

LEM

ELECTRICAL POWER SUBSYSTEM

COURSE NO: 30115-04

S T U D Y G U I D E

For Training Purposes Only



LEM
ABBREVIATION
LIST

LL1 790-1

LEM

ELECTRICAL POWER SUBSYSTEM

COURSE NO: 30115-04

STUDY GUIDE

For Training Purposes Only

DATE: April 15, 1966

NEW ONE WILL BE JUNE DATED

REQUEST - Bill CONRAD
X 1183 PL 19

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Henry Sabot

LEM Training

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Preface

This document is designed to support the Electrical Power Subsystem.

Course 30115-04

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List of References

LDW 390-21000	Schematic - Level III Electrical Power Subsystem
LDW 540-21000-21	Vehicle -- Level 2A Sheet No. XIV Electrical Power
IMA 790-1	Lunar Excursion Module Familiarization Manual
ICD No:	MH01-05273-414 CM/LEM Power Transfer Functional Requirements
LSC 390-6	Inverter Assembly
LSC 390-21000	Battery, Primary Power, Ascent
LSC 390-22000	Battery, Primary Power, Descent
LSC 390-23	Junction Box, Relay
LSC 390-24	Relay, Deadface
LSC 390-25	Electrical Control Assembly, Ascent
LSC 390-26	Electrical Control Assembly, Descent

A. INTRODUCTION TO ELECTRICAL POWER SUBSYSTEM

The Electrical Power Subsystem (EPS) provides all electrical power necessary for the LEM to complete its planned mission. During other phases of the Apollo Mission power is supplied to the LEM through the EPS by Vehicle Ground Power Supply (VGPS), Launch Umbilical Tower (LUT) and CSM-LEM Docking Umbilical (CSM-LEM PWR). Functionally, the EPS consists of a d-c section and an a-c section. Primary d-c power originates at six silver oxide-zinc batteries, four in the descent stage and two in the ascent stage. All four descent batteries are required to provide the electrical power necessary to perform the complete LEM mission exclusive of the ascent phase. A curtailed mission can be executed using three descent batteries. Failure of two descent batteries requires the LEM mission to be aborted. Either ascent battery can supply all ascent electrical power loads during normal mission operations and an abort. A-C electrical power is provided by two solid-state inverters supplying a-c power to all LEM electronic equipment. Two additional silver oxide-zinc batteries, separate from the EPS, supply power to pyrotechnic devices. In addition to the primary batteries and solid-state inverters the EPS comprises four electrical control assemblies (ECA), a relay junction box (RJB), a deadface relay (DFR), one control and display panel, two circuit breaker panels, and two sensor power fuse assemblies.

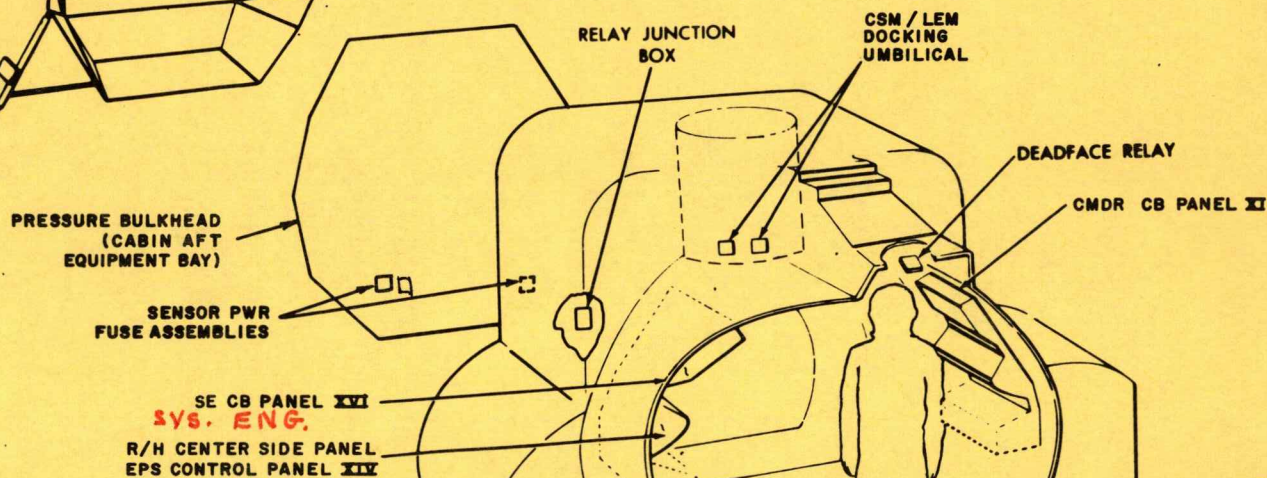
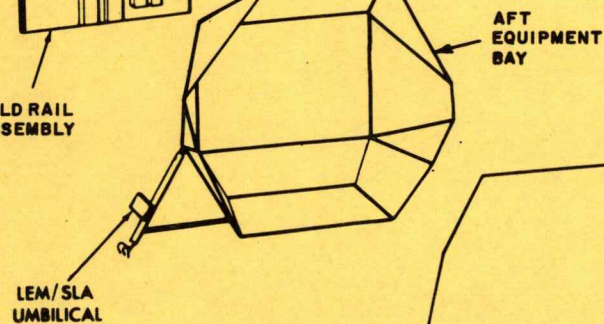
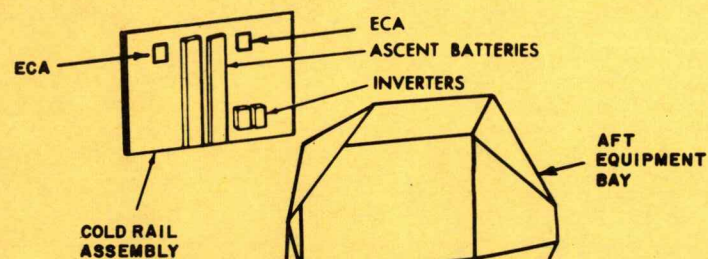
ECA
RJB
DFR

Location of equipment is as follows:

<u>Equipment</u>	<u>Location</u>
1. Ascent batteries (2)	Aft Equipment Bay
2. Ascent ECA's (2)	Cold Rail
3. Inverters (2)	Assembly
4. Sensor power fuse assembly (2)	Aft equipment bay pressure bulkhead
5. Descent batteries (4)	Descent stage
6. Descent ECA's (2)	fourth quadrant
7. Relay junction box	Upper unpressurized equipment area
8. Deadface relay	forward bulkhead
9. CMDR CB Panel XI	Upper L/H panel
10. SE CB Panel XVI	Upper and center
11. EPS Control Panel XIV	R/H panels

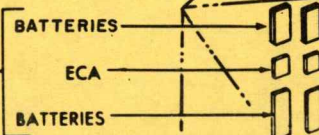
ELECTRICAL CONTROL
ASSY.

sys. ENG.

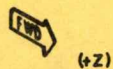


INTERSTAGE
CONNECTOR ASSEMBLY

DESCENT STAGE
4th QUADRANT

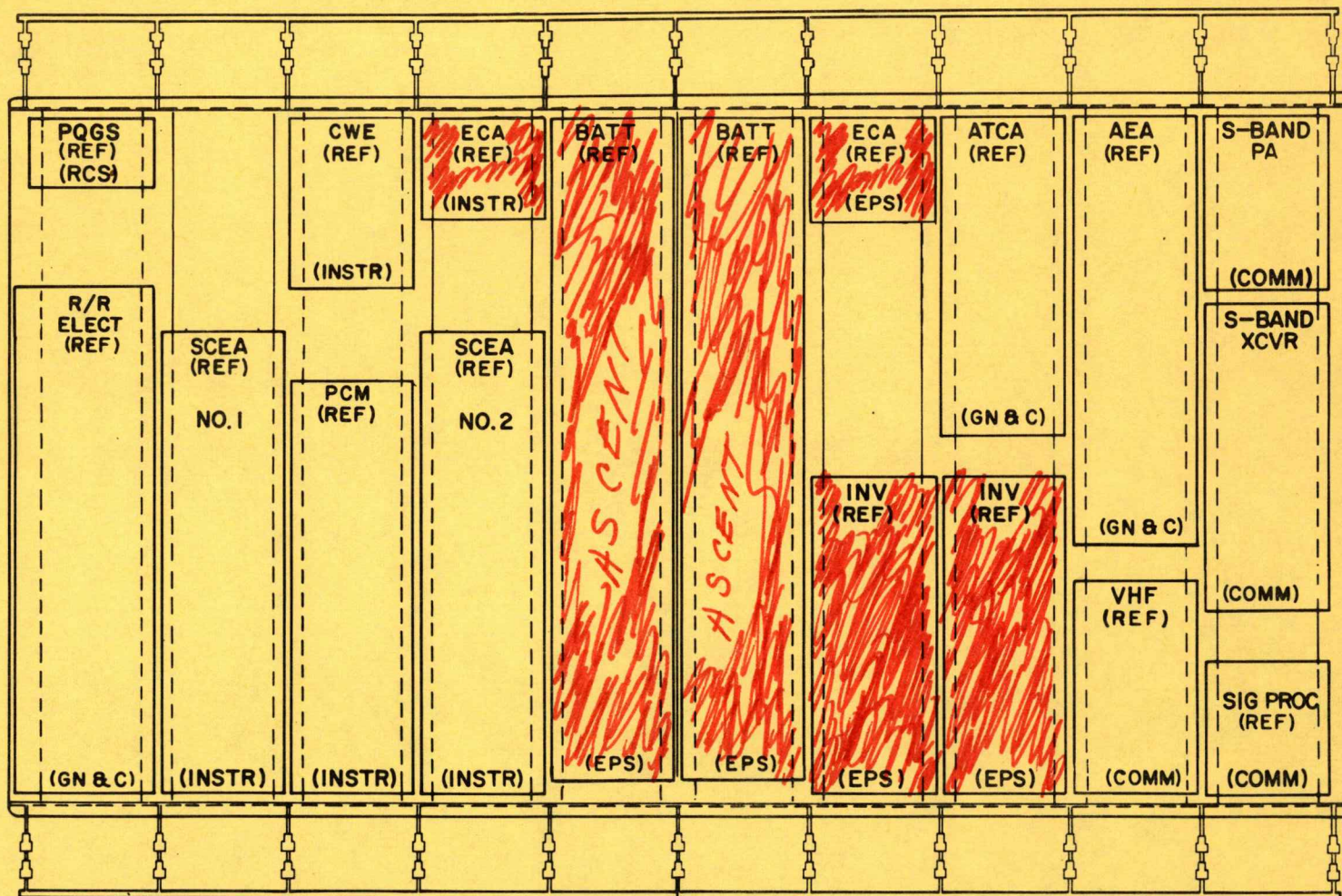


COLD RAIL ASSEMBLY



EPS COMPONENT LOCATION

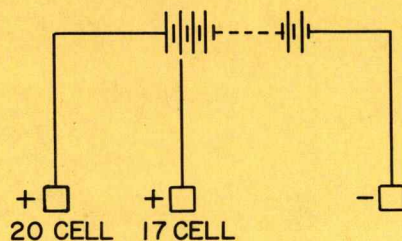
T30100-1
MAY 66



-Z65.50
VIEW LOOKING FWD

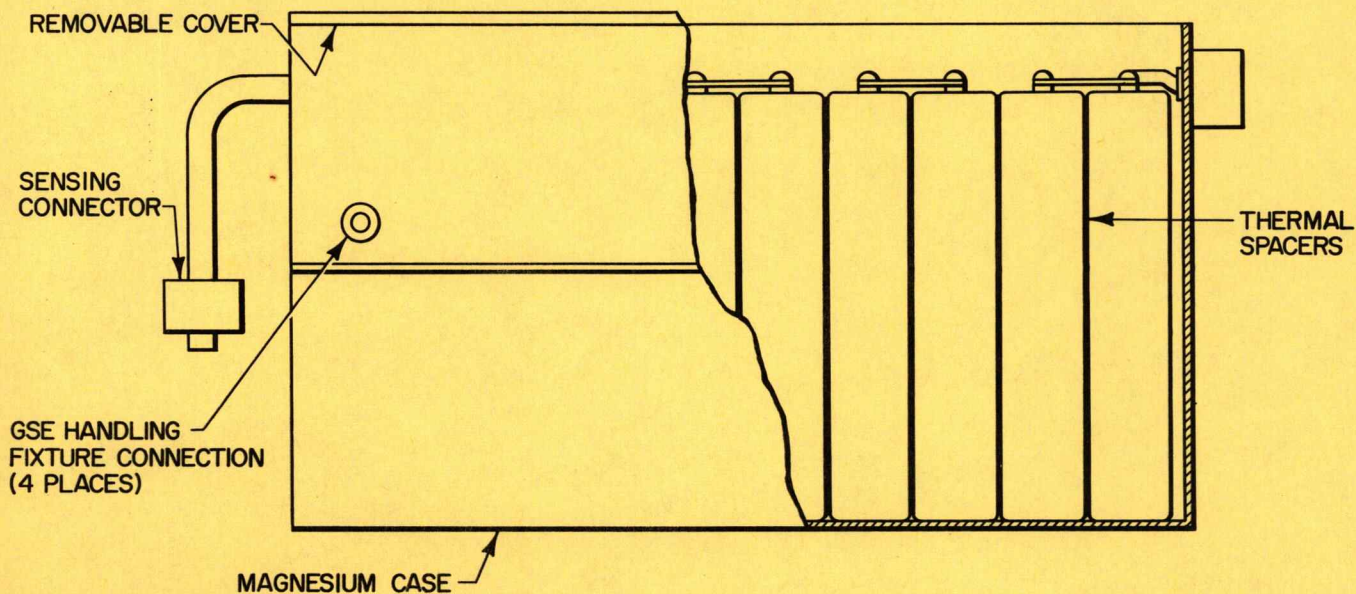
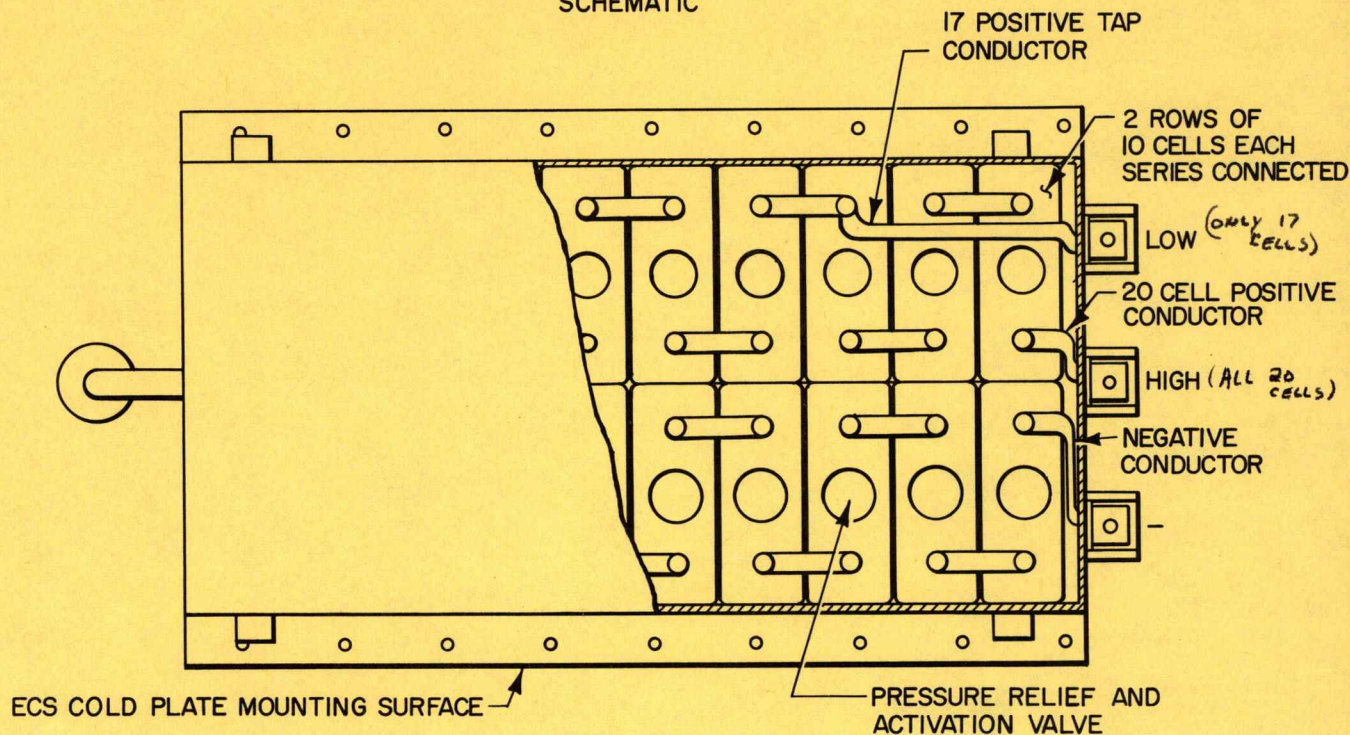
AFT EQUIPMENT BAY-ERA ARRANGEMENT

