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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

LUNAR MODULE SYSTEMS HANDBOOK VEHICLE LM-1

*AS-206
REV B*

MARCH 16 1967

SPECIAL NOTICE

DO NOT DISCARD REVISION A, DATED OCTOBER
27, 1966. REVISION A REFLECTS THE MANNED
LM CONFIGURATION AND SHOULD BE RETAINED
FOR REFERENCE PURPOSES UNTIL THE LM-2
(AS-258) SYSTEMS HANDBOOK IS PUBLISHED.

PREPARED BY

FLIGHT CONTROL DIVISION



MANNED SPACECRAFT CENTER
HOUSTON, TEXAS

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LUNAR MODULE SYSTEMS HANDBOOK

VEHICLE LM-1
AS-206
REV B

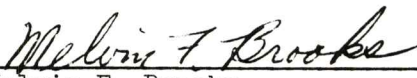
PREFACE

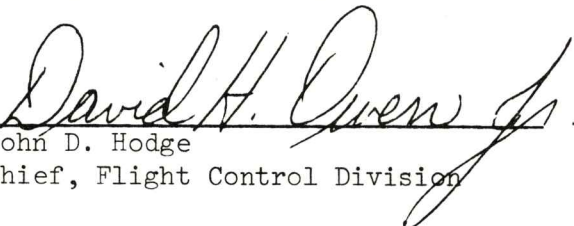
This handbook has been prepared by the Flight Control Division, Manned Spacecraft Center, Houston, Texas, with technical support by Grumman Aircraft Engineering Corporation (GAEC). Information contained within this document represents the LM-1 Systems as of March 16, 1967.

This document is intended for specialized use by Flight Controllers in real-time and near-real-time operations. Comments concerning the contents should be directed to Mr. James E. Hannigan, Lunar Module Systems Branch, Building 45, Room 426, Phone HU3-5526.

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Approved by:


Melvin F. Brooks
Chief, Lunar Module Systems Branch


John D. Hodge
Chief, Flight Control Division

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SECTION 1
INTRODUCTION

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1.1 VEHICLE CONFIGURATION

This handbook has been prepared in accordance with the Apollo Spacecraft Program Office (ASPO) policy issued on October 12, 1966, which specified LM-1 would be flown unmanned and LM-2 would no longer be capable of completely unmanned flight. This policy change also included a change in LM-1 mission requirements resulting in a simplified version of the AS-206 timeline. The mission objectives are confined to full duration burns of each stage, restart of each stage, fire-in-the-hold (FITH) abort mode, and depletion burn of the ascent stage.

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On October 20, 1966, Contract Change Authorization (CCA) No. 398 to GAEC Contract NAS-9-1100 was issued to implement the LM-1 hardware changes based on the above policy change. This CCA deleted the requirement for all equipment not directly associated with the revised mission. In addition, CCA 401 issued on October 20, 1966, specified system changes to LM-1 to eliminate critical single-point failures, primarily within the LM Mission Programmer (LMP). This CCA deleted numerous command functions and added two new command functions. Measurement Change Request (MCR) 654 accounts for the telemetry changes resulting from CCA 398 and 401.

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This updating includes all the system changes and the revised command and measurement lists.

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Table 1-1 Standard Abbreviations and Acronyms for LM Documentation

AC	ALTERNATING CURRENT
ACA	ATTITUDE CONTROLLER ASSEMBLY
ACCUM	ACCUMULATOR
ACT	ACTUAL/ACTUATOR
AEA	ABORT ELECTRONICS ASSEMBLY
AELD	ASCENT ENGINE LATCHING DEVICE
AGC	AUTOMATIC GAIN CONTROL
AGS	ABORT GUIDANCE SECTION
ALIGN	ALIGNMENT
ALM	ALARM
ALT	ALTIMETER/ALTITUDE/ALTERNATE
AM	AMMETER/AMPLITUDE MODULATION
AMP	AMPERE
AMP HR	AMPERE HOUR
ANT	ANTENNA
APS	ASCENT PROPULSION SYSTEM
ARM	ARMED
ASA	ABORT SENSOR ASSEMBLY
ASC	ASCENT
ASSY	ASSEMBLY
ATCA	ATTITUDE & TRANSLATION CONTROL ASSEMBLY
ATT	ATTITUDE
AUTO	AUTOMATIC
AUX	AUXILIARY
AVAIL	AVAILABLE
AZ	AZIMUTH
BAT	BATTERY
BIP	BIPROPELLANT
BCN	BEACON
BPS	BITS PER SECOND
BTS	BITS PER SAMPLE

Table 1-1 Standard Abbreviations and Acronyms for LM Documentation (Cont'd)

CAB	CABIN
CAL	CALIBRATE/CALIBRATION
CALC	CALCULATE/CALCULATED
CB	CIRCUIT BREAKER
C-BND	C-BAND
CBL	CABLE
CC	CONTACT CLOSURE
CDR	COMMANDER
CDU	COUPLING DATA UNIT
CES	CONTROL ELECTRONICS SECTION
CHAR	CHARACTER
CL	CLOSE
CLSD	CLOSED
CMD	COMMAND
CMDED	COMMANDED
CNTL	CONTROL
CO ₂	CARBON DIOXIDE
COMM	COMMUNICATIONS
COMP	COMPARE
COND	CONDITION/CONDITIONING/CONDITIONER
CONT	CONTINUE
COOL	COOLANT
CP	COMMAND PILOT
CPS	CYCLES PER SECOND
CRT	CATHODE-RAY-TUBE
CTG	CARTRIDGE
CUR	CURRENT
D	DOWNWARD THRUSTING RCS ENGINE
DAC	DIGITAL ANALOG CONVERTER
DB	DECIBEL
DC	DIRECT CURRENT
DCA	DIGITAL COMMAND ASSEMBLY

Table 1-1 Standard Abbreviations and Acronyms for LM Documentation (Cont'd)

DECA	DESCENT ENGINE CONTROL ASSEMBLY
DECR	DECREASE
DEDA	DATA ENTRY AND DISPLAY ASSEMBLY
DEG	DEGREE
DESC	DESCENT
DET	DETENT/DETECTOR
DFI	DEVELOPMENTAL FLIGHT INSTRUMENTATION
DIFF	DIFFERENCE/DIFFERENTIAL
DIG	DIGITAL
DIR	DIRECT
DISCH	DISCHARGE
DISP	DISPLAY
DIV	DIVERTER
DLAY	DELAY
DPLY	DEPLOY/DEPLOYED
DPS	DESCENT PROPULSION SYSTEM
DSKY	DISPLAY AND KEYBOARD
ECA	ELECTRONICS CONTROL ASSEMBLY
ECS	ENVIRONMENTAL CONTROL SYSTEM
EKG	ELECTROCARDIOGRAM
ELEC	ELECTRICAL/ELECTRICALLY
EMER	EMERGENCY
ENBL	ENABLE
ENG	ENGINE
ENGR	ENGINEER
EPS	ELECTRICAL POWER SYSTEM
EQUIP	EQUIPMENT
ERR	ERROR
EXT	EXTEND
F	FAHRENHEIT/FORWARD THRUSTING RCS ENGINE
FAIL	FAILURE
FDAI	FLIGHT DIRECTOR ATTITUDE INDICATOR
FITH	FIRE IN THE HOLD

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Table 1-1 Standard Abbreviations and Acronyms for LM Documentation (Cont'd)

FL	FLAG
FM	FREQUENCY MODULATION
FP	FLIGHT PROGRESS
FREQ	FREQUENCY
FWD	FORWARD
GASTA	GIMBAL ANGLE SEQUENCING TRANSFORMATION ASSEMBLY
GDA	GIMBAL DRIVE ACTUATOR
GLY	GLYCOL
GMBL	GIMBAL
GND	GROUND
GUID	GUIDANCE
HBR	HIGH BIT RATE
HE	HELIUM
H/H	ALTITUDE/ALTITUDE RATE
HI	HIGH
HL	HIGH LEVEL
HLD	HOLD
H ₂ O	WATER
HSD	HIGH SPEED DATA
HV	HIGH VOLTAGE
HVR	HOVER
H/X	HEAT EXCHANGER
ID	IDENTIFICATION
IG	INNER GIMBAL
IGA	INNER GIMBAL ANGLE
IGN	IGNITION
IMU	INERTIAL MEASUREMENT UNIT
IN	INLET
INJ	INJECTOR
INCR	INCREASE
INST	INSTRUMENTATION
INVTR	INVERTER

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Table 1-1 Standard Abbreviations and Acronyms for LM Documentation (Cont'd)

IRIG	INERTIAL RATE INTEGRATING GYRO
ISO	ISOLATION
ISS	INERTIAL SENSOR SYSTEM
JETT	JETTISON
JD	JET DRIVER
LAT	LATITUDE/LATERAL
LBR	LOW BIT RATE
LDG	LANDING
LGC	LM GUIDANCE COMPUTER
LIM	LIMIT/LIMITS
LMP	LM MISSION PROGRAMER
LO	LOW
LONG	LONGITUDE
LR	LANDING RADAR
LSB	LEAST SIGNIFICANT BIT
LV	LOW VOLTAGE
LVL	LEVEL
MAN	MANUAL/MANIFOLD
MAP	MESSAGE ACCEPTANCE PULSE
MAX	MAXIMUM
MET	MISSION ELAPSED TIME
MFC	MAIN FEEDER CONTACTOR
MG	MIDDLE GIMBAL
MGA	MIDDLE GIMBAL ANGLE
MIN	MINIMUM
MOCR	MISSION OPERATIONS CONTROL ROOM
MPX	MULTIPLEX
MSFN	MANNED SPACEFLIGHT NETWORK
MSB	MOST SIGNIFICANT BIT
MTR	METER
(-)	NEGATIVE
NORM	NORMAL

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Table 1-1 Standard Abbreviations and Acronyms for LM Documentation (Cont'd)

O ₂	OXYGEN
OB	ONBOARD
OG	OUTER GIMBAL
OGA	OUTER GIMBAL ANGLE
OPN	OPEN
OPR	OPERATE
OUT	OUTLET/OUTPUT
OVR	OVER
OVRD	OVERRIDE
OX	OXIDIZER
PA	POWER AMPLIFIER
PART	PARTIAL
PCA	PROGRAM COUPLER ASSEMBLY
PCM	PULSE CODE MODULATION
PCT	PER CENT
PGNS	PRIMARY GUIDANCE AND NAVIGATION SYSTEM
PFS	PER CENT FULL SCALE
PIPA	PULSED INTEGRATING PENDULOUS ACCELEROMETER
ΔP	DIFFERENTIAL PRESSURE
PLSD	PULSED
PLSS	PORTABLE LIFE SUPPORT SYSTEM
PM	PHASE MODULATION
PNLS	PANELS
PO	POWER OUTPUT
POS	POSITION
PRA	PROGRAM READER ASSEMBLY
PRESS	PRESSURE
PRIM	PRIMARY
PROG	PROGRAM
PROP	PROPELLANT/PROPULSION
PSIA	POUNDS PER SQUARE INCH ABSOLUTE
PSID	POUNDS PER SQUARE INCH DIFFERENTIAL

Table 1-1 Standard Abbreviations and Acronyms for LM Documentation (Cont'd)

PTA	PULSE TORQUE ASSEMBLY
PVR	PRECISION VOLTAGE REFERENCE
PWR	POWER
PYRO	PYROTECHNIC
QD	QUICK DISCONNECT
QTY	QUANTITY
QUAD	QUADRANT
RC/OC	REVERSE CURRENT/OVERCURRENT
RCS	REACTION CONTROL SYSTEM
RCVR	RECEIVER
REC	RECORDER
RECD	RECEIVED
REF	REFERENCE
REG	REGULATOR
REL	RELEASE
RET	RETRACT/RETURN
REV	REVERSE
RF	RADIO FREQUENCY
RFLT	REFLECT/REFLECTED
RGA	RATE GYRO ASSEMBLY
RLY	RELAY
RNG	RANGE/RANGING
RR	RENDEZVOUS RADAR
RS	REMOTE SITE
RSVR	RESOLVER
RUPT	RUPTURE
S	SIDEWARD THRUSTING RCS ENGINE
S-BND	S-BAND
S/C	SPACECRAFT
SCS	STABILIZATION AND CONTROL SYSTEM
SE	SYSTEMS ENGINEER

Table 1-1 Standard Abbreviations and Acronyms for LM Documentation (Cont'd)

SEC	SECONDARY/SECOND
SEL	SELECT
SEP	SEPARATION/SEPARATOR
SEQ	SEQUENCE
SET	SET/SETTING
SIG	SIGNAL
SLA	SPACECRAFT LAUNCH ADAPTER
S/O	SHUT OFF
SOL	SOLENOID
SOV	SHUT OFF VALVE
SP	SPARE
S/S	SAMPLES PER SECOND
SSR	STAFF SUPPORT ROOM
ST	STATIC
STGE	STAGE
STBY	STANDBY
STR	STRENGTH
STRB	STROBE
SUP	SUPPLY
SUSP	SUSPENSION
SVO	SERVO
SW	SWITCH
SYNCH	SYNCHRONIZATION
SYS	SYSTEM
TCA	THRUST CHAMBER ASSEMBLY
TCP	THRUST CHAMBER PRESSURE
TEMP	TEMPERATURE
THROT	THROTTLE
TJM	TOWER JETTISON MOTOR
TK	TANK
TLM	TELEMETRY
TOL	TOLERANCE

Table 1-1 Standard Abbreviations and Acronyms for LM Documentation (Concluded)

TRANS	TRANSLATION
TRUN	TRUNNION
T/TCA	THRUST/TRANSLATION CONTROLLER ASSEMBLY
TTY	TELETYPE/TELETYPEWRITER
U	UPWARD THRUSTING RCS ENGINE
UHF	ULTRA-HIGH FREQUENCY
V	VOLT
ΔV	CHANGE IN VELOCITY
VAC	ALTERNATING CURRENT VOLTS
VAR	VARIABLE
VDC	DIRECT CURRENT VOLTS
VEL	VELOCITY
VHF	VERY HIGH FREQUENCY
VLV(S)	VALVE/VALVES
VPI	VALVE POSITION INDICATOR
VRMS	VOLT ROOT MEAN SQUARE
W	WATT
WB	WIDEBAND
W/B	WATER BOILER
X	CROSS
XMTR	TRANSMITTER
XPNDR	TRANSPONDER
(ϕ)	PHASE

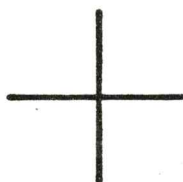
TABLE 1-2 DRAWING SYMBOLS STANDARDS

1. ZONE

BZ₆
1.2.1

2. LEADS

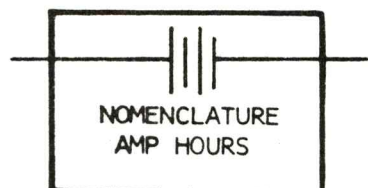
A. CROSSOVER



B. CONNECTED



3. BATTERY



4. BUS

DESIGNATION



V



LUNAR
BUS

5. GROUNDS

A. SYSTEM

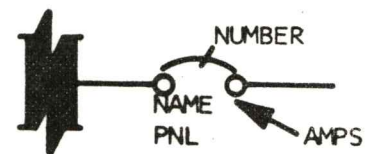


B. FRAME

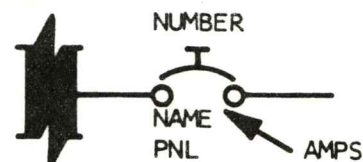


6. CIRCUIT BREAKERS

A. TOGGLE



B. PUSHBUTTON



7. FUSES

A. GENERAL



B. FUSISTOR



TABLE 1-2 DRAWING SYMBOLS STANDARDS (CONT'D)

8. DIODES

A. GENERAL



B. ZENER



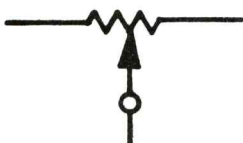
C. TUNNEL



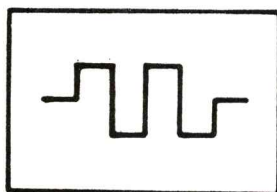
D. CONTROL RECTIFIER



9. POTENTIOMETER



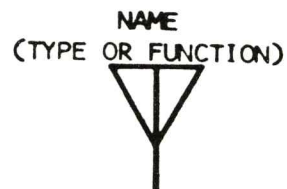
10. HEATER



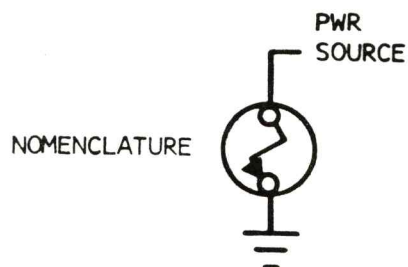
11. THERMOSTAT



12. ANTENNA



13. EXPLOSIVE



14. AMPLIFIER

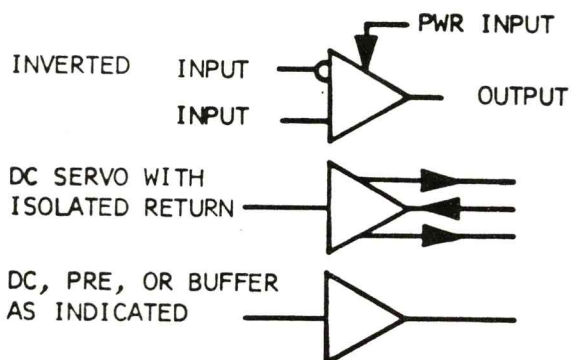


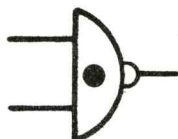
TABLE 1-2 DRAWING SYMBOLS STANDARDS (CONT'D)

15. GATES

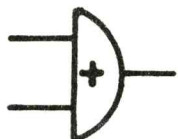
A. AND



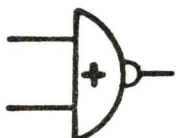
B. NAND



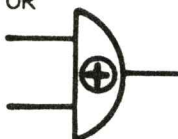
C. OR



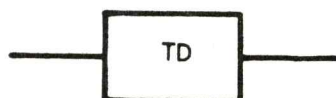
D. NOR



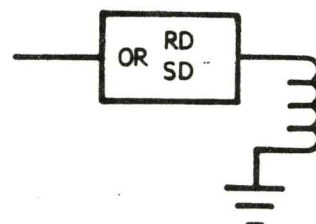
E. EXCLUSIVE OR



16. TIME DELAY



17. RELAY DRIVER OR SOLENOID DRIVER



18. COMMAND



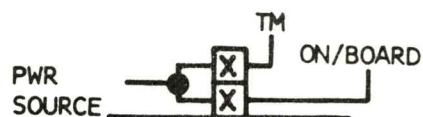
19. SENSOR

A. SINGLE SOURCE



LETTER INDICATES TYPE
PA = PRESS, PSIA W = WETNESS
PD = PRESS, PSID POS = POSITION
T = TEMP
1 = QUANTITY, ETC.
Δ = DELTA

B. DOUBLE SOURCE



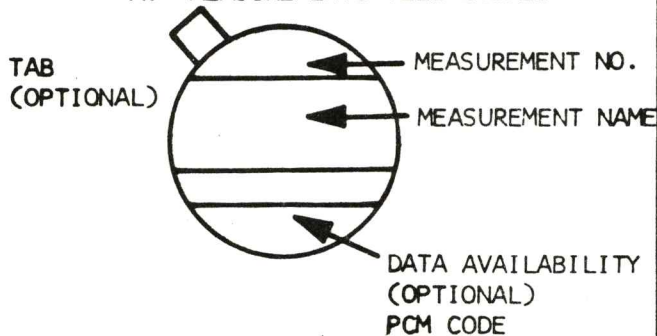
VG VELOCITY GENERATOR
FEEDBACK TRANSDUCER

POS POSITION FEEDBACK TRANSDUCER

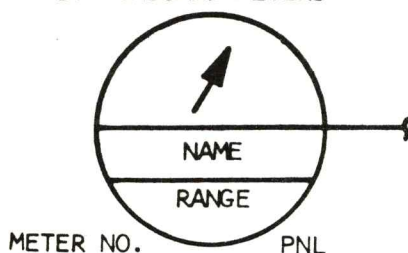
TABLE 1-2 DRAWING SYMBOLS STANDARDS (CONT'D)

20. TELEMETRY

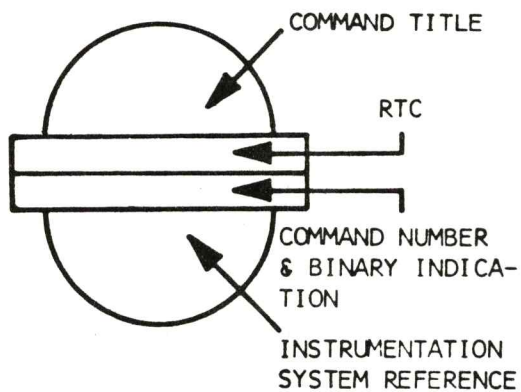
A. MEASUREMENTS TELEMETERED



B. ONBOARD METERS

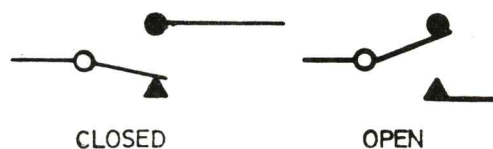


C. BI-LEVEL CMD



21. RELAYS

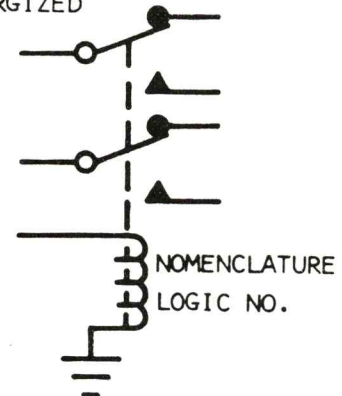
A. MOMENTARY CONTACTS



B. SOLID CONTACTS



C. NON-LATCHING RELAYS SHOWN IN DE-ENERGIZED POSITION



D. LATCHING

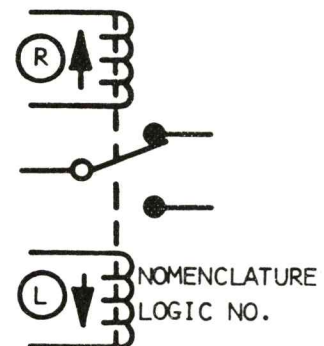
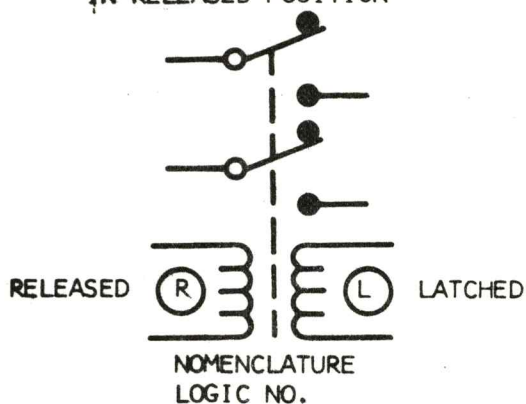


TABLE 1-2 DRAWING SYMBOLS STANDARDS (CONT'D)

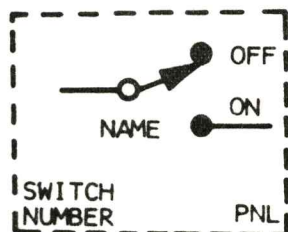
21. RELAYS (CONT'D)

E. LATCHING RELAYS SHOWN
IN RELEASED POSITION

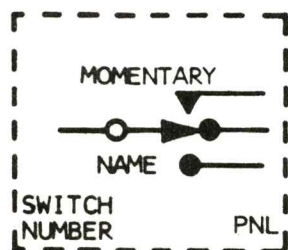


22. SWITCHES

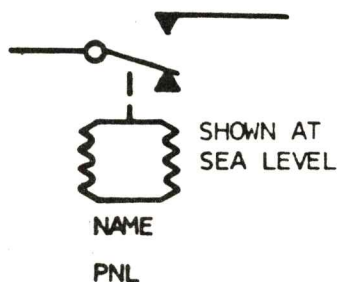
A. TWO POSITION



B. THREE POSITION



C. BARO



22. SWITCHES (CONT'D)

C. PUSH BUTTON

1. SOLID

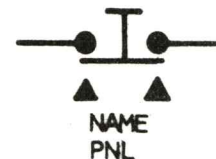


2. MOMENTARY

(A)



(B)



D. COAX

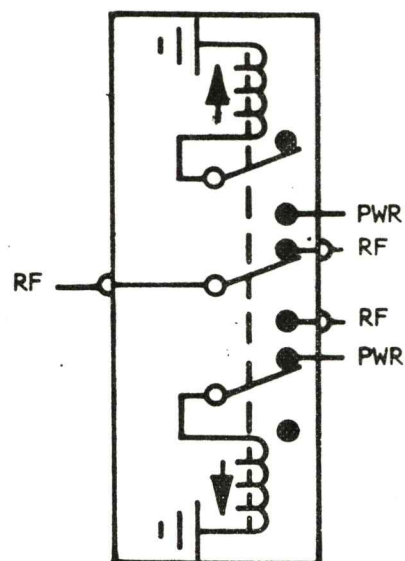
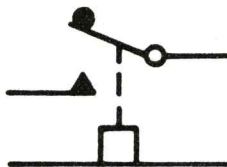


TABLE 1-2 DRAWING SYMBOLS STANDARDS (CONT'D)

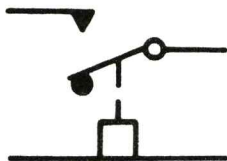
22. SWITCHES

E. PRESSURE

1. CLOSED DECREASE PRESSURE

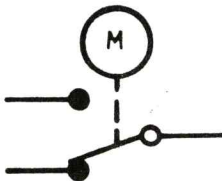


2. CLOSED INCREASED PRESSURE

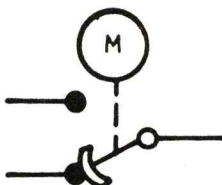


F. MOTOR

1. BREAK BEFORE MAKE

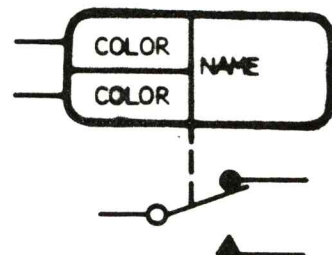
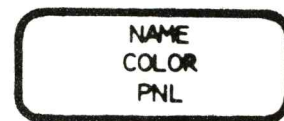
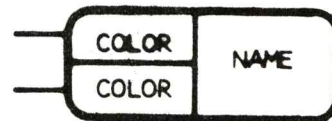


2. MAKE BEFORE BREAK



23. LIGHTS

A. TEDELIGHTS



24. ANNUNCIATOR FLAG

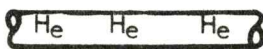
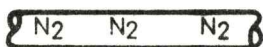
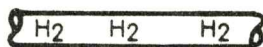
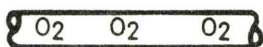
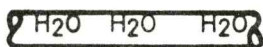
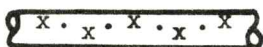


(GENERALLY, THIS IS ASSOCIATED WITH A SWITCH POSITION AND SHOULD BE LOCATED IN THE SAME BLOCK AS THE SWITCH.)

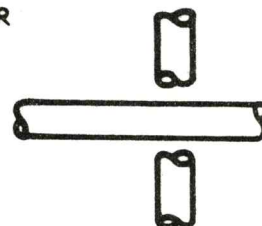
TABLE 1-2 DRAWING SYMBOLS STANDARDS (CONT'D)

LM
AS-206
REV B

25. LINES

A. GLYCOL	
B. HELIUM	
C. NITROGEN	
D. HYDROGEN	
E. OXYGEN	
F. WATER	
G. STEAM	
H. FUEL	
I. FUEL RETURN	
J. OXIDIZER	
K. OXIDIZER RETURN	
L. HYD HIP	
M. HYD LOP	

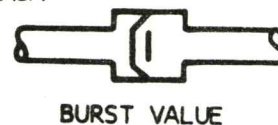
26. PIPE CROSSOVER



27. FILTER



28. BURST DIAPHRAGM



29. VENTURI



30. VENT



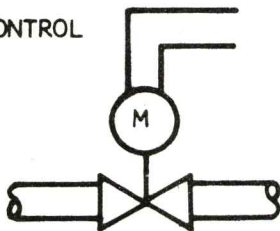
31. FILL AND DRAIN



TABLE 1-2 DRAWING SYMBOLS STANDARDS (CONT'D)

32.

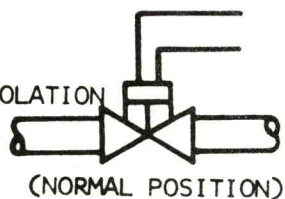
A. MOTOR CONTROL



B. MANUAL CONTROL



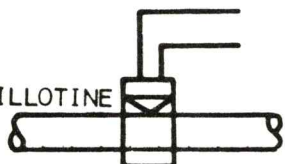
C. PYRO ISOLATION



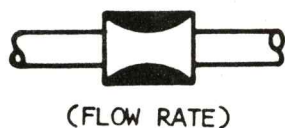
D. CHECK



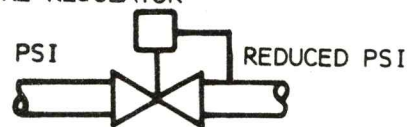
E. PYRO GUILLLOTINE



F. ORIFICE



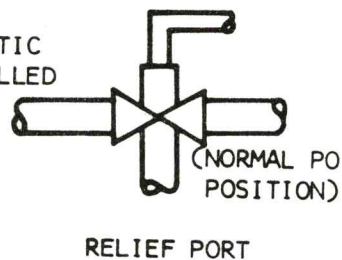
G. PRESSURE REGULATOR



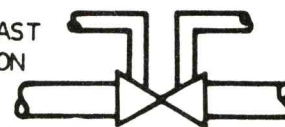
H. RELIEF VALVE



I. PNEUMATIC CONTROLLED VALVE WITH LINE BLEED



J. FAIL LAST POSITION PNEUMATIC VALVE



K. SOLENOID VALVE

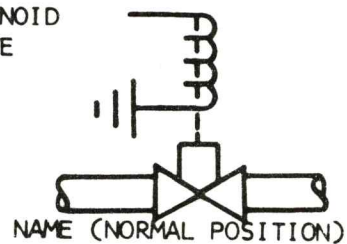


TABLE 1-2 DRAWING SYMBOLS STANDARDS (CONT'D)

32.

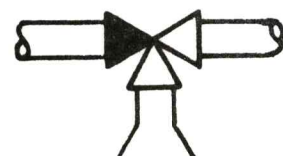
L.



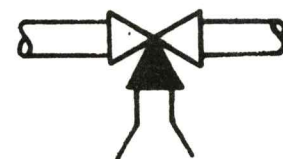
M.



N.



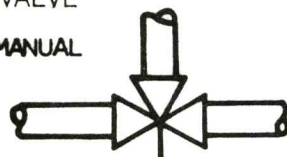
O.



P. THREE WAY VALVE

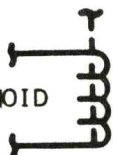
MANUAL

1.



2.

SOLENOID



3.

MOTOR
CONTROLLED



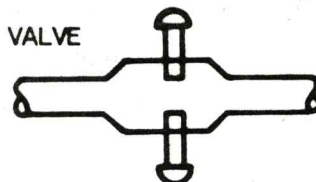
4.

BALL VALVE

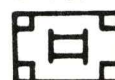


R.

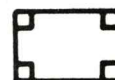
PU VALVE



33. DISCONNECTS

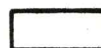


SELF-SEALING



QUICK

34. DEADFACE CHARGE



35. 4 WIRE RESOLVER

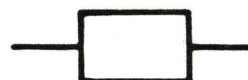


X = SINE WINDING

● = MINUS SINE

— = COSINE WINDING

36. NON-AMPLIFYING DEVICE,
IDENTIFIED



37. SYSTEM INTERCONNECT

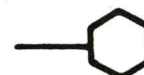
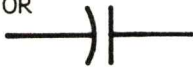


TABLE 1-2 DRAWING SYMBOLS STANDARDS (CONCLUDED)

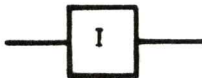
38. DRAWING NOTE REFERENCE



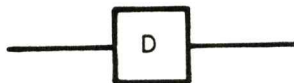
39. CAPACITOR



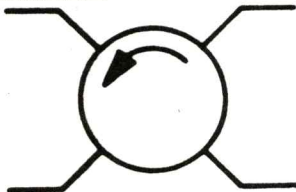
40. DIGITAL INVERTER



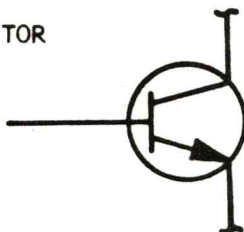
41. DEMODULATOR



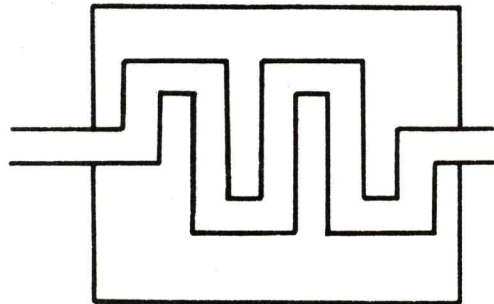
42. R.F. CIRCULATOR

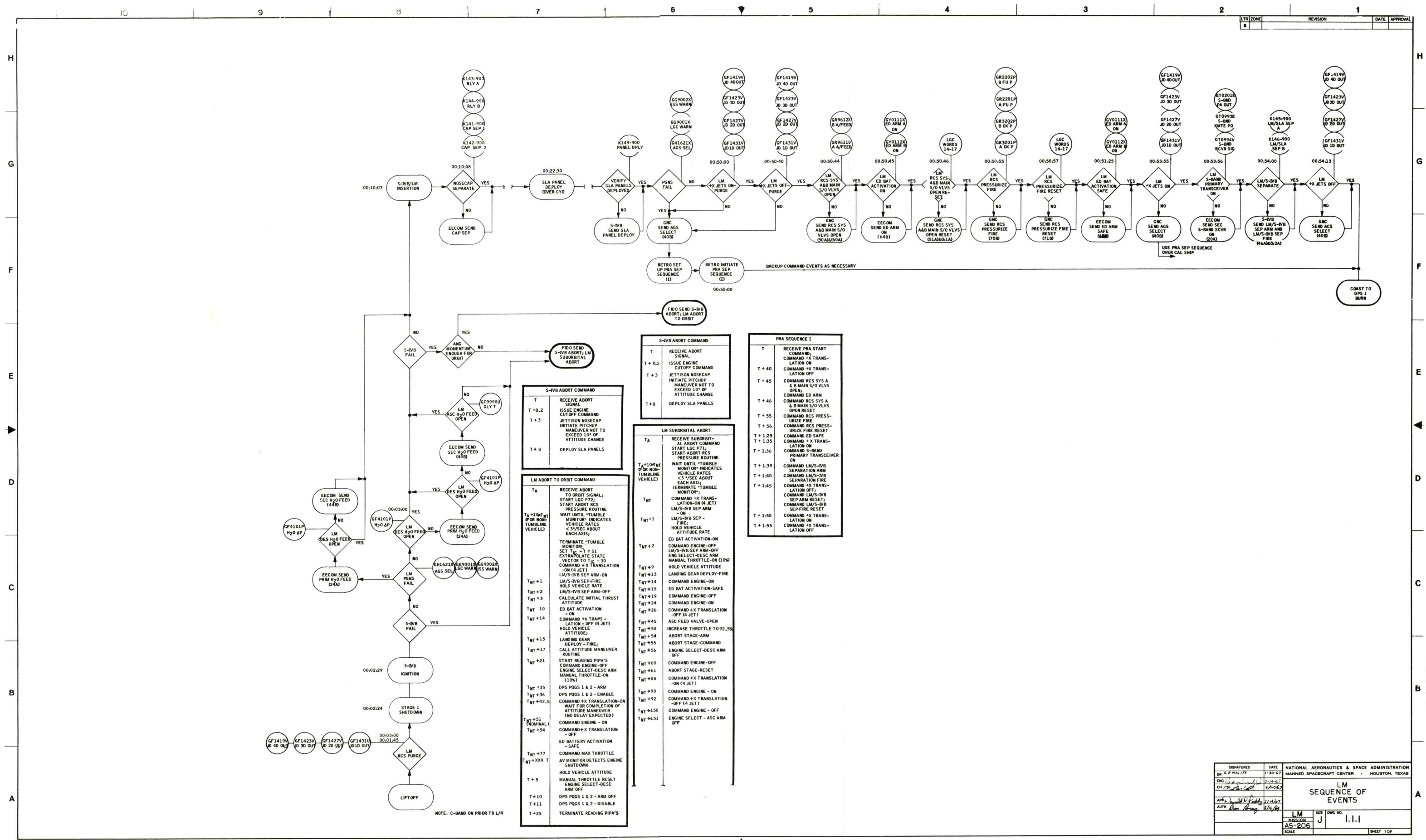


43. TRANSISTOR



44. HEAT EXCHANGER





LM
AS-206

2. PYROTECHNIC

...e foot
...force to
...k disconnect"

R-B

...stem B. System A
...ignites the explosive

R-B

...sed with the Spacecraft
...rms separate functions.

R-B

*

SECTION 2
PYROTECHNIC

LM
AS-206
REV B

2.1 SYSTEM DESCRIPTION

The LM Pyro system is composed of two fully redundant systems, "A" and "B". All switches, prime relays, and RTC relays in System A have counterparts in System B which are actuated simultaneously.

All pyrotechnic initiators used on the LM are the Single Bridge Apollo Standard Initiator (SBASI) type. These initiators have only two pins and due to several design changes are more reliable than the four pin or dual bridge type. The LM pyro electrical system is a shielded floating ground system whereas the Command Service Module (CSM) uses a grounded pyro system. The difference between the two systems is due to a compromise between EMI and static electricity effects on the pyro systems. The LM floating ground system decreases the possibility of EMI effects detonating the pyrotechnics. Any static buildup on this system is handled by bleed resistors.

R-B

All interstage current carrying cables and all interstage cables which would affect the ascent stage by being grounded are routed through the interstage electrical circuit interrupters. (See Table 2-3) The descent water line and all interstage cables, except one, are routed through the interstage cable cutter. This one exception is a five foot DFI TM cable with a pull-away plug requiring 50 to 200 pounds force to release. All interstage oxygen and glycol lines have "quick disconnect" type connectors and are not pyrotechnic in nature.

R-B

There is one difference between System A and System B. System A ignites the explosive staging bolts while System B ignites the explosive staging nuts.

R-B

The LM pyro system should not be confused with the Spacecraft LM Adapter (SLA) pyro system which performs separate functions.

R-B

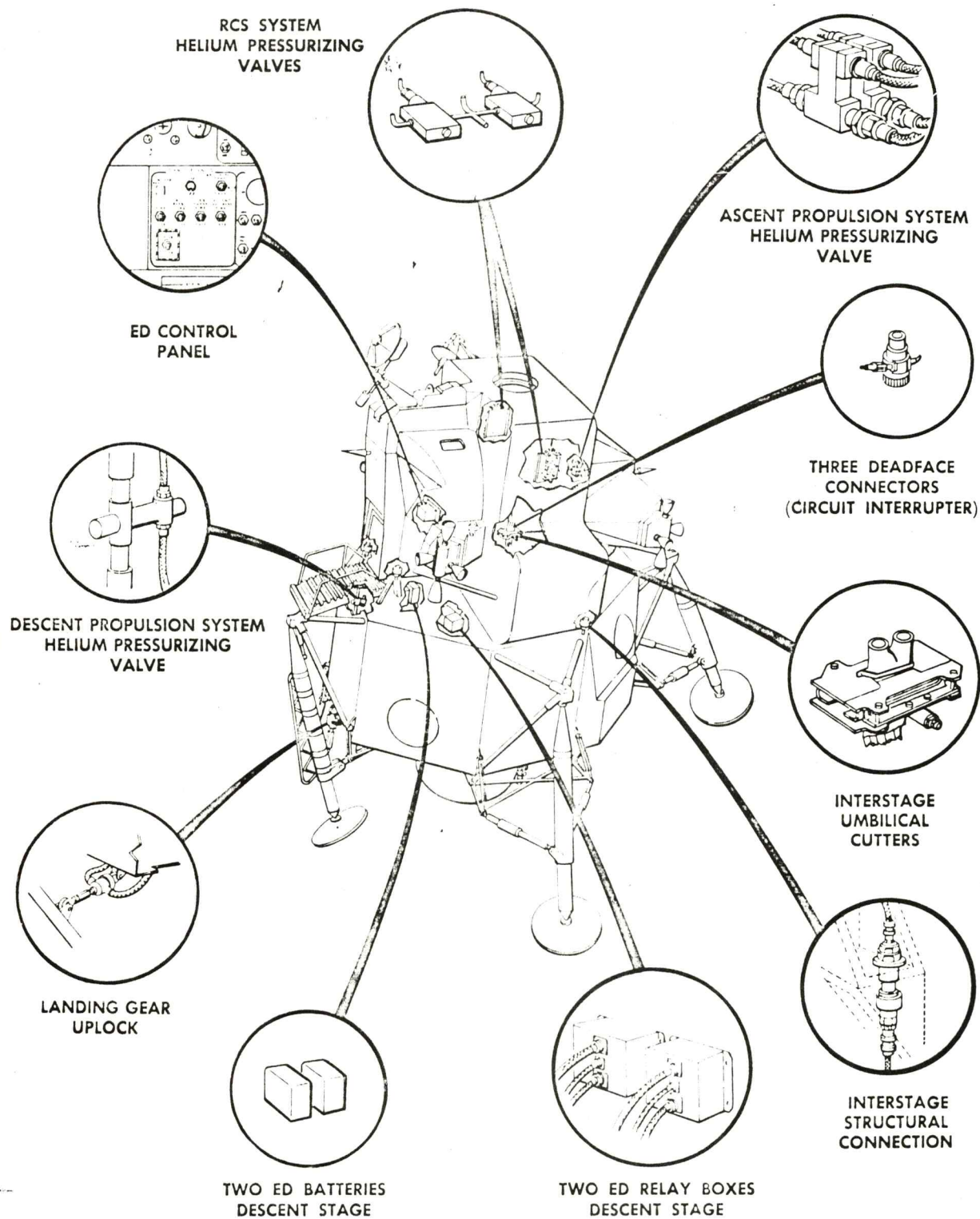


FIGURE 2-1 EXPLOSIVE DEVICES COMPONENT LOCATIONS

LM
AS-206
REV B

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(See Back)

TABLE 2-1 CAPABILITIES AND LIMITATIONS

NO.	FUNCTION	COMPONENTS	SYSTEM A INITIATORS	SYSTEM B INITIATORS	
1	STAGING EXPLOSIVE NUTS EXPLOSIVE BOLTS ELECTRICAL CIRCUIT INTERRUPTERS CABLE CUTTER	FOUR NUTS FOUR BOLTS THREE INTERRUPTERS ONE CUTTER	0 4 3 1	4 0 3 1	ONE INITIATOR PER NUT OR BOLT TWO INITIATORS PER INTERRUPTER, ONE FROM SYSTEM A AND ONE FROM SYSTEM B. ONE INITIATOR CAN OPERATE THE INTERRUPTER TWO OPPOSING BLADES, ONE POWERED BY SYSTEM A AND ONE POWERED BY SYSTEM B. TWO TUBES INTERCONNECT THE CHARGES BEHIND EACH BLADE SUCH THAT ONE INITIATOR CAN FIRE THE CHARGE BEHIND BOTH BLADES. ONE BLADE CAN SEVER THE INTERSTAGE UMBILICAL THE SYSTEM
2	RCS SYSTEM A RCS SYSTEM B	TWO VALVES IN PARALLEL TWO VALVES IN PARALLEL	1 1	1 1	VALVES ARE THE SINGLE INITIATOR TYPE PLACED IN PARALLEL. ONE VALVE WILL PRESSURIZE THE SYSTEM
3	DESCENT ENGINE PRESSURIZE HE, PRESS. OX ISOLATION VALVE FUEL ISOLATION VALVE	ONE VALVE ONE VALVE ONE VALVE	1 1 1	1 1 1	VALVE IS DUAL INITIATOR TYPE, ONE POWERED FROM SYSTEM A AND ONE FROM SYSTEM B. ONE INITIATOR WILL OPERATE THE VALVE
4	ASCENT ENGINE PRESSURIZE HE, PRESS. TANK 1 HE, PRESS. TANK 2 OX ISOLATION VALVES FUEL ISOLATION VALVES	ONE VALVE ONE VALVE TWO VALVES IN PARALLEL TWO VALVES IN PARALLEL	1 1 1 1	1 1 1 1	VALVES ARE DUAL INITIATOR TYPE WITH ONE PORT PLUGGED. WITH THE VALVES IN PARALLEL ONE IS POWERED FROM SYSTEM A AND THE OTHER IS POWERED FROM SYSTEM B. ONE VALVE WILL PRESSURIZE THE SYSTEM

2.2 CAPABILITIES AND LIMITATIONS

- A. THE PYRO SYSTEM HAS TWO
30 VOLT BATTERIES RATED
AT 0.75 AMP HOURS, ONE
FOR SYSTEM A AND ONE FOR
SYSTEM B. BOTH PYRO
BATTERIES ARE LOCATED
IN THE DESCENT STAGE

TABLE 2-2 PRELAUNCH STATUS OF SWITCH/CIRCUIT BREAKER POSITION

NAME	NUMBER	POSITION
LANDING GEAR DEPLOY	2510 PNL VIII	SAFE
STAGE	255 PNL VIII	SAFE
RCS PRESSURIZE	252 PNL VIII	SAFE
ASCENT HE PRESSURIZE	254 PNL VII	SAFE
ASCENT HE SELECT	253 PNL VIII	BOTH
ABORT STAGE	1514 PNL I	SAFE
MASTER ARM	257 PNL VII	OFF
ABORT STAGE	4CB 2	CLOSED
ABORT STAGE	4CB 3	CLOSED
LOGIC POWER B	4CB 5	CLOSED
LOGIC POWER A	4CB 6	CLOSED

2.3 SYSTEM OPERATION

1. AT LEAST ONE PYRO BUS MUST
BE ARMED FOR ANY PYRO FUNCTION
TO OCCUR
2. THE PROPUSSION SYSTEMS
(DPS,APS,) WILL OPERATE
PROPERLY FOR A SHORT
TIME IN A PREPRESSURIZED
BLowDOWN MODE IF BOTH
PYRO BUSES FAIL TO ARM.
THE APPROXIMATE TIMES ARE:
DPS - 17 SEC
APS - 6 SEC
THE RCS SYSTEM WILL NOT
OPERATE IN A PREPRESSURIZED
BLowDOWN MODE

TABLE 2-3 DESCENT STAGE FUNCTIONS LOST AT STAGING

ELECTRICAL CIRCUIT INTERRUPTER #1 (P174)

1. BAT 3 & 4 POWER			
2. ECA 1 & 2 POWER			
3. DESCENT ENGINE CONTROL ASSY (DECA)			
4. GIMBAL DRIVE ACTUATORS (PITCH & ROLL)			
5. DESCENT ENGINE FUNCTIONS			
6. OPERATIONAL TELEMETRY			
GC0201V	BAT 1 VOLT	GH1301X	DPS ON
GC0202V	BAT 2 VOLT	GH1311V	MAN THRUST CMD
GC0203V	BAT 3 VOLT	GH1313V	PITCH GDA POS
GC0204V	BAT 4 VOLT	GH1314V	ROLL GDA POS
GC1201C	BAT 1 CUR	GH1323V	P TRM FAIL
GC1202C	BAT 2 CUR	GH1330X	R TRM FAIL
GC1203C	BAT 3 CUR	GH1331V	AUTO THRUST CMD
GC1204C	BAT 4 CUR	GH1348X	DPS ARM
GC4361X	BAT 1 HI TAP	GL4026X	CES AC PWR FAIL
GC4362X	BAT 1 LO TAP	GL4027X	CES DC PWR FAIL
GC4363X	BAT 2 HI TAP	GQ3018P	DPS H REG PRESS
GC4364X	BAT 2 LO TAP	GQ3435P	DPS H PRESS
GC4365X	BAT 3 HI TAP	GQ3603Q	DPS FUEL 1 QTY
GC4366X	BAT 3 LO TAP	GQ3604Q	DPS FUEL 2 QTY
GC4367X	BAT 4 HI TAP	GQ3611P	DPS FUEL PRESS
GC4368X	BAT 4 LO TAP	GQ4103Q	DPS OX 1 QTY
GC9961U	BAT 1 MAL	GQ4104Q	DPS OX 2 QTY
GC9962U	BAT 2 MAL	GQ4111P	DPS OX PRESS
GC9963U	BAT 3 MAL	GQ4455Q	DPS PROP LO
GC9964U	BAT 4 MAL	GQ4111X	ED ARM A ON
		GQ4112X	ED ARM B ON
		GQ4121X	STG RLY A FIRE
		GQ4122X	STG RLY B FIRE

ELECTRICAL CIRCUIT INTERRUPTER #2 (P173)

1. BAT 1 & 2 POWER			
2. ECA 1 & 2 POWER			
3. LUNAR DRILL POWER			
4. DESCENT ENGINE FUNCTIONS			
5. DFI TELEMETRY			
6. OPERATIONAL TELEMETRY			
GQ3309X	DPS HE, 1 CLSD		
GQ3310X	DPS HE, 2 OPN		
GQ3718T	DPS FUEL 1 TEMP		
GQ3719T	DPS FUEL 2 TEMP		
GQ4218T	DPS OX 1 TEMP		
GQ4219T	DPS OX 2 TEMP		
GQ6510P	DPS TCP		
GQ6506H	VAR INJ ACT POS		
GQ7498U	DPS PROP VLVS Δ POS		
GQ7499U	DPS PROP VLVS Δ POS		
GQ7511T	DPS THROAT T 1		
GQ7512T	DPS THROAT T 2		

ELECTRICAL CIRCUIT INTERRUPTER #3 (I72)

1. DFI TELEMETRY			
2. OPERATIONAL TELEMETRY			
GL4222X	LM/SLASEP		
GQ7513T	DPS THROAT T 3		

* POWER IS IN PARALLEL TO BOTH DESCENT ECAs THROUGH ECPS 1 AND 2

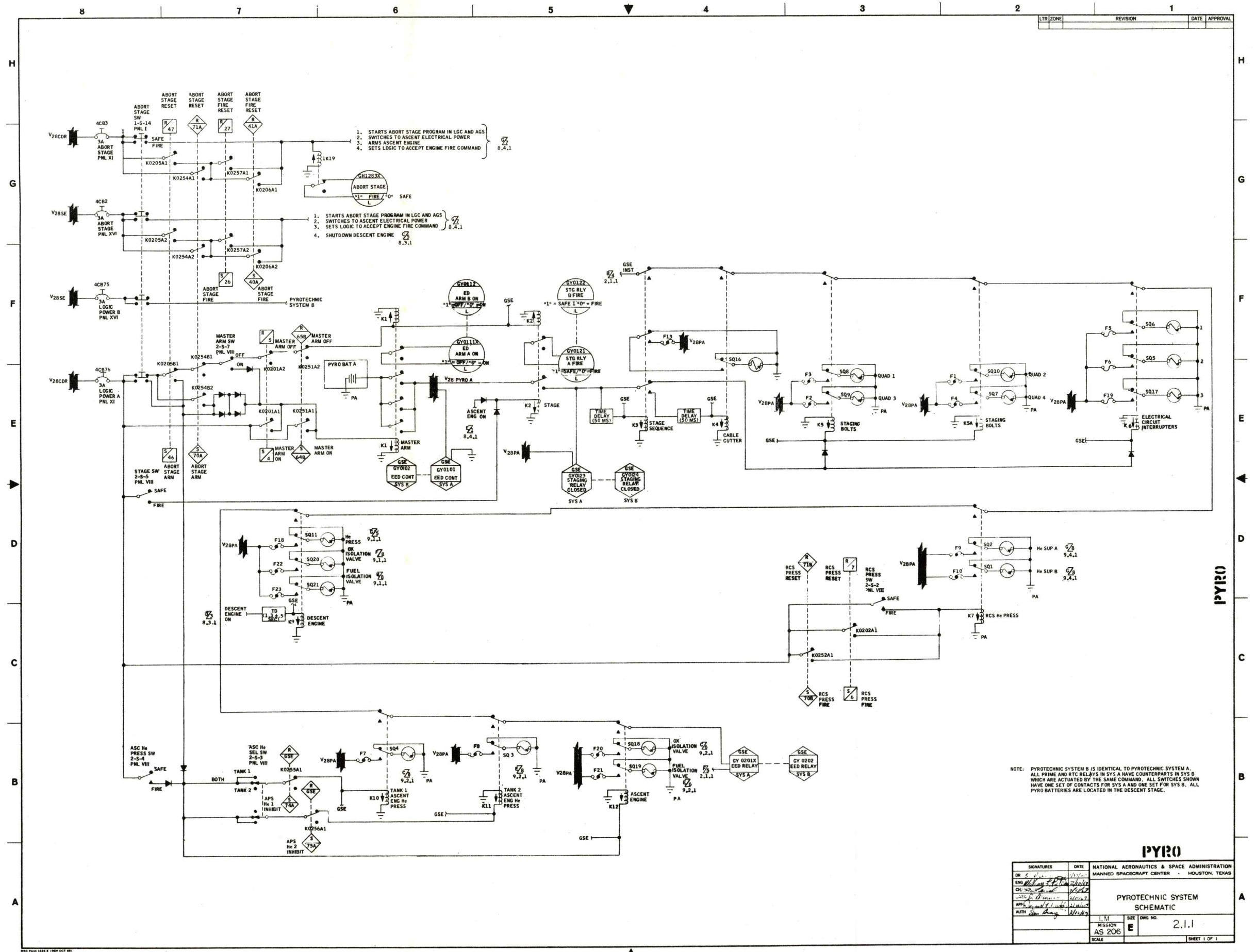
2.4 COMPARISON OF AS-206 PGWCS AND PRA CONTROLLED ABORT STAGE SEQUENCES

THE SEQUENCE OF EVENTS ASSOCIATED WITH THE NOMINAL LM ABORT STAGE MANEUVER
WILL BE FOLLOWED IN THE LM-1 (AS-206) MISSION UNDER PGWCS CONTROL. LM MISSION PROGRAMMER
(LMP) IMPLEMENTATION REQUIRES THAT THE TIMING OF THIS SEQUENCE BE MODIFIED SLIGHTLY FOR
THE ABORT STAGE MANEUVER ACCOMPLISHED UNDER PROGRAM READER ASSEMBLY (PRA) CONTROL.
THE TWO AS-206 CONTROL MODE SEQUENCES FOR ABORT STAGE ARE COMPARED IN TABLE 2-4.
THE TIMING OF THE ASSOCIATED EVENTS IS BASED UPON THE ACTIVATION OF THE ABORT STAGE COMMAND
FOR EACH CASE; HOWEVER, FOR THE PRA CONTROL MODE, THE TAPE FRAME INCREMENTS ARE ALSO
INDICATED FOR THOSE FUNCTIONS DISCRETELY COMMANDED BY THE PRA. IT SHOULD BE NOTED THAT
THE ONLY VARIATIONS WHICH EXIST BETWEEN THE TWO MODES ARE THE ABSENCE OF LGC ASSOCIATED
FUNCTIONS AND A 26 ms LAG IN ARMING THE ASCENT ENGINE AND A.E. THRUST BUILD-UP TO 90 PER
CENT IN THE PRA MODE. IN ALL OTHER RESPECTS, THE TWO SEQUENCES ARE IDENTICAL.

TABLE 2-4
COMPARISON OF AS-206 PGWCS AND PRA CONTROLLED ABORT STAGE SEQUENCES

EVENT	PGWCS SEQ TIME	PRA SEQ TIME
ABORT STAGE INITIATED	-1	-1
ASCENT ENGINE PRESSURIZATION INITIATED		
ASCENT HELIUM PRESSURIZATION TANK VALVES AND ISOLATION VALVES OPENED	-.97	-.97
ABORT STAGE FIRE INITIATED	0 SEC	0 SEC
ASCENT ENGINE START DELAY TIMER INITIATED		
LGC RECEIVES "ABORT STAGE" DISCRETE AND STARTS ASCENT PROGRAM	.009	NA
LGC CONTINUED "ENGINE ON" COMMAND THRU STAGING		
DESCENT ENGINE SHUTDOWN INITIATED BY DECA	.025	.025
DESCENT BATTERIES OFF LINE	.070	.070
LGC RECOGNIZES ABORT STAGE DISCRETE	.140	NA
LGC STARTS LM ATTITUDE HOLD		
LGC STARTS COMPUTATION OF NEW AIMPOINT FOR THRUST VECTOR ASCENT STAGE CONTROL AND STARTS NEW GUIDANCE LAW		
PRA INITIATED DESCENT ARM OFF	NA	.250
DESCENT ENGINE THRUST DECAYED 90% (MAXIMUM TIME)	.275	.275
ASCENT ENGINE ARMED	.412	NA
ASCENT ENGINE START INITIATED		
ASCENT/DESCENT STAGING INITIATED (ASCENT ENGINE ARMED)	.436	.436
(ASCENT ENGINE START INITIATED)	NA	NA
ASCENT/DESCENT STAGE INTERSTAGE BOLTS PYROTECHNICALLY EXPLODED	.448	.448
ASCENT/DESCENT STAGE CONNECTING UMBILICAL DEADFACED ON ASCENT STAGE		
ASCENT/DESCENT STAGE UMBILICAL SEVERED BY GUILLOTINE	.502	.502
LGC RECEIVES STAGE VERIFIED DISCRETE		NA
ASCENT ENGINE THRUST BUILD UP TO 90% (MINIMUM TIME)	.687	.713
LGC INITIATED DESCENT ENGINE ARM OFF	1.140	NA
LGC TERMINATES LM ATTITUDE HOLD		NA
LGC COMMENCES ASCENT STAGE THRUST VECTOR CONTROL		NA

DWG NO. 2.1.1
DETAIL SHEET NO. 1



SECTION 3
POWER

LM
AS-206
REV A

or zinc primary
and two dc

3. ELECTRICAL POWER

*

SECTION 3
ELECTRICAL POWER

LM
AS-206
REV A

3.1 SYSTEM DESCRIPTION

3.1.1 LM DC Electrical System

- A. The LM dc electrical system consists of six silver zinc primary batteries, four Electrical Control Assemblies (ECA), and two dc buses (commander's and system engineer's).
- B. Four of the primary batteries and two ECA's are located in the descent stage. A low voltage tap is provided at the 17 cell point of each 20 cell descent battery, but will not be used on AS-206. To avoid over-voltage conditions due to using all 20 cells, the descent batteries will be predischarged before lift-off.
- C. Two of the LM primary batteries and two ECA's are located in the ascent stage. To avoid over-voltage conditions, the ascent batteries will be predischarged prior to liftoff.

3.1.2 LM AC Electrical System

The LM ac electrical system consists of two single phase ac inverters and one ac bus, and is located in the ascent stage. Only one of the ac inverters will supply power to the ac bus at any given time.

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LM
AS-206
REV B

TABLE 3-1 AS-206 LOAD ANALYSIS

R-B

<u>SYSTEM</u>	<u>WATTS</u>	<u>DC AMPS AT 30 VDC</u>	
ELECTRICAL			
ELECTRICAL CONTROL ASSEMBLY (DESCENT)	20.0	0.67	R-B
ELECTRICAL CONTROL ASSEMBLY (ASCENT)	10.0	0.33	
DISTRIBUTION CONTROL	53.0	1.77	
METERS & FLAGS (DESCENT AND ASCENT)	4.5	0.15	
METERS & FLAGS (ASCENT)	3.5	0.11	
INVERTER LOSSES (EFF = 65%)	76.	0.32	R-B
ENVIRONMENTAL			
GLYCOL PUMPS (2)	61.0	2.02	R-B
COMMUNICATIONS			
S-BAND XMTR/RCVR	36	1.20	R-B
S-BAND PWR AMP	72	2.4	
SIG PROC ASSY	15.5	0.52	
INSTRUMENTATION			
PCMTE	10	0.33	
C&WEA	13.6	0.45	
SIG COND UNITS	30.7	1.02	
SENSORS (DESCENT AND ASCENT)	17.5	.58	R-B
SENSORS (ASCENT)	14	.47	
C-BAND BEACON (2)	56.0	1.87	
VHF XMTRS (5)	280	9.3	
DFI (EXCEPT XMTRS)	311	10.4	R-B
DUAL FEED COUPLER	1.5	0.05	
PROGRAMMER			
PRA	23	.71	R-B
DCA	15.0	0.50	
PCA	14	0.47	
GUIDANCE			
IMU	300.0	10.0	
LGC	110.0	3.67	
			R-B

*

TABLE 3-1 AS-206 LOAD ANALYSIS (CONCLUDED)

<u>SYSTEM</u>	<u>WATTS</u>	<u>DC AMPS AT 30 VDC</u>
CONTROL		
DECA	38	1.27
DECA (AC)	2.7	0.09
GIMBAL DRIVE ACTUATORS (AC)	120	4.0
ATCA	56.5	1.88
S&C CONT ASSY	2.4	0.08
PROPULSION		
ASCENT ENG PROP VALVE	200.0	6.67
ASCENT ENG ISOL REG SOL VALVE	56.0	1.87
ASCENT ENG GAGING	1.5	0.04
DESCENT ENG ISOL REG SOL VALVE	56.0	1.87
DESCENT ENG GAGING	16.0	0.53
THROTTLE ACT AMP	336	11.2
MIX RATIO CONT ACT	21	0.71
DESCENT ENG PROP VALVE	145	4.84
RCS		
THRUST CHAMBER ASSY	112 PER TCA	3.74 PER TCA
ASCENT INTERCONNECT VALVE	70 PER VLV	2.33 PER VLV
MAIN PROP SOV	70 PER VLV	2.33 PER VLV
CLUSTER SOL VALVE	70 PER VLV	2.33 PER VLV
CROSSFEED VALVE	70 PER VLV	2.33 PER VLV
THRUSTER PRESS. TRANSDUCER	4.5	0.15
PROP QTY GAGING	5.0	0.17
THRUSTER HEATERS	764	25.5
TYPICAL POWER LOADS		
COAST	50.6 AMPS (EXCLUDING RCS CLUSTER HEATERS)	
*DPS BURN	60.9 AMPS (EXCLUDING RCS CLUSTER HEATERS)	
APS BURN	56.8 AMPS (EXCLUDING RCS CLUSTER HEATERS)	

*DOES NOT INCLUDE THROTTLE ACTUATION AMPLIFIER POWER (APPROXIMATELY 11.6 AMPS PEAK).

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TABLE 3-2 COMMANDER'S BUS CIRCUIT BREAKER TABULATIONS (PANEL XI)

<u>SYSTEM</u>	<u>CIRCUIT BREAKER</u>	<u>RATING</u>	<u>NOMENCLATURE</u>	
PYROTECHNICS	4CB76	3A	LOGIC PWR A	
	4CB149	3A	LDG GEAR FLAG	
ELECTRICAL	4CB129	3A	DOCK WINDOW (HEATER)	
	4CB6	3A	ASC ECA CONT	
	4CB8	3A	DES ECA CONT	
	4CB10	3A	DES ECA	
	4CB15	3A	ASC ECA	
	4CB12	25A	INV 1	
	4CB4	50A	X LUNAR BUS TIE	R-B
	4CB184	25A	BAL LOAD CROSS TIE	
	4CB20	100A	BUS CROSS TIE	
	4CB18	100A	BAT FEED TIE	R-B
	4CB26	100A	BAT FEED TIE	
ENVIRONMENTAL	4CB107	5A	CABIN FAN 1	
	4CB138	20A	SUIT FAN 1	
	4CB117	3A	GLYCOL PUMP 1	
	4CB141	3A	GLYCOL PUMP 2	
COMMUNICATIONS	4CB137	5A	SEC S-BND XMTR/RCVR	
	4CB136	5A	SEC S-BND PWR AMPL	R-B
	4CB86	3A	CDR AUDIO	
	4CB87	3A	VHF A RCVR	
	4CB162	3A	VHF B XMTR	
INSTRUMENTATION	4CB131	3A	SIG CONDR 1	
	4CB22	3A	DC BUS VOLT	
	4CB181	50A	R/D INST	
PROGRAMER	4CB179	50A	LMP FEED	R-B
GUIDANCE (PRIMARY)	4CB122	7.5A	LGC/DSKY	
	4CB105	10A	LDG RDR	
	4CB157	3A	LDG RDR (HEATER)	
	4CB124	20A	IMU OPR	
	4CB155	5A	RDR OPR (HEATER)	R-B
	4CB156	5A	RNDZ STBY (HEATER)	
	4CB29	15A	RNDZ RDR	
	4CB213	3A	AOT (HEATER)	
	4CB154	3A	SIG STR DISP	
	4CB161	3A	IMU STBY	

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TABLE 3-2 COMMANDERS BUS CIRCUIT BREAKER TABULATIONS (PANEL XI) (CONCLUDED)

<u>SYSTEM</u>	<u>CIRCUIT BREAKER</u>	<u>RATING</u>	<u>NOMENCLATURE</u>	
CONTROL	4CB3	3A	ABORT STAGE	
	4CB81	3A	ATCA (PNGS)	
	4CB69	20A	DECA PWR	R-B
	4CB40	7.5A	AELD	
	4CB59	15A	ATT DIR CONT	
	4CB80	3A	DES ENG CONT	
	4CB106	3A	ENG FIRE OVRD	
PROPULSION	4CB74	5A	DES HE. REG	
	4CB67	5A	ISOL VLV	
	4CB63	15A	QUAD 1 TCA-A	
	4CB62	15A	QUAD 2 TCA-A	R-B
	4CB61	15A	QUAD 3 TCA-A	
	4CB60	15A	QUAD 4 TCA-A	
	4CB72	5A	MAIN SOV-A	
				R-B
	4CB51	5A	ASC FEED	
(HEATERS)	4CB218	7.5A	QUAD 1 RCS SYS A/B-1	
(PANEL X)	4CB219	7.5A	QUAD 2 RCS SYS A/B-1	
	4CB220	7.5A	QUAD 3 RCS SYS A/B-1	R-B
	4CB221	7.5A	QUAD 4 RCS SYS A/B-1	
MISC (FLIGHT DISPLAY'S)	4CB88	3A	GASTA	
	4CB168	3A	THRUST DISP	
	4CB97	3A	FDAI	
	4CB133	3A	X-PNTR	
	4CB123	3A	RNG/RNG RT-ALT/ALT RT	
	4CB159	3A	EVENT TIMER	
LIGHTING	4CB146	3A	ANUN DOCK/COMPNT	

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TABLE 3-3 SYSTEMS ENGINEERS BUS CIRCUIT BREAKER TABULATIONS (PANEL XVI)

<u>SYSTEM</u>	<u>CIRCUIT BREAKER</u>	<u>RATING</u>	<u>NOMENCLATURE</u>	
PYROTECHNICS	4CB75	3A	LOGIC PWR B	
ELECTRICAL (DES STAGE)	4CB7	3A	ASC ECA CONT	
	4CB9	3A	DES ECA CONT	
	4CB5	50A	X LUNAR BUS TIE	R-B
	4CB14	3A	ASC ECA	
	4CB183	25A	BAL LOAD CROSS TIE	
	4CB19	100A	BUS CROSS TIE	
	4CB25	100A	BAT FEED TIE	R-B
	4CB17	100A	BAT FEED TIE	
	4CB16	3A	DISPLAY	
	4CB11	3A	DEC ECA	
	4CB13	25A	INV 2	
	4CB182	50A	SCIENTIFIC EQUIP	R-B
	4CB108	5A	CABIN FAN 2	
	4CB109	3A	CABIN FAN CONT	
ENVIRONMENTAL	4CB120	3A	SUIT FAN CONT	
	4CB132	3A	SIG SENSOR	
	4CB119	20A	SUIT FAN 2	R-B
	4CB112	3A	DIVERT VLV	
	4CB113	3A	CABIN REPRESS	
	4CB84	3A	CO ₂ SENSOR	
	4CB140	3A	DISP	
	4CB98	5A	PRI GLYCOL EVAP FLOW	R-B
	4CB96	3A	GLYCOL PUMP SEC	
COMMUNICATIONS	4CB102	3A	PMP	
	4CB85	3A	S.E. AUDIO	
	4CB30	5A	PRIM S-BND PWR AMPL	
	4CB111	5A	PRIM S-BND XMTR/RCVR	R-B
	4CB153	3A	DISPLAY	
	4CB104	3A	TV	
	4CB114	3A	VHF B RCVR	
	4CB115	3A	VHF A XMTR	
	4CB31	3A	S-BND ANT (HEATER)	
	4CB110	3A	S-BND ANT	
INSTRUMENTATION	4CB99	3A	CWEA	
	4CB125	3A	PCMTE	
	4CB1	3A	SIG CONDR 2	
	4CB21	3A	DC BUS VOLT	
	4CB132	3A	SIG SENSOR	
GUIDANCE (ABORT)	4CB28	10A	AEA	
	4CB79	20A	ASA	R-B

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TABLE 3-3 SYSTEMS ENGINEERS BUS CIRCUIT BREAKER TABULATIONS (PANEL SVI)
(Concluded)

R-B

<u>SYSTEM</u>	<u>CIRCUIT BREAKER</u>	<u>RATING</u>	<u>NOMENCLATURE</u>
CONTROL	4CB37	3A	ENGINE ARM
	4CB41	7.5A	AELD
	4CB82	7.5A	ATCA
	4CB2	3A	ABORT STAGE
PROPULSION	4CB50	3A	TEMP/PRESS/DISP FLAGS
	4CB49	5A	ISOL VLV-B
	4CB45	15A	QUAD 1 TCA-B
	4CB44	15A	QUAD 2 TCA-B
	4CB43	15A	QUAD 3 TCA-B
	4CB42	15A	QUAD 4 TCA-B
	4CB54	5A	CROSSFEED
	4CB73	5A	MAIN SOV-B
	4CB52	5A	ASC FEED
	4CB121	3A	PQGS
	4CB68	3A	DISPLAY (HEATER)
	4CB53	5A	ASC HE. REG
	4CB103	3A	TEMP/PRESS. DISPLAY
	4CB32	3A	PQGS
(HEATERS)	4CB222	7.5A	QUAD 1 RCS SYS A/B-2
	4CB223	7.5A	QUAD 2 RCS SYS A/B-2
	4CB224	7.5A	QUAD 3 RCS SYS A/B-2
	4CB225	7.5A	QUAD 4 RCS SYS A/B-2
MISC (FLIGHT DISPLAYS)	4CB126	3A	FDAI
	4CB134	3A	X-POINTER
LIGHTING	4CB128	5A	FLOOD
	4CB147	5A	MASTER ALARM
	4CB160	25A	TRACK
	4CB148	3A	ANUN/DOCK/COMPNT
CREW PROVISIONS	4CB33	3A	CAMERA SEQUENCE

R-B

R-B

R-B

R-B

R-B

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TABLE 3-4 AC BUS CIRCUIT BREAKER TABULATIONS (PANEL XI)

R-B

<u>SYSTEM</u>	<u>CIRCUIT BREAKER</u>	<u>RATING</u>	<u>NOMENCLATURE</u>
ELECTRICAL	4CB144	3A	CDR WINDOW (HEATER)
	4CB152	3A	S.E. WINDOW (HEATER)
	4CB23	5A	AC BUS FEED TIE
	4CB24	5A	AC BUS FEED TIE
COMMUNICATIONS	4CB34	1A	S-BAND ANT
INSTRUMENTATION	4CB202	3A	TAPE RCDR
	4CB27	1A	AC BUS VOLT
GUIDANCE	4CB203	3A	AGS
	4CB212	3A	AOT LAMP
	4CB206	3A	RNDZ RDR
CONTROL	4CB207	3A	DECA GIMBAL
PROPULSION	4CB169	3A	HE/PQGS DISP
	4CB163	3A	(RCS) PQGS DISPLAY
MISC (FLIGHT DISPLAY'S)	4CB201	3A	GASTA
	4CB209	1A	CDR FDAI
	4CB204	3A	RNG/RNG RT
			ALT/ALT RT
	4CB210	1A	SE FDAI
LIGHTING	4CB211	3A	INTGL
	4CB200	3A	NUM

R-B

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TABLE 3-5 LMP CIRCUIT BREAKER TABULATION

R-B

<u>CIRCUIT BREAKER</u>	<u>RATING</u>	<u>NOMENCLATURE</u>
CB1	3A	PRI H ₂ O FEED
CB2	3A	SEC H ₂ O FEED
CB3	25A	INV 1
CB4	25A	INV 2
CB5	3A	DCA
CB6	3A	PCA
CB7	3A	PRA
CB8	3A	EPS LOGIC
CB9	3A	LMP INTERLOCK CONTROL

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TABLE 3-6 LM SUBSYSTEM VOLTAGE REQUIREMENTS

Subsystem	Voltage Required	
	DC	AC
COMMUNICATIONS	25 - 31.5 V	--
CREW PROVISIONS	20 - 32 V	115 ± 2.5 V
DISPLAYS	25 - 31.5 V	115 ± 2.5 V
ENVIROMENTAL CONTROL	25 - 31.5 V	--
ELECTRICAL POWER	24 - 32 V	--
INSTRUMENTATION (EXCEPT CAUTION AND WARNING)	20 - 32 V	115 ± 2.5 V
CAUTION AND WARNING	18 - 32.5 V	--
DFI	24 - 32 V	--
PGNCS (EXCEPT THE FOLLOWING)	25 - 31.5 V	115 ± 2.5 V
(a) IMU STANDBY	22.5 - 32.5 V	--
(b) IMU OPERATE	26.0 - 32.5 V	--
(c) RADAR CDU'S	26.0 - 32.5 V	--
(d) LGC	25.0 - 32.0 V	--
(e) AOT	25.0 - 32.0 V	115 ± 2.5 V
PROPULSION		
(a) ASCENT ENGINE	21 - 32 V	--
(b) DESCENT ENGINE CONTROL ASSEMBLY	22 - 32.5 V	115 ± 2.5 V
(c) DESCENT ENGINE	20 - 32 V	--
REACTION CONTROL	24 - 32 V	--
STABILIZATION AND CONTROL	25 - 31.5 V	--
PYROTECHNIC (LOGIC POWER ONLY)	24 - 32 V	--

R-B

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TABLE 3-7 TRANSLUNAR BUS CONFIGURATION

The EPS returns associated with the following circuit breakers are connected to the translunar bus.

<u>BUS</u>	<u>CB NO.</u>	<u>CB NAME</u>	<u>FUNCTION</u>
CDR	4CB10	DES ECA	POWER ECA #2, 3.2.1
CDR	4CB146	ANUN DOCK/COMPNT	LIGHTING, 12.2.1
CDR	4CB124	IMU OPR	7.2.1
CDR	4CB161	IMU STBY	IMU HTRS, 7.2.1
CDR	4CB155	HTR RNDZ OPR	RR ANT HTR*
CDR	4CB157	HTR LDG RDR	L/R ANT HTR*
SE	4CB11	DES ECA	POWERS ECA #1, 3.2.1
SE	4CB28	AEA	POWERS AEA*
SE	4CB31	S-BAND ANT	S-BAND STEERABLE ANT HTR, 5.1.1

R-B

*NO DRAWING IN THE HANDBOOK BECAUSE THE EQUIPMENT HAS BEEN REMOVED.

