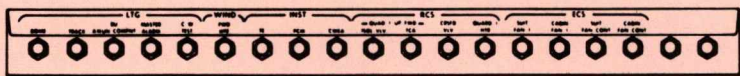
Electrical Power Control

1.3.8 SYSTEMS ENGINEER'S LOWER SIDE CONSOLE (XII)

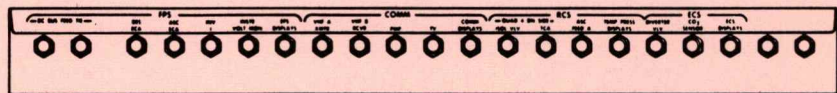
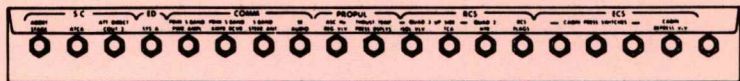
Audio Panel

Communications Panel

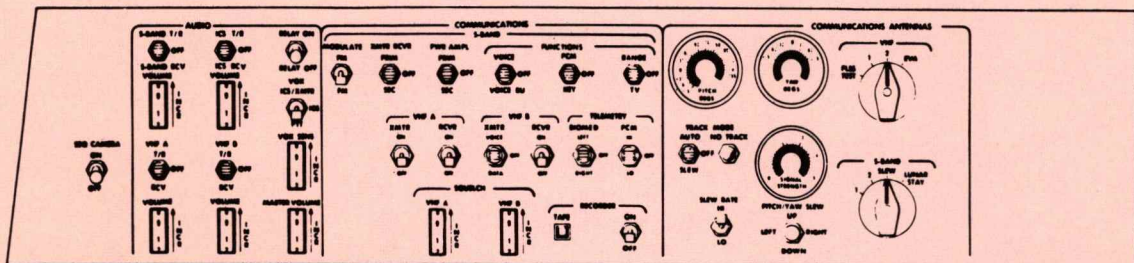
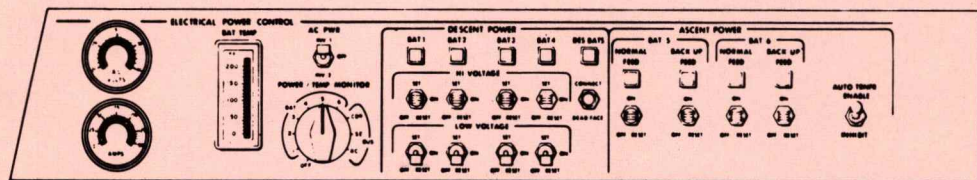
Communications Antennas Panel



XVI



XIV



XII

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1.3.9 LOWER CENTER PANEL (III)

Radar Panel

Stabilization and Control Panel

Heater Control Panel

Lighting Panel

1.3.10 BOTTOM CENTER PANEL (IV)

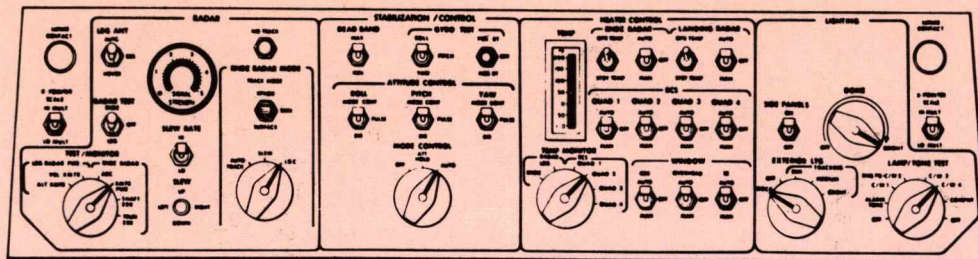
Primary Guidance and Navigation Control

1.3.11 BOTTOM SIDE PANEL (V)

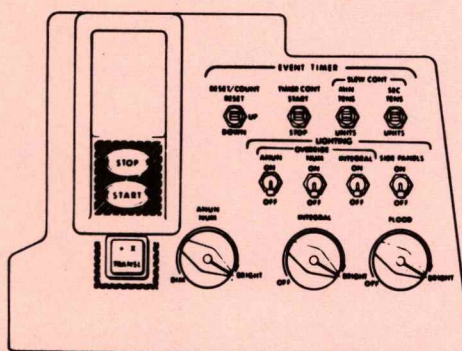
Lighting Panel

1.3.12 BOTTOM SIDE PANEL (VI)

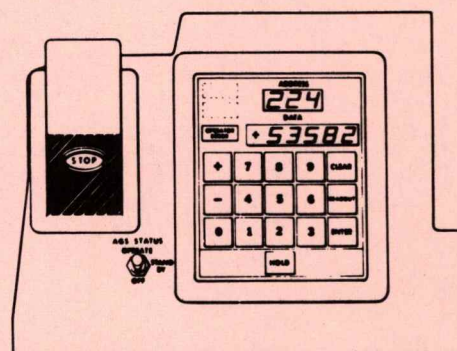
Abort Guidance Control



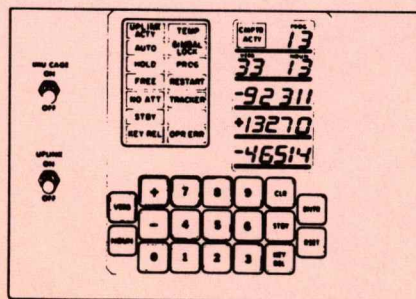
III



V



VI



IV

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1.4 Unique Displays

1.4.1 Caution and Warning

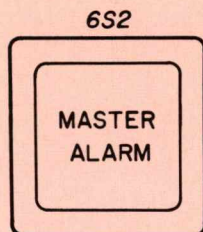
In order that the astronauts may be made aware of an out-of-tolerance condition in any LEM subsystem without the necessity for continuous monitoring of meters, the Caution and Warning Electronics Assembly (CWEA) was designed. The CWEA is itself a part of the Instrumentation subsystem, but monitors all LEM subsystems and will register an indication to the astronauts if certain limits are exceeded.

Failures or malfunctions are placed in one of two categories:

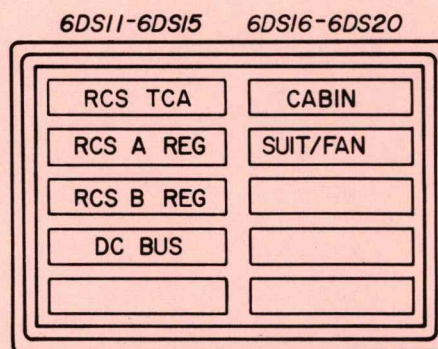
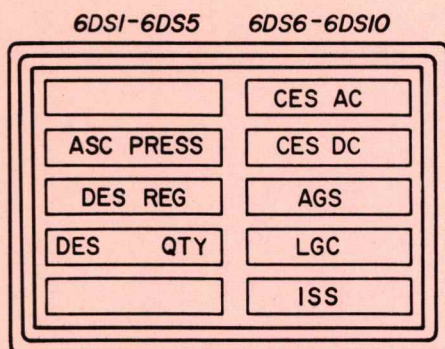
Warning -- malfunctions which require immediate corrective action and affect crew safety.

Caution -- generally will indicate the occurrence of one of several malfunctions in a given subsystem which will not require immediate repair or immediately affect crew safety.

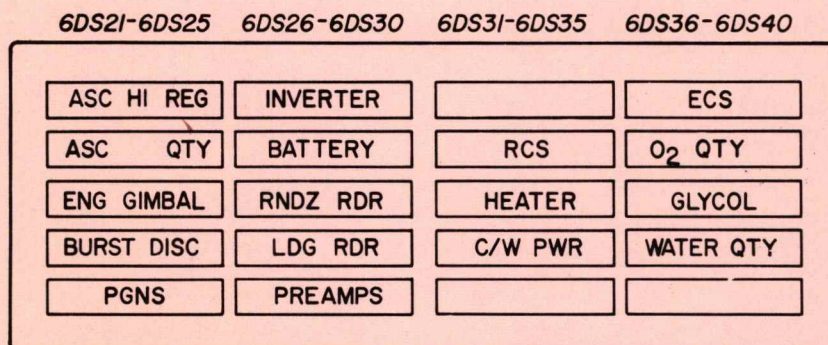
Caution and Warning indications are made by three methods. For either a caution or warning situation a 3000 cps tone is heard on each astronaut's headset and both Master Alarm Lights (6S2-6S3) are activated. These lights are mounted in a capsule which can be pushed to trigger a switch. Either of these switches, being pushed, will deactivate the tone and light for both astronauts. In addition to the tone and master alarm lights, an individual caution or warning indicator is lighted to denote the area of malfunction. This light remains on until the situation activating its circuit is corrected: at which time it is extinguished. The Warning Indicators (6DS1-6DS20) are mounted on Panel I and the Caution Indicators (6D21-6DS40) are mounted on Panel II.



MASTER ALARM LIGHTS (PANELS I AND II)



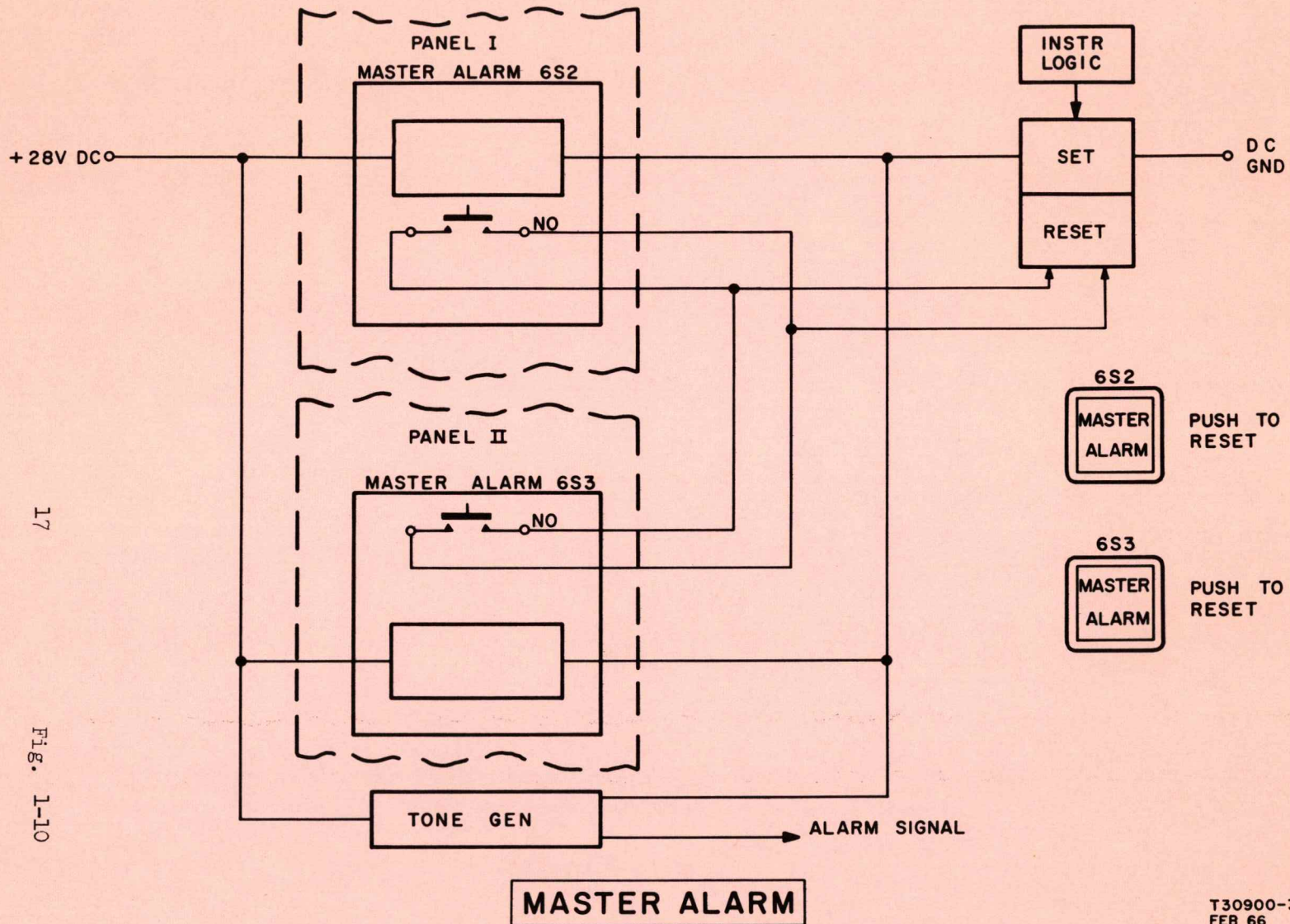
WARNING LIGHTS (PANEL I)



CAUTION LIGHTS (PANEL II)

CAUTION AND WARNING DISPLAYS

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17

Fig. 1-10

6-DS-2 ASCENT PROPULSION LOW PRESS WARNING LIGHT

The (ASC PRESS) warning light is illuminated if either: (1) the pressure in either of two ascent helium tanks falls below 3000 psia prior to staging; or (2) if the blanket pressure in the fuel or oxidizer lines at the bi-propellant valves of the ascent stage decays below 120 psia. If illuminated by a low helium pressure, this light is extinguished by a signal from a deadface switch resulting from separation of the descent and ascent stages; if illuminated by low fuel or oxidizer pressure the light is extinguished only by restoration of pressure.

6-DS-3 HI/LOW HELIUM REG OUTLET PRESS WARNING LIGHT

The (DES REG) warning light is illuminated if the pressure within the descent helium lines downstream of the regulators rises above 260 psia or falls below 220 psia. The light is extinguished when nominal pressures are restored or staging is accomplished (deadface switch). This signal will be enabled by a delayed DES ENG "ON" command.

6-DS-4 DESCENT PROPELLANT LOW QUANTITY WARNING LIGHT

The (DES QTY) warning light is illuminated if, prior to staging, the fuel or oxidizer in the descent tanks falls below a quantity such that approximately 10 seconds of burning time remains. This low level signal is enabled only if a descent engine "ON" command is present.

6-DS-6 CONTROL ELECTRONICS SECTION AC VOLTAGE FAILURE WARNING LIGHT

The (CES AC) warning light is illuminated if the AC voltage (single phase 28V 800 cps or three phase 26V 800 cps) in the Control Electronics Section of the STAB/CONT subsystem is out of tolerance. The light is extinguished when the Gyro Test Control switch (11-S-1) is actuated to either the POS RT or NEG RT position.

6-DS-7 CONTROL ELECTRONICS SECTION DC VOLTAGE FAILURE WARNING LIGHT

The (CES DC) warning light is illuminated if the DC voltage of one or more of the DC power supplied (+15V, -15V, +4.3V, +6V, -6V) in the Control Electronics Section of the STAB/CONT subsystem is out of tolerance. The light is extinguished when 11-S-1 is actuated to either the POS RT or NEG RT position.

6-DS-8 AGS FAILURE WARNING LIGHT

The (AGS) Warning Light is illuminated if: (1) a failure is sensed in any of the following AGS power supplies +28V, +12V, or 28V 400 cps, or (2) if a fail signal is generated by the AEA test assembly. The signals to illuminate this light are inhibited if the AGS Status Switch (12-S-7) is in the OFF position.

6-DS-9 LGC POWER FAILURE WARNING LIGHT

The (LGC) Warning Light is illuminated if a failure occurs in the LGC in: (1) the power supplies (+28V, +13V or +3V), or (2) the counter or (3) the scaler. The light is extinguished by either: (1) restoration of nominal voltage, or (2) placing the Guidance Control Switch (9-S-6) to the AGS position.

6-DS-10 INERTIAL SUBSYSTEM FAILURE WARNING LIGHT

The (ISS) Warning Light is illuminated if a failure of any of the following occurs: the 3.2KC power supply, the 800 cps 5% supply, the PIPA during main engine thrusting or the CDU. The light is extinguished by placing 9-S-6 to the AGS position.

6-DS-11 RCS TCA WARNING LIGHT

The (RCS TCA) Warning Light is illuminated if there is a primary coil command to fire a specific thruster, but no chamber pressure at that thruster. Additionally, a failure such that opposing co-linear jets are on simultaneously, illuminates the light. The light is extinguished when the isolation valve associated with the failed TCA is closed.

6-DS-12 RCS "A" REGULATOR FAILURE WARNING LIGHT

6-DS-13 RCS "B" REGULATOR FAILURE WARNING LIGHT

The (RCS "A" REG) Warning Light is illuminated if the pressure in the helium line of the pressurized RCS System "A" rises above 205 psia or falls below 165 psia. The light is extinguished when the nominal pressure is restored or if both helium regulator solenoid valves of System "A" (as operated by the System "A" Regulators #1 and #2 (8-S-2 and 8-S-3)) are closed. The (RCS "B" REG) Warning Light for System "B" is illuminated and extinguished in an identical manner as the (RCS "A" REG) Warning Light.

6-DS-14 DC BUS VOLTAGE FAILURE WARNING LIGHT

The (DC BUS) Warning Light is illuminated if a low voltage condition ($<26.5V$) occurs on either the Commander's or the Systems Engineer's DC electrical bus. The light is extinguished by restoration of a nominal voltage condition.

6-DS-16 CABIN LOW PRESSURE WARNING LIGHT

The (CABIN) Warning Light is illuminated if the cabin pressure falls below 4.6 psia. The light is extinguished when cabin pressure is restored to a level greater than 4.8 psia. This indicator will not operate during periods of intentional cabin depressurization (i.e., when the EGRESS position is selected on the Atmosphere Revitalization Section Pressure Regulator Valves (7-H-1 and 7-H-2), or if the Cabin Repressurization Valve (7-H-3) is manually placed in the OPEN position.

6-DS-17 SUIT/FAN LOW PRESSURE WARNING LIGHT

The (SUIT/FAN) Warning Light is illuminated if either: (1) the pressure within the suit falls below 3.12 psia or (2) if the #2 suit circulating fan fails. If illuminated by low suit pressure, it is extinguished by restoration of a nominal pressure. If illuminated because of #2 fan failure, the light is extinguished by deactivation of the Suit Fan AP Control Circuit Breaker (4-CB-120).

6-DS-21 HIGH He REG OUTLET PRESS CAUTION LIGHT

The (ASC HI REG) Caution Light is illuminated if the helium pressure downstream of the regulators in the ascent helium lines is greater than 220 psia. The light is extinguished when pressure is reduced to a nominal value.

6-DS-22 ASCENT PROPELLANT LOW QUANTITY CAUTION LIGHT

The (ASC QTY) Caution Light is illuminated if the level of ascent fuel or oxidizer in the ascent tanks reaches a value such that approximately 10 seconds burning time remains. The signal is intended to permit the crew to manually shut down the ascent engine to avoid possible explosive effects resulting from depletion of either fuel or oxidizer before the other, and to indicate that ascent engine thrusting is not available for midcourse correction or rendezvous braking. These low level signals are enabled only if the ascent engine is on.

6-DS-23 AUTOMATIC GIMBAL FAILURE CAUTION LIGHT

The (ENG GIMBAL) Caution Light is illuminated if a difference between the gimbal drive signal and gimbal response from the Y or Z-axis trim function is sensed. This signal is enabled only if the Descent Engine is armed. Additionally, the signal is disabled following staging (deadface switch).

6-DS-24 DESCENT PROPULSION BURST DISC FAILURE CAUTION LIGHT

The (BURST DISC) Caution Light is illuminated if the burst disc at the descent propulsion helium tank is ruptured. The light is extinguished by separation of the descent stage (deadface switch). This malfunction indication applies only if a supercritical helium pressurization scheme is adopted.

6-DS-25 PGNS FAILURE CAUTION LIGHT

The (PGNS) Caution Light is illuminated if any of the following conditions is sensed: (1) middle roll gimbal angle is greater than $\pm 60^\circ$; (2) deviations in IMU temperature are greater than $\pm 5^\circ$ from normal; (3) the "AND" of RNDZ RADAR OPERATE and RADAR CDU FAIL; (4) the "AND" of RNDZ RADAR TRACK ENABLE and DATA NOT GOOD; (5) the "AND" of LDG RADAR DATA NOT GOOD and the landing radar antenna in the DESCENT or HOVER position; (6) a DATA GOOD signal with an ambiguous antenna position signal; (7) failure of some program check; (8) restart; (9) PIPA failure during periods when not thrusting. The light is extinguished either by selecting the AGS position on 9-S-6 by actuating the DSKY RESET pushbutton.

6-DS-26 INVERTER FAILURE CAUTION LIGHT

The (INVERTER) Caution Light is illuminated either: (1) if the AC bus voltage is $\leq 112V$ or (2) if the AC bus frequency is ≤ 398 cps or ≥ 402 cps. The light is extinguished when within-tolerance conditions are restored, or if the AC Power Control Switch (4-S-14) is turned off.

6-DS-27 BATTERY FAILURE CAUTION LIGHT

The (BATTERY) Caution Light is illuminated if an over-current, reverse-current, or over-temperature condition occurs in any of the four descent or two ascent batteries. The light is extinguished when nominal conditions are restored or if the affected battery is turned off.

6-DS-28 RENDEZVOUS RADAR DATA FAILURE CAUTION LIGHT

The (RNDZ RDR) Caution Light is illuminated if a rendezvous radar data-not-good condition occurs. The light is extinguished when a "Data Good" condition is restored, or if the rendezvous radar is turned off. This signal is enabled only if the Rendezvous Radar mode switch (17-S-3) is in the AUTO TRACK position.

6-DS-29 LANDING RADAR DATA FAILURE CAUTION LIGHT

The (LDG RDR) Caution Light is illuminated if: (1) the Landing Radar Range Data is not good, or (2) if the velocity data is not good. This light is not enabled until both range and velocity "data good" signals have been achieved. The light is extinguished when a "data good" condition is restored, or if the landing radar is turned off.

6-DS-30 PRE AMPS POWER FAILURE CAUTION LIGHT

The (PRE AMPS) Caution Light is illuminated by an out-of-tolerance condition in either of two parallel redundant -4.7V regulated supplies which power the RCS jet pre-amplifiers. This light is extinguished either by the stage deadface switch or by actuation of the Abort pushbutton (1-S-13).

6-DS-32 RCS FAILURE CAUTION LIGHT

The (RCS) Caution Light is illuminated if: (1) out-of-tolerance ratios of fuel and oxidizer quantities remain in the tanks of either RCS System "A" or "B", or (2) if the pressure of the helium tank in either RCS system drops below 1700 psia. If illuminated by an out-of-tolerance Oxidizer/Fuel ratio, the light is extinguished by selecting the momentary ON position of the QTY TEST switch (8-S-6). If illuminated by a low helium pressure condition, the light is extinguished by selecting the He position of the RCS Temp/Press Monitor Switch (8-S-19).

6-DS-33 HEATER FAILURE CAUTION LIGHT

The (HEATER) Caution Light is illuminated by an out-of-tolerance temperature condition in: (1) any of the four RCS thruster quads, or (2) the S-band antenna assembly, (3) the rendezvous radar antenna assembly, (4) landing radar antenna assembly. The light is extinguished by positioning the Temperature Monitor switch (18-S-10) to the affected heater assembly position.

6-DS-34 C/W REG POWER FAILURE CAUTION LIGHT

The (C/W PWR) Caution Light is illuminated if any one or more of the following regulated power supplies fail: +9V, +23V, +4V, -3V, -2V, +2.3V. The light is extinguished only by restoration of nominal power to the CWEA. Unlike the other C/W lights, this light is undimmable.

6-DS-36 ECS FAILURE CAUTION LIGHT

The (ECS) caution light is illuminated by any of the following malfunctions: glycol pump failure; CO₂ partial pressure greater than 7.6 mm of mercury; water separator failure; or suit fan #1 failure. The light is extinguished by correction of the malfunction which illuminated it as follows: restoration of glycol pump pressure as a result of selecting #2 pump or selecting the EMER position if #2 has failed; or restoration of nominal CO₂ partial pressure level; or restoration of nominal water separator speed; or selection of the #2 suit fan.

6-DS-37 OXYGEN QUANTITY CAUTION LIGHT

The (O₂ QTY) caution light is illuminated if a low quantity condition (<135 psia) occurs in the descent oxygen tank, or if a less than full quantity condition (<684 psia) occurs in either ascent oxygen tank, or if a low quantity condition (<95 psia) occurs in ascent tank #1. The light is extinguished by momentarily positioning the O₂/H₂O QTY MON switch (7-S-2) to the C/W RESET position. The descent tank low quantity signal and the ascent tanks less than full signals are inhibited following staging (deadface switch).

6-DS-38 GLYCOL FAILURE CAUTION LIGHT

The (GLYCOL) caution light is illuminated by either of two malfunctions: (1) low glycol quantity in the primary coolant loop; or (2) high glycol temperature in the primary loop as sensed at the glycol water evaporator outlet. Both signals are inhibited following selection of the SEC position of the Glycol Pump switch (7-S-3). If illuminated by the high temperature condition, restoration of the temperature to a nominal level also extinguishes the light.

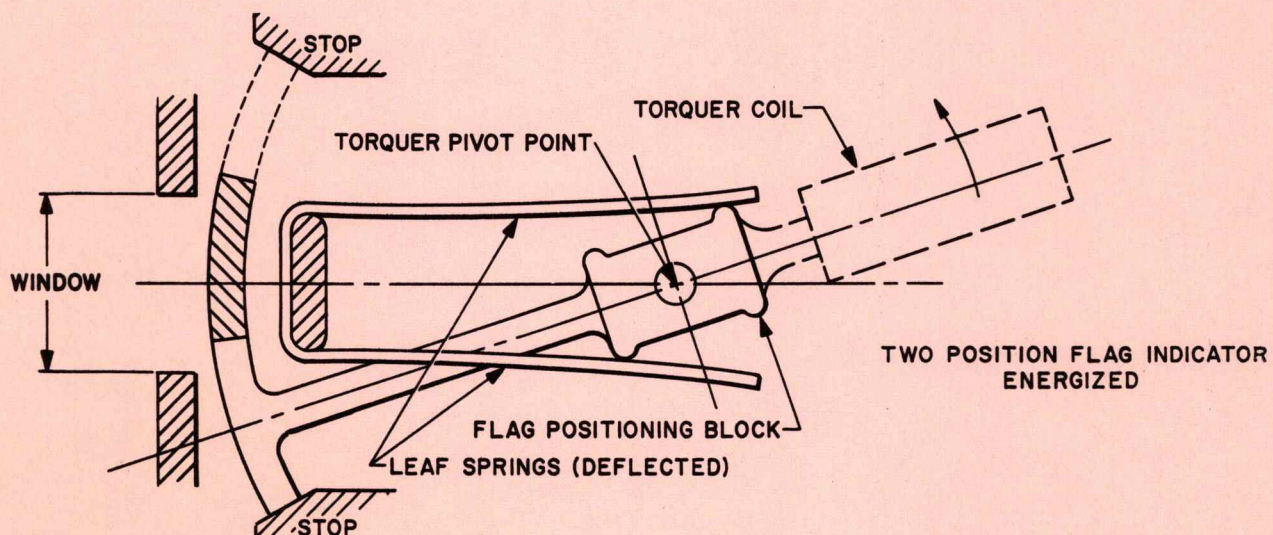
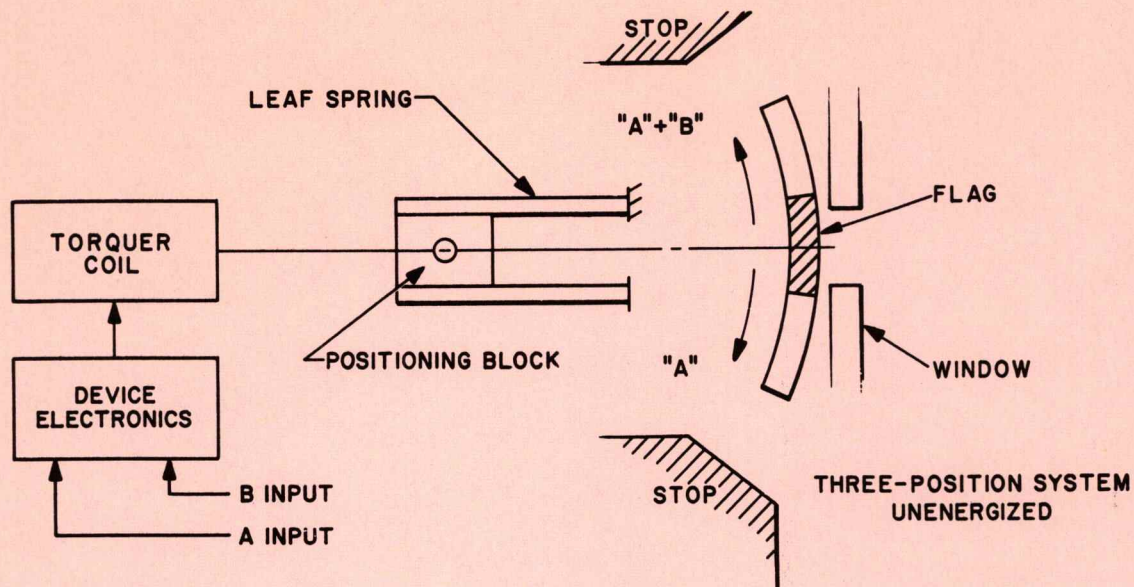
6-DS-39 WATER QUANTITY CAUTION LIGHT

The (WATER QTY) caution light is illuminated if the quantity remaining in the descent water tank falls below 10%, or if a less than full condition occurs in either ascent water tank, or if unequal levels occur in either of these ascent tanks. The light is extinguished by momentarily positioning 7-S-2 to the C/W RESET position. The descent tank low level signal and the ascent tanks less than full signals are inhibited following staging (deadface switch).

1.4.2 Flag Indicators

LEM Flag Indicators are of the "Leaf Spring Positioning Concept" (LSPC) type. The major consideration leading to the design of the LSPC was an operational requirement specifying that the off flag must return to the viewing window in case of a complete power failure. This requirement necessitated the use of a spring strong enough to return the appropriate off flag to a neutral position, and hold it stable in this position under all environmental conditions with no power to the device. The LSPC device draws no power in an off position mode. The center flag will appear in the viewing aperture with no signal to the device. Cantilevered leaf springs acting against a rectangular positioning block, positively retain the flag dial assembly in position. A signal from the electronic circuit sends current to the torquer coil, driving the dial against the stop and exposing the flag. Upon removal of the signal, the flag will return to the center position.

For the three-position device, two inputs to the electronics assembly are used. With an input at "A" and "B", the flag is driven against the lower stop. With inputs at "A" and "B", the flag is driven against the upper stop. The two-position device operates on the same principle as the three-position device except that current flows in only one direction through the circuit, and the dial moves only to expose a second flag.



FLAG INDICATORS

1.4.3 "Servometric" Indicator

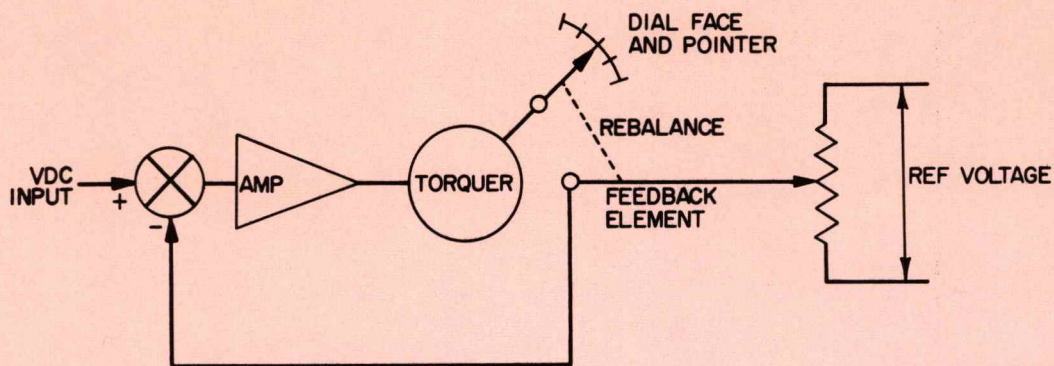
The "Servometric" concept employs the closed-loop rebalance principle to position a pointer in accordance with an input signal, as shown. An output from a feedback transducer mounted on the pointer is compared with the input signal. The resulting error signal is amplified and utilized to drive the pointer (and transducer) to the correct position by means of a simple, direct-drive D'Arsonval type of torquer. The simplicity, low power, and low weight of meter movements are achieved without their open loop operation, poor dynamic stability under vibration and acceleration, and cumbersome vibration isolation. The concept also provides the fast response, high accuracy, stability, mechanical ruggedness, and closed loop operation associated with servoed displays but without their bulk, weight, and mechanical complexity.

The "Servometric" concept requires one moving element -- the torquer. This electromechanical element must move a pointer for display indication, operate from a DC input signal, and have an accurate position feedback element. The type of concept selected was the permanent magnet DC torquer. These devices are somewhat similar in appearance to a D'Arsonval meter movement but their characteristics and construction are different in that the mechanism parameters are chosen to be compatible with the associated rebalance potentiometers. Power to the moving element is brought in through flexible metal ribbons and no brushes or slip rings are required.

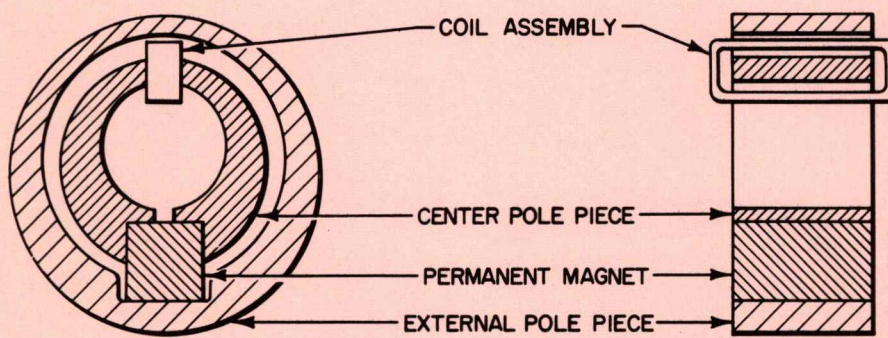
One torquer is required for each channel displayed (a dual indicating instrument requires two torquers). Two basic torquers are required in the four different LEM displays. They are the 250 degree torquer and the 50 degree torquer. Both torquers operate on the same concept, but are constructed differently for the specific packages and dial displays.

The 250° torquer is so named because it has an active rotational capability of 250°. It is designed to be packaged in a standard two-inch round display. The torquer uses the concept of an internal magnet, a center pole piece, and an external pole piece. The permanent magnet is charged with north and south polarity which is conducted into the pole pieces, which are made of high-permeability soft iron. The center pole is in contact with the north pole of the magnet. It distributes the lines of flux throughout the 250° air gap and acts like a unipole magnet of north polarity. The concept of design is based on maintaining a nearly constant level of flux density in all parts of the circuit.

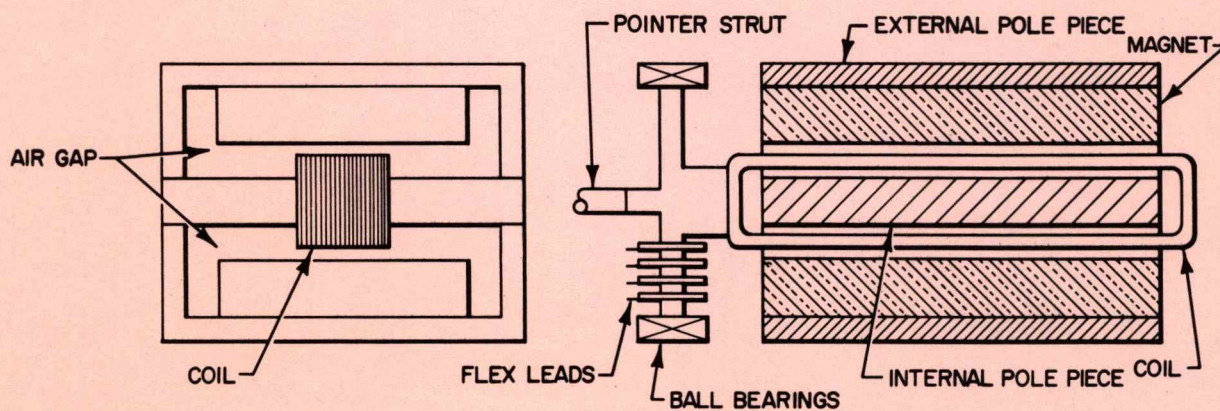
The 50° torquer is a mechanism designed for use in the vertical scale displays and the Cross-Pointer. The torquer is designed using a concept utilizing two magnets. The circuit concept is especially suited for small angles of travel and develops high torques. The torque is high because two air gaps are provided so that two legs of the coil are in the magnetic field. The magnets and iron pole pieces are all pie shaped to provide a magnetic field only in the arc of the coil swing.



SERVOMETRIC INDICATOR CONCEPT



250° TORQUER



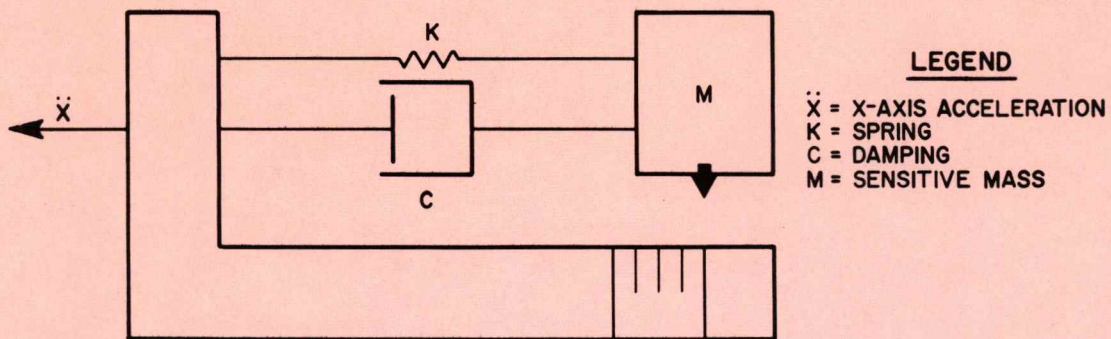
50° TORQUER

1.4.4 Thrust/Weight Indicator

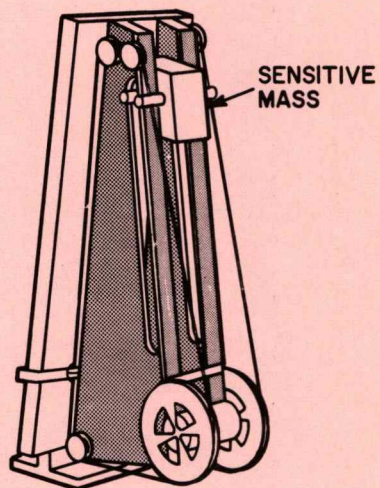
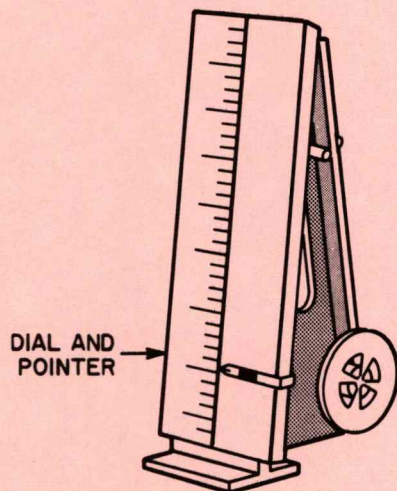
The Thrust-to-Weight Ratio Indicator is an acceleration measuring device which will be mounted in the LEM instrument panel. The indicator will be read out by the pilot, the information to be used for monitoring descent engine performance during lunar orbit checkout and X-axis acceleration of the ship during lunar landing. A moving pointer travels along a fixed vertical scale to indicate the desired reading.