T30609-143
APRIL 66



Silver ~~OXIDE~~ OXIDE

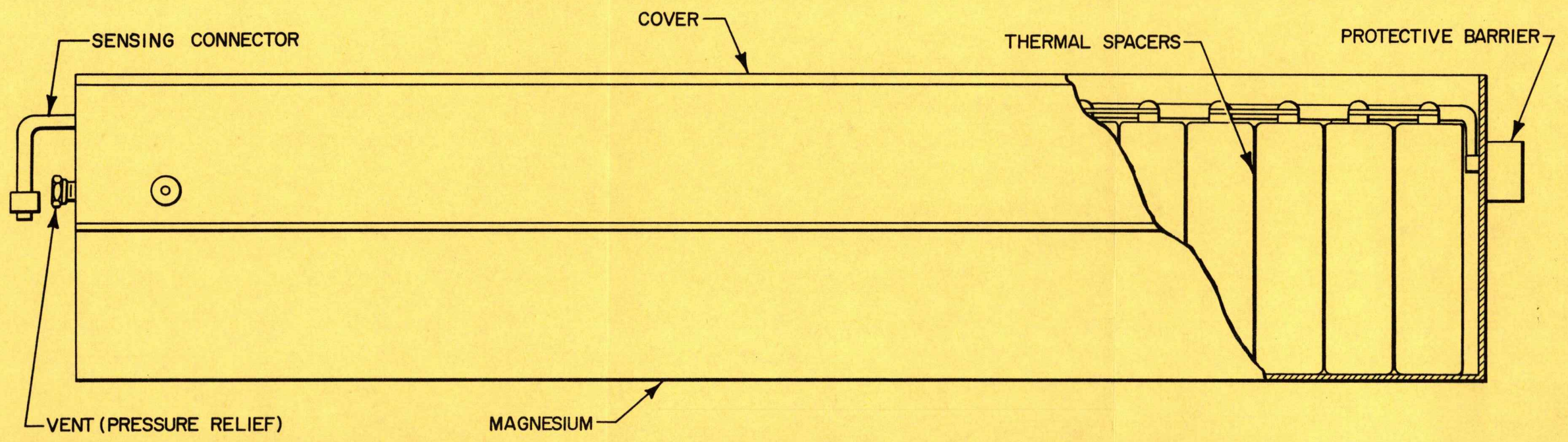
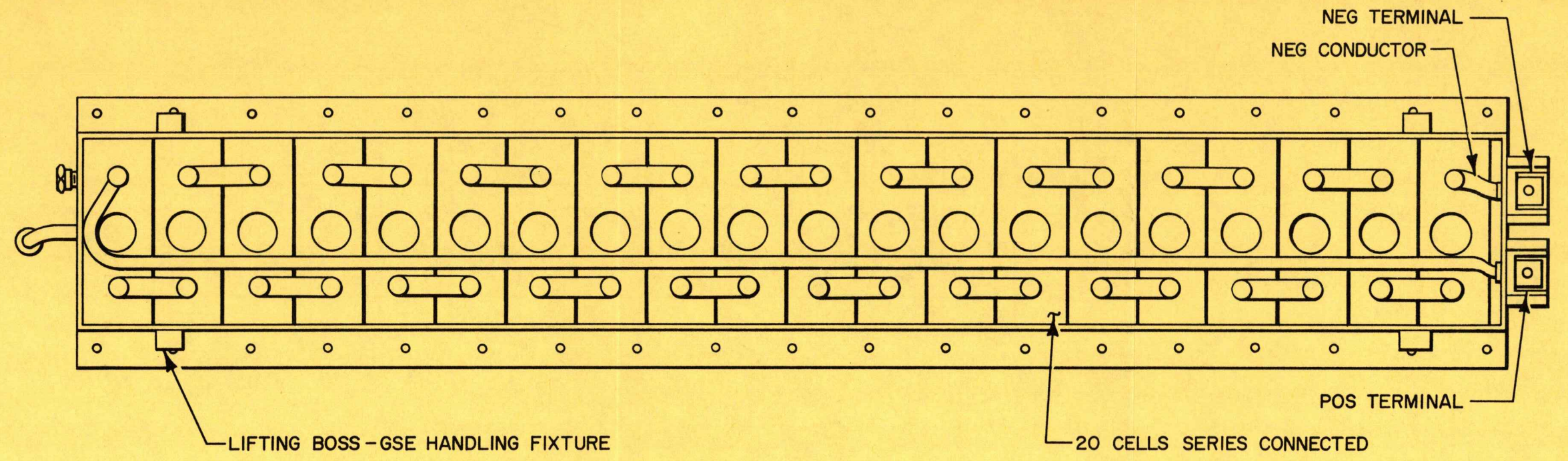
SCHEMATIC



DESCENT BATTERY

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MAY 66

EPS



ASCENT BATTERY

B. EPS COMPONENT FUNCTIONAL DESCRIPTION

The d-c section of the EPS consists of four descent batteries, two descent electrical control assemblies (ECA), a relay junction box (RJB), a deadface relay (DFR), two ascent batteries, two ascent electrical control assemblies (ECA), a control panel, two circuit breaker panels and two sensor power fuse assemblies.

Descent Batteries: The four descent batteries are rated at 400 ampere hours each at a nominal output of 28 vdc. These 20-cell batteries are installed in the LEM fully charged. Each battery has a 17-cell low voltage power tap whose output is used to power the LEM equipment starting at T-30 min through the launch phase ending with CSM transposition and docking.

The mechanical and environmental specifications are such that each descent battery can operate in a vacuum while being cooled by a thermal control system in which the battery heat sink surface is conductively mounted on a coolant-cooled cold plate structure. Each 20-cell descent battery has a 17-cell low-voltage power tap whose output is used to power the LEM equipment during launch and various checkout modes of the mission. The full 20-cell high-voltage battery power is used for LEM operational modes. Each descent ECA provides on-off control of each descent battery high- and low-voltage source and governs the activation of the high- and low voltage main power feeder contactors. These contactors enable the connection of either the 17-cell or the 20-cell descent battery tap to the appropriate d-c power bus, at the discretion of the astronauts.

Each descent battery can deliver a minimum of 400 ampere-hours of power when discharged according to a nominal load profile within 30 days after activation and can be discharged at a current drain of 25 amperes for 16 hours at an ambient temperature of +80°F. Under this initial discharge condition, the minimum battery voltage is 28 volts. The descent battery power capacity remaining after the second and third discharge cycles (when discharged within 60 days after activation) is 340 ampere-hours or more under the same residual battery voltage and ambient temperature ratings, having withstood a continuous 25-ampere current drain for at least 13.6 hours. Each battery has a nominal terminal voltage of 30.0 volts. Minimum and maximum battery terminal voltages under all discharge conditions are 28.0 and 32.5 volts, respectively.

25 x 16 = 400 AMP-HRS

Ascent Batteries: The ascent batteries are used from lunar ascent to docking of the LEM ascent stage with the orbiting CSM, or during an abort that requires separation of the LEM ascent and descent stages. The batteries are checked periodically before separation and during lunar stay. Both batteries undergo a partial discharging procedure before installation in the LEM, to alleviate their inherent high plateau voltage characteristic.

Each ascent battery can deliver 296 ampere-hours of power when discharged in accordance with a nominal load profile within 30 days after initial activation and can be discharged at a current drain of 25 amperes for 11.8 hours at an ambient temperature of +80°F. Under these initial discharge conditions, the battery terminal voltage is 28 volts or more. The ascent battery power capacity remaining after the second and third discharge cycles (when discharged within 60 days after activation) is 252 ampere-hours or more under the same residual battery voltage and ambient temperature ratings, having withstood a continuous 25-ampere current drain for at least 10.1 hours. Each battery has a nominal terminal voltage of 30.0 volts. Minimum and maximum battery terminal voltages under all discharge conditions are 28.0 and 32.5 volts, respectively.

Electrical Control Assemblies (ECA): Four electrical control assemblies (ECA's) provide protection and control of all six primary batteries. One ECA is used in conjunction with each of two ascent batteries; the other two ECA's provide separate control of two pairs of descent batteries. Each descent ECA contains high-voltage, low-voltage, and overcurrent latching relays; a reverse current relay; and two battery-current monitors. Each ascent ECA consists of a battery, normal- and reverse-current monitor, an alternate overcurrent monitor, and a normal overcurrent monitor. Self-contained transistorized dc-to-ac inverters in each ascent and descent ECA provide operating power to ECA sensing and monitoring electronics. Three regulated d-c outputs (+18 volts, +12 volts, and -6 volts) obtained from each inverter provide operating power for the ECA transistorized current-sensing circuitry.

Connection of battery power to various d-c power feed buses is provided through systematic actuation of ECA latching relays that govern the status (on-off connection) of battery power contactors. The low-voltage relays (descent ECA) are actuated from the LEM ELECTRICAL POWER CONTROL panel or the CSM (via the relay junction box). The high-voltage relays are actuated from the same control panel and, under abort conditions, are reset by abort relays. Resetting of the high-voltage relays under abort conditions requires prior actuation of the ascent ECA main feeder contactors. On-off control of both ascent batteries is provided through the use of two

ECA contactors that control connection of these batteries to their separate feeder systems. This arrangement enables the use of a battery in the event of a feeder failure or use of a feeder in the event of a battery failure.

Relay Junction Box & Deadface Relay: The relay junction box (RJB) provides logic and junction points for connecting external power to the LEM from the CSM and the launch umbilical tower (LUT). In addition, the RJB provides control and power junction points for the ascent and descent ECA's and deadfacing for half of the main power cables between ascent and descent stages; the other half is handled by the deadface relay.

The descent ECA battery logic control provides individual control of a low voltage contactor (LVC) and a main feed contactor (MFC), from the ELECTRICAL POWER CONTROL panel; simultaneous control of the on-off circuitry from all LVC's, from LUT; simultaneous control of the on-off circuitry of all LVC's, from the CSM; and simultaneous off signals to the MFC's, from abort logic.

Two redundant relays to maintain voltage are energized upon receipt of an abort signal, and immediately provide logic for switching from descent to ascent batteries.

The relay junction box (RJB) deadface relay is a latching type dpst on-off switch on the ELECTRICAL POWER CONTROL panel; it is automatically opened by the abort logic. This relay, in conjunction with the deadface relay, provides the deadfacing for the main power lines between ascent and descent stages.

Two redundant latching relays connect power from the CSM to the LEM during translunar operation. An interlock prevents the LEM and CSM power supplies from being on simultaneously.

The launch umbilical tower (LUT) relay is a dpst latching relay controlled from ground support equipment. This relay is used to connect ground power to the LEM when the LEM EPS batteries are not in use.

The deadface relay (DFR) is a dpst latching relay with contacts that operate in conjunction with the RJB deadface relay contacts to provide the deadfacing of the main power lines between the ascent and descent stages. The deadface relay operates in parallel with, and from the same controls and logic as the RJB deadface relay, the manual on-off switch from ELECTRICAL POWER CONTROL panel, and the automatic off signal from the abort control logic.

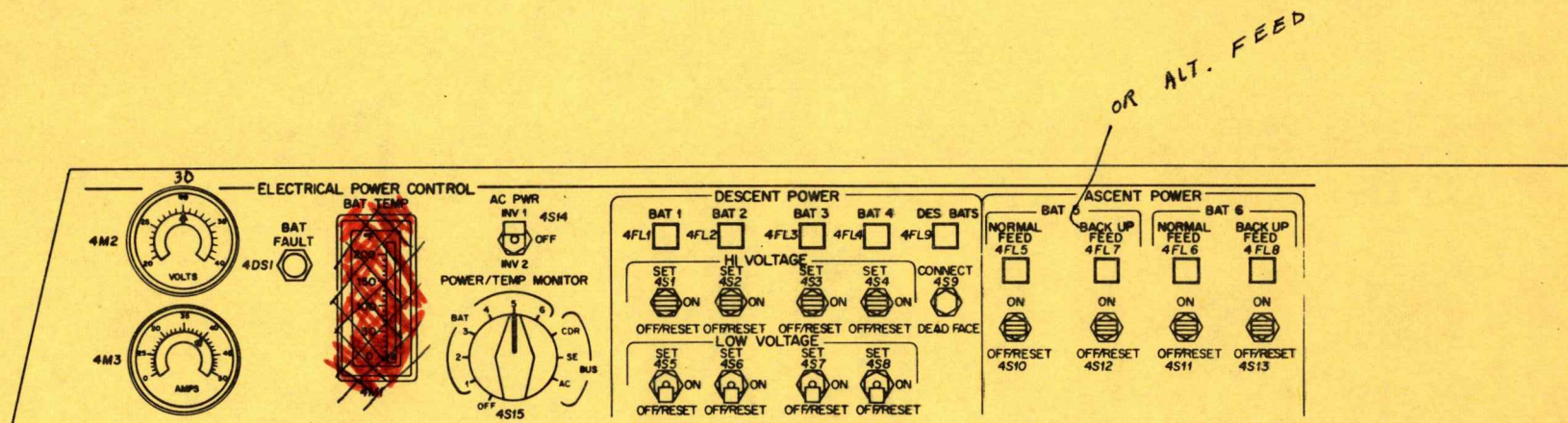
HAVE SPLIT Bus System.