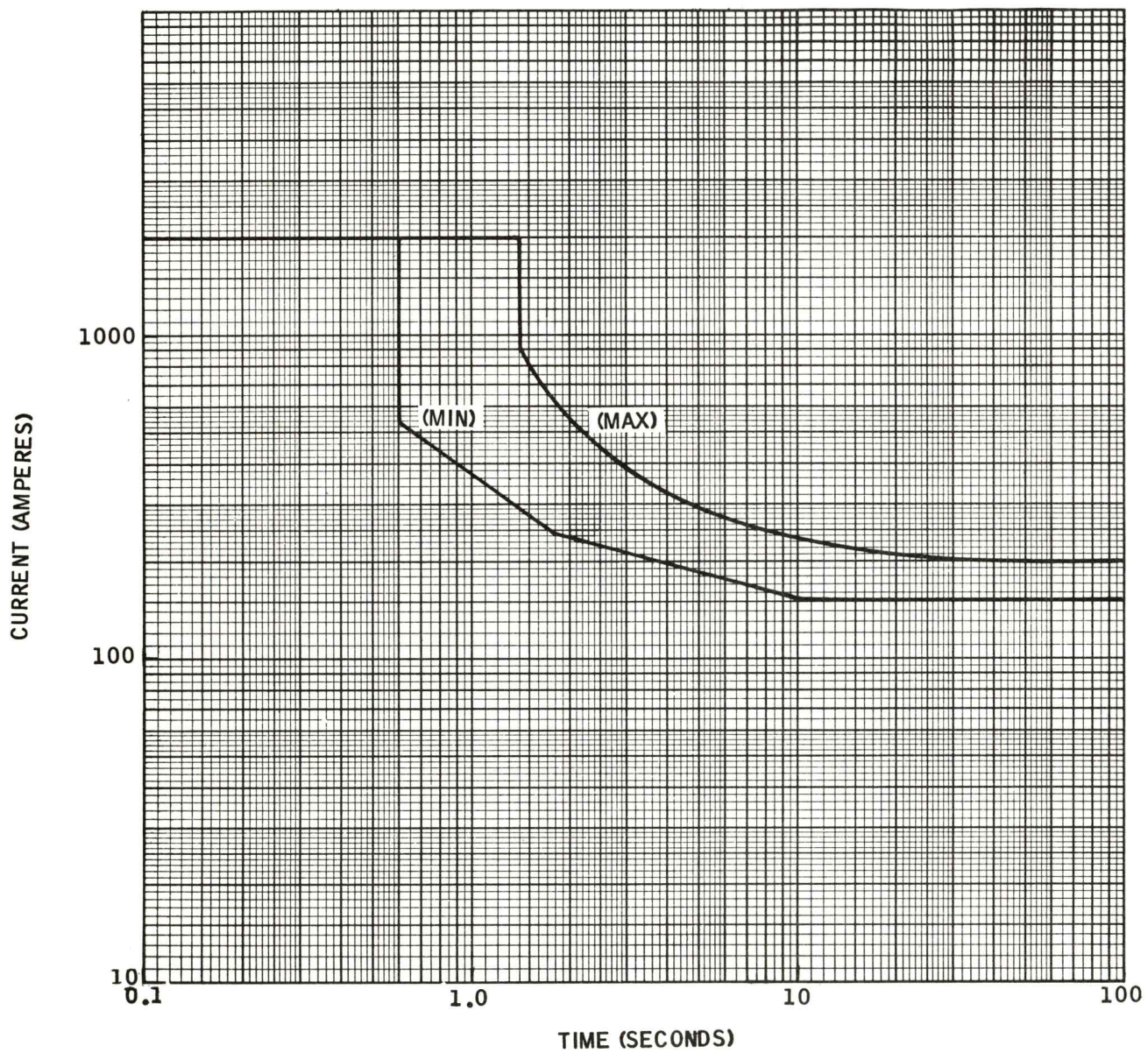


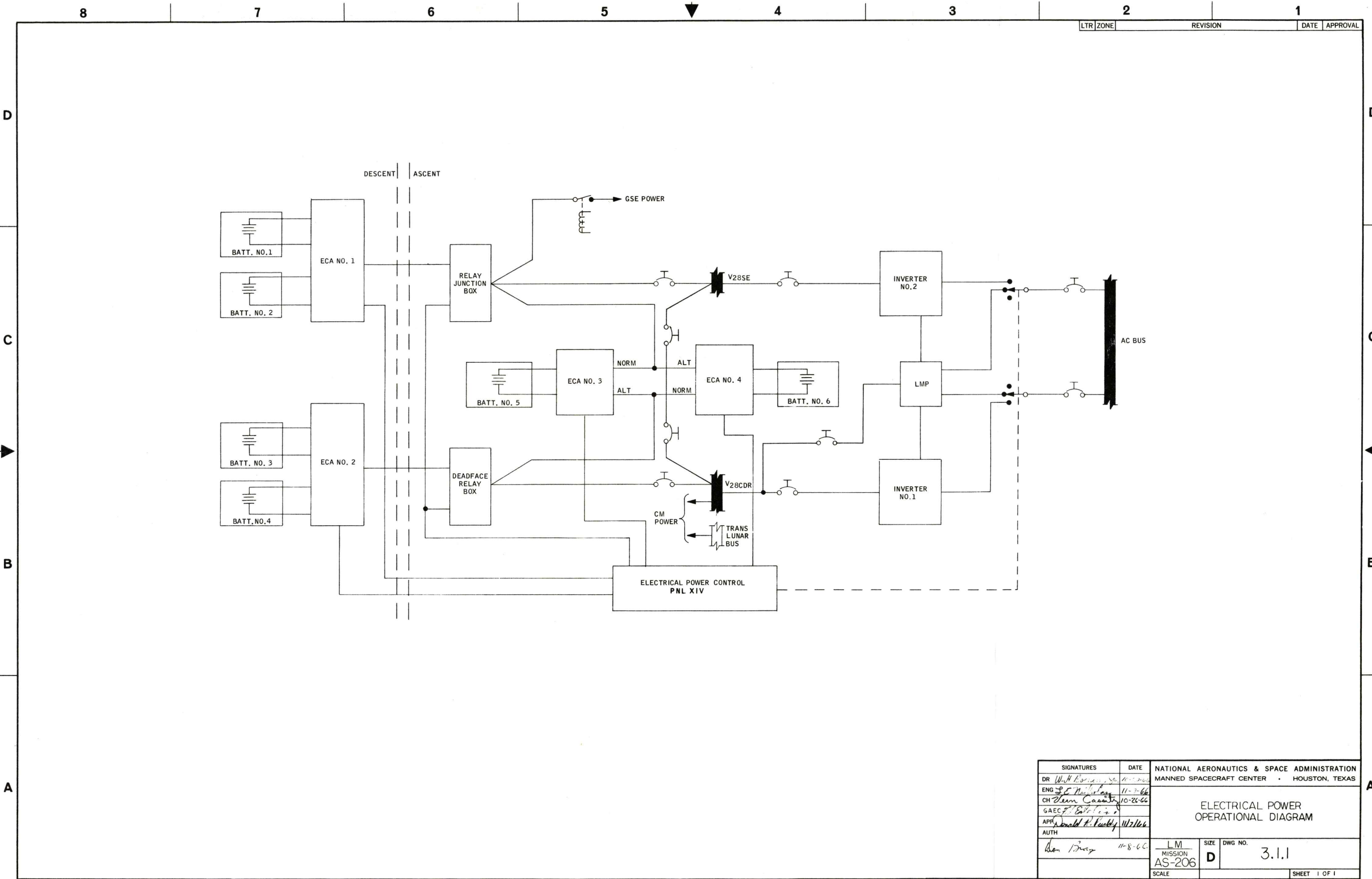
Figure 3-1 Current Monitor Overcurrent Trip Limits.

TABLE 3-8 PRELAUNCH STATUS OF SWITCH/CIRCUIT BREAKER POSITIONS

<u>NAME</u>	<u>NUMBER</u>	<u>POSITION</u>
SWITCH		
AC POWER	4-S-14	OFF
POWER/TEMP MONITOR	4-S-15	OFF
*BAT. 1 HI VOLT	4-S-1	OFF/RESET CENTER
*BAT. 2 HI VOLT	4-S-2	OFF/RESET CENTER
*BAT. 3 HI VOLT	4-S-3	OFF/RESET CENTER
*BAT. 4 HI VOLT	4-S-4	OFF/RESET CENTER
*BAT. 1 LOW VOLT	4-S-5	OFF/RESET CENTER
*BAT. 2 LOW VOLT	4-S-6	OFF/RESET CENTER
*BAT. 3 LOW VOLT	4-S-7	OFF/RESET CENTER
*BAT. 4 LOW VOLT	4-S-8	OFF/RESET CENTER
*BAT. 5 NORMAL FEED	4-S-10	OFF/RESET CENTER
*BAT. 5 BACKUP FEED	4-S-12	OFF/RESET CENTER
*BAT. 6 NORMAL FEED	4-S-11	OFF/RESET CENTER
*BAT. 6 BACKUP FEED	4-S-13	OFF/RESET CENTER
DEADFACE SWITCH	4-S-9	CONNECT
**ASCENT POWER TRANSFER	4-S-16	ENABLE
CIRCUIT BREAKER		
X-LUNAR BUS TIE	4CB4	CLOSED
ASC ECA CONT	4CB6	CLOSED
DES ECA CONT	4CB8	CLOSED
DES ECA	4CB10	CLOSED
INV 1	4CB12	OPEN
ASC ECA	4CB15	CLOSED
BAT. FEED TIE	4CB18	CLOSED
BUS CROSS TIE	4CB20	CLOSED
DC BUS VOLT	4CB22	CLOSED
AC BUS FEED TIE (INV #1)	4CB23	CLOSED
AC BUS FEED TIE (INV #2)	4CB24	CLOSED
BAT. FEED TIE	4CB26	CLOSED
AC BUS VOLT	4CB27	CLOSED
LMP FEED	4CB179	CLOSED
R/D INST	4CB181	CLOSED
X-LUNAR BUS TIE	4CB5	CLOSED
ASC ECA CONT	4CB7	CLOSED
DES ECA CONT	4CB9	CLOSED
DES ECA	4CB11	CLOSED
INV #2	4CB13	OPEN
ASC ECA	4CB14	CLOSED
DISP	4CB16	OPEN
BAT FEED TIE	4CB17	CLOSED
BUS CROSS TIE	4CB19	CLOSED
DC BUS VOLT	4CB21	CLOSED
BAT FEED TIE	4CB25	CLOSED
BAL LOAD CROSS TIE	4CB183	OPEN
BAL LOAD CROSS TIE	4CB184	OPEN

*THESE SWITCHES ARE MOMENTARY TYPE AND THE OFF/RESET CENTER IS THE NORMAL POSITION.

**THIS SWITCH IS NOT WIRED.



SIGNATURES		DATE	NATIONAL AERONAUTICS & SPACE ADMINISTRATION	
DR	W. H. Rouse	11-8-66	MANNED SPACECRAFT CENTER	HOUSTON, TEXAS
ENG	J. E. McElroy	11-7-66	ELECTRICAL POWER OPERATIONAL DIAGRAM	
CH	Don Casady	10-26-66		
GAECF	W. H. Rouse	11-8-66		
APR	Donald R. Rouse	11/7/66		
AUTH	Don Rouse	11-8-66	LM MISSION AS-206	SIZE D
			SCALE	DWG NO. 3.1.1
				SHEET 1 OF 1

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(See Back)

3.2 SYSTEM DATA

3.2.1 PREDISCHARGED DESCENT BATTERY

CAPACITY 293 AMP-HRS
TERMINAL VOLTAGE 28.0 TO 32.5VDC

3.2.2 ASCENT BATTERY

CAPACITY 296 AMP-HRS
TERMINAL VOLTAGE 28.0 TO 32.5VDC

3.2.3 AC BUS

VOLTAGE 115 $\pm$ 2.5VAC
FREQUENCY 400 $\pm$ 10CPS

3.2.4 MALFUNCTION INDICATION

- A. THE LIMITS FOR A MALFUNCTION INDICATION ARE:
OVER-TEMPERATURE $>145^{\circ}\pm 5^{\circ}\text{F}$ (RESETS AT $125^{\circ}\pm 5^{\circ}\text{F}$)
OVER-CURRENT SEE FIGURE 3-1
REVERSE CURRENT -6 ± -10 AMPS (INDICATION WILL BE RESET AT -4 AMPS)
- B. THERE WILL BE NO CAPABILITY FOR A DESCENT BATTERY MALFUNCTION INDICATION CAUSED BY A BATTERY OVER-TEMPERATURE IF THE BATTERY IS OFF
- C. THERE WILL BE NO CAPABILITY FOR THE RESPECTIVE ASCENT BATTERY MALFUNCTION INDICATION CAUSED BY A BATTERY OVER-TEMPERATURE IF BAT. 5 IS NOT CONNECTED TO THE S.E.'s OR BAT. 6 IS NOT CONNECTED TO THE CDR's BUS. ALSO, THE BACKUP FEED PATHS, DO NOT HAVE AUTOMATIC OVERCURRENT PROTECTION.

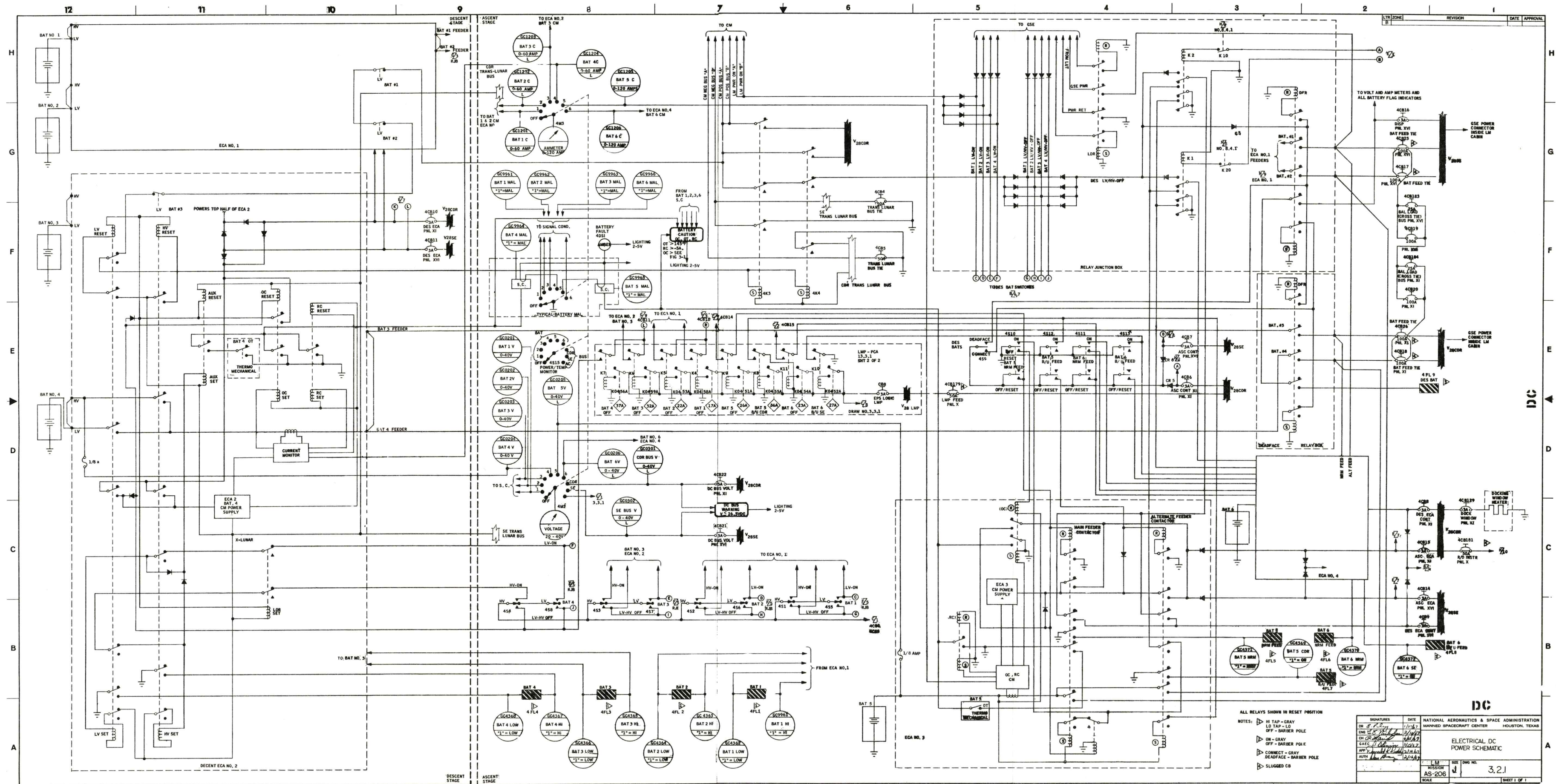
TABLE 3-9 PRELAUNCH STATUS OF SWITCH/CIRCUIT BREAKER POSITIONS

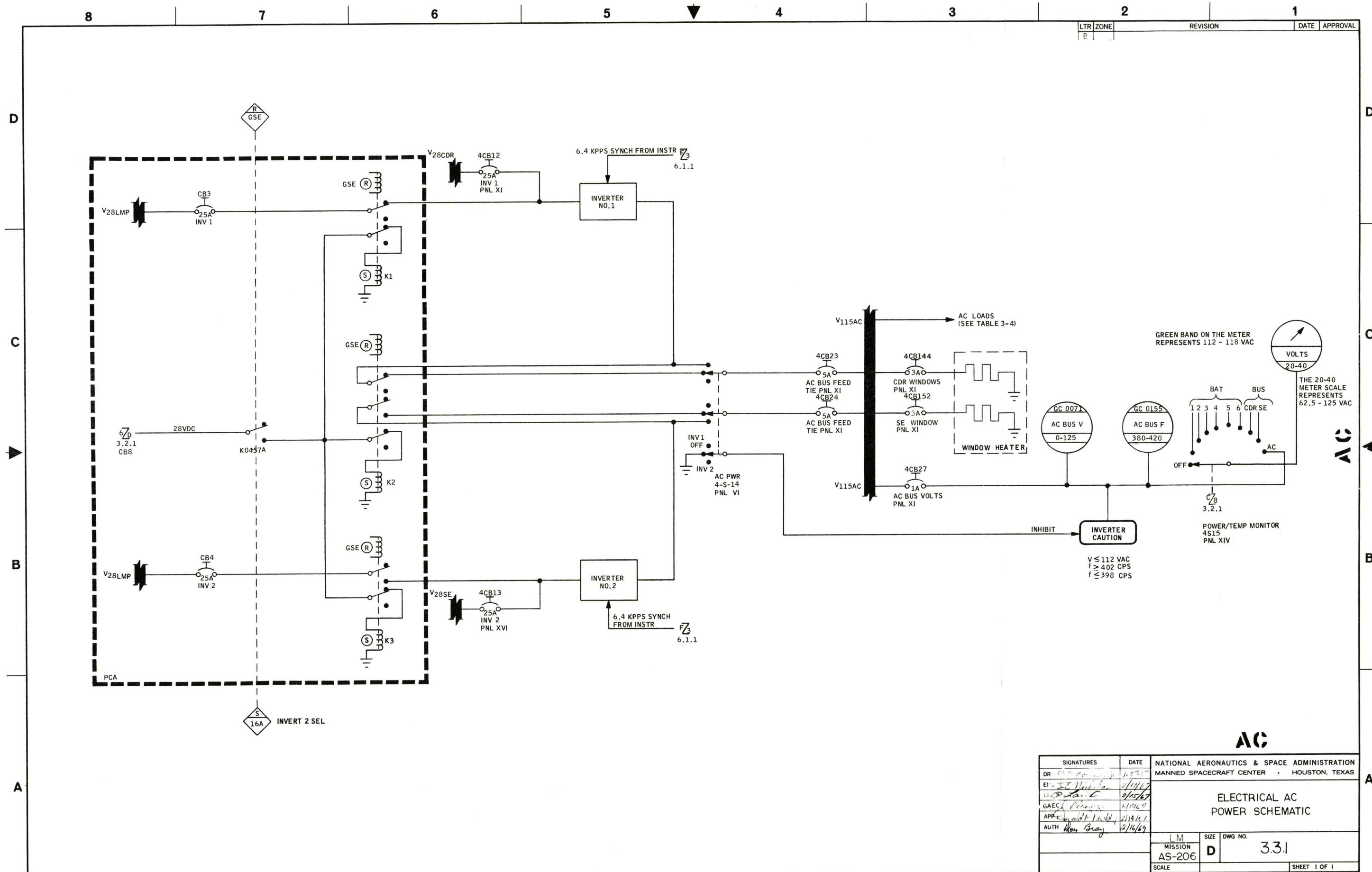
NAME	NUMBER	POSITION
SWITCH		
AC POWER	4-S-14	OFF
POWER/TEMP MONITOR	4-S-15	OFF
* BAT. 1 HI VOLT	4-S-1	OFF/RESET CENTER
* BAT. 2 HI VOLT	4-S-2	OFF/RESET CENTER
* BAT. 3 HI VOLT	4-S-3	OFF/RESET CENTER
* BAT. 4 HI VOLT	4-S-4	OFF/RESET CENTER
* BAT. 1 LOW VOLT	4-S-5	OFF/RESET CENTER
* BAT. 2 LOW VOLT	4-S-6	OFF/RESET CENTER
* BAT. 4 LOW VOLT	4-S-8	OFF/RESET CENTER
* BAT. 5 NORMAL FEED	4-S-10	OFF/RESET CENTER
* BAT. 5 BACKUP FEED	4-S-12	OFF/RESET CENTER
* BAT. 6 NORMAL FEED	4-S-11	OFF/RESET CENTER
* BAT. 6 BACKUP FEED	4-S-13	OFF/RESET CENTER
DEADFACE SWITCH	4-S-9	CONNECT
** ASCENT POWER TRANSFER	4-S-16	ENABLE
CIRCUIT BREAKER		
X-LUNAR BUS TIE	4CB4	CLOSED
ASC ECA CONT	4CB6	CLOSED
DES ECA CONT	4CB8	CLOSED
DES ECA	4CB10	CLOSED
INV 1	4CB12	OPEN
ASC ECA	4CB15	CLOSED
*** BAT. FEED TIE	4CB18	CLOSED
BUS CROSS TIE	4CB20	CLOSED
DC BUS VOLT	4CB22	CLOSED
AC BUS FEED TIE (INV #1)	4CB23	CLOSED
AC BUS FEED TIE (INV #2)	4CB24	CLOSED
*** BAT. FEED TIE	4CB26	CLOSED
AC BUS VOLT	4CB27	CLOSED
*** LMP FEED	4CB179	CLOSED
*** R/D INST	4CB181	CLOSED
X-LUNAR BUS TIE	4CB5	CLOSED
ASC ECA CONT	4CB7	CLOSED
DES ECA CONT	4CB9	CLOSED
DES ECA	4CB11	CLOSED
INV #2	4CB13	OPEN
ASC ECA	4CB14	CLOSED
*** BAT. FEED TIE	4CB17	CLOSED
BUS CROSS TIE	4CB19	CLOSED
DC BUS VOLT	4CB21	CLOSED
*** BAT. FEED TIE	4CB25	CLOSED
BAL LOAD CROSS TIE	4CB183	OPEN
BAL LOAD CROSS TIE	4CB184	OPEN

* THESE SWITCHES ARE MOMENTARY TYPE AND THE OFF/RESET CENTER IS THE NORMAL POSITION

** THIS SWITCH IS NOT WIRED

*** THESE CIRCUIT BREAKERS ARE SLUGGED





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SECTION 4

ENVIRONMENTAL CONTROL SUBSYSTEM

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4. ENVIRONMENTAL CONTROL
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SECTION 4

ENVIRONMENTAL CONTROL SUBSYSTEM

4.1 SUBSYSTEM DESCRIPTION

4.1.1 Oxygen Supply Section

A. Configuration

1. The descent oxygen tank will not be installed therefore, the descent oxygen shutoff valve will be closed and the line capped.
2. Each ascent oxygen tank will be partially filled to 4.35 psia.
3. The oxygen control module, (which normally reduces LM oxygen pressure) will not be installed.

B. Function

1. Ascent oxygen will be supplied directly to the sensing ports of both the primary and secondary water regulators. Ascent tank Number 2 will provide reference pressure to the primary regulators while ascent tank Number 1 will provide an independent source of pressure to the secondary regulator.
2. The LM cabin is not required to be pressurized, consequently a cabin pressure decay of up to 1.8 pounds of oxygen per hour may be anticipated.

4.1.2 Suit Loop

A. Configuration

1. Installed but functionally disabled by opening appropriate circuit breakers.

B. Function

1. None

4.1.3 Water Supply Section

A. Configuration

1. Descent water tank will be installed, however, there is no requirement to load water based on the present mission plan.

2. Ascent tanks will supply water to the water boiler during the entire mission.
3. The water feed line to the smaller water boiler (item number 224) will be capped since the reduced heat load precludes using this unit.

B. Function

1. To supply water to the water boiler such that proper thermal control may be accomplished.

C. Operation

1. Primary Water Feed - The water tank select valve, preset to ASCENT, allows water to flow through the primary feed path up to the primary water feed valve. At 3 minutes after liftoff, the LMP (LGC mode) will command the valve OPEN, allowing water to flow to the primary water boiler. RTC 24A, PRI H₂O FEED and RTC 25A, PRI H₂O RESET, are available to backup this onboard command.
2. Primary Water Feed Verification - Prior to opening the feed valve, water pressure downstream of the regulators will be between 15.45 psia, (water was loaded using an ambient reference pressure) and ASC H₂O Tank Pressure (43 psia). Subsequent to this loading, the oxygen tanks will be loaded to 4.35 psia resulting in a ΔP of between 11.1 (15.45 - 4.35) and 38.65 (43.0 - 4.35) psid. This will be reflected by PRI H₂O REG ΔP (GF4101P) having an off-scale high reading of 2.0 psid. Upon opening the feed valve at T + 3 minutes, H₂O ΔP will decay in order to become compatible with the ascent oxygen reference pressure. The drop in ΔP can be verified by GF4101P decreasing to the nominal value of 0.75 psid.
3. Secondary Water Feed - In the event that the primary water feed valve does not open on command, the secondary feed path may be used by sending RTC 44B, SEC H₂O FEED and RTC 45B,

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SEC H₂O RESET. Upon receipt of this command the feed valve, in the independently regulated secondary path, will open. Water will flow through this parallel path to a point downstream of the primary feed valve where the paths are manifolded and provide a common feed to the water boiler.

4. Secondary Water Feed Verification - Verification of the secondary valve opening cannot be ascertained in a manner analogous to the primary path since there is no regulator ΔP measurement. However, a continued rise in GLY TEMP (GF9998U) is indicative of the valve not opening.
5. Water Regulation - Nominal regulated water pressure varies from 0.5 to 1.0 psid above oxygen tank pressure. The pressure of the water supplied to the water boiler should not exceed 6.5 psia in order to maintain optimum performance.
6. Water Boiler Operation - A porous plate sublimator rejects heat to the vacuum of space by the sublimation of ice. The heat rejection capability of the water boiler is greatly reduced if the heat load is either below the "freeze-up" point or above the "breakthrough" point of the unit. These limits are defined as follows:
 - a. Breakthrough - This refers to a water boiler condition where the heat load is sufficient to cause the vapor pressure at the inlet face of the plate to exceed the triple point pressure. If, at this point, the pore size is too large to support the water feed pressure, breakthrough will occur. This condition may also exist in the event that the water feed pressures become exceedingly high. Both water regulators must fail before the regulated pressure would reach this limit.

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When the aforementioned condition is present, heat rejection capability is reduced and water usage is high since the water may pass into the plate and escape to ambient. For anticipated temperature and Btu profiles, see Figures 4-1 (TBD) and 4-2 (TBD).

- b. Freezeup - If the heat load dissipated by the water boiler drops below a lower limit, the ice layer will grow so as to fill the water passages. The expanding ice layer will rupture the sublimator, rendering it useless.

4.1.4 Glycol Loops

A. Configuration

1. Both glycol pumps will be on.
2. The primary glycol loop is installed and operable.
3. The secondary glycol loop is installed but it will be left dry and disabled since it cannot be used on this flight.
4. As a result of the LM-1 simplification program the following pieces of equipment will not require cooling since they are no longer on the vehicle.
 - a. VHF Transceivers
 - b. Rendezvous Radar Electronics Assembly (RRE)
 - c. Abort Sensor Assembly (ASA)
 - d. Tracking Lights (TLE).

B. Function

1. To provide, by forced convection, thermal control of spacecraft electronic equipment.

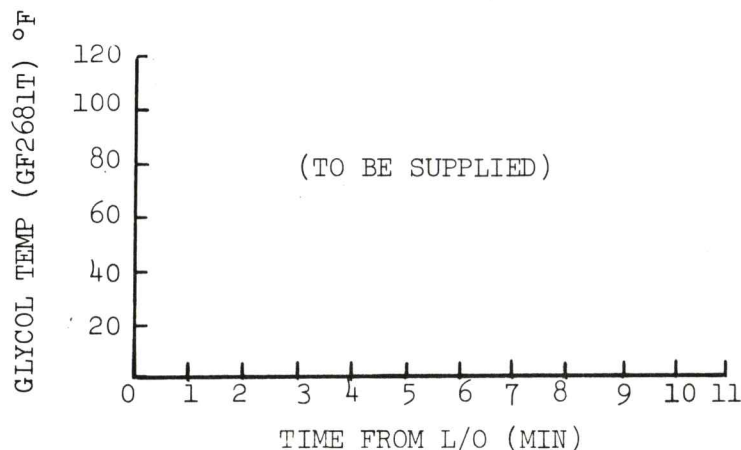
C. Operation

1. Prelaunch Cooling - AS-206 is a launch of a powered up LM, and spacecraft cooling must be provided up to liftoff. Since the LM ECS water boilers must be exposed to a vacuum environment to operate properly, a freon boiler is installed

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in the primary glycol loop. From T-5 hours to liftoff, a freon supply unit at the LUT base supplies freon to this boiler. Flyaway umbilicals terminate the freon supply at liftoff. Cooling requirements prior to T-5 hours are satisfied by the Glycol Trim Control Unit (GTCU) installed in parallel with the primary pumps. This unit pumps glycol through the onboard loop and out to a refrigeration unit to reject the heat.

2. Pump Switchover - The automatic switchover circuitry is such that should a transient cause the switchover from Pump 1 to Pump 2, it is impossible to return to Pump 1 on an unmanned mission. To avoid the possibility of losing a good pump both glycol pumps will be placed on the line prior to launch. The automatic switchover circuitry has been deactivated and the capability of executing RTC 50B, (Pump 2 SEL), and RTC 51B, (Pump 1 SEL), has been deleted.
3. Glycol Temperature Behavior During Launch - Since there will be no active cooling during the first three minutes of powered flight, GLY TEMP (GF9998U) will behave as follows:



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FIGURE 4.1 ESTIMATED TEMP PROFILE
TO BE SUPPLIED LATER

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FIGURE 4.2 ESTIMATED BTU PROFILE

TO BE SUPPLIED LATER

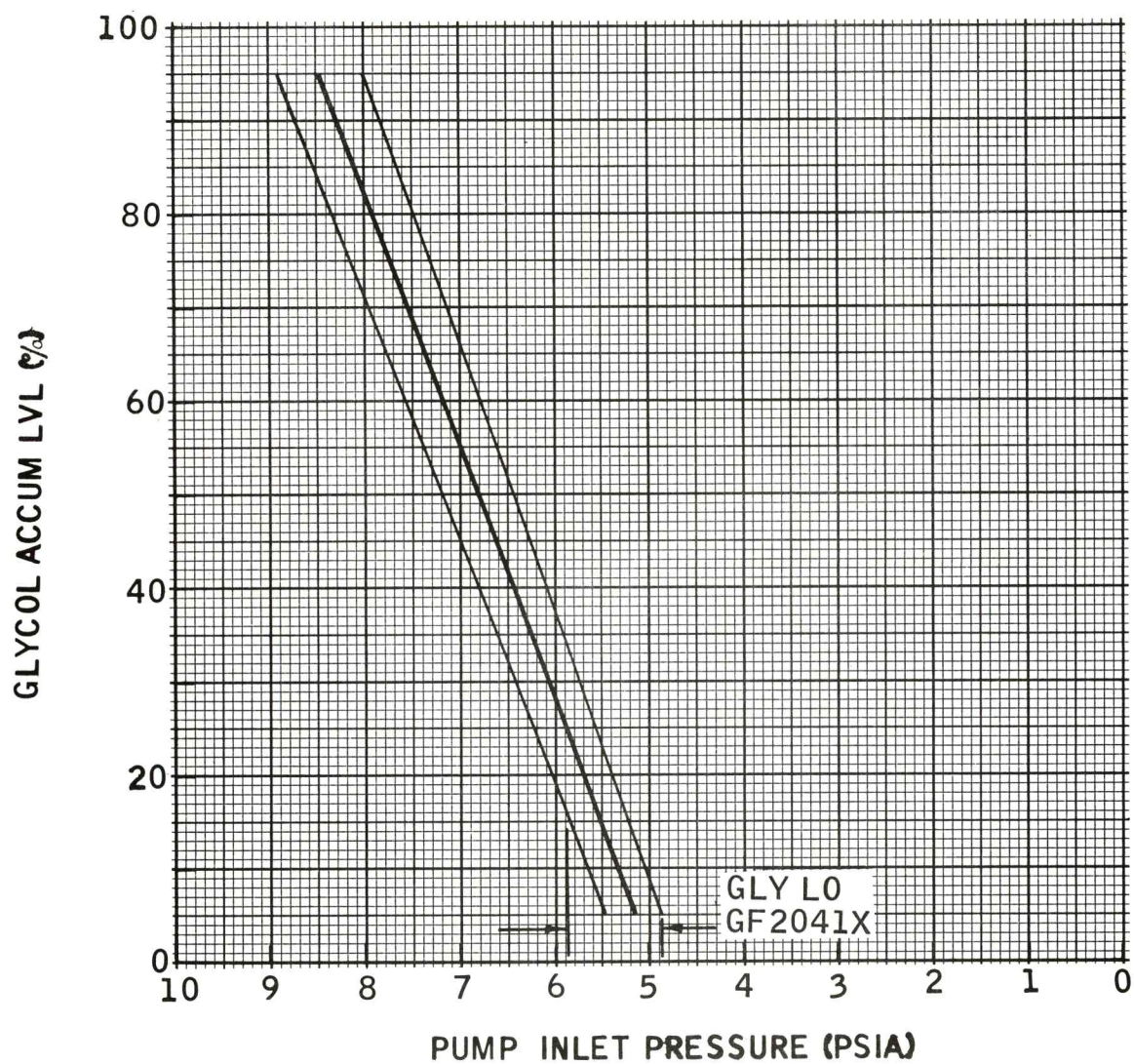


Figure 4-3 Glycol Accumulator Quantity.

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TABLE 4-1 PRELAUNCH STATUS OF VALVES AND SWITCHES

<u>Switch/Valve Name</u>	<u>Position</u>	<u>Notes</u>
<u>Oxygen Supply Section</u>		
Desc O2 (7-H-15)		The O2 control module, on which these valves are located, will not be installed.
Asc O2 No. 1 (7-H-21)		
Asc O2 No. 2 (7-H-5)		
PLSS Fill (7-H-4)		
Cabin Repress (7-H-3)		
Demand Reg A (7-H-1)		
Demand Reg B (7-H-2)		
Cabin Relief & Dump Valve (7-H-11)	AUTO	Valves are preset to this position in order to permit cabin "bleed" during launch.
Cabin Relief & Dump Valve (7-H-20)	AUTO	
Cabin Repress (4CB113)	ASC #1	These circuit breakers will be opened since the associated hardware is not required for an unmanned mission. Switch position irrelevant for LM-1.
Cabin Fan 1 (4CB107)		
Cabin Fan 2 (4CB108)		
Cabin Fan Control (4CB109)		
O2/H2O Qty Mon Sw (7-S-2)		
<u>Suit Loop</u>		
CDR Suit Flow (7-H-6)		The Suit Circuit Assembly, on which these valves are located, will be electrically disabled by pulling circuit breakers and capping electrical connectors.
S.E Suit Flow (7-H-7)		
Suit Circuit Relief (7-H-9)		
Suit Gas Diverter (7-H-8)		
Cabin Gas Return (7-H-17)		
CO2 Cannister Select (7-H-19)		
CO2 Primary Cannister Vent (7-H-23)		
CO2 Secondary Cannister Vent (7-H-24)		
Water Sep Sel (7-H-10)		
Suit Fan (7-S-1)		These circuit breakers will be opened since the associated hardware is not required for an unmanned mission.
CO2 Sensor (4CB84)		
Divert Vlv (4CB112)		
Suit Fan 1 (4CB138)		
Suit Fan 2 (4CB119)		
Suit Fan Control (4CB120)		
Displays (4CB140)		
<u>Water Supply Section</u>		
Water Tank Select (7-H-14)	ASCENT	This setting will permit ascent H2O flow to the water boiler via the primary feed path, when the primary feed valve is opened by the LMP.

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TABLE 4-1 PRELAUNCH STATUS OF VALVES AND SWITCHES (Concluded)

<u>Switch/Valve Name</u>	<u>Position</u>	<u>Notes</u>
<u>Water Supply Section (Cont'd)</u>		
Primary Feed (7-S-4)	NEUTRAL	Momentary toggle spring loaded to neutral. Switch is not required to initiate H ₂ O flow via the LMP.
PRIM H ₂ O Feed (4CB98)	OPEN	Power is supplied to solenoid by the LMP.
SEC Glycol Evap Flow (7-H-18)	CLOSE	The secondary glycol loop is dry for this mission.
SEC Suit Evap Flow (7-H-16)	OPEN	Valve is required open to allow H ₂ O to the water boiler via the secondary feed path. R&D solenoid (secondary H ₂ O feed valve) is located downstream from this valve.
PLSS/Drink (7-H-13)	CLOSE	Not required on unmanned mission.
O ₂ Press. H ₂ O Qty Mon	ASC #1	Switch position irrelevant for LM-1.
<u>Glycol Loop</u>		
Glycol Pump Select (7-S-3)	No. 1	Required for Pump 1 operation.
Glycol Pump 1 (4CB117)	CLOSE	Pump 1 will be On.
Glycol Pump 2 (4CB141)	CLOSE	Pump 2 will be On.
Glycol Pump Sec (4CB96)	OPEN	The secondary glycol loop is dry for this mission.
Suit Temp (7-H-22)	COLD	Suit loop temp control is not required due to the unmanned configuration.
Cabin Temp (7-H-12)	COLD	Assures minimum temperature of glycol to aft equipment bay.

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4.2 ECS CONSTRAINTS

4.2.1 Water Supply Section

- A. Failure of the PRIM FEED valve to open will result in equipment malfunction in _____ minutes, if SEC FEED valve is not opened.
- B. A failed close regulator will result in an increase of GLY TEMP (GF9998U) in _____ minutes. (Corresponds to _____ Btu/hours into water boiler.

4.2.2 Primary Glycol Loop

Loss coolant recirculation (pumps fail) will result in water boiler freezeup in _____ minutes and equipment overheating in _____ minutes.

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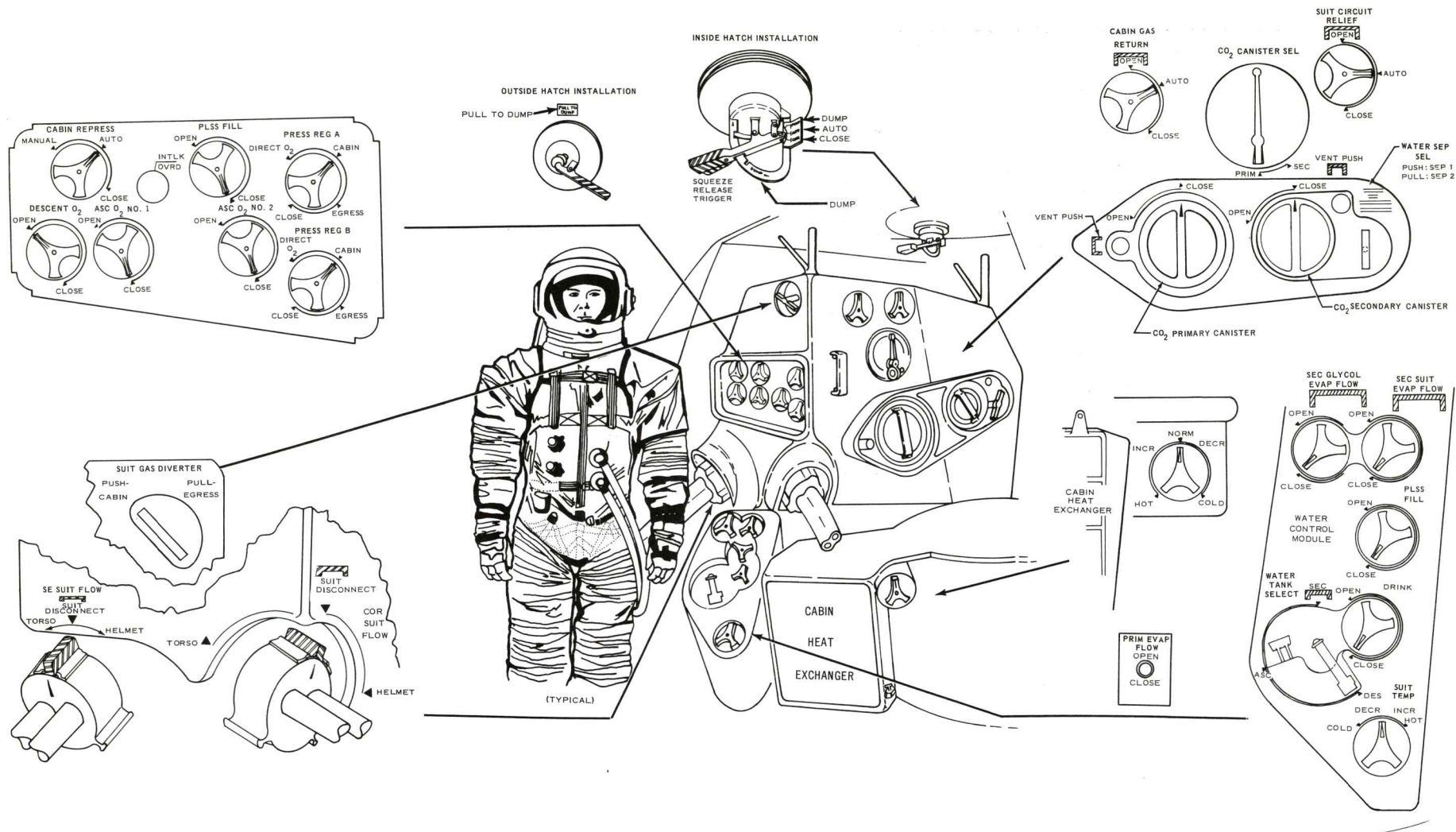


FIGURE 4-4 ENVIRONMENTAL CONTROL MODULE LAYOUT

ECS SYSTEMS DATA

EQUIPMENT

DATA

WATER SUPPLY SECTION

1. H₂O REGULATORS

A. MAX. FLOW RATE = .85 LB/MIN

GLYCOL LOOP

1. COOLANT

A. 35% ETHYLENE GLYCOL AND 65% H₂O
 B. QUANTITY PRIMARY LOOP = 44 LBS
 C. NOMINAL FLOW RATE = 340 LBS/HR
 D. SPECIFIC HEAT = 0.870 BTU/LB-F° AT 75°F

2. PUMP(S)

A. 5.65 LBS/MIN AT 42°F AND $\Delta P = 34$ PSID
 B. PAD DISCHARGE PRESSURE ≈ 55.0 PSIA
 C. NOMINAL PUMP $\Delta P \approx 34$ PSID
 D. NOMINAL PUMP DISCHARGE PRESSURE ≈ 42 PSIA

3. PUMP RELIEF VALVES

A. CRACK = 33 PSID, FULL OPEN = MAX 36.0 PSID,
 RESEAT = 32 PSID

4. WATER BOILER

A. MAXIMUM CAPACITY = 17,000 BTU/HR
 B. MINIMUM LOAD (TO PREVENT FREEZEUP) =
 400 BTU/HR
 C. THE POSSIBILITY OF FREEZEUP EXISTS BELOW
 HEAT LOAD OF 800 BTU/HR
 D. MAX. H₂O PRESS. APPROX. 6.5 PSIA, MINIMUM
 ALLOWABLE H₂O PRESS. = 2.5 PSIA

5. GLYCOL TEMPERATURE

A. ESTIMATED NOMINAL TEMP BAND FOR GF9998U
 HIGH = 46 °F LOW = 36 °F
 B. NORMAL MAXIMUM INLET TEMP OF LOW TEMP
 ELECTRONICS = 50°F
 C. GF9998U READING 47°F IS INDICATION THAT
 INLET TEMP OF THE LOW TEMP ELECTRONICS
 IS APPROACHING UPPER LIMIT.

6. GLYCOL ACCUMULATOR
(SEE FIG. 4-3)

A. 95% FULL ACCUMULATOR = 8.49 $\pm$.42 PSIA PUMP
 INLET PRESSURE.
 B. 50% LEVEL = 5.16 $\pm$.28 PSIA PUMP INLET
 PRESSURE.
 C. GLYCOL LEVEL AT 10 $\pm$ 5% WILL TRANSMIT A
 DISCRETE SIGNAL (GLY LOW GF2041X).

ECS CONSUMABLES

TANK	VOLUME FT ³	CAPACITY				ACTUAL LOADING				RESIDUAL	
		QUANTITY		PRESSURE PSIA	TEMPERATURE °F	QUANTITY		PRESSURE PSIA	TEMPERATURE °F	QUANTITY	
		LBS	%			LBS	%			LBS	%
A/1 H ₂ O	0.910 ¹	42.3	100 ²	43.0	80					1.00	2.35
A/2 H ₂ O	0.910 ¹	42.3	100 ²	43.0	80					1.00	2.35

HEAT CONVERSION

1. 1KWH = 3413 BTU
2. 1LB OF H₂O REJECTS $\approx$ 1025 BTU
3. ESTIMATED BTU LOAD IS SHOWN ON FIG. 4-2.
(TBD)

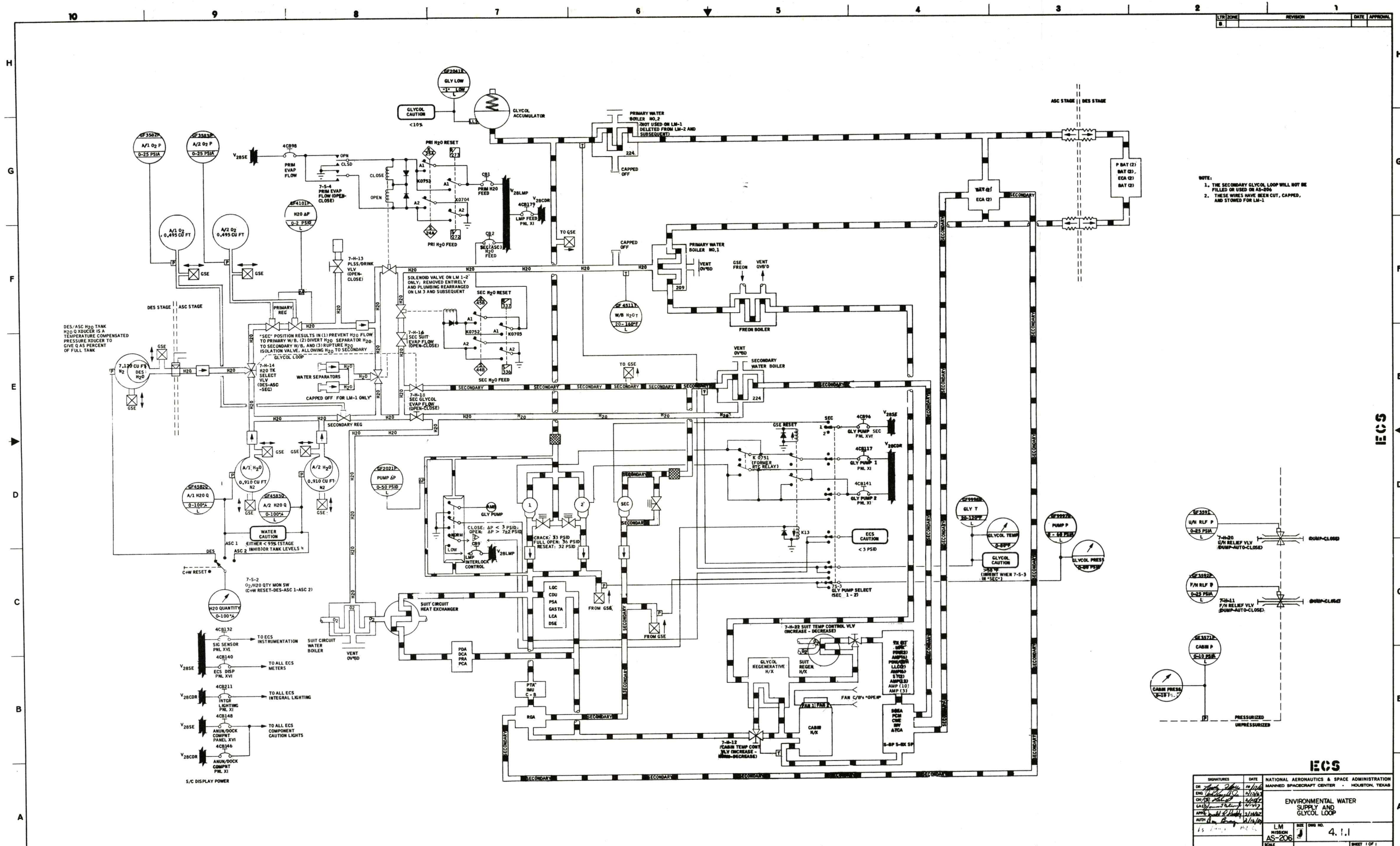
WATER USAGE

1. AVERAGE USAGE FOR HEAT REJECTION = 4.0
TO 5.0 LB/HR
2. ESTIMATED WATER USAGE PROFILE IS SHOWN
ON FIG. 4-1. (TBD)

1. THIS INCLUDES H₂ + WATER VOLUME
2. ANY WATER QUANTITY UP TO THIS FIGURE MAY BE LOADED AND THE MEASURING DEVICE ADJUSTED
TO INDICATED 100%.

ECS SWITCH AND VALVE POSITION AT LIFTOFF

SWITCH NO.	NAME	POSITION
7-S-2	O ₂ /H ₂ O QTY MON SW	ASC # 1
7-S-3	GLY PUMP SELECT	NO. 1
7-S-4	PRIM FEED	NUETRAL
7-H-13	PLSS/DRINK VLV	CLOSE
7-H-14	H ₂ O TK SELECT VLV	ASCENT
7-H-16	SEC SUIT EVAP FLOW	OPEN
7-H-16	SEC GLY EVAP FLOW	CLOSE
7-H-12	CABIN TEMP CONT VLV	COLD
7-H-12	SUIT TEMP CONT VLV	COLD
7-H-22	F/H RELIEF VLV	AUTO
7-H-11	U/H RELIEF VLV	AUTO
7-H-20		
4CB96	GLY PUMP SEC	OPEN
4CB98	PRIM EVAP FLOW	OPEN
CB1	PRIM H ₂ O FEED	CLOSE
CB2	SEC H ₂ O FEED	CLOSE
4CB179	LMP FEED	CLOSE
4CB140	ECS DISP	OPEN
4CB211	INTGR LIGHTING	OPEN
4CB146	ANUN/DOCK COMPNT	OPEN
4CB146	ANUN/DOCK COMPNT	OPEN
4CB117	GLY PUMP 1	CLOSE
4CB141	GLY PUMP 2	CLOSE
4CB132	SIG SENSOR	CLOSE



SECTION 5
COMMUNICATIONS

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consists of two S-Band transceivers and
ivers, two audio centers, a premodu-
as. For AS-206, the S-Band
g ranging and operational
ight Antenna No. 2 (-z).
n be switched during flight.
installed for LM-1 and
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SECTION 5
COMMUNICATIONS

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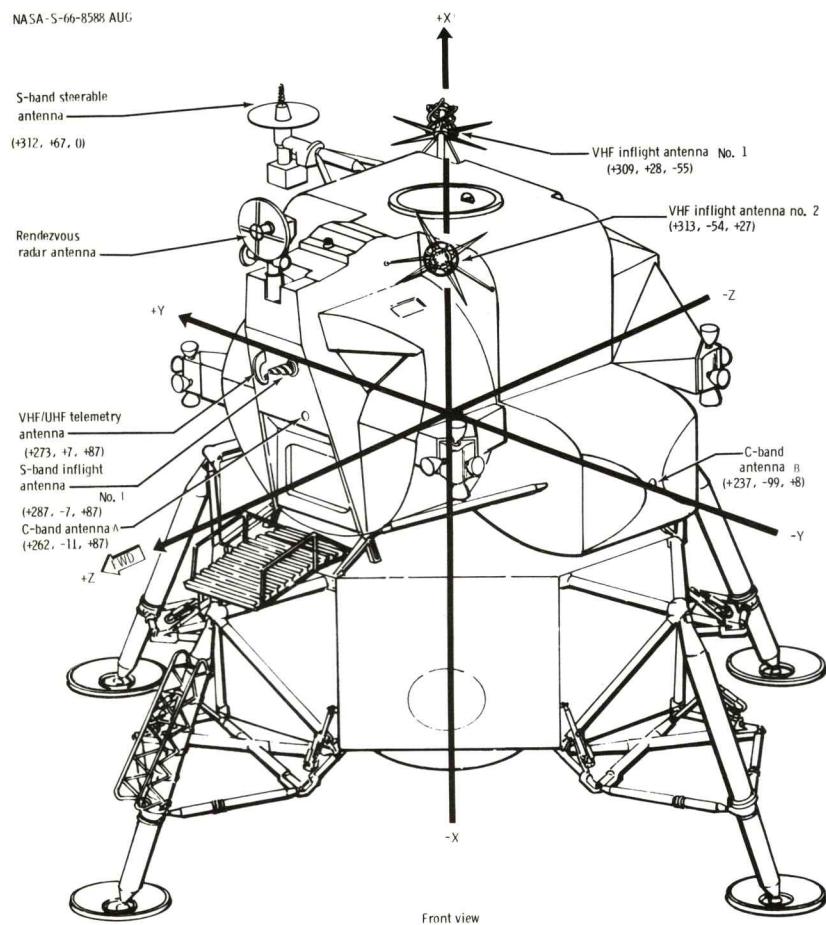
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5.1 SYSTEM DESCRIPTION

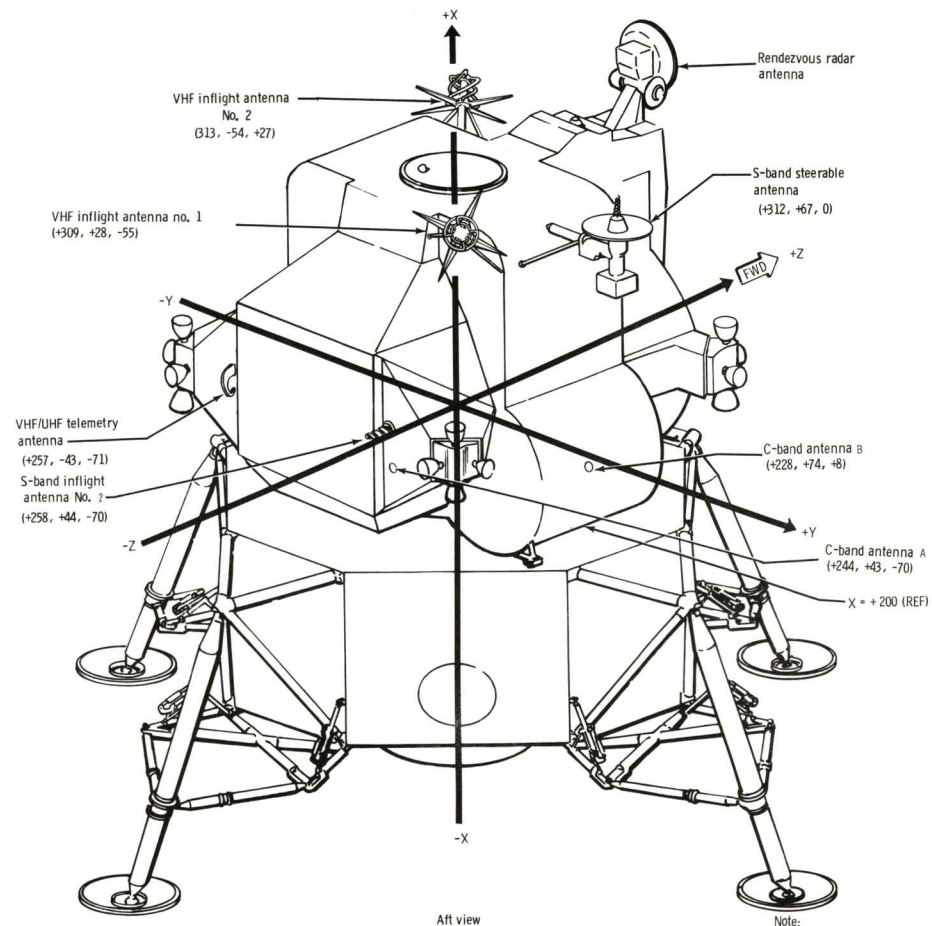
5.1.1 Communications System

The communications system consists of two S-Band transceivers and power amplifiers, two VHF/AM transceivers, two audio centers, a premodulation processor, and associated antennas. For AS-206, the S-Band will provide the capability for performing ranging and operational PCM data transmission using the S-Band Inflight Antenna No. 2 (-z). There is no means by which S-Band antennas can be switched during flight. The operational VHF/AM transceivers will not be installed for LM-1 and the audio centers, while installed, will not be used.

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Front view



Aft view

Note:
All antenna location coordinates are given in inches, rounded off to the nearest inch, and are given in the following order: X, Y, Z.

Figure 5-1 LM-1 communications antenna locations.

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(See Back)

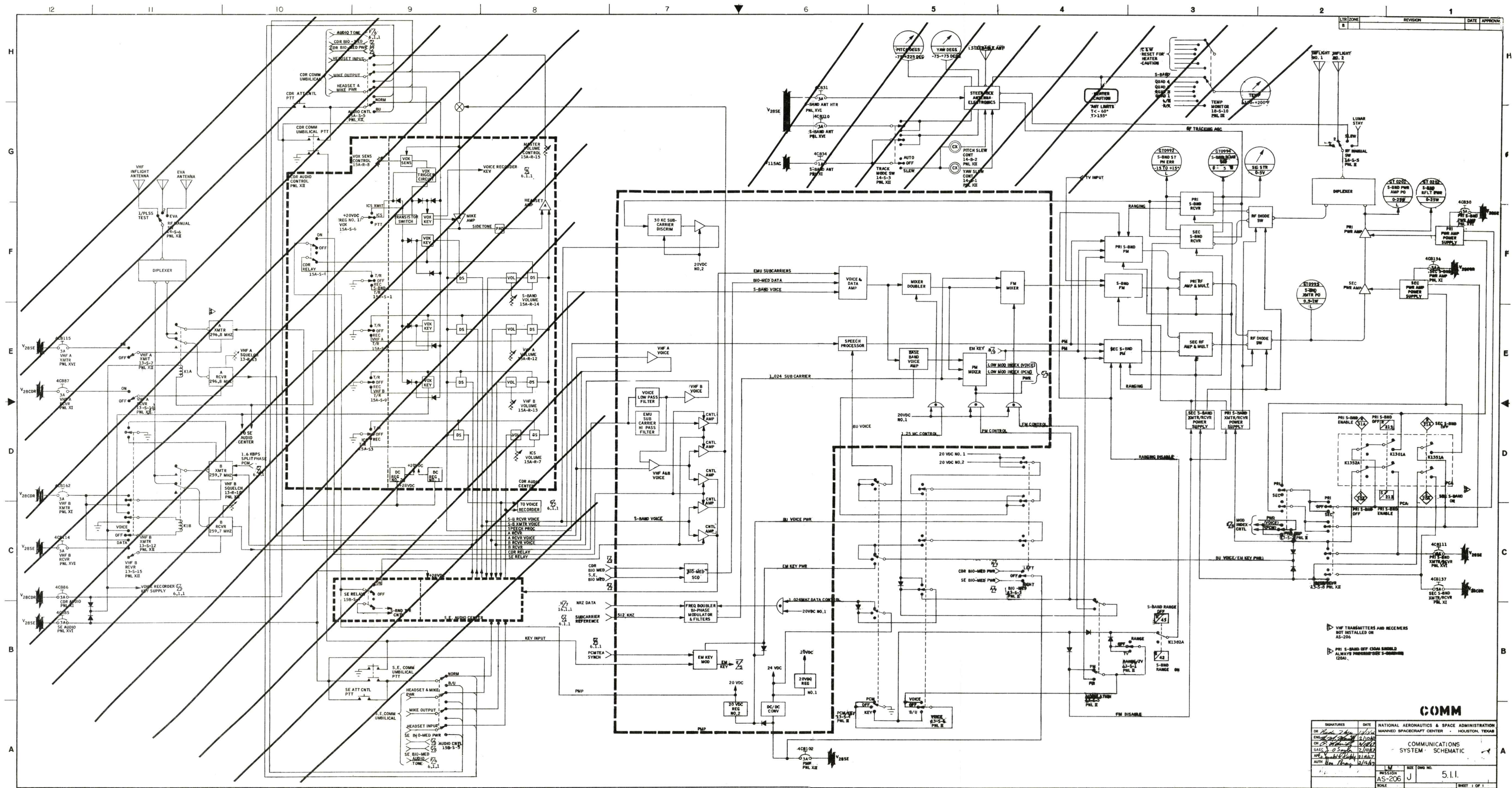
5.2 SYSTEM DATA

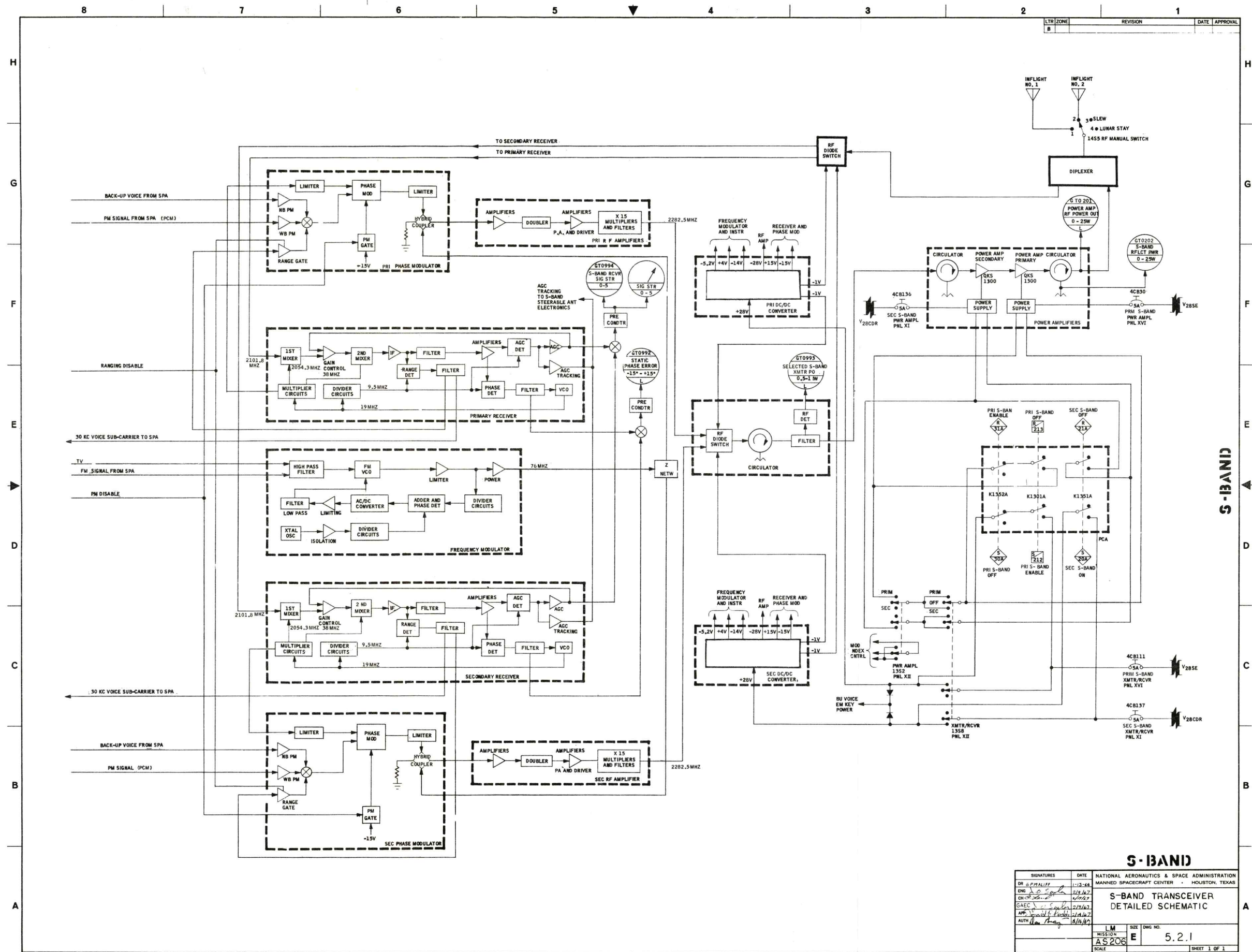
5.2.1 S-BAND

- A. TRANSCEIVER POWER REQUIREMENTS 36 WATTS
- B. RECEIVER CHARACTERISTICS
1. PHASE LOCK RECEIVER
 2. FREQUENCY 2101.8 MHZ
 3. SENSITIVITY -127 dbm
- C. TRANSMITTER CHARACTERISTICS
1. MODULATION PM OR FM
 2. FREQUENCY FM 2282.5 MHZ
PM 240
221 F_R MHZ
 3. RF POWER OUTPUT 0.75 TO 1.5 WATTS
- D. POWER AMPLIFIER CHARACTERISTICS
1. TYPE AMPLITRON (QKS 1300)
 2. RF DRIVE LEVEL 0.72 WATTS (MIN)
 3. RF POWER OUTPUT 20 WATTS
 4. POWER INPUT 68.6 WATTS
- E. THE APPLICATION OF DC POWER TO THE PRIMARY OR SECONDARY POWER AMPLIFIER POWER SUPPLY WILL START AN AUTOMATIC 20 SECOND WARMUP SEQUENCE. AFTER THE WARMUP PERIOD, -1800 VDC IS APPLIED TO THE AMPLITRON ENABLING THE TUBE TO LOCK ON THE INPUT RF SIGNAL. IF THE AMPLITRON FAILS TO LOCK, THE POWER SUPPLY WILL AUTOMATICALLY REVERT TO THE WARMUP MODE AND THE CYCLE WILL BE REPEATED. THE MAXIMUM WARMUP TIME FOR A POWER AMPLIFIER IS 60 SECONDS.

TABLE 5-1 PRELAUNCH STATUS OF SWITCH/CIRCUIT BREAKER POSITIONS

SWITCH NAME	NUMBER	POSITION
AUDIO CONT	15A-S-5 AND 15B-S-5	NORM
S-BAND T/R	15A-S-1 AND 15B-S-1	OFF
ICS T/R	15A-S-3 AND 15B-S-3	OFF
RELAY	15A-S-4 AND 15B-S-4	OFF
S-BND RCVR VOL	15A-R-14 AND 15B-R-14	CCW
ICS RCVR VOL	15A-R-7 AND 15B-R-7	CCW
VOX ICS/XMTR	15A-S-6 AND 15B-S-6	PTT
VHF A T/R	15A-S-2 AND 15B-S-2	OFF
VHF B T/R	15A-S-9 AND 15B-S-9	OFF
VOX SENS	15A-R-8 AND 15B-R-8	CCW
VHF A VOL	15A-R-12 AND 15B-R-12	CCW
VHF B VOL	15A-R-13 AND 15B-R-13	CCW
MASTER VOL	15A-R-15 AND 15B-R-15	CCW
MODULATOR	13-S-5	PM
S-BND XMTR/RCVR	13-S-8	OFF
PWR AMP	13-S-2	OFF
VOICE/BU VOICE	13-S-6	OFF
PCM/KEY	13-S-4	PCM
RANGE/TV	13-S-1	OFF
VHF A XMTR	13-S-7	OFF
VHF A RCVR	13-S-10	OFF
VHF B XMTR	13-S-12	OFF
VHF B RCVR	13-S-15	OFF
BIOMED	13-S-3	OFF
SQUELCH VHF A	13-R-10	CCW
SQUELCH VHF B	13-R-15	CCW
VHF RF SW	14-S-6	1
S-BND RF SW	14-S-5	2
RECORDER	13-S-11	OFF
TRACK MODE	14-S-3	OFF
<u>CIRCUIT BREAKER NAME</u>		
S-BAND ANT HTR	4CB31	OPEN
S-BAND ANT	4CB34	OPEN
SEC S-BND XMTR/RCVR	4CB137	CLOSED
SEC S-BND PWR AMP	4CB136	CLOSED
VHF A RCVR	4CB87	OPEN
VHF B XMTR	4CB162	OPEN
CDR AUDIO	4CB86	OPEN
SE AUDIO	4CB85	OPEN
VHF A XMTR	4CB715	OPEN
VHF B RCVR	4CB114	OPEN
PRI S-BND PWR AMP	4CB30	CLOSED
PRI S-BND XMTR/RCVR	4CB111	CLOSED
S-BND ANT	4CB110	OPEN
PMP	4CB102	CLOSED
TV	4CB104	OPEN
DISP	4CB153	OPEN





assemblies
and
pressurized

to plug-in
of a common
includes a pre-regulator,
regulator and an isolated
electronics to condition
based on the design

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Assembly (C&WEA)

onauts with a rapid check of LM sub-
monitoring critical subsystem parameters
the LM mission. The astronauts receive

SECTION 6
INSTRUMENTATION

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6.1 SYSTEM DESCRIPTION

The Instrumentation Subsystem consists of the following units:

- A. Sensors (Transducers)
- B. Signal Conditioning Electronics Assembly (SCEA)
- C. Caution and Warning Electronics Assembly (C&WEA)
- D. Pulse Code Modulation and Timing Electronics Assembly (PCMTEA)
- E. Data Storage Electronics Assembly (DSEA)

6.1.1 Sensors (Transducers)

All sensors are permanently installed in the LM. They are utilized to sense such physical data as temperature, pressure, switch position, valve position, frequency, voltage, and current. This physical data is converted to electrical signals and sent to the SCEA, PCMTEA, C&WEA, and/or displays.

6.1.2 Signal Conditioning Electronics Assembly (SCEA)

The SCEA is divided into two electronic replaceable assemblies (ERA's). The ERA's are located in the ascent stage of the LM and are mounted on cold rails in the aft equipment bay (an unpressurized area).

Each ERA has space for mounting up to twenty-two plug-in replaceable subassemblies. Each subassembly consists of a common section and signal channels. The common section includes a pre-regulator, a 10 kc oscillator power supply, a 1.8 kc oscillator and an isolated power supply. The signal channels include all electronics to condition data signals for PCM. The subassemblies are based on the design configurations noted in Table 6-1.

6.1.3 Caution and Warning Electronics Assembly (C&WEA)

The C&WEA provides the astronauts with a rapid check of LM subsystem status by continually monitoring critical subsystem parameters during the manned phases of the LM mission. The astronauts receive

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TABLE 6-1 ANALOG SUBASSEMBLIES

SUB ASSY	FUNCTION	INPUTS		CHANNEL	REMARKS
		BI-POLAR	UNI-POLAR	AVAILABILITY	
501-1	DC AMP	-100 MV TO +100 MV -2.5 V TO +2.5 V	0 TO +200 MV 0 TO +5.0 V	4 SINGLE CHANNELS	RECEIVES ANALOG VOLTAGES AND CONDITIONS THEM TO A ZERO TO +5.0 VDC FULL SCALE OUTPUT.
502-2	ATTENUATOR	-20 VDC TO +20 VDC -2.5 VDC TO +2.5 VDC	0 TO +40 VDC 0 TO +5.0 VDC	4 SINGLE CHANNELS	PROVIDES ISOLATION AND ATTENUATES INPUT SIGNAL TO A ZERO TO +5.0 VDC OUTPUT.
503-2	AC TO DC CONVERTER	0 TO 21 VOLTS RMS 0 TO 31 VOLTS RMS 0 TO 100 VOLTS RMS 0 TO 150 VOLTS RMS		3 SINGLE CHANNELS	FULL SCALE OUTPUT (5.0 VDC)
504-1	ANALOG BUFFER	0 TO 5 VDC		4 SINGLE CHANNELS	UNITY GAIN DEVICE
504-2	DISCRETE BUFFER	DISCRETE SWITCH CLOSURE		10 DUAL CHANNELS	OUTPUT IS A STEP VOLTAGE BETWEEN 4 AND 6 VDC FOR "ON" AND 0+.5 VDC FOR "OFF". -0
504-3	DISCRETE BUFFER	DISCRETE SWITCH CLOSURE		12 DUAL CHANNELS	OUTPUT IS A STEP VOLTAGE BETWEEN 4 AND 6 VDC FOR "ON" AND 0+.5 VDC FOR "OFF". -0
504-4	DISCRETE BUFFER	DISCRETE SWITCH CLOSURE		12 DUAL CHANNELS AND SOLID STATE SW CLOSURES	ONE OUTPUT IS A STEP VOLTAGE BETWEEN 4 AND 6 VDC FOR "ON" AND 0+.5 VDC FOR "OFF". -.1 OTHER OUTPUT IS A SOLID STATE SW CLOSURE USED NORMALLY FOR FLAG INDICATORS.
504-5	DISCRETE BUFFER	DISCRETE SWITCH CLOSURE		12 CHANNELS SINGLE STEP	OUTPUT IS A STEP VOLTAGE BETWEEN 4 AND 6 VDC FOR "ON" AND 0+.5 VDC FOR "OFF". -.1
505-1	FREQUENCY TO DC CONVERTER	20 TO 130 VOLTS RMS WITH FREQUENCY VARIATIONS BETWEEN 380 AND 420 CPS		3 SINGLE CHANNELS	OUTPUT OF ZERO VOLTS DC WILL CORRESPOND TO 380 CPS AND +5 VDC WILL CORRESPOND TO 420 CPS.
506-2,3	RESISTANCE TO DC CONVERTER	BRIDGE UNBALANCE ERRORS OF 0 TO 130 MV		4 DUAL CHANNELS	CONVERTS A RESISTANCE CHANGE TO A 0 TO +5.0 VDC OUTPUT
507-1	PHASE DEMODULATOR	15 TO 26 VOLTS RMS		4 SINGLE CHANNELS	COMPARES INPUT PHASE AND AMPLITUDE WITH A REFERENCE SIGNAL AND PRODUCES A 0-5 VDC OUTPUT AS COMPARED TO THE REFERENCE.

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visual caution*, warning*, flag and/or indicator closures.

The C&WEA is capable of handling data in the form of analog signals, discrete voltage levels and switch closures. The C&WEA can evaluate this data and determine if the input signals are within the prescribed limits, and provide caution, warning, flag, advisory, and telemetry relay closures as required; there are three types of analog signal evaluation:

1. High limit - voltage above a specified value
2. Low limit - voltage below a specified value
3. Bandpass - voltage above or below a specified value

The C&WEA is also capable of processing inhibits which allow the C&WEA logic to ignore out-of-tolerance conditions when it is desirable to do so.

6.1.4 Pulse Code Modulation and Timing Electronics Assembly (PCMTEA)

A. The PCMTEA consists of the following components:

1. Analog multiplexer drivers
2. High-level analog multiplexer
3. Calibrator
4. Analog-to-digital converter (coder)
5. Programmer
6. Digital multiplexer
7. Output register
8. Power supply
9. Timing equipment

B. Input signals for the PCM equipment are of three types:

high-level analog, parallel digital, and serial digital.

Some parallel digital and high-level analog inputs are supplied directly to the PCMTEA from subsystem sensors; all other signals are first processed through the SCEA.