The Thrust-to-Weight indicator is only sensitive to acceleration inputs along its axis of mass motion. A mass in the unit is constrained to linear motion and supported longitudinally by a constant rate spiral spring. The inertia force of the mass is balanced by the spring force. The displacement of the mass is proportional to the inertia force, and hence to the input acceleration, under conditions of constant acceleration. Displacement of the mass is translated to pointer displacement, giving an output which is linearly proportional to input acceleration.

The pointer assembly consists of an aluminum pointer which is epoxied to a plastic sliding block. The block slides in a track which is machined in the mechanism frame and which constrains the pointer assembly, except in the direction motion. A hairpin-type spring is epoxied to the pointer. The spring ends serve as attach points for the pointer cord, and thermal contraction of the cord is compensated for by deflection of the spring. Pulley bearing loads are thus kept at very low levels and friction is minimized.



ACCELEROMETER SCHEMATIC



T/W INDICATOR

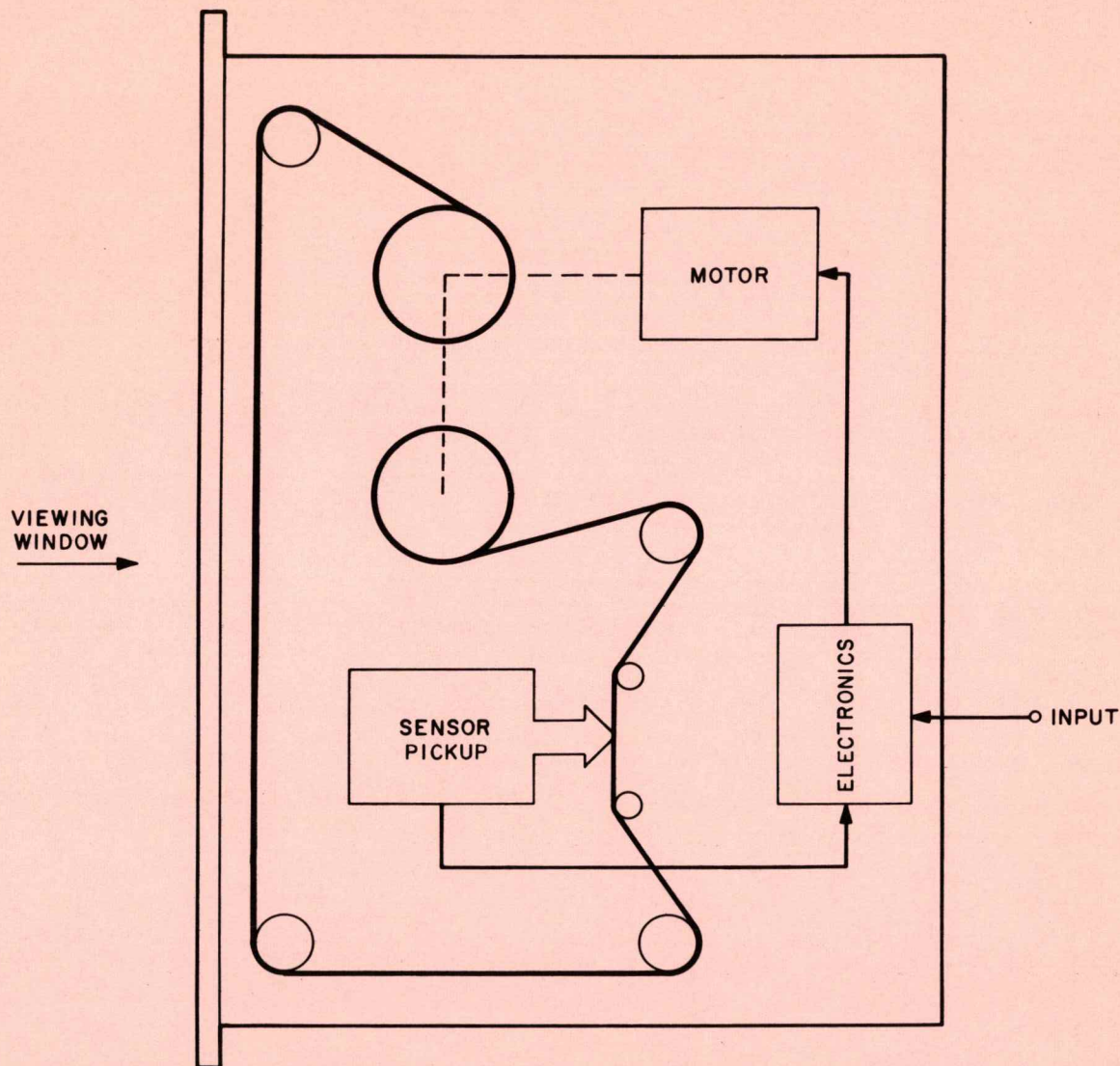
T30900-65
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1.4.5 Range/Range Rate Indicator

The Range/Range Rate Indicator displays range and range rate by means of vertically moving tapes, reading against a fixed reference marker. Digital coding on the back of the display tapes is read by means of sensors, and in effect, the display tape and readhead comprise a digital encoder.

Driving the tapes are stepper motors, controlled by the integral electronics. The integral electronics comprised mainly of microelectronic integrated circuits, for a special purpose digital computer, capable of recognizing which of the many inputs is being received by the indicator and comparing the input data against the tape feedback and generating an error word to operate the stepper motor.

Each tape drive consists of a stepper motor driving wrap-up spool to which the tape is affixed at one end. The other end of the tape is attached to another spool connected to the motor driven wrap-up spool by a constant tension spring gear. The utilization of a constant tension spring provides a tape tension that is relatively constant irrespective of the varying wrap-up diameters on the tape spools. Bearing mounted flanged rollers are used to guide the path of the tapes across the sensors.



RANGE/RANGE RATE INDICATOR SCHEMATIC

1.4.6 Flight Director Attitude Indicator

In order that the astronauts may monitor the LEM attitude with respect to a given reference axis, some form of attitude display is required. A system of servo-motors, servo-amplifiers, and synchro-resolvers has been designed to display the LEM attitude on a panel mounted device. This device is the Flight Director Attitude Indicator (FDAI). Its primary display is a sphere, mounted to gimbal about three orthogonal axes and oriented so as to never present its gimbal points to an observer.

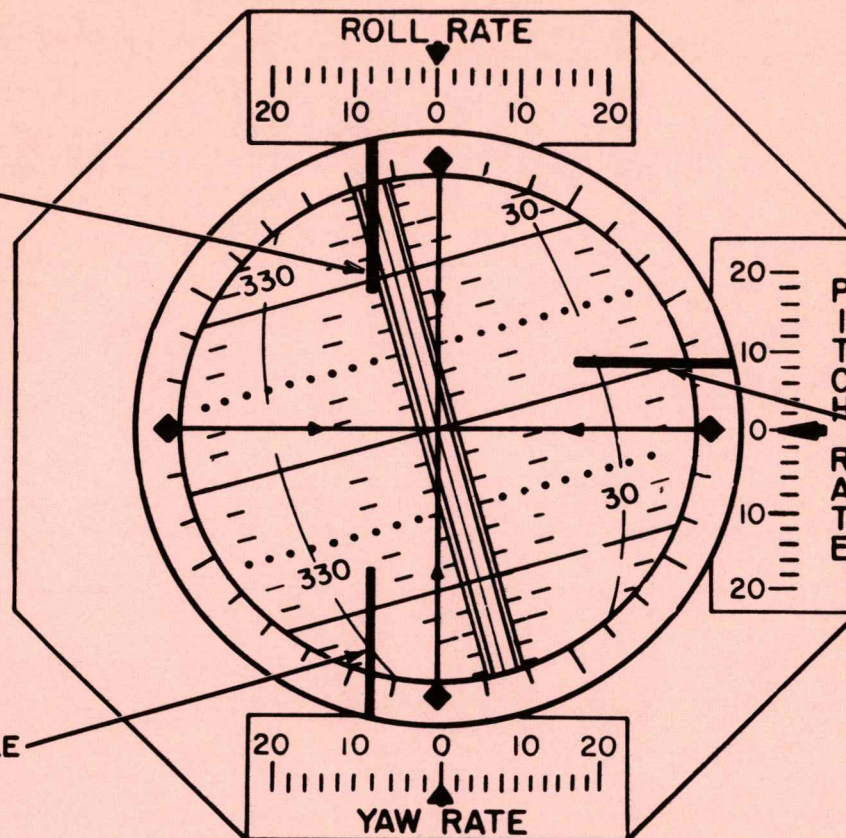
In addition to indicating the attitude of the LEM, the FDAI incorporates six meters to indicate rate and error of roll, pitch, and yaw. The RATE indicators meter the rate of change of angular position and the ERROR needles indicate the deviation between the programmed and the actual attitude. The error needles can also be used to monitor the rendezvous radar antenna position with respect to the LEM axes.

Between the sensing servos on the stable platform and the FDAI ball itself is a complex system of electronic and mechanical components. This unit, the Gimbal Angle Sequence Transformation Assembly (GASTA), was designed to operate in conjunction with the FDAI and to modify its input signals to the required configuration. This circuitry is necessary to transform the angular position of the stable platform gimbals to signals of the proper configuration to operate the FDAI ball properly. It is to be noted that the outer gimbal of the stable platform allows rotation about the X-axis, while the outer gimbal of the FDAI ball allows rotation of the ball about the Z-axis. A similar difference exists with the middle gimbals, which allow stable platform rotation about the Z-axis and ball rotation about the X-axis. The inner gimbals of both allow rotation about the same axis. The GASTA is also a signal conditioner which takes 26V, 800 cps signals from the Inertial Measuring Unit (IMU) of the Primary Guidance and Navigation System (PGNS) and converts them to 15V, 800 cps signals.

Signals may reach the attitude indicator from the two possible sources. The primary source is the IMU (stable platform) and the secondary source is the Abort Guidance System (AGS). The primary signals must be routed through the GASTA: but since the AGS has its own GASTA Function Unit, its signals are sent directly to the FDAI.

The RATE meters are fed from the Stabilization and Control (S&C) rate gyros in either mode of operation. Inputs to the ERROR meters (when metering computer/attitude error) are from either PGNS or AGS, depending on the mode selected. The Rendezvous Radar (RR) shaft angle is fed to the PITCH ERROR needle and the RR trunnion angle is fed to the YAW ERROR needle (when metering RR).

ROLL ERROR NEEDLE

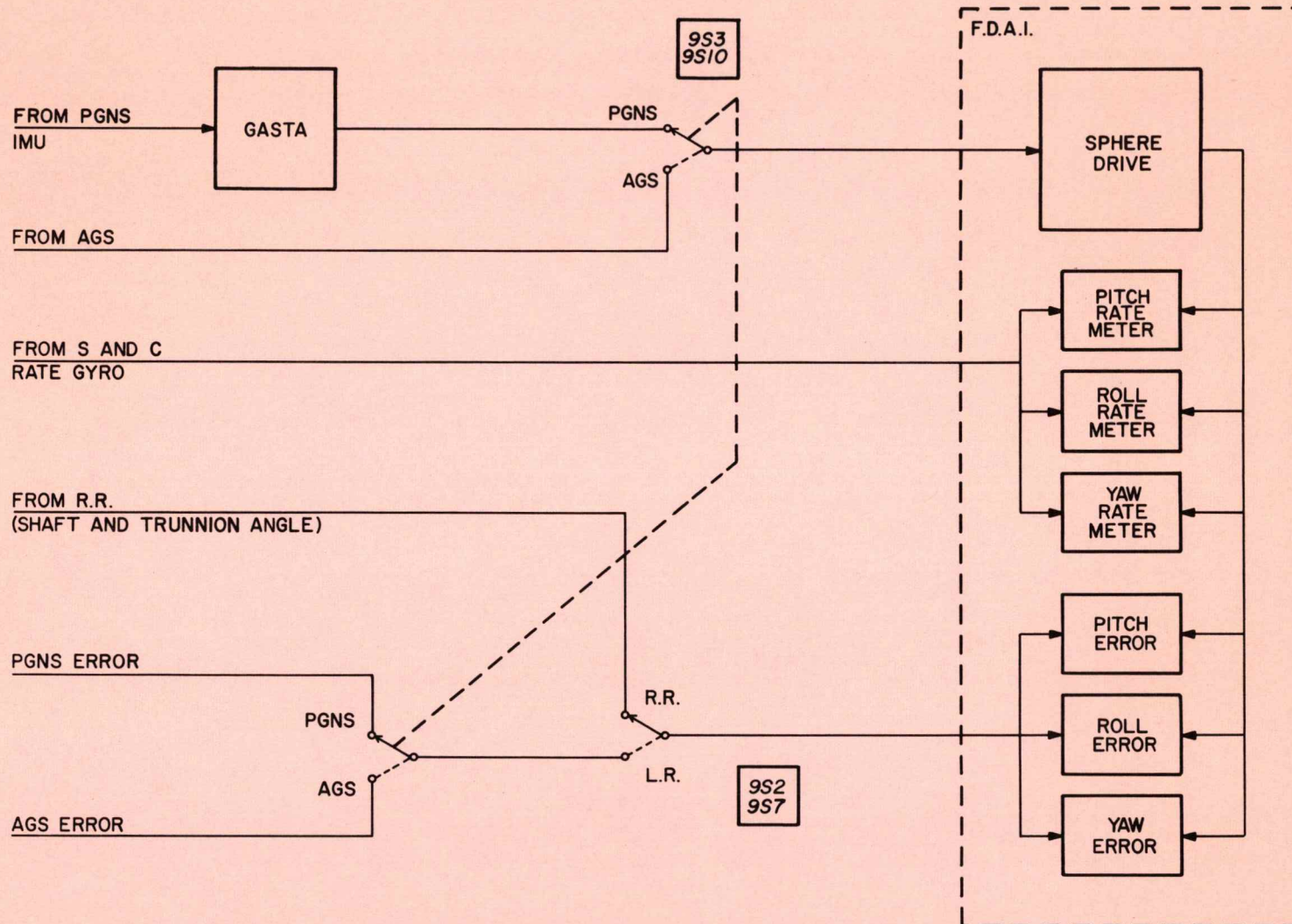


PITCH ERROR NEEDLE

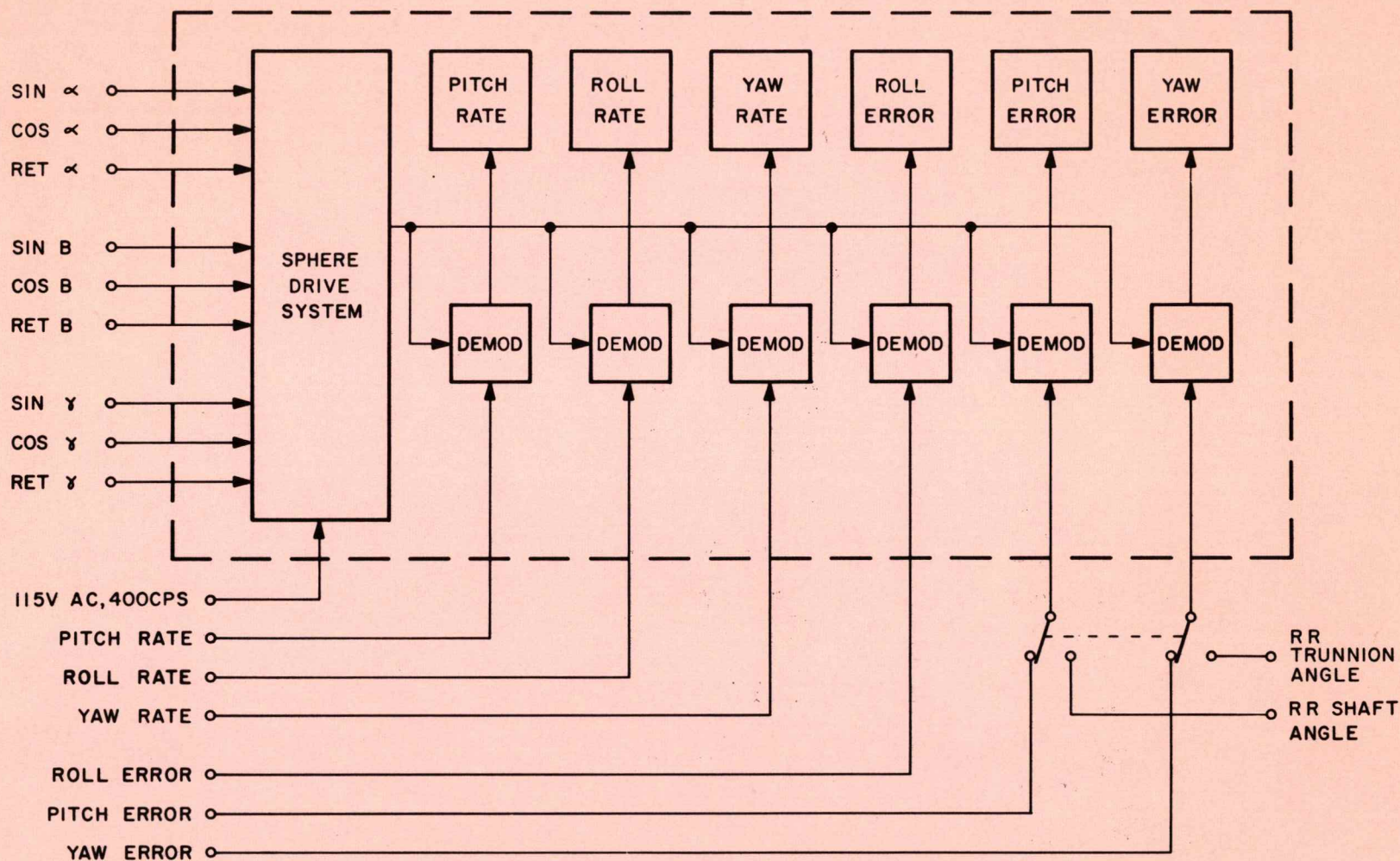
YAW ERROR NEEDLE

F.D.A.I.

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JAN 66



FLIGHT DIRECTOR ATTITUDE
INDICATOR INTERFACE BLOCK DIAGRAM



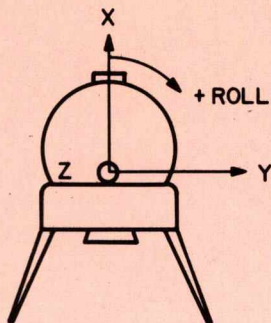
36

Fig. 1-17

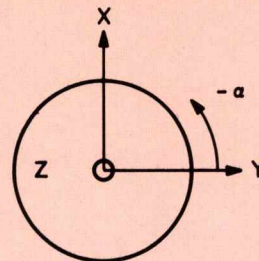
FDAI INPUT BLOCK DIAGRAM

T30900-24
NOV 65

ROLL: VEHICLE ROTATES ABOUT Z AXIS

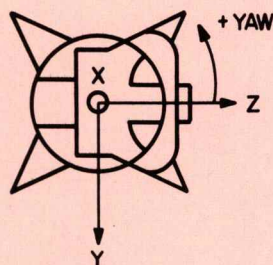


BALL ROTATES ABOUT Z AXIS, SEEN AS ROTATION ABOUT THE LINE OF VIEW.

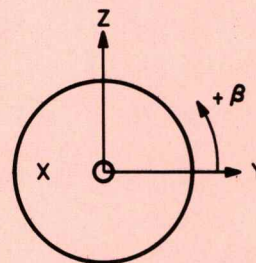


FRONT VIEW

YAW: VEHICLE ROTATES ABOUT X AXIS

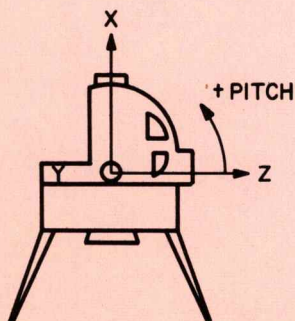


BALL ROTATES ABOUT X AXIS, SEEN AS ROTATION FROM SIDE TO SIDE.

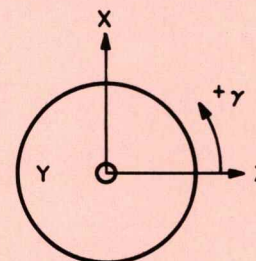


TOP VIEW

PITCH: VEHICLE ROTATES ABOUT Y AXIS



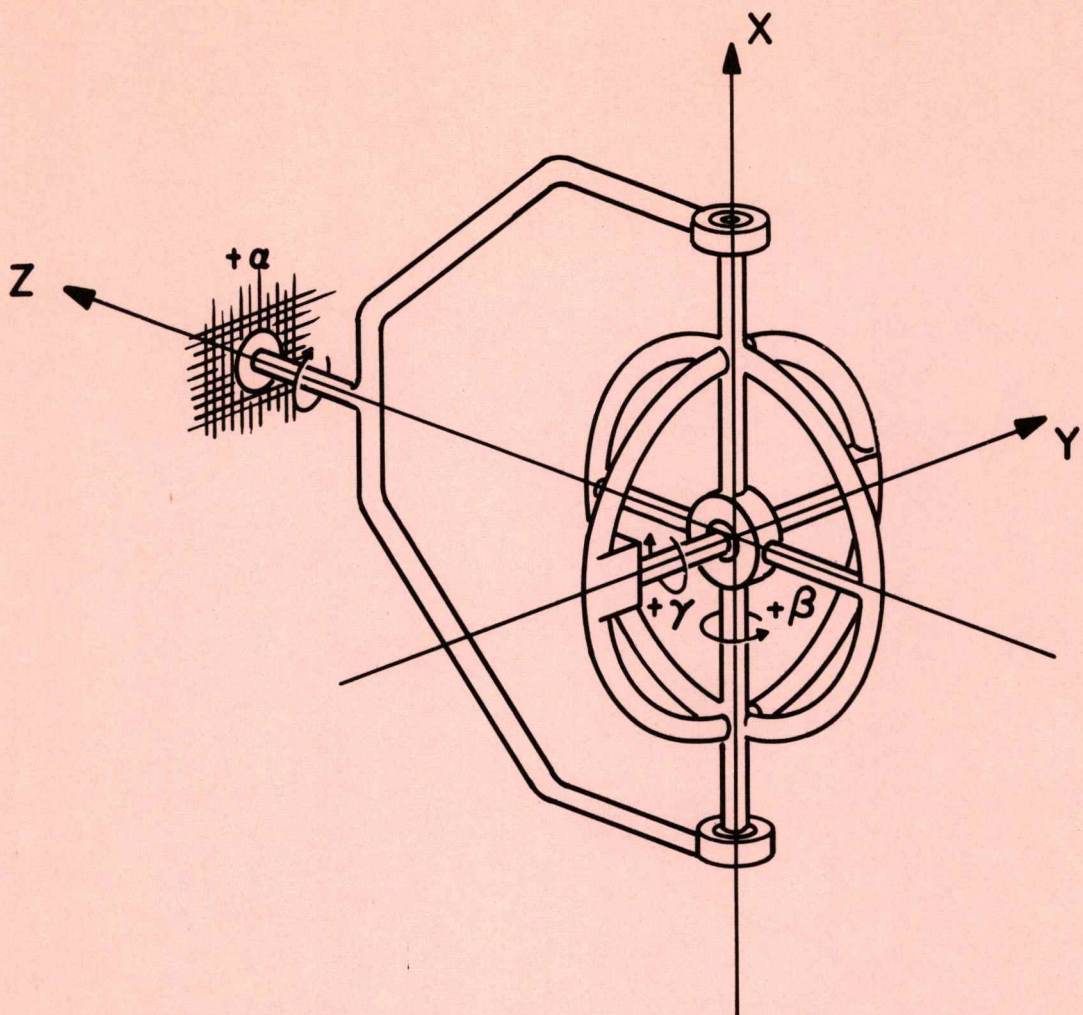
BALL ROTATES ABOUT Y AXIS, SEEN AS ROTATION FROM TOP TO BOTTOM.



SIDE VIEW

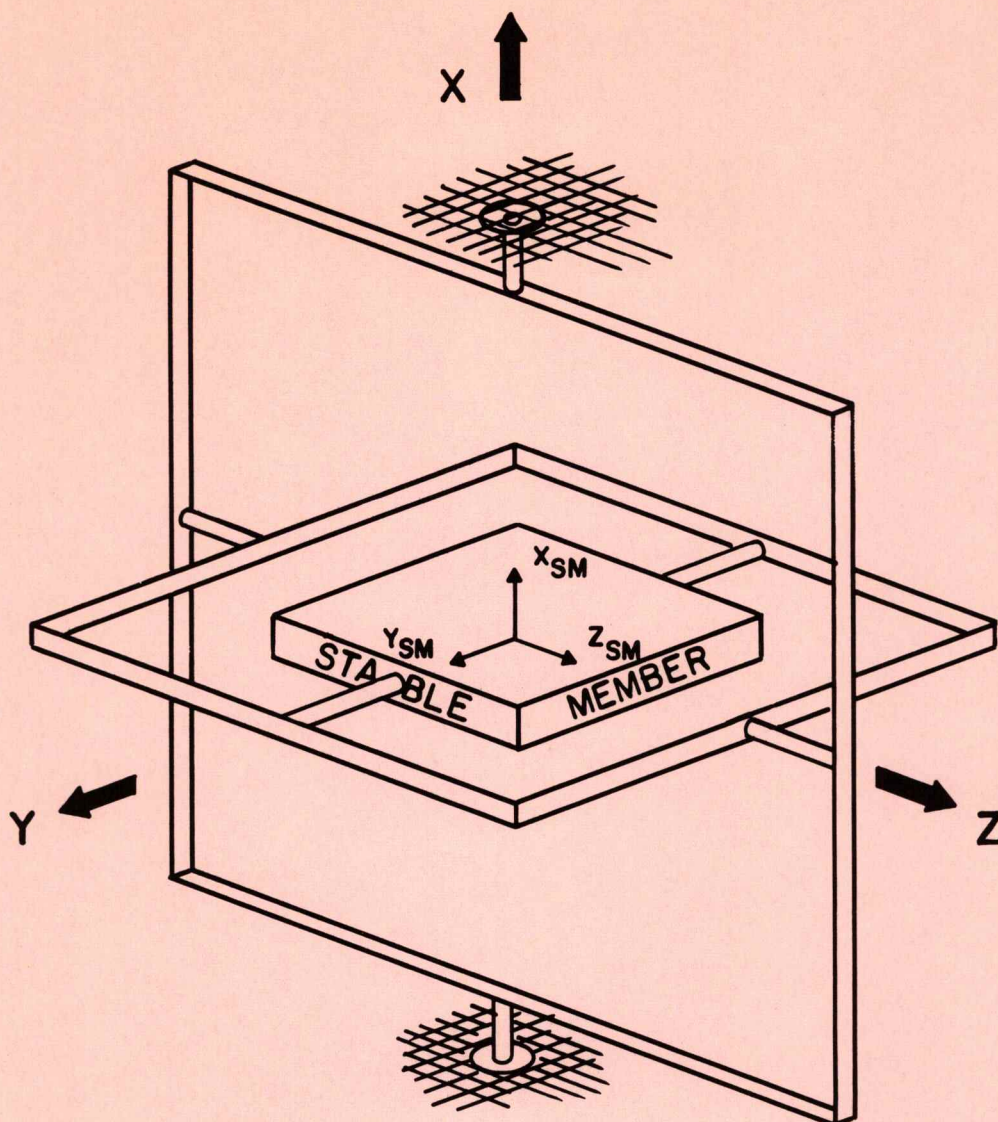
LEM ATTITUDE VARIATION
FDAI BALL ROTATION

T30900-45
DEC 65



ORIENTATION AND GIMBALLING
OF THE FDAI BALL

T30900-46
DEC 65



STABLE PLATFORM

T30900-47
DEC 65

1.5 Unique Controls

1.5.1 Thrust/Translation Controller

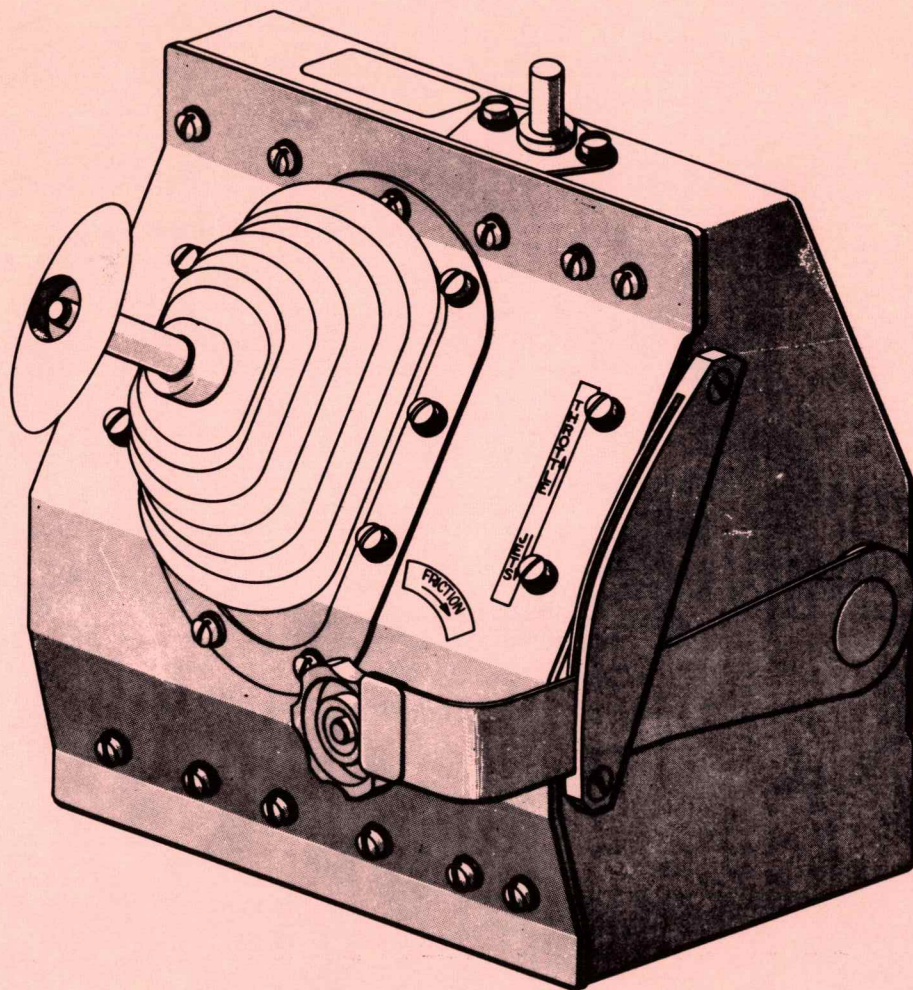
The translation controller is functionally an integrated translation and thrust controller used by the astronaut to command vehicle translations by the reaction jets and to throttle the descent engine between 10% and 100% maximum thrust magnitude. Physically, it is a three-axis, tee-handle, left-hand controller mounted with its longitudinal axis approximately 28° from a line parallel to the vehicle Z-axis. Two controllers are installed in the LEM, one available for each astronaut.

Due to the controller's mounting position, vehicle translations correspond approximately to astronaut hand motions. Motion of the controller to the left or right will command translations along the Y-axis, and movement of the controller forward or backward will result in translations along the Z-axis. To afford the integrated thrust/translation control capability, a manually operated two-position lever is located on the controller. Controller up or down motion will command translations along the X-axis when the lever is set to the JETS position. With the lever in the THROTTLE position, up or down motion results in varying the thrust magnitude of the descent engine. Regardless of lever setting, the controller has translation command capability along the Y and Z axes.

A pair of detent switches are located about each controller axis and a transducer is positioned along the longitudinal axis. The detent switches provide a discrete signal to the LGC when the astronaut moves the controller out of its neutral or detent position. The discrete signal commands the computer to issue translational change commands in accordance with the controller motion. The transducer provides an electrical output proportional to controller displacement when the lever is at the THROTTLE position. These signals are routed to the descent engine throttle servo to command proportional thrust magnitude control.

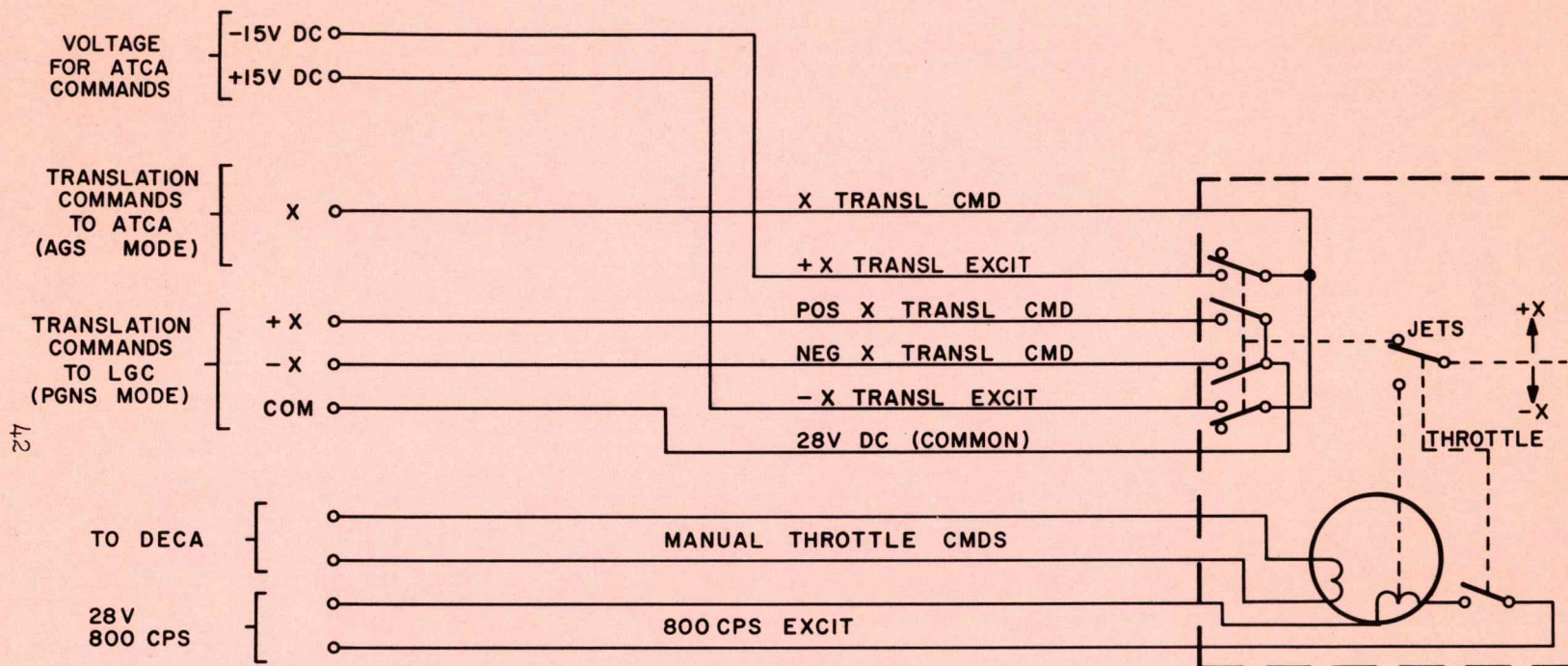
41

Fig. 1-21



TRANSLATION CONTROLLER

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DEC 64



TYPICAL THRUST / TRANSLATION CONTROL SECTION

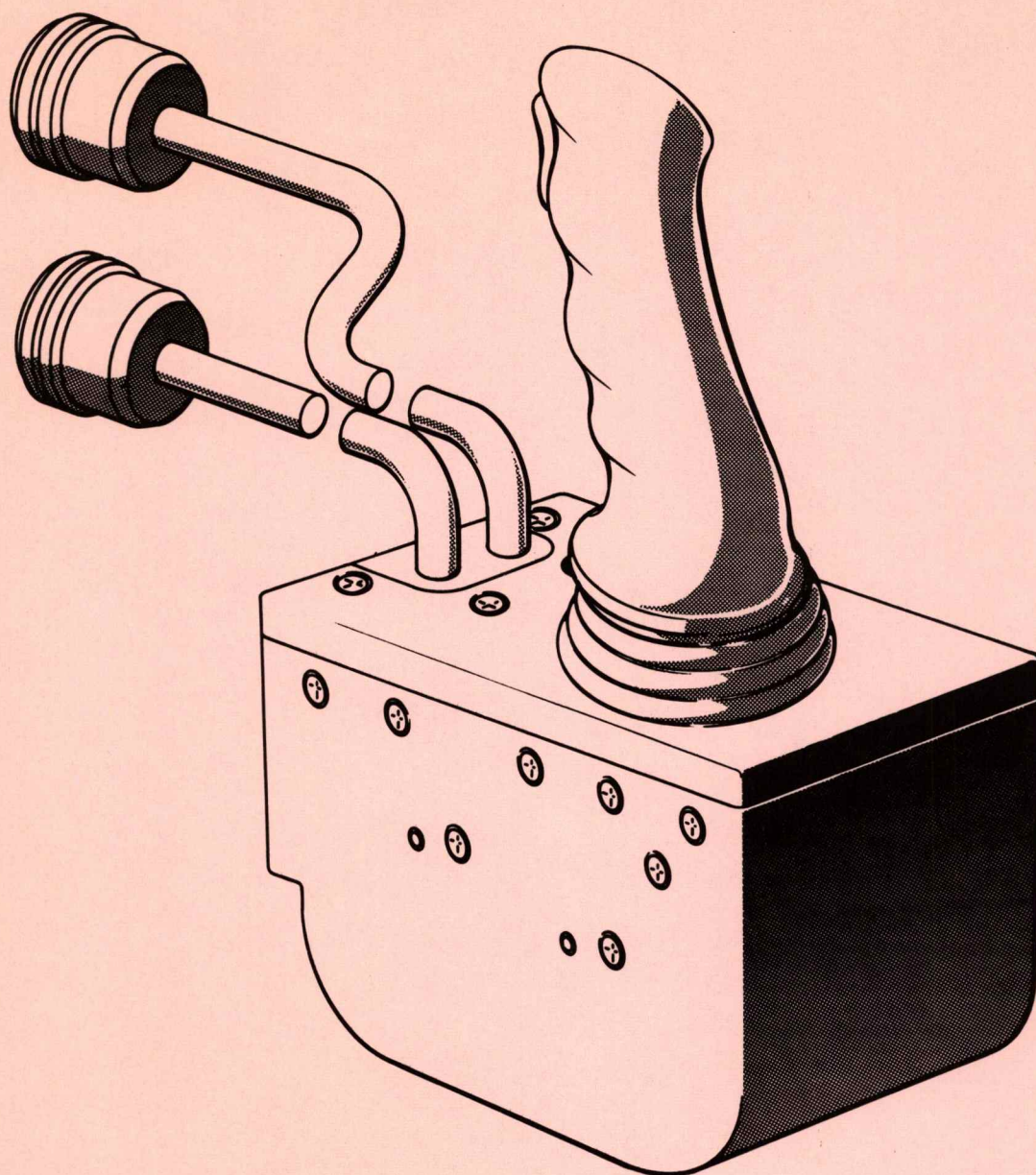
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1.5.2 Attitude Controller

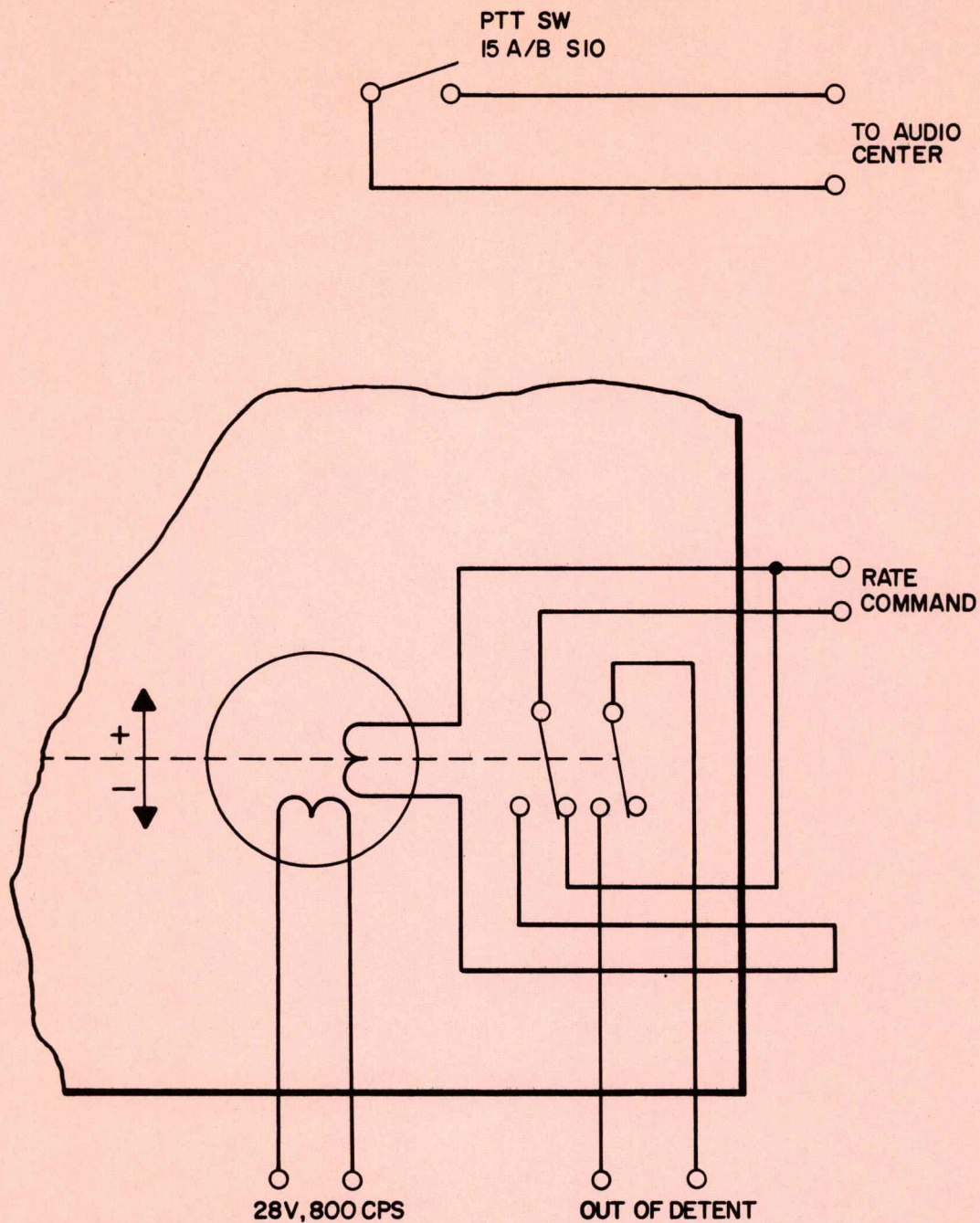
Vehicle attitude changes can be commanded manually by the use of either one of the two three-axis, pistol-grip, right-hand attitude controllers. One attitude controller is used by each astronaut. The attitude controller is installed with its longitudinal axis approximately parallel to the LEM X-axis so that vehicle rotations will correspond to astronaut hand movements. Clockwise or counterclockwise rotation of the controller about its longitudinal axis will command vehicle yaw left or yaw right rotation about the X-axis. Forward or backward movement of the controller will command vehicle pitch-down or pitch-up rotation about the Y-axis. Movement of the controller to the left or right will command a roll-left or a roll-right rotation about the Z-axis.

