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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

UNIVERSAL SATURN LAUNCH VEHICLE SYSTEMS HANDBOOK

AS-508 AND SUBSEQUENT VEHICLES

FEBRUARY 20, 1970

PREPARED BY

MARSHALL SPACE FLIGHT CENTER/
FLIGHT CONTROL OFFICE

FLIGHT CONTROL DIVISION

MANNED SPACECRAFT CENTER
HOUSTON, TEXAS

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APOLLO

UNIVERSAL SATURN LAUNCH VEHICLE SYSTEMS HANDBOOK

AS-508 AND SUBSEQUENT VEHICLES

PREFACE

This handbook has been prepared by the Marshall Space Flight Center/ Flight Control Office, and Flight Control Division, Manned Spacecraft Center, Houston, Texas. Information contained within this handbook represents the Saturn Launch Vehicle Systems for AS-508 and subsequent vehicles as of February 20, 1969.

Information as shown, reflects the launch vehicle systems with major emphasis on material for use by flight control personnel in real time; however, caution should be exercised in using these systems drawings for any purpose other than flight control.

Comments and questions concerning this handbook are solicited and should be referenced to the Marshall Space Flight Center/Flight Control Office located at the Manned Spacecraft Center, Houston, Texas.

Approved by:

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Manager, Marshall Space Flight Center/Flight Control Office

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Eugene F. Kranz
Chief, Flight Control Division

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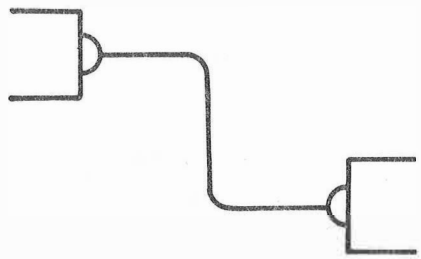
1. ZONE

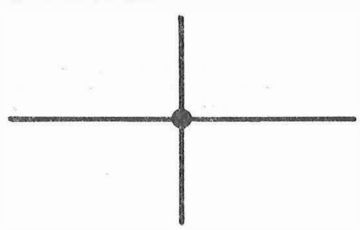
B Z 6
1.2.1

2. RF CABLE

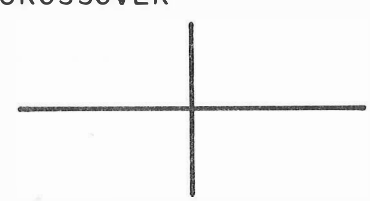


3. POWER AND CONTROL

4. LEADS
   A. CONNECTED

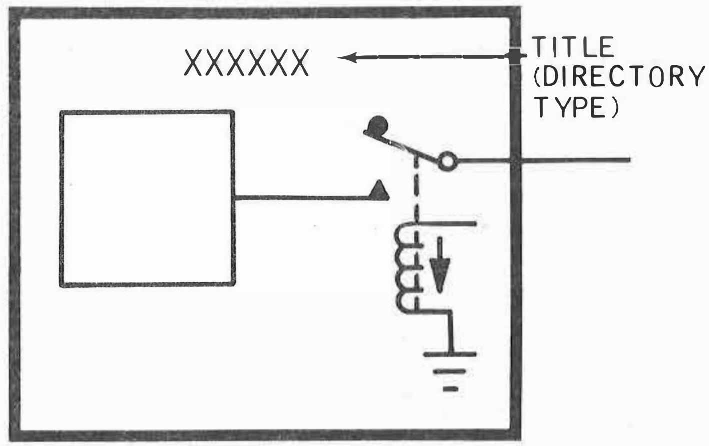


   B. CROSSOVER



5. FLOW ARROWS

6. COMPONENT ENCLOSURE

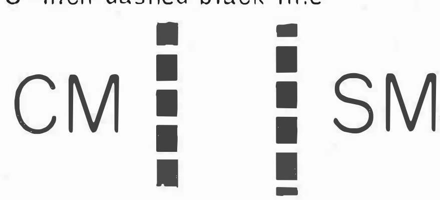


A. MAIN ENCLOSURE
   1/16-inch solid black line

B. SUB ENCLOSURE
   No. 3 pen solid black line

C. COMPONENT ENCLOSURE WITH CREW (MANUAL) CONTROL
   1/16-inch dashed black line

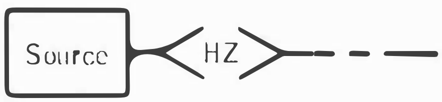
D. MODULE INTERFACE AND SYSTEMS ASSEMBLIES
   1/8-inch dashed black line



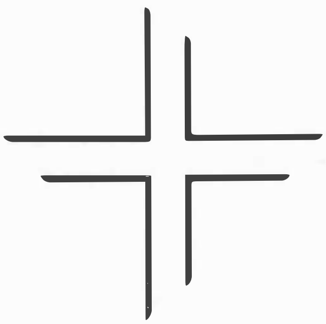
7. FEEDBACK LINES

8. LINKAGE

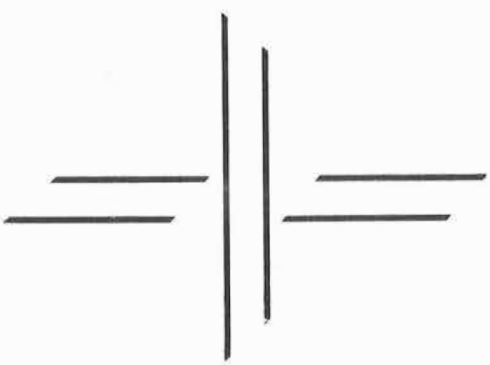
9. TIMING PULSES



10. PLUMBING CONNECTED

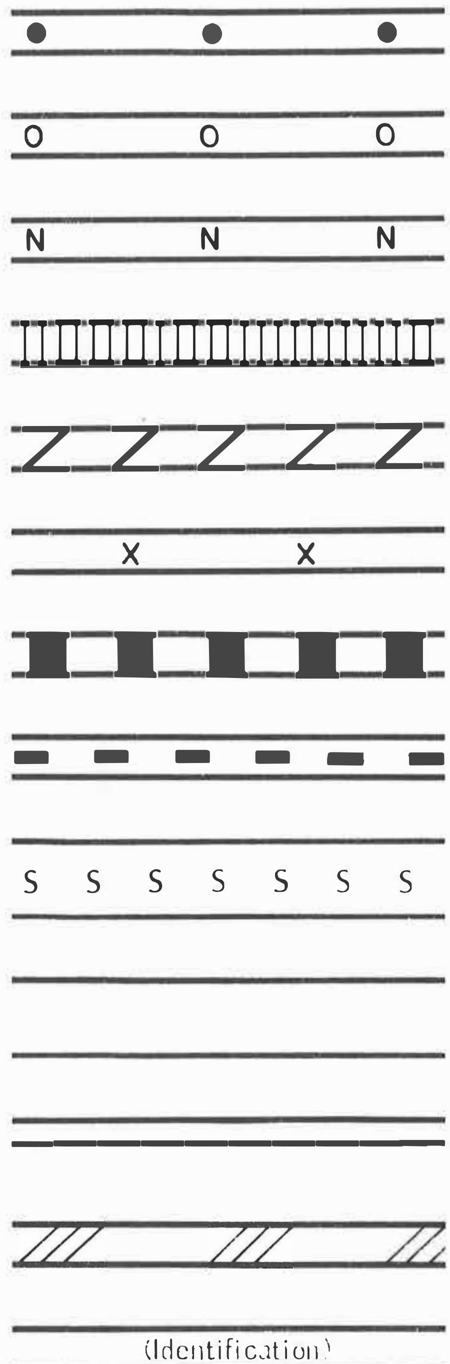


11. PLUMBING CROSSOVER



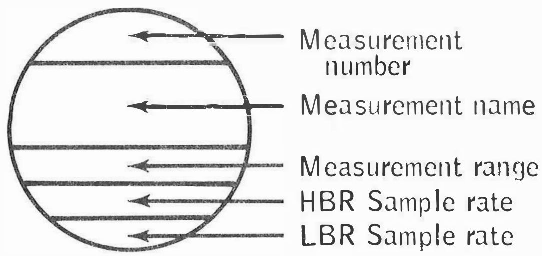
12. LINE DESIGNATION

A. WATER
B. OXYGEN
C. NITROGEN
D. HELIUM
E. PRIMARY COOLANT
F. SECONDARY COOLANT
G. FUEL
H. HYDROGEN
J. STEAM
K. SUIT LOOP
L. SENSE LINES
M. OXIDIZER
N. OTHERS

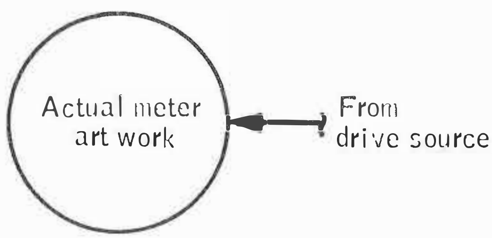


SATURN LAUNCH VEHICLE SYSTEMS HANDBOOK

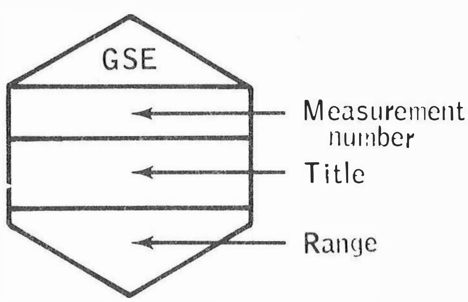
13. MEASUREMENTS TELEMETERED



14. ONBOARD METERS

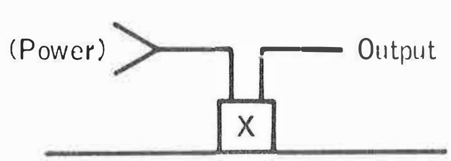


15. MEASUREMENTS TO GSE

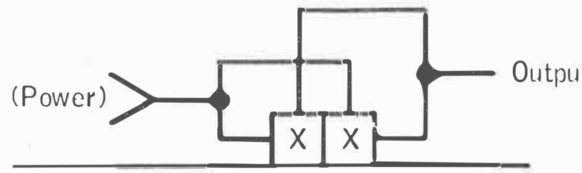


16. SENSORS

A. SINGLE SOURCE



B. DOUBLE SOURCE

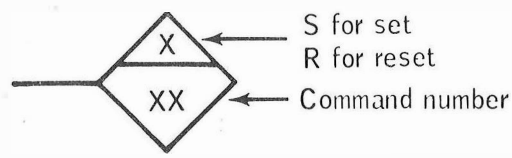


Letter indicates the type:

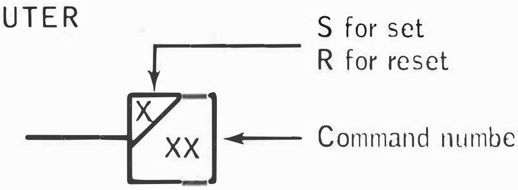
Examples	P	Pressure
	T	Temperature
	Q	Quantity
	W	Wetness
	R	Rate

17. COMMANDS

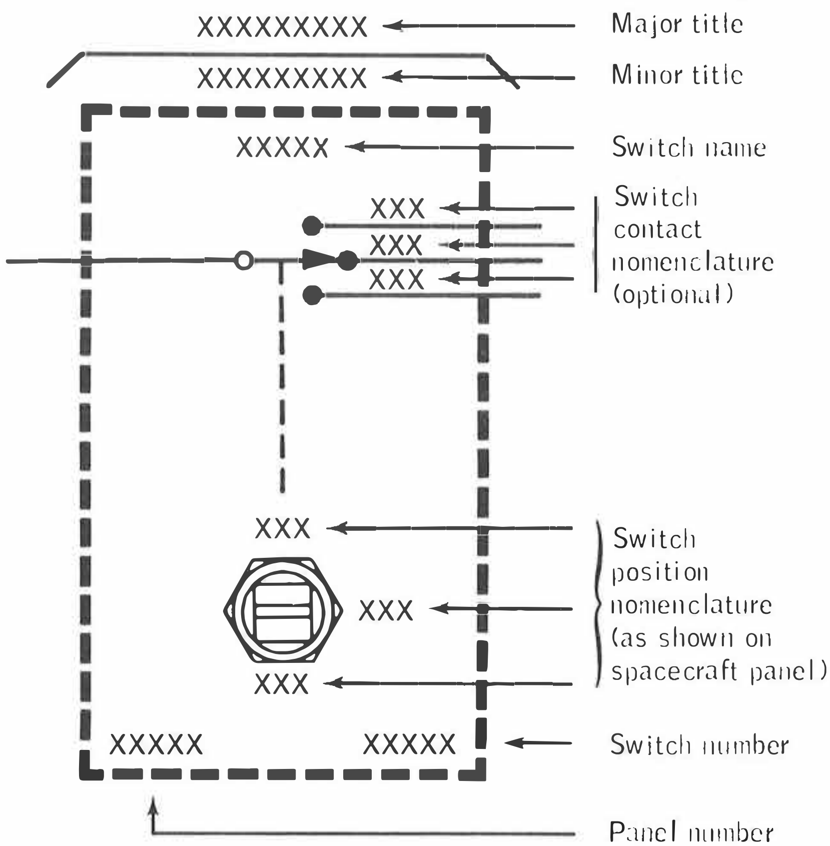
A. RTC



B. COMPUTER



18. SWITCHES



Switch Nomenclature

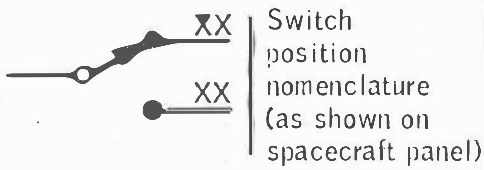
Major title : The title given to a group of switches on the panel

Minor title : The title given to a sub-group of switches that has a major title

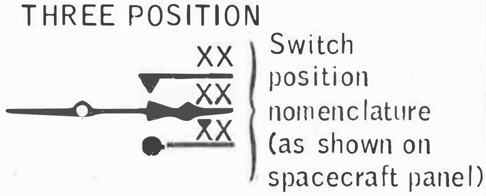
Switch name : The name of a given switch as it appears on the panel

SATURN LAUNCH VEHICLE SYSTEMS HANDBOOK

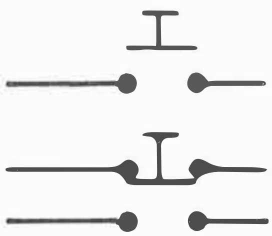
A. TWO POSITION



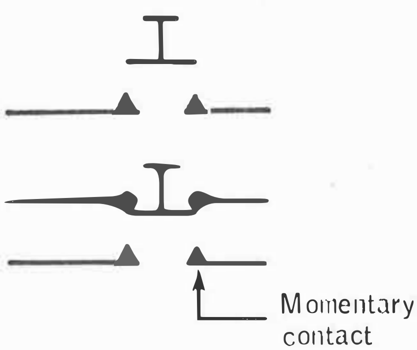
B. THREE POSITION



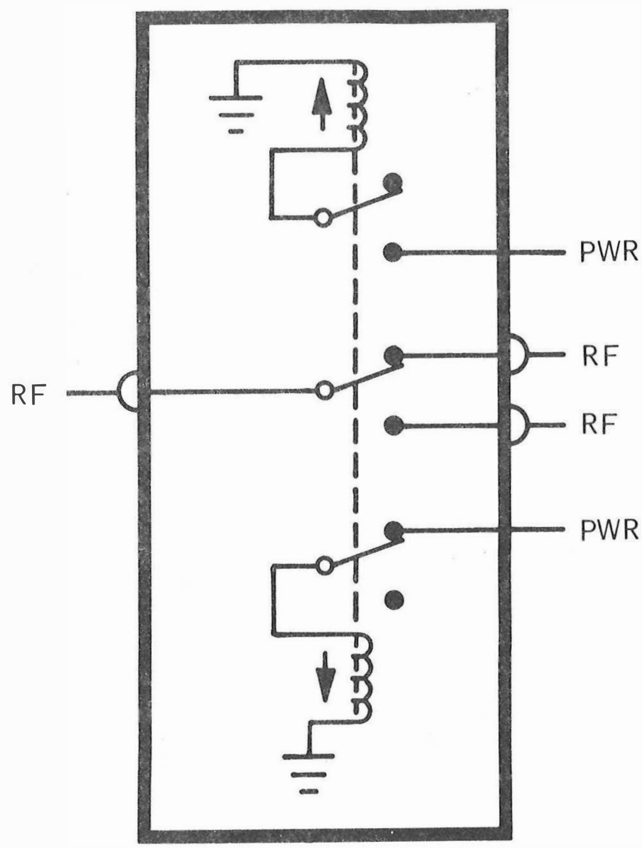
C. PUSHBUTTON LATCHING



D. MOMENTARY

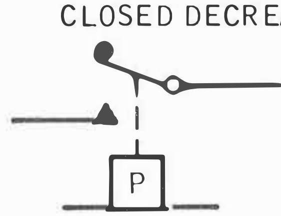


E. COAX

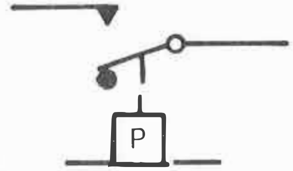


F. PRESSURE

CLOSED DECREASE

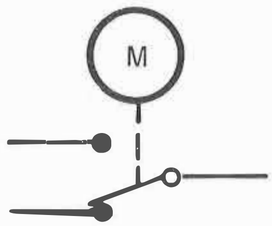


CLOSED INCREASE

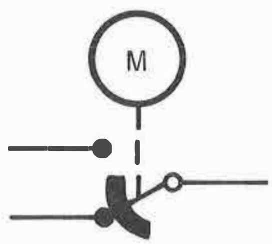


G. MOTOR

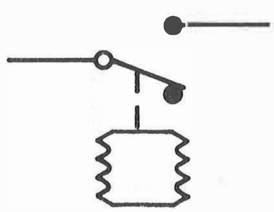
BREAK BEFORE MAKE



MAKE BEFORE BREAK



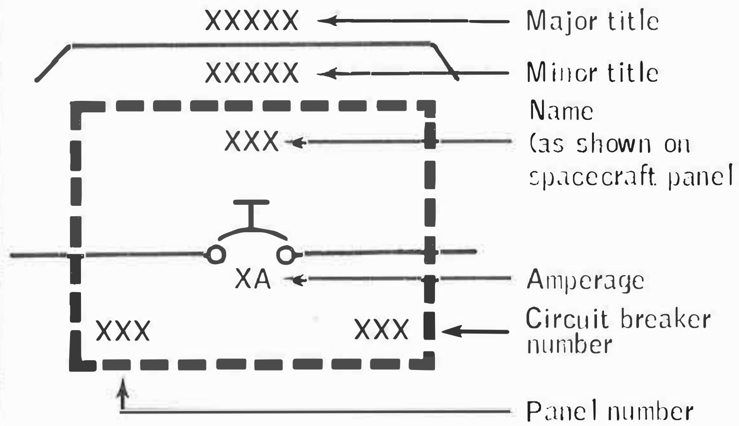
H. BARO



J. COAX

19. CIRCUIT BREAKERS

PUSHBUTTON



AUTOMATIC

20. FUSE

GENERAL

FUSISTOR

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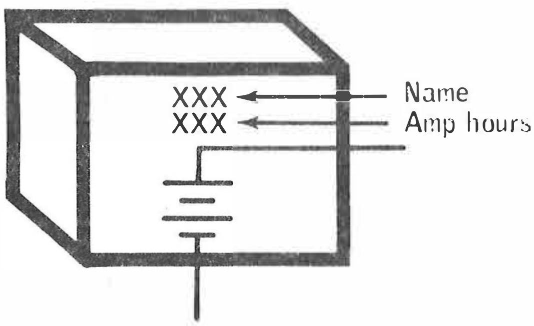
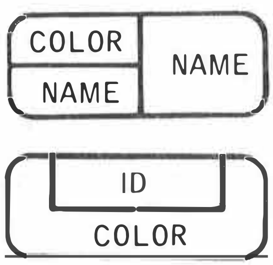
21. BATTERY

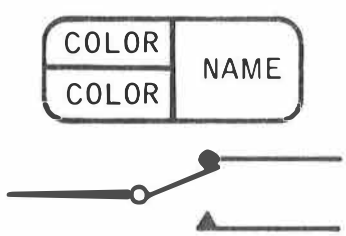


22. LIGHTS

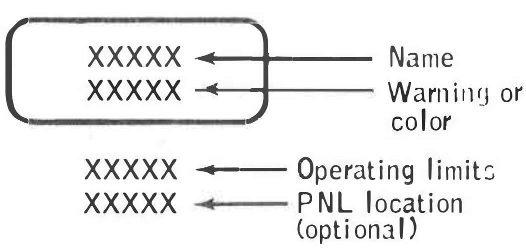
A. TELELIGHTS



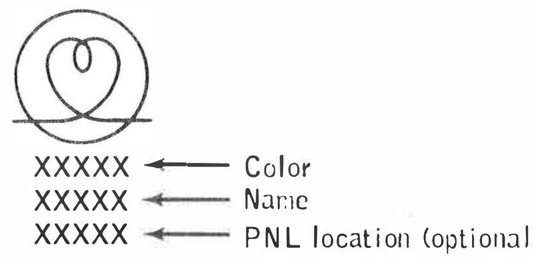
B. SWITCHING



C. CAUTION AND WARNING

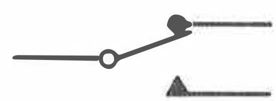


D. COMPONENT

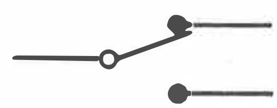


23. RELAY

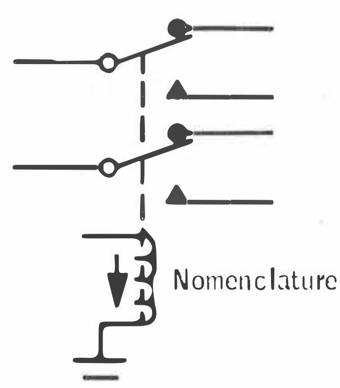
A. MOMENTARY CONTACT



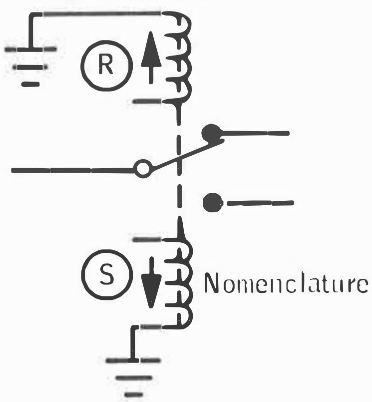
B. LATCHING CONTACT



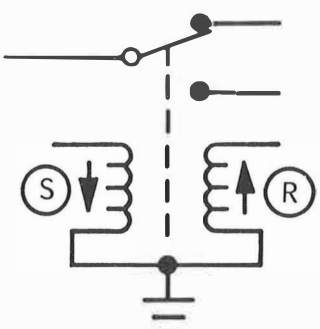
C. NON-LATCHING CONTACT



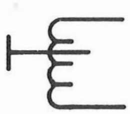
D. LATCHING RELAY



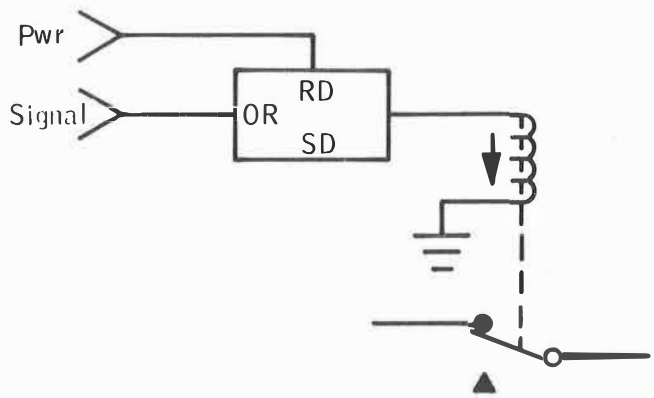
OR



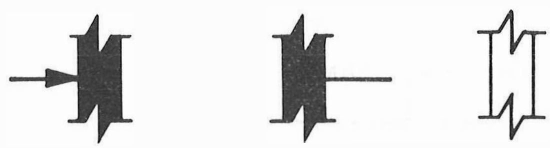
E. RELAY WITH MANUAL OVERRIDE



24. RELAY OR SOLENOID DRIVER



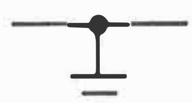
25. BUSES



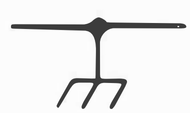
Bus feed   Bus output   Neg bus

26. GROUNDS

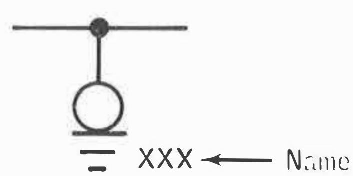
A. SYSTEM



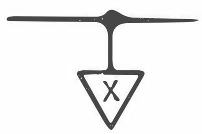
B. FRAME



C. FLOATING OR CONTROLLED



D. SIGNAL



27. DIODES

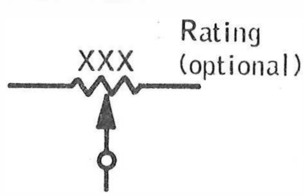
A. GENERAL

B. ZENER

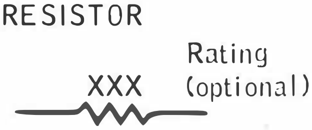
C. TUNNEL

D. CONTROL RECTIFIER (SCR)

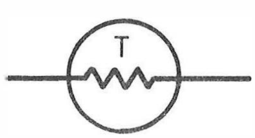
28. POTENTIOMETER



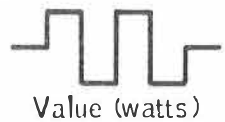
29. FIXED RESISTOR



30. THERMISTOR

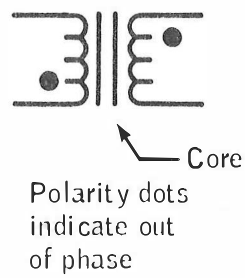


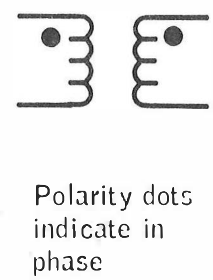
31. HEATER



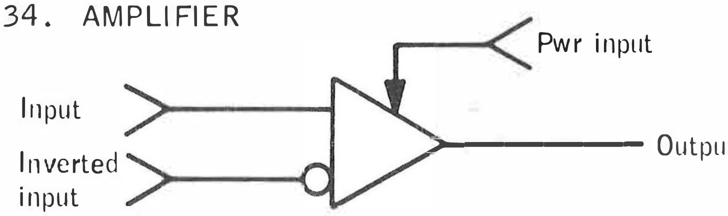
32. THERMOSTAT

33. TRANSFORMERS

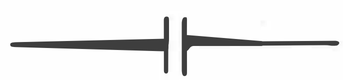




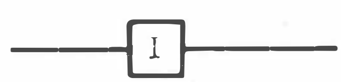
34. AMPLIFIER



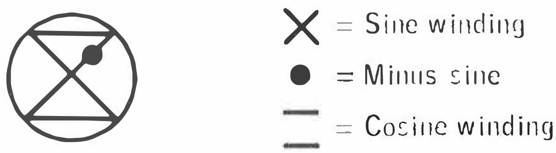
35. CAPACITOR



36. DIGITAL INVERTER

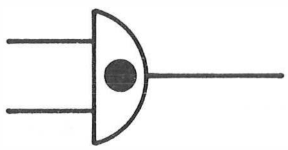


37. WIRE RESOLVER

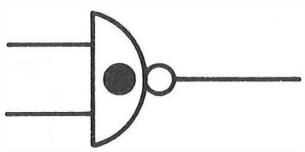


38. GATES

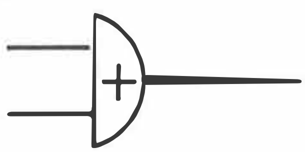
A. AND



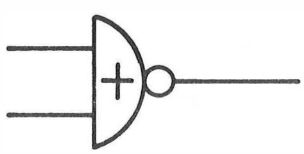
B. NAND



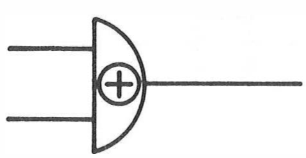
C. OR



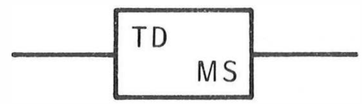
D. NOR



E. EXCLUSIVE OR

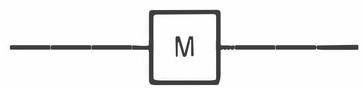


39. TIME DELAY

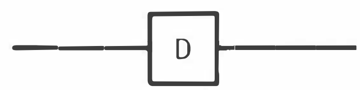


40. FILTER

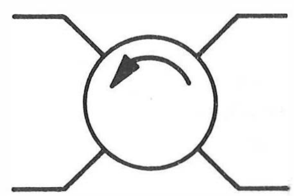
41. MODULATOR



42. DEMODULATOR

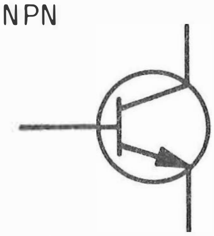


43. RF CIRCULATOR

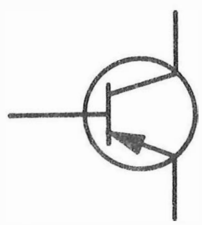


44. TRANSISTORS

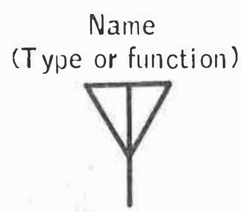
A. NPN



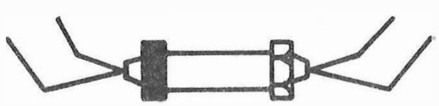
B. PNP



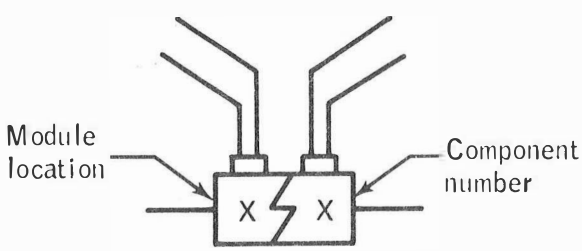
45. ANTENNA



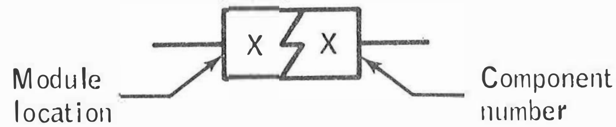
46. EXPLOSIVE BOLT AND NUT



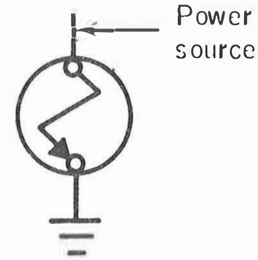
47. ELECTRICAL CIRCUIT INTERRUPTER



OR

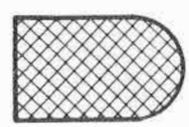


48. EXPLOSIVE INITIATOR

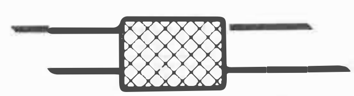


49. DETONATOR

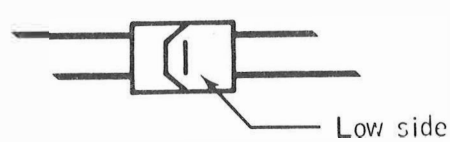
50. DIFFUSER



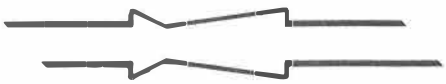
51. MECHANICAL FILTER



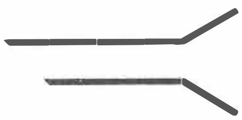
52. BURST DIAPHRAGM



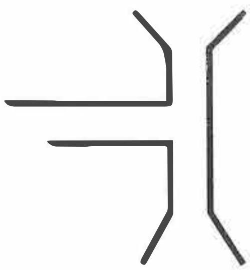
53. VENTURI



54. VENT

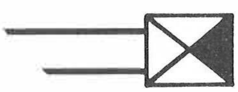


55. THRUST NEUTRALIZED VENT

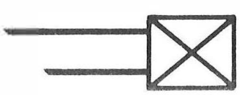


56. DISCONNECT

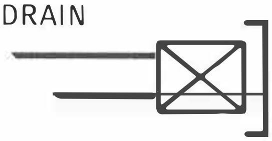
A. SELF-SEALING



B. QUICK

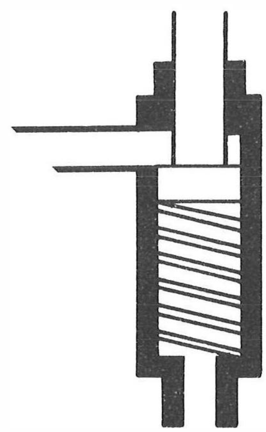


C. QUICK DISCONNECT FILL AND DRAIN



D. FILL AND DRAIN

57. BALL VALVE ACTUATOR

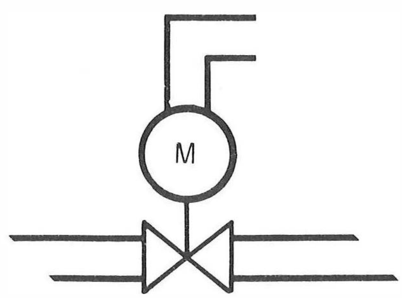


58. VALVES

Open

Closed

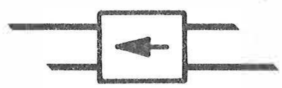
A. MOTOR CONTROL



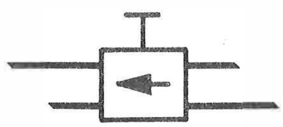
SATURN LAUNCH VEHICLE SYSTEMS HANDBOOK

B. MANUAL CONTROL

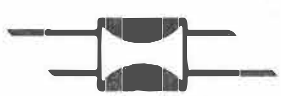
C. CHECK VALVE



D. CHECK VALVE WITH MANUAL OVERRIDE



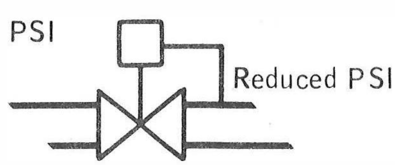
E. ORIFICE



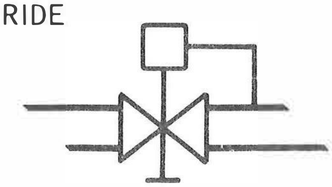
(Flow rate)

F. FLOW METER

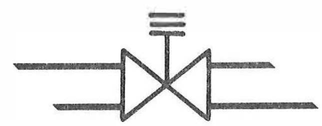
G. PRESSURE REGULATOR



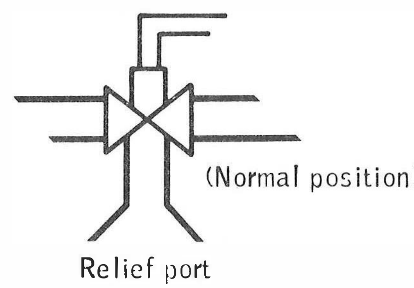
H. PRESSURE REGULATOR WITH MANUAL OVERRIDE



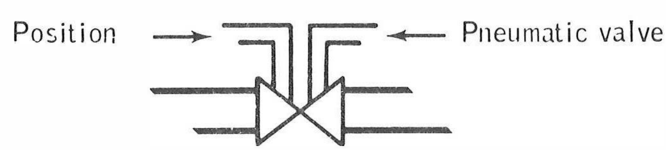
J. RELIEF VALVE



K. PNEUMATIC CONTROLLED VALVE WITH LINE BLEED

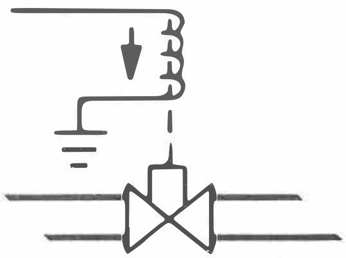


L. FAIL LAST



SATURN LAUNCH VEHICLE SYSTEMS HANDBOOK

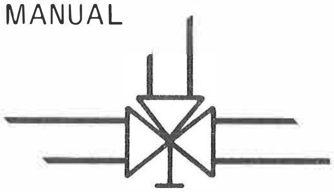
M. SOLENOID VALVE



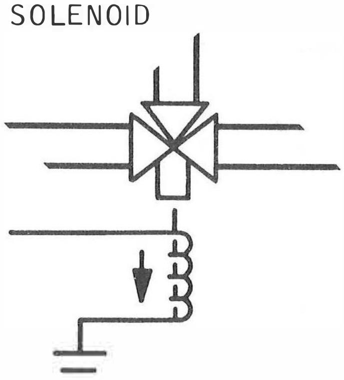
Name (Normal position)

N. THREE-WAY VALVE

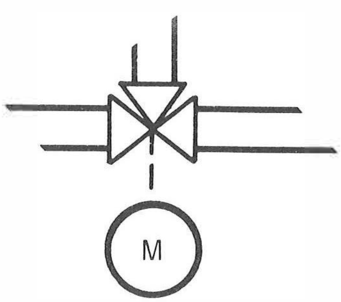
MANUAL



SOLENOID

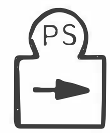


MOTOR CONTROLLED



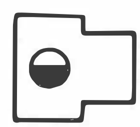
O. PRESSURE SWITCH

P. PRESSURE SWITCH AND CHECK VALVE

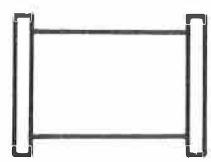


Q. PRESSURE REGULATOR

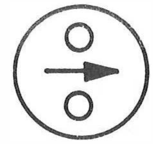
R. ANTI-FLOOD VALVE WITH BYPASS PORT



S. HEAT EXCHANGER

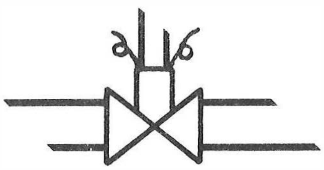


T. RECIRCULATION PUMP

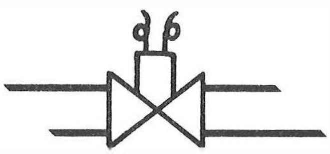


U. HYDRAULIC PUMP

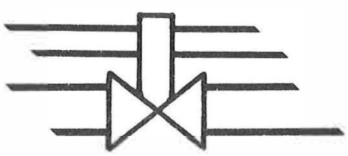
V. SOLENOID AND PNEUMATIC COMBINATION



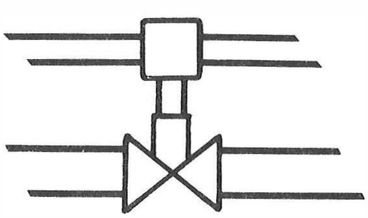
W. SOLENOID VALVE



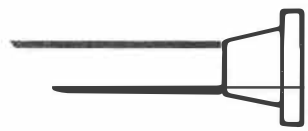
X. SOLENOID VALVE WITH BLEED LINES



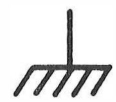
Y. PNEUMATICALLY ACTUATED VALVE



Z. AUTOMATIC CHECKOUT

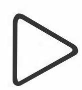


59. PHYSICAL RESTRAINTS



60. VEHICLE SKIN

61. DRAWING NOTE REFERENCE



1 INTRODUCTION

SECTION 1

INTRODUCTION

1.1 GENERAL

This is a Universal Saturn Launch Vehicle Systems Handbook for vehicles AS-508 and subsequent. Handbooks will not be reissued on an individual mission basis. Updates and revisions are not currently planned although page and drawing changes may be issued as necessary.

2 S-IC SEQUENTIAL SYSTEMS

SECTION 2

S-IC SEQUENTIAL SYSTEMS

2.1 S-IC SWITCH SELECTOR FUNCTIONS (OCTAL)

CH	Code	Function	Figure No.
	000		
37	001	SPARE	
5	002	FUEL PRESSURIZING VALVE NO. 2 OPEN	2-4
30	003	SPARE	
74	004	SPARE	
81	005	SPARE	
97	006	SPARE	
63	007	SPARE	
	010		
87	011	SPARE	
111	012	SPARE	
94	013	SPARE	
49	014	SPARE	
14	015	OUTBOARD ENGINES CUTOFF BACKUP ENABLE	
51	016	SPARE	
39	017	SPARE	
	020		
16	021	INBOARD ENGINE CUTOFF BACKUP	
24	022	SPARE	
9	023	OUTBOARD ENGINE CUTOFF ENABLE	2-3
75	024	SPARE	
109	025	SPARE	
82	026	SPARE	
71	027	SPARE	
	030		
68	031	SPARE	
57	032	SPARE	
96	033	SPARE	
33	034	SPARE	
7	035	FUEL PRESSURIZING VALVE NO. 4 OPEN	2-4
35	036	SPARE	
17	037	TWO ADJACENT OUTBOARD ENGINES OUT CUTOFF ENABLE	2-3
	040		
53	041	SPARE	
23	042	SPARE	
31	043	SPARE	
61	044	SPARE	
93	045	SPARE	
102	046	SPARE	
90	047	SPARE	
	050		
69	051	SPARE	
65	052	SPARE	
73	053	SPARE	
48	054	SPARE	
6	055	FUEL PRESSURIZING VALVE NO. 3 OPEN	2-4
52	056	SPARE	
40	057	SPARE	
	060		
38	061	SPARE	
44	062	SPARE	

CH	Code	Function	Figure No.
18	063	SPARE	
110	064	SPARE	
92	065	SPARE	
101	066	SPARE	
67	067	SPARE	
	070		
58	071	SPARE	
64	072	SPARE	
95	073	SPARE	
29	074	SPARE	
25	075	SPARE	
36	076	SPARE	
8	077	INBOARD ENGINE CUTOFF (START OF TIME BASE NO. 2)	2-3
	100		
21	101	SPARE	
46	102	SPARE	
32	103	SPARE	
98	104	SPARE	
108	105	SPARE	
76	106	SPARE	
89	107	SPARE	
	110		
66	111	SPARE	
62	112	SPARE	
112	113	SPARE	
105	114	SPARE	
12	115	SPARE	
41	116	SPARE	
34	117	SPARE	
	120		
22	121	SPARE	
19	122	S-IC/S-II SEPARATION (NO. 2)	
45	123	SPARE	
56	124	SPARE	
91	125	SPARE	
99	126	SPARE	
86	127	SPARE	
	130		
84	131	SPARE	
100	132	SPARE	
60	133	SPARE	
88	134	SPARE	
27	135	SPARE	
42	136	SPARE	
2	137	S-IC TELEMETER CALIBRATE ON	2-2
	140		
4	141	SPARE	
3	142	MULTIPLE ENGINE CUTOFF ENABLE	2-3
10	143	SEPARATION AND RETRO EBW NO. 1 ARM	2-4
55	144	SPARE	
107	145	SPARE	
77	146	SPARE	

CH	Code	Function	Figure No.
85	147	SPARE	
	150		
83	151	SPARE	
79	152	SPARE	
59	153	SPARE	
70	154	SPARE	
47	155	SPARE	
20	156	SEPARATION AND RETRO EBW NO. 2 ARM	
15	157	S-IC/S-II SEPARATION (NO. 1)	2-4
	160		
50	161	SPARE	
13	162	SPARE	2-1
11	163	SPARE	
54	164	SPARE	
106	165	SPARE	
78	166	SPARE	
104	167	SPARE	
	170		
103	171	SPARE	
80	172	SPARE	
72	173	SPARE	
28	174	SPARE	
26	175	SPARE	
43	176	SPARE	
1	177	S-IC TELEMETER CALIBRATE OFF	2-2

2.2 S-IC SWITCH SELECTOR SCHEMATICS

The next pages present the S-IC switch selector commands and affected systems in schematic form. Each command and its inverse are diagrammed for reference. An explanation of the more involved relationships is also presented where applicable. Supplemental information may be obtained from the related systems drawing.

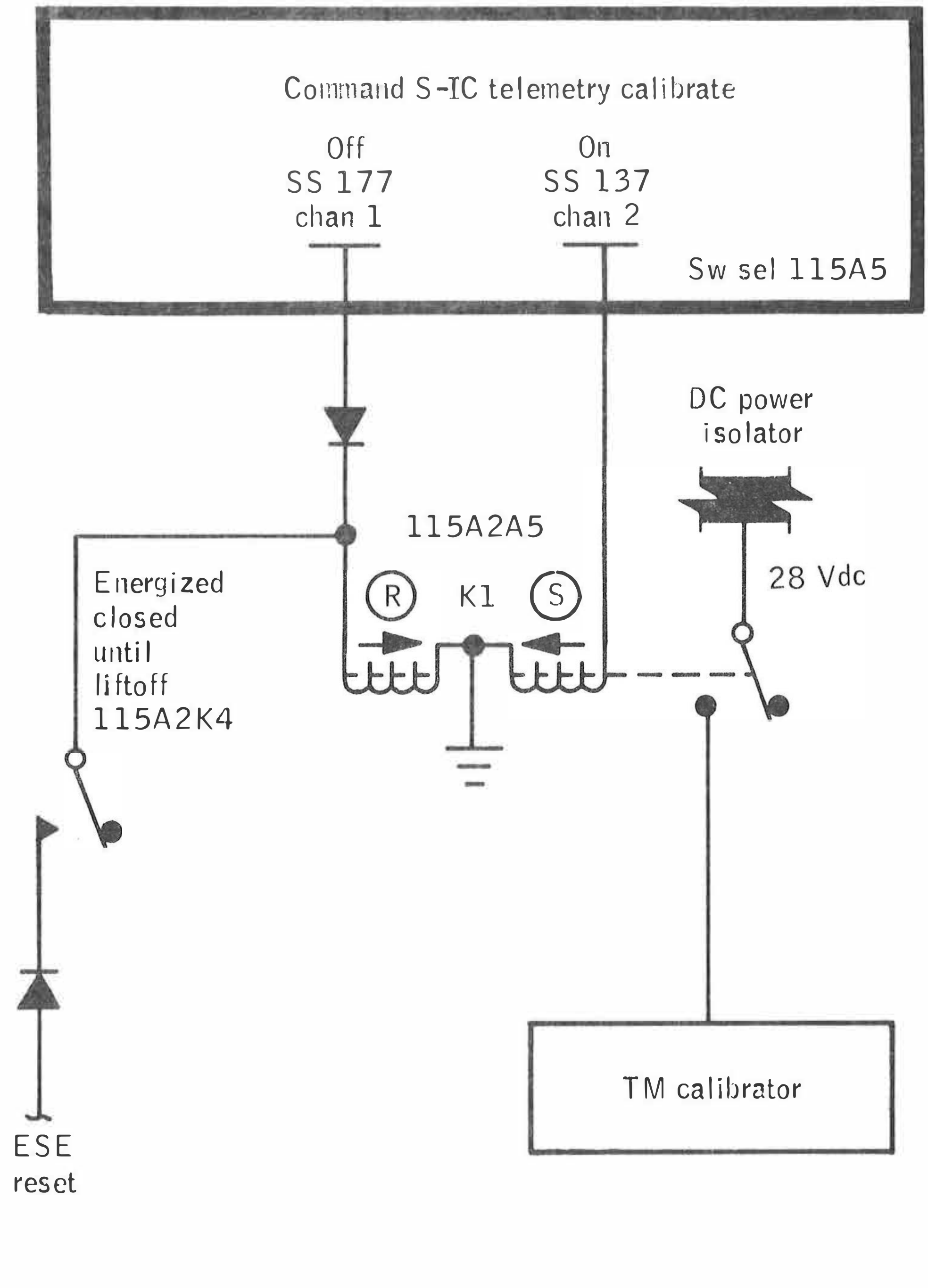


Figure 2-1. - S-IC TM calibrate.

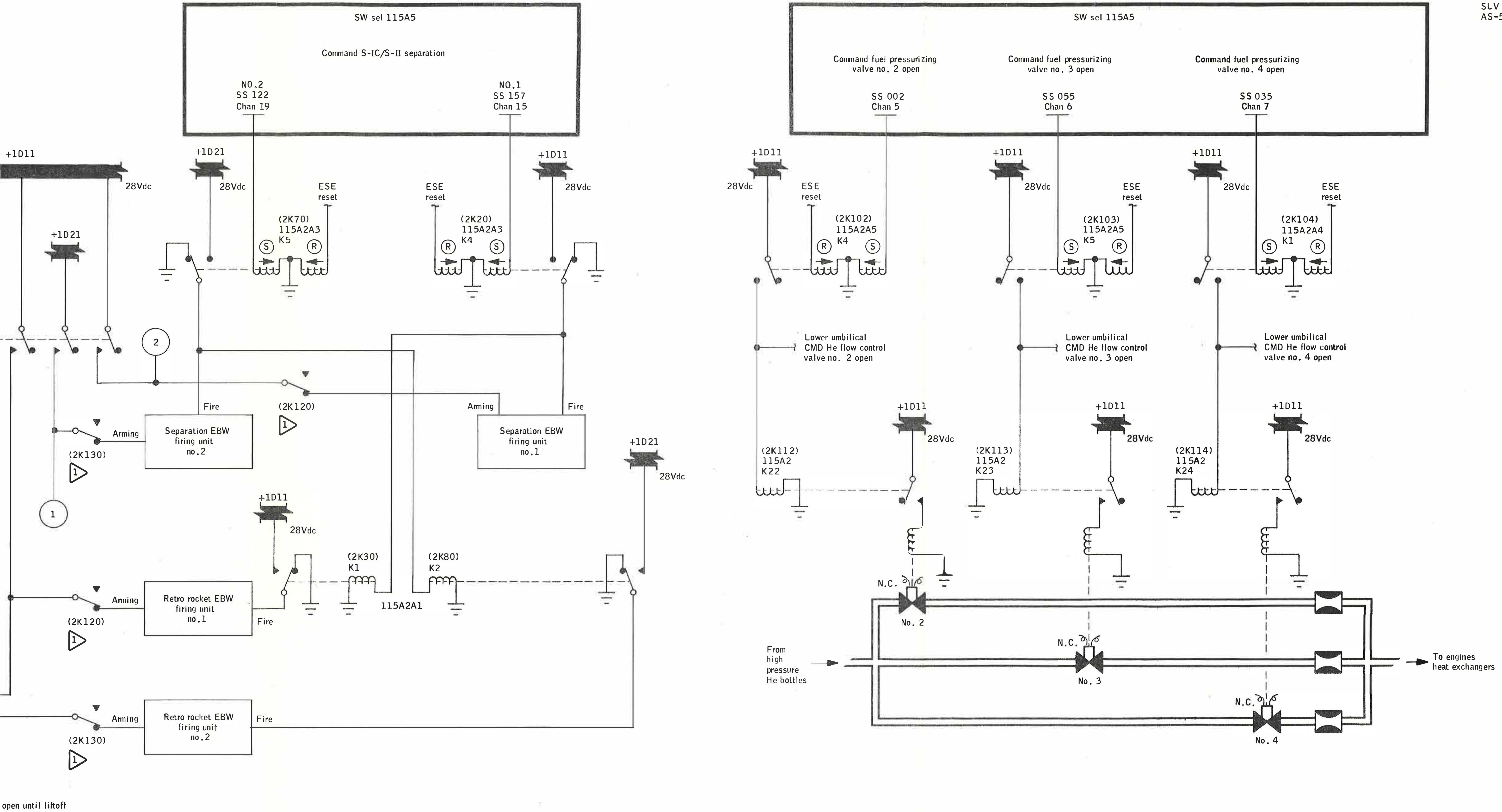


Figure 2-2. - S-IC/S-II separation and fuel pressurization valve operation.