* Definitions:

Caution - Malfunctions not requiring immediate attention but which would affect crew safety if action is not taken. Malfunctions in subsystems which time share displays. Malfunctions in subsystems whose displays are not readily visible to the astronaut.

Warning - Malfunctions that affect crew safety and require immediate attention.

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- C. The PCM equipment accepts the high-level analog signals through the multiplexer. The multiplexer forms pulse-amplitude-modulated (PAM) outputs representative of the analog inputs. The high-level PAM outputs of the multiplexer are supplied to high-speed gates (see Table 6-5) for application to the analog-to-digital converter on command from the programmer.
- D. The calibrator supplies two precision voltage outputs (4.25 and 0.75 volts dc) to the multiplexer to ensure that overall accuracy of data is maintained through the PCMTEA.
- E. The analog-to-digital converter converts the high-level PAM outputs of the high-speed gates into eight-bit binary words. For a zero-volt input, the converter generates the binary equivalent of a decimal 1(00000001). Each additional 19.7 millivolts of input signal increases the binary output by one; therefore, with a 5.00 volt dc input, the binary output will be 254 (11111110). For an input exceeding 5 volts dc, the binary output will be all ones (11111111); for an input less than 0 Vdc, the binary output will be all zeros (00000000).
- F. The programmer generates the necessary commands for analog and digital data sampling and operations, and supplies the basic timing for data transfer and subcarrier frequencies required in the PCMTEA as well as other subsystems. The programmer selects the high-bit rate or low-bit rate data-sampling formats by actuating Switch 13S13.
- G. The output of the analog-to-digital converter is supplied to the digital multiplexer. This multiplexer gates the analog-to-digital converter outputs, along with the frame synch and format identification words from the programmer and the serial digital and parallel digital data from the SCEA or from the subsystem sensors, to the output register. When these data exceed eight bits per word, the most significant eight bits

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are gated to the output first and then followed by the next most significant eight bits. The register converts these eight-bit words (parallel by bit) to serial outputs and routes them to the Communications Subsystem. These data are sampled and routed to the Communications Subsystem in non-returned-to-zero (NRZ) format at 51,200 bits per second (high bit rate) or 1,600 bits per second (low-bit rate), and split phase (RZ) format at 1,600 bits per second. Data generated by the LM Guidance Computer (LGC) in the Primary Guidance, Navigation, and Control (PGN&C) Subsystem are supplied to the output register in a 40-bit serial word format. Data generated by the Abort Guidance Computer (AGS) are supplied to the output register in a 24-bit serial word format.

- H. The timing equipment consists of an oscillator component, timing generator, time accumulator, and an output buffer. The oscillator component accepts a 1024 kc signal from the LGC, frequency doubles it, and routes it to the timing generator. The frequency doubled 1024 kc LGC signal also controls the output of an internal 2048 kc crystal oscillator. Therefore, if the LGC signal fails, the oscillator component can instantaneously switch to the crystal oscillator signal without any interruption of the signal to the timing generator.

The timing generator supplies sync pulses to the Electrical Power Subsystem, the Guidance, Navigation, and Control Subsystem, and the Communications Subsystem via the output buffer. It also supplies the time accumulator with a 1 cps signal that is converted to mission-elapsed-time data. The time accumulator recycles to zero at 40 days or upon interruption of PCMTEA power. These data are routed to the DSEA (when used) for simultaneous recording with voice.

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The timing generator supplies all the timing signals required in the programmer for generating frame sync, frame identification, and format identification data.

- I. Internally Redundant Measurement Sampling (See Figure 6-1) - Some data words are wired redundantly within their respective multiplexer (analog or digital). This does not, in effect, double the sampling rate for such parameters because the redundant data word loading is spaced unevenly timewise. (Were the time correlation evenly spaced, then sampling would be essentially doubled or supercommutated). Refer to Figure 6-1 for a depiction of the time correlation. An example of this type of parameter would be the battery currents GC1201-1206C. Redundant transducers, which supply duplicate data concerning a particular parameter, are wired to the PCMTE external connector and may be treated as two separate data points. An example of this type of parameter would be GQ3018P and GQ3025P (LM-2 and sub) DPS HE REG PRESS.

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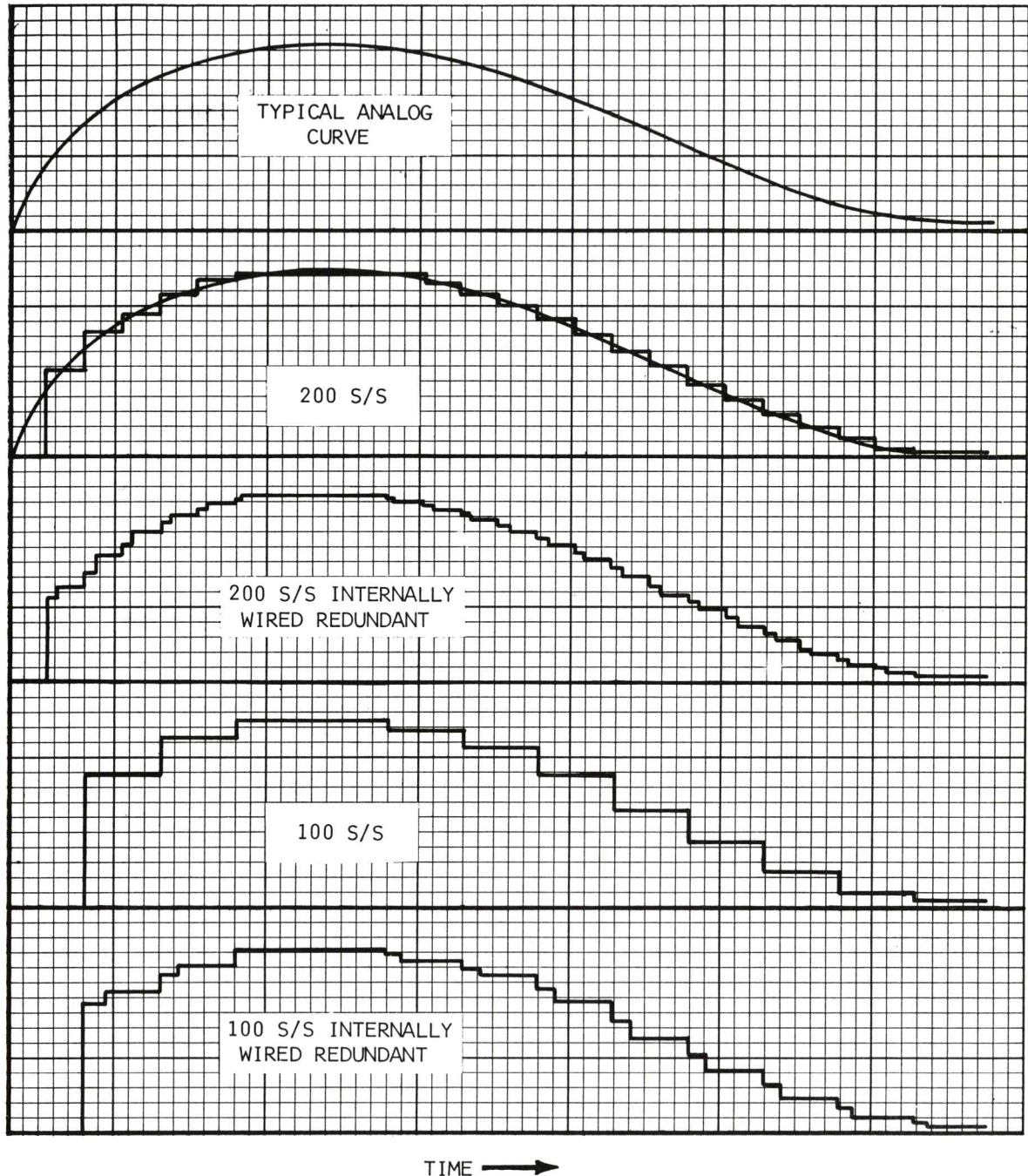


FIGURE 6-1 TIME CORRELATION - INTERNALLY REDUNDANT SAMPLING

TABLE 6-2 STATE OF DESCENT STAGE REAL-TIME ANALOG MEASUREMENTS AFTER STAGING

*

The following measurements will indicate a minimum signal consisting of a PCM word of 00000001.

GC0201	Bat. 1 Volt
GC0202	Bat. 2 Volt
GC0203	Bat. 3 Volt
GC0204	Bat. 4 Volt
GQ3018	DPS He. Reg Press.

The following measurements will indicate a maximum signal consisting of a PCM word of 11111111.

GQ7513	DPS Throat T 3
GQ3718	DPS Fuel 1 Temp
GQ3719	DPS Fuel 2 Temp
GQ4218	DPS Ox 1 Temp
GQ4219	DPS Ox 2 Temp

The PCM word for the following signals will float. The measurement will tend to a minimum value, but may be susceptible to noise.

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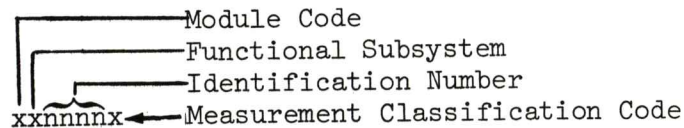
GC1201	Bat. 1 Cur
GC1202	Bat. 2 Cur
GC1203	Bat. 3 Cur
GC1204	Bat. 4 Cur
GQ3603	DPS Fuel 1 Qty
GQ3604	DPS Fuel 2 Qty
GQ3611	DPS Fuel Press.
GQ4103	DPS Ox 1 Qty
GQ4104	DPS Ox 2 Qty
GQ4111	DPS Ox Press.
GQ6510	DPS TCP
GQ6806	Var Inj Act. Pos
GQ3435	DPS He. Press.

TABLE 6-3 SPACECRAFT INSTRUMENTATION

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1. MEAS ID - Measurement identification number as delineated below:



Module Code: A = Adapter - NAA
G = LM GAEC

Functional Subsystem Codes:

- A = Adapter
- C = Electrical Power
- D = Command
- F = Environmental Control
- G = Navigation and Guidance
- H = Stab and Control - CES
- I = Stab and Control - AGS
- L = Instrumentation
- M = Mechanical Design
- N = Radars
- P = Propulsion - Ascent Engine
- Q = Propulsion - Descent Engine
- R = Reaction Control
- T = Communications
- W = Programmer
- Y = Pyrotechnics

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Measurement Classification Codes:

- B = Phase
- C = Current
- E = Power
- F = Frequency
- H = Position
- J = Biomedical
- L = Velocity
- P = Pressure
- Q = Quantity
- R = Rate
- T = Temperature
- U = Combined meas.
- V = Voltage
- W = Time
- X = Discrete Event

2. MEAS DESCRIPTION - A brief "field title" given to each measurement.

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TABLE 6-3 SPACECRAFT INSTRUMENTATION (Cont'd)

3. SENSOR RANGE - Actual range of the transducer utilized for the measurement indicated.
- Low - High: The lowest and highest analog range for each measurement.
- Discretes will be delineated as follows:
- (1) Clsd - Opn: Relay or valve position
 - (2) Off - ON: Status of measurement
 - (3) Absnt - Presnt: Malfunction present or absent
4. TM DATA RANGE - Actual telemetered range of the data to be received by the ground stations.
1. Discretes - "0" or "1" with applicable indication
 2. Analog - Lowest and highest telemetered data range for each analog measurement.
- ACC PCT - Spacecraft telemetered data range Root Sum Square (RSS) accuracy in percent of full scale.
5. ONBOARD DISPLAY RANGE - Indicated range of the spacecraft onboard display.
- ACC PCT - Onboard display Root Sum Square accuracy in percent of full scale.
6. C&W LIMITS - The low and high value of the accuating parameter inputs to the onboard caution and warning instrumentation.
7. ADV - The spacecraft onboard advisory indication; light or flag designation number listed.
8. ESTIMATED NORMAL OPERATING LIMITS - Best engineering estimate of the low, normal, and high limits of the respective analog parameters. Discrete parameters are designated as such.
9. CRITICAL LIMITS - The high and/or low limits of each measurement that will cause permanent loss of equipment and/or life, or mission.
10. S/C SAMPLING - Spacecraft PCMTE data sampling rate using the following code:

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TABLE 6-3 SPACECRAFT INSTRUMENTATION (Concluded)

EXAMPLE: 50/1DPER

Internally wired redundant on high
and low bit rate within the PCMTE
Event
Parallel
Digital
Low-bit rate samples per second
High-bit rate samples per second

NOTE

Where the redundant "R" is shown as
1R/1..... the internal redundancy is
wired for high-bit rate only.

Alphabetic characters utilized to describe the types of input
channels to PCM:

AH = Analog, High-Level
D = Digital
P = Parallel
S = Serial
E = Event

11. NOTES - May contain any other pertinent notation concerning each
respective parameter.

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TABLE 6-3.1 SPACECRAFT INSTRUMENTATION FOR SLA (S-IVB/IU)

MEAS ID	MEAS DESCRIPTION	PAM LOCATION TABLE V PAM NO. - SEQ NO.	SCERA LOCATION TABLE IV SCERA/LOC	TM DATA RANGE			RSS ACC PCT	ONBOARD DISPLAY RANGE		RSS ACC PCT	C&W LIMITS		ADV	ESTIMATED NORMAL OPERATING LIMITS		CRITICAL LIMITS		S/C SAMPLING	NOTES
				LOW	HIGH	UNITS		LOW	HIGH		LOW	HIGH		LOW	HIGH	LOW	HIGH		
K141-900	CAP/SLA PHYS 1			0 = SEP					-		-		-					120 S/S	IU TM
K142-900	CAP/SLA PHYS 2			0 = SEP					-		-		-					120 S/S	IU TM
K143-900	NOSECAP RLY A			1 = RLY CLSD					-		-		-					12 S/S	IU TM
K144-900	NOSECAP RLY B			1 = RLY CLSD					-		-		-					12 S/S	IU TM
K145-900	LM/SLA SEP CMD A			1 = RLY CLSD					-		-		-					12 S/S	IU TM
K146-900	LM/SLA SEP CMD B			1 = RLY CLSD					-		-		-					12 S/S	IU TM
K147-900	SLA DEPLOY CMD A			1 = RLY CLSD					-		-		-					12 S/S	IU TM
K148-900	SLA DEPLOY CMD B			1 = RLY CLSD					-		-		-					12 S/S	IU TM
K149-900	SLA PANEL DEPLOY			1 = DEPLOY					-		-		-					12 S/S	IU TM

TABLE 6-3.2 SPACECRAFT INSTRUMENTATION FOR ELEC/COMM

MEAS ID	MEAS DESCRIPTION	PAM LOCATION TABLE V PAM NO. - SEQ. NO.	SCERA LOCATION TABLE IV SCERA/LOC	TM DATA RANGE				RSS ACC PCT	ONBOARD DISPLAY RANGE		RSS ACC PCT	C&W LIMITS		ADV	ESTIMATED NORMAL OPERATING LIMITS			CRITICAL LIMITS		S/C SAMPLING	NOTES
				LOW	HIGH	UNITS	LOW		HIGH	LOW		HIGH	LOW		NORM	HIGH	LOW	HIGH			
GC0071V	AC BUS VOLT	3-10	1/17 1/18	0	125	VRMS	1.27		GREEN BAND		4.63	112		-	112.5		117			1/1 AH	GL4046 4M2
GC0155F	AC BUS FREQ	3-14	1/16 1/18	380	420	CPG	1.27					398	402	-						1 AH	GL4046
GC0201V	BAT. 1 VOLT	1-8	2/16	0	40	VDC	1.12	20	40	4.47				-	28		32.5		1 AH	4M2	
GC0202V	BAT. 2 VOLT	1-7	2/16	0	40	VDC	1.12	20	40	4.47				-	28		32.5		1 AH	4M2	
GC0203V	BAT. 3 VOLT	1-9	2/16	0	40	VDC	1.12	20	40	4.47				-	28		32.5		1 AH	4M2	
GC0204V	BAT. 4 VOLT	1-7	2/16	0	40	VDC	1.12	20	40	4.47				-	28		32.5		1 AH	4M2	
GC0205V	BAT. 5 VOLT	2-5	2/17	0	40	VDC	1.12	20	40	4.47				-	28		32.5		1/1 AH	4M2	
GC0206V	BAT. 6 VOLT	2-6	2/18	0	40	VDC	1.12	20	40	4.47				-	28		32.5		1/1 AH	4M2	
GC0301V	CDR BUS VOLT	3-12/14	1/15 1/18	0	40	VDC	1.27	20	40	4.6	26.5			-	28		32.5		1/1 AH	4M2 GL4034	
GC0302V	SE BUS VOLT	1-11	2/8 2/15	0	40	VDC	1.50	20	40	4.9	26.5			-	28		32.5		1/1 AH	4M2 GL4034	
GC1201C	BAT. 1 CUR	1-9/3-11	---	0	60	AMPS	1.58	0	120	2.5				-					1/1 AHR	4M3	
GC1202C	BAT. 2 CUR	3-12/1-13	---	0	60	AMPS	1.58	0	120	2.5				-					1/1 AHR	4M3	
GC1203C	BAT. 3 CUR	1-9/3-9	---	0	60	AMPS	1.58	0	120	2.5				-					1/1 AHR	4M3	
GC1204C	BAT. 4 CUR	3-9/10	---	0	60	AMPS	1.58	0	120	2.5				-					1/1 AHR	4M3	
GC1205C	BAT. 5 CUR	1-8/3-11	---	0	120	AMPS	1.58	0	120	2.5				-					1/1 AHR	4M3	
GC1206C	BAT. 6 CUR	1-9/3-9	---	0	120	AMPS	1.58	0	120	2.5				-					1/1 AHR	4M3	
GC4361X	BAT. 1 HI TAP	---	2/4	ALWAYS ZERO										4FL1					1 DPE	BAT HI TAPS WIRED TO LO TAP DISCRETES EM-1 ONLY	
GC4362X	BAT. 1 LO TAP	---	2/4	1 = HI										4FL1					1 DPE		
GC4363X	BAT. 2 HI TAP	---	2/4	ALWAYS ZERO										4FL2					1 DPE		
GC4364X	BAT. 2 LO TAP	---	2/4	1 = HI										4FL2					1 DPE		
GC4365X	BAT. 3 HI TAP	---	2/4	ALWAYS ZERO										4FL3					1 DPE		
GC4366X	BAT. 3 LO TAP	---	2/4	1 = HI										4FL3					1 DPE		
GC4367X	BAT. 4 HI TAP	---	2/4	ALWAYS ZERO										4FL4					1 DPE		
GC4368X	BAT. 4 LO TAP	---	2/4	1 = HI										4FL4					1 DPE		
GC4369X	BAT. 5 B/U CDR	---	2/4	1 = ON										4FL7					1 DPE		
GC4370X	BAT. 6 NORM CDR	---	2/4	1 = ON										4FL6					1 DPE		
GC4371X	BAT. 5 NORM SEQ	---	2/4	1 = ON										4FL5					1 DPE	GL9001 GL4047 GL9001 GL4047 GL9001 GL4047 GL9001 GL4047	
GC4372X	BAT. 6 B/U SEQ	---	2/4	1 = ON										4FL8					1 DPE		
GC9961U	BAT. 1 MAL	---	2/12 2/13	1 = MAL								OC/OT/RC		-					1 DPE		
GC9962U	BAT. 2 MAL	---	2/12 2/13	1 = MAL								OC/OT/RC		-					1 DPE		
GC9963U	BAT. 3 MAL	---	2/12 2/13	1 = MAL								OC/OT/RC		-					1 DPE		
GC9964U	BAT. 4 MAL	---	2/12 2/13	1 = MAL								OC/OT/RC		-					1 DPE		
GC9965U	BAT. 5 MAL	---	2/12 2/13	1 = MAL								OC/OT/RC		-					1 DPE		
GC9966U	BAT. 6 MAL	---	2/12 2/13	1 = MAL								OC/OT/RC		-					1 DPE		
GL0300	FRAME SYNC AND ID	---	---	---										-						50/1 DP	
GL0302	LBR	---	---	---										-						1/1 DP	10R/1 AH 10R/1 AH 10/1 DP 1/1 DPER 1/1 DPER
GL0401V	CAL 85 PCT	3-5/1-4	---	0	5.00	VDC	0.50							-		4.25					
GL0402V	CAL 15 PCT	3-5/4-5	---	0	5.00	VDC	0.50							-		0.75					
GL0501W	MET	---	---	---										-							
GL4054X	C&W PWR FAIL	---	---	1 = FAIL										POWER FAIL							
GL4221X	DFI CAL ON	---	---	1 = ON										-							

TABLE 6-3.2 SPACECRAFT INSTRUMENTATION FOR ELEC/COMM (CONCLUDED)

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MEAS ID	MEAS DESCRIPTION	PAM LOCATION TABLE V		SCERA LOCATION TABLE IV		TM DATA RANGE			RSS ACC PCT	ONBOARD DISPLAY RANGE		RSS ACC PCT	C&W LIMITS		ADV	ESTIMATED NORMAL OPERATING LIMITS			CRITICAL LIMITS		S/C SAMPLING	NOTES
		PAM NO.	SEQ. NO.	SCERA/LOC	LOW	HIGH	UNITS			LOW	HIGH		LOW	HIGH		LOW	NORM	HIGH	LOW	HIGH		
GL4222X	LM/SLA SEP	---	---	---	1	=	SEP				---		---		-		DISCRETE				1 DPE	
GT0201E	S-BND PWR AMP PO	1-14		---	0		25 W								-		18W				1/1 AH	
GT0202E	S-BND RFLT PWR	1-13		---	0		25 W								-		1.8W				1 AH	
GT0441X	DCA STATUS	---		---			---				---		---		-						50 DP	
GT0619V	UHF SIG STR	2-5		---	-114	-59	DBM						---		-		-75DBM		-99DBM		1 AH	
GT0992B	S-BND ST PH ERR	2-14/2-3		---	-15	+15	DEG						---		-						10 AH	
GT0993E	S-BND XMTR PO	1-14		---	0.3	1.5	W						---		-	0.75W		1. SW			1/1 AH	
GT0994V	S-BND SIG STR	3-3		---	0	4.2	VDC		0		5		---		-	0.5		5.0			10 AH	
GY0111X	ED ARM A ON	---		1/14	1	=	ON				---		---		-		DISCRETE				1/1 DPER	
GY0112X	ED ARM B ON	---		1/14	1	=	ON				---		---		-		DISCRETE				1/1 DPER	
GY0121X	STG RLY A FIRE	---		1/14	1	=	FIRE				---		---		-		DISCRETE				1/1 DPER	
GY0122X	STG RLY B FIRE	---		1/14	1	=	FIRE				---		---		-		DISCRETE				1/1 DPER	

TABLE 6-3.3 SPACECRAFT INSTRUMENTATION FOR ECS

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MEAS ID	MEAS DESCRIPTION	PAM LOCATION TABLE V PAM NO. - SEQ. NO.	SCERA LOCATION TABLE IV SCERA/LOC	TM DATA RANGE				ONBOARD DISPLAY RANGE			C&W LIMITS		ADV	ESTIMATED NORMAL OPERATING LIMITS			CRITICAL LIMITS		S/C SAMPLING	NOTES
				LOW	HIGH	UNITS	RSS ACC PCT	LOW	HIGH	RSS ACC PCT	LOW	HIGH		LOW	NORM	HIGH	LOW	HIGH		
GF2021P	PRI GLY PUMP ΔP	1-10/3-9	---	0	50	PSID	1.87	---	---	---	---	---	---	28	---	38	---	---	1/1 AHR	GL4058 NOT TM 7M2A (GL4057 7M4A (GL4057 7M4A
GF2041X	GLY LEVEL LOW	---	2/3	1	=	LOW	---	---	---	---	CC	---	---	DISCRETE			---	---	1/1DPER	
GF2936X	SEL GLY PUMP FAIL	---	---	---	---	---	---	---	---	---	CC	---	7DS3	---	---	---	---	---	---	
GF3571P	CABIN PRESS.	1-9/3-11	---	0	10	PSIA	2.55	0	10	3.20	---	---	---	0	---	5.0	---	---	1/1 AHR	
GF3582P	ASC 1 O ₂ PRESS.	1-14	1/7	0	25	PSIA	2.62	0	100%	---	---	---	---	---	4.35	---	---	---	1 AH	(GL4057 7M4A
GF3583P	ASC 2 O ₂ PRESS.	2-13	1/7	0	25	PSIA	2.62	0	100%	---	---	---	---	---	4.35	---	---	---	1 AH	(GL4057 7M4A
GF3591P	U/H RLF PRESS.	3-15	---	0	25	PSIA	2.55	---	---	---	---	---	---	0	---	5.8	---	---	1/1 AH	R-B (GL4059 7M4B (GL4059 7M4B 7M5A 7M5B (GL4058
GF3592P	F/H RLF PRESS.	1-14	---	0	25	PSIA	2.55	---	---	---	---	---	---	0	---	5.8	---	---	1/1 AH	
GF4101P	PRI H ₂ O REG ΔP	2-12/4-14	1/18	0	2	PSID	3.04	---	---	---	---	---	---	0.5	---	1.0	---	---	1/1 AHR	
GF4511T	PRI W/B H ₂ O TEMP	4-15	2/6	20	160	°F	---	---	---	---	---	---	---	40	---	60	---	---	1/1 AH	
GF4582Q	ASC 1 H ₂ O QTY	2-6/4-8	1/8	0	100	PCT	2.91	0	100	3.49 95	---	---	---	---	---	---	---	---	1/1 AHR	(GL4059 7M4B
GF4583Q	ASC 2 H ₂ O QTY	2-6/4-8	1/8	0	100	PCT	2.91	0	100	3.49 95	---	---	---	---	---	---	---	---	1/1 AHR	(GL4059 7M4B
GF9997U	GLY PUMP PRESS.	3-6	---	0	60	PSIA	2.06	0	80	2.50	---	---	---	32	---	37	---	---	1/1 AH	7M5A
GF9998U	GLY TEMP	3-11	1/10	20	120	°F	2.77	0	80	3.95 47.6	---	---	---	38	---	45	---	---	1/1 AH	7M5B (GL4058

TABLE 6-3.4 SPACECRAFT INSTRUMENTATION FOR GNC

MEAS ID	MEAS DESCRIPTION	PAM LOCATION TABLE V PAM NO. - SEQ NO.	SCERA LOCATION TABLE IV SCERA/LOC	TM DATA RANGE			RSS ACC PCT	ONBOARD DISPLAY RANGE		RSS ACC PCT	C&W LIMITS		ADV	ESTIMATED NORMAL OPERATING LIMITS			CRITICAL LIMITS		S/C SAMPLING	NOTES
				LOW	HIGH	UNITS		LOW	HIGH		LOW	HIGH		LOW	NORM	HIGH	LOW	HIGH		
GG0001X GG0117H	PG-15 CMTR WORD POS ALT (LGC)					---		---			---			---					50 DS	---
GG0118L	VEL ALT RATE (LGC)					---		-700	+700 F/S	(0.5 FT)	---			VARIES					---	NOT TM 9M9B
GG0119L	VEL FWD (LGC)					---		-200	+200 F/S	7.28	---			VARIES					---	NOT TM 9M2/3
GG0120L	VEL LAT (LGC)					---		-200	+200 F/S	7.28	---			VARIES					---	NOT TM 9M2/3
GG1040V	PLS TORQ REF	1-7/3-6		85	135	VDC	4.03				---			120					1 AHR	---
GG1110V	2.5 VDC TM BIAS	2-7/4-7		0	5	VDC	2.06				---			2.5					1R/1 AH	---
GG1201V	IMU 28 VAC 800	2-11		0	31.10	VRMS	4.03				---			28					1/1 AH	---
GG1331V	IRIG SUSP 3.2 KC	2-5		0	31.10	VRMS	4.03				---			28					1/1 AH	---
GG1513X	IMU STBY			1 = STBY							---			DISCRETE					1/1 DPER	---
GG1523X	LGC OPR	---		1 = OPR							---			DISCRETE					1/1 DPER	---
GG2001V	X PIPA OUT IN ϕ	2-1/1-2		-2.5	+2.5	VRMS	4.03				---			VARIES					50 AHR	---
GG2021V	Y PIPA OUT IN ϕ	1-1		-2.5	+2.5	VRMS	4.03				---			VARIES					50 AHR	---
GG2041V	Z PIPA OUT IN ϕ	3-1/2-2		-2.5	+2.5	VRMS	4.03				---			VARIES					50 AHR	---
GG2107V	IG SVO ERR IN ϕ	1-1/2-1		-3	+3	VRMS	4.03				---			VARIES					100 AHR	---
GG2110C	IG TORQ MTR CUR	3-2		-0.5	+0.5	AMPS	4.03				---			VARIES					100 AH	---
GG2112V	IG RSVR OUT SIN	3-5		-20.25	+20.25	VRMS	4.03				---			VARIES					10/1 AH	---
GG2113V	IG RSVR OUT COS	3-4		-20.25	+20.25	VRMS	4.03				---			VARIES					10/1 AH	---
GG2121V	IG RSVR SIN (EXP)	2-2		-5	+5	VRMS	4.03				---			VARIES					100 AH	---
GG2122V	IG RSVR OUT SIN					---		0	28 VRMS		---			VARIES					---	NOT TM 9M1/6
GG2123V	IG RSVR OUT COS					---		0	28 VRMS		---			VARIES					---	NOT TM 9M1/6
GG2137V	MG SVO ERR IN ϕ	3-1/2-1		-3	+3	VRMS	4.03				---			VARIES					100 AHR	---
GG2140C	MG TORQ MTR CUR	3-2		-0.5	+0.5	AMPS	4.03				---			VARIES					100 AH	---
GG2142V	MG RSVR OUT SIN	4-3/2-3		-20.25	+20.25	VRMS					---			VARIES					10R/1 AH	---
GG2143V	MG RSVR OUT COS	1-4/1-5		-20.25	+20.25	VRMS					---			VARIES					1/1 AH	---
GG2151V	MG RSVR SIN (EXP)	2-1		-5	+5	VRMS	4.03				---			VARIES					10 AH	---
GG2152V	MG RSVR OUT SIN					---		0	28 VRMS		---			VARIES					---	NOT TM 9M1/6
GG2153V	MG RSVR OUT COS					---		0	28 VRMS		---			VARIES					---	NOT TM 9M1/6
GG2167V	OG SVO ERR IN ϕ	1-2/2-2		-3	+3	VRMS	4.03				---			VARIES					100 AHR	---
GG2170C	OG TORQ MTR CUR	3-2		-0.9	+0.9	AMPS	4.03				---			VARIES					100 AH	---
GG2172V	OG RSVR OUT SIN	3-4		-20.25	+20.25	VRMS	4.03				---			VARIES					10/1 AH	---
GG2173V	OG RSVR OUT COS	1-3/1-8		-20.25	+20.25	VRMS	4.03				---			VARIES					1/1 AH	---
GG2181V	OG RSVR SIN (EXP)	2-2		-5	+5	VRMS	4.03				---			VARIES					10 AH	---
GG2182V	OG RSVR OUT SIN	---				---		0	28 VRMS		---			VARIES					---	NOT TM 9M1/6
GG2183V	OG RSVR OUT COS	---				---		0	28 VRMS		---			VARIES					---	NOT TM 9M1/6
GG2217V	PITCH ATT ERR (PGNS)	---				---		-30	+30 DEG	3.92	---			VARIES					---	NOT TM 9M1/6

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TABLE 6-3.4 SPACECRAFT INSTRUMENTATION FOR GNC (CONT'D)

MEAS ID	MEAS DESCRIPTION	PAM LOCATION TABLE V PAM NO. - SEQ NO.	SCERA LOCATION TABLE IV SCERA/LOC	TM DATA RANGE			RSS ACC PCT	ONBOARD DISPLAY RANGE		RSS ACC PCT	C&W LIMITS		ADV	ESTIMATED NORMAL OPERATING LIMITS			CRITICAL LIMITS		S/C SAMPLING	NOTES
				LOW	HIGH	UNITS		LOW	HIGH		LOW	HIGH		LOW	NORM	HIGH	LOW	HIGH		
GG2219V	PITCH ATT ERR	4-4	---	-5	+5	VRMS	4.03	---	---	---	---	---	-	---	VARIES	---	---	---	10 AH	---
GG2247V	ROLL ATT ERR (PGNS)	---	---	---	---	---	---	-30	+30 DEG	3.92	---	---	-	---	VARIES	---	---	---	---	NOT TM 9M1/6
GG2249V	YAW ATT ERR	4-5	---	-5	+5	VRMS	4.03	---	---	---	---	---	-	---	VARIES	---	---	---	10 AH	---
GG2277V	YAW ATT ERR (PGNS)	---	---	---	---	---	---	-30	+30 DEG	3.92	---	---	-	---	VARIES	---	---	---	---	NOT TM 9M1/6
GG2279V	ROLL ATT ERR	2-4	---	-5	+5	VRMS	4.03	---	---	---	---	---	-	---	VARIES	---	---	---	10 AH	---
GG2300T	PIPA TEMP	1-11/3-14	---	120	140	°F	4.03	---	---	---	---	---	-	120	130	140	---	---	1/1 AHR	---
GG2301T	IRIG TEMP	3-12	---	123	143	°F	4.03	---	---	---	---	---	-	123	133	143	---	---	1 AH	---
GG6020T	PIPA CAL TEMP	1-10	---	0	150	°F	4.03	---	---	---	---	---	-	---	82	---	---	---	1 AH	---
GG9001X	LGC WARNING	---	2/3	1 =	WARNING	---	---	---	---	---	CC	---	-	---	DISCRETE	---	---	---	1/1 DPE	GL4029
GG9002X	ISS WARNING	---	2/3	1 =	WARNING	---	---	---	---	---	CC	---	-	---	DISCRETE	---	---	---	1/1 DPE	GL4030
GG9003X	PGNS CAUTION	---	2/3	1 =	CAUTION	---	---	---	---	---	CC	---	-	---	DISCRETE	---	---	---	1/1 DPE	GL4045
GH1204X	OUT DET	---	2/14	1 =	OUT	---	---	---	---	---	---	---	-	---	DISCRETE	---	---	---	1 DPE	---
GH1214X	AUTO ON	---	2/14	1 =	ON	---	---	---	---	---	---	---	-	---	DISCRETE	---	---	---	1/1 DPE	---
GH1217X	AUTO OFF	---	2/14	1 =	OFF	---	---	---	---	---	---	---	-	---	DISCRETE	---	---	---	1 DPE	---
GH1230X	APS ARM	---	1/3	1 =	ARM	---	---	---	---	---	---	---	-	---	DISCRETE	---	---	---	10 AH	---
GH1240V	X-TRANS CMD	1-3	2/17	-10	+10	VDC	---	---	---	---	---	---	-	---	---	---	---	---	10 AH	---
GH1247V	YAW ERR CMD	1-12/4-4	2/18	-13	+13	VDC	1.12	---	---	---	---	---	-	---	0.5	---	---	---	10 AH	---
GH1248V	PITCH ERR CMD	1-12/2-4	2/18	-13	+13	VDC	1.12	---	---	---	---	---	-	---	0.5	---	---	---	10 AH	---
GH1249V	ROLL ERR CMD	1-13/2-4	2/18	-13	+13	VDC	1.12	---	---	---	---	---	-	---	0.5	---	---	---	10 AH	---
GH1260X	APS ON	---	2/2	1 =	ON	---	---	---	---	---	---	---	-	---	DISCRETE	---	---	---	10 AH	---
GH1283X	ABORT STAGE	---	2/14	1 =	STAGE	---	---	---	---	---	---	---	-	---	DISCRETE	---	---	---	10 AH	---
GH1286X	ENG FIRE OVER- RIDE	---	2/14	1 =	ON	---	---	---	---	---	---	---	-	---	DISCRETE	---	---	---	10 AH	---
GH1301X	DPS ON	---	2/3	1 =	ON	---	---	---	---	---	---	---	-	---	DISCRETE	---	---	---	10 AH	---
GH1311V	MAN THRUST CMD	4-12	1/15	0	14.6	VDC	5.12	0	100%	4.94	---	---	-	---	DISCRETE	---	---	---	10 AH	---
GH1313V	PITCH GDA POS	1-6/3-3	2/9	-15	+15	VRMS	1.50	---	---	---	---	---	-	---	VARIES	---	---	---	10 AH	---
GH1314V	ROLL GDA POS	1-5/4-3	2/9	-15	+15	VRMS	1.50	---	---	---	---	---	-	---	VARIES	---	---	---	10 AH	---
GH1323X	P TRM FAIL	---	2/3	1 =	FAIL	---	---	---	---	---	CC	---	-	---	DISCRETE	---	---	---	10 AH	---
GH1330X	R TRM FAIL	---	2/3	1 =	FAIL	---	---	---	---	---	CC	---	-	---	DISCRETE	---	---	---	10 AH	---
GH1331V	AUTO THRUST CMD	3-15/4-3	1/15	0	12	VDC	5.81	0	{100% } {13.56}	5.50	---	---	-	---	.015	---	---	---	10 AH	---
GH1348X	DPS ARM	---	1/3	1 =	ARM	VDC	---	---	---	---	---	---	-	---	DISCRETE	---	---	---	10 AH	---
GH1401V	RGA SP MTR A-B	---	2/7	---	---	---	---	---	---	---	23 VRMS	29	-	---	---	---	---	---	1 DPE	---
GH1402V	RGA SP MTR B-C	---	2/7	---	---	---	---	---	---	---	23 VRMS	29	-	---	---	---	---	---	---	GL4026
GH1403V	RGA SP MTR C-A	---	2/7	---	---	---	---	---	---	---	23 VRMS	29	-	---	---	---	---	---	---	GL4026
GH1405V	RGA PICKOFF EXCIT	---	1/17	---	---	---	---	---	---	---	26 VRMS	30.8	-	---	---	---	---	---	---	GL4026
GH1406V	+15 VDC SUP	---	2/19	---	---	---	---	---	---	---	14 VDC	16	-	---	---	---	---	---	---	GL4027
GH1407V	-15 VDC SUP	---	2/19	---	---	---	---	---	---	---	-16 VDC	-14	-	---	---	---	---	---	---	GL4027
GH1408V	4.3 VDC SUP	---	2/8	---	---	---	---	---	---	---	3.8 VDC	4.8	-	---	---	---	---	---	---	GL4027
GH1418V	JD 4U OUTPUT	---	1/4	1 =	ON	---	---	---	---	---	---	---	-	---	DISCRETE	---	---	---	200 DPE	GL4031
GH1419V	JD 4D OUTPUT	---	1/4	1 =	ON	---	---	---	---	---	---	---	-	---	DISCRETE	---	---	---	200 DPE	GL4031
GH1420V	JD 4F OUTPUT	---	1/4	1 =	ON	---	---	---	---	---	---	---	-	---	DISCRETE	---	---	---	200 DPE	GL4031

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TABLE 6-3.4 SPACECRAFT INSTRUMENTATION FOR GNC (CONCLUDED)

MEAS ID	MEAS DESCRIPTION	PAM LOCATION TABLE V PAM NO. - SEQ. NO.	SCERA LOCATION TABLE IV SCERA/LOC	TM DATA RANGE			RSS ACC PCT	ONBOARD DISPLAY RANGE		RSS ACC PCT	C&W LIMITS		ADV	ESTIMATED NORMAL OPERATING LIMITS			CRITICAL LIMITS		S/C SAMPLING	NOTES
				LOW	HIGH	UNITS		LOW	HIGH		LOW	HIGH		LOW	NORM	HIGH	LOW	HIGH		
GH1421V	JD 4S OUTPUT	---	1/4	1 = ON	---			---	---				-		DISCRETE				200 DPE	GL4031
GH1422V	JD 3U OUTPUT	---	1/4	1 = ON	---			---	---				-		DISCRETE				200 DPE	GL4031
GH1423V	JD 3D OUTPUT	---	1/4	1 = ON	---			---	---				-		DISCRETE				200 DPE	GL4031
GH1424V	JD 3F OUTPUT	---	1/4	1 = ON	---			---	---				-		DISCRETE				200 DPE	GL4031
GH1425V	JD 3S OUTPUT	---	1/4	1 = ON	---			---	---				-		DISCRETE				200 DPE	GL4031
GH1426V	JD 2U OUTPUT	---	1/2	1 = ON	---			---	---				-		DISCRETE				200 DPE	GL4031
GH1427V	JD 2D OUTPUT	---	1/2	1 = ON	---			---	---				-		DISCRETE				200 DPE	GL4031
GH1428V	JD 2F OUTPUT	---	1/2	1 = ON	---			---	---				-		DISCRETE				200 DPE	GL4031
GH1429V	JD 2S OUTPUT	---	1/2	1 = ON	---			---	---				-		DISCRETE				200 DPE	GL4031
GH1430V	JD 1U OUTPUT	---	1/2	1 = ON	---			---	---				-		DISCRETE				200 DPE	GL4031
GH1431V	JD 1D OUTPUT	---	1/2	1 = ON	---			---	---				-		DISCRETE				200 DPE	GL4031
GH1432V	JD 1F OUTPUT	---	1/2	1 = ON	---			---	---				-		DISCRETE				200 DPE	GL4031
GH1433V	JD 1S OUTPUT	---	1/2	1 = ON	---			---	---				-		DISCRETE				200 DPE	GL4031
GH1461V	RGA YAW RATE	2-3/3-4	2/10	-3.5 +3.5 VRMS	2.74			---	---				-						10/1 AHR	
GH1462V	RGA PITCH RATE	2-3/3-5	2/10	-3.5 +3.5 VRMS	2.74			---	---				-						10/1 AHR	
GH1463V	RGA ROLL RATE	2-3/3-4	2/10	-3.5 +3.5 VRMS	2.74			---	---				-						10/1 AHR	
GH1488V	PR1 -4.7 VDC	---	2/15	---	---			---	---		-5.2	VDC	-4.2	-					---	GL4050
GH1489V	SEC -4.7 VDC	---	2/15	---	---			---	---		-5.2	VDC	-4.2	-					---	GL4050
GH1493V	+6 VDC SUP	---	2/19	---	---			---	---		-5.45	VDC	6.6	-					---	GL4027
GH1494V	-6 VDC SUP	---	2/19	---	---			---	---		-6.6	VDC	-5.4	-					---	GL4027
GH1497V	YAW RGA SIG	---	---	---VRMS	---			-2.8	+2.8	6.00	---	---	---	-					---	9M1/6
GH1498V	PITCH RGA SIG	---	---	---VRMS	---			-2.8	+2.8	6.00	---	---	---	-					---	9M1/6
GH1499V	ROLL RGA SIG	---	---	---VRMS	---			-2.8	+2.8	6.00	---	---	---	-					---	9M1/6
GH1603X	MIN D-SND (INVRS LOGIC)	---	1/3	1 = 0 VDC VDC	---			---	---		---	---	---	-		DISCRETE			1 DPE	INVERSE GRND DIS
GH1608X	AUTO MODE	---	2/14	1 = ON	---			---	---		---	---	---	-		DISCRETE			1 DPE	
GH1609X	ATT HOLD	---	2/14	1 = HOLD	---			---	---		---	---	---	-		DISCRETE			1 DPE	
GH1621X	AGS SEL	---	2/3	1 = SEL	---			---	---		---	---	---	-		DISCRETE			1/1 DPE	
GH1896X	UNBAL CPLS	---	2/14	1 = ON	---			---	---		---	---	---	-		DISCRETE			1 DPE	
GL4026X	CES AC PWR FAIL	---	---	1 = FAIL	---			---	---		---	---	6DS6	-		DISCRETE			1/1 DPER	GH1401-3V GH1405V GH1406-8V GH1492,4V
GL4027X	CES DC PWR FAIL	---	---	1 = FAIL	---			---	---		---	---	6DS7	-		DISCRETE			1/1 DPER	
GW5151V	PRA COMPARE	---	---	1 = COMPARE	---			---	---		---	---	---	-		DISCRETE			50 DPE	
GW5153V	PRA CLOCK ON	---	---	1 = ON	---			---	---		---	---	---	-		DISCRETE			10 DPE	
GY0050X	ABORT CMD	---	1/2	1 = CMD	---			---	---		---	---	---	-		DISCRETE			1/1 DPER	

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TABLE 6-3.5 SPACECRAFT INSTRUMENTATION FOR PROPULSION

MEAS ID	MEAS DESCRIPTION	PAM LOCATION TABLE V PAM NO. - SEQ NO.	SCERA LOCATION TABLE IV SCERA/LOC	TM DATA RANGE			RSS ACC PCT	ONBOARD DISPLAY RANGE			RSS ACC PCT	C&W LIMITS		ADV	ESTIMATED NORMAL OPERATING LIMITS			CRITICAL LIMITS		S/C SAMPLING	NOTES
				LOW	HIGH	UNITS		LOW	HIGH			LOW	HIGH		LOW	NORM	HIGH	LOW	HIGH		
GP0001P	APS HE 1 PRESS.	1-14/2-12	1/3	0	4000	PSIA	1.96	0	4000	1.94	2993.6			-						1/1 AHR	GL4022
GP0002P	APS HE 2 PRESS.	2-9/4-11	1/9	0	4000	PSIA	1.96	0	4000	1.94	2993.6			-						1/1 AHR	10M1 GL4022
GP0025P	APS HE REG PRESS.	3-7	1/8	0	300	PSIA	1.96		-				220.2	-						1/1 AHR	10M1 GL4041
GP0201T	APS HE 1 TEMP	1-11/3-14	2/21	-200	+200	°F	1.78	-200	+200	1.78				-						1/1 AHR	10M1
GP0202T	APS HE 2 TEMP	2-5/4-7	2/21	-200	+200	°F	1.78	-200	+200	1.78				-						1/1 AHR	10M1
GP0318X	APS HE 1 CLSD		1/12	1 = CLSD																1 DPE	
GP0320X	APS HE 2 CLSD		1/12	1 = CLSD																1 DPE	
GP0718T	APS FUEL TEMP	2-13/4-12	1/8	20	120	°F	2.78	40	100	4.97										1/1 AHR	10M4A
GP0908X	APS FUEL LO		2/2	1 = LO																1/1 DPE	GL4042
GP1218T	APS OX TEMP	2-11/4-13	1/8	20	120	°F	2.78	40	100	4.97										1/1 AHR	10M4B
GP1408X	APS OX LO		2/2	1 = LO																1/1 DPE	GL4042
GP1501P	APS FUEL PRESS.	2-8/4-10	1/19	0	250	PSIA	2.15	0	300	2.65	119.75			-						1/1 AHR	GL4022
GP1503P	APS OX PRESS.	2-10/4-9	1/19	0	250	PSIA	2.15	0	300	2.65	119.75			-						1/1 AHR	10M3A GL4022
GP2010P	APS TCP	2-13/3-15	-	0	150	PSIA	2.06		-					-						1/1 AHR	10M3B
GP2997U	APS PROP VLVS ΔPOS		2/14	1 = MISMATCH					-					-						1 DPE 100 DPE	
GP2998U																					
GQ3018P	DPS HE REG PRESS.	4-8	1/19	0	300	PSIA	1.96		-		220		260	-						1/1 AH	GL4023
GQ3309X	DPS HE 1 CLSD		-	1 = CLSD					-					-						1 DPE	
GQ3310X	DPS HE 2 OPN		-	1 = OPN					-					-						1 DPE	
GQ3435P	DPS HE PRESS.	1-6/3-6	-	0	2000	PSIA	1.21	0	2000	1.35				-						1/1 AHR	10M1
GQ3603Q	DPS FUEL 1 QTY	2-9/4-11	-	0	95	PCT	**		SELECTED					-						1R/1 AH	10M5B
GQ3604Q	DPS FUEL 2 QTY	2-10/4-9	-	0	95	PCT	**		SELECTED					-						1R/1 AH	10M5B
GQ3605Q	DPS FUEL QTY SEL		-	-		PCT		0	99	***				-						-	10M5B
GQ3611P	DPS FUEL PRESS.	1-10/3-10	-	0	300	PSIA	1.87	0	300	2.69				-						1/1 AHR	10M3A
GQ3718T	DPS FUEL 1 TEMP	2-7/4-6	1/9	20	120	°F		40	100					-						1 AHR	10M4A
GQ3719T	DPS FUEL 2 TEMP	1/4-13	1/9	20	120	°F		40	100					-						1 AHR	10M4A
GQ4103Q	DPS OX 1 QTY	2-13/4-12	-	0	95	PCT	**		SELECTED					-						1R/1 AH	10M5A
GQ4104Q	DPS OX 2 QTY	2-11/4-15	-	0	95	PCT	**		SELECTED					-						1R/1 AH	10M5A
GQ4105Q	DPS OX QTY SEL		-	-		PCT		0	99	***				-						-	10M5A
												** ACC 0 TO 8 PCT 8 TO 25 PCT 25 TO 95 PCT		1.12% 0.71% 1.12%	*** ACC 0 TO 8% QTY 8 TO 25% QTY 25 TO 95% QTY			1.0% 0.5% 1.0%			

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TABLE 6-3.5 SPACECRAFT INSTRUMENTATION FOR PROPUSION

MEAS ID	MEAS DESCRIPTION	PAM LOCATION TABLE V PAM NO. - SEQ NO.	SCERA LOCATION TABLE IV SCERA/LOC	TM DATA RANGE				RSS ACC PCT	ONBOARD DISPLAY RANGE		RSS ACC PCT	C&W LIMITS		ADV	ESTIMATED NORMAL OPERATING LIMITS		CRITICAL LIMITS		S/C SAMPLING	NOTES
				LOW	HIGH	UNITS	LOW		HIGH	LOW		HIGH	LOW		NORM	HIGH	LOW	HIGH		
GQ4111P	DPS OX PRESS.	1-5/3-7	-	0	300	PSIA	1.87	0	300	2.69	-	-	-	-	-	-	-	1/1 AHR	10M3B	
GQ4218T	DPS OX 1 TEMP	1-5/3-8	1-10	20	120	°F	2.78	40	100	4.97	-	-	-	-	-	-	-	1 AHR	10M4B	
GQ4219T	DPS OX 2 TEMP	1-6/3-8	1-10	20	120	°F	2.78	40	100	4.97	-	-	-	-	-	-	-	1 AHR	10M4B	
GQ4455X	DPS PROP LO	-	2/2	1 = LO	-	-	-	-	-	-	-	-	-	-	-	-	-	1 DPE	GL4024	
GQ6510P	DPS TCP	1-8/3-10	-	0	200	PSIA	1.87	0	100%	3.50	CC	-	-	-	-	-	-	1/1 AHR	9M7A	
GQ6806H	VAR INJ ACT POS	2-14/4-1/4-2	-	0	1	INCH	1.12	-	-	-	-	-	-	-	-	-	-	50 AH		
				0	100	PCT	-	-	-	-	-	-	-	-	-	-	-	1/1 AH		
GQ7498U																				
	DPS PROP VLVS ΔPOS	-	2/14	1 = ON	-	-	-	-	-	-	-	-	-	-	-	-	-	100 DPE		
																		1 DPE		
GQ7499U																				
GQ7511T	DPS THROAT T 1	3-15	-	-100	2000	°F	-	-	-	-	-	-	-	-	-	-	-	1 AH		
GQ7512T	DPS THROAT T 2	2-6	-	-100	2000	°F	-	-	-	-	-	-	-	-	-	-	-	1 AH		
GQ7513T	DPS THROAT T 3	2-7	-	-100	2000	°F	-	-	-	-	-	-	-	-	-	-	-	1/1 AH		
GR1085Q	RCS PROP A QTY	1-12/3-14	-	0	100	PCT	-	-	-	-	-	-	-	-	-	-	-	1R/1 AH		
GR1089T	RCS A HE TEMP	1-12/3-12	2/20	20	120	°F	-	-	-	-	-	-	-	-	-	-	-	1/1 AHR		
GR1095Q	RCS PROP B QTY	1-11/3-13	-	0	100	PCT	-	-	-	-	-	-	-	-	-	-	-	1R/1 AHR		
GR1099T	RCS B HE TEMP	1-13/3-13	2/20	20	120	°F	-	-	-	-	-	-	-	-	-	-	-	1/1 AHR		
GR1101P	RCS A HE PRESS.	2-11/4-14	1/6	0	3500	PSIA	1.96	0	4000	2.60	1696	-	-	-	-	-	-	1/1 AHR	GL4052	
GR1102P	RCS B HE PRESS.	2-12/4-12	1/6	0	3500	PSIA	1.96	0	4000	2.60	1696	-	-	-	-	-	-	1/1 AHR	8M1A	
GR1201P	RCS A REG PRESS.	3-11/4-11	1/6	0	350	PSIA	1.96	0	400	2.60	170	200	-	-	-	-	-	1 AH	GL4032	
GR1202P	RCS B REG PRESS.	4-13	1/6	0	350	PSIA	1.96	0	400	2.60	170	200	-	-	-	-	-	1/1 AH	8M1A	
GR2121T	RCS A FUEL TEMP	2-8	2/20	20	120	°F	2.78	20	120	3.38	-	-	-	-	-	-	-	1/1 AH	GL4033	
GR2122T	RCS B FUEL TEMP	2-8	2/20	20	120	°F	2.78	20	120	3.38	-	-	-	-	-	-	-	1/1 AH	8M1B	
GR2201P	A FUEL MFLD PRESS	1-1/1-7/3-6/4-1	-	0	350	PSIA	1.87	0	400	2.55	-	-	-	-	-	-	-	200 AHR	8M2A	
GR2202P	B FUEL MFLD PRESS	1-5/3-1/3-8	-	0	350	PSIA	1.87	0	400	2.55	-	-	-	-	-	-	-	1R/1AH	8M2B	
GR3201P	A OX MFLD PRESS.	1-7/2-2/3-7	-	0	350	PSIA	1.87	0	400	2.55	-	-	-	-	-	-	-	200 AHR	8M1A	
GR3202P	B OX MFLD PRESS.	1-2/1-6/2-1/3-8	-	0	350	PSIA	1.87	0	400	2.55	-	-	-	-	-	-	-	1R/1AH	8M1B	
GR5031P	TCP 4U	-	-	-	-	-	-	-	-	-	CC	-	-	-	-	-	-	200 AHR	8M1B	
GR5032P	TCP 4D	-	-	-	-	-	-	-	-	-	CC	-	-	-	-	-	-	1R/1AH		
GR5033P	TCP 4F	-	-	-	-	-	-	-	-	-	CC	-	-	-	-	-	-	-	GL4031	
GR5034P	TCP 4S	-	-	-	-	-	-	-	-	-	CC	-	-	-	-	-	-	-	GL4031	
GR5035P	TCP 3U	-	-	-	-	-	-	-	-	-	CC	-	-	-	-	-	-	-	GL4031	
GR5036P	TCP 3D	-	-	-	-	-	-	-	-	-	CC	-	-	-	-	-	-	-	GL4031	
GR5037P	TCP 3F	-	-	-	-	-	-	-	-	-	CC	-	-	-	-	-	-	-	GL4031	
GR5038P	TCP 3S	-	-	-	-	-	-	-	-	-	CC	-	-	-	-	-	-	-	GL4031	
GR5039P	TCP 2U	-	-	-	-	-	-	-	-	-	CC	-	-	-	-	-	-	-	GL4031	

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TABLE 6-3.5 SPACECRAFT INSTRUMENTATION FOR PROPULSION (CONCLUDED)

MEAS ID	MEAS DESCRIPTION	PAM LOCATION TABLE V PAM NO. - SEQ NO.	SCERA LOCATION TABLE IV SCERA/LOC	TM DATA RANGE			RRS ACC PCT	ONBOARD DISPLAY RANGE		RSS ACC	C&W LIMITS		ADV	ESTIMATED NORMAL OPERATING LIMITS			CRITICAL LIMITS		S/C SAMPLING	NOTES
				LOW	HIGH	UNITS		LOW	HIGH		LOW	HIGH		LOW	NORM	HIGH	LOW	HIGH		
GR5040P	TCP 2D	-	-	-	-	-	-	-	-	-	CC	-	-	-	DISCRETE	-	-	-	GL4031	
GR5041P	TCP 2F	-	-	-	-	-	-	-	-	-	CC	-	-	-	DISCRETE	-	-	-	GL4031	
GR5042P	TCP 2S	-	-	-	-	-	-	-	-	-	CC	-	-	-	DISCRETE	-	-	-	GL4031	
GR5043P	TCP 1U	-	-	-	-	-	-	-	-	-	CC	-	-	-	DISCRETE	-	-	-	GL4031	
GR5044P	TCP 1D	-	-	-	-	-	-	-	-	-	CC	-	-	-	DISCRETE	-	-	-	GL4031	
GR5045P	TCP 1F	-	-	-	-	-	-	-	-	-	CC	-	-	-	DISCRETE	-	-	-	GL4031	
GR5046P	TCP 1S	-	-	-	-	-	-	-	-	-	CC	-	-	-	DISCRETE	-	-	-	GL4031	
GR6001T	QUAD 4 TEMP	4-6	1/20	20	200	°F	2.17	-100	200	2.37	36.4	186.7	-	-	-	-	-	1/1 AH	GL4053	
GR6002T	QUAD 3 TEMP	4-7	1/20	20	200	°F	2.17	-100	200	2.37	36.4	186.7	-	-	-	-	-	1/1 AH	GL4053	
GR6003T	QUAD 2 TEMP	4-10	1/20	20	200	°F	2.17	-100	200	2.37	36.4	186.7	-	-	-	-	-	1/1 AH	GL4053	
GR6004T	QUAD 1 TEMP	4-10	1/20	20	200	°F	2.17	-100	200	2.37	36.4	186.7	-	-	-	-	-	1/1 AH	GL4053	
GR9609U	RCS MAIN A CLSD	-	1/12	1 = CLSD	-	-	-	-	-	-	-	-	8FL5	-	DISCRETE	-	-	1/1 DPER	18M1	
GR9610U	RCS MAIN B CLSD	-	1/12	1 = CLSD	-	-	-	-	-	-	-	-	8FL7	-	DISCRETE	-	-	1/1 DPER	18M1	
GR9611U	ASC FEED A OPN	-	1/13	1 = OPEN	-	-	-	-	-	-	-	-	8FL6	-	DISCRETE	-	-	1/1 DPER	18M1	
GR9612U	ASC FEED B OPN	-	1/13	1 = OPEN	-	-	-	-	-	-	-	-	8FL8	-	DISCRETE	-	-	1/1 DPER	18M1	
GR9613U	A/B X-FEED OPN	-	1/13	1 = OPEN	-	-	-	-	-	-	-	-	8FL17	-	DISCRETE	-	-	1/1 DPER	18M1	
GR9661U	4A ISO CLSD	-	1/13 1/14	1 = CLSD	-	-	-	-	-	-	-	-	8FL14	-	DISCRETE	-	-	1 DPE	18M1	
GR9662U	4B ISO CLSD	-	1/13 1/14	1 = CLSD	-	-	-	-	-	-	-	-	8FL16	-	DISCRETE	-	-	1 DPE	18M1	
GR9663U	3A ISO CLSD	-	1/13 1/14	1 = CLSD	-	-	-	-	-	-	-	-	8FL13	-	DISCRETE	-	-	1 DPE	18M1	
GR9664U	3B ISO CLSD	-	1/13 1/14	1 = CLSD	-	-	-	-	-	-	-	-	8FL15	-	DISCRETE	-	-	1 DPE	18M1	
GR9665U	2A ISO CLSD	-	1/13 1/14	1 = CLSD	-	-	-	-	-	-	-	-	8FL10	-	DISCRETE	-	-	1 DPE	18M1	
GR9666U	2B ISO CLSD	-	1/13 1/14	1 = CLSD	-	-	-	-	-	-	-	-	8FL12	-	DISCRETE	-	-	1 DPE	18M1	
GF9667U	1A ISO CLSD	-	1/13 1/14	1 = CLSD	-	-	-	-	-	-	-	-	8FL9	-	DISCRETE	-	-	1 DPE	18M1	
GR9668U	1B ISO CLSD	-	1/13 1/14	1 = CLSD	-	-	-	-	-	-	-	-	8FL11	-	DISCRETE	-	-	1 DPE	18M1	

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TABLE 6-4 SIGNAL CONDITIONING MEASUREMENT ASSIGNMENT

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TABLE 6-5 TELEMETRY VERSUS PAM GATES

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PAM 1						PAM 2						PAM 3						PAM 4						
SEQ	CHANNEL(S)	ELEC/COMM	ECS	GNC	PROP	SEQ	CHANNEL(S)	ELEC/COMM	ECS	GNC	PROP	SEQ	CHANNEL(S)	ELEC/COMM	ECS	GNC	PROP	SEQ	CHANNEL(S)	ELEC/COMM	ECS	GNC	PROP	
1	200AH1 (200AH4) 100AH1 (100AH9) 100AH8 100AH15 50AH1	--	--	GG2107 GG2107 GG2021	GR2201	1	200AH2 (200AH5) 100AH2 100AH9 (100AH1) 100AH16 (100AH3) 50AH2 (50AH5)			GG2151 GG2107 GG2137 GG2001	GR3202	1	200AH3 100AH3 (100AH16) 100AH10 (100AH18) 100AH17 50AH3 (50AH6)	--	--	GG2137 GG2137 GG2041	GR2202	1	200AH4 (200AH1) 100AH4 (100AH12) 100AH11 100AH18 (100AH10) 50AH4	--	--	--	GR2201 -- -- -- GQ6806	
2	200AH5 (200AH2) 100AH5 100AH12 (100AH4) 100AH19 (100AH13) 50AH5 (50AH2)	--	--	GG2167 GG2167 GG2001	GR3202	2	200AH6 100AH6 100AH13 (100AH19) 100AH20 50AH6 (50AH3)			GG2121 GG2167 GG2181 GG2041	GR3201	2	200AH7 100AH7 100AH14 100AH21 50AH7	--	--	GG2170 GG2140 GG2110	--	2	100AH22 50AH8	--	--	--	-- GQ6806	
3	10AH1 10AH8 10AH18 10AH28 10AH37 (10AH13)	--	--	GH1240 -- GG2173 --	--	3	10AH2 10AH9 (10AH40)*** 10AH19 (10AH43) 10AH29 (10AH45) 10AH38 (10AH34)	GT0992		GG2142 GH1461 GH1462 GH1463	--	3	10AH3 10AH10 10AH20 10AH30 10AH39 (10AH15)	GT0994	--	--	-- -- GH1313 --	--	3	10AH4 10AH11 10AH21 10AH31 10AH40 (10AH9)***	--	--	--	-- -- GH1331 GH1314 GG2142
4	10AH12 10AH22 10AH32 10AH41 (10AH26)***	--	--	GG2143 -- -- --	--	4	10AH5 10AH13 (10AH37) 10AH23 10AH33 10AH42 (10AH7)	--	--	GH1249 -- GG2279 GH1248 --	--	4	10AH6 (10AH44) 10AH14 10AH24 10AH34 (10AH38) 10AH43 (10AH19)	--	--	GG2113 GG2172 GH1463 GH1461	--	4	10AH7 (10AH42) 10AH15 (10AH39) 10AH25 10AH35 10AH44 (10AH6)	--	--	--	-- -- GH1247 GG2219 --	
5	1AH3 (1AH48) 1AH7 1AH11 1AH15 (1AH44)*** 1AH19 (1AH29)			GG2143 GH1314 -- GR2202 GQ4111	GQ4218	5	1AH1 1AH5 1AH9 1AH13 (1AH27) 1AH17 (1AH46)	GT0619		GG1331 -- -- -- --	GP0202	5	10AH16 10AH26 (10AH41)*** 10AH36 (10AH27)*** 10AH45 (10AH29)	GG1040 GL0401 GL0402		GG2112 -- GH1462	--	5	10AH17 10AH27 (10AH36)***	GL0402		GG2249		
6	1AH22 1AH26 1AH30 (1AH6) 1AH34 (1AH56) 1AH38 (1AH52)***	--	--	GH1313 -- GQ3435 GQ4219 GR3202	--	6	1AH20 (1AH54) 1AH24 (1AH50) 1AH28 (1AH12) 1AH32 1AH36			GF4582 GF4583 -- -- GC0206	GQ7512	6	1AH2 (1AH49) 1AH6 (1AH30) 1AH10 1AH14 (1AH45)*** 1AH18			GG1040 GF9997 -- -- --	GR3435 GR2201 -- -- --	6	1AH4 (1AH47) 1AH8 1AH12 (1AH28) 1AH16 (1AH43)***	--	--	--	-- -- -- --	
7	1AH41 1AH45 (1AH14)*** 1AH49 (1AH2) 1AH53 (1AH21)*** 1AH57	GC0202		-- -- GG1040 GR3201 --	GR2201	7	1AH39 1AH43 (1AH16)*** 1AH47 (1AH4) 1AH51 (1AH23)*** 1AH55 (1AH31)	--	--	-- -- GG1110 -- --	GQ7513 GQ3718 -- -- --	7	1AH21 (1AH53)*** 1AH25 1AH29 (1AH19) 1AH33 1AH37	--	--	GR3201 -- GQ4111 -- GP0025	--	7	1AH23 (1AH51)*** 1AH27 (1AH13) 1AH31 (1AH55) 1AH35	--	--	--	-- GP0202 GR6002	
8	1AH60 1AH64 1AH68 (1AH102) 1AH72 1AH76 (1AH86)	--	--	-- -- GC1205 GC0201 --	--	8	1AH58 (1AH88) 1AH62 (1AH92) 1AH66 1AH70 1AH74	--	--	-- -- -- -- --	GP1501 GR2121 -- GR2122 --	8	1AH40 1AH44 (1AH15)*** 1AH48 (1AH3) 1AH52 (1AH38)*** 1AH56 (1AH34)	--	--	-- -- GR2202 GQ4218 GR3202 GQ4219	--	8	1AH42 1AH46 (1AH17) 1AH50 (1AH24) 1AH54 (1AH20)	--	--	--	-- -- GF4583 GF4582	
9	1AH79 1AH83 (1AH98) 1AH87 (1AH75) 1AH91 (1AH106) 1AH95 (1AH63)	GC0203		-- -- GF3571 GC1206 GC1201 GC1203	--	9	1AH77 (1AH104)*** 1AH81 (1AH96)*** 1AH85 1AH89 (1AH65) 1AH93 (1AH100)	--	--	-- -- -- -- --	GR3603 -- -- -- GP0002	9	1AH59 (1AH99) 1AH63 (1AH95) 1AH67 (1AH94) 1AH71 1AH75 (1AH87)	GC1203 GC1204 -- -- GC1206		GF2021 -- -- -- --	--	9	1AH61 (1AH105) 1AH65 (1AH89) 1AH69 (1AH101)*** 1AH73 (1AH97)	--	--	--	-- GP1503 GR3604	
10	1AH99 (1AH59) 1AH103 (1AH90) 1AH107 1AH111 1AH115	--	--	GF2021 -- -- -- --	GR3611	10	1AH97 (1AH73) 1AH101 (1AH69)*** 1AH105 (1AH61) 1AH109 1AH113	--	--	-- -- -- -- --	GR3604 GR3604 GP1503 -- --	10	1AH78 1AH82 1AH86 (1AH76) 1AH90 (1AH103) 1AH94 (1AH67)	GC0071 -- GC1204 -- --		GR3611 GR3611 -- -- --	--	10	1AH80 1AH84 1AH88 (1AH58) 1AH92 (1AH62)	--	--	--	-- GR6003 GR6004 -- GP1501	
11	1AH119 (1AH146)*** 1AH123 (1AH166) 1AH127 1AH131 (1AH142) 1AH135 (1AH170)	--	--	GG2300 -- -- -- GP0201	GR1095	11	1AH117 (1AH148) 1AH121 1AH125 (1AH160) 1AH129 (1AH144) 1AH133 (1AH176)***			GG1201 -- GR1101 GP1218 GQ4104	GQ3719	11	1AH98 (1AH83) 1AH102 (1AH68) 1AH106 (1AH91) 1AH110 1AH114	GC1205 GC1201		GF3571 -- -- GF9998 --	GR1201	11	1AH96 (1AH81)*** 1AH100 (1AH93) 1AH104 (1AH77)*** 1AH108 1AH112	--	--	--	-- GP0002 GR3603 -- GR1201	
12	1AH139 1AH143 (1AH134) 1AH147 (1AH130) 1AH151 (1AH162)*** 1AH155			GH1247 GR1089 -- GR1085 GH1248	--	12	1AH137 1AH141 (1AH168) 1AH145 (1AH124) 1AH149 (1AH164)*** 1AH153 (1AH179)	--	--	GF4101 -- -- -- GP0001	--	12	1AH118 1AH122 (1AH167) 1AH126 1AH130 (1AH147) 1AH134 (1AH143)	GC1202 GC0301		GG2301 -- -- -- GR1089	--	12	1AH116 (1AH165)*** 1AH120 (1AH169) 1AH124 (1AH145) 1AH128 1AH132	--	--	--	-- GQ4103 GP0718 GR1102 --	
13	1AH159 1AH163 (1AH154) 1AH167 (1AH122) 1AH171 1AH175	GT0202		-- -- GC1202 -- --	GR1099	13	1AH157 1AH161 (1AH152) 1AH165 (1AH116)*** 1AH169 (1AH120) 1AH173 (1AH178)	--	--	GF3583 -- -- -- --	--	13	1AH138 1AH142 (1AH131) 1AH146 (1AH119)*** 1AH150 1AH154 (1AH163)	--	--	-- -- -- -- GR1099	--	13	1AH136 1AH140 1AH144 (1AH129) 1AH148 (1AH117) 1AH152 (1AH161)	--	--	--	-- GR1202 GP1218 GQ3719 --	
14	1AH179 (1AH153) 1AH183 1AH187 1AH191 1AH195	--	--	GF3592 -- GF3582 -- --	GP0001	14	1AH177 (1AH172) 1AH181 1AH185 1AH189 1AH193	--	--	GT0992 -- -- -- --	--	14	1AH158 1AH162 (1AH151)*** 1AH166 (1AH123) 1AH170 (1AH135) 1AH174	GC0155		GR1085 GG2300 GP0201 GC0301	--	14	1AH156 1AH160 (1AH125) 1AH164 (1AH149)*** 1AH168 (1AH141) 1AH172 (1AH177)	--	--	--	-- GR1101 -- GF4101 --	
												15	1AH178 (1AH173) 1AH182 1AH186 1AH190 1AH194	--	--	GH1331 -- -- GF3591 --	GP2010 GQ7511 -- -- --	15	1AH176 (1AH133)*** 1AH180 1AH184 1AH188 1AH192	--	--	--	-- -- -- -- GF4511	

*LBR
 ***REDUNDANT PBR ONLY
 () REDUNDANT CHANNEL

TABLE 6-6 MEASUREMENTS ON UNREGULATED DC

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CIRCUIT BREAKER 4 CB 132, 3A, SE PNL XVI FUSE ASSEMBLIES AND SENSOR POWER

I. FUSE ASSEMBLY 4A9

FUSE NO.	MEAS NO.	FIELD TITLE
F1	GF3582P	ASC 1 O ₂ PRESS.
2	GF3583P	ASC 2 O ₂ PRESS.
4	GF2741P}	(GLY PUMP PRESS.)
5	GF2921P}	
7	GF4582Q	ASC 1 H ₂ O QTY
8	GF4583Q	ASC 2 H ₂ O QTY
10	GR1101P	RCS A HE. PRESS.
11	GR1102P	RCS B HE. PRESS.
12	GR1201P	RCS A REG PRESS.
13	GR1202P	RCS B REG PRESS.
14	DFI	
15	DFI	
16	DFI	
17	DFI	
18	DFI	
19	DFI	
20	GR3201P	A OX MFLD PRESS.
21	GR3202P	B OX MFLD PRESS.
23	GP0001P	APS HE. 1 PRESS.
24	GP0002P	APS HE. 2 PRESS.
25	GP0025P	APS HE. REG PRESS.
26	GP0908X	APS FUEL LOW
27	GP1408X	APS OX LOW
28	GP1501P	APS FUEL PRESS.
29	GP1503P	APS OX PRESS.
30	GP2010P	APS TCP
32	GQ3018P	DPS HE. REG PRESS.
33	GQ3611P	DPS FUEL PRESS.
34	GQ3435P	DPS HE. PRESS.
35	GQ6510P	DPS TCP
36	GQ4111P	DPS OX PRESS.
39	THROTTLE INSTRUMENTATION REFERENCE POWER	
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II. FUSE ASSEMBLY 4A10
--40 FUSES. (NONE LOADED)

III. ECS FUSE ASSEMBLY

3	GF3571P	CABIN PRESS.
4	GF3591P	U/H RLF PRESS.
5	GF3592P	F/H RLF PRESS.
6	GF2021P	PRI GLY PUMP ΔP
9	GF4101P	PRI H ₂ O REG ΔP

LM
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Rev B

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(See Back)

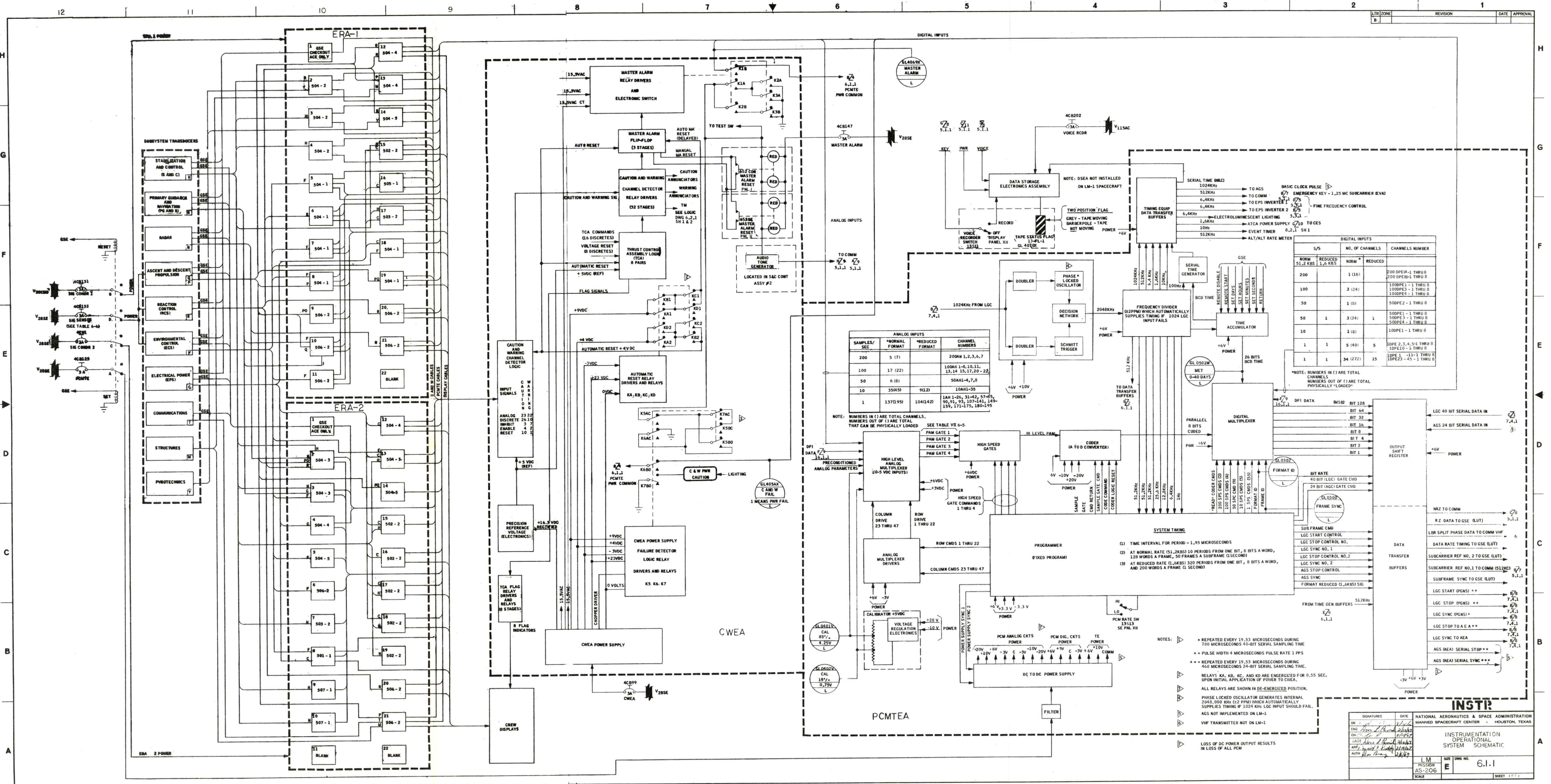
TABLE 6-7 PCMTEA SINGLE POINT FAILURES

FAILURE OF:	DATA LOST
ANALOG MULTIPLEXER SEQUENCER	UP TO 5 ANALOG CHANNELS
ANALOG MULTIPLEXER DRIVER	UP TO 20 ANALOG CHANNELS (4 SEQ)
HIGH-SPEED PAM GATE	UP TO 75 ANALOG CHANNELS
DIGITAL MULTIPLEXER	(1) LOSS OF ALL ANALOG DATA (2) LOSS OF ALL DATA IN SAME BIT POSITION (3) LOSS OF ALL DATA
OUTPUT REGISTER	(1) LOSS OF ALL SERIAL DIGITAL DATA (AGS OR PGNS) (2) LOSS OF ALL DATA
DATA TRANSFER BUFFERS	LOSS OF ALL DATA
PROGRAMMER (1) COUNTERS (2) MATRIX	LOSS OF ALL DATA (1) LOSS OF UP TO 20 ANALOG CHANNELS (2) LOSS OF DIGITAL DATA (3) LOSS OF ALL DATA