A-C Inverters: Two solid-state inverters supply all a-c power requirements in the LEM. Each inverter supplies 115 ± 2 volts rms, operating on an input of 28 ± 4 volts dc, and can deliver an output of 350 volt-amperes. Each unit can be synchronized, using 6.4-kilopulse-per-second (kpps) master timing pulses delivered by the LEM guidance computer (IGC). Under these conditions, the inverter output frequency is 400 ± 4 cps. In the absence of IGC timing pulses, the output frequency is 400 ± 10 cps. The output waveform contains less than 5% total harmonic distortion; the maximum allowable peak output transient voltage is 225 volts. All foregoing conditions are invalid when the input supply voltage is 20 volts or less. The inverters are individually connected to the Commander's and Systems Engineer's 28-volt buses by operating the INV 1 and INV 2 circuit breakers on the Systems Engineer's and the Commander's upper side consoles respectively. The output of each inverter is connected to the main a-c distribution bus by control switches and relays, arranged according to a double, three-input AND-INHIBIT gate logic system. During checkout procedures performed before LEM-CSM separation, inverter No. 1 is energized by closing the INV 1 circuit breaker. The inverter output is connected to the main a-c distribution bus by setting the AC PWR switch on the ELECTRICAL POWER CONTROL panel to INV 1. If inverter No. 1 fails, the other inverter can be energized by closing the INV 2 circuit breaker. Its output is connected to the main a-c distribution bus by setting the AC PWR switch to INV 2.

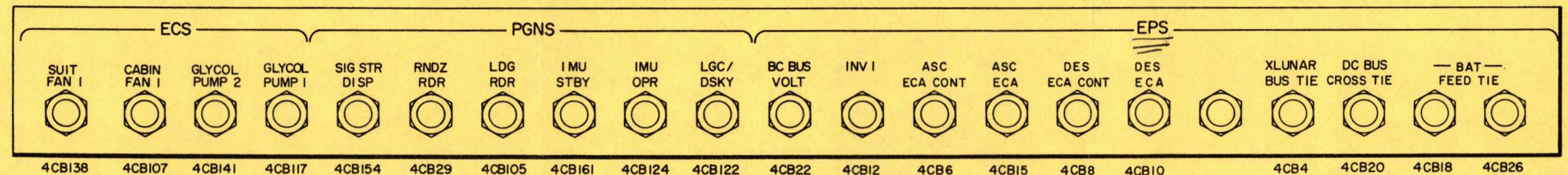
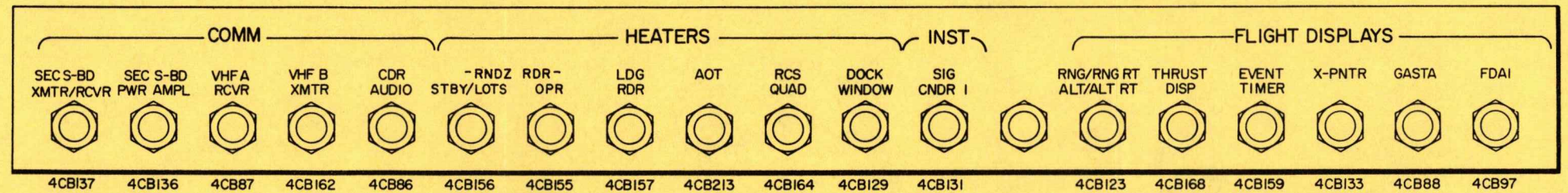
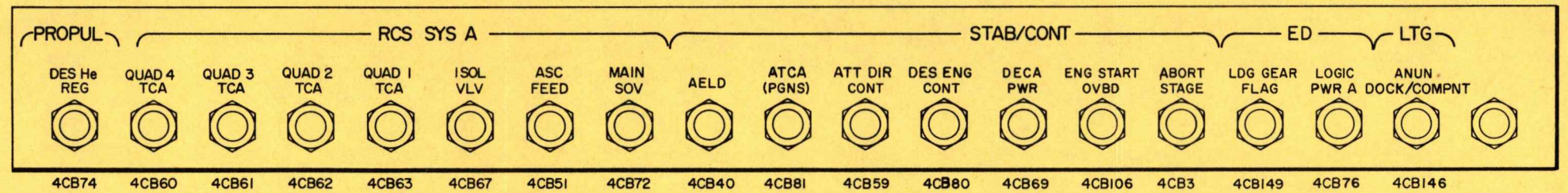
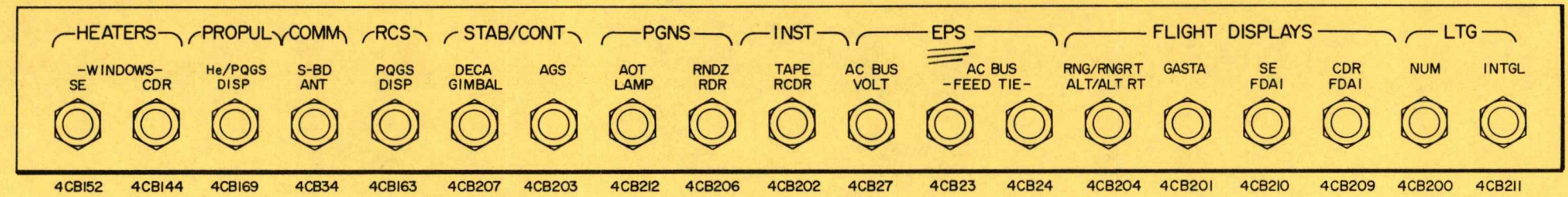
Control Panel

Control of the distribution system is provided on the Systems Engineer's Power Distribution, Panel XIV. The panel consists of the following controls and displays:

1. Eight SPTT (momentary (SET) - maintain (ON) - momentary (OFF/RESET) switches to control the contactors for each descent battery, (two for each battery).
2. Four flags indicate the status of the descent battery contactors, (one flag for each battery).
3. Four DPTT (momentary (ON) - maintain-momentary (OFF/RESET) switches control the contactors in each ascent ECA (two for each battery).
4. Four flags indicate the position of the ascent ECA contactors, (one for each contactor).

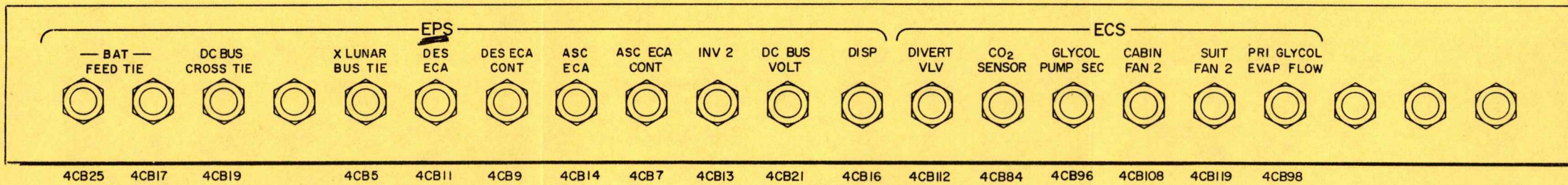
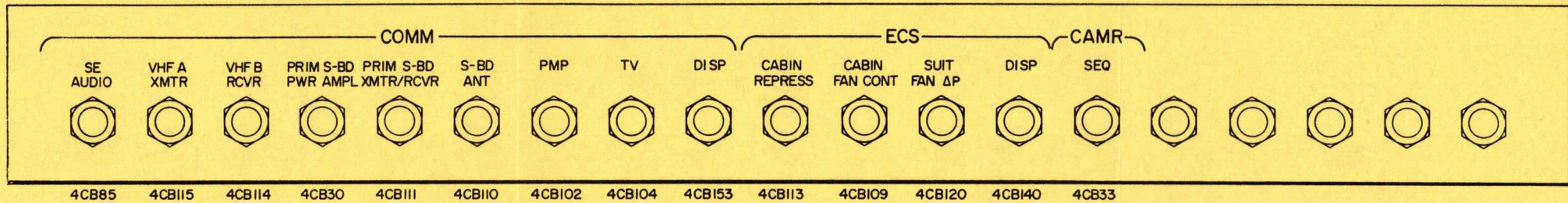
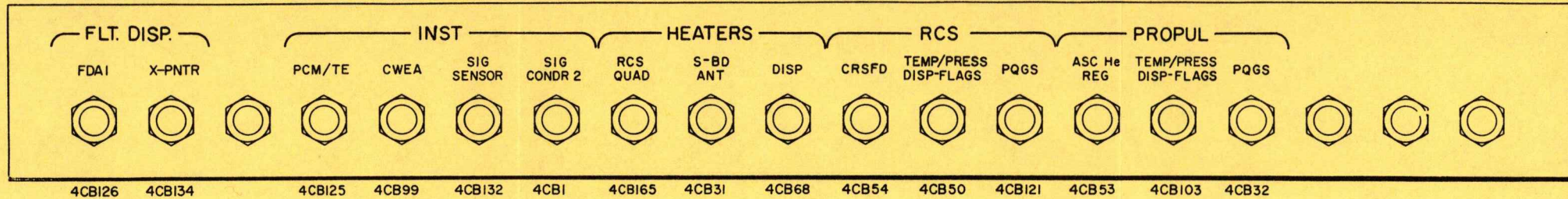
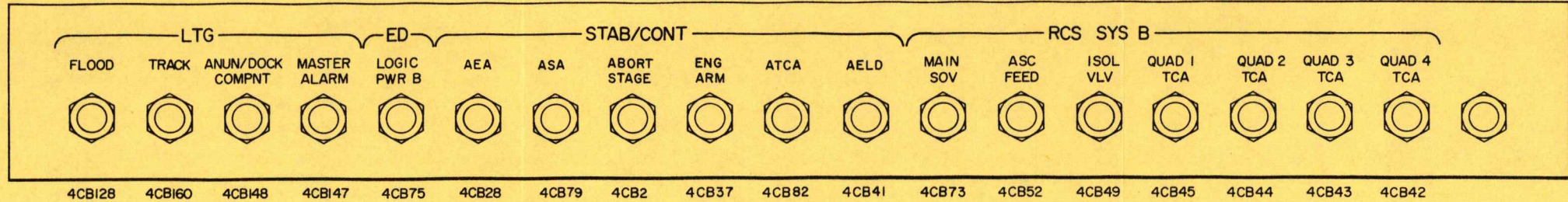


PANEL XIV
SE EPS CONTROL PANEL



CMDR CB PANEL
PANEL XI

T30100-3
MAY 66



SE CB PANEL
PANEL XVI

T30100-4
MAY 66

5. One SPTT (momentary (CONTACT) - maintain-momentary (DEADFACE) switch controls the "deadfacing" of the main power lines between the descent and ascent stages.
6. One flag indicates the condition of the Deadface Relays.
7. One ammeter indicates battery current.
8. One voltmeter indicates battery and bus voltages.
9. One rotary selector switch for the analog meters (ammeter, voltmeter).
10. One DPST switch inhibits automatic ascent power when two descent batteries are off the line.

Circuit Breaker Panels

Two DC busses (Commander's and S.E.'s) are connected electrically by the main power feeder system. Where redundant or functionally redundant equipment exists, an attempt is being made to place these equipments on different busses so that each bus can perform an abbreviated abort mission.

Sensor Power Fuse Assemblies

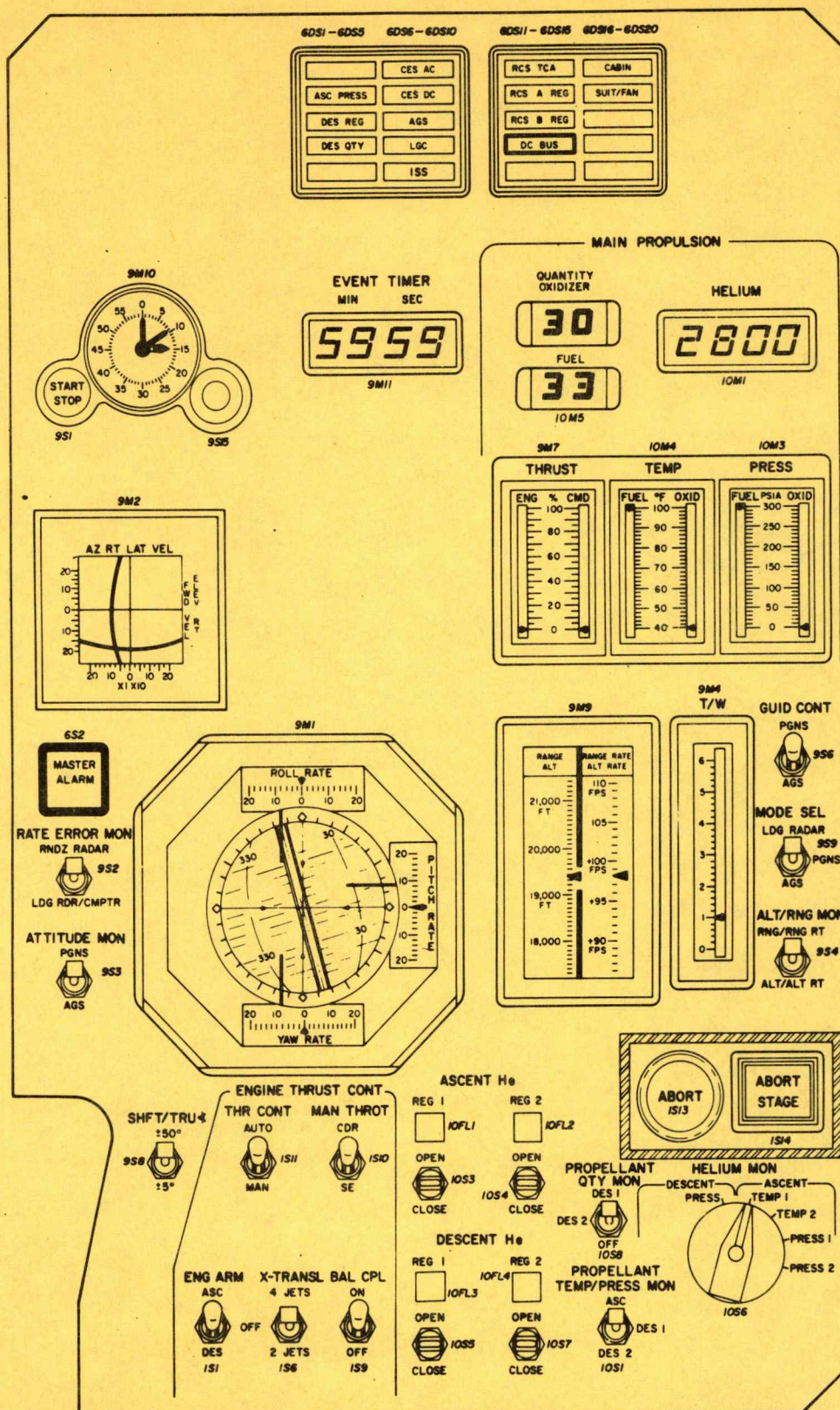
Two Sensor Power Fuse Assemblies provide a secondary DC bus system supplying excitation to ECS RCS and Propulsion transducers which in turn develop instrumentation display and telemetry information. Each assembly consists of forty (40) fuses each rated at 1/4 amp.