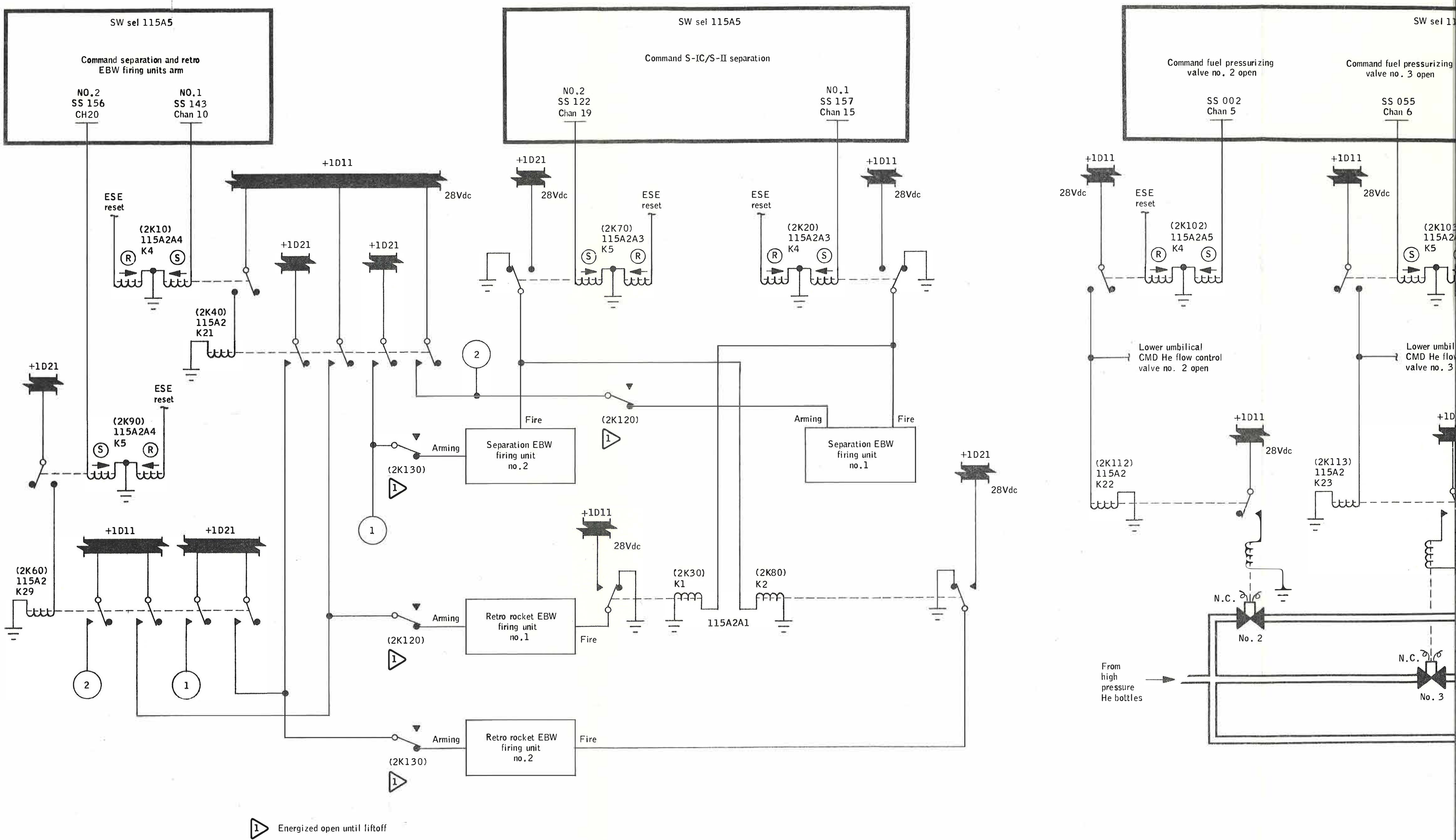
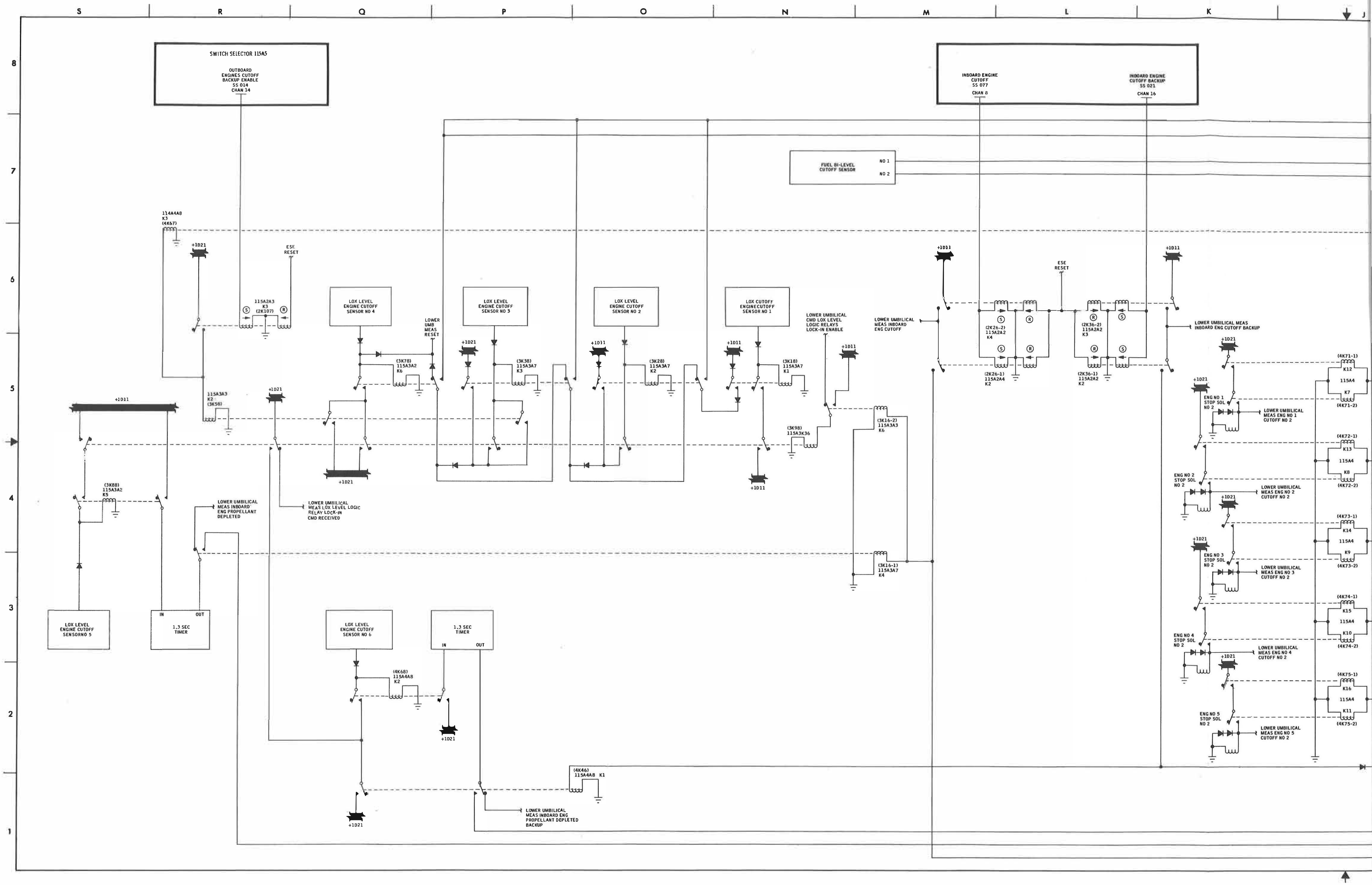
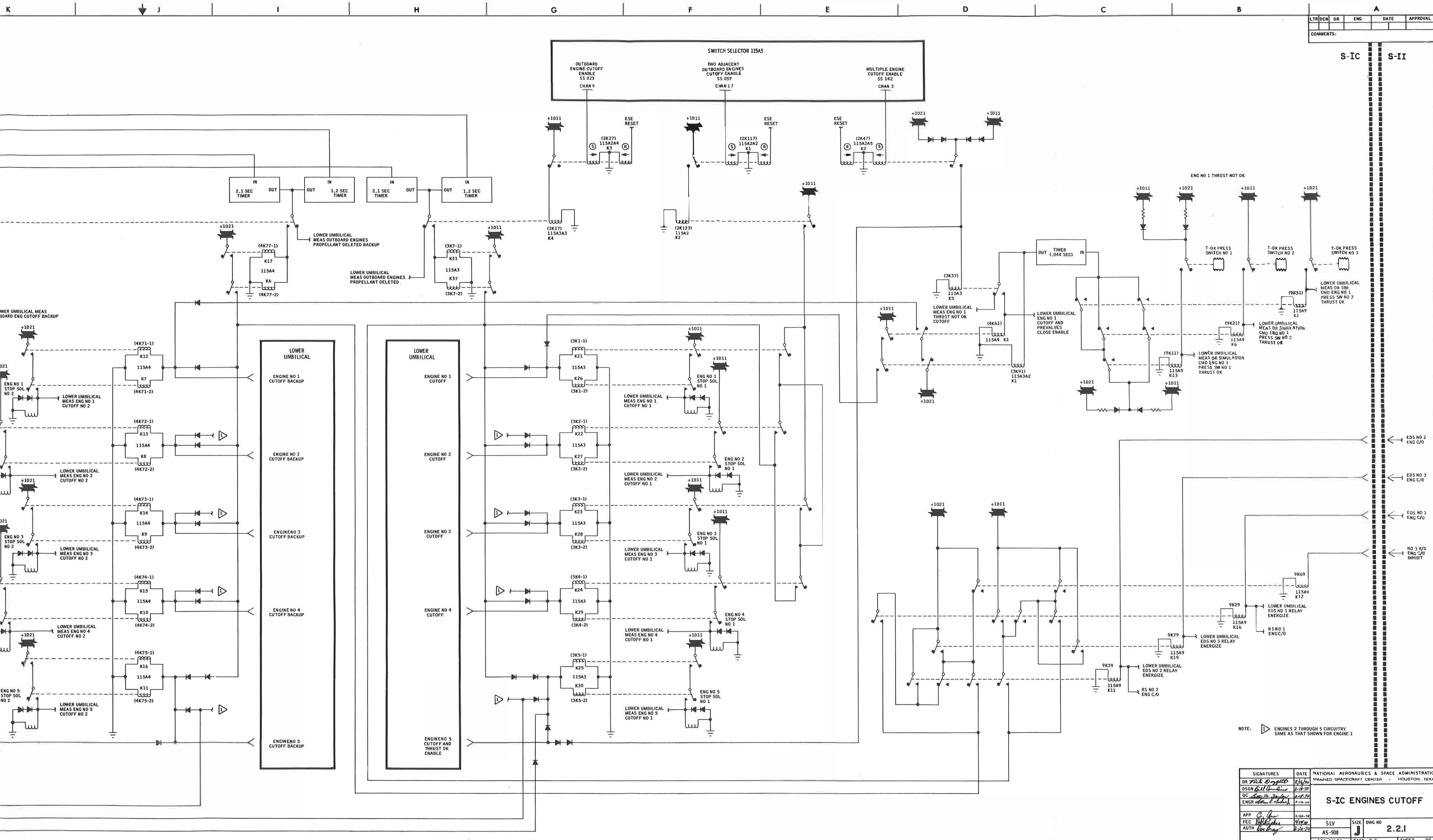


Figure 2-2. - S-IC/S-II separation and fuel pressurization valve operation.



S
R
Q
P
O
N
M
L
K
J
8
7
6
5
4
3
2
1
SWITCH SELECTOR 115A5
OUTBOARD ENGINES CUTOFF BACKUP ENABLE SS 014 CHAN 14
INBOARD ENGINE CUTOFF SS 077 CHAN 8
INBOARD ENGINE CUTOFF BACKUP SS 021 CHAN 16
FUEL BI-LEVEL CUTOFF SENSOR
NO 1
NO 2
114A4A8 K3 (4K67)
+1D21
ESE RESET
115A2A3 K3 (2K107)
S
R
LOX LEVEL ENGINE CUTOFF SENSOR NO 4
LOWER UMB MEAS RESET
(3K78) 115A3A2 K6
LOX LEVEL ENGINE CUTOFF SENSOR NO 3
(3K38) 115A3A7 K3
LOX LEVEL ENGINE CUTOFF SENSOR NO 2
(3K28) 115A3A7 K2
LOX CUTOFF ENGINECUTOFF SENSOR NO 1
(3K18) 115A3A7 K1
+1D11
LOWER UMBILICAL CMD LOX LEVEL LOGIC RELAYS LOCK-IN ENABLE
LOWER UMBILICAL MEAS INBOARD ENG CUTOFF
(2K26-2) 115A2A2 K4
(2K26-1) 115A2A4 K2
(2K36-2) 115A2A2 K3
(2K36-1) 115A2A2 K2
LOWER UMBILICAL MEAS INBOARD ENG CUTOFF BACKUP
115A3A3 K2 (3K58)
(3K98) 115A3K36
(3K16-2) 115A3A3 K6
(3K16-1) 115A3A7 K4
(3K88) 115A3A2 K5
LOWER UMBILICAL MEAS INBOARD ENG PROPELLANT DEPLETED
LOWER UMBILICAL MEAS LOX LEVEL LOGIC RELAY LOCK-IN CMD RECEIVED
LOX LEVEL ENGINE CUTOFF SENSORNO 5
1.3 SEC TIMER
IN
OUT
LOX LEVEL ENGINE CUTOFF SENSOR NO 6
(4K68) 115A4A8 K2
(4K46) 115A4A8 K1
LOWER UMBILICAL MEAS INBOARD ENG PROPELLANT DEPLETED BACKUP
ENG NO 1 STOP SOL NO 2
LOWER UMBILICAL MEAS ENG NO 1 CUTOFF NO 2
ENG NO 2 STOP SOL NO 2
LOWER UMBILICAL MEAS ENG NO 2 CUTOFF NO 2
ENG NO 3 STOP SOL NO 2
LOWER UMBILICAL MEAS ENG NO 3 CUTOFF NO 2
ENG NO 4 STOP SOL NO 2
LOWER UMBILICAL MEAS ENG NO 4 CUTOFF NO 2
ENG NO 5 STOP SOL NO 2
LOWER UMBILICAL MEAS ENG NO 5 CUTOFF NO 2
(4K71-1) K12 115A4 K7 (4K71-2)
(4K72-1) K13 115A4 K8 (4K72-2)
(4K73-1) K14 115A4 K9 (4K73-2)
(4K74-1) K15 115A4 K10 (4K74-2)
(4K75-1) K16 115A4 K11 (4K75-2)



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S-IC ENGINES CUTOFF

SLV AS-508 | SIZE J | DWG NO 2.2.1 | PAGE 2-7

3 S-IC ELECTRICAL POWER SYSTEM

SECTION 3

S-IC ELECTRICAL POWER SYSTEM

3.1 GENERAL NOTES

The electrical system of the S-IC stage consists of two systems: the operational power subsystem and the instrumentation subsystem. Onboard power is supplied by two identical 28-volt batteries. Battery No. 1 powers the operational loads such as valve controls, pressurization systems, sequencing, and primary flight control systems. Battery No. 2 supplies power to the backup control systems and measurement loads such as telemetry systems, transducers, multiplexers, and transmitters. Both batteries supply power to their loads through a common main power distributor; however, each battery is completely isolated from the other.

During the prelaunch checkout period all electrical power, except for the two range safety systems, is supplied from GSE. The two range safety systems are powered by batteries 1 and 2, respectively, for redundancy of the range safety system. At T - 50 seconds, the power is transferred by ground command to the onboard battery power. However, power for engine ignition and for equipment heaters continues to come from the GSE until terminated by umbilical disconnect.

There are no provisions for switching or transferring power between the operational system and the instrumentation system. The two batteries supply two completely independent power systems to satisfy requirements for power redundancy in the range safety system, the engine cutoff system, the sequencing system, and the EDS system. Because of this isolation, no failure of any kind in one system can cause equipment failure in the other system.

The batteries are a silver oxide-zinc type and are received in a dry charged condition. They are activated by the addition of electrolyte which is an aqueous solution of potassium hydroxide. Each battery consists of twenty cells with a nominal voltage of 1.5 Vdc ($28^{+4}_{-1.5}$ Vdc per 20 cell group). The capacity of each battery is 640 ampere-minutes. The gross weight of each battery is 22 pounds.

4 S-IC PROPULSION SYSTEMS

SECTION 4

S-IC PROPULSION SYSTEMS

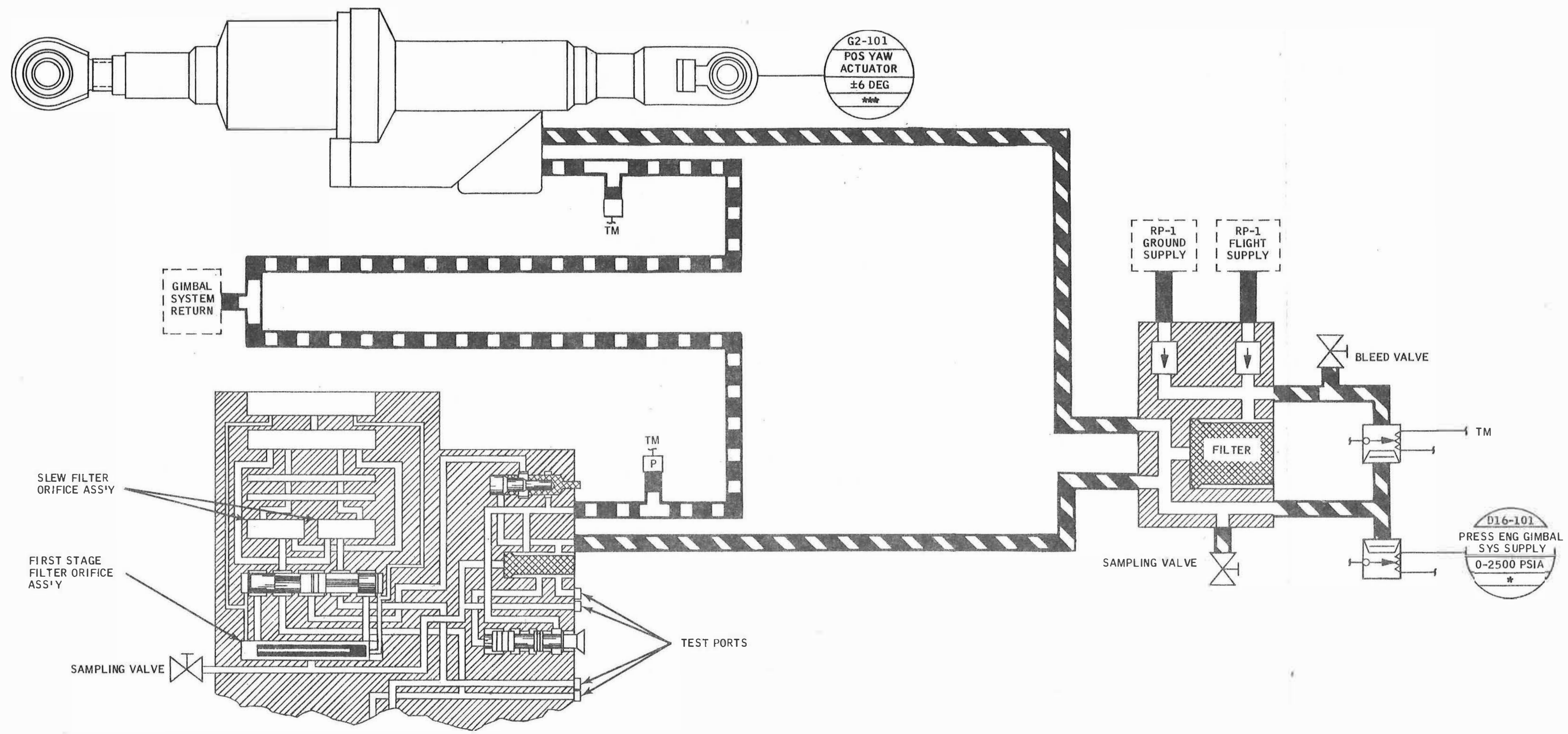
4.1 HYDRAULIC SYSTEM

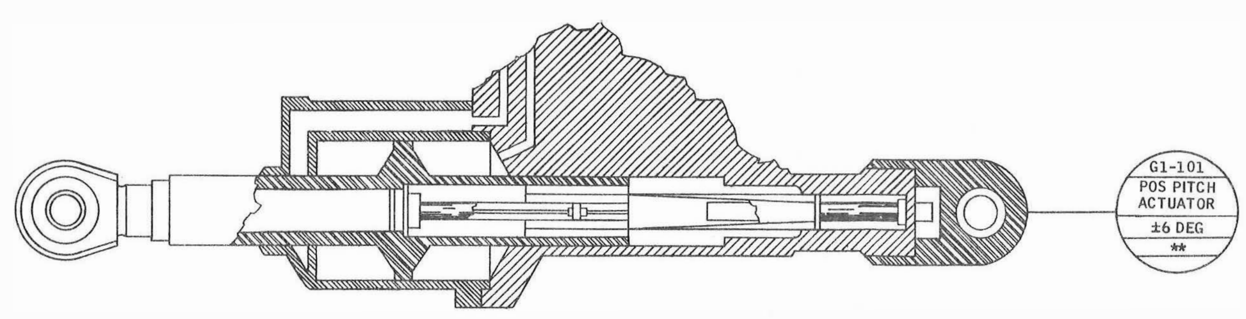
The four outboard engines, positioned by their respective gimbaling systems, are used to control the vehicle during S-IC boost. All four gimbal systems are identical, and each gimbals an entire engine independently. During standby operation, high pressure fluid (RP-1) is supplied from a ground source through the engine control pressure quick disconnect coupling and the filter manifold to two servo valve actuators. The fluid returns to the ground source through the checkout valve and engine control pressure return quick disconnect coupling. During engine operation, high pressure control fluid (RP-1) is supplied from the No. 1 fuel discharge of the turbopump assembly through the filter manifold to the servo valve and actuators. The fluid returns through the checkout valve to the No. 2 fuel inlet of the turbopump assembly.

H G F E D C B A

LTR	DR	ENGR	DATE	APPROVAL

YAW ACTUATOR

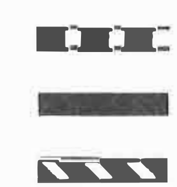




PITCH ACTUATOR

*ENG	MEAS NO	TM CHAN NO
1	D16-101	AP1A1-09-06-00
2	D16-102	AP1A1-09-07-00
3	D16-103	AP1A1-09-08-00
4	D16-104	AP1A1-09-09-00
**ENG	MEAS NO	TM CHAN NO
1	G1-101	DP1A0V15-00-00
2	G1-102	CP1B0V18-00-00
3	G1-103	CP1G0V23-00-00
4	G1-104	CP1B0V24-00-00
***ENG	MEAS NO	TM CHAN NO
1	G2-101	DP1A0V21-00-00
2	G2-102	CP1B0V25-00-00
3	G2-103	CP1B0V08-00-00
4	G2-104	CP180V09-00-00

LEGEND



SIGNATURES	DATE
DR Bobby J. Odom	1-27-70
DSGN	3-14-69
QC Betty M.	3-14-69
ENGR	3-13-69
APP	3/13/69
FEC Dean B.	3/19/69
AUTH	

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PROPULSION HYDRAULIC SYSTEM S-IC

SLV AS-508 | SIZE D | DWG NO. 4.1.1

34 X 22 | PAGE 4-2 | SHEET 1 OF 1

4.2 FUEL PRESSURIZATION

4.2.1 Tank Prepressurization

Prepressurization of the fuel tank is required prior to engine ignition to insure the necessary net positive suction pressure at the engine pump inlets.

Prepressurization of the fuel tank is initiated at T - 1.5 minutes. The fuel tank vent valve is closed and the ground prepressurization solenoid valve is opened. Helium flows from the ground helium distribution console, through the umbilical connections, and into the fuel tank. The fuel tank prepressurization switch is set to actuate at 29 psia and deactuate at 27.5 psia. The switch operates to close the ground prepressurization helium valve when fuel tank pressure reaches 29 psia. Prepressurization is complete at approximately T - 50 seconds.

4.2.2 Flight Pressurization

During S-IC powered flight, fuel ullage pressure is maintained by helium supplied from helium cylinders. Flight pressurization is initiated at lift-off, at which time the fuel pressurization valve in the manifold assembly becomes operative. The opening of this valve allows helium to flow from the helium cylinders, through the engine turbine exhaust heat exchangers where it is heated and expanded, and into the top of the fuel tank. Action of the fuel pressurization valves maintains the ullage pressure between 21.5 and 31.0 psia. The following pressurization valve sequence is programed and is based on predetermined helium requirements as a function of flight time.

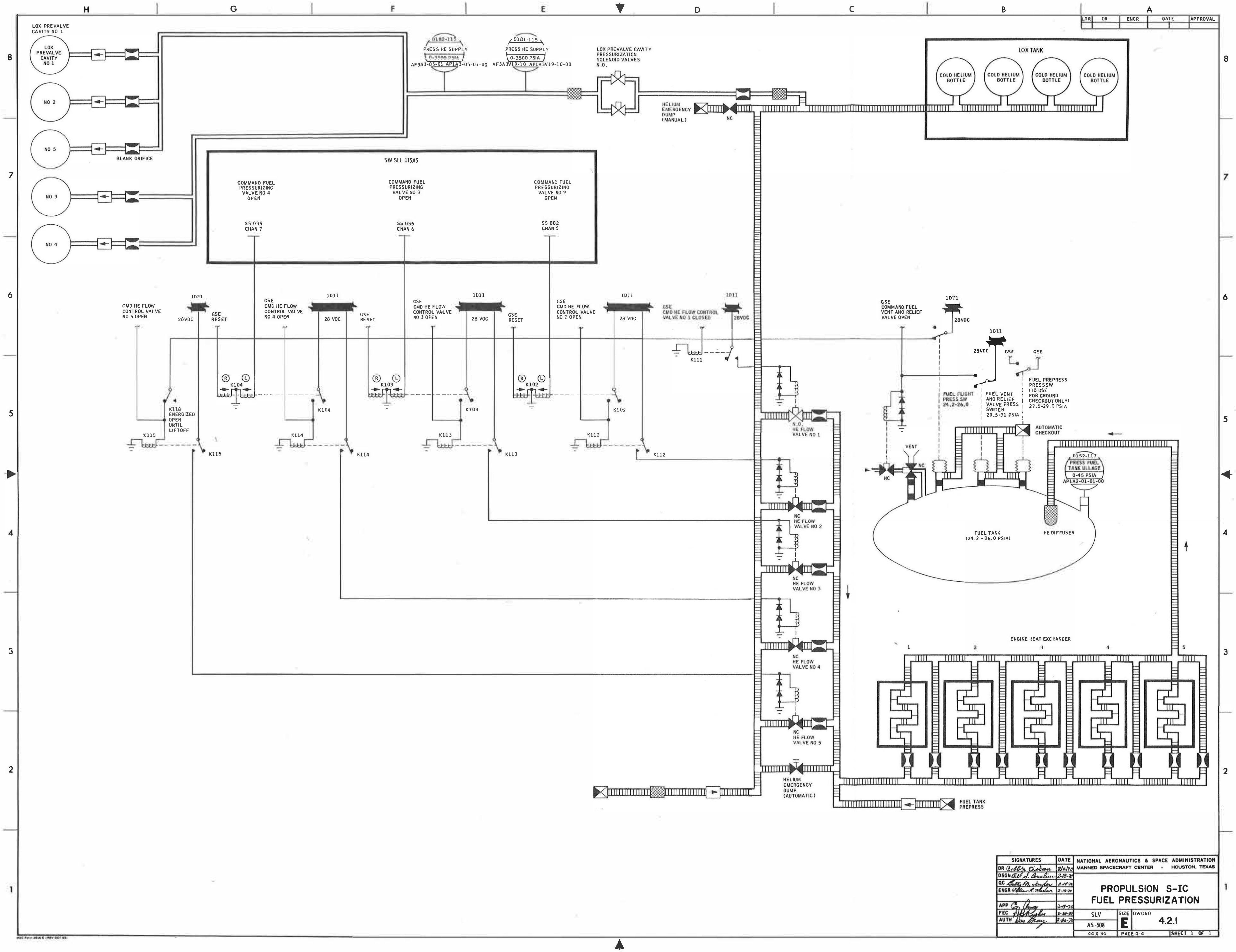
A. Valve No. 2 is opened at 49.5 seconds from lift-off.
B. Valve No. 3 is opened at 95.3 seconds from lift-off.
C. Valve No. 4 is opened at 132.4 seconds from lift-off.

Valve No. 5 operates independently and is controlled by the fuel tank pressure switch which operates at pressures between 21.5 and 19.5 psia. Its function is to supply additional fuel tank pressure if helium demands are greater than can be provided by the other four valves. The fuel tank vent and relief pressure switch is set to operate between 31.5 and 29.7 psia. Its function is to keep the fuel tank pressure from exceeding the maximum operational level by causing the fuel tank vent valve to open, thus venting excess ullage pressure.

4.2.3 Pogo Suppression

Early Saturn flights indicated there existed within the S-IC stage an instability of pogo type which resulted from the dynamic coupling of the structure and the propellant feed and engine thrust systems. The frequency of this oscillation was approximately 5.3 cycles per second, which is close to the first longitudinal vehicle frequency for the period of flight between 125 and 130 seconds.

To eliminate this problem the cavity between the lox flow tube and prevalve housing is utilized as an accumulator. Gaseous helium from the cold helium supply is introduced into this cavity to interface with the lox in the duct and act as a spring, thereby lowering the natural frequency of the lox liquid column. This results in the decoupling of the system.



LOX PREVALVE CAVITY NO 1
LOX PREVALVE CAVITY NO 1
NO 2
NO 5
NO 3
NO 4
BLANK ORIFICE
D182-115 PRESS HE SUPPLY 0-3500 PSIA
AF3A3-05-01 AP1A3-05-01-00
D181-115 PRESS HE SUPPLY 0-3500 PSIA
AF3A3V19-10 AP1A3V19-10-00
LOX PREVALVE CAVITY PRESSURIZATION SOLENOID VALVES N.O.
HELIUM EMERGENCY DUMP (MANUAL)
NC
LOX TANK
COLD HELIUM BOTTLE
SW SEL 115A5
COMMAND FUEL PRESSURIZING VALVE NO 4 OPEN
SS 035 CHAN 7
COMMAND FUEL PRESSURIZING VALVE NO 3 OPEN
SS 055 CHAN 6
COMMAND FUEL PRESSURIZING VALVE NO 2 OPEN
SS 002 CHAN 5
CMD HE FLOW CONTROL VALVE NO 5 OPEN
1021
28VDC
GSE RESET
GSE CMD HE FLOW CONTROL VALVE NO 4 OPEN
1011
28 VDC
GSE CMD HE FLOW CONTROL VALVE NO 3 OPEN
GSE CMD HE FLOW CONTROL VALVE NO 2 OPEN
GSE CMD HE FLOW CONTROL VALVE NO 1 CLOSED
K104
K103
K102
K111
K118 ENERGIZED OPEN UNTIL LIFTOFF
K115
K114
K113
K112
GSE COMMAND FUEL VENT AND RELIEF VALVE OPEN
FUEL FLIGHT PRESS SW 24.2-26.0
FUEL VENT AND RELIEF VALVE PRESS SWITCH 29.5-31 PSIA
FUEL PREPRESS PRESS SW (TO GSE FOR GROUND CHECKOUT ONLY) 27.5-29.0 PSIA
AUTOMATIC CHECKOUT
VENT
D182-117 PRESS FUEL TANK ULLAGE 0-45 PSIA
AP1A2-01-01-00
FUEL TANK (24.2 - 26.0 PSIA)
HE DIFFUSER
N.O. HE FLOW VALVE NO 1
NC HE FLOW VALVE NO 2
NC HE FLOW VALVE NO 3
NC HE FLOW VALVE NO 4
NC HE FLOW VALVE NO 5
HELIUM EMERGENCY DUMP (AUTOMATIC)
ENGINE HEAT EXCHANGER
1 2 3 4 5
FUEL TANK PREPRESS
LTR OR ENGR DATE APPROVAL
SIGNATURES DATE
DR DSGN QC ENGR APP FEC AUTH
NATIONAL AERONAUTICS & SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER · HOUSTON, TEXAS
PROPULSION S-IC
FUEL PRESSURIZATION
SLV AS-508
SIZE E
DWG NO 4.2.1
44 X 34
PAGE 4-4
SHEET 1 OF 1

4.3 LOX PRESSURIZATION AND CONDITIONING

4.3.1 Lox Pressurization

The S-IC lox pressurization and conditioning subsystem is designed to pressurize and condition the oxidizer in the S-IC stage tank to insure the availability of lox at the pressure, temperature, and density required by the lox pump inlet. The subsystem can be divided into three function-oriented areas operating at different periods as shown below. The areas are as follows:

A. Lox conditioning

B. Tank prepressurization

C. Flight pressurization

4.3.2 Lox Conditioning

Lox conditioning is necessary to prevent geysering in the suction ducts and to provide the lox pump inlet with a uniform density oxidizer. The conditioning is accomplished by both helium bubbling and thermal pumping. In order to establish a path for thermal recirculation, the suction ducts are interconnected as shown in the schematic. At the start of lox loading, the interconnect valves No. 1 and No. 4 are in their normal positions and the emergency bubbling valve is closed. The ground bubbling valve is opened and ambient helium flows into suction ducts No. 1 and No. 3. As the tank fills with lox, two separate thermal pumping systems are established in the lox suction ducts. One thermal pumping system consists of flow down suction duct No. 2 and up duct No. 1, and the other consists of flow down suction ducts No. 4 and No. 5 and up duct No. 3.

Helium bubbling is terminated when the lox tank is about 6.5 percent full and thermal pumping is established. When bubbling is terminated, thermal pumping becomes the means of lox conditioning. However, should the thermal pumping process be disrupted due to premature closure of an interconnect valve or lox prevalve, helium gas will be bubbled into all five suction ducts upstream of the prevalves through the helium emergency bubbling subsystem. The helium emergency bubbling subsystem will also operate if emergency conditions develop which require closing of the prevalves or if the temperatures of the lox in the suction ducts should increase excessively. Any time the lox reaches -284°F, helium is automatically introduced into all five lox ducts to prevent geysering. Should premature closure of the prevalves occur, interconnect valve No. 2 will be opened and lox trapped below the outboard prevalves will be vented through the interconnect valves No. 1 and No. 4, and up inboard suction duct No. 5. Lox trapped below the inboard prevalve will be vented through the bypass check valve.

4.3.3 Prepressurization

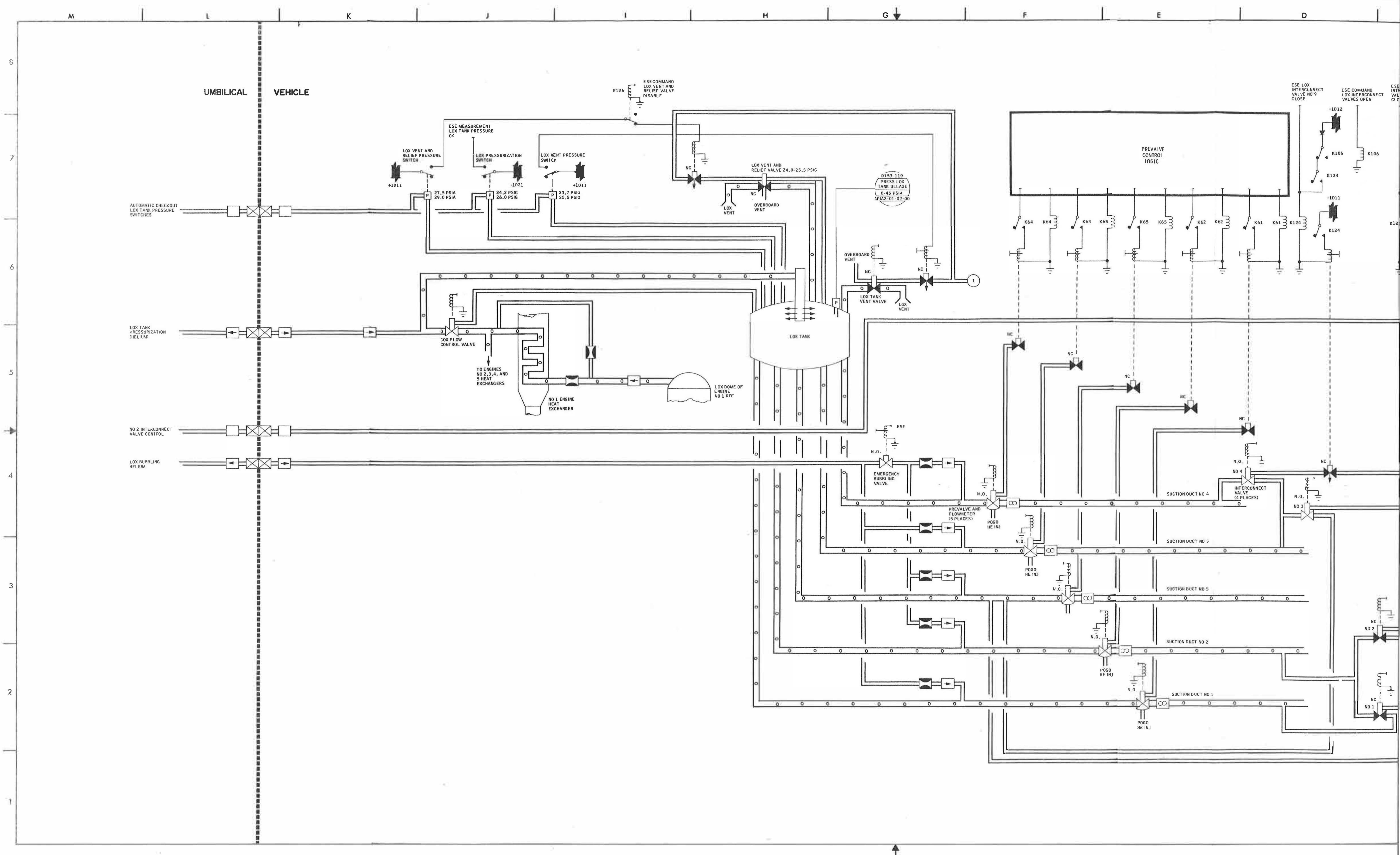
Prepressurization of the lox tank is required prior to lift-off to provide the necessary lox pressure at the engine pump inlets.

Prepressurization of the lox tank is initiated at T - 72 seconds. Both lox tank vent valves are closed. Bubbling through ducts No. 1 and No. 3 is terminated. The ground prepressurization valve is then opened and ambient helium gas flows from the ground supply and into the lox tank. The ground prepressurization valve is closed when the prepressurization pressure switch senses tank ullage pressure at 26.0 psia. Approximately 10 seconds will be required for prepressurization. Engine ignition at T - 8.9 seconds will result in lox consumption and ullage pressure decrease. The prepressurization switch will deactuate at 24.2 psia, thereby opening the ground prepressurization valve and providing supplemental ground pressure until lift-off.

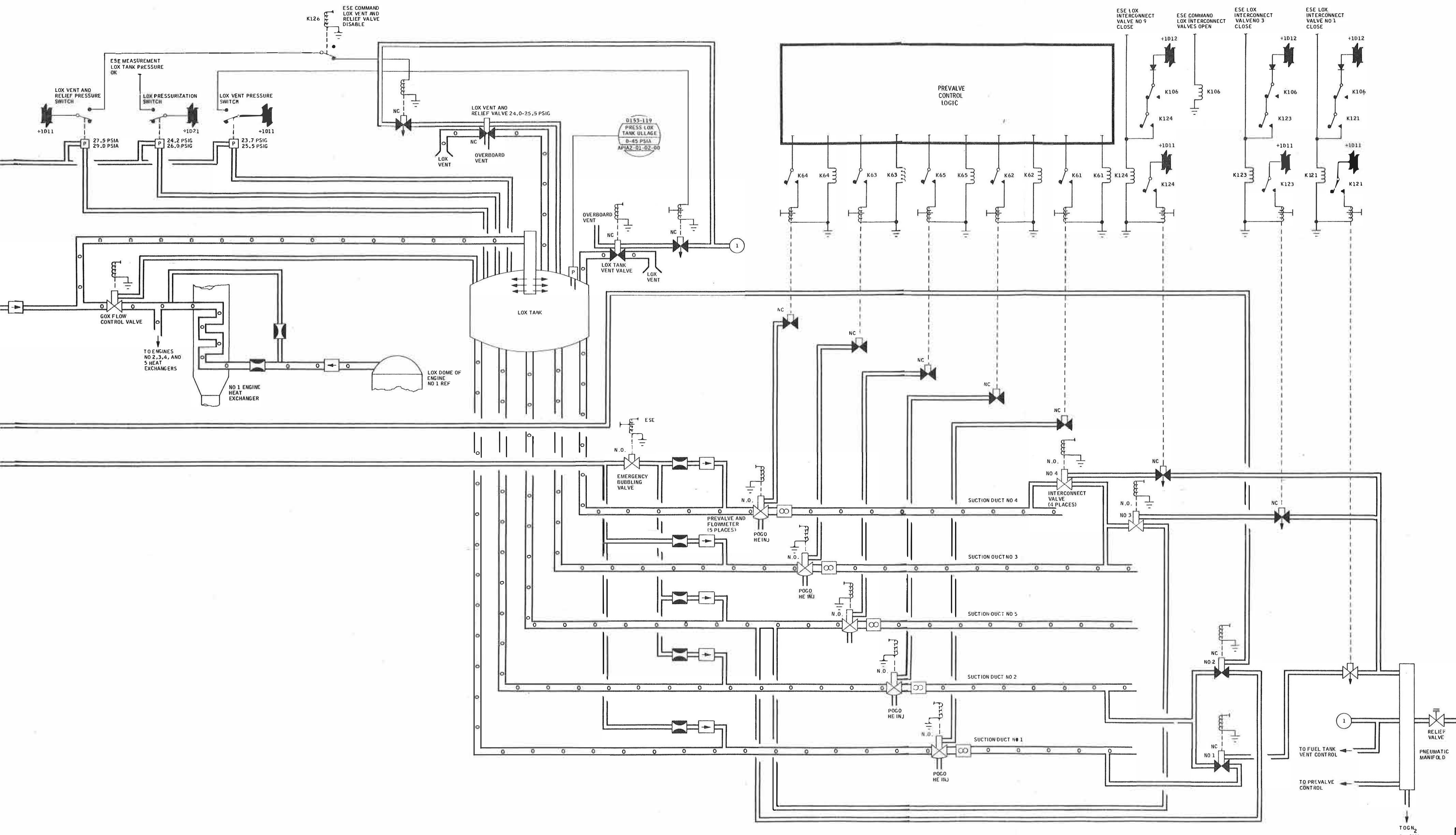
4.3.4 Flight Pressurization

Flight pressurization of the lox tank is required to provide the necessary lox pressure at the engine pump inlets. At ignition command, the turbopumps begin to supply lox to the lox dome of each engine. Some of this lox is bled from the lox dome and passed through the heat exchanger where the turbine exhaust heat converts the lox to gox. Some lox is bypassed around the heat exchanger through an orifice in order to regulate the gox temperature. As the engine progresses into main stage, each engine contributes to the lox pressurization system. The gox flows from each heat exchanger into a common pressurization manifold containing a gox flow control valve. This valve has an adjustable minimum stop which insures a specific gox flow to maintain lox tank ullage pressure at 18 to 21 psia subsequent to lift-off. During the time period between engine ignition and lift-off, minimum flow occurs through the gox flow control valve. Until lift-off this flow is supplemented by the prepressurization described above and the tank is maintained at 24 to 26 psia. After lift-off and throughout the flight, the gox flow control valve maintains lox tank ullage pressure at 18 to 21 psia by modulating gox flow between an optimized range of 30 to 50 pounds per second (with a maximum flow capacity of 60 pounds per second). The actual pressurant flow depends on the tank pressure sensed by a reference pressure line connecting the valve with the lox tank.

Zero gox venting during flight is the design objective; however, should tank pressure venting be required, it will be performed as follows: The flight vent pressure switch will assume primary control of tank venting until approximately T + 70 seconds. This switch, which actuates at 31.5 psia and deactuates at 29.7 psia, will open the lox vent and relief valve. As the vehicle gains altitude, the external ambient pressure decreases, and between approximately T + 64 and T + 75 seconds, either the flight vent pressure switch or the mechanical relief may cause venting. The mechanical relief system of the lox vent and relief valve which actuates at 25.5 psig and deactuates at 23.5 psig, becomes the primary mode for venting after T + 75 seconds.



M
L
K
J
I
H
G
F
E
D
UMBILICAL
VEHICLE
ESE COMMAND LOX VENT AND RELIEF VALVE DISABLE
K126
ESE MEASUREMENT LOX TANK PRESSURE OK
LOX VENT AND RELIEF PRESSURE SWITCH
LOX PRESSURIZATION SWITCH
LOX VENT PRESSURE SWITCH
+1D11
+1D21
27.5 PSIA
29.0 PSIA
24.2 PSIG
26.0 PSIG
23.7 PSIG
25.5 PSIG
LOX VENT AND RELIEF VALVE 24.0-25.5 PSIG
D153-119 PRESS LOX TANK ULLAGE 0-45 PSIA A2-01-02-00
LOX VENT
OVERBOARD VENT
AUTOMATIC CHECKOUT LOX TANK PRESSURE SWITCHES
LOX TANK PRESSURIZATION (HELIUM)
GOX FLOW CONTROL VALVE
TO ENGINES NO 2,3,4, AND 5 HEAT EXCHANGERS
NO 1 ENGINE HEAT EXCHANGER
LOX DOME OF ENGINE NO 1 REF
LOX TANK
LOX TANK VENT VALVE
NO 2 INTERCONNECT VALVE CONTROL
LOX BUBBLING HELIUM
ESE
EMERGENCY BUBBLING VALVE
PREVALVE AND FLOWMETER (5 PLACES)
POGO HE INJ
PREVALVE CONTROL LOGIC
K64
K63
K65
K62
K61
K124
K106
+1D12
ESE LOX INTERCONNECT VALVE NO 9 CLOSE
ESE COMMAND LOX INTERCONNECT VALVES OPEN
INTERCONNECT VALVE (4 PLACES)
SUCTION DUCT NO 4
SUCTION DUCT NO 3
SUCTION DUCT NO 5
SUCTION DUCT NO 2
SUCTION DUCT NO 1
NC
N.O.
NO 4
NO 3
NO 2
NO 1



SIGNATURES	DATE	NATIONAL AERONAUTICS & SPACE ADMINISTRATION MANNED SPACECRAFT CENTER · HOUSTON, TEXAS
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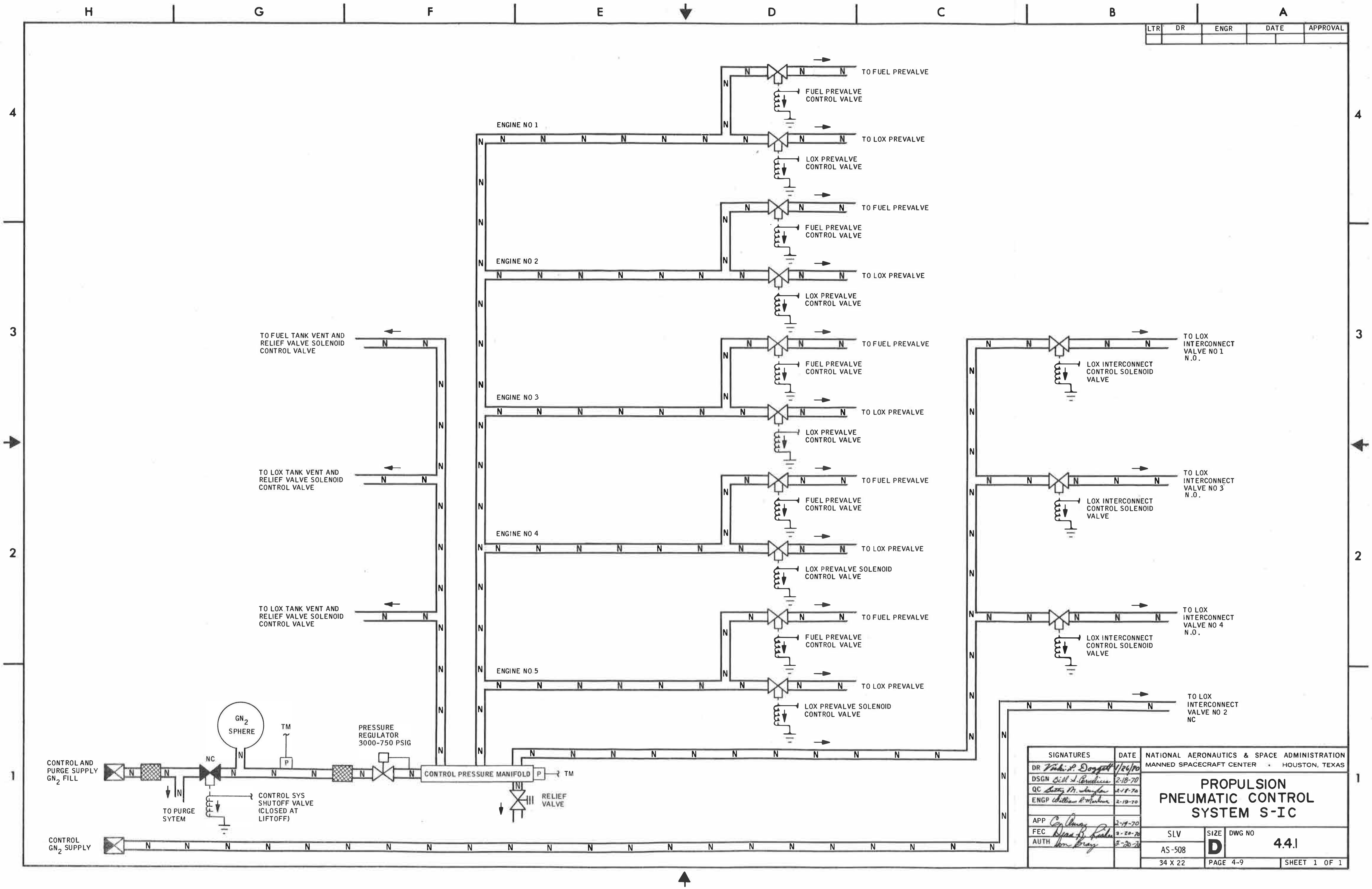
QC Seth M. Taylor	2-18-70	
ENGR William R. Marlow	2-19-70	
APP C. Ame	2-19-70	SLV · AS-508 · SIZE J · DWG NO 4.3.1
FEC Dean B. Lisle	2/20/70	
AUTH Roy Bray	2-20-70	71.5 X 34 · PAGE 4-7 · SHEET 1 OF 1

4.4 PNEUMATIC CONTROL SYSTEM

Prior to pressurization of the 3000 psig (1.27 ft^3) GN_2 storage sphere, the normally closed GN_2 solenoid valve must be in the open position. Ground supplied gaseous nitrogen is introduced through a GN_2 storage self-sealing quick disconnect coupling, GN_2 pressurization filter, and GN_2 solenoid valve into the sphere. The sphere is pressurized to approximately 1500 psig prior to propellant tanking. Pressurization to approximately 3000 psig occurs at T - 5-1/2 hours. The GN_2 solenoid valve is closed shortly before lift-off and remains closed throughout flight. Nitrogen flows from the sphere through the pneumatic control filter and pneumatic control regulator where the gas pressure is reduced to approximately 750 psi. Gaseous nitrogen then flows from the regulator to the control pressure manifold which contains a pneumatic control relief valve. The relief valve mechanically opens to relieve overpressure if manifold pressure becomes excessive.

On the S-IC vehicle during flight, gaseous nitrogen flows from the pressure manifold to three normally closed three-way solenoid valves. Upon completion of an electrical circuit by the actuation of the fuel tank vent and relief pressure switch, the fuel vent and relief control solenoid valve opens to allow gaseous nitrogen to open the normally closed fuel tank vent and relief valve. Similarly, upon completion of an electrical circuit by the acutation of the lox tank vent and relief pressure switch, the lox vent and relief control solenoid valve opens to allow gaseous nitrogen to open the normally closed lox tank vent and relief valve.

The GN_2 control sphere and purge sphere are pressurized simultaneously from a ground source. Gaseous nitrogen flows through the GN_2 coupling and GN_2 filter, then separates and continues through the normally closed GN_2 solenoid valve and the purge system fill solenoid valve into the storage sphere and the purge sphere, respectively. The solenoid valves are in the open position throughout the countdown, but are closed prior to lift-off and remain closed to isolate the two systems during flight. GN_2 control pressure is also routed to three normally open lox interconnect valves (Nos. 1, 2, and 4) to hold these valves closed throughout flight.



ENGINE NO 1
ENGINE NO 2
ENGINE NO 3
ENGINE NO 4
ENGINE NO 5
TO FUEL PREVALVE
FUEL PREVALVE CONTROL VALVE
TO LOX PREVALVE
LOX PREVALVE CONTROL VALVE
LOX PREVALVE SOLENOID CONTROL VALVE
TO FUEL TANK VENT AND RELIEF VALVE SOLENOID CONTROL VALVE
TO LOX TANK VENT AND RELIEF VALVE SOLENOID CONTROL VALVE
TO LOX INTERCONNECT VALVE NO 1 N.O.
TO LOX INTERCONNECT VALVE NO 3 N.O.
TO LOX INTERCONNECT VALVE NO 4 N.O.
TO LOX INTERCONNECT VALVE NO 2 NC
LOX INTERCONNECT CONTROL SOLENOID VALVE
GN_2 SPHERE
TM
PRESSURE REGULATOR 3000-750 PSIG
CONTROL PRESSURE MANIFOLD
RELIEF VALVE
CONTROL AND PURGE SUPPLY GN_2 FILL
NC
TO PURGE SYTEM
CONTROL SYS SHUTOFF VALVE (CLOSED AT LIFTOFF)
CONTROL GN_2 SUPPLY
LTR DR ENGR DATE APPROVAL
SIGNATURES DATE
DR
DSGN
QC
ENGP
APP
FEC
AUTH
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PROPULSION PNEUMATIC CONTROL SYSTEM S-IC
SLV
AS-508
SIZE D
DWG NO 4.4.1
34 X 22
PAGE 4-9
SHEET 1 OF 1

4.5 F-1 ENGINES

4.5.1 General Description

Five F-1 engines are used on the S-IC stage of the Saturn AS-505 vehicle to provide thrust during first stage boost. The five engines are similar, including interface connections, however, the four outboard engines are gimbal mounted for thrust vector control, whereas, the center engine is rigidly attached to the thrust structure. Each engine delivers approximately 1.5 million pounds of thrust. The F-1 is a single start, bipropellant engine using rocket propellant (liquid) (RP-1) for fuel and liquid oxygen (LOX) for oxidizer.

The engine hydraulic system is an integral part of the engine and used RP-1 as the hydraulic fluid during flight. The fuel is bled from high pressure side of the turbopump and is used to drive the engine positioning actuators and various hydraulically actuated valves, and is then returned to the pump inlet.

Ground support equipment is required to start the engine, but once started is self sustaining. The F-1 engine system consists of the following: gas generator, turbopump assembly, dual media heat exchanger, thrust chamber, nozzle extension, checkout valve, four-way control valve, two main LOX valves, two main fuel valves, hypergol manifold, bearing coolant control valve, two pyrotechnic igniters, and two thrust chamber pyrotechnic igniters.

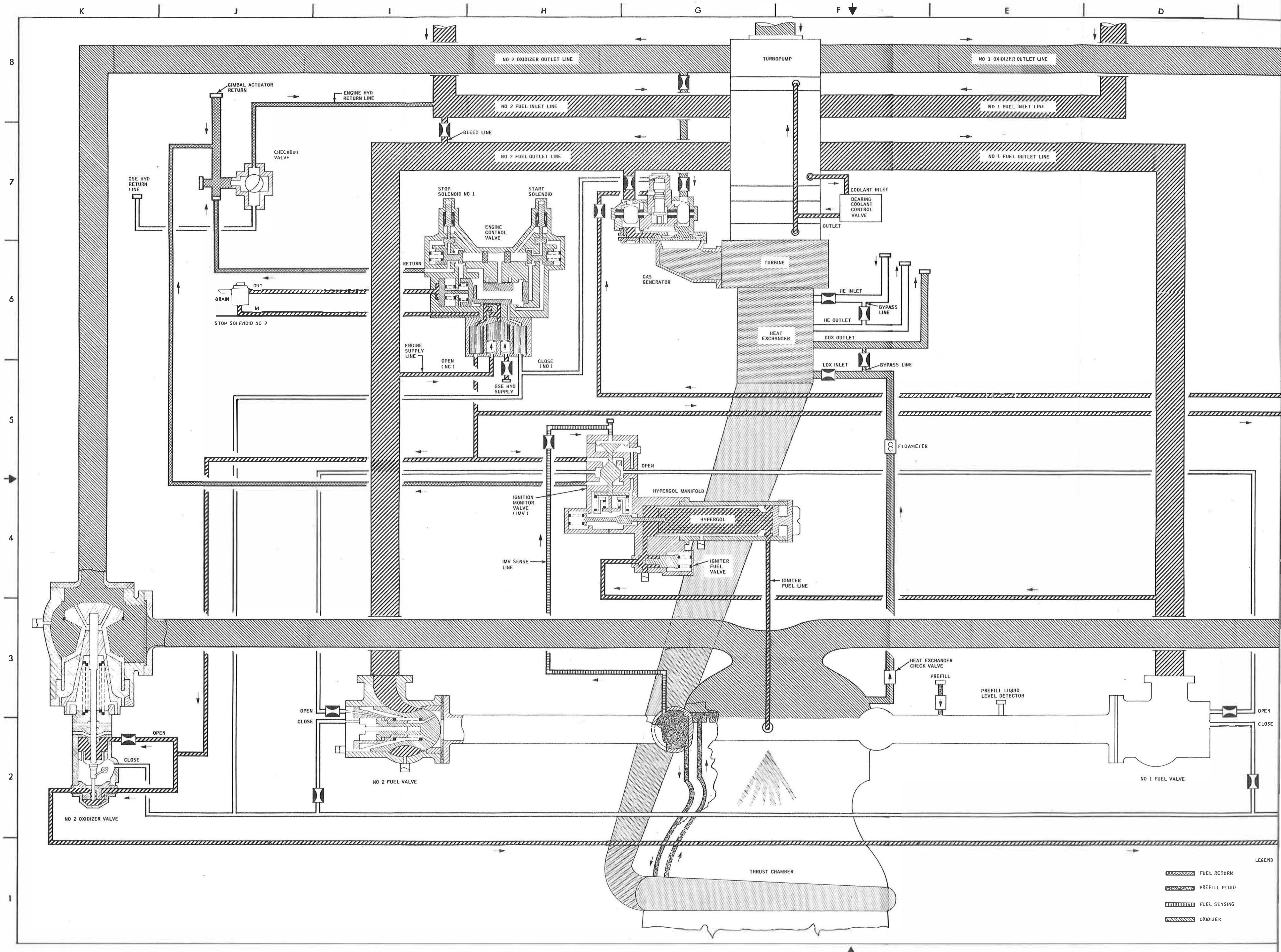
As a result of a pogo type instability during S-IC boost on the AS-502 vehicle, a helium LOX prevalve cavity pressurization system has been added to S-IC stage. The purpose of this system is to decrease the likelihood of a pogo oscillation by injecting helium into the LOX prevalve cavity of each outboard engine such that the cavity acts as a vibration damper, thereby lowering the natural frequency of the LOX liquid column in the feedlines of these engines to disrupt phasing.