TABLE 6-8 PRELAUNCH STATUS OF SWITCH AND CIRCUIT BREAKER POSITIONS

NAME	NUMBER	POSITION
SWITCHES		
MASTER ALARM, CDR	6S2	EXTINGUISHED
MASTER ALARM, SE	6S3	EXTINGUISHED
PCM	13S13	HI
TAPE RECORDER	13S11	OFF
CKT BREAKERS		
TAPE RECORDER	4CB202	OPEN
SIG CONDR 1	4CB131	CLOSED
MASTER ALARM	4CB147	OPEN
PCMTEA	4CB125	CLOSED
C&WEA	4CB899	CLOSED
SIG SENSOR	4CB132	CLOSED
SIG CONDR	4CB1	CLOSED

DWG NO. 6.1.1
DETAIL SHEET NO. 1



FRAME	WD 5	WD 37	WD 69	WD 98	WD 100	WD 101
1	10A04	10A01	10A03	10A05	11A17	10A02
2	10A04	10A05	10A06	10E1	11A17	10A07
3	10A08	10A09	10A10	10E2	11A17	10A11
4	10A12	10A13	10A14	10E3	10E2	10A15
5	10A16	10A17	10A18	10E4	10E3	10A19
6	10A20	10A20	10A21	11A5	11A7	10A22
7	10A23	10A24	10A25	10E5	11A1	10A26
8	10A27	10A28	10A29	10E6	11A7	10A27
9	10A31	10A32	10A33	10E7	10A4	10A30
10	10A35	10A36	10A37	10E8	11E1	10A38
11	10A39	10A39	10A40	10E9	11A5	11A7
12	10A42	10A43	10A44	10E9	11A17	10A45
13	10A46	10A47	10A48	10E10	11A2	10A49
14	10A50	10A51	10A52	10E11	10E3	10A53
15	10A54	10A55	10A56	10E12	11E1	10A57
16	10D7	10A58	10A59	11A5	11A7	10A60
17	10A61	10A62	10A63	10E13	11A17	10A64
18	10A65	10A66	10A67	10E14	10E2	10A68
19	10A69	10A70	10A71	10E15	10E8	10A72
20	10A73	10A74	10E15	10E16	11E1	10A76
21	10A77	10A77	10A77	10A79	10E17	10A79
22	10A80	10A81	10A82	10E17	11A17	10A83
23	10A84	10A85	10A86	10E18	10E12	10A87
24	10A88	10A89	10A90	10E19	10E10	10A91
25	10A92	10A93	10A94	10E20	11E1	10A95
26	10A96	10A97	10A98	11A5	11A7	10A99
27	10A100	10A101	10A102	10E21	11A17	10A103
28	10A104	10A105	10A106	10E22	11A27	10A107
29	10A108	10A109	10A110	10E23	10E24	10A111
30	10A112	10A113	10A114	10E24	11A1	10A115
31	10A116	10A117	10A118	10E25	11A1	10A119
32	10A120	10A121	10A122	10E26	11A1	10A123
33	10A124	10A125	10A126	10E27	11A2	10A127
34	10A129	10A129	10A130	10E28	10E29	10A131
35	10A132	10A133	10A134	10E30	11E1	10A135
36	10A136	10E31	10E32	11A5	11A7	10A139
37	10A140	10A141	10A142	10E33	11A17	10A143
38	10A144	10A145	10A146	10E32	11A27	10A147
39	10A148	10A149	10A150	10E33	10E34	10A151
40	10A153	10A154	10E34	10E35	10E36	10A155
41	10A156	10A157	10A158	11A5	11A7	10A159
42	10A160	10A161	10A162	10E36	11A17	10A163
43	10A164	10A165	10A166	10E37	11A17	10A167
44	10A168	10A169	10A170	10E38	10E39	10A171
45	10A172	10A173	10A174	10E40	11E1	10A175
46	10A176	10A177	10A178	11A5	11A7	10A179
47	10A180	10A181	10A182	10E41	10E42	10A183
48	10A184	10A185	10A186	10E42	11A17	10A187
49	10A188	10A189	10A190	10E43	10E44	10A191
50	10A192	10A193	10A194	10E44	10E45	10A195

HBR FORMAT

	P		P		P		P		P		P		P		P		P		P	
	F		F		F		F		F		F		F		F		F		F	
SYMC	A	SYMC	A	SYMC	A	SYMC & PRIME	A	SEE	A	22E1a	A	22E1b	A	12E1						
51D1e	21	51D1b	21	51D1c	21	4151D1d	51	ABOVE	51	61	71	81								
22A1	A	22A2	A	22A3	A	22A4	A	22A5	A	22A6	A	22A7	A	12E2						
91	101	111	121	131	141	151	161	171	181	191	201									
12A1	A	12A2	A	12A3	A	12A4	A	12A5	A	12A6	A	12A7	A	51E1						
171	181	191	201	211	221	231	241													
12A8	A	12A9	A	12A10	A	12A11	A	12A12	A	12A13	A	12A14	A	51E2						
251	261	271	281	291	301	311	321													
1101A	1101B	1101C	1101D	1101E	1101F	1101G	1101H	1101I	1101J	1101K	1101L	1101M	1101N	1101O	1101P	1101Q	1101R	1101S	1101T	1101U
11A	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40
30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51
22A1	A	22A2	A	22A3	A	22A4	A	22A5	A	22A6	A	22A7	A	12E4						
411	421	431	441	451	461	471	481	491	501	511	521	531	541	551	561	571	581	591	601	611
12A15	A	12A16	A	12A17	A	12A18	A	12A19	A	12A20	A	12A21	A	12A22						
491	501	511	521	531	541	551	561	571	581	591	601	611	621	631	641	651	661	671	681	691
51A1	A	51A2	A	51A3	A	51A4	A	51A5	A	51A6	A	51A7	A	51A8						
571	581	591	601	611	621	631	641	651	661	671	681	691	701	711	721	731	741	751	761	771
11A	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41
31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51
22A1	A	22A2	A	22A3	A	22A4	A	22A5	A	22A6	A	22A7	A	12E2						
791	801	811	821	831	841	851	861	871	881	891	901	911	921	931	941	951	961	971	981	991
12A1	A	12A2	A	12A3	A	12A4	A	12A5	A	12A6	A	12A7	A	51E3						
811	821	831	841	851	861	871	881	891	901	911	921	931	941	951	961	971	981	991		
12A8	A	12A9	A	12A10	A	12A11	A	12A12	A	12A13	A	12A14	A	51E4						
891	901	911	921	931	941	951	961	971	981	991										
51D2	A	SEE ABOVE	A	11A 6 B C	16 16 16	SEE ABOVE	A	SEE ABOVE	A	22E1a	A	22E1b	A	12E5						
971	981	991	41001	1001	1011	1021	1031	1041	1051	1061	1071	1081	1091	1101	1111	1121	1131	1141	1151	1161
22A1	A	22A2	A	22A3	A	22A4	A	22A5	A	22A6	A	22A7	A	12E4						
1091	1101	1111	1121	1131	1141	1151	1161	1171	1181	1191	1201	1211	1221	1231	1241	1251	1261	1271	1281	1291
12A15	A	12A16	A	12A17	A	12A18	A	12A19	A	12A20	A	12A21	A	12A22						
1191	1201	1211	1221	1231	1241	1251	1261	1271	1281	1291	1301	1311	1321	1331	1341	1351	1361	1371	1381	1391
51D51a	A	51D51b	A	51D51c	A	51D51d	A	51D51e	A	51D52a	A	51D52b	A	51D52c	A	51D52d	A	51D52e	A	51D52f
1391	13991	13901	13901	13901	13901	13901	13901	13901	13901	13901	13901	13901	13901	13901	13901	13901	13901	13901	13901	13901

PF PRIME FRAME

A ALL PRIME FRAMES 1-50
B PRIME FRAMES 1, 6, 11—46
C 2,7,12 —47
D 3,8,13 —48
E 4,9,14 —49
F 5,10,15 —50

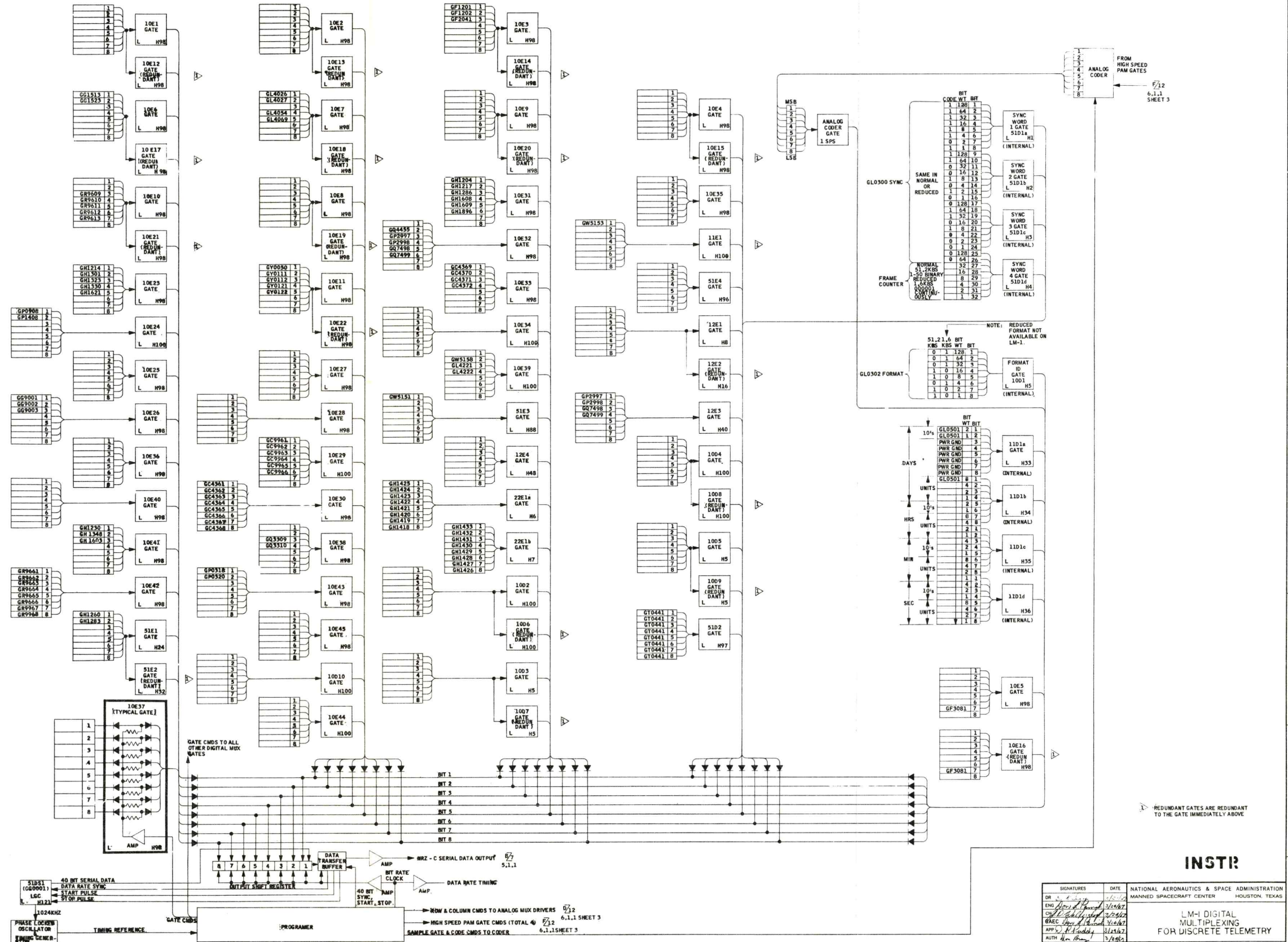
WORD ABBREVIATIONS

*A= ANALOG
*D= DIGITAL PARALLEL
*E= DIGITAL PARALLEL EVENT
*DS= DIGITAL SERIAL

10 = 1 S/S
11 = 10 S/S
12 = 100 S/S
51 = 50 S/S
22 = 200 S/S

EXAMPLE:

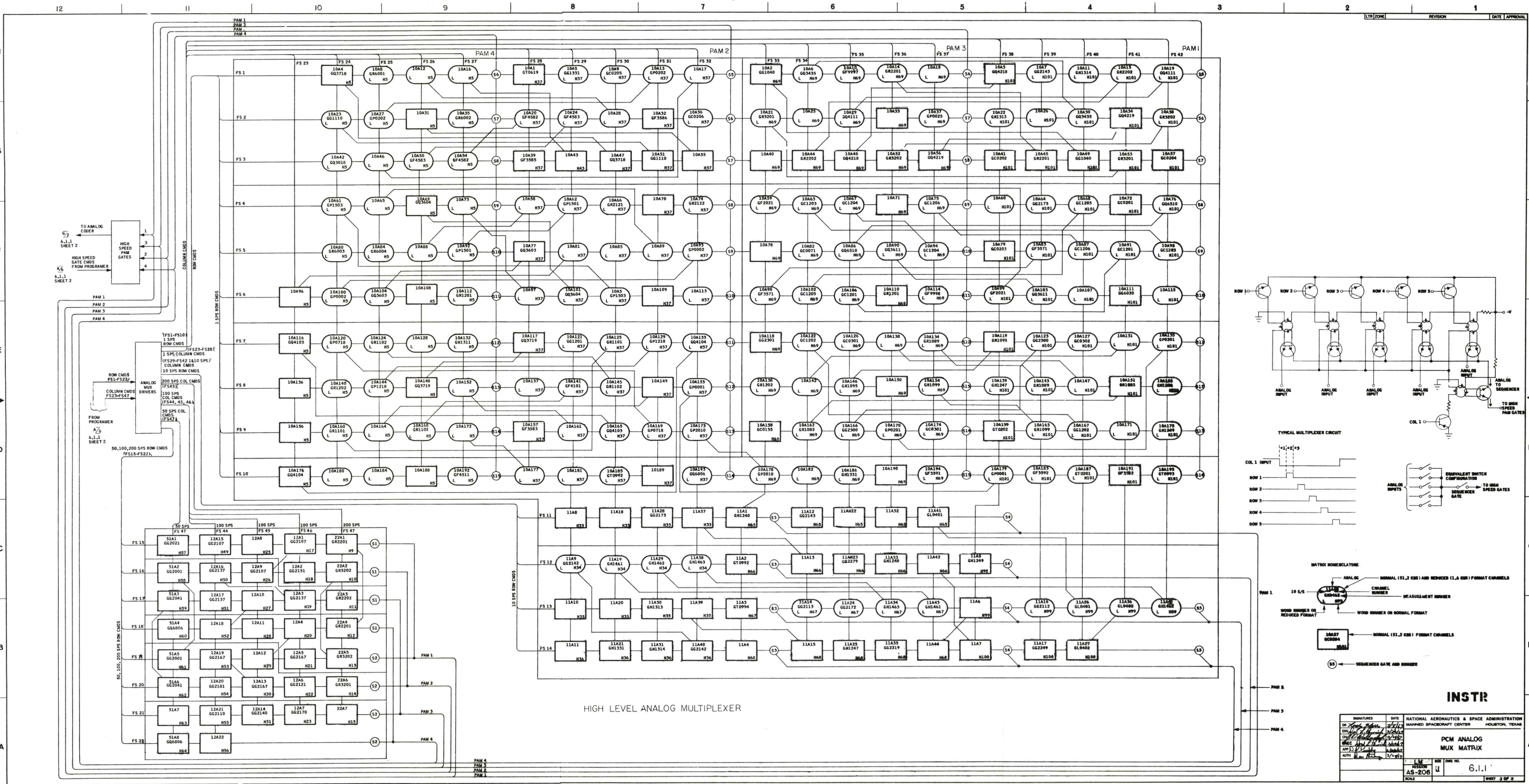
$\frac{22}{\uparrow}$	$\frac{A}{\uparrow}$	$\frac{4}{\uparrow}$
200 S/S	ANALOG	CHANNEL

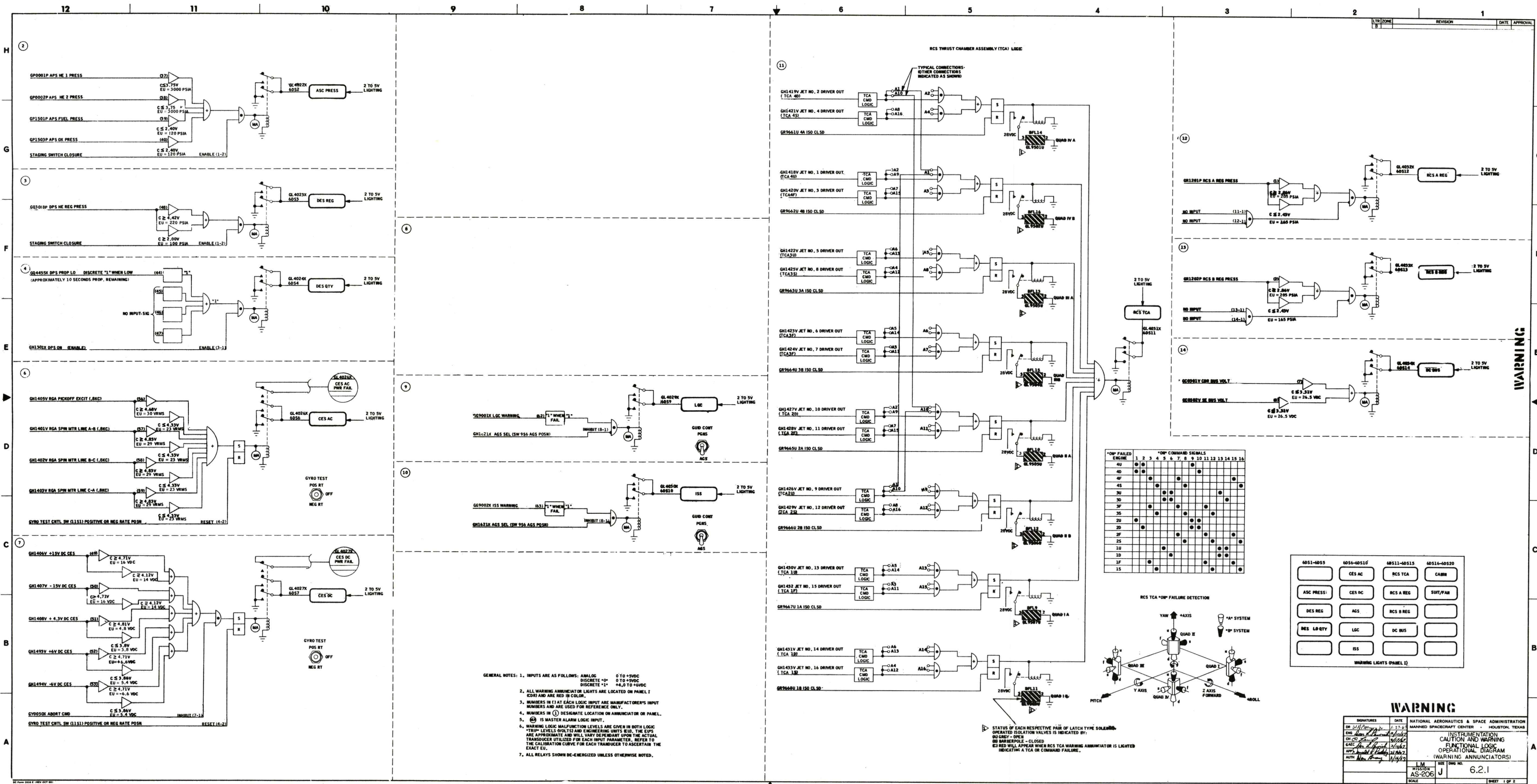


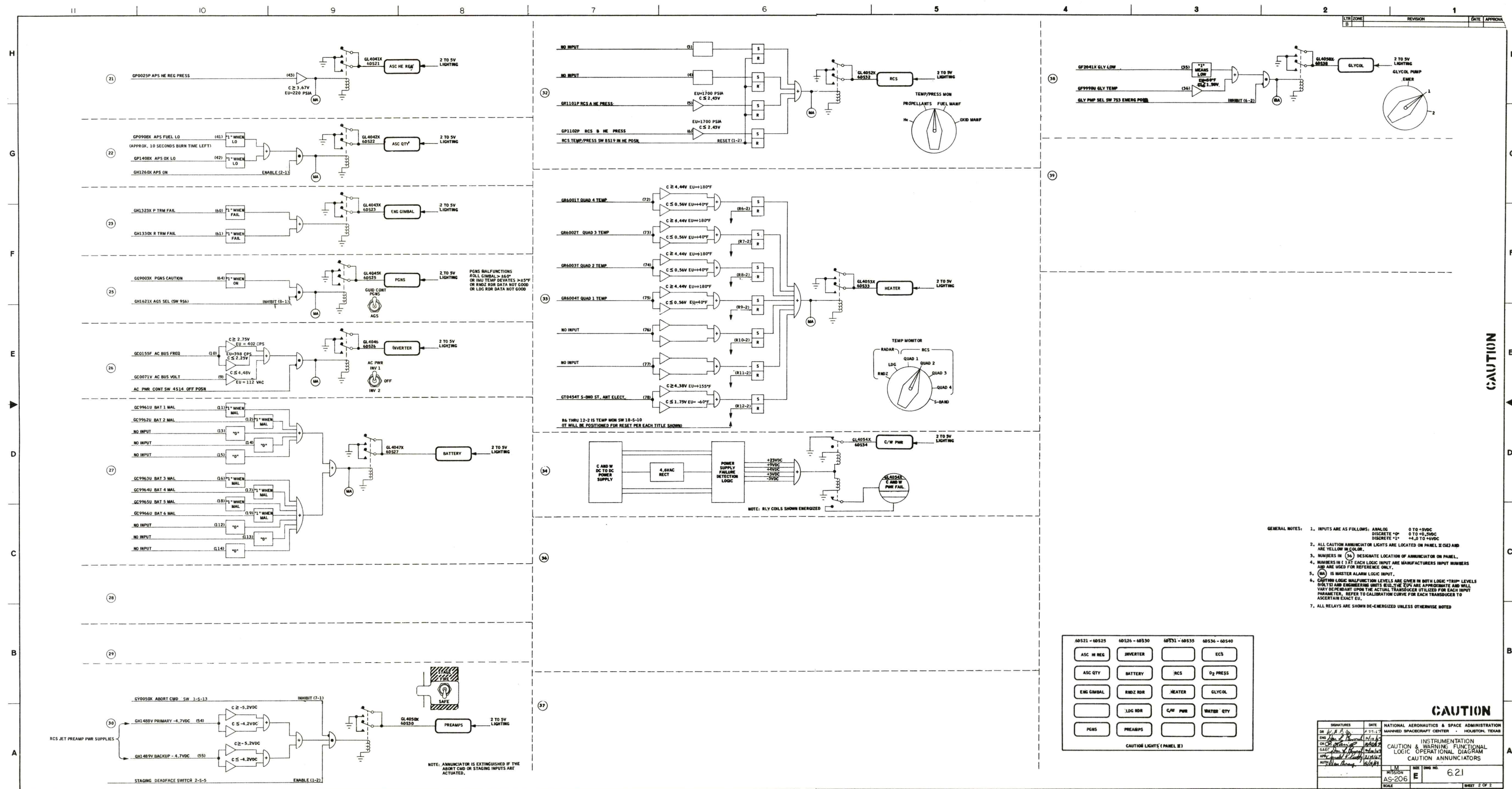
1 REDUNDANT GATES ARE REDUNDANT TO THE GATE IMMEDIATELY ABOVE

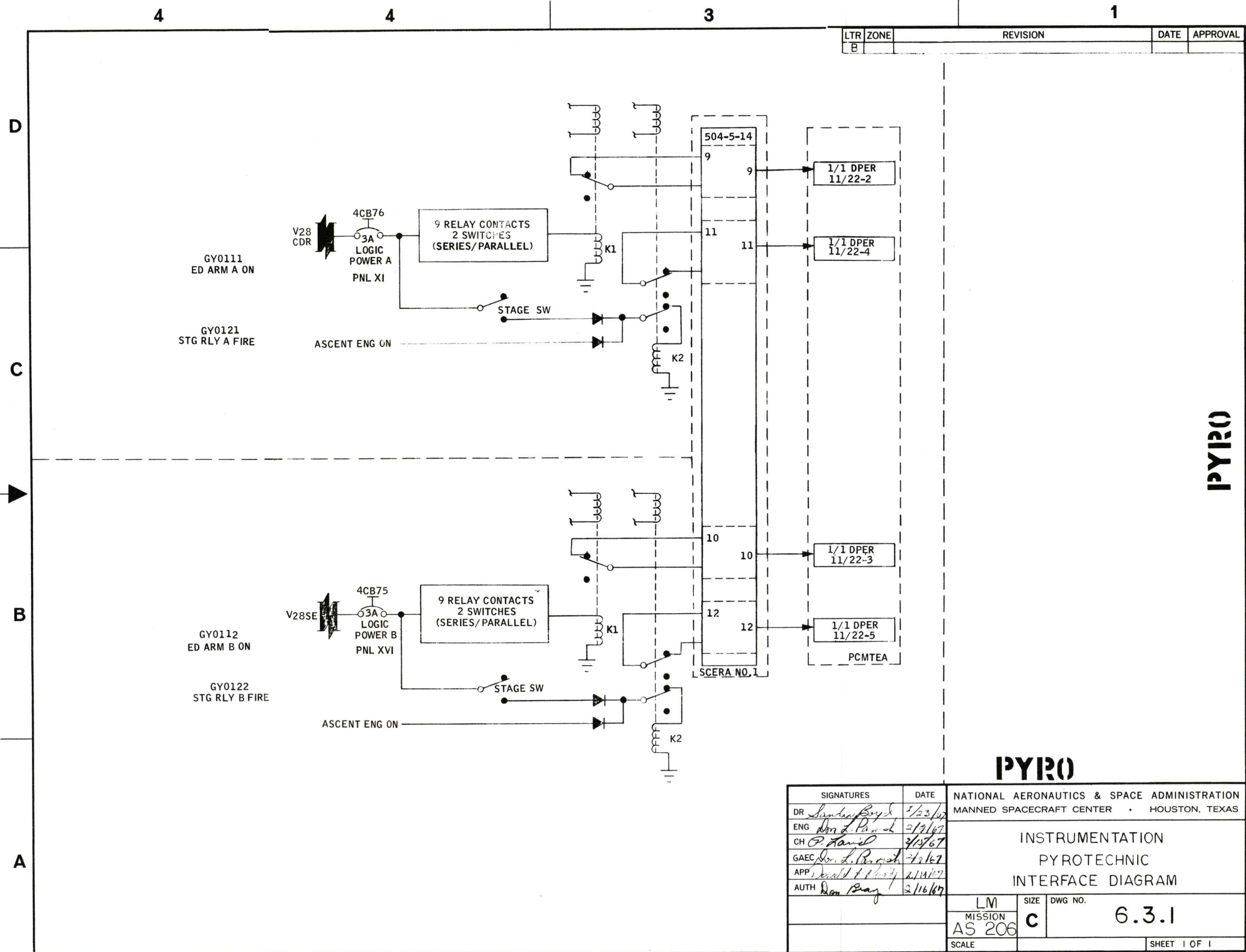
INSTR

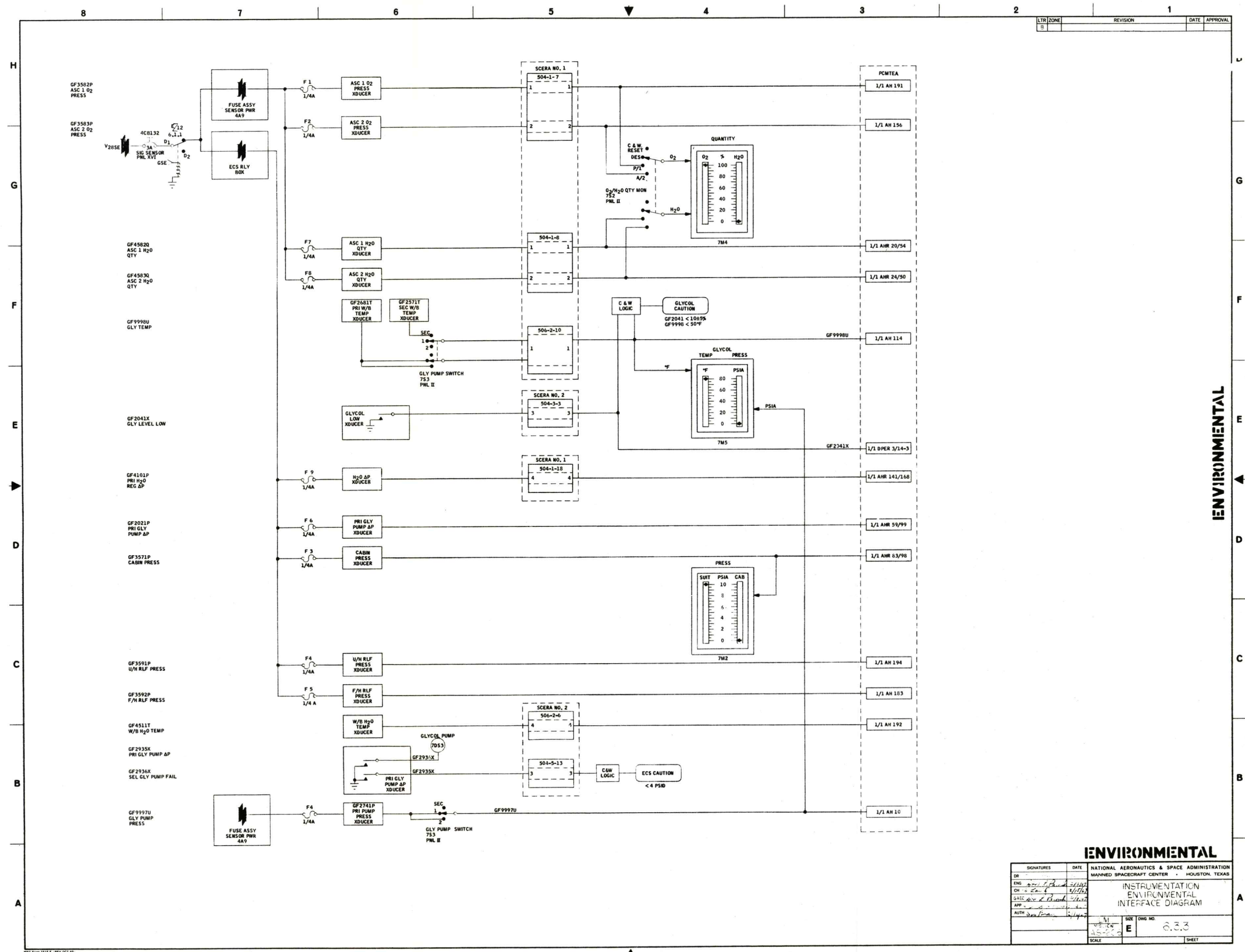
SIGNATURES		DATE	NATIONAL AERONAUTICS & SPACE ADMINISTRATION MANNED SPACECRAFT CENTER HOUSTON, TEXAS		
DR	<i>[Signature]</i>	3/24/67	LM-1 DIGITAL MULTIPLYING FOR DISCRETE TELEMETRY		
CH	<i>[Signature]</i>	3/24/67			
ENG	<i>[Signature]</i>	3/24/67			
GACC	<i>[Signature]</i>	3/24/67			
APP	<i>[Signature]</i>	3/24/67			
AUTH	<i>[Signature]</i>	3/24/67			
		LM MISSION AS-206	SIZE E	DWG NO. 6.1.1	
			SHEET 2 OF 3		

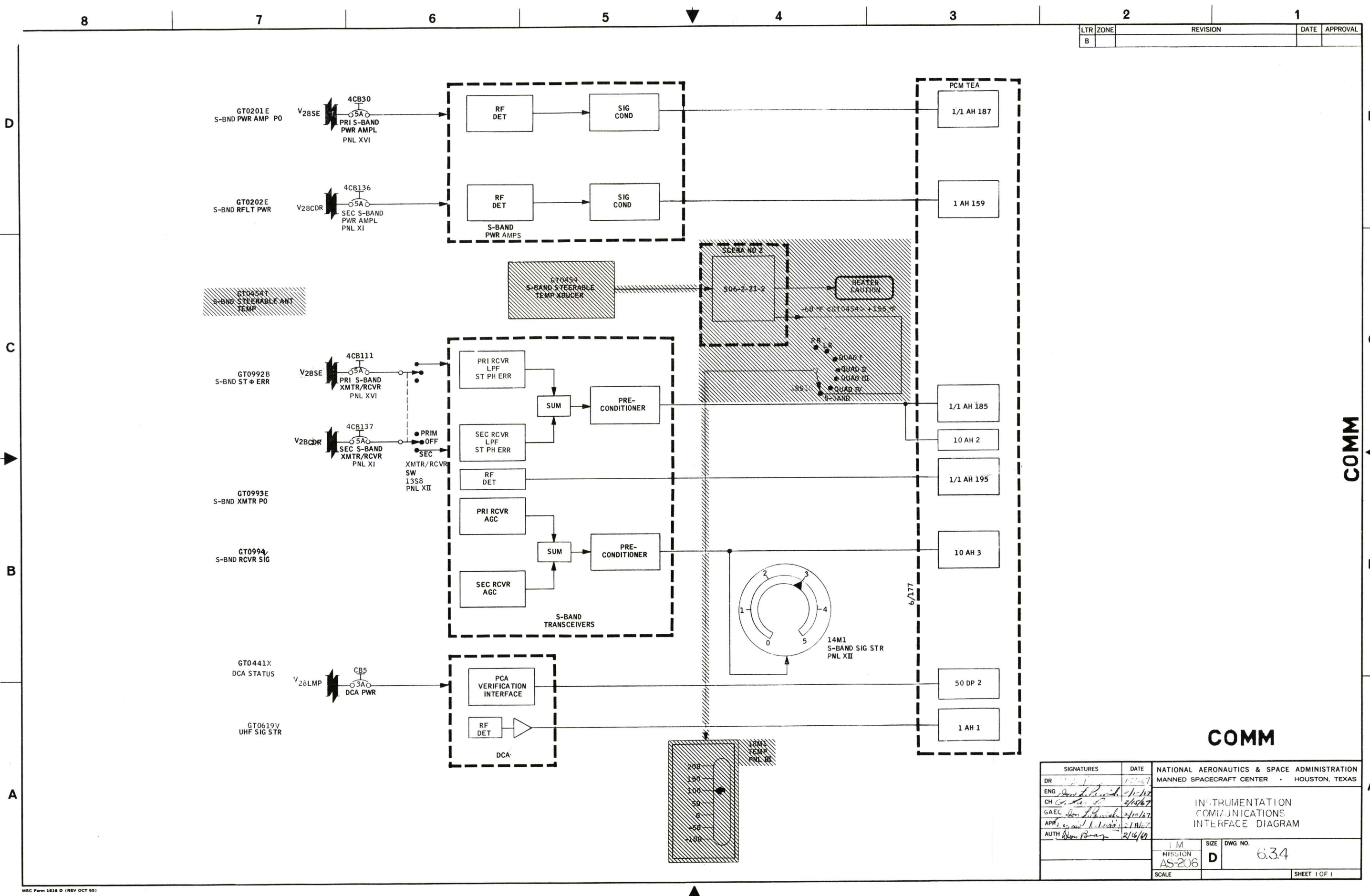




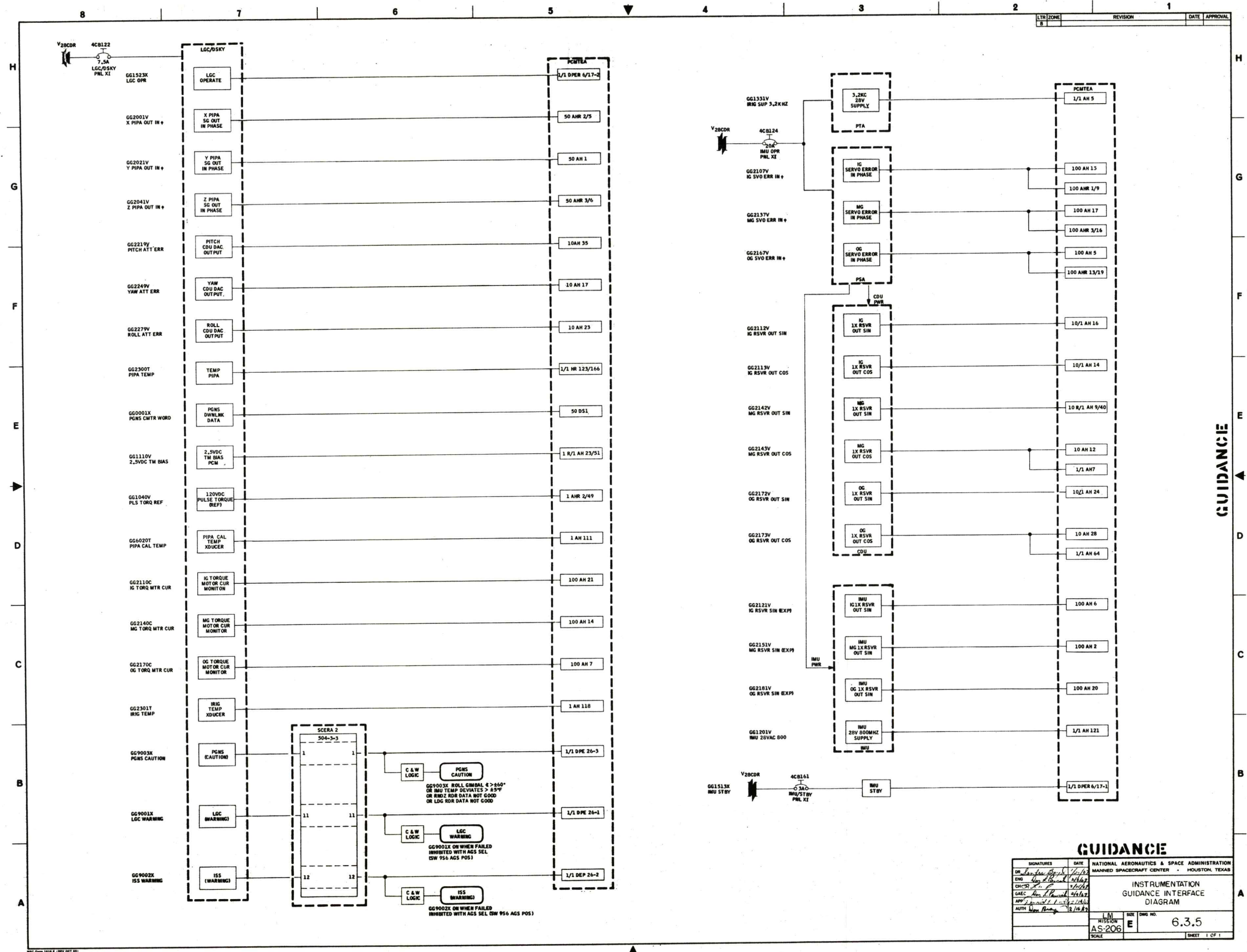


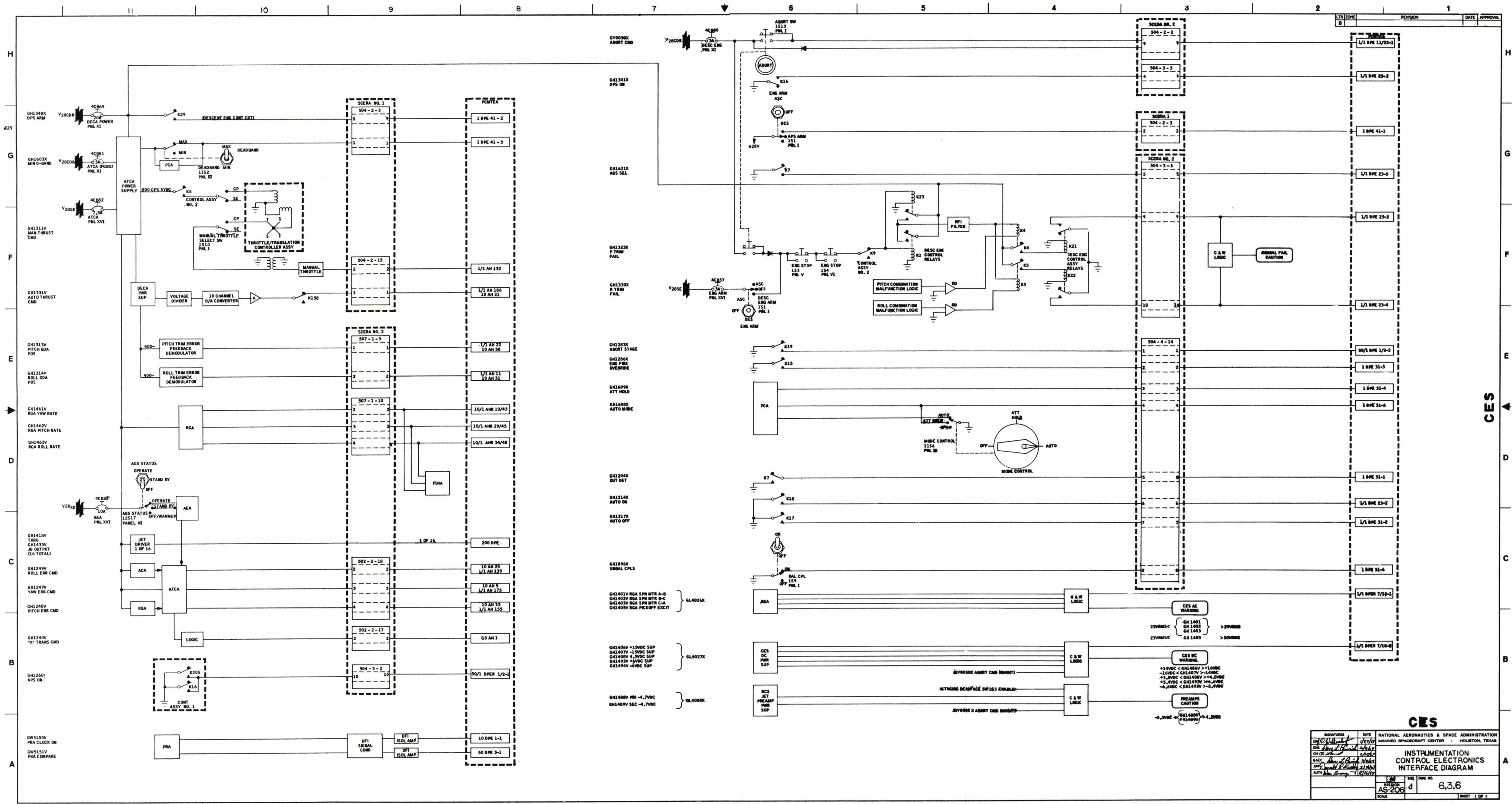


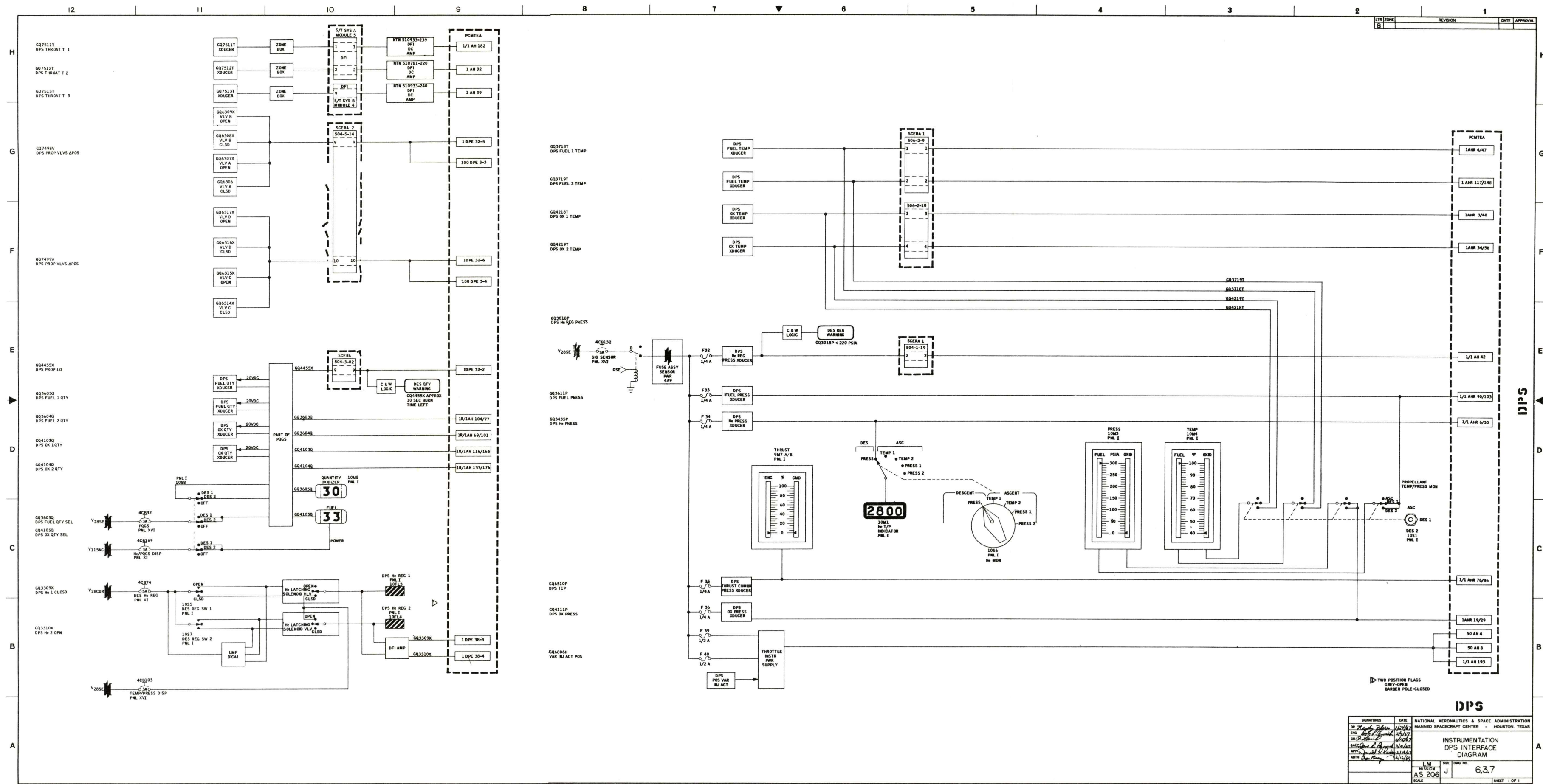


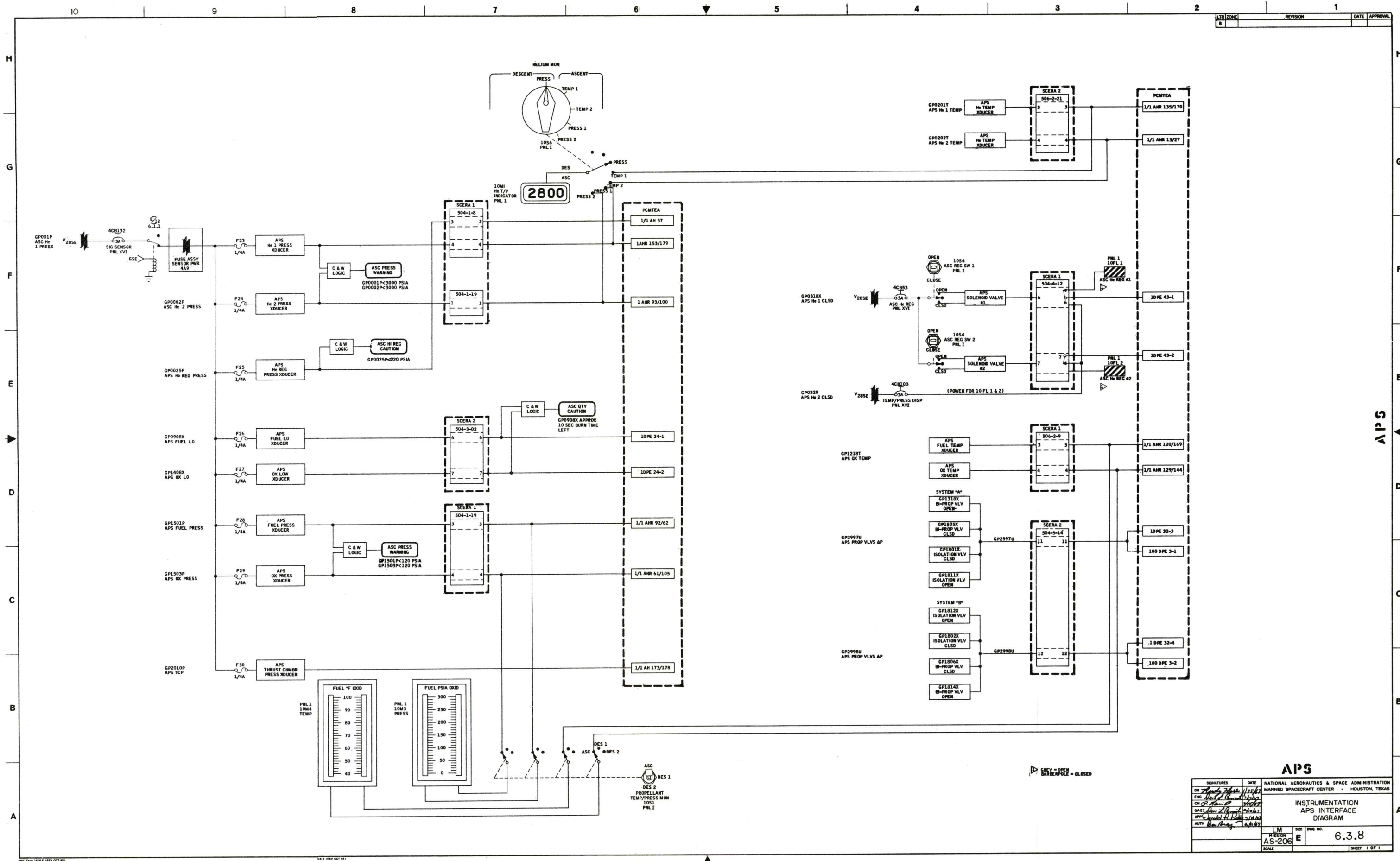


SIGNATURES		DATE	NATIONAL AERONAUTICS & SPACE ADMINISTRATION	
DR		1/1/67	MANNED SPACECRAFT CENTER • HOUSTON, TEXAS	
ENG		2/1/67		
CH		2/1/67		
GAEC		2/1/67		
APP		2/1/67		
AUTH		2/1/67		
			MISSION	SIZE DWG NO.
			AS-206	D 6.34
			SCALE	SHEET 1 OF 1

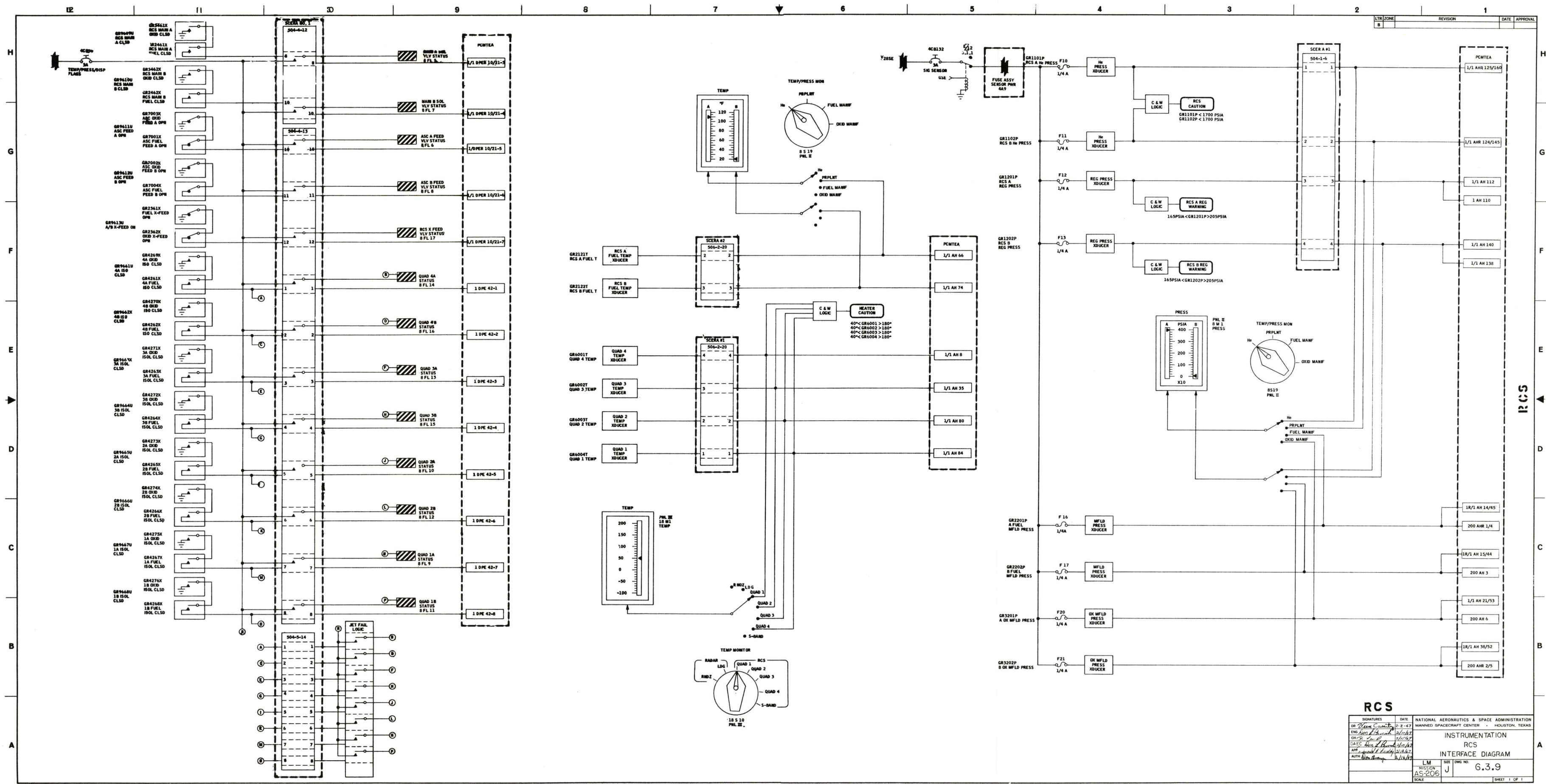








SIGNATURES		DATE	NATIONAL AERONAUTICS & SPACE ADMINISTRATION	
DR	<i>John F. Kennedy</i>	1/15/67	MANNED SPACECRAFT CENTER - HOUSTON, TEXAS	
ENG	<i>W. J. R. R. R. R.</i>	1/15/67		
CHK	<i>W. J. R. R. R. R.</i>	1/15/67		
DATE	<i>1/15/67</i>	1/15/67		
APP	<i>W. J. R. R. R. R.</i>	1/15/67		
AUTH	<i>W. J. R. R. R. R.</i>	1/15/67		
			INSTRUMENTATION APS INTERFACE DIAGRAM	
MISSION AS-206		SIZE E	DRAWING NO. 6.3.8	
SCALE		SHEET 1 OF 1		



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7. PGNS

velocity

for Mission

(PTA)

er (LGC)
board (DSKY)

SECTION 7

PGNS

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7.1 GENERAL

7.1.1 General Information

The PGNS is the primary means of accomplishing guidance, navigation and control for the Lunar Module (LM). The system is designed to perform these functions in a self-contained mode, requiring no data from sources external to the LM after system initialization. On Mission AS-206 the primary mode of operation shall also be self-contained. However, provision is made for insertion of navigation, target and mode control data from the ground via the LGC (LM Guidance Computer) if desired. On AS-206, a secondary method of guidance and control is provided by the Program Reader Assembly (PRA) which replaces the LM Guidance Computer function. The Abort Guidance system which ordinarily has this backup function has been deleted on AS-206. With respect to the LM, the terms guidance and navigation are defined as:

- A. Guidance - The orientation of a thrust vector with respect to inertial space and the regulation of the level of thrust where possible so that specific end conditions on a desired trajectory are met.
- B. Navigation - The determination of vehicle position and velocity with respect to a known coordinate frame.

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7.1.2 PGNS Hardware Configuration

The Primary Guidance, Navigation and Control System for Mission AS-206 is comprised of the following assemblies:

- A. Inertial Subsystem (ISS)
 - 1. Inertial Measurement Unit (IMU)
 - 2. Inertial System CDU's (ICDU's)
 - 3. Power Servo Assembly (PRA)
 - 4. Pulse Torquing Assembly (PTA)
- B. Computer Subsystem (CSS)
 - 1. LM Guidance Computer (LGC)
 - 2. Display and Keyboard (DSKY)

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- C. Optics Subsystem (deleted on AS-206)
 - 1. Alignment Optical Telescope (AOT)
- D. Radar Subsystem (deleted on AS-206)
 - 1. Rendezvous Radar CDU's (RRCDU's)

7.1.3 Inertial Measurement Unit (IMU)

The Inertial Measurement Unit (IMU) is the primary inertial sensing device of the LM. Three rate Integrating Gyroscopes (IRIG's) and three Pulse Integrating Pendulous Accelerometers (PIPA's) are mounted on the stable member (inner gimbal) of a three gimbal system. The stable member is held nonrotating with respect to inertial space by three gimbal servos, which derive their input error signals from three gyroscopes. The stable member is aligned at prelaunch to a known reference coordinate which is held fixed with respect to earth via gyrocompassing until Gyro Reference Release (GRR). At or near liftoff GRR is initiated by sensing 1.12 acceleration, however GRR may be backed up by RF uplink if necessary. Once the system is released to become inertial, it will remain unchanged throughout the flight. There is no realignment of the inertial reference after liftoff, and the system will be in the inertial reference mode continuously. Velocity changes along three orthogonal axes are sensed by accelerometers, which produce signals that represent incremental changes in velocity. Attitude of the LM is generated by the inner, middle, and outer gimbal resolvers. These attitude signals are inputs to the CDU's and to the FDAI via the GASTA. IMU temperature control is completely automatic and remains in operation once power is applied to the system.

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7.1.4 Inertial System CDU's (ICDU's)

The Coupling Data Units (CDU's) perform two basic functions: An analog-to-digital conversion (A/D) and a digital-to-analog conversion (D/A) of information. In the (A/D) conversion, the CDU's convert and transfer angular information between the IMU and LGC. For each of the three inertial system CDU's, each IMU gimbal angle resolver provides the respective CDU with analog gimbal angle signals that represent the attitude of the LM with respect to the navigation base.

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The CDU converts these signals to digital form and transforms them serially to the LGC in angle increments. In the (D/A) conversion, attitude-error signals are converted from digital to 800 cps analog signals which are applied to the Flight Director Attitude Indicators (FDAI). The CDU's also have the capability of providing via the D/A portion drive signals to the IMU gimbals to coarse align the stable member to a known orientation with respect to the navigation base. On AS-206, this function will be performed prelaunch only, during initial alignment.

7.1.5 Power Servo Assembly (PSA)

The purpose of the power and servo assembly (PSA) is to provide a central mounting point for the majority of the PGNS power supplies, amplifiers and other modular electronic components. The PSA is mounted on a coldplate through which water-glycol coolant flows to dissipate operating heat.

7.1.6 Pulse Torque Assembly (PTA)

The Pulse Torque Assembly (PTA) consists of a group of modular electronic assemblies used in the pulsing circuits of the gyros and accelerometers. Heat dissipation is accomplished in the same manner as with the PSA.

7.1.7 LM Guidance Computer (LGC)

The LM Guidance Computer (LGC) is the central data processing device of the PGNS system. The LGC inputs include; gimbal angle increments from the CDU's, incremental changes in velocity via the PIPA's and vehicle status inputs from the Control Electronics System (CES).

For the AS-206A Mission, the LGC will function as a completely automatic programmer that will control all onboard functions for the unmanned vehicle. The PGNS will automatically accomplish all guidance, navigation, and control of the LM. An uplink command capability exists for the LM to provide a limited amount of program change, in real time, by ground control. A major failure with either the LGC

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or IMU will automatically remove PGNS from control of the vehicle. This will force the LM into a PRA or ground RTC backup control. A major failure to PGNS would prevent any long APS or DPS test on the unmanned LM.

The LGC will perform all functions that are normally accomplished by the astronaut to control the unmanned LM. A 12-bit parallel word is sent from the LGC to the PCA for controlling relay functions in the LMP. This parallel word consists of 8 bits for a command and a 4-bit enable code to enable the PCA decoder. Should the 4-bit enable code show an error, the LGC command is inhibited and will not be accepted by the LMP. All other commands and inputs to and from the LM will be executed in normal methods such as auto throttle, engine ON/OFF descent gimbal drive, et cetera.

In addition to the above, the LGC performs four major functions:

- A. Calculates steering signals and generates engine, engine gimbaling and RCS jet commands to keep the LM on a required trajectory, and continually updates it's own estimate of the present trajectory.
- B. Maintains the stable member (inner gimbal) of the IMU to a coordinate system defined to a prelaunch orientation by the appropriate drift corrections.
- C. Serves as an overall catastrophic failure detection monitor for the IMU and CDU's. Also, by fixed subroutines the LGC monitors catastrophic failures in the PIPA loops and certain internal computer malfunctions.
- D. Provides for key LGC stored and computed parameters and various status discretes necessary to the PGNS functions to be downlinked to the ground via TM.

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7.2 PGNS OPERATION

7.2.1 PGNS Interfaces

The following list tabulates the electrical and functional interfaces between the PGNS and the remainder of the LM spacecraft. For reference consult MIT Document NEI6015000 PGNS and Control System for LM (Classified).

- A. Mode and Status
 - 1. PGNS in control of Spacecraft
 - 2. Attitude Hold Mode
 - 3. Auto Stabilization Mode
 - 4. Auto Throttle Mode
 - 5. Stage Verify
 - 6. Engine Armed
 - 7. Abort
 - 8. Abort Stage
 - 9. Thruster Fail Discretes
 - 10. GDA Fail Discretes
- B. Engine and Jet Control
 - 1. RCS Jet Commands
 - 2. Roll/Pitch Gimbal Trim Commands
 - 3. Increase/Decrease Throttle Rate
 - 4. Engine ON/OFF Commands
- C. Angle Data Signals
 - 1. Attitude Errors
 - 2. Gimbal Angles
- D. Maneuver Command Signals
 - 1. Translation Commands
 - 2. Out of Detent
 - 3. Attitude Rate Commands
 - 4. Rotation Commands
- E. Timing Signals and Telemetry

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- F. Caution and Warning Signals
- G. Power, Reference and Lighting
- H. DSKY and PCA (LMP) Commands

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7.2.2 Guidance and Navigation Functions

- A. PGNS performs the guidance function in the following manner:
The LGC senses incremental velocity changes using the PIPA information in a known inertial orientation (angular increments from ICDU's). From this information the steering signals are derived to orient the thrust vector to a near optimum position in inertial space. Engine ON commands are issued by the LGC when certain initial conditions are satisfied. For AS-206 these conditions may be an absolute time interval from some preceding event (e.g. APS - 2) or the satisfaction of trajectory conditions arrived at by some navigation function. Engine OFF commands are generated by the LGC when desired end conditions for the burn are met.
- B. The PGNCS navigation function is handled internal to the LGC. This function is performed both during thrust phase and during coast. It is performed on a 2 second basis during thrusting and on a 585 second basis during coast. During thrusting, external inputs, gimbal angle increments and PIPA data are required from the ISS and CDU, while during coasting phases, no external system input is required.

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7.3 INERTIAL MEASUREMENT UNIT SCHEMATIC NOTES (Drawing 7.2.1)

A. Notes

All latching relays are shown in the reset position and all unlatching relays are shown in the de-energized position.