A position transducer, a pair of detent switches, and a pair of limit switches are located about each controller axis. The transducer provides an electrical output proportional to controller displacements and is used to command proportional vehicle angular rates. The detent switches provide a discrete signal to the LGC when the astronaut moves the controller out of its neutral or detent position. The discrete signal informs the computer to issue attitude change commands to the RCS via driver electronics in accordance with the controller displacement. Additional switches are used with the ATCA to command direct or pulsed reaction jet firing while the controller is displaced off center. The limit switches at the "hardover" position are hard-wired to the secondary RCS jet solenoids and enable the astronaut to fire the reaction jets directly, regardless of flight control mode or controlling system.

Mounted on the front of the attitude controller handle is a push button. This is the push-to-talk (PTT) switch for the astronaut's audio system.



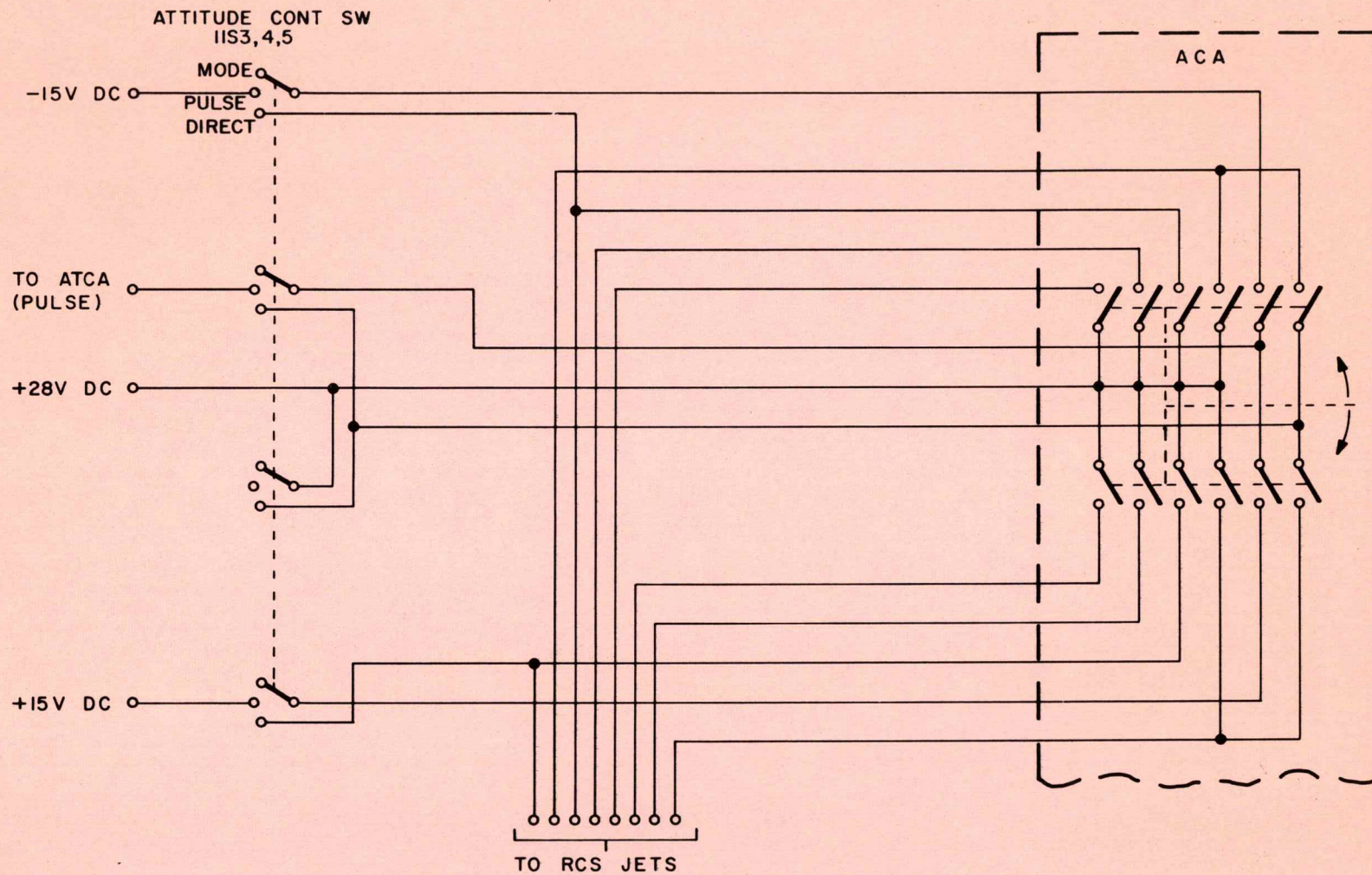
ATTITUDE CONTROLLER ASSEMBLY



TYPICAL PROPORTIONAL SECTION,
ATTITUDE CONTROL ASSEMBLY

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Fig. 1-25



TYPICAL DISCRETE ATTITUDE CONTROL SECTION

T30900-31
DEC 65

1.5.3 ECS Manual Controls

The Environmental Control Subsystem (ECS) has a bank of manual valve and regulator controls located on a unit in the rear section of the crew compartment on the System Engineer's side.

✓ 7-H-1 ATMOSPHERE REVITALIZATION
SECTION PRESSURE REGULATORS

4-Position Faucets

These controls (OPEN - NORM - EGRESS - CLOSE), in OPEN position, permit unregulated flow of oxygen into the suit circuit. The NORM position regulates oxygen flow into the suit circuit to maintain a pressure of $5.0 \pm .2$ psia. This mode is selected during normal pressurized cabin operations. The EGRESS position regulates oxygen flow into the suit circuit to maintain a pressure of $3.7 \pm .2$ psia. This mode is selected during lunar egress operations and at any other time the cabin is unpressurized. The CLOSE position prevents oxygen flow to the suit circuit. The CLOSE position is selected only when one of the regulator valves fail open. The OPEN position is selected if both the normal or egress automatic regulators have failed to supply oxygen to the suit circuit.

✓ 7-H-3 CABIN REPRESSURIZATION VALVE

3-Position Faucet

This valve (OPEN - AUTO - CLOSE), in the OPEN position, permits direct, unregulated flow of oxygen into the cabin from the oxygen manifold. The AUTO position enables the valve to respond to inputs from the cabin pressure sensor. The valve fully opens whenever cabin pressure drops past 4.6 psia, and closes as cabin pressure rises past 4.8 psia. If both 7-H-1 and 7-H-2 are in any position other than NORM or EGRESS, the automatic mode of 7-H-3 is disabled. The CLOSE position mode of 7-H-3 is disabled. The CLOSE position prevents oxygen flow into the cabin from the oxygen manifold.

- ✓ 7-H-4 PLSS FILL VALVE
2-Position Faucet
- ✓ 7-H-5 ASCENT OXYGEN VALVE
- ✓ 7-H-15 DESCENT OXYGEN VALVE
- ✓ 7-H-21 ASCENT OXYGEN VALVE
2-Position Faucets
- 7-H-6 FLOW CONTROL VALVES
- 7-H-7
3-Position Collar Controls

This valve (OPEN-CLOSE), in the OPEN position, permits flow of oxygen to the primary oxygen storage tank in the PLSS. The CLOSE position prevents flow of oxygen to the PLSS oxygen storage tank.

These valves (OPEN-CLOSE), in the OPEN position, permit flow of oxygen from their respective oxygen tank to the oxygen manifold. The CLOSE position prevents flow of oxygen. In order for the ascent oxygen valves to be placed in the OPEN position, the descent oxygen valve must be placed in the CLOSE position. A mechanical interlock is in the system to prevent ascent oxygen from flowing to the empty descent oxygen tank. In the event that the Descent O₂ valve will not close, an override of the mechanical interlock is provided so that the Ascent O₂ valve can be opened.

These controls (FACEPLATE OPEN - SUIT DISCONNECT - FACEPLATE CLOSE) are located at the junction of the suit umbilical and the ARS and are rotatable collars with three positions. They are operated in conjunction with a suit O₂ flow control mounted directly on the suit which will be referred to as the Body Flow Valve. In the FACEPLATE CLOSE position the Body Flow Valve will be in the open position, thus permitting half of the suit oxygen flow to pass directly into the body of the space suit at the waist and half of the flow to pass to the helmet and down over the astronaut's body surface and into ducts at the four suit extremities. From here, the oxygen will flow through the extremity ducts to the exhaust umbilical.

NOTE: When operating from the PLSS, the Body Flow Valve on the suit will be in the CLOSE position, thus allowing the PLSS flow to pass entirely to the helmet and then similarly as above. There will be no oxygen flow directly into the waist as before.

Code Control/Indicator

Function

NOTE: When operating from the PLSS, the Body Flow Valve on the suit will be in the CLOSE position, thus allowing the PLSS flow to pass entirely to the helmet and then similarly as above. There will be no oxygen flow directly into the waist as before.

The SUIT DISCONNECT position will prevent suit circuit oxygen flow to the space suit at the connector and the flow will bypass the suit and flow directly to the downstream portion of the suit circuit. In the FACEPLATE OPEN position the Body Flow Valve will be in the CLOSE position. The suit circuit gas flow will pass through the four extremity ducts and out into the space suit. The gas will then flow over the astronaut's body surface and out the faceplate into the cabin. 7-H-6 controls flow through the CDR's suit and 7-H-7 controls flow through the SE's suit.

7-H-8 CABIN GAS DIVERTER VALVE
2-Position "T" Handle

This control (PUSH: OPEN - PULL: CLOSE), in the PUSH:OPEN position, permits the gas flow in the suit circuit to pass into the cabin. This is done during open-face plate operation so that the suit circuit will provide sufficient air flow to maintain the oxygen level of the cabin within limits. This valve has provision for automatic closure by a signal from the cabin pressure sensor whenever cabin pressure drops below 4.6 psia. This valve will also close automatically whenever 7-H-1 and 7-H-2 are in the EGRESS position. In the PULL:CLOSE position the gas flow in the suit circuit is prevented from passing into the cabin.

7-H-9 SUIT CIRCUIT RELIEF VALVE

3-Position Faucet

This control (OPEN - AUTO - CLOSE) prevents the over pressurization of the suit circuit and the space suit. The AUTO position permits the valve to be operated by an aneroid device in response to suit circuit pressure. The valve is fully open with a suit pressure of 4.4 psia or greater, and fully closed whenever the suit pressure is less than 4.1 psia. The OPEN position manually overrides the automatic mode to open the valve fully. The CLOSE position manually overrides the automatic mode to close the valve fully.

7-H-10 WATER SEPARATOR SELECT VALVE

2-Position "T" Handle

This control (PUSH: SEP 1 - PULL: SEP 2) permits the selection of either of two water separators which separates the condensed moisture in the gas and vents this water to the primary water boiler. The PUSH: SEP 1 position selects the #1 separator and the PULL: SEP 2 position selects the #2 separator.

7-H-11 CABIN RELIEF AND DUMP VALVES

7-H-20

3-Position Bar Levers

These controls (CLOSE - AUTO - DUMP) provide the dual function of cabin depressurization and cabin pressure relief. There is one control on each LEM hatch. The normal position for this control is the AUTO position, which allows the valve to act as a pressure relief device. An aneroid sensor within the valve causes the valve to open at a pressure of 5.8 psia or greater, thus bleeding off excess cabin pressure. The CLOSE position permits manual override of the automatic position and serves to close and lock the relief valve so that no gas escape is possible in the event of failure of the automatic feature. The DUMP position also overrides the AUTO position and permits the crew to dump the cabin pressure. A squeeze trigger on the Dump Valve Control handle must be depressed to unlock the control handle before it can be moved to another

7-H-12 CABIN TEMPERATURE CONTROL VALVE
MODULATING FAUCET

position. This same dump valve, also has a two-position control handle on the outside of the hatch. This outside handle has the legend, PULL TO DUMP and is spring loaded to close. Pulling and holding the handle out for approximately 90 sec. will dump the LEM cabin pressure. This "out" position of the outside handle is comparable to the DUMP position of the inside handle. The spring loaded "in" position of the outside handle is comparable to the AUTO position of the inside handle.

This control (MAX HEAT - NORMAL - MAX COOL) is used to regulate cabin temperature through adjustment of the temperature of the glycol supplied to the cabin heat exchanger. In the NORMAL position the temperature of the glycol is automatically adjusted to maintain a cabin gas temperature of $70 \pm 5^{\circ}\text{F}$. Should cabin temperature exceed these limits or should a lower or higher temperature be desired, movement of the control in either the MAX COOL (clockwise) or MAX HEAT (counterclockwise) direction will automatically divert glycol of higher or lower temperature respectively into the coolant flow by changing the set point for regulation.

7-H-13 DRINK WATER VALVE
2-Position Faucet

This control (OPEN - CLOSE) is used to control water flow for drinking and food preparation. The OPEN position supplies water to the water hose and the CLOSE position prevents water flow to the water hose.

- 7-H-14 WATER TANK SELECT VALVE
3-Position Fold-Out Hand Crank

This control (DES - ASC - EMER) in the DES position selects the descent water tank to provide water for the primary water boilers, and for the PLSS and DRINK WATER VALVES for the period between manning and pre-lunar ascent. Upon manning, the primary water feed valve is opened allowing water from the descent tank to flow to the primary water boilers. The ASC position selects both ascent water tanks to provide water to primary boilers and water valves. To place 7-H-14 in the EMER position a safety trigger near the handle must be manually tripped. This position: (1) prevents all water flow from water tanks to the primary water boilers, and water valves (2) diverts all water from the water separators to the emergency water glycol boilers and (3) ruptures the water isolation valve disc, thus providing an accumulator action for the emergency coolant system loop.

- 7-H-16 EMERGENCY SUIT BOILER VALVE
2-Position Faucet

This control (OPEN - CLOSE) provides an emergency means of cooling the suit circuit. In the OPEN position this valve allows water to flow to the emergency suit water boiler. The CLOSE position prevents flow of water to the boiler and is the normal position for this valve.

- 7-H-17 CABIN GAS RETURN VALVE
3-Position Faucet

This control (OPEN - AUTO - CLOSE) provides for the return of cabin gas back into the suit circuit under normal operations or provides suit circuit integrity under rapid cabin decompression. In the OPEN position cabin gas is fed back into the suit circuit for revitalization. The AUTO position allows gas flow into, but not out of, the suit circuit. This is accomplished through the use of a one way check valve. The CLOSE position provides an override of the one way check valve, thus insuring suit circuit integrity during unpressurized cabin operations.

7-H-18 EMERGENCY GLYCOL BOILER VALVE

2-Position Faucet

This control (OPEN - CLOSE) provides a flow of water to the emergency glycol water boiler to maintain temperature limits for the emergency glycol loop. The OPEN position permits full water flow to the boiler. The CLOSE position prevents water flow to the emergency glycol water boiler and is the normal position for this valve.

7-H-19 CO₂ CANISTER SELECT VALVE

2-Position Bar Lever

This control (PRIMARY - SECONDARY), in the PRIMARY position, allows the suit circuit gas to be filtered through the primary LiOH canister thereby removing CO₂ and noxious gases from the suit circuit gas. Selecting the SECONDARY position permits the suit circuit gas to be filtered through the secondary LiOH canister while changing the primary canister.

7-H-22 SUIT TEMPERATURE CONTROL VALVE

Modulating Faucet

This control (DECREASE - INCREASE) permits the regulation of suit circuit temperature by varying the temperature of glycol through the heat exchanger. When the handle is turned in the INCREASE direction (clockwise), glycol of higher temperature is diverted to the suit regenerative heat exchanger in order to increase suit circuit gas temperature. Turning the handle in the DECREASE direction (counterclockwise) diverts glycol of a lower temperature to the suit regenerative heat exchanger in order to decrease suit circuit gas temperature.

7-H-23 PRIMARY CANISTER VENT BUTTON

7-H-24 SECONDARY CANISTER VENT BUTTON
MOMENTARY PUSHBUTTON

These pushbuttons (PUSH - TO VENT) are associated with the primary and secondary LiOH canisters respectively. When the button is depressed the gas within a canister is vented thus diminishing the internal pressure within the canister and facilitating removal of the canister from the suit circuit. Note: 7-H-19 must be placed to the opposite canister position from the one which is to be replaced before the push-to-vent pushbuttons should be actuated.

7-H-25 PRIMARY WATER FEED

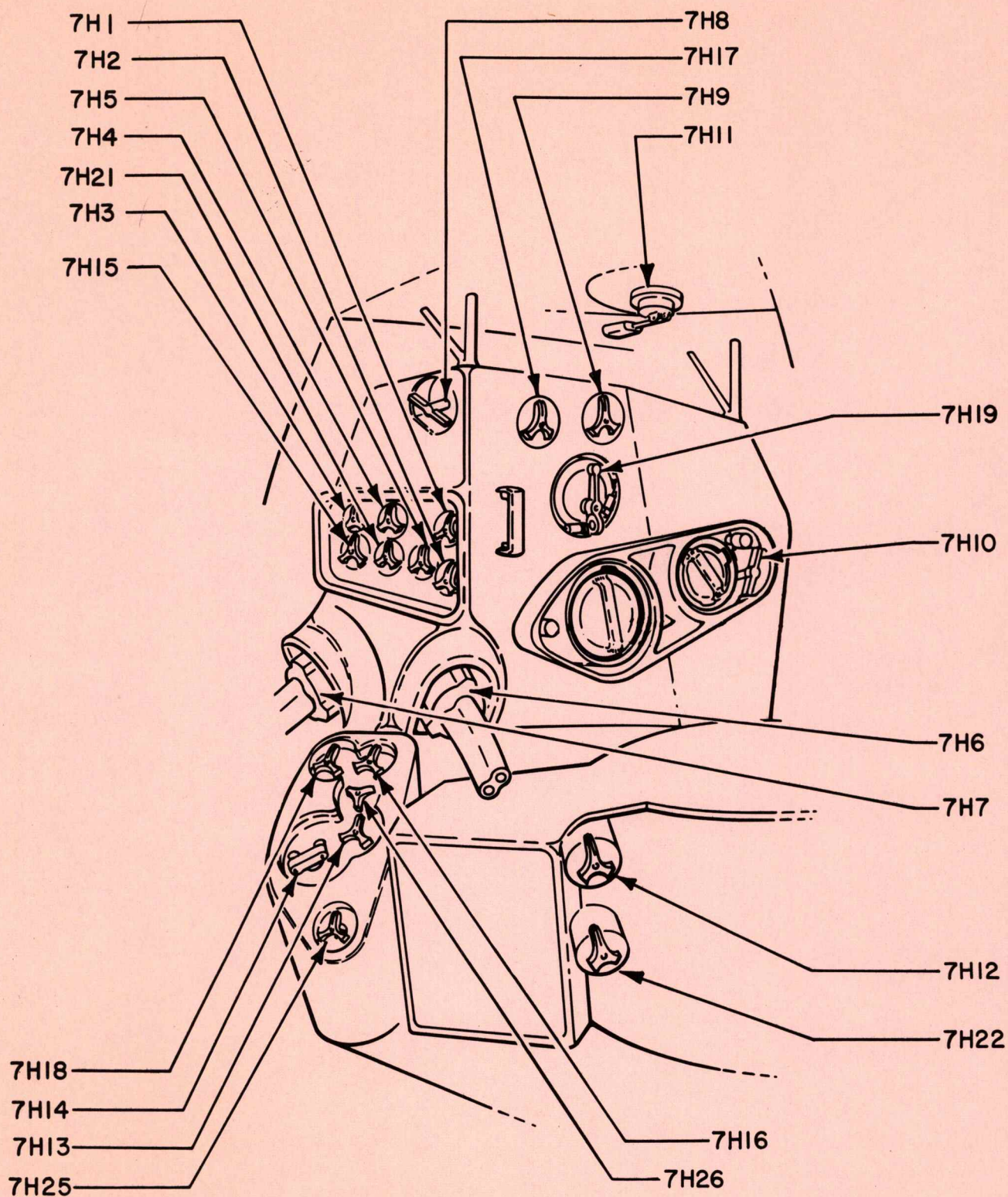
2-Position Faucet

This control permits the flow of water from the water manifold to the primary water boiler. When the LEM is first manned, the valve is placed in the OPEN position, thus permitting water feed to the primary water boiler. Placing the valve in the CLOSE position will shut off the flow of water to the primary water boiler.

7-H-26 PLSS WATER VALVE

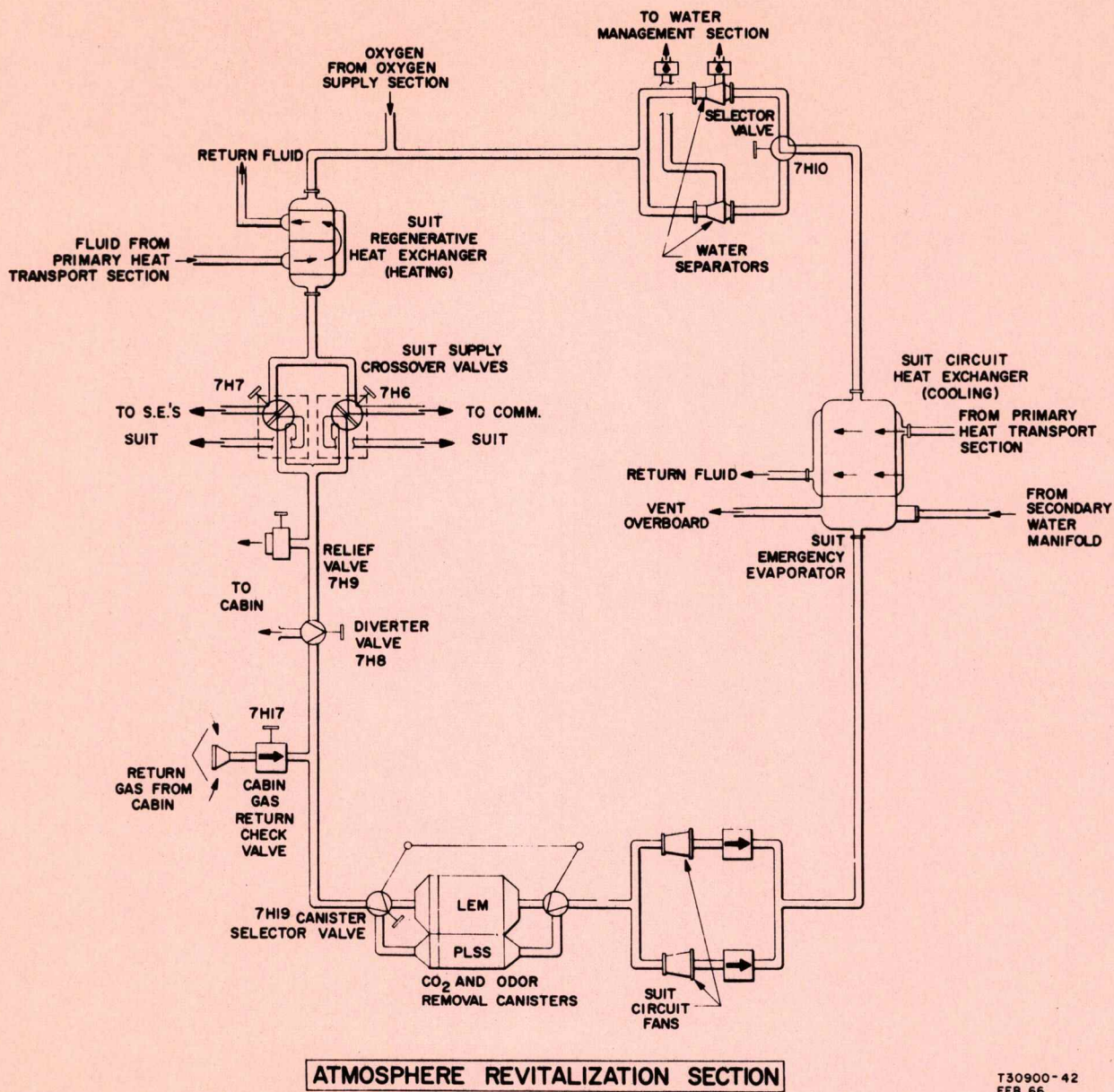
2-Position Faucet

This control (OPEN - CLOSE) supplies water for PLSS recharging directly at unregulated descent water tank pressure. The OPEN position supplies water to the hose and the CLOSE position prevents water flow to the hose.

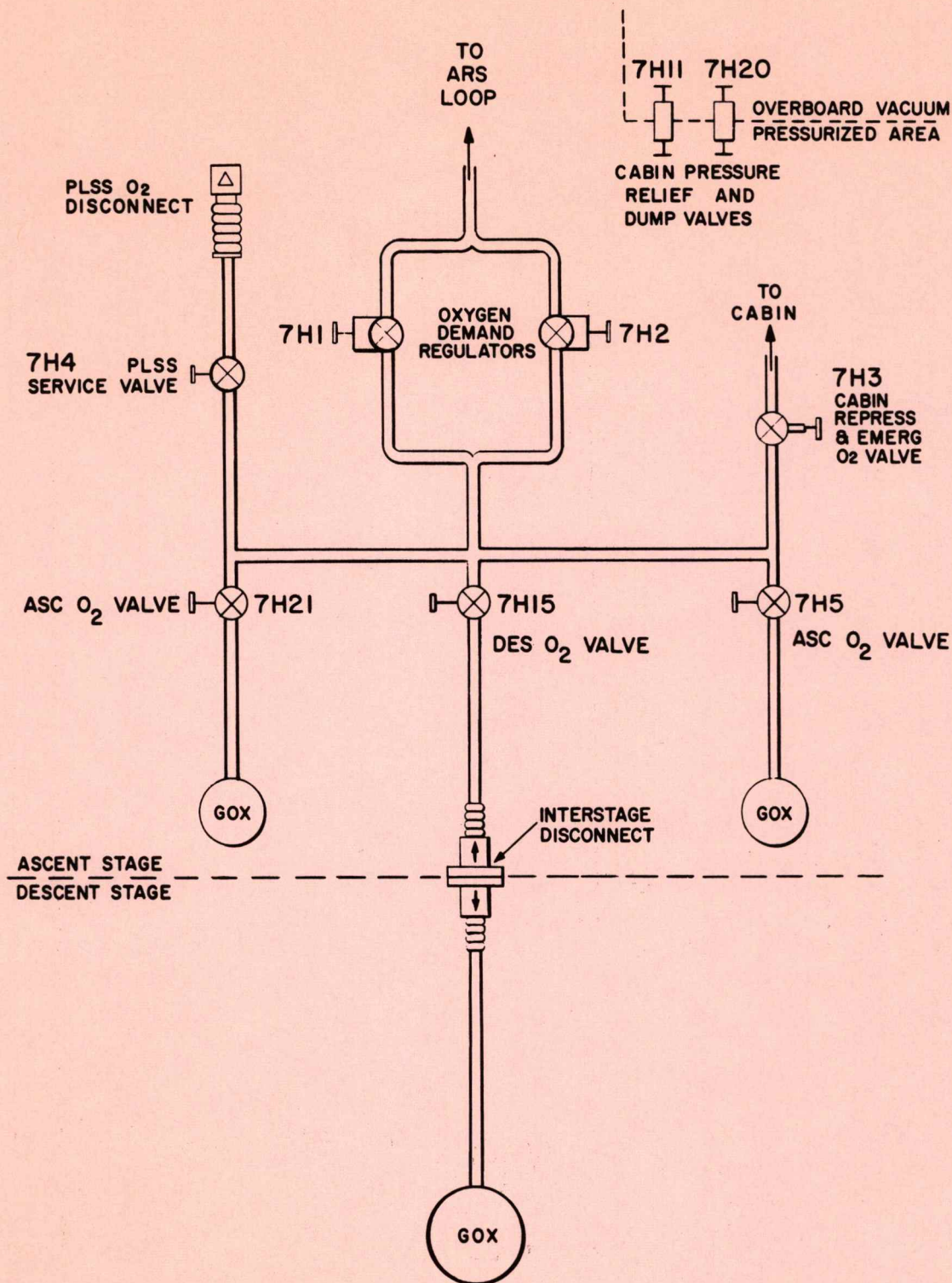


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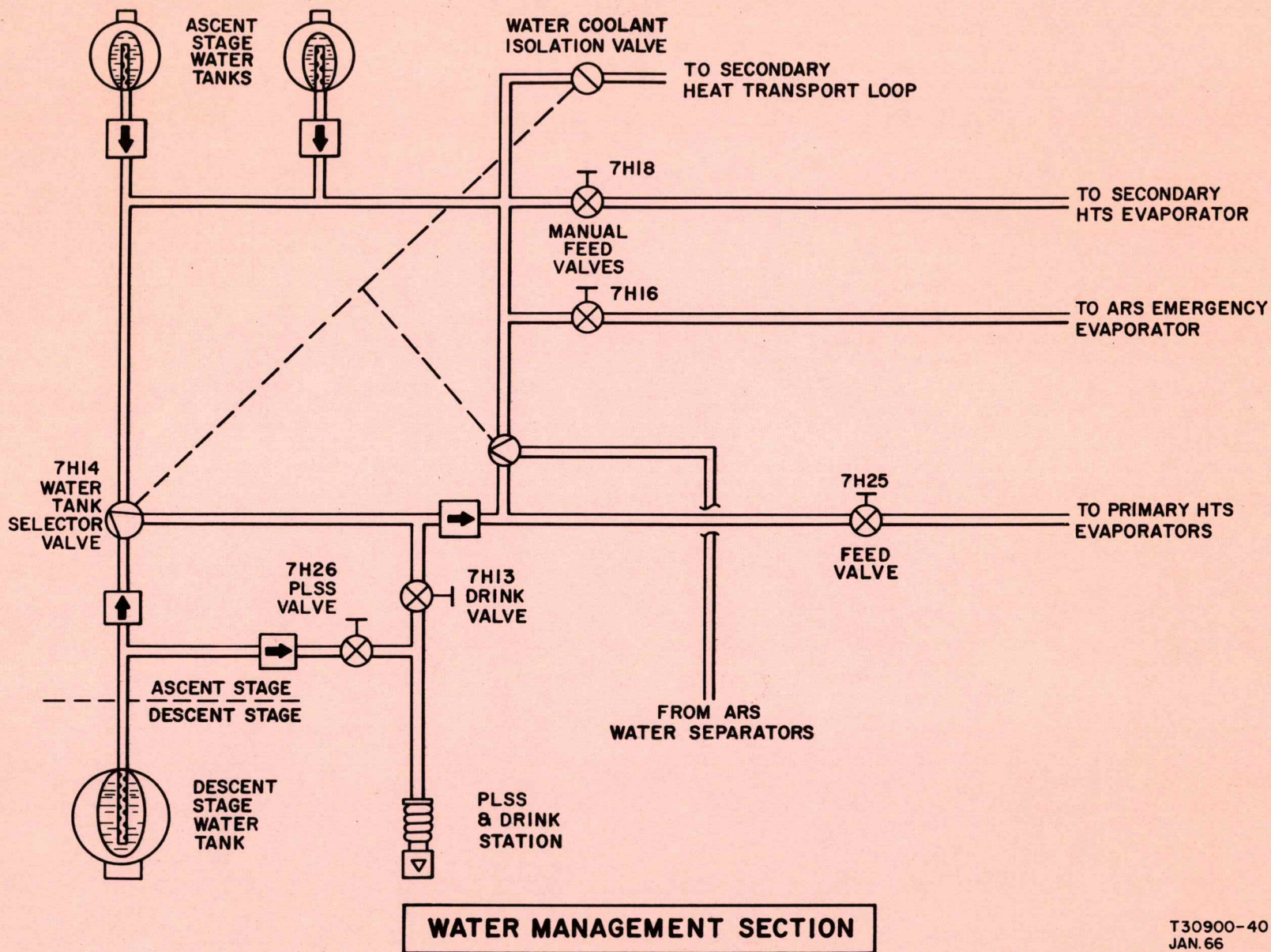


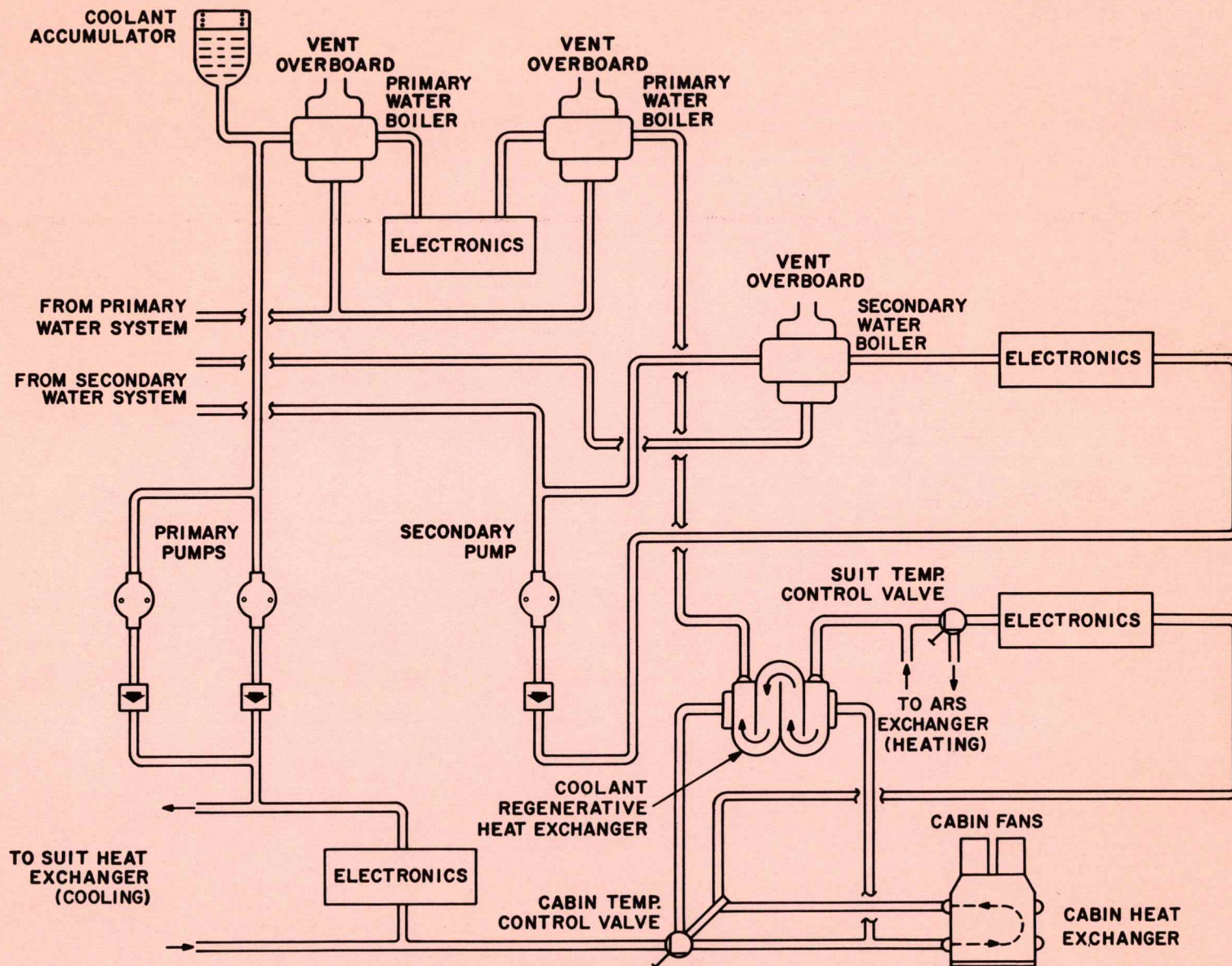
**OXYGEN SUPPLY AND CABIN PRESSURE
CONTROL SECTION**

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Fig. 1-29





HEAT TRANSPORT SECTION

1.5.4

Alignment Optical Telescope (AOT)

The Alignment Optical Telescope (AOT) is a unity power 60 degrees field-of-view optical instrument similar to a periscope. The AOT is operated manually by the astronauts with mark commands initiated by the astronauts while viewing stars through the AOT. The AOT line-of-sight may be rotated to one of three viewing positions with a fourth position used for storage. The AOT is mounted in the forward part of the LEM with the shaft axis parallel to the LEM X axis and the center of the field-of-view approximately 45° above the X axis and 60° to either side of the Z axis or on the XZ plane. The purpose of the AOT is to provide angular data from star sightings for use in stable platform alignment via the LGC to a reference coordinate system.