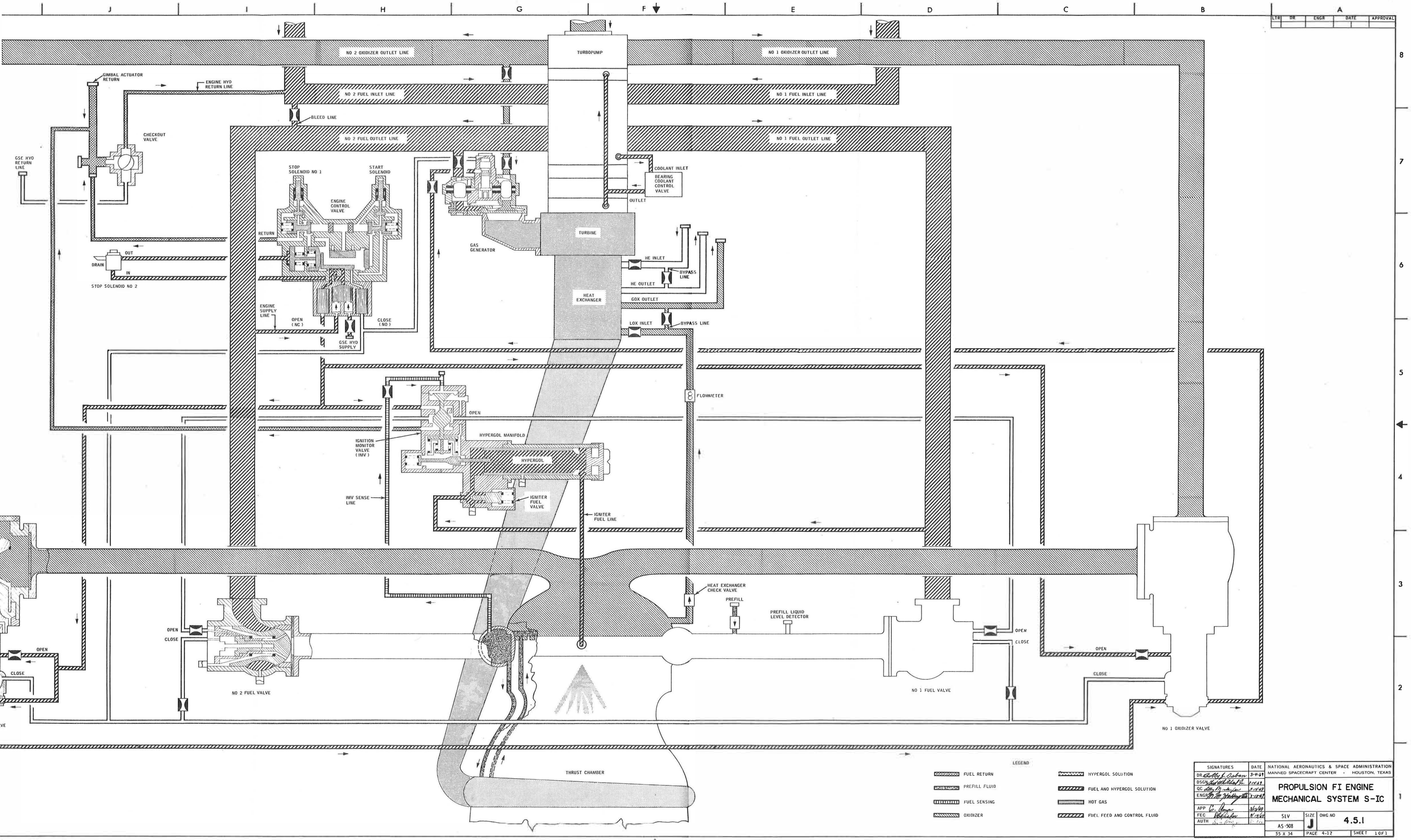
4.5.2 Start Sequence and Main Stage Operation

The start of the F-1 engines of the S-IC will be accomplished in a 1-2-2 order with a minimum stagger timer of 0.3 seconds. The center (No. 5) engine will be started first, followed by the diametrically opposed pairs of the other four engines. At engine start, the checkout valve moves to the engine return position. This transfers the hydraulic fuel return from the ground line and directs the return to the turbopump No. 2 low pressure fuel inlet. When the engine start command is received, the high level (600 psia) LOX dome and gas generator purge is initiated; the ignition stage timer is energized; and the turbopump bearing heaters are deenergized. When the pyrotechnic igniter fuses burn through and the ignition is detected, the four-way solenoid valve start solenoid is energized. Hydraulic pressure holding the gas generator ball valve, oxidizer valves and fuel valves closed is relieved and directed to the turbopump No. 2 low pressure fuel inlet. Hydraulic filter and four-way solenoid valve manifold is now directed to the opening ports of the oxidizer valves and to the No. 2 sequence valve located on and actuated by the No. 2 oxidizer valve. The oxidizer valves open and admit LOX into the thrust chamber. As the oxidizer valves reach approximately 16 percent open, the gates in the sequence valves are opened and hydraulic pressure is directed through the No. 2 sequence valve, to and through No. 1 sequence valve, and to the gas generator ball valve opening port. The gas generator ball valve opens, propellants under tank pressures enter the gas generator combustion chamber through the injector, and the propellant mixture is ignited by the gas generator igniters. The exhaust gas is ducted through the turbopump turbine, through the thrust chamber exhaust manifold where the fuel-rich mixture is re-ignited by the turbine exhaust gas igniters. As the turbine accelerates the oxidizer pumps, the pump discharge pressure increases and propellants at increasing flow rates are supplied to the gas generator. Turbopump acceleration continues; and as the fuel pressure increases, the bearing coolant control valve opens at approximately 225 psig and directs cooling fuel onto the turbopump shaft bearings. When the fuel pressure increases to 375 ± 30 psig, the igniter fuel poppet opens and allows fuel pressure to build up against the hypergol cartridge burst diaphram. The hypergol diaphram burst under increasing fuel pressure, unlocking the ignition monitor valve poppet; and hypergol fluid, followed by the ignition fuel, enters the thrust chamber. When hypergolic fluid enters the thrust chamber and contacts the oxidizer, spontaneous combustion occurs and establishes thrust chamber ignition flame.

During initial engine operation, thrust chamber pressure is transmitted to the sodium nitrite prefill and routed through the checkout valve to the ignition monitor valve. When the thrust chamber pressure increases to approximately 20 psig, the ignition monitor valve actuates and directs hydraulic fuel to the opening ports of the fuel valves.

The fuel valves open; fuel is admitted to the thrust chamber, and the gas generator fuel purge comes on. As fuel enters the thrust chamber fuel manifold, 30 percent of the fuel is routed directly through the injector to the thrust chamber combustion zone. The other 70 percent of the fuel passes through the thrust chamber tubes for cooling and then passes through the injector into the thrust chamber zone. The thrust chamber pressure increases until the gas generator reaches rated power (controlled by orifices in the propellant lines feeding the gas generator). When engine fuel pressure increases above the ground source fuel pressure, the hydraulic pressure source is transferred to the engine and the thrust OK pressure switches pickup. The engine is now at main stage. Main stage continues until cutoff is given or caused by low thrust.





SIGNATURES	DATE
DR Bobby J. Osban	3-4-69
DSGN	3-14-69
QC	3-14-69
ENGR	3-18-69
APP C.	3/13/69
FEC	3/19/69
AUTH	

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PROPULSION FI ENGINE MECHANICAL SYSTEM S-IC

SLV	SIZE	DWG NO
AS-508	J	4.5.1
55 X 34	PAGE 4-12	SHEET 1 OF 1

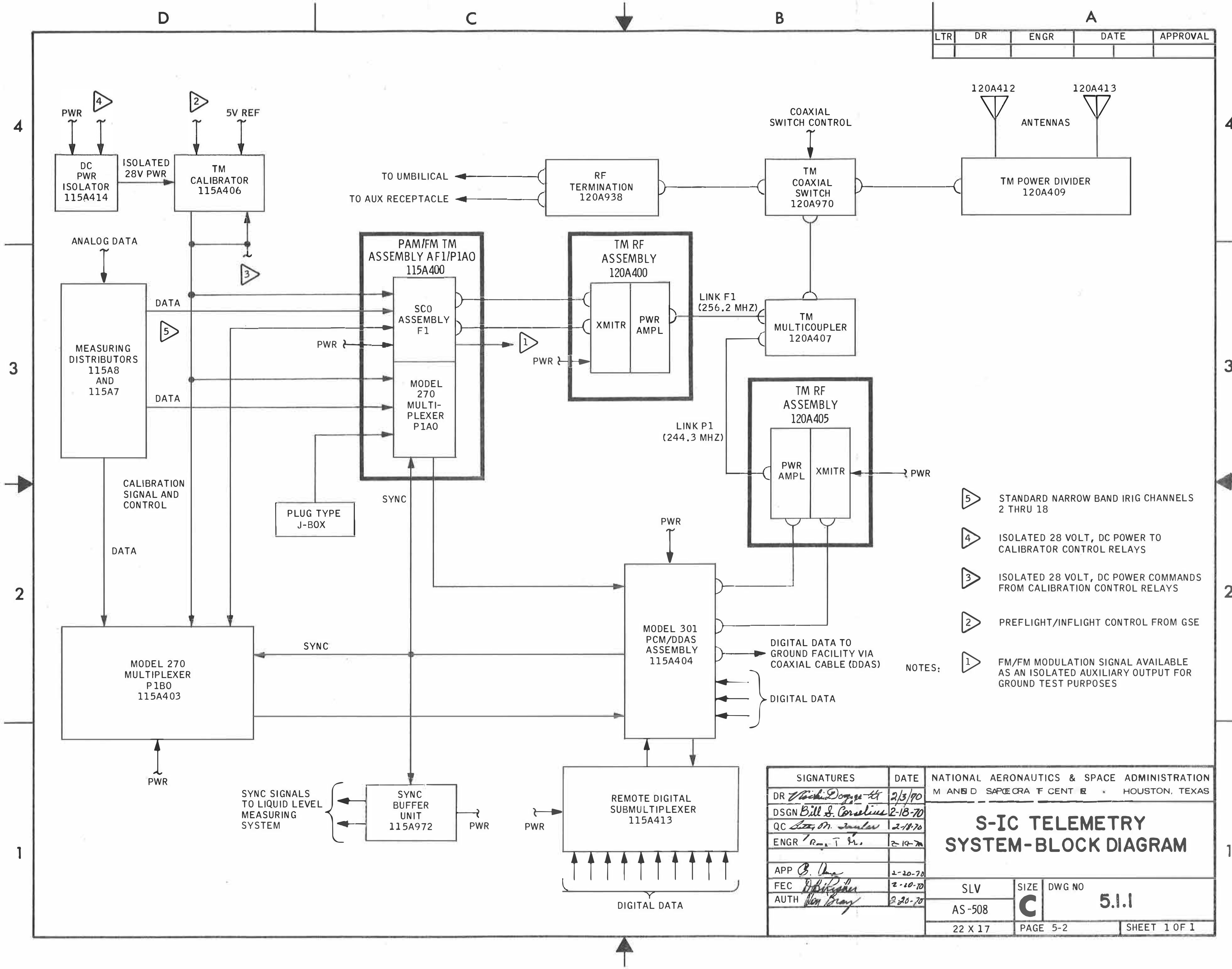
5 S-IC
INSTRUMENTATION
AND TELEMETRY

SECTION 5

S-IC INSTRUMENTATION AND TELEMETRY

5.1 S-IC TELEMETRY SYSTEM DESCRIPTION

The telemetry system installed on AS-508 is composed of two VHF-RF links. One FM/FM link and one PCM/FM link are incorporated to handle the data and fulfill the measurement requirements. Drawing 5.1.1 is a block diagram of the S-IC telemetry system. Data in the low-to-medium frequency range are monitored by the FM/FM and the PCM/FM links.



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LTR
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DATE
APPROVAL
PWR
4
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5V REF
DC PWR ISOLATOR 115A414
ISOLATED 28V PWR
TM CALIBRATOR 115A406
3
ANALOG DATA
MEASURING DISTRIBUTORS 115A8 AND 115A7
DATA
5
DATA
CALIBRATION SIGNAL AND CONTROL
DATA
PAM/FM TM ASSEMBLY AF1/P1A0 115A400
SCO ASSEMBLY F1
PWR
MODEL 270 MULTI-PLEXER P1A0
PLUG TYPE J-BOX
SYNC
1
TO UMBILICAL
TO AUX RECEPTACLE
RF TERMINATION 120A938
TM RF ASSEMBLY 120A400
XMITR
PWR AMPL
PWR
COAXIAL SWITCH CONTROL
TM COAXIAL SWITCH 120A970
LINK F1 (256.2 MHZ)
TM MULTICOUPLER 120A407
120A412
120A413
ANTENNAS
TM POWER DIVIDER 120A409
TM RF ASSEMBLY 120A405
PWR AMPL
XMITR
PWR
LINK P1 (244.3 MHZ)
PWR
MODEL 301 PCM/DDAS ASSEMBLY 115A404
DIGITAL DATA TO GROUND FACILITY VIA COAXIAL CABLE (DDAS)
DIGITAL DATA
MODEL 270 MULTIPLEXER P1B0 115A403
SYNC
PWR
SYNC SIGNALS TO LIQUID LEVEL MEASURING SYSTEM
SYNC BUFFER UNIT 115A972
PWR
PWR
REMOTE DIGITAL SUBMULTIPLEXER 115A413
DIGITAL DATA
NOTES:
5 STANDARD NARROW BAND IRIG CHANNELS 2 THRU 18
4 ISOLATED 28 VOLT, DC POWER TO CALIBRATOR CONTROL RELAYS
3 ISOLATED 28 VOLT, DC POWER COMMANDS FROM CALIBRATION CONTROL RELAYS
2 PREFLIGHT/INFLIGHT CONTROL FROM GSE
1 FM/FM MODULATION SIGNAL AVAILABLE AS AN ISOLATED AUXILIARY OUTPUT FOR GROUND TEST PURPOSES
SIGNATURES
DATE
DR 2/3/70
DSGN 2-18-70
QC 2-18-70
ENGR 2-19-70
APP 2-20-70
FEC 2-20-70
AUTH 2-20-70
NATIONAL AERONAUTICS & SPACE ADMINISTRATION
HOUSTON, TEXAS
S-IC TELEMETRY SYSTEM-BLOCK DIAGRAM
SLV
AS-508
SIZE C
DWG NO 5.1.1
22 X 17
PAGE 5-2
SHEET 1 OF 1

6 S-IC/S-II
STAGING

SECTION 6

S-IC/S-II STAGING

6.1 SUBSYSTEMS (GENERAL DESCRIPTION)

6.1.1 Exploding Bridge Wire Firing Units

Exploding bridge wire (EBW) firing units are used to generate the high-voltage, high-energy pulse required to initiate the electric detonators. Each EBW unit consists of a high-voltage supply, an energy storage unit, a trigger circuit, and a switching device. The power supply uses 28-Vdc vehicle power to charge a storage capacitor to 2300 volts. Upon receipt of a signal, the trigger circuit actuates the switching device which causes the storage capacitor to discharge across the detonator.

6.1.2 EBW Detonators

The EBW detonators (one for each firing unit) are the electrically activated devices used to initiate the high explosive ordnance trains. When a high-voltage, high-energy pulse is applied to the bridge wire element in the detonator, the wire explodes and releases a large amount of energy. This energy ignites a small quantity of chemical explosive, which, in turn, detonates a larger, more powerful output charge. This final charge detonates the explosive ordnance train.

No heat sensitive primary explosives are used and the detonators are not sensitive to accidental application of vehicle or ground power, static discharge, or RF energy. A spark gap in one pin of the firing circuitry prevents burnout of the bridge wire if power is accidentally applied. This gap has a breakdown voltage of 600 to 1200 volts.

6.1.3 Confined Detonating Fuse

A confined detonating fuse (CDF) manifold is used to transfer the detonation shock wave from an EBW detonator to the multiple CDF assemblies. The manifold consists of a metal body with an EBW detonator located at one end. A linear shaped charge (LSC) is installed in a hole through the center of the manifold. A detonation shock wave initiated by the EBW detonator will propagate through the LSC and ignite each CDF assembly. The CDF assembly consists of a low-energy detonator cord encased in a multilayered protective sheath. The sheath is designed so that all explosive effects are contained within the sheath.

6.1.4 S-IC Retrorockets

Eight solid propellant S-IC retrorockets are mounted in pairs on the aft S-IC stage structure, under the four F-1 engine fairings, and are used to retard the S-IC stage after separation. Each retrorocket has a burning time of 0.67 seconds and develops a thrust of 92,375 pounds (vacuum thrust at 70°F). The thrust level developed by seven retrorockets, with any one retrorocket out, is adequate to separate the S-IC stage a minimum of 6 feet from the vehicle in less than 1 second.

Each retrorocket is ignited by either of two pyrogen initiators mounted on its aft structure. The CDF assemblies connect the pyrogen initiators to the respective firing units, thus completing the ordnance train.

6.1.5 S-II Ullage Rockets

Four solid propellant S-II ullage rockets are mounted at equal intervals around the periphery of the S-II interstage. The ullage rockets provide the positive thrust required to settle the J-2 engine propellants prior to engine start. With any one ullage rocket out, the remaining rockets are capable of maintaining a minimum vehicle acceleration of 0.1 g during the coast portion of S-IC/S-II separation.

Each ullage rocket burns for 3.8 seconds and develops a thrust of 22,000 lbs (in vacuum). Two pyrogen initiators are mounted on each ullage rocket and complete the ordnance train required for rocket ignition.

6.1.6 Linear Shaped Charge

The linear shaped charge is used to sever the vehicle structure during separation. The explosive is designed so that, when detonated, the force of the explosion is focused along a line to provide the required cutting action.

The detonator blocks complete the ordnance train to accomplish physical separation. An EBW detonator is mounted on each detonator block, thus linking the block with the respective firing unit. Each end of the LSC is attached to a detonator block either of which can fire the explosive charge.

6.2 OPERATION

A dual plane separation technique is used for S-IC/S-II separation. First plane physical separation is initiated by the Instrument Unit (IU) at the end of S-IC boost phase, following shutdown of the four outboard F-1 engines. Second plane separation is initiated approximately 30 seconds later. Separation requires the performance of the following major functions in the sequence described.

6.2.1 EBW Firing Units Armed

Liftoff relays render the EBW firing units inoperative while the vehicle is on the launch pad. This inhibit is removed with umbilical disconnect at liftoff. At approximately 14.5 seconds after inboard engine cutoff the IU sends out the command to arm the S-II ullage rockets and second plane separation EBW firing units. The arm command is routed through the S-II switch selector to the S-II stage electrical circuitry to supply plus 28 Vdc to the firing units. Approximately 0.2 seconds later the IU sends out the command to arm the first plane separation and retrorocket No. 1 EBW firing units and 0.2 seconds later the command to arm the first plane separation and retrorocket No. 2 EBW firing units. These two arm commands are routed through the S-IC switch selector to the S-IC stage electrical circuitry to supply plus 28 Vdc to the firing units. The firing units use this energy to charge the internal storage capacitors to 2300 volts to provide the firing pulse for separation (LSC detonation) and retrorocket ignition.

6.2.2 S-IC Engine Cutoff

Cutoff of the center F-1 engine is commanded by the Launch Vehicle Digital Computer at approximately 134 seconds after liftoff. The four outboard F-1 engines shutdown is enabled at approximately 153 seconds after liftoff.

6.2.3 S-II Ullage Rocket Ignition

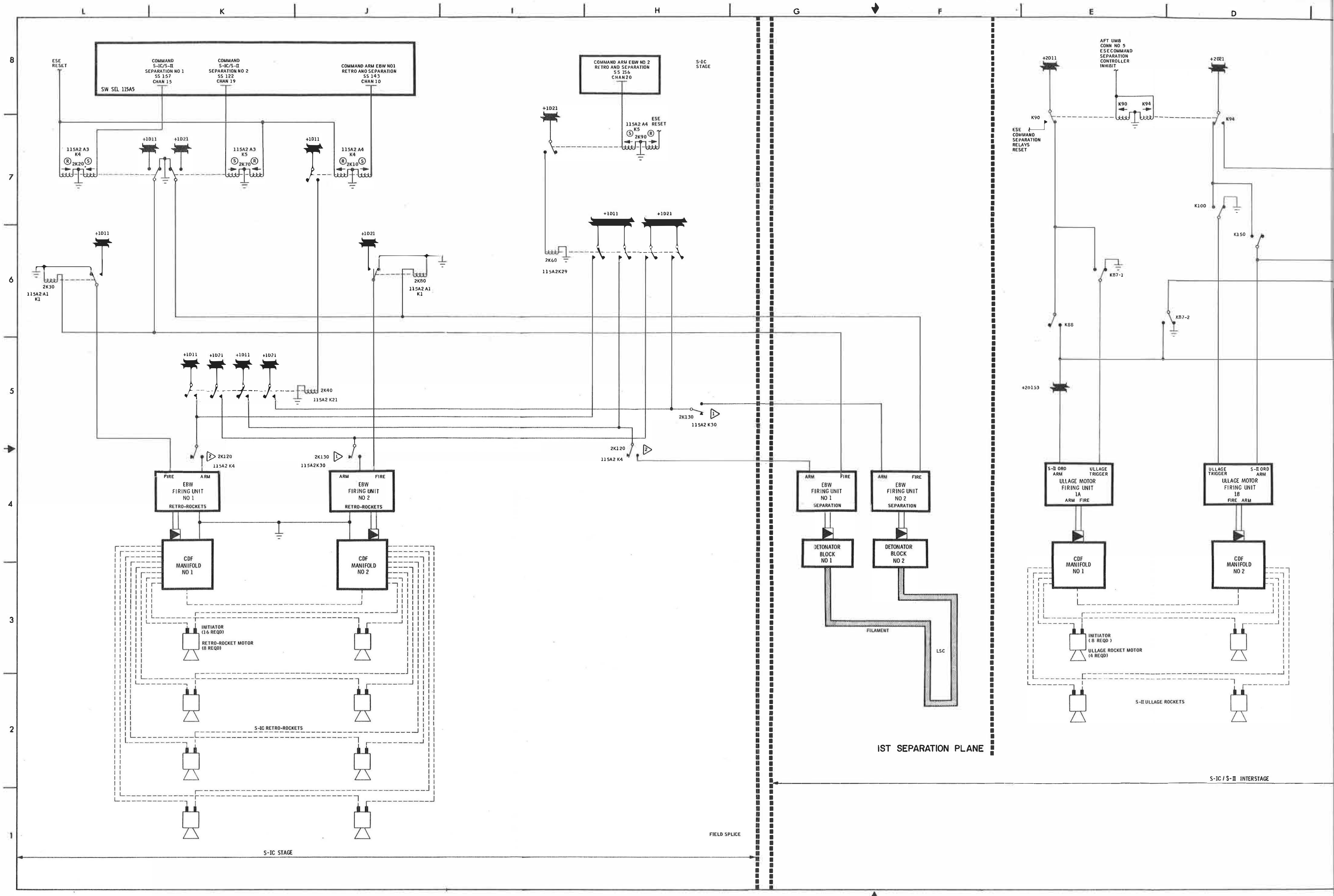
Immediately following S-IC engine shutdown, the IU initiates ullage rocket ignition. The signal is routed through the S-II switch selector and the S-II electrical circuitry to trigger the ullage rocket firing units. The internal storage capacitors discharge a high-energy pulse, causing the bridge wires to explode, releasing the energy required to detonate the explosive charge. The detonation propagates through the EBW detonators.

6.2.4 First Plane Separation And S-IC Retrorocket Ignition

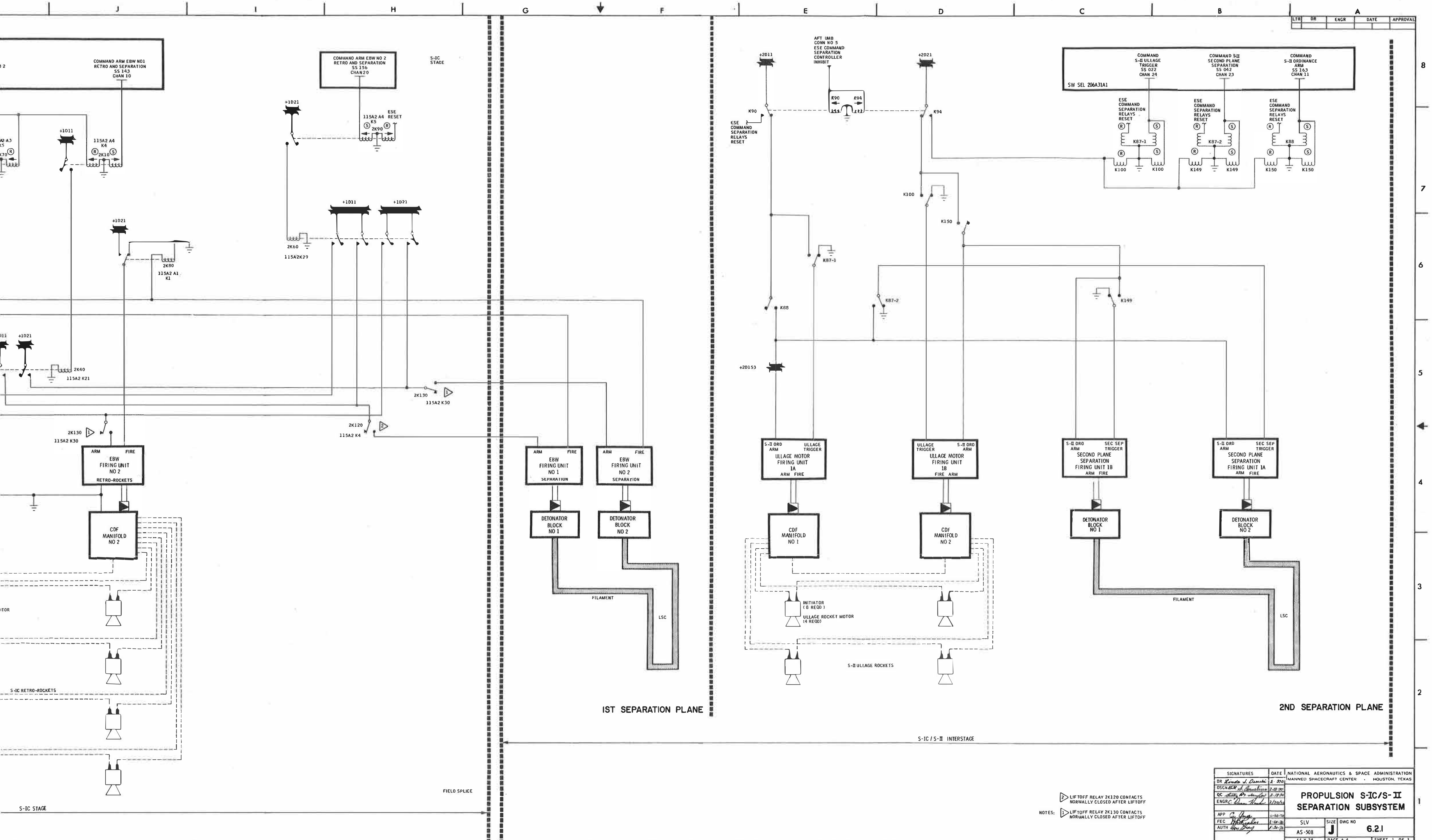
First plane separation is initiated immediately after S-II ullage rocket ignition at approximately 163 seconds after liftoff. The separation command is routed through the S-IC switch selector to the S-IC electrical circuitry to trigger the ordnance train for first plane separation and retrorocket ignition. The LSC and, in turn, the retrorockets ignite to separate the structure and retard the S-IC stage.

6.2.5 Second Plane Separation

The storage capacitors in the two EBW firing units are charged by the application of 28 Vdc to the charging circuits during the latter part of S-IC boost. The trigger signal is issued by the S-II switch selector at 31 seconds after S-IC outboard engines cutoff, causing the storage capacitor in each EBW firing unit to discharge its stored energy into the EBW detonator. This in turn detonates the linear shaped charge (LSC) which is routed around the periphery of the interstage. Detonation of the LSC assembly severs the tension members attaching the S-IC/S-II interstage, allowing it to fall away from the accelerating S-II.



COMMAND S-IC/S-II SEPARATION NO 1 SS 157 CHAN 15
COMMAND S-IC/S-II SEPARATION NO 2 SS 122 CHAN 19
COMMAND ARM EBW NO1 RETRO AND SEPARATION SS 143 CHAN 10
SW SEL 115A5
COMMAND ARM EBW NO 2 RETRO AND SEPARATION SS 156 CHAN 20
S-IC STAGE
ESE RESET
115A2 A3 K4
115A2 A3 K5
115A2 A4 K4
115A2 A4 K5
2K20
2K70
2K10
2K90
2K30
115A2 A1 K1
2K80
2K60
115A2K29
2K40
115A2 K21
2K120
115A2 K4
2K130
115A2K30
115A2 K30
EBW FIRING UNIT NO 1 RETRO-ROCKETS
EBW FIRING UNIT NO 2 RETRO-ROCKETS
CDF MANIFOLD NO 1
CDF MANIFOLD NO 2
INITIATOR (16 REQD)
RETRO-ROCKET MOTOR (8 REQD)
S-IC RETRO-ROCKETS
FIELD SPLICE
S-IC STAGE
EBW FIRING UNIT NO 1 SEPARATION
EBW FIRING UNIT NO 2 SEPARATION
DETONATOR BLOCK NO 1
DETONATOR BLOCK NO 2
FILAMENT
LSC
1ST SEPARATION PLANE
AFT UMB CONN NO 5 ESE COMMAND SEPARATION CONTROLLER INHIBIT
ESE COMMAND SEPARATION RELAYS RESET
K90
K94
K100
K150
K87-1
K87-2
K88
ULLAGE MOTOR FIRING UNIT 1A
ULLAGE MOTOR FIRING UNIT 1B
CDF MANIFOLD NO 1
CDF MANIFOLD NO 2
INITIATOR (8 REQD)
ULLAGE ROCKET MOTOR (4 REQD)
S-II ULLAGE ROCKETS
S-IC / S-II INTERSTAGE


J
I
H
G
F
E
D
C
B
A
COMMAND ARM EBW NO1 RETRO AND SEPARATION SS 143 CHAN 10
COMMAND ARM EBW NO 2 RETRO AND SEPARATION SS 156 CHAN 20
S-IC STAGE
AFT UMB CONN NO 5 ESE COMMAND SEPARATION CONTROLLER INHIBIT
COMMAND S-II ULLAGE TRIGGER SS 022 CHAN 24
COMMAND S-II SECOND PLANE SEPARATION SS 042 CHAN 23
COMMAND S-II ORDINANCE ARM SS 163 CHAN 11
SW SEL 206A31A1
ESE COMMAND SEPARATION RELAYS RESET
115A2 A4 K4
115A2 A4 K5
ESE RESET
2K60
115A2K29
2K80
115A2 A1 K1
2K40
115A2 K21
2K130
115A2 K30
2K120
115A2 K4
K90
K94
K100
K150
K149
K88
K87-1
K87-2
EBW FIRING UNIT NO 2 RETRO-ROCKETS
CDF MANIFOLD NO 2
S-IC RETRO-ROCKETS
EBW FIRING UNIT NO 1 SEPARATION
EBW FIRING UNIT NO 2 SEPARATION
DETONATOR BLOCK NO 1
DETONATOR BLOCK NO 2
FILAMENT
LSC
ULLAGE MOTOR FIRING UNIT 1A
ULLAGE MOTOR FIRING UNIT 1B
CDF MANIFOLD NO 1
CDF MANIFOLD NO 2
INITIATOR (8 REQD)
ULLAGE ROCKET MOTOR (4 REQD)
S-II ULLAGE ROCKETS
SECOND PLANE SEPARATION FIRING UNIT 1B
SECOND PLANE SEPARATION FIRING UNIT 1A
IST SEPARATION PLANE
2ND SEPARATION PLANE
S-IC / S-II INTERSTAGE
FIELD SPLICE
S-IC STAGE
NOTES:
1 LIFTOFF RELAY 2K130 CONTACTS NORMALLY CLOSED AFTER LIFTOFF
2 LIFTOFF RELAY 2K120 CONTACTS NORMALLY CLOSED AFTER LIFTOFF
NATIONAL AERONAUTICS & SPACE ADMINISTRATION MANNED SPACECRAFT CENTER - HOUSTON, TEXAS
PROPULSION S-IC/S-II SEPARATION SUBSYSTEM
SLV
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6.2.1
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7 S–II
SEQUENTIAL
SYSTEMS

S-II SEQUENTIAL SYSTEMS

7.1 S-II SWITCH SELECTOR FUNCTIONS (OCTAL)

CH	Code	Function	Figure No.
	000		
37	001	SPARE	
5	002	COMMAND S-II/S-IVB SEPARATION	11.1.1
30	003	COMMAND START PAM-FM/FM CALIBRATION	7-9
74	004	SPARE	
81	005	SPARE	
97	006	SPARE	
63	007	SPARE	
	010		
87	011	SPARE	
111	012	SPARE	
94	013	SPARE	
49	014	COMMAND ENGINES READY BYPASS RESET	7-4
14	015	COMMAND S-II LOX STEP PRESSURIZATION ON	9.3.1
51	016	SPARE	
39	017	SPARE	
	020		
16	021	SPARE	
24	022	COMMAND S-II ULLAGE TRIGGER	6.2.1
9	023	COMMAND STOP PAM FM/FM CALIBRATION	7-9
75	024	SPARE	
109	025	SPARE	
82	026	SPARE	
71	027	SPARE	
	030		
68	031	SPARE	
57	032	SPARE	
96	033	SPARE	
33	034	COMMAND S-II ENGINE START	7-7
7	035	COMMAND S-II LH_2 STEP PRESSURIZATION	7-6
35	036	SPARE	
17	037	SPARE	
	040		
53	041	SPARE	
23	042	COMMAND S-II SECOND PLANE SEPARATION	6.2.1
31	043	COMMAND S-II ENGINES CUTOFF RESET	7-4
61	044	COMMAND OPEN LOOP ARM RESET*	
93	045	SPARE	
102	046	SPARE	
90	047	SPARE	
	050		
69	051	SPARE	
65	052	SPARE	
73	053	SPARE	
48	054	COMMAND S-II LH_2 RECIRCULATION PUMPS OFF	7-7
6	055	COMMAND S-II START PHASE LIMITER CUT-OFF ARM RESET	7-4
52	056	SPARE	
40	057	SPARE	

*Required for ground checkout only

*

CH	Code	Function	Figure No.
	060		
38	061	S-II LH_2 TANK HIGH PRESS VENT MODE	
44	062	SPARE	
18	063	COMMAND CUTOFF S-II ENGINES	7-4
110	064	SPARE	
92	065	SPARE	
101	066	SPARE	
67	067	SPARE	
	070		
58	071	HIGH (5.5) ENGINE MIXTURE RATIO OFF	
64	072	SPARE	
95	073	SPARE	
29	074	SPARE	
25	075	COMMAND S-II START PHASE LIMITER CUTOFF ARM	7-4
36	076	SPARE	
8	077	COMMAND S-II/S-IVB ORDNANCE ARM	11.1.1
	100		
21	101	SPARE	
46	102	SPARE	
32	103	COMMAND ACTIVATE PU SYSTEM*	7-3
98	104	SPARE	
108	105	SPARE	
76	106	SPARE	
89	107	SPARE	
	110		
66	111	SPARE	
62	112	SPARE	
112	113	SPARE	
105	114	SPARE	
12	115	COMMAND S-II HYDRAULIC ACCUMULATORS UNLOCK	7-8
41	116	SPARE	
34	117	SPARE	
	120		
22	121	SPARE	
19	122	COMMAND PREVALVES LOCKOUT RESET	7-4
45	123	SPARE	
56	124	LOW (4.3) ENGINE MIXTURE RATIO ON	
91	125	SPARE	
99	126	PREVALVES CLOSE ARM	
86	127	SPARE	
	130		
84	131	SPARE	
100	132	SPARE	
60	133	COMMAND OPEN LOOP ARM*	
88	134	COMMAND CHILLDOWN VALVES CLOSE	7-2
27	135	SPARE	
42	136	COMMAND S-II LH_2 DEPLETION SENSOR CUTOFF ARM	7-4
2	137	SPARE	

*Required for ground checkout only

CH	Code	Function	Figure No.
	140		
4	141	SPARE	
3	142	COMMAND S-II LOX DEPLETION SENSOR CUTOFF ARM	7-4
10	143	SPARE	
55	144	SPARE	
107	145	SPARE	
77	146	SPARE	
85	147	SPARE	
	150		
83	151	SPARE	
79	152	SPARE	
59	153	HIGH (5.5) ENGINE MIXTURE RATIO ON	
70	154	SPARE	
47	155	SPARE	
20	156	COMMAND ENGINES READY BYPASS	7-5
15	157	COMMAND CENTER ENGINE CUTOFF	7-1
	160		
50	161	SPARE	
13	162	SPARE	
11	163	COMMAND S-II ORDNANCE ARM	6.2.1
54	164	SPARE	
106	165	SPARE	
78	166	SPARE	
104	167	SPARE	
	170		
103	171	SPARE	
80	172	SPARE	
72	173	SPARE	
28	174	SPARE	
26	175	SPARE	
43	176	SPARE	
11	177	SPARE	

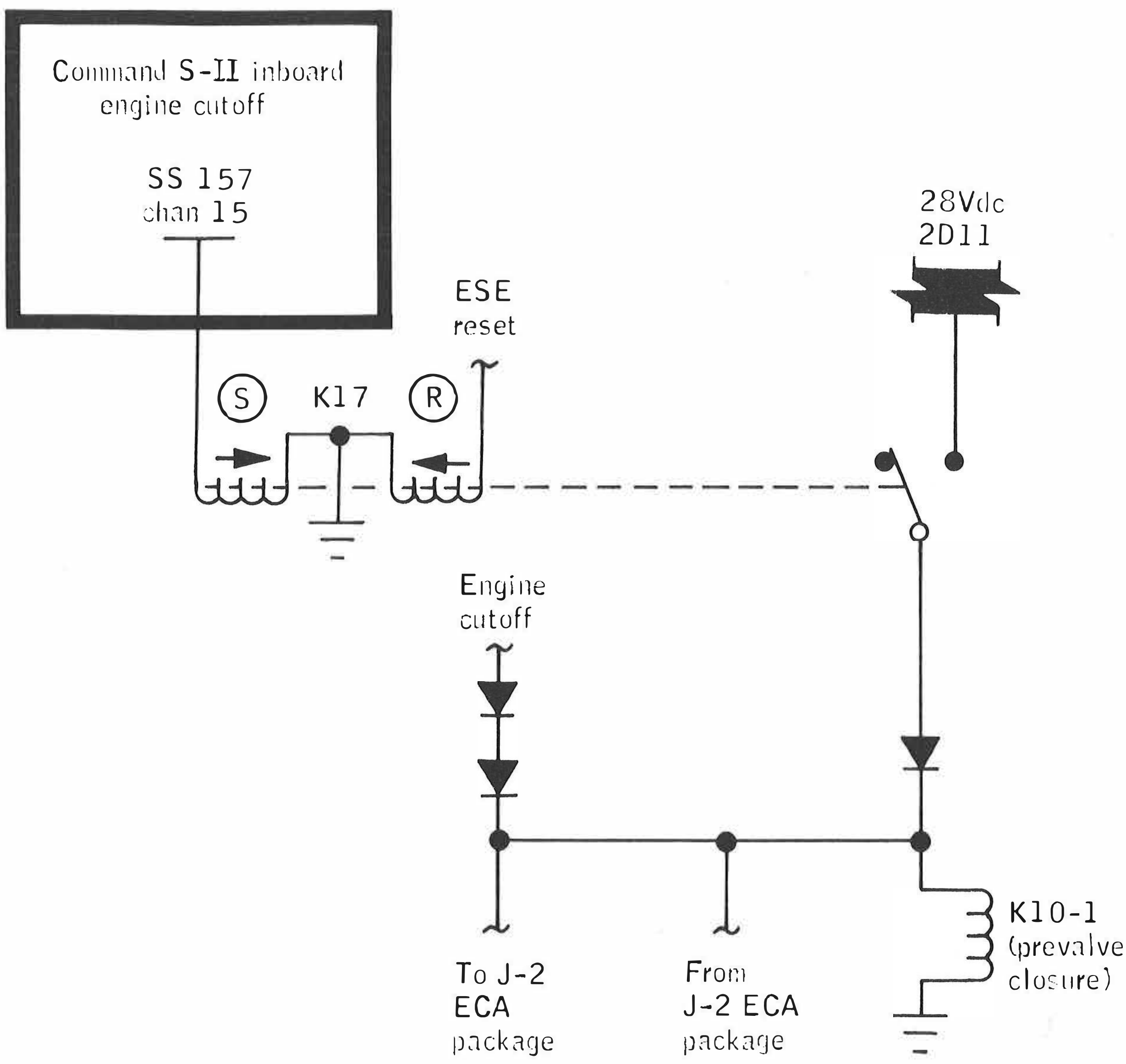


Figure 7-1.- S-II inboard engine cutoff.

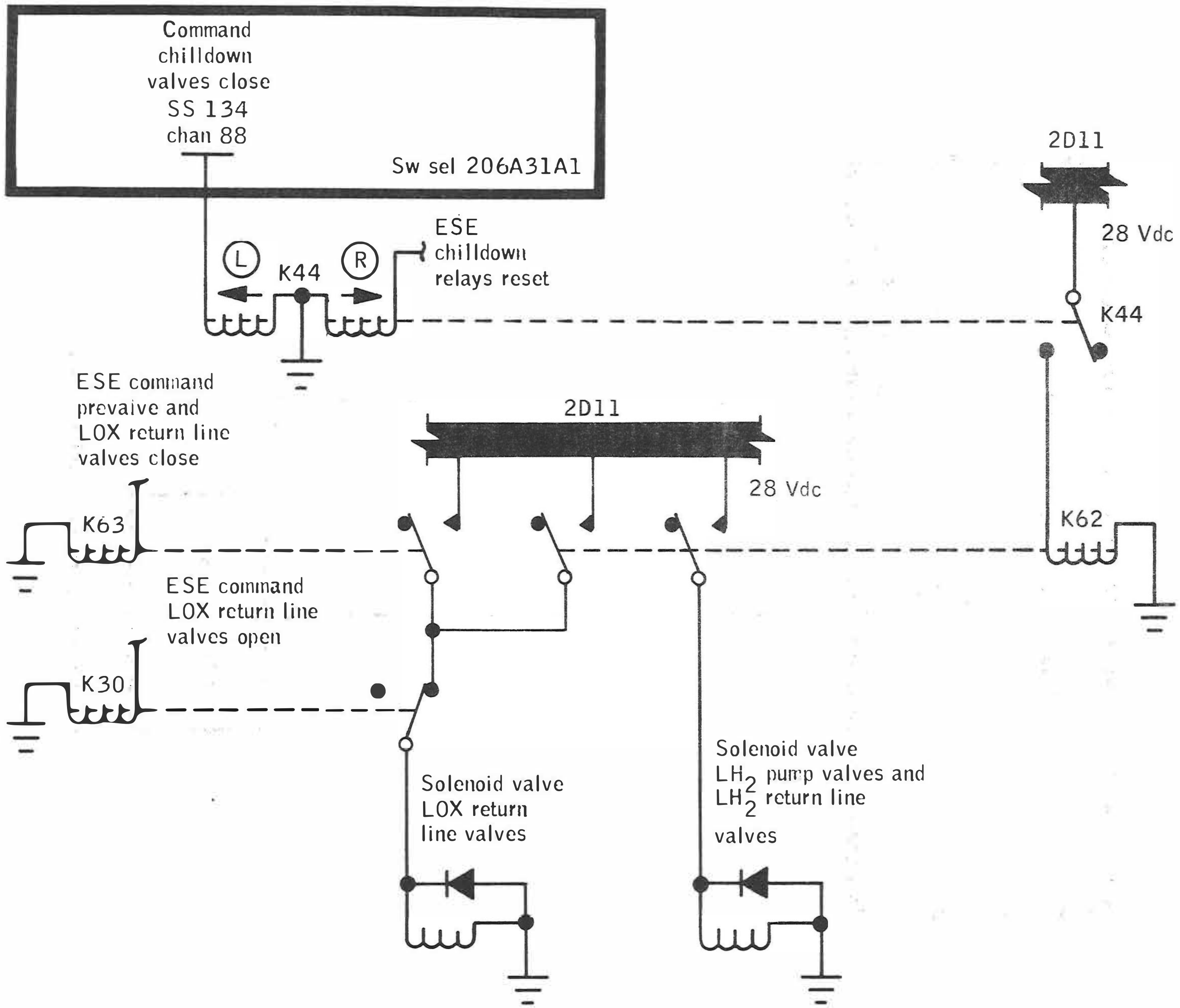
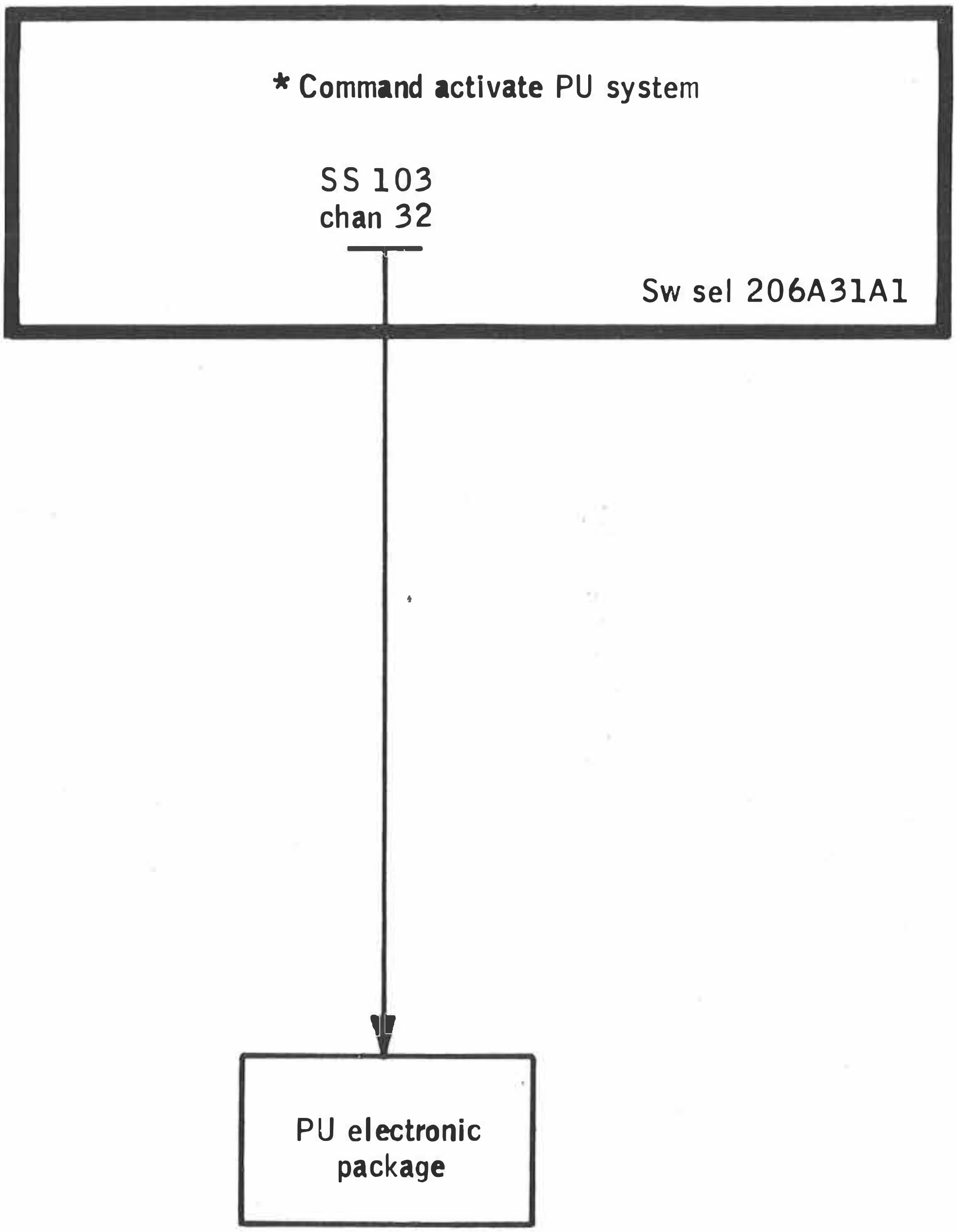
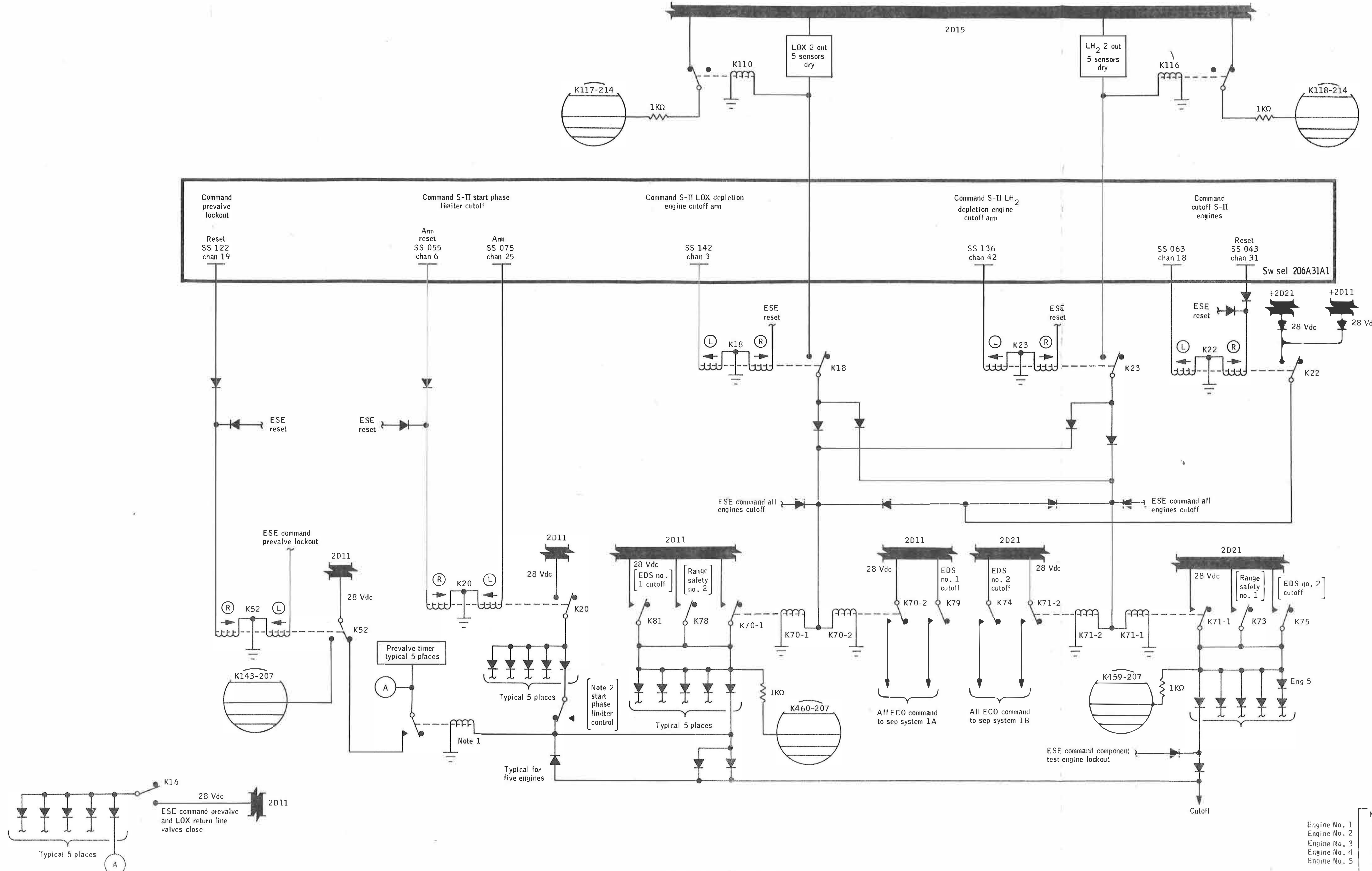


Figure 7-2.- S-II recirculation valve control.



*Used during ground checkout only.

Figure 7-3.- S-II PU system activate.



	Note 1	Note 2
Engine No. 1	K6-1	K24
Engine No. 2	K7-1	K29
Engine No. 3	K8-1	K41
Engine No. 4	K9-1	K65
Engine No. 5	K10-1	K72

Figure 7-4. - S-II engine cutoff.

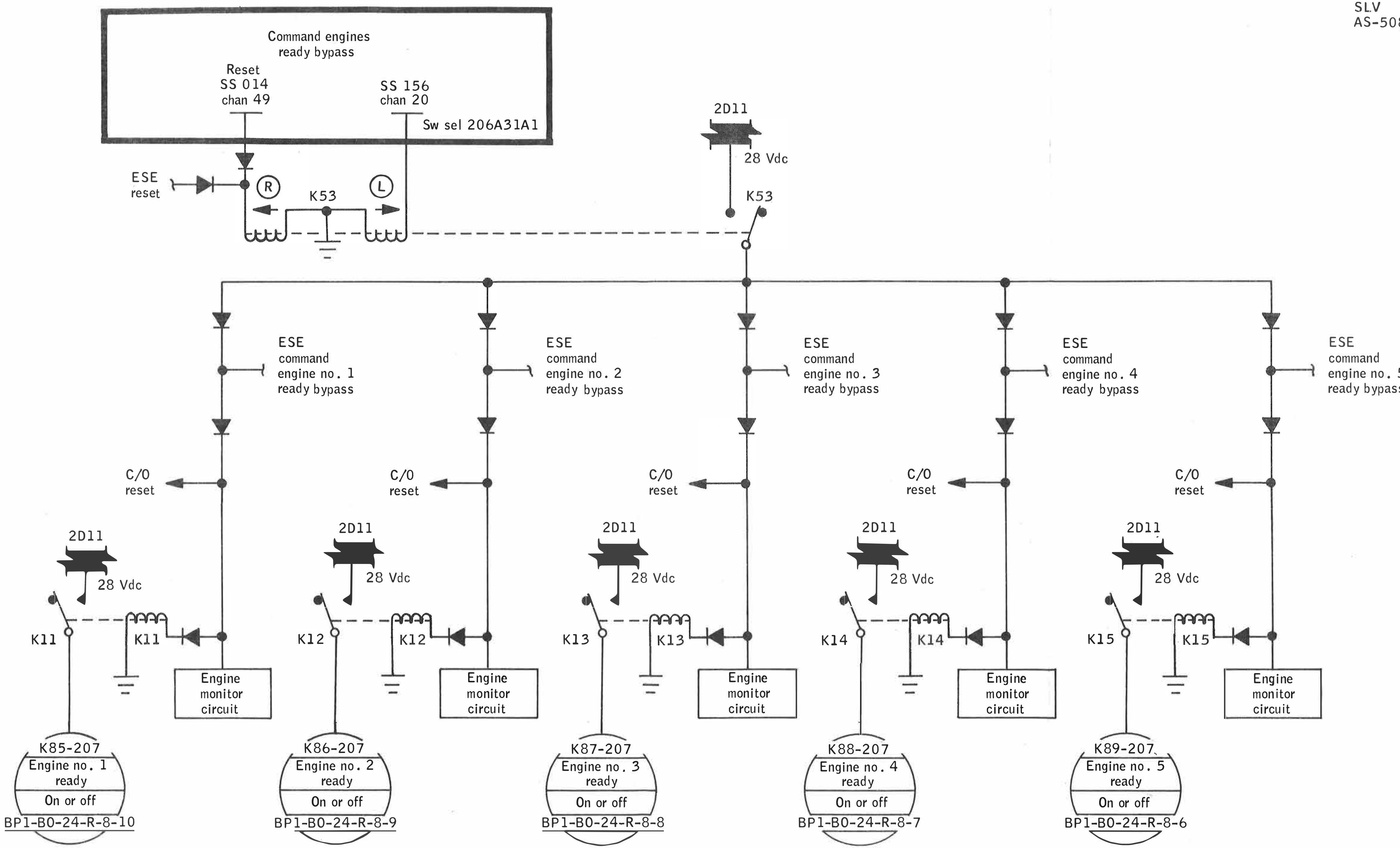


Figure 7-5.- S-II engine ready bypass.