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7.4 COUPLING DATA UNIT SCHEMATIC NOTES (Drawing 7.3.1)

A. The following abbreviations are applicable to the CDU schematic:

1. Aig = Inner gimbal angle (actual)
2. Amg = Middle gimbal angle (actual)
3. Aog = Outer gimbal angle (actual)
4. ΔA_{ic} = Increment of command angle (inner gimbal)
5. ΔA_{mc} = Increment of command angle (middle gimbal)
6. Aoc = Increment of command angle (outer gimbal)
7. AGS = Abort Guidance System
8. CDU = Coupling Data Unit
9. CS = Crew Systems
10. EX = Attitude Error signal about X-axis
11. EY = Attitude Error signal about Y-axis
12. EZ = Attitude Error signal about Z-axis
13. IMU = Inertial Measurement Unit
14. ISS = Inertial Subsystem
15. LGC = LM Guidance Computer
16. PC = Percent
17. RR = Rendezvous Radar

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7.5 COMPUTER SCHEMATIC NOTES (Drawing 7.4.1)
(To be supplied at a later date)

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TABLE 7-1 AS-206 DOWNLINK FORMAT

LM
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WORD NUMBER	FIRST REGISTER	SECOND REGISTER	WORD ORDER CODE
1	DOWNLIST I D	*SYNC BITS (00437-OCTAL)	0
2	LATEST CAL STATE VEC X POS MSB	*LATEST CAL STATE VEC X POS LSB	1
3	LATEST CAL STATE VEC Y POS MSB	*LATEST CAL STATE VEC Y POS LSB	1
4	LATEST CAL STATE VEC Z POS MSB	*LATEST CAL STATE VEC Z POS LSB	1
5	LATEST CAL STATE VEC X VEL MSB	*LATEST CAL STATE VEC X VEL LSB	1
6	LATEST CAL STATE VEC Y VEL MSB	*LATEST CAL STATE VEC Y VEL LSB	1
7	LATEST CAL STATE VEC Z VEL MSB	*LATEST CAL STATE VEC Z VEL LSB	1
8	STATE VECTOR TIME MSB	*STATE VECTOR TIME LSB	1
9	GARBAGE	*DESIRED CDU X	1
10	DESIRED CDU Y	*DESIRED CDU Z	1
11	DELV X MSB	*DELV X LSB	1
12	DELV Y MSB	*DELV Y LSB	1
13	DELV Z MSB	*DELV Z LSB	1
14	OUTPUT TO LMP	*OUTPUT TO LMP	1
15	OUTPUT TO LMP	*OUTPUT TO LMP	1
16	OUTPUT TO LMP	*OUTPUT TO LMP	1
17	OUTPUT TO LMP	*OUTPUT TO LMP	1
18	SPARE	*SPARE	1
19	SPARE	*SPARE	1
20	UPVERB	*COMPNUMB	1
21	STATE COUNT	*UPOLOMOD	1
22	ST BUFF +0	*ST BUFF +1	1
23	ST BUFF +2	*ST BUFF +3	1
24	ST BUFF +4	*ST BUFF +5	1
25	ST BUFF +6	*ST BUFF +7	1
26	ST BUFF +8D	*ST BUFF +9D	1
27	ST BUFF +10D	*ST BUFF +11D	1
28	ST BUFF +12D	*ST BUFF +13D	1
29	I MODE 30	*I MODE 33	1
30	TIME OF EVENT MSB	*TIME OF EVENT LSB	1
31	GUIDANCE THRUST CMD MSB	*GUIDANCE THRUST CMD LSB	1
32	MOMENT OFFSET (Q)	*MOMENT OFFSET (R)	1
33	PREDICTED ENGINE ON TIME MSB	*PREDICTED ENGINE ON TIME LSB	1
34	REDO COUNTER	*GARBAGE	1
35	GARBAGE	*ACTUAL CDU X	1
36	ACTUAL CDU Y	*ACTUAL CDU Z	1
37	DERIVED RATE (P)	*DERIVED RATE (Q)	1
38	GARBAGE	*DERIVED RATE (R)	1
39	FLAGWORD 0	*FLAGWORD 1	1
40	FLAGWORD 2	*DAP BOOLS	1
41	CHANNEL 11	*CHANNEL 12	1
42	CHANNEL 13	*CHANNEL 14	1
43	CHANNEL 30	*CHANNEL 31	1
44	CHANNEL 32	*CHANNEL 33	1
45	DSPTAB +0	*DSPTAB +1	1
46	DSPTAB +2	*DSPTAB +3	1
47	DSPTAB +4	*DSPTAB +5	1
48	DSPTAB +6	*DSPTAB +7	1
49	DSPTAB +8D	*DSPTAB +9D	1
50	DSPTAB +10D	*DSPTAB +11D	1

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TABLE 7-1 AS-206 DOWNLINK FORMAT (Concluded)

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WORD NUMBER	FIRST REGISTER	SECOND REGISTER	WORD ORDER	CODE
51	TIME 2	*TIME 1	1	
52	SPARE	*SPARE	1	
53	SPARE	*SPARE	1	
54	SPARE	*SPARE	1	
55	SPARE	*SPARE	1	
56	SPARE	*SPARE	1	
57	SPARE	*SPARE	1	
58	SPARE	*SPARE	1	
59	SPARE	*SPARE	1	
60	SPARE	*SPARE	1	
61	SPARE	*SPARE	1	
62	SPARE	*SPARE	1	
63	SPARE	*SPARE	1	
64	OUTPUT TO LMP	*OUTPUT TO LMP	1	
65	OUTPUT TO LMP	*OUTPUT TO LMP	1	
66	OUTPUT TO LMP	*OUTPUT TO LMP	1	
67	OUTPUT TO LMP	*OUTPUT TO LMP	1	
68	SPARE	*SPARE	1	
69	SPARE	*SPARE	1	
70	MISSION PHASE REGISTER 4	*MISSION PHASE REGISTER 3	1	
71	MISSION PHASE REGISTER 2	*MISSION PHASE REGISTER 1	1	
72	MISSION TIME REGISTER 4	*MISSION TIME REGISTER 3	1	
73	MISSION TIME REGISTER 2	*MISSION TIME REGISTER 1	1	
74	PRESENT MISSION PHASE	*GARBAGE	1	
75	TIME TO GO MSB	*TIME TO GO LSB	1	
76	BURN DATA	*BURN DATA	1	
77	BURN DATA	*BURN DATA	1	
78	BURN DATA	*BURN DATA	1	
79	BURN DATA	*BURN DATA	1	
80	BURN DATA	*BURN DATA	1	
81	BURN DATA	*BURN DATA	1	
82	BURN DATA	*BURN DATA	1	
83	BURN DATA	*BURN DATA	1	
84	BURN DATA	*BURN DATA	1	
85	GARBAGE	*ACTUAL CDU X	1	
86	ACTUAL CDU Y	*ACTUAL CDU Z	1	
87	DERIVED RATE (P)	*DERIVED RATE (Q)	1	
88	GARBAGE	*DERIVED RATE (R)	1	
89	FLAGWORD 0	*FLAGWORD 1	1	
90	FLAGWORD 2	*DAP BOOLS	1	
91	CHANNEL 11	*CHANNEL 12	1	
92	CHANNEL 13	*CHANNEL 14	1	
93	CHANNEL 30	*CHANNEL 31	1	
94	CHANNEL 32	*CHANNEL 33	1	
95	DSPTAB +0	*DSPTAB +1	1	
96	DSPTAB +2	*DSPTAB +3	1	
97	DSPTAB +4	*DSPTAB +5	1	
98	DSPTAB +6	*DSPTAB +7	1	
99	DSPTAB +8D	*DSPTAB +9D	1	
100	DSPTAB +10D	*DSPTAB +11D	1	

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TABLE 7-2 MISSION AS-206 - MISSION PHASES

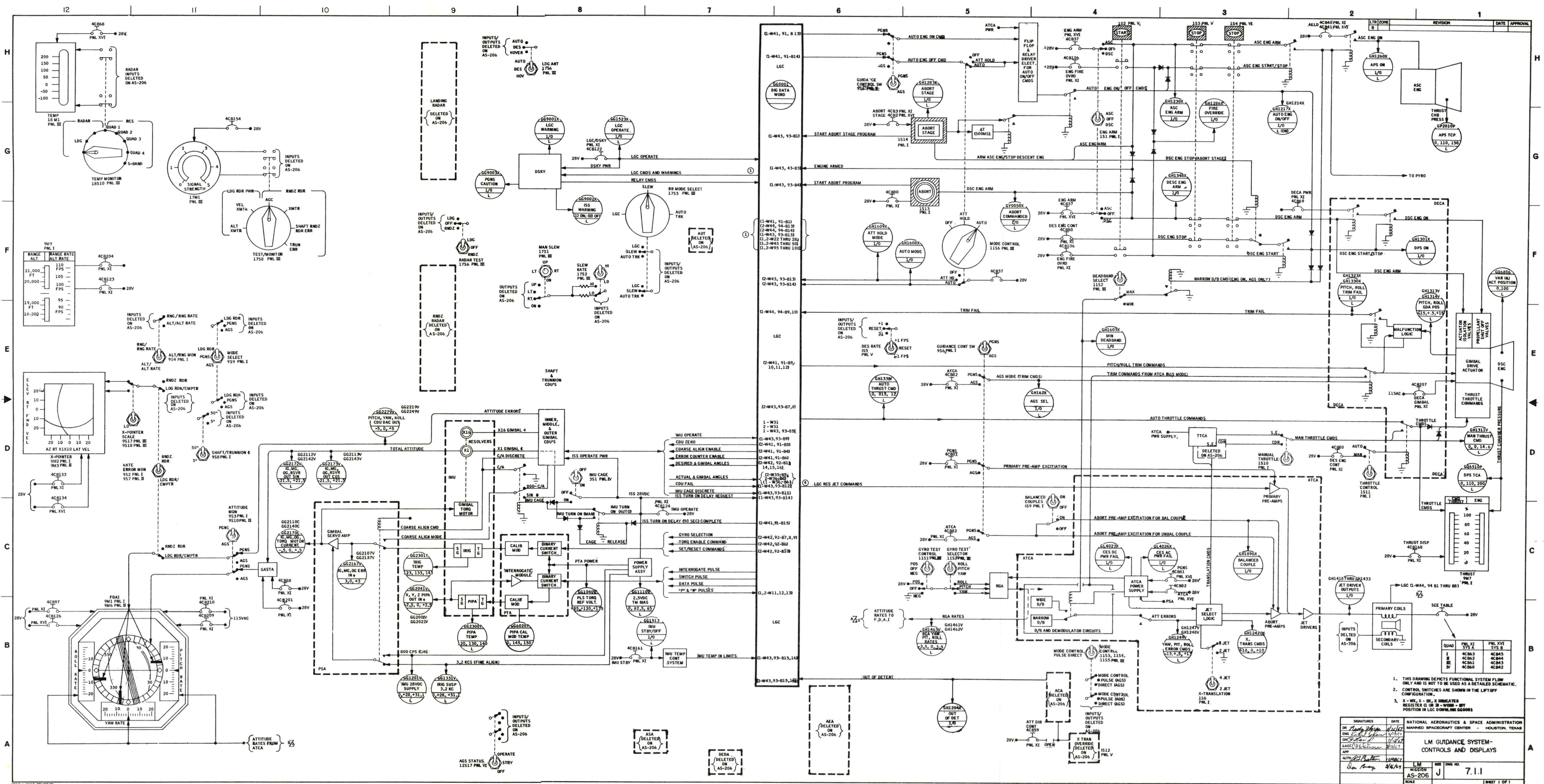
LM
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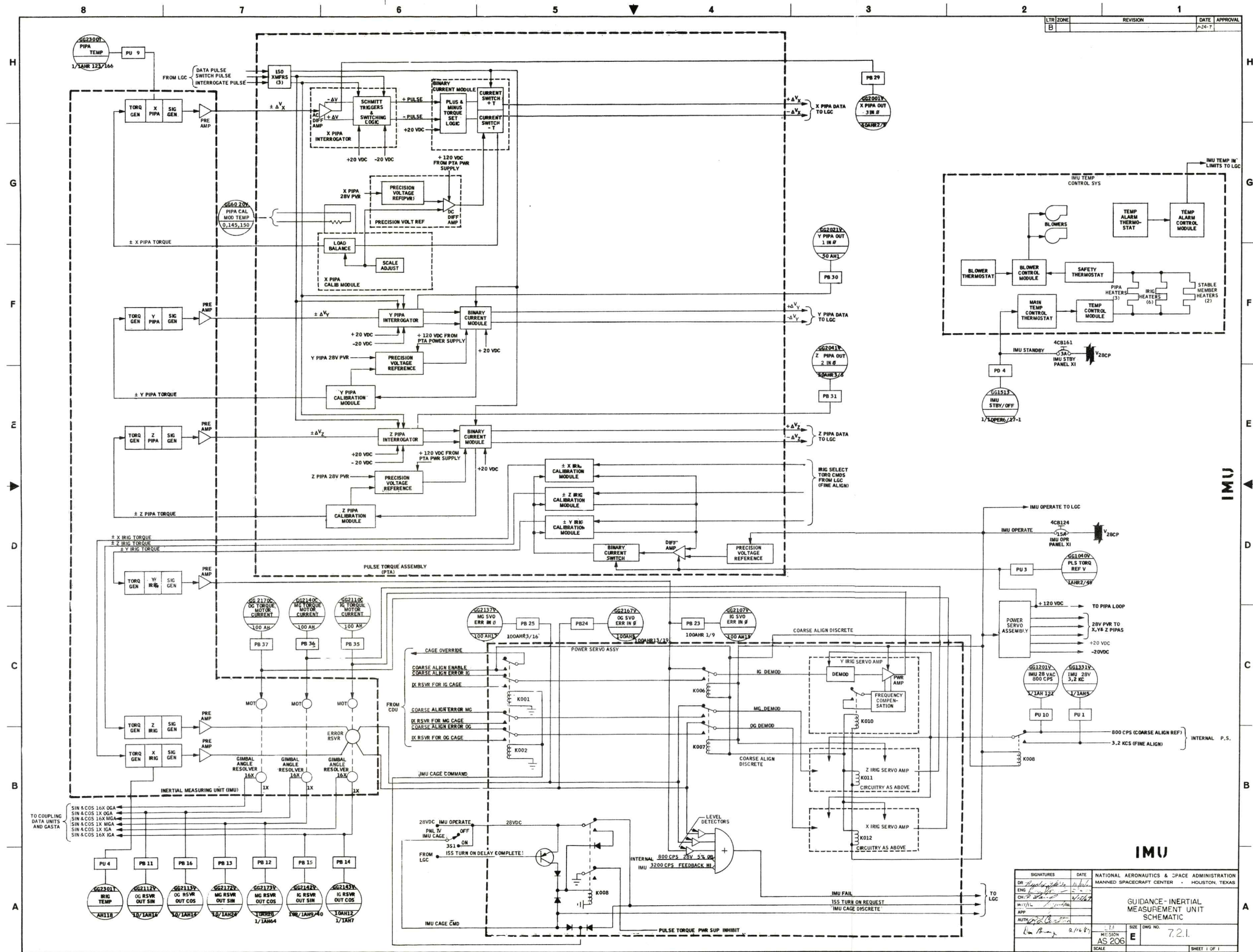
*

<u>Phase No.</u>	<u>Phase</u>	<u>Programs Executed</u>
1	Prelaunch Alignment	01, 02
2	Guidance Reference Release	07, 11, 12
3	Suborbital Abort	71
4	Contingency Orbit Insertion	72
5	*	*
6	Coast - S-IVB Attached	13
7	S-IVB/LM Separate	14
8	DPS Cold Soak	15
9	DPS 1	31, 41
10	*	*
11	DPS 2/FITH/APS 1	32, 42, 43, 44, 72
12	*	*
13	APS 2	34, 46
14	*	*
15	*	*
16	*	*
17	*	*
18	*	*
19	*	*

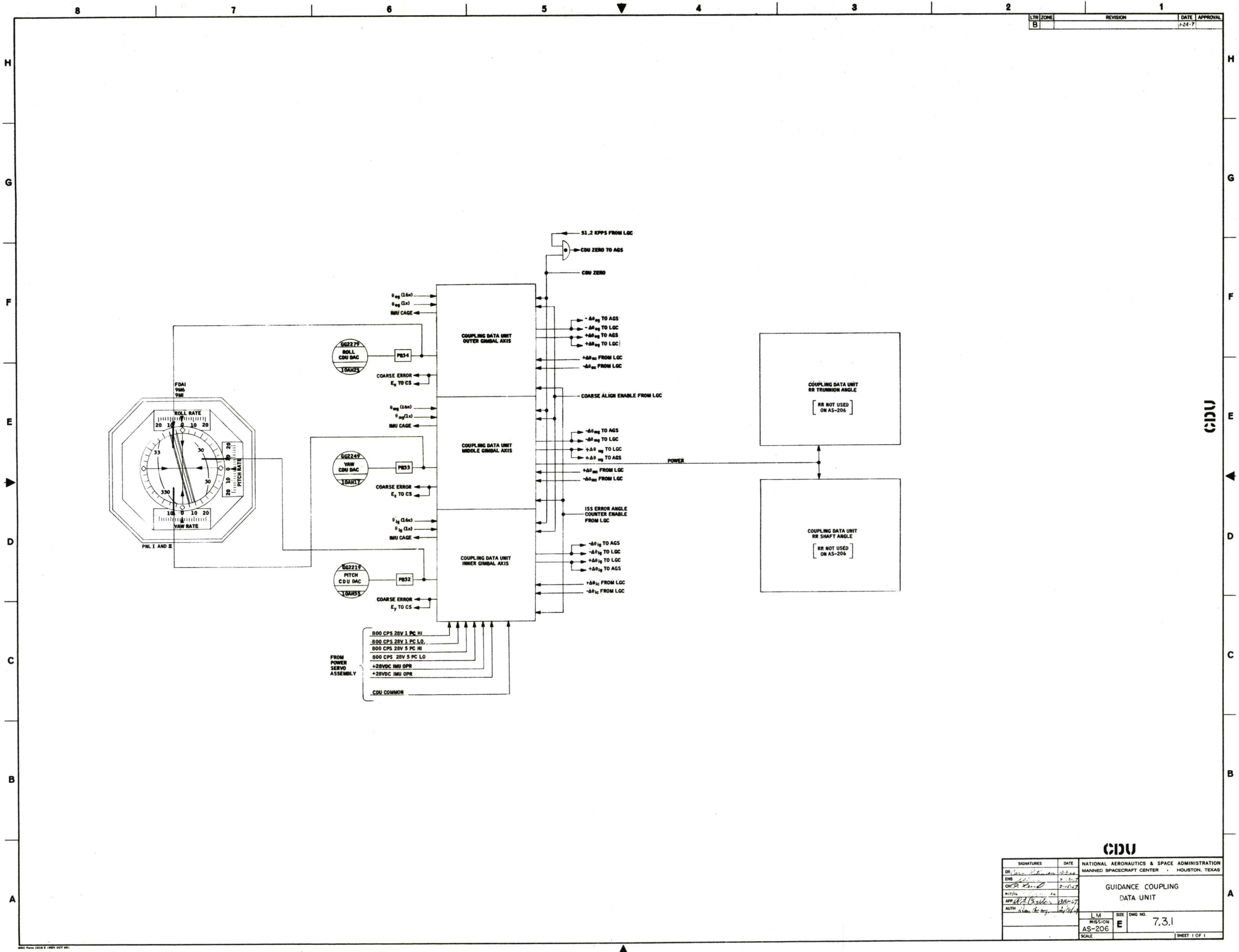
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*Not used for Mission AS-206

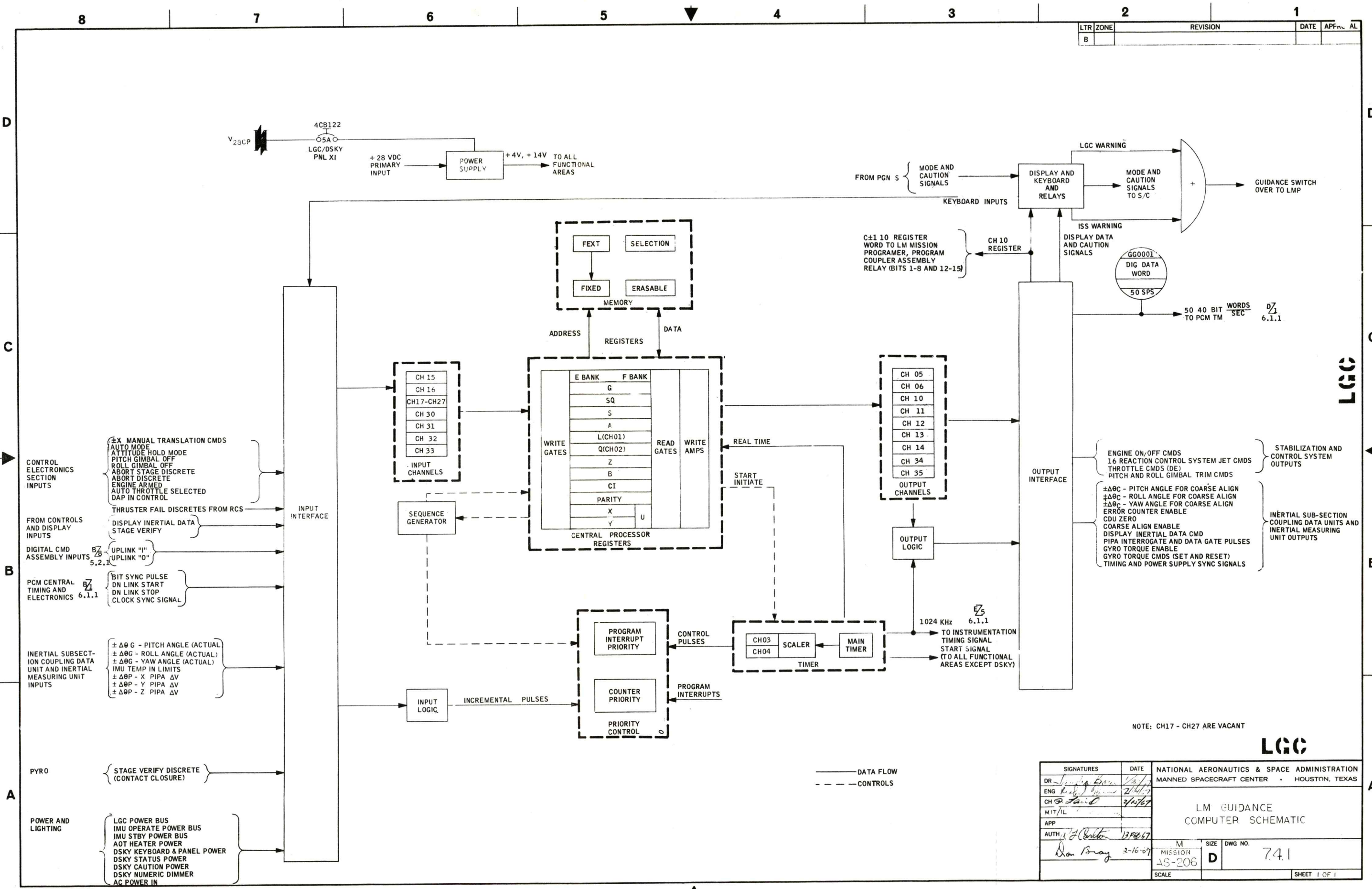




SIGNATURES	DATE	NATIONAL AERONAUTICS & SPACE ADMINISTRATION
DR. [Signature]	2/16/67	MANAGED SPACECRAFT CENTER - HOUSTON, TEXAS
ENG. [Signature]		
CH. [Signature]		
APP. [Signature]		
SCALE	AS 206	7.2.1
		SHEET 1 OF 1

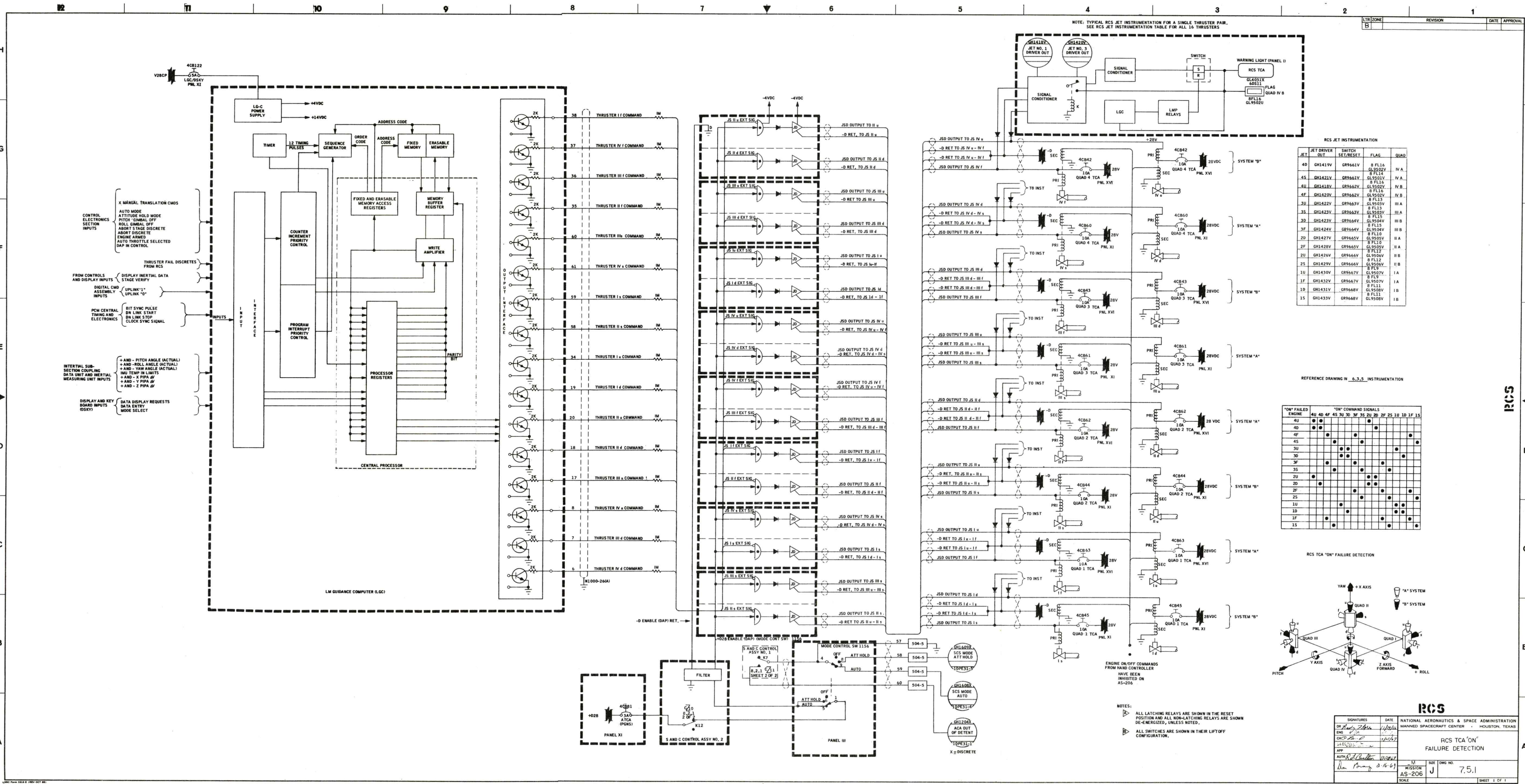


SIGNATURES		DATE	NATIONAL AERONAUTICS & SPACE ADMINISTRATION MANNED SPACECRAFT CENTER - HOUSTON, TEXAS	
DR.		12-2-67	GUIDANCE COUPLING DATA UNIT	
ENG.		2-12-67		
CHP.		2-12-67		
PLT/IL				
APP.		12-2-67		
AUTH.		2-12-67		
L.M.			SIZE	DWG NO.
MISSION			AS-206	7.3.1
SCALE			SHEET 1 OF 1	



LTR	ZONE	REVISION	DATE	APPROVAL
B				

SIGNATURES		DATE	NATIONAL AERONAUTICS & SPACE ADMINISTRATION MANNED SPACECRAFT CENTER • HOUSTON, TEXAS	
DR	<i>James B. ...</i>	12/1/67	LM GUIDANCE COMPUTER SCHEMATIC	
ENG	<i>Robert ...</i>	2/16/67		
CH	<i>P. ...</i>	2/16/67		
MIT/IL				
APP				
AUTH	<i>Don Bray</i>	2-16-67		
MISSION		SIZE	DWG NO.	
AS-206		D	741	
SCALE		SHEET 1 OF 1		

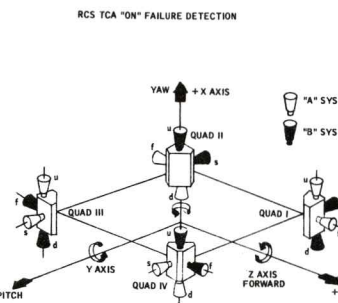


RCS JET INSTRUMENTATION

JET	JET DRIVER	SWITCH	FLAG	QUAD
4D	GH141V	GR9661V	8 FL16 GL9502V	IV A
4S	GH1421V	GR9661V	8 FL16 GL9501V	IV A
4U	GH1418V	GR9662V	8 FL16 GL9505V	IV B
4F	GH1420V	GR9662V	8 FL16 GL9505V	IV B
3U	GH1422V	GR9663V	8 FL13 GL9505V	III A
3S	GH1423V	GR9663V	8 FL13 GL9505V	III A
3D	GH1423V	GR9664V	8 FL15 GL9504V	III B
3F	GH1424V	GR9664V	8 FL15 GL9504V	III B
2D	GH1427V	GR9665V	8 FL10 GL9505V	II A
2F	GH1428V	GR9665V	8 FL10 GL9505V	II A
2U	GH1426V	GR9666V	8 FL12 GL9506V	II B
2S	GH1429V	GR9666V	8 FL12 GL9506V	II B
1U	GH1430V	GR9667V	8 FL9 GL9507V	I A
1F	GH1432V	GR9667V	8 FL9 GL9507V	I A
1D	GH1431V	GR9668V	8 FL11 GL9508V	I B
1S	GH1433V	GR9668V	8 FL11 GL9508V	I B

REFERENCE DRAWING IN 6.3.5 INSTRUMENTATION

ENGINE	4D	4S	4U	4F	3U	3S	3D	3F	2U	2S	2D	2F	1U	1D	1F	1S
4U																
4S																
4F																
3U																
3S																
3D																
3F																
2U																
2S																
2D																
2F																
1U																
1D																
1F																
1S																



RCS

RCS TCA 'ON' FAILURE DETECTION

DATE: 1/1/61

BY: [Signature]

CHKD: [Signature]

APP: [Signature]

SCALE: 7.5:1

SHEET 1 OF 1

SECTION 8
CONTROL

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Functions

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8. CONTROL

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One mode is fully automatic and one is

8.1 GENERAL

8.1.1 Control Electronics Section (CES) Functions

The CES operates in both the primary guidance control path and the abort guidance control path.

When operating as part of the primary guidance control path in conjunction with the PGNS, the CES provides the implementation of the control signals originating from the LGC as follows:

- A. Converts reaction control jet commands to the required electrical power to operate the RCS jet solenoid valves.
- B. Accepts discrete (ON/OFF) descent engine rotation commands. Upon receipt of an ON command, the descent engine is rotated about its gimbal axes at a constant angular rate until receipt of an OFF command.
- C. Accepts both LGC and manual engine ON/OFF commands and routes them to propulsion to fire or stop the descent or ascent engine.
- D. Accepts LGC and manual thrust commands to throttle the descent engine 10 to 100 percent of its range.

When operating in the abort guidance control path the CES performs the following functions:

- A. Accepts rate damping signals from the RGA's and fires the proper RCS jets to achieve attitude control.
- B. Accepts manual +X translation commands and fires RCS jets to accelerate the LM in the desired direction.
- C. Automatically rotates the gimballed descent engine for trim control.
- D. Accepts manual engine ON/OFF commands and routes them to the descent or ascent engine.
- E. Accepts manual throttle commands to control the thrust of the descent engine.

8.1.2 Modes of Attitude Control

Two basic modes of attitude control are provided by the CES and are selectable on the control panel. One mode is fully automatic and one is

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semiautomatic.

- A. Automatic Mode - The automatic mode provides fully automatic attitude control of the LM.
- B. Attitude Hold Mode - This is a semiautomatic mode in which the pilot commands an angular rate proportional to the displacement of the attitude controller. The vehicle will hold attitude when the controller is in the neutral position.

8.1.3 Translation Control (RCS)

Both automatic and manual translational control using the RCS thrusters are available. Automatic control consists of jet commands from the LGC to the jet drivers in the ATCA. These are used for translations of small velocity increments and ullage settling prior to main engine ignition after coasting phases. Manual control in PGNS operation consists of +X ON/OFF commands from the LMP by way of the LGC. In AGS operation only manual control is available. Control consists of +X ON/OFF commands from the LMP to the jet logic in the ATCA. The voltage is sufficient to saturate the pulse ratio modulators and give ON/OFF control of the RCS jets.

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8.1.4 Attitude and Translation Control Assembly (ATCA)

The ATCA supplies the signals which control the firing of the reaction jets and the signals for automatic trim of the gimbaled descent engine in AGS operation. The dc voltages required in all of the CES subassemblies and the synchronized ac voltage for the RGA, and LMP are also generated within this assembly. The input signals and the RGA are processed in the ATCA and are directed to the appropriate jets and the descent engine control assembly.

Drawing 8.2.1 Sheet 1 of 2 shows a schematic diagram of the ATCA. In PGNS operation, only the LGC preamplifiers are enabled by the guidance selector switch. LGC jet commands are amplified by the preamplifiers and jet drivers and sent to the primary solenoids of the RCS. In AGS operation, only the abort preamplifiers are enabled and jet signals from

the pulse ratio modulators are amplified and drive the RCS primary solenoids. Pitch, roll, and yaw signals are processed in three similar channels. The RGA rate signals are the only inputs to the ATCA for attitude control in the AGS mode. The gains of the summing amplifiers are changed when the LM is staged to account for the change in vehicle moment of inertia. The RGA ac signals are changed to dc by keyed demodulators and filters.

In the roll and pitch channels the demodulator output is sent to the DECA to control the trim of the gimbaleed descent engine. The deadband circuitry provides for either a wide deadband (+5 degrees) or a narrow deadband (+0.3 degrees) depending on the mission phase. In automatic and attitude hold modes, the signals from the deadband circuits are applied to the jet select logic. The jet select combines the attitude and translation inputs, determines whether two or four jets will fire to control rotation and X-axis translation, and applies the resultant signals to eight pulse ratio modulators, generate pulses which vary in width and frequency depending on the input voltage in order to control the duty ratio of the RCS jets. Each pulse ratio modulator controls two opposing jets. The jet to be fired is determined by the sign of the pulse ratio modulator input voltage.

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8.1.5 Descent Engine Control Assembly (DECA)

The DECA contains circuitry for controlling three functions of the descent engine. Engine throttling commands from the PGNS and crew are processed and sent to the descent engine. PGNS or ATCA signals are processed for positioning the Gimbal Drive Actuators to control engine trim. ON/OFF commands are processed in the DECA to control descent engine ignition and shutdown. The schematic diagram of the DECA is shown in Drawing 8.3.1.

Manual throttle commands can be applied to the descent engine with the throttle control switch on the control panel in either the manual or automatic position. Manual throttle commands consists of ac voltages, proportional to TTCA X-axis displacement, applied to the DECA. The DECA

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demodulates and filters the signal and sends a proportional dc throttle voltage to the descent engine.

Automatic throttle signals can only be applied to the descent engine when the throttle control switch is in the automatic position. The LGC sends automatic throttle commands to the DECA in the form of pulses on one of two lines. Pulses on one line advance a forward-backward counter while pulses on the other line decrease the count. A dc voltage proportional to the count is generated and sent to the descent engine for automatic throttle control.

In PGNS operation automatic trim control is provided by the LGC. When the LGC determines descent engine trim is required, it sends a trim command to the DECA on either a trim positive or a trim negative line for the roll or pitch axis. The trim signal is routed through a malfunction logic circuit to a power switching circuit. The power switching circuit applies 400 cycle, 115 volts power to the proper Gimbal Drive Actuator. The GDA rotates the descent engine and sends a 400 cycle signal proportional to its position back to the DECA. The DECA demodulates and differentiates the feedback signal and applies it back to the malfunction logic circuit. If the GDA is not moving in the commanded direction, the malfunction logic generates a trim failed signal. This signal removes the 400 cycle power from the power switching circuit and sends TRIM FAILED signals to the LGC and Instrumentation.

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In abort guidance operation, roll and pitch trim signals, are received from the roll and pitch error channels in the ATCA. A comparator and threshold circuit in the DECA generates trim negative or trim positive commands and sends them to the malfunction logic. The malfunction logic controls the power switching circuits the same as in PGNS operation.

8.1.6 Gimbal Drive Actuator (GDA)

The two GDA's are low-speed electromechanical devices each containing a 115V 400 cps ac motor driving a screw jack and a position transducer. Under control of the DECA the GDA's rotate the descent

engine about the pitch and roll axes so that the thrust vector goes through the LM center of gravity. One GDA controls the pitch gimbal and the other controls the roll gimbal.

Each GDA is capable of extending or retracting two inches from the mid-position and will gimbal the descent engine a maximum of plus or minus six degrees about the LM Y and Z-axis. The position transducer receives 115V 400 cps, 7.5 volts per inch travel from the mid-position; in-phase when extended and 180°, out-of-phase when retracted past the mid-position. The transducer output is sent back to the DECA malfunction logic.

8.1.7 CES Interfaces

The CES receives the following signals from the PGNS:

- A. ON/OFF commands for each of the 16 reaction control jets.
- B. ON/OFF commands for the ascent or descent engine.
- C. Descent engine trim commands.
- D. Thrust magnitude commands for the descent engine.
- E. 800 cycle per second power to excite the LMP.

The CES feeds the following signals to the PGNS in the primary mode.

- A. Gimbal fail signals.
- B. +X Translation ON/OFF Commands.

The CES provides the following to the descent engine:

- A. Ignition and shutdown commands
- B. Automatic and manual throttling commands
- C. Rotation of the gimbal engine.

The CES also interfaces with the:

- A. Electrical Power Subsystem (EPS) - The CES receives required electrical power from the EPS
- B. Reaction Control Subsystem (RCS) - The CES provides the signals to actuate the RCS jet solenoids.
- C. Ascent Engine - The CES provides commands for ascent engine ignition and shutdown.

- D. Displays and Controls Subsystem - The CES provides inputs to the appropriate controls and displays to enable control and monitoring of the SCS.
- E. Instrumentation Subsystem - CES provides signals to the Instrumentation Subsystem for inflight monitoring.
- F. Environmental Control Subsystem (ECS) - The ECS provides mounting surfaces and thermal protection for the CES equipment.
- G. Structure Subsystem - The Structure Subsystem provides the area and mounting accommodations to house the CES equipment within the structure.
- H. Explosive Devices Subsystem (EDS) - The CES interfaces with the EDS for stage status information.

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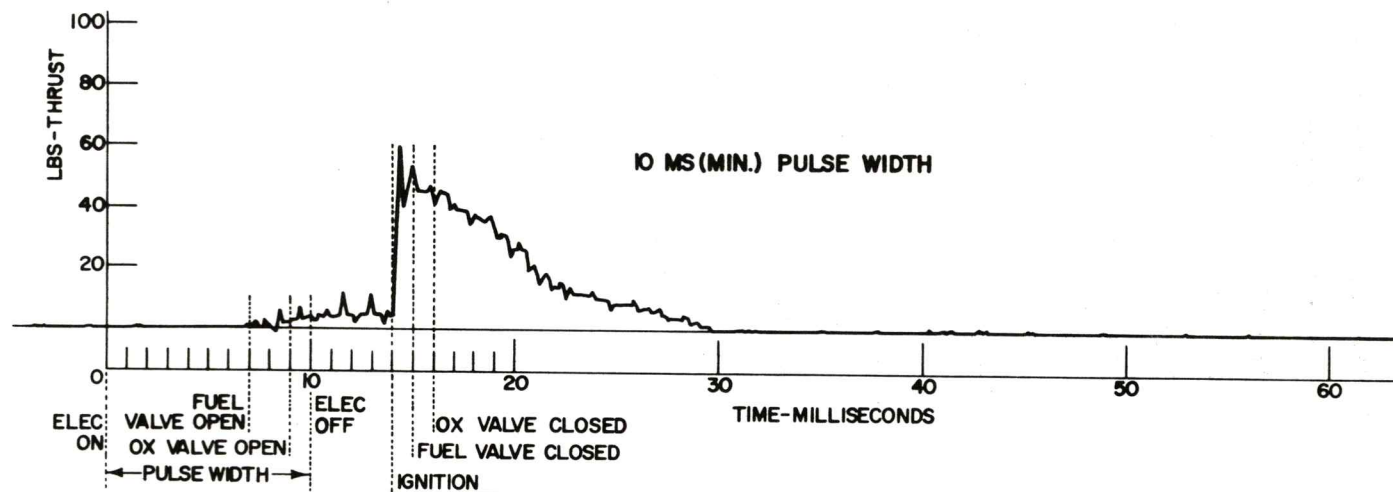
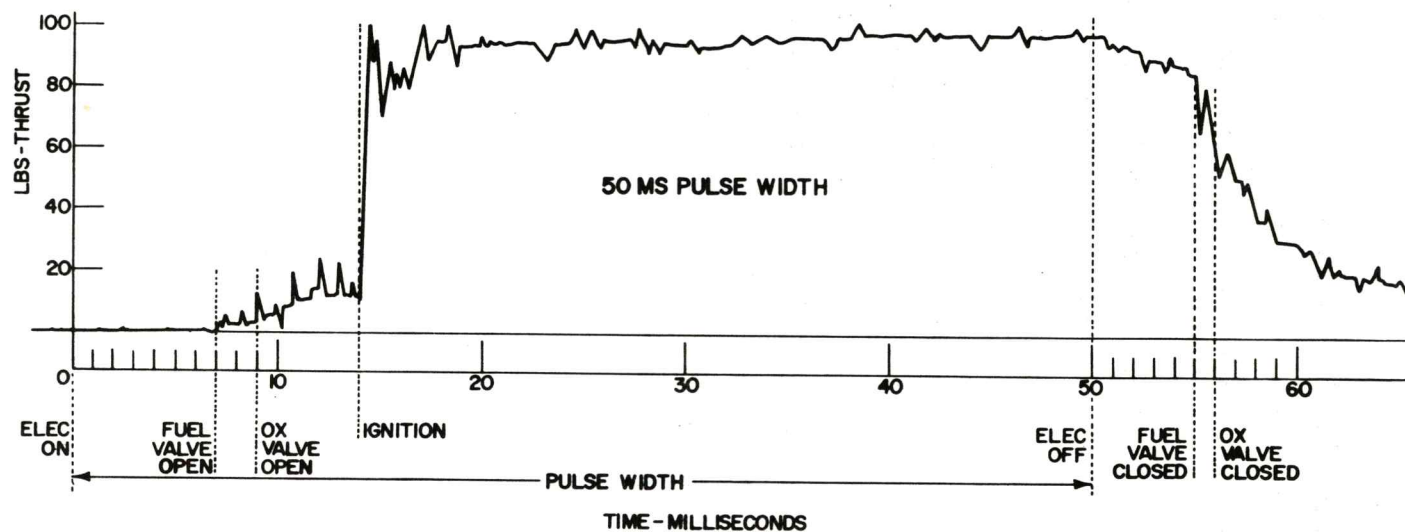
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8.2 CONTROL ELECTRONICS SYSTEM GENERAL NOTES

- A. The Control Electronics System (CES) will have power applied and will be operating prior to launch and remain on throughout the mission. The primary guidance will utilize only a portion of the CES for control of the LM.
- B. Manual throttling of the Descent Engine System in degrees of 10, 30, 50, and 100 percent throttle settings can be tested if the PGNS fails AS-206 by the PRA. The reset position of the throttle is 10 percent.
- C. There will not be an automatic closed loop guidance for the PRA/AGS control during DPS and APS burns. Should a failure occur in the PGNS, the PRA will perform a minimum alternate propulsion test. The requirements for using the PRA/AGS control for a propulsion test will depend upon the time of failure of PGNS.

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GRAPH, THRUST VS. TIME, RCS

FIGURE 8-1

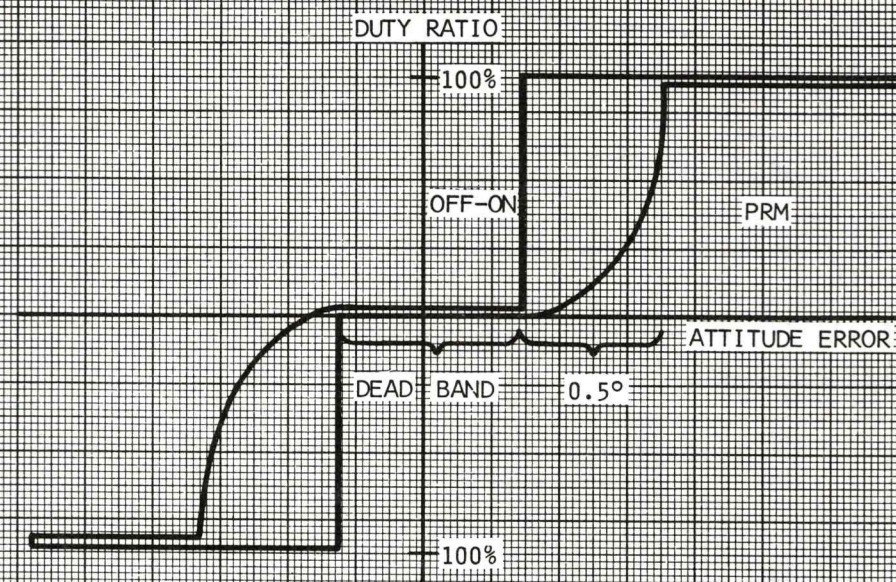


FIGURE 8-2 SWITCHING CHARACTERISTICS OF PULSE-RATIO MODULATOR

01-8

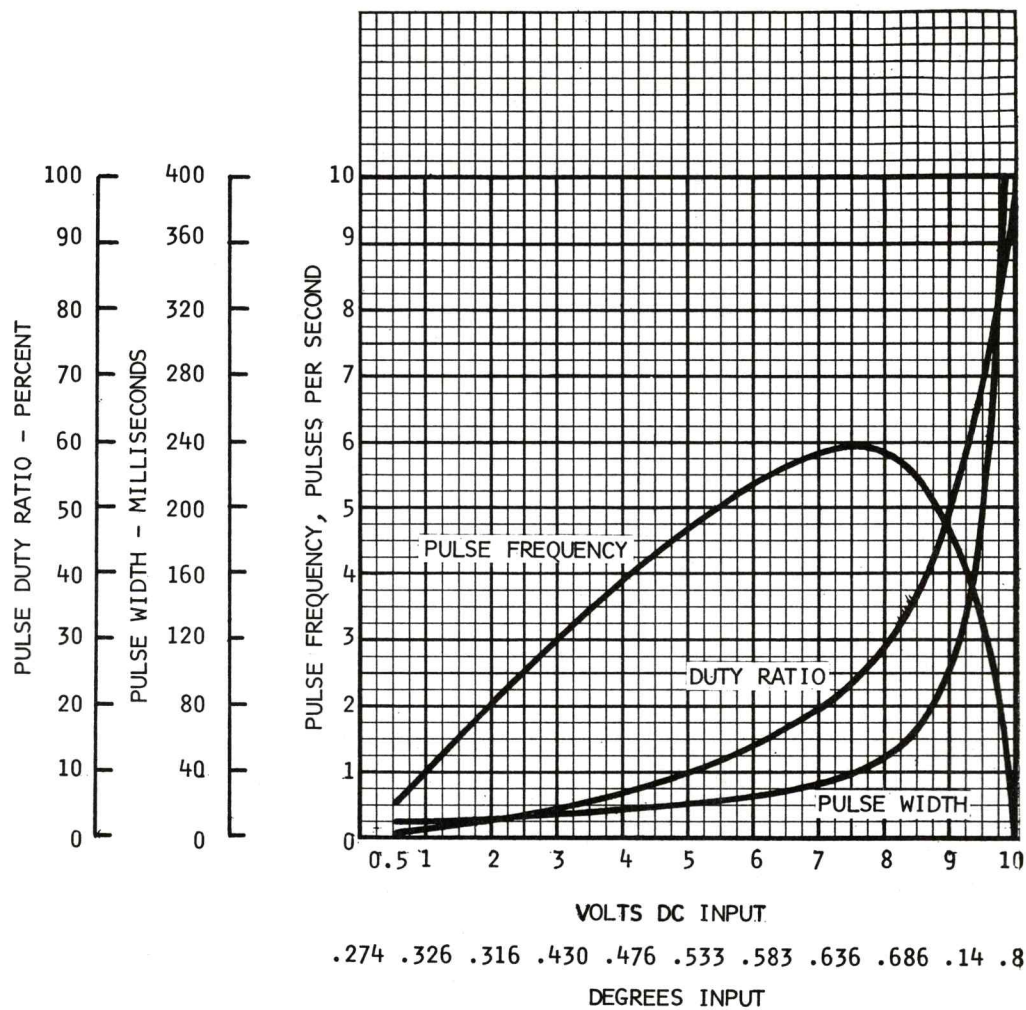


FIGURE 8-3 PERFORMANCE OF PULSE, RATIO MODULATOR.

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TABLE 8-1 RCS PROPELLANT USAGE FOR LM AUTOPILOT

A. Ascent Engine Burn
1.0 degree deadband

<u>Torque/Inertia</u>	<u>Disturbance Torque</u>	<u>RMS Attitude Error</u>	<u>Propellant Usage Rate</u>
0.2 rad/sec ²	0 ft lb	0 deg	0.000030 lb/sec
	350	0.511	0.240
	850	0.664	0.566
0.3 rad/sec ²	0	0	0.000044 lb/sec
	350	0.511	0.242
	850	0.664	0.566
0.5 rad/sec ²	0	0	0.000074 lb/sec
	350	0.511	0.246
	850	0.664	0.568
0.7 rad/sec ²	0	0	0.001030 lb/sec
	350	0.511	0.249
	850	0.664	0.572

B. Rotational Maneuvers

<u>Torque/Inertia</u>	<u>Maneuver Rate</u>	<u>Propellant Usage</u>
0.04 rad/sec ²	0.2 deg/sec	0.15 lb
	3.0	1.93
	5.0	3.2
	10.0	6.4
0.10 rad/sec ²	0.2 deg/sec	0.07
	3.0	0.8
	5.0	1.3
	10.0	2.6
0.30 rad/sec ²	0.2 deg/sec	0.032
	3.0	0.29
	5.0	0.46
	10.0	0.88
0.80 rad/sec ²	0.2 deg/sec	--
	3.0	0.12
	5.0	0.19
	10.0	0.35

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TABLE 8-1 RCS PROPELLANT USAGE FOR LM AUTOPILOT (Concl'd)

C. Attitude Hold

<u>Torque/Inertia</u>	<u>Deadband</u>	<u>Propellant Usage Rate</u>
0.04 rad/sec^2	0.3 deg	0.012 lb/min
	5.0	0.0007
0.10 rad/sec^2	0.3 deg	0.030 lb/min
	5.0	0.0018
0.30 rad/sec^2	0.3 deg	0.09 lb/min
	5.0	0.0053
0.80 rad/sec^2	0.3 deg	0.24 lb/min
	5.0	0.014

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TABLE 8-2 PRELAUNCH STATUS OF SWITCH POSITIONS

SWITCH NUMBER	SWITCH TITLE	SWITCH POSITION
1-S-1	ENG ARM	OFF
1-S-2	ENG START	OFF
1-S-3	ENG STOP	OFF
1-S-4	ENG STOP	OFF
1-S-5	DES RATE	CENTER
1-S-6	X-TRANSLATION	4 JET
1-S-7	PROBE CUTOFF	OFF
1-S-8	ENG GIMBAL	ENABLE
1-S-9	BAL CPL	ON
1-S-10	MAN THROTTLE	SYS ENG
1-S-11	THRUST CONTROL	AUTO
1-S-12	+X TRANSLATION	OFF
1-S-13	ABORT	GUARD DOWN-SW OFF
1-S-14	ABORT STAGE	GUARD DOWN-SW OFF
3-S-1	IMU CAGE	OFF
9-S-2	RATE ERROR MON	CMPTR
9-S-3	ATTITUDE MON	PGNS
9-S-4	ALT/RNG MON	RNG/RNG RT
9-S-6	GUID CONT	PGNS
9-S-7	RATE ERROR MON	CMPTR
9-S-8	SHFT/TRU	$\pm 50^\circ$
9-S-9	MODE SELECT	PGNS
9-S-10	ATTITUDE MON	PGNS
9-S-11	RESET/CONTROL	(RESET) UP
9-S-12	TIMER CONTROL	CENTER POS
9-S-17	X POINTER SCALE	HI MULT
9-S-18	X POINTER SCALE	HI MULT

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TABLE 8-2 PRELAUNCH STATUS OF SWITCH POSITIONS (Concl'd)

SWITCH NUMBER	SWITCH TITLE	SWITCH POSITION
11-S-1	GYRO TEST	OFF
11-S-2	DEADBAND	MIN
11-S-3	ATTITUDE CONTROL - PITCH	MODE CONTROL
11-S-4	ATTITUDE CONTROL - ROLL	MODE CONTROL
11-S-5	ATTITUDE CONTROL - YAW	MODE CONTROL
11-S-6	MODE CONTROL	AUTO
11-S-7	GYRO TEST	PITCH
12-S-1	KEYBOARD	OFF
12-S-12	KEYBOARD	OFF
12-S-13	CLEAR SWITCH	OFF
12-S-14	ENTER SWITCH	OFF
12-S-15	READOUT SWITCH	OFF
12-S-16	HOLD SWITCH	OFF
12-S-17	AGS STATUS	WARMUP
16-R-3	INTEGRAL UPLINK	DIM ON
17-S-1	MANUAL SLEW	OFF
17-S-2	SLEW RATE	LOW
17-S-3	R. R. MODE SEL	SLEW
17-S-5	LDG RADAR ANT	#1 DES
17-S-6	RADAR TEST	OFF
17-S-8	TEST MONITOR	AGC
18-S-10	TEMP MONITOR	RNDZ
19-S-6	LMP TCA ISOLATION	ENABLE

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TABLE 8-3 PRELAUNCH STATUS OF CIRCUIT BREAKERS

CIRCUIT BREAKER NUMBER	TITLE	POSITION
4CB2	ABORT STAGE	CLOSED
4CB3	ABORT STAGE	CLOSED
4CB28	AEA	OPEN
4CB29	RNDZ PWR	OPEN
4CB37	ENG ARM	CLOSED
4CB40	AELD	CLOSED
4CB41	AELD	CLOSED
4CB59	ATT DIR CONT.	OPEN
4CB69	DECA PWR	CLOSED
4CB79	ASA	OPEN
4CB80	DES ENG CONT	CLOSED
4CB81	ATCA (PGNS)	CLOSED
4CB82	ATCA	CLOSED
4CB88	GASTA	OPEN
4CB105	LDG RDR	OPEN
4CB106	ENG FIRE OVERRIDE	CLOSED
4CB122	LGC/DSKY	CLOSED
4CB123	ALT/ALT RT RNG/CONTROL	OPEN
4CB124	IMU OPERATE	CLOSED
4CB126	FDAI	OPEN
4CB133	X-PNTR	OPEN
4CB134	X-PNTR	OPEN
4CB154	SIG STR DISP	OPEN
4CB155	RNDZ RDR OPR	OPEN
4CB156	RNDZ RDR STBY	OPEN
4CB157	LDG RDR	OPEN
4CB161	IMU STBY	CLOSED
4CB179	LMP FEED	CLOSED & SLUGGED
4CB201	GASTA	OPEN

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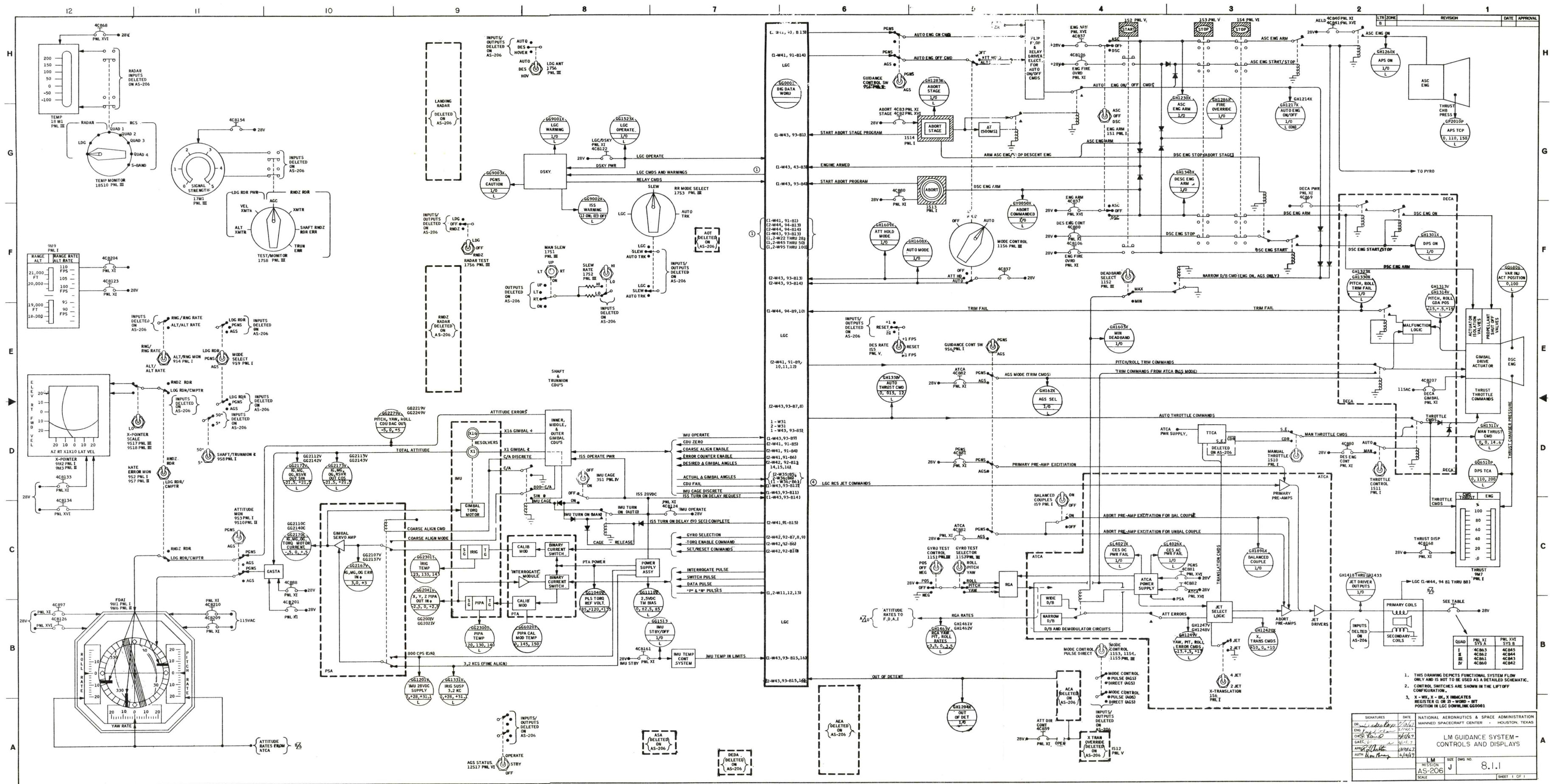
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TABLE 8-3 PRELAUNCH STATUS OF CIRCUIT BREAKERS (Concl'd)

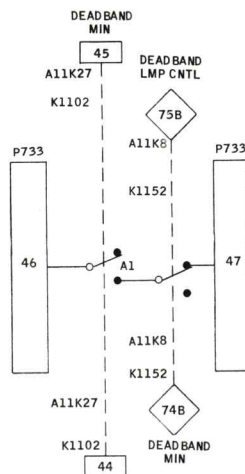
CIRCUIT BREAKER NUMBER	TITLE	POSITION
4CB203	AEA	OPEN
4CB204	ALT/ALTRT RNG/REQST	OPEN
4CB206	RNDZ RDR	OPEN
4CB207	DECA GIMBAL	CLOSED
4CB209	CD FDAI	OPEN
4CB210	SE FDAI	OPEN
4CB212	AOT LAMP	OPEN

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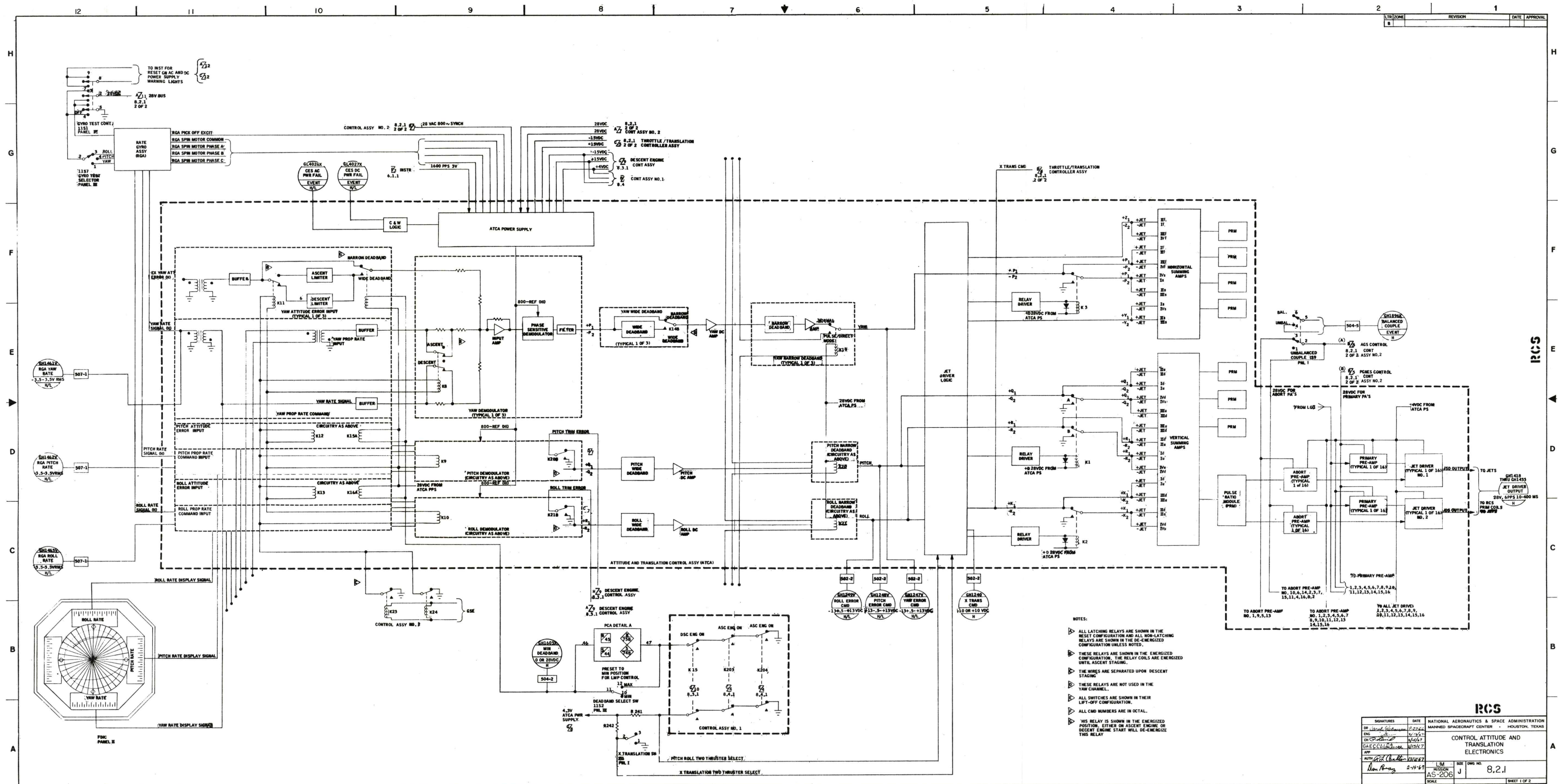
DETAIL A

DEAD BAND SELECT

PCA SWITCHING EQUATION

46 TO 47 = 44,74B

DWG NO. 8.2.1 (1 OF 2)
DETAIL SHEET NO. 1

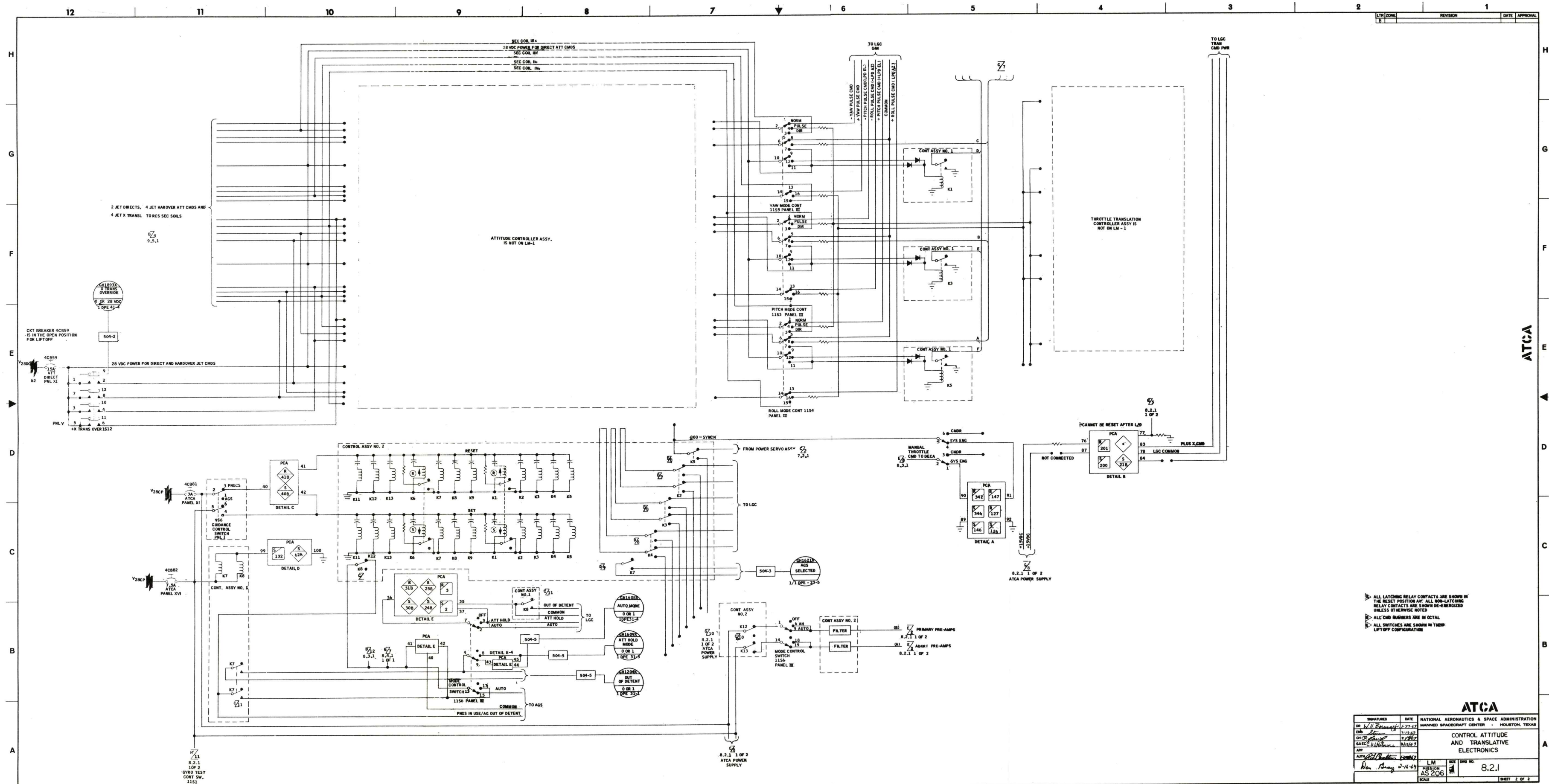


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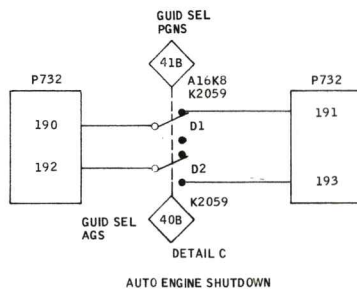
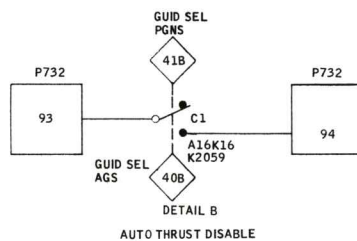
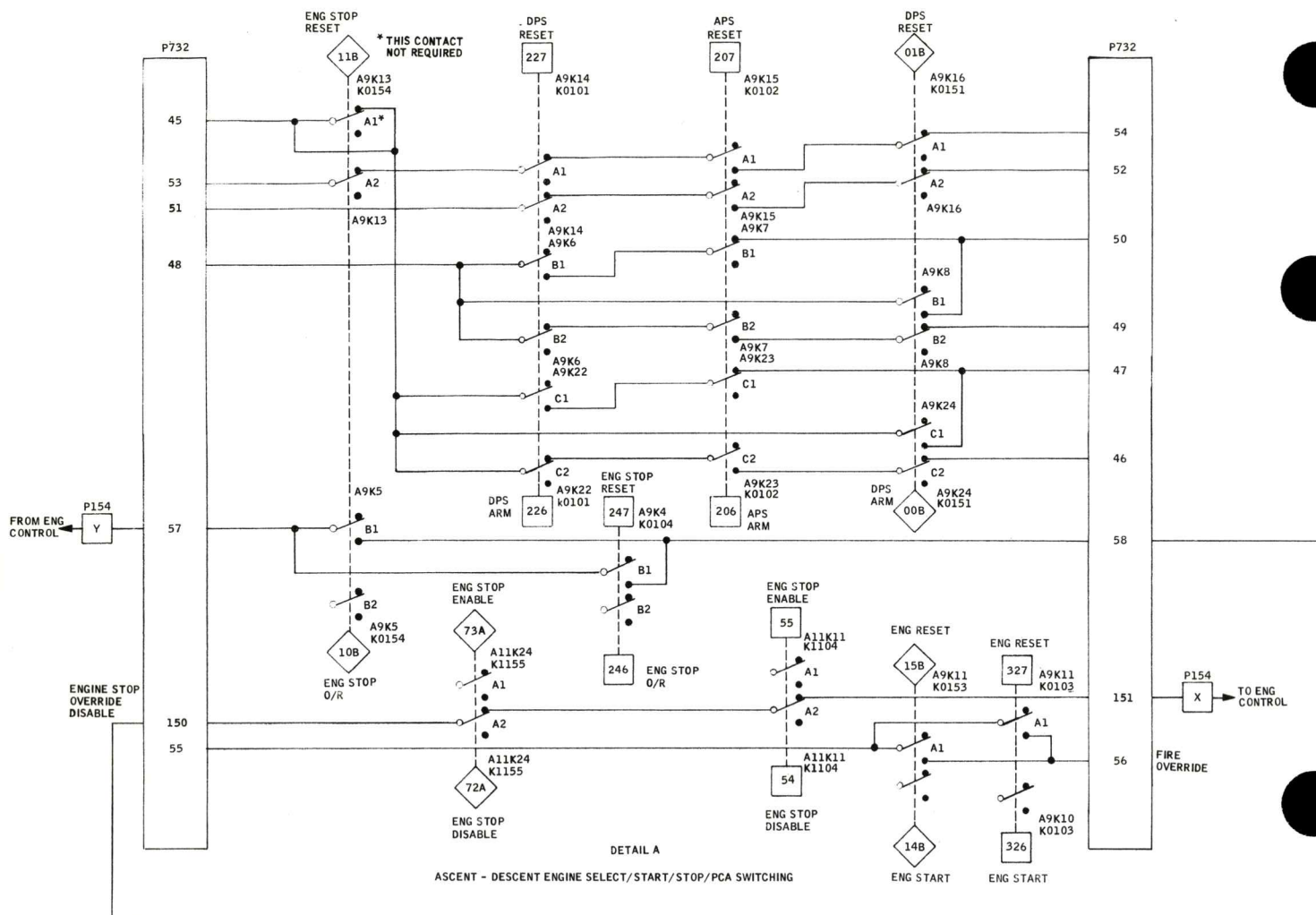
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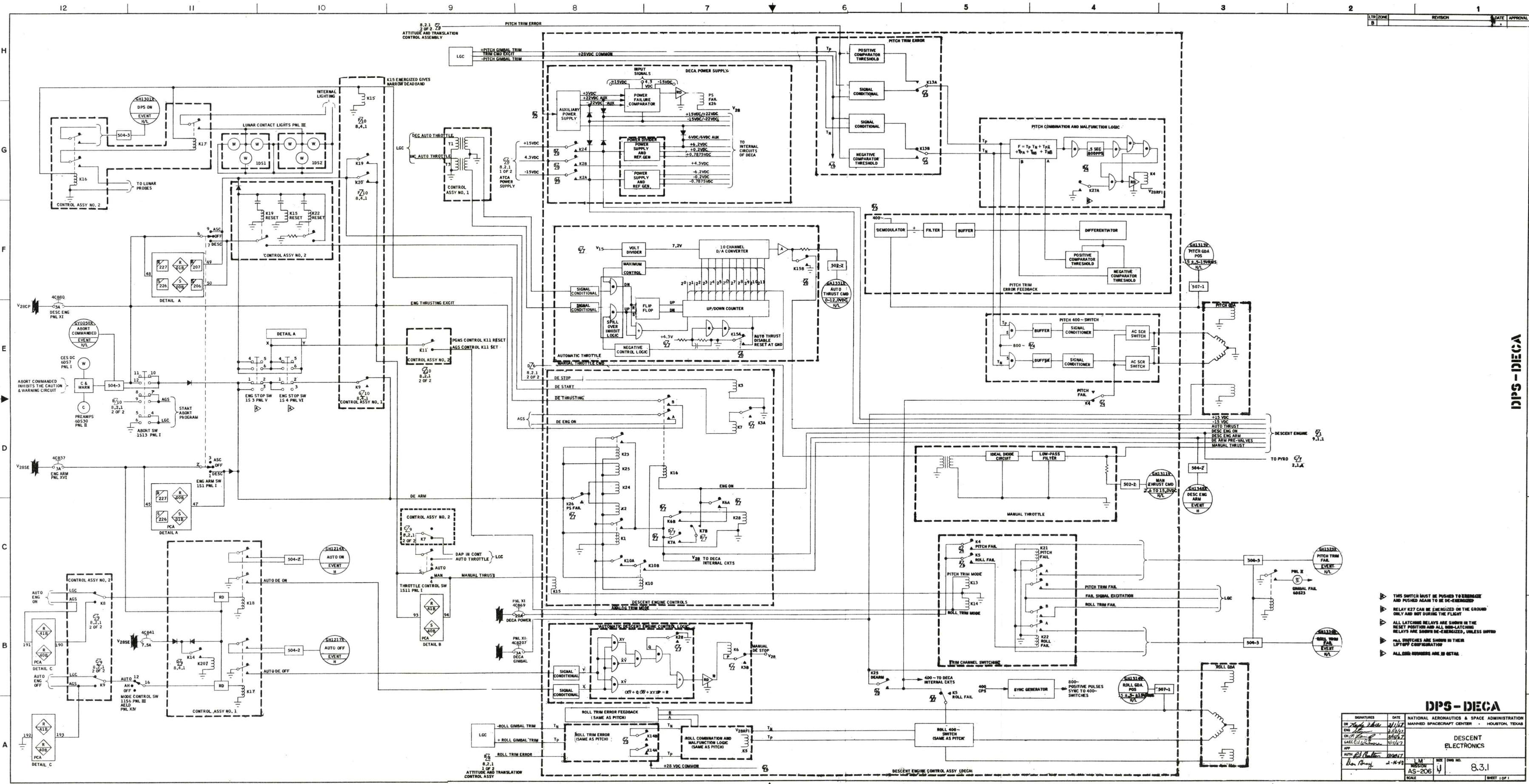
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PCA SWITCHING EQUATIONS

48 TO 49 = 206 (226 + 00B)
 48 TO 50 = 226 + 206 + 00B
 45 TO 47 = 226 + 206 + 00B
 191 TO 190 = 41B
 192 TO 193 = 40B
 93 TO 94 = 40B

NOTE: ALL SET CMDS ARE EVEN NUMBERS AND THE RESET CMDS ARE ODD NUMBERS AND ONE NUMBER LARGER THAN THE SET CMD
 EXAMPLE: 46 SET AND 47 RESET
 70A SET AND 71A RESET



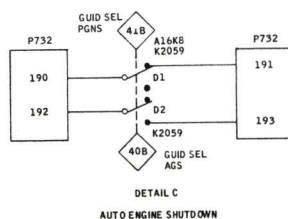
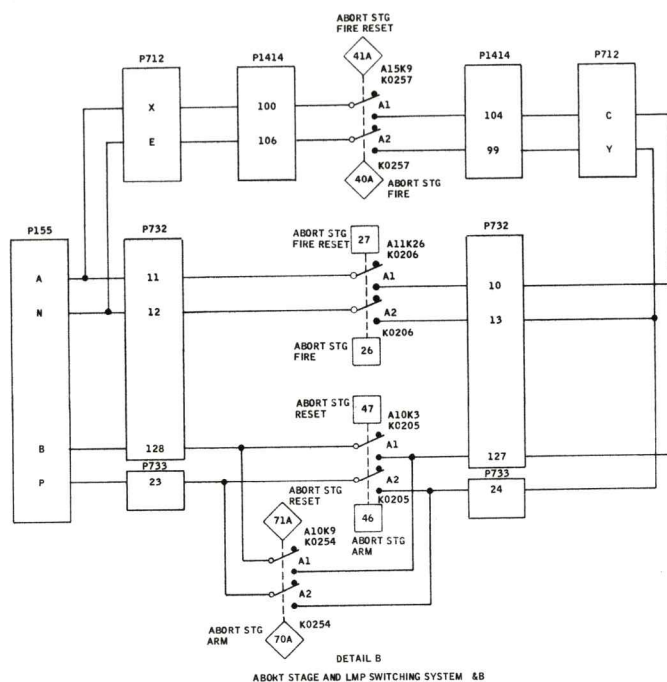
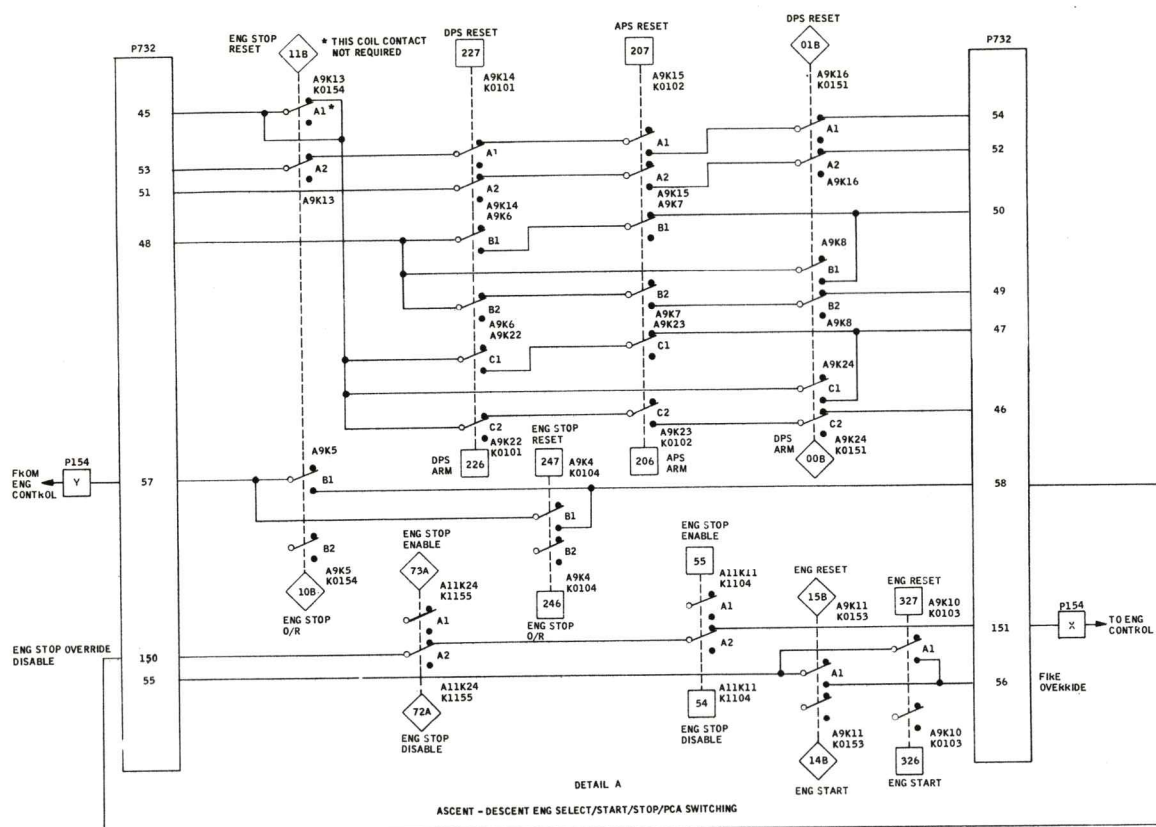
THIS SWITCH MUST BE PUSHED TO REARM AND PUSHED AGAIN TO BE DE-ARMED.
RELAY KEY CAN BE ENERGIZED ON THE GROUND ONLY AND NOT DURING THE FLIGHT.
ALL LATCHING RELAYS ARE SHOWN IN THE RESET POSITION AND ALL NON-LATCHING RELAYS ARE SHOWN DE-ENERGIZED, UNLESS SHOWN OTHERWISE.
ALL SWITCHES ARE SHOWN IN THEIR NORMAL POSITION.
ALL DIMENSIONS ARE IN INCHES.

SIGNATURES		DATE	NATIONAL AERONAUTICS & SPACE ADMINISTRATION	
DR	W. J. Zick	2/1/67	MANNED SPACECRAFT CENTER - HOUSTON, TEXAS	
ENG	W. J. Zick	2/1/67	DESCENT ELECTRONICS	
CHIEF	W. J. Zick	2/1/67	AS-206	
QA	W. J. Zick	2/1/67	REV. NO. 8.3.1	
APP	W. J. Zick	2/1/67	SCALE	
AUTH		2-1-67	SHEET 1 OF 1	

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Rev B

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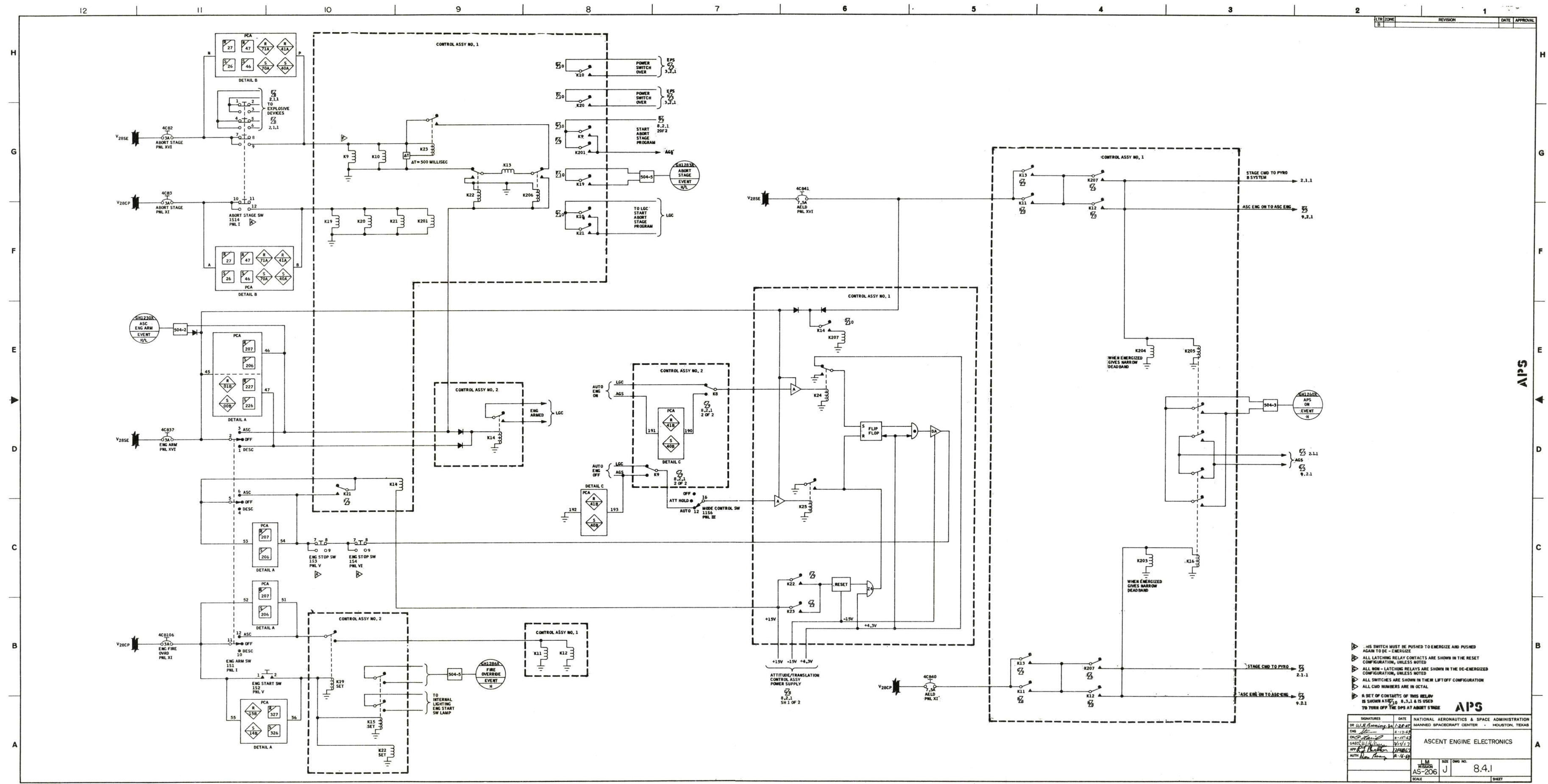
(See Back)



PCA SWITCHING EQUATIONS

A TO B = (46 * 26) + (46 * 40A) + (70A * 40A) + (70A * 26)
N TO P = (46 * 26) + (46 * 40A) + (70A * 40A) + (70A * 26)
45 TO 46 = 206 (226 + 008)
45 TO 47 = 226 (206 + 008)
53 TO 54 = 206 (008 + 226 + 108)
52 TO 51 = 206 (226 + 008)
55 TO 56 = 326 + 148
192 TO 193 = 408
191 TO 190 = 408

NOTE: ALL SET CMDS ARE EVEN NUMBERS AND THE
RESET CMDS ARE ODD NUMBERS AND ONE
NUMBER LARGER THAN THE SET CMD.
EXAMPLE: 46 SET AND 47 RESET
70ASET AND 71A RESET



SECTION 9
PROPULSION

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(RCS) is composed of two parallel,
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valves and plumbing necessary
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in each system.
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9. PROPULSION

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only during
interconnect feed valves

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SECTION 9
PROPULSION

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9.1 REACTION CONTROL SYSTEM

9.1.1 General Description

The Reaction Control Subsystem (RCS) is composed of two parallel, independent systems ("A" system and "B" system). Each system contains identical components with the associated valves and plumbing necessary to deliver the propellants to the thrust chamber assemblies. Normally both systems are operated together, but the arrangement of the engines is such that complete control in all axes is possible despite a failure of either system.