Mounted to the right side of the AOT is the computer control and reticle dimmer assembly. Located on this control box is a thumbwheel which provides the astronaut the capability of adjusting the brightness of the AOT reticle light when taking a star sighting. The MARK-X and MARK-Y pushbuttons are also located on this assembly and are used by the astronaut to send discrete signals to the LGC when making star sightings for an IMU inflight alignment. A REJECT pushbutton is also available should an invalid mark discrete be sent to the LGC.

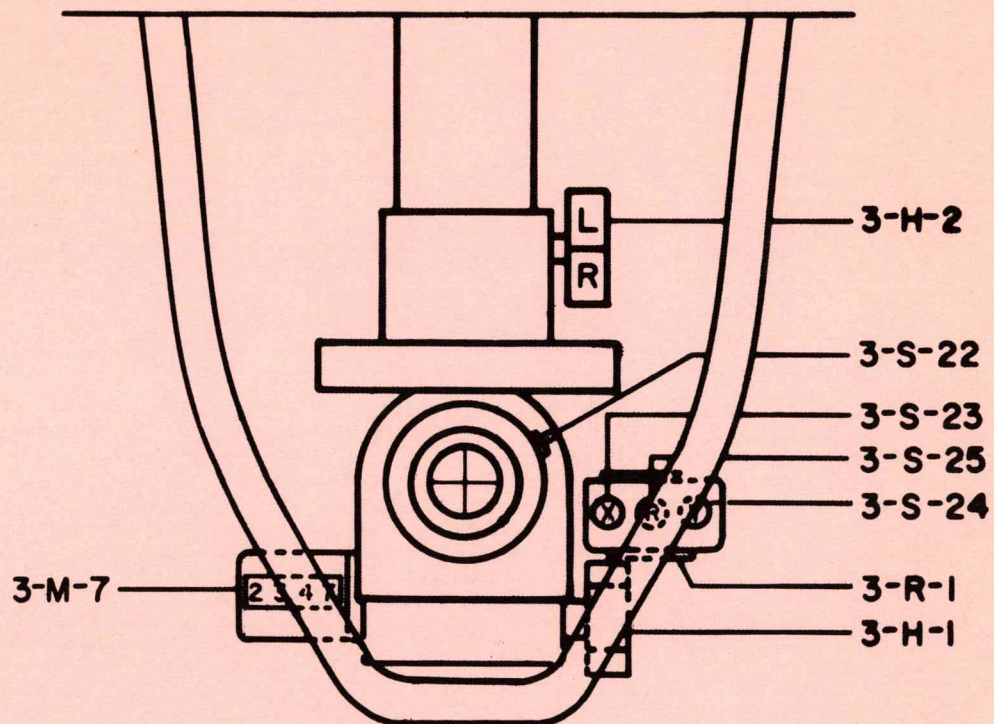
- | | | |
|--------|------------------------------|--|
| 3-S-22 | EYEPiece ADJUST LEVER | This lever moves the eyepiece toward or away from the eye of the observer. |
| 3-S-23 | MARK X SWITCH | Depression of this pushbutton sends a signal to the LGC indicating that the star is aligned on the X reticle position. |
| 3-S-24 | MARK Y SWITCH | Depression of this pushbutton sends a signal to the LGC indication that the star is aligned on the Y reticle position. |
| 3-S-25 | MARK REJECT SWITCH | Depression of this pushbutton sends a signal to the LGC indicating that the last Mark signal was incorrect and no action is to be taken until a new Mark signal is received. |
| 3-R-1 | RETICLE ILLUMINATION CONTROL | This continuous rotary (OFF-BRIGHT) controls the brightness of the AOT reticle. |
| 3-H-1 | RETICLE CONTROL | This continuous rotary control associated with 3-M-7 rotates the AOT Reticle in order to measure the elevation angle of a star. |

3-H-2 AZIMUTH CONTROL

This six-position rotary switch (LR - L - F - R - RR - CL) controls the rotating prism. The prism can be rotated to cover any of five 60° sectors from left rear (LR), left (L), forward (F), right (R) and right rear (RR). In the CL position, the rotating prism is stowed under a protective cover.

3-M-7 AOT COUNTER

This four-digit indicator displays, in degrees, the rotation of the Reticule Control Knob. The extreme right digit displays tenths of degrees.



ALIGNMENT OPTICAL TELESCOPE

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1.6 Controls & Displays Panel and Function Reference

1.6.1 Panel I - (Engine/Thrust Control)

<u>Code</u>	<u>Control/Indicator</u>	<u>Function</u>
1-S-1	ENGINE ARM SWITCH 3-POSITION TOGGLE LOCK-LOCK-LOCK	This three-position toggle (ASC - OFF - DES) provides arming signals to the engines. The ASC position provides an arming signal enabling firing of the ascent engine while simultaneously signalling the LGC that the engine is armed. In the OFF position the arming signals are removed from the engine valves and the LGC. In the DES position the descent engine is armed and the LGC is notified that the engine is armed. However, regardless of the position of this switch, the appropriate engine will be armed if 1-S-13 or 1-S-14 are actuated.
1-S-6	X-TRANSLATION SWITCH 2-POSITION TOGGLE MAIN-MAIN	This two-position toggle (4 JETS - 2 JETS) selects the number of jets that will be utilized in X-axis translation maneuvers. This control can only be used with the AGS system.
1-S-9	BALANCED COUPLES SWITCH 2-POSITION TOGGLE LOCK-LOCK	This two-position toggle (ON-OFF) selects either balanced pairs of RCS jets in a couple or unbalanced X-axis RCS jets for use in maintaining pitch and roll attitude during the ascent engine thrust phase when the AGS is in the guidance loop. This switch is normally in the ON position (balanced couples) during the initial phases of lunar ascent. This provides maximum stabilization and control over any center of gravity thrust vector misalignment. After some minimum burn time (to be determined) when the balanced couples operation is no longer required, the switch can be positioned to OFF to conserve fuel.

<u>Code</u>	<u>Control/Indicator</u>	<u>Function</u>
1-S-10	MANUAL THROTTLE SWITCH 2-POSITION TOGGLE LOCK-LOCK	This two-position toggle (CDR -SE) selects the controller which will be used for manual descent engine thrust level adjustment if its corresponding select lever is in the THROTTLE position. Thus, in the CDR position, only the Commander's Controller is enabled to adjust descent engine thrust level, and in the SE position only the Systems Engineer's Controller is enabled.
1-S-11	THRUST CONTROL SWITCH 2-POSITION TOGGLE LOCK-LOCK	This two-position toggle (AUTO - MAN) provides the capability of switching from automatic throttle control (LGC) to manual throttle control. In the AUTO position, LGC command signals are summed with the manual command signals of the throttle selected by 1-S-10 for descent engine throttle control. Only the LGC command signals are displayed on the Thrust indicator (9-M-7). In the MAN position LGC throttle command signals to the descent engine are interrupted. The display shows manual throttle commands; and the descent engine throttle is fed only by the manual throttle command signals.
1-S-13	ABORT SWITCH GUARDED PUSHBUTTON MAINTAIN	This pushbutton is activated to initiate an abort using the descent engine. Activation of this switch causes the following events to occur at the appropriate time: (a) a command signal is sent to arm the descent engine, (b) a signal is sent via instrumentation to telemetry indicating that the vehicle is preparing for an abort, and (c) a signal is sent to the LGC and AGS to compute and execute the abort trajectory by using the abort program.

<u>Code</u>	<u>Control/Indicator</u>	<u>Function</u>
1-S-14	ABORT STAGE SWITCH GUARDED PUSHBUTTON MAINTAIN	This pushbutton is activated to initiate an abort using the ascent engine. Activation of this switch will cause the following events to occur at the appropriate times: (a) a command signal is sent to the electro-explosive devices to pressurize the ascent engine, (b) a signal is sent to the LGC and AGS to compute and execute the abort trajectory using the abort stage program, (c) a signal is sent via instrumentation to telemetry indicating that the vehicle is preparing to stage for an abort, (d) the descent engine is shut down, and (e) an ASCENT ENGINE ON command is enabled which in turn fires the appropriate electro-explosive devices to initiate vehicle staging. At the same time the LGC will turn on the ascent engine and signal telemetry via the serial down-link that the ascent engine has been started. At some point in the Abort Stage sequence, electrical power is transferred automatically from descent batteries to ascent batteries.

Panel I - (Flight Control)

<u>Code</u>	<u>Control/Indicator</u>	<u>Function</u>
9-S-1	ELAPSED TIMER SHAFT/ STOP PUSHBUTTON MOMENTARY	Depression of this pushbutton will (a) stop the Elapsed Timer (9-M-10), (b) engage the setting gears (enable 9-S-15), and (c) set the seconds hand at "0". Depressing the button again will start the timer.

<u>Code</u>	<u>Control/Indicator</u>	<u>Function</u>
9-S-2	RATE ERR MON SWITCH (CDR) 2-POSITION TOGGLE MAIN-MAIN	This two-position toggle (RNDZ RADAR - LDG RDR/COMPTR) enables signal inputs to the FDAI and the X-Pointer displays. In the RNDZ RADAR position, shaft and trunnion angles from the Rendezvous Radar are displayed on the pitch and yaw error needles of the FDAI, and LOS Azimuth and Elevation rates are displayed on the X-Pointer display, (illuminating LOS AZ and LOS ELEV). In the LDG RDR/COMPTR position, vehicle attitude errors are displayed on the FDAI error needles and forward and lateral velocities are displayed on the X-Pointer display, (illuminating LAT VEL and FWD VEL) 9-S-2 enables inputs to 9-M-1 and 9-M-2.
9-S-3	ATTITUDE MON SWITCH (CDR) 2-POSITION TOGGLES MAIN-MAIN	This two-position toggle (PGNS - AGS) selects the source of Attitude data to be displayed on the FDAI. In the PGNS position, vehicle total Attitude signals (after conditioning by GASTA) are sent to the FDAI ball and LGC Attitude error signals are sent to the FDAI pitch roll and yaw error needles. In the AGS position, the AGS total vehicle attitude signals are sent to the FDAI ball and AGS attitude error signals are sent to the FDAI pitch, yaw and roll error needles. 9-S-3 enables signals to 9-M-1.
9-S-4	ALT/RNG MON SWITCH 2- POSITION TOGGLE MAIN-MAIN	This two-position toggle (RNG/RNG RT - ALT/ALT RT) selects the display legend on 9-M-9 and Rendezvous Radar range and range rate data or landing altitude and altitude rate data to be displayed. In the RNG/RNG RT position Rendezvous Radar range and rate data is sent to the display. In the ALT/ALT RT position data from whatever source is selected by 9-S-9 will be sent to the display.

<u>Code</u>	<u>Control/Indicator</u>	<u>Function</u>
9-S-6	GUID CONT SWITCH 2-POSITION TOGGLE LOCK-LOCK	This two-position toggle (PGNS - AGS) selects either PGNS or AGS for guidance control of the LEM.
9-S-8	SHFT/TRN SWITCH 2-POSITION TOGGLE MAIN-MAIN	This two-position toggle ($\pm 50^\circ$ - $\pm 5^\circ$) selects the range of rendezvous radar shaft and trunnion angles to be displayed on the pitch and yaw error needles of the FDAI. In the $\pm 50^\circ$ position a full deflection of the FDAI pitch and yaw needles indicates shaft and trunnion angles of $\pm 50^\circ$ (or greater). In the $\pm 5^\circ$ position a full deflection of the FDAI pitch and yaw error needles indicate shaft and trunnion angles of $\pm 5^\circ$ (or greater). Less than full deflection needle positions are linearly proportional to shaft and trunnion angles of less than $\pm 50^\circ$ or $\pm 5^\circ$ respectively.
9-S-9	MODE SEL SWITCH 3-POSITION TOGGLE MAIN-MAIN-MAIN	This three-position toggle (LDG RADAR - PGNS - AGS) selects radar or computer data for display on 9-M-2, 9-M-3, and 9-M-9. In the LDG RADAR position radar Altitude, Altitude Rate, Forward and Lateral Velocity data are enabled for display. In the PGNS position LGC computed Altitude, Altitude Rate, and Forward Lateral Velocity are displayed. In the AGS position AGS computed Altitude, Altitude Rate and Lateral Velocity data are enabled for display. The data from the source selected by 9-S-9 are displayed on the X-Pointers only when 9-S-2 and 9-S-7 are in the LDG RDR/CMPTR position respectively. When 9-S-2 and 9-S-9 are in the RNDZ RADAR position, no inputs from 9-S-9 are accepted to the X-Pointers. Data from the source selected by 9-S-9 is displayed on the Altitude/Range Indicator only when 9-S-4 is in the ALT/ALT RT position. When 9-S-4 is in the RNG/RNG RT position, no inputs from 9-S-9 are accepted to the Altitude/Range Indicator.

<u>Code</u>	<u>Control/Indicator</u>	<u>Function</u>
9-S-15	ELAPSED TIMER SET SWITCH TWO CONCENTRIC FINGER TIP CONTROLS	These concentric controls are used to adjust the hour hand (outer control) and the minute hand (inner control) of 9-M-10. One revolution of the outer control turns the hour hand 15 hours. One revolution of the inner control turns the minute hand 60 minutes. The hands of this Elapsed Timer can be set in either a clockwise or counterclockwise direction.
9-M-1	FLIGHT DIRECTOR ATTITUDE INDICATOR (CDR)	This indicator displays: (1) Vehicle Attitude, Attitude Rates and Attitude Errors or (2) Vehicle Attitude, Attitude Rates and Rendezvous Radar Shaft and Trunnion angles, depending upon the position of 9-S-2. The position of 9-S-3 will select either PGNS or AGS as the source of displayed vehicle Attitude and Attitude errors for 9-M-1. The attitude rate information displayed on the three meters surrounding the ball is always obtained from the CES rate gyros. The shaft and trunnion angles are displayed respectively on the pitch and yaw error needles of 9-M-1 when 9-S-2 is in the RNDZ RADAR position.
9-M-2	X-POINTER (CDR)	This indicator displays: (1) Forward and Lateral Velocities, (2) Lateral Velocities only or (3) Rendezvous Radar LOS Elevation and Azimuth Angular Rates. What is displayed on 9-M-2 is a function of the position of 9-S-2 and 9-S-9. Forward and lateral velocities are measured in the horizontal plane along the LEM Z and Y body axes when the source driving the display is the PGNS. When the landing radar is the driving source the forward and lateral velocities are coincident with LEM Z and Y body axis velocities. When the AGS system is the driving source, lateral velocity is the only information displayed and is vehicle Y body axis velocity.

<u>Code</u>	<u>Control/Indicator</u>	<u>Function</u>
9-M-4	THRUST WEIGHT INDICATOR	This indicator is a self-contained accelerometer which displays instantaneous X-axis acceleration in lunar "g" units (1 "g" = 5.23 ft/sec ²). The instrument may be used to provide a gross check on engine performance since any given throttle setting will provide a specific acceleration when the vehicle has a given mass.
9-M-7	THRUST INDICATOR	This indicator displays descent engine chamber pressure (left pointer), or manual throttle commands or LGC thrust commands (right pointer) as switched by 1-S-11. If the manual mode is selected by 1-S-11, then the right pointer will indicate either the CDR's or SE's throttle commands depending on the position of the Manual Throttle Select (1-S-10). The display range is 0-100% thrust. Under normal operation of LGC command authority both pointers will be aligned at the same scale reading. A divergence between needle settings will indicate a malfunction or that the manual throttle authority is being introduced to enable a smooth transition to full manual control. If the latter is true, then the Thrust Control switch (1-S-11) will be switched to MAN when the LGC thrust command pointer reaches 10% thrust. After switching to MAN, both pointers should be aligned if the system responds correctly.
9-M-9	ALTITUDE/RANGE INDICATOR	This indicator will display either Range/Range Rate information or Alt/Alt Rate information as selected by 9-S-4. The Range/Range Rate data are from the Rendezvous Radar. The Altitude/Altitude Rate information is from one of three sources; the Landing Radar, PGNS or AGS as selected by 9-S-9. When Landing Radar information is selected, true altitude

9-M-9

rate data are available if the LEM X axis is verticle. When either PGNS or AGS is selected inertially derived altitude and altitude rate data are available for display.

9-M-10

ELAPSED TIMMER
3-POINTER CLOCK

This meter will display time (up to 60 hours) in hours, minutes and seconds and is controlled by 9-S-1 and 9-S-15.

9-M-11

EVENT TIMER INDICATOR
4-PLACE DIGITAL DISPLAY

This four digit indicator displays time in minutes and seconds. It is capable of counting up or down. The maximum time displayed is 59 minutes, 59 seconds. 9-S-11, 9-S-12, 9-S-13, and 9-S-14 control the operation and settings of this display.

Panel I - (Main Propulsion)

<u>Code</u>	<u>Control/Indicator</u>	<u>Function</u>
10-S-1	PROPELLANT TEMPERATURE PRESSURE MONITOR SWITCH 3-POSITION TOGGLE MAIN-MAIN-MAIN	This three-position toggle (ASC - DES 1 - DES 2) selects for monitoring on 10-M-3 and 10-M-4 the propellant tank pressures and temperatures. In the ASC position, ascent propellant tank pressures and temperatures are displayed. In the DES 1 position, the descent propellant #1 are displayed, and in the DES 2 position, the descent propellant #2 values are displayed. Propellant #1 values and propellant #2 values are in each case one fuel tank and one oxidizer tank temperature and pressure.
10-S-3	ASCENT HELIUM REGULATOR #1 SWITCH	Each of these three-position toggles (OPEN - CLOSE) controls a latch-type solenoid-operated valve located upstream of each helium pressure regulator. The solenoid valves are normally in the opened position. Selecting the OPEN position will actuate the associated shutoff valve, opening it and enabling
10-S-4	ASCENT HELIUM REGULATOR #2 SWITCH TWO 3-POSITION TOGGLES MOM-MAIN-MOM	

10-S-4
(Cont)

helium to flow through the regulator. Selecting the CLOSE position will actuate the associated shutoff valve, closing it and isolating that leg. Positive feedback of the solenoid valve position is provided by the status of 10-FL-1 and 10-FL-2.

10-S-5

DESCENT HELIUM REGULATOR
#1 SWITCH

Each of these three-position toggles (OPEN - CLOSE) controls a latch-type solenoid-operated valve upstream of each helium pressure regulator. The solenoid valve associated with 10-S-5 is normally in the opened position while the solenoid valve associated with 10-S-7 is normally in the closed position. Selecting the OPEN position will actuate the associated shutoff valve, opening it and enabling helium to flow through the regulator. Selecting the CLOSE position will actuate the associated shutoff valve, closing it and isolating that leg. Positive feedback of the solenoid valve position is provided by the status of 10-FL-3 and 10-FL-4.

10-S-7

DESCENT HELIUM REGULATOR
#2 SWITCH
TWO 3-POSITION TOGGLES
MOM-MAIN-MOM

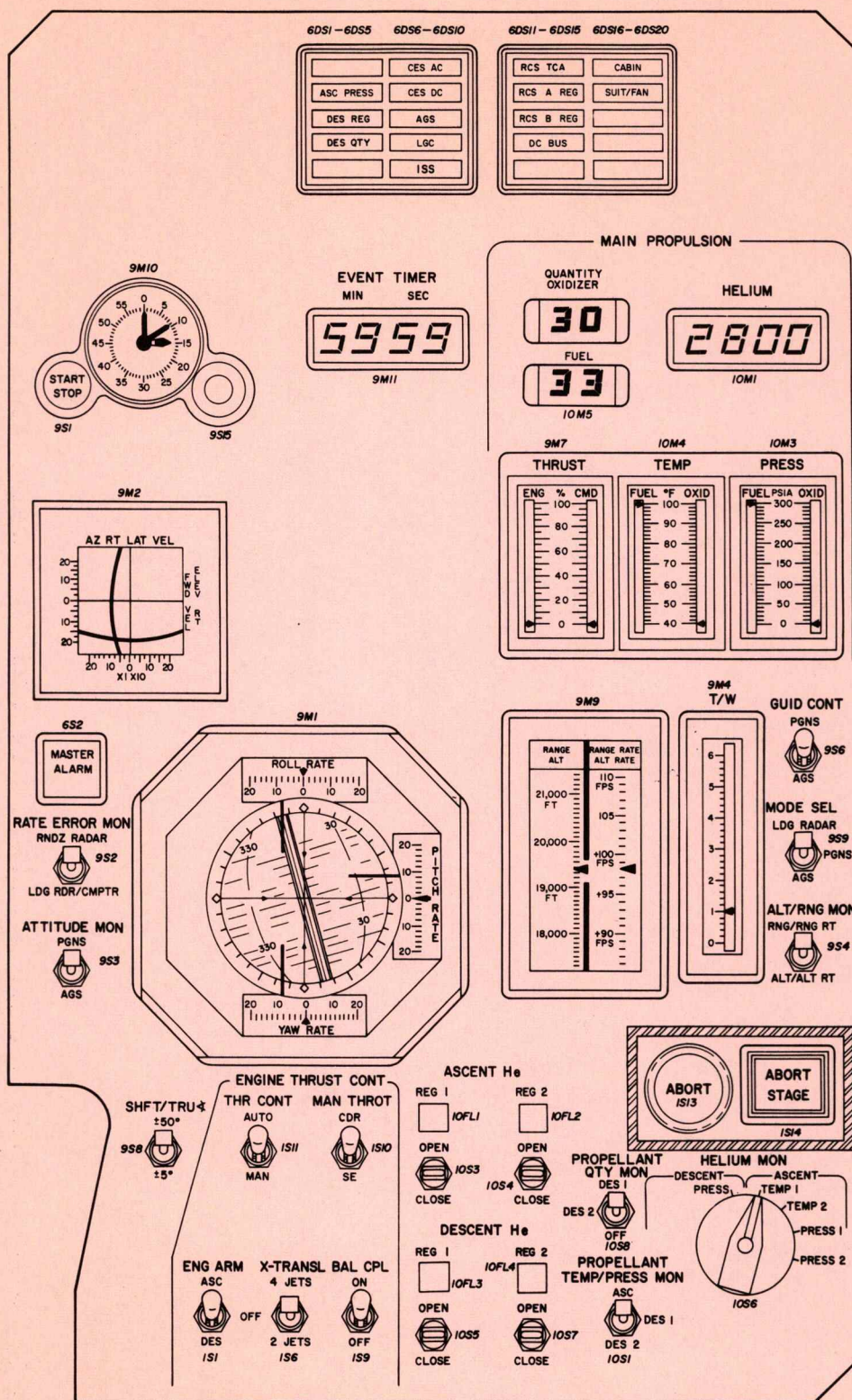
10-S-6

HELIUM MONITOR SWITCH
5-POSITION ROTARY

This five position rotary switch (DESCENT: PRESS, ASCENT: TEMP 1 - PRESS 1 - TEMP 2 - PRESS 2) selects for monitoring on 10-M-1, temperatures or pressures of ambient helium in ascent or descent tanks. In the DESCENT PRESS position, supercritical helium pressure is sensed in a common manifold just downstream of the two tanks. Selection of the ascent switch positions permit monitoring of ambient helium temperatures and pressures in the ascent system. Pressures are sensed at two independent manifolds downstream of the tanks and upstream of the squib valves.

<u>Code</u>	<u>Control/Indicator</u>	<u>Function</u>
10-S-8	PROPELLANT QUANTITY MON SWITCH 3-POSITION TOGGLE MAIN-MAIN-MAIN	This three-position toggle (DES 1 - DES 2 -OFF) selects a pair of descent tanks for monitoring the percent of oxidizer and fuel quantities remaining in the tanks on indicator 10-M-5. Selecting the DES 1 position enables the discrete outputs from the quantity gaging sensor probe of oxidizer tank #1 and fuel tank #1 to be displayed on 10-M-5. Selecting the DES 2 position enables the discrete outputs from the quantity gaging sensor probe of oxidizer tank #2 and fuel tank #2 to be displayed on 10-M-5. In the OFF position, DC power is removed from the gaging system and no digital tank quantities are displayed on 10-M-5.
10-M-1	HELIUM INDICATOR 4-PLACE DIGITAL DISPLAY	This display indicates supercritical helium pressure in the descent system and the temperatures and pressures in the ascent system as selected by 10-S-6.
10-M-3	PRESSURE INDICATOR	This dual scale indicator displays fuel and oxidizer pressures for the ascent or descent propellant system as selected by 10-S-1.
10-M-4	TEMPERATURE INDICATOR	This dual scale indicator displays fuel and oxidizer temperatures for the ascent or descent propellant system as selected by 10-S-1.
10-M-5	OXIDIZER/FUEL QUANTITY INDICATORS TWO 2-PLACE DIGITAL DISPLAYS	These indicators display the percentage of usable oxidizer and fuel quantities remaining in the descent tanks only, as selected by 10-S-8.

<u>Code</u>	<u>Control/Indicator</u>	<u>Function</u>
10-FL-1	ASCENT HELIUM REGULATOR STATUS #1	Each of these two-position flags (GREY - BARBERPOLE) indicates the open (GREY) or closed (BARBERPOLE) status of its respective latch-type solenoid-operated valve, as controlled by 10-S-3 and 10-S-4.
10-FL-2	ASCENT HELIUM REGULATOR STATUS #2 TWO 2-POSITION STATUS FLAGS	
10-FL-3	DESCENT HELIUM REGULATOR STATUS #1	Each of these two position flags (GREY - BARBERPOLE) indicates the open (GREY) or closed (BARBERPOLE) status of its respective latch-type solenoid-operated valve, as controlled by 10-S-5 and 10-S-7.
10-FL-4	DESCENT HELIUM REGULATOR STATUS #2 TWO 2-POSITION STATUS FLAGS	



PANEL I

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1.6.2 Panel II - (Flight Control)

<u>Code</u>	<u>Control/Indicator</u>	<u>Function</u>
9-S-7	RATE ERR MON SWITCH (SE) 2-POSITION TOGGLE MAIN-MAIN	This two-position toggle (RNDZ RADAR - LDG RDR/CMPTR) enables signal inputs to the FDAI and the X-Pointer displays. In the RNDZ RADAR position, shaft and trunnion angles from the Rendezvous Radar are displayed on the pitch and yaw error needles of the FDAI, and LOS Azimuth and Elevation rates are displayed on the X-Pointer display, (illuminating LOS AZ and LOS ELEV). In the LDG RDR/CMPTR position, vehicle attitude errors are displayed on the FDAI error needles and forward and lateral velocities are displayed on the X-Pointer display, (illuminating LAT VEL and FWD VEL) 9-S-7 enables inputs to 9-M-6 and 9-M-3.
9-S-10	ATTITUDE MON SWITCH (SE) 2-POSITION TOGGLES MAIN-MAIN	This two-position toggle (PGNS - AGS) selects the source of Attitude data to be displayed on the FDAI. In the PGNS position, vehicle total Attitude signals (after conditioning by GASTA) are sent to the FDAI ball and LGC Attitude error signals are sent to the FDAI pitch roll and yaw error needles. In the AGS position, the AGS total vehicle attitude signals are sent to the FDAI ball and AGS attitude error signals are sent to the FDAI pitch, yaw and roll error needles. 9-S-10 enables signals to 9-M-6.
9-M-6	FLIGHT DIRECTOR ATTITUDE INDICATOR (SE)	Indicator displays: (1) Vehicle Attitude, Attitude Rates and Attitude Errors or (2) Vehicle Attitude, Attitude Rates and Rendezvous Radar Shaft and Trunnion Angles, depending upon the position of 9-S-2 and 9-S-7. The position of 9-S-10 will select either PGNS or AGS as the source of displayed vehicle attitude rate information displayed on the three meters surrounding the ball is always obtained from the CES rate gyros. The shaft

<u>Code</u>	<u>Control/Indicator</u>	<u>Function</u>
9-M-6 (Cont)		attitude and attitude errors for 9-M-6. The attitude rate information displayed on the three meters surrounding the ball is always obtained from the CES rate gyros. The shaft and trunnion angles are displayed respectively on the pitch and yaw error needles of 9-M-6 when 9-S-7 is in the RNDZ RADAR position.
9-M-3	X-POINTER (SE)	This indicator displays: (1) Forward and Lateral Velocities, (2) Lateral Velocities only or (3) Rendezvous Radar LOS Elevation and Azimuth Angular Rates. What is displayed on 9-M-3 is a function of the position of 9-S-7 and 9-S-9. Forward and lateral velocities are measured in the horizontal plane along the LEM Z and Y body axes when the source driving the display is the PGNS. When the landing radar is the driving source the forward and lateral velocities are coincident with LEM Z and Y body axis velocities. This is true only when the radar beams are coincident with the vehicle body axis. When the AGS system is the driving source, lateral velocity is the only information displayed and is vehicle Y body axis velocity.

Panel II - (Environmental Control Subsystem)

<u>Code</u>	<u>Control/Indicator</u>	<u>Function</u>
7-S-1	SUIT FAN SELECT SWITCH 3-POSITION ROTARY	This three-position rotary (1-2-OFF) selects either of two suit fans to circulate breathing oxygen in the suit circuit. In the nominal condition, fan #1 is selected and operating. Failure of the selected fan results in illumination of the Suit Circuit Fan

<u>Code</u>	<u>Control/Indicator</u>	<u>Function</u>
7-S-1 (Cont)		component light (7-DS-1) as well as activation of the (ECS) caution light (6-DS-36). Selection of the 2 position activates the #2 fan and extinguishes the component light. Selection of the OFF position de-energizes the suit fans.
7-S-2	O ₂ /H ₂ O QTY MON SWITCH 4-POSITION ROTARY	This four-position rotary (C/W RESET - DES - ASC 1 - ASC 2) selects for monitoring on indicator 7-M-4 the quantities remaining in the descent or ascent oxygen and water storage tanks. Thus, in the DES position, descent oxygen quantity and quantity remaining in the descent water tank is displayed on 7-M-4. In the ASC 1 position, quantity remaining in the #1 ascent water tank is displayed on 7-M-4. A corresponding relationship exists between the ASC 2 switch position, and the #2 ascent oxygen and water tanks and the two indicators. Selection of the C/W RESET position routes a signal to the CWEA to extinguish either the (O ₂ QTY) caution light (6-DS-37) or the (WATER QTY) caution light (6-DS-39) if it is illuminated.
7-S-3	GLYCOL PUMP SELECT SWITCH 3-POSITION ROTARY	This three-position rotary (SEC - 1 - 2) selects either of two circulating pumps in the primary coolant loop, or the circulating pump in the emergency coolant loop. In the nominal condition, with the switch in the 1 position, #1 pump will be operating. Failure of this pump results in the illumination of the (Glycol) component caution light (7-DS-3), and activation of the (ECS) caution light (6-DS-36). The #2 pump must be selected by manually placing the rotary switch to the 2 position. Selection of the SEC position activates the glycol pump in the secondary coolant loop.

<u>Code</u>	<u>Control/Indicator</u>	<u>Function</u>
7-M-1	CO ₂ PARTIAL PRESSURE INDICATOR	This indicator displays the partial pressure of carbon dioxide in mm of Hg of the gas in the Atmosphere Revitalization Section.
7-M-2	CABIN/SUIT PRESSURE INDICATORS	This indicator displays cabin interior pressure in psia as sensed by an aneroid sensor on the cabin pressure sensor switch. This indicator displays suit circuit pressure in psia, sensed downstream of the suit gas supply connectors.
7-M-3	CABIN/SUIT TEMPERATURE INDICATOR	This indicator displays the temperature of the cabin interior in degrees Fahrenheit, sensed at the cabin heat exchanger. This indicator displays the temperature in the suit circuit in degrees Fahrenheit, sensed at the suit circuit regenerative heat exchanger.
7-M-4	OXYGEN/WATER QUANTITY INDICATOR	This indicator displays the oxygen quantity remaining in the descent oxygen tank or in either one of the two ascent oxygen tanks, as selected by 7-S-2. Quantity is displayed in percent. This indicator displays the water quantity remaining in the descent water tank or either of the two ascent tanks, as selected by 7-S-2. Quantity remaining is displayed in percent.
7-M-5	GLYCOL TEMPERATURE/PRESSURE INDICATOR	This indicator normally displays, in psia, the glycol pump discharge pressure in the primary coolant loop. However, following failure of the primary loop and selection of the secondary coolant pump (using 7-S-3), this indicator displays secondary glycol pump discharge pressure. This indicator normally displays, in degrees Fahrenheit, the glycol tempera-

<u>Code</u>	<u>Control/Indicator</u>	<u>Function</u>
7-M-5 (Cont)		ture in the primary coolant loop. However, following failure of the primary loop and selection of the secondary coolant pump (using 7-S-3) this indicator displays secondary coolant loop glycol temperature.
7-DS-1	SUIT CIRCUIT FAN COMPONENT CAUTION LIGHT	This light illuminates to indicate a low ΔP across the suit fan assembly which is caused by malfunction of the operating suit fan. Selection of the other fan, (using 7-S-1), extinguishes the light. It will illuminate again if the newly selected fan fails to develop the proper ΔP within approximately 25 seconds, or if a subsequent failure occurs in the selected fan.
7-DS-3	GLYCOL PUMP COMPONENT CAUTION LIGHT	This light illuminates to indicate a low ΔP across the operating glycol pump. Once the operating glycol pump fails, the component caution light will remain illuminated until a normal ΔP is restored again.
7-DS-6	CO ₂ PARTIAL PRESSURE COMPONENT CAUTION LIGHT	This light illuminates to indicate that the CO ₂ partial pressure in the suit circuit exceeds 7.6 mm of mercury. The light also illuminates if the secondary canister is selected by 7-H-19. This light will remain illuminated until: (1) the primary canister is replaced by an unsaturated canister, (2) 7-H-19 is positioned to the primary canister position, and (3) the CO ₂ partial pressure has been restored to a within-tolerance condition.
7-DS-7	WATER SEPARATOR COMPONENT CAUTION LIGHT	This light illuminates to indicate a low speed or failure condition in the selected water separator. The light remains illuminated until the other water separator is manually selected (using 7-H-10), and until it comes up to the desired speed.

Panel II - (Reaction Control Subsystem)

<u>Code</u>	<u>Control/Indicator</u>	<u>Function</u>
8-S-1	QUANTITY MONITOR SWITCH 3-POSITION TOGGLE MAIN-MAIN-MAIN	This three-position toggle (SYS A - SYS B - OFF) selects either RCS System A or System B tanks for monitoring oxidizer and fuel quantities on 8-M-3. In the OFF position, DC power is removed from 8-M-3 and no digital values are displayed.
8-S-6	QTY TEST SWITCH 2-POSITION TOGGLE MOM-MAIN	This two-position toggle (ON - OFF) is normally in the OFF (maintain) position. The ON (momentary) position is used in conjunction with 8-S-1 and 8-M-3 to test the propellant quantity gaging section of either System A or System B.
8-S-7	MAIN SHUTOFF VALVE SWITCH: SYSTEM A	Each of these three-position toggles (OPEN- -CLOSE) simultaneously actuates a pair of latch-type, solenoid-operated fuel and oxidizer shutoff valves which control the flow of propellant downstream of the propellant tanks. These valves are opened after check-out by moving the toggle to the OPEN position; however, if a malfunction exists in one of the systems (either "A" or "B"), propellant flow in the malfunctioning system can be interrupted by moving the toggle to the CLOSE position. These switches are locked in the center position and momentarily held in the OPEN or CLOSE position. Positive feedback of the solenoid valve position is displayed by 8-FL-5 and 8-FL-7.
8-S-9	MAIN SHUTOFF VALVE SWITCH: SYSTEM B	
	TWO 3-POSITION TOGGLES MOM-LOCK-MOM	

<u>Code</u>	<u>Control/Indicator</u>	<u>Function</u>
8-S-8	MANIFOLD SWITCH: SYSTEM A	Each of these three-position toggles (OPEN- -CLOSE) actuates a pair of latch-type, solenoid-operated fuel and oxidizer valves which ties the RCS propellant lines to a manifold which may be connected to the ascent tanks. These solenoid valves are normally closed. In the event of an RCS malfunction, the ascent system can supply fuel and oxidizer to either System "A" jets or System "B" jets or both. Opening these valves with 8-S-20 in the CLOSE position will interconnect System A with System B for crossfeed operation. The status of the solenoid valves is displayed by 8-FL-6 and 8-FL-8.
8-S-10	MANIFOLD SWITCH: SYSTEM B TWO 3-POSITION TOGGLES MOM-LOCK-MOM	
8-S-11	THRUSTER PAIR SWITCH, QUAD #1; SYSTEM A	Each of these three-position toggles (OPEN- -CLOSE) activates two latch-type, solenoid-operated TCA isolation valves controlling fuel and oxidizer flow to a pair of TCA's. Activation of the switch provides a pulse to trigger the valve to the open or closed position. The valves are normally in the open position. The toggles can be used for emergency shutdown of the thrust chambers during flight. Positive feedback of the solenoid valve position is displayed by 8-FL-9 through 8-FL-16.
8-S-12	THRUSTER PAIR SWITCH, QUAD #2; SYSTEM A	
8-S-13	THRUSTER PAIR SWITCH, QUAD #1; SYSTEM B	
8-S-14	THRUSTER PAIR SWITCH, QUAD #2; SYSTEM B	
8-S-15	THRUSTER PAIR SWITCH, QUAD #3; SYSTEM A	
8-S-16	THRUSTER PAIR SWITCH, QUAD #4; SYSTEM A	
8-S-17	THRUSTER PAIR SWITCH, QUAD #3; SYSTEM B	
8-S-18	THRUSTER PAIR SWITCH, QUAD #4; SYSTEM B EIGHT 3-POSITION TOGGLES MOM-MAIN-MOM	

<u>Code</u>	<u>Control/Indicator</u>	<u>Function</u>
8-S-19	TEMPERATURE/PRESSURE MONITOR SELECT SWITCH 4-POSITION ROTARY	This four-position rotary (He - PRPINT - FUEL MANF - OXID MANF) is used to monitor pressures and temperatures of Systems A and B on 8-M-1 and 8-M-2. In the He position, it monitors the helium tank pressures and temperatures. In the PRPINT position, it monitors the fuel and oxidizer tank pressures as sensed at the helium regulator outlet and the propellant temperature as sensed in the fuel tank. The System A and B fuel and oxidizer manifold pressures are monitored on 8-M-1 in the FUEL MANF and OXID MANF positions respectively. The temperature pointers on 8-M-2 will deflect to the lowest graduation mark since manifold temperatures are not sensed.
8-S-20	ASCENT TIE SWITCH 3-POSITION TOGGLE MOM-LOCK-MOM	This three-position toggle (OPEN- -CLOSE) actuates a pair of latch-type, solenoid-operated fuel and oxidizer valves which enable the flow of propellant from the ascent tanks to the RCS subsystem. These solenoid valves are normally closed. In the event of an RCS malfunction, the ascent system can supply fuel and oxidizer. The status of the solenoid valves is displayed by 8-FI-17.
8-M-1	PRESSURE INDICATOR	This indicator displays the pressures in the helium tanks or at the fuel or oxidizer tanks, or in the fuel or oxidizer manifolds of System A and B, as selected by 8-S-19.
8-M-2	TEMPERATURE INDICATOR	This indicator displays the temperatures in the helium or fuel tanks of System A and B as selected by 8-S-19.