TOTAL 80

C. SYSTEM FUNCTIONAL DESCRIPTION

The LEM EPS subsystem has the capability of controlling all power to other LEM subsystems throughout all phases of the Apollo Mission starting with Launch Pad to completion of the LEM Mission. GSE will supply pre-launch DC & AC power requirements to T-30 min. The LEM and CSM will supply all power to the LEM from T-30 min to the completion of the LEM mission. A brief description of the EPS follows:

The output of each battery is applied to an ECA. In the descent stage the ECA's are designed to provide for four independent battery control circuits, one control circuit for each Descent Battery. The Ascent ECA's are designed to provide four independent battery control circuits, two identical control circuits for each Ascent Stage Battery.



PANEL I

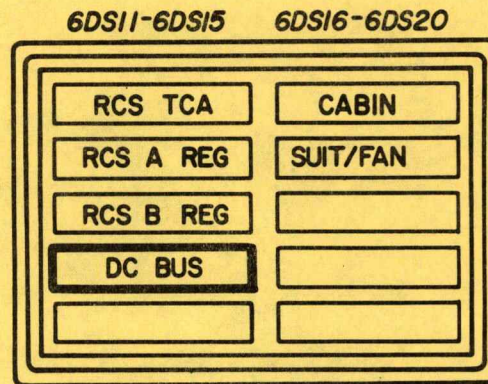
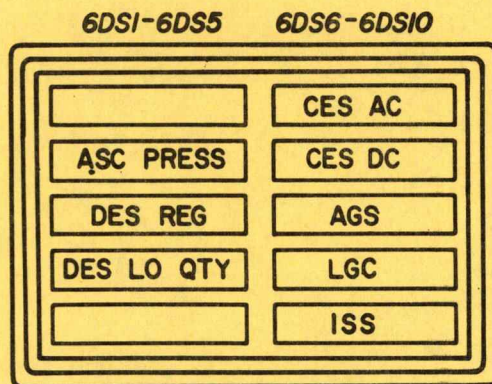
COMMANDER

SIDE

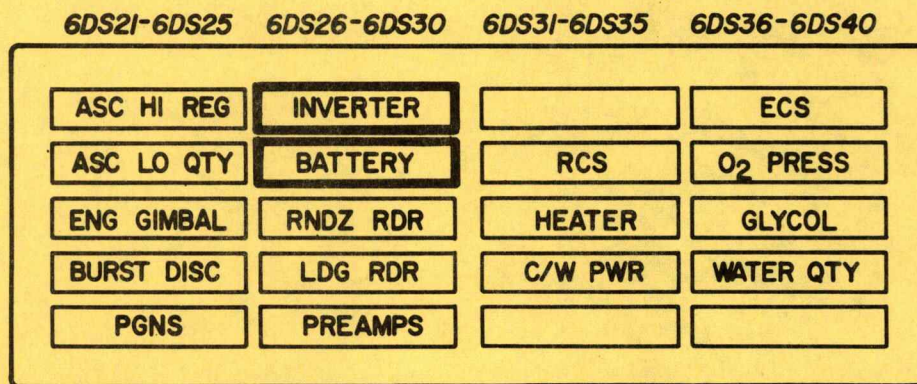


MASTER ALARM LIGHTS (PANELS I AND II)

BRIGHT FLASHING & TONE IN HEAD PHONES



WARNING LIGHTS (PANEL I) COMMANDER'S PANEL



CAUTION LIGHTS (PANEL II) ASS. ENG. PANEL

CAUTION AND WARNING DISPLAYS

Reverse current and overcurrent conditions are monitored by the ECA's. Each ECA battery control circuit will have the capability to detect a battery or feeder malfunction and operate a Main Feed Contractor associated with the malfunctioning battery to remove it from the EPS distribution system.

Descent Stage battery power is controlled and monitored by the descent ECA's and is properly switched and applied to the Relay Junction Box (RJB) and the Deadface Relay Box (DFR). Descent batteries No.s 1 and 2 main power feeders, are routed through the RJB deadface relays and applied to the System Engineer's CB Panel XVI. Batteries No.s 3 and 4 main power feeders, are routed through the DFR deadface relays and applied to the Commander's CB Panel XI. This circuit arrangement provides for deadfacing all descent battery power in the event of an "ABORTED" LEM mission.

Ascent Stage Battery power is controlled and monitored by the Ascent ECA's and is properly switched and applied through feeder cables to terminal junction points in the RJB and DFR. Power is applied through common main power feeders to the Systems Engineer's and Commander's CB Panels DC Bus System.

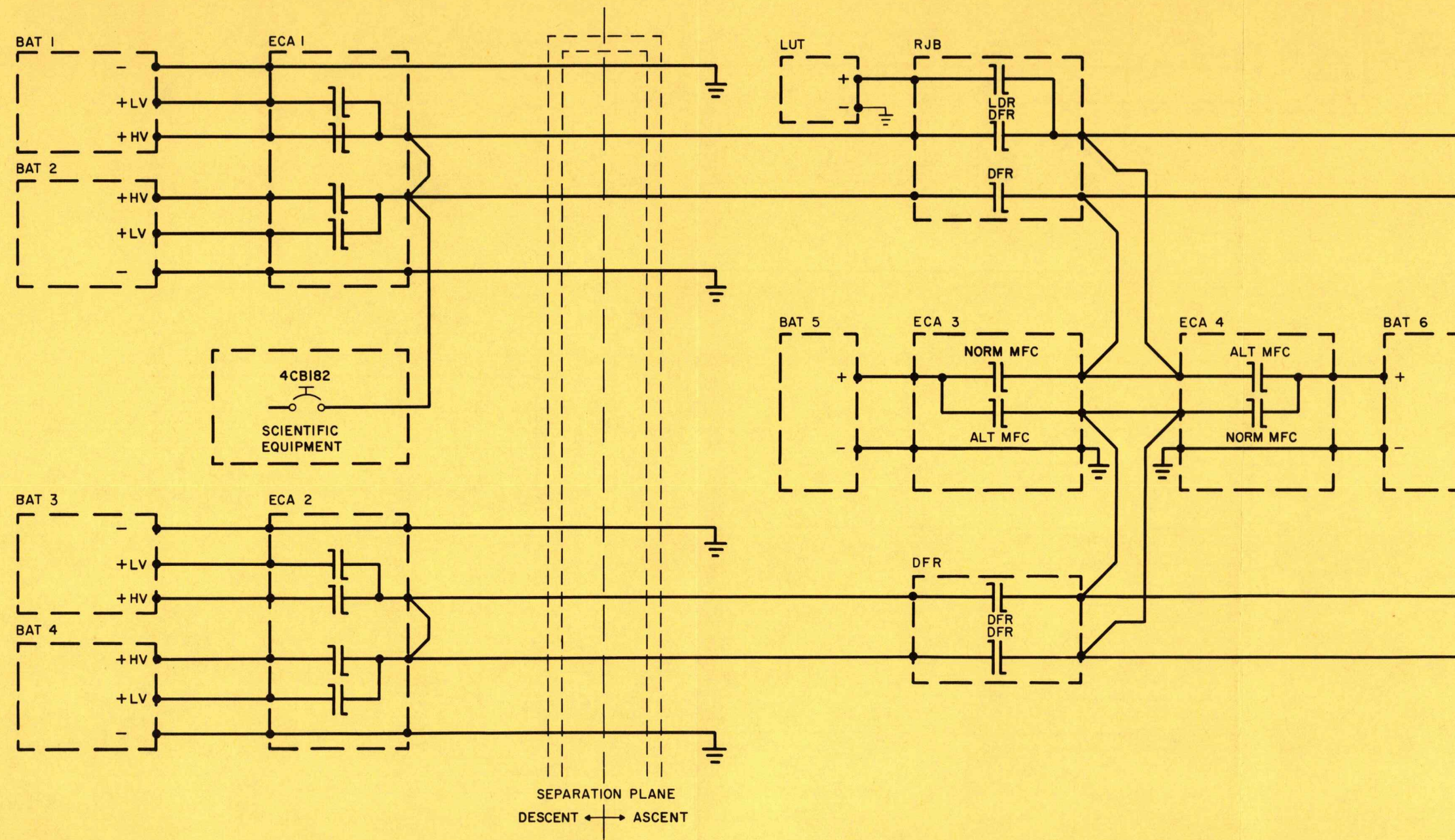
In addition to providing for deadfacing Descent Batteries No.s 1 and 2 and terminal junction points for the Ascent Batteries, the RJB also provides power/control interface between the following Apollo Space Vehicles and Ground Support Equipment.

1. Launch Umbilical Tower (LUT) Ground Power
2. CSM/LEM Power
3. EPS/Guidance and Navigation, "ABORT STAGE" Command

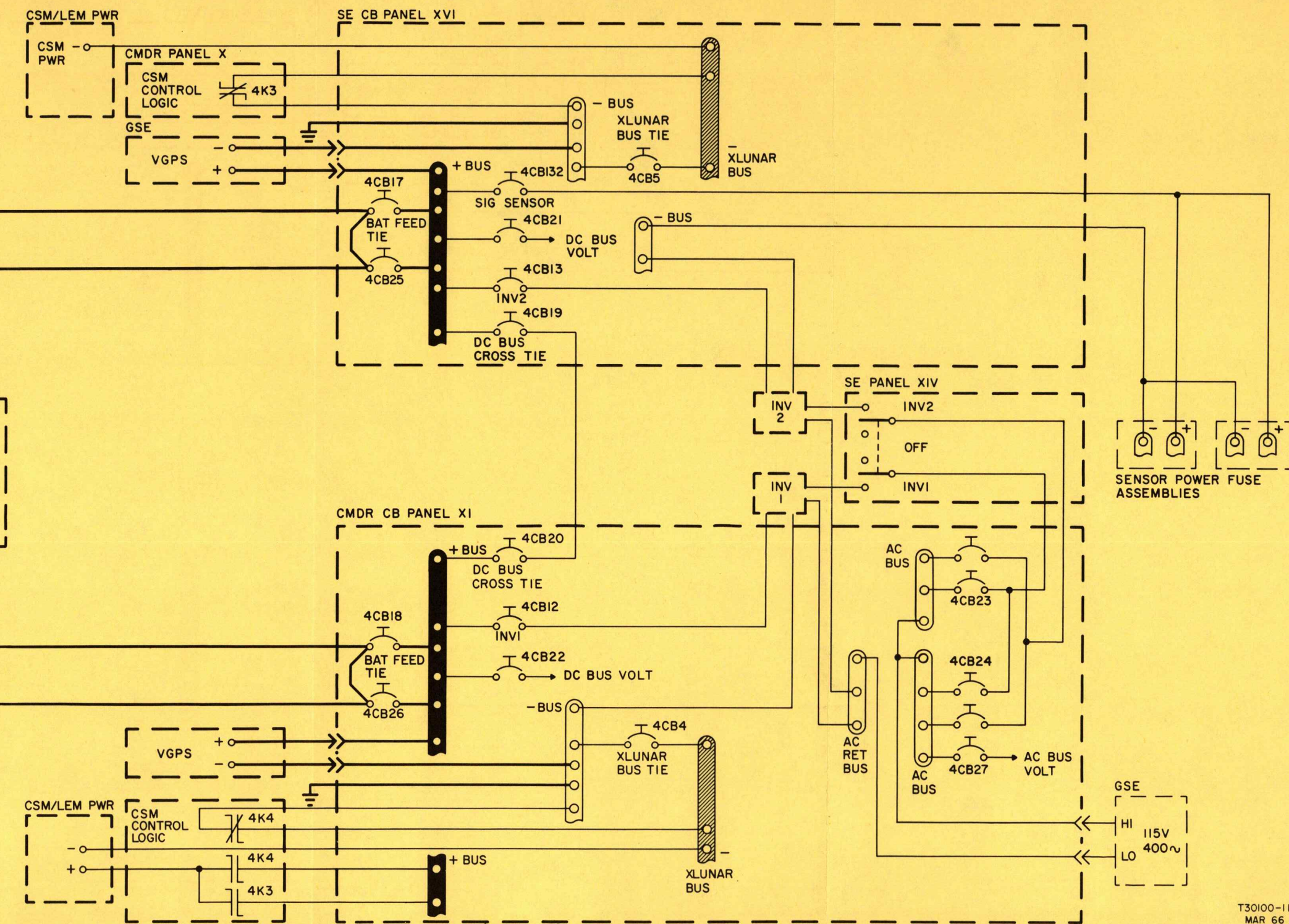
Ascent and Descent Battery power feeders are routed through circuit breaker devices to the DC Bus Assemblies. The circuit breakers provide a main feeder overcurrent protection. From the DC Bus Assembly, DC power is distributed through circuit breakers to all LEM subsystems.

Two general purpose inverters supply all AC power requirements for the LEM vehicle. An inverter select switch controls both inverters, either of which has the capability to adequately supply LEM AC loads. The inverter output is applied to an AC bus which supplies AC power through circuit breakers to LEM AC operated equipment.

Manual control of both inverters and each battery is provided by an EPS control panel. This control panel will also provide the crew with a visual display of EPS operational status.



POWER DISTRIBUTION SYSTEM DC AND AC



D. SYSTEM FUNCTIONAL OPERATION

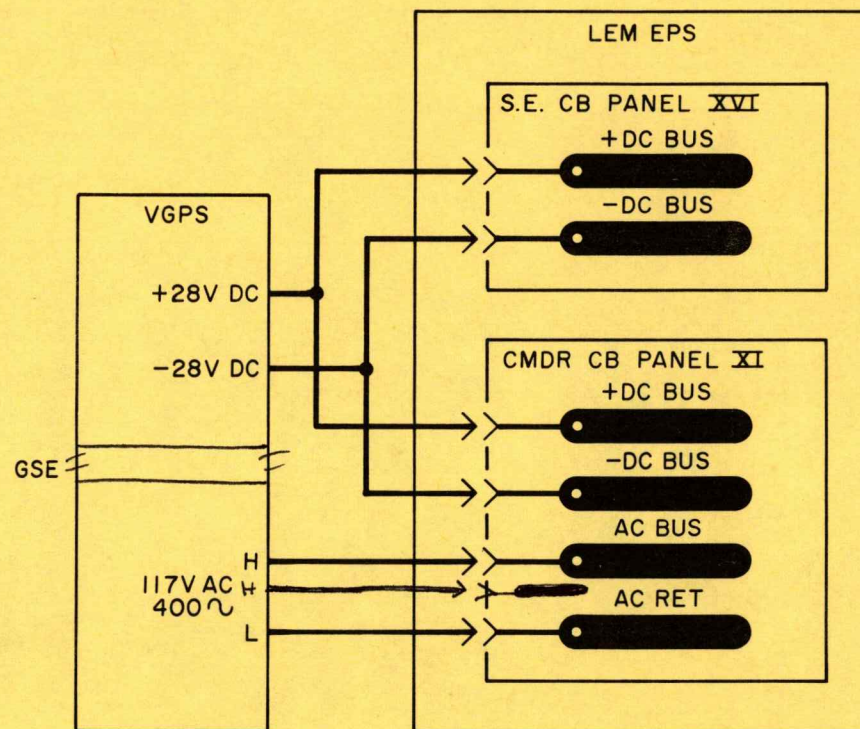
The EPS subsystem operates in seven modes of operation as follows:

1. GSE
 - a. VGPS VEHICLE GROUND POWER SUPPLY
 - b. LUT to T-30 min LAUNCH UMBILICAL TOWER
DESCENT BAT. ON LV.
2. T-30 min through CSM transposition
3. Translunar - CSM/LEM POWER
4. Descent Power
5. Ascent Power
6. ~~Automatic transfer for descent to ascent~~
7. EPS "ABORT" configuration

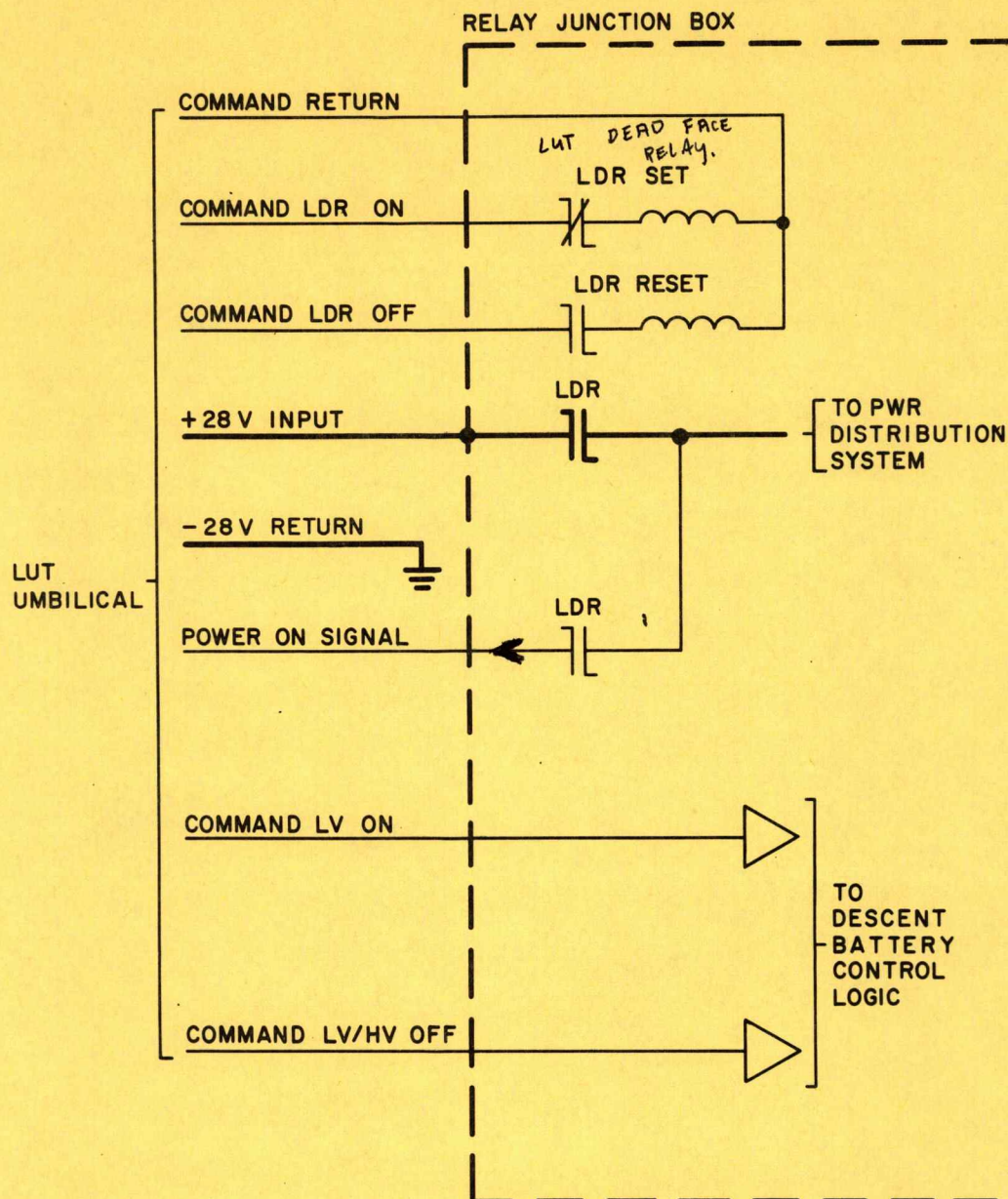
The EPS Subsystem is also comprised of a DC Power Distribution System and an AC Power System.

GSE Mode of Operation

Pre-launch LEM DC and AC power will be supplied by the Vehicle Ground Power Supply (VGPS). An umbilical cable will be carried on board the LEM and manually connected to two GSE connectors located under the lower circuit breaker tier at the Commanders and System Engineer's panels. At approximately T-7 hours this GSE umbilical cable will be removed. The SLA/LEM assembly will now be connected to the Launch Umbilical Tower (LUT) by an umbilical. An internal SLA cable will interface the SLA connector to an external LEM connector located on a landing gear leg. LUT power is supplied to the EPS system through the RJB. LUT remote control includes LDR "SET" and "RESET", LEM "LV ON" and "LV OFF", and a LUT power "ON" signal. The LDR (LUT Deadface Relay) supplies power through the System Engineers main power feeders to the SE DC bus. Power is supplied to the CMDR DC bus through two DC BUS cross tie circuit breakers. The LDR also supplies a power ON signal back to the LUT control center. LUT through the EPS RJB controls descent battery LV ON and LV OFF. Prerequisite of the EPS system controls are as follows:



GSE-LEM POWER INTERFACE



LUT CONTROL LOGIC

T30100-5
MAR 66

1. Deadface Relays - "CONNECT" or "SET" position
2. DC BUS CROSS TIE circuit breakers (2) must be "CLOSED"
3. DES ECA circuit breakers (2) must be "CLOSED"

T-30 min Through CSM Transposition

At T-30 min LUT will "RESET" the LDR and initiate EPS descent LV ON. The EPS batteries will supply limited power to certain critical equipments from T-30 min through launch to completion of CSM transposition and docking.

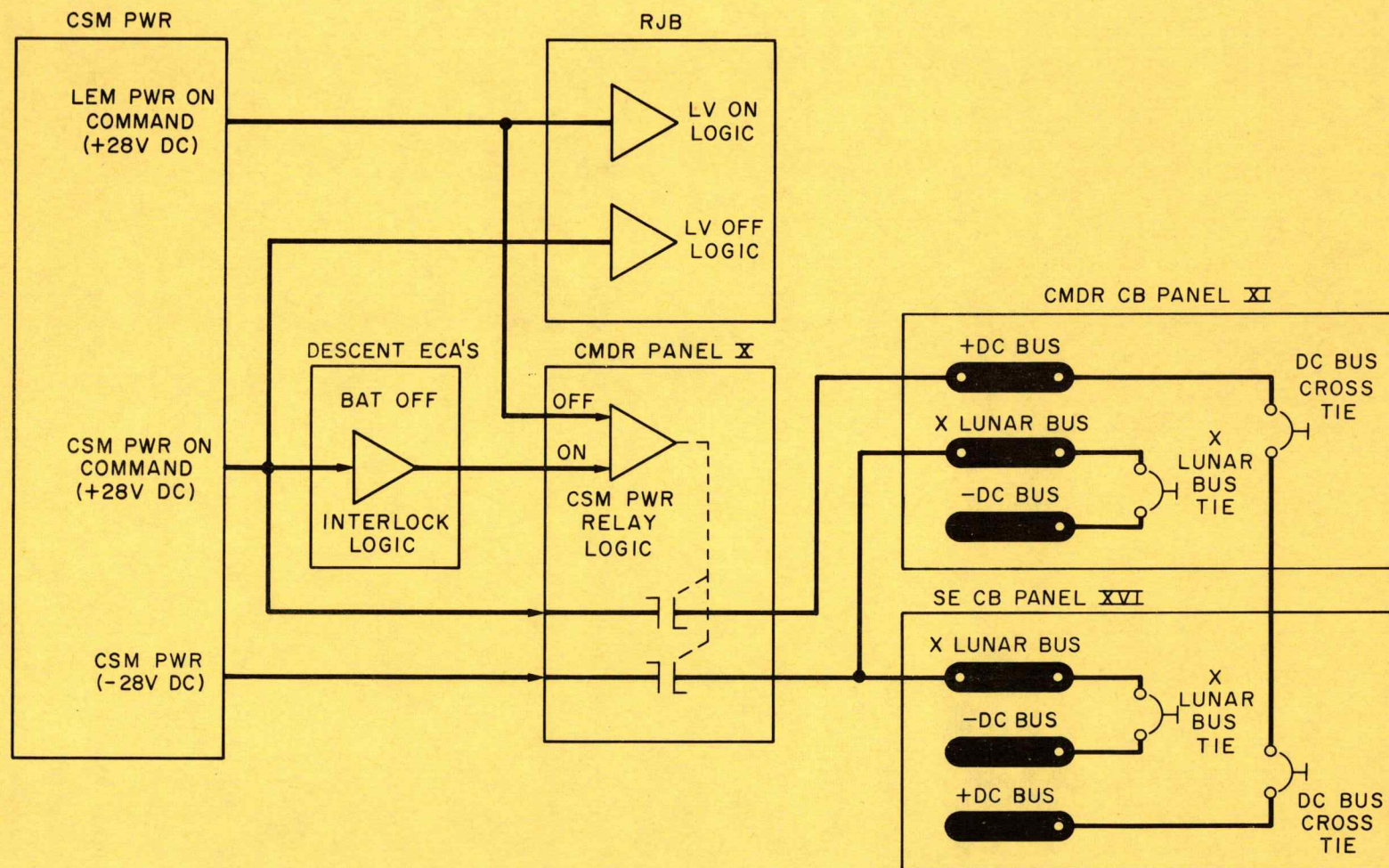
Translunar - CSM to LEM Power

On completion of CSM transposition and docking, CSM will connect a power and control umbilical cable to the LEM. The CSM will de-activate LEM power and then supply power to the LEM critical equipments utilizing the LEM's Translunar Bus. CSM/LEM control logic prohibits CSM power to the LEM bus distribution system while LEM battery power is "ON". CSM/LEM control logic is as follows:

1. CSM initiates CSM power to the LEM
 - a. CSM selects control switch to "CSM POWER ON" position
 - b. A control signal to LEM EPS de-activates descent battery "LV OFF"
 - c. Descent ECA's LV and HV "OFF" logic returns control signal to initiate relay logic supplying CSM power to LEM TRANSLUNAR bus system
2. CSM de-activates CSM power to the LEM
 - a. CSM selects control switch to OFF position
3. CSM initiates LEM power on
 - a. CSM selects control switch to "LEM POWER ON" position
 - b. A control signal de-activates the LEM's CSM relay logic and in addition initiates descent ECA's LV "ON" logic

Prerequisite of the EPS system controls are as follows:

1. Requirements for launch configuration
2. TRANSLUNAR BUS TIE circuit breakers (2) must be OPEN



CSM/LEM POWER

Descent Power

EPS descent power 'Controls and Displays' are located on the EPS Control Panel XIV. Each of four descent batteries are provided with individual HV and LV "ON-OFF" selector switches and flag indicators. A Power/Temp Monitor switch selects individual batteries for metered voltage and current displays. Battery LV control is effected through the RJB to an appropriate ECA while battery HV control is direct to the ECA. Additional LV control is effected within the RJB through internal logic receiving control signals from the following.

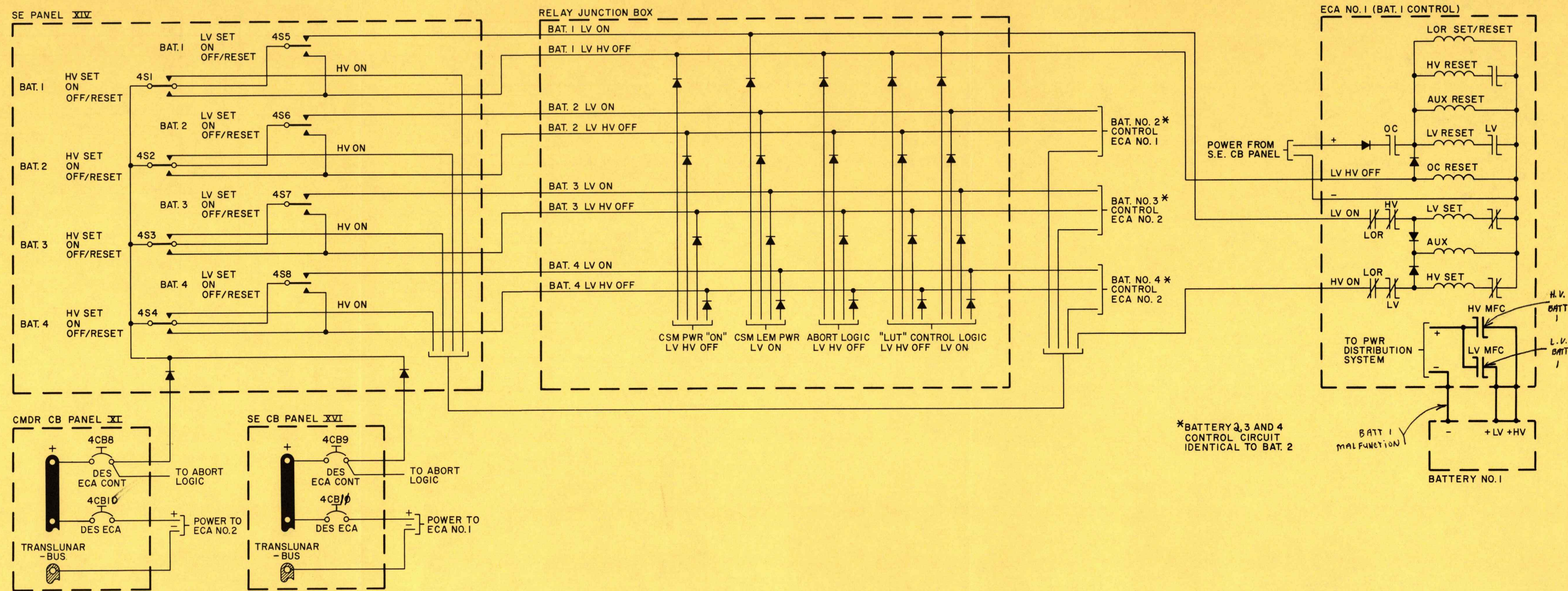
1. CSM/LEM power "ON" and "OFF"
2. LUT control logic power "ON" and "OFF"
3. LEM abort logic

Descent battery selector control and descent ECA power are redundantly provided by two DES ECA CONT and two DEC ECA circuit breakers, one each located at the Commanders and System Engineer's CB panels. Negative return from the descent ECA's is connected to the translunar bus.

The functional operation of a descent ECA is as follows:

1. Selection of either HV SET or LV SET will initiate either HV or LV main feed contacts and place the battery on the line to the power distribution system. It is impossible to select both HV and LV "ON" at the same time. Further, OFF/RESET must be initiated prior to changing selection from LV to HV or vice-versa.
2. Selection of either HV or LV will initiate auxiliary HV or LV contacts providing instrumentation signals for telemetry and "FLAG" indication stating battery is "ON".
3. A current monitor assembly supplies
 - a. current readout
 - b. reverse current relay control
 - c. overcurrent relay control

The above readout signals are applied to instrumentation for telemetry, caution warning and advisory display.