Helium pressurization is accomplished by an electrical RCS pressurization command to two parallel squib actuated isolation valves in each system.

Downstream are two series helium regulators which reduce the helium supply pressure for propellant tank pressurization. In normal operation, the upstream regulator is in control and reduces the pressure to the proper level, while the downstream regulator senses a demand and remains open as the sensed demand is below the setting.

Normally open propellant shutoff valves, located just downstream of the propellant tanks in each system, are capable of isolating the propellant tanks of either system in case of an upstream malfunction or depletion of propellants. These valves are operated in pairs (fuel and oxidizer) for each system by prime commands from the LGC, commands from the PRA, or RTC commands from the ground.

Normally closed fuel and oxidizer manifold crossfeed valves exist which can be opened to supply either system's propellants to all sixteen thrusters in case of a failed system. These two valves are operated as a pair by prime commands from the LGC or commands from the PRA. No RTC control exists for the crossfeed valves.

In addition, normally closed ascent feed valves, connecting ascent propellants to both systems fuel and oxidizer manifolds independently, may be opened to conserve RCS propellants. It should be emphasized that ascent propellants may be utilized in the RCS thrusters only during positive "X" axis acceleration. These ascent interconnect feed valves

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are operated in pairs for each system by prime programed commands from the LGC or by commands from the PRA. No RTC control is available for these valves. Also, during ascent feed operation, the main shutoff valves of the appropriate systems are closed and the crossfeed valves opened.

Normally open isolation valves exist in the propellant lines feeding thruster pairs, allowing the isolation of a thruster pair containing a failed open thruster. Through an onboard failure detection logic, the LGC senses an electrically failed thruster and automatically closes the appropriate isolation valves to isolate the failed pair. No PRA or RTC control of this function is available. The LGC is also capable of controlling the vehicle's attitude and translation without using the isolated thruster pair.

Each of the four RCS engine clusters consists of four rocket engine assemblies, each delivering approximately 100 pounds thrust. The engine assembly consists of an oxidizer and fuel solenoid valves, injector head, and combustion chamber. Each solenoid valve is a fail safe (in closed position) electrical solenoid operated valve. The fuel valve provides a two millisecond fuel lag, which with the injector premix igniter cup insures smooth engine start in the pulse mode. The injector has light unlike impinging doublets for main chamber ignition. Chamber cooling is provided by radiation and internal film cooling from eight fuel singlets along the injector outer periphery.

R-B

The RCS performs the following functions:

- A. Provides small thrust impulses to stabilize the LM during descent and ascent burns.
- B. Provides necessary thrust impulses to control the vehicle attitude and translation during all maneuvers.
- C. Provides necessary thrust impulses to accomplish separation maneuvers.
- D. Provides necessary thrust impulses to accomplish accelerations for ullage settling for the descent and ascent propellant tanks when required.

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The RCS is capable of operating in either a pulsed or a steady-state mode and is controllable by the LGC, or by a manual Attitude Controller Assembly (ACA) during manned flights. In "Normal" mode, attitude and translational maneuvers are accomplished by commands from either computer of variable frequency and pulse width to the primary coils of the engines. In "Pulsed" mode, the LGC sends one pulse for each out-of-detent movement of the ACA to the primary coils and in "Direct" mode, the ACA sends commands directly to the secondary coils of the RCS engines.

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9.2 DESCENT PROPULSION SYSTEM (DPS)

9.2.1 General

- A. The descent engine is a throttleable engine over a 10:1 range and develops 10,500 pounds of thrust in a vacuum at full throttle and 1,050 pounds minimum thrust. It consists primarily of an ablative lined thrust chamber with a crushable, radiation cooled nozzle extension; a variable area injector; a pair of flow control valves; four electromechanical flow control actuators; and eight propellant shutoff valves. It is mounted in the center compartment of the descent stage and is pivoted at the throat of the combustion chamber on a gimbal ring that is an integral portion of the engine assembly. The ring is suspended in the structure, pivoted in a line 90 degrees opposite to the engine pivots, so that the engine is capable of being gimballed ± 6 degrees in any direction by means of vehicle mounted gimbal actuators.

R-B

- The mechanical throttling scheme utilizes variable-area, cavitating venturi flow control valves mechanically linked to a variable area injector in order to separate propellant flow control and propellant injector functions so that each may be optimized without compromising the other, and to insure that propellant flow rates are made insensitive to downstream pressure variations in the injector and combustion chamber. At maximum thrust, operation is conventional. At approximately 70 percent minimum thrust, cavitation commences in the valve throats. From this level down to minimum thrust, the valve functions as a cavitating venturi. As thrust is reduced, the actuator reduces the flow at the control valves and moves the injector sleeve to reduce the injector apertures.
- B. The engine is activated and throttled by the LM Guidance Computer, which starts a sequence of events resulting in firing squibs and igniting the engine.

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The propellants are nitrogen tetroxide and a 50/50 blend of Unsymmetrical Dimethyl hydrozine (UDMH) and hydrazine called Aerozine 50. The freezing point of nitrogen tetroxide at standard conditions is 12°F; the boiling point is 70°F. The freezing point of Aerozine 50 at standard pressure is 21°F and the boiling point is 170°F.

9.2.2 Helium Storage Tank

Supercritical helium is stored in a double walled cryogenic storage container. It consists of an inner spherical tank with an outer jacket; the void between the tank and its jacket is filled with aluminized mylar insulation and evacuated to minimize heat transfer. The material used is titanium. The tank has associated fill and vent ports and a pressure relief device consisting of two burst discs, in series. Inside the inner tank is a helium/helium heat exchanger constructed of titanium tubing.

9.2.3 The Propellant Shutoff Valves

The shutoff valves are fuel pressure-actuated ball valves, fuel is introduced to the valve actuators through solenoid operated pilot valves, all of which are energized simultaneously during engine startup. During the start, the solenoids unseat the caged balls from the actuator inlet ports and seat them against the overboard vent ports. Fuel enters the actuator cavities; the actuator pistons connected to rack and pinion linkages twist the ball valves 90 degrees to the open position, permitting flow to the injector. The series parallel redundancy in the valve arrangement provides for positive start and cutoff. During shutdown, the solenoids are de-energized, opening the vent ports. The spring loaded actuators close the shutoff valves and residual actuating fuel is vented overboard into space. A mismatch circuitry is tied in with this system. It takes the output of eight microswitches and puts them through a summing network. The output of this network is then telemetered to ground indicating any disparity in valve positions.

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9.2.4 Propellant Quantity Gaging System (PQGS)

A capacitance type quantity gaging system is used to provide propellant quantity information via telemetry to the ground during positive "G" conditions. The PQGS will be a continuous gaging system with capabilities for gaging propellants in each descent stage tank between 95 percent of propellants remaining and one inch of the tank bottom. The accuracy of the system between 95 percent and 25 percent of the propellants remaining is ± 1.0 percent of full tank capacity. Between 25 percent of propellants remaining and one inch of the tank bottom, the system accuracy is ± 0.5 percent of full tank capacity. Due to component heating in a vacuum, the system is constrained to 15 minutes of operation at any one time, however, the total operating life is 5000 hours. The LGC is programed to automatically turn the PQGS ON and OFF before and after each burn. In addition the PQGS will provide a discrete signal when the propellant level is a predetermined distance from the tank bottom, corresponding to 120 seconds engine operating time remaining at 25 percent thrust.

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9.2.5 Fuel/Helium Heat Exchanger

This heat exchanger absorbs heat from the engine fuel which has been circulated from the fuel tanks directly to the heat exchanger, before its ultimate delivery to the engine. It is a two pass heat exchanger, that is, helium from the storage tank absorbs heat from the fuel on the first pass. Then flows back to the helium/helium heat exchanger inside of the storage tank, then is reheated on the second pass.

9.2.6 Thrust Chamber

The thrust chamber consists of a composite ablative cooled nozzle extension (area ratio of 16:1) a crushable radiation cooled nozzle extension (area ratio of 49:1) and a gimbal ring assembly. The ablative components are encased in a continuous titanium shell and jacketed in a stainless steel foil/glass wool composite thermal blanket. The radiation cooled nozzle extension is made from stainless steel. The nozzle extension is flanged to the titanium chamber shell. The gimbal assembly is located at the chamber throat plane and provides for a ± 6 degree gimbal of the

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thrust vector during flight. The assembly is manufactured from aluminum alloy, except for the bearings, which are made of high strength steel.

9.2.7 Flow Control Valves

Flow control valves are non-redundant venturis with movable pintle sleeves. Engine throttling is initiated by an electrical signal to the throttle actuator commanding an increase or decrease in engine thrust. Operation of the throttle actuator drives the linkage cross beam to a new position, thus repositioning the pintles in the flow control valves. This axial movement of the pintles results in decreasing or increasing the pintle flow areas the precise amounts to control propellant weight flow rate and thrust.

9.2.8 Throttle Actuator

The throttle actuator is an electromechanical linear servoactuator powered by redundant motors. It is located between the fuel and oxidizer flow control valves on the engine head end. The output shaft of the actuator is attached to the throttle linkage. Three torque motors drive the jack screw. The actuator is designed to operate within specification using two motors, or at a reduced rate using only one. The actuator case is hermetically sealed to prevent cold welding in a vacuum environment. Although the actuator could operate without lubrication, a compound with a known off-gasing rate is included to maintain a small positive pressure if the actuator case leaks. Performance redundancy is provided by designing each of the three separate servo channels to have equal output performance. For a null-type or inoperative failure, two separate servo channels failing can be tolerated. The two malfunctioning motors will be driven along with the load by the one operating motor. In the case of a saturated or hardover-type failure of one servo channel, the load is effectively increased by the two operating motors which have the capability of overriding the malfunction and providing the required output performance.

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9.2.9 Pressure Regulators

There are two regulators, one in each parallel leg of the system, the primary leg being normally open and providing helium at 245 psia downstream. Each leg has a solenoid valve upstream of the regulator which is controlled from the cabin or maybe commanded from the ground. The secondary leg is normally closed (but may be opened as required). It also provides 245 psi downstream.

9.2.10 Quadcheck Valves

There are two such valves, one in each of the lines leading to the propellant tanks. They are made up of four check valves arranged in a series - parallel configuration, the primary purpose being to prevent prevent propellant vapors from mixing in the upstream manifold.

9.2.11 Propellant Tanks (Titanium)

There are four propellant tanks, two each for oxidizer and fuel. They are interconnected on top and on bottom, within each system to insure equal usage and pressure. Each tank has a volume of 63 cubic feet.

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9.2.12 Supercritical Helium

The helium pressure timeline begins with the DPS propellant loading. This occurs at about 18 hours before nominal liftoff when the supercritical helium loading pressure is approximately 100 psia. Due to the heat transfer from the surroundings, the helium pressure increases at the rate of approximately 10 psi per hour until the descent engine is fired. During low level thrust, the pressure builds up at a rate of 100 psi per minute. Subsequently, after engine shutdown, the pressure rises sharply at about 150 psi per hour for one hour, after which time, the pressure again increases at a rate of 10 psi per hour. Since the minimum DE turn-on pressure is 400 psia, approximately 15 hours from nominal liftoff are required before this pressure is achieved.

The time range between 33 and 130 hours from DPS propellant loading or 400 to 1400 psia, respectively, defines the region which will safely allow normal engine operation at the maximum throttle duty cycle.

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Ignition of the descent engine during low supercritical helium tank pressures (i.e., below about 350 psia) results in a "blowdown" or degraded engine operating mode. Too high a pressure (above 1920 ± 50 psia) could rupture the burst disc, thus terminating pressurization which results in degraded "limited blowdown" mode.

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9.3 ASCENT PROPULSION SYSTEM

9.3.1 General

- A. The Ascent Propulsion System (APS) consists of a non-gimbaling, constant thrust, hypergolic type engine of 3500 pounds thrust and associated propellant tanking and pressurization system. The APS provides the capability for powered ascent of the Lunar Module (LM) from the lunar surface and any subsequent orbit adjustments necessary for successful rendezvous with the Command/Service Module. In addition the APS provides propellant to the RCS during APS operation on lunar ascent.
- B. The ascent engine is activated and controlled by automatic start/stop commands originating in the LM guidance computer or by manual start/stop commands. All APS start sequences are essentially identical; with the addition of initiation of explosive devices on the Fire-in-the-Hole (FITH) burn.

1. FITH Burn

Prior to FITH the Ascent Propulsion system is dormant: This burn sequence is initiated by an abort stage command from the LGC, PRA, or RTC. The sequence performs the following functions: arms the explosive devices power bus and ignites pyrotechnics to open the helium isolation valves, and arms the engine fire circuit. The engine fire signal is initiated, which ignites the remainder of the explosive devices; fuel and oxidizer isolation valves, stage holddown bolts, circuit interrupters, and cable cutters. This signal also opens the actuator isolation valves, which allows fuel pressure at 165 psi to operate the propellant shutoff valve mechanism and opens the propellant shutoff valves. This allows fuel (Aerozine⁵⁰) and oxidizer (nitrogen tetroxide) to flow under pressure to the thrust chamber where they ignite hypergolically. The engine continues to operate until the LGC initiates

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an engine stop command automatically or the engine is disarmed by RTC.

2. Subsequent APS burns.

At the end of the FITH the system is fully pressurized and in operational standby mode. The engine may be ignited by either a normal programmed LGC fire command sequence or RTC fire override command. Either method fires the engine by opening the isolation and actuator isolation valves. Fuel pressure operates the actuator mechanism which opens both the oxidizer and fuel shutoff valves and allows propellant flow to the thrust chamber. Shutdown of the engine is accomplished by LGC command or RTC engine stop override.

9.3.2 Notes

- A. Pressure Reducing Regulators. This regulating system uses two regulators in a parallel arrangement, each regulator housing contains dual regulators. This arrangement provides the overall regulation system with added redundancy. Each regulator contains a pilot valve and seat assembly which modulates inlet pressure to control the opening of a main poppet valve and seat assembly, and reduces the upstream pressure to that required to provide correct propellant tank pressurization. Minimum operating inlet pressure is 500 psi for rated output. Below 500 psi the regulated output is 179 ± 1 psi.
- B. Propellant Shutoff Valves. The propellant shutoff valves are a series parallel arrangement of eight ball valves, four each oxidizer and fuel. This arrangement is to insure continued operation of the engine in the event of valve failure. The valves are operated by a piston actuator assembly which is controlled by fuel pressure through solenoid isolation and actuator isolation valves.

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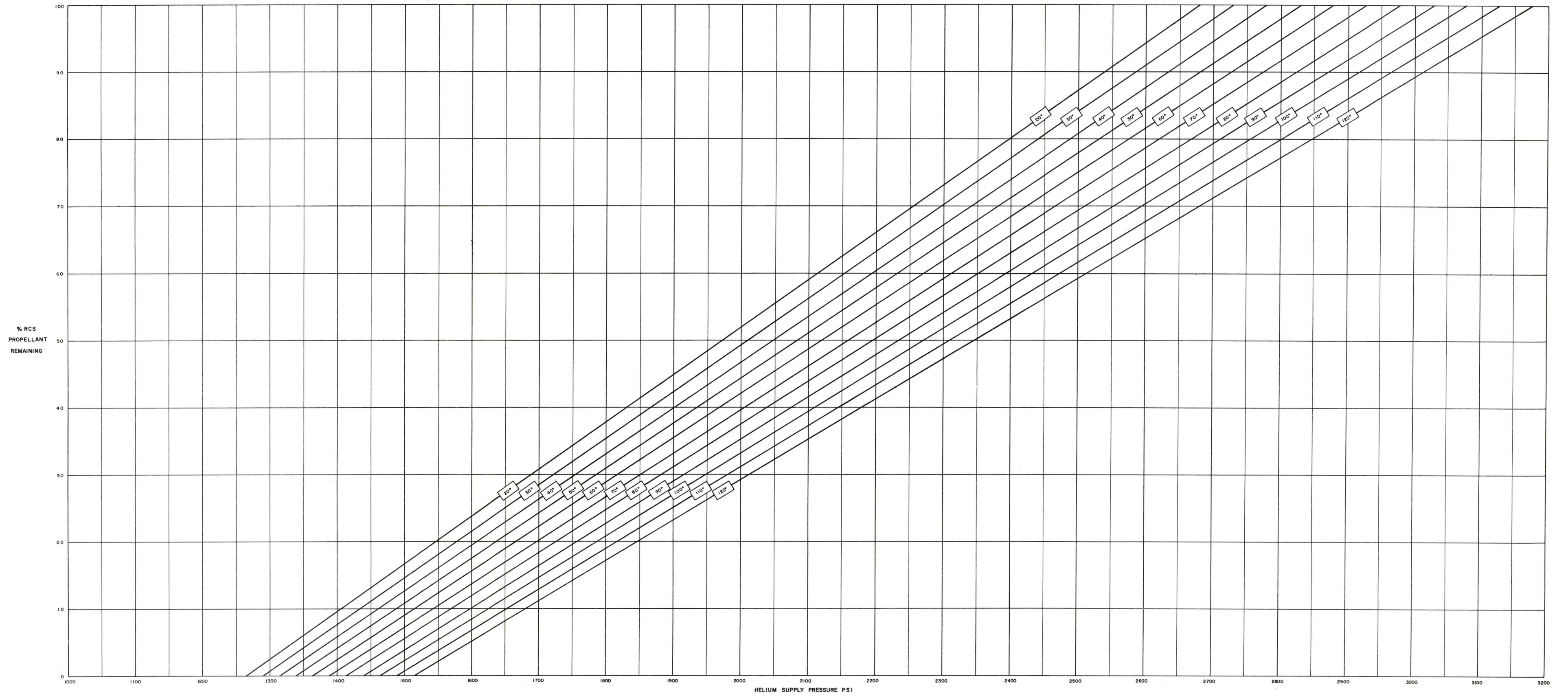
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1. The solenoid-operated actuator isolation and actuator valves and the main ball valves are normally closed. In the closed position, all solenoids are de-energized and the actuation fuel is shut off by action of the spring-loaded solenoid plungers on the ball poppets seated in the lower pilot valve seats. The back side of the actuator pistons are vented to preclude air lock. In the open position, all solenoids are energized, and fuel actuation forces at 165 psi, act against the spring-loaded plunger, thus permitting fuel to flow to the actuator pistons to initiate oxidizer and fuel valve opening. At this point, the actuator valve pilot valves are forced against the upper valve seat, thus sealing off the vent port. When the electrical signal is removed, the pilot valves are returned to their lower seat position to seal off the actuation pressure. Closing of the main propellant ball valves is accomplished by the return spring action of the actuator piston springs as the fuel actuation pressure decays and expels the entrapped fuel in the cylinders and pilot passages out through the pilot vent port.
2. All shutoff valves are opened simultaneously at engine start, and closed simultaneously at engine shutdown. The time from signal initiation to full open or from signal cutoff to full closed is 150 milliseconds. Switches are installed in the oxidizer housing to provide a TM indication of valve position. Eight microswitches (four open and four closed) make up the summing electronics for system "A" and system "B". An open and close microswitch is used for each crank actuator. In case of a valve mismatch, flow is diverted from the malfunctional path to the parallel flow path.

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- C. Ascent Propulsion Low Pressure 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 bipropellant 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 dead face switch resulting from staging if illuminated by low fuel or oxidizer pressure, the light is extinguished only by restoration of pressure.
- D. Ascent Propellant Low Quantity Caution Light. The (APS 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. These low level signals are enabled only if the ascent engine is on.
- E. The (APS Hi Reg) caution light is illuminated if reg out manifold pressure falls below 220 psi.

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TABLE 9-1 CAPABILITIES AND LIMITATIONS APS, DPS, AND RCS

	APS	DPS	RCS
<u>HELIUM SOURCE PRESS.</u>			
VOLUME	5800 IN ³	5.87 FT ³	920 IN ³
PRESSURES			
BURST	5250 PSI	3420 PSI	7000 PSI
PROOF	4660 PSI	2045 PSI	4650 PSI
NOMINAL LOADED	3050 PSI	400 PSI	3050 PSI
<u>REGULATORS</u>			
CONFIGURATION	SERIES/PARALLEL	PARALLEL	SERIES
CLASS I			
PRIMARY			
SETTING	184±4 PSI	245± ³ / ₂ PSI	179±2 PSI
LOCKUP	192±3 PSI	250± ³ / ₂ PSI	188 PSI
SECONDARY			
SETTING	190±4 PSI		185±2 PSI
LOCKUP	197±3 PSI		194 PSI
CLASS II			
PRIMARY			
SETTING	176±4 PSI	245± ³ / ₂ PSI	
LOCKUP	183±3 PSI	250± ³ / ₂ PSI	
SECONDARY			
SETTING	182±4 PSI		
LOCKUP	189±3 PSI		
MINIMUM OPERATING PRESSURE	500 PSI	400 PSI	400 PSI
<u>QUAD CHECK VALVES</u>			
PRESSURE			
BURST	810 PSI	810 PSI	750 PSI
PROOF	540 PSI	540 PSI	500 PSI
ΔP DROP	5 PSI	5 PSI	4±1 PSI
CRACKING ΔP	2±5 PSI	2±.5 PSI	2±.5 PSI

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TABLE 9-1 CAPABILITIES AND LIMITATIONS APS, DPS AND RCS (Cont'd.)

	APS	DPS	RCS
<u>COMPATIBILITY VALVES</u>			
	SERIES/PARALLEL	SERIES	N/A
ACTUATION TIMES			
OPEN	0.1 SEC	0.1 SEC	N/A
PRESSURE DROP	0 PSI	0 PSI	N/A
PROOF	540 PSI	540 PSI	N/A
BURST	810 PSI	810 PSI	N/A
<u>TANK ASSEMBLY</u>			
BURST DISC RUPTURE	238±12 PSID	288±20 PSID	234±12 PSID
BLEED VALVE			
CRACK	0 PSI	0 PSI	0 PSI
RESEAT	20-80 PSI	20 PSI	80 PSI
RELIEF VALVE			
CRACK	225 PSI	260 PSI	238±12 PSI
FULL FLOW	250 PSI	275 PSI	
RESEAT	225 PSI	254 PSI	220 PSI
PROP TANKS			
VOLUME			
FUEL	34 FT ³	126 FT ³	3305 IN ³
OX	34 FT ³	126 FT ³	4112 IN ³
PRESSURES			
BURST	375 PSI	405 PSI	375 PSI
PROOF	333 PSI	358 PSI	333 PSI
<u>FUEL HELIUM HEAT EXCHANGER</u>			
PRESSURES	N/A		N/A
PROOF FUEL	N/A	540 PSI	N/A
HELIUM	N/A	2200 PSI	N/A
BURST FUEL	N/A	810 PSI	N/A
HELIUM	N/A	3300 PSI	N/A
<u>MAIN SHUTOFF, TCA ISOL, X FEED,</u>			
<u>APS INNCT VALVES</u>	N/A	N/A	
ACTUATION TIMES	N/A	N/A	
OPEN			0.25 SEC
CLOSE	N/A	N/A	0.25 SEC

R-B

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REV B

Table 9-1 CAPABILITIES AND LIMITATIONS APS, DPS, AND RCS (Cont'd)

	APS	DPS	RCS
ACTUATION VOLTAGE			
MAX	N/A	N/A	32.0 VDC
MIN	N/A	N/A	18.0 VDC
PRESSURES	N/A	N/A	
PROOF	N/A	N/A	360 PSI
BURST	N/A	N/A	1050 PSI
DROP	N/A	N/A	2.0±.25 PSI
<u>ACTUATOR ISOLATION VALVES</u>			
ACTUATION TIMES			
OPEN	0.03 SEC	.03 SEC	N/A
CLOSE	0.03 SEC	0.03 SEC	N/A
ACTUATION VOLTAGE			
MAX	32V	32V	N/A
MIN	21V	21V	N/A
PRESSURES			
BURST	750 PSI	750 PSI	N/A
PROOF	500 PSI	500 PSI	N/A
<u>PROPELLANT SHUTOFF VALVES</u>			
ACTUATION VOLTAGE			
MAX	32V	32V	N/A
MIN	21V	21.5V	N/A
PRESSURES			
OPEN			
CRACK	80 PSI	60 PSI	N/A
FULL OPEN	120 PSI	100 PSI	N/A
CLOSE			
START	70 PSI	90 PSI	N/A
FULL CLOSE	30 PSI	30 PSI	N/A
DROP			N/A
<u>ENGINES</u>			
NOMINAL THRUST	3500	10500-1050	100
COOLING	FILM & ABLATIVE COOLING	FILM & RADIATION	FILM & RADIATION
LIFE	447 SEC	960 SEC	500 SEC PULSE 500 SEC STEADY STATE
INJECTOR TYPE	TRIPLET ORIFICES (2 OX & 1 FUEL) IN A GRID PATTERN ON INJECTOR FACE. ON OUTER PERIPHERY ORIFICES ARE DOUB-LETS (1 OX & 1 FU) TO PROVIDE REDUCED TEMP BARRIER AT ABLATIVE CHAMBER WALL	VARIABLE AREA	8 FUEL FOR COOL- ing 8 ON 8 FOR MAIN CHAMBER 1 ON 1 FOR PRE-IGNITER

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TABLE 9-1 CAPABILITIES AND LIMITATIONS APS, DPS, AND RCS (Concluded)

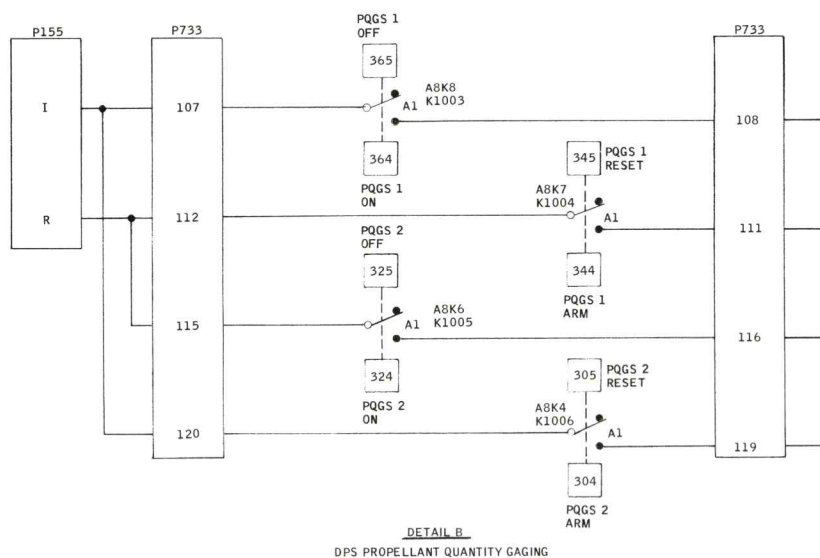
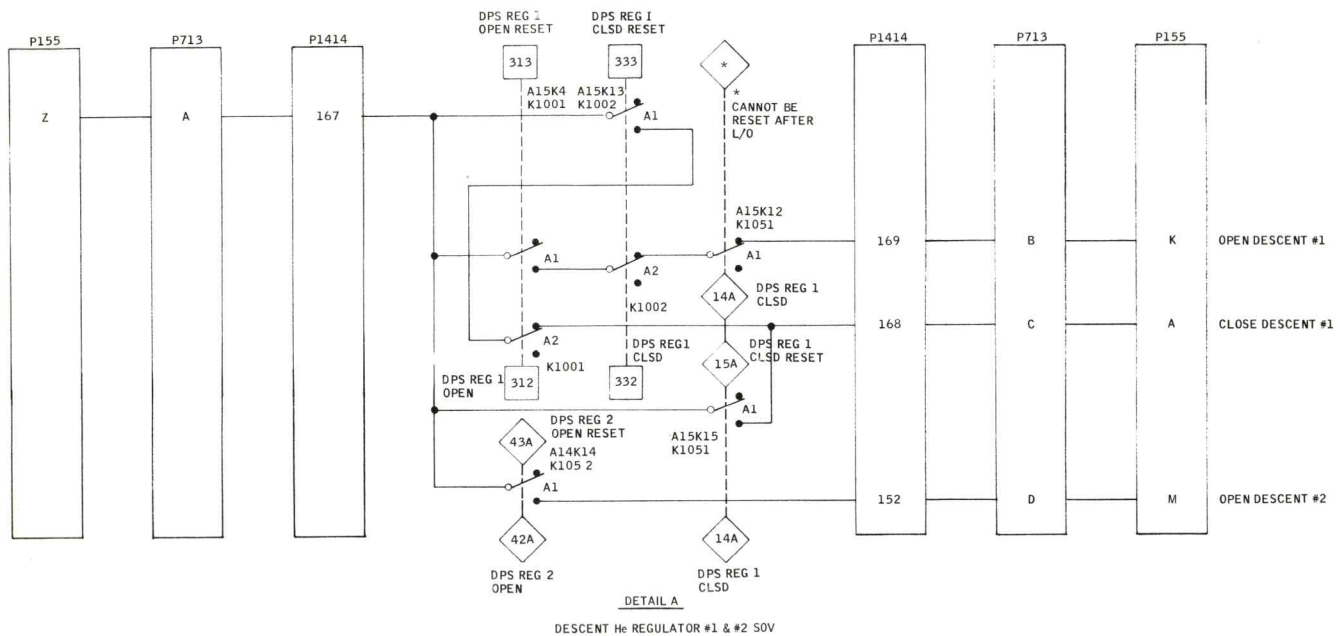
	APS	DPS	RCS
O/F RATIO	1.6/1	1.6/1	2.0/1
FLOW RATES			
OXID (lb/SEC)	7.0	21 (MAX)	0.24
FUEL (lb/SEC)	4.3	13 (MAX)	0.12
THRUST CHAMBER PRESSURE	110 PSI	118 PSI (MAX)	96 PSI
MINIMUM OPERATING TIME	1.0 SEC	N/A	0.013 SEC

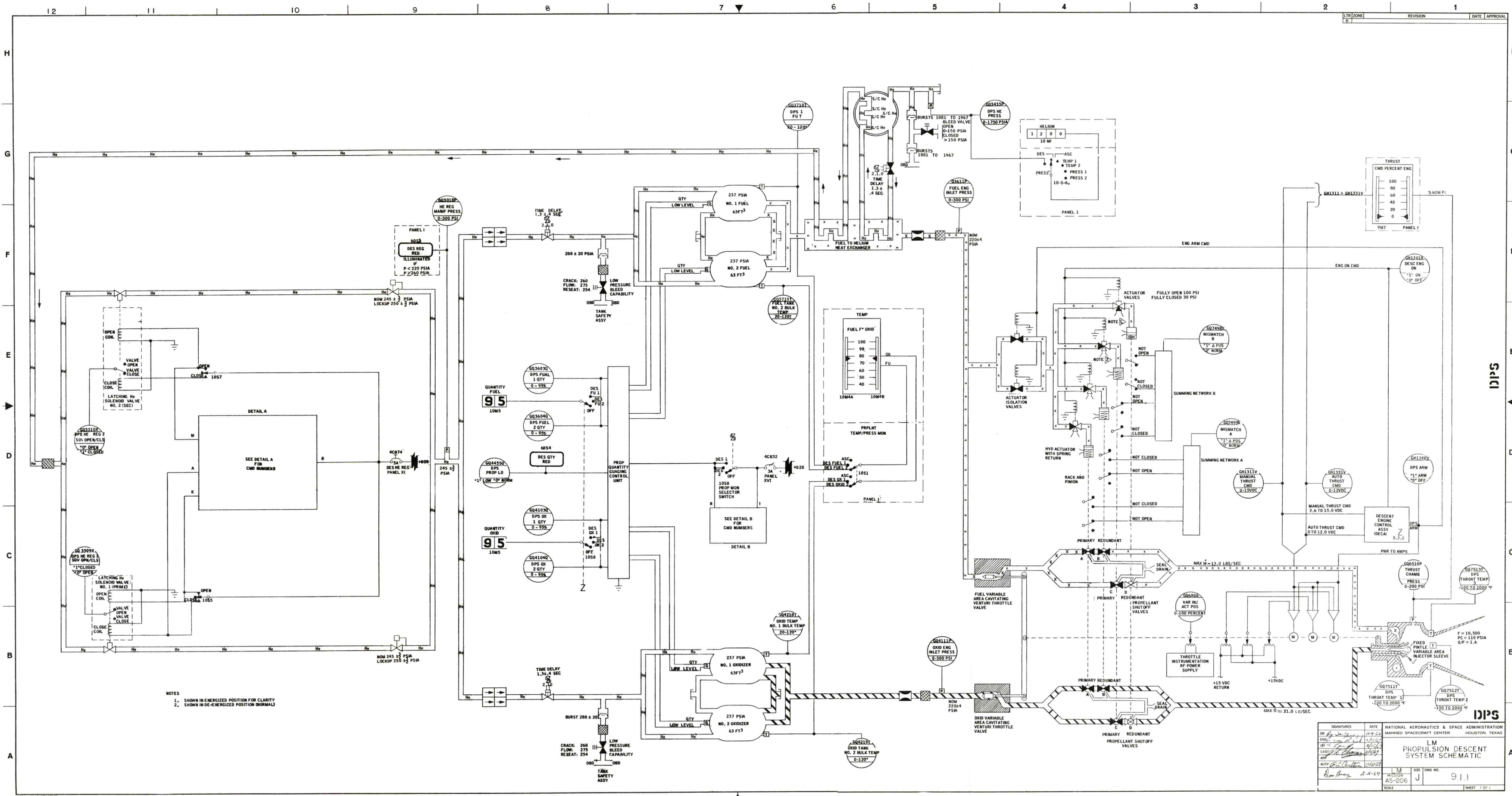
R-B

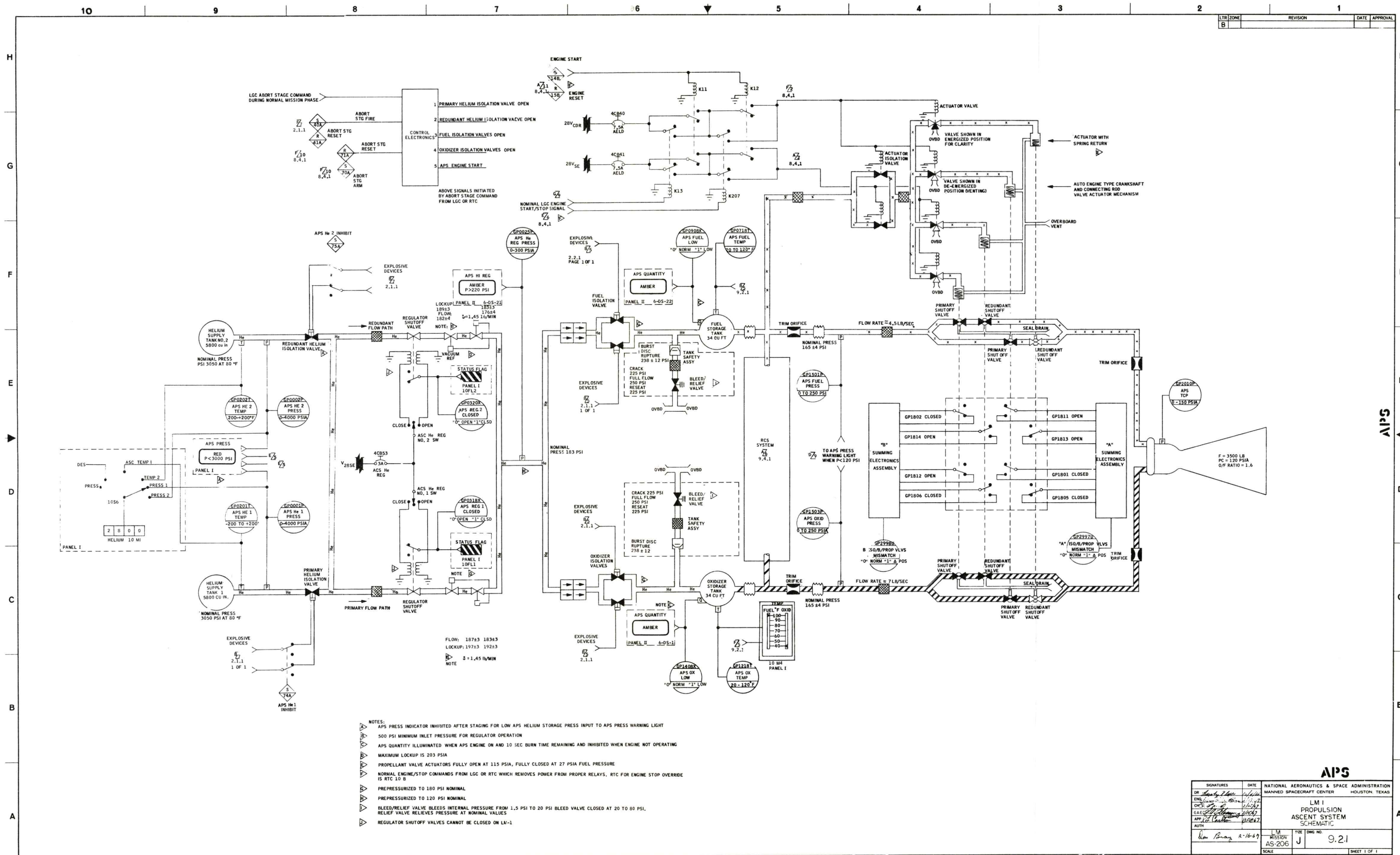
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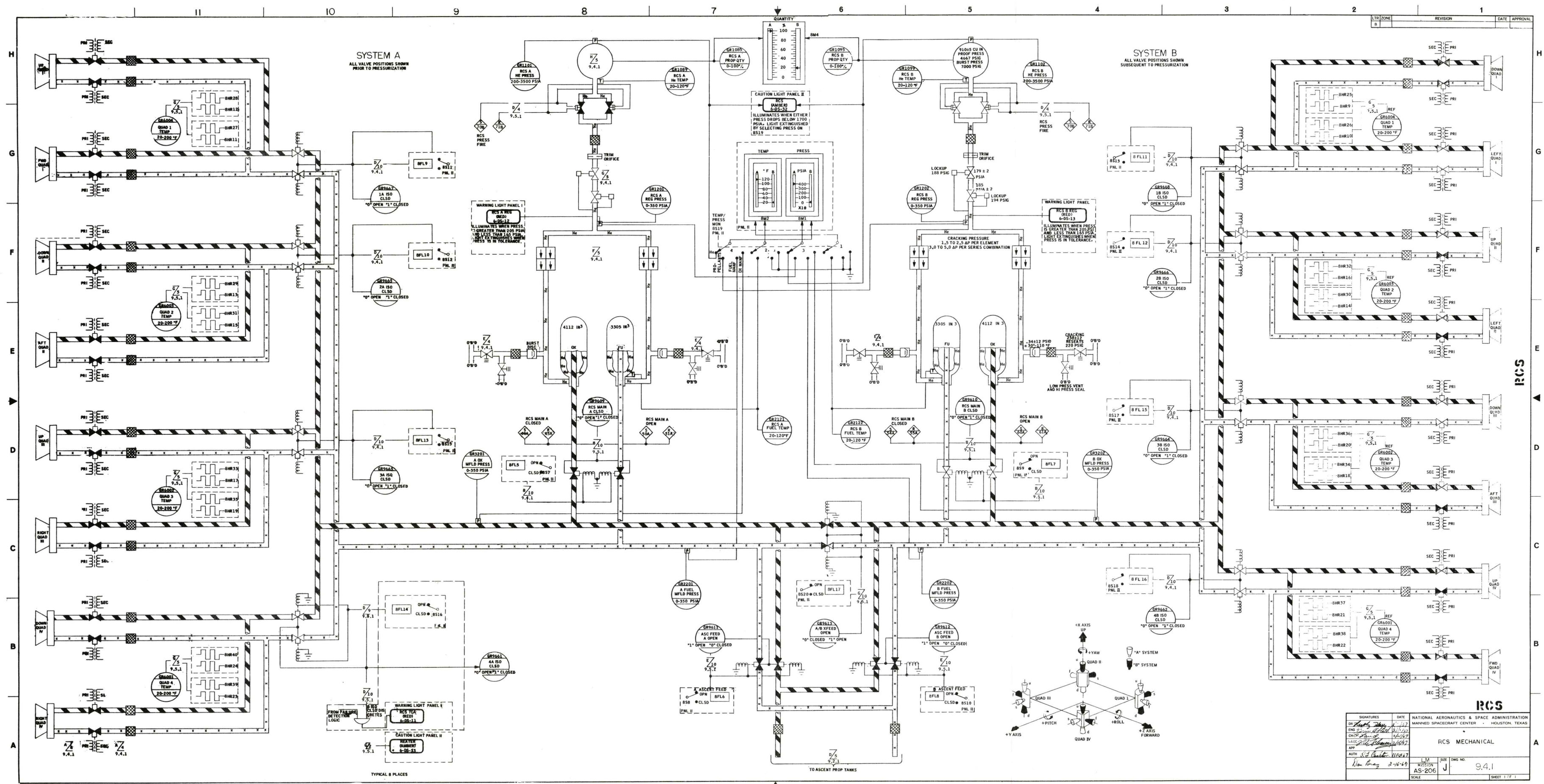


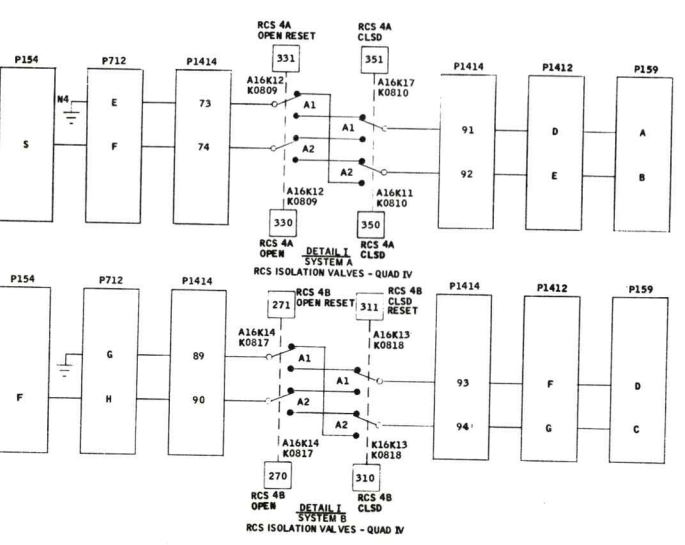
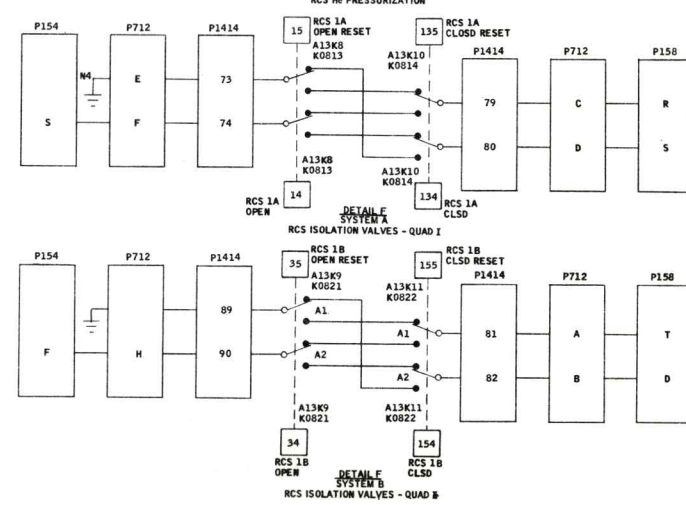
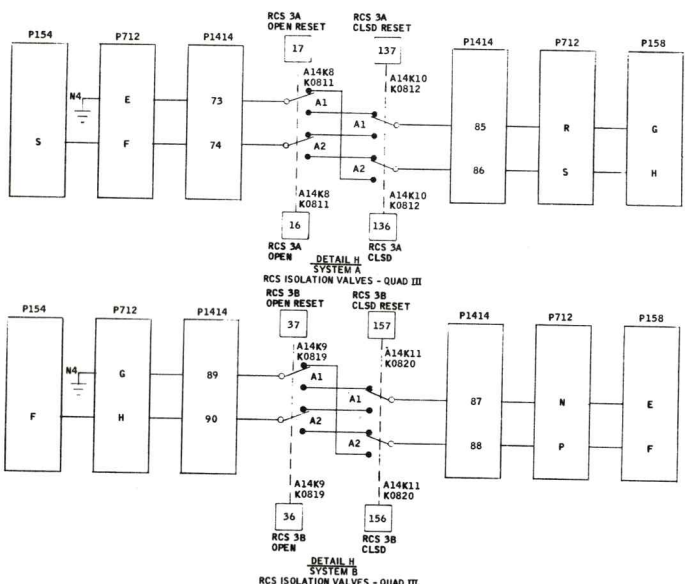
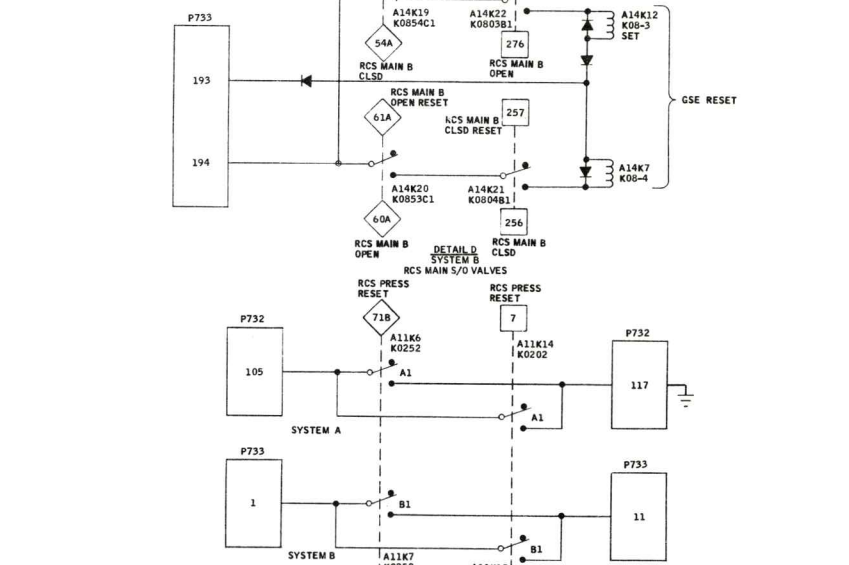
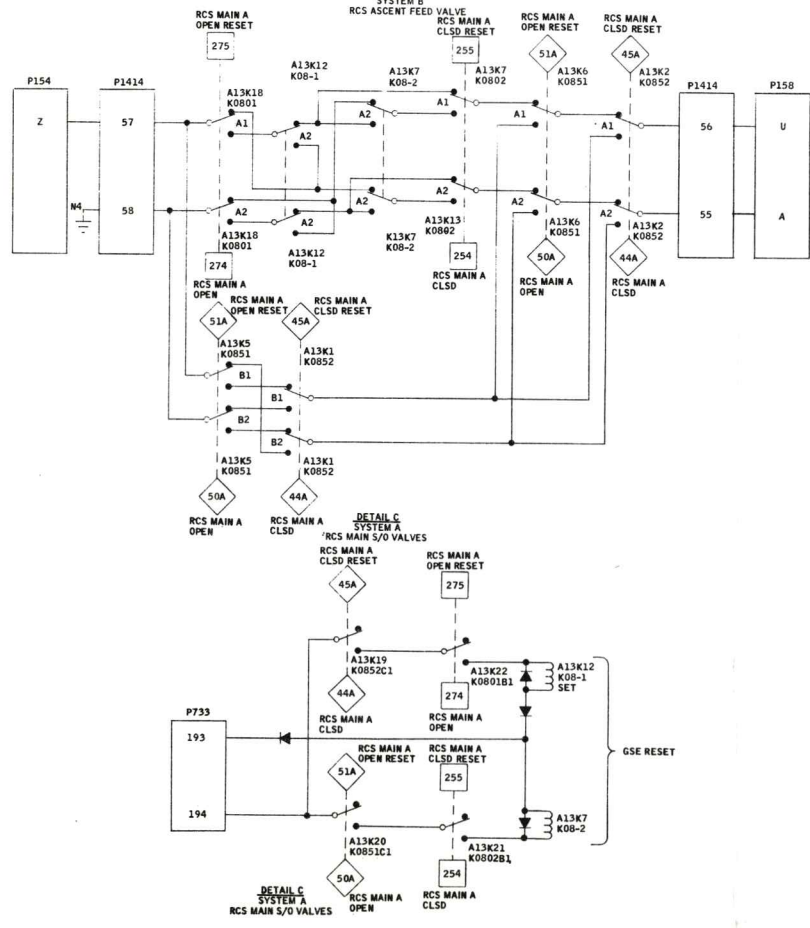
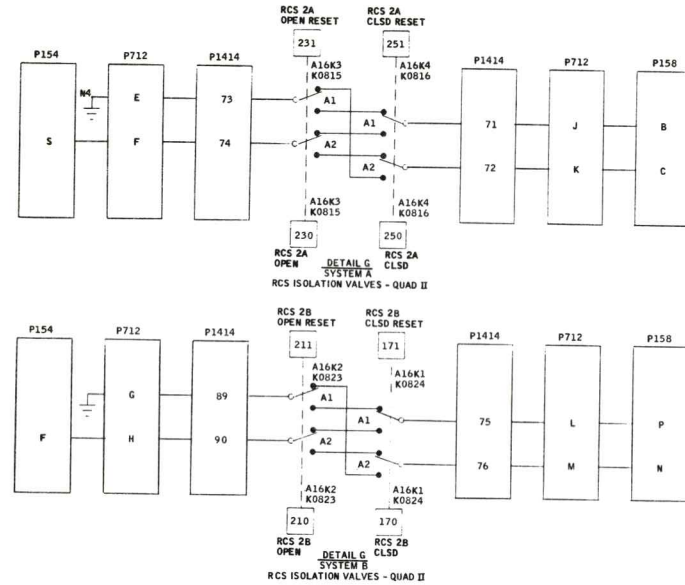
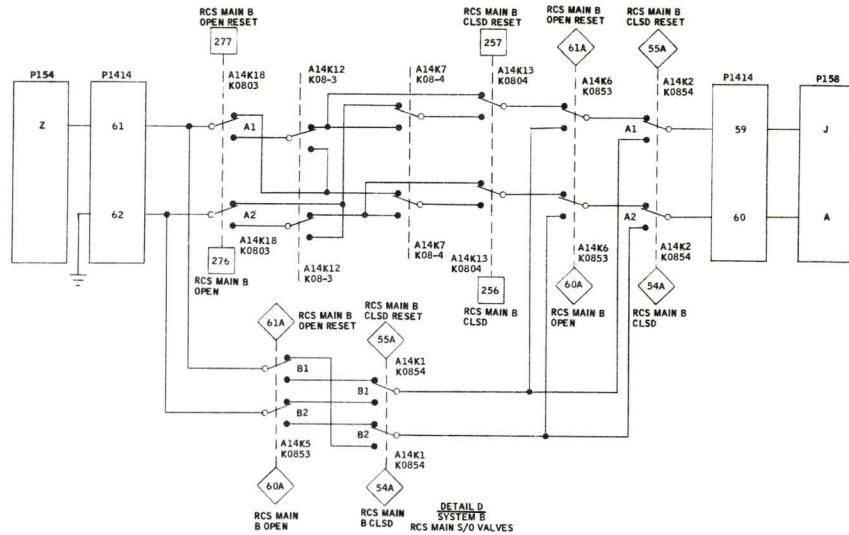
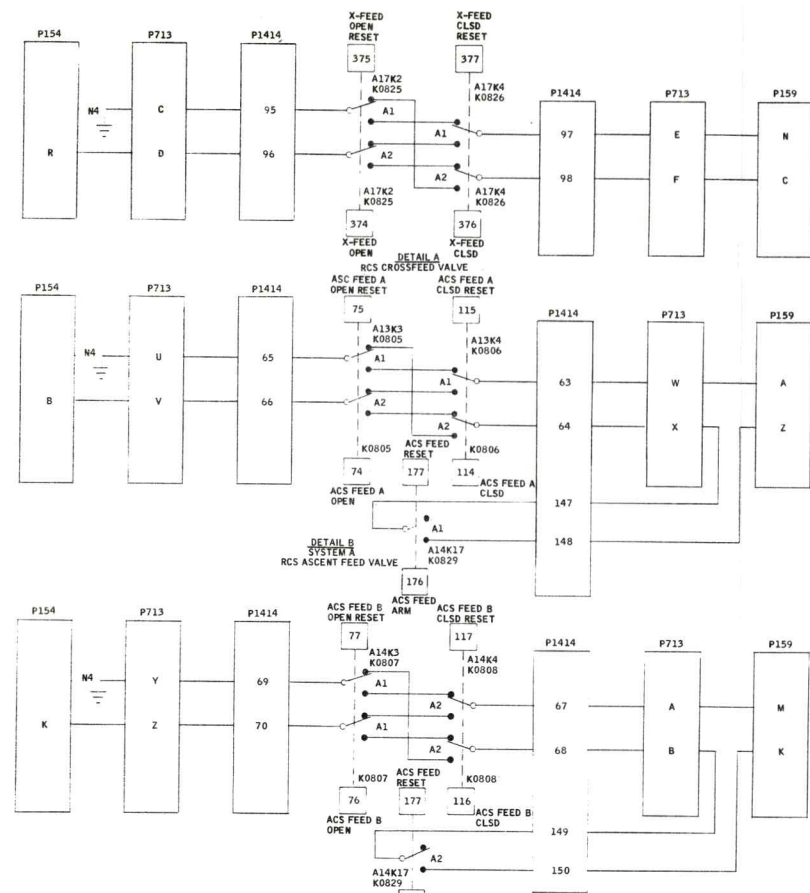
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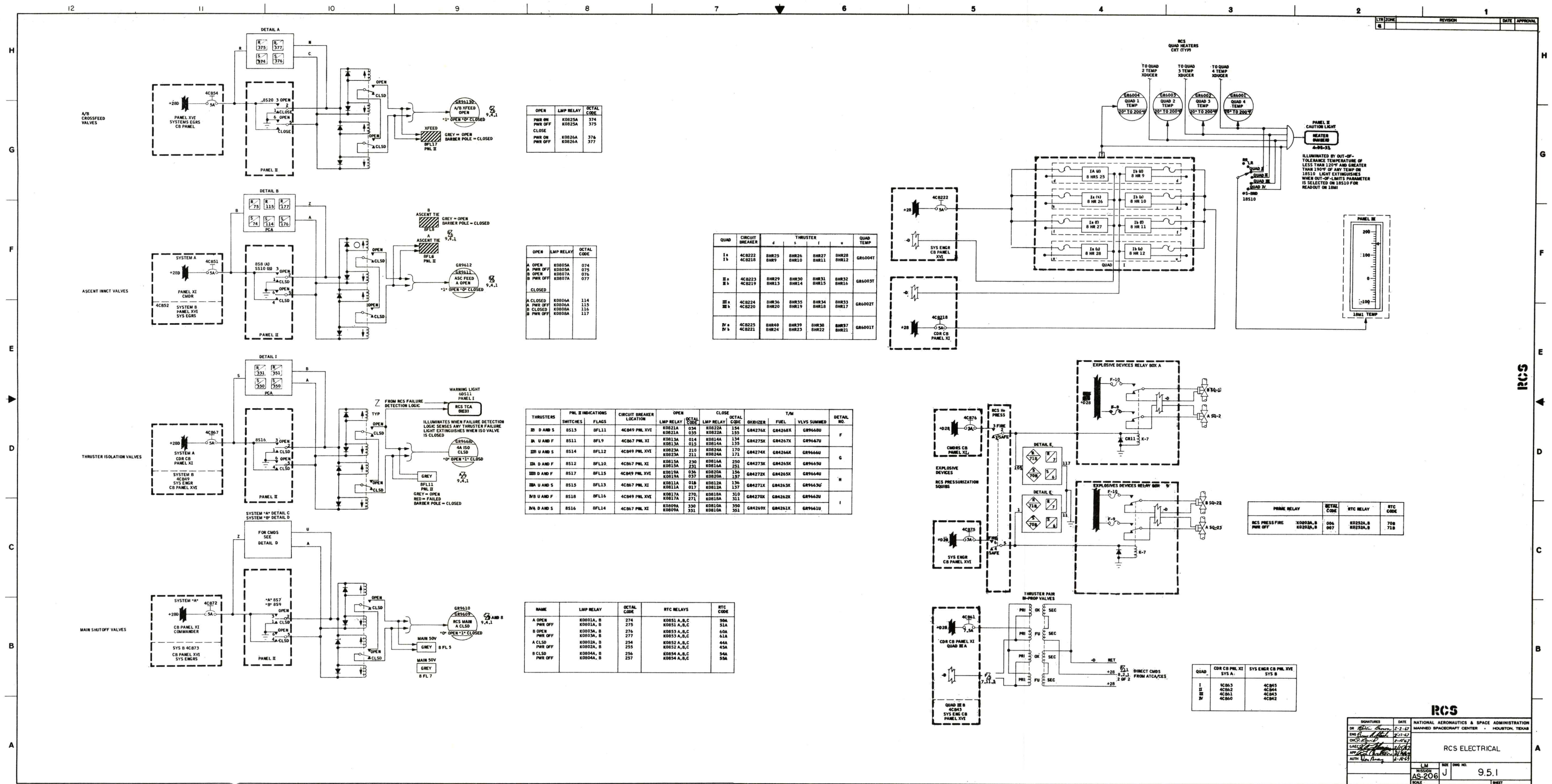
LM
AS-206
REV A

DRAWING 9.3.1

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SECTION 10
STRUCTURES

LM
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consists of two stages, the Ascent Stage
es are joined together by four explosive
Both stages will function as a single
n alone. Separation of the stages
the bolts and by explosively

R-B

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SECTION 10
STRUCTURES

LM
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10.1 SYSTEM DESCRIPTION

10.1.1 Stage Description

The Lunar Module (LM) consists of two stages, the Ascent Stage and the Descent Stage. The stages are joined together by four explosive bolts and an interstage umbilical. Both stages will function as a single unit or the Ascent Stage will function alone. Separation of the stages is accomplished by explosively blowing the bolts and by explosively severing the interstage umbilical.

R-B

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REV B

10.1.2 Structural Makeup

- A. The Ascent Stage's structural makeup is divided into five structural areas; the Crew Compartment, Midsection, Aft Equipment Bay, tank and equipment mountings and the outer skin and insulation. Aluminum alloys are used in the construction of the Ascent Stage with some titanium used for bracketry and fasteners.

The Crew Compartment Section is constructed as a pressure tight unit, approximately 92 inches in diameter.

The Forward Midsection bulkhead provides the structural interface between the Crew Compartment and midsection. These two sections, mated and sealed, constitute the entire pressurized volume available for crew operation in the LM.

The Aft Equipment Bay is constructed of an aluminum alloy frame, secured to the aft midsection bulkhead by a trusswork of aluminum alloy tubing. The entire compartment is unpressurized. The frame contains a series of cold rails for structural mounting and thermal control of electronic equipment. In addition, tubular trusses are provided for structural support of the tankage located within the compartment.

The complete LM Ascent Stage is covered with a thermal and micrometeoroid shield. This shield is a composite of an outer sheet of thin aluminum or aluminized mylar or both.

- B. The primary load carrying structure of the Descent Stage consists of two pairs of parallel beams arranged in a cruciform, plus upper and lower decks and end enclosure bulkheads. The beams, decks, and bulkheads are of the conventional skin and stringer construction. These are formed from aluminum alloy. The skins, or webbing is chem-milled to reduce weight. All joints are secured together with standard mechanical fasteners. The center compartment, formed by the beams cruciform construction, contains the Descent Engine. The areas on either

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LM
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REV B

side of the center section, formed by the beams (along the Z and Y axis), house the four main propellant tanks for the Descent Engine.

Additional support and strut assemblies are secured to the main beams forming diagonal bays or quadrants. The entire Descent Stage (top view) is shaped to form a modified octagon aluminum alloy. Outriggers extend from the ends of each of the two pairs of beams, providing for four points of attachment to the Spacecraft LM Adapter (SLA).

R-B

- C. The landing gear are removed from LM-1.

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REV B

10.2 SYSTEM DATA

APPROXIMATE VEHICLE WEIGHTS	
SECTION	WEIGHT, LB
LM Ascent Stage (DRY)	4,850
LM Descent Stage (DRY)	3,550
RCS Propellants	550
DPS Propellants	17,400
APS Propellants	<u>5,000</u>
TOTAL	31,350

R-B

R-B

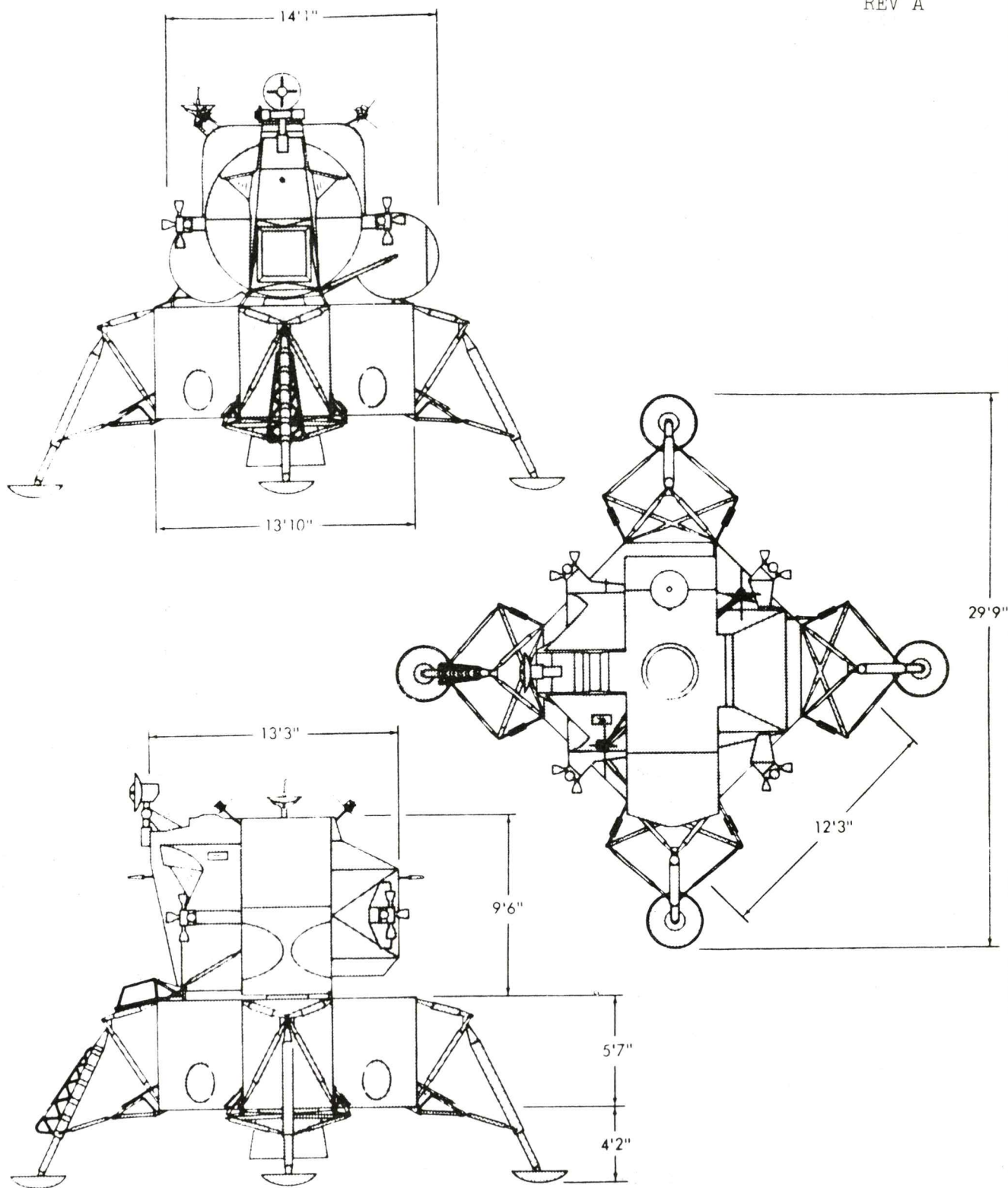


Figure 10-1 LM Dimensions

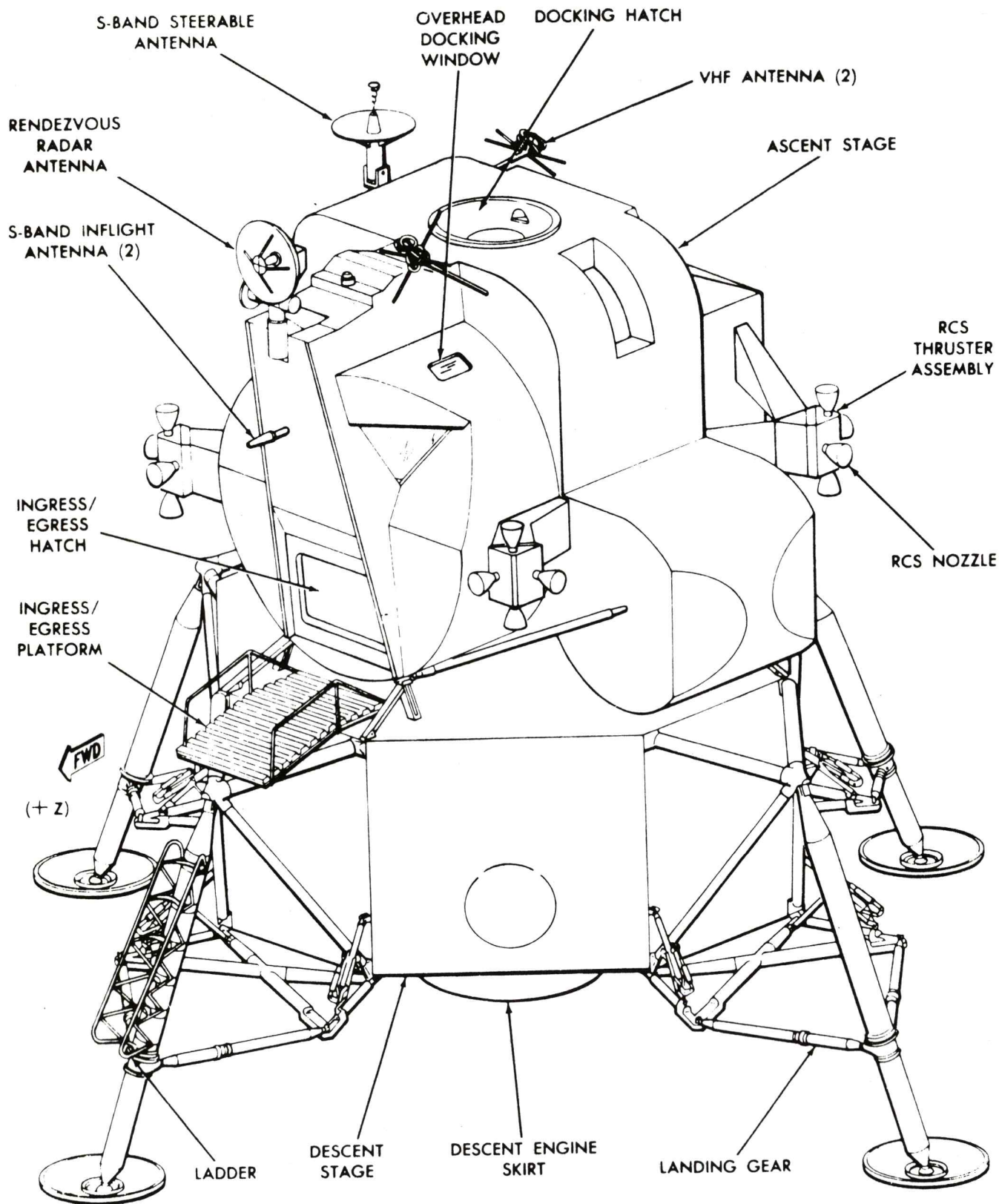
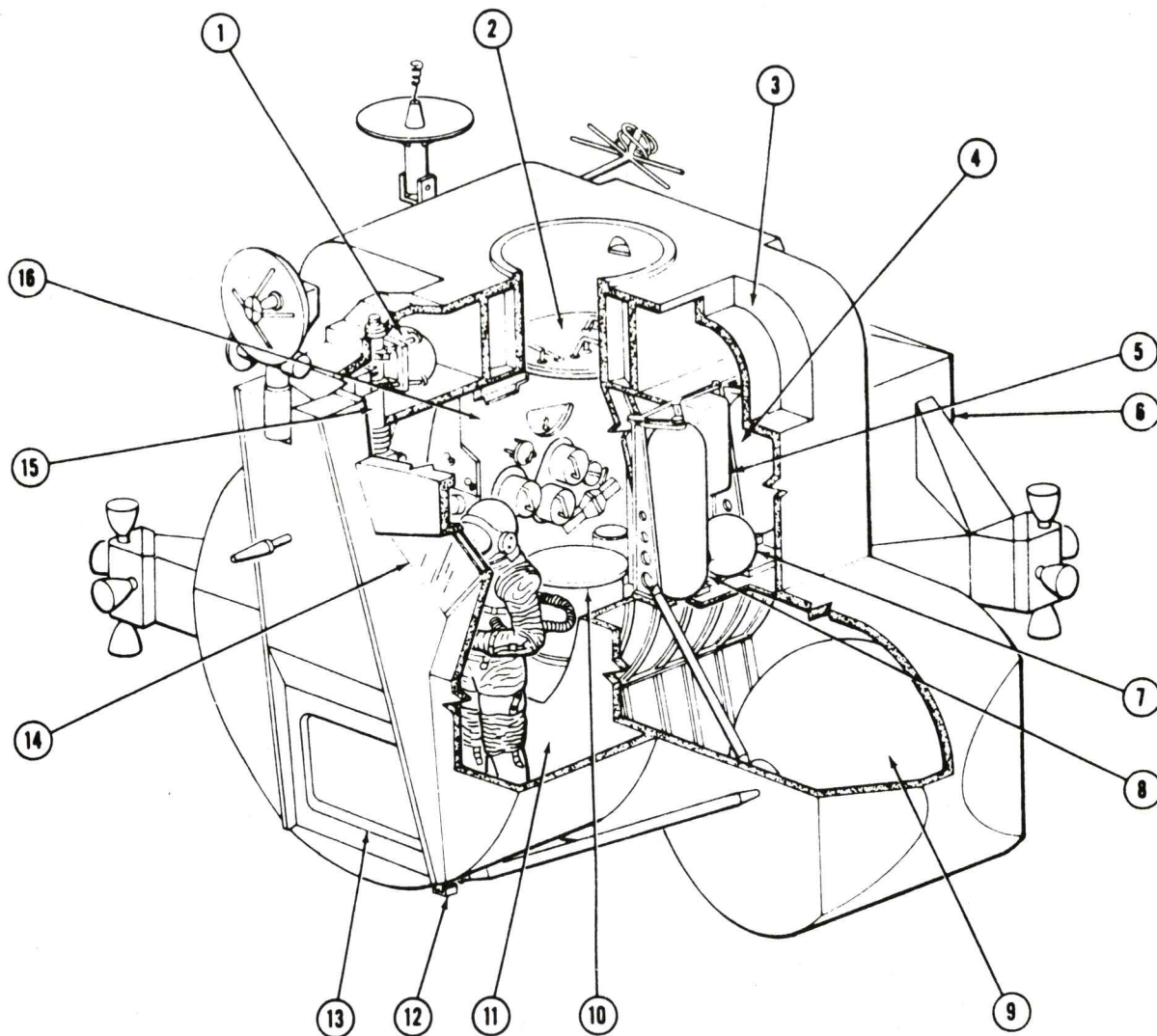


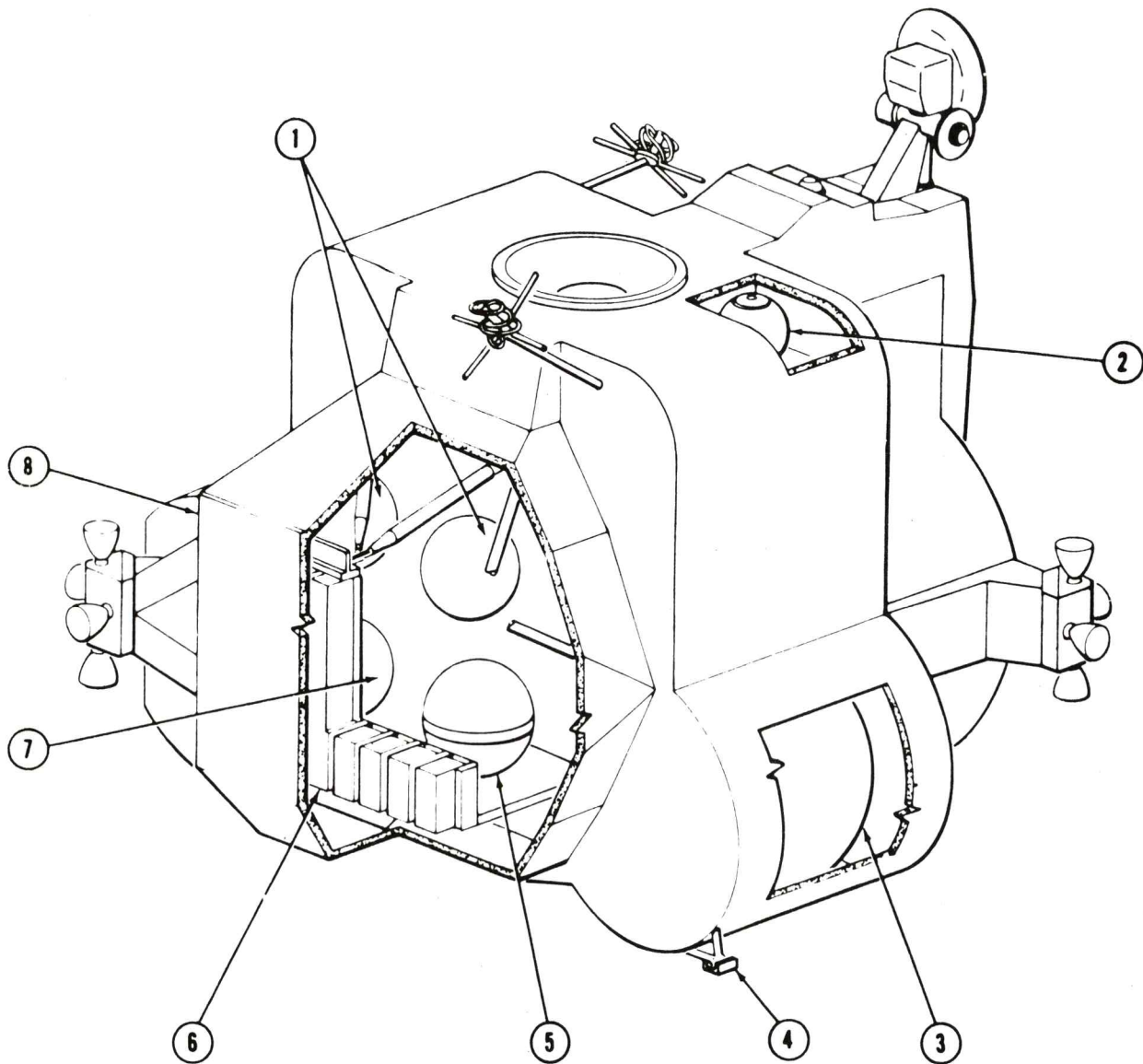
Figure 10-2 LM Structure



1. INERTIAL MEASURING UNIT
2. DOCKING HATCH
3. DOCKING TARGET RECESS
4. FUEL TANK (RCS)
5. HELIUM PRESSURE
REGULATING MODULE
6. AFT EQUIPMENT BAY
7. HELIUM TANK (RCS)

8. OXIDIZER TANK (RCS)
9. FUEL TANK
10. ASCENT ENGINE COVER
11. CREW COMPARTMENT
12. FORWARD INTERSTAGE FITTING
13. INGRESS/EGRESS HATCH
14. CABIN WINDOW
15. ALIGNMENT OPTICAL TELESCOPE
16. MIDSECTION

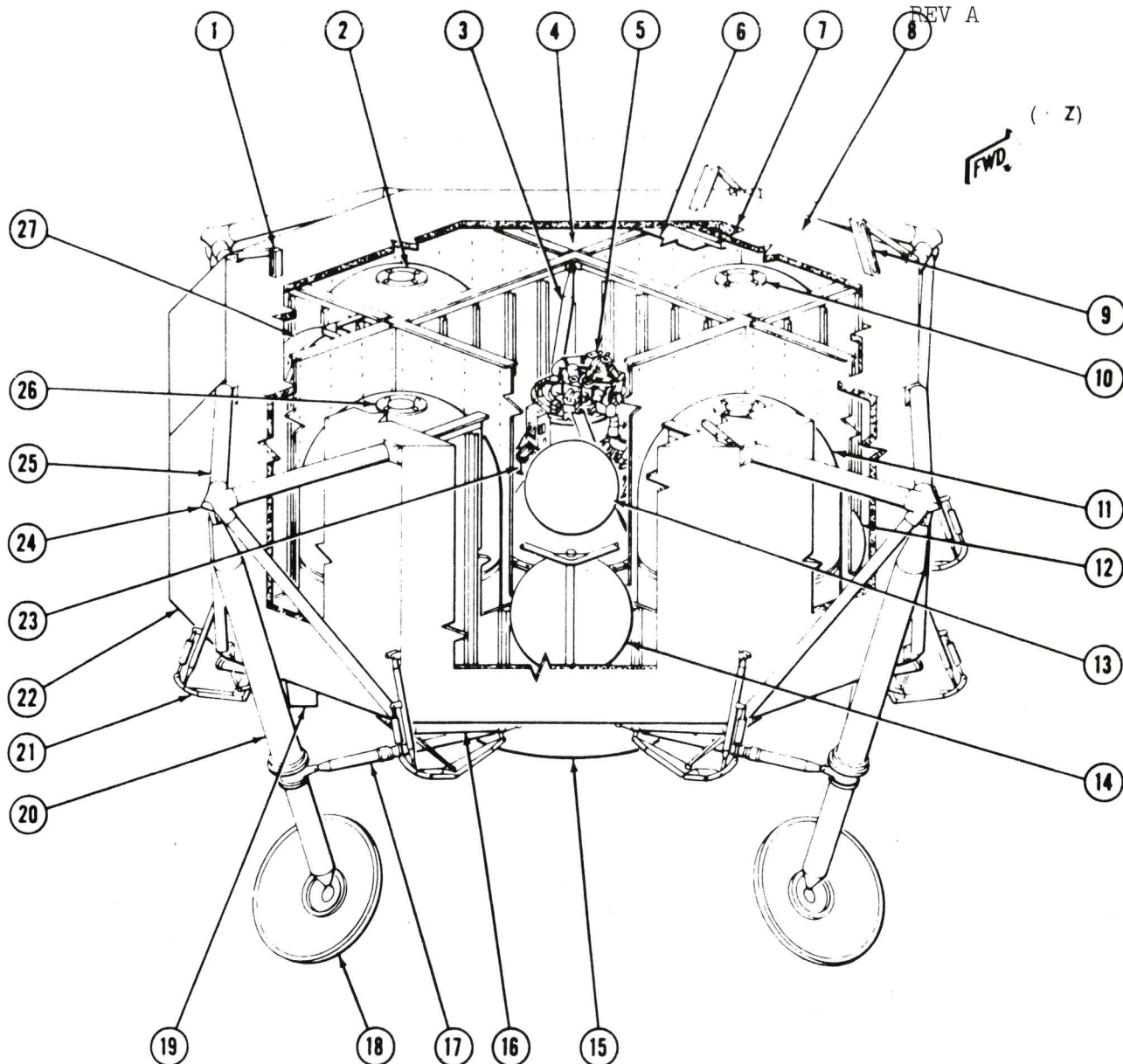
Figure 10-3 Ascent Stage (Sheet 1 of 2)



1. GASEOUS OXYGEN TANKS
2. WATER TANKS (2)
3. OXIDIZER TANK
4. AFT INTERSTAGE FITTING (2)
5. HELIUM TANK

6. ELECTRONIC REPLACEABLE ASSEMBLY
7. HELIUM TANK
8. AFT EQUIPMENT BAY

Figure 10-3 Ascent Stage (Sheet 2 of 2)



- | | |
|--|------------------------------|
| 1. AFT INTERSTAGE FITTING | 14. HELIUM TANK/CRYOGENIC |
| 2. FUEL TANK | 15. DESCENT ENGINE SKIRT |
| 3. ENGINE MOUNT | 16. TRUSS ASSEMBLY (LDG GR) |
| 4. PLSS, S-BAND ANTENNA
STORAGE BAY | 17. SECONDARY STRUT (LDG GR) |
| 5. DESCENT ENGINE | 18. PAD (LDG GR) |
| 6. STRUCTURAL SKIN | 19. LANDING RADAR ANTENNA |
| 7. INSULATION | 20. PRIMARY STRUT (LDG GR) |
| 8. THERMAL SHIELD | 21. LOCK ASSEMBLY (LDG GR) |
| 9. FORWARD INTERSTAGE FITTING | 22. SCIENTIFIC EQUIPMENT BAY |
| 10. OXIDIZER TANK | 23. GIMBAL RING |
| 11. FUEL TANK | 24. ADAPTER ATTACHMENT POINT |
| 12. BATTERY STORAGE BAY | 25. OUTRIGGER |
| 13. OXYGEN TANK | 26. OXIDIZER TANK |
| | 27. WATER TANK |

NOTE:
LANDING GEAR SHOWN IN
RETRACTED POSITION

Figure 10-4 Descent Stage

SECTION 11
MISCELLANEOUS

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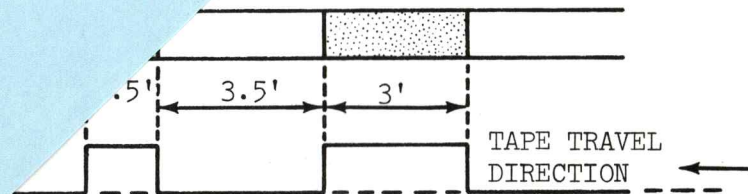
12. SPACECRAFT LM
ADAPTER

R-B

...e
... of a
... cap and
... vels through
... to a length of
... the tape is pulled
... (conductive).