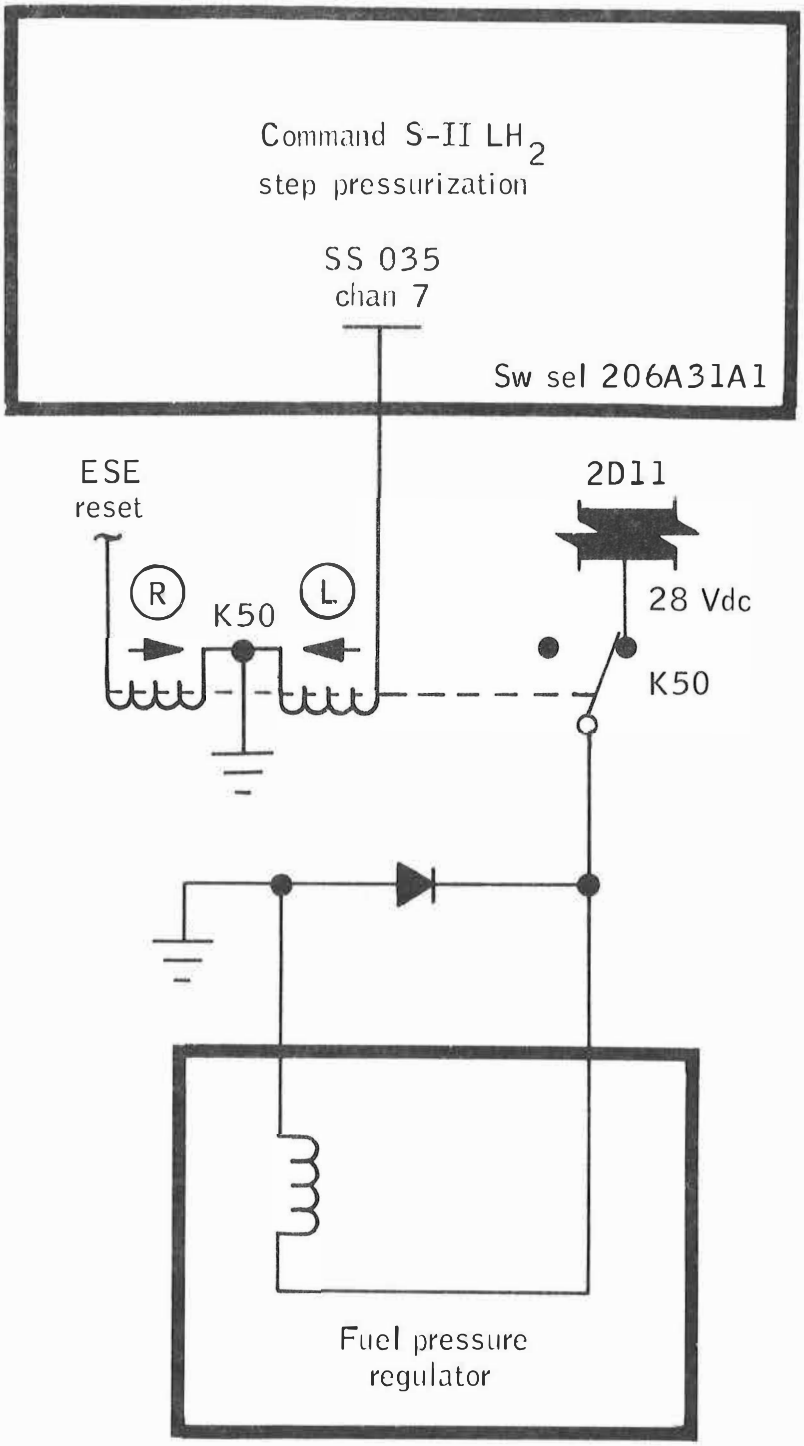


Figure 7-6.- S-II LH_2 step pressurization.

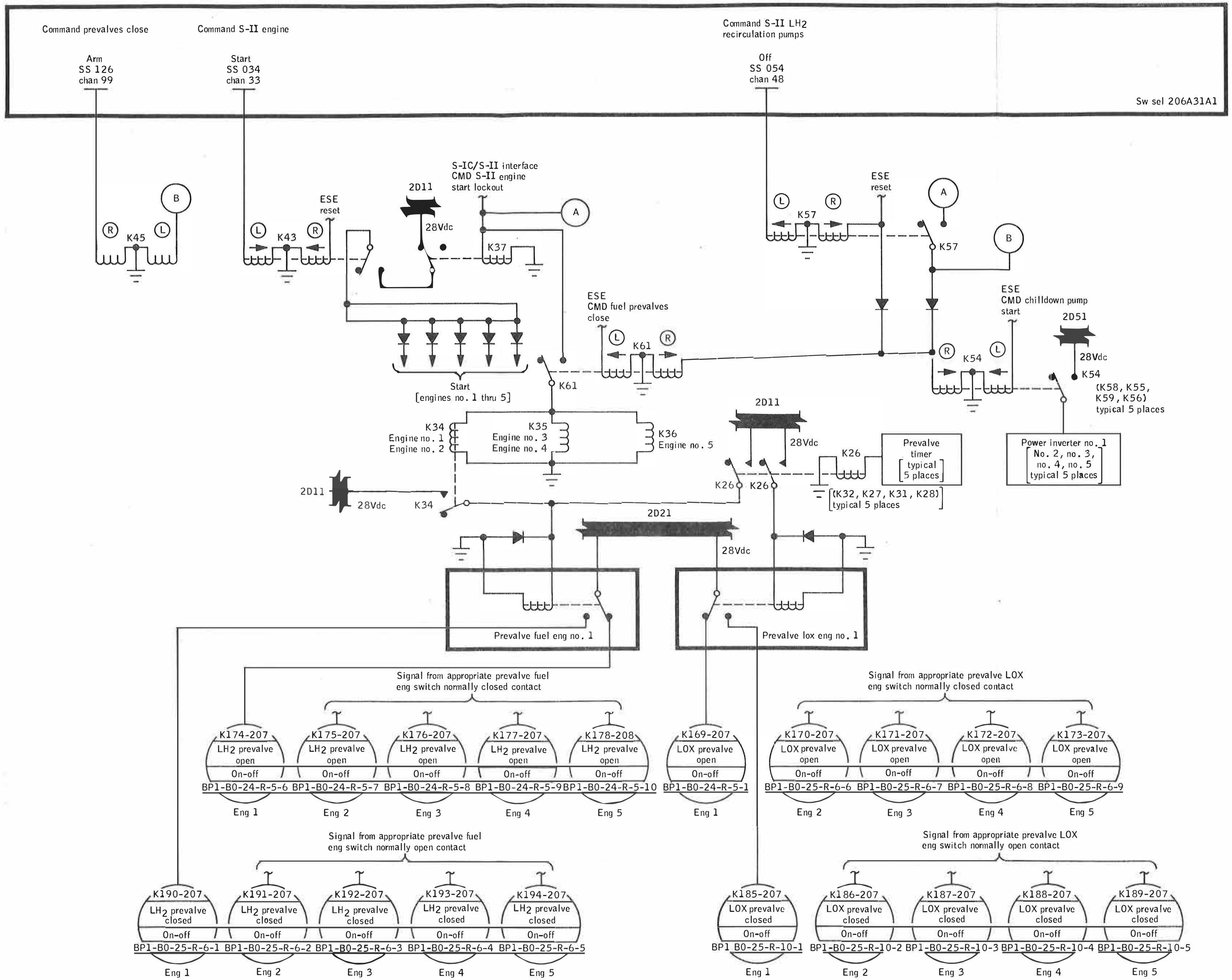


Figure 7-7. - S-II recirculation stop and engine start.

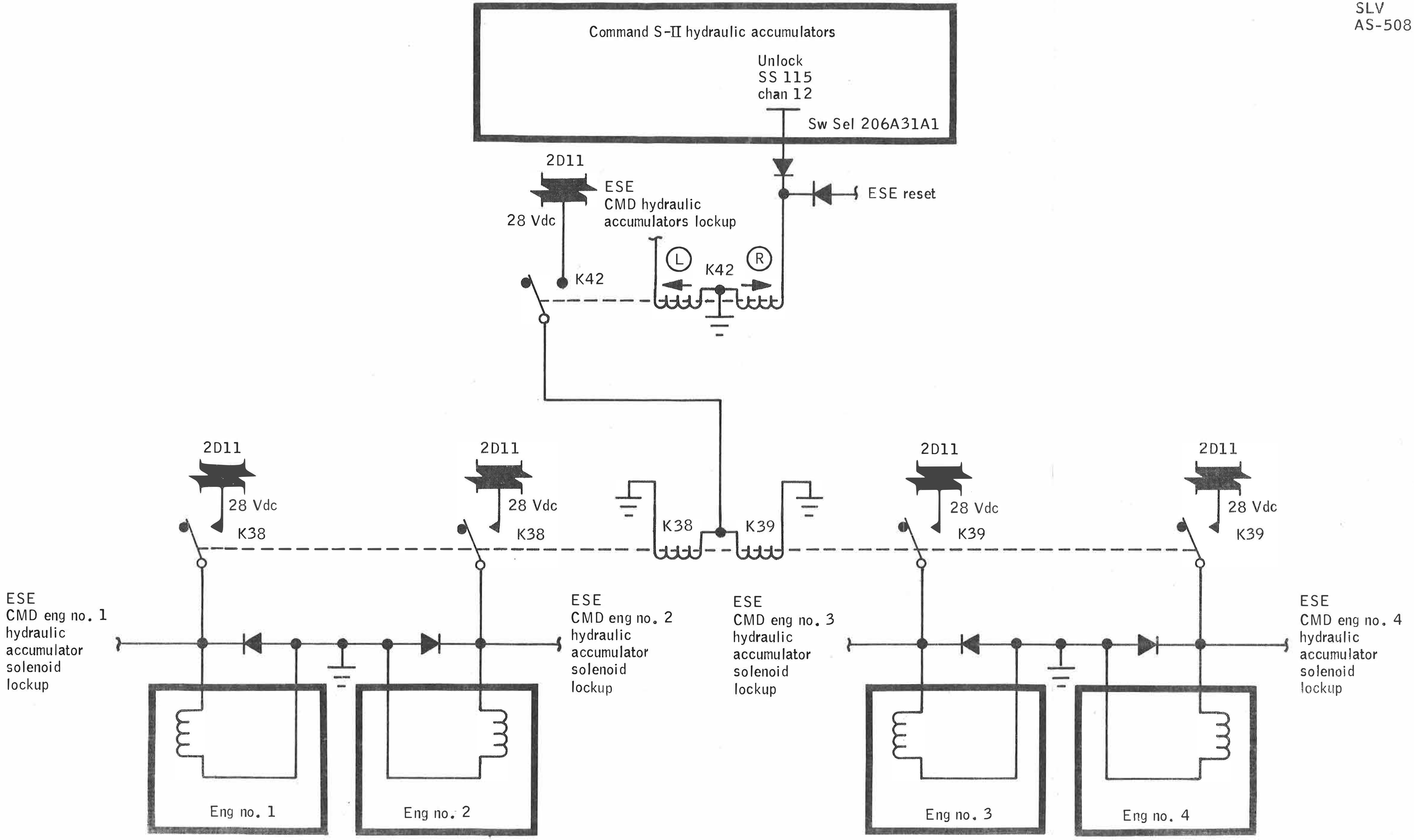


Figure 7-8. - S-II hydraulic accumulators unlock.

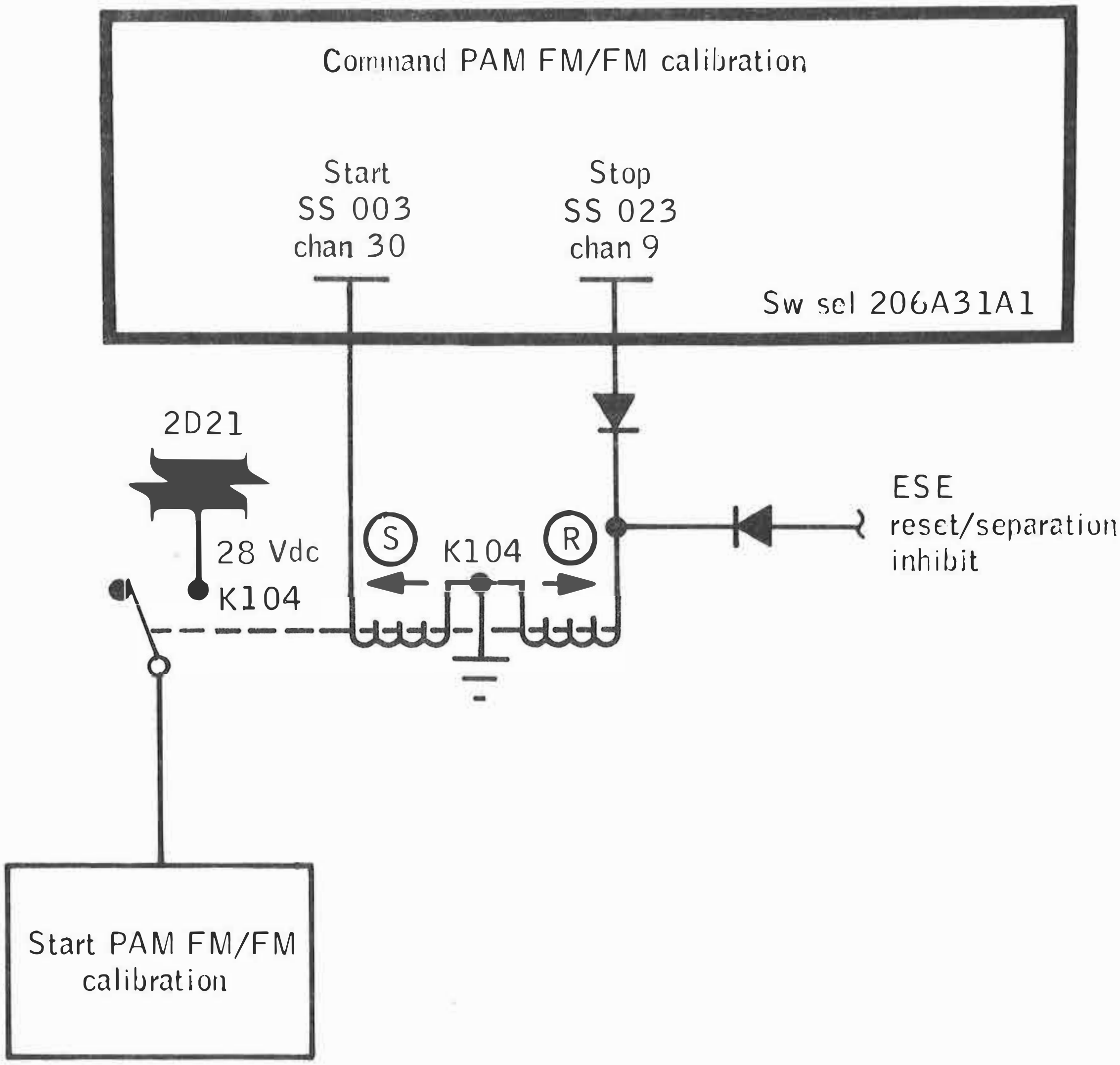


Figure 7-9.- S-II FM/FM calibration.

8 S-II ELECTRICAL POWER SYSTEM

SECTION 8

S-II ELECTRICAL POWER SYSTEM

8.1 GENERAL

The Saturn S-II electrical power system provides electrical energy to systems and components during ground and flight operations. During ground operations, power is supplied to the stage through umbilicals and drag-on cables from external sources. Four silver-oxide/zinc batteries provide power for flight operations.

The stage bus systems supply nominal 28 or 56 Vdc power to the system loads within the tolerances listed below:

Bus	Min	Max
Main dc bus	26 Vdc	32 Vdc
Instrumentation dc bus	26 Vdc	32 Vdc
Ignition dc bus	25 Vdc	31 Vdc
Recirculation dc bus	51 Vdc	60 Vdc

The main, instrumentation, ignition, and recirculation dc buses are powered during flight by batteries. Power can be supplied during ground operations by either regulated dc supplies or by batteries. The heater and ground dc buses are powered only during ground operations.

The main dc bus system supplies nominal 28-Vdc power to the systems loads. Power for ground operation is supplied by a regulated dc supply using remote sensing for regulation control. Flight power is supplied by a 35 ampere-hour battery.

Transfer from ground power to battery power requires a make-before-break (MBB) 200-ampere power transfer switch. The MBB design prevents power interruption at transfer. Auxiliary contacts are provided to indicate switch position.

An additional 200-ampere power transfer switch applies power to the propellant management system. An auxiliary contact indicates the reset (Power Off) position of the switch.

The instrumentation dc bus system supplies nominal 28-Vdc power to the system loads. Power for ground operation is supplied by a regulated dc supply using remote sensing for regulation control. Flight power is supplied by a 35 ampere-hour battery.

Transfer from ground power to battery power requires a make-before-break (MBB) 200-ampere power transfer switch. Auxiliary contacts indicate switch position. A separate auxiliary contact automatically applies power to the RF transmitters at transfer to internal power.

The recirculation dc bus system supplies nominal 56-Vdc power to five recirculation pump-motor inverters. Power for ground operation is supplied by a regulated dc supply using remote sensing for regulation control. Flight power is supplied by two 25 ampere-hour batteries connected in series.

Transfer from ground power to battery power is supplied by a make-before-break (MBB) 200-ampere power transfer switch. Auxiliary contacts indicate switch position.

The five inverters are turned on sequentially by five magnetic latching relays for checkout and operational purposes. The relays switch only control power to the inverters; the output stages are connected directly to the recirculation dc bus. Provisions have been included for monitoring relay position prior to power application.

The ignition dc bus system supplies nominal 28-Vdc power to the five J-2 engine ignition buses. Power for ground operation is supplied from the main dc bus regulated supply. Flight power is supplied from the 28-volt tap on the recirculation battery system.

Transfer from the main bus ground power supply to battery power is accomplished using the second set of power contacts in the main bus power transfer switch.

8.1.1 Related Instrumentation Equipment

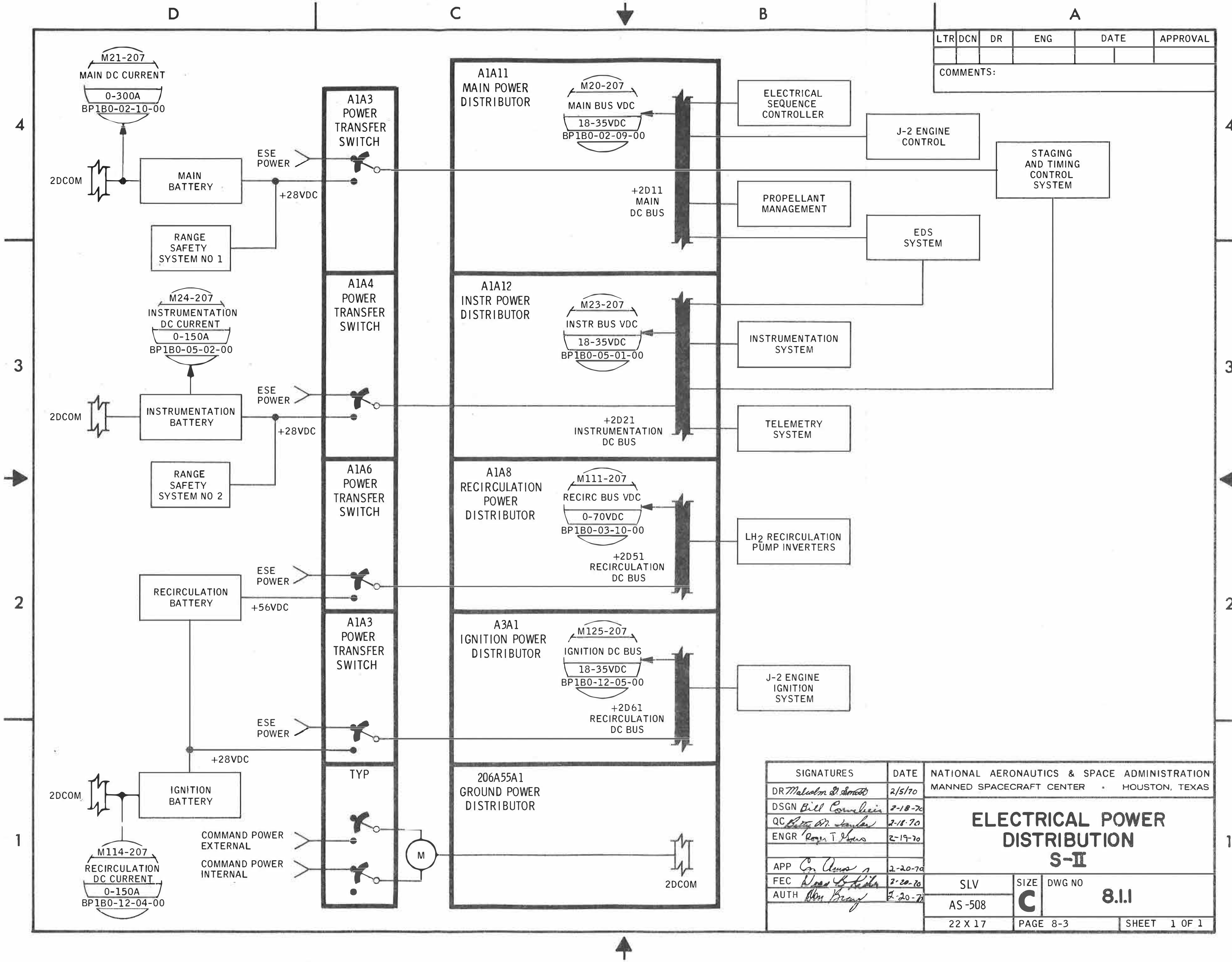
Two types of signal conditioners are incorporated into the bus systems. For the main, instrumentation, and ignition dc buses, an attenuator converts an 18 to 35 Vdc bus voltage into a 0 to 5 Vdc signal. For the recirculation dc bus, an attenuator converts a 0 to 70 Vdc bus voltage into a 0 to 5 Vdc signal.

For the main, instrumentation, and recirculation batteries, the current sensors convert the negative wire battery currents from 0 to 300 amperes, 0 to 150 amperes, and 0 to 150 amperes respectively, into 0 to 5 Vdc signals. Measurement of negative wire battery currents allows for continuous monitoring of the battery currents after battery installation. The current sensors measure the magnetic field surrounding the wires rather than using a calibrated shunt in the power wire.

8.1.2 Measurements

The following list contains measurements of the electrical power system parameters. These measurements will be displayed on MSC consoles in support of Saturn launch operations.

Function	Number	Signal
Main dc bus voltage	M020-207	18 to 35V (0 to 5V)
Main dc bus current	M021-207	0 to 300A (0 to 5V)
Instrumentation dc bus voltage	M023-207	18 to 35V (0 to 5V)
Instrumentation dc bus current	M024-207	0 to 150A (0 to 5V)
Recirculation dc bus voltage	M111-207	0 to 70V (0 to 5V)
Recirculation dc bus current	M114-207	0 to 150A (0 to 5V)
Ignition dc bus voltage	M125-207	18 to 35V (0 to 5V)
Recirculation battery 1 temperature	C540-200	0 to 140F (0 to 5V)
Recirculation battery 2 temperature	C541-200	0 to 140F (0 to 5V)



LTR	DCN	DR	ENG	DATE	APPROVAL

COMMENTS:

SIGNATURES	DATE
DR	2/5/70
DSGN	2-18-70
QC	2-18-70
ENGR	2-19-70
APP	2-20-70
FEC	2-20-70
AUTH	2-20-70

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ELECTRICAL POWER DISTRIBUTION S-II

SLV	SIZE	DWG NO
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9 S-II PROPULSION SYSTEM

SECTION 9

S-II PROPULSION SYSTEM

9.1 S-II HYDRAULIC SYSTEM

9.1 General Notes

The S-II hydraulic system provides attitude control by gimbaling the four outboard engines during powered flight. The system consists of four independent, closed-loop, hydraulic control subsystems which provide power for gimbaling. Electrohydraulic actuators (two per outboard engine), mounted in perpendicular planes, furnish gimbal forces by extending or retracting simultaneously in accordance with electrical input signals. Each actuator is capable of gimbaling 6.1° outboard (S-II-1 through 3 and 11 and subs, 5.7° S-II-4 through 10) and 7.5° inboard.

9.1.2 System Description

The S-II stage engine actuation system is a closed hydraulic system that provides power to gimbal the J-2 engines. The engine position feedback control loop is a closed system of mechanical feedback devices located within each servoactuator. A complete, separate, and identical system is provided for each outboard engine. An external hydraulic power source is utilized for servicing.

The system schematic is shown in Drawing 9.1.1. Major system components include an engine-driven main pump; an (electric-motor-driven) auxiliary pump; two electrically controlled, hydraulically powered servoactuators utilizing mechanical feedback and containing actuator lockup valves; and an accumulator reservoir manifold assembly which, in addition to the accumulator and reservoir, includes the main system filters, ground-hydraulic-power quick-disconnect couplings, and relief valves.

Fluid is distributed throughout the system by way of flexible hose assemblies and rigid tubing. Gimbal forces are provided by the two servoactuators which are mounted with their piston centerlines parallel (except for precant) to the engine center-line null position. Engine position control is achieved by an electrical signal proportional to the engine position command, transmitted from the control computer to each of the servoactuators, one for pitch and one for yaw. The servoactuators are operated differentially for roll.

During engine firing, the prime source of hydraulic power is the main pump, which is driven by the J-2 engine oxidizer turbopump. An accumulator, with the aid of the main pump, supplies power during the S-IC/S-II separation transient and supplements the main pump during S-II boost peak hydraulic power demands. During ground operation, when the engine is not functioning, hydraulic power is supplied by the auxiliary motor pump. Inlet pressurization for both pumps is derived from the accumulator gas pressure acting on the reservoir fluid through a pressurizing piston, when the system is shut down. When operating, pressurization is provided by accumulator oil pressure (bootstrap). The system contains approximately 460 in^3 of hydraulic fluid for a serviced configuration.

9.1.3 Component Description

9.1.3.1 Main pump.- The main pump is a variable-displacement, pressure-compensated, piston-type unit. Except for peak power demands, hydraulic power during engine operations is supplied to the servoactuators solely by the main pump. The pump is attached to the J-2 engine oxidizer turbopump accessory drive pad through a thermal barrier integral with the pump assembly. The barrier provides protection for the pump subassembly from the extremely low and high temperatures of the drive pad. Low temperatures are caused by the pressure of lox in the turbopump during propellant loading. High temperatures are a result of turbopump exhaust gases during S-II boost. Suitable static gas seals are provided between the pump subassembly and barrier and between the barrier and drive pad. Power is transmitted from the turbopump to the main pump by a separate quill shaft. To prevent overloading of the turbopump in the event of main pump seizure, a section of the main pump's drive shaft (internal to the pump) is designed to shear at 500 to 600 in-lbs.

The pump case drain flows through a filter and check valve and is then directed to the suction line through an external line. The purpose of the case drain check valve is to prevent a high rate of loss of system fluid (from the reservoir) in the event of pump shaft seal failure. A check valve is incorporated at the pressure outlet port to prevent motoring the lox turbopump. There is, however, a normally closed solenoid operated bypass valve and load orifice to provide reverse flow through the pump case for thermal control of the pump and its associated inlet and outlet lines during periods with propellants loaded prior to launch. (The flow is provided by the auxiliary motor pump, the next component described.) The valve is an integral part of the pump and directs the flow from the pump outlet port to the pump case, downstream of the high-pressure check valve. The pump discharge flow rate is regulated by a pressure compensator.

Significant main pump characteristics:

Displacement	0.256 in^3 per revolution max
Operating speed	7000 to 9000 rpm
Rated delivery	8 gpm at 8000 rpm
Rated discharge pressure*	3500 psi
Rated inlet pressure	80 psi
Shaft power	20 hp at rated delivery and pressure

9.1.3.2 Auxillary motor pump.- The auxiliary motor pump consists of a variable-displacement, pressure-compensated, piston-type pump mated to and driven by a 400-cycle, 115/200-volt, four-wire, GSE-operated ac motor. The motor receives power and is controlled from an external ground supply. The auxiliary motor pump is mounted on the S-II stage thrust structure on a common panel with the accumulator reservoir manifold assembly. It is capable of emergency two-phase operation. The thermal protector is provided in the motor to protect it from overheating. The pump case drain line is connected to the accumulator-reservoir manifold assembly upstream from the reservoir filter. Check valves are included in the case drain and outlet ports to prevent loss of system fluid and to prevent driving the motor.

The auxiliary motor pump provides hydraulic power to accomplish limited "cold" gimbaling during ground operation of the system. In addition, the auxiliary motor pump operates as required to fill the accumulator prior to accumulator lockup and to maintain system fluid temperature control during system operation with S-II stage propellants tanked.

Significant auxiliary motor pump characteristics:

Displacement	0.066 in^3 per revolution max
Operating speed	7600 ± 400 rpm
Rated delivery	2 gpm at 7600 rpm
Rated discharge pressure**	3650 psi
Rated inlet pressure	80 psi
Input power	4800 watts at rated delivery and pressure

9.1.3.3 Accumulator-reservoir manifold assembly.- The accumulator-reservoir manifold assembly (ARMA) is mounted on the S-II stage thrust structure and includes the following as integral parts of the unit:

A. Accumulator
B. Reservoir
C. High and low pressure relief valves
D. Solenoid operated accumulator lockup valves
E. High and low pressure filters
F. Thermal switch
G. Nitrogen charging valve
H. Hydraulic ground power disconnects
I. Bleed valve

*The pressure compensator is preset by the subcontractor at 3500/3650 psi: however, it is capable of adjustment to a discharge pressure of from 3000 psi to 3800 psi with an appropriate change in ratings.
**3650/3800.

The accumulator is an in-line, hydropneumatic, high-pressure piston type unit. The gas chamber is precharged with nitrogen and the liquid chamber is charged with hydraulic fluid from the motor pump. The function of the accumulator is to store high-pressure fluid to gimbal the engine at S-IC/S-II stage separation prior to full main pump operation, to supplement main pump flow during peak system demands, to supplement auxiliary pump flow during cold gimbaling, and to dampen pump discharge pulsations and system surges. Storage and release of high-pressure fluid is accomplished by closing the lockup valves prior to lift-off and opening the valves at separation.

Significant accumulator characteristics:

Nitrogen precharge pressure at 70°F	2200 psi
Nitrogen precharge volume	300 in^3
Operating pressure	3650 psi
Full stroke hydraulic fluid volume	120 in^3

The lockup valves consist of two normally open valves actuated by a solenoid. The solenoid is of the ac type and actuates in a range of 18 to 32 volts, with a dropout voltage of not less than 2 volts. The continuous power drain is a maximum of 50 watts. The valves close the accumulator inlet and outlet ports, thus storing high-pressure fluid in the accumulator. The fluid is available for functional demand when the valves are opened by deenergizing the solenoid. The stored fluid is then exposed to system pressure. Fluid partially bypasses the accumulator when the valves are closed. This feature prevents "dead heading" (zero outlet flow) the auxiliary pump in the event of a failed valve, a condition which could cause the pump to overheat. The bypass also serves the purpose of allowing main pump flow to reach the servoactuators in the event of an accumulator lock malfunction during S-II boost. This bypass is also designed to provide fluid circulation through the accumulator for temperature control when the lockup valves are open. Between 20 to 50 percent of the fluid entering the manifold flows through the accumulator.

The reservoir is an in-line, low-pressure, variable-volume, piston type which receives return fluid from the system and supplies low-pressure fluid to both pumps. As shown on the system schematic (Drawing 9.1.1), the reservoir can be pressurized by either the accumulator gas or by the accumulator hydraulic fluid. The former means of pressurization is provided by a small piston, located in the gas chamber, acting directly on the reservoir piston shaft. This is effective only at reservoir volumes of from full to full minus 60 in^3 minimum. The purpose of this feature is to provide pressurization of the auxiliary pump inlet at pump start. The pressure in the reservoir is approximately 50 psi during this mode of operation. When the reservoir contains less fluid than that described above, such as exists when the accumulator is partially full to full, the reservoir is pressurized in a typical "bootstrap" fashion wherein the force on the small piston in the hydraulic fluid chamber of the accumulator is balanced by the force acting on the reservoir piston. The reservoir piston-to-bootstrap piston area ratio is nominally 40:1, providing a pressure of 88 psi to the reservoir for a system pressure of 3500 psi.

Significant reservoir characteristics:

Full stroke fluid volume	200 in^3
Fluid pressure (pneumatic spring)	50 psi
Fluid pressure derived from accumulator fluid pressure (bootstrap)	88 psi

The high- and low-pressure relief valves protect their respective portions of the system from overpressure. The low-pressure valve is plugged prior to flight by means of a captive plug chained to the assembly. The plug is removed from the valve outlet port during hydraulic ground power operations where inadvertent overpressurization of the low-pressure side of the system is possible due to human errors such as failure to couple the low-pressure return to the ground console. Suitable GSE is then attached to the valve outlet port to transport any leakage flow to the ground source.

The characteristics of the relief valves are as follows:

	High-pressure valve	Low-pressure valve
Cracking pressure, psi	3850 minimum	200 minimum
Rated flow	8 gpm at 4450 psid	8 gpm at 225 psid
Reseat pressure, psi	3700 minimum	175 minimum

All fluid, including that entering through the high-pressure disconnect from the ground hydraulic power unit, passes through the high-pressure filter prior to entering the system. All return fluid passes through the low-pressure filter prior to entering the reservoir. Both high- and low-pressure filters are rated at 15 microns absolute.

The thermal switch senses system return fluid temperature and, in conjunction with the control circuitry of the external 400 cycle 115 volt ac supply console, prevents operation of the auxiliary motor pump when system return fluid temperature exceeds 200 ± 10°F.

The manifold assembly incorporates the necessary porting to connect the system pumps to the servoactuators. In addition, the manifold assembly incorporates mounting and porting provisions for the various components previously discussed.

9.1.3.4 Servoactuator.- The servoactuators (two per system) are linear, double-acting, equal-area, piston-type units. The developed force, direction, and velocity are determined by an electrohydraulic servovalve. The valve and actuator together with the actuator piston-position mechanical feedback, constitute a position servo wherein the torque developed in the feedback loop just balances that developed in the torque motor when the actuator is at its commanded position. A pictorial schematic of the servoactuator is shown in Drawing 9.1.1. Each unit includes the following integral components:

A. Servovalve with a hydromechanical load damping network
B. Prefiltration bypass valve
C. Filter
D. Hydraulic lock valve
E. Cylinder bypass valve with plunger for manual operation and solenoid operated pilot valve for remote operation
F. Piston bypass valve
G. Dual element piston position potentiometer
H. Removable mid-stroke mechanical lock
I. Removable visual piston position indicator

Significant servoactuator characteristics:

Operating pressure	3650 psi
Effective piston area	13 in^2
Stroke	±1.51 in. (engine movement = 7.5° for actuator extended, 7.1° for actuator retracted) Capability of reducing stroke by 0.4 in. (extend and retract) is provided.
Rated torque motor current	50 milliamperes

Rates at design loads and differential pressures:

Actuator rate (in. per sec)	Design load (lbs)	Differential pressure (supply to return psi)
2.0 minimum	30,000 minimum	3500 maximum
2.0 minimum	24,000 minimum	2700 maximum
5.2 maximum	No load	3400 to 3500

The servovalve is a four-way, electrhydraulic-flow-control valve utilizing mechanical feedback from the actuator piston to the first stage. The first stage consists of a torque motor operating a flapper valve. The motor coil receives engine position command signals and torques the flapper in proportion to these signals. The flapper valve acts as an hydraulic amplifier in positioning the second stage power spool. In addition, the flapper is torqued by the mechanical feedback mechanism in proportion to actuator piston position. Thus, the flapper sums the opposing torques from the torque motor and the mechanical feedback mechanism, nulling the power spool as the engine reaches its commanded position. The power spool ports high-pressure fluid to one side of the actuator piston and simultaneously ports the opposite side of the piston to return. The resulting differential pressure causes the piston to move in accordance with the command signal. The valve utilizes dynamic pressure feedback (DPF) load damping to insure servoactuator performance as specified in the procurement specification. Provision has been made in the servoactuator design so that the servovalve can be removed and replaced by an electrical feedback type of the same capacity and performance characteristics for backup capability in the event electrical feedback is made a requirement in the future.

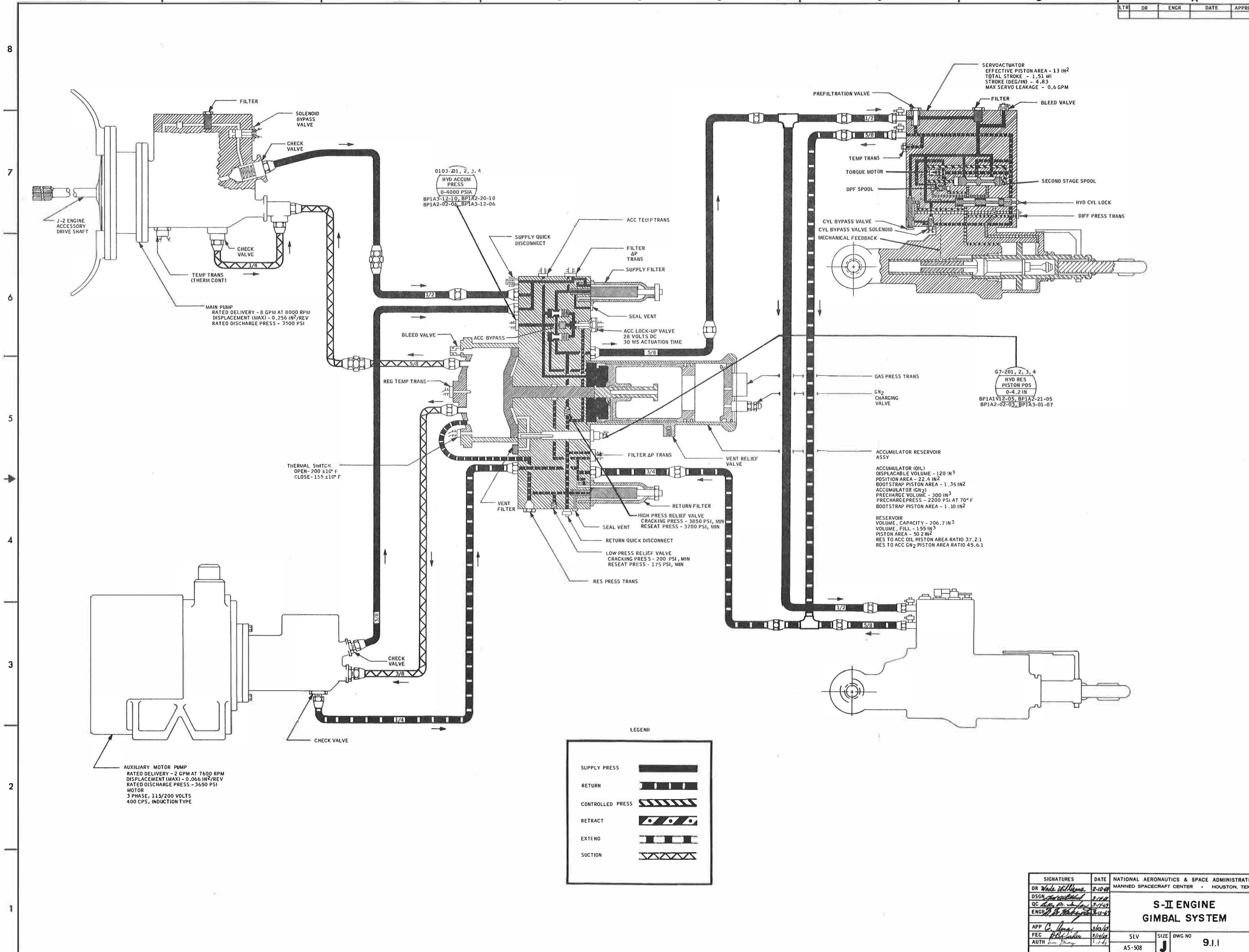
The servoactuator prefiltration valve is located at the servoactuator pressure inlet port. This valve ports servoactuator inlet fluid directly to the outlet port in order to bypass the servoactuator during flushing operations.

Each servoactuator incorporates a pressure actuated hydraulic lock valve which locks the actuator piston, hence the engine, in the event inlet pressure to the actuator is lost. The lock valve actuates from open to close and vice versa within a pressure bank of 1300 to 1700 psi.

A cylinder bypass valve is incorporated in each servoactuator. When opened, this valve allows hydraulic fluid to flow from either side of the actuator piston to the opposite side. The valve can be operated either manually or remotely by electrical power. The purpose of the manual feature is to relieve hydraulic locking of the actuator piston, thereby allowing manual movement of the actuator in the absence of hydraulic power. The purpose of the remote feature is to eliminate the force input of the actuator during the start of J-2 engine static firings when the side load arresting mechanism (SLAM) is in place. The SLAM-to-engine attachment may not be capable of withstanding a force (from the actuators) in addition to that produced by the engine start transients. The bypass valve closes automatically at actuator inlet pressures of less than 500 psi but permits manual operation below 100 psi. The valve employs a differential area spool which has its smaller area always exposed to system pressure to provide the normally closed feature. For remote operation, a solenoid-operated pilot valve is used to open the bypass valve. With 28-Vdc power applied to the solenoid, system pressure is ported to the larger piston area of the bypass valve, thereby producing the force necessary to open the valve. The pressure required to perform this function is approximately 500 psi. Upon removal of power to the solenoid, the larger spool area is ported to return pressure allowing the valve to close.

The actuator piston contains a bypass valve for the purpose of allowing fluid to circulate through the actuator during the system temperature control cycle when propellants are tanked. The valve is open during the last 0.10 inch of piston stroke in the extended direction and passes 0.20 gpm at 3500 psid.

Each servoactuator contains a dual-element piston-position potentiometer which is described under "instrumentation" in this section.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APPROVAL
8
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3
2
1
J-2 ENGINE ACCESSORY DRIVE SHAFT
FILTER
SOLENOID BYPASS VALVE
CHECK VALVE
CHECK VALVE
1/4
TEMP TRANS (THERM CONT)
MAIN PUMP
RATED DELIVERY - 8 GPM AT 8000 RPM
DISPLACEMENT (MAX) - 0.256 IN^3/REV
RATED DISCHARGE PRESS - 3500 PSI
0103-201, 2, 3, 4
HYD ACCUM PRESS
0-4000 PSIA
BP1A3-12-10, BP1A2-20-10
BP1A2-02-06, BP1A3-12-06
ACC TEMP TRANS
SUPPLY QUICK DISCONNECT
FILTER ΔP TRANS
SUPPLY FILTER
1/2
SEAL VENT
ACC LOCK-UP VALVE
28 VOLTS DC
30 MS ACTUATION TIME
BLEED VALVE
ACC BYPASS
5/8
5/8
REG TEMP TRANS
THERMAL SWITCH
OPEN - 200 ±10° F
CLOSE - 155 ±10° F
FILTER ΔP TRANS
VENT RELIEF VALVE
3/4
VENT FILTER
RETURN FILTER
HIGH PRESS RELIEF VALVE
CRACKING PRESS - 3850 PSI, MIN
RESEAT PRESS - 3700 PSI, MIN
SEAL VENT
RETURN QUICK DISCONNECT
LOW PRESS RELIEF VALVE
CRACKING PRESS - 200 PSI, MIN
RESEAT PRESS - 175 PSI, MIN
RES PRESS TRANS
3/8
CHECK VALVE
3/8
1/4
CHECK VALVE
AUXILIARY MOTOR PUMP
RATED DELIVERY - 2 GPM AT 7600 RPM
DISPLACEMENT (MAX) - 0.066 IN^3/REV
RATED DISCHARGE PRESS - 3650 PSI
MOTOR
3 PHASE, 115/200 VOLTS
400 CPS, INDUCTION TYPE
SERVOACTUATOR
EFFECTIVE PISTON AREA - 13 IN^2
TOTAL STROKE - 1.51 MI
STROKE (DEG/IN) - 4.83
MAX SERVO LEAKAGE - 0.6 GPM
PREFILTRATION VALVE
FILTER
BLEED VALVE
1/2
5/8
TEMP TRANS
TORQUE MOTOR
DPF SPOOL
SECOND STAGE SPOOL
HYD CYL LOCK
DIFF PRESS TRANS
CYL BYPASS VALVE
CYL BYPASS VALVE SOLENOID
MECHANICAL FEEDBACK
GAS PRESS TRANS
GN_2 CHARGING VALVE
G7-201, 2, 3, 4
HYD RES PISTON POS
0-4.2 IN
BP1A1V12-05, BP1A2-21-05
BP1A2-02-03, BP1A3-01-07
ACCUMULATOR RESERVOIR ASSY
ACCUMULATOR (OIL)
DISPLACABLE VOLUME - 120 IN^3
POSITION AREA - 22.4 IN^2
BOOTSTRAP PISTON AREA - 1.35 IN^2
ACCUMULATOR (GN_2)
PRECHARGE VOLUME - 300 IN^3
PRECHARGEPRESS - 2200 PSI AT 70° F
BOOTSTRAP PISTON AREA - 1.10 IN^2
RESERVOIR
VOLUME, CAPACITY - 206.7 IN^3
VOLUME, FILL - 155 IN^3
PISTON AREA - 50 2 IN^2
RES TO ACC OIL PISTON AREA RATIO 37.2:1
RES TO ACC GN_2 PISTON AREA RATIO 45.6:1
1/2
5/8
LEGEND
SUPPLY PRESS
RETURN
CONTROLLED PRESS
RETRACT
EXTEND
SUCTION
SIGNATURES
DATE
DR Wade Williams 2-10-69
DSGN 3-14-69
QC 3-14-69
ENGR 3-13-69
APP C. Ang 3/13/69
FEC 3/14/69
AUTH 3-17-69
NATIONAL AERONAUTICS & SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER • HOUSTON, TEXAS
S-II ENGINE
GIMBAL SYSTEM
SLV
AS-508
SIZE
J
DWG NO
9.1.1
44 X 34
PAGE 9-6
SHEET 1 OF 1

9.2 S-II LH_2 PRESSURIZATION AND CONDITIONING

9.2.1 Prelaunch Phase

Prepressurization is initiated in the terminal countdown sequence at approximately T - 97 seconds and continues until T - 30 seconds. The two fuel tank vent valves are closed and in the low-pressure vent mode. The disconnect valve and ground prepressurization valves are opened to allow gaseous helium to flow from the ground source through the prepressurization solenoid valve and into the fuel tank distributor. The fuel tank pressure is maintained between 34 and 36 psia prior to launch.

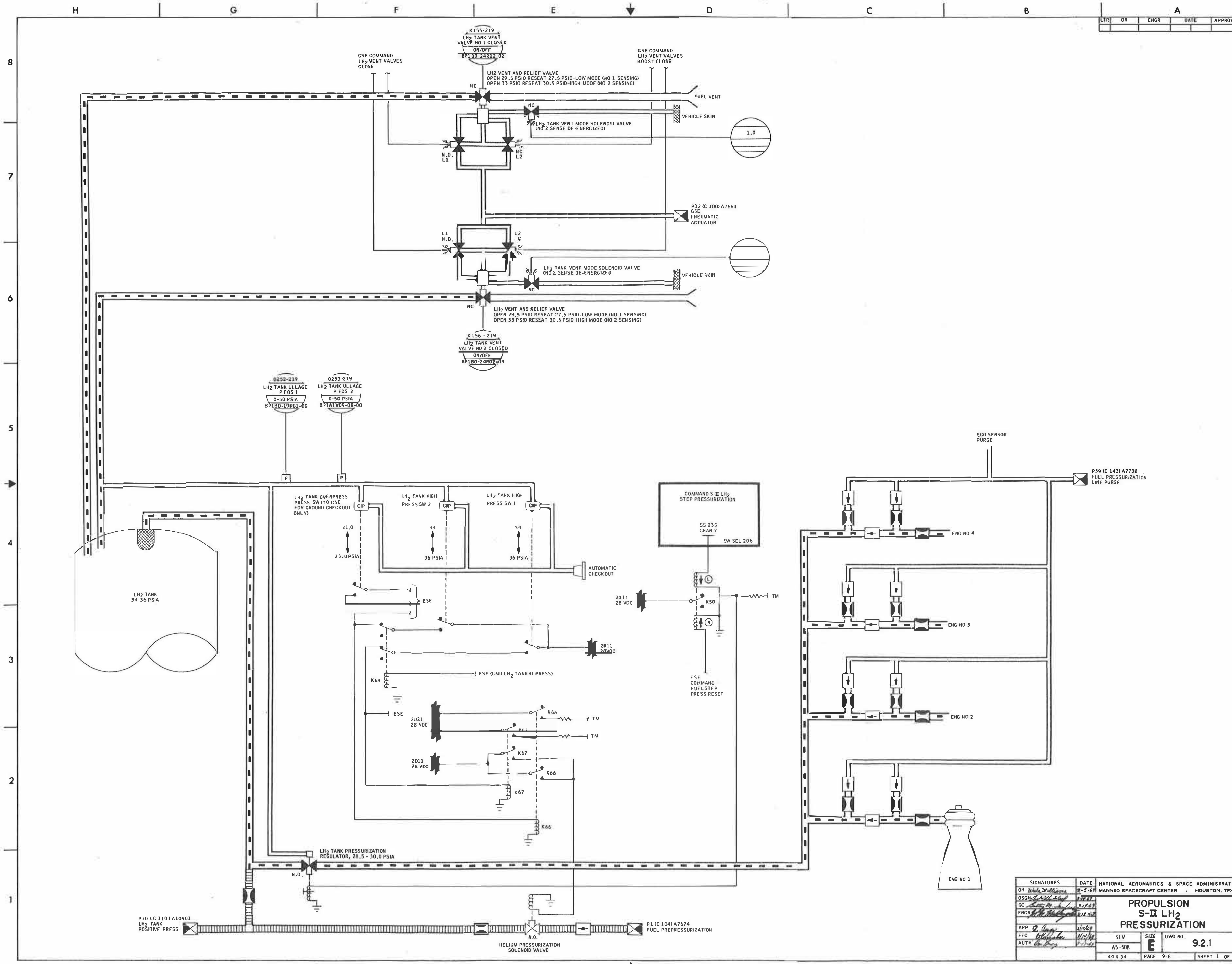
LH_2 propellant conditioning is accomplished by recirculation of tank propellants through the low-pressure suction ducts and LH_2 turbopumps of each engine to insure proper NPSH at the pump inlets for engine start. Five submerged electrically driven cryogenic pumps force LH_2 through normally open pump discharge valves into the suction ducts downstream of the closed LH_2 prevalves. Flow continues through the engine pumps and out the normally open gas-generator bleed valves and into a return line. The five return lines are manifolded, and a single return line routes the fluid back into the tank through a normally open recirculation return valve. LH_2 recirculation is initiated during the prelaunch phase and is terminated near engine start. Upon termination of recirculation, the pump discharge valves are closed, LH_2 prevalves are opened, and the recirculation pumps are turned off. The recirculation return line valve is closed 5 seconds after S-II engine start command.

9.2.2 Boost and Burn Phase

During the S-IC boost, the LH_2 vent valve control solenoid valves are energized, thus placing the LH_2 vent valves in the low-pressure vent mode. The low-pressure vent mode maintains the S-II LH_2 tank ullage pressure in the range of 27.5 to 29.5 psid relative to altitude ambient preserve until S-IC cutoff.

At T_3 + 0.1 seconds, the normally closed solenoid valves will be deactivated to place the vent valves in the high-pressure vent mode, which changes the vent valve range to 30.5 to 33.0 psid. During S-II powered flight the ullage pressure in the fuel tank is maintained by gaseous hydrogen bled from the four outboard engines.

After S-II engine ignition, liquid hydrogen is heated in the regenerative cooling tubes of the engine and tapped off from the thrust chamber injector manifold in the form of gaseous hydrogen to serve as a pressurizing medium. The ullage pressure drop in the fuel tank is sensed by the pressure regulator which regulates the GH_2 flow into the ullage space. The pressure is maintained at a nominal range of 28.5 to 30.0 psia by the pressure regulator. At approximately 300 seconds after S-II start, the regulator is actuated and locked into a full open position by an integral solenoid valve energized by the "step pressurization" command from the switch selector. The regulator, in a full open position, permits increased flow of GH_2, which raises the ullage pressure to the vent valve cracking range of 30.5 to 33.0 psig to provide adequate LH_2 NPSH in the final seconds of S-II burn.



SIGNATURES	DATE	NATIONAL AERONAUTICS & SPACE ADMINISTRATION MANNED SPACECRAFT CENTER · HOUSTON, TEXAS
DR	2-5-69	PROPULSION S-II LH_2 PRESSURIZATION
DSGN	3-18-69	
QC	3-18-69	
ENGR	3-12-69	
APP		SLV AS-508 · SIZE E · DWG NO. 9.2.1
FEC		
AUTH		44 X 34 · PAGE 9-8 · SHEET 1 OF 1

9.3 LOX PRESSURIZATION AND CONDITIONING

9.3.1 Lox Conditioning

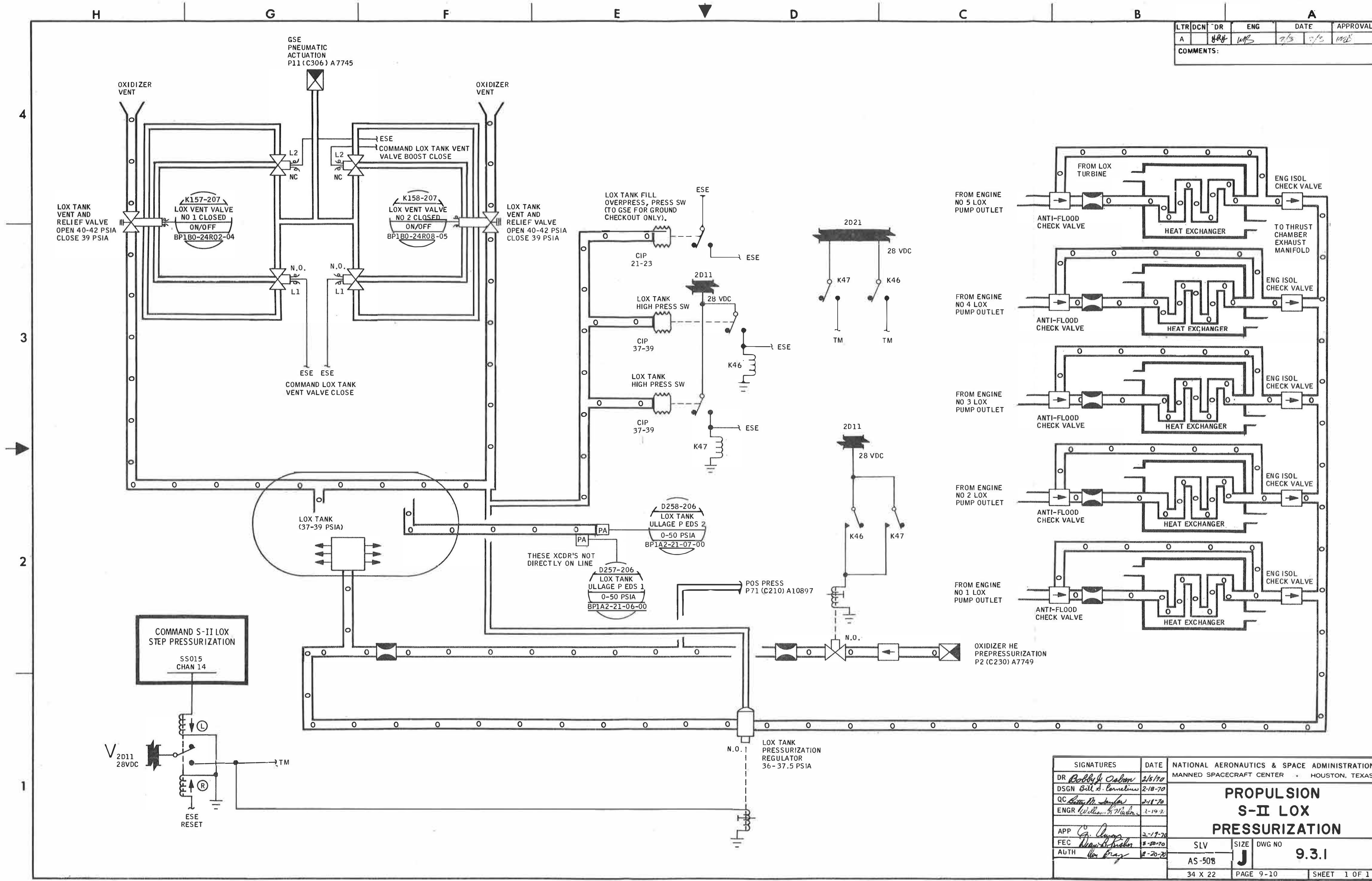
Lox conditioning is necessary to provide lox at the required temperature and density at the lox pump inlet. Conditioning of lox is initiated at the start of lox fill. Conditioning is accomplished by recirculating the lox down the suction ducts, through the engine lox pumps, through the engine lox bleed valves, and into the lox tank. Lox recirculation is accomplished by thermopumping induced by natural convection and augmented at T - 30 minutes by injecting gaseous helium into the lox recirculation return lines. The helium is injected through bosses into the return lines by opening the two redundant helium injection control valves. Thermopumping is effected by the lox density differential present between the engine inlet and the uninsulated return lines. The heat absorbed by the lox from the engine components during this cycle maintains thermal pumping. Helium injection is terminated just prior to engine start by closing the helium injection valves. The engine lox bleed valves are commanded closed at engine start followed 5 seconds later by the closing of the lox return line valves.