DESCENT BATTERY CONTROL LOGIC

An overcurrent condition will automatically remove the affected battery from the power distribution system. OFF/RESET must be initiated prior to returning the affected battery to the line. If an overcurrent condition still exists, the current monitor will again automatically shut down the battery.

A reverse current condition will initiate caution warning only. The astronaut will make a determination of the indication and perform corrective action.

4. Battery overtemperature contact closure 'signals' pass through an auxiliary ECA contactor supplying information to instrumentation for telemetry and caution warning. No panel display is available. The astronaut will make a determination of the indication and perform corrective action.
5. Battery voltage is read directly from battery HV terminal and is supplied to instrumentation for telemetry and advisory display.
6. Additional HV and LV contacts supply CSM/LEM power logic when the descent battery has been removed from the power distribution system.
7. An auxiliary contact provides ENABLE - INHIBIT logic as yet not determined for the EPS.

Prerequisites of the EPS system controls are as follows:

1. Deadface relays - "CONNECT" or "SET" position.
2. TRANSLUNAR BUS TIE circuit breakers (2) "OPEN" at earth launch to lunar orbit; "CLOSED" when the LEM is manned in lunar orbit.
3. DC BUS CROSS TIE circuit breakers (2) must be "CLOSED".
4. DES ECA CONT (2) and DES ECA (2) circuit breakers must be "CLOSED".

Ascent Power

EPS ascent power 'controls and displays' are located on the EPS Control Panel XIV. Each of two ascent batteries are provided with dual selector switches, NORMAL FEED and BACK UP FEED (ALTERNATE) and flag indicators. A Power/Temp monitor switch selects each

battery for metered voltage and current displays. Ascent battery selector control and ascent ECA power are redundantly provided by two ASC ECA CONT and two ASC ECA_u circuit breakers, one each, located at the Commander's and Systems Engineer's CB panels. However, ascent battery control logic precludes the possibility of complete BUS power failure. Both NORMAL and BACK UP FEED are connected directly to the ascent battery permitting initiation of ascent power without the bus distribution system being energized.

The ascent batteries are interfaced into the power distribution at the bus feeder side of the RJB and DFR.

Battery #5 NORM supplies power to the System Engineer's DC bus and battery #6 NORM supplies power to the Commander's DC bus. Selection of BACK UP of either battery will place it to the opposite DC bus. It is permissible for either or both ascent battery to operate in NORM and BACK UP MODE.

The functional operation of an ascent ECA is divided into two parts; NORM FEED control and BACK UP FEED (ALT) control. Both are identical, each section supplies identical readouts to instrumentation for telemetry and displays. ECA operation is as follows:

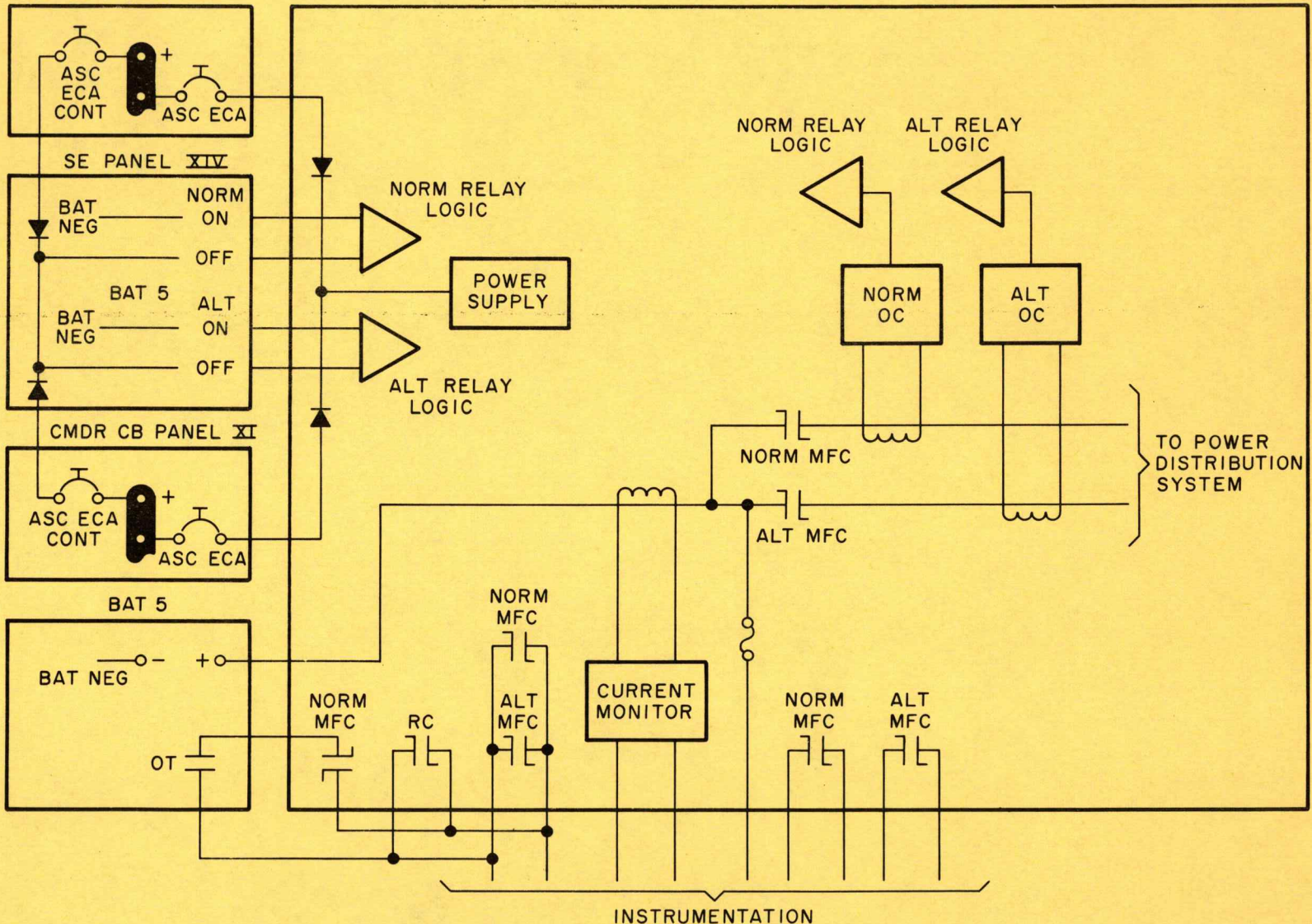
1. Selection of either NORM or ALT will initiate main feed contacts and place the battery on the line to the power distribution system. Both NORM and ALT may be selected for either or both ascent batteries.
2. Selecting either NORM or ALT will initiate auxiliary contacts providing instrumentation signals for telemetry and flag indication stating battery is "ON".
3. There are three current monitor assemblies.
 - a. one common unit supplying reverse current relay control and current readout
 - b. two separate units for overcurrent relay control gaurd NORM and ALT FEED.

The above readout signals are applied to instrumentation for telemetry, caution light and advisory display.

An overcurrent condition of either NORM or ALT feed will automatically remove the battery from the affected feed and associated sector of the power distribution system. OFF/RESET must be initiated prior to returning the affected battery to the line. If an overcurrent condition still exists, the overcurrent monitor will again shut down the feed.

SE CB PANEL XVI

ECA 3



ASCENT CONTROL AND ECA LOGIC

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A reverse current condition will initiate caution warning only. The astronaut will have to make a determination of the indication and perform corrective action.

4. Battery overtemperature contact closure 'signals' pass through an auxiliary NORM ECA contactor supplying information to instrumentation for telemetry and caution lights. No panel display is available. The astronaut will make a determination of the indication and perform corrective action. This information is not available when the battery is utilized in the BACK UP mode of operation.
5. Battery voltage is read directly from battery input terminal and is supplied to instrumentation for telemetry and advisory display.
6. Additional NORM and ALT contacts supply ABORT logic permitting "SHUT DOWN" of descent batteries only after an ascent battery is on the line. This assures continuity of power to the DC bus system.
7. An additional ALT auxiliary contact completes the path for an ABORT command to the NORM FEED selector provided the battery has not already been instated in the BACK UP mode.

Prerequisites of the EPS system controls are as follows:

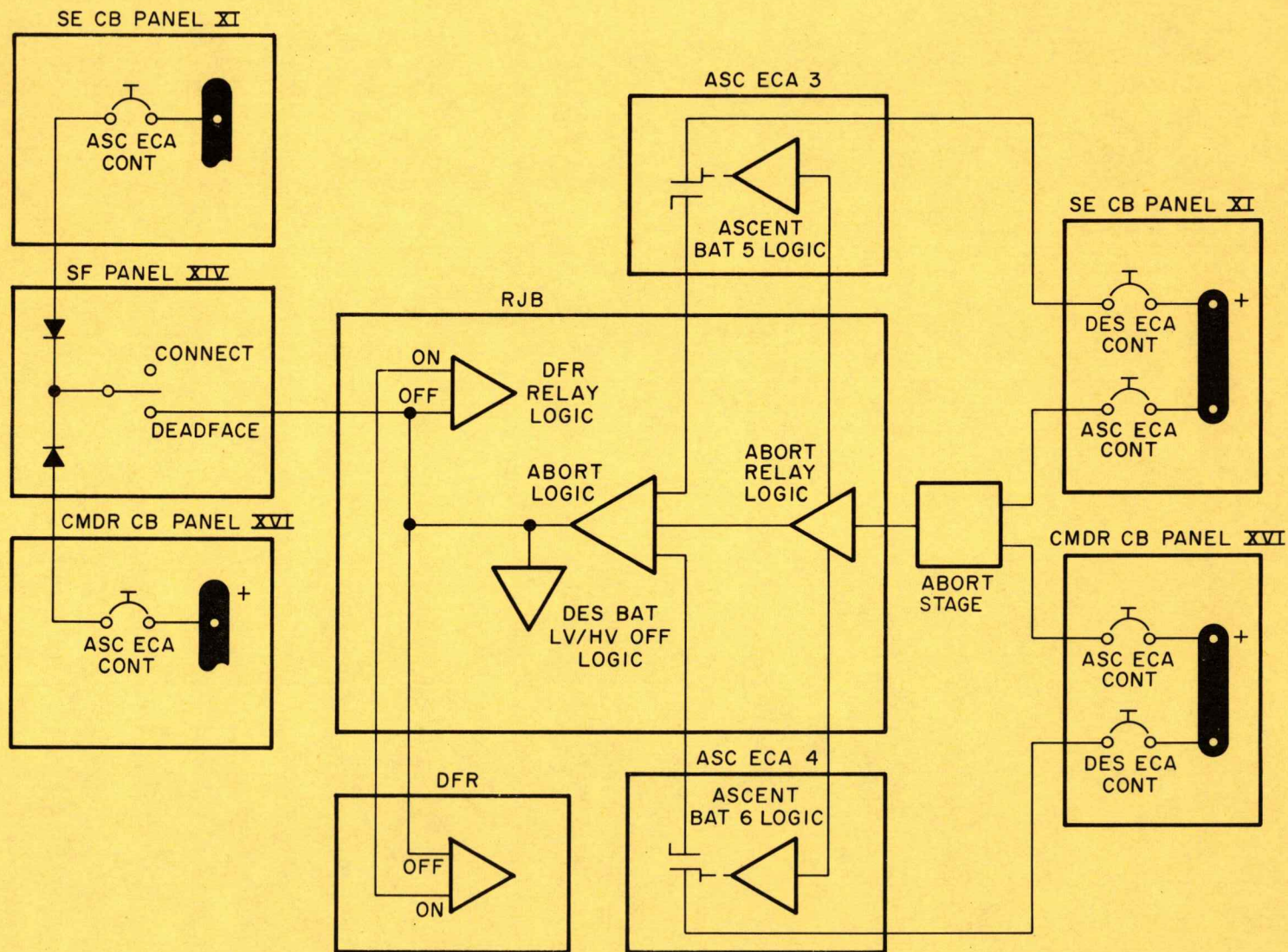
1. ASC ECA CONT (2) and ASC ECA (2) circuit breakers must be "CLOSED".
2. DC BUS CROSS TIE circuit breakers (2) must be "CLOSED".
3. TRANSLUNAR BUS TIE circuit breakers (2) must be "CLOSED".
4. DISPLAY circuit breaker must be "CLOSED".

Automatic Transfer Descent to Ascent

This section to be added at a later date.

EPS Abort Configuration

The EPS ABORT mode of operation consists of automatically transferring the LEM DC BUS loads from descent batteries to ascent batteries maintaining continuous uninterrupted DC power to the bus distribution system. This condition is initiated by operating the ABORT STAGE switch.



DEADFACE RELAY AND ABORT LOGIC

A normal transfer of batteries can be initiated by the following manual controls:

1. Manually select ascent batteries to "ON" status.
2. Manually select descent batteries to "OFF" status.
3. Select DES BATS switch to "DEADFACE" position.

Auxiliary DFR contacts in the RJB and DFR provide direct control to a DES BATS flag display.

In the automatic mode the same sequence of events occurs. The "Abort Stage" switch initiates two ABORT relays which in turn initiates the NORM main feed contactors of each ascent ECA provided the ECA's have not been previously selected in the ALT mode of operation. Additional ABORT relay contacts supply an OFF/RESET signal through the RJB to all four descent batteries and to the deadface relay only after the ascent battery main feed contactors have placed them on the line.

Prerequisites of the EPS system controls are as follows:

1. ASC ECA CONT circuit breakers (2) must be "CLOSED".
2. DES ECA CONT circuit breakers (2) must be "CLOSED".
3. DISPLAY circuit breaker must be "CLOSED".

DC Bus Distribution

A system of 'bus feeder cables' interfaces the descent batteries and ECA's through the RJB and DFR to a BUS distribution system located at the Commanders and System Engineer's circuit breaker panels. The ascent batteries and ECA's are connected to the feeder cable system at the RJB and DFR.

GSE ground power is manually connected directly to the DC and AC bus system. GSE LUT DC power is interfaced through the SLA/LEM assembly to the RJB. In addition the LUT control center can initiate the descent batteries LV "ON" or "OFF".

CSM/LEM power is interfaced with the LEM through a docking umbilical cable located in the LEM docking tunnel. CSM/LEM relay logic is located at the Commanders Panel X. CSM negative return is interfaced to the EPS TRANSLUNAR negative bus which separates critical LEM equipments from the regular EPS NEG BUS and provides a 'positive' ground return loop to the CSM power system.

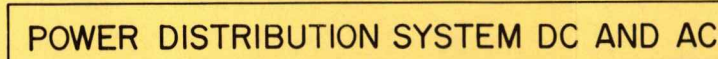
A secondary DC distribution is provided by two Sensor Fuse Power Assemblies.