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GLASS WOVEN TAPE
JUST AFTER SEP



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SECTION 12
SPACECRAFT LM ADAPTER

LM
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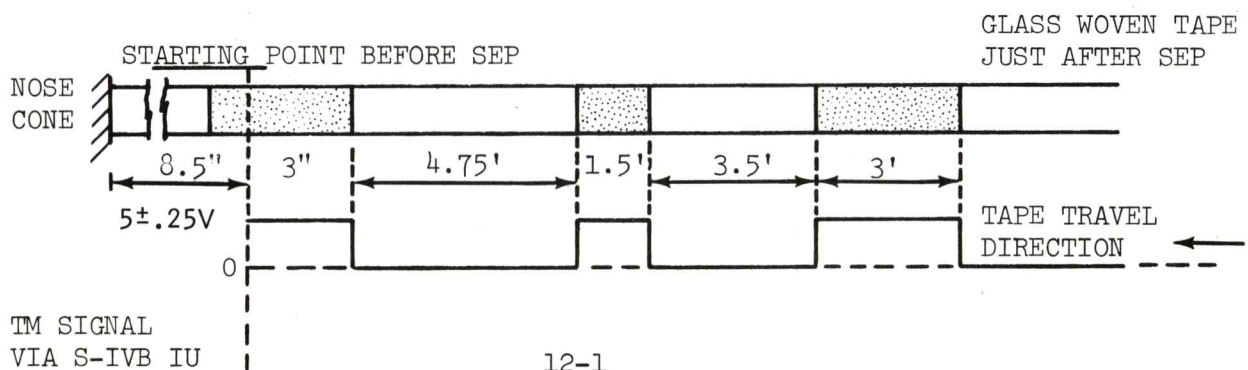
12.1 SYSTEM DESCRIPTION

12.1.1 LM Adapter

The Spacecraft LM Adapter (SLA) connects the nose cap to the S-IVB Instrumentation Unit (IU). It also houses the LM,SLA Spacecraft Jettison Controller (SJC) and power supplies.

12.1.2 Nose Cap

- A. The nose cap will be separated from the SLA by 16 springs which are positioned symmetrically around the base circumference of the nose cap and the forward SLA panels (Figure 12-5). The metallic interface between the nose cap and SLA will be sheared by a Mild Detonating Fuse (MDF) (Figure 12-2), and ignited by two detonators 180 degrees from one another upon programed command from the IU Switch Selector (or by backup RTC), via the SJC logic.
- B. There are two transducers to indicate nose cap physical separation (K141-900 and K142-900). They are located near the top of the forward set of SLA panels, 180 degrees from one another. As the nose cap is separated from the SLA, these transducers sense the conductivity or non-conductivity of a woven glass tape which is attached between the nose cap and the transducer itself in the SLA. The tape travels through the sensor from a conductive starting point to a length of about 16 feet. The following results as the tape is pulled through the sensor. (Shaded areas: Conductive).



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12.1.3 SLA

- A. The SLA is a truncated conic structure with a cone element of 29 feet and a X-Axis length of 28 feet. The forward diameter is 12.8 feet and the aft diameter is 21 feet. The SLA is divided into two sets of four panels. The aft set is fixed and the forward set is deployable (Figure 12-1). The panels consist of 1.7 inch aluminum-alloy honeycomb, bonded to face sheets of aluminum of varying thickness.
- B. The SLA panels will be deployed upon programed command from the IU Switch Selector (or by backup RTC) via the SJC logic. R-B
The SLA panels will deploy 45^{+5}_{-11} degrees with the momentum to do this created by three elements:
1. The explosive devices that shear the panels from one another at the seam lines provide 20 percent of the force required (see Figure 12-3).
 2. The eight thrusters located at the corners of the panels which provide two degrees of panel movement or another 20 percent of the force required. (See Figure 12-3).
 3. The four cable spring loaded exterior pulley assemblies (one per panel) provide the remaining 60 percent of the force required. (See Figure 12-4)
- C. The momentum of the SLA panels is stopped by eight attenuator struts located between the aft panels and forward panels (Figure 12-4). These struts contain crushable aluminum honeycomb core to absorb the energy. After the panels have reached the deployed position, they are retained in that position by a clutch on each spring loaded pulley assembly.

12.1.4 LM/SLA Separation

- A. The LM is attached within the aft adapter at four points by straps which coincide with the panel hinge positions (Figure 12-1). After the forward panels have properly separated and R-B

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LM
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deployed, the LM +X Reaction Control System (RCS) thrusters will be ignited and within 5 seconds a signal will be sent from the LM mission programmer (or by backup RTC) which will sever these straps by the SLA pyrotechnic devices. At the same time the straps are severed, the LM/SLA guillotine cuts the electrical connections between the SLA and the LM. This guillotine is mounted just below the +Y LM leg mount on the aft SLA panel. Thirteen additional seconds of RCS burn move the LM away from the SLA/S-IVB with a resultant delta velocity of about 5 ft/sec.

R-B

B. S-IVB/SLA Attitude Control. (Before LM/SLA SEP) all maneuvering shall be done using the S-IVB attitude control subsystem.

1. The Instrument Unit (IU) rate gyros shall provide the rate information for thrust vector control (TVC) and attitude control for the coast phase.
2. The S-IVB attitude control subsystem will be capable of attitude control in earth orbit for a minimum time of 4.5 hours and capable of maximum limit cycle rates (attitude deadband equal to or less than plus or minus 1.0 degree in pitch, roll, and yaw) as follows:

	Rate (Degree/Sec)		
	<u>PITCH</u>	<u>YAW</u>	<u>ROLL</u>
a. S-IVB/SLA/LM immediately prior to LM withdrawal	<u>+0.0128</u>	<u>+0.0256</u>	<u>+0.0972</u>
b. S-IVB/SLA during withdrawal of LM	<u>+0.0146</u>	<u>+0.0296</u>	<u>+0.0974</u>

R-B

3. Continuous orbital pitch shall be required of the S-IVB to maintain the vehicle's X-Axis perpendicular to the local vertical before LM/SLA separation. Prior to LM separation and withdrawal, the S-IVB will go to an inertial attitude hold with the maximum limit cycle rates as specified above.

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12.1.5 Venting

During the boost phase, the nose cap, the SLA, the IU and the S-IVB forward skirt will be vented to the atmosphere through vent holes (total vent sectional area is 200 in²) symmetrically located around the periphery of the S-IVB forward skirt.

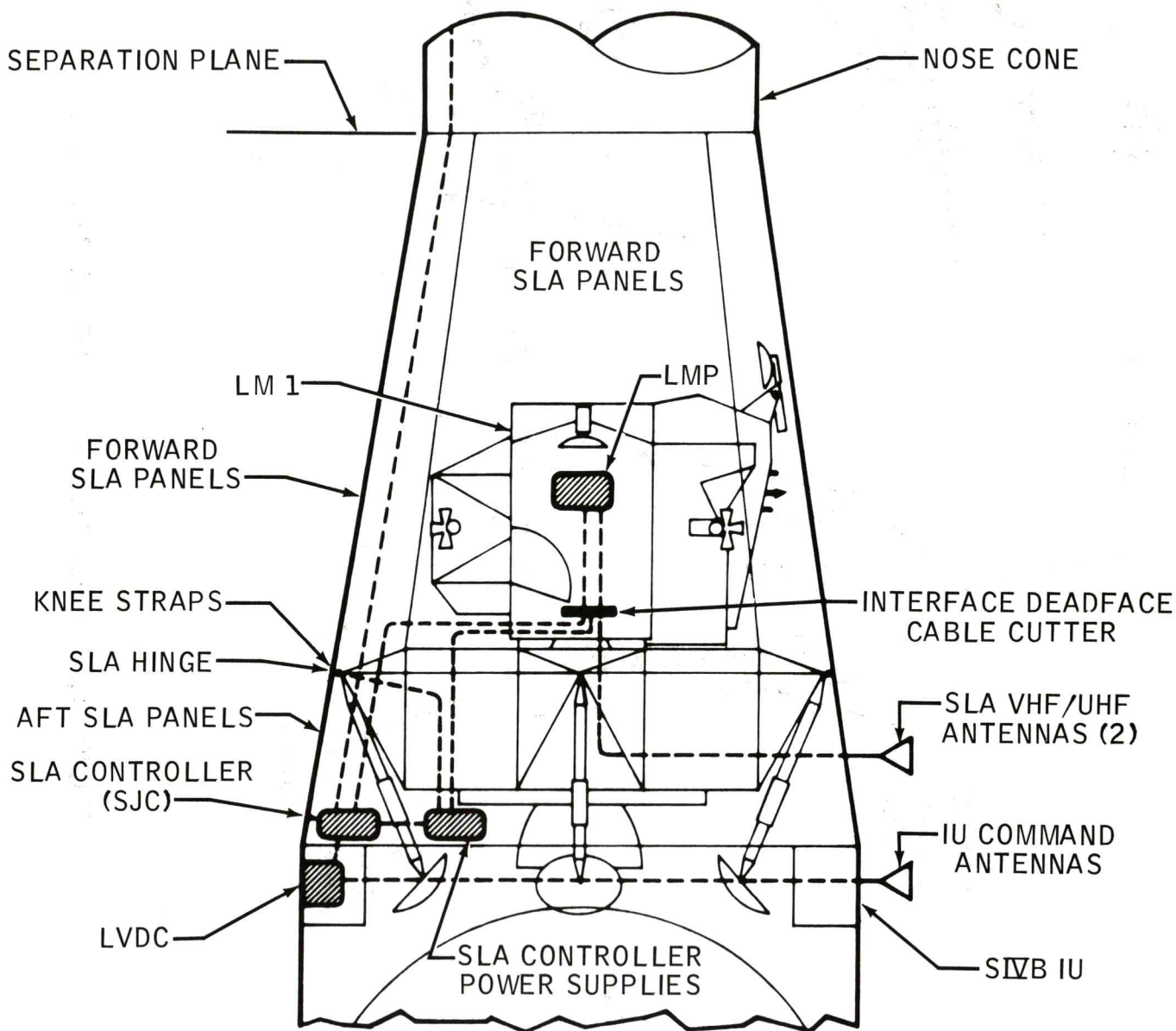


FIGURE 12-1. - NOSE CONE/SLA/LM/SIVB CONFIGURATION

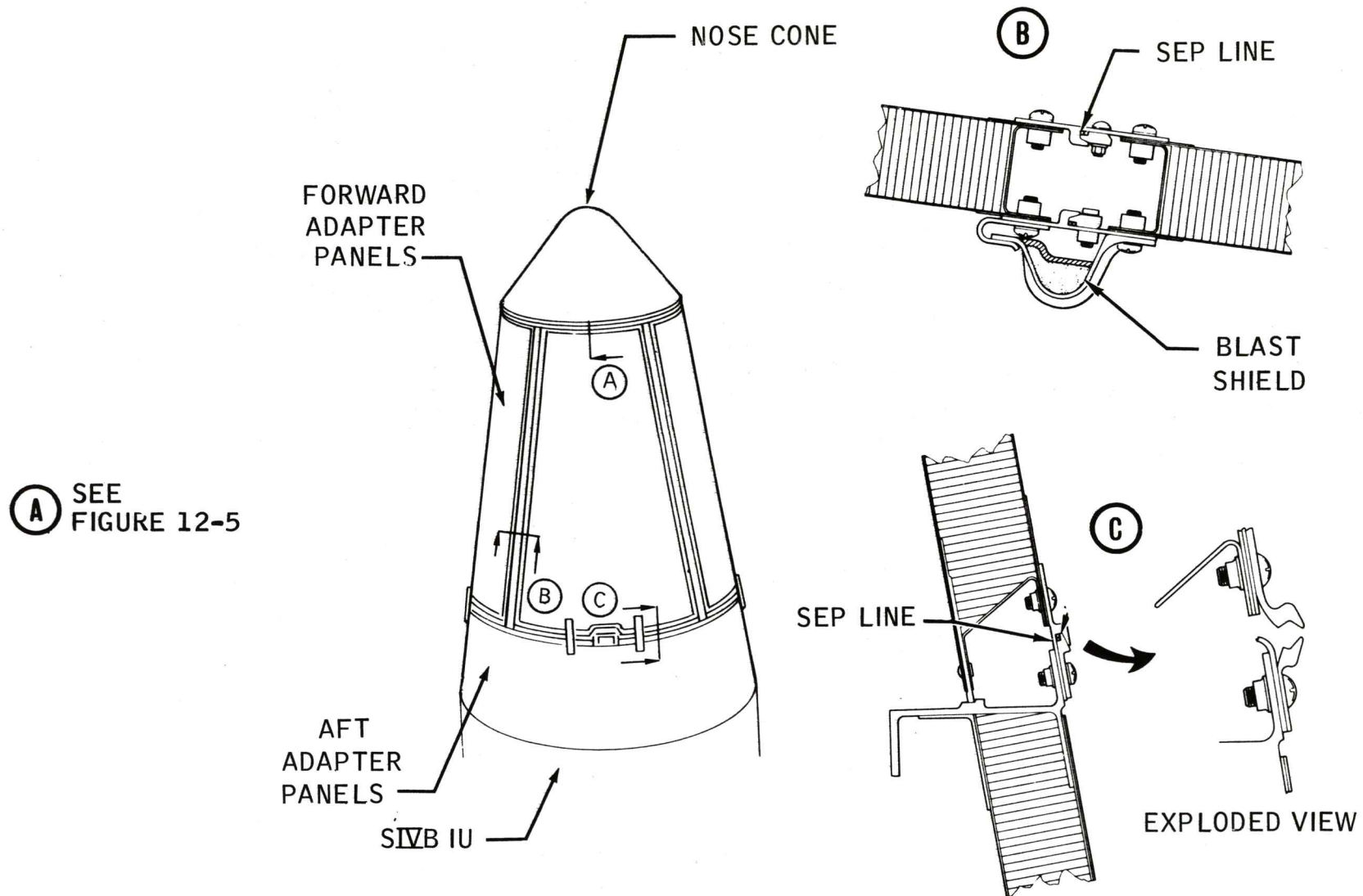


FIGURE 12-2. - ADAPTER PANEL SEPARATION LINE

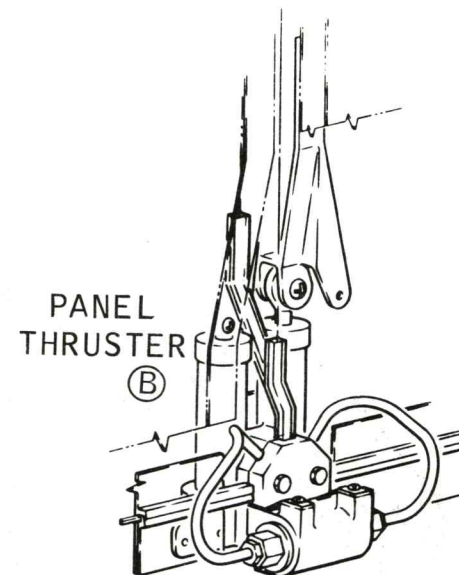
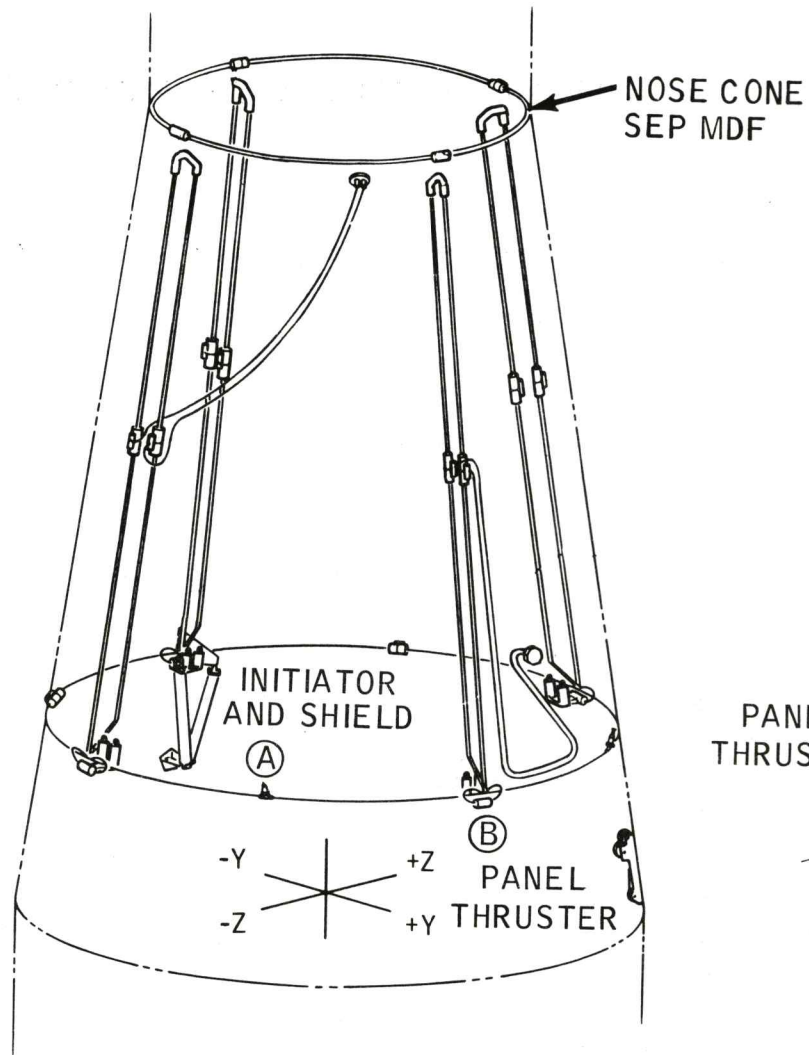
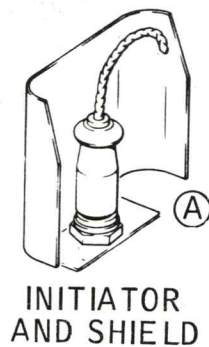


FIGURE 12-3. - ADAPTER SEPARATION SYSTEM

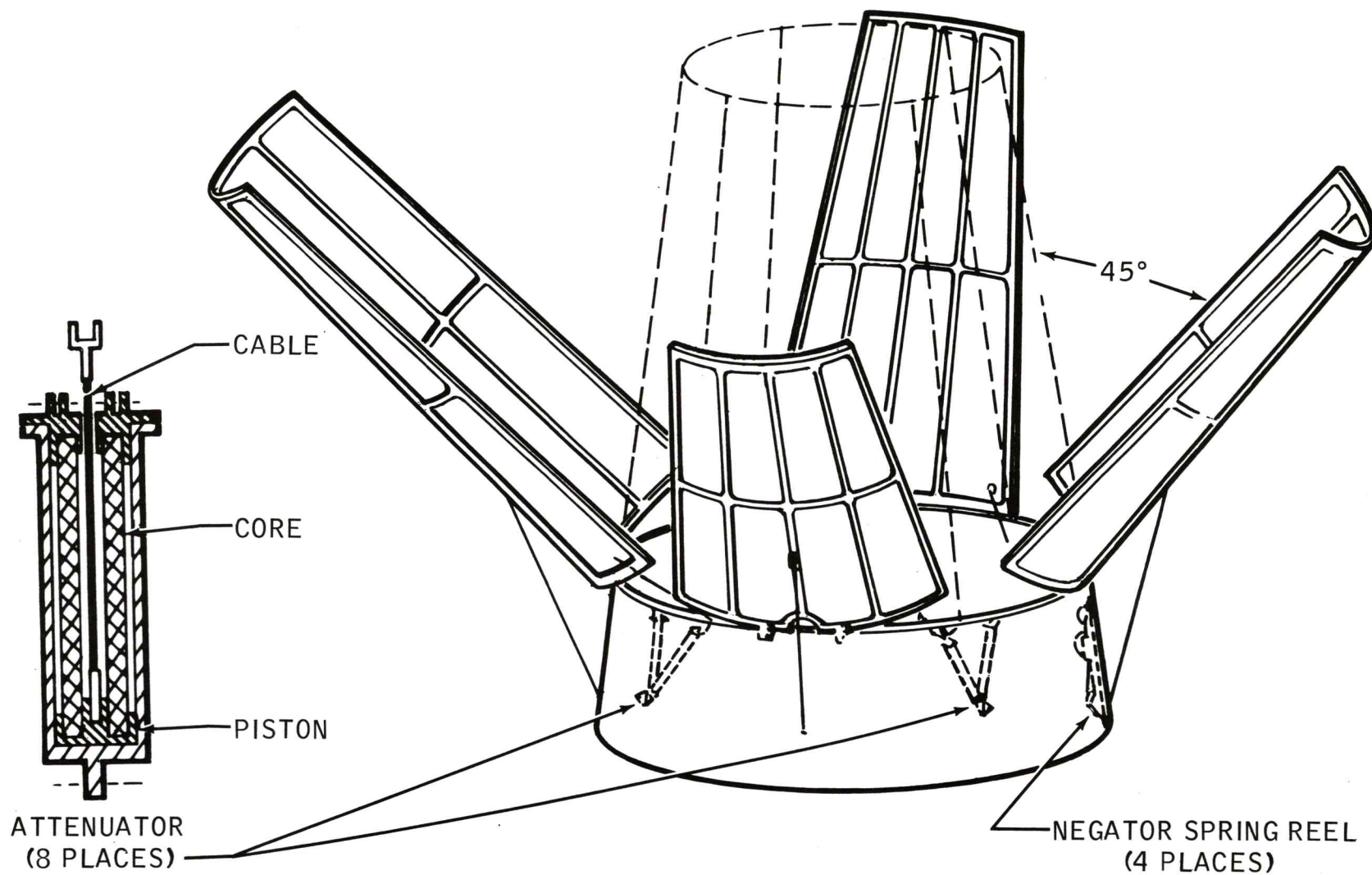


FIGURE 12-4. - SLA PANEL DEPLOYMENT.

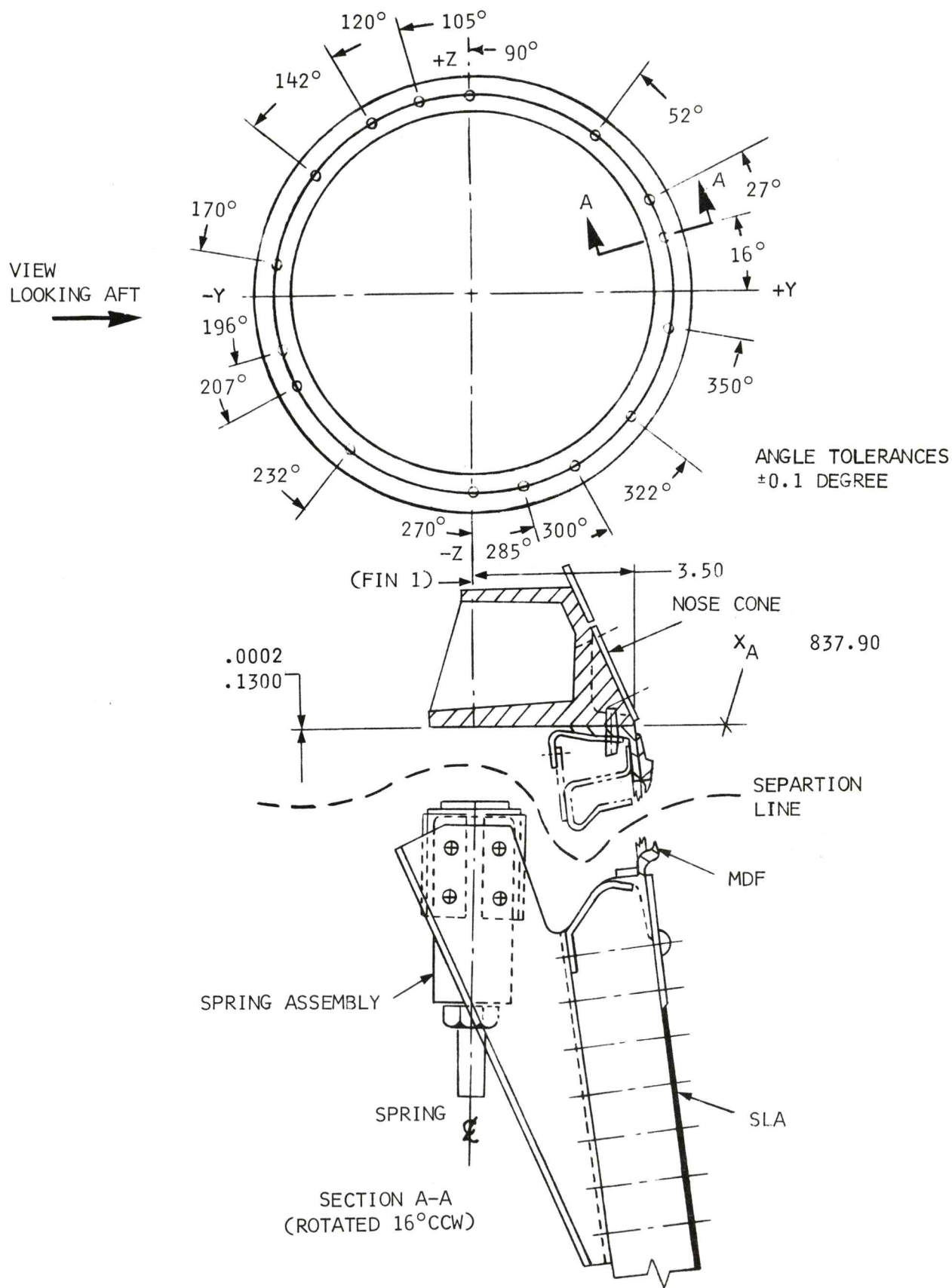


FIGURE 12-5 SLA/NOSE CONE INTERFACE JETTISON SPRING INSTALLATION

12.2 SYSTEM DATA

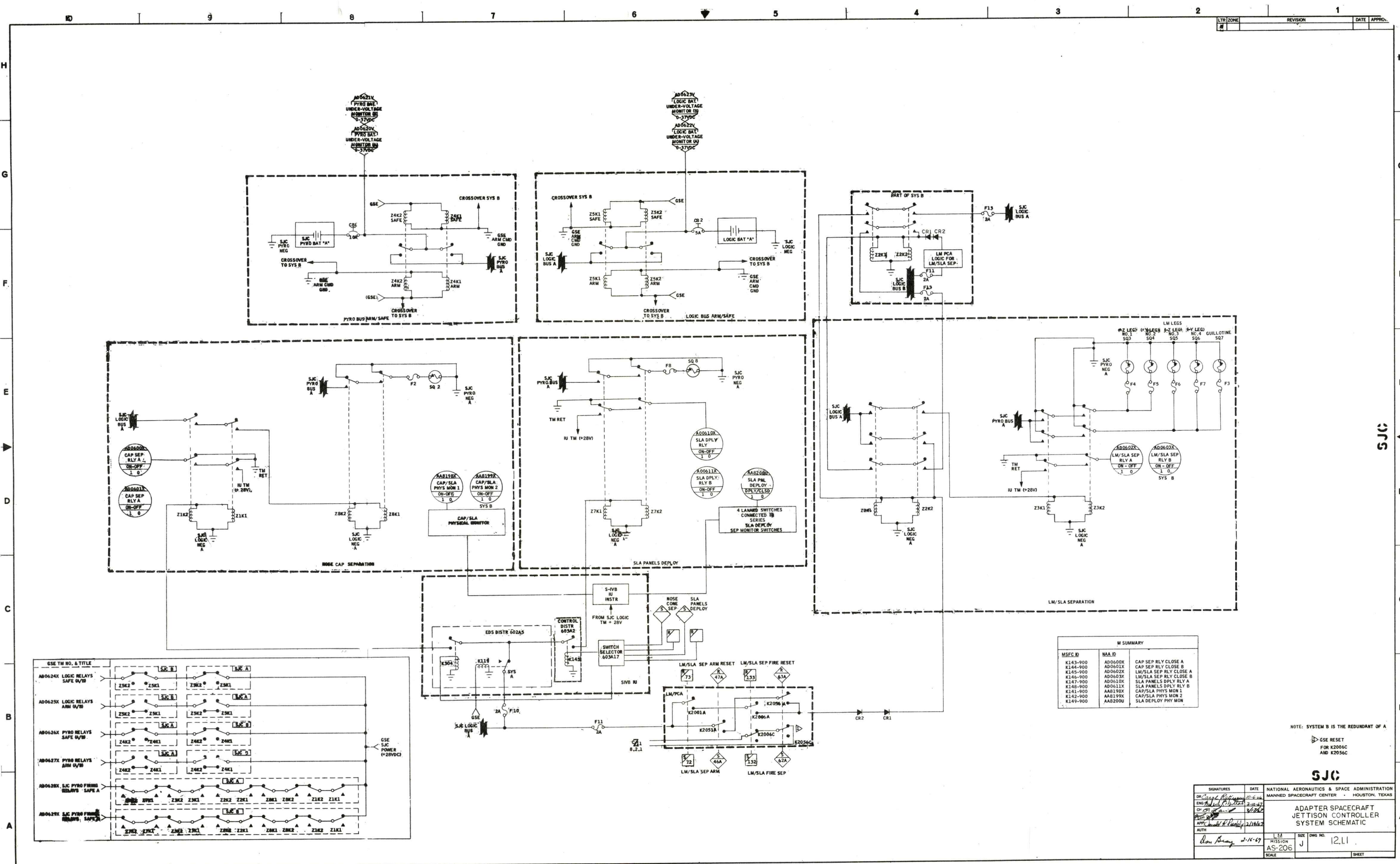
12.2.1 SJC LOGIC BATTERY CHARACTERISTICS

- A. THE SJC LOGIC BATTERY CAPACITY IS FIVE AMP HOURS WHEN DISCHARGED AT A TWO AMP RATE. END LIFE VOLTAGE SHALL BE 26,0 VOLTS OR GREATER
- B. NO LOAD VOLTAGE LIMITS: $31,5 \text{ VOLTS} \pm 2,0 \text{ VOLTS}$
- C. TRANSIENT VOLTAGE LIMITS: 26 TO 35,5 V WITH RECOVERY TO STEADY STATE WITHIN ONE SECOND

12.2.2 SJC PYRO BATTERY CHARACTERISTICS

- A. THE SJC PYRO BATTERY CAPACITY IS 0,75 AMP HOURS WHEN DISCHARGED AT AN INTERMITTENT RATE
- B. NO LOAD VOLTAGE LIMITS: $36 \pm 1,8 \text{ VOLTS}$
- C. TRANSIENT VOLTAGE LIMITS: 26 TO 37,8 VOLTS WITH RECOVERY TO STEADY STATE WITHIN ONE SECOND

DETAIL 12.1.1



M SUMMARY		
MSFC ID	MAA ID	DESCRIPTION
K143-900	AD0600X	CAP SEP RLY CLOSE A
K144-900	AD0601X	CAP SEP RLY CLOSE B
K145-900	AD0602X	LM/SLA SEP RLY CLOSE A
K146-900	AD0603X	LM/SLA SEP RLY CLOSE B
K147-900	AD0610X	SLA PANELS DPLY RLY A
K148-900	AD0611X	SLA PANELS DPLY RLY B
K141-900	AAB198X	CAP/SLA PHYS MON 1
K142-900	AAB199X	CAP/SLA PHYS MON 2
K149-900	AAB200X	SLA DEPLOY PHYS MON

SIGNATURES		DATE	NATIONAL AERONAUTICS & SPACE ADMINISTRATION MANNED SPACECRAFT CENTER - HOUSTON, TEXAS	
ENG. [Signature]		2-15-69	ADAPTER SPACECRAFT JETTISON CONTROLLER SYSTEM SCHEMATIC	
AUTH. [Signature]		2-15-69	LM HISTORICAL AS-206	SIZE J DWG NO. 12.11
			SCALE	SHEET

NOTE: SYSTEM B IS THE REDUNDANT OF A
GSE RESET FOR K2006C AND K2056C

SJC

SECTION 13

PROGRAMER

LM
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Automatic package in

Commands will enable

ow the LM to

13. LM MISSION PROGRAMER

01
ed vehicle
or ground

SECTION 13
LM MISSION PROGRAMMER

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13.1 INTRODUCTION

The LM Mission Programmer (LMP) is a semiautomatic package in which ground commands or LM Guidance Computer (LGC) commands will enable control normally provided by the astronaut, this will allow the LM to meet the requirements for unmanned near-earth orbit missions.

The LMP consists of four basic units:

- A. The Program Reader Assembly (PRA) contains a contingency program (on fixed tape) to be used in the event of failure of the prime mode (i.e., the LGC) (fixed tape contains a maximum of 64 addressable sequences).
- B. The Digital Command Assembly (DCA) provides an uplink capability so that ground commands can be routed to the LGC, PRA, PCA and then to the basic LM subsystem for control.
- C. The Program Coupler Assembly (PCA) provides coupling of the LGC, PRA and certain DCA commands to control the basic LM subsystems.
- D. The Power Distribution Assembly (PDA) provides the 28 Vdc power distribution and current protection for the LMP components.

The basic operation of the LMP will be LGC to PCA to LM subsystems. Backup or test modes will be ground to DCA to LGC to PCA to LM subsystems, ground to DCA to PRA to PCA to LM subsystems, and ground to DCA to PCA to LM subsystems. Under normal operation the computer will command the LMP to perform various operations normally performed by the astronaut. However, in case the LGC fails, the PRA will backup under a limited capacity those functions normally provided by the LGC. The ground control through PRA and PCA is limited and control of this normally manned vehicle cannot be compared with those vehicles which are designed for ground control only.

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A. DCA System Description

The DCA consists of a UHF Receiver, two decoders and interface circuits of the LM Guidance Computer (LGC), Program Reader Assembly (PRA), and Program Coupler Assembly (PCA). The DCA will accept and process six each LGC commands, or two PRA commands, or two Real-Time Commands (RTC's) or two DCA Test Commands per second.

1. The bit configuration for each type of command is as follows:

a. LGC (22 Bits)

<u>1 2 3</u>	<u>4 5 6</u>	<u>7</u>	<u>8 9 10 11 12 13 14 15 16 17 18 19</u>
Vehicle	System	Synch	<u>20 21 22</u>
Address	Address	Bit	Triple Redundant 5-Bit Word

b. PRA (22 Bits)

<u>1 2 3</u>	<u>4 5 6</u>	<u>7 8 9 10 11 12</u>	<u>13</u>	<u>14</u>	<u>15</u>
Vehicle	System	Time Word	Initiate	Forward	Reverse
Address	Address			Search	Search
<u>16</u>	<u>17 18 19 20 21 22</u>				
Start	Fill Bits				

c. RTC (12 Bits)

<u>1 2 3</u>	<u>4 5 6</u>	<u>7 8 9 10 11 12</u>
Vehicle	System	Command Function
Address	Address	

d. DCA Test (22 Bits)

<u>1 2 3</u>	<u>4 5 6</u>	<u>7 8 9 10 11 12 13 14 15 16 17 18 19 20 21</u>
Vehicle	System	
Address	Address	Test Word

2. The DCA Test Commands are used to test the operational capability of the DCA. The following test commands are available for the DCA checkout and analysis.

TEST	BIT CONFIGURATION		FUNCTION
	"1-6"	"7-22"	
DCA ENABLE	011 101	000 000 000 000 0	ENABLE BOTH DECODERS
DECODER A TEST	011 101	000 100 000 000 0	INHIBITS DECODER "A"
DECODER B TEST	011 101	001 000 000 000 0	INHIBITS DECODER "B"
DCA SELF TEST	011 101	001 100 000 000 0	SELF TESTS BOTH DECODERS

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Upon transmission of either the Decoder B Test or Decoder A Test, the DCA Clear Command must be sent to enable the decoder that has been inhibited.

3. DCA Receiver Characteristics

- a. Frequency 450 MHz
- b. Sensitivity -99 dbm

4. The following DCA Status Messages (GT0441) will be generated by the DCA:

	MSB	LSB
a. STANDBY	1 0 1 0 0 1 0 0	
b. OFF	0 0 0 0 0 0 0 0	
c. MAP (LGC, PRA, or RTC)	0 1 0 1 1 0 1 1	
d. MAP (Test)	0 1 0 0 0 1 0 0	

The MAP will be generated for 55 ± 5 ms for each command processed by the DCA. The decoder accepts only those commands which have the correct vehicle address, a valid system address, and the correct message length.

B. Program Reader Assembly (PRA)

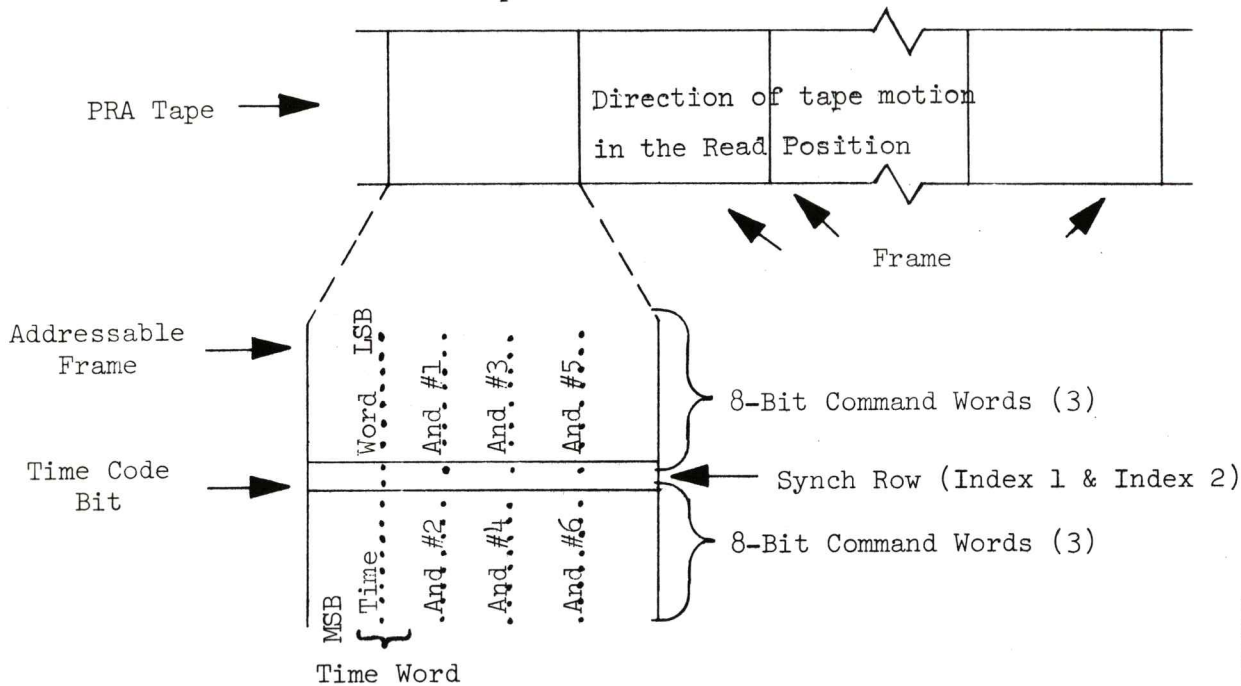
1. PRA Modes

- a. In the "standby" mode, the PRA electronics are powered up, but the tape is not running.
- b. In the "search" mode, the reader searches the tape for a particular preprogramed addressable frame selected by the ground (see Section B.3.b herein). When the frame is found the tape stops, a compare pulse is emitted, and the PRA goes to the "standby" mode.
- c. In the "operate" mode, the tape moves by the read head and the commands are executed through the prime relays in the PCA.

2. PRA Tape

The PRA tape may contain up to 1000 frames, 64 of which can be addressable. Each frame contains a time word and up to six commands.

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When the PRA is operating, the tape moves by the read head and stops when a time word appears. This 16-bit time word is entered into a 16-bit register and compared with the contents of a 16-bit timer counter. The timer counter is incremented by a 1 pps clock and when the counter and register compare, a compare pulse is emitted. Upon reception of the compare pulse, the tape is moved one frame by the read head until the next time word appears. As the tape passes under the read head each command on the frame is processed and routed to the PCA prime relays.

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3. PRA Control

- a. The PRA may be operated from the ground at any time, but the outputs to the PCA prime relays will not be effective while PGNS is in control. To enable PRA control of the LM, the AGS must be selected by an ISS Fail or LGC Warn discrete, or by an AGS SELECT RTC. This will stop the PRA and put it in the "stand-by" mode.

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- b. Three 16-bit PRA updata words (see A.1.b herein) are necessary to locate and start a subroutine.
- (1) The first 16-bit word contains the vehicle and system addresses, a six-bit time word to preset the six most significant bits in the timer counter to compare with the time word on the desired addressable frame, a binary "1" in the "initiate" location to zero the PRA clock so it may be preset, and binary "0's" in all other locations.
 - (2) The second 16-bit word contains the vehicle and system addresses, the six-bit "time" word in the time word locations, a binary "1" in the "forward (reverse) search" location to cause the tape to be searched for the desired frame, and binary "0's" in all other locations.
 - (3) The third 16-bit word contains the vehicle and system addresses, the six-bit "time" word in the time word locations, a binary "1" in the "start" location causing the PRA to begin reading the tape (see B.2 herein), and binary "0's" in all other locations.
- c. To effectively stop the PRA while it is operating, the AGS SELECT RTC may be sent.

4. Telemetry Measurements

- a. The PRA COMPARE (GW5151V) indicates that the time word in the 16-bit register (derived from a frame on the tape) has compared with the time word in the timer counter (derived from a PRA updata word or from a 1 pps clock. This measurement should be used for verification of the reception and execution of the first PRA updata word [see B.3.b.(1) herein].

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- b. The PRA CLOCK ON (GW5153V) indicates the 1 pps clock pulses are being fed to the timer counter and should appear upon PRA reception of the third PRA update word [see B.3.b.(3) herein].

C. Program Coupler Assembly (PCA)

1. Prime Relay Matrix

The Prime Relay Matrix contains 254 prime relays, any one of which may be actuated at a time. All prime relays are operable by either the PRA or the LGC and provide the necessary switching functions normally performed by astronauts.

2. RTC Relay Matrix

The RTC Relay Matrix contains 95 relays, any one of which may be actuated at a time by uplink through the DCA (see A.1.c herein).

3. Relay Nomenclature

a. Prime or RTC Relays

Ex. K 01 63

Subsystem Relay
Code Number
[see C.3(c) herein].

Prime Relays: Nos. 1-49

RTC Relays: Nos. 51-99

b. Interlock Relays

Ex. K08-1

c. Subsystem Code

- 01 Attitude and Engine Control
- 02 Pyrotechnic Devices
- 04 Electrical Power
- 06 Instrumentation
- 07 Environmental Control
- 08 Reaction Control
- 10 Propulsion

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- 11 Control Electronics
- 13 Communications
- 20 Development Flight Instrumentation

13.2 LM MISSION PROGRAMER (LMP) SYSTEM SCHEMATIC NOTES

A. The MASTER RESET function resets all prime relays except the following:

1. LND Radar (267)
2. C-Band Transponder (Off) (153)
3. Flight Control Auto Enable (3)

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B. The automatic guidance switchover function switches from PGNS to AGS, enables the prime relay matrix to accept PRA commands and put the PRA in the "standby" mode.

C. LM/SLA antenna switchover is an automatic function occurring at LM/SLA separation. Microswitches on two of the LM legs enable the switchover contacts at separation.

D. LMP Operational Capabilities

1. APS started by LGC/PRA can be stopped by "engine stop override" ground or prime relay command.
2. DPS can be started from ground by descent arm and engine start override.
3. DPS started by ground can be stopped by "engine stop override."
4. APS started by LGC abort stage prime relay cannot be stopped by ground engine stop override. To stop APS in this mode a prime relay master reset or PGNS/AGS - AGS select is required from the ground. An LGC updata instruction to the LGC to issue an auto engine off will stop the engine in this mode.
5. APS cannot be started by a ground abort stage function when PGNS/AGS switch is in AGS.
6. APS may be started by an ascent arm prime relay and an engine start override RTC. An engine stop override RTC will stop the APS.
7. APS may be started by an ascent arm prime relay and an ascent on prime relay. An engine stop override RTC will

stop the APS.

8. An APS started by PRA while in AGS select mode requires a ground descent engine arm to stop the ascent engine by RTC.
9. In the AGS mode, the FITH is accomplished with an "engine arm" of the ascent engine by prime relay and an "engine start override" by prime or RTC relays.
10. While in the AGS select mode, the normal "abort stage" function on the present LMP configured vehicle cannot be performed by either ground or prime relay.
11. The ground relays in the PCA must be in the initial "reset" position if the LGC/PRA mode is to operate normally. Except as listed below, all ground relays set by ground should be reset at the end of each operation.
12. The reset position of the manual throttle is 30 percent thrust in the LMP. A master reset RTC will perform this.
13. An abort stage signal should be sent prior to ascent engine operation. This provides for ascent helium pressurization on the unmanned LM.
14. If the ground isolates both ascent helium Tanks 1 and 2, the ascent propulsion system cannot be pressurized by either real-time ground commands, LMP, prime relays, or by an astronaut onboard.
15. A prime relay failure will require the PGNS/AGS switch to be in PGNS and an "abort stage" by ground command to start APS by the updata link control.
16. A PCA total power failure (circuit breaker) will disable the auto switchover from PGNS to AGS and will disable all prime relay control.
17. A PCA power supply failure will disable all prime relay control and will necessitate complete backup of the LM by ground commands. The auto function for direct interface from the LGC to LM would still function normally while in the PGNS mode of control.

TABLE 13-1 PRA SEQUENCES AND USES

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TO BE SUPPLIED LATER

TABLE 13-2 LM-1 (AS-206) PRA COMMAND/CODE TIMELINE

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TO BE SUPPLIED LATER

TABLE 13-3 LMP REAL-TIME COMMANDS BY CODE

CODE	MATRIX POINT	RELAY DESIGNATION	RELAY FUNCTIONAL DESIGNATION	COMMAND NAME
00A	1-1S	A6K17(S) A6K9(S)	K0157A,B	THREE AXIS ATTITUDE CONTROLLER NEGATIVE PITCH LO - 5 - DEG/SEC - ON -
01A	1-1R	A6K17(R) A6K9(R)	K0157A,B	THREE AXIS ATTITUDE CONTROLLER NEGATIVE PITCH LO - 5 - DEG/SEC - OFF -
02A	1-2S	A6K18(S) A6K10(S)	K0156A,B	THREE AXIS ATTITUDE CONTROLLER POSITIVE PITCH LO - 5 - DEG/SEC - ON -
03A	1-2R	A6K18(R) A6K10(R)	K0156A,B	THREE AXIS ATTITUDE CONTROLLER POSITIVE PITCH LO - 5 - DEG/SEC - OFF -
04A	2-1S	A7K9(S) A7K17(S)	K0159B,A	THREE AXIS ATTITUDE CONTROLLER NEGATIVE YAW LO - 5 - DEG/SEC - ON -
05A	2-1R	A7K9(R) A7K17(R)	K0159B,A	THREE AXIS ATTITUDE CONTROLLER NEGATIVE YAW LO - 5 - DEG/SEC - OFF -
06A	2-2S	A7K18(S) A7K10(S)	K0158A,B	THREE AXIS ATTITUDE CONTROLLER POSITIVE YAW LO - 5 - DEG/SEC - ON -
07A	2-2R	A7K18(R) A7K10(R)	K0158A,B	THREE AXIS ATTITUDE CONTROLLER POSITIVE YAW LO - 5 - DEG/SEC - OFF -
10A	3-1S	A8K17(S) A8K9(S)	K0161A,B	THREE AXIS ATTITUDE CONTROLLER NEGATIVE ROLL LO - 5 - DEG/SEC - ON -
11A	3-1R	A8K17(R) A8K9(R)	K0161A,B	THREE AXIS ATTITUDE CONTROLLER NEGATIVE ROLL LO - 5 - DEG/SEC - OFF -
12A	3-2R	A8K18(S) A8K10(S)	K0160A,B	THREE AXIS ATTITUDE CONTROLLER POSITIVE ROLL LO - 5 - DEG/SEC - ON -
13A	3-2R	A8K18(R) A8K10(R)	K0160A,B	THREE AXIS ATTITUDE CONTROLLER POSITIVE ROLL LO - 5 - DEG/SEC - OFF -
14A	4-1S	A15K15(S) A15K12(S)	K1051A, K1051B	DPS VALVES - DPS REG 1 CLSD
15A	4-1R	A15K15(P)	K1051A	DPS VALVES - DPS REG 1 CLSD RESET
16A	4-2S	A12K23(S)	K0457A	ELECTRICAL - INVERT 2 SEL
17A	4-2R	A12K24(S)	K0458A	ELECTRICAL - RAT. 1 OFF
20A	5-1S	A15K14(S)	K1351A	COMMUNICATIONS - SEC S-BND ON
21A	5-1R	A15K14(R)	K1351A	COMMUNICATIONS - SEC S-BND OFF
22A	5-2S	A12K15(S)	K0453A	ELECTRICAL - RAT. 2 OFF
23A	5-2R	A12K16(S)	K0454A	ELECTRICAL - RAT. 6 OFF
24A	6-1S	A15K2(S)	K0753A	ENVIRONMENTAL - PRI H2O FEED
25A	6-1R	A15K2(R)	K0753A	ENVIRONMENTAL - PRI H2O RESET
26A	6-2S	A12K7(S)	K0451A	ELECTRICAL - BAT. 5 OFF
27A	6-2R	A12K8(S)	K0452A	ELECTRICAL - BAT. 6 B/U SE

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TABLE 13-3 LMP REAL-TIME COMMANDS BY CODE (CONT'D)

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CODE	MATRIX POINT	RELAY DESIGNATION	RELAY FUNCTIONAL DESIGNATION	COMMAND NAME
30A	7-1S	A15K1(S)	K1352A	COMMUNICATIONS - PRI S-BND OFF
31A	7-1R	A15K1(R)	K1352A	COMMUNICATIONS - PRI S-BND ENABLE
32A	7-2S	A12K13(S)	K0459A	ELECTRICAL - BAT. 3 OFF
33A	7-2R			
34A	8-1S	A15K8,17	K0855A,0855B	
35A	8-1R	A15K8,17	K0855A,0855B	
36A	8-2S	A12K21(S)	K0455A	ELECTRICAL - BAT. 5 B/U OFF
37A	8-2R	A12K22(S)	K0456A	ELECTRICAL - BAT. 4 OFF
40A	9-1S	A15K9,19	K0257A	FLT CONTR - ABORT STG FIRE
41A	9-1R	A15K9,19(R)	K0257	FLT CONTR - ABORT STG FIRE RESET
42A	9-2S	A14K14(S)	K1052A	DPS VALVES - DPS REG 2 OPEN
43A	9-2R	A14K14(R)	K1052A	DPS VALVES - DPS REG 2 OPEN RESET
44A	10-1S	A13K1(S)2(S)19(S)	K0852B,A,C	RCS VALVES - RCS MAIN A CLSD
45A	10-1R	A13K1(R)2(R)19(R)	K0852B,A,C	RCS VALVES - RCS MAIN A CLSD - RESET
46A	10-2S	A12K2(S)A13K15(S)	K2051A,K2051B	PYRO - LM/SLA SEP ARM
47A	10-2R	A12K2(R)A13K15(R)	K2051A,K2051B	PYRO - LM/SLA SEP ARM RESET
50A	11-1S	A13K5(S)K6(S)K20(S)	K0851B,A,C	RCS VALVES - RCS MAIN A OPEN
51A	11-1R	A13K5(R)K6(R)K20(R)	K0851B,A,C	RCS VALVES - RCS MAIN A OPEN RESET
52A	11-2S	A12K9(S)	K2055A	COMMUNICATIONS - C-BND OFF
53A	11-2R	A12K9(R)A12K25(R)	K2055A,B	COMMUNICATIONS - C-BND ON
54A	12-1S	A14K2(S)K1(S)K19(S)	K0854A,B,C	RCS VALVES - RCS MAIN B CLSD
55A	12-1R	A14K2,K1,K19(R)	K0854A,B,C	RCS VALVES - RCS MAIN B CLSD RESET
56A	12-2S			
57A	12-2R			
60A	13-1S	A14K6(S)K5(S)K20(S)	K0853A,B,C	RCS VALVES - RCS MAIN B OPEN RESET
61A	13-1R	A14K6(S)K5(S)K20(R)	K0853A,B,C	RCS VALVES - RCS MAIN B OPEN
62A	13-2S	A12K19,KL1,A13K17(S)	K2056A,C,K2056B	PYRO - LM/SLA SEP FIRE
63A	13-2R	A12K19(R)A13K1(R)	K2056A,K2056B	PYRO - LM/SLA SEP FIRE RESET
64A	14-1S	A10K17,K18,K20(S)	K0253A,B,C,D	
65A	14-1R	A10K17,K18,K20(R)	K0253A,B,C,D	
66A	14-2S	A11K16(S)	K1154A	
67A	14-2R	A11K16(R)	K1154A	

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TABLE 13-3 LMP REAL-TIME COMMANDS BY CODE (CONT'D)

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REV B

CODE	MATRIX POINT	RELAY DESIGNATION	RELAY FUNCTIONAL DESIGNATION	COMMAND NAME
70A	15-1S	A10K9(S)K10(S)K11(S)	K0254A,B,C	FLT CONTR - ABORT STG ARM
71A	15-1R	A10K9(R)K10(R)K11(R)	K0254A,B,C	FLT CONTR ABORT STG RESET
72A	15-2S	A11K24(S)	K1104A	ENG ON-OFF-ENG STOP DISABLE
73A	15-2R	A11K24(R)	K1104A	ENG ON-OFF-ENG STOP ENABLF
74A	16-1S	A10K1(S)K6(S)	K0255A,B	ENG ON-OFF-APS HF. 1 INHIBIT
75A	16-1R	A10K2(S)K7(S)	K0256A,B	ENG ON-OFF-APS HE. 2 INHIBIT
76A	16-2S			
77A	16-2R			
00B	1-3S	A9K16(S)K8(S)K24(S)	K0151A,B,C	ENG ON-OFF-DPS ARM
01B	1-3R	A9K16(R)K8(R)K24(R)	K0151A,B,C	ENG ON-OFF-DPS RESET
04B	2-3S	A9K2(S)	K1751A	
05B	2-3R	A9K3(S)	K1752A	
10B	3-3S	A9K13(S)K5(S)	K0154A,B	ENG ON-OFF-ENG STOP O/R
11B	3-3R	A9K13(R)K5(R)	K0154A,B	ENG ON-OFF-ENG STOP RESET
14B	4-3S	A9K11(S)	K0153A	ENG ON-OFF-ENG START
15B	4-3R	A9K11(R)	K0153A	ENG ON-OFF-ENG RESET
20B	5-3S	A9K9(S)K17(S)	K0162A,B	
21B	5-3R	A6K26(S)A7K26(S) A8K26(S)	K0163B,C,A	TRANSLATION CMDS - +X DISABLE
24B	6-3S	A11K1(S)K9(S)K17(S)	K1151A,B,C	FLT CONTR - ATT HOLD ON
25B	6-3R	A11K1(R)K9(R)K17(R)	K1151A,B,C	FLT CONTR - AUTO ENABLE
30B	7-3S	A11K2(S)K10(S)	K1153A,B	FLT CONTR - AUTO ON
31B	7-3R	A11K2(R)K10(R)	K1153A,B	FLT CONTR - ATT HOLD ENABLE
34B	8-3S	A16K5(S)K15(S)	K2057A,C	FLT CONTR - PRIME RLY RESET
35B	8-3R	A16K5(R)K15(R)	K2057A,C	FLT CONTR - PRIME RLY OFF
40B	9-3S	A16K17(S)K9(S)K16(S) K8(S)A11K3	K2059A,B,C,D,E	FLT CONTR - GUID SEL AGS
41B	9-3R	A16K17(R),K9(R), K16(R),K8(R)	K2059A,B,C,D	FLT CONTR - GUID SEL PGNS
44B	10-3S	A17K11(S)	K0752A	ENVIRONMENT - SEC H ₂ O FEED

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TABLE 13-3 LMP REAL-TIME COMMANDS BY CODE (CONCLUDED)

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CODE	MATRIX POINT	RELAY DESIGNATION	RELAY FUNCTIONAL DESIGNATION	COMMAND NAME
45B	10-3R	A17K11(R)	K0752A	ENVIRONMENTAL - SEC H2O RESET
50B	11-3S	A17K14(S)	K0751A	
51B	11-3R	A17K14(R)	K0751A	
54B	12-3S	A17K9(S)	K2060A	COMMUNICATIONS - DFI CAL ON
55B	12-3R	A17K9(R)K1(S)	K2060A,K2060B	
60B	13-3S	A17K7(S),K12(S)	K0155A,B	
61B	13-3R	A17K7(R),K12(R)	K0155A,B	COMMUNICATIONS - DFI CAL OFF
64B	14-3S	A11K4(S),K5(S)	K0251A,B	
65B	14-3R	A11K4(R),K5(R)	K0251A,B	
70B	15-3S	A11K6(S),K7(S)	K0252A,B	PYRO - MASTER ARM ON
71B	15-3R	A11K6(R),K7(R)	K0252A,B	
74B	16-3S	A11K8(S)	K1152A	
75B	16-3R	A11K8(R)	K1152A	PYRO - MASTER ARM OFF
				RCS VALVES - RCS PRESS. FIRE
				RCS VALVES - RCS PRESS. RESET
				FLT CONTR - DEADBAND MIN
				FLT CONTR - DEADBAND LMP CONTR

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TABLE 13-4 LMP PRIME (LGC&/OR PRA SEQUENCED) COMMAND

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REV B

OCTAL	DECIMAL CODE	RELAY DESIGNATION	RELAY FUNCTIONAL DESIGNATION	COMMAND NAME
2	2	A11K18(S),25(S)	K1101A, B	FLT CONTR - ATT HOLD ON
3	3	A11K18(R),25(R)	K1101A, B	FLT CONTR - AUTO ENABLE
4	4	A11K12(S),13(S)	K0201A, B	PYRO - MASTER ARM ON
5	5	A11K12(R),13(R)	K0201A, B	PYRO - MASTER ARM OFF
6	6	A11K14(S),15(S)	K0202A, B	RCS VALVES - RCS PRESS. FIRE
7	7	A11K14(R),15(R)	K0202A, B	RCS VALVES - RCS PRESS. RESET
10	8	A10K21(S),27(S)	K0203B, A	LANDING GEAR DEPLOY - FIRE OK
11	9	A10K21(R),27(R)	K0203B, A	LANDING GEAR DEPLOY - OFF
12	10	A12K14(S)	K0034	SPARE
13	11	A12K14(R)	K0034	SPARE
14	12	A13K8(S)	K0813A	RCS VALVES - RCS 1A OPEN
15	13	A13K8(R)	K0813A	RCS VALVES - RCS 1A OPEN RESET
16	14	A14K8(S)	K0811A	RCS VALVES - RCS 3A OPEN
17	15	A14K8(R)	K0811A	RCS VALVES - RCS 3A OPEN RESET
20	16	A11K19(S)	K0028	SPARE
21	17	A11K19(R)	K0028	SPARE
22	18	A11K20(S)	K0029	SPARE
23	19	A11K20(R)	K0029	SPARE
24	20	A11K21(S)	K0030	SPARE
25	21	A11K21(R)	K0030	SPARE
26	22	A11K26(S)	K0206	FLT CONTR - ABORT STG FIRE
27	23	A11K26(R)	K0206	FLT CONTR - ABORT STG FIRE RESET
30	24	A10313(S),14(S)	K0204A, B	DPS HELIUM PRE PRESSURIZATION FIRE (DEM 283)
31	25	A10K13(R),14(R)	K0204A, B	DPS HELIUM PRE PRESSURIZATION OFF (LEM 283)
32	26	A12K26(S)	K1702A	LANDING RADAR SELF TEST - ON
33	27	A12K26(R)	K1702A	LANDING RADAR SELF TEST - OFF
34	28	A13K9(S)	K0821A	RCS VALVES - RCS 1B OPEN
35	29	A13K9(R)	K0821A	RCS VALVES - RCS 1B OPEN RESET
36	30	A14K9(S)	K0819A	RCS VALVES - RCS 3B OPEN
37	31	A14K9(R)	K0819A	RCS VALVES - RCS 3B OPEN RESET
40	32	A11K22(S)	K1103A	AGS STATUS ASA - STANDBY/OPERATE
41	33	A1K22(R)	K1103A	AGS STATUS ASA - WARMUP
42	34	A11K23(S)	K1302A	COMMUNICATIONS S-BND RNG ON
43	35	A11K23(R)	K1302A	COMMUNICATIONS S-BND RNG OFF
44	36	A11K27(S)	K1102A	FLT CONTR DEADBAND LMP CONTR
45	37	A11K27(R)	K1102A	FLT CONTR DEADBAND LMP

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TABLE 13-4 LMP PRIME (LGC &/OR PRA SEQUENCED) COMMAND (CONT'D)

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REV B

OCTAL	DECIMAL CODE	RELAY DESIGNATION	RELAY FUNCTIONAL DESIGNATION	COMMAND NAME
46	38	A10K3(S),4(S),5(S)	K0205A, B, C	FLT CONTR - ABORT STG ARM
47	39	A10K3(R),4(R),5(R)	K0205A, B, C	FLT CONTR - ABORT STG RESET
50	40	A10K8(S)	K0024	SPARE
51	41	A10K8(R)	K0024	SPARE
52	42	A12K6(S)	K0033A	SPARE
53	43	A12K6(R)	K0033A	SPARE
54	44	A11K11(S)	K1104A	ENG ON-OFF-ENG STOP DISABLE
55	45	A11K11(R)	K1104A	ENG ON-OFF-ENG STOP ENABLE
56	46			SPARE
57	47			SPARE
60	48	A6K11(S),19(S)	K0107B, A	THREE AXIS ATTITUDE CONTROLLER NEGATIVE PITCH HI (15°/SEC) - ON
61	49	A6K11(R),19(R)	K0107B, A	THREE AXIS ATTITUDE CONTROLLER NEGATIVE PITCH HI (15°/SEC) - OFF
62	50	A7K11(S),19(S)	K0109B, A	THREE AXIS ATTITUDE CONTROLLER NEGATIVE YAW HI (15°/SEC) - ON
63	51	A7K11(R),19(R)	K0109B, A	THREE AXIS ATTITUDE CONTROLLER NEGATIVE YAW HI (15°/SEC) - OFF
64	52	A8K11(S),19(S)	K0111B, A	THREE AXIS ATTITUDE CONTROLLER NEGATIVE ROLL HI (15°/SEC) - ON
65	53	A8K11(R),19(R)	K0111B, A	THREE AXIS ATTITUDE CONTROLLER NEGATIVE ROLL HI (15°/SEC) - OFF
66	54	A10K15(S)	K0025	SPARE
67	55	A10K15(R)	K0025	SPARE
70	56	A10K16(S)	K0026	SPARE
71	57	A10K16(R)	K0026	SPARE
72	58	A12K3,A13K14(S)	K2001A, B	PYRO - LM/SLA SEP ARM
73	59	A12K3,A13K14(R)	K2001A, B	PYRO - LM/SLA SEP ARM RESET
74	60	A13K3(S)	K0805A	RCS VALVES - ASC FEED A OPEN
75	61	A13K3(R)	K0805A	RCS VALVES - ASC FEED A OPEN RESET
76	62	A14K3(S)	K0807A	RCS VALVES - ASC FEED B OPEN
77	63	A14K3(R)	K0807A	RCS VALVES - ASC FEED B OPEN RESET
100	64	A6K12(S),20(S)	K0114B, A	THREE AXIS ATTITUDE CONTROLLER NEGATIVE PITCH LO (5°/SEC) - ON
101	65	A6K12(R),20(R)	K0114B, A	THREE AXIS ATTITUDE CONTROLLER NEGATIVE PITCH LO (5°/SEC) - OFF
102	66	A7K12(S),20(S)	K0116B, A	THREE AXIS ATTITUDE CONTROLLER NEGATIVE YAW LO (5°/SEC) - ON
103	67	A7K12(R),20(R)	K0116B, A	THREE AXIS ATTITUDE CONTROLLER NEGATIVE YAW LO (5°/SEC) - OFF
104	68	A8K12(S),20(S)	K0118B, A	THREE AXIS ATTITUDE CONTROLLER NEGATIVE ROLL LO (5°/SEC) - ON
105	69	A8K12(R),20(R)	K0118B, A	THREE AXIS ATTITUDE CONTROLLER NEGATIVE ROLL LO (5°/SEC) - OFF
106	70	A9K27(S)	K0105A	2 JET/4 JET SELECT - 2 JET SELECT
107	71	A9K27(R)	K0105A	2 JET/4 JET SELECT - 4 JET
110	72	A10K24(S)	K0022	SPARE
111	73	A10K24(R)	K0022	SPARE
112	74	A12K1(S)	K0032A	SPARE
113	75	A12K1(R)	K0032A	SPARE

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TABLE 13-4 LMP PRIME (LGC &/OR PRA SEQUENCED) COMMAND (CONT'D)

LM
AS-206
REV B

OCTAL	DECIMAL CODE	RELAY DESIGNATION	RELAY FUNCTIONAL DESIGNATION	COMMAND NAME
114	76	A13K4(S)	K0806A	RCS VALVES - ASC FEED A CLSD
115	77	A13K4(R)	K0806A	RCS VALVES - ASC FEED A CLSD RESET
116	78	A14K4(S)	K0808A	RCS VALVES - ASC FEED B CLSD
117	79	A14K4(R)	K0808A	RCS VALVES - ASC FEED B CLSD RESET
120	80	A6K14(S),22(S)	K0113B, A	THREE AXIS ATTITUDE CONTROLLER POSITIVE PITCH LO (5°/SEC) - ON
121	81	A6K14(R),22(R)	K0113B, A	THREE AXIS ATTITUDE CONTROLLER POSITIVE PITCH LO (5°/SEC) - OFF
122	82	A7K14(S),22(S)	K0115B, A	THREE AXIS ATTITUDE CONTROLLER POSITIVE YAW LO (5°/SEC) - ON
123	83	A7K14(R),22(R)	K0115B, A	THREE AXIS ATTITUDE CONTROLLER POSITIVE YAW LO (5°/SEC) - OFF
124	84	A8K14(S),22(S)	K0117B, A	THREE AXIS ATTITUDE CONTROLLER POSITIVE ROLL LO (5°/SEC) - ON
125	85	A8K14(R),22(R)	K0117B, A	THREE AXIS ATTITUDE CONTROLLER POSITIVE ROLL LO (5°/SEC) - OFF
126	86	A9K21(S)	K0126A	THROTTLE CONTR - MAN. THROTTLE - 10% ON
127	87	A9K21(R)	K0126A	THROTTLE CONTR - MAN. THROTTLE - 30% ON
130	88	A10K23(S)	K0023	SPARE
131	89	A10K23(R)	K0023	SPARE
132	90	A12K20(S),A13K16(S)	K2006A, B	PYRO - LM/SLA SEP FIRE
		A12K12(S)	K2006C	
133	91	A12K20(R),A13K16(R)	K2006A, B	PYRO - LM/SLA SEP FIRE RESET
134	92	A13K10(S)	K0814A	RCS VALVES - RCS 1A CLSD
135	93	A13K10(R)	K0814A	RCS VALVES - RCS 1A CLSD RESET
136	94	A14K10(S)	K0812A	RCS VALVES - RCS 3A CLSD
137	95	A14K10(R)	K0812A	RCS VALVES - RCS 3A CLSD RESET
140	96	A6K15(S),23(S)	K0106B, A	THREE AXIS ATTITUDE CONTROLLER POSITIVE PITCH HI (15°/SEC) - ON
141	97	A6K15(R),23(R)	K0106B, A	THREE AXIS ATTITUDE CONTROLLER POSITIVE PITCH HI (15°/SEC) - OFF
142	98	A7K15(S),23(S)	K0108B, A	THREE AXIS ATTITUDE CONTROLLER POSITIVE YAW HI (15°/SEC) - ON
143	99	A7K15(R),23(R)	K0108B, A	THREE AXIS ATTITUDE CONTROLLER POSITIVE YAW HI (15°/SEC) - OFF
144	100	A8K15(S),23(S)	K0110B, A	THREE AXIS ATTITUDE CONTROLLER POSITIVE ROLL HI (15°/SEC) - ON
145	101	A8K15(R),23(R)	K0110B, A	THREE AXIS ATTITUDE CONTROLLER POSITIVE ROLL HI (15°/SEC) - OFF
146	102	A9K20(S)	K0127A	THROTTLE CONTR - MAN. THROTTLE - 50% ON
147	103	A9K20(R)	K0127A	THROTTLE CONTR - MAN. THROTTLE - 50% OFF
150	104	A10K22(S)	K0027	SPARE
151	105	A10K22(R)	K0027	SPARE
152	106	A12K17(S)	K2005	COMMUNICATIONS - C-BND ON
153	107	A12K17(R)	K2005	COMMUNICATIONS - C-BND OFF
154	108	A13K11(S)	K0822A	RCS VALVES - RCS 1B CLSD
155	109	A13K11(R)	K0822A	RCS VALVES - RCS 1B CLSD RESET
156	110	A14K11(S)	K0820A	RCS VALVES - RCS 3B CLSD
157	111	A14K11(R)	K0820A	RCS VALVES - RCS 3B CLSD RESET