<u>Code</u>	<u>Control/Indicator</u>	<u>Function</u>
8-M-3	OXIDIZER/FUEL QUANTITY INDICATORS TWO 2-PLACE DIGITAL DISPLAYS	These indicators display the percentage of oxidizer and fuel quantities remaining in either System A or B tanks, as selected by 8-S-1.
8-FL-5	MAIN SHUTOFF VALVE STATUS: SYSTEM A	Each of these two-position flags (GREY - BARBERPOLE) indicates the open (GREY) or closed (BARBERPOLE) status of its respective pair of latch-type solenoid-operated valves as controlled by 8-S-7 and 8-S-9.
8-FL-7	MAIN SHUTOFF VALVE STATUS: SYSTEM B TWO 2-POSITION FLAGS	
8-FL-6	MANIFOLD STATUS: SYSTEM A	Each of these two-position flags (GREY - BARBERPOLE) indicates the open (GREY) or closed (BARBERPOLE) status of its respective pair of latch-type solenoid-operated valves as controlled by 8-S-8 and 8-S-10.
8-FL-8	MANIFOLD STATUS: SYSTEM B TWO 2-POSITION FLAGS	
8-FL-9	THRUSTER PAIR STATUS, QUAD #1; SYSTEM A	Each of these flags (GREY - BARBERPOLE - RED) normally indicates the open (GREY) or closed (BARBERPOLE) status of its respective pair of latch-type solenoid-operated isolation valves. In addition a third position (RED) will automatically appear (in conjunction with the RCS TCA warning light) to indicate a TCA failure. In the event of such a failure, the Thruster Pair switch associated with the red flag would be actuated to the CLOSE position. This action will shut down the malfunctioning TCA and display the barberpole position.
8-FL-10	THRUSTER PAIR STATUS, QUAD #2; SYSTEM A	
8-FL-11	THRUSTER PAIR STATUS, QUAD #1; SYSTEM B	
8-FL-12	THRUSTER PAIR STATUS, QUAD #2 SYSTEM B	
8-FL-13	THRUSTER PAIR STATUS, QUAD #3; SYSTEM A	
8-FL-14	THRUSTER PAIR STATUS, QUAD #4; SYSTEM A	
8-FL-15	THRUSTER PAIR STATUS, QUAD #3; SYSTEM B	
8-FL-16	THRUSTER PAIR STATUS, QUAD #4; SYSTEM B EIGHT 3-POSITION FLAGS	

Code

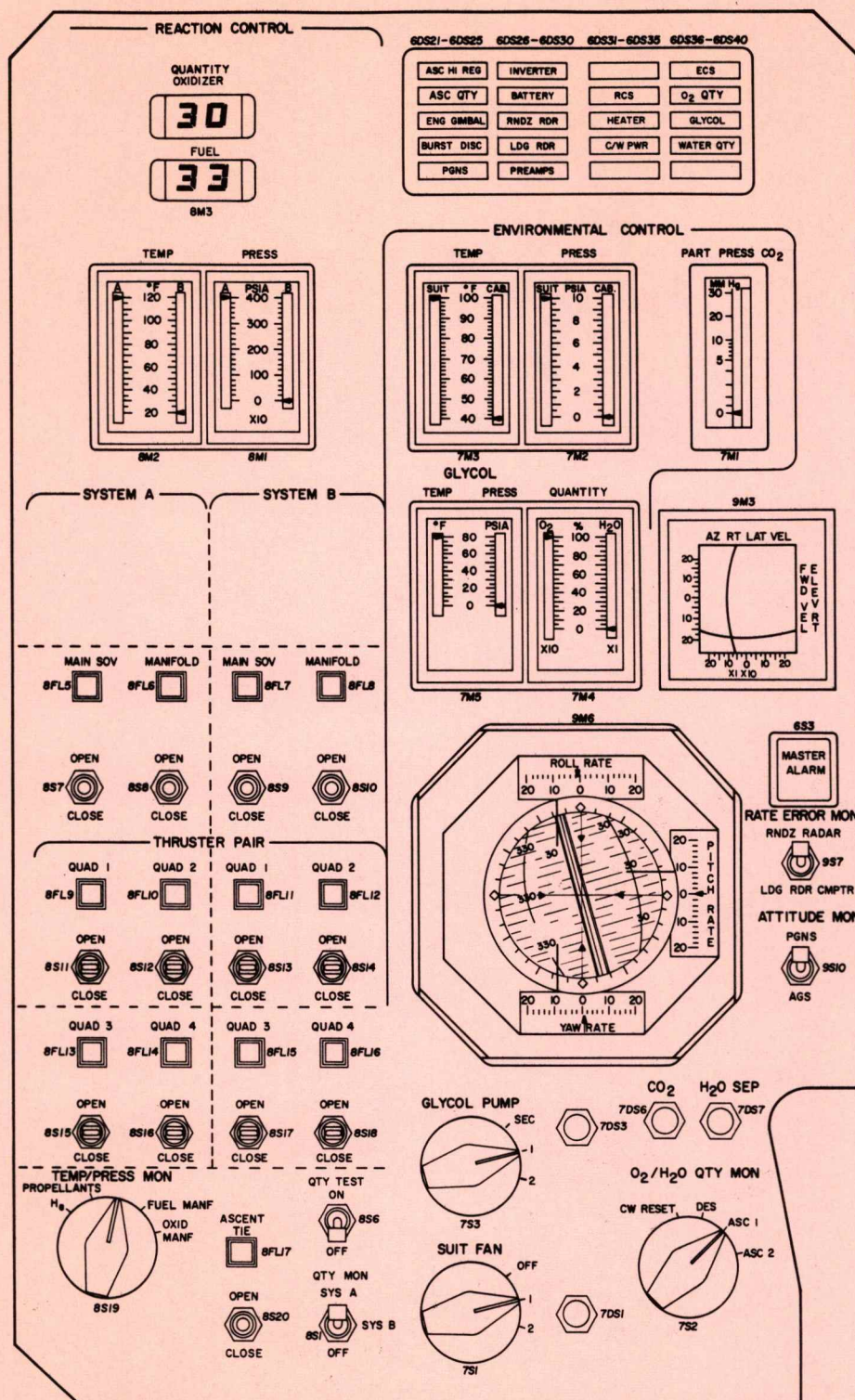
Control/Indicator

Function

8-FL-17

ASCENT TIE STATUS
2-POSITION FLAG

This two-position flag (GREY - BARBERPOLE) indicates the open (GREY) or closed (BARBERPOLE) status of the latch-type solenoid-operated fuel and oxidizer ascent interconnect valves as controlled by 8-S-20.



PANEL II

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1.6.3 Panel III (Engine/Thrust Control)

<u>Code</u>	<u>Control/Indicator</u>	<u>Function</u>
1-DS-1	LUNAR CONTACT LIGHT (CDR)	One light is located at the Commander's station and one is located at the Systems Engineer's station. Both illuminate red when the probe(s) on the vehicle's landing gear touch the lunar surface. They provide positive feedback to the crew that the descent engine should be turned off. These lights will extinguish when either 1-S-3 or 1-S-4 is actuated.
1-DS-2	LUNAR CONTACT LIGHT (SE)	

Panel III (Flight Control)

<u>Code</u>	<u>Control/Indicator</u>	<u>Function</u>
9-S-17	X-POINTER SCALE SWITCH (CDR)	These two-position toggles (HI MULT - LO MULT) control the scale range of 9-M-2 and 9-M-3. When LOS rates are displayed, the HI MULT position will provide a scale of +20 mrad/sec., and the LO MULT position will illuminate the "X.1" multiplier to provide a scale of +2 mrad/sec. When horizontal velocities are displayed, the HI MULT position will illuminate the "X 10" multiplier to provide a scale of +200 ft/sec. The LO MULT position will provide a scale of +20 ft/sec. 9-S-17 controls scale range inputs to 9-M-2; and 9-S-18 controls scale range inputs to 9-M-3.
9-S-18	X-POINTER SCALE SWITCH (SE)	
	TWO 2-POSITION TOGGLES	
	MAIN-MAIN	

Panel III (Radar)

<u>Code</u>	<u>Control/Indicator</u>	<u>Function</u>
17-S-1	MANUAL SLEW SWITCH SPRING LOADED 4-WAY CENTER OFF TOGGLE	This four-way toggle (UP - RIGHT - DOWN - LEFT) slews the trunnion and/or shaft servos positioning the Rendezvous Radar antenna for manual acquisition of the target and subsequent automatic tracking. Two antenna slew rates are available through 17-S-2. Target acquisition is determined from 17-M-1 and AUTO TRACK is enabled through 17-S-3. The position of the Rendezvous Radar antenna (shaft and trunnion) can be determined from either the Commander's or Systems Engineer's FDAI (9-M-1 or 9-M-6) pitch and yaw error needles when the Rate/Error Monitor switches (9-S-2 and 9-S-7) are positioned to RNDZ RADAR.
17-S-2	SLEW RATE SWITCH 2-POSITION TOGGLE MAIN-MAIN	This two position toggle (HI-LO) provides two rates for manually slewing the Rendezvous Radar antenna. The HI slew rate is 9°/sec. and the LO slew rate is 1°/sec. The HI slew rate is used for quick, coarse adjustments to guide the antenna in the direction of the target. The LO slew rate is used for slow, fine adjustments to drive the antenna toward maximum signal strength as monitored on 17-M-1 thus enabling the subsequent initiation of auto track through 17-S-3.
17-S-3	RNDZ RADAR MODE SWITCH 3-POSITION ROTARY	This three-position rotary (AUTO TRACK - SLEW - LGC) enables control of the Rendezvous Radar antenna drive. In the AUTO TRACK position, track is maintained by comparing the received radar signals from the shaft and trunnion channels; the resultant error condition signals are used to drive the antenna servos thus maintaining track. In the SLEW position

<u>Code</u>	<u>Control/Indicator</u>	<u>Function</u>
17-S-3 (Cont)		the Rendezvous Radar antenna drive is controlled manually from 17-S-1. In the LGC position the computer automatically drives the antenna towards the target. Once the target is acquired the Radar will automatically maintain track and the No-Track component caution light (17-DS-1) will extinguish. The system is capable of maintaining automatic track only when 17-S-9 is in either the XPNDR or SKIN positions.
17-S-5	LDG ANT SWITCH 3-POSITION TOGGLE LOCK-LOCK-LOCK	This three position toggle (AUTO - DES - HOVER) in the AUTO position enables the LGC to position the Landing Radar antenna appropriate to a particular mission phase. Prior to the HOVER point the antenna is in the descent position. At HOVER, the antenna is positioned by the LGC to the HOVER position. The DES and HOVER positions provide an override of the antenna position drive signal in case of LGC/Antenna interface failure. The DES position is also used to reposition the antenna after testing.
17-S-6	RADAR TEST SWITCH 3-POSITION TOGGLE MAIN-LOCK-MAIN	This three position toggle (RNDZ - OFF - LDG) provides signals to the Rendezvous and Landing Radar's test circuitry. In the RNDZ position test circuitry is enabled and Rendezvous Radar performance is determined by monitoring 17-M-1, the Altitude/Range meter (9-M-9), and the X-Pointers (9-M-2 and 9-M-3) after the appropriate positioning of 17-S-8.

<u>Code</u>	<u>Control/Indicator</u>	<u>Function</u>
17-S-8	TEST MONITOR SWITCH 6-POSITION ROTARY	<p>This six-position rotary (LDG RADAR PWR: ALT XMTR - VEL XMTR; RNDZ RADAR: AGC - XMTR PWR - SHAFT ERR - TRUN ERR) selects either Landing or Rendezvous Radar test data or flight performance data for monitoring on meter 17-M-1. In the ALT XMTR position, the altitude transmitter power output is displayed on 17-M-1 during testing and flight operations. In the VEL XMTR position, the velocity transmitter power output is displayed on 17-M-1 during testing and flight operations. In the AGC position, during testing, a specific value of receiver signal strength will be displayed on 17-M-1; however, during flight operations the signal will vary. In the XMTR PWR position, during flight operations a specific value of transmitter output power is displayed on 17-M-1. In the SHAFT ERR and/or TRUN ERR positions, during testing, angle error signals will be displayed as needle fluctuations with equal amplitude on 17-M-1. During flight operations these error signals will be displayed as needle fluctuations which represent the smoothness of servo tracking, and will usually be unequal in amplitude.</p>
17-S-9	RNDZ RADAR TRACK MODE	<p>This three-position toggle (XPNDR - SKIN - SURFACE) selects the operational tracking mode of the Rendezvous Radar. In the XPNDR position the radar interrogates the transponder, and the radar tracking error correction signals drive the antenna to maintain track. In the SKIN position the radar transmitter's signal is reflected by the target and the radar's tracking error correction signals drive the antenna to maintain track. In the SURFACE position the AUTO TRACK capability of the radar is disabled and the LGC or crew must continually drive the antenna (17-S-3 can be in either the LGC or SLEW position) to obtain</p>

<u>Code</u>	<u>Control/Indicator</u>	<u>Function</u>
17-S-9 (Cont)		altitude information from the Rendezvous Radar.
17-DS-1	NO TRACT LIGHT COMPONENT CAUTION LIGHT	The illumination of this light indicates that the Rendezvous Radar has broken track (data-not-good) in any one of the three tracking modes.
17-M-1	SIGNAL STRENGTH METER	The Signal Strength Meter displays Landing Radar and Rendezvous Radar data as selected by 17-S-8 for test and flight operations.

Panel III (Stabilization & Control)

<u>Code</u>	<u>Control/Indicator</u>	<u>Function</u>
11-S-1	GYRO TEST CONTROL SWITCH 3-POSITION TOGGLE MOM-LOCK-MOM	This three-position toggle (POS RT - OFF - NEG RT) enables a test signal to be applied to the rate gyro selected by 11-S-7. It is maintained in the OFF position and momentarily held in the other two. When this switch is held in the POS RT position, a +5°/sec attitude rate will be indicated on the appropriate attitude needles of the Flight Director Attitude indicators (9-M-1 and 9-M-6). The NEG RT position produces the opposite effect. In OFF, no test signal is produced.
11-S-2	DEADBAND SWITCH 2-POSITION TOGGLE MAIN-MAIN	This two-position toggle (MAX - MIN) selects either a large amplitude limit cycle (MAX) for the attitude control system, to conserve RCS fuel during coasting flight, or a narrow deadband (MIN) for periods when accurate manual control is required. Regardless of this switch position the minimum deadband will operate during main engine thrusting. This switch is not functional when the PGNS is in use.

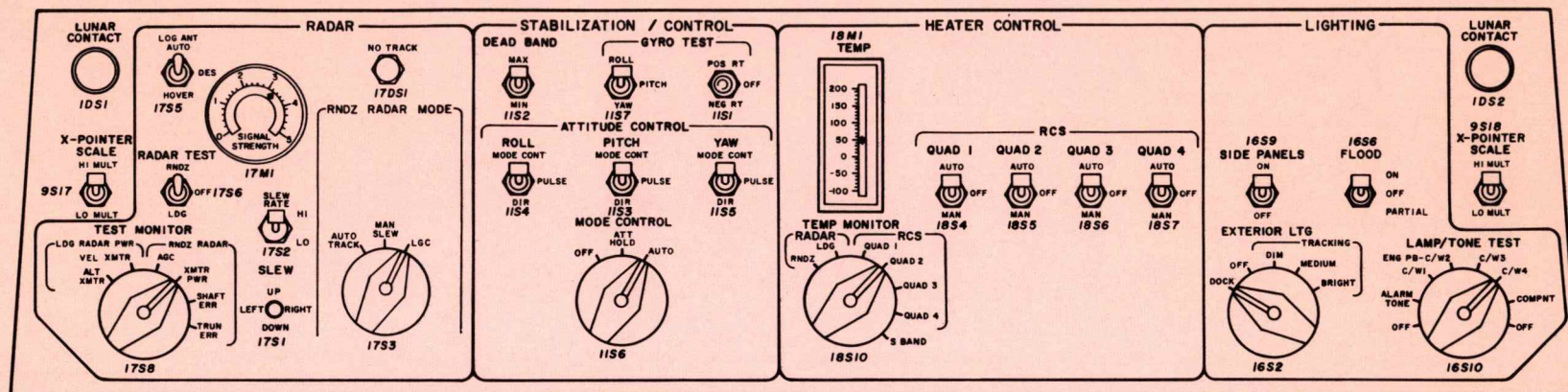
<u>Code</u>	<u>Control/Indicator</u>	<u>Function</u>
11-S-3	PITCH ATTITUDE CONTROL SWITCH	<p>These three Attitude Control Switches (MODE CONT-PULSE - DIR) are used, normally only with the AGS, in conjunction with switch 11-S-6 to establish vehicle attitude control. All three switches will normally be placed in the MODE CONT position. In this position, vehicle attitude control about the appropriate axis is determined by 11-S-6. If the AGS has been selected on the Guidance Control switch (9-S-6) and if one of the three Attitude Control switches is in the PULSE or DIR position, attitude about that axis can only be controlled manually. If the PGNS has been selected on 9-S-6, the PULSE position is inoperative (attitude commands are generated by the IGC and vehicle attitude control is automatic), but the DIR position will permit ACA operation of reaction jets. Under AGS control, the PULSE and DIR modes differ only in the way the reaction jets fire. When PULSE is selected, two jets in the appropriate axis are pulsed at a constant rate for as long as the attitude controller is displaced. When DIR is selected and the ACA's displaced, the two jets are activated continuously instead of being pulsed. When 11-S-6 is in the OFF position, only the DIR position is operative.</p>
11-S-4	ROLL ATTITUDE CONTROL SWITCH	
11-S-5	YAW ATTITUDE CONTROL SWITCH	
	THREE 3-POSITION TOGGLES	
	MAIN-MAIN-MAIN	
11-S-3		
11-S-4		
11-S-5		
11-S-6	ATTITUDE MODE CONTROL SWITCH 3-POSITION ROTARY MAIN-MAIN-MAIN	<p>This three-position rotary (OFF - ATT HOLD - AUTO) affects the outputs of the Attitude Controllers the Translation Controllers and the Selected Guidance Computer. In the OFF position, the Attitude Controllers are only operative (1) in the "hardover" position and (2) when one or more of the Attitude Control switches is in the DIR position, which provides the crew with 2-jet direct attitude control of that axis. The translation outputs of the T/TCA and the computer attitude commands are also disabled when 11-S-6 is in the OFF position, but the main</p>

<u>Code</u>	<u>Control/Indicator</u>	<u>Function</u>
11-S-6 (Cont)		<p>attitude commands are also disabled when 11-S-6 is in the OFF position, but the main engine throttle command outputs are not affected. However, with this switch in the OFF position, main-engine off signals from the LGC and the AGS are not enabled and the main engines can only be turned off manually.</p> <p>In the ATT HOLD position the crew can command an angular rate proportional to the displacement of the ACA. This mode is implemented to operate with either the PGNS or AGS. When the ACA is in the neutral position, the rate command goes to zero and the vehicle attitude will be held. In the ATT HOLD position, the RCS translation outputs of the T/TCA are enabled. As with the OFF position, the throttle outputs of the T/TCA and the "hardover" direct capabilities of the ACA are not affected by selection of ATT HOLD position.</p> <p>When the Guidance Control switch is in the AGS position and the AUTO position is selected, attitude error signals are sent to the Control Electronics Section from the Abort Guidance Section. The resultant signals control the firing of the reaction jets through the selectable deadband. When the Guidance Control Switch is in the PGNS position, rate compensated steering errors are generated by the LGC and ON/OFF commands are fed to the jet drivers. In the AUTO position the RCS translation outputs of the T/TCA are enabled. The T/TCA throttle outputs and the ACA "hardover" outputs are unaffected. Attitude Controller proportional commands will normally be ineffective in this mode.</p>

<u>Code</u>	<u>Control/Indicator</u>	<u>Function</u>
11-S-7	GYRO TEST SELECT SWITCH 3-POSITION TOGGLE MAIN-MAIN-MAIN	This three-position toggle (ROLL - PITCH - YAW) associated with 11-S-1, selects the rate gyro which is to be tested. The test output is displayed as described for switch 11-S-1.
Panel III (Heater Control)		
18-S-4	RCS QUAD 1 HEATER SWITCH	These three-position toggles (AUTO - OFF - MAN) are used primarily during lunar stay to control temperature of the four RCS quads. In the AUTO position each heater will automatically maintain the temperature of its respective quad within the preset limits. If a malfunction occurs in the automatic control, the operator can select the MAN position, which will provide heat continuously to the quad; or the OFF position, which will turn off the heater. The temperature of a quad may be monitored by selecting the appropriate position of 18-S-10 and reading the value displayed on 18-M-1. If the temperature of any of the quads exceeds the range 40°F to 180°F the (HEATER) caution light will illuminate.
18-S-5	RCS QUAD 2 HEATER SWITCH	
18-S-6	RCS QUAD 3 HEATER SWITCH	
18-S-7	RCS QUAD 4 HEATER SWITCH	
	FOUR 3-POSITION TOGGLES MAIN-MAIN-MAIN	
18-S-10	TEMPERATURE MONITOR SELECT SWITCH 7-POSITION ROTARY	This seven-position rotary (RADAR: RNDZ - LDG; RCS: QUAD 1 - QUAD 2 - QUAD 3 - QUAD 4; S-BAND) selects the rendezvous or landing radar antenna assembly, the RCS quads, or the S-band antenna assembly for temperature monitoring.
18-M-1	TEMPERATURE INDICATOR	This indicator displays the temperature, in degrees Fahrenheit, of the radar antenna assemblies or RCS quads or S-band antenna assembly selected by switch 18-S-10.

<u>Code</u>	<u>Control/Indicator</u>	<u>Function</u>
Panel III - (Lighting Control)		
16-S-2	EXTERIOR LIGHTING CONTROL 5-POSITION ROTARY	This five-position rotary switch (DOCK-OFF; TRACKING: DIM-MEDIUM-BRIGHT) controls the docking and tracking lights. In the DOCK position the docking lights are turned on. In the DIM, MEDIUM and BRIGHT positions, the tracking light is turned on at 1%, 10%, and 100% brightness respectively. The OFF position interrupts power to either docking or tracking lights. The LTA-1 panel configuration does not show a MEDIUM position.
16-S-6	FLOODLIGHT CONTROL 3-POSITION TOGGLE MAIN-MAIN-MAIN	This three-position toggle (ON - OFF - PARTIAL) turns on all the floodlights in the ON position. In the PARTIAL position, only the two overhead floodlights, fitted with reflectors (which can be rotated), are turned on. In the OFF position, all floodlights will be turned off. The two overhead lights can also be turned on by opening the overhead hatch. This overrides all positions of 16-S-6.
16-S-9	SIDE PANELS SWITCH (SE) 2-POSITION TOGGLE MAIN-MAIN	This two-position toggle (ON-OFF) provides ON/OFF control of the SE's side panel EL illumination. In the ON position, this switch connects the integral lights located on the SE's side panels to 16-R-3 and 16-S-3. In the OFF position, the side panels are not connected to 16-R-3 and 16-S-3 and are therefore not illuminated with EL.

<u>Code</u>	<u>Control/Indicator</u>	<u>Function</u>
16-S-10	LAMP/TONE TEST SWITCH 8-POSITION ROTARY	<p>This eight-position rotary (OFF - ALARM/TONE - C/W 1 - ENG PB and C/W 2 - C/W 3 - C/W 4 - COMPNT - OFF) is used to perform the following test functions. In the ALARM/TONE position, it tests the lamps in the Master Alarm buttons (6-S-2 and 6-S-3) and the Audible Tone (6-T-1). In the C/W 1 position it tests the lamps in one bank of the Caution/Warning annunciators (6-DS-1 through 6-DS-10). The ENG PB and C/W 2 position tests the lamps in the Engine Start (1-S-2) and Stop (1-S-3 and 1-S-4) buttons as well as the second bank of C/W annunciators (6-DS-11 through 6-DS-20). In the C/W 3 and C/W 4 positions the lamps in the remaining two banks of C/W annunciators (6-DS-21 through 6-DS-30 and 6-DS-31 through 6-DS-40) are tested. In the COMPNT position the lamps in the Component Caution lights and lunar contact lights are tested. OFF positions are located at each end of the switching sequence. This will permit the switch to be placed in an OFF position, without recycling through the test position.</p>



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Fig. 1-34

PANEL III

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1.6.4 Panel IV (Primary Guidance and Navigation Subsystem)

The Bottom Center Panel, (Panel IV) accessible to both crew members, is called the Display System and Keyboard (DSKY). The DSKY, a part of Guidance, Navigation, and Control, is used to exchange information between the crew members and the LEM Guidance Computer (LGC). The keyboard has 19 pushbuttons. These are used to program digital information into the computer. The 14 annunciator lights and the 6 digital displays provide the crew with answers from the LGC. Such information as Alignment Optical Telescope sightings, times, mode changes, etc., may be set into the LGC. It may provide the astronauts with times, angles temperatures, and will even show them when they have made an error.

<u>Code</u>	<u>Control/Indicator</u>	<u>Function</u>
3-S-1	IMU Cage Switch 2 position toggle (MAIN-MAIN)	It cages the gyros in the IMU when "ON".

IMU CAGE
ON
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OFF

UPLINK ACTY	TEMP
AUTO	GIMBAL LOCK
HOLD	PROG
FREE	RESTART
NO ATT	TRACKER
STBY	
KEY REL	OPR ERR

CMPTR ACTY	PROG 13
VERB 33	NOUN 13
- 92311	
+13270	
-96514	

VERB	+	7	8	9	CLR	ENTR
	-	4	5	6	STBY	
	NOUN	0	1	2	3	
					RSET	

PANEL IV

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1.6.5 Panel V (Engine/Thrust Control)

<u>Code</u>	<u>Control/Indicator</u>	<u>Function</u>
1-S-2	ENGINE START SWITCH GUARDED PUSHBUTTON MAINTAIN	This pushbutton provides a manual override capability for immediate firing of either the descent or ascent engine, depending upon the position of 1-S-1. Once actuated, the engine fire command continues and the button is illuminated red. Activation of 1-S-3 or 1-S-4 interrupts the override function and extinguishes the light.
1-S-3	ENGINE STOP SWITCH GUARDED PUSHBUTTON MAINTAIN	This pushbutton (1-S-3) sends a discrete stop signal to the descent and ascent engines independent of the position of 1-S-1. When actuated, the button remains depressed and is illuminated red. It is reset by depressing it a second time.
1-S-5	RATE OF DESCENT SWITCH 3-POSITION TOGGLE MOM-MAIN-MOM	This switch enables the establishment of a vehicle rate of descent under PGNS authority. Each switch actuation provides a discrete pulse changing the rate of descent by 2 feet per second. A switch actuation in the +X direction decreases the rate of descent by 2 feet per second. A switch actuation in the -X direction increases the rate of descent by 2 feet per second. Vehicle response to these commands is monitored on the Alt Rate meter (9-M-9B).

<u>Code</u>	<u>Control/Indicator</u>	<u>Function</u>
1-S-12	+X AXIS TRANSLATION SWITCH GUARDED PUSH- BUTTON MOMENTARY	This pushbutton is located at the Commander's station. When it is held in the depressed position it provides 4 jet translation in the +X direction by energizing the RCS secondary coils. Upon release of the button the signal is removed from the coils, terminating the jet firings.

Panel V (Flight Control)

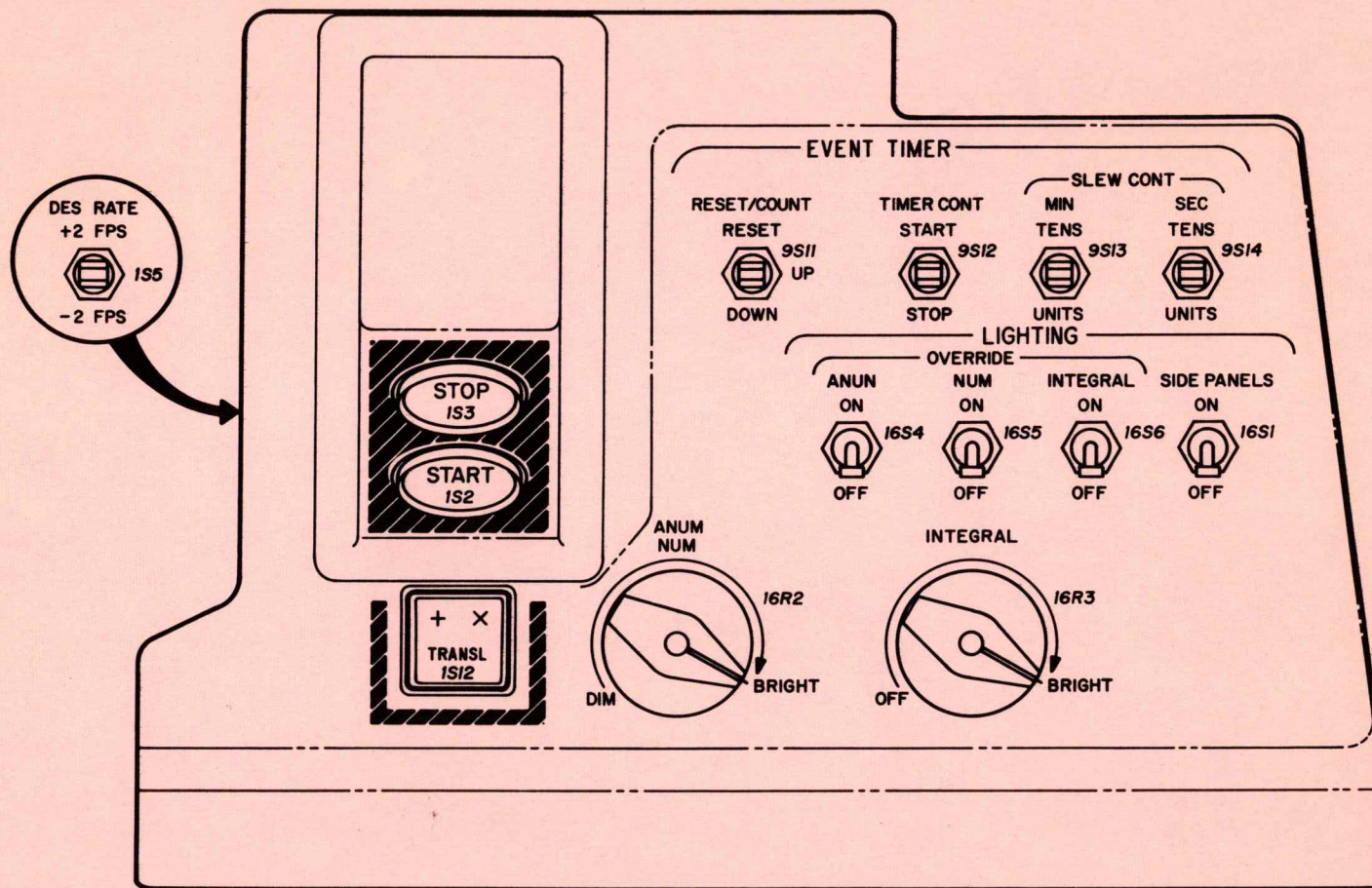
<u>Code</u>	<u>Control/Indicator</u>	<u>Function</u>
9-S-11	RESET/COUNT SWITCH 3-POSITION TOGGLE MOM-MAIN-MAIN	This three-position toggle (RESET - UP - DOWN) is used to reset the Event Timer and select the direction in which the timer will count. The momentary spring loaded RESET position immediately resets 9-M-11 to zero. Zero is maintained until a start pulse is initiated by activation of 9-S-12. In the UP position the timer will count in an increasing direction to 59 minutes and 59 seconds, return to zero and begin counting up again. In the DOWN position the timer will count in a decreasing direction from a preset value to 0 minutes and 0 seconds and then begin counting up.
9-S-12	TIMER CONTROL SWITCH MOM-MAIN-MOM	This three-position toggle (START - STOP) has two momentary spring loaded positions. In the START position the Event Timer will begin counting in a direction selected by 9-S-11. In the STOP position the count is stopped and frozen until either the START position is again selected or the RESET/COUNT switch is activated.

<u>Code</u>	<u>Control/Indicator</u>	<u>Function</u>
9-S-13	MIN SLEW CONTROL SWITCH	These toggles are used to set the four digits of 9-M-11. They have two momentary spring loaded positions (TENS-UNITS) which permit resetting each of the four digits independently. Positioning 9-S-13 to the TENS position slews the tens column digit of the minutes pair at the rate of 2 digits per second as long as the toggle is held in this position. In the UNITS position, the unit column digit of the minutes pair is changed at a rate of 2 digits per second. All digits change in an increasing direction, regardless of the position of 9-S-11. In the center maintain position the slewing function is disabled. 9-S-14 is used in the same manner to set the seconds pair of the digits on the Events Timer Indicator.
9-S-14	SEC SLEW CONTROL SWITCH	
	TWO 3-POSITION TOGGLE MOM-MAIN-MOM	

Panel V (Lighting Control)

<u>Code</u>	<u>Control/Indicator</u>	<u>Function</u>
16-R-2	ANUN/NUM CONTROL CONTINUOUS ROTARY	This continuous rotary (DIM BRIGHT) controls the brightness of the annunciators, the component caution lights, the activated state of the engine start and stop pushbuttons, the electro-luminescent numeric displays and time-shared displays (i.e., temporary legends or multipliers). An override switch (16-S-4) is provided for the annunciators, component caution lights and pushbuttons, and a second override switch (16-S-5) for the EL numeric and time-shared displays in the event that either portion of the ANUN/NUM control fails.

<u>Code</u>	<u>Control/Indicator</u>	<u>Function</u>
16-R-3	INTEGRAL LIGHTING CONTROL CONTINUOUS ROTARY	This continuous rotary (DIM BRIGHT) controls the brightness of the low level EL integrally illuminated markings and displays from DIM to BRIGHT. Should this control fail, or if the brightness range is inadequate, it may be bypassed by 16-S-3.
16-S-1	SIDE PANELS SWITCH (CDR) 2-POSITION TOGGLE MAIN-MAIN	This two-position toggle (ON - OFF) provides ON/OFF control of the CDR's side panel EL illumination. In the ON position, this switch connects the integral lights located on the CDR's side panels to 16-R-3 and 16-S-3. In the OFF position, the side panels are not connected to 16-R-3 and 16-S-3 and are therefore not illuminated with EL.
16-S-3	INTEGRAL OVERRIDE SWITCH 2-POSITION TOGGLE MAIN-MAIN	This two-position toggle (ON - OFF) supplies full voltage (115V, 400 cps) to the low level EL integrally illuminated markings and displays. In the OFF position, these markings and displays are controlled by 16-R-3. In the ON position, 16-R-3 is bypassed and 115V 400 cps is applied directly to the EL markings and displays.
16-S-4	ANUN OVERRIDE SWITCH 2-POSITION TOGGLE MAIN-MAIN	This two-position toggle (ON -OFF) provides a full voltage bypass of the brightness control of the ANUN portion of the ANUN/NUM control. In the OFF position the annunciators, component caution lights and pushbutton intensities are controlled by 16-R-2. In the ON position that control is bypassed and 5V DC is applied directly to the annunciators, component caution lights and pushbuttons.
16-S-5	NUM OVERRIDE SWITCH 2-POSITION TOGGLE MAIN-MAIN	This two-position toggle (ON - OFF) provides a full voltage override to the brightness control of the NUM portion of the ANUN/NUM control. In the OFF position, the electro-lumin- escent numerics and the time-shared displays are controlled by the ANUN/NUM control bypassed and 115V 400 cps is supplied directly to the numerics and displays.



PANEL V

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1.6.6 Panel VI (Engine/Thrust Control)

<u>Code</u>	<u>Control/Indicator</u>	<u>Function</u>
1-S-4	ENGINE STOP SWITCH GUARDED PUSHBUTTON MAINTAIN	This pushbutton (1-S-4) sends a discrete stop signal to the descent and ascent engines independent of the position of 1-S-1. When actuated, the button remains depressed and is illuminated red. It is reset by depressing it a second time.

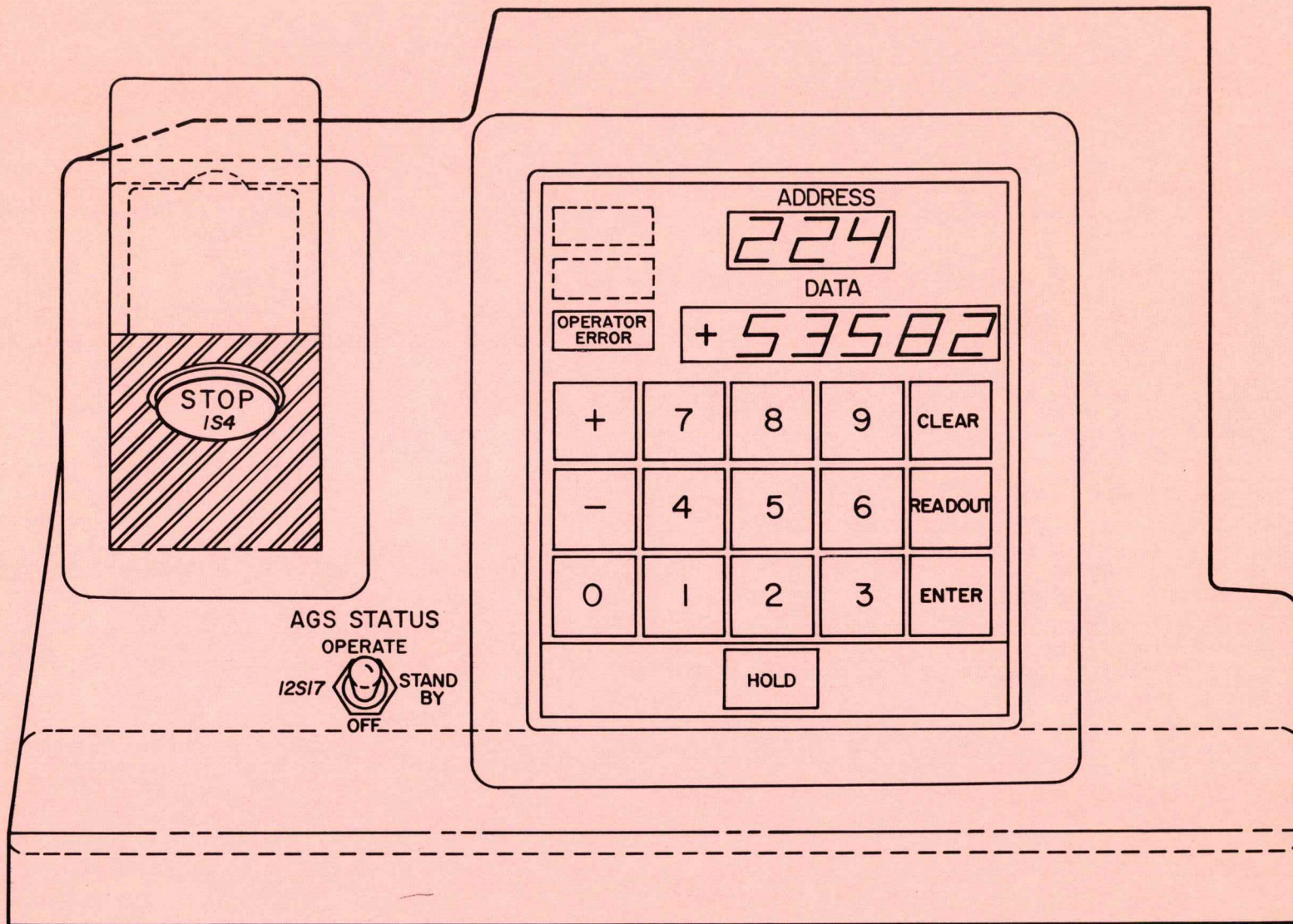
Panel VI (Abort Guidance Subsystem)

The SE Abort Guidance Panel (Panel VI) contains the Data Entry and Display Assembly (DEDA). Similar to the DSKY, the DEDA is used to communicate with the Abort Guidance System (AGS). Since the AGS is less complicated than the Primary Navigation and Control System, (it has only to compute an abort program), fewer displays are required. A 3 digit address read-out (12-M-1), and a sign (+, -) and 5 digit data indicator (12-M-2) are provided. A sixteen push-button (12-S-1 through 12-S-16) keyboard gives the Systems Engineer the capability of entering data into the AGS computer. The "OPERATOR ERROR" Light (12-DS-1) will light, should the crew member make a mistake. Mistakes recognized by the DEDA are such things as failure to push the "+" or "-" key before entering numerical data, or pressing too many pushbuttons before the data are entered. 1-S-4 - Engine Stop Switch (SE) - Same as 1-S-3.