9.3.2 Tank Prepressurization

Prepressurization of the lox tank is required prior to lift-off to provide the required NPSH for engine start. Prepressurization starts at approximately T - 187 seconds and continues until T - 30 seconds. Opening the ground prepressurization valve allows helium at minus 275° F to flow from the ground source, through the vehicle prepressurization valve, and into the lox tank through the distributor. When the lox tank pressure reaches 37 to 39 psia, the prepressurization valve is closed by either of the two tank pressure switches.

9.3.3 Flight Pressurization

Pressurization of the lox tank during S-II powered flight is performed by gaseous oxygen supplied by heating lox in the engine heat exchanger. Lox supplied to the heat exchanger is bled from the lox pump outlet. After S-II ignition the engine turbine exhaust passes through the heat exchanger. When the lox pump discharge pressure reaches a pressure of 100 psi, the lox heat exchanger antiflood check valve permits lox bled from the lox pump outlet to pass into the heat exchanger. Gox produced by the heat exchanger flows to the tank and is regulated by the gox regulator control valve within the range of 36 to 37.5 psia. At approximately 100 seconds after S-II start, the regulator is actuated and locked into a full open position by an integral solenoid valve energized by the "step pressurization" command from the switch selector. The regulator, in a full open position, permits increased flow of GH_2, which raises the ullage pressure to the vent valve setting range of 39 to 42 psia to provide adequate lox NPSH in the final seconds of S-II burn.



H G F E D C B A
LTR DCN DR ENG DATE APPROVAL
COMMENTS:
GSE PNEUMATIC ACTUATION P11 (C306) A7745
OXIDIZER VENT
OXIDIZER VENT
ESE
COMMAND LOX TANK VENT VALVE BOOST CLOSE
L2
NC
LOX TANK VENT AND RELIEF VALVE OPEN 40-42 PSIA CLOSE 39 PSIA
K157-207 LOX VENT VALVE NO 1 CLOSED ON/OFF BP1B0-24R02-04
K158-207 LOX VENT VALVE NO 2 CLOSED ON/OFF BP1B0-24R08-05
LOX TANK VENT AND RELIEF VALVE OPEN 40-42 PSIA CLOSE 39 PSIA
N.O.
L1
ESE ESE
COMMAND LOX TANK VENT VALVE CLOSE
LOX TANK FILL OVERPRESS, PRESS SW (TO GSE FOR GROUND CHECKOUT ONLY).
CIP 21-23
LOX TANK HIGH PRESS SW
CIP 37-39
LOX TANK HIGH PRESS SW
CIP 37-39
2D11
28 VDC
K46
K47
2D21
28 VDC
K47 K46
TM TM
2D11
28 VDC
K46 K47
LOX TANK (37-39 PSIA)
PA
D258-206 LOX TANK ULLAGE P EDS 2 0-50 PSIA BP1A2-21-07-00
THESE XCDR'S NOT DIRECTLY ON LINE
D257-206 LOX TANK ULLAGE P EDS 1 0-50 PSIA BP1A2-21-06-00
POS PRESS P71 (C210) A10897
COMMAND S-II LOX STEP PRESSURIZATION
SS015 CHAN 14
V_{2D11} 28VDC
L
R
TM
ESE RESET
N.O.
LOX TANK PRESSURIZATION REGULATOR 36-37.5 PSIA
OXIDIZER HE PREPRESSURIZATION P2 (C230) A7749
FROM LOX TURBINE
FROM ENGINE NO 5 LOX PUMP OUTLET
ANTI-FLOOD CHECK VALVE
HEAT EXCHANGER
ENG ISOL CHECK VALVE
TO THRUST CHAMBER EXHAUST MANIFOLD
FROM ENGINE NO 4 LOX PUMP OUTLET
FROM ENGINE NO 3 LOX PUMP OUTLET
FROM ENGINE NO 2 LOX PUMP OUTLET
FROM ENGINE NO 1 LOX PUMP OUTLET
SIGNATURES DATE
DR DSGN QC ENGR APP FEC AUTH
NATIONAL AERONAUTICS & SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER • HOUSTON, TEXAS
PROPULSION S-II LOX PRESSURIZATION
SLV AS-508
SIZE J
DWG NO 9.3.1
34 X 22
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9.4 S-II PNEUMATIC CONTROL SYSTEM

9.4.1 Countdown Through Lift-Off

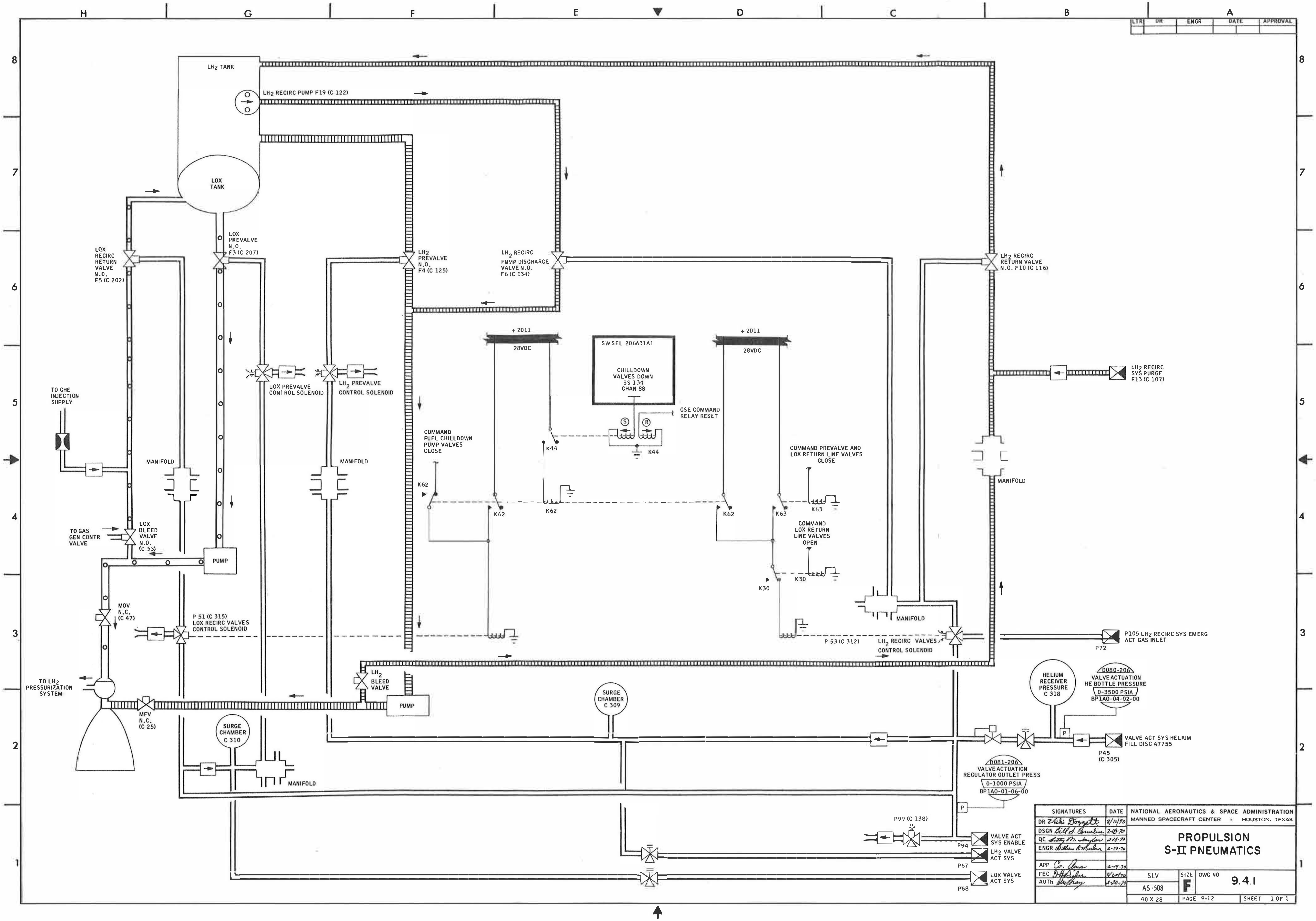
The S-II pneumatic subsystem is prepressurized with helium at ambient temperature and 1500 psig at approximately T - 6.5 hours. The LH_2 prevalves are actuated at the closed position. The LH_2 and lox recirculation valves and the lox prevalves are left in their normally open position. The subsystem is pressurized at approximately T - 30 minutes with helium at ambient temperature until a pressure of 3000 psia is attained in the high-pressure helium receiver. The regulator closes automatically when the pressure downstream reaches 750 psia. The normally closed pneumatic-actuation solenoid valves prevent the actuation of the normally open lox and LH_2 recirculation valves to their closed positions until commanded by the switch selector.

9.4.2 Lift-Off Through S-IC Boost

Pressure is maintained to hold the LH_2 prevalves in the closed position for chilldown until 0.5 seconds prior to S-IC/S-II separation.

9.4.3 Staging and S-II Burn

During the staging and S-II ignition sequence, the LH_2 prevalves are opened, and all lox and LH_2 recirculation valves are pneumatically closed. The low-pressure helium receivers contain sufficient pressure for prevalve actuation in the event of engine failure.



SIGNATURES	DATE
DR Vicki Dorsett	2/11/70
DSGN Bill J. Cornelius	2-18-70
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ENGR William R. Martin	2-19-70
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PROPULSION
S-II PNEUMATICS

SLV AS-508 | SIZE F | DWG NO 9.4.1
40 X 28 | PAGE 9-12 | SHEET 1 OF 1

9.5 J-2 ENGINE SYSTEM

9.5.1 General Description

The engine system consists of five single start J-2 engines. The J-2 engine is a 230,000-pound-thrust, high-performance engine, utilizing liquid oxygen (lox) and liquid hydrogen (LH_2) as propellants. The center engine is fixed in position and is thermally protected on the upper half of the engine by a flame impingement shield. Each outboard engine is capable of being independently gimbaled for attitude control.

9.5.2 Operational Description

9.5.2.1 Start.- All five engines are started simultaneously at a nominal mixture ratio of 5 lox/1 fuel and maintain this ratio until "steady state" operation is attained.

9.5.2.2 Steady state.- All five engines operate at approximately 100 percent thrust and a mixture ratio of 5.5 lox/1 fuel until PU shift at about 320 seconds of burn. At this time, the EMR is changed to 4.5 lox/1 fuel which reduces thrust and increases efficiency (Isp).

9.5.2.3 Cutoff.- Each engine initiates a cutoff sequence upon receipt of a command from the switch selector or from lox or fuel depletion sensors. Under normal conditions, all engines are shut down simultaneously by propellant depletion signals from any two of five sensors located in the lox and LH_2 tanks.

9.5.2.4 Malfunction detection.- Each engine is provided with a system to detect malfunctions and to affect a safe shutdown. Once an engine attains main stage operation, it may be shut down if both main stage OK pressure switches deactuate due to low-level thrust. If neither main stage OK pressure switch has indicated sufficient thrust for main stage operation at expiration of the ignition phase timer, a shutdown of the particular engine is initiated. The main stage OK pressure switches are checked through the remote checkout self-sealing quick-disconnect coupling.

9.5.3 Engine Purges

9.5.3.1 Helium tank purge.- Prior to propellant loading, helium purge gas is supplied from the GSE through the helium tank fill self-sealing quick-disconnect coupling, the manifold leading to each engine, the helium fill check valve, and into the helium tank.

9.5.3.2 Start tank purge and prechill.- The start tank is purged utilizing the start tank fill self-sealing quick-disconnect coupling, the start tank GH_2 fill check valve, the start tank fill filter, and the normally closed start tank vent and relief valve. Approximately 20 minutes prior to launch, cold GH_2 (1250 psig and -250° F) is supplied in the same manner for prechill purposes.

9.5.3.3 Thrust chamber LH_2 jacket purge and preconditioning.- Prior to chilldown of the thrust chamber, helium purge gas is supplied through the thrust chamber LH_2 jacket purge and preconditioning self-sealing quick-disconnect coupling, the manifold leading to each engine, the thrust chamber LH_2 purge and preconditioning check valve, and into the main LH_2 feed line downstream of the normally closed main LH_2 valve. The gas passes through the thrust chamber and out of the system through the fuel injector. The bell of the engine thrust chamber is subcooled to approximately -250° F with cold helium through this same purge and preconditioning route.

9.5.3.4 Turbopump purge.- Helium purge gas is supplied through the turbopump purge self-sealing quick-disconnect coupling, the manifold leading to each engine, and then to four engine locations. The four engine purges performed are as follows:

A. Seal cavity of LH_2 pump - Flow passes through a turbopump check valve. Purge gas exits through the turbopump check valve and the LH_2 pump seal cavity bleed self-sealing quick-disconnect coupling.

B. Seal cavity of LH_2 turbine - Flow passes through a turbopump check valve and LH_2 turbine seal cavity purge orifice. Purge gas exits through overboard bleed lines.

C. Seal cavity of lox pump - Flow passes through a turbopump check valve and lox turbine seal cavity purge orifice. Purge gas exits through overboard bleed lines.

D. LH_2 injection of gas generator - Flow passes through gas generator check valve and the gas generator LH_2 injector purge orifice. The purge gas exits through the exhaust aspirator located on the thrust chamber.

9.5.3.5 Lox dome purge.- At engine start, the normally closed helium control solenoid valve located within the pneumatic control package is opened, allowing gaseous helium to flow from the helium tank, through the normally closed pressure-actuated purge valve, the lox dome purge orifice, the lox dome purge check valve, the normally closed main lox valve, and into the thrust-chamber lox dome. Purge gas exits through the lox injector. When the four-way main stage control solenoid valve is closed, the purge terminates after approximately 1 second. Lox dome purge is also accomplished during helium tank purge.

9.5.3.6 Lox turbopump intermediate seal purge.- The lox turbopump intermediate seal purge is very similar to the lox dome purge, with gaseous helium entering the lox turbopump seal cavity through the lox pump intermediate seal purge orifice. Purge gas exits through the lox seal cavity manifold. This purge is continuous throughout engine operation. Lox turbopump intermediate seal purge is also accomplished during helium tank purge.

9.5.3.7 Gas generator lox injector purge.- Purge gas flows from the helium tank, through the pressure-actuated purge valve, the gas generator lox injector purge check valve, and into the gas generator lox injector. Purge gas exits through the exhaust aspirator located on the thrust chamber. This purge is performed coincident with the lox dome purge. Gas generator lox injector purge is also accomplished during helium tank purge.

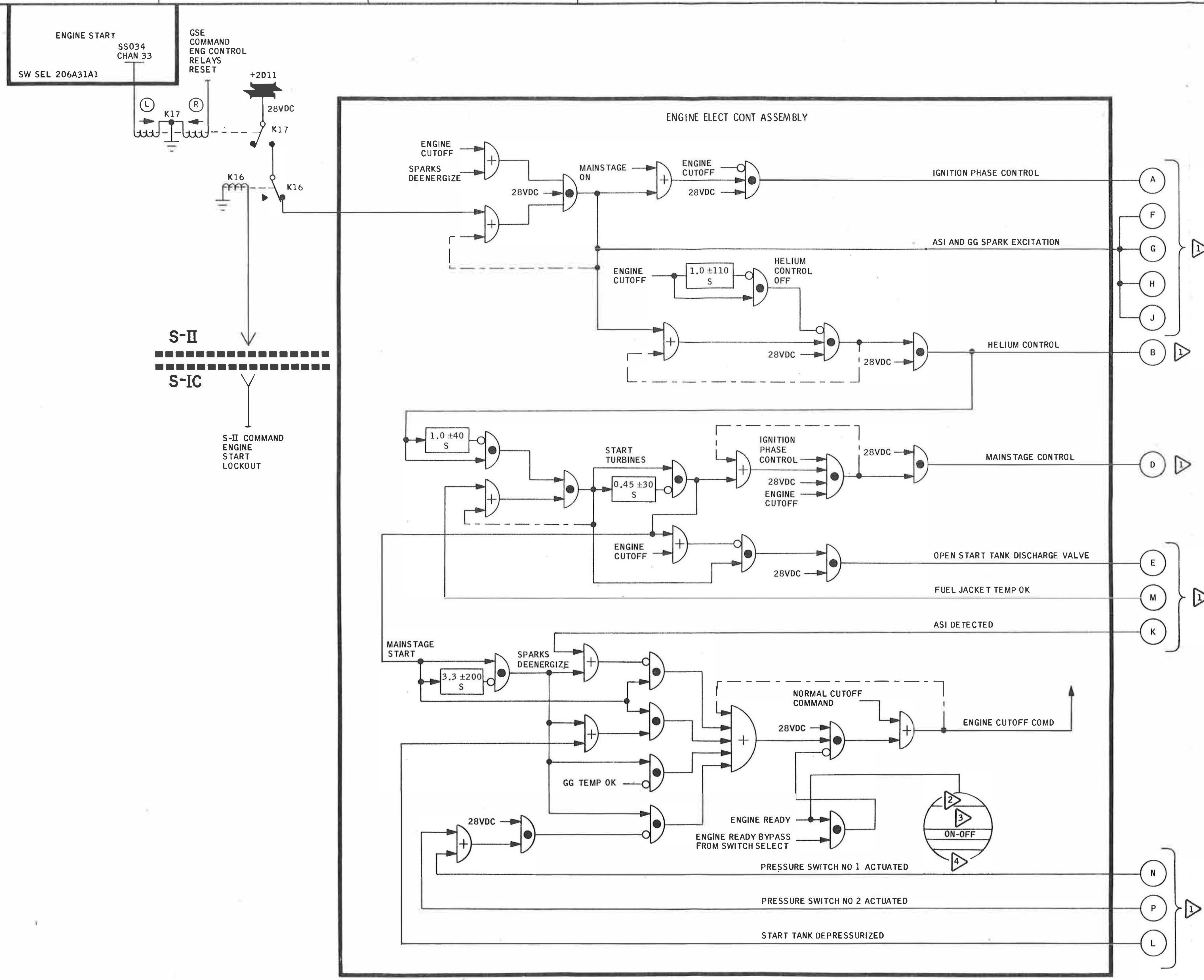
NOTE

For J-2 engine data, further information may be obtained from the Rocketdyne publication, "Preliminary Technical Engine Data Manual," R-3825-1.

9.5.4 Propellant Management System

9.5.4.1 General description.- The propellant management system monitors propellant mass for control of propellant loading, utilization, and depletion. Components in this system include continuous-capacitance probes, propellant utilization valves, discrete liquid-level sensors, and ground and onboard electronics.

9.5.4.2 Propellant loading.- The control of propellant loading and replenishing is performed by a ground-based computer in conjunction with related equipment and systems. The stage-mounted propellant-management electronics continuously monitor the output of the LH_2 tank continuous-capacitance probe and the lox tank continous probe. During loading operations, the signal from each probe is transmitted from the onboard propellant-management electronics to a ground checkout and display. Point-level sensors are provided for both the LH_2 and lox systems. These, however, are not telemetered but are only hard-wired on S-II-6 through S-II-10 stages. Beginning with S-II-11, all but four in each tank will be deleted. The LH_2 fast-fill emergency-cutoff sensor and the lox fast-fill emergency-cutoff sensor indicate 98 percent mass of propellant loaded. The LH_2 overfill emergency-cutoff sensor and the lox overfill emergency-cutoff sensor indicate 101 percent mass of propellant loaded. The signals received from the 98-percent-mass discrete liquid-level sensors in either tank stops fast fill automatically. The overfill signal received from the 101-percent-mass discrete liquid-level sensors automatically stops the entire loading sequence.



LTR	DR	ENGR	DATE	APPROVAL

1 SEE ENGINE SYSTEM DRAWING FOR A,B,D,E,F,G,H,J,K,L,M,N, AND P.

2 KB5-207 KB6-207 KB7-207 KB8-207 KB9-207

3 ENGINE 1 READY ENGINE 2 READY ENGINE 3 READY ENGINE 4 READY ENGINE 5 READY

4 BP1B0-24R08-10 BP1B0-24R08-09 BP1B0-24R08-08 BP1B0-24R08-07 BP1B0-24R08-06

SIGNATURES	DATE
DR	2/14/69
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PROPULSION J2 ENGINE LOGIC S-II STAGE

SLV AS-508 | SIZE D | DWG NO 9.5.1

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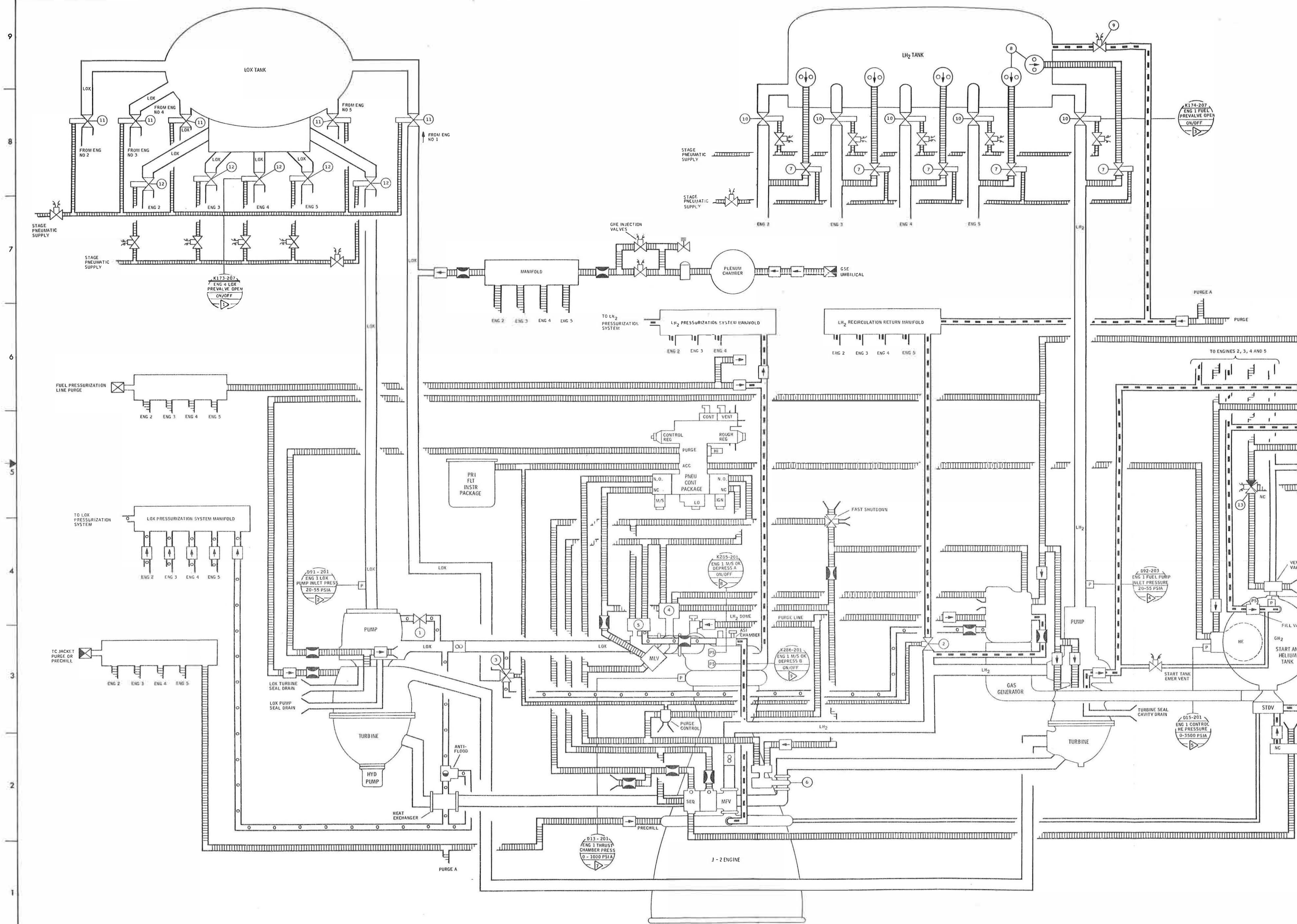

LEGEND

1. PU VALVE
2. LH_2 BLEED VALVE
3. LOX BLEED VALVE
4. SEQUENCE VALVE
5. ASI LOX VALVE
6. OXIDIZER TURBINE BYPASS VALVE
7. LH_2 RECIRCULATION BYPASS VALVE
8. LH_2 RECIRCULATION PUMP
9. LH_2 RECIRCULATION RETURN VALVE
10. LH_2 PREVALVE
11. LOX RECIRCULATION RETURN VALVE
12. LOX PREVALVE
13. START TANK VENT CONTROL VALVE

	MEAS NO	MEASUREMENT NAME	TELEMETRY CHANNEL
9	K286-201	E1 M/S OK DEPRESS B	BP1B0-25R01-06
	K286-202	E2 M/S OK DEPRESS B	BP1B0-25R01-07
	K286-203	E3 M/S OK DEPRESS B	BP1B0-25R01-08
	K286-204	E4 M/S OK DEPRESS B	BP1B0-25R01-09
	K286-205	E5 M/S OK DEPRESS B	BP1B0-25R01-10
8	K285-201	E1 M/S OK DEPRESS A	BP1B0-25R01-01
	K285-202	E2 M/S OK DEPRESS A	BP1B0-25R01-02
	K285-203	E3 M/S OK DEPRESS A	BP1B0-25R01-03
	K285-204	E4 M/S OK DEPRESS A	BP1B0-25R01-04
	K285-205	E5 M/S OK DEPRESS A	BP1B0-25R01-05
7	013-201	E1 THRUST CHAMBER P	BP1B0V23-06-00
	013-202	E2 THRUST CHAMBER P	BP1B0V18-01-00
	013-203	E3 THRUST CHAMBER P	BP1B0V23-05-00
	013-204	E4 THRUST CHAMBER P	BP1B0V07-10-00
	013-205	E5 THRUST CHAMBER P	BP1B0V06-06-00
6	016-201	E1 START TANK P	BP1A3-01-04-00
	016-202	E2 START TANK P	BP1A2-16-00-00
	016-203	E3 START TANK P	BP1A2-02-02-00
	016-204	E4 START TANK P	BP1A3-02-02-00
	016-205	E5 START TANK P	BP1A3-02-03-00
5	015-201	E1 HELIUM TANK P	BP1A3-21-09-00
	015-202	E2 HELIUM TANK P	BP1A2-16-03-00
	015-203	E3 HELIUM TANK P	BP1A2-21-02-00
	015-204	E4 HELIUM TANK P	BP1A3-17-03-00
	015-205	E5 HELIUM TANK P	BP1A3-17-08-00
4	092-201	E1 ENGINE INLET LH_2 P	BP1A1V25-00-00
	092-202	E2 ENGINE INLET LH_2 P	BP1A2-20-09-00
	092-203	E3 ENGINE INLET LH_2 P	BP1A2-01-07-00
	092-204	E4 ENGINE INLET LH_2 P	BP1A3-12-04-00
	092-205	E5 ENGINE INLET LH_2 P	BP1B0V07-04-00
3	K174-207	E1 LH_2 PREVALVE OPEN	BP1B0-24R05-06
	K175-207	E2 LH2 PREVALVE OPEN	BP1B0-24R05-07
	K176-207	E3 LH_2 PREVALVE OPEN	BP1B0-24R05-08
	K177-207	E4 LH_2 PREVALVE OPEN	BP1B0-24R05-09
	K178-207	E5 LH_2 PREVALVE OPEN	BP1B0-24R05-10
2	091-201	E1 ENGINE INLET LOX P	BP1A3-19-00-00
	091-202	E2 ENGINE INLET LOX P	BP1A2-20-06-00
	091-203	E2 ENGINE INLET LOX P	BP1A2-16-02-00
	091-204	E4 ENGINE INLET LOX P	BP1A3-21-06-00
	091-205	E5 ENGINE INLET LOX P	BP1A3-25-00-00
1	K169-207	E1 LOX PREVALVE OPEN	BP1B0-24R05-10
	K170-207	E2 LOX PREVALVE OPEN	BP1B0-25R06-06
	K171-207	E3 LOX PREVALVE OPEN	BP1B0-25R06-07
	K172-207	E4 LOX PREVALVE OPEN	BP1B0-25R06-08
	K173-207	E5 LOX PREVALVE OPEN	BP1B0-25R06-09

NOTES:

SIGNATURES	DATE
DR M. Smith	2-18-70
DSGN Bill S. Cornelius	2-18-70
QC Betty M Taylor	2-18-70
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PROPULSION, J-2 ENGINE SYSTEM, S-II STAGE

SLV AS-508 | SIZE J | DWG NO 9.5.2

60.5 X 38.25 | PAGE 9-16 | SHEET 1 OF 1

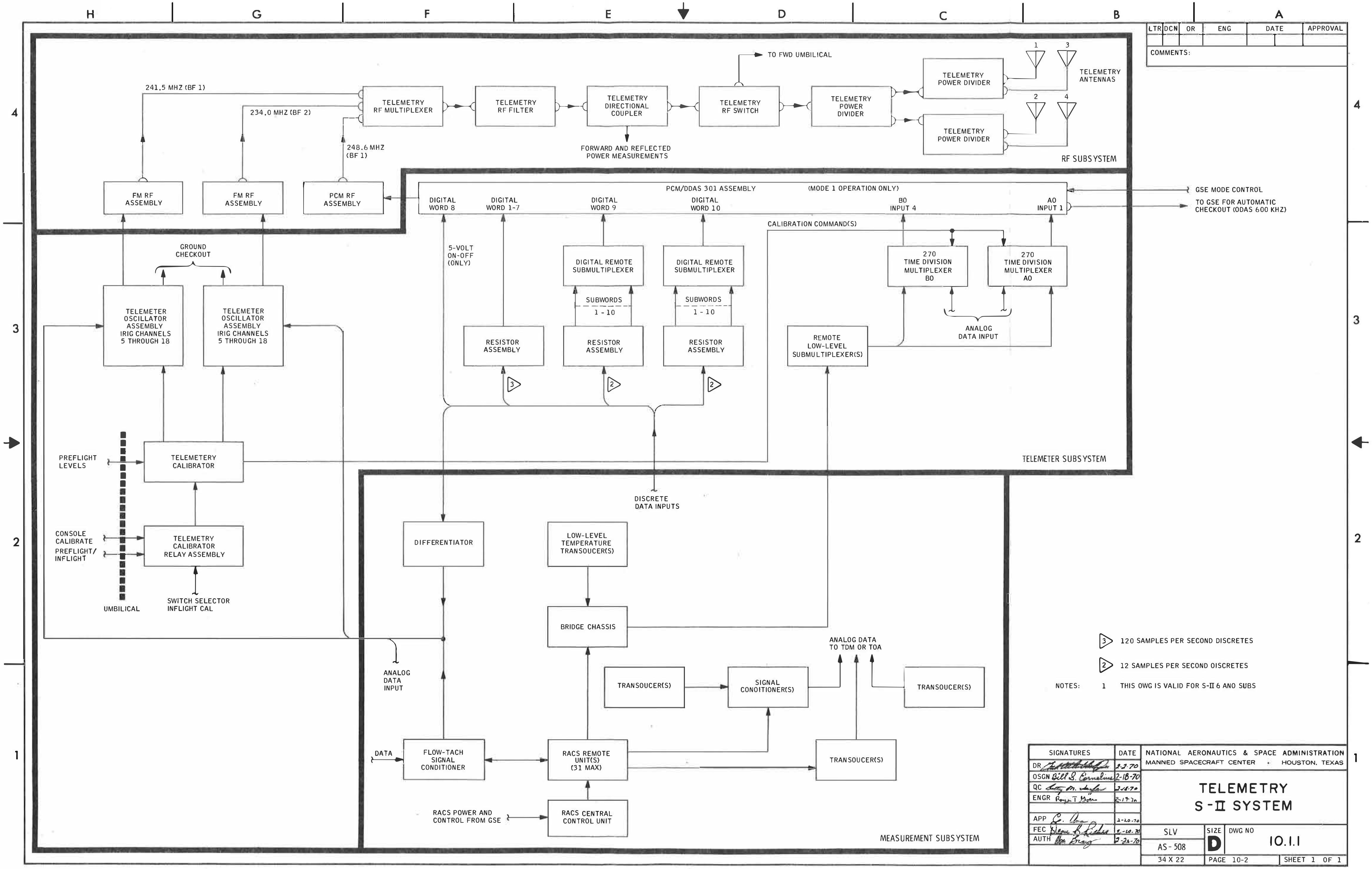
10 S-II
INSTRUMENTATION
AND TELEMETRY

SECTION 10

S-II INSTRUMENTATION AND TELEMETRY

10.1 S-II TELEMETRY SYSTEM DESCRIPTION

The S-II stage telemetry equipment consists of three telemetry links including two types of telemetry subsystems, FM/FM and PCM/FM. Drawing 10.1.1 is a block diagram of the S-II telemetry subsystems.



TO FWD UMBILICAL
241.5 MHZ (BF 1)
234.0 MHZ (BF 2)
248.6 MHZ (BF 1)
TELEMETRY RF MULTIPLEXER
TELEMETRY RF FILTER
TELEMETRY DIRECTIONAL COUPLER
FORWARD AND REFLECTED POWER MEASUREMENTS
TELEMETRY RF SWITCH
TELEMETRY POWER DIVIDER
TELEMETRY POWER DIVIDER
TELEMETRY POWER DIVIDER
TELEMETRY ANTENNAS
1
2
3
4
RF SUBSYSTEM
FM RF ASSEMBLY
FM RF ASSEMBLY
PCM RF ASSEMBLY
PCM/DDAS 301 ASSEMBLY
(MODE 1 OPERATION ONLY)
DIGITAL WORD 8
DIGITAL WORD 1-7
DIGITAL WORD 9
DIGITAL WORD 10
B0 INPUT 4
A0 INPUT 1
GSE MODE CONTROL
TO GSE FOR AUTOMATIC CHECKOUT (DDAS 600 KHZ)
CALIBRATION COMMAND(S)
GROUND CHECKOUT
5-VOLT ON-OFF (ONLY)
DIGITAL REMOTE SUBMULTIPLEXER
DIGITAL REMOTE SUBMULTIPLEXER
SUBWORDS 1 - 10
SUBWORDS 1 - 10
270 TIME DIVISION MULTIPLEXER B0
270 TIME DIVISION MULTIPLEXER A0
ANALOG DATA INPUT
TELEMETER OSCILLATOR ASSEMBLY IRIG CHANNELS 5 THROUGH 18
TELEMETER OSCILLATOR ASSEMBLY IRIG CHANNELS 5 THROUGH 18
RESISTOR ASSEMBLY
RESISTOR ASSEMBLY
RESISTOR ASSEMBLY
REMOTE LOW-LEVEL SUBMULTIPLEXER(S)
PREFLIGHT LEVELS
TELEMETERY CALIBRATOR
TELEMETER SUBSYSTEM
DISCRETE DATA INPUTS
CONSOLE CALIBRATE
PREFLIGHT/ INFLIGHT
TELEMETRY CALIBRATOR RELAY ASSEMBLY
SWITCH SELECTOR INFLIGHT CAL
UMBILICAL
DIFFERENTIATOR
LOW-LEVEL TEMPERATURE TRANSDUCER(S)
BRIDGE CHASSIS
ANALOG DATA INPUT
ANALOG DATA TO TDM OR TDA
TRANSDUCER(S)
SIGNAL CONDITIONER(S)
TRANSDUCER(S)
DATA
FLOW-TACH SIGNAL CONDITIONER
RACS REMOTE UNIT(S) (31 MAX)
TRANSDUCER(S)
RACS POWER AND CONTROL FROM GSE
RACS CENTRAL CONTROL UNIT
MEASUREMENT SUBSYSTEM
3 120 SAMPLES PER SECOND DISCRETES
2 12 SAMPLES PER SECOND DISCRETES
NOTES: 1 THIS DWG IS VALID FOR S-II 6 AND SUBS
LTR DCN OR ENG DATE APPROVAL
COMMENTS:
SIGNATURES DATE
DR 2-3-70
DSGN Bill S. Cornelius 2-18-70
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ENGR 2-17-70
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NATIONAL AERONAUTICS & SPACE ADMINISTRATION
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TELEMETRY S-II SYSTEM
SLV AS-508
SIZE D
DWG NO 10.1.1
34 X 22
PAGE 10-2
SHEET 1 OF 1

11 S-II/S-IVB
STAGING

SECTION 11
S-II/S-IVB STAGING

11.1 PHYSICAL SEPARATION

Physical separation is initiated by the instrument unit (IU) at the end of S-II boost phase, following shutdown of the five J-2 engines. Separation requires the performance of the following major functions in the sequence described below.

11.1.1 EBW Firing Units Armed

A ground latched interlock renders the exploding bridge wire (EBW) firing units inoperative while the vehicle is on the launch pad. The interlock is released with umbilical disconnect during lift-off, and the subsystem is reset to flight condition. At approximately 492 seconds after lift-off, the IU sends out the command to arm the S-II/S-IVB separation ordnance. The ordnance arm command is routed through the S-II switch selector to the S-II stage electrical circuitry to supply plus 28 Vdc to the EBW firing units for S-II/S-IVB separation and retrorocket ignition. The firing units use this energy to charge the internal storage capacitors to 2300 volts to provide the firing pulse for rocket ignition and mild detonating fuse (MDF) detonation.

11.1.2 Separation

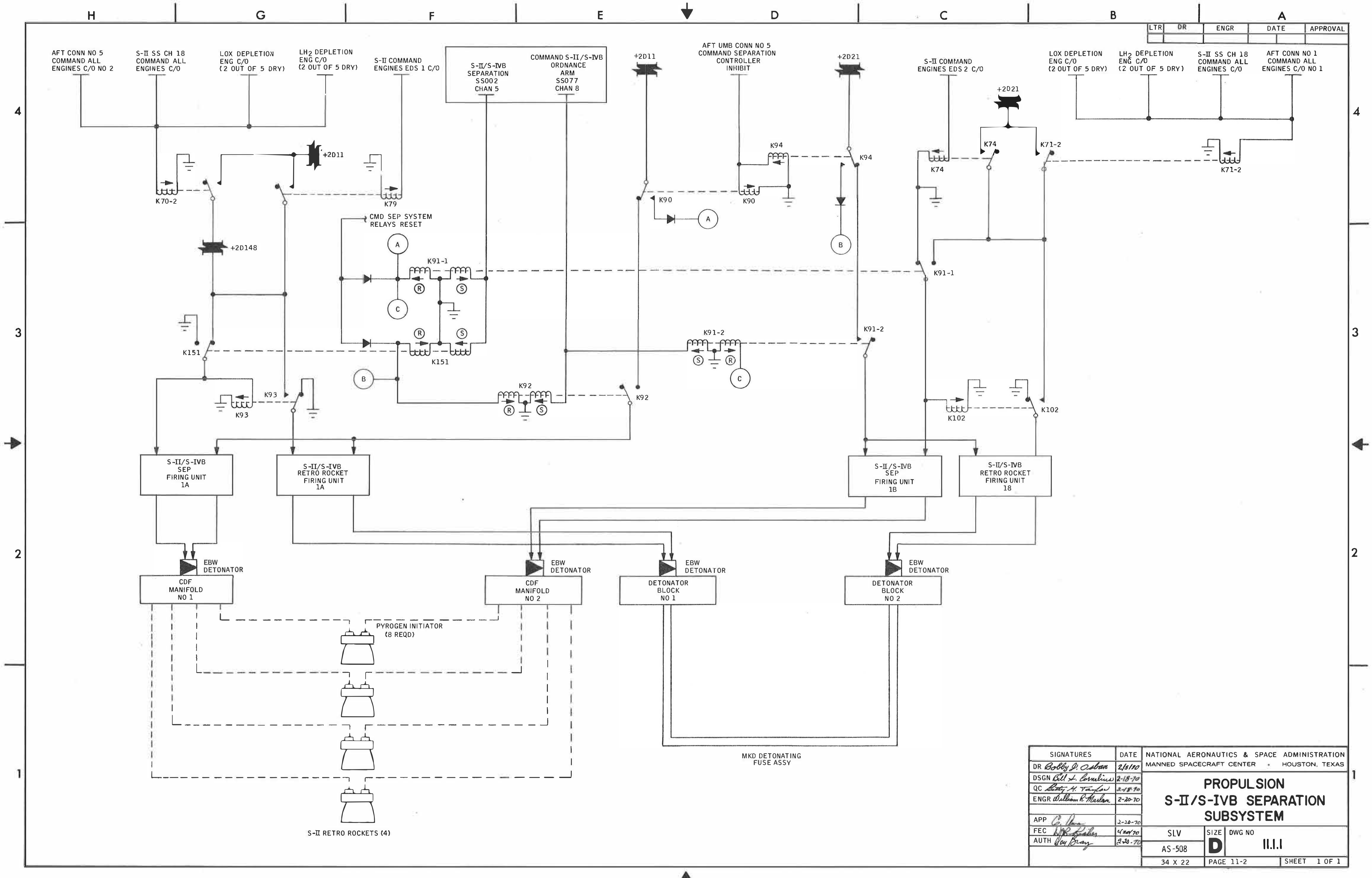
Separation is initiated at approximately 557 seconds after lift-off. The separation command is routed through the S-II switch selector to the S-II electrical circuitry to trigger the ordnance train for separation and retrorocket ignition.

Four solid-propellant S-II retrorockets are mounted at equal intervals on the periphery of the S-II/S-IVB interstage structure and are used to retard the S-II stage with the interstage assembly after separation. Each retrorocket has a burning time of 1.54 seconds and develops a 34,810-lb vacuum thrust.

Each retrorocket is ignited by either of two pyrogen initiators mounted on its aft structure. The confined detonating fuse (CDF) assemblies connect the pyrogen initiators to the respective firing units, thus completing the ordnance train.

The mild detonating fuse is used to sever the vehicle structure during separation. Two trains of MDF's are installed in a groove in the aft skirt. A tension plate riveted to the aft skirt and bolted to the aft interstage joins these structures at the separation plane. The thinnest section of the tension plate is located directly over the groove containing the MDF used to sever the tension plate.

The detonator blocks complete the ordnance train to accomplish physical separation. An EBW detonator is mounted on each detonator block, thus linking the block with the respective firing unit. Each end of the MDF is attached to a detonator block either of which can fire the explosive charge. The MDF and, in turn, the retrorockets ignite to separate the structure and retract the S-II stage.



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SIGNATURES	DATE
DR	2/5/70
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PROPULSION S-II/S-IVB SEPARATION SUBSYSTEM

SLV AS-508 | SIZE D | DWG NO 11.1.1

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12 S-IVB
SEQUENTIAL
SYSTEMS

S-IVB SEQUENTIAL SYSTEMS

12.1 S-IVB SWITCH SELECTOR FUNCTIONS (OCTAL)

Chan	Code	Function	Figure No.
37	001	COMMAND AMBIENT REPRESS MODE SELECTOR OFF AND CRYO ON	14-5
5	002	COMMAND PU ACTIVATE ON	14-11
30	003	COMMAND ENGINE MAINSTAGE CONTROL VALVE OPEN ON	14-10
74	004	COMMAND BURNER LOX SHUTDOWN VALVE CLOSE ON	14-5
81	005	COMMAND LH_2 TANK REPRESS CONTROL VALVE OPEN OFF	14-5
97	006	COMMAND POINT LEVEL SENSOR ARMING	14-10
63	007	COMMAND TM CALIBRATE OFF	16-5
87	011	COMMAND LH_2 TANK CONT VENT VALVE CLOSE OFF	14-3
111	012	COMMAND LH_2 TANK CONT VENT ORIFICE SHUTOFF VALVE OPEN ON	14-3
94	013	COMMAND LOX TANK VENT VALVE CLOSE	14-4
49	014	COMMAND INFLIGHT RELAYS OFF	16-4
14	015	COMMAND START TANK RECHARGE VALVE OPEN	14-5
51	016	COMMAND HEAT EXCHANGER BYPASS VALVE CONTROL DISABLE (PREFLIGHT)	14-4
39	017	COMMAND LH_2 TANK REPRESS CONTROL VALVE OPEN ON	14-5
16	021	COMMAND FUEL INJECTION TEMP OK BYPASS RESET	14-10
24	022	COMMAND ENGINE PUMP PURGE CONTROL VALVE ENABLE ON	14-8
9	023	COMMAND S-IVB ENGINE START ON	14-10
75	024	COMMAND BURNER LOX SHUTDOWN VALVE CLOSE OFF	14-5
109	025	COMMAND ENGINE HELIUM CONTROL VALVE OPEN ON	14-10
82	026	COMMAND PREVALVES CLOSE ON	14-7
71	027	COMMAND BURNER EXCITERS OFF	14-5
68	031	COMMAND FIRST BURN RELAY ON	14-3
57	032	COMMAND FIRE ULLAGE JETTISON ON	15-2
96	033	COMMAND LOX TANK VENT AND NPV VALVES BOOST CLOSE OFF	14-4
33	034	COMMAND SECOND BURN RELAY OFF	14-3
7	035	COMMAND PU INVERTER AND DC POWER ON	14-11
35	036	COMMAND PU FUEL BOILOFF BIAS OFF	14-11
17	037	COMMAND PU MIXTURE RATIO 4.5 ON	14-11
53	041	COMMAND S-IVB ENGINE EDS CUTOFF #2 DISABLE	14-10
23	042	COMMAND LOX CHILLDOWN PUMP OFF	14-7
31	043	COMMAND START TANK RECHARGE VALVE CLOSE	14-5
61	044	COMMAND BURNER LH_2 PROPELLANT VALVE CLOSE OFF	14-5
93	045	COMMAND LOX TANK VENT VALVE OPEN	14-4
102	046	COMMAND S-IVB APS ULLAGE ENGINE NO. 2 OFF	15-1
90	047	COMMAND BURNER LOX SHUTDOWN VALVE OPEN OFF	14-5
69	051	COMMAND FIRST BURN RELAY OFF	14-3
65	052	COMMAND ENGINE MAINSTAGE AND IGNITION PHASE CONTROL VALVES OPEN OFF	14-10
73	053	COMMAND ULLAGE FIRING RESET	15-2
48	054	COMMAND INFLIGHT RELAYS ON	16-4
6	055	COMMAND PU ACTIVATE OFF	14-11
52	056	COMMAND LH_2 TANK LATCHING RELIEF VALVE LATCH ON	14-3
40	057	COMMAND PASSIVATION ENABLE	14-10
38	061	COMMAND LH_2 TANK VENT VALVE OPEN ON	14-3
44	062	COMMAND LOX TANK NPV VALVE LATCH OPEN ON	14-4
18	063	COMMAND PU MIXTURE RATIO OFF	14-11
110	064	COMMAND ENGINE HELIUM CONTROL VALVE OPEN OFF	14-10
92	065	COMMAND CHILLDOWN SHUTOFF PILOT VALVE CLOSE OFF	14-7
101	066	COMMAND S-IVB APS ULLAGE ENGINE NO. 2 ON	15-1
67	067	COMMAND S-IVB ENGINE EDS CUTOFF NO. 2 ENABLE	14-10

Chan	Code	Figure	Figure No.
58	071	COMMAND FUEL CHILLDOWN PUMP ON	14-7
64	072	COMMAND ENGINE IGNITION PHASE CONTROL VALVE OPEN ON	14-10
95	073	COMMAND LOX TANK VENT AND NPV VALVES BOOST CLOSE ON	14-4
29	074	COMMAND AUXILIARY HYDRAULIC PUMP FLIGHT MODE OFF	14-1
25	075	COMMAND ENGINE PUMP PURGE CONTROL VALVE ENABLE OFF	14-8
36	076	COMMAND AMBIENT REPRESS MODE SELECTOR ON AND CRYO OFF	14-5
8	077	COMMAND PU INVERTER AND DC POWER OFF	14-11
21	101	COMMAND AMBIENT HELIUM SUPPLY SHUTOFF VALVE CLOSED OFF	14-8
46	102	COMMAND REGULAR CALIBRATE RELAYS ON	16-4
32	103	COMMAND SECOND BURN RELAY ON	14-3
98	104	COMMAND START TANK RECHARGE ENABLE	14-5
108	105	COMMAND LH_2 TANK CONTINUOUS VENT RELIEF OVERRIDE SHUTOFF VALVE OPEN OFF	14-3
76	106	COMMAND LH_2 TANK VENT VALVE CLOSE	14-3
89	107	COMMAND BURNER LOX SHUTDOWN VALVE OPEN ON	14-5
66	111	COMMAND PU MIXTURE RATIO 5.5 ON	14-11
62	112	COMMAND TM CALIBRATE ON	16-5
112	113	COMMAND LH_2 TANK CONT VENT ORIFICE SHUTOFF VALVE OPEN OFF	14-3
105	114	COMMAND LOX TANK NPV VALVE OPEN ON	14-4
12	115	COMMAND S-IVB ENGINE CUTOFF ON	14-10
41	116	COMMAND PASSIVATION DISABLE	14-10
34	117	COMMAND PU FUEL BOILOFF BIAS ON	14-11
22	121	COMMAND LOX CHILLDOWN PUMP ON	14-7
19	122	COMMAND LH_2 TANK LATCHING RELIEF VALVE LATCH OFF	14-3
45	123	COMMAND LOX TANK NPV VALVE LATCH OPEN OFF	14-4
56	124	COMMAND FIRE ULLAGE IGNITION ON	15-2
91	125	COMMAND CHILLDOWN SHUTOFF PILOT VALVE CLOSE ON	14-7
99	126	COMMAND LH_2 TANK LATCHING RELIEF VALVE OPEN ON	14-3
86	127	COMMAND BURNER AUTOMATIC CUTOFF SYS DISARM	14-5
84	131	COMMAND LH_2 TANK CONT VENT VALVE CLOSE ON	14-3
100	132	COMMAND LH_2 TANK LATCHING RELIEF VALVE OPEN OFF	14-3
60	133	COMMAND BURNER LH_2 PROPELLANT VALVE CLOSE ON	14-5
88	134	COMMAND ULLAGE CHARGING RESET	15-2
27	135	COMMAND S-IVB ENGINE START OFF	14-10
42	136	COMMAND S-IVB APS ULLAGE ENGINE NO. 1 ON	15-1
2	137	COMMAND START TANK VENT CONTROL VALVE OPEN OFF	14-8
4	141	COMMAND LOX TANK REPRESS CONTROL VALVE OPEN OFF	14-5
3	142	COMMAND LOX TANK REPRESS CONTROL VALVE OPEN ON	14-5
10	143	COMMAND ENGINE READY BYPASS	14-10
55	144	COMMAND CHARGE ULLAGE JETTISON ON	15-2
107	145	COMMAND LH_2 TANK CONTINUOUS VENT RELIEF OVERRIDE SHUTOFF VALVE OPEN ON	14-3
77	146	COMMAND LH_2 TANK VENT AND LATCHING RELIEF VALVE BOOST CLOSE ON	14-3
85	147	COMMAND BURNER AUTOMATIC CUTOFF SYS ARM	14-5
83	151	COMMAND PREVALVES CLOSE OFF	14-7
79	152	COMMAND LOX TANK PRESSURIZATION SHUTOFF VALVES CLOSE	14-4
59	153	COMMAND FUEL CHILLDOWN PUMP OFF	14-7
70	154	COMMAND BURNER EXCITERS ON	14-5
47	155	COMMAND REGULAR CALIBRATE RELAYS OFF	16-4
20	156	COMMAND AMBIENT HELIUM SUPPLY SHUTOFF VALVE CLOSED ON	14-8
15	157	COMMAND SINGLE SIDEBAND SYSTEM DISABLE	16-4
50	161	COMMAND HEAT EXCHANGER BYPASS VALVE CONTROL ENABLE	14-4

Chan	Code		Figure No.
13	162	COMMAND S-IVB ENGINE CUTOFF OFF	14-10
11	163	COMMAND FUEL INJECTION TEMP OK BYPASS	14-10
54	164	COMMAND CHARGE ULLAGE IGNITION ON	15-2
106	165	COMMAND LOX TANK NPV VALVE OPEN OFF	14-4
78	166	COMMAND LH_2 TANK VENT AND LATCHING RELIEF VALVE BOOST CLOSE OFF	14-3
104	167	COMMAND LOX TANK FLIGHT PRESSURE SYSTEM OFF	14-4
103	171	COMMAND LOX TANK FLIGHT PRESSURE SYSTEM ON	14-4
80	172	COMMAND LOX TANK PRESSURIZATION SHUTOFF VALVES OPEN	14-4
72	173	COMMAND BURNER LH_2 PROPELLANT VALVE OPEN OFF	14-5
28	174	COMMAND AUXILIARY HYDRAULIC PUMP FLIGHT MODE ON	14-1
26	175	COMMAND BURNER LH_2 PROPELLANT VALVE OPEN ON	14-5
43	176	COMMAND S-IVB APS ULLAGE ENGINE NO. 1 OFF	15-1
1	177	COMMAND START TANK VENT CONTROL VALVE OPEN ON	14-8

13 S-IVB
ELECTRICAL
POWER SYSTEMS

SECTION 13

S-IVB ELECTRICAL POWER SYSTEMS

13.1 GENERAL NOTES

A. Electrical power for the Saturn launch vehicle is provided by batteries in each stage to operate the functions of that stage. In this manner, complete power isolation is maintained between stages. Grounds are also isolated except for a single point interconnection.

B. All batteries on the Saturn launch vehicle are 28 V except those used for chilldown inverters and auxiliary hydraulic pumps which are 56 V.

C. All power distribution is at 28 Vdc (except auxiliary hydraulic pump and chilldown pumps). Where ac or voltages other than 28 Vdc are required, the conversion is within and as a part of the using equipment.