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TABLE 13-4 LMP PRIME (LGC &/OR PRA SEQUENCED) COMMAND (CONT'D)

LM
AS-206
REV B

OCTAL	DECIMAL CODE	RELAY DESIGNATION	RELAY FUNCTIONAL DESIGNATION	COMMAND NAME
160	112	A6K16(S),27(S)	K0120A, B	NEGATIVE X-AXIS TRANSLATION - ON
161	113	A6K16(R),27(R)	K0120A, B	NEGATIVE X-AXIS TRANSLATION - OFF
162	114	A7K16(S),27(S)	K0122A, B	NEGATIVE Y-AXIS TRANSLATION - ON
163	115	A7K16(R),27(R)	K0122A, B	NEGATIVE Y-AXIS TRANSLATION - OFF
164	116	A8K16(S),27(S)	K0124A, B	NEGATIVE Z-AXIS TRANSLATION - ON
165	117	A8K16(R),27(R)	K0124A, B	NEGATIVE Z-AXIS TRANSLATION - OFF
166	118			SPARE
167	119			SPARE
170	120	A16K1(S)	K0824A	RCS VALVES - RCS 2B CLSD
171	121	A16K1(R)	K0824A	RCS VALVES - RCS 2B CLSD RESET
172	122	A15K18(S)	K0038A	SPARE
173	123	A15K18(R)	K0038A	SPARE
174	124			SPARE
175	125			SPARE
176	126	A14K17(S)	K0829	RCS VALVES - ASC FEED ARM
177	127	A14K17(R)	K0829	RCS VALVES - ASC FEED RESET
200	128	A6K24(S),25(S)	K0119A, B	TRANS CMDS +X TRANS ON
201	129	A6K24(R),25(R)	K0119A, B	TRANS CMDS +X TRANS OFF
202	130	A7K24(S),25(S)	K0121A, B	POSITIVE Y-AXIS TRANSLATION - ON
203	131	A7K24(R),25(R)	K0121A, B	POSITIVE Y-AXIS TRANSLATION - OFF
204	132	A8K24(S),25(S)	K0123A, B	POSITIVE Z-AXIS TRANSLATION - ON
205	133	A8K24(R),25(R)	K0123A, B	POSITIVE Z-AXIS TRANSLATION - OFF
206	134	A9K7(S),15(S),23(S)	K0102B, A, C	ENG ON-OFF - APS ARM
207	135	A9K7(R),15(R),23(R)	K0102B, A, C	ENG ON-OFF - APS RESET
210	136	A16K2(S)	K0823A	RCS VALVES - RCS 2B OPEN
211	137	A16K2(R)	K0823A	RCS VALVES - RCS 2B OPEN RESET
212	138	A15K5(S)	K1301A	COMMUNICATIONS - PRI S-BND ENABLE
213	139	A15K5(R)	K1301A	COMMUNICATIONS - PRI S-BND OFF
214	140			SPARE
215	141			SPARE
216	142	A14K16(S)	K0040	SPARE
217	143	A14K16(R)	K0040	SPARE
220	144	A6K1(S)	K0001A	SPARE
221	145	A6K1(R)	K0001A	SPARE
222	146	A7K1(S)	K0008	SPARE
223	147	A7K1(R)	K0008	SPARE
224	148	A8K1(S)	K0015	SPARE
225	149	A8K1(R)	K0015	SPARE

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TABLE 13-4 LMP PRIME (LGC &/OR PRA SEQUENCED) COMMAND (CONT'D)

LM
AS-206
REV B

OCTAL	DECIMAL CODE	RELAY DESIGNATION	RELAY FUNCTIONAL DESIGNATION	COMMAND NAME
226	150	A9K6(S), 14(S), 22(S)	K0101B, A, C	ENG ON-OFF - DPS ARM
227	151	A9K6(R), 14(R), 22(R)	K0101B, A, C	ENG ON-OFF - DPS RESET
230	152	A16K3(S)	K0815A	RCS VALVES - PCS 2A OPEN
231	153	A16K3(R)	K0815A	RCS VALVES - RCS 2A OPEN RESET
232	154	A15K7(S)	K0827A	SPARE
233	155	A15K7(R)	K0827A	SPARE
234	156			SPARE
235	157			SPARE
236	158	A14K15(S)	K0041	SPARE
237	159	A14K15(R)	K0041	SPARE
240	160	A6K2(S)	K0002	SPARE
241	161	A6K2(R)	K0002	SPARE
242	162	A7K2(S)	K0009	SPARE
243	163	A7K2(R)	K0009	SPARE
244	164	A8K2(S)	K0016	SPARE
245	165	A8K2(R)	K0016	SPARE
246	166	A9K4(S)	K0104B	ENG ON-OFF - ENG STOP O/R
247	167	A9K4(R)	K0104B	ENG ON-OFF - ENG STOP RESET
250	168	A16K4(S)	K0816A	RCS VALVES - RCS 2A CLSD
251	169	A16K4(R)	K0816A	RCS VALVES - RCS 2A CLSD RESET
252	170	A15K10(S)	K0828A	SPARE
253	171	A15K10(R)	K0828A	SPARE
254	172	A13K21(S), 13(S)	K0802B, A	RCS VALVES - RCS MAIN A CLSD
255	173	A13K21(R), 13(R)	K0802B, A	RCS VALVES - RCS MAIN A CLSD RESET
256	174	A14K13(S), 21(S)	K0804A, B	RCS VALVES - RCS MAIN B CLSD
257	175	A14K13(R), 21(R)	K0804A, B	RCS VALVES - RCS MAIN B CLSD RESET
260	176	A6K3(S)	K0003	SPARE
261	177	A6K3(R)	K0003	SPARE
262	178	A7K3(S)	K0010	SPARE
263	179	A7K3(R)	K0010	SPARE
264	180	A8K3(S)	K0017	SPARE
265	181	A8K3(R)	K0017	SPARE
226	182	A9K1(S)	K1701A	LANDING RADAR - ON
227	183	A9K1(R)	K1701A	LANDING RADAR - OFF
270	184	A16K14(S)	K0817A	RCS VALVES - RCS 4B OPEN
271	185	A16K14(R)	K0817A	RCS VALVES - RCS 4B OPEN RESET

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TABLE 13-4 LMP PRIME (LGC &/OR PRA SEQUENCED) COMMAND (CONT'D)

LM
AS-206
REV B

OCTAL	DECIMAL CODE	RELAY DESIGNATION	RELAY FUNCTIONAL DESIGNATION	COMMAND NAME
272	186	A15K3(S)	K0704A	ENVIRONMENTAL - PRI H ₂ O FEED
273	187	A15K3(R)	K0704A	ENVIRONMENTAL - PRI H ₂ O RESET
274	188	A13K18(S), 22(S)	K0801A, B	RCS VALVES - RCS MAIN A OPEN
275	189	A13K18(R), 22(R)	K0801A, B	RCS VALVES - RCS MAIN A OPEN RESET
276	190	A14K18(S), 22(S)	K0803A, B	RCS VALVES - RCS MAIN B OPEN
277	191	A14K18(R), 22(R)	K0803A, B	RCS VALVES - RCS MAIN B OPEN RESET
300	192	A6K4(S)	K0004	SPARE
301	193	A6K4(R)	K0004	SPARE
302	194	A7K4(S)	K0011	SPARE
303	195	A7K4(R)	K0011	SPARE
304	196	A8K4(S)	K1006A	DPS POGS - POGS 2 ARM
305	197	A8K4(R)	K1006A	DPS POGS - POGS 2 RESET
306	198	A9K25(S)	K0601A	MASTER C&W ALARM RESET - ON
307	199	A9K25(R)	K0601A	MASTER C&W ALARM RESET - OFF
310	200	A16K13(S)	K0818A	RCS VALVES - RCS 4B CLSD
311	201	A16K13(R)	K0818A	RCS VALVES - RCS 4B CLSD RESET
312	202	A15K4(S)	K1001A	DPS VALVES - DPS REG 1 OPEN
313	203	A15K4(R)	K1001A	DPS VALVES - DPS REG 1 OPEN RESET
314	204	A17K13(S)	K0050	SPARE
315	205	A17K13(R)	K0050	SPARE
316	206	A17K8(S)	K0049	SPARE
317	207	A17K8(R)	K0049	SPARE
320	208	A6K6(S)	K0005	SPARE
321	209	A6K6(R)	K0005	SPARE
322	210	A7K6(S)	K0012	SPARE
323	211	A7K6(R)	K0012	SPARE
324	212	A8K6(S)	K1005A	DPS POGS - POGS 2 ON
325	213	A8K6(R)	K1005A	DPS POGS - POGS 2 OFF
326	214	A9K10(S)	K0103A	ENG ON-OFF - ENG START
327	215	A9K10(R)	K0103A	ENG ON-OFF - ENG RESET
330	216	A16K12(S)	K0809A	RCS VALVES - RCS 4A OPEN
331	217	A16K12(R)	K0809A	RCS VALVES - RCS 4A OPEN RESET
332	218	A15K13(S)	K1002A	DPS VALVES - REG 1 CLSD
333	219	A15K13(R)	K1002A	DPS VALVES - REG 1 CLSD RESET
334	220	A17K3(S)	K0048	SPARE
335	221	A17K3(R)	K0048	SPARE
336	222	A17K6(S)	K0703A	ENVIRONMENTAL - SEC H ₂ O FEED
337	223	A17K6(R)	K0703A	ENVIRONMENTAL - SEC H ₂ O RESET

TABLE 13-4 LMP PRIME (LGC &/OR PRA SEQUENCED) COMMAND (CONCLUDED)

LM
AS-206
REV B

OCTAL	DECIMAL CODE	RELAY DESIGNATION	RELAY FUNCTIONAL DESIGNATION	COMMAND NAME
340	224	A6K7(S)	K0006	SPARE
341	225	A6K7(R)	K0006	SPARE
342	226	A7K7(S)	K0013	SPARE
343	227	A7K7(R)	K0013	SPARE
344	228	A8K7(S)	K1004A	DPS POGS - PQGS 1 ARM
345	229	A8K7(R)	K1004A	DPS POGS - PQGS 1 RESET
346	230	A9K18(S)	K0125A	THROTTLE CONTR MANUAL THROTTLE - 100% ON
347	231	A9K18(R)	K0125A	THROTTLE CONTR MANUAL THROTTLE - 100% OFF
350	232	A16K11(S)	K0810A	RCS VALVES - RCS 4A CLSD
351	233	A16K11(R)	K0810A	RCS VALVES - RCS 4A CLSD RESET
352	234			SPARE
353	235			SPARE
354	236	A17K5(S)	K2010A	DFI T/M CALIBRATE - ON
355	237	A17K5(R)	K2010A	DFI T/M CALIBRATE - OFF
356	238	A17K10(S)	K0044A	SPARE
357	239	A17K10(R)	K0044A	SPARE
360	240	A6K8(S)	K0007	SPARE
361	241	A6K8(R)	K0007	SPARE
362	242	A7K8(S)	K0014	SPARE
263	243	A7K8(R)	K0014	SPARE
364	244	A8K8(S)	K1003A	DPS POGS - PQGS 1 ON
365	245	A8K8(R)	K1003A	DPS POGS - PQGS 1 OFF
366	246	A9K26(S)	K0701A	COMMUNICATIONS - DFI CAL ON
367	247	A9K26(R)	K0701A	COMMUNICATIONS - DFI CAL OFF
370	248	A16K10(S)	K0045	SPARE
371	249	A16K10(R)	K0045	SPARE
372	250	A16K7(S)	K0046	SPARE
373	251	A16K7(R)	K0046	SPARE
374	252	A17K2(S)	K0825A	RCS VALVES - X-FEED OPEN
375	253	A17K2(R)	K0825A	RCS VALVES - X-FEED OPEN RESET
376	254	A17K4(S)	K0826A	RCS VALVES - X-FEED CLSD
377	255	A17K4(R)	K0826A	RCS VALVES - X-FEED CLSD RESET

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TABLE 13-5 LMP CMD INFORMATION

LM
AS-206
RFV B

LM 1 COMMANDS

COMMAND TITLE	PRIME		MATRIX LOC	RTC		DISCRETE TM VERIFICATION	ASSOCIATED ONBOARD VALVE/SWITCH/CB	FUNCTION	
	CMD NO. DEC	OCT		CMD NO. OCT	MATRIX LOC				
PYRO MASTER ARM ON	4	4	MO-L4	64B	13-3S	GY0111X (0) GY0112X (0)	2-S-7 MASTER ARM "ON"	CONNECTS THE PYRO BATTERIES TO THE PYRO BUSES. 2.1.1 ZONE E7	R-B
MASTER ARM OFF	5	5	MO-L5	65B	13-3R	GY0111X (1) GY0112X (1)	2-S-7 MASTER ARM "OFF"	DISCONNECTS THE PYRO BATTERIES FROM THE PYRO BUSES. 2.1.1 ZONE F7	R-B
									R-B
									R-B
RCS VALVES									R-B
RCS PRESS. RESET	7	7	MO-L7	71B	14-3R	-	2-S-2 RCS PRESSURIZE "SAFE" (SW IS MOMENTARY)	REMOVES POWER FROM THE RCS QUIBS. 2.1.1 ZONE D3	
ENG ON-OFF									
APS HE 1 INHIBIT	-	-	-	74A	15-1S	-	2-S-3 TANK SELECT SW "TANK 2"	OPENS THE POWER FEED TO THE SQUIB TO PRESSURIZE ASCENT ENGINE HE TANK 1. 2.1.1 ZONE D3	
APS HE 2 INHIBIT	-	-	-	75A	15-1R	-	2-S-3 TANK SELECT SW "TANK 1"	OPENS THE POWER FEED TO THE SQUIB TO PRESSURIZE ASCENT ENGINE HE TANK 2 2.1.1 ZONE A6	

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TABLE 13-5 LMP CMD INFORMATION (CONT'D)

LM
AG-206
REV B

LM 1 COMMANDS

COMMAND TITLE	PRIME			RTC		DISCRETE TM VERIFICATION	ASSOCIATED ONBOARD VALVE/SWITCH/CB	FUNCTION	
	CMD NO. DEC	MATRIX OCT	LOC	CMD NO. OCT	MATRIX LOC				
<u>ELECTRICAL</u>									
BAT 1 OFF	-	-	-	17A	3-2R	GC4361X(0) GC4362X(0)	4-S-1 BAT #1 HI "OFF/ RESET" 4-S-5 BAT #1 LO "OFF/ RESET"	DISCONNECTS BAT #1 FROM SE BUS 3.2.1 ZONE E-7	R-B R-B
BAT 2 OFF	-	-	-	22A	4-2S	GC4363X(0) GC4364X(0)	4-S-2 BAT #2 HI "OFF/ RESET" 4-S-6 BAT #2 LO "OFF/ RESET"	DISCONNECTS BAT #2 FROM SE BUS 3.2.1 ZONE E-7	R-B R-B
BAT 3 OFF	-	-	-	32A	6-2S	GC4365X(0) GC4366X(0)	4-S-3 BAT #3 HI "OFF/ RESET" 4-S-7 BAT #3 LO "OFF/ RESET"	DISCONNECTS BAT #3 FROM CDR BUS 3.2.1 ZONE E-7	R-B R-B
BAT 4 OFF	-	-	-	37A	7-2R	GC4367X(0) GC4368X(0)	4-S-4 BAT #4 HI "OFF/ RESET" 4-S-8 BAT #4 LO "OFF/ RESET"	DISCONNECTS BAT #4 FROM CDR BUS 3.2.1 ZONE E-8	R-B R-B
BAT 5 OFF	-	-	-	26A	5-2S	GC4371X(0)	4-S-10 BAT #5 NORM "OFF/RESET"	DISCONNECTS BAT #5 FROM SE BUS 3.2.1 ZONE E-7	R-B
BAT 6 OFF	-	-	-	23A	4-2R	GC4370X(0)	4-S-11 BAT #6 NORM "OFF/RESET"	DISCONNECTS BAT #6 FROM CDR BUS 3.2.1 ZONE E-6	R-B
BAT 5 B/U CDR	-	-	-	36A	7-2S	GC4369X(1)	4-S-12 BAT #5 B/U "ON"	CONNECTS BAT #5 TO CDR BUS 3.2.1 ZONE E-7	R-B
BAT 6 B/U SE	-	-	-	27A	5-2R	GC4372X(1)	4-S-13 BAT #6 B/U "ON"	CONNECTS BAT #6 TO SE BUS 3.2.1 ZONE E-6	R-B
INVERT 2 SEL	-	-	-	16A	3-2S	-	4-S-14 AC PWR "INV 2"	CONNECTS INVERTER NO. 2 TO THE AC BUS. DISCONNECTS INVERTER NO. 1 3.3.1 ZONE C-7	R-B

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TABLE 13-5 LMP CMD INFORMATION (CONT'D)

LM
AS-206
REV B

LM 1 COMMANDS

COMMAND TITLE	PRIME		MATRIX LOC	RTC		DISCRETE TM VERIFICATION	ASSOCIATED ONBOARD VALVE/SWITCH/CB	FUNCTION	
	CMD NO. DEC	OCT		CMD NO. OCT	MATRIX LOC				
ENVIRONMENTAL PRI H ₂ O FEED	186	272	M11-L10	24A	5-1S	GF4101P GF9998U	PRIMARY EVAPORATOR FLOW VALVE "OPEN"	ENERGIZES AND OPENS PRI WATER VALVE AND PERMITS WATER TO FLOW FROM THE DESCENT WATER TANK TO THE PRIMARY GLYCOL LOOP WATER BOILERS 4.1.1 ZONE F7	R-B
PRI H ₂ O RESET	187	273	M11-L11	25A	5-1R			DE-ENERGIZES PRI WATER VALVE WHICH REMAINS LATCHED OPEN 4.1.1 ZONE G7	R-B
SEC H ₂ O FEED	222	337	M13-L14	44B	9-3S	GF9998U		ENERGIZES AND OPENS SEC WATER VALVE AND PERMITS WATER TO FLOW FROM THE ASCENT WATER TANKS TO THE PRIMARY WATER BOILERS. 4.1.1 ZONE E7	R-B
SEC H ₂ O RESET	223	340	M13-L15	45B	9-3R			DE-ENERGIZES SEC WATER VALVE WHICH REMAINS LATCHED OPEN. 4.1.1 ZONE F7	R-B
									R-B
									R-B

LM
AS-206
REV B

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TABLE 13-5 LMP CMD INFORMATION (CONT'D)

LM
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REV B

LM 1 COMMANDS

COMMAND TITLE	PRIME			RTC		DISCRETE TM VERIFICATION	ASSOCIATED ONBOARD VALVE/SWITCH/CB	FUNCTION	
	CMD NO. DEC	OCT	MATRIX LOC	CMD NO. OCT	MATRIX LOC				
<u>COMMUNICATIONS</u> S-BND RNG ON	34	42	M2-L2	-	-	-	13-S-1 RANGE/TV "RANGE"	ENABLES S-BAND RANGING FUNCTION - 5.1.1 ZONE B3	R-B
S-BND RNG OFF	35	43	M2-L3	-	-	-	13-S-1 RANGE/TV "TV"	DISABLES S-BAND RANGING FUNCTION 5.1.1 ZONE B3	R-B
PRI S-BND ENABLE	138	212	M8-L10	31A	6-1R	-	13-S-8 XMTR/RCVR "PRI" 13-S-2 PWR AMP "PRI"	TURNS ON THE PRI S-BAND XMTR, RCVR, AND PWR AMP DEPENDING UPON THE RELATION- SHIP BETWEEN THE PRIME RELAYS AND THE RTC RELAYS. 5.1.1 ZONE D2 5.2.1 E2	R-B
PRI S-BND OFF	139	213	M8-L11	30A	6-1S	-	13-S-8 XMTR/RCVR "OFF" 13-S-2 PWR AMP "OFF"	TURNS OFF THE PRI S-BAND EQUIPMENT. 5.1.1 ZONE D2 5.2.1 D2	R-B
SEC S-BND ON	-	-	-	20A	4-1S	-	13-S-8 XMTR/RCVR "SEC" 13-S-2 PWR AMP "SEC"	TURNS ON THE SEC S-BAND XMTR, RCVR, AND PWR AMP. SEC S-BAND ON SHOULD ALWAYS BE PROCEEDED BY PRI S-BND OFF. 5.1.1 ZONE D1 5.2.1 D2	R-B
SEC S-BND OFF	-	-	-	21A	4-1S	-	13-S-8 XMTR/RCVR "OFF" 13-S-2 PWR AMP "OFF"	TURNS OFF THE SEC S-BAND EQUIPMENT. 5.1.1 ZONE D1 5.2.1 E2	R-B
C-BND ON	106	152	M6-L10	53A	10-2R	-	19-S-1 C-BAND PWR "ON"	RTC'S ARE PERMANENTLY INHIBITED FROM TURNING THE C-BAND ON OR OFF DUE TO THE ONBOARD SW BEING IN THE ON POSITION. 16.1.1 ZONE G3	R-B

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TABLE 13-5 LMP CMD INFORMATION (CONT'D)

LM
AS-206
REV B

LM 1 COMMANDS

COMMAND TITLE	PRIME			RTC		DISCRETE TM VERIFICATION	ASSOCIATED ONBOARD VALVE/SWITCH/CB	FUNCTION	
	CMD NO. DEC	OCT	MATRIX LOC	CMD NO. OCT	MATRIX LOC				
COMMUNICATIONS (CONCLUDED) C-BND OFF	107	153	M6-L11	52A	10-25	-	19-S-1 C-BAND PWR "OFF"	16.1 ZONE F3	R-B

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TABLE 13-5 LMP CMD INFORMATION (CONT'D)

LM
AS-206
REV B

LM 1 COMMANDS

COMMAND TITLE	PRIME		MATRIX LOC	RTC		DISCRETE TM VERIFICATION	ASSOCIATED ONBOARD VALVE/SWITCH/CB	FUNCTION
	CMD NO. DEC	OCT		CMD NO. OCT	MATRIX LOC			
<u>INSTRUMENTATION</u>								
DFI CAL ON	236	366	M14-L12	54B	11-3S	GL4221 (1)	R&D TM CAL "ON"	INTERRUPTS NORMAL SENSOR DATA FROM THE DFI TM SYSTEM AND REPLACES THE DATA WITH PRECISION VOLTAGES FOR SUBSEQUENT CALIBRATION OF DFI DATA. 16.1,1 ZONE G11
DFI CAL OFF	237	367	M14-L13	55B	11-3R	GL4221 (0)	R&D TM CAL "OFF"	URNS OFF CALIBRATION MODE AND RETURNS NORMAL DATA FLOW. THE RTC PERMANENTLY INHIBITS CONTROL OF THE DFI CAL FUNCTION BY PRIME RELAY. 16.1,1 ZONE H11

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TABLE 13-5 LMP CMD INFORMATION (CONT'D)

LM
AC-206
REV B

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LM 1 COMMANDS

COMMAND TITLE	PRIME			RTC		DISCRETE TM VERIFICATION	ASSOCIATED ONBOARD VALVE/SWITCH/CB	FUNCTION
	CMD NO. DEC	OCT	MATRIX LOC	CMD NO. OCT	MATRIX LOC			
PYRO								
LM/SLA SEP ARM	58	72	M3-L10	46A	9-2S	GL4222*** (1)	-	ENABLES LM/SLA SEP CMD. 12.1.1 ZONE B5
LM/SLA SEP ARM RESET	59	73	M3-L11	47A	9-2R	-	-	RELEASES SEP ARM FUNCTION 12.1.1 ZONE B5
LM/SLA SEP FIRE	90	132	M5-10	62A	12-2S	GL4222*** (1)	-	WHEN ENABLED BY THE LM/SLA SEP ARM, SIGNALS THE SLA SEQUENCER WHICH IN TURN FIRES THE RESTRAINING STAPS ALLOWING THE LM TO SEPARATE. EITHER SEP ARM AND SEP PRIME RELAYS OR SEP ARM AND SEP RTC RELAYS MUST BE USED BEFORE SEPARATION CAN OCCUR. 12.1.1 ZONE B5
LM/SLA SEP FIRE RESET	91	133	M5-L11	63A	12-2R	-	-	RELEASES SEP FUNCTION. 12.1.1 ZONE B5

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***GL4222 IS ACTIVATED BY PHYSICAL SEPARATION OF THE LM AND THE SLA.

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TABLE 13.5 LMP CMD INFORMATION (CONT'D)
PROPULSION DESCENT HE REGULATORS

LM
AS-206
REV B

COMMAND TITLE	CMD DEC	PRIME NO. OCT	MATRIX LOC	RTC CMD NO. OCT	MATRIX LOC	DISCRETE TM VERIFICATION	ASSOCIATED ONBOARD VALVE/SWITCH/CB	FUNCTION
<u>DPS VALVES</u>		312					10S5	APPLIES PWR TO OPEN D.E. REG #1 BY JUMPING SW 10S5 (OPEN CONTACT) BY ACTIVATING RELAY K1001. RELAYS K1002 & K1051 MUST BE RESET. SEE DWG 9.1.1
DPS REG 1 OPEN								
DPS REG 1 OPEN RESET		313					10S5	REMOVES PWR TO OPEN D.E. REG #1 BY RESETTING K1001. THIS CMD SHOULD BE GIVEN 2 SECONDS AFTER CMD 312 HAS BEEN GIVEN TO AVOID PWR LOSS
DPS REG 1 CLSD		332		14A*			10S5	APPLIES PWR TO CLOSE D.E. REG #1 BY JUMPING SW 10S5 (CLOSE CONTACTS) BY ACTIVATING RELAY K1002. CMD 14A PUTS PWR TO SW 10S5 VIA RELAY K1051. HOWEVER, K1001 IS PERMANENTLY ISOLATED WHEN THIS IS DONE.
DPS REG 1 CLSD RESET		333		15A			10S5	REMOVES PWR TO CLOSE DESCENT REG VAL #1 BY RESETTING K1002. CMD 5A RESET K1051. GIVE THIS CMD 2 SEC AFTER CMD 332/14A.
DPS REG 2 OPEN				42A			10S7	APPLIES PWR TO OPEN D.E. REG #2 BY JUMPING SW 10S7 (OPEN CONTACT) BY ACTIVATING RELAY K1052. SEE DWG 9.1.1
DPS REG 2 OPEN RESET				43A			10S7	REMOVES PWR TO OPEN D.E. REG #2 BY RESETTING K1052. GIVE THIS CMD 2 SECONDS AFTER 42A.
**WARNING CMD 14A PERMANENTLY CLOSES D.E. REG VAL #1. CMD 15A JUST REMOVES POWER FROM VAL COIL. REG VAL #1 IS STILL INHIBITED. FEC-TSG 45								

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F V B

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TABLE 13-5 LMP CMD INFORMATION (CONT'D)
RCS MSKV SYSTEM "A"

LM
AS-206
REV B

COMMAND TITLE	CMD DEC	PRIME NO. OCT	MATRIX LOC	RTC		DISCRETE TM VERIFICATION	ASSOCIATED ONBOARD VALVE/SWITCH/CB	FUNCTION
				CMD NO. OCT	MATRIX LOC			
RCS MAIN A OPEN		274		50A			MAIN S/O VAL "A" 8S7 PNL II	APPLIES PWR TO OPEN M S/O VALVES BY JUMPING SW 8S7 (OPEN CONTACT) BY ACTIVATING RELAY K0801. (SEE DWG 9.4.1)
RCS MAIN A OPEN RESET		275		51A			MAIN S/O VAL "A" 8S7 PNL II	REMOVES PWR TO OPEN M S/O VALVES BY RESETTNG K0801. THIS CMD SHOULD BE GIVEN 2 SECONDS AFTER CMD 274 HAS BEEN GIVEN TO AVOID PWR LOSS (NOTE: IF 50A IS SENT 51A MUST BE SENT TO REMOVE PWR AND ENABLE PRIME CMD)
RCS MAIN A CLSD		254		44A			MAIN S/O VAL "A" 8S7 PNL II	APPLIES PWR TO CLOSE M S/O VALVES BY JUMPING SW 8S7 (CLOSE CONTACT) BY ACTIVATING RELAY K0802.
RCS MAIN A CLSD RESET		255		45A			MAIN S/O VAL "A" 8S7 PNL II	REMOVES PWR TO CLOSE M S/O VALVES BY RESETTNG RELAY K0802. THIS CMD SHOULD BE GIVEN 2 SECONDS AFTER CMD 254 HAS BEEN GIVEN TO AVOID PWR LOSS (NOTE: IF 44A IS SENT 45A MUST BE SENT TO REMOVE PWR AND ENABE PRIME CONTROL.)

NOTE: CMDS 50A AND 44A INHIBIT PRIME CMDS. THESE RELAYS (K0851 & K0852) MUST BE RESET BY CMDS 51A AND 45A IN ORDER TO ENABLE PRIME CMDS.

WARNING: IF CMDS 44A AND 274 ARE SENT SIMULTANEOUSLY CMDS 274 AND 275 ARE PERMANENTLY INHIBITED.
IF CMDS 50A AND 254 ARE SENT SIMULTANEOUSLY CMDS 254 AND 255 ARE PERMANENTLY INHIBITED.

TABLE 13-5 LMP CMD INFORMATION (CONT'D)

RCS MSKV SYSTEM "A"

LM
AS-206
REV B

COMMAND TITLE	CMD DEC	PRIME NO. OCT	MATRIX LOC	RTC		DISCRETE TM VERIFICATION	ASSOCIATED ONBOARD VALVE/SWITCH/CB	FUNCTION
				CMD NO. OCT	MATRIX LOC			
RCS MAIN B OPEN		276		60A			MAIN S/O VALVE "A" 8S9 PNL II	SAME AS 274 EXCEPT RELAY K0803 JUMPS 8S9 (SEE DWG 9.4.1)
RCS MAIN B OPEN RESET		277		61A			MAIN S/O VALVE "A" 8S9 PNL II	SAME AS 275 EXCEPT RELAY K0803 IS RESET TO REMOVE PWR
RCS MAIN B CLSD		256		54A			MAIN S/O VALVE "A" 8S9 PNL II	SAME AS 254 EXCEPT RELAY K0804 JUMPS 8S9
RCS MAIN B CLSD RESET		257		55A			MAIN S/O VALVE "A" 8S9 PNL II	SAME AS 255 EXCEPT RELAY K0804 IS RESET TO REMOVE PWR
NOTE: CMS 60A AND 54A INHIBIT PRIME CMDS. THESE RELAYS (K0853 & K0854) MUST BE RESET BY CMDS 61A AND 55A IN ORDER TO ENABLE PRIME CMDS.								
WARNING: IF CMDS 54A AND 276 ARE SENT SIMULTANEOUSLY, CMDS 277 AND 276 ARE PERMANENTLY INHIBITED.								
IF CMDS 60A AND 256 ARE SENT SIMULTANEOUSLY, CMDS 256 AND 257 ARE PERMANENTLY INHIBITED.								

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LM
AS-206
REV B

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TABLE 13-5 LMP CMD INFORMATION (CONT'D)

RCS ISOLATION VALVES -- QUAD III

LM
AS-206
REV 1

COMMAND TITLE	CMD DEC	PRIME NO. OCT	MATRIX LOC	RTC CMD NO. OCT	MATRIX LOC	DISCRETE TM VERIFICATION	ASSOCIATED ONBOARD VALVE/SWITCH/CB	FUNCTION
RCS 3A OPEN		16					8S15 PNL II	APPLIES PWR TO OPEN RCS ISO VAL BY JUMPING THE OPEN CONTACTS OF SW 8S15 BY ACTIVATING RELAY K0311 SEE DWG 9.4.1
RCS 3A OPEN RESET		17					8S15 PNL II	REMOVES PWR TO OPEN RCS ISO VAL BY RESETTNG K0311. THIS CMD SHOULD BE GIVEN 2 SECONDS AFTER CMD 16 HAS BEEN GIVEN TO AVOID PWR LOSS.
RCS 3A CLSD		136					8S15 PNL II	APPLIES PWR TO CLOSE RCS ISO VAL BY JUMPING THE CLOSE CONTACTS OF SW 8S15 BY ACTIVATING RELAY K0812.
RCS 3A CLSD RESET		137					8S15 PNL II	REMOVE PWR TO CLOSE RCS ISO VAL BY RESETTNG K0812. THIS CMD SHOULD BE GIVEN 2 SECONDS AFTER CMD 136 HAS BEEN GIVEN TO AVOID PWR LOSS
RCS 3B OPEN		36					8S17 PNL II	SAME AS 16 EXCEPT RELAY K0819 JUMPS 8S17. SEE DWG 9.4.1
RCS 3B OPEN RESET		37					8S17 PNL II	SAME AS 17 EXCEPT K0819 IS RESET
RCS 3B CLSD		156					8S17 PNL II	SAME AS 136 EXCEPT K0820 JUMPS 8S17
RCS 3B CLSD RESET		157					8S17 PNL II	SAME AS 137 EXCEPT K0820 IS RESET
FEC-TSG 45								

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TABLE 13-5 LMP CMD INFORMATION (CONT'D)
RCS ASCENT INTERCONNECT VAL

LM
AS-206
REV B

COMMAND TITLE	CMD DEC	PRIME NO. OCT	MATRIX LOC	RTC CMD NO. OCT	MATRIX LOC	DISCRETE TM VERIFICATION	ASSOCIATED ONBOARD VALVE/SWITCH/CB	FUNCTION
ASC FEED ARM		176					8S8 & 8S10 PNL II PNL II	CLOSES K0829 WHICH ENABLES PCA TO OPERATE ASCENT FEED VALVES. SYSTEM A & SYSTEM B.
ASC FEED RESET		177					8S8 & 8S10 PNL II PNL II	DISABLES PCA TO OPERATE ASCENT FEED VALVES. SYSTEM A & SYSTEM B BY OPENING K0829 SEE DWG 9.4.1
ASC FEED A OPEN		74					8S8 PNL II	APPLIES PWR TO OPEN RCS ISO VAL BY JUMPING THE OPEN CONTACTS OF SW 8S8 BY ACTIVATING RELAY K0805. SEE DWG 9.4.1
ASC FEED A OPEN RESET		75					8S8 PNL II	REMOVES PWR TO OPEN RCS ISO VAL BY RESETTING K0805. THIS CMD SHOULD BE GIVEN 2 SECONDS AFTER CMD 74 HAS BEEN GIVEN TO AVOID PWR LOSS.
ASC FEED A CLSD		114					8S8 PNL II	APPLIES PWR TO CLOSE RCS ISO VAL BY JUMPING THE CLOSE CONTACTS OF SW 8S8 BY ACTIVATING RELAY K0806.
ASC FEED A CLSD RESET		115					8S8 PNL II	REMOVE PWR TO CLOSE RCS ISO VAL BY RESETTING K0806. THIS CMD SHOULD BE GIVEN 2 SECONDS AFTER CMD 114 HAS BEEN GIVEN TO AVOID PWR LOSS
ASC FEED B OPEN		76					8S10 PNL II	SAME AS 74 EXCEPT RELAY K0807 JUMPS 8S10 SEE DWG 9.4.1
ASC FEED B OPEN RESET		77					8S10 PNL II	SAME AS 75 EXCEPT K0807 IS RESET
ASC FEED B CLSD		116					8S10 PNL II	SAME AS 114 EXCEPT K0808 JUMPS 8S10
ASC FEED B CLSD RESET		117					8S10 PNL II	SAME AS 115 EXCEPT K0808 IS RESET
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LM
AS-206
REV B

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TABLE 13-5 LMP CMD INFORMATION (CONT'D)

RCS ISOLATION VALVES - QUAD I

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AS-206
REV B

COMMAND TITLE	CMD DEC	PRIME NO. OCT	MATRIX LOC	RTC CMD NO. OCT	MATRIX LOC	DISCRETE TM VERIFICATION	ASSOCIATED ONBOARD VALVE/SWITCH/CB	FUNCTION
RCS 1A OPEN		14					8S11 PNL II ISO VAL "A"	APPLIES PWR TO OPEN RCS ISOLATION VALVES BY JUMPING THE OPEN CONTACTS OF SW 8S11 BY ACTIVATING RELAY K0813. SEE DWG 9.4.1
RCS 1A OPEN RESET		15					8S11 PNL II ISO VAL "A"	REMOVES PWR TO OPEN RCS ISOLATION VALVES BY RESETTING K0813. THIS CMD SHOULD BE GIVEN 2 SECONDS AFTER CMD 14 HAS BEEN GIVEN TO AVOID PWR LOSS.
RCS 1A CLSD		134					8S11 PNL II ISO VAL "A"	APPLIES PWR TO CLOSE RCS ISOLATION VALVES BY JUMPING THE CLOSE CONTACTS OF SW 8S11 BY ACTIVATING RELAY K0814.
RCS 1A CLSD RESET		135					8S11 PNL II ISO VAL "A"	REMOVE PWR TO CLOSE RCS ISOLATION VALVES BY RESETTING K0814. THIS CMD SHOULD BE GIVEN 2 SECONDS AFTER CMD 134 HAS BEEN GIVEN TO AVOID PWR LOSS.
RCS 1B OPEN		34					ISO VAL B 8S13 PNL II	SAME AS 14 EXCEPT RELAY K0821 JUMPS 8S13 SEE DWG 9.4.1
RCS 1B OPEN RESET		35					ISO VAL B 8S13 PNL II	SAME AS 15 EXCEPT K0821 IS RESET
RCS 1B CLSD		154					ISO VAL B 8S13 PNL II	SAME AS 134 EXCEPT RELAY K0822 JUMPS 8S13
RCS 1B CLSD RESET		155					ISO VAL B 8S13 PNL II	SAME AS 135 EXCEPT K0822 IS RESET.

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TABLE 13-5 LMP CMD INFORMATION (CONT'D)

IM
AS-206
REV B

CONTROL MODE SELECT

COMMAND TITLE	CMD DEC	PRIME NO. OCT	MATRIX LOC	RTC CMD NO. OCT	MATRIX LOC	DISCRETE TM VERIFICATION	ASSOCIATED ONBOARD VALVE/SWITCH/CB	FUNCTION
ATT HOLD ENABLE				31B			MODE CONTR SELECT SW 1156 PNL III	SEE DWG 8.4.1 ALLOWS "ATT HOLD" OR "AUTO" TO BE SELECTED
AUTO ON				30B			MODE CONTR SELECT SW 1156 PNL III	ALLOWS "OFF" OR AUTO TO BE SELECTED BUT INHIBITS "ATT HOLD"
ATT HOLD ON		2		24B			MODE CONTR SELECT SW 1156 PNL III	ALLOWS "OFF" OR "ATT HOLD" TO BE SELECTED BUT INHIBITS "AUTO"
AUTO ENABLE		3		25B			MODE CONTR SELECT SW 1156 PNL III	ALLOWS "ATT HOLD" OR "AUTO" TO BE SELECTED BUT INHIBITS "OFF"
"AUTO" MODE	3	3		30B & 25B		GH1603X "1"	MODE CONTR SELECT SW 1156 PNL III	SELECTS "AUTO" IF NOT INHIBITED IF CMDS 30B & 25B ARE SENT "AUTO" MODE IS INSURED.
"ATT HOLD" MODE	2	2		31B & 24B		GH1603X "0"	MODE CONTR SELECT SW 1156 PNL III	SELECTS "ATT HOLD" IF NOT INHIBITED IF CMDS 31B & 24B ARE SENT "ATT HOLD" MODE IS INSURED.

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TABLE 13-5 LMP CMD INFORMATION (CONT'D)

PROPELLANT QUANTITY GAGING SYSTEM

LM
AS-206
REV B

DPS PQGS

COMMAND TITLE	CMD DEC	PRIME NO. OCT	MATRIX LOC	RTC CMD NO. OCT	MATRIX LOC	DISCRETE TM VERIFICATION	ASSOCIATED ONBOARD VALVE/SWITCH/CB	FUNCTION
PQGS 1 ARM		344					MAIN PROP PNL I SW 10SB	RELAY K1004 & K1003 ARE IN SERIES. IF BOTH ARE CLOSE PWR IS APPLIED TO THE PQG PROPELLANT QUANTITY GAGING CONTR UNIT. K1004 IS OPENED (RESET) BY CMD 345 AND CLOSED (SET) BY CMD 334. K1003 IS OPENED (RESET) BY CMD 365 AND CLOSED (SET) BY CMD 364. SEE DWG 9.1.1
PQGS 1 ON		364					MAIN PROP PNL I SW 10SB	
PQGS 1 OFF		365					MAIN PROP PNL I SW 10SB	
PQGS 1 RESET		345					MAIN PROP PNL I SW 10SB	
PQGS 2 ARM		304					MAIN PROP PNL I SW 10SB	RELAY K1006 & K1005 ARE IN SERIES. IF BOTH ARE CLOSE PWR IS APPLIED TO THE PQG PROPELLANT QUANTITY GAGING CONTR. K1006 IS OPENED (RESET) BY CMD 305 AND CLOSED (SET) BY CMD 304. K1005 IS OPENED (RESET) BY CMD 325 AND CLOSED (SET) BY CMD 324 NOTE: SYSTEM 2 IS REDUNDANT TO SYSTEM #1 (I.E. THE TWO SYSTEMS ARE IN PARALLEL)
PQGS 2 ON		324					MAIN PROP PNL I SW 10SB	
PQGS 2 OFF		325					MAIN PROP PNL I SW 10SB	
PQGS 2 RESET		305					MAIN PROP PNL I SW 10SB	

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PTV B

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TABLE 13-5 LMP CMD INFORMATION

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REV B

COMMAND TITLE	CMD DEC	PRIME		(ASCENT & DESCENT) RTC		DISCRETE TM VERIFICATION	ASSOCIATED ONBOARD VALVE/SWITCH/CB	FUNCTION
		NO. OCT	MATRIX LOC	CMD NO. OCT	MATRIX LOC			
ENG STOP DISABLE		54		72A			NONE	THESE RELAYS K1104 & K1155 ARE IN SERIES WITH EACH OTHER AND IN SERIES WITH K0104 & K0154. (ENG STOP OVERRIDE RELAYS) THIS ALLOWS THE SETTING OF EITHER RELAY TO DISABLE ENG STOP OVERRIDE.
ENG STOP ENABLE		55		73A				CMD 55 RESETS K1104 & CMD 73A RESETS K1155, BOTH MUST BE RESET TO ENABLE ENG STOP OVERRIDE.

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TRANSLATION COMMANDS

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PEV B

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TABLE 13-5 LMP CMD INFORMATION (CONT'D)

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AS-206
REV B

THROTTLE CONTROL

COMMAND TITLE	CMD DEC	PRIME NO. OCT	MATRIX LOC	RTC CMD NO. OCT	MATRIX LOC	DISCRETE TM VERIFICATION	ASSOCIATED ONBOARD VALVE/SWITCH/CB	FUNCTION
<u>THROTTLE CONTR</u>		126					1S10 PNL I CDR THRUST/ TRANSLATION CON- TROLLER	SIMULATES 10% MAN THROTTLE BY SETTING RELAY K0126 WHICH SEND (S&C C.A #2) SIGNAL THROUGH THE 10% TAP OF TI IN THE PCA SEE DWG 8.2.1 (2 OF 2)
MAN. THROTTLE - 10% ON								
MAN. THROTTLE - 30% ON		127					1S10 PNL I CDR THRUST/ TRANSLATION CON- TROLLER	SIMULATES 30% THROTTLE BY RESETTING RELAY K0126 WHICH SENDS A (S&C C.A. #2) SIGNAL THROUGH THE 30% WINDING NTI OF THE PCA
MAN. THROTTLE - 50% ON		146					1S10 PNL I CDR THRUST/ TRANSLATION CON- TROLLER	SIMULATES 50% THROTTLE BY SETTING RELAY K0127 WHICH ROUTES A (S&C C.A. #2) SIGNAL THROUGH THE 50% TAP OF TI IN THE PCA, DISABLES 30% → 10%
MAN. THROTTLE - 50% OFF		147					1S10 PNL I CDR THRUST/ TRANSLATION CON- TROLLER	RETURN THROTTLE SETTING TO 10% OR 30% DEPENDING ON RELAY K1026 (CMDS 126 OR 127). RELAY K0127 IS RESET BY CMD 147. ENABLES 30% → 10%
MAN. THROTTLE - 100% ON		346					1S10 PNL I CDR THRUST/ TRANSLATION CON- TROLLER	SIMULATES 100% THROTTLE BY SETTING RELAY K0125 WHICH ROUTES A (S&C C.A.) SIGNAL THROUGH THE 100% TAP OF TI IN THE PCA). DISABLES 50% → 10%
MAN. THROTTLE - 100% OFF		347					1S10 PNL I CDR THRUST/ TRANSLATION CON- TROLLER	RETURNS THROTTLE SETTING TO 10% OR 30% DEPENDING ON RELAY K1026 (CMD 126 & 127). RELAY K0125 IS SET BY CMD 347. ENABLES 50% → 10%

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TABLE 13-5 LMP CMD INFORMATION (CONCLUDED)

LM
AS-206
REV P

COMMAND TITLE	CMD DEC	PRIME NO. OCT	MATRIX LOC	RTC		DISCRETE TM VERIFICATION	ASSOCIATED ONBOARD VALVE/SWITCH/CB	FUNCTION
				CMD NO. OCT	MATRIX LOC			
FLT CONTP				40B			956	SETS RELAY K2059 WHICH APPLIES PWR TO SFT K11, K12, K13, K6, K7, K8, K9, K1, K2, K3, K4, K5. THE PRA IS PLACED IN STANDRY AND AUTO THRUST IS INHIBITED.
GUID SEL AGS								
GUID SEL PGNS				41B			956	RESETS RELAY K2059 WHICH APPLIES PWR TO RESET K11, K12, K13, K6, K7, K8, K9, K1, K2, K3, K4, K5. PGNS IS ENABLED SEE DWG 8.2.1 (SHEET 2 OF 2)
PRIME RLY RESET				34B			N/A	SETS RELAY K2057 WHICH RESETS ALL RELAYS IN THE PRIME RELAY MATRIX EXCEPT K1101 (AUTO MODE) K2005 (C-RAND) K1701 (LND RADAR).
PRIME RLY OFF				35B			N/A	RESETS RELAY K2057 SEE DWG 13.3.1 (2 OF 2)
ABORT STG FIRE		26		40A			1S14	RELAYS K0206 & K0205 ARE IN SERIES. IF BOTH ARE SET (CMD 26 & 46) THE ABORT STAGE SEQUENCE WILL OCCUR. SW 1S14 IS THEN BYPASSED. RTC CMDS 40A & 70A ACCOMPLISH THE SAME THING WITH RELAYS K0254 AND K0257
ABORT STG ARM		46		70A			1S14	
STR FIRE RESET		27		41A			1S14	RELAY K0206 IS RESET BY CMD 27 RELAY K0257 IS RESET BY CMD 41A
STG RESET		47		71A			1S14	RELAY K0205 IS RESET BY CMD 47 RELAY K0204 IS RESET BY CMD 71A SEE DWG 8.4.1
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TABLE 13-6 LM COMMAND CARD RELAY REFERENCE

RTC	ON OR OPEN		SYSTEM	OFF OR CLOSE		RTC	PRIME RELAYS (FUN.)ON/OFF (MOD)ON/OFF		GND RELAYS (FUN.)ON/OFF (MOD)ON/OFF	
	PRIME			PRIME						
			<u>FLIGHT CONTROLS</u>							
25B	(AUTO EN)		ATT ENABLE		(ATT HD EN)	31B			K1151 A,B,C	A11K19,17
30B	(AUTO ON)	3	ATT ON	2	(ATT HOLD ON)	24B	K1101 A,B	A11K18, 25	K1151853 A,B	A11K2,10
75B	(LMP CTR)	44	DEADBAND	45	◇(MIN)	74B	K1102 A	A11K27	K1152 A	A11K8
41B	(PNGS)	N/A	GUID SEL	N/A	(AGS)	40B			K2059 A,B,C, D	A16K17,9,16,8
*** 34B	(RESET)	N/A	PRIME RELAY	N/A	(OFF)	35B			K2057 A,C	A16K5, 15
70A	(ARM)	46	ABORT STAGE	47	◇(RESET)	71A	K0205 A,B,C	A10K3,4,5	K0254 A,B,C	A10K9,10,11
40A/41A	(FIRE/FIRE RESET)	26/27	ABORT STAGE	N/A		N/A	K0206A	A11K26	K0257 A	A15K9
			<u>EECOM</u>							
			<u>PYRO</u>							
64B	(ON)	4	MASTER ARM	5	◇(OFF)	65B	K0201 A,B	A11K12,13	K0251 A,B	A11K4,5
46A	(ARM)/(ARM RESET)	72	LM/SLA SEP	N/A		47A	K2001 A,B	A12K3, A13K14	K0251 A,B	A11K4,5
62A/63A	FIRE/FIRE RESET	132/133	LM/SLA SEP	N/A	-	N/A	K2006 A,B,C	A12K12,20 A13K16	K0256 A,B	A10K2,7
			<u>ELECTRICAL</u>							
N/A	-	N/A	BAT. 1	N/A	(OFF)	17A			K0458 A	A12K24
N/A	-	N/A	BAT. 2	N/A	(OFF)	22A			K0453 A	A12K16
N/A	-	N/A	BAT. 3	N/A	(OFF)	32A			K0459 A	A12K13
N/A	-	N/A	BAT. 4	N/A	(OFF)	37A			K0456 A	A12K22
N/A	-	N/A	BAT. 5	N/A	(OFF)	26A			K0451 A	A12K7
36A	B/U COR	N/A	BAT. 5	N/A	-	N/A			K0455 A	A12K21
N/A	-	N/A	BAT. 6	N/A	(OFF)	23A			K0454 A	A12K16
27A	B/U SE	N/A	BAT. 6	N/A	-	N/A			K0452 A	A12K8
16A	SEL	N/A	INVERT 2	N/A	-	N/A			K0457 A	A12K23
			<u>ENVIRONMENT</u>							
24A/25A	(FEED/ RESET)	272/273	PRI H ₂ O	N/A	-	N/A	K0704 A	A15K3	K0753 A	A15K2
44B/45B	(FEED/ RESET)	336/337	SEC H ₂ O	N/A	-	N/A	K0703 A	A17K6	K0752 A	A17K11
50B	ENABLE		SEC H ₂ O FEED COMM	51B	(RESET)					
N/A	(ON)	42	S-BAND RANGE	43	◇(OFF)	N/A	K1302 A	A11K23	K1352 A	A15K1
31A	(ENABLE)	212	PRI S-BND	213	◇(OFF)	30A	K1301 A	A15K5	K1351 A	A15K14
20A	(ON)	N/A	SEC S-BND	N/A	(OFF)	21A			K0255 A,B	A10K1,6
53A	(ON)	152	C-BND	153	(OFF)	+52A	K2005 A	A12K17	K2060 A,B	A17K9,1
54B	(ON)	354	DFI CAL	355	◇(OFF)	+55B	K0107 A,B	A6K19,11		

*****CMD AVAILABILITY DEPENDS ON COCKPIT SW.

***WARNING - DON'T SEND MASTER RELAY RESET DURING ASC ENG OPERATION.

◇INDICATES POSITION AFTER MASTER RELAY RESET IS GIVEN.

TABLE 13-6 LM COMMAND CARD RELAY REFERENCE (Concluded)

RTC	ON OR OPEN		SYSTEM	OFF OR CLOSE		PRIME RELAYS (FUNCTIONAL) ON/OFF (MOD) ON/OFF			GND RELAYS (FUN.) ON/OFF (MOD) ON/OFF	
	PRIME			PRIME						
			<u>PROPULSION THROTTLE CONTROL</u>							
N/A	100% (N)	346	MAN THROTTLE	347	OFF	N/A	K0125 A	A9K18		
N/A	(50% (N)	146	MAN THROTTLE	147	50% OFF	N/A	K0127 A	A9K20		
N/A	(30% ON)	127 ♦	MAN THROTTLE	N/A		N/A	K0126 A	A1K21		
	(10% ON)	126	MAN THROTTLE							
			<u>TRANSLATION CNTR</u>							
N/A	(ON)	200	+X TRANSLATION	201 ♦	(OFF)	N/A	K0119 A,B	A6K24,25	/K0163 A,B,C	A8K26,A6K26
N/A	----	N/A	+X		(DISABLE)	21B*				A7K26
			<u>ENG ON-OFF</u>							
N/A	L (ARM)	206	APS	207 ♦	(RESET)	N/A	K0102 A,B,C	A9K15,7,23	K0151 A,B,C	A9K16,8,14
00B	L (ARM)	226	DPS	227 ♦	(RESET)	01B	K0101 A,B,C	A9K14,6,22	K0153 A	A9K11
14B/15B	(START/RESET)	326/327	ENG	N/A	----	N/A	K0103 A	A9K10	K0154 A,B	A9K13,5
10B	(OVERRIDE)	246	ENG STOP	247 ♦	(RESET)	11B	K0104 B	A9K4	K1155 A	A11K24
72A	(DISABLE)	54	ENG STOP	55 ♦	(ENABLE)	73A	K1104 A	A11K11	K0255 A,B	A10K1,6
74A	(INHIBIT)	N/A	APS HE. 1	N/A	----	N/A			K0256 A,B	A10K2,7
75A	(INHIBIT)	N/A	APS HE. 2	N/A	----	N/A				
			<u>DE REG VAL CNTR</u>							
N/A	(OPEN/RESET)	312/313	DPS REG 1	332/333	(CLOSED/RESET)	14A*/15A	K1001A	A15K4		
N/A	----	N/A	DPS REG 2	N/A	(OPEN/RESET)	42A/43A				
			<u>DPS PQGS</u>							
N/A	(ARM)	344	PQGS #1	345	(RESET)	N/A	K1004A	A8K7		
N/A	(ON)	364	PQGS #1	365	(OFF)	N/A	K1003A	A8K8		
N/A	(ARM)	304	PQGS #2	305	(RESET)	N/A	K1006A	A8K4		
N/A	(ON)	324	PQGS #2	325	(OFF)	N/A	K1005A	A8K6		
			<u>RCS VALVES</u>							
70B/71B	(FIRE/RESET)	6/7	RCS PRESS.	N/A		N/A	K0202 A,B	A11K14,15	K0252 A,B	A11K6,7
N/A	(ARM)	176	ASC FEED	177 ♦	(RESET)	N/A	K0829 A	A13K3		
N/A	L (OPEN/RESET)	74/75	ASC FEED "A"	114/115	(CLOSE/RESET)	N/A	K0805/6 A	A13K3/4		
N/A	L (OPEN/RESET)	76/77	ASC FEED "B"	116/117	(CLOSE/RESET)	N/A	K0807/8 A	A14K3/4		
N/A	L (OPEN/RESET)	374/375	CROSSFEED	376/377	(CLOSE/RESET)	N/A	K0825/26 A	A17K2/4		
50A+/51A	L (OPEN/RESET)	274/275	RCS MAIN "A"	254/255	(CLOSE/RESET)	44A+/45A	K0801/02 A,B	A13K18,22/ 13,21	K0851/52 A,B,C	A13K6,5,20/ A13K2,1,19
60A+/61A	L (OPEN/RESET)	276/277	RCS MAIN "B"	256/257	(CLOSE/RESET)	54A+/55A	K0803/04 A,B	A14K18,22/ 13,21	K0853/54 A,B,C	A14K6,5,20/ A14K2,1,19
N/A	L (OPEN/RESET)	14/15	RCS 1 "A"	134/135	(CLOSE/RESET)	N/A	K0813/14 A	A13K8/10		
N/A	L (OPEN/RESET)	34/35	RCS 1 "B"	154/155	(CLOSE/RESET)	N/A	K0821/22 A	A13K9/11		
N/A	L (OPEN/RESET)	230/231	RCS 2 "A"	250/251	(CLOSE/RESET)	N/A	K0815/16 A	A16K3/4		
N/A	L (OPEN/RESET)	210/211	RCS 2 "B"	170/171	(CLOSE/RESET)	N/A	K0823/24 A	A16K2/1		
N/A	L (OPEN/RESET)	16/17	RCS 3 "A"	136/137	(CLOSE/RESET)	N/A	K0811/12 A	A14K8/10		
N/A	L (OPEN/RESET)	36/37	RCS 3 "B"	156/157	(CLOSE/RESET)	N/A	K0819/20 A	A14K9/11		
N/A	L (OPEN/RESET)	330/331	RCS 4 "A"	350/351	(CLOSE/RESET)	N/A	K0809/10 A	A16K12/11		
N/A	L (OPEN/RESET)	270/271	RCS 4 "B"	310/311	(CLOSE/RESET)	N/A	K0817/18 A	A16K14/13		

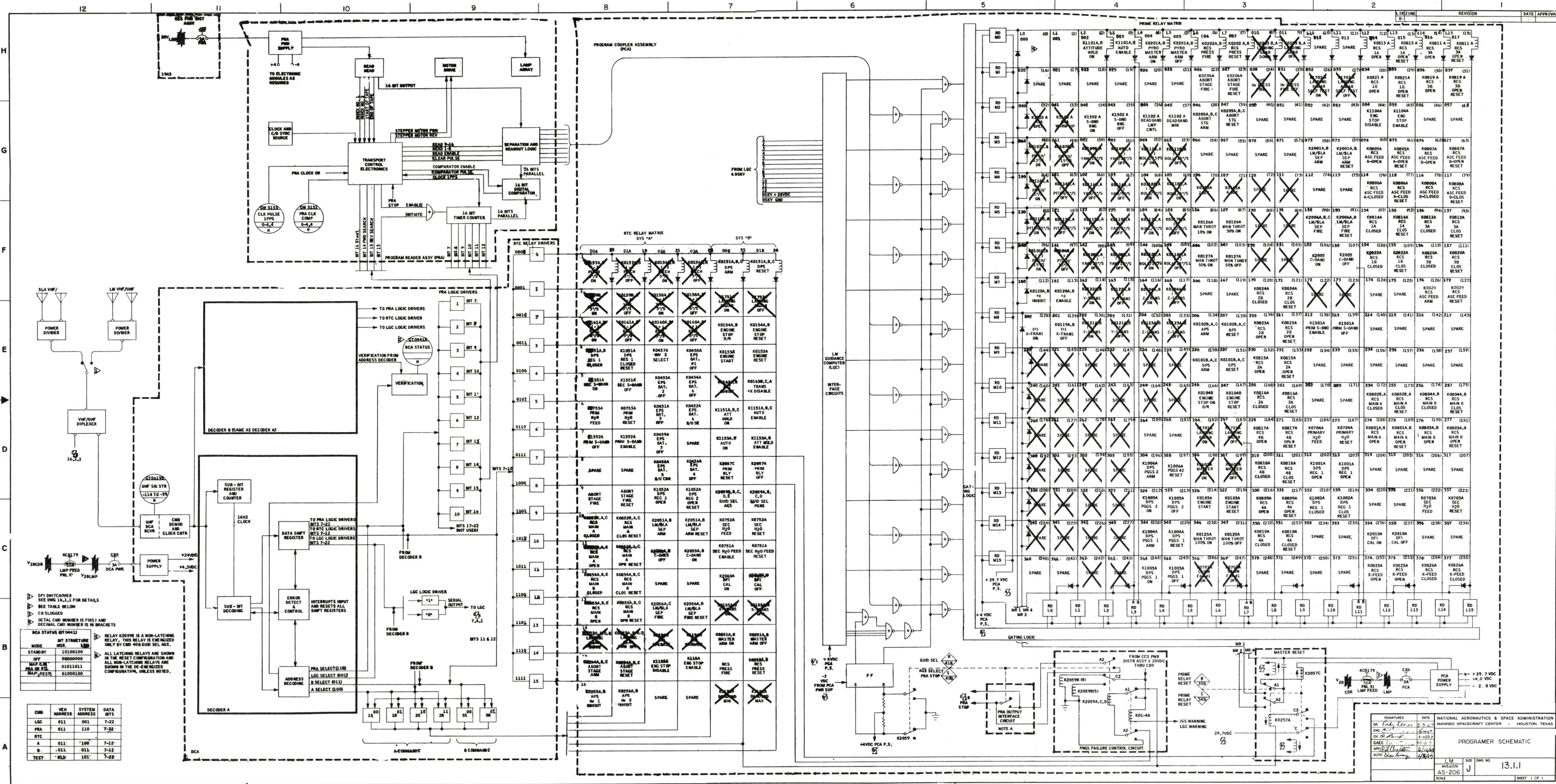
*PERMANENTLY INHIBITS FUNCTION
EN - ENABLE

L - INTERLOCK - UNLESS RESET CMD IS SENT, OTHER CMDS ARE INHIBITED
+ RTC - PERMANENTLY INHIBITS PRIME CMD CONTROL

NOTE: ON ALL VALUES WITH (OPEN/RESET) LISTED THE CMD IS OPEN AND
OPEN RESET OR CLOSE AND CLOSE RESET.

TABLE 13-7 DECIMAL TO OCTAL CONVERSION TABLE

	0	1	2	3	4	5	6	7	8	9
0	0	1	2	3	4	5	6	7	10	11
10	12	13	14	15	16	17	20	21	22	23
20	24	25	26	27	30	31	32	33	34	35
30	36	37	40	41	42	43	44	45	46	47
40	50	51	52	53	54	55	56	57	60	61
50	62	63	64	65	66	67	70	71	72	73
60	74	75	76	77	100	101	102	103	104	105
70	106	107	110	111	112	113	114	115	116	117
80	120	121	122	123	124	125	126	127	130	131
90	132	133	134	135	136	137	140	141	142	143
100	144	145	146	147	150	151	152	153	154	155
110	156	157	160	161	162	163	164	165	166	167
120	170	171	172	173	174	175	176	177	200	201
130	202	203	204	205	206	207	210	211	212	213
140	214	215	216	217	220	221	222	223	224	225
150	226	227	230	231	232	233	234	235	236	237
160	240	241	242	243	244	245	246	247	250	251
170	252	253	254	255	256	257	260	261	262	263
180	264	265	266	267	270	271	272	273	274	275
190	276	277	300	301	302	303	304	305	306	307
200	310	311	312	313	314	315	316	317	320	321
210	322	323	324	325	326	327	330	331	332	333
220	334	335	336	337	340	341	342	343	344	345
230	346	347	350	351	352	353	354	355	356	357
240	360	361	362	363	364	365	366	367	370	371
250	372	373	374	375	376	377	400			
	0	1	2	3	4	5	6	7	8	9



DTI SWITCHOVER
SEE DWG 10.1.1 FOR DETAILS
SEE TABLE BELOW
C8 SLIDING
OCTAL CMD NUMBER IS FIRST AND
DECIMAL CMD NUMBER IS IN BRACKETS

MODE	DTI STRUCTURE	DTI
STANDBY	10100100	10100100
OFF	00000000	00000000
MAX ENG	01010011	01010011
MAX DE RET	01001000	01001000
TEST	01001000	01001000

RELAY K20596 IS A NON-LATCHING RELAY. THIS RELAY IS ENERGIZED ONLY BY CMD 400 GUID SEL ASS.

ALL LATCHING RELAYS ARE SHOWN IN THE RESET CONFIGURATION AND ALL NON-LATCHING RELAYS ARE SHOWN IN THE DE-ENERGIZED CONFIGURATION, UNLESS NOTED.

PRA SELECT 100
LGC SELECT 001
B SELECT 011
A SELECT 100

CMD	VEN	SYSTEM	DATA
LGC	011	001	7-22
PRA	011	110	7-22
RTG	011	100	7-12
A	011	011	7-12
B	011	011	7-12
TEST	011	101	7-22

SIGNATURES
DATE
NATIONAL AERONAUTICS & SPACE ADMINISTRATION
HOUSTON, TEXAS

PROGRAMMER SCHEMATIC

LM
MISSION
AS-206

SIZE
DWG NO
J

13.1.1

SHEET 1 OF 1

SECTION 14

INTRAVEHICULAR MOBILIZATION UNIT (EMU)

LM
AS-206
REV B

14. EMU

SECTION 14
EXTRAVEHICULAR MOBILIZATION UNIT (EMU)

LM
AS-206
REV B

Not applicable for LM-1

SECTION 15
LIGHTING AND CONTROLS

LM
AS-206
REV B

SECTION 15
LIGHTING AND CONTROLS

LM
AS-206
REV B

R-B

e
 pressed
 starts
 consists of (1)
 signal conditioning
 conditioning package R
 cal alternates approxi-
 0 percent and 100 percent
 channel. The total "on" time
 auto cal is $2.0 + 2.0$ seconds.
 - 0
 age auto cal terminates, the
 sequence lasts for $2.0 + 2.0$ seconds
 - 0
 n, the R cal begins which also lasts
 nds. At the conclusion of the R cal
 atire system is returned to the data mode
 FI CAL command remains. The Z cal is

*

DEVELOPMENTAL FLIGHT INSTRUMENTATION/COMMUNICATIONS

16.1 SYSTEM DESCRIPTION

16.1.1 Developmental Flight Instrumentation

The Developmental Flight Instrumentation (DFI) consists of the instrumentation and communications equipment required for flight qualification of the lunar LM, but not generally required during the conduct of real-time earth orbital mission operations. The DFI equipment includes five VHF transmitters, two C-Band Beacons, a Digital Command Assembly, an instrumentation section, and associated antennas.

A. Instrumentation Section

The Instrumentation Section provides the capability for detection, signal conditioning and calibration of the R&D measurements. Capability is provided to operate in two modes (1) data and (2) calibration.

1. In the data mode all measurements are telemetered and there is no reference signal for calibration.
2. During the calibration mode, all data signals are terminated and known reference voltages are impressed on all data channels. The DFI CAL function starts an automatic calibrate sequence which consists of (1) a modulation package auto cal, (2) a signal conditioning package Z cal, and (3) a signal conditioning package R cal. The modulation package auto cal alternates approximately every 0.5 seconds between 0 percent and 100 percent full scale on each TM VCO channel. The total "on" time of the modulation package auto cal is $2.0 + 2.0 - 0$ seconds. After the modulation package auto cal terminates, the Z cal begins. This sequence lasts for $2.0 + 2.0 - 0$ seconds and at its conclusion, the R cal begins which also lasts for $2.0 + 2.0 - 0$ seconds. At the conclusion of the R cal sequence, the entire system is returned to the data mode even if the DFI CAL command remains. The Z cal is

R-B

*

LM
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approximately 15 percent full scale and the R cal is approximately 85 percent full scale with the exact engineering unit levels being a function of each measurement range. In the event the calibrate command is interrupted before the calibration sequence is completed, the DFI subsystem will automatically at that time, return to the data mode. The PCM measurements that are affected by the DFI calibration sequence are shown in Table 16.1.

B. Communication Section

The DFI/COMMUNICATION Section (DFI/COMM) provides the capability for the transmission of the R&D measurements, operational measurements, tracking information, and for the reception of ground commands.

1. The five DFI/COMM VHF transmitters provide for the transmission of the following:

a. Xmtr A	230.9 MHZ	FM/FM
b. Xmtr B	237.8 MHZ	PCM/FM
c. Xmtr C	241.5 MHZ	PAM/FM/FM
d. Xmtr D	247.3 MHZ	PAM/FM/FM
e. Xmtr E	257.3 MHZ	PAM/FM/FM

R-B

2. The five DFI/COMM VHF transmitters and the DCA will use the SLA VHF/UHF antennas prior to LM/SLA separation and the LM VHF/UHF antennas at LM/SLA separation. Antenna switchover is automatic at LM/SLA separation.
3. There are two C-Band beacons used simultaneously for AS-206. Both beacons will use the same double pulse interrogation code, that is, two input pulses are required by the transponders to produce one output pulse.
4. The DCA consists of a UHF receiver, two decoders, and interface circuits for the LM Guidance Computer (LGC), Program Reader Assembly (PRA), and Program Coupler Assembly (PCA). For details on the DCA, see Section 13.

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Rev B

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(See Back)

16.2 SYSTEMS DATA

16.2.1 DFI/COMM

A. VHF TRANSMITTER

1. RF POWER OUTPUT 10 WATTS
2. POWER INPUT 56 WATTS

B. C-BAND BEACON CHARACTERISTICS

1. RECEIVER
 - a. FREQUENCY 5690 MHZ
 - b. SENSITIVITY -70 dbm
 - c. INTERROGATION PULSE WIDTH 0.5 to 0.8 μ s
 - d. DECODER PULSE SPACING 3.5 $\pm$ 0.1 μ s
2. TRANSMITTER
 - a. FREQUENCY 5765 MHZ
 - b. PULSE WIDTH 0.75 $\pm$ 0.1 μ s
 - c. BEACON PULSE DELAY 3.0 $\pm$ 0.1 μ s
 - d. PRF 0-2670 PPS
 - e. PEAK POWER OUTPUT 500 to 750 WATTS
 - f. PAVG (PEAK PWR - 750 WATTS) 0 to 1.5 WATTS
 - (PEAK PWR - 500 WATTS) 0 to 1 WATT

C. DCA RECEIVER CHARACTERISTICS

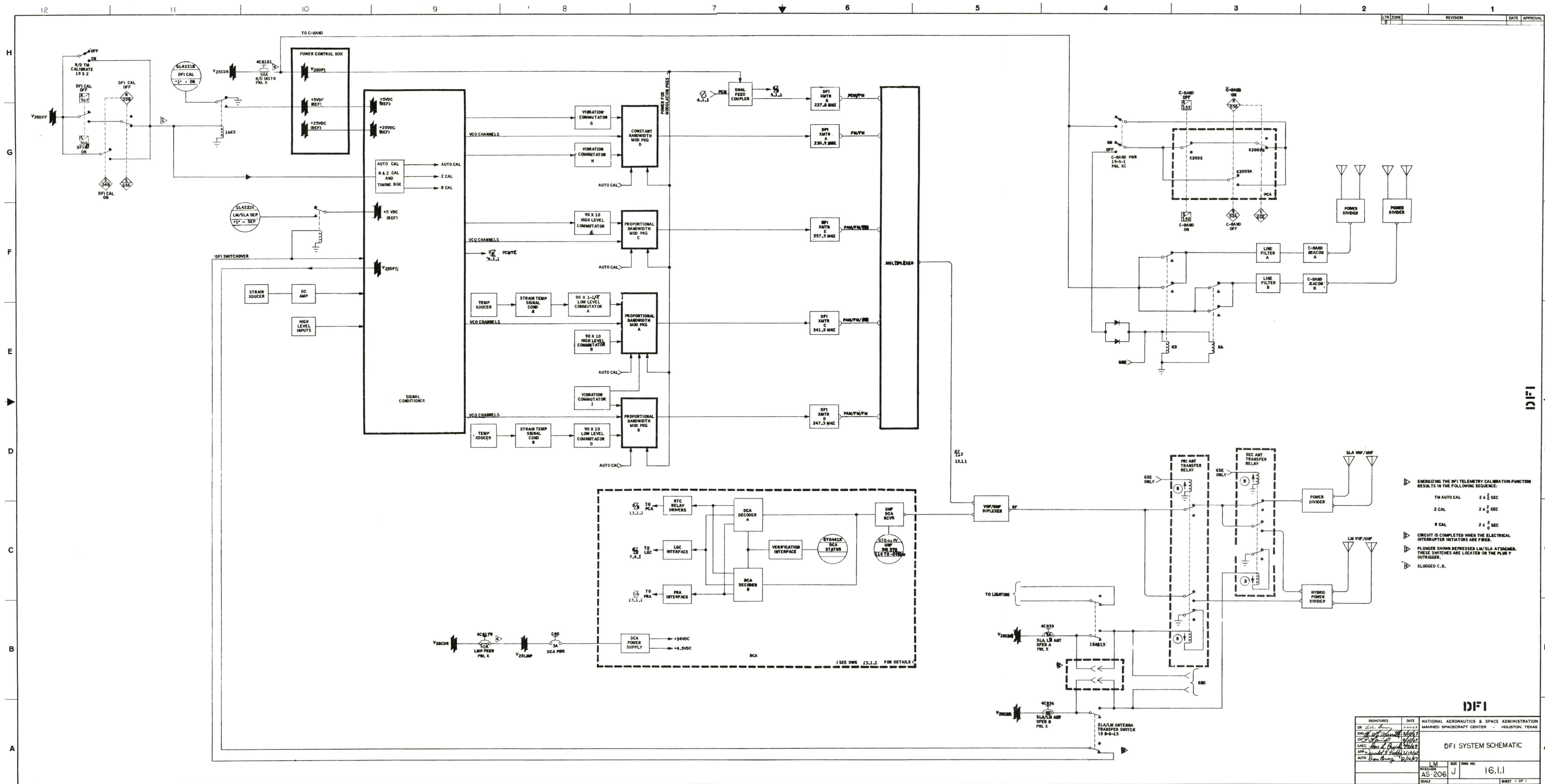
1. FREQUENCY 450 MHZ
2. SENSITIVITY -99 dbm

TABLE 16-1 PCM MEASUREMENTS AFFECTED BY DFI CAL

MEAS NO.	MEAS DESCRIPTION	CAL APPLIED
GQ7511T	DPS THROAT T 1	R CAL, Z CAL
GQ7512T	DPS THROAT T 2	R CAL, Z CAL
GQ7513T	DPS THROAT T 3	R CAL, Z CAL
GW5151V	PRA COMPARE	R CAL, Z CAL
GW5153V	PRA CLOCK ON	R CAL, Z CAL
GL4221X	DFI CAL	INDICATES A "1" AND REMAINS "ON" DURING CAL COMMAND

TABLE 16-2 PRELAUNCH STATUS OF SWITCH/CIRCUIT BREAKER POSITIONS

NAME	NUMBER	POSITION
SWITCH		
R/D TM CALIBRATE	19S2 PNL X	OFF
C-BAND PWR	19S1 PNL X	ON
CIRCUIT BREAKER		
R/D INST	4CB161	CLOSED
SLA/LM ANT XFER A	4CB35	CLOSED
SLA/LM ANT XFER B	4CB36	CLOSED
DCA PWR	CB5	CLOSED



ENERGIZING THE DFI TELEMETRY CALIBRATION FUNCTION RESULTS IN THE FOLLOWING SEQUENCE:

FUNCTION	TIME
TM AUTO CAL	2 ± 0 SEC
Z CAL	2 ± 0 SEC
R CAL	2 ± 0 SEC

CIRCUIT IS COMPLETED WHEN THE ELECTRICAL INTERRUPTER INITIATORS ARE FIRED.

PLUGGER SHOWN DEPRESSING LM/SLA ATTACHMENT. THESE SWITCHES ARE LOCATED ON THE PLUS V OUTRIGGER.

SLUGGED C.B.

SIGNATURES		DATE	NATIONAL AERONAUTICS & SPACE ADMINISTRATION	
DR	AS-206	1-1-67	MANNED SPACECRAFT CENTER - HOUSTON, TEXAS	
ENG	AS-206	1-1-67		
CAE	AS-206	1-1-67		
APP	AS-206	1-1-67		
AUTH	AS-206	1-1-67		

DFI SYSTEM SCHEMATIC

MISSION: AS-206

SCALE: J

DATE: 16.1.1

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APOLLO

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**FCD
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NASA**