The functional operation of the DC Bus Distribution System is as follows:

1. Descent batteries 1 and 2 are individually connected to ECA 1. The battery outputs of the ECA are paralleled and connected by a dual feeder system to the RJB DFR relay assembly. The parallel feeder system continues to the System Engineer's POS Bus through two BAT FEED TIE circuit breakers.
2. Descent batteries 3 and 4 are individually connected to ECA 2. Battery outputs again are paralleled and connected by a dual feeder system to the DFR relay assembly. The Parallel feeder system continues to the Commanders POS Bus through two BAT FEED TIE circuit breakers.
3. The LUT umbilical tie to the distribution system is made through the RJB LUT Deadface relay. LUT power is interfaced with Battery 1 and 2 feeder system to SE DC BUS. Two DC BUS CROSS TIE circuit breakers connect the SE DC BUS to CMDR DC BUS.
4. Ascent battery 5 is connected to ECA 3 and ascent battery 6 is connected to ECA 4. ECA 3 NORM supplies power to SE DC BUS and ECA 4 NORM supplies power to CMDR DC BUS. The ALT mode of each ascent ECA reverses battery connection to DC busses.
5. GSE BGPS manually connects to the SE DC bus system and to the CMDR DC and AC bus system.
6. CSM/LEM control logic and power input are interfaced at the Commanders Panel X. DC power is supplied to the CMDR DC BUS and then to the SE DC BUS through two DC BUS CROSS TIE circuit breakers. CSM DC return is interfaced to both SE and CMDR translunar bus. The translunar busses are connected to the NEG busses through two TRANSLUNAR BUS TIE circuit breakers.
7. A SIG SENSOR circuit breaker supplies power to two Sensor Fuse Power Assemblies.

The diagram illustrates the power distribution and control logic for a spacecraft system. Key components and connections include:

- Power Sources:** CSM/LEM PWR, VGPS, and a 115V AC source (117V).
- Buses:** + BUS, - BUS, XLUNAR BUS, DC BUS, and AC BUS.
- Control Panels:** SE CB PANEL XVI, CMDR PANEL X, CMDR CB PANEL XI, and SE PANEL XIV.
- Relays and Switches:** 4CB17, 4CB21, 4CB13, 4CB19, 4CB20, 4CB12, 4CB22, 4CB18, 4CB26, 4CB4, 4CB23, 4CB24, 4CB27.
- Fuses:** 4K3, 4K4, and 30 fuses for sensor power.
- Sensors:** SIG SENSOR, DC BUS VOLT, and INV. VOLT.
- Handwritten Notes:** "SYSTEM PWG. VOLT.", "CMDR VOLT.", "INV. VOLT. INV. FREQ.", and "30 fuses".



VGPS- VEHICLE GROUND
Power supply.

8. Bus voltage readouts are available from two DC BUS VOLT circuit breakers supplying signals to instrumentation for telemetry, WARNING light and advisory display. The Power/Temp Monitor switch selects either the SE or CMDR busses for metered voltage displays.

Prerequisites of the EPS system controls are as follows:

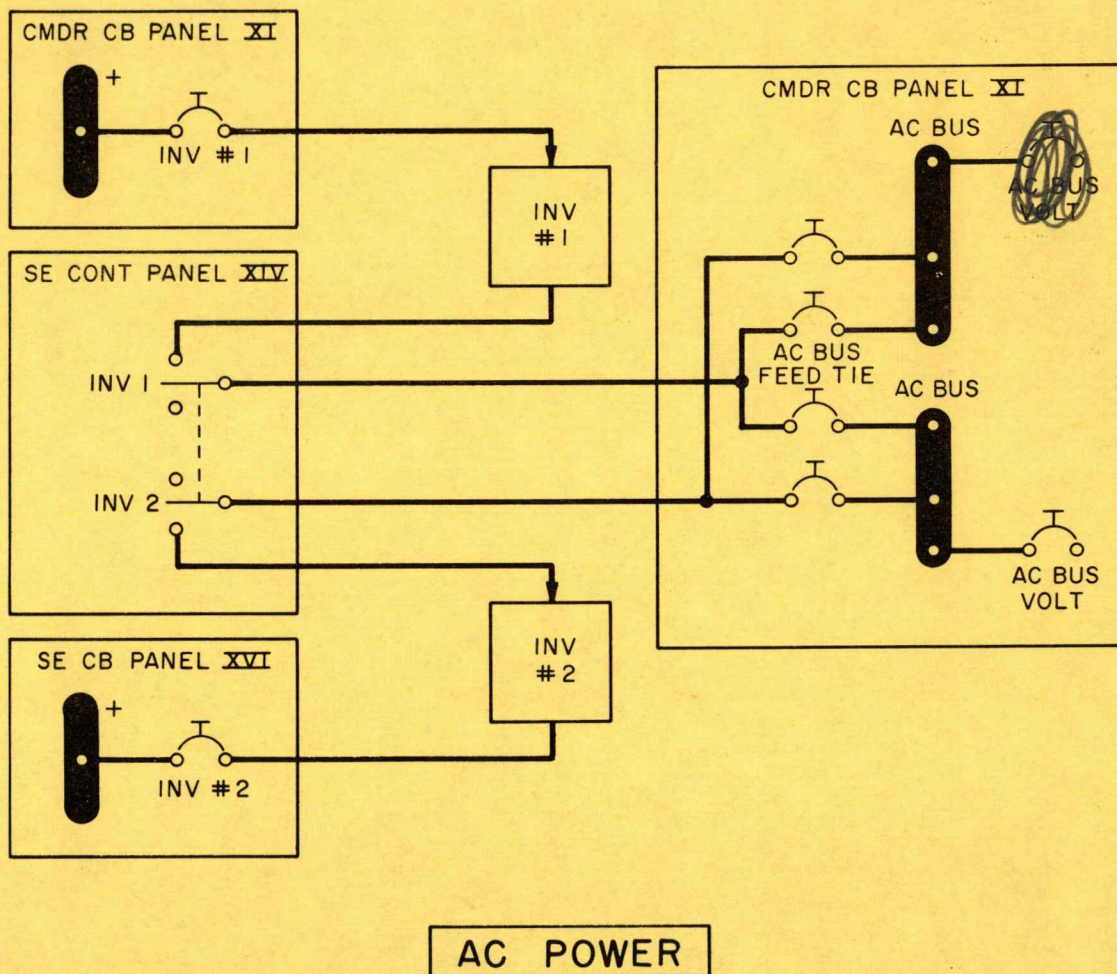
1. BAT FEED TIE circuit breakers (4) must be "CLOSED".
2. DC BUS CROSS TIE circuit breakers (2) must be "CLOSED".
3. TRANSLUNAR BUS TIE circuit breakers (2)
 - a. "OPEN" for earth launch to lunar orbit
 - b. "CLOSED" for lunar descent
4. SIG SENSOR circuit breaker must be "CLOSED".
5. DC BUS VOLT circuit breakers (2) must be "CLOSED".

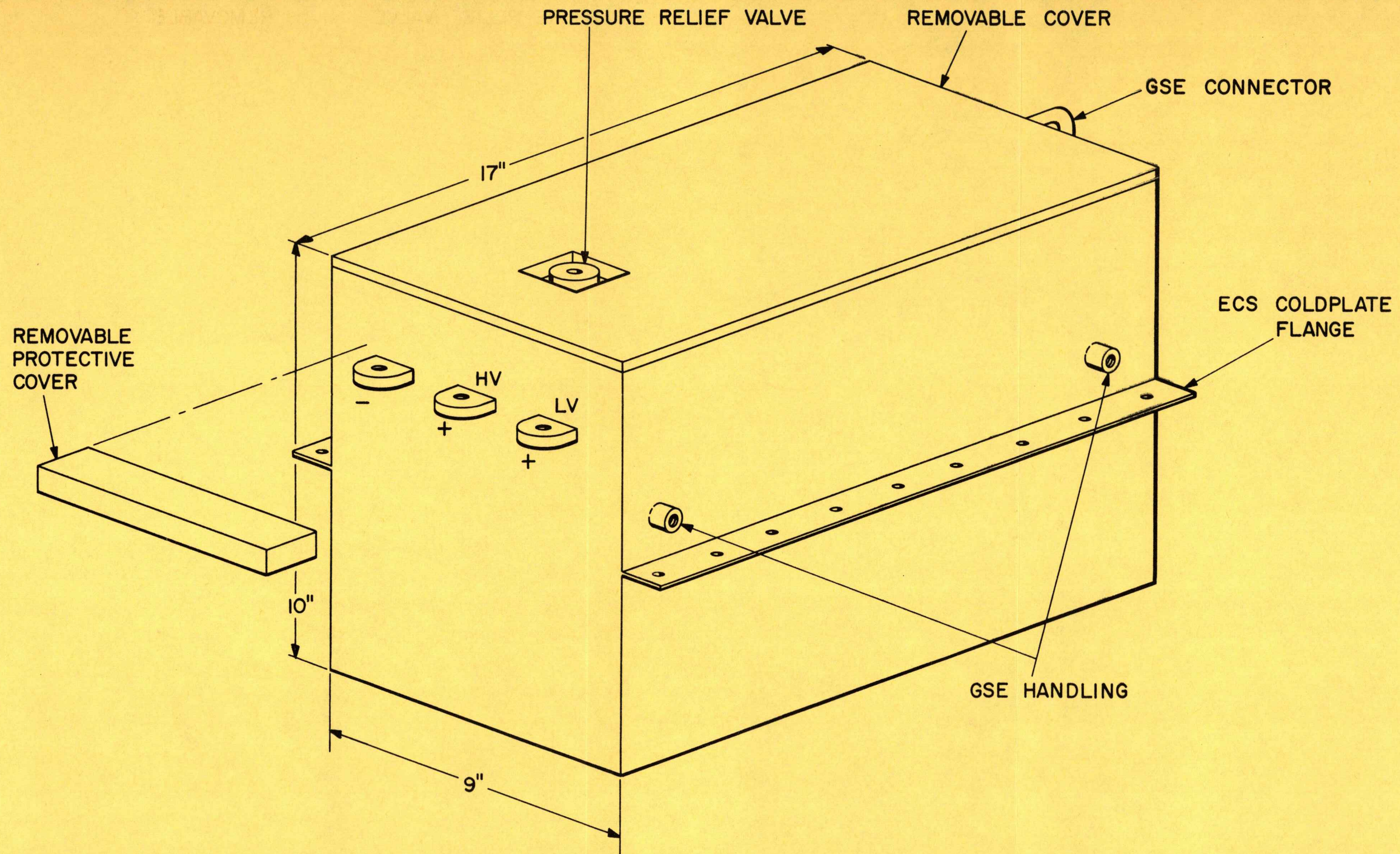
AC Power

AC power is redundantly provided by two identical inverters. The inverters are initiated by engaging INV #1 and INV #2 circuit breakers one each located on the Commander's and System Engineer's CB panels. Selection of an individual inverter is accomplished by the AC PWR inverter switch. Either inverter can be selected and placed on the AC split bus system through isolating AC BUS FEED TIE circuit breakers. An AC bus voltage and frequency readout signal is supplied to instrumentation for telemetry caution light and advisory display. Only voltage is telemetered. An out-of-tolerance frequency will initiate caution warning only. The astronaut will make a determination of the indication and perform corrective action. A Power/Temp Monitor switch will select the AC bus for a metered voltage display.

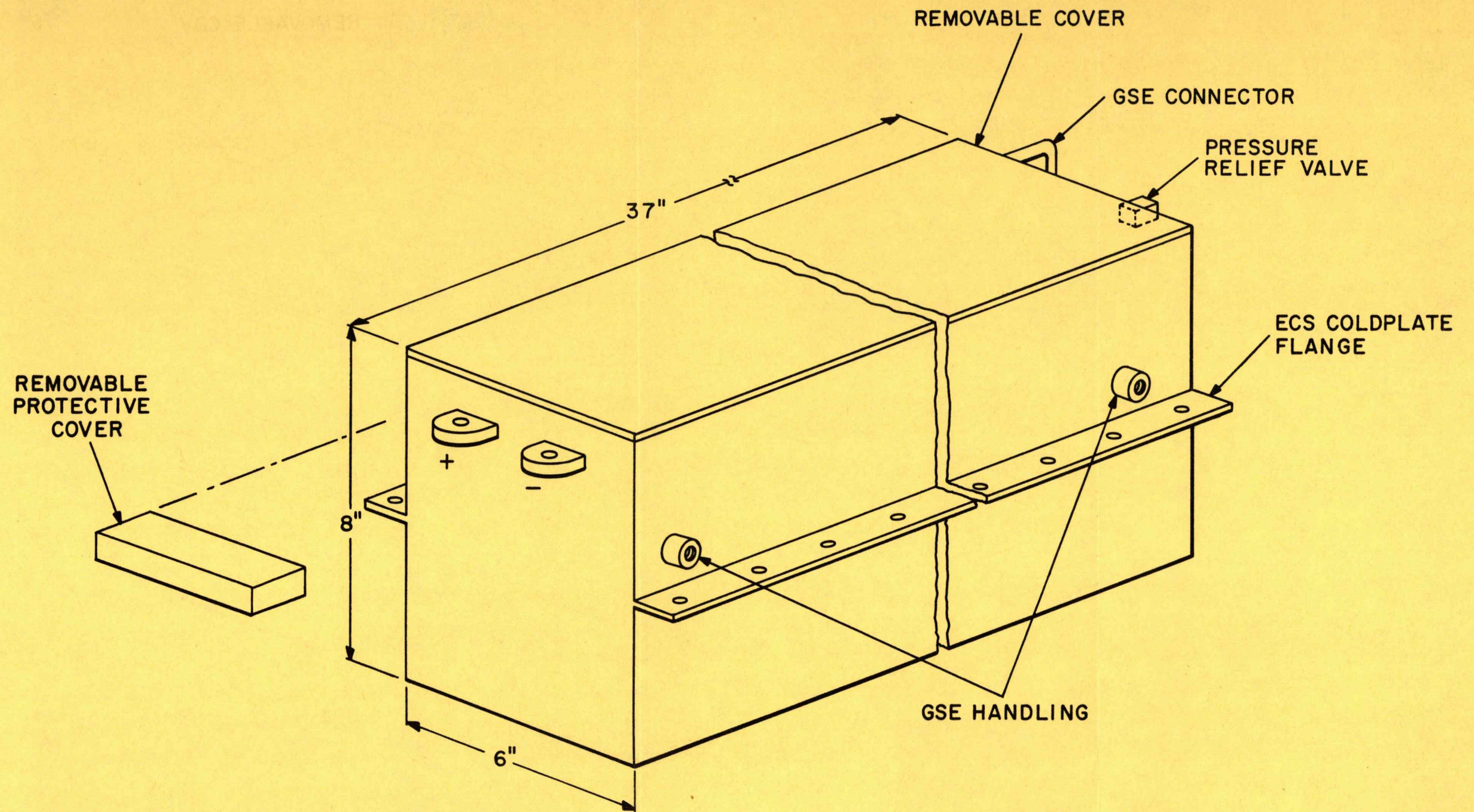
Prerequisites of the EPS system controls are as follows:

1. INV #1 and INV #2 circuit breakers must be "CLOSED".
2. AC BUS FEED TIE circuit breakers (4) must be "CLOSED".
3. AC BUS VOLT circuit breaker must be "CLOSED".