<u>Code</u>	<u>Control/Indicator</u>	<u>Function</u>
12-S-17	AGS STATUS SWITCH THREE-POSITION TOGGLE MAIN-MAIN-MAIN	This switch enables the crew to place the AGS in any one of three states. In OFF, no power is furnished the AGS, except to the Abort Sensor Assembly (ASA) heaters. In STANDBY, full power goes to the entire ASA, and the Abort Electronics Assembly (AEA) is placed in its warmup mode. In OPERATE, full power is supplied to both ASA and AEA.

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Fig. 1-37



PANEL VI

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1.6.7 Panel VIII (Engine/Thrust Control)

<u>Code</u>	<u>Control/Indicator</u>	<u>Function</u>
1-S-7	PROBE CUTOFF SEITCH 2-POSITION TOGGLE LOCK-LOCK	This two-position toggle (ENABLE - OFF) is located at the Commander's station. In the ENABLE position, the probe(s) signal will shut down the descent engine upon contact with the lunar surface. In the OFF position, the probe(s) signal will not shut down the descent engine. In either case, manual shut down of the descent engine through 1-S-3 or 1-S-4 is not affected.

Panel VIII (Explosive Devices Subsystem)

<u>Code</u>	<u>Control/Indicator</u>	<u>Function</u>
2-S-1	DESCENT PRESSURIZATION SWITCH 2-POSITION TOGGLE MOM-LOCK	This two-position toggle (FIRE - SAFE) actuates squib valves which permit helium to flow from the descent helium tanks to pressurize the Descent Propulsion Subsystem. Positive feedback of the firing of the squibs is provided by a nominal reading on the Main Propulsion Subsystem's Fuel and Oxidizer Pressure Meter (10-M-3).
2-S-2	RCS PRESSURIZATION SWITCH 2-POSITION TOGGLE MOM-LOCK	This two-position toggle (FIRE - SAFE) actuates squib valves which permit helium to flow from the RCS helium tanks to pressurize the Reaction Control Subsystem. Positive feedback of the firing of the squibs is provided by a nominal pressure reading on the Reaction Control Subsystem's Pressure Indicator (8-M-1).

<u>Code</u>	<u>Control/Indicator</u>	<u>Function</u>
2-S-3	ASCENT HELIUM SELECT SWITCH 3-POSITION TOGGLE LOCK-LOCK-LOCK	This three-position toggle (TANK 1 - BOTH - TANK 2) selects the squib valves of either Ascent Helium Tank 1 or 2, or both, for firing by use of 2-S-4.
2-S-4	ASCENT HELIUM PRESSURIZATION SWITCH 2-POSITION TOGGLE MOM-LOCK	This two-position toggle (FIRE - SAFE) actuates the squib valves of the tank(s) selected by 2-S-3. Actuation of these squib valves will pressurize the Ascent Propulsion subsystem. Positive feedback of the firing of the squibs is provided by a nominal pressure reading on 10-M-3.
2-S-5	STAGE SWITCH 2-POSITION GUARDED TOGGLE LOCK-LOCK	This guarded two-position toggle (FIRE - SAFE) actuates the explosive devices which separate the descent stage from the ascent stage. This control will only be used when staging is desired without firing the ascent engine.
2-S-7	MASTER ARM SWITCH 2-POSITION TOGGLE LOCK-LOCK	This two-position toggle (ON-OFF) enables the actuation of all vehicle explosive devices by actuating redundant relays that apply power to the EDS busses. Thus, this switch must be in the ON position in order for 2-S-1, 2-S-2, 2-S-4, 2-S-5, 2-S-10 to perform their designated functions.
2-S-10	LANDING GEAR DEPLOY SWITCH 2-POSITION TOGGLE MOM-LOCK	This two-position toggle (FIRE - SAFE) actuates the explosive devices which release the stowed landing gear. Positive feedback of landing gear deployment is provided by 2-FL-1.

<u>Code</u>	<u>Control/Indicator</u>	<u>Function</u>
2-FL-1	LANDING GEAR STATUS 2-POSITION FLAG	This two-position flag (GREY - BARBERPOLE) indicates stowed (BARBERPOLE) or deployed (GREY) status of the LEM landing gear, as sensed at all four landing struts.

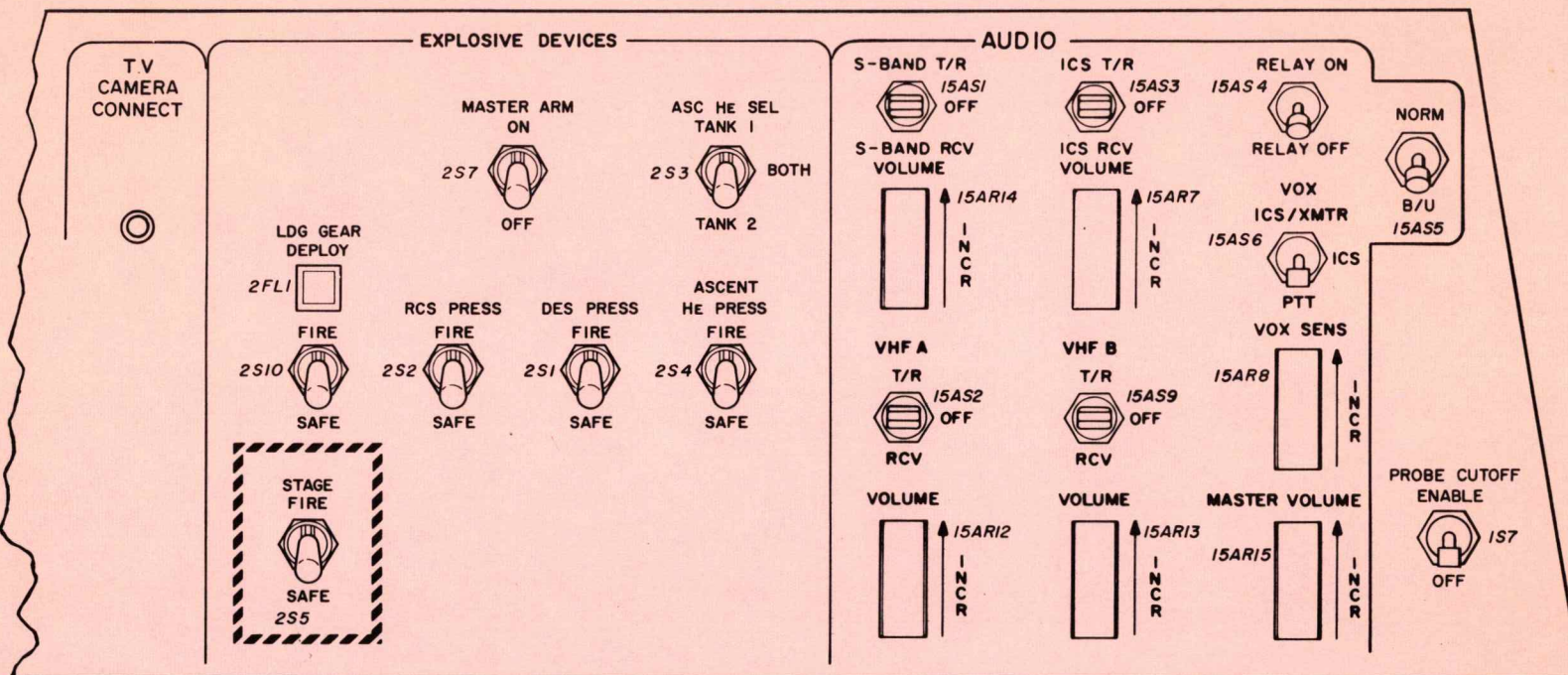
Panel VIII (Audio Control -- Duplicated on Panel XII)

<u>Code</u>	<u>Control/Indicator</u>	<u>Function</u>
15A-S-1 (15B-S-1)	S-BAND SWITCH 3-POSITION TOGGLE MAIN-MAIN-MAIN	This three-position toggle (S-BAND T/R - OFF - S-BAND RCV), in the S-BAND T/R position, routes received S-band voice to the headset, and mike amplifier outputs to the PMP for transmission via S-band equipment. In the OFF position, neither the S-band receiver nor transmitter output is routed through the audio center. In the S-band RCV position, the audio center is enabled to accept received S-band voice.
15A-S-2 15A-S-9 (15B-S-2) (15B-S-9)	VHF A SWITCH VHF B SWITCH TWO 3-POSITION TOGGLES MAIN-MAIN-MAIN	These three-position toggles (T/R - OFF - RCV), in the T/R position, routes received VHF A voice signals to the headsets, and mike amplifier outputs to the PMP for transmission via the VHF equipment. In the T/R position the VOX keying voltage is routed to the VHF A transmitter. In the OFF position neither the VHF A receiver nor transmitter can be utilized. In the RCV position the audio center is enabled to accept received VHF A voice. 15A-S-9 enables the same control capabilities with the VHF B equipment.

<u>Code</u>	<u>Control/Indicator</u>	<u>Function</u>
15A-S-3 (15B-S-3)	INTERCOM SWITCH 3-POSITION TOGGLE MAIN-MAIN-MAIN	This three-position toggle (ICS T/R - OFF - ICS RCV), in the ICS T/R position, routes mike amplifier outputs to the ICS bus and from there to the headset. In the OFF position the intercom capability is disabled. In the ICS RCV position voice signals on the ICS bus are routed to the headsets.
15A-S-4 (15B-S-4)	RELAY SWITCH 2-POSITION TOGGLE LOCK-LOCK	This two-position toggle (RELAY ON - RELAY OFF), in the RELAY ON position, establishes a voice conference capability among the earth, LEM and the extravehicular astronaut, and relays received extravehicular astronaut biomed data to earth. Additionally, in the event of failure of the CSM-earth S-band link, received VHF from CSM can be relayed to earth via the LEM S-band transmitter. In the RELAY OFF position these capabilities are interrupted. Only one Relay switch should be ON at a time. In addition, appropriate switch positions on both audio control panels must be selected to establish the desired relay link.
15A-S-5 (15B-S-5)	AUDIO CONTROL SWITCH 2-POSITION TOGGLE MAIN-MAIN	This two-position toggle (NORM - BU) selects the audio center and microphone circuit which is to be utilized. In the NORM position the crewman is using his own audio center and microphone assembly. In the BU position he is utilizing the other crewman's audio center and microphone assembly.
15A-S-6 (15B-S-6)	VOX SWITCH 3-POSITION TOGGLE MAIN-MAIN-MAIN	This three-position toggle (ICS/XMTR - ICS - PTT) selects the manner in which the various equipments are keyed. In the ICS/XMTR position the VOX control circuitry in the audio center is enabled to key both

<u>Code</u>	<u>Control/Indicator</u>	<u>Function</u>
15A-S-6 (15B-S-6) (Cont)		the intercom and selected transmitter(s). In the ICS position, only the intercom is VOX operated; selected transmitters are keyed only by the push-to-talk (PTT) switches (15-S-10 and 15-S-11). In the PTT position the VOX circuit is disabled and both the intercom and selected transmitters can be keyed only by the PTT switches. In any switch position the PTT function will override the VOX mode.
15A-R-7 (15B-R-7)	ICS VOLUME CONTROL THUMBWHEEL	This thumbwheel (INCR) permits continuous adjustment of the level of the audio input of the ICS to the headset. Movement of the thumbwheel in an upward direction increases the volume; a downward movement decreases it.
15A-R-8 (15B-R-8)	VOX SENSITIVITY THUMBWHEEL	This thumbwheel (INCR) permits continuous adjustment of the threshold of the VOX control circuit in the audio center. Movement of the thumbwheel in an upward direction increases VOX sensitivity, a downward movement decreases it.
15A-S-10 (15A-S-10)	PTT SWITCH MOMENTARY PUSHBUTTON	This momentary pushbutton, located on the astronaut's attitude controller, is used to key the intercom and/or selected transmitter(s).
15A-S-11 (15B-S-11)	PTT/KEYER SWITCH MOMENTARY PUSHBUTTON	This momentary pushbutton, located on the astronaut's Communications umbilical, is used to key the intercom and/or selected transmitter(s). Additionally, in the event of a voice communication failure, the S-band Function switch 13-S-4 can be placed in the KEY position, thus enabling the PTT switch to serve as a Morse code keyer. (In this mode, the PM section of the S-band transmitter is utilized to transmit Morse code.)

<u>Code</u>	<u>Control/Indicator</u>	<u>Function</u>
15A-R-12	VHF A VOLUME CONTROL	These thumbwheels (INCR) permits continuous adjustment of the audio level of the VHF A and VHF B receiver signals to the headset amplifier.
15A-R-13	VHF B VOLUME CONTROL	
(15B-R-12)	TWO THUMBWHEELS	
(15B-R-13)		
15A-R-14	S-BAND VOLUME CONTROL	This thumbwheel (INCR) permits continuous adjustment of the audio level of the S-band receiver signal to the headset amplifier.
(15B-R-14)	THUMBWHEEL	
15A-R-15	MASTER VOLUME CONTROL	This thumbwheel (INCR) permits continuous adjustment of the level of all audio outputs (received VHF A and B, ICS and S-band) from the headset amplifier simultaneously. Thus, individual input levels would be set by using the respective volume control thumbwheels, and the overall level would be adjusted with this thumbwheel.
(15B-R-15)	THUMBWHEEL	



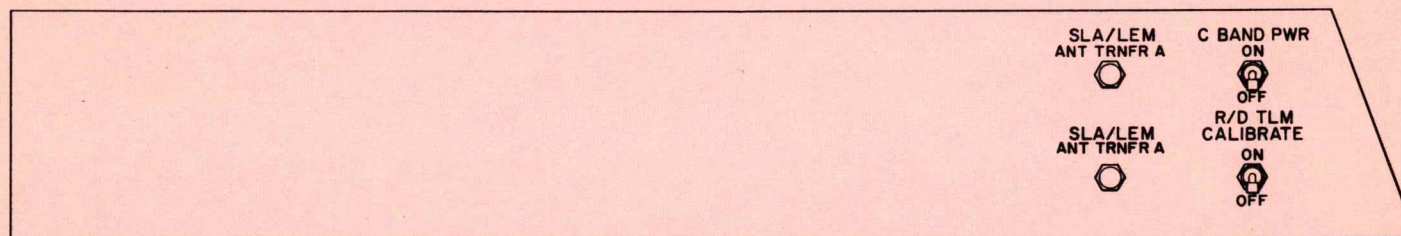
PANEL VIII

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DEC 65

1.6.8 Panel X

At the present time there is no requirement for the use of this panel in any of the manned LEM's. It is planned to be used on the early unmanned flights. At this printing, insufficient information is available on this panel configuration.

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PANEL X

Fig. 1-39

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1.6.9 Panels XI and XVI - ELECTRICAL POWER SUBSYSTEM (CIRCUIT BREAKERS)

<u>Subsystem/Code</u>	<u>Panel Nomenclature</u>	<u>Panel Location</u>		<u>Component(s) Served</u>
		<u>XI</u>	<u>XVI</u>	
Explosive Devices				
4-CB-75	LOGIC PWR B		X	All explosive devices toggle switches.
4-CB-76	LOGIC PWR A	X		All explosive devices toggle switches.
4-CB-149	LDG GEAR FLAG	X		Landing gear status indicator (2-FL-1).
Primary Guidance and Navigation				
4-CB-29	RNDZ RDR	X		Rendezvous radar power supply. This circuit breaker serves as the ON-OFF control for this component.
4-CB-105	LDG RDR	X		Landing radar power supply. This circuit breaker serves as the ON-OFF control for this component.
4-CB-122	LGC/DSKY	X		LEM guidance computer power supply. This circuit breaker serves as the ON-OFF control for this component.
4-CB-124	IMU OPR	X		IMU power supply. This circuit breaker serves as the ON-OFF control for this component.
4-CB-154	SIG STR DISP	X		Signal Strength meter (17-M-1).
4-CB-161	IMU STBY	X		This circuit breaker serves as the ON-OFF control for the PIPA and Inertial Reference Integrating gyro control heaters.

<u>Subsystem/Code</u>	<u>Panel Nomenclature</u>	<u>Panel Location</u>		<u>Component(s) Served</u>
		<u>XI</u>	<u>XVI</u>	
4-CB-206	RNDZ RDR	X		Rendezvous Radar power supply. This circuit breaker serves as the ON-OFF control for this component (AC).
4-CB-212	AOT LAMP	X		AOT lamp. This circuit breaker serves as the ON-OFF control for this component (AC).
4-CB-84	CO ₂ SENSOR		X	CO ₂ sensor.
4-CB-96	GLYCOL PUMP EMER		X	Emergency glycol pump.
4-CB-98	PRIM H ₂ O FEED		X	Primary water boiler water feed solenoid valve.
4-CB-107	CABIN FAN 1	X		Cabin fan #1.
4-CB-108	CABIN FAN 2		X	Cabin fan #2.
4-CB-109	CABIN FAN CONT		X	Cabin differential pressure sensor and relay.
4-CB-112	DIVERT VLV		X	Suit circuit diverter valve.
4-CB-113	CABIN REPRESS		X	Cabin repressurization and emergency O ₂ valve
4-CB-117	GLYCOL PUMP 1	X		Glycol pump #1.
4-CB-119	SUIT FAN 2		X	Suit fan #2.
4-CB-120	SUIT FAN CONT		X	Fan differential pressure sensor.
4-CB-138	SUIT FAN 1	X		Suit fan #1.

<u>Subsystem/Code</u>	<u>Panel Nomenclature</u>	<u>Panel Location</u>		<u>Component(s) Served</u>
		<u>XI</u>	<u>XVI</u>	
4-CB-140	DISP		X	ECS displays: i.e., CO ₂ Partial Pressure indicator (7-M-1) Cabin Temperature indicator (7-M-3A), Suit Temperature indicator (7-M-3B), Cabin Pressure indicator (7-M-2A), Suit Pressure indicator (7-M-2B), Glycol Pressure indicator (7-M-5A), Glycol Temperature indicator (7-M-5B), Oxygen Quantity indicator (7-M-4B).
4-CB-141	GLYCOL PUMP 2	X		Glycol pump #2.
Reaction Control				
4-CB-42	QUAD 4 - TCA		X	TCA Fuel and Oxidizer valves of Quad 4, System B.
4-CB-43	QUAD 3 - TCA		X	TCA Fuel and Oxidizer valves of Quad 3, System B.
4-CB-44	QUAD 2 - TCA		X	TCA Fuel and Oxidizer valves of Quad 2, System B.
4-CB-45	QUAD 1 - TCA		X	TCA Fuel and Oxidizer valves of Quad 1, System B.
4-CB-49	ISOL VLV		X	Oxidizer and Fuel isolation valves of System B.
4-CB-50	TEMP/PRESS DISP - FLAGS		X	All status flags (8-FL-1 to 8-FL-17) and Temperature and Pressure indicators (8-M-1A, 8-M-1B, 8-M-2A, and 8-M-2B).
4-CB-51	ASC FEED	X		Ascent interconnect Oxidizer and Fuel valves of System A.

<u>Subsystem/Code</u>	<u>Panel Nomenclature</u>	<u>Panel Location</u>		<u>Component(s) Served</u>
		<u>XI</u>	<u>XVI</u>	
4-CB-52	ASC FEED		X	Ascent interconnect Oxidizer and Fuel valves of System B.
4-CB-54	CRSFD		X	Oxidizer and Fuel crossfeed valves.
4-CB-60	QUAD 4 - TCA	X		TCA Fuel and Oxidizer valves of Quad 4, System A.
4-CB-61	QUAD 3 - TCA	X		TCA Fuel and Oxidizer valves of Quad 3, System A.
4-CB-62	QUAD 2 - TCA	X		TCA Fuel and Oxidizer valves of Quad 2, System A.
4-CB-63	QUAD 1 - TCA	X		TCA Fuel and Oxidizer valves of Quad 1, System A.
4-CB-67	ISOL VLV	X		Oxidizer and Fuel isolation valves of System A.
4-CB-70	He REG SOV	X		Primary Helium regulator shutoff valve of System A and the redundant Helium regulator shutoff valve of System B.
4-CB-71	He REG SOV		X	Primary Helium regulator shutoff valve of System B and the redundant Helium regulator shutoff valve of System A.
4-CB-72	MAIN SOV	X		Oxidizer and Fuel main shutoff valves of System A.
4-CB-73	MAIN SOV		X	Oxidizer and Fuel main shutoff valves of System B.
4-CB-121	PQGS		X	Propellant Quantity G

<u>Subsystem/Code</u>	<u>Panel Nomenclature</u>	<u>Panel Location</u>		<u>Component(s) Served</u>
		<u>XI</u>	<u>XVI</u>	
4-CB-121	PQGS		X	Propellant Quantity Gaging Control Unit Assembly.
4-CB-163	PQGS DISP	X		Oxidizer and Fuel Quantity indicators (8-M-3A and 8-M-3B) (AC).
Flight Displays				
4-CB-83	V		X	V indicator (9-M-5).
4-CB-88	GASTA	X		Gimbal angle sequence transformation assembly.
4-CB-97	FDAI	X		Attitude indicator assembly (9-M-1).
4-CB-123	RNG/RNG & ALT/ALT RT	X		Range/Altitude indicator (9-M-9A and 9-M-9B).
4-CB-126	FDAI		X	Attitude indicator assembly (9-M-6).
4-CB-133	X-PNTR	X		LOS RT/HORIZ VEL indicator (9-M-2).
4-CB-134	X-PNTR		X	LOS RT/HORIZ VEL indicator (9-M-3).
4-CB-159	EVENT TIMER	X		Event Timer display (9-M-11). This circuit breaker serves as the ON-OFF control for this component.
4-CB-168	THRUST DISP	X		Thrust indicator power supply. This circuit breaker serves as the ON-OFF control for this component.
4-CB-201	GASTA	X		Gimbal angle sequence transformation assembly (AC).

<u>Subsystem/Code</u>	<u>Panel Nomenclature</u>	<u>Panel Location</u>		<u>Component(s) Served</u>
		<u>XI</u>	<u>XVI</u>	
4-CB-204	RNG/RNG & ALT/ALT RT	X		Range/Altitude indicator (9-M-9A and 9-M-9B) (AC).
4-CB-209	CDR FDAI	X		Sphere drive system of the Attitude indicator assembly (9-M-1) (AC).
4-CB-210	SE FDAI	X		Sphere drive system of the Attitude indicator assembly (9-M-6) (AC).
Main Propulsion				
4-CB-32	PQGS		X	Main Propulsion quantity display (10-M-5A and 10-M-5B) and gaging system.
4-CB-53	ASC He REG		X	Latching Helium solenoid valves 1 and 2.
4-CB-74	DES He REG	X		Latching Helium solenoid valves 1 and 2.
4-CB-103	TEMP/PRESS DISP		X	Fuel and Oxidizer Pressure indicator (10-M-3A and 10-M-3B), Fuel and Oxidizer Temperature indicator (10-M-4A and 10-M-4B) and flags (10-FL-1 through 10-FL-4).
4-CB-169	He TEMP/PRESS	X		Helium Temp/Press indicator (10-M-1) (AC).

<u>Subsystem/Code</u>	<u>Panel Nomenclature</u>	<u>Panel Location</u>		<u>Component(s) Served</u>
		<u>XI</u>	<u>XVI</u>	
Stabilization and Control				
4-CB-2	ABORT STAGE		X	Abort Staging Electronics.
4-CB-3	ABORT STAGE	X		Abort Staging Electronics.
4-CB-28	AGS		X	Abort Guidance Section (Primary Power).
4-CB-37	ENG ARM		X	Powers Engine Arm switch.
4-CB-40	AELD	X		Ascent engine latching device.
4-CB-87	VHF A RCVR	X		VHF Receiver Assembly.
4-CB-102	PMP		X	Pre-modulation Processor portion of the Signal Processing Assembly. This circuit breaker serves as the ON-OFF control for the PMP.
4-CB-104	TV		X	Portable Television Camera. This circuit breaker serves as the ON-OFF control for the TV camera.
4-CB-110	S-BD ANT		X	Electronics section of the S-BAND Steerable Antenna Assembly.
4-CB-111	PRIM S-BD XMTR/ RCVR		X	Primary S-BAND trasmitter, receiver and power supply and portions of the PMP (for key functions).
4-CB-114	VHF B RCVR		X	VHF Receiver Assembly.

<u>Subsystem/Code</u>	<u>Panel Nomenclature</u>	<u>Panel Location</u>		<u>Component(s) Served</u>
		<u>XI</u>	<u>XVI</u>	
4-CB-115	VHF A XMTR		X	VHF Transmitter Assembly.
4-CB-136	SEC S-BD PWR AMPL	X		Secondary S-BAND Power Amplifier and Power Supply.
4-CB-137	SEC S-BD XMTR/ RCVR	X		Secondary S-BAND transmitter, receiver and power supply and portions of the PMP (for key functions).
4-CB-153	DISP		X	The Communication's Displays, i.e., Signal Strength Meter (14-M-1), Antenna Pitch Meter (14-M-3) and the Antenna Yaw Meter (14-M-4).
4-CB-162	VHF B XMTR	X		VHF B Transmitter Assembly.
Lighting				
4-CB-128	FLOOD		X	Floodlights.
4-CB-146	ANUN/DOCK/ COMPNT	X		Power supply for Caution/Warning Annunciators (6-DS-1 through 6-DS-40), Lunar Contact Lights (1-DS-1 and 1-DS-2), Component Caution Lights (4-DS-1, 4-DS-2, 7-DS-1, 7-DS-3, 7-DS-6, 7-DS-7, 12-DS-1, 14-DS-1, 17-DS-1) and the Docking Lights. These circuit breakers except for Docking Lights also serve as ON-OFF control for the components listed above.
4-CB-147	MASTER ALARM		X	The two master alarm lights and the tone generator.

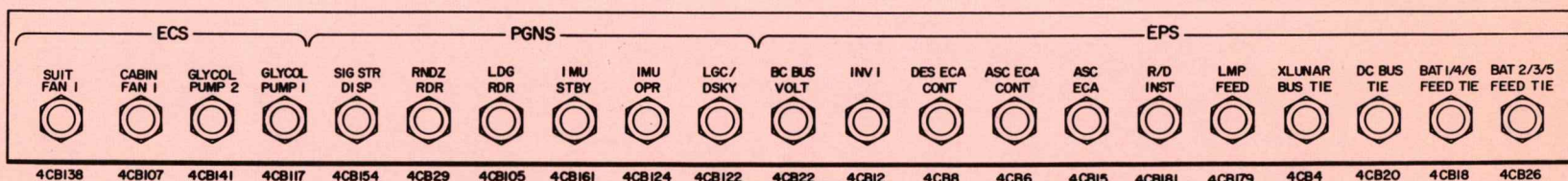
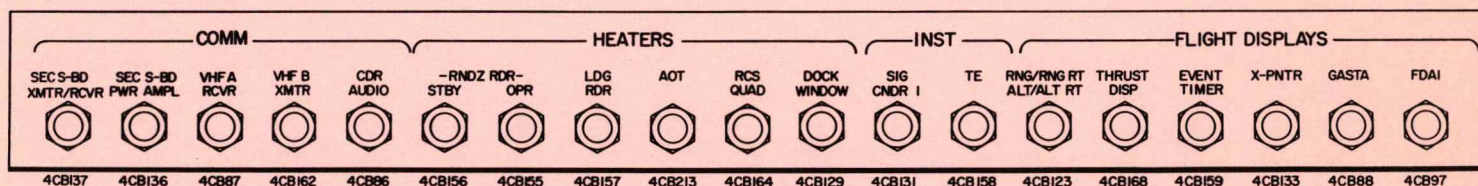
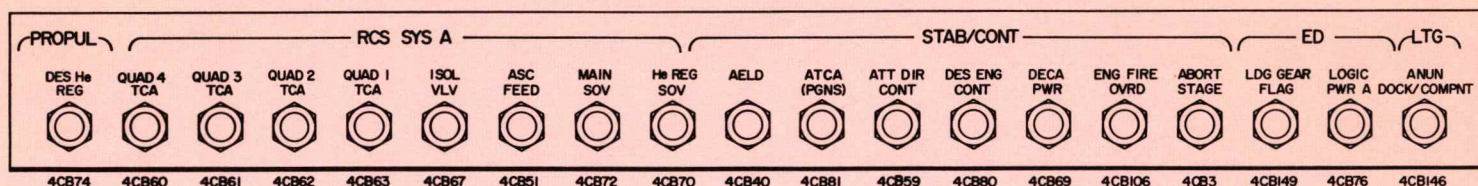
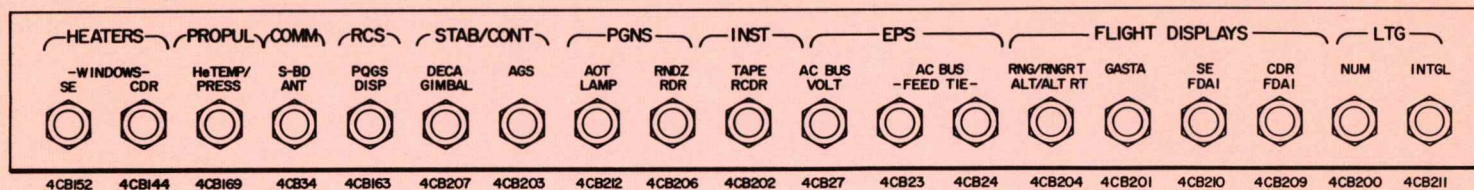
<u>Subsystem/Code</u>	<u>Panel Nomenclature</u>	<u>Panel Location</u>		<u>Component(s) Served</u>
		<u>XI</u>	<u>XVI</u>	
4-CB-148	ANUN/DOCK/COMPNT		X	Alternate power supply (to 4-CB-146) for Caution/Warning Annunciators (6-DS-1 through 6-DS-40), Lunar Contact Lights (1-DS-1 and 1-DS-2), Component Caution Lights (4-DS-1, 4-DS-2, 7-DS-1, 7-DS-3, 7-DS-6, 7-DS-7, 12-DS-1, 14-DS-1, 17-DS-1) and the Docking Lights. These circuit breakers except for Docking Lights also serve as ON-OFF control for the components listed above.
4-CB-160	TRACK		X	Tracking Lights.
4-CB-200	NUM	X		Numeric displays (3-M-1, 3-M-2, 3-M-3, 3-M-4, 3-M-5, 3-M-6, 8-M-3A, 8-M-3B, 9-M-5, 9-M-11, 10-M-1, 10-M-5A, 10-M-5B, 12-M-1 and 12-M-2) (AC).
4-CB-211	INTGL	X		Low level integral lighting (AC).
Heaters Control				
4-CB-31	S-BD ANT		X	S-band Antenna Heater.
4-CB-68	DISP		X	RCS, Radar and S-band Antenna heater temperatures.
4-CB-129	DOCK WINDOW	X		Powers docking window heater.
4-CB-144	CDR WINDOW	X		Powers Commander's window heater (AC).
4-CB-152	SE WINDOW	X		Powers Systems Engineer's window heater (AC).

<u>Subsystem/Code</u>	<u>Panel Nomenclature</u>	<u>Panel Location</u>		<u>Component(s) Served</u>
		<u>XI</u>	<u>XVI</u>	
4-CB-155	RNDZ RDR OPR	X		Rendezvous Radar Heater Control Circuit maintains temperature of antenna gyros.
4-CB-156	RNDZ RDR STBY	X		Rendezvous Radar Heater Control Circuit maintains temperature of crystal oven.
4-CB-157	LDG RDR	X		Landing Radar Heater Control Circuit.
4-CB-164	RCS QUAD	X		Quad thermostat and heater assembly.
4-CB-165	RCS QUAD		X	Quad thermostat and heater assembly.
4-CB-213	AOT	X		AOT Heater
Electrical Power				
4-CB-4	XLUNAR BUS TIE	X		Switches CDR's bus translunar loads to LEM single point ground.
4-CB-5	XLUNAR BUS TIE		X	Switches SE's bus translunar loads to LEM single point ground.
4-CB-6	ASC ECA CONT	X		Powers both Ascent ECA contactor coils.
4-CB-7	ASC ECA CONT		X	Powers both Ascent ECA contactor coils.
4-CB-8	DES ECA CONT	X		Powers both Descent ECA contactor coils.
4-CB-9	DES ECA CONT		X	Powers both Descent ECA contactor coils.
4-CB-10	DES ECA		X	Powers both Descent Electronic Control Assemblies.

<u>Subsystem/Code</u>	<u>Panel Nomenclature</u>	<u>Panel Location</u>		<u>Component(s) Served</u>
		<u>XI</u>	<u>XVI</u>	
4-CB-11	DES ECA		X	Powers both Descent Electronic Control Assemblies.
4-CB-12	INV 1	X		AC Inverter #1.
4-CB-13	INV 2		X	AC Inverter #2.
4-CB-14	ASC ECA		X	Powers both Descent Electronic Control Assemblies.
4-CB-15	ASC ECA	X		Powers both Descent Electronic Control Assemblies.
4-CB-16	DISP		X	The Electrical Power System Displays (4-M-2 and 4-M-3) and flags (4-FL-1 through 4-FL-9).
4-CB-17	BAT 1/4/6 FEED TIE		X	Ties Batteries 1, 4 and 6 Feeders to the System Engineer's Bus Feeder.
4-CB-18	BAT 1/4/6 FEED TIE	X		Ties Batteries 1, 4 and 6 Feeders to the Commander's Bus Feeder.
4-CB-19	DC BUS TIE		X	Ties CDR Bus Feeder to CDR Bus.
4-CB-20	DC BUS TIE	X		Ties CDR Bus Feeder to CDR Bus.
4-CB-21	DC BUS VOLT		X	DC Bus voltage instrumentation.
4-CB-22	DC BUS VOLT	X		DC Bus voltage instrumentation.
4-CB-23	AC BUS FEED TIE	X		Connects Inverter Outputs through Inverter Switch to AC Bus (AC).

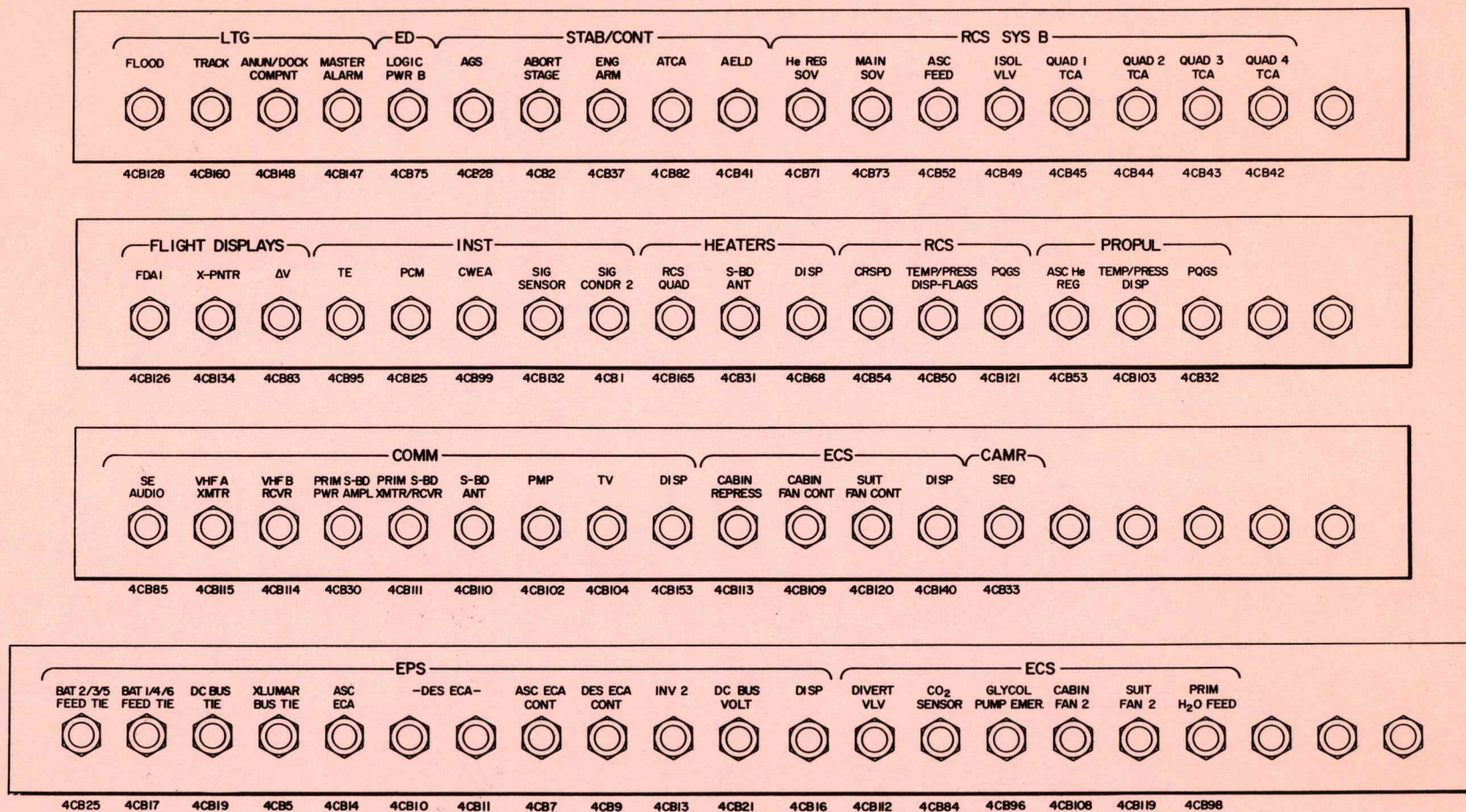
<u>Subsystem/Code</u>	<u>Panel Nomenclature</u>	<u>Panel Location</u>		<u>Component(s) Served</u>
		<u>XI</u>	<u>XVI</u>	
4-CB-24	AC BUS FEED TIE	X		Connects Inverter Outputs through Inverter Switch to AC Bus (AC).
4-CB-25	BAT 2/3/5 FEED TIE		X	Ties Batteries 2, 3 and 5 Feeders to the Systems Engineer's Bus Feeder.
4-CB-26	BAT 2/3/5 FEED TIE	X		Ties Batteries 2, 3 and 5 Feeders to the Commander's Bus Feeder.
4-CB-27	AC BUS VOLT	X		AC Bus voltage instrumentation (AC).
4-CB-179	IMP FEED	X		Powers IMP Bus.
4-CB-181	R/D INST	X		Powers R/D equipment.
Instrumentation				
4-CB-1	SIG CONDR 2		X	Electronic Replaceable Assembly #2.
4-CB-95	TE		X	Timing Electronics Circuit.
4-CB-99	CWEA		X	Caution and Warning Electronics Assembly.
4-CB-125	PCM		X	Pulse Code Modulator
4-CB-131	SIG CONDR 1	X		Electronic Replaceable Assembly #1.
4-CB-132	SIG SENSOR		X	All pre-conditioned transducers.
4-CB-158	TE	X		Timing Electronics Circuit.
4-CB-202	TAPE RCDR	X		Data Storage Electronics Assembly (AC).