13.2 S-IVB ELECTRICAL SYSTEM

A. Four batteries located in the forward and aft skirts of the stage provide electrical power for the S-IVB stage. The battery descriptions and expected usage are as follows:

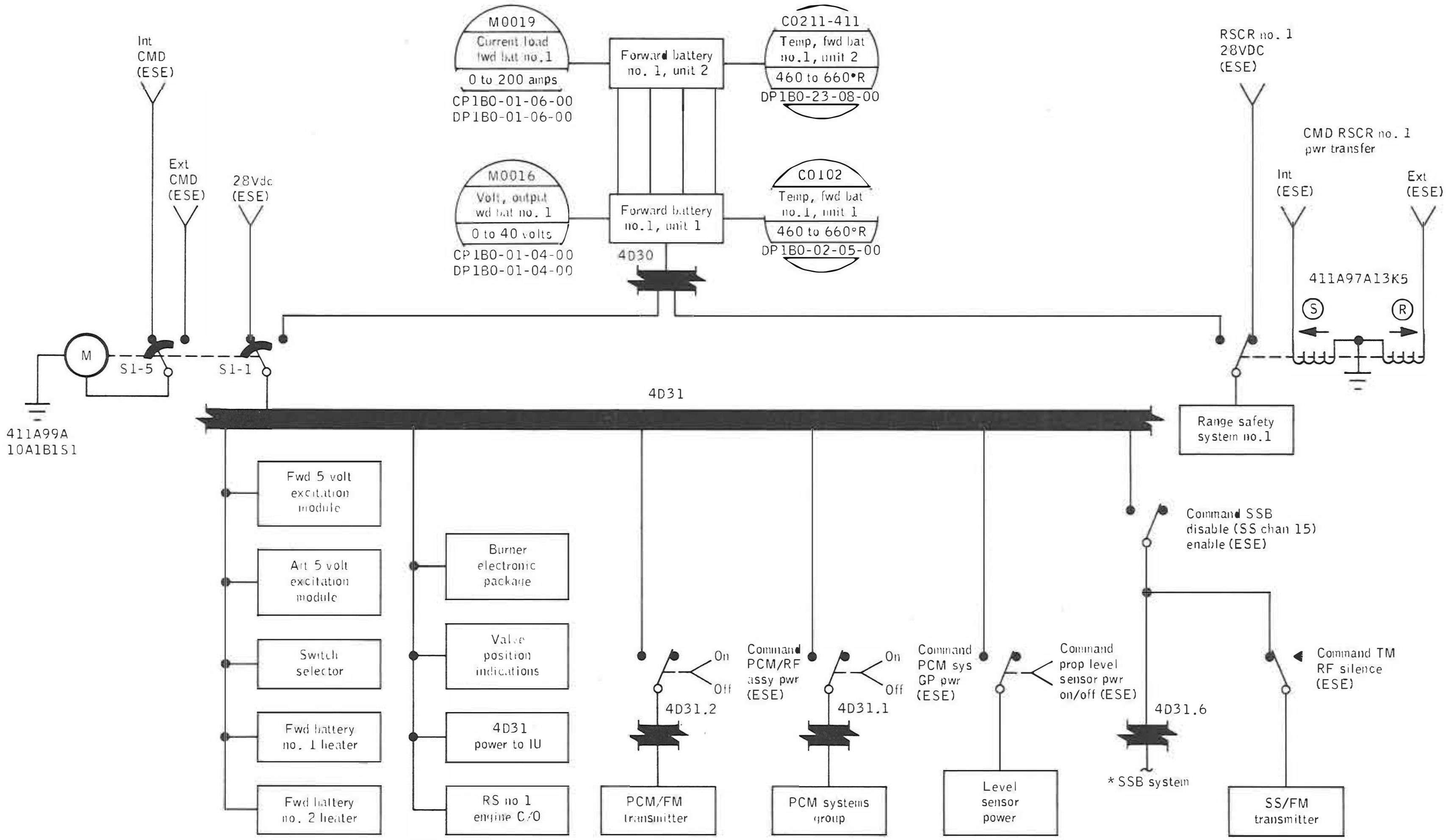
Battery	Location	Voltage (Vdc)	Capacity (amp/hr)	Expected Usage (amp/hr)
Fwd #1	Fwd skirt	28 ±2	300	145.2
Fwd #2	Fwd skirt	28 ±2	25	25.6
Aft #1	Aft skirt	28 ±2	300	60.2
Aft #2	Aft skirt	56 ±4	75	39.6

Table 13-I gives the S-IVB electrical load distribution.

TABLE 13-I.- S-IVB ELECTRICAL LOAD DATA

Function	Current (amp)
FORWARD BATTERY NO. 1	
PCM/FM System Group	6.50
PCM RF System Group	4.80
5V Excit Modules	1.60
Fwd Battery No. 1 Heater	12.00
Fwd Battery No. 2 Heater	3.40
Range Safety System No. 1	0.25
O_2-H_2 Burner Voter Regulator	0.10
Switch Selector Power	0.04
SSB/FM Transmitter Group	5.60
FORWARD BATTERY NO. 2	
Programed EMR Commands	0.75
Range Safety System No. 2	0.25
PU Inverter and dc Power	3.60
Fwd 5V Excit Module No. 2	0.30
AFT BATTERY NO. 1	
Battery Heater Aft 1	9.00
Battery Heater Aft 2	6.00
Lox Flight Press System	3.04
First Burn Relay	4.00
Engine Pump Purge Valve Open	0.70
Second Burn Relay	3.00
LH_2 Repress Valve Open	3.00
Lox Repress Valve Open	3.00
Lox Chilldown Pump Purge Control Valve	<1.0
Prevalves	2.0
Charge Ullage Ignition	1.5
Fire Ullage Ignition	<1.0
Chilldown Shutoff Valves	2.0
J-2 Engine Control Power (Coast)	<1.0
J-2 Engine Control Power (Start)	11.3
J-2 Engine Control Power (Burn)	8.0
Ignition Power (Coast)	<1.0
Ignition Power (Start Sequence)	20.0
Lox Tank Flight Press	6.0
Charge Ullage Jettison	1.5
Fire Ullage Jettison	<1.0
LH_2 Control Vent Open	2.0
LH_2 Cont Vent Close	3.0
Coast Period	<1.0
Auxiliary Propulsion System	20.0 (max)
O_2-H_2 Burner Exciters	2.0
AFT BATTERY NO. 2	
Lox Chilldown Pump	14.00
LH_2 Chilldown Pump	14.00
Aux Hyd Pump Flight Mode	40.00

(Brace note, Lox Chilldown Pump Purge Control Valve through O_2-H_2 Burner Exciters:) These loads consume 10.21 amp-hrs of battery capacity. preflight loads use another 20.0 amp-hrs.



Note: Switch selector channels refer to the S-IVB switch selector

Figure 13-1. - Forward bus no. 1 - schematic.

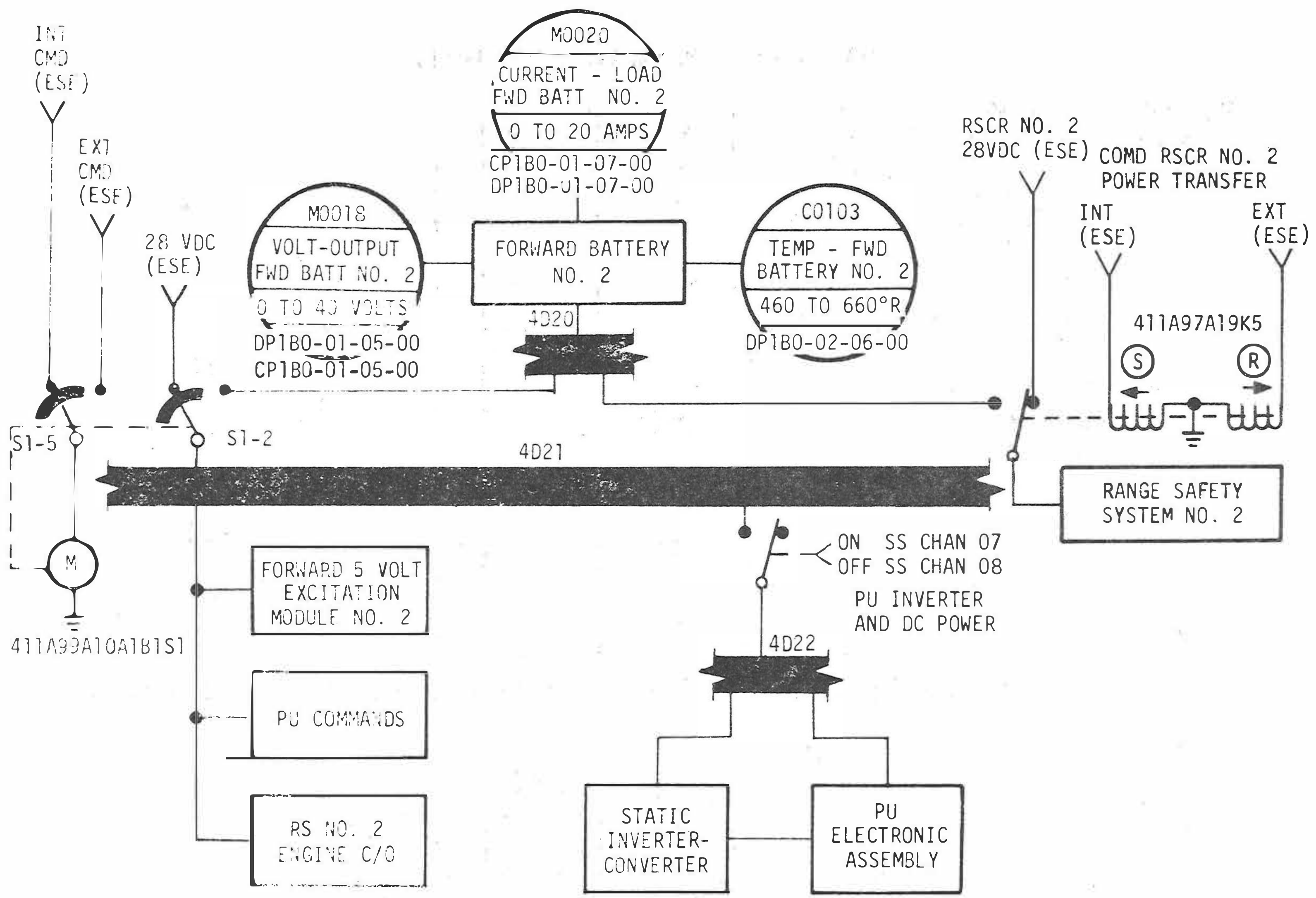


Figure 13-2.- Forward Bus No. 2 - schematic.

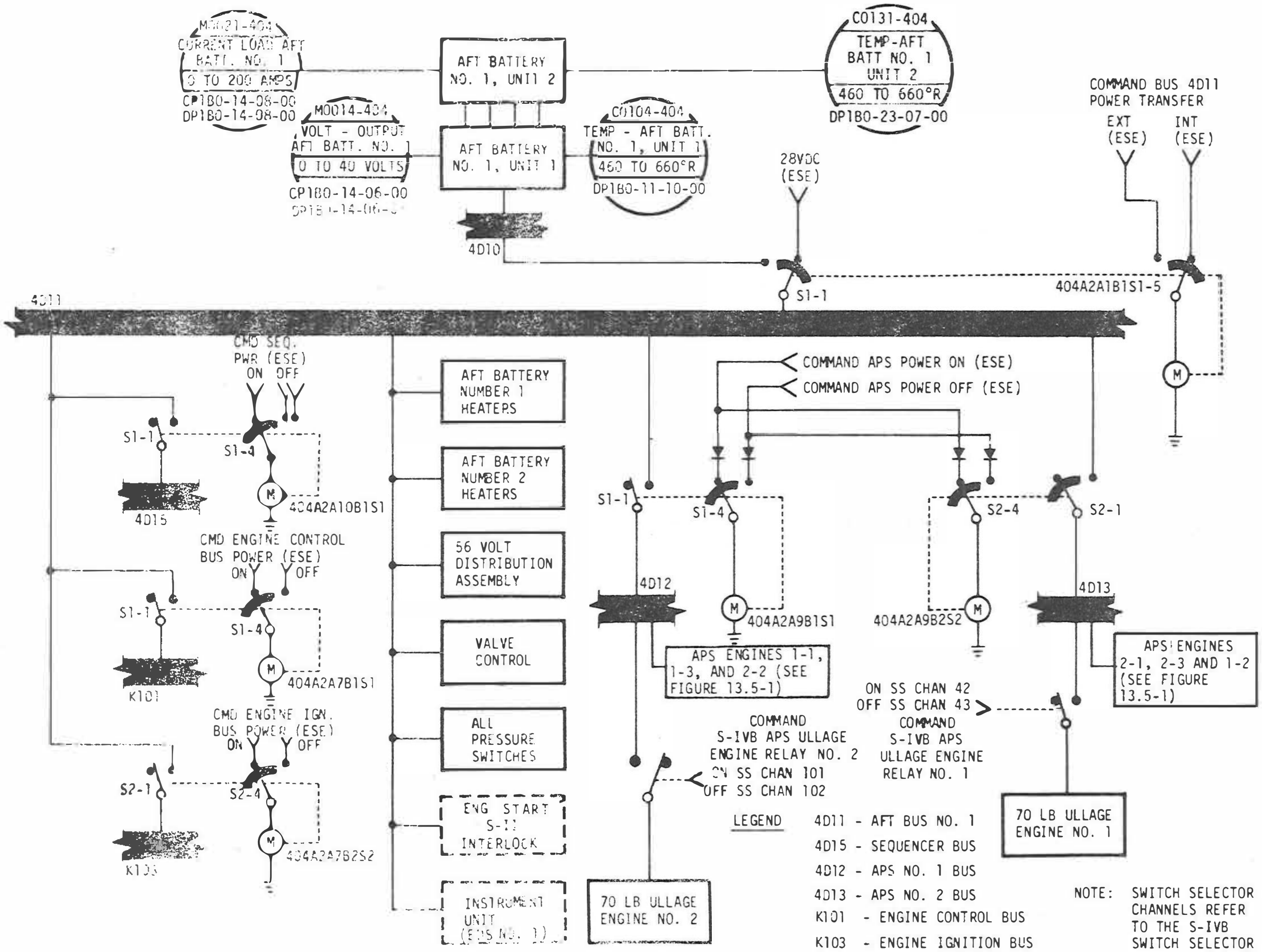


Figure 13-3.- Aft Bus No. 1 - schematic.

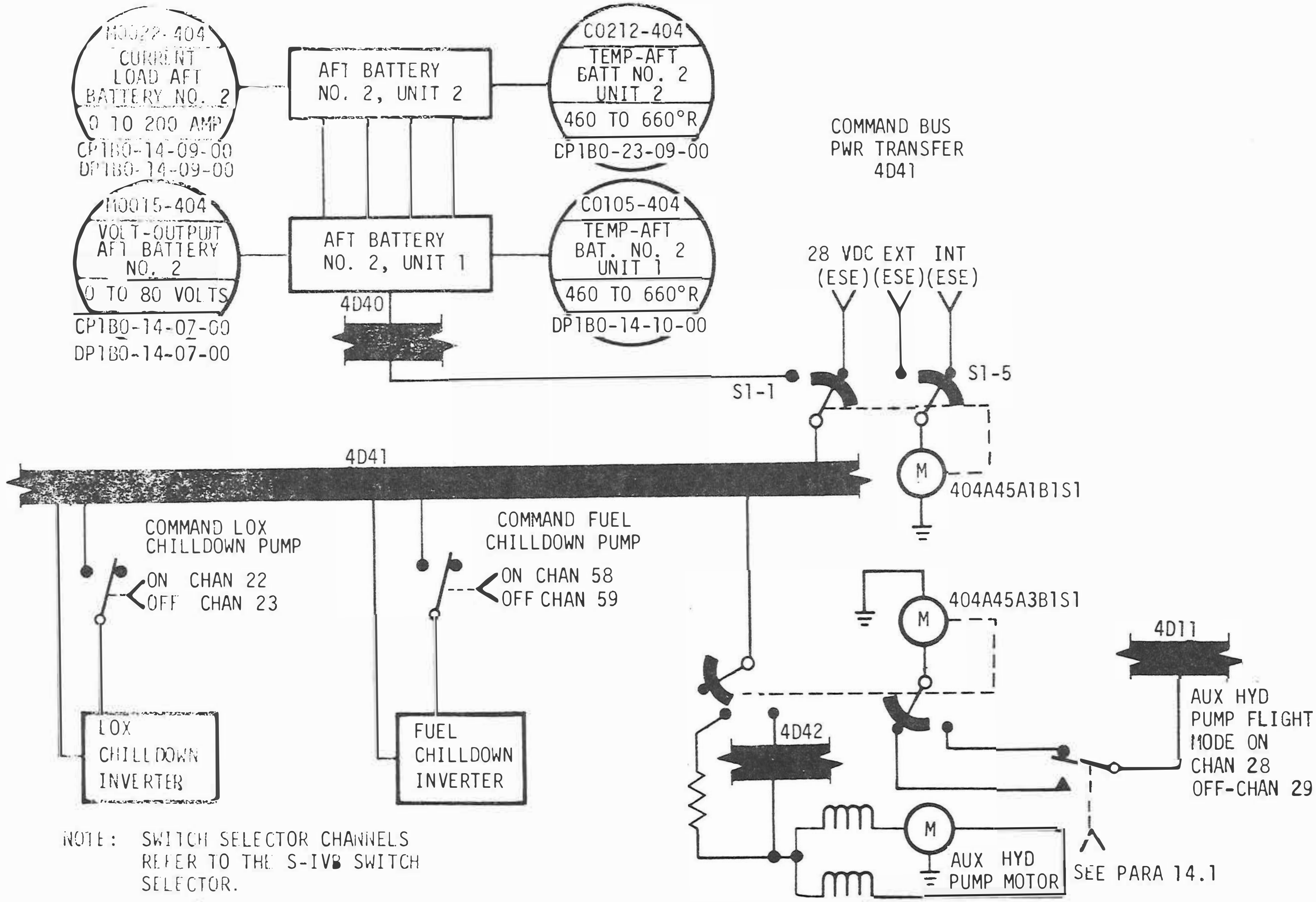


Figure 13-4.- Aft Bus No. 2 - schematic.

14 S-IVB
PROPULSION
SYSTEMS

SECTION 14

S-IVB PROPULSION SYSTEMS

14.1 HYDRAULIC SYSTEM

Pitch and yaw control requirements of the S-IVB stage during main stage burn are accomplished by varying the direction of the J-2 engine thrust vector. Roll control is provided by the auxiliary propulsion system. The required gimbal rate for directional control is provided by an independent, closed-loop, hydraulic system (Figure 14-1). Gimbal forces, provided by two electrohydraulic servoactuators, are available during J-2 engine firing (hot gimbaling) or non-firing (cold gimbaling). Engine position is proportional to the electrical input command signal to the servovalve in the actuator.

The hydraulic system consists of five major components mounted on the engine and stage structure and are connected by metal tubing and teflon lined flexible hoses (Figure 14-2).

The five major components include:

A. Engine-driven hydraulic pump
B. Auxiliary pump
C. Accumulator-reservoir assembly
D. Yaw hydraulic actuator
E. Pitch hydraulic actuator

Depending upon mode of operation, hydraulic power for gimbaling the engine is derived from the engine-driven pump and/or the auxiliary pump and may be supplemented by the accumulator.

14.1.1 Engine-Driven (Main) Hydraulic Pump

The pump is a yoke-type, variable displacement pump with a flow rate of 8 gpm at 8,000 rpm and 3,600 psia nominal pressure. The pump, mounted on the LOX turbine gas collector dome accessory pad, is powered by a crown-spline quill shaft extending from the turbine accessory drive to the pump. It provides the high flow rate required to gimbal the engine at a nominal gimbal rate of 8 deg/sec (15 deg/sec max).

14.1.2 Auxiliary Hydraulic Pump

The auxiliary hydraulic pump is a fixed angle, variable delivery pump with a rated flow of 1.5 gpm at a nominal 3,600 psia. The pump is driven by a 56 Vdc motor requiring either a ground service power or stage power. The motor cavity is filled with dry air. This air maintains a positive pressure within the motor to prevent excessive brush wear; it also transfers motor-generated heat to the hydraulic fluid. The heat thermally conditions the fluid during prelaunch propellant loading operations and during the orbital coast phase. The pump is started prior to launch and is used to pressurize the hydraulic system and center the J-2 engine prior to ignition. The auxiliary pump operates in parallel with the main pump during engine burn and acts as a backup in case of main pump failure.

14.1.3 Accumulator - Reservoir Assembly

The accumulator-reservoir assembly is a combination nitrogen gas powered piston type accumulator and a differential piston type reservoir. The accumulator stores the system high pressure fluid supply when the pumps are operating and reduces pressure surges and pulsations. It also furnishes hydraulic flow to supplement the pumps during excessive actuator demands. The reservoir stores the system low pressure fluid supply, and provides initial inlet head to the hydraulic pumps for starting.

The accumulator-reservoir is the moving piston type. The accumulator side of the assembly has two coaxial pistons with vented seals. The gas side is precharged through the gaseous nitrogen fill valve with gaseous nitrogen at 2,350 ± 50 psia at 70°F, and is monitored by a 0 to 4,000 psig gage. The inner piston serves as a pneumatic ram to provide reservoir pressure at the auxiliary pump inlet, thus preventing cavitation during start. The reservoir is pressurized to 170 psig by the "bootstrap" action of the accumulator fluid during operating periods of the pumps and to 63 psig by the pneumatic action of the accumulator gaseous nitrogen during non-operating periods of the pumps.

14.1.4 Hydraulic Actuators

There are two hydraulic actuators. Each actuator is a piston type, linear, double acting unit capable of delivering 42,000 lb force at a pressure of 3,650 psia in the extend or retract position. The actuators are mounted from the thrust structure to the J-2 engine across the gimbal plane of the S-IVB stage. They are located 90 degrees apart with respect to the longitudinal axis of the stage and provide engine thrust vector directional control by gimbaling the engine in the pitch and yaw planes. The engine can be gimbaled +7.5 to -7.5 degrees in a square pattern in proportion to the electrical command signals from the instrument unit to the servovalves. The actuators can extend or retract separately or in unison.

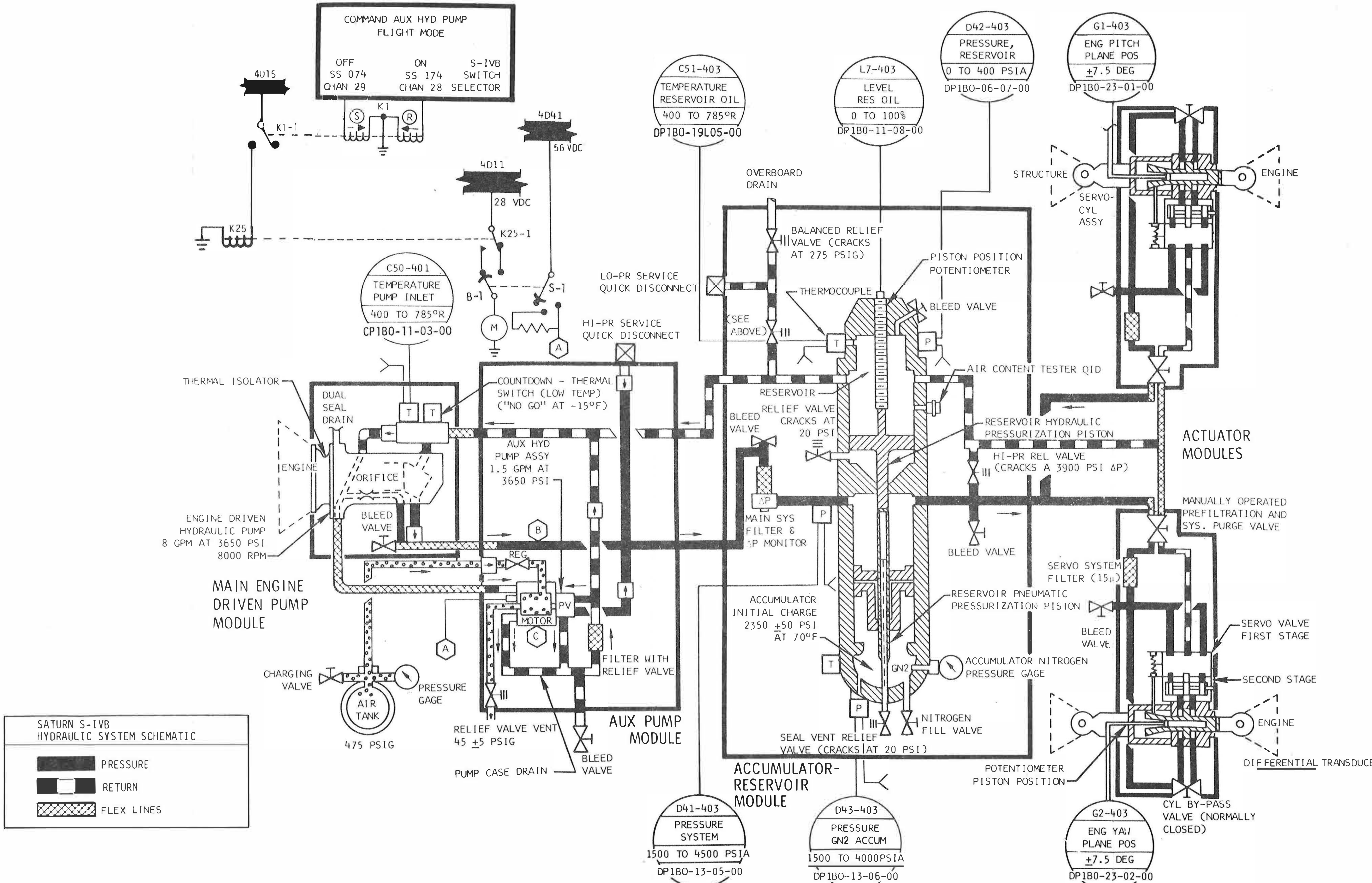


Figure 14-1.- Propulsion - S-IVB hydraulic system.

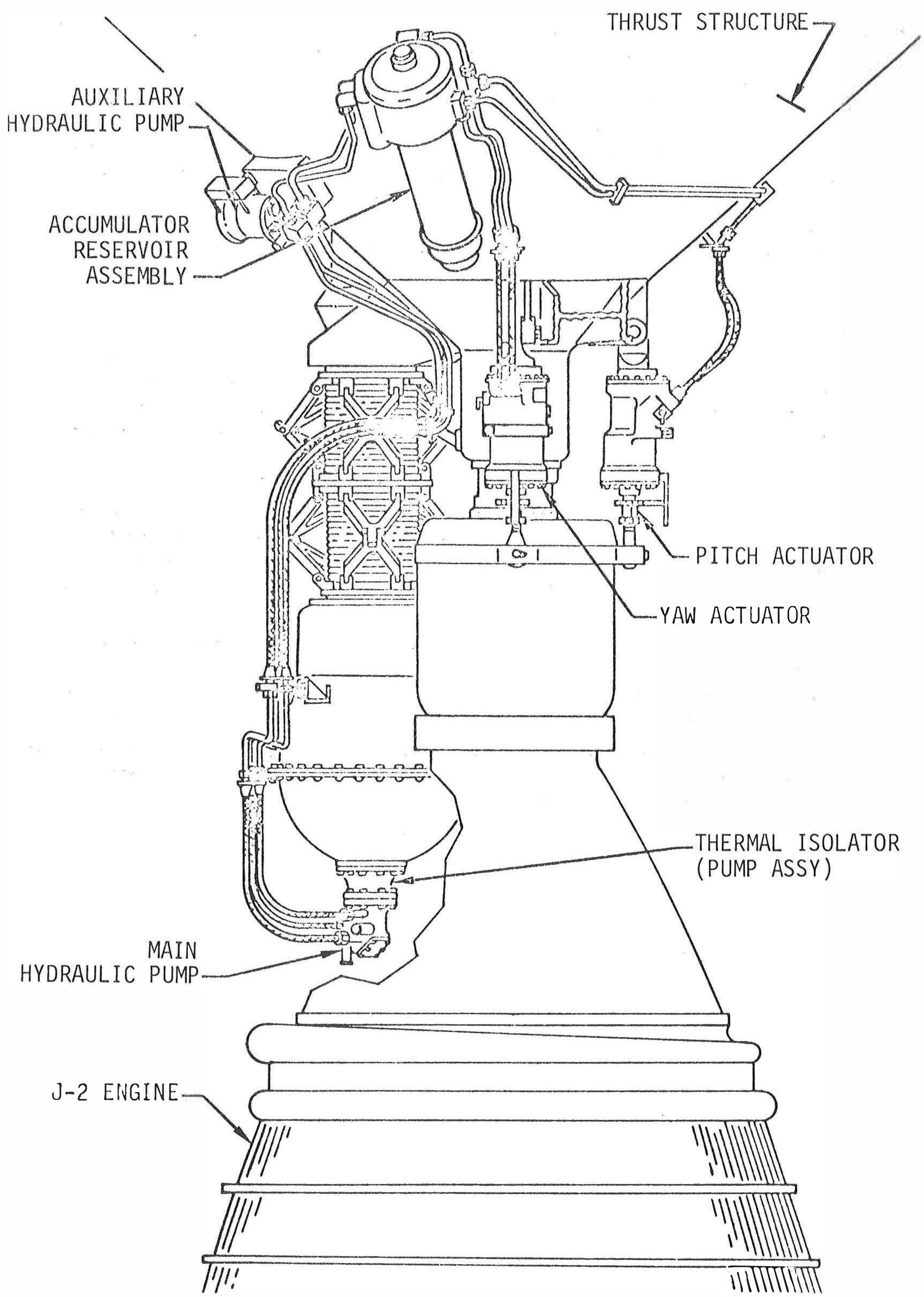


Figure 14-2.- Hydraulic system installation.

14.2 FUEL PRESSURIZATION

During the rapid-fill phase, LH_2 is supplied at the rate of 3000 gpm. The directional vent is in the ground position and the LH_2 tank vent-and-relief valve is open during this time. The final topping fill rate is 250 gpm. At the start of final topping, the vent-and-relief valve is closed and prepressurization is initiated with helium from ground source at 600 psia at -360° F. The prepressurization pressure is controlled by the Ground Fill, Prepress, Repress, and Flight Control Pressure Switch which actuates when the ullage pressure increases to 31 psia and deactuates when the ullage pressure decays to 28 psia. When actuated, the pressure switch will terminate pressurant flow into the tank by closing valves in the GSE Pneumatics Module. Prior to lift-off the directional control valve is switched to the flight position. During boost and prior to engine start it is anticipated that LH_2 ullage pressure will rise to near LH_2 tank relief pressure of 31 to 34 psia. If this occurs, or if at any other flight time venting occurs, the gases will vent through the nonpropulsive vent.

The fuel tank ullage pressure must be maintained at proper pressures to assure a net positive suction pressure at the LH_2 pump inlet to insure proper engine start and operation.

During engine firing GH_2 is bled from the J-2 engine tapoff at 750 psia and at -260° F and directed through the Fuel Tank Pressurization Control Module to the fuel tank to maintain adequate LH_2 tank ullage pressure. The electrical circuitry is reconfigured so that the pressure switch discussed above controls an over-control valve in the Pressurization Control Module. Upon actuation, the pressure switch will reduce the pressurant flowrate by closing the over-control valve. The over-control valve will be opened allowing increased pressurant flowrate when the pressure switch is deactuated.

Between burn periods the pressurization system is deactivated and continuous venting of the tank is performed. This is not a relief vent, but rather a controlled vent using the boiloff gases as a propulsive source. The tank pressure is held to 20 psia by the continuous vent system. The vented gases are directed aft and provide a continuous low thrust (6 to 15 lbf) on the vehicle to maintain the proper propellant position.

Repressurization of the fuel tank to the engine start levels for any subsequent burns is accomplished by the dual repress system (see paragraph 14.4). In order to enhance the reliability of the repressurization, an additional pressure switch (the Repress Switch) has been installed to sense fuel ullage pressure. This switch is electrically in series with the above-mentioned switch and has the same actuation and deactuation values. Repress pressurant flow is terminated when both pressure switches are actuated.

During the second burn the pressurant flowrate is controlled in essentially the same manner as during the first burn. A command locks the pressure switch out of the control circuitry at a predetermined time during the second burn allowing maximum pressurant flowrate for the remainder of the burn.

The fuel pressurization system is shown schematically in Figure 14-3.

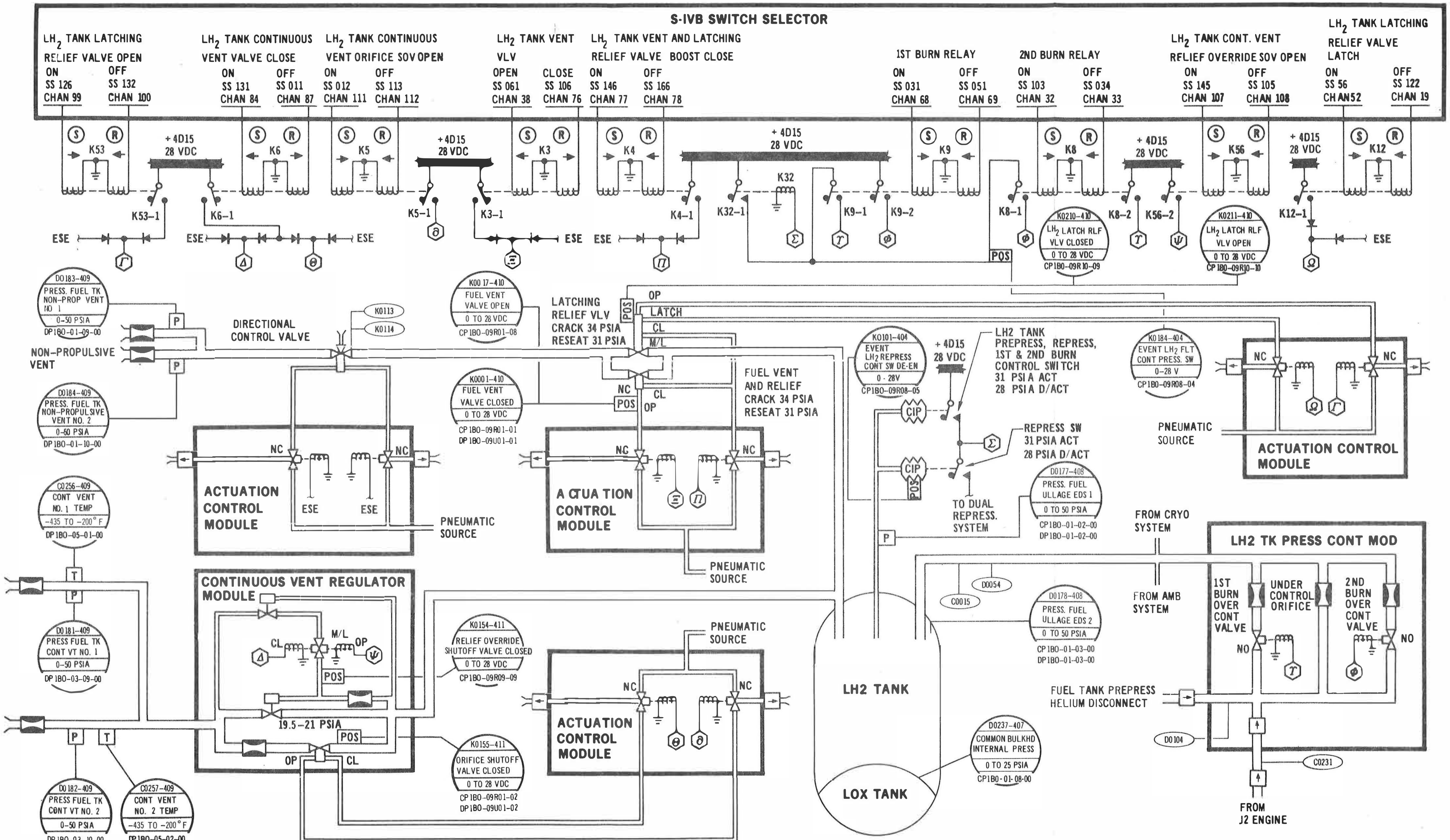


Figure 14-3.- LH_2 pressurization system schematic.

14.3 LOX PRESSURIZATION

At the beginning of lox tank fill, the vent-and-relief valve is opened. During rapid fill, lox is supplied to the tank at a maximum rate of 1000 gpm and is then reduced to 200 gpm during slow fill. When slow fill is complete, the vent-and-relief valve is closed and prepressurization begins. The primary pressurant for the lox tank is helium which is passed through an ESE heat exchanger and stored at 3000 ± 100 psia at -420° F in nine spheres located in the LH_2 tank. The ground fill line for these spheres also connects to the onboard Lox Tank Pressurization Module where the closed cold-helium shutoff valves prevent flow into lox tank ullage. At the time of prepressurization, in addition to closing the vent, the ground control of the cold-helium shutoff valves is removed allowing the valves to be controlled by the Lox Tank Prepress, Repress, and Flight Control Pressure Switch. This switch, which senses lox ullage pressure, actuates when the pressure increases to 41 psi and deactuates when the pressure decays to 38 psia. Helium from the cold-helium ground fill will flow into the LOX ullage until the pressure switch is actuated thereby closing the cold-helium shutoff valves. Heat exchange in the ullage chills the pressurant causing a pressure decay allowing the pressure switch to deactuate. This deactuation allows the cold-helium shutoff valves to open and admit more pressurant gas. The process is repeated until stabilization.

The LOX Tank Regulator Backup Pressure Switch has been installed in the system downstream of the cold-helium shutoff valves. This switch actuates at 465^{+20}_{-15} psia and deactuates at 350^{+20}_{-15} psia. In case of regulator failure the backup pressure switch would close the cold-helium shutoff valves when actuated and open them when deactuated. This cyclic operation is called the "bang-bang mode" and the frequency is greater than the redundant valves have been tested for at this time. Therefore, the backup pressure switch only controls the shutoff valves in the pressurization module. During prepressurization, the backup pressure switch is deactivated.

During boost, the cold-helium shutoff valves are commanded closed. Just prior to the first engine burn this close command is removed and the electrical circuitry is reconfigured so that the ullage sensing pressure switch discussed above controls the Heat Exchanger Bypass Valve. Because of the high demand for pressurant gas in the initial 24 seconds of the burn, the bypass valve is held open to provide maximum flow. During the burn, helium from the cold helium spheres passes through the regulator where its pressure is reduced to 385^{+28}_{-32} psia, through the shutoff valves, and past the plenum chamber into a manifold. A portion of the cold helium flows to the engine heat exchanger where it is heated and expanded. Another portion flows through an undersized orifice to the lox pressurization line where it is mixed with the output from the heat exchanger. The combined flow is directed into the lox tank. Flow through two orifices is sufficient to maintain tank pressure during engine firing. As lox tank pressure decays to 38 psia, the flight pressure switch drops out allowing the heat exchanger bypass valve to go to its normally open position. This permits additional flow from the heat exchanger to increase the lox tank pressure. When the lox tank pressure reaches 41 psia, the flight pressure switch picks up, closing the heat exchanger bypass valve. The lox tank pressure cycles between 38 and 41 psia. At engine cutoff, the flight pressure switch is disabled and the cold-helium shutoff valves are commanded closed again.

The lox tank pressurization system is deactivated during the coast period between burns. There is a vent system similar to the LH_2 tank in that there is a vent-and-relief valve and a nonpropulsive vent-and-relief valve as backup. However, should the tank be commanded to vent or have relief vent, there is a propulsive force directed through the approximate center of gravity.

Prior to restart, the lox tank is repressurized to the flight control pressure switch settings of 38 to 41 psia. This is accomplished by the dual repressurization system which is explained in paragraph 14.4

The lox pressurization system is shown schematically in Figure 14-4.

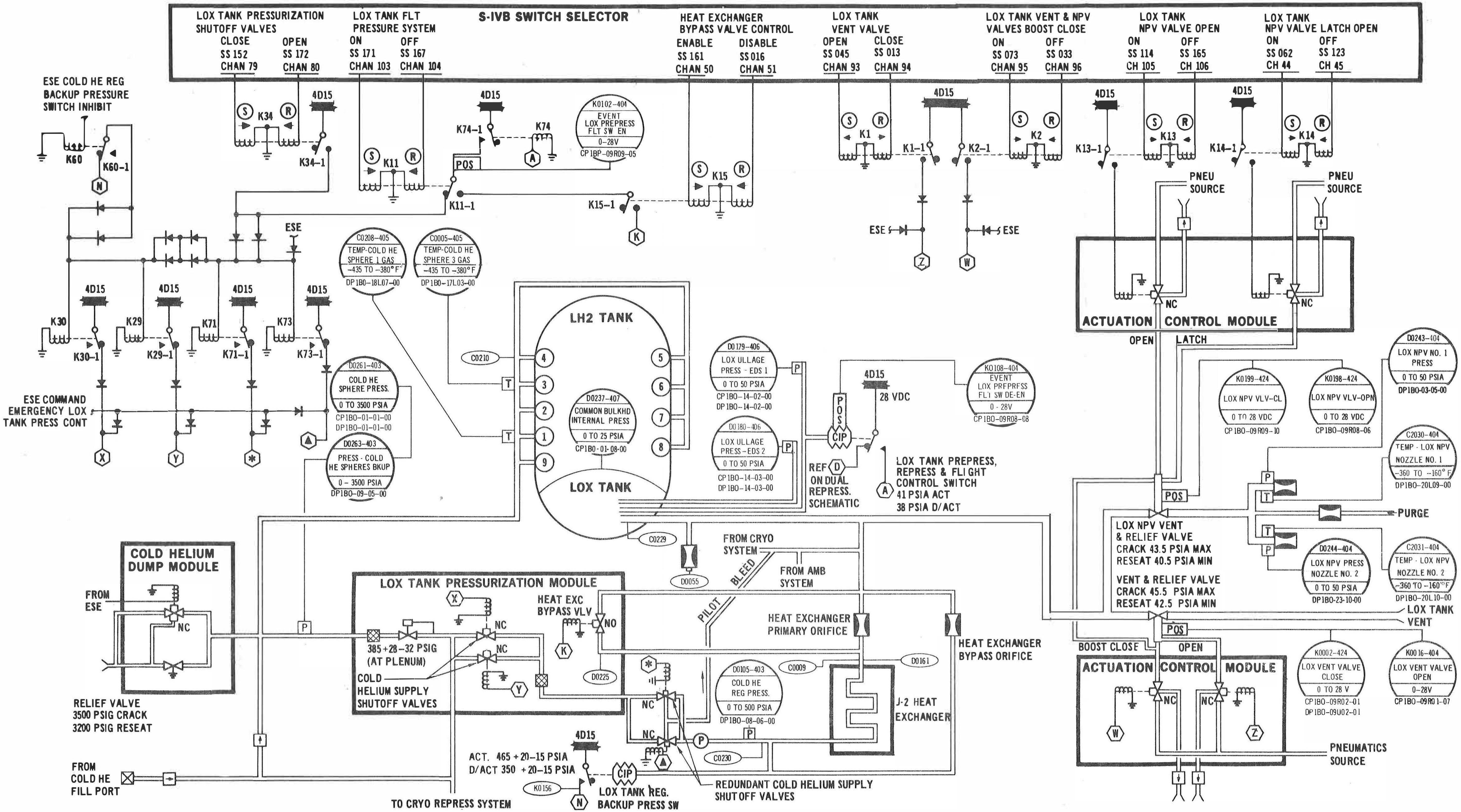


Figure 14-4.- Lox pressurization system schematic.

14.4 DUAL REPRESSUIZATION

The dual repressurization system, which consists of an ambient system and a cryogenic system, pressurizes both lox and fuel tanks to engine operation levels prior to J-2 engine restart.

The ambient system is made up of seven 4.5-cu ft spheres which are charged to 3100 ± 100 psia at 70 ± 10° F through the ESE system. Two of the spheres are designated for lox tank repressurization and the remaining five for fuel tank repressurization. When an ambient repress is required, the dual system is configured to the ambient mode and the appropriate repress control valve opened. Helium will flow through an orifice into the tank ullage until the ullage-sensing pressure switches (paragraphs 14.2 and 14.3) are actuated thereby closing the repress control valves.

The cryogenic system is essentially a separate propulsion system. When prepressurization is required, hydrogen and oxygen are fed from the main propellant tanks under tank head conditions to the O_2-H_2 burner where they are ignited and burned. Cold helium for lox pressurization (paragraph 4.3) is tapped downstream of the regulator in the Lox Tank Pressurization Module, split into lox and fuel systems, and passed through the O_2-H_2 burner to the respective propellant tank ullages. In the burner, the cold helium is heated by the combustion gases and expanded to an acceptable pressurant quality. Both lox and fuel systems have control modules which consist of shutoff valves controlled by the ullage-sensing pressure switches (paragraphs 14.2 and 14.3). Both systems also have tank repress regulator backup pressure switches. These switches provide the same function for their respective systems as the Lox Tank Regulator Backup Pressure Switch (paragraph 14.3) except that their control is limited to their respective repress system shutoff valves.

The O_2-H_2 burner is mounted on the thrust structure and when operating produces 16- to 30-lbf thrust. The thrust vector is directed approximately through the center of gravity of the vehicle and helps settle propellants during repressurization.

On current missions the cryogenic mode is the primary repressurization method for the second engine burn with the ambient system as a backup. The ambient system also provides a backup supply to the stage and engine pneumatic systems and a recharge potential for the engine start tank.

The dual repressurization system is shown schematically in Figure 14-5, and the interconnection of the ambient spheres is shown in Figure 14-6.

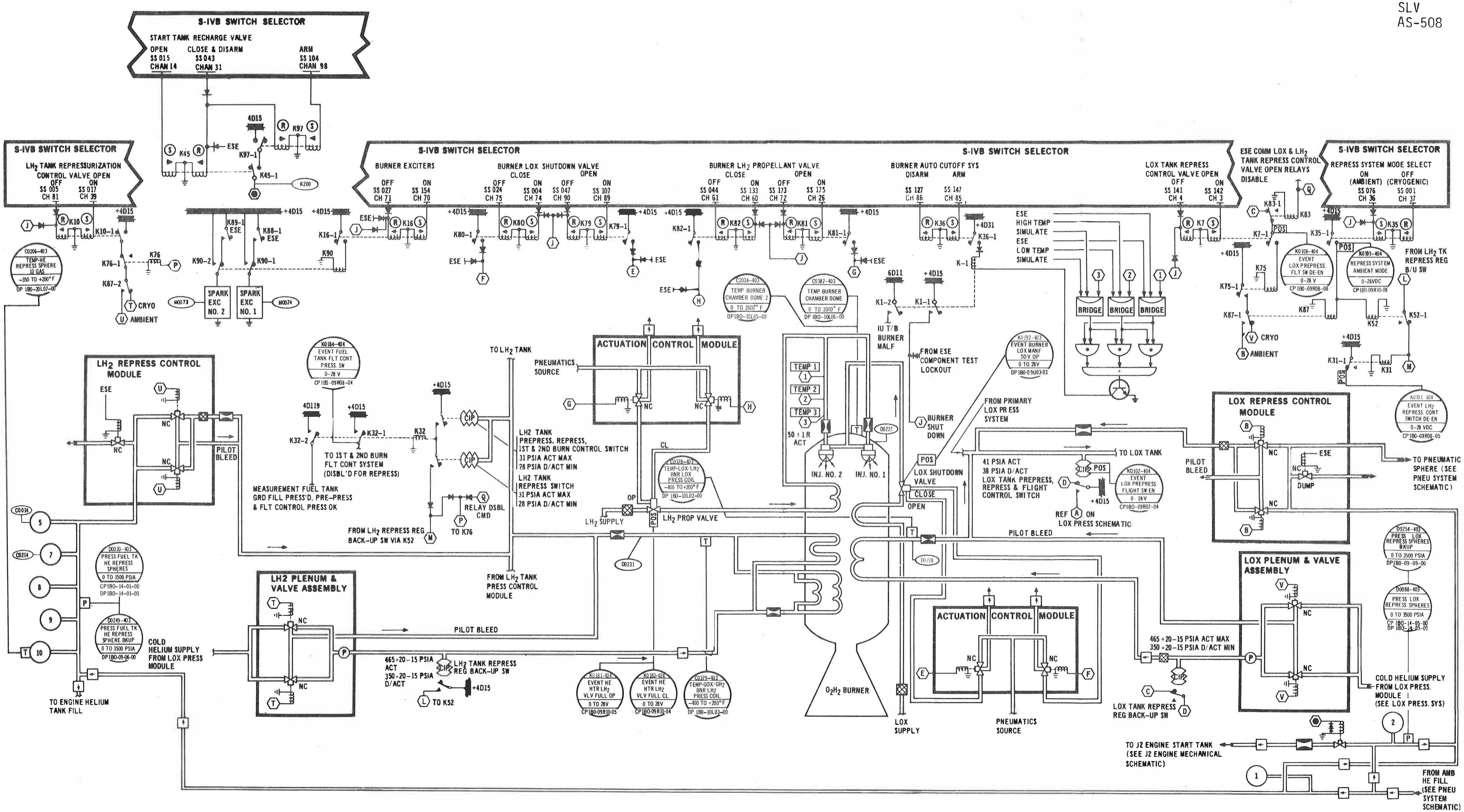


Figure 14-5.- Dual repressurization system schematic.

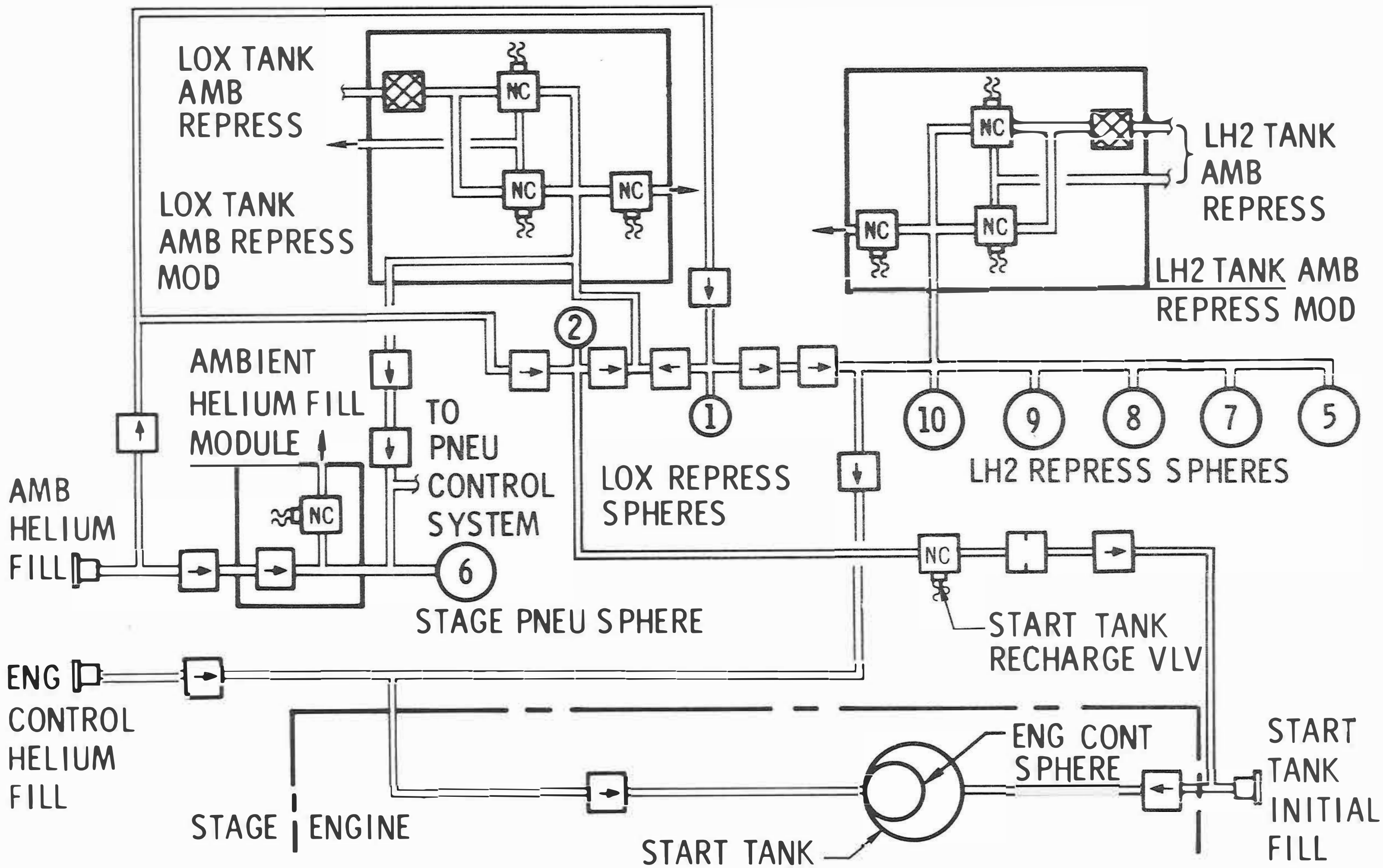


Figure 14-6.- Ambient helium spheres interconnect schematic.

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14.5 PROPELLANT CHILLDOWN SUBSYSTEM

Chilldown of the lox and LH_2 feed systems is accomplished by a closed-loop forward-flow recirculation system. Propellant is circulated from the tanks by centrifugal pumps through low-pressure feed ducts, the J-2 engine propellant pumps, the engine bleed valves, and back to the tanks through return lines.

The forward-flow chilldown subsystems are activated during ground operation prior to lift-off and are maintained during boost to engine prestart. The chilldown subsystems insure that the J-2 turbopumps are properly conditioned for all burns.

Prior to propellant tank prepressurization, the recirculation line shutoff valves are opened, the prevalves are closed, and recirculation flow is initiated. At prestart, with the chilldown pumps still running, the prevalves are actuated open, allowing reverse flow, which removes any trapped gas bubbles from the low pressure feed ducts. After engine start the bleed valves, which allow return flow to the tanks, are closed and the chilldown pumps turned off. During restart preparations, the chilldown pumps are turned on, the prevalves closed, and recirculation flow reinitiated to provide proper turbopump conditioning. The chilldown process described above is repeated.

The chilldown system is shown schematically on Figure 14-7.

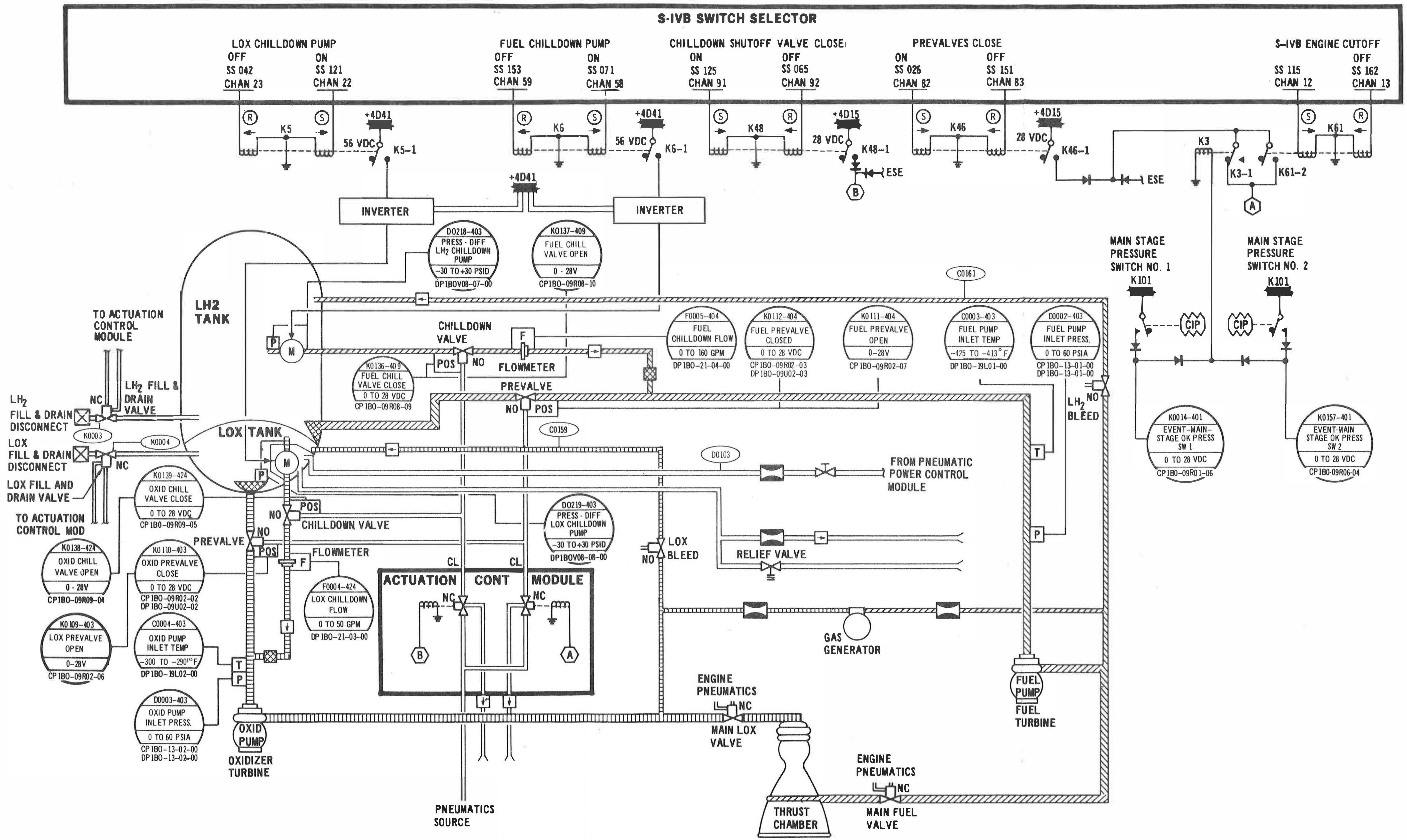


Figure 14-7.- Chilldown system schematic.