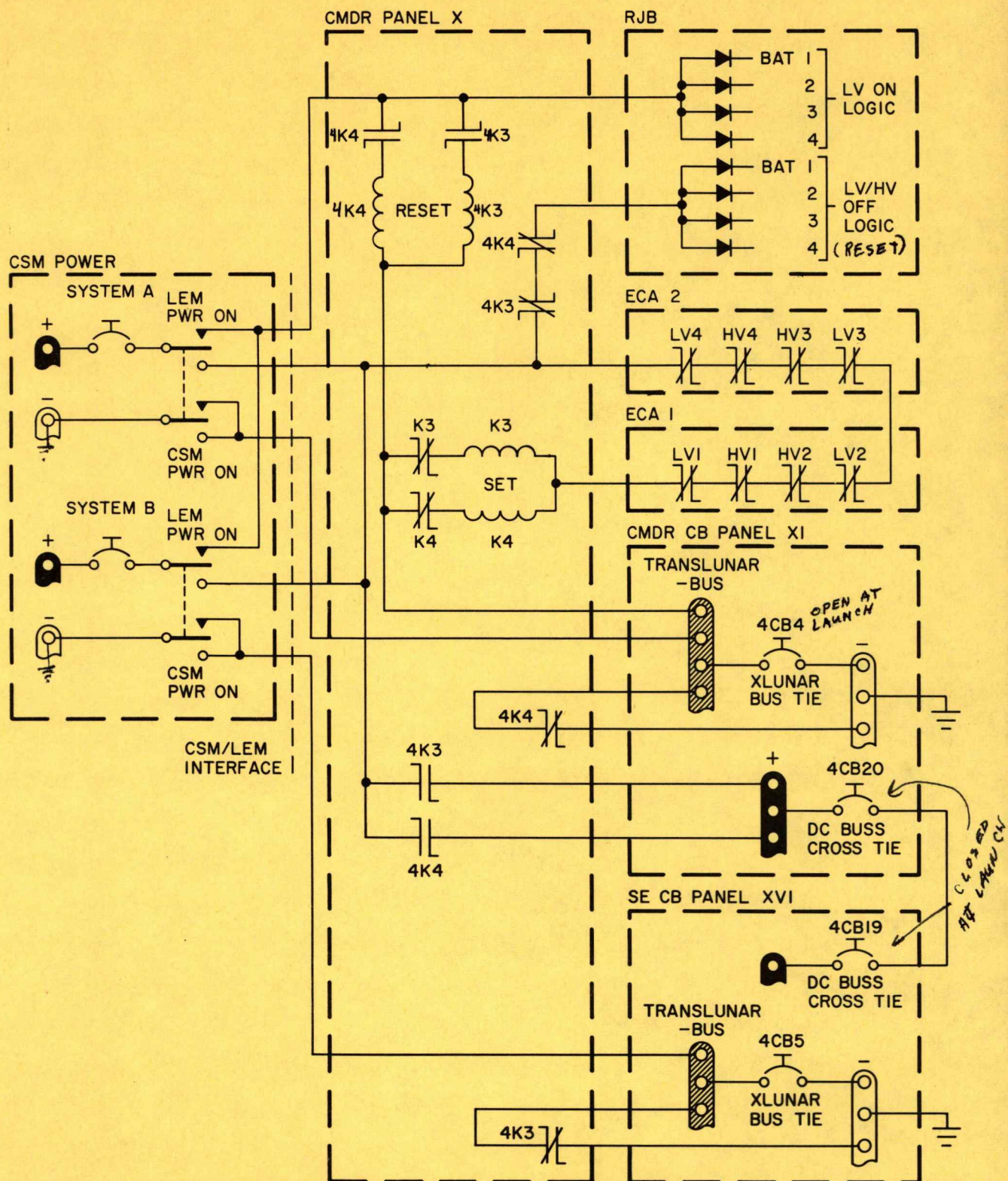




DESCENT BATTERY OUTLINE



ASCENT BATTERY OUTLINE

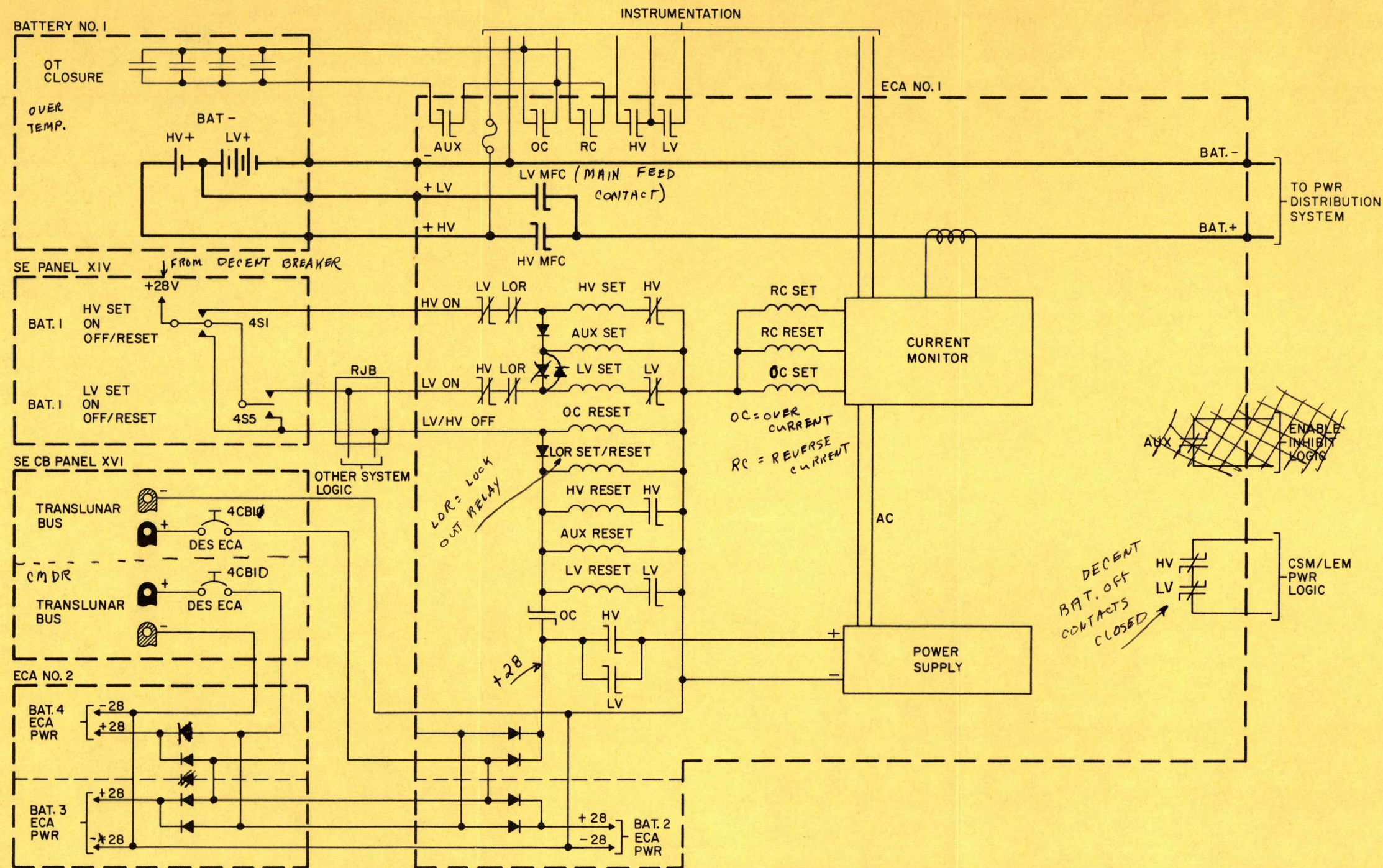


CSM/LEM POWER CONTROL LOGIC

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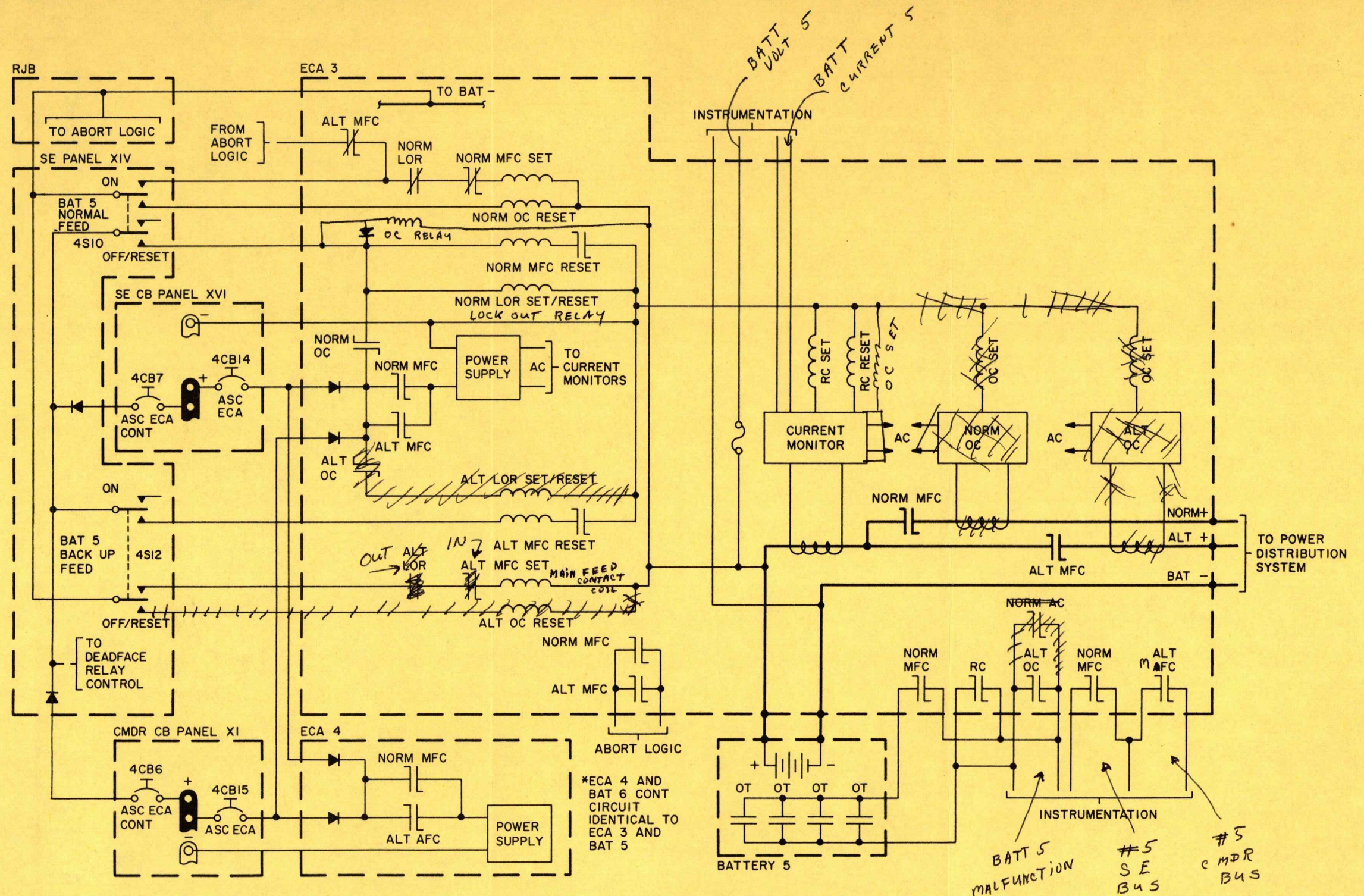
CSM \neq IN PARALLEL WITH LEM POWER

OC = 1000 AMP / 360 MS

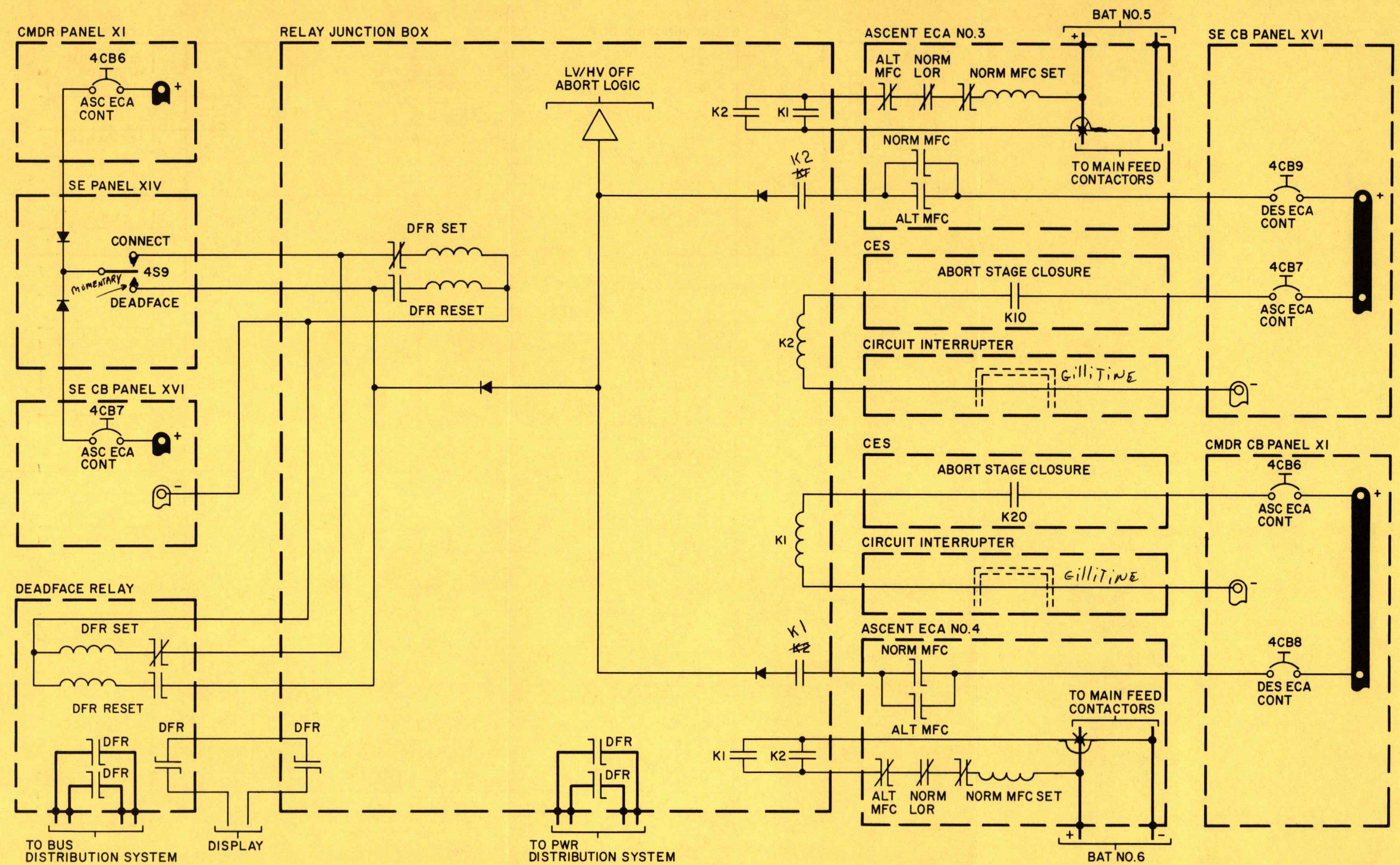


DESCENT ECA LOGIC

ECA = ELECTRICAL
CONTROL
ASSEMBLY



CAN TURN ON ASCENT
BATT. WITH NO POWER



EPS DEADFACE RELAY AND ABORT LOGIC



GRUMMAN AIRCRAFT ENGINEERING CORPORATION
BETHPAGE • LONG ISLAND • NEW YORK