<u>Subsystem/Code</u>	<u>Panel Nomenclature</u>	<u>Panel Location</u> <u>XI</u> <u>XVI</u>	<u>Component(s) Served</u>
Camera			
4-CB-33	SEQ	X	Sequence camera assembly.



PANEL XI

T30900-20
DEC 65



PANEL XVI

1.6.10 Panel XII (Audio Control)

-See Panel VIII

Panel XII (Communications)

<u>Code</u>	<u>Control/Indicator</u>	<u>Function</u>
13-S-1	RANGE/TV FUNCTION SWITCH 3-POSITION TOGGLE MAIN-MAIN-MAIN	This switch (RANGE - OFF - TV) permits the selection of either the ranging or the TV function for transmission via the S-band equipment. In the RANGE position, received ranging signals are retransmitted, via the phase modulated S-band transmitter (13-S-5 in FM position) back to earth. In the TV position, the frequency modulated transmitter (13-S-5 in FM position) is used to transmit television data to earth. Television transmission requires: (1) that the S-band power amplifier, controlled by switch 13-S-2 be energized, (2) that the S-band erectable antenna be connected, (3) that the S-band Antenna Select switch (14-S-5) be in the LUNAR STAY position and (4) that 13-S-6 be in either the VOICE or OFF position. If 13-S-1 is in the OFF position neither ranging nor TV data can be transmitted.
13-S-2	POWER AMPLIFIER SWITCH 3-POSITION TOGGLE MAIN-MAIN-MAIN	This switch (PRIM - OFF - SEC) permits the selection of either of two redundant power amplifiers for use with the S-band equipment. When activated, an amplifier requires a 62 watt power input; however, during certain phases of the lunar stay, S-band transmissions are possible in a low power mode, with the power amplifier turned off. This switch is enabled only if 13-S-8 is in the PRIM or SEC position, thus preventing operation of either power amplifier without a driving signal.

<u>Code</u>	<u>Control/Indicator</u>	<u>Function</u>
13-S-3	BIOMEDICAL SWITCH 3-POSITION TOGGLE MAIN-MAIN-MAIN	This switch (LEFT - OFF - RIGHT) selects which crew station hardline biomedical data will be sent to earth via the S-band. In the LEFT and RIGHT positions, inputs are fed from the Commander's and Systems Engineer's stations respectively. With this switch in the OFF position, and with 13-S-6 in the VOICE BU position, the transmission of hardline biomed and EMU data is interrupted, and additional speech processing takes place to enhance the intelligibility of the voice signal transmitted to earth.
13-S-4	PCM/KEY FUNCTION SWITCH 3-POSITION TOGGLE MAIN-MAIN-MAIN	This switch (PCM - OFF - KEY) permits the selection of either the telemetry or the emergency keying function for transmission via the S-band equipment. In the PCM position, telemetry data is routed to the PMP for transmission to earth via the S-band. (This function is used in conjunction with 13-S-13.) In the OFF position no data is transmitted, nor is the subcarrier transmitted. In the KEY position all other selected S-band functions (13-S-1, 13-S-3, 13-S-5 and 13-S-6) are interrupted and the PM section of the selected S-band transmitter is enabled; DC power is applied to the PMP emergency key gating circuitry, and the PTT/Keyer switches (15A-S-11 and 15B-S-11) located on the ECS umbilicals, are enabled to serve as Morse code keyers for emergency transmissions.
13-S-5	MODULATE SWITCH 2-POSITION TOGGLE MAIN-MAIN	This switch (PM - FM) permits selection of either the PM or the FM mode of transmission for the S-band transmitter. All S-band transmission modes are normally PM, except for television transmissions during the lunar stay, which require the FM mode. In addition, transmission of television data requires that 13-S-2 and 13-S-8 be in the PRIM or SEC positions.

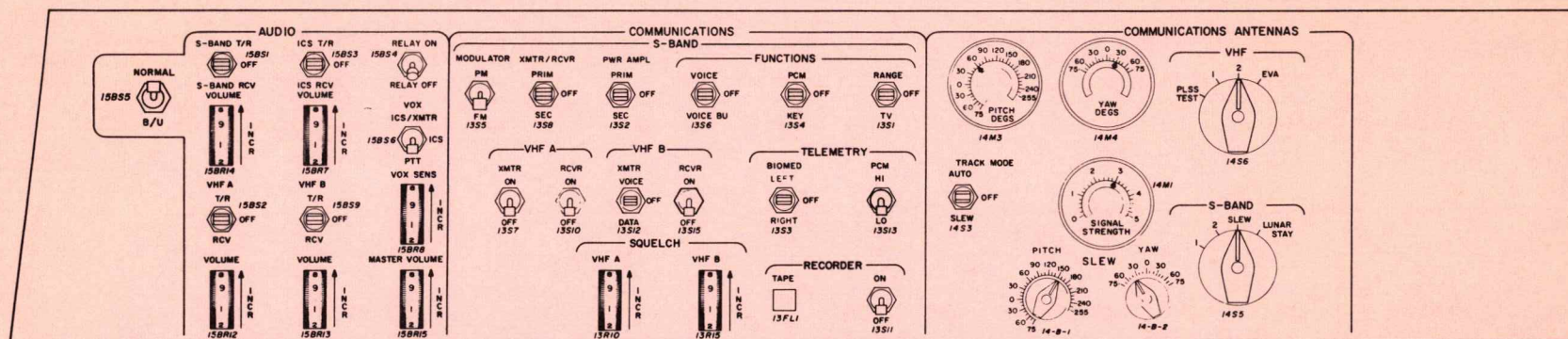
<u>Code</u>	<u>Control/Indicator</u>	<u>Function</u>
13-S-6	VOICE FUNCTION SWITCH 3-POSITION TOGGLE MAIN-MAIN-MAIN	This switch (VOICE - OFF - VOICE BU) permits the selection of either normal voice or backup voice for transmission via the S-band equipment. In the VOICE position, the voice output is modulated onto a 1.25 mcs subcarrier within the PMP and routed to the S-band PM transmitter for transmission to earth. If the FM transmitter is selected, and 13-S-1 is in the OFF position, the voice is routed to the FM transmitter for modulation directly on the carrier (used during lunar stay). In the VOICE BU position, the PM section of the S-band transmitter is automatically selected (regardless of the position of 13-S-5) to transmit voice directly on the carrier, bypassing the PMP. In the VOICE BU position, the ranging or television function of 13-S-1 is interrupted if either has been selected. In the OFF position, all S-band voice transmission capability is interrupted.
13-S-7	VHF A TRANSMITTER SWITCH 2-POSITION TOGGLE MAIN-MAIN	This switch (ON - OFF) controls primary power to the VHF A transmitter. In the ON position, electrical power is applied to the transmitter assembly, and in the OFF position power to the assembly is interrupted.
13-S-8	TRANSMITTER/RECEIVER SWITCH 3-POSITION TOGGLE MAIN-MAIN-MAIN	This switch (PRIM - OFF - SEC) selects either of two redundant transmitter/receiver combinations. The redundant components involved are: power supplies, receivers, PM modulators and transmitter chains. In the OFF position power to this S-band equipment is interrupted.
13-S-10	VHF A RECEIVER SWITCH	These switches (ON - OFF) control primary power to the VHF A receiver and VHF B receiver respectively. In the ON position, electrical power is applied to the A or B receiver assembly and in the OFF position power to the assembly is interrupted.
13-S-15	VHF B RECEIVER SWITCH TWO 2-POSITION TOGGLES	

<u>Code</u>	<u>Control/Indicator</u>	<u>Function</u>
13-S-11	TAPE RECORDER SWITCH 2-POSITION TOGGLE MAIN-MAIN	This switch (ON - OFF) is used in conjunction with the VOX circuit for controlling tape recording. In the ON position the recorder equipment is capable of being turned on and off automatically under the control of the VOX trigger signal. In the OFF position the VOX trigger signal to the recorder is interrupted. The recorder unit includes a ten-hour tape supply. End of tape sensing provides automatic turn-off and termination of tape movement.
13-S-12	VHF B TRANSMITTER SWITCH 3-POSITION TOGGLE MAIN-MAIN-MAIN	This switch (VOICE - OFF - DATA) provides primary power to the VHF B transmitter for either of two modes of operation. In the VOICE position the transmitter can be used for voice transmissions to the CSM of EVA and in the DATA position this equipment can be used to transmit PCM data to the CSM. However, in the DATA position, 13-S-13 must be in the LO position. In the OFF position power to the assembly is interrupted.
13-S-13	PCM RATE SWITCH 2-POSITION TOGGLE MAIN-MAIN	This switch (HI - LO) selects the high or low bit rate telemetry to be transmitted via PCM to earth on S-band. Additionally, with this switch in the LO position, and with switch 13-S-12 in the DATA position, telemetry data is transmitted to the CSM and recorded there for eventual re-transmission to earth. (Used when LEM is behind the moon).
13-R-10	VHF A SQUELCH CONTROL THUMBWHEEL	These thumbwheels (INCR) permit continuous adjustment of the threshold of the VHF/A or VHF/B receiver squelch circuits. That is, they adjust the level which the incoming signal must exceed in order for it to be heard, and thereby serve to reduce the noise level in the VHF A or VHF B receiver during periods when no voice signal is present.
13-R-15	VHF B SQUELCH CONTROL THUMBWHEEL	

<u>Code</u>	<u>Control/Indicator</u>	<u>Function</u>
13-FL-1	TAPE STATUS 2-POSITION FLAG	This flag (GREY - BARBERPOLE) indicates, in the GREY position, that the tape is moving and that voice recording is taking place. Conversely, the BARBERPOLE position indicates that the tape is not moving and that voice recording is not taking place.
Panel XII (Communications Antennas)		
<u>Code</u>	<u>Control/Indicator</u>	<u>Function</u>
14-S-3	TRACK MODE SELECT SWITCH 3-POSITION TOGGLE MAIN-MAIN-MAIN	This three-position toggle (AUTO - OFF - SLEW) selects the control mode by which the S-band steerable antenna is positioned. In the OFF position, power to the antenna drive motors is interrupted. In the SLEW position the steerable antenna is positioned by using 14-B-1 and 14-B-2 to peak 14-M-1. In the AUTO position, the earth sensor is activated, which will automatically keep the antenna pointed at earth, provided the antenna is oriented to within ± 10 degrees of the earth.
14-S-5	S-BAND ANTENNA SELECT SWITCH 4-POSITION ROTARY	This four-position rotary (1 - 2 - SLEW - LUNAR STAY) provides selection of any of the four S-band antennas for communication with earth. The 1 and 2 positions select #1 and #2 omni-directional antennas respectively, for use in the event of S-band steerable antenna failure. The SLEW position selects the steerable antenna, and the LUNAR STAY position selects the S-band erectable antenna for use during lunar stay. A lock mechanism is incorporated in this rotary knob to prevent inadvertent selection of the LUNAR STAY position in the absence of an antenna load at the connector.

<u>Code</u>	<u>Control/Indicator</u>	<u>Function</u>
14-S-6	VHF ANTENNA SELECT SWITCH 4-POSITION ROTARY	This four-position rotary (PLSS TEST - 1 - 2 - EVA) provides selection of any of three VHF antennas for communication with the command module or the extra-vehicular astronaut. A fourth position, PLSS TEST, is used in conjunction with a hardline connection to the portable life support system to checkout EVA two-way voice communications and telemetry transmission prior to LEM egress. The 1 and 2 antennas are used for communicating with the CSM, and the EVA antenna is used for communicating with the extra-vehicular astronaut during lunar stay. A lock mechanism is incorporated in this rotary knob to prevent inadvertent selection of either the PLSS TEST or EVA position in the absence of an antenna load on them.
14-B-1 14-B-2	PITCH SLEW CONTROL YAW SLEW CONTROL TWO CONTINUOUS ROTARY CONTROLS	Each of these rotary controls actuates a synchro transmitter which generates position command signals to the antenna drive assembly in the pitch and yaw axes, when 14-S-3 is in the SLEW position. Positioning these controls transmits corresponding position commands to the antenna drive assembly in two axes, and position signals from the antenna assembly drive the panel indicators (14-M-3 and 14-M-4).
14-M-1	SIGNAL STRENGTH INDICATOR	This indicator displays the intensity of S-band signals received from the earth. It is utilized in conjunction with 14-B-1 and 14-B-2 to manually establish signal contact with the earth. When peaked, it indicates that the S-band steerable antenna is pointing at the earth. It can be used as an indication of the pointing accuracy of the steerable antenna or erectable antenna, or it can indicate which of the two in-flight antennas is providing the best link to earth.

<u>Code</u>	<u>Control/Indicator</u>	<u>Function</u>
14-M-3	ANTENNA PITCH INDICATOR	These indicators display the pitch (14-M-3) and yaw (14-M-4) angles of the S-band dish antenna. The antenna pitch limits are 255° above and 75° below a plane parallel to the vehicle Y-Z plane. The antenna yaw limits are 75° to the left and 75° to the right of a plane parallel to the vehicle X-Y plane. The initial pitch and yaw angles which will orient the antenna toward earth are obtained from a computer readout. Then, the antenna is positioned to the desired pitch and yaw angles by using 14-B-1 and 14-B-2, and by reference to the antenna pitch and yaw indicators.
14-M-4	ANTENNA YAW INDICATOR	



PANEL XII

1.6.11 Panel XIV (Electrical Power Subsystem)

<u>Code</u>	<u>Control/Indicator</u>	<u>Function</u>
4-S-1	BATTERY #1 HIGH VOLTAGE SWITCH	Each three-position toggle (ON -- OFF/RESET) controls the high voltage power output from one of the four descent batteries. Selecting the ON position will place the battery high voltage tap on the line. Selecting the OFF/RESET position disconnects the high voltage battery power tap from the line. Prior to selecting the ON position, the OFF/RESET position must be selected so that the electronic control assembly contactors will be set to enable battery power application to the DC Bus. The electronic control assembly controls battery connection to the DC bus. In the event of over current in a battery, the ECA will trip this battery off the line. Positive feedback of the tripped status of each battery is provided by 4-FL-1, 4-FL-2, 4-FL-3, and 4-FL-4.
4-S-2	BATTERY #2 HIGH VOLTAGE SWITCH	
4-S-3	BATTERY #3 HIGH VOLTAGE SWITCH	
4-S-4	BATTERY #4 HIGH VOLTAGE SWITCH FOUR 3-POSITION TOGGLES MOM-MAIN-MOM	
4-S-5	BATTERY #1 LOW VOLTAGE SWITCH	Each three-position toggle (ON -- OFF/RESET) controls low voltage power output from one of the four descent batteries. Selecting the ON position will place the battery low voltage tap on the line. Selecting the OFF/RESET position disconnects the low voltage battery power tap from the line. Prior to selecting the ON position, the OFF/RESET position must be selected so that the electronic control assembly contactors will be set to enable battery power application to the DC Bus.
4-S-6	BATTERY #2 LOW VOLTAGE SWITCH	
4-S-7	BATTERY #3 LOW VOLTAGE SWITCH	
4-S-8	BATTERY #4 LOW VOLTAGE SWITCH FOUR 3-POSITION TOGGLES MOM-MAIN-MOM	

<u>Code</u>	<u>Control/Indicator</u>	<u>Function</u>
4-S-5		In the event of over current in a battery the ECA will trip this battery off the line. Positive feedback of the tripped status of each battery is provided by 4-FL-1, 4-FL-2, 4-FL-3 and 4-FL-4.
4-S-6		
4-S-7		
4-S-8		
(Cont)		
4-S-9	DESCENT BATTERIES SWITCH 3-POSITION TOGGLE MOM-LOCK-MOM	This three-position toggle (CONNECT - DEADFACE) enables power interruption of the descent batteries feed path to the ascent stage. The switch is normally in the CONNECT position, thus allowing power flow from the descent batteries to the ascent stage. Selecting the DEADFACE position initiates the deadface relays thus isolating the descent batteries upstream from the staging guillotine (ascent side). The switch may be placed in the CONNECT position again and the descent battery power feed path is restored. Positive feedback of descent battery connection is provided by 4-FL-9.
4-S-10	BATTERY #5 - NORMAL FEED SWITCH	These three-position toggles (ON - OFF/RESET) normally control ascent battery #5 and ascent battery #6 power feed paths to both busses respectively. Selecting the ON position will place the battery on the line. Selecting the OFF/RESET position disconnects the battery power from the line and sets up the contactors in the electronic control assembly for overcurrent protection. The ECA controls battery connection to the DC bus and will disconnect the batteries in the event of an overcurrent
4-S-11	BATTERY #6 - NORMAL FEED SWITCH TWO 3-POSITION TOGGLES MOM-MAIN-MOM	

LUT

<u>Code</u>	<u>Control/Indicator</u>	<u>Function</u>
4-S-10 4-S-11 (Cont)		Positive feedback of the tripped status of battery #5 and battery #6 is provided by 4-FL-5 and 4-FL-6 respectively.
4-S-12 4-S-13	BATTERY #5 BACKUP FEED SWITCH BATTERY #6 BACKUP FEED SWITCH TWO 3-POSITION TOGGLES MOM-MAIN-MOM	These three position toggles (ON -- OFF/RESET) control the ascent battery #5 and ascent battery #6 power feed path to both busses. Selecting the ON position will place the battery on the line. Selecting the OFF/RESET position disconnects the battery power from the line and sets up the contactors in the ECA for overcurrent protection. In the event of battery #6 failure or battery #5 feeder line failure, 4-S-12 will be placed to ON. The ECA controls battery connection to the DC bus and will disconnect the battery in the event of an overcurrent. Positive feedback is provided by 4-FL-7. In the event of battery #5 failure or battery #6 feeder line failure, this switch will be placed to ON. The ECA controls battery connection to the DC bus and will disconnect the battery in the event of an overcurrent. Positive feedback is provided by 4-FL-8.
4-S-14	AC POWER SWITCH 3-POSITION TOGGLE LOCK-LOCK-LOCK	This three-position toggle (INV 1 - OFF - INV 2) controls AC power to the AC bus. Prior to earth launch, ground power is supplied to the AC bus through the OFF position of this switch. After launch this becomes an open or neutral position and will be used as an OFF function for the switch. Selecting the INV 1 position permits the #1 inverter to supply power to the AC bus.

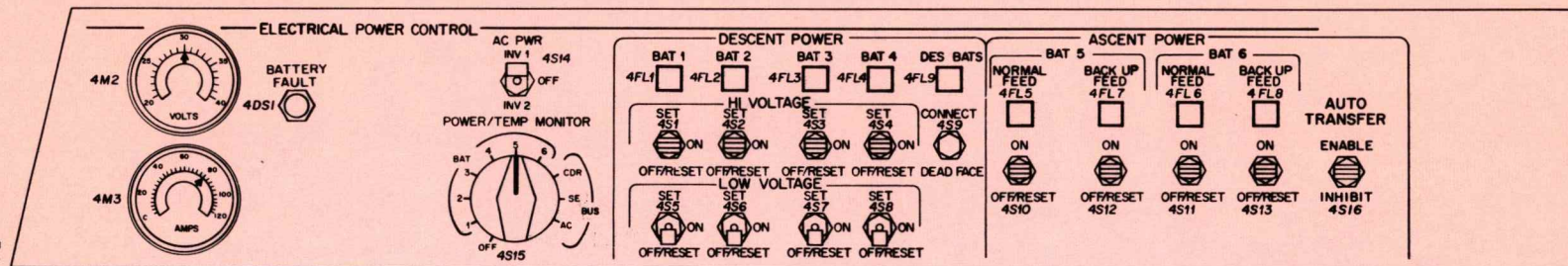
<u>Code</u>	<u>Control/Indicator</u>	<u>Function</u>
4-S-14 (Cont)		Selecting the INV 2 position permits the #2 inverter to supply power to the AC bus. Positive feedback of AC bus status is supplied by 4-M-2.
4-S-15	POWER/TEMPERATURE MONITOR SELECT SWITCH 10-POSITION ROTARY	This ten-position rotary (OFF - 1 - 2 - 3 - 4 - 5 - 6 - CDR - SE -AC) enables voltage-current monitoring of batteries 1 through 6 and voltage monitoring of the CDR, SE or AC busses on meters 4-M-2 and 4-M-3. Additionally, over-temperature and current fault isolation capability is enabled whenever the switch is in any position 1 through 6 and that particular battery is, in fact, in an over-temperature, reverse or over current condition. This condition is indicated by illumination of either the over-temperature component caution light (4-DS-1) or the current fault component caution light (4-DS-2). Selecting the OFF position de-energizes the EPS displays.
4-S-16	ASCENT POWER AUTO TRANSFER SWITCH 2-POSITION TOGGLE LOCK-LOCK	This two-position toggle (ENABLE - INHIBIT) controls the automatic switch-over feature, whereby the two ascent batteries energize the busses in the event of failure of two or more descent batteries. The switch is normally in the ENABLE position so as to allow the two ascent batteries to energize the busses when an overcurrent condition trips two or more descent batteries off the line.

<u>Code</u>	<u>Control/Indicator</u>	<u>Function</u>
4-S-16 (Cont)		The INHIBIT position is used during the unmanned portion of the mission providing the capability of powering the LEM from the CSM. If after automatic transfer to ascent power it is desired to use the remaining good descent batteries the INHIBIT position will be utilized. Positive feedback that the ascent power automatic transfer has taken place is provided by 4-FL-5 and 4-FL-6.
4-M-2	VOLTMETER	This meter will indicate the voltage of any of the six batteries, the SE, the CDR or AC bus depending on the position of 4-S-15.
4-M-3	AMMETER	This meter will indicate the current of any of the six batteries depending on the position of 4-S-15.
4-FL-1 4-FL-2 4-FL-3 4-FL-4	DESCENT BATTERY #1 STATUS DESCENT BATTERY #2 STATUS DESCENT BATTERY #3 STATUS DESCENT BATTERY #4 STATUS FOUR 3-POSITION FLAGS	Each flag (GREY - LO - BARBERPOLE) indicates that the battery High Voltage Tap is on the line when the GREY position is in view. The Low Voltage Tap is on the line when the LO position is in view. The battery is off the line when the BARBERPOLE position is in view.
4-FL-5	ASCENT BATTERY #5 NORMAL FEED STATUS 2-POSITION FLAG	This flag (GREY - BARBERPOLE) indicates that battery #5 is powering the Systems Engineer's bus when the GREY position is in view. In the BARBERPOLE position, battery #5 is not feeding the Systems Engineer's bus through this normal feed path.

<u>Code</u>	<u>Control/Indicator</u>	<u>Function</u>
4-FL-6	ASCENT BATTERY #6 NORMAL FEED STATUS 2-POSITION FLAG	This flag (GREY - BARBERPOLE) indicates that battery #6 is powering the Commander's bus when the GREY position is in view. In the BARBERPOLE position, battery #6 is not feeding the Commander's bus through this normal feed path.
4-FL-7	ASCENT BATTERY #5 BU FEED STATUS 2-POSITION FLAG	This flag (GREY -BARBERPOLE) indicates that battery #5 is powering the Commander's bus when the GREY position is in view. In the BARBERPOLE position, battery #5 is not feeding the Commander's bus through this backup feed path.
4-FL-8	ASCENT BATTERY #6 BU FEED STATUS 2-POSITION FLAG	This flag (GREY - BARBERPOLE) indicates that battery #6 is powering the Systems Engineer's bus when the GREY position is in view. In the BARBERPOLE position, battery #6 is not feeding the Systems Engineer's bus through this backup feed path.
4-FL-9	DESCENT BATTERY STATUS 2-POSITION FLAG	This flag (GREY - BARBERPOLE) indicates whether the descent deadface has been accomplished. The GREY position indicates that the descent batteries are connected to the ascent stage. The BARBERPOLE position indicates that the descent batteries have been disconnected and deadfaced.
4-DS-1	BATTERY FAULT COMPONENT CAUTION LIGHT	This light illuminates to indicate a particular battery over-temperature, over-current, or reverse current condition when 4-S-15 is placed to that battery position and an over-temperature condition exists. A battery over-temperature, over-current, or reverse current condition will illuminate the (BATTERY) caution annunciator (6-DS-27) and cause the astronaut to seek out the battery problem by using 4-S-15.

14.5

Fig. 1-43



PANEL XIV

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1.7 Design Requirements For Displays

<u>SUBSYSTEM</u>	<u>DISPLAY</u>	<u>RANGE</u>	<u>VOLTAGE INPUT</u>	<u>SCALE DIVISIONS</u>
EPS	(4-M-2)	20-40 volts	2.5-5 V	1 volt
	(4-M-3)	0-120 amps	0-5 V	5 amps
		0-60 amps	0-5 V	5 amps
ECS	(7-M-5)	0-80 psia	0-5 V	5 psia
	(7-M-5)	0-80° F	0-5 V	5° F
	(7-M-4)	0-100%	0-5 V	5%
	(7-M-1)	0-30 mm Hg	0-5 V	Non-linear
	(7-M-2)	0-10 psia	0-5 V	.5 psia
	(7-M-3)	40°-100° F	1-4 V	2° F
RCS	(8-M-1)			
	HELIUM	0-3500 psia	0-5 V	200 psia
	PROP	0-350 psia	0-5 V	20 psia
	FUEL	0-350 psia	0-5 V	20 psia
	OXID	0-350 psia	0-5 V	20 psia
	(8-M-2)			
	HELIUM	20-120° F	0-5 V	5° F
	PROP	20-120° F	0-5 V	5° F
	FUEL	20-120° F	0-5 V	5° F
	OXID	20-120° F	0-5 V	5° F
	(8-M-3)	0-99%	A pulse train in binary coded decimal format. Binary 1 is 4.5 V max. Binary 0 is 0+ .5 V DC.	
				1%

<u>SUBSYSTEM</u>	<u>DISPLAY</u>	<u>RANGE</u>	<u>VOLTAGE INPUT</u>	<u>SCALE DIVISIONS</u>
FLIGHT CONTROL	(9-M-2, 9-M-3)			
	VELOCITY	0 + 20 fps 0 - 200 fps	0 + .5 V 0 - 5 V	1 fps 10 fps
	RATE	0 + 2 mrad/sec. 0 - 20 mrad/sec.	0 + .5 V 0 - 5 V	.1 mrad/sec. 1 mrad/sec.
	(9-M-9)			
	DISTANCE	0-40,000 ft (LDG RDR INPUT)	Ten serial digital inputs, 16 or 18 bit serial words. A binary one is either 5 or 7 volts. A volts.	5 ft 100 ft 2 nm
		0-400 nm (RNDZ RDR INPUT)		
	RATE	0 + 500 fps (LDG RDR INPUT)	Same	1 fps
		0 + 4900 fps (RNDZ RDR INPUT)		
	(9-M-4)	0-6 "g"	Mechanical response to vehicle accelera- tion.	.2 "g"
	(9-M-7)	0-100% 10-100%	0-2.75 V 0-4.583 V (AUTO) .89-4.658 V (MAN)	5% 5%
	(9-M-1, 9-M-6)			
	ATTITUDE	0-360°	15 sin wt sine and 15 sin wt cose (e = gimbal angle)	PITCH 5° ROLL 10° YAW 10°

<u>SUBSYSTEM</u>	<u>DISPLAY</u>	<u>RANGE</u>	<u>VOLTAGE INPUT</u>	<u>SCALE DIVISIONS</u>
	SHAFT/TRUNNION ANGLES	$0 \pm 5^\circ$ $0 \pm 50^\circ$	$0 \pm .2648$ V, 800 cps (AUTO MODE), $0 \pm$.141 V, 400 cps (MAN MODE)	Qualitative
	PITCH/ROLL/YAW ERRORS	$0 \pm 2^\circ$ (PGNS INPUT) 0 ± 1.7 (AGS - MIN DEADBAND INPUT) $0 \pm 14.4^\circ$ (AGS - MAX DEAD- BAND INPUT)	$0 \pm .2648$ V, 800 cps	Qualitative
	PITCH/ROLL/YAW RATES	$0 \pm 20^\circ/\text{sec.}$	$0 \pm .8$ V, 800 cps	$2^\circ/\text{sec.}$
	(9-M-11)	0-59 min. 59 sec.	Pulse train is 10 pulses/sec. square wave. Pulse amp- litude is 3.5 volts.	1 sec.
	(9-M-10)	0-60 hours	Self-contained Battery Operated	1 sec.
	(9-M-5)	-100 to 99999 fps	A pulse train having a varying repetition rate. Pulse ampli- tude is 6 V.	1 fps
PROP	(10-M-3)	0-300 psia (DES) 0-250 psia (ASC)	0-5 V 0-5 V	10 psia 10 psia
	(10-M-4)	40-100°F	1-4 V	2°F

<u>SUBSYSTEM</u>	<u>DISPLAY</u>	<u>RANGE</u>	<u>VOLTAGE INPUT</u>	<u>SCALE DIVISIONS</u>
	(10-M-1)			
	PRESS	0-3500 psia	0-5 V	10 psia
	TEMP	-120 to +100°F	0-5 V	1°F
	(10-M-5)	0-99%	A pulse train in binary coded decimal format. Binary 1 is 4.5 V max. Binary 0 is 0 \pm .5 V DC.	1%
COMM	(14-M-3)	-75 to +255°	0-5 V	10°
	(14-M-4)	-75 to +75°	0-5 V	10°
	(14-M-1)	0-5 units	0-5 V	.2 units
RADAR	(17-M-1)	0-5 units	0-5 V	.2 units
HEATER	(18-M-1)			
	RADAR, S-BAND	-100 to +200°F	1.25-5 V	10°F
	QUAD	+20 to 200°F	0-5 V	10°F

SECTION TWO

LIGHTING

The LEM lighting consists of exterior and interior illumination. The choice of illumination is based upon vehicle performance, crew visual tasks, operator fatigue, interior contrast relationships and interior-exterior environmental relationships. The lighting system must give optimum performance and maximum reliability and yet be compatible with electrical power and vehicle weight restrictions.

2.1 Interior Lighting

The LEM interior illumination shall consist of integral lighted components and flood lighting devices.

2.1.1 Integral Lighted Components

There are three types of integral lighted components: Panel areas, Displays, and Caution and Warning (C&W) annunciators. These integral lighted components utilize either electroluminescent (EL) or incandescent devices. Provision is made for manually controlling the brightness of an integral lighting components in a continuous fashion. All nomenclature on the display and control panels is integrally lighted by white electroluminescent lamps in conjunction with suitable overlays. The displays have electroluminescent light sources contained within the display enclosure. The information contained in the display consists of white illuminated markings on a non-illuminated background. The non-illuminated pointer travels over an illuminated background. Numeric EL Displays have illuminated green or white digital markings on a non-illuminated background. Provisions are made for manually controlling the brightness continuously from the maximum. Caution and Warning (C&W) and component caution annunciators and numeric displays are dimmable on the same control.

2.1.2 Flood Lighting

Flood lighting is provided as a secondary means of illuminating all display and control panel areas. In addition, illumination is provided as necessary within the crew compartment for the performance of crew duties or tasks. Panel flood lighting fixtures are provided for each of the forward display panels and provides even illumination of the panel areas. No panel area depends solely upon one lamp for its illumination. The color of the illumination is white.

2.2 Exterior Lighting

Exterior illumination consists of docking and tracking lights on the LEM to provide orientation cues to the crew of the CSM.

2.2.1 Docking Lights

Docking lights are provided for visual orientation cues and gross attitude determination during rendezvous and docking. These lights shall be on/off controlled by the onboard crew during the lunar docking phase. Provision is made to illuminate these lights automatically prior to the trans-lunar docking maneuver.

2.2.2 Tracking Light

A tracking light is provided to allow visual tracking of the LEM by the CSM. This light is on/off controlled and dimmed by the LEM.

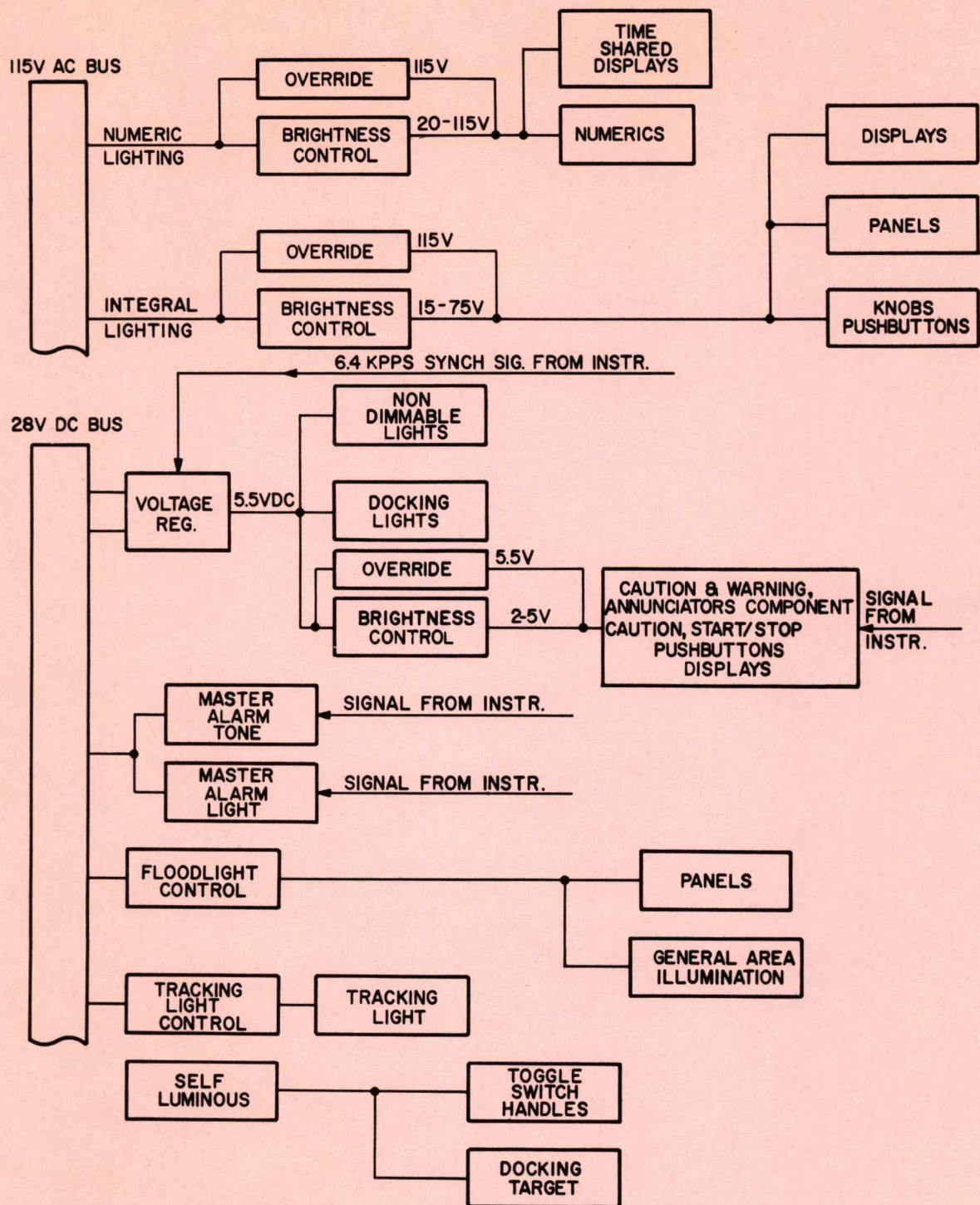
2.3 Self-Luminous Devices

2.3.1 Switches

The switch position of toggles is illuminated by means of self-luminous devices. These devices enable the crew to visually check the switch position during the low ambient illumination conditions.

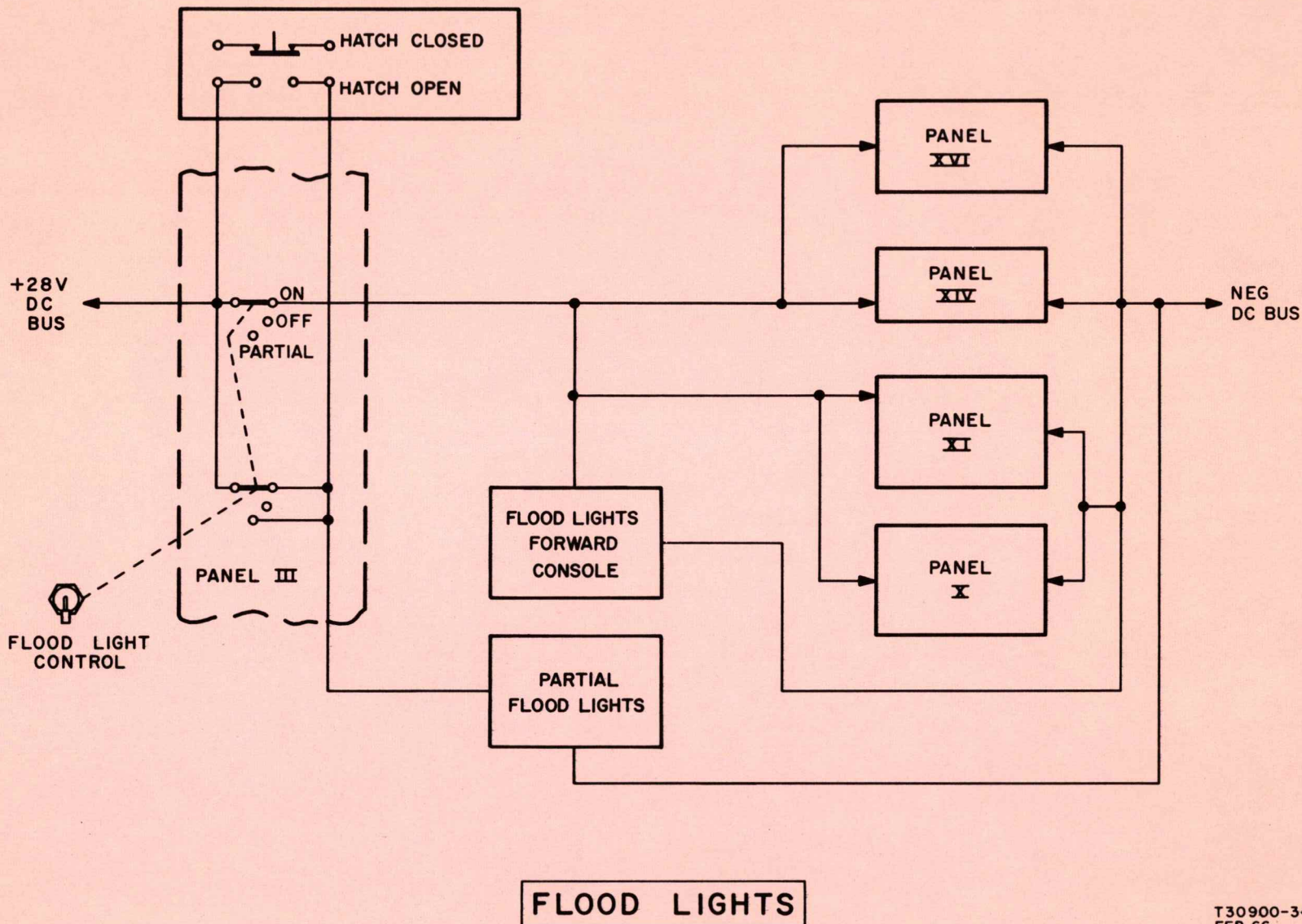
2.3.2 Docking Target

A self-luminous docking target is provided which will aid the crew in visually aligning the CM to the LEM during the final docking maneuver.