14.6 PNEUMATIC CONTROL SYSTEM

The pneumatic control system provides supply pressure for all stage pneumatically operated valves with the exception of J-2 engine valving. A pneumatic-power control module filters ambient helium flowing from the ambient helium sphere and regulates the sphere pressure of 3100 ± 100 psia at 70 ± 10° F down to 455 to 515 psia. The regulator in the system has a tendency to increase the pressure when the flow rate is low. The regulator will lock up at 565 psia.

The regulated pressure is used as indicated below:

A. LH_2 vent-and-relief valve actuation
B. LH_2 latching relief valve actuation
C. LH_2 vent directional control valve actuation
D. LH_2 continuous-vent orifice shutoff valve actuation
E. Lox tank vent-and-relief valve actuation
F. Lox tank nonpropulsive vent valve actuation
G. Lox and LH_2 prevalves and chilldown shutoff valves actuation
H. Lox fill-and-drain valve actuation
I. LH_2 fill-and-drain valve actuation
J. O_2-H_2 burner LH_2 propellant valve actuation
K. O_2-H_2 burner lox shutdown valve actuation
L. J-2 engine GH_2 start-tank vent valve actuation
M. Lox chilldown pump motor enclosure purge
N. Lox and LH_2 turbopump turbines and gas generator purge

Items A through K above are each equipped with a separate actuation control module. Each module contains two solenoid valves which, on command, exercise on/off control of each respective valve. The pneumatic control system is protected from overpressurization by a solenoid valve/pressure switch combination which serves as a backup to the regulator. In the event of regulator malfunction causing system pressure to rise to 600 ± 15 psia, the pressure switch will actuate thereby causing the normally open solenoid valve to close. When the pressure decays to 490 ± 25 psia the switch will drop out, and the valve will open again.

The pneumatic control system is shown schematically on Figure 14-8.

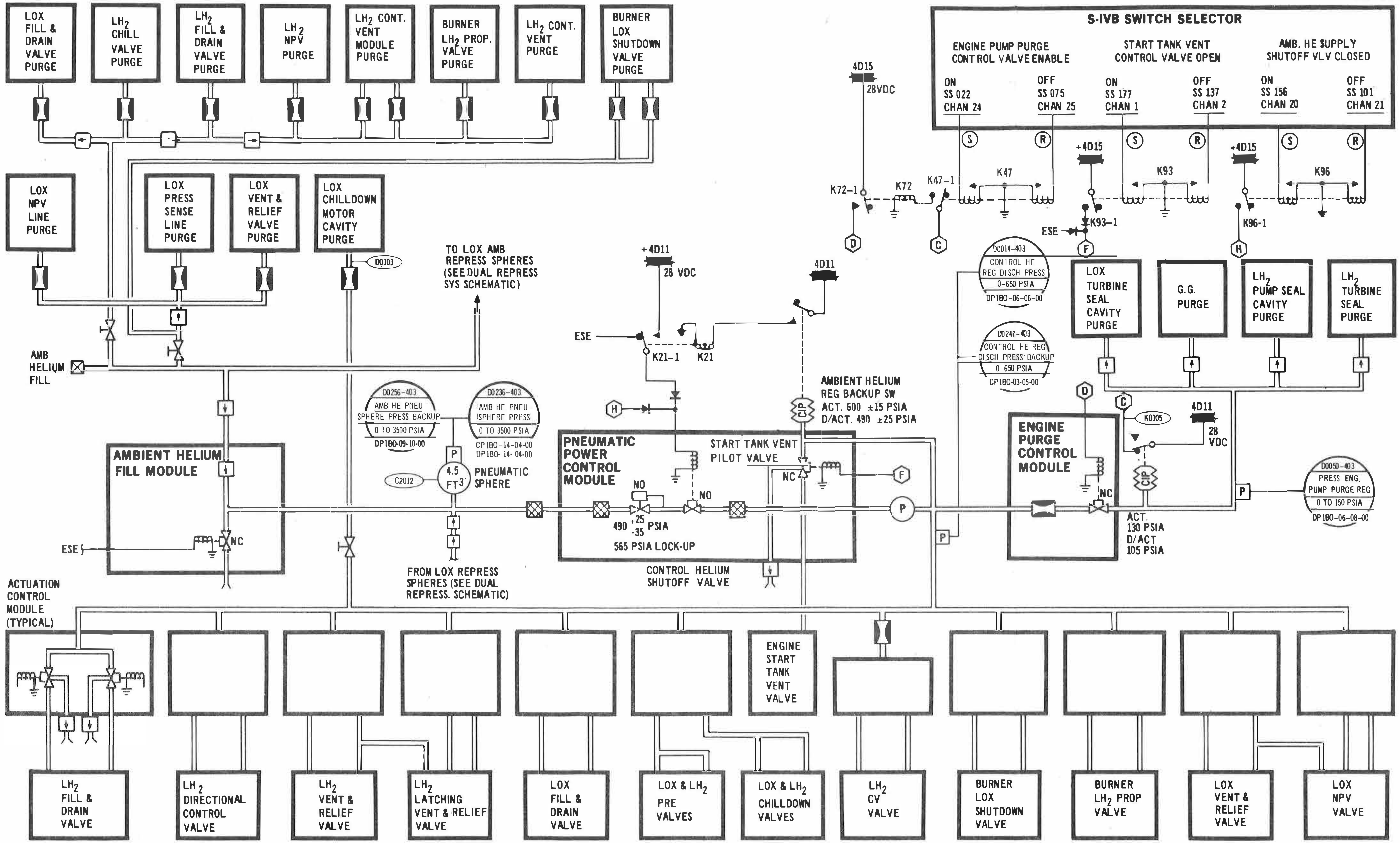


Figure 14-8.- Pneumatic system schematic.

14.7 J-2 ENGINE

At engine start command, the electrical control package activates the following:

A. Spark plug exciters to energize the spark plugs in the augmented spark igniter (ASI) chamber and the gas generator

B. Helium control solenoid which allows helium into the pneumatic control system, closing the bleed valves, charging the accumulator, and purging the main lox dome and gas generator lox injector

C. Ignition phase control solenoid which opens the ASI lox valve allowing lox to flow to the ASI chamber, the main LH_2 valve allowing LH_2 to flow through the thrust chamber tubes and injector, and to the ASI chamber

At the completion of these events, there is flame in the ASI chamber, hydrogen flowing through the tubes and injector to condition the thrust chamber for main stage operation, and purge pressure in the lox dome to prevent the entry of hydrogen.

Upon expiration of a predetermined time calculated to allow satisfactory thrust chamber conditioning, an electrical signal is sent to open the start-tank discharge valve allowing the start bottle to blow down, thus supplying energy to spin the propellant turbopumps. The signal also activates the ignition phase timer which, upon expiration, deenergizes the start tank solenoid, closing the start-tank discharge valve. Simultaneously, the signal energizes the main stage control solenoid which opens the main lox valve and terminates the lox dome purge. As the first stage actuator of the main lox valve moves from the closed position, control helium from the ignition phase control solenoid passes through the sequence ports opening the gas generator valve and closing the oxidizer turbine bypass valve.

When the gas generator valve opens, oxidizer and fuel from the respective pump discharge regions flow into the gas generator and are ignited. The exhaust from this ignition causes an increase in pump speed and a corresponding increase in pump discharge pressure. The main lox valve moves to the full-open position and the gas generator pressure increases allowing the engine performance to build up to a stable mainstage operating level. During steady-state first burn, the start tank which provided energy for start is refilled.

When an engine cutoff signal is received by the electrical control package, it deenergizes the main-stage and ignition-phase solenoid valves and energizes the helium-control-solenoid deenergize timer. This, in turn, permits closing pressure to the main LH_2 valve, main lox valve, and the ASI lox valve. The gas generator valve closes and the lox turbine bypass valve opens to complete the engine cutoff sequence. Upon expiration of the helium-control-solenoid deenergize timer, the helium-control solenoid deenergizes thereby venting the helium in the pneumatic-control low-pressure systems, and the lox and LH_2 bleed valves open. The engine is enabled for restart as required in the flight sequence.

The engine system is shown mechanically in Figure 14-9 and electrically in Figure 14-10.

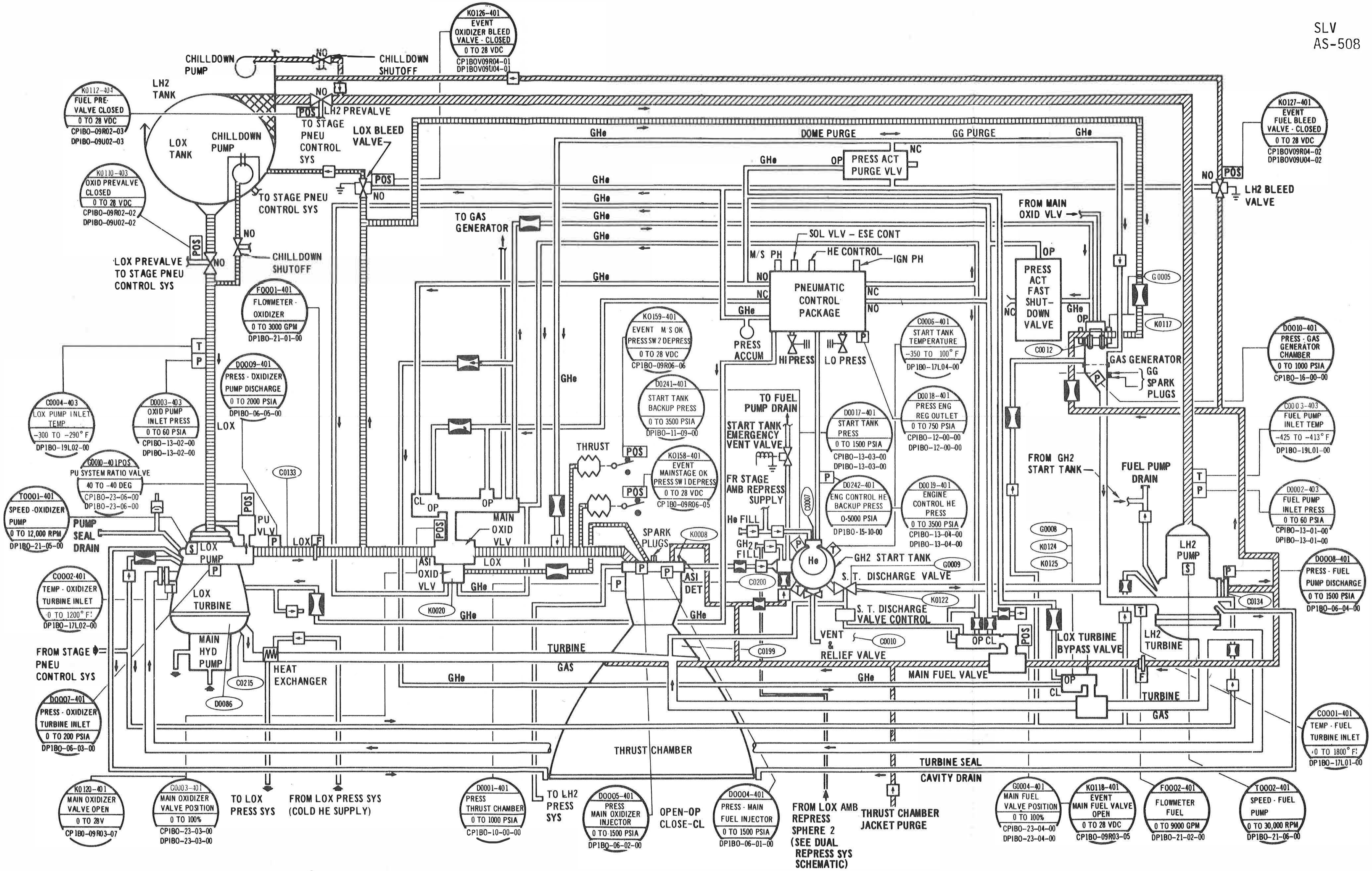


Figure 14-9.- J-2 engine mechanical system schematic.

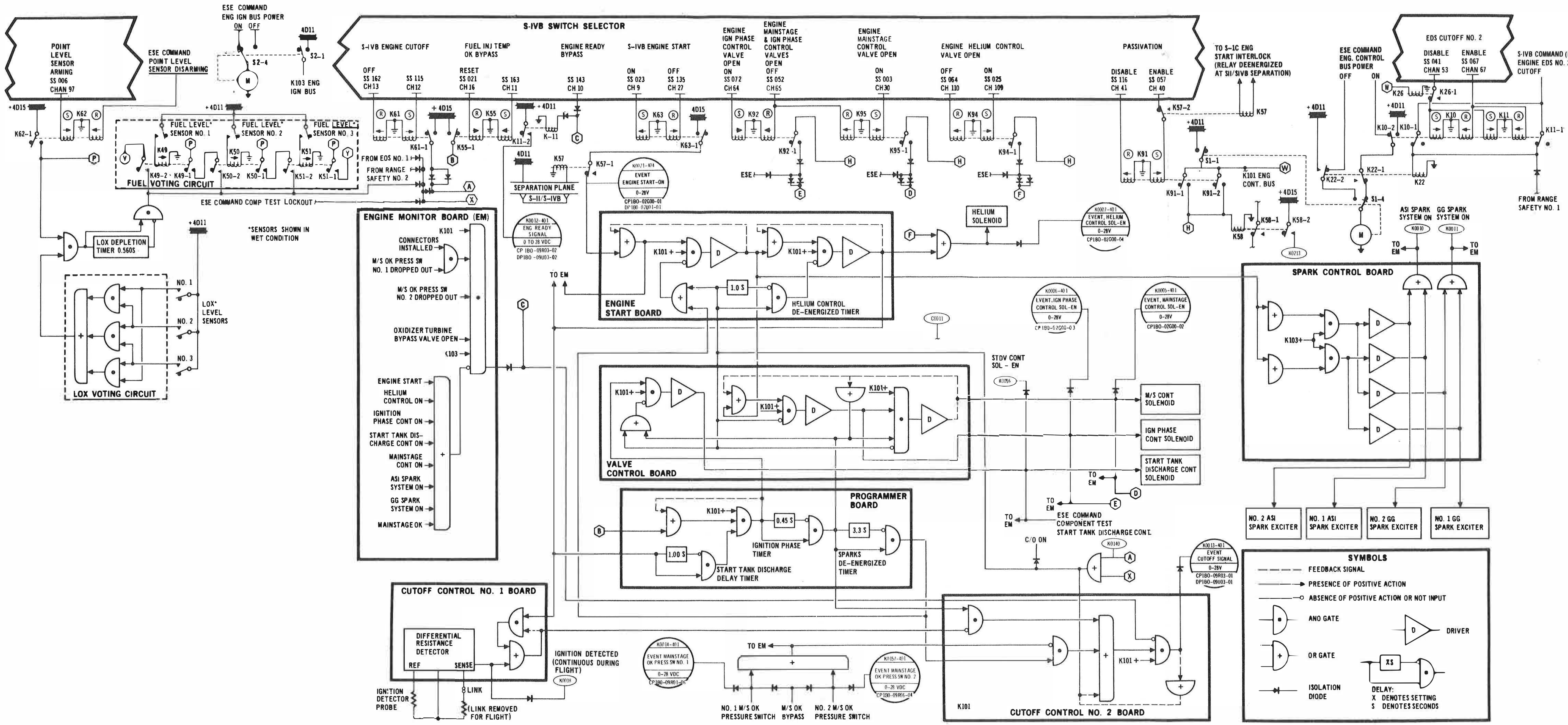


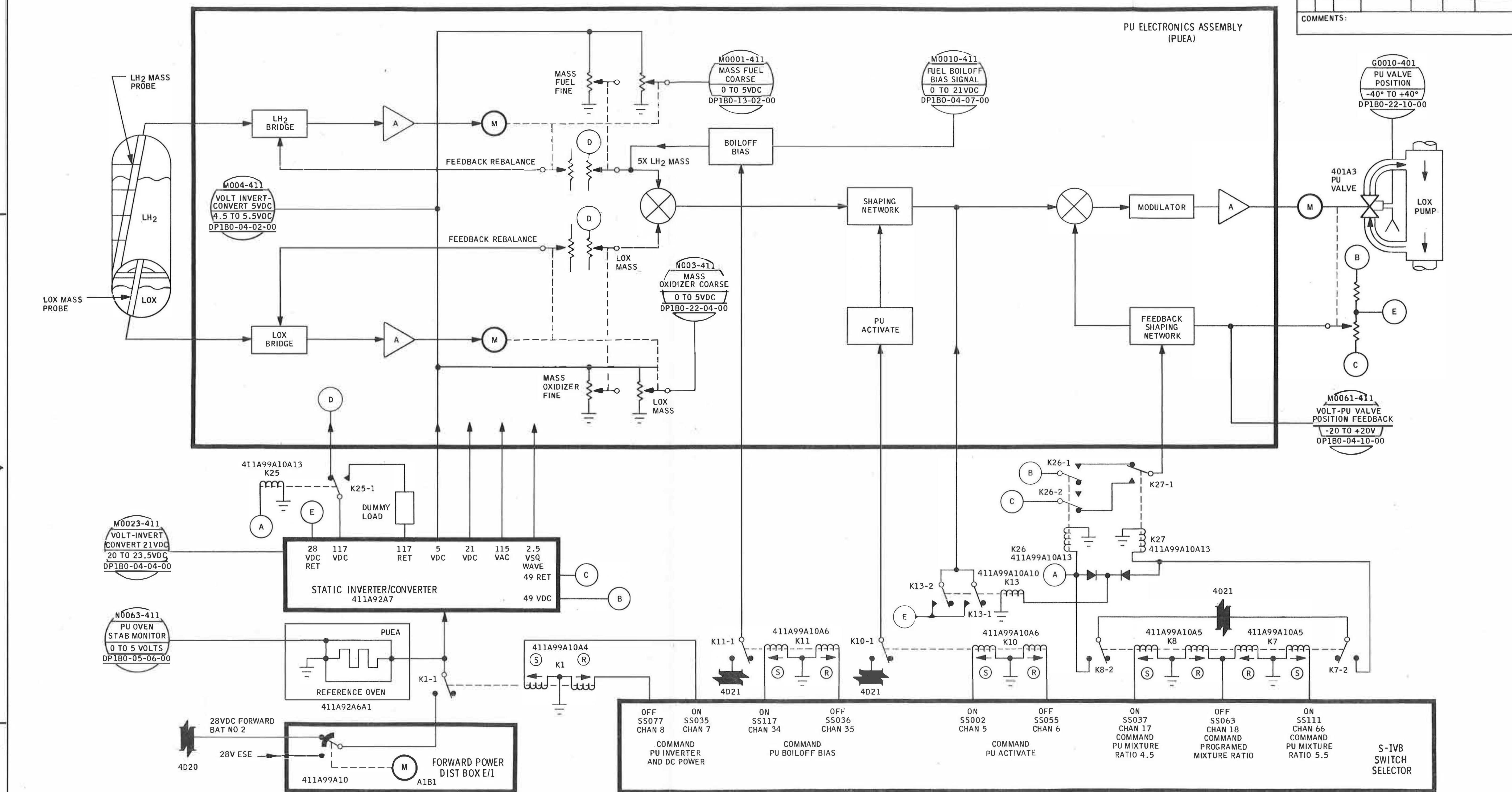
Figure 14-10.- J-2 engine system control schematic (electrical).

14.8 PROPELLANT UTILIZATION

The PU subsystem is a propellant-mass-ratio control device consisting of capacitance mass sensors, an engine lox flow control valve, and an electronic assembly to enable control. The metering probes provide capacitance output directly proportional to tank propellant mass. The changing level of dielectric (lox or LH_2) changes the capacitance value of the probe, which is fed into the PU electronics assembl. . (See Drawing 14.8.1.)

In the PU electronics assembly the sum of the LH_2 and lox potentiometers are fed to a shaping network. The amplified, modulated signal is applied to a valve positioning servo. The servomotor controls the PU valve position, varying engine mixture ratio to compensate for tank mass unbalance. PU valve potentiometer feedback nulls the amplifier output. Additional potentiometers supply telemetry and mass loading signals.

The signals from the PU electronics assembly position a servomotor which controls the lox bypass valve on the J-2 engine within ±10 percent of 5:1 engine mixture ratio. Propellant residuals are maintained to less than 575 lbm (0.25 percent) total usable load.



LTR	DCN	DR	ENG	DATE	APPROVAL

COMMENTS:

NOTE: 1 ON THIS DRAWING, DIRECTION OF RELAY ARROW SHOWS DIRECTION THAT THE RELAY PULLS RATHER THAN DIRECTION OF CURRENT FLOW

SIGNATURES	DATE
DR Bobby J. Osborn	2/4/70
DSGN Bill J. Cornelius	2-18-70
QC Betty M. Taylor	2-18-70
ENGR Richard Cottrell	2-20-70
APP	2-20-70
FEC	2-20-70
AUTH	2-20-70

NATIONAL AERONAUTICS & SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER • HOUSTON, TEXAS

PU SYSTEM

SLV AS-508 | SIZE D | DWG NO 14.8.1
34 X 22 | PAGE 14-20 | SHEET 1 OF 1

15 AUXILIARY PROPULSION SYSTEM

SECTION 15

AUXILIARY PROPULSION SYSTEM

15.1 APS DESCRIPTION

The auxiliary propulsion system provides attitude control for the S-IVB stage during all operational phases and provides propellant settling thrust just after J-2 engine cutoff and prior to J-2 engine burn. System components are contained in two separate modules place 180 degrees apart on the aft skirt. Each module contains a cluster of liquid bipropellant hypergolic engines, a positive-expulsion propellant feed system, and a helium pressurization system. The engine cluster in each module consists of three 150-lbf attitude control engines and one 70-lbf ullage settling engine. (See Figure 15-1.)

The APS modules receive command signals from the IU and perform the following functions:

A. Roll control during J-2 engine burn

B. Attitude stabilization after J-2 burn

C. Maneuvering attitude control

D. Propellant settling (first and second burn cutoff and second burn start)

The instrument unit provides all firing commands. These commands actuate fuel and oxidizer solenoid valves to release hypergolic propellants to the engines. The engines operate in short pulse-type bursts ranging from 0.65 msec to as much as required. The APS ullage (propellant settling) rockets (one in each module) are first enabled during the J-2 engine first burn cutoff. Firing continues for approximately 86 seconds, through the engine cutoff transient decay and the activation of the LH_2 tank propulsive vent system. The APS ullage rockets are again energized at the end of the coast period prior to restart. Propellant settling is thus assured to provide liquids to the pumps during the chilldown process. It is noted that propellant settling for first burn start is provided by solid ullage rockets. The control system for these is shown in Figure 15-2.

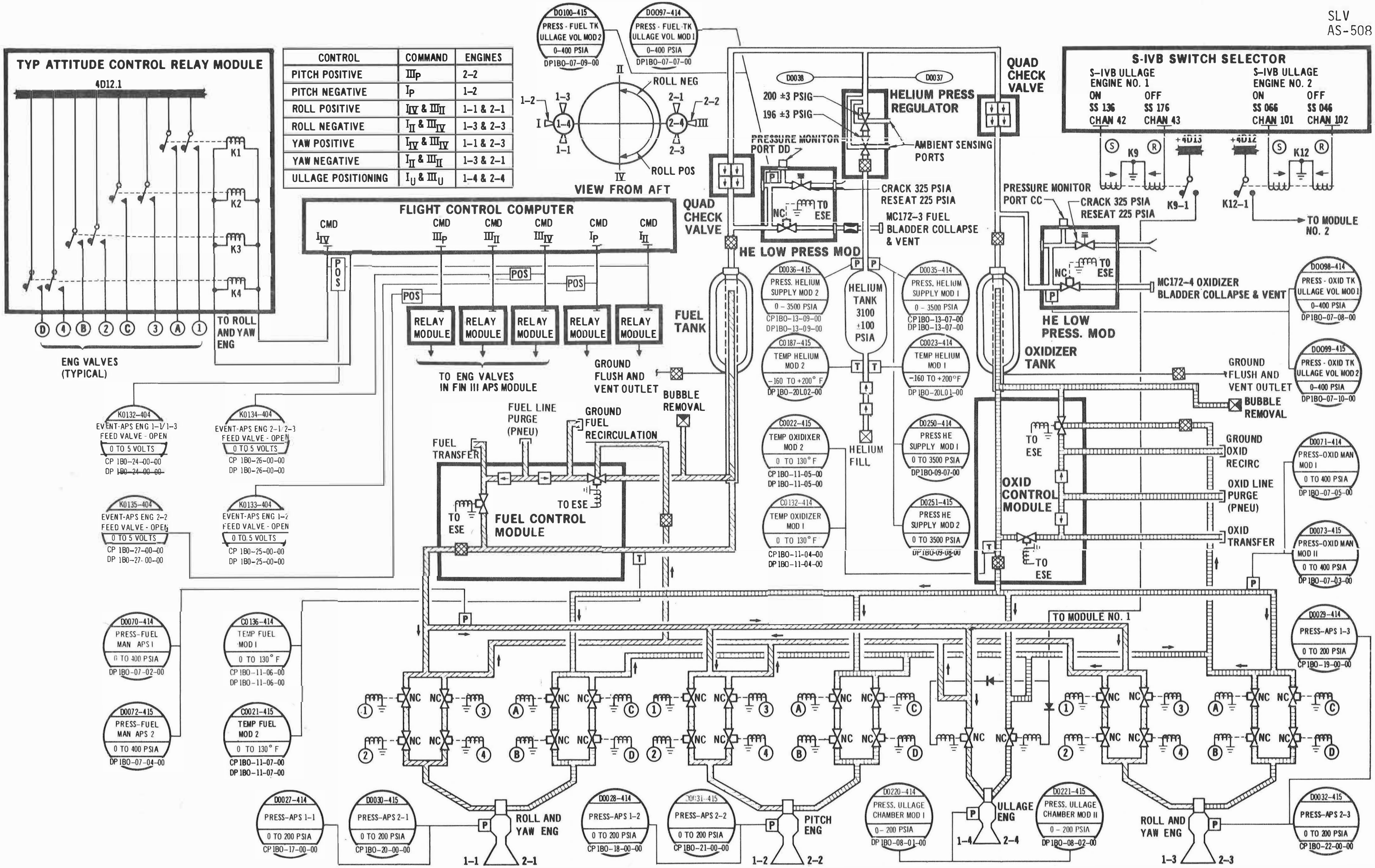


Figure 15-1.- Auxiliary propulsion system.

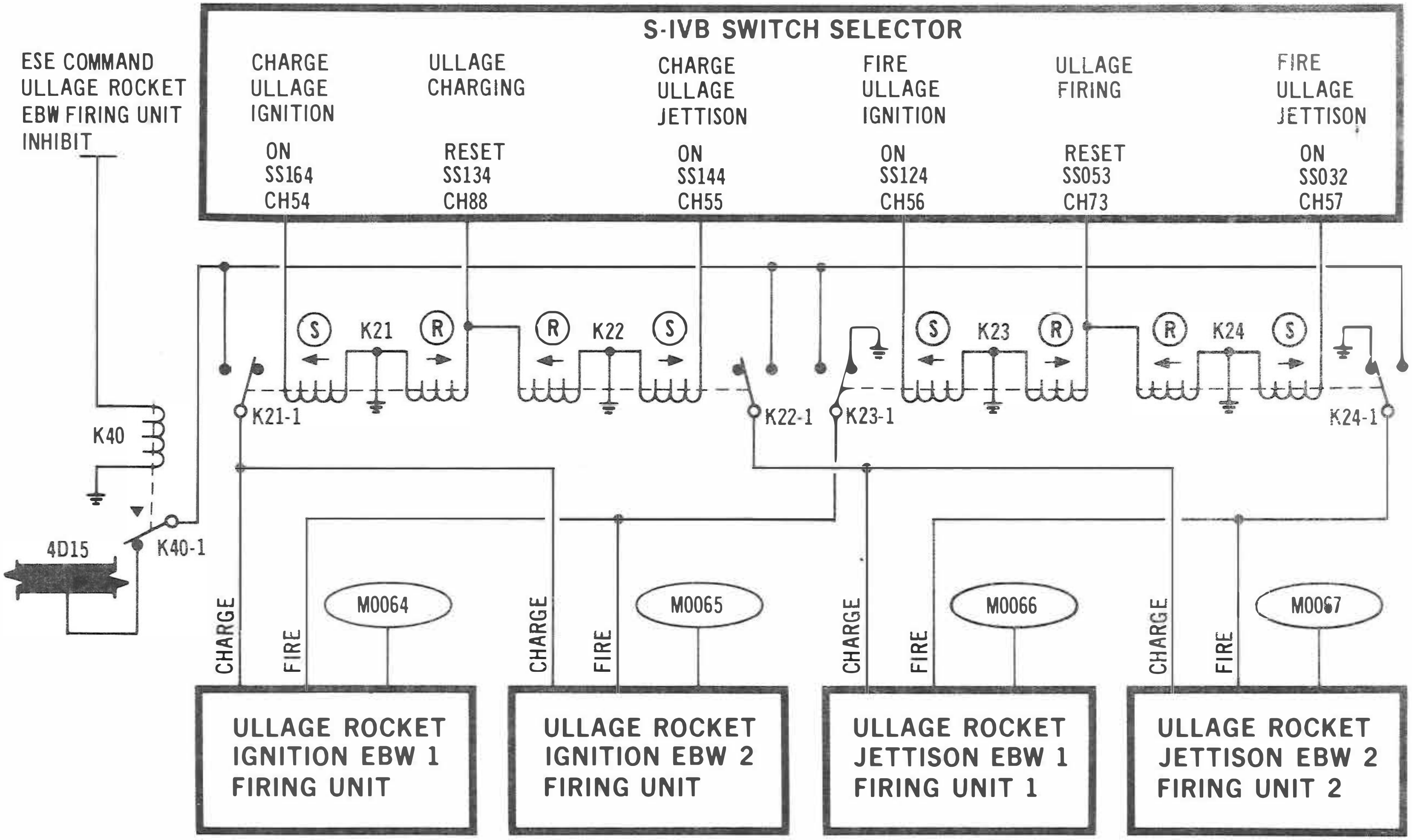


Figure 15-2.- Solid ullage rocket control system schematic.

16 S-IVB
INSTRUMENTATION
AND TELEMETRY

SECTION 16
S-IVB INSTRUMENTATION AND TELEMETRY

16.1 TELEMETRY SYSTEMS

Each stage of the launch vehicle has in independent measuring and telemetry system. Prior to launch, coaxial cables from each stage telemetry system supply digital data to the checkout facility. During flight, telemetered data is radiated from separate antenna systems on each stage. (See Figure 16-1.)

16.1.1 S-IVB/IU Interface

Some flight measurements, those designated by NASA as S-IVB flight control measurements, are on redundant links between the instrument unit (IU) and S-IVB stage. S-IVB measurement data, Figure 16-2, are routed directly to model 270 multiplexers DP1BO and CP1BO or to a remote analog submultiplexer and then to model 270 multiplexer DP1BO. The DP1BO multiplexer output is interfaced to the IU PCM system, and CP1BO multiplexer output is processed through the S-IVB stage PCM/FM system. In each instance, flight control measurements are subsequently telemetered to Manned Space Flight Network (MSFN) stations where they are relayed to Mission Control Center (MCC) for real-time monitoring by flight control personnel.

The S-IVB stage also utilizes the PCM/FM and SSB/FM* telemetry systems to telemeter flight measurements to MSFN stations. These measurements are recorded as flight measurement data and engineering data. (See Figure 16-2.)

16.1.2 S-IVB Stage Telemetry System

The PCM/FM telemetry system consists of a remote digital submultiplexer (RDSM), a remote analog submultiplexer, two model 270 multiplexers (CP1BO and DP1BO), model 301 PCM/DDAS assembly, RF assembly model II PCM/FM transmitter, bidirectional coupler, forward power detector, and a reflected power detector. This system is the prime means of providing MCC data to be monitored by the flight controllers.

The SSB/FM telemetry system consists of an SSB/FM translator, an SSB/FM isolation amplifier, an RF assembly model II SSB/FM transmitter, and a bidirectional coupler. The SSB/FM system is used for special applications such as providing transmission capability for wide-band data.*

16.1.3 S-IVB Stage PCM-FM Telemetry System Measurements

Measurement N18-411 represents PCM/FM transmitter output power. The sample represents a signal from the forward power detector conditioned by a low-gain dc amplifier and applied to CP1BO and DP1BO model 270 multiplexers. The measurement is a direct indication of PCM transmitter power (0 to 145 mV) with a measurement characteristic of 20 ± 5 watts nominal (100 ± 25 mV). (See Figure 16-3.)

Measurement N55-411 is a measurement from the reflected power detector conditioned by a breakpoint amplifier and applied to CP1BO and DP1BO model 270 multiplexers. The measurement is a direct indication of antenna system reflected power (0 to 109 mV) with readings below 50 mV not reliable. The measurement characteristic is voltage standing wave ratio (VSWR) less than or equal to 1.7 determined by the following equation:

$$VSWR = \frac{\sqrt{N18\text{-}411} + \sqrt{N55\text{-}411}}{\sqrt{N18\text{-}411} - \sqrt{N55\text{-}411}} \leq 1.7 \text{ (max)}$$

*The SSB/FM system effectivity ceases at AS-508.

16.1.4 S-IVB Stage Transducer Excitation Modules

Forward battery No. 1 (forward power distribution assembly) applies the required power to the forward (No. 1) and aft 5-volt excitation modules. The output of these excitation modules supplies the required excitation voltage to the forward and aft transducers. Redundant emergency detection transducer excitation voltage is supplied by forward battery No. 2 (forward power distribution assembly) through the forward (No. 2) 5-volt excitation module. (See Figure 16-6.)

16.1.5 S-IVB Stage 5 V Excitation Module Measurements

Measurement M24-411 represents an expanded scale measurement of the output voltage of the forward 5-volt excitation module. Measurement M25-404 represents an expanded scale measurement of the output voltage of the aft 5-volt excitation module. Measurement M68-411 represents an expanded scale measurement of the output voltage of the forward 5-volt excitation module. The range scale of each of these measurements is 4.5 to 5.5 volts. The measurement characteristic for M24, M25, and M68 should remain stable within the limits of 5.000 ± 0.025 Vdc. While numerous measurements derive power from the 5-volt excitation modules, they do not provide direct indication of 5-volt excitation module performance.

A sample of the output voltage of an excitation module is impressed on an expanded-scale dc voltage network, processed through a dc amplifier, and applied as a data input to model 270 multiplexers CP1B0 and DP1B0. (See Figure 16-7.)

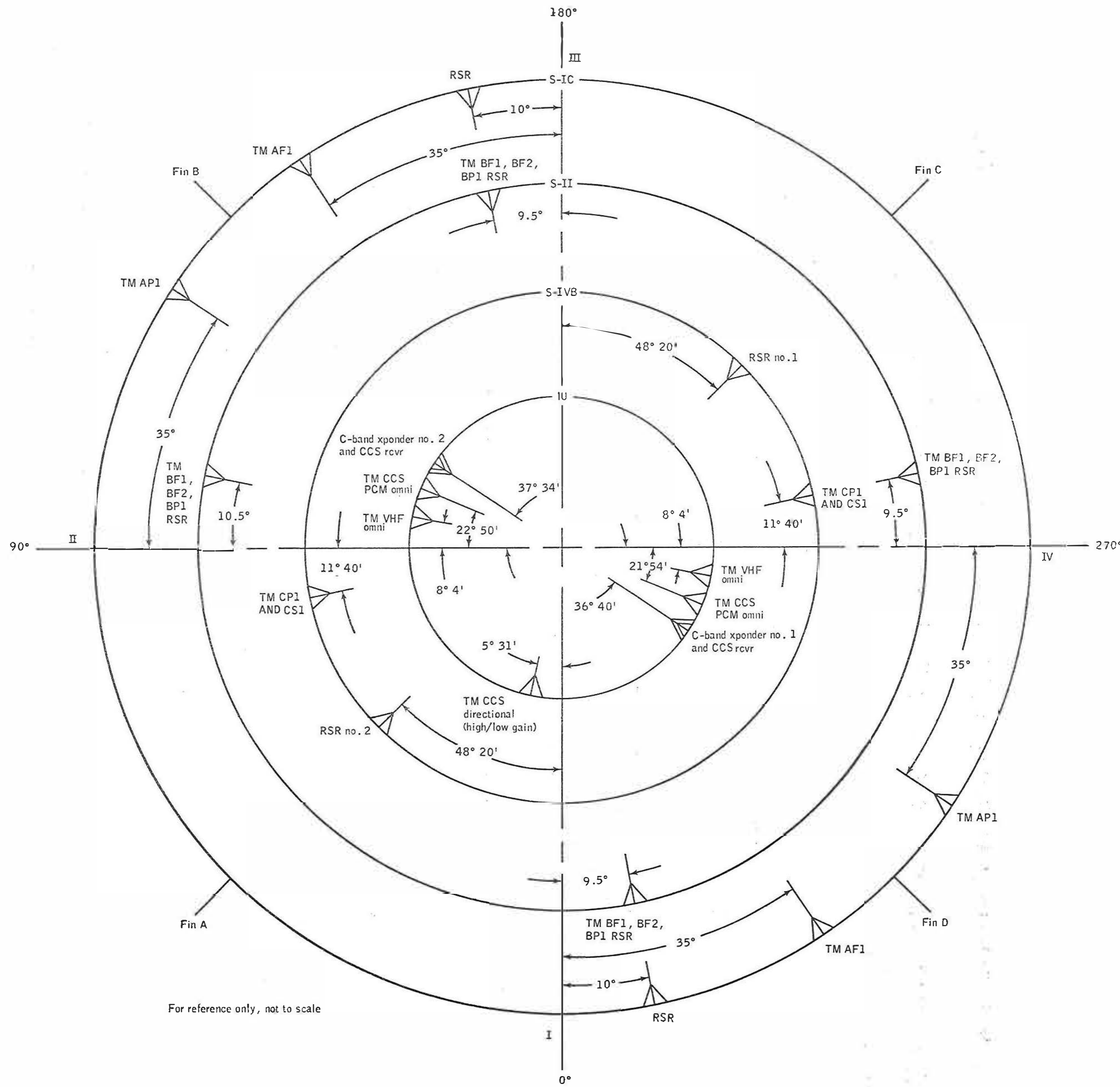
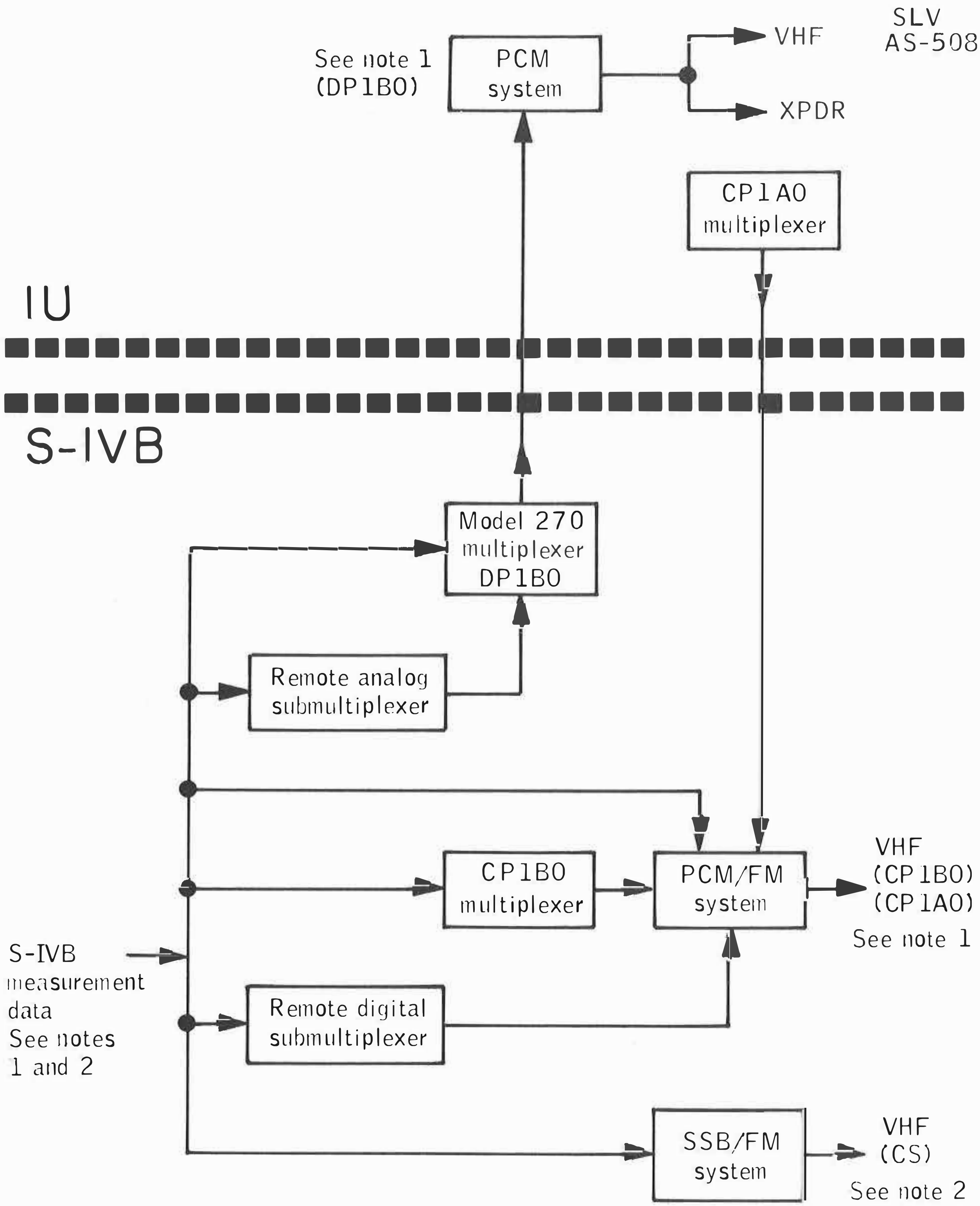


Figure 16-1. - Antenna locations-aft looking forward.



Notes:

1. Flight control measurements and engineering data measurements--
   NASA approved flight control measurements used for flight controller monitoring
2. Engineering data measurements--all S-IVB flight measurements

Figure 16-2. - S-IVB/IU telemetry interface.

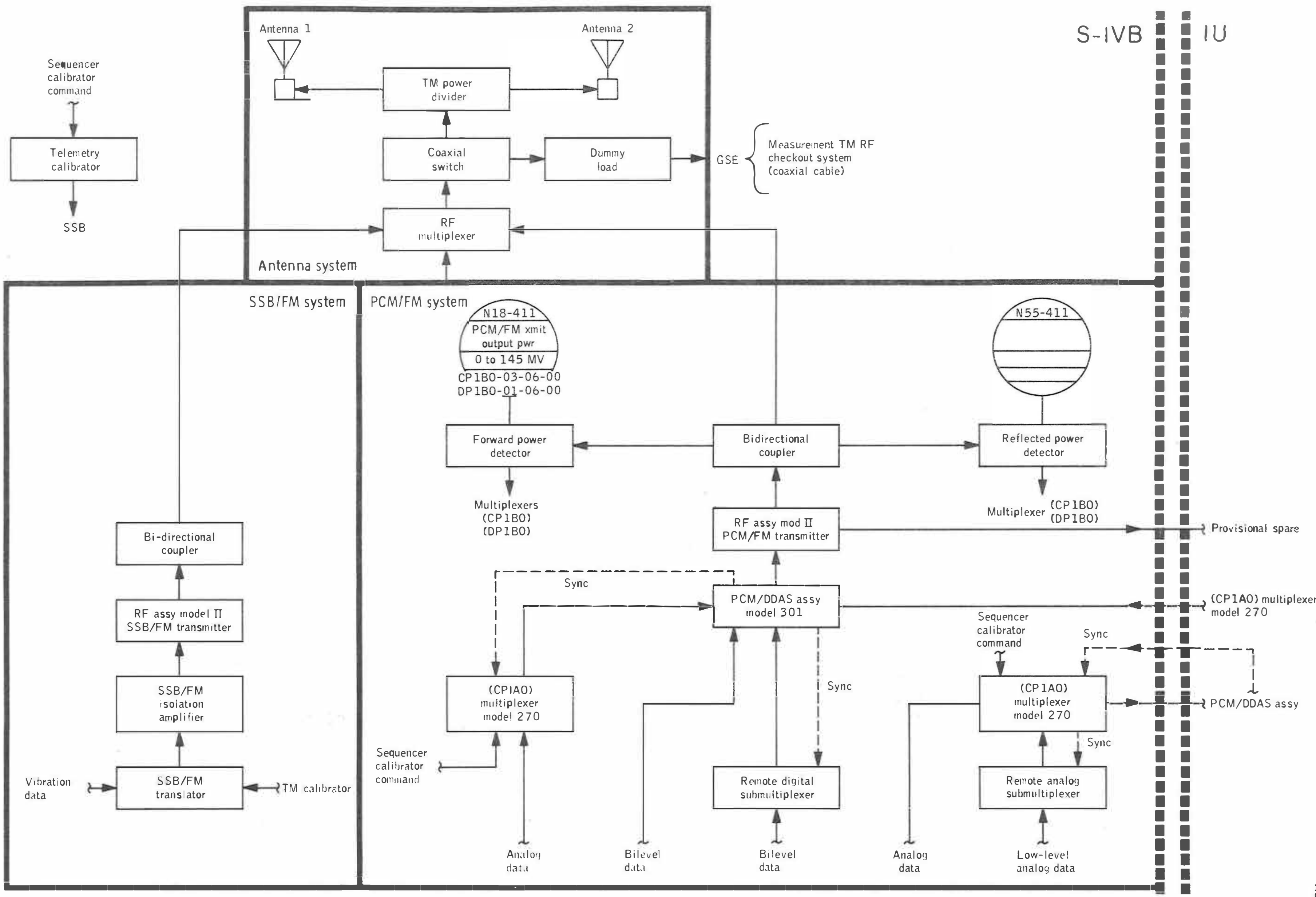


Figure 16-3. - Instrumentation data flow - S-IVB telemetry system.

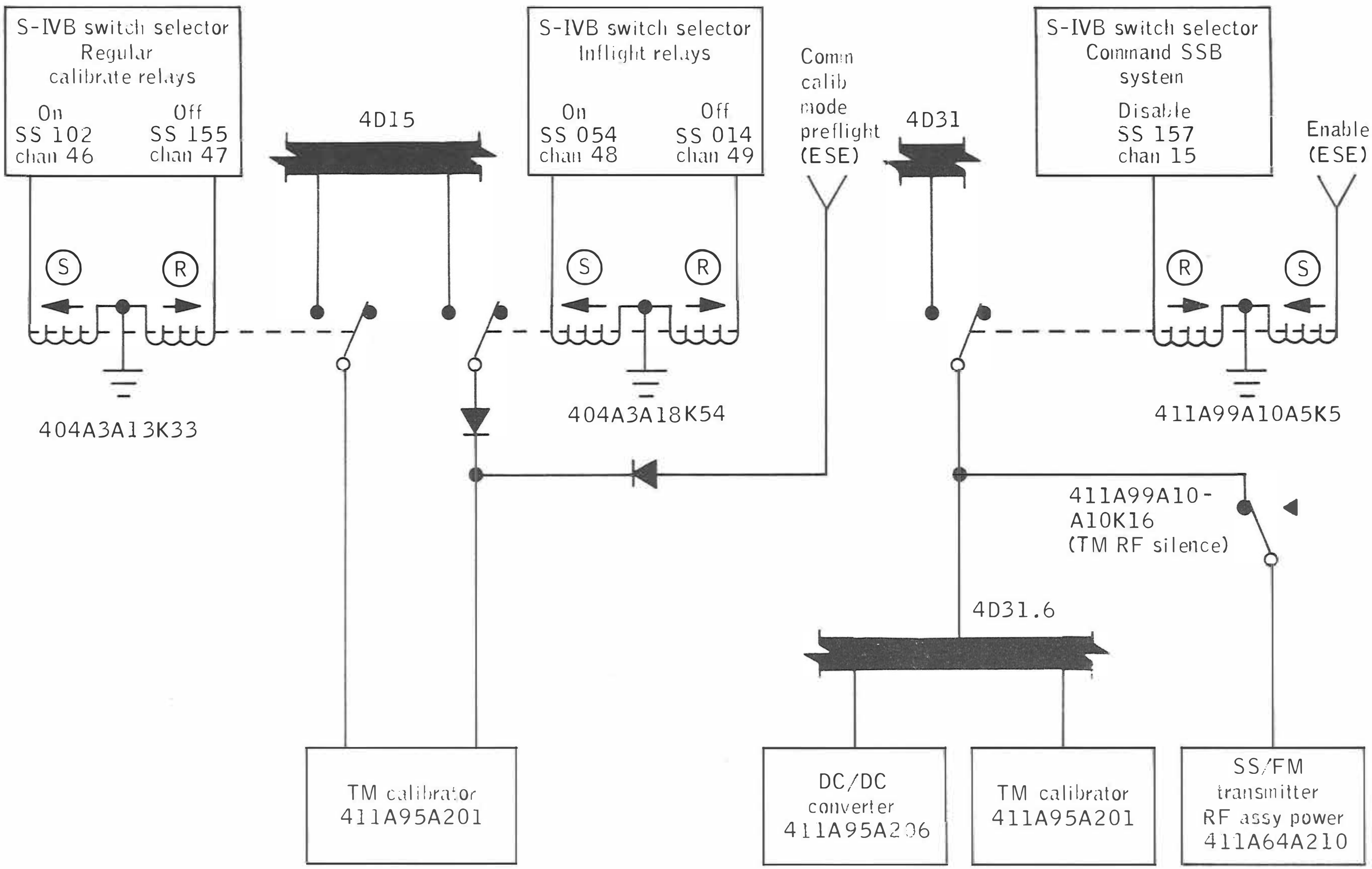


Figure 16-4. - Power and calibration - SSB system.

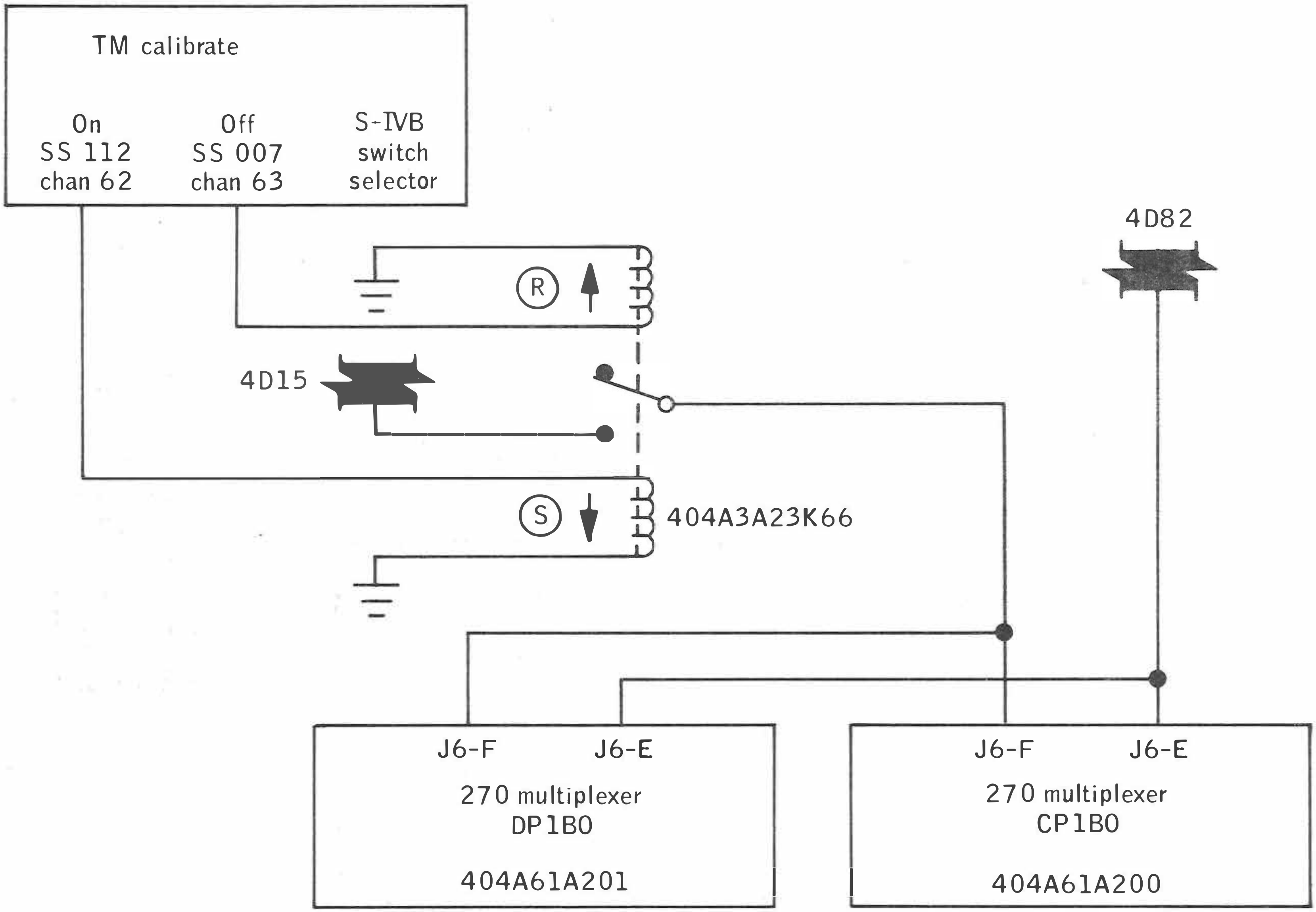


Figure 16-5. - TM calibration control - schematic.