LIGHTING BLOCK DIAGRAM

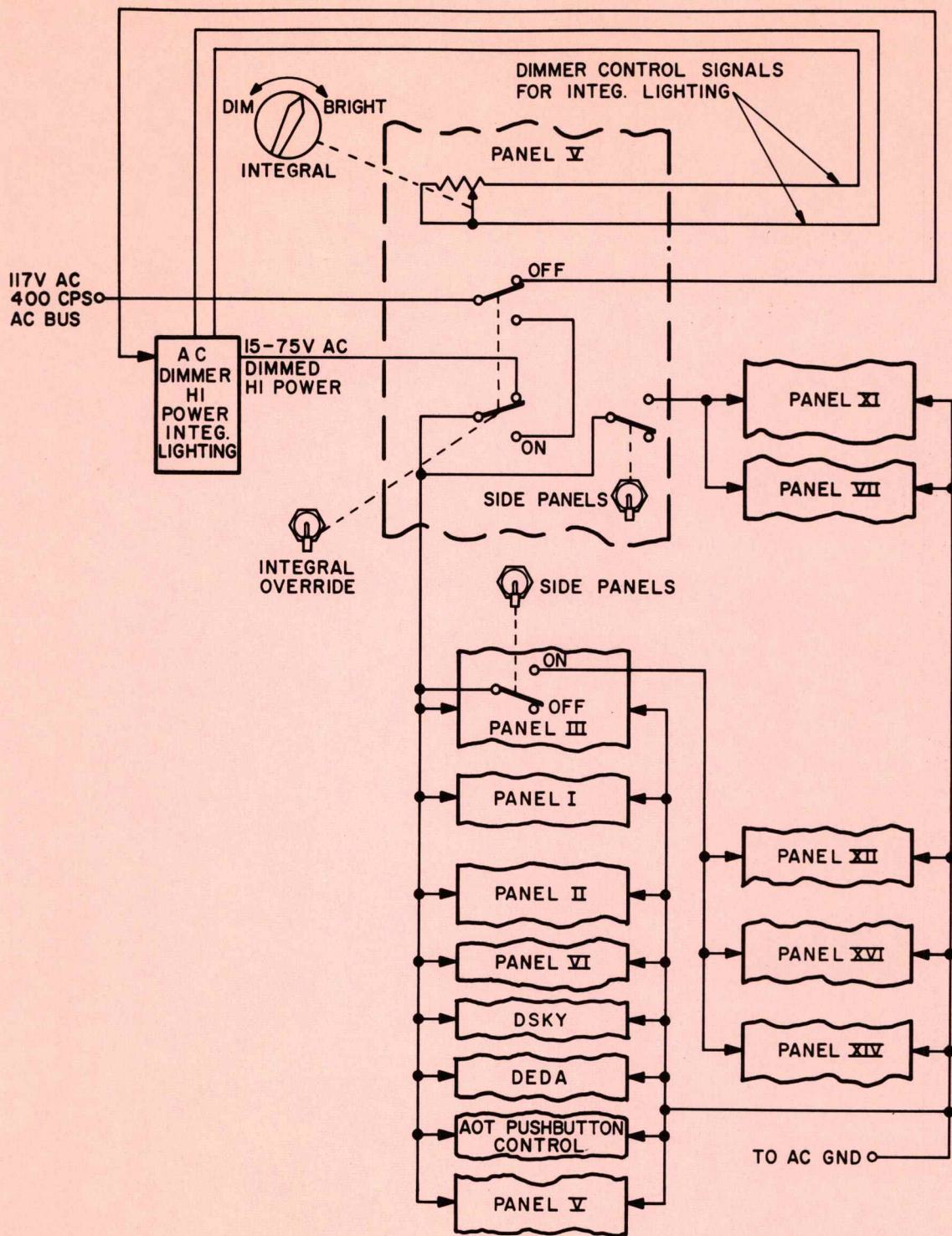
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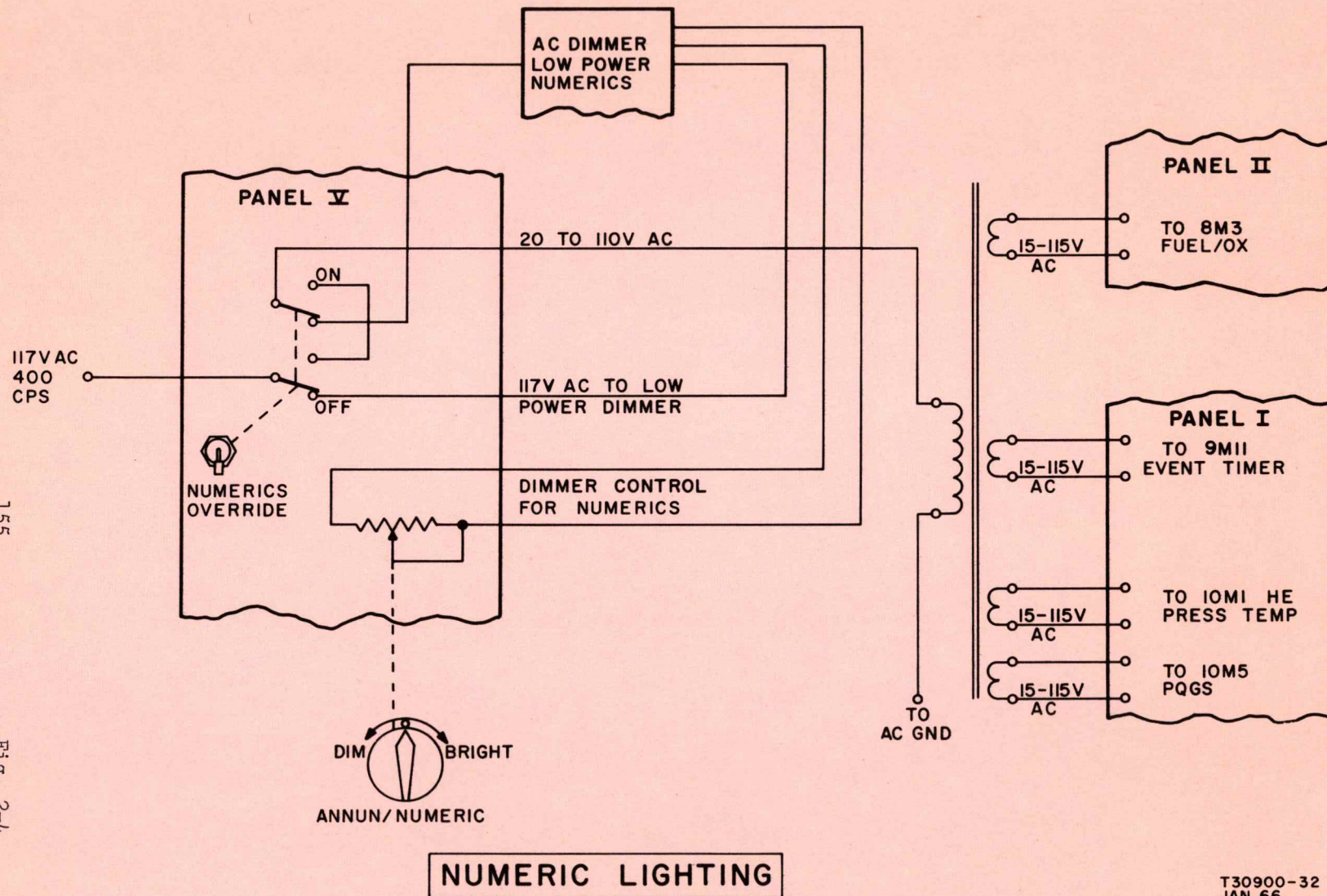
Fig. 2-2

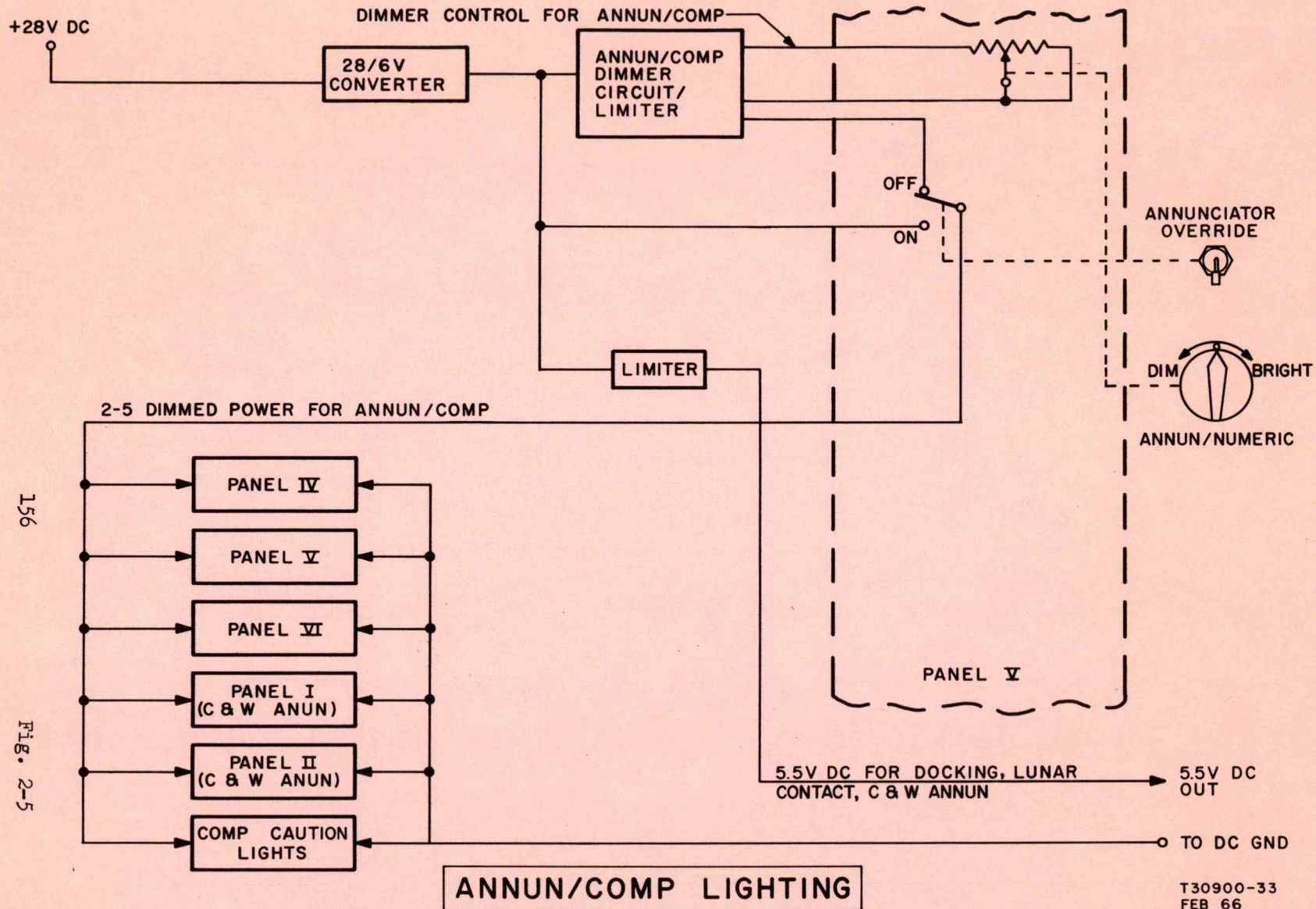
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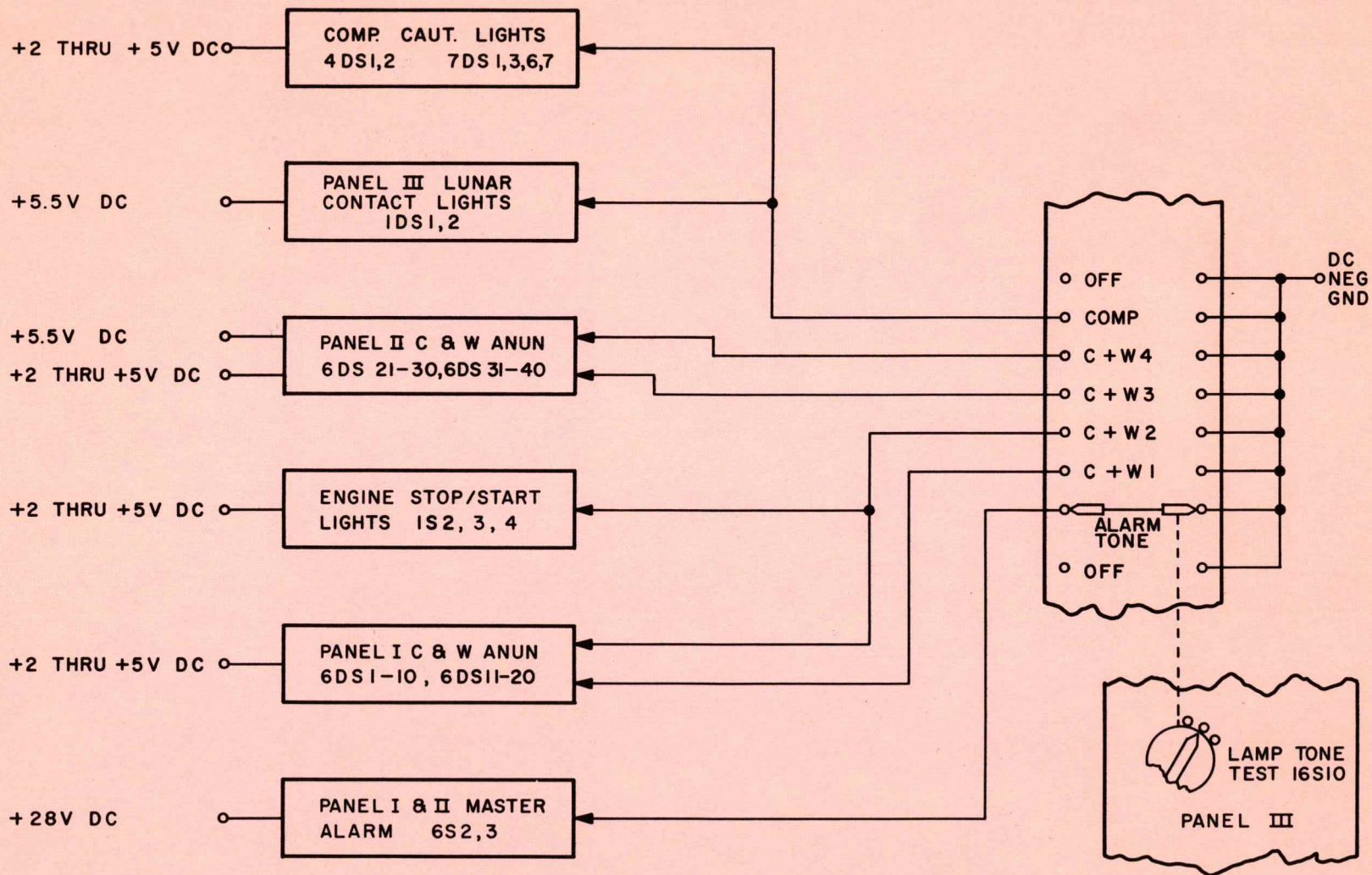
Fig. 2-4





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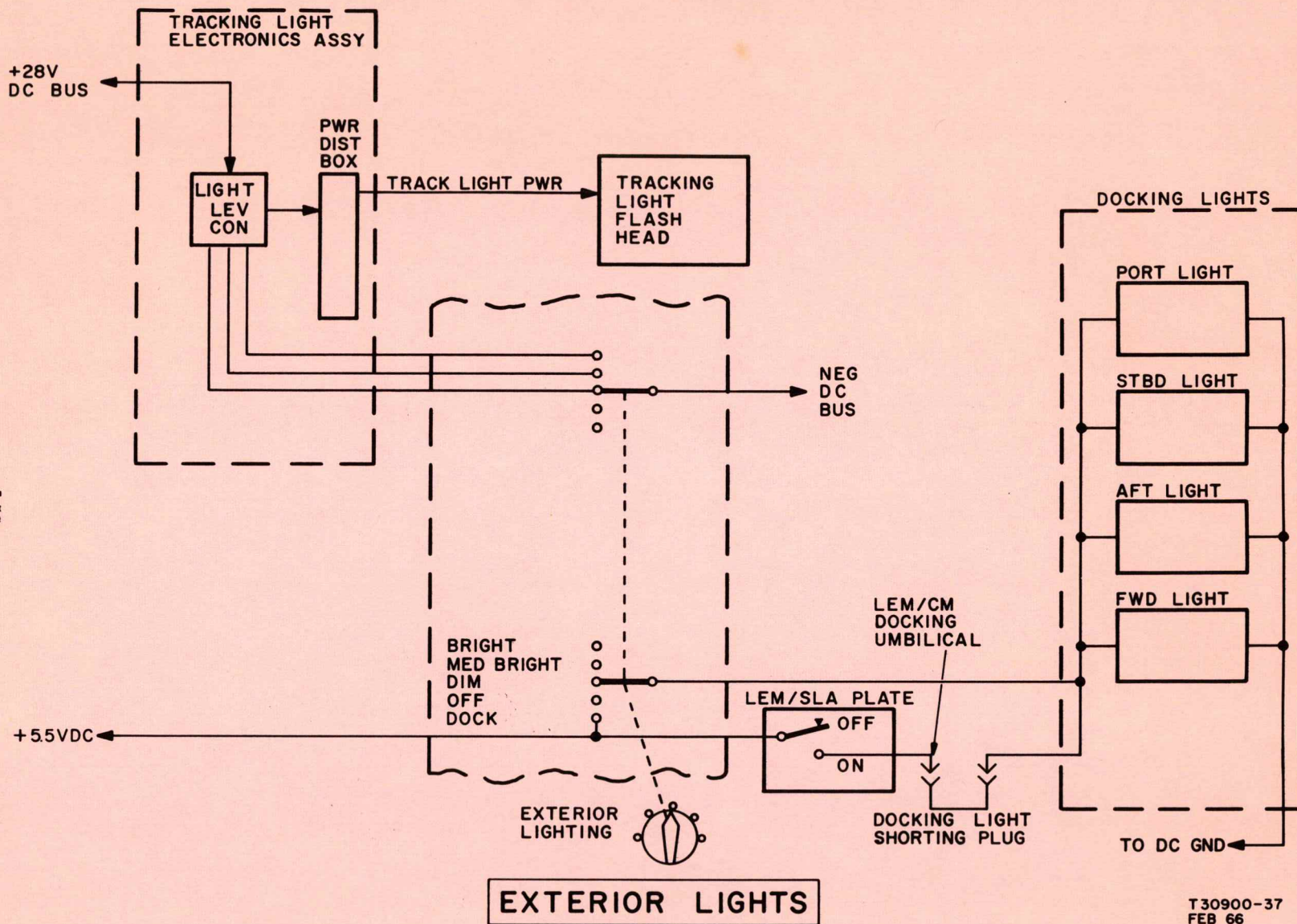
Fig. 2-6



LAMP/TONE TEST CIRCUIT

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Fig. 2-7



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Fig. 2-8

SECTION THREE

CREW PROVISIONS

3.1 Extravehicular Mobility Unit

The extravehicular mobility unit (EMU) is a multilayered unit that consists of a liquid-cooled garment, a pressure garment assembly, a thermal meteoroid garment, a portable life support system, an emergency oxygen subsystem, biomedical and environmental sensors, and dosimeters. To accomplish a safe, manned mission, the EMU is constructed as an anthropomorphic, closed-circuit, pressure vessel that envelops the entire astronaut. With the portable life support system attached to the pressure garment assembly, the astronaut has a livable envelope that can sustain his activities in the LEM or in the lunar environment. Inside the EMU, the astronaut is supplied 100% oxygen. The normal operating pressure of the EMU is 3.7 psia; it weighs approximately 120 pounds.

3.1.1 Liquid-Cooled Garment

The liquid-cooled garment (LCG), the innermost component of the EMU, is worn by each astronaut during all LEM operations. It maintains body temperature at a comfortable level while the astronauts are in the LEM and on the lunar surface.

3.1.2 Pressure Garment Assembly

The pressure garment assembly (PGA) includes a torso and limb suit, a helmet, and a pair of intervehicular gloves. The PGA is worn during all LEM operations. The PGA is the basic item of the life-support system. It aids in shielding the astronauts from the thermal-vacuum environments of outer space and, if the thermal meteoroid garment is worn, enables them to leave the LEM in free space to perform various functions. The PGA also provides emergency backup protection if cabin pressure is lost. The materials of which the PGA is made resist the abrasive and radiation environments of free space and the lunar surface and minimize the possibility of damage to the PGA during astronaut ingress and egress via the forward or upper entrance hatches. The PGA permits the astronaut to enter and leave unaided through either hatch during the mission. Manipulation of the feet, hands, legs, forearms, arms, head, and torso is possible. The astronauts are able to walk, climb, crouch, and rise from a supine to standing position. The use of tools and LEM controls, voice and telemetry communications, and sightings (inside and outside the LEM) are included in the EMU's performance capabilities. The torso and limb suit is an anthropomorphic pressure vessel that covers the

body and limbs, except the head and hands; intervehicular boots are part of the suit. A helmet and a pair of intervehicular gloves can be attached to the suit to complete the astronaut's enclosure within the normal 3.7 -psia atmosphere. The intervehicular boots provide thermal insulation protection; the bottom of the boots is covered with Velcro-hook material, which, in conjunction with the Velcro-pile material on the cabin floor, provides additional restraint for the astronauts. Assembled to the torso and limb suit, the boots become part of the closed-circuit pressurized envelope provided by the PGA. The primary function of the helmet is to protect the head against high-impact loads and to provide a life support environment. Separate glare visors are attached to the exterior of the helmet, permitting the astronaut to read vehicle and space data under a wide range of illumination. A microphone and earphones are in the helmet. Helmet construction is compatible with physiological needs and permits eating and drinking. The intervehicular gloves provide adequate finger dexterity in all pressurized environments. A wrist seal in the sleeves of the torso and limb suit permits replacing damaged gloves with extravehicular gloves while the suit is pressurized.

3.1.3 Thermal Meteoroid Garment

The thermal meteoroid garment (TMG) includes a thermal meteoroid suit, extravehicular gloves and thermal mittens, and extravehicular boots. These items do not become part of the pressurized envelope provided by the PGA; they are worn over the PGA. The main function of the TMG is to insulate and protect against harmful thermal radiation and protect against micro-meteoroids. The thermal meteoroid suit provides thermal insulation against the lunar-surface environment. It is worn over the PGA, but does not cover the helmet or gloves. It is a loose-fitting, two-piece, multilayered, pajama suit with an aluminized outer coating that renders the suit reflective. The astronaut can don the suit, unaided, in the LEM. Each astronaut has a pair of extravehicular gloves. A lanyard permits the gloves to be attached to, or removed from, the PGA sleeves. The extravehicular gloves provide insulation protection and are worn during the lunar stay. The wrist seal in the torso and limb suit permits emergency replacement of the intervehicular gloves with the extravehicular gloves while the suit is pressurized. Wearing the extravehicular gloves does not hinder the astronauts in performing emergency and maintenance tasks or in manipulating and erecting mission task equipment. Each astronaut also has a pair of mittens that are worn over the extravehicular gloves. The mittens can be removed for short intervals for added dexterity.

Each astronaut has a pair of extravehicular boots for use on lunar surface. These boots are worn over the intervehicular boots to provide additional insulation. The extravehicular boots, like the thermal suit, have a reflective outer coating. The astronaut can don the boots, unaided, in the LEM before descending to the lunar surface.

3.1.4 Portable Life Support System

The portable life support system (PLSS) is a self-contained, rechargeable system that provides limited-time life support for an astronaut exposed to extravehicular free space, a decompressed LEM, or the lunar-surface environment. The PLSS consists of subsystems components that provide primary oxygen supply storage; control of contamination, humidity, pressure, ventilation or recirculation, temperature, and electrical power; voice communications facilities; and telemetry transmission facilities. Each PLSS includes a pressurized oxygen reservoir that supplies pure oxygen to satisfy body needs for normal and emergency situation. Each reservoir filling provides a maximum supply of approximately 4 hours of oxygen. A 3-hour supply of oxygen is used for completing the mission, with a 1-hour supply of oxygen for contingency. Primary oxygen maintains a steady 3.7 -psia operating pressure within the EMU. The ventilation or recirculation system conditions and recirculates the oxygen in the pressurized PGA for cooling, decontamination (solid and gaseous), and dehumidification. Electrical power is supplied by a PLSS battery to all EMU equipment for activity outside the LEM. A VHF system provides simultaneous two-way communication between the astronauts on the lunar surface and the LEM, between two extravehicular astronauts in EMU's, or between the astronaut on the lunar surface and the CSM transmitter and receiver. The communication system microphone and earphones are in the PGA helmet. Telemetry transmits environmental and biomedical data via VHF to the LEM.

WATER-COOLED LONG-JOHNS

FIBER GLASS HELMET

THIN NYLON LAYER

PRESSURIZATION LAYER

HEAVY TIGHT-WEAVED NEOPRENE
-COATED NYLON BLADDER

OUTER RESTRAINT LAYER

NYLON ALUMINUMIZED ON
THE EXTERIOR

OUTER THERMAL GARMENT

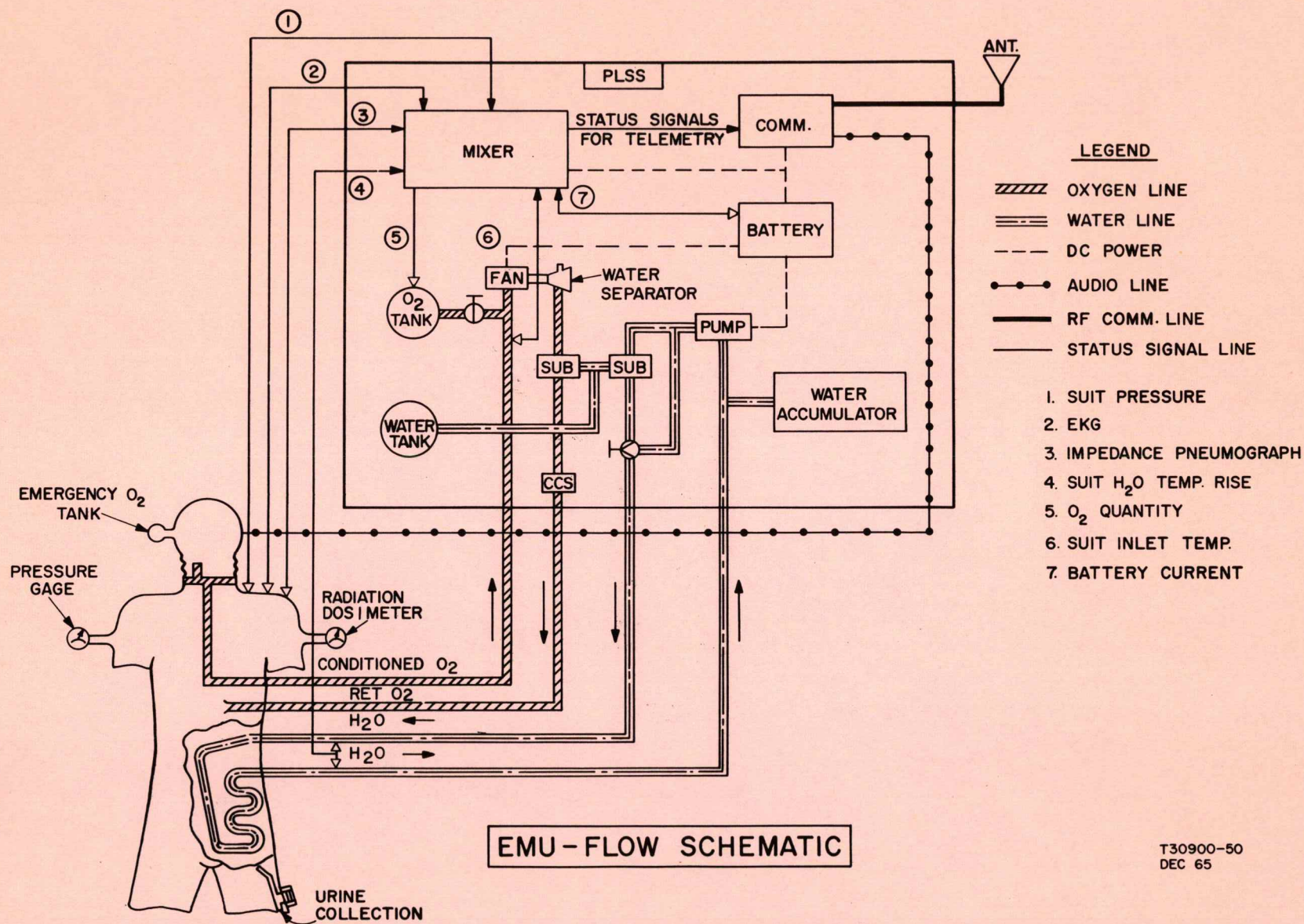
14 LAYERS OF NYLON AND
ALUMINUM-COATED MYLAR

EXTRAVEHICULAR MOBILITY UNIT

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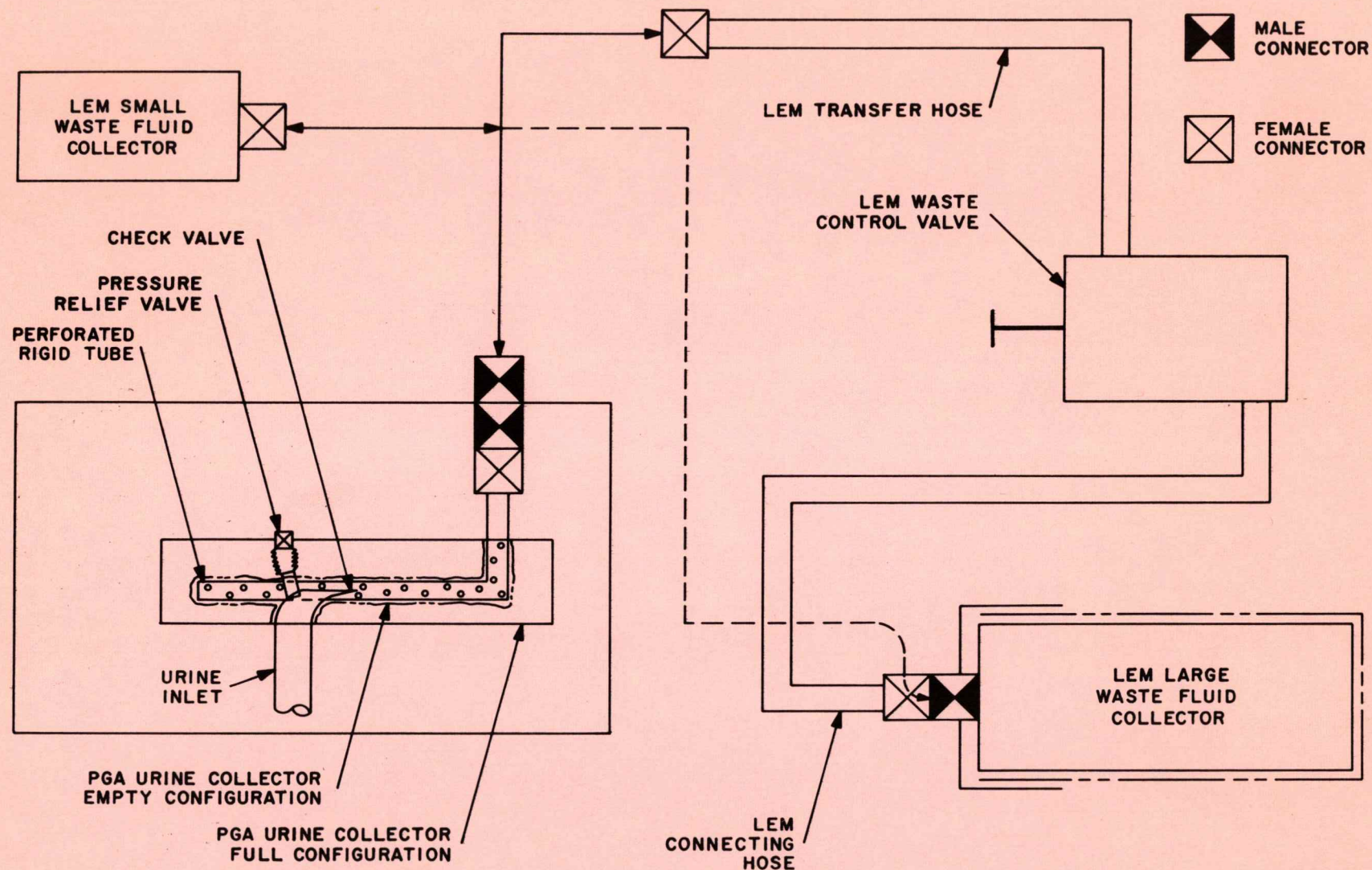
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Fig. 3-1



3.2 Waste Management

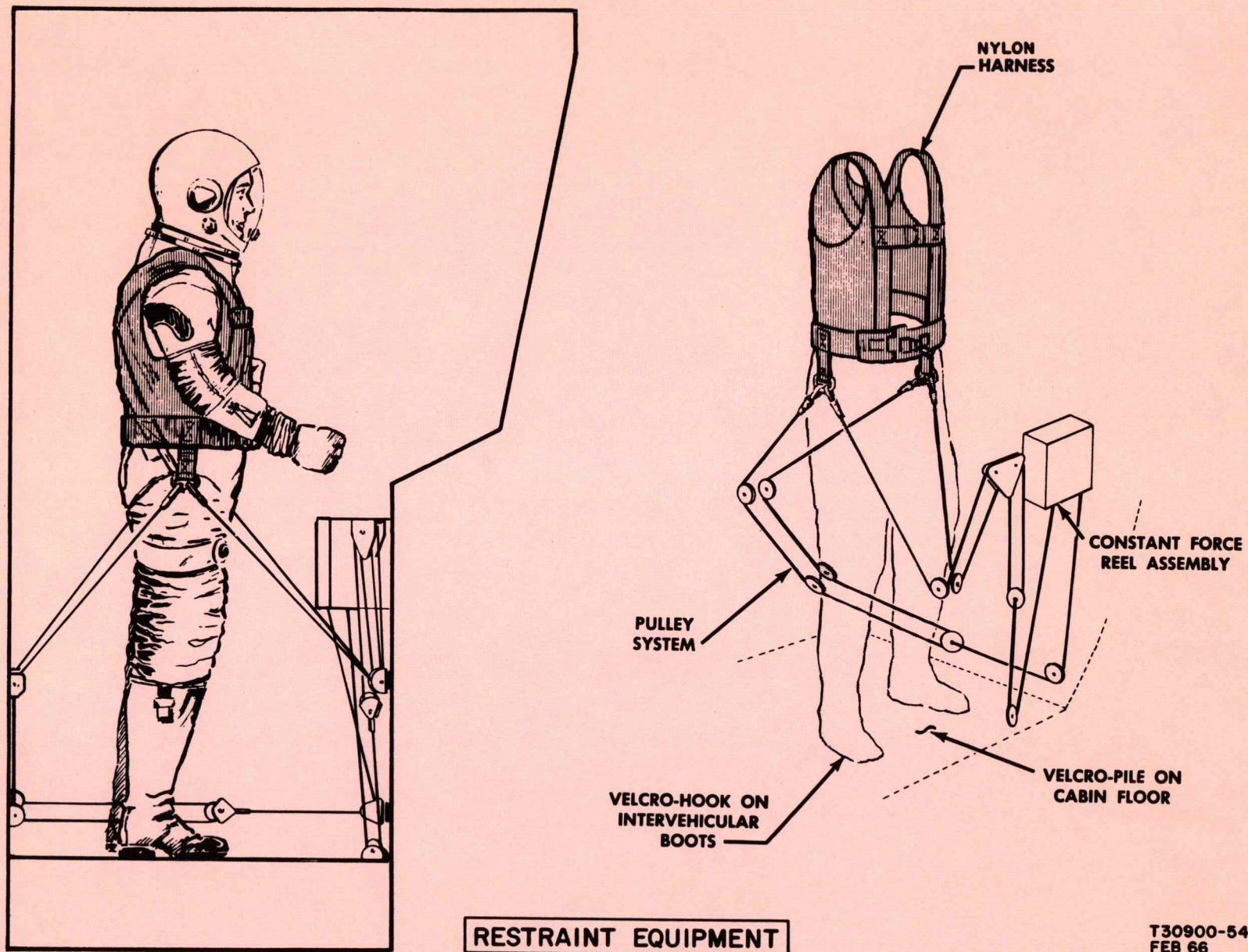
PGA waste management devices include provisions for temporary stowage and subsequent removal of urine. The LEM waste management section (WMS) uses the controlled pressure differential between the PGA and the cabin as the force to transfer waste fluid from the PGA waste management devices to the LEM waste fluid collector assembly. Operation of the WMS is started and stopped with the waste control valve. The waste control valve also protects the astronaut from excessive negative pressure differentials. One operational cycle includes evacuation, transfer, and stowage of the waste fluids. The WMS can transfer and evacuate waste fluid from the PGA under the effects of zero-gravity spaceflight and of 1/6 -gravity lunar-surface conditions. The waste fluid collector assembly can be removed at intervals and replaced with an unused collector assembly.



LEM WASTE MANAGEMENT SECTION BLOCK DIAGRAM

3.3 Support and Restraint

Support and restraint equipment is provided at the crew stations in the forward cabin section. During flight operations, the constant force reel assembly provides the astronauts with a zero-g tiedown force of approximately 25 pounds, in combination with the Velcro-hook (intervehicular) boots and the Velcro-pile material on the cabin floor. The support and restraint equipment includes a handgrip and two elongated, U-shaped, shock-attenuating armrest assemblies for each astronaut. When leaning on these armrests, the astronauts have sufficient freedom of motion for operation of the LEM controls and (after the reel is manually locked) protection against negative g's.



3.4 Food

Prepared food suitable for eating in space environments is supplied to the astronauts. The menus include liquid and solid foods of adequate nutritional and caloric value, with low residue-producing characteristics to minimize biological wastes. Reconstituted food can only be consumed with the helmet removed. To prevent spoilage and conserve space, dehydrated food is sealed in pliable plastic packages. To reconstitute the food, the water umbilical hose is attached to the inlet end of the water dispenser (water gun); the outlet end of the water dispenser is inserted into the neck of the food package. Squeezing the trigger of the water dispenser regulates the flow of water into the food package. The astronaut then kneads the food and water until they are thoroughly mixed. Squeezing the bag forces food into the mouth. The water dispenser is also used for drinking water. Reconstituted food will not be eaten in a pressurized PGA. Special puree-type food in tubes is provided for emergency eating.

3.5 Medicine

Medical supplies (GFE) planned for the mission consist of six capsules. Four capsules are Darvon (pain killers); two are Dexadrine (pep pills). The package of capsules is to be attached with Velcro-pile to the interior of the food compartment, readily accessible when the compartment is opened.

SECTION FOUR

G.S.E.

There exists at present a requirement for two units of Ground Support Equipment (GSE) which have interface with Crew Systems. These units are:

4.1 430-42020 Waste Management System Leak Test Unit

After assembly and during pre-launch checkout of the LEM, a requirement exists for leak checking the WMS using helium gas. The Leak Test Unit shall be capable of pressurizing the WMS with helium to 10 psig and detecting leaks of helium with the Leak Test Unit's portable leak detector.

4.2 410-42100 Displays & Controls Test Station (Bench Test Maint. Equip. (BTME))

The D & C Test Station will be capable of the following:

Measure the required parameters to an order greater than the specified requirements. Supply a minimum of 25% more power than required. Generate stimuli with tolerances and accuracies greater than the specified requirements. Isolate a malfunction to the lowest replaceable level. Perform complete section tests and/or independent assembly tests. Register the accumulated operating time on the unit under test.



GRUMMAN AIRCRAFT ENGINEERING CORPORATION
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