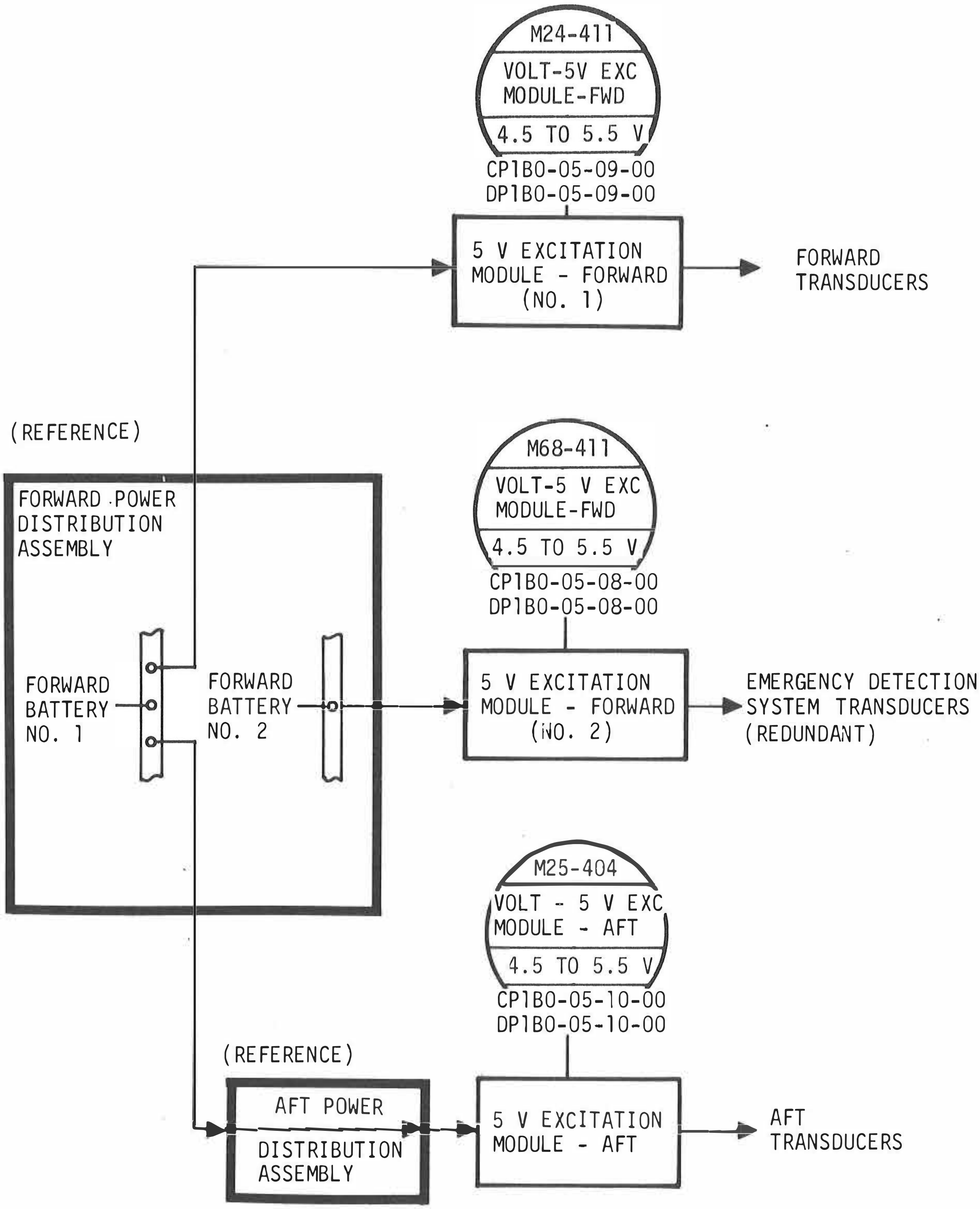


Figure 16-6.- Instrumentation - S-IVB transducer excitation modules.

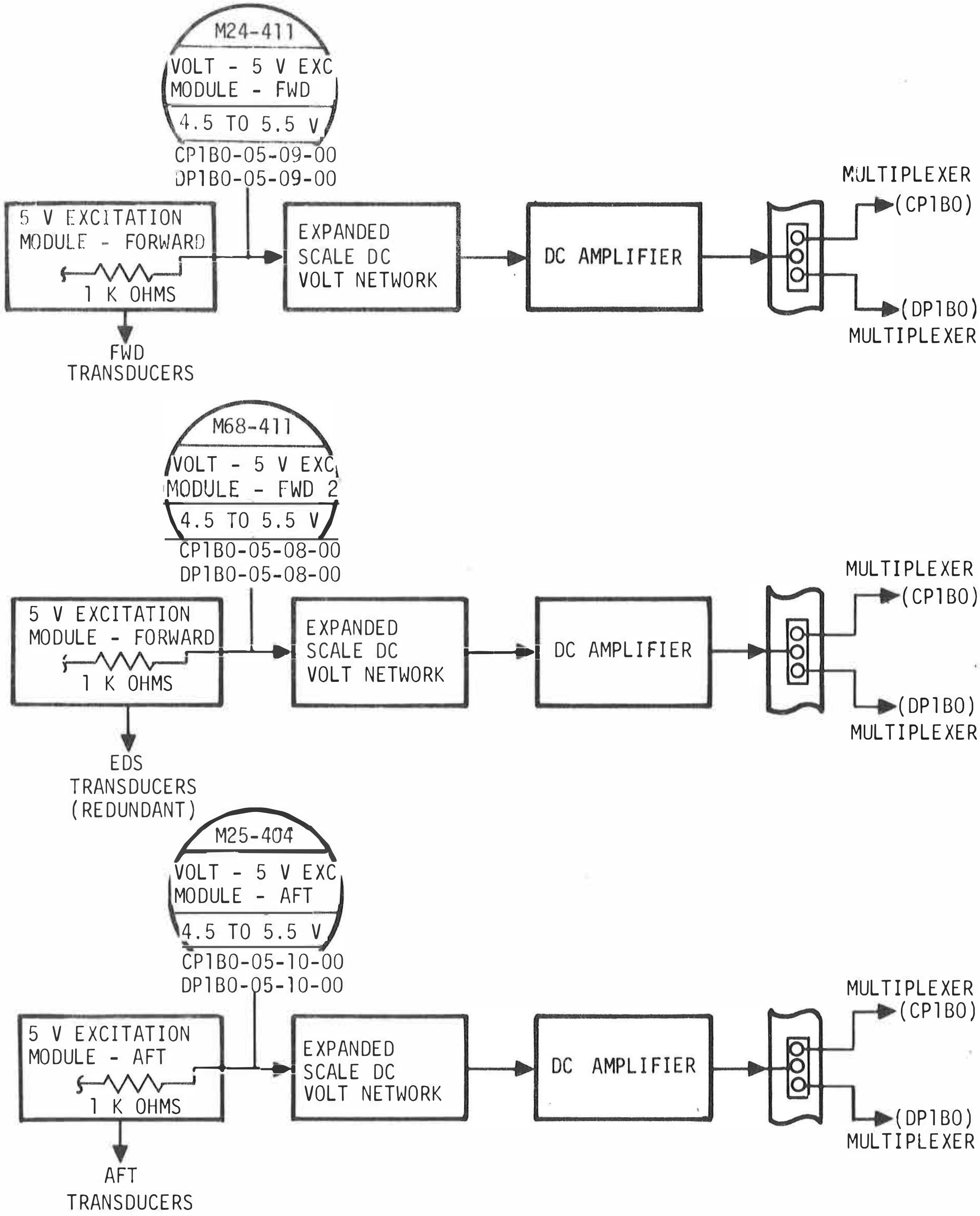


Figure 16-7.- Instrumentation - S-IVB volt excitation module measurements.

17 IU SEQUENTIAL
SYSTEMS

SECTION 17

IU SEQUENTIAL SYSTEMS

17.1 GENERAL

A. Sequential operations (control of discrete functions) in the Saturn launch vehicle are controlled by the Launch Vehicle Digital Computer (LVDC) through the Launch Vehicle Data Adapter (LVDA), both located in the IU, either directly through output discrete commands, or through the switch selector located in each of the stages. The switch selector output drives relays located either in the unit affected, or in the stage sequencer.

B. The switch selector provides for isolation of power between the separate stages. The inputs utilize 28 Vdc from the IU while each stage switch selector output operates from 28 Vdc supplied by the stage in which the switch selector is located.

17.2 DEFINITION OF TIME BASES FOR TIME SEQUENCES

17.2.1 General

The Launch Vehicle Flight Sequence Program contains eight primary time bases and four alternate time bases in order to achieve an optimum vehicle mission with suitable sequential operation and timing of flight vehicle events. Safeguards are used where necessary to prevent premature initiation of time bases.

Proper establishment of time bases provides a safe and reliable vehicle on the pad and throughout the flight. Each time base will be established by the normal method when the required criteria, as outlined in MSFC Switch Selector ICD, have been received by the Launch Vehicle Digital Computer (LVDC). If a time base is not established, subsequent time bases cannot be started and the vehicle mission cannot be completed. Therefore, to further increase mission reliability in the absence of the normal time base signals, backup methods are used for establishing time bases. Both the normal and backup methods for starting each time base are explained in the following paragraphs.

17.2.2 Time Base Definitions

A. Time Base 1 (T_1)

Time Base 1 (T_1) is initiated by a lift-off signal provided by the deactuation of the lift-off relay in the IU at the umbilical disconnect. However, as a safety measure, the Launch Vehicle Digital Computer (LVDC) will not recognize the lift-off signal and start T_1 prior to receiving guidance reference release plus 16.0 seconds (lift-off - 1 second).

A backup method for starting T_1 is provided should the LVDC fail to receive or recognize the lift-off signal. If T_1 is not initiated by 17.5 seconds after guidance reference release, the LVDC will monitor the vertical accelerometer. If a significant positive acceleration (in excess of one g) exists, the LVDC assumes that lift-off has occurred and begins T_1. A time adjustment is made by the computer.

No "negative backup" (i.e., provisions for the LVDC to return to prelaunch conditions) is provided because the Saturn V vehicle could safely complete T_1 on the pad without catastrophic results, in the event T_1 began by error.

B. Time Base 2 (T_2)

The S-IC inboard engine will be cut off by the LVDC through the S-IC switch selector at a predetermined time. The LVDC will monitor the down-range accelerometer. If sufficient down-range velocity exists, the LVDC will start Time Base 2 (T_2).

Use of the down-range velocity reading provides a safeguard against starting T_2 on the pad should T_1 be started without lift-off. Furthermore, if T_2 is not established, no subsequent time bases can be started. This insures a safe vehicle requiring at least one additional failure to render the vehicle unsafe on the pad.

C. Time Base 3 (T_3)

Time Base 3 (T_3) is initiated at S-IC outboard engines cutoff by either of two redundant outboard engines cutoff signals. However, the LVDC must arm outboard engines propellant depletion cutoff prior to starting T_3. Outboard engines propellant depletion cutoff relay is armed prior to predicted outboard engines cutoff.

D. Time Base 4 (T_4)

After arming S-II/LOX depletion cutoff sensors, the LVDC will initiate Time Base 4 (T_4) upon receiving either of two signals, S-II engines cutoff or S-II engines out. The S-II engines depletion cutoff signal is the primary signal for starting T_4. The S-II engines out signal from the thrust OK circuitry is a backup. A redundant S-II engines cutoff command is issued at T_4 + 0.0 as a safeguard against having started T_4 with the thrust of the S-II engines present.

E. Alternate Time Base 4a (T_{4a})

Time Base 4a will be initiated by spacecraft initiation of S-II/S-IVB separation. The starting of Time Base 4a will be inhibited until T_3 + 1.4 seconds. This time base and its sequence of events will be programed for use in early staging of the S-IVB stage. If T_{4a} is used, the LVDC will go to primary Time Base 5 at S-IVB cutoff.

F. Time Base 5(T_5)

Time Base 5 is initiated by any two of the following four inputs to the LVDC.

1. J2 engine out "A" LVDC discrete input from the engine thrust not OK switch A.
2. J2 engine out "B" LVDA discrete input from the engine thrust not OK switch B.
3. The command from the LVDC indicating that the proper velocity has been achieved.
4. Loss of thrust indicated by a program check of the ST124 platform accelerometers.

As a safeguard against starting T_5 with the engine operating, the LVDC will issue a redundant cutoff command at the start of T_5.

G. Time Base 6 (T_6)

After a predetermined time in Time Base 5, Time Base 6 shall be initiated by the LVDC upon solving the restart equation. However, the starting of Time Base 6 can be inhibited by the "Translunar Injection Inhibit" signal (DIN 6) from the spacecraft or a ground generated DCS command (TD&E enable). A target update can start T_6 provided T_6 is not inhibited by the DIN 6 or the DCS command.

H. Alternate Time Base 6a or 6b (T_{6a} or T_{6b})

Alternate Time Base 6a or 6b will be programed for use should the O_2-H_2 burner malfunction between the time T_6 + 48.0 seconds and T_6 + 496.9 seconds. These alternate time bases will be initiated by the LVDC upon receiving an "O_2-H_2 Burner Malfunction" signal from the S-IVB. T_{6a} or T_{6b} will be initiated depending on the time of the O_2-H_2 Burner Malfunction" signal. The LVDC returns to Time Base 6 after completion of the events in Time Base 6a or 6b.

I. Alternate Time Base 6c (T_{6c})

Alternate Time Base 6c is programed for use should a failure occur which would require a delay in the S-IVB restart attempt. The spacecraft "Translunar Injection Inhibit" signal (DIN 6) is required by the LVDC before this alternate time base is initiated. The LVDC is programed to look for the Translunar Injection Inhibit signal at T_6 + 41.0 seconds, at which time T_{6c} shall be initiated if the signal is present. The LVDC is also programed to look for the Translunar Injection Inhibit signal at T_6 + 497.3 seconds and then once per computer cycle (approximately once per second) between the times T_6 + 497.3 and T_6 + 560.0 seconds. If the signal is present the LVDC will initiate T_{6c}. Upon completion of Time Base 6c, the LVDC returns to TB5 updated by the time elapsed in TB6 and Alternate TB6c.

J. Time Base 7 (T_7)

Time Base 7 is initiated in the same manner as Time Base 5 with the exception that a time, T_6 + 585 seconds, replaces the velocity cutoff condition in the initiation logic. Any two of the four will start Time Base 7. A redundant S-IVB Engine Cutoff command is issued at the start of T_7 as a safeguard against having started T_7 with the thrust of the S-IVB engine present.

K. Time Base 8 (T_8)

The starting of Time Base 8 shall be inhibited in the LVDC. This inhibit must be removed by DCS command prior to LVDC initiation of Time Base 8. However, the LVDC does not accept the DCS command to remove the inhibit (S-IVB Propellant Dump Inhibit) until 480 seconds after the DCS evasive maneuver command has been received. The LVDC will not accept the DCS evasive maneuver command until after T_7 + 3600 seconds. If the inhibit is removed, the LVDC will initiate TB8.

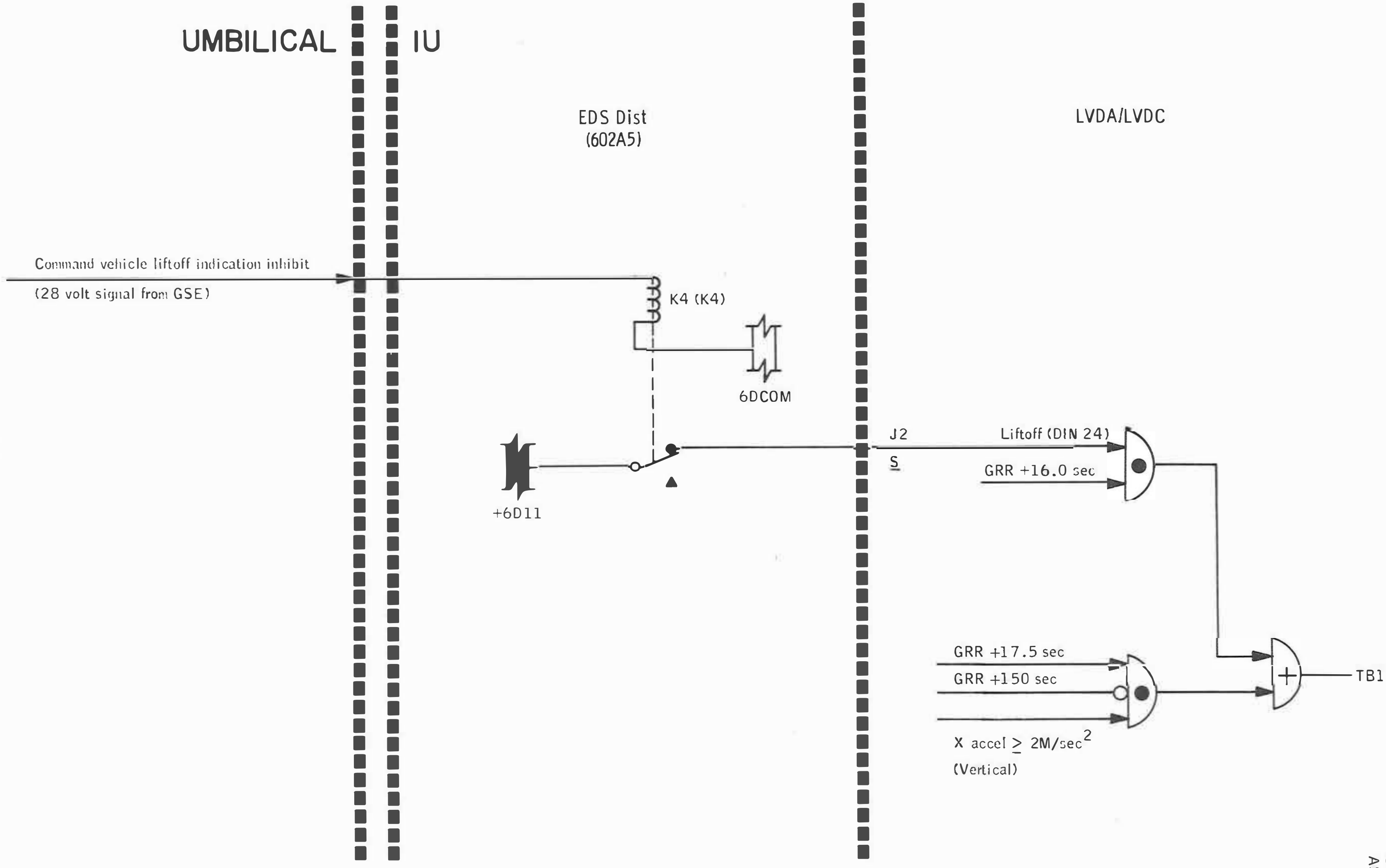


Figure 17-1. - TB1 start logic.

LVDA/DC

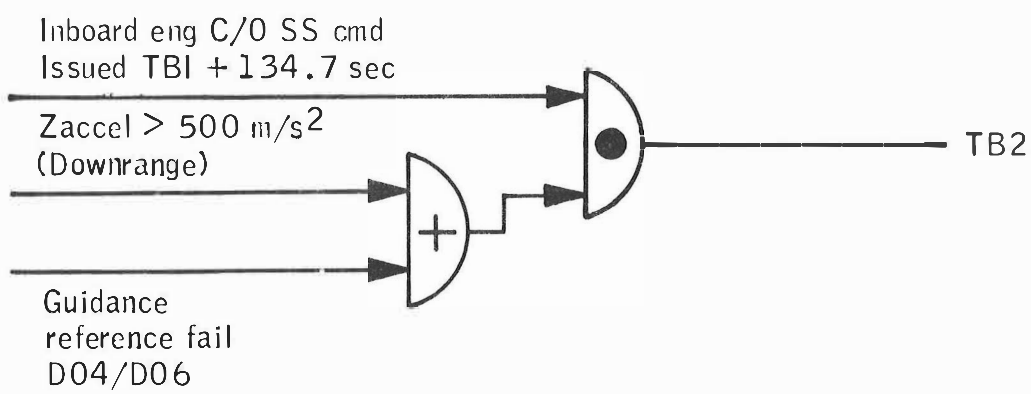


Figure 17-2. - TB 2 start logic.

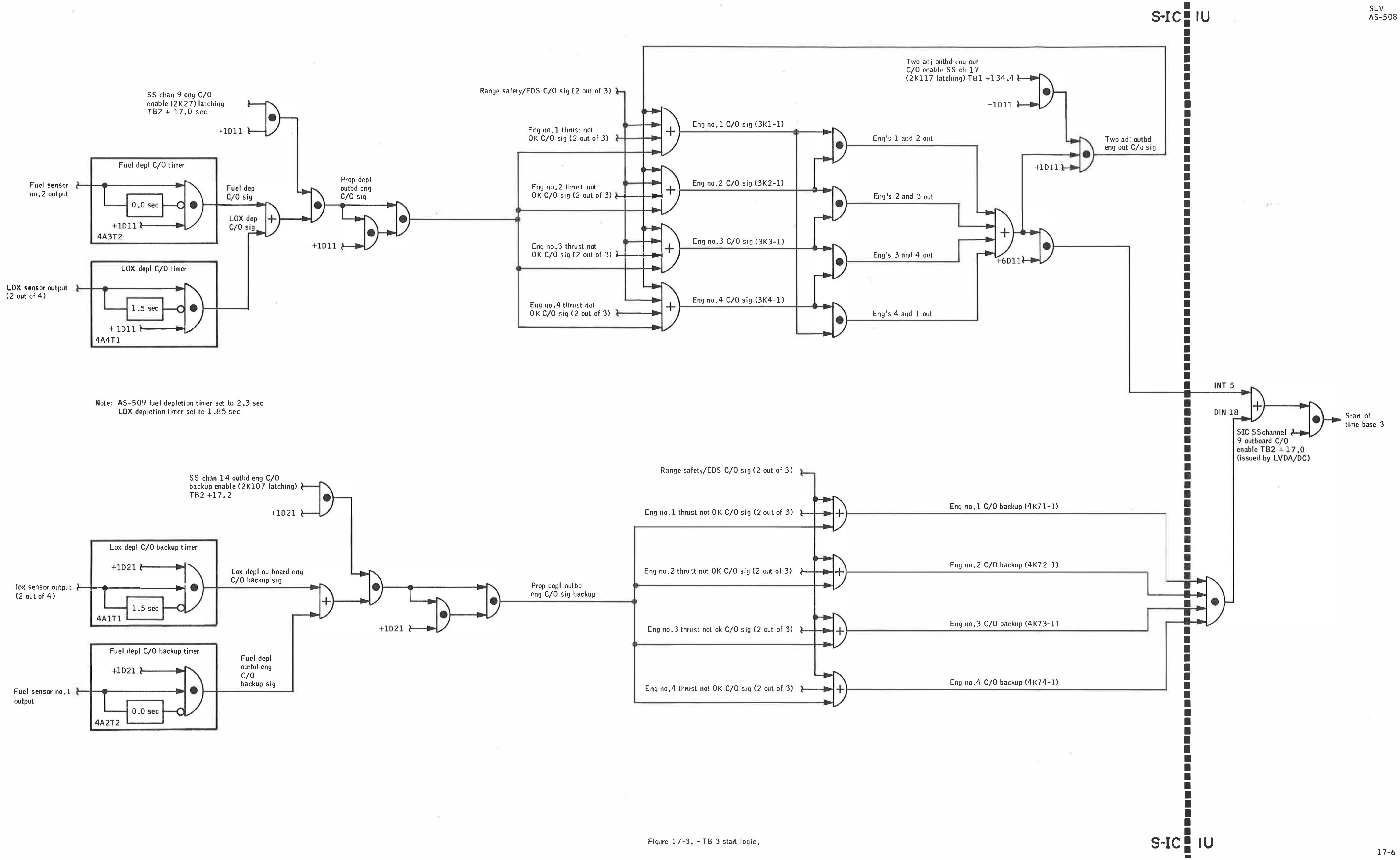


Figure 17-3. - TB 3 start logic.

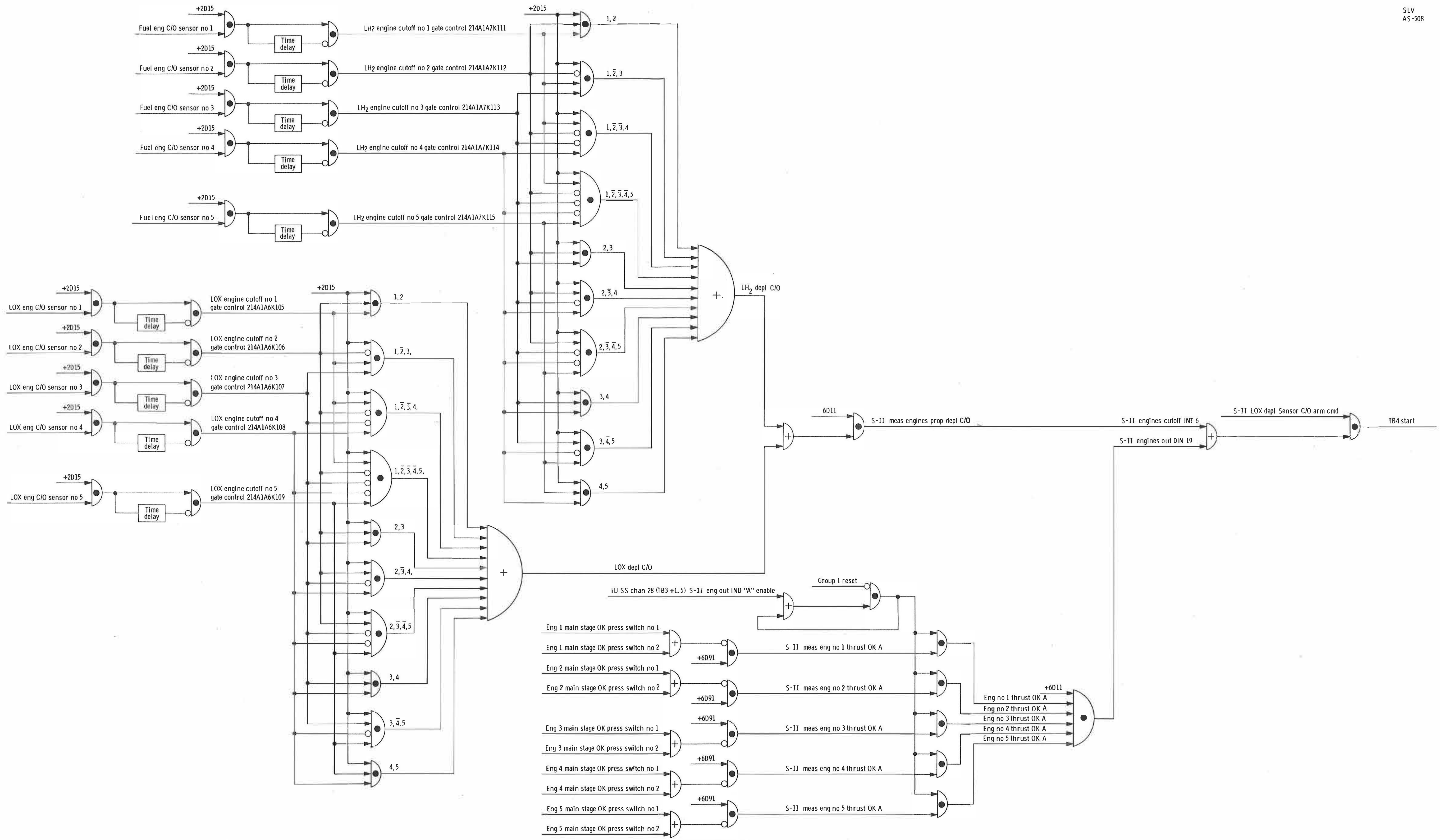


Figure 17-4. - TB4 start logic.

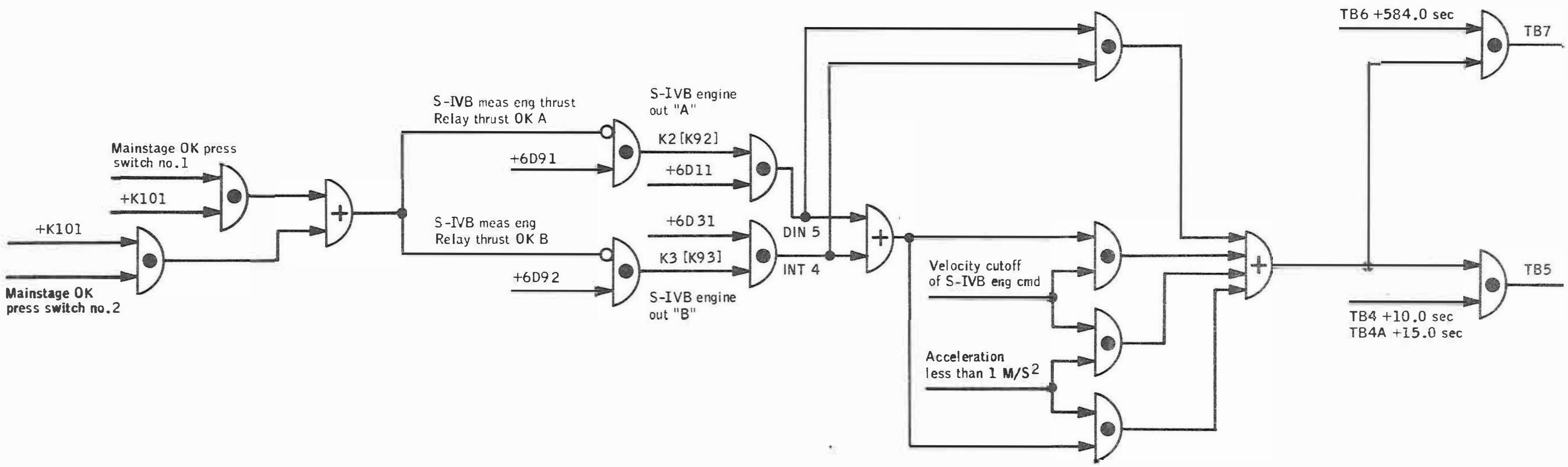


Figure 17-5. - TB5 and TB7 start logic.

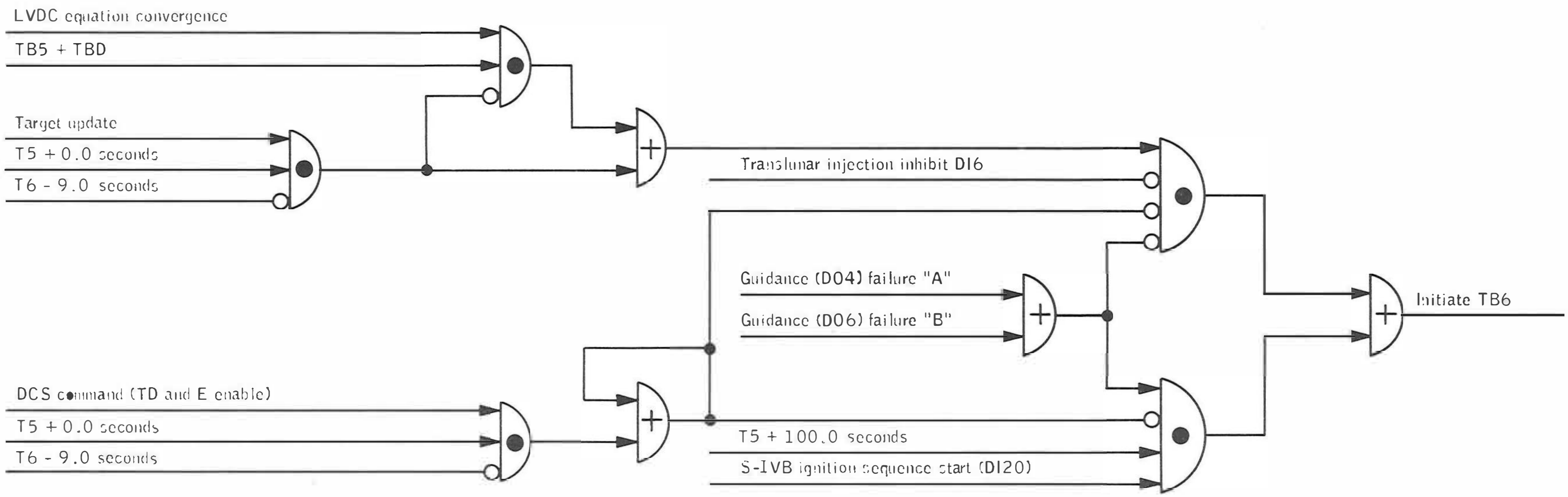


Figure 17-6. - TB6 start logic.

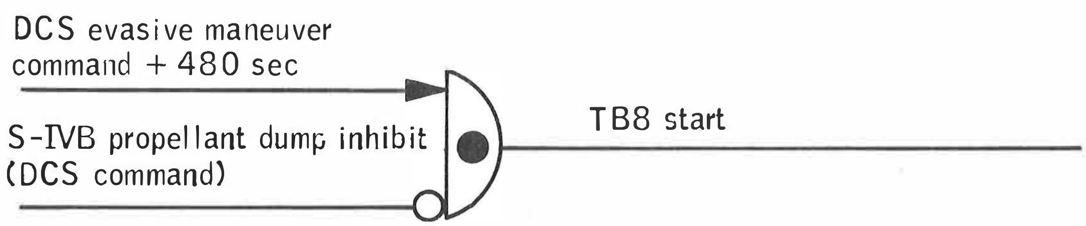


Figure 17-7. - TB8 start logic.

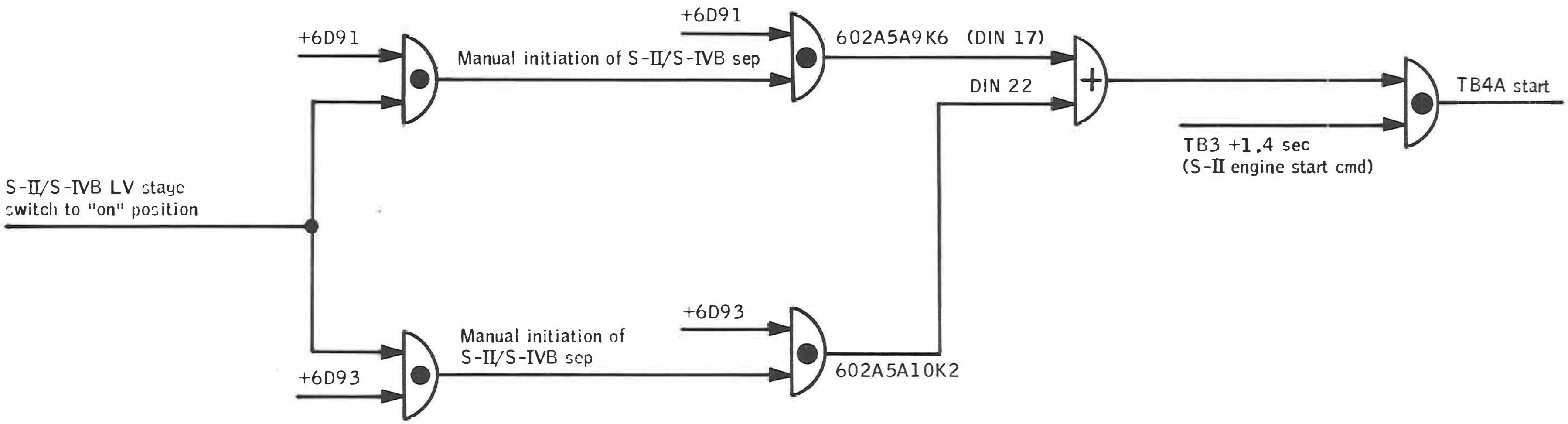


Figure 17-8. - TB4a start logic.

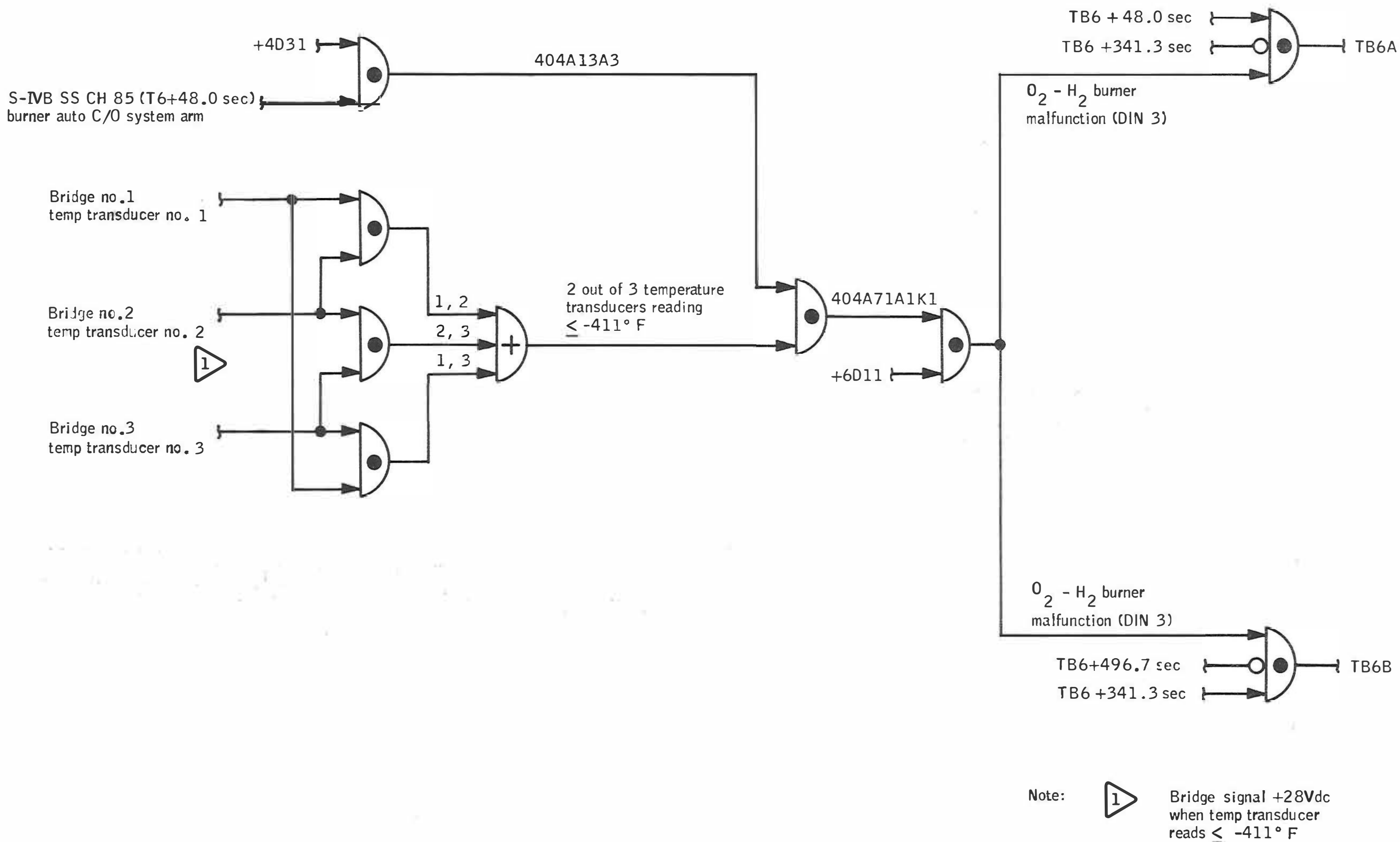


Figure 17-9. - TB6a and TB6b start logic.

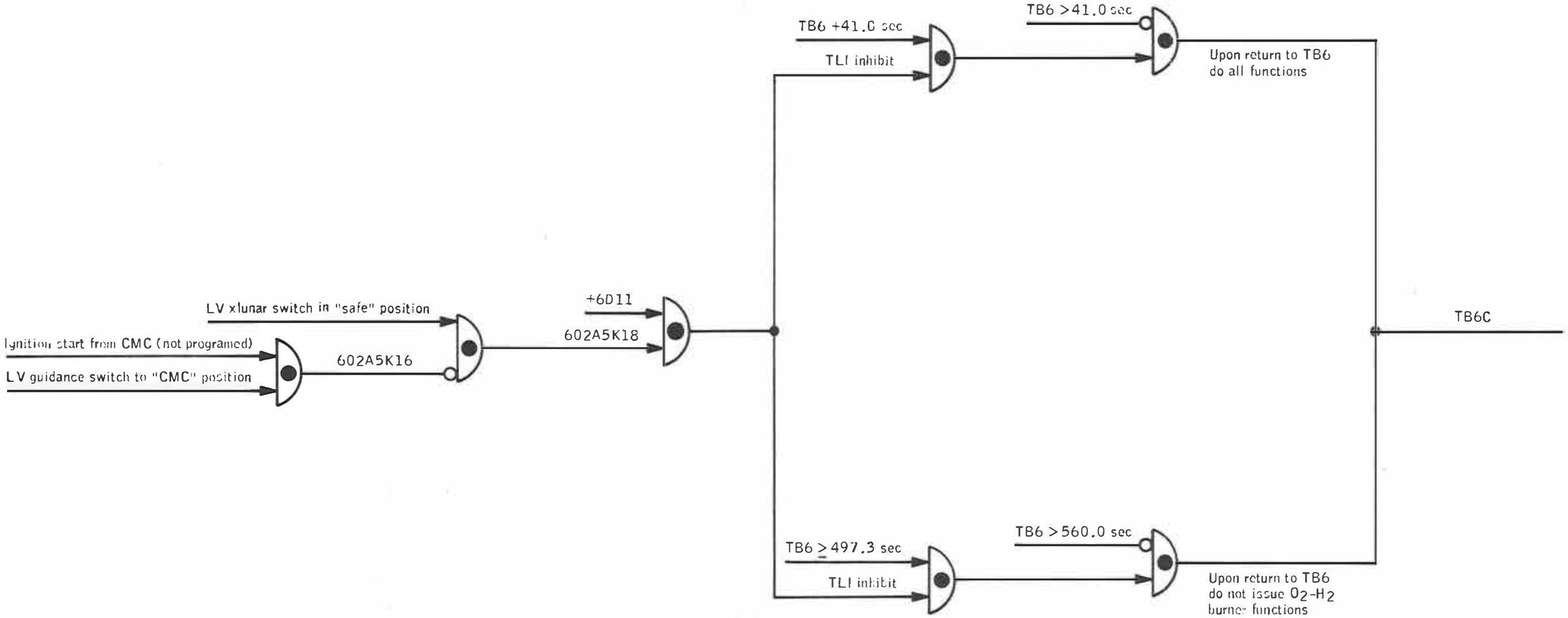


Figure 17-10. - TB6c start logic.

17.3 FLIGHT SEQUENCE PROGRAM

The flight sequence of events is not incorporated in this handbook. Frequent and late changes to the flight program make it difficult to meet the scheduled completion date of this document.

Consequently, it is incumbent on the user to obtain an updated copy of the Switch Selector Interface Control Document for this information.

17.4 INTRODUCTION TO SWITCH SELECTOR CONTROL COMMANDS

The IU switch selector controlled commands, and the channel designation, are independently listed in Paragraph 17.4.1 below. Switch selector functions labeled as spares are not wired for use on this mission.

17.4.1 IU Switch Selector Functions (Octal)

CH	Code	Function	Figure No.
	000		
37	001	SPARE	
5	002	COMMAND FCC SWITCH POINT NO. 6	17-12
30	003	SPARE	
74	004	COMMAND FLIGHT CONTROL COMPUTER S-IVB BURN MODE ON "B"	17-11
81	005	COMMAND S-IVB RESTART ALERT OFF	17-11
97	006	SPARE	
63	007	COMMAND CCS COAX SWITCH-FAIL SAFE-OMNI ANTENNA	17-21
	010		
87	011	COMMAND S-IC OUTBOARD ENGINES CANT OFF "C"	17-28
111	012	SPARE	
94	013	SPARE	
49	014	SPARE	
14	015	SPARE	
51	016	COMMAND S-IC TWO ENGINES OUT AUTO-ABORT INHIBIT ENABLE	17-14
39	017	SPARE	
	020		
16	021	COMMAND AUTO-ABORT ENABLE RELAYS RESET	17-20
24	022	COMMAND TELEMETER CALIBRATOR INFLIGHT CALIBRATE OFF	17-17
9	023	COMMAND S-IVB ENGINE OUT INDICATION ENABLE "A" ON	
75	024	COMMAND FLIGHT CONTROL COMPUTER S-IVB BURN MODE OFF "B"	17-11
109	025	COMMAND SENSOR BIAS ON	17-14
82	026	COMMAND IU COMMAND SYSTEM ENABLE	17-19
71	027	SPARE	
	030		
68	031	COMMAND SPACECRAFT CONTROL OF SATURN ENABLE	17-26
57	032	SPARE	
96	033	SPARE	
33	034	COMMAND SWITCH ENGINE CONTROL TO S-II "A"	17-11
7	035	COMMAND FLIGHT CONTROL COMPUTER SWITCH POINT NO. 7	17-12
35	036	COMMAND S-IC TWO ENGINES OUT AUTO-ABORT INHIBIT	17-14
17	037	COMMAND RATE MEASUREMENTS SWITCH	17-27
	040		
53	041	COMMAND S-IVB ENGINE OUT INDICATION "B" ENABLE RESET	17-13
23	042	COMMAND TELEMETER CALIBRATOR INFLIGHT CALIBRATE ON	17-17
31	043	COMMAND FLIGHT CONTROL COMPUTER S-IVB BURN MODE ON "A"	17-11
61	044	SPARE	
93	045	SPARE	
102	046	SPARE	
90	047	SPARE	

CH	Code	Function	Figure No.
	050		
69	051	COMMAND SPACECRAFT CONTROL OF SATURN DISABLE	17-26
65	052	COMMAND CCS COAX SWITCH-LOW GAIN ANTENNA	17-21
73	053	SPARE	
48	054	COMMAND ENABLE S-II ENGINE OUT INDICATION ENABLE "B" ON	17-11
6	055	SPARE	
52	056	SPARE	
40	057	SPARE	
	060		
38	061	COMMAND ENABLE LAUNCH VEHICLE ENGINES EDS CUTOFF	17-22
44	062	COMMAND FLIGHT CONTROL COMPUTER SWITCH POINT NO. 5	17-12
18	063	COMMAND S-IVB ENGINE OUT INDICATION "A" ENABLE RESET	17-13
110	064	COMMAND COOLING SYSTEM ELECT ASSY POWER OFF	17-24
92	065	SPARE	
101	066	SPARE	
67	067	SPARE	
	070		
58	071	COMMAND CCS TRANSMITTER INHIBIT ON	17-21
64	072	COMMAND CCS COAX SWITCH HIGH GAIN ANTENNA	17-21
95	073	SPARE	
29	074	SPARE	
25	075	SPARE	
36	076	SPARE	
8	077	SPARE	
	100		
21	101	COMMAND FLIGHT CONTROL COMPUTER SWITCH POINT NO. 2	17-12
46	102	COMMAND S-IVB ULLAGE THRUST PRESENT OFF	17-16
32	103	SPARE	
98	104	SPARE	
108	105	COMMAND H_2O COOLANT VALVE CLOSED	17-23
76	106	SPARE	
89	107	SPARE	
	110		
66	111	SPARE	
62	112	SPARE	
112	113	SPARE	
105	114	SPARE	
12	115	COMMAND FLIGHT CONTROL COMPUTER S-IVB BURN MODE OFF "A"	17-11
41	116	COMMAND INHIBIT EXCESSIVE P, Y and R AUTO-ABORT OFF	17-25
34	117	COMMAND EXCESSIVE RATE ROLL AUTO ABORT INHIBIT ON	17-25
	120		
22	121	COMMAND FLIGHT CONTROL COMPUTER SWITCH POINT NO. 3	17-12
19	122	SPARE	
45	123	SPARE	
56	124	COMMAND C-BAND TRANSPONDER NO. 2 INHIBIT ON	17-15
91	125	SPARE	
99	126	SPARE	
86	127	COMMAND S-IC OUTBOARD ENGINE CANT OFF B	17-28

CH	Code	Function	Figure No.
	130		
84	131	COMMAND S-IC OUTBOARD ENGINE CANT ON B	17-28
100	132	SPARE	
60	133	SPARE	
88	134	SPARE	
27	135	COMMAND FLIGHT CONTROL COMPUTER SWITCH POINT NO. 9	17-12
42	136	COMMAND ENABLE EXCESSIVE ROLL AUTO ABORT INHIBIT OFF	17-25
2	137	COMMAND EXCESSIVE RATE (P, Y & R) AUTO-ABORT INHIBIT ON	17-25
	140		
4	141	COMMAND FLIGHT CONTROL SWITCH POINT NO. 4	17-12
3	142	SPARE	
10	143	SPARE	
55	144	COMMAND C-BAND TRANSPONDER NO. 1 INHIBIT ON	17-15
107	145	COMMAND WATER COOLANT VALVE OPEN	17-23
77	146	SPARE	
85	147	COMMAND S-IC OUTBOARD ENGINE CANT ON C	17-28
	150		
83	151	COMMAND S-IC OUTBOARD ENGINE CANT ON A	17-28
79	152	SPARE	
59	153	COMMAND CCS TRANSMITTER INHIBIT OFF	17-21
70	154	SPARE	
47	155	COMMAND FLIGHT CONTROL COMPUTER SWITCH POINT NO. 8	17-12
20	156	COMMAND EXCESSIVE RATE ROLL AUTO-ABORT INHIBIT RESET	17-25
15	157	COMMAND ENABLE EXCESSIVE RATE (P, Y & R) AUTO-ABORT INHIBIT ON	17-25
	160		
50	161	COMMAND INHIBIT EXCESSIVE ROLL AUTO ABORT	17-25
13	162	COMMAND ENABLE EXCESSIVE P, Y and R AUTO-ABORT INHIBIT OFF	17-25
11	163	COMMAND S-IVB ENGINE OUT INDICATION ENABLE "B" ON	17-13
54	164	COMMAND C-BAND TRANSPONDERS NO. 1 AND NO. 2 ON	17-15
106	165	SPARE	
78	166	SPARE	
104	167	SPARE	
	170		
103	171	SPARE	
80	172	S-IVB RESTART ALERT ON	17-12
72	173	SPARE	
28	174	COMMAND S-II ENGINE OUT INDICATION ENABLE "A" ON	17-11
26	175	COMMAND FLIGHT CONTROL COMPUTER SWITCH POINT NO. 1	17-12
43	176	COMMAND S-IVB ULLAGE THRUST PRESENT INDICATION ON	17-16
1	177	COMMAND Q-BALL POWER OFF	17-18

17.4.2 Switch Selector Cross-Reference Tables

This section is included in the handbook to facilitate the translation of the switch selector channel identifications from whatever form in which they may be obtained into the form desired.

A switch selector channel may be identified by the channel number, the octal code corresponding to that channel number, or the complement of that octal code.

Some peculiarities in the downlink or ground transmission of downlinked information, may cause the flight controller to be presented with the switch selector bit pattern in inverted order. Correspondingly, the complement of the inverted order may appear, should the onboard system reject the true code.

Three tables are presented on the following pages. Each table gives channel; true, complement forward; true, complement reverse.

Table 17-I lists by channel number. Table 17-II lists by forward octal true. Table 17-III lists by reverse octal true. It should be noted that complements increase ordinally from the bottom of the page and can be read from the true octal list with minimum difficulty. Table 17-III includes an underscore beneath the principal form corresponding to the normally expected bit pattern.

TABLE 17-I. SWITCH SELECTOR CROSS-REFERENCE TABLE
(IN SEQUENCE BY CHANNEL NUMBER)

	FORWARD		REVERSE	
Channel Number	Octal True	Octal Comp	Octal True	Octal Comp
1	177	200	376	001
2	137	240	372	005
3	142	235	106	271
4	141	236	206	171
5	002	375	100	277
6	055	322	264	113
7	035	342	270	107
8	077	300	374	003
9	023	354	310	067
10	143	234	306	071
11	163	214	316	061
12	115	262	262	115
13	162	215	116	261
14	015	362	260	117
15	157	220	366	011
16	021	356	210	167
17	037	340	370	007
18	063	314	314	063
19	122	255	112	265
20	156	221	166	211
21	101	276	202	175
22	121	256	212	165
23	042	335	104	273
24	022	355	110	267
25	075	302	274	103
26	175	202	276	101
27	135	242	272	105
28	174	203	076	301
29	074	303	074	303
30	003	374	300	077
31	043	334	304	073
32	103	274	302	075
33	034	343	070	307
34	117	360	362	015
35	036	341	170	207
36	076	301	174	203
37	001	376	200	177
38	061	316	214	163
39	017	360	360	017
40	057	320	364	013
41	116	261	162	215
42	136	241	172	205
43	176	201	176	201
44	062	315	114	263
45	123	354	312	065

TABLE 17-I.- SWITCH SELECTOR CROSS-REFERENCE TABLE - Continued
(IN SEQUENCE BY CHANNEL NUMBER)

	FORWARD		REVERSE	
Channel Number	Octal True	Octal Comp	Octal True	Octal Comp
46	102	275	102	275
47	155	222	266	111
48	054	323	064	313
49	014	363	060	317
50	161	216	216	161
51	016	361	160	217
52	056	321	164	213
53	041	336	204	173
54	164	213	056	321
55	144	233	046	331
56	124	253	052	325
57	032	345	130	247
58	071	306	234	143
59	153	224	326	051
60	133	244	332	045
61	044	333	044	333
62	112	265	122	255
63	007	370	340	037
64	072	305	134	243
65	052	325	124	253
66	111	266	222	155
67	067	310	354	023
68	031	346	230	147
69	051	326	224	153
70	154	223	066	311
71	027	350	350	027
72	173	204	336	041
73	053	324	324	053
74	004	373	040	337
75	024	353	050	327
76	106	271	142	235
77	146	231	146	231
78	166	211	156	221
79	152	225	126	251
80	172	205	136	241
81	005	372	240	137
82	026	351	150	227
83	151	226	226	151
84	131	246	232	145
85	147	230	346	031
86	127	250	352	025
87	011	366	220	157
88	134	243	072	305
89	107	270	342	035
90	047	330	344	033

TABLE 17-I.- SWITCH SELECTOR CROSS-REFERENCE TABLE - Concluded
(IN SEQUENCE BY CHANNEL NUMBER)

	FORWARD		REVERSE	
Channel Number	Octal True	Octal Comp	Octal True	Octal Comp
91	125	252	252	125
92	065	312	254	123
93	045	332	244	133
94	013	364	320	057
95	073	304	334	043
96	033	344	330	047
97	006	371	140	237
98	104	273	042	335
99	126	251	152	225
100	132	245	132	245
101	066	311	154	223
102	046	331	144	233
103	171	206	236	141
104	167	210	356	021
105	114	263	062	315
106	165	212	256	121
107	145	232	246	131
108	105	272	242	135
109	025	352	250	127
110	064	313	054	323
111	012	365	120	257
112	113	264	322	055

TABLE 17-II.- SWITCH SELECTOR CROSS-REFERENCE TABLE
(IN SEQUENCE BY BINARY CODE FORWARD)

FORWARD		REVERSE		
Octal True	Octal Comp	Octal True	Octal Comp	Channel Number
001	376	200	177	37
002	375	100	277	5
003	374	300	077	30
004	373	040	337	74
005	372	240	137	81
006	371	140	237	97
007	370	340	037	63
010				
011	366	220	157	87
012	365	120	257	111
013	364	320	057	94
014	363	060	317	49
015	362	260	117	14
016	361	160	217	51
017	360	360	017	39
020				
021	356	210	167	16
022	355	110	267	24
023	354	310	067	9
024	353	050	327	75
025	352	250	127	109
026	351	150	227	82
027	350	350	027	71
030				
031	346	230	147	68
032	345	130	247	57
033	344	330	047	96
034	343	070	307	33
035	342	270	107	7
036	341	170	207	35
037	340	370	007	17
040				
041	336	204	173	53
042	335	104	273	23
043	334	304	073	31
044	333	044	333	61
045	332	244	133	93
046	331	144	233	102
047	330	344	033	90
050				
051	326	224	153	69
052	325	124	253	65
053	324	324	053	73
054	323	064	313	48
055	322	264	113	6

TABLE 17-II.- SWITCH SELECTOR CROSS-REFERENCE TABLE - Continued
(IN SEQUENCE BY BINARY CODE FORWARD)

FORWARD		REVERSE		
Octal True	Octal Comp	Octal True	Octal Comp	Channel Number
056	321	164	213	52
057	320	364	013	40
060				
061	316	214	163	38
062	315	114	263	44
063	314	314	063	18
064	313	054	323	110
065	312	254	123	92
066	311	154	223	101
067	310	354	023	67
070				
071	306	234	143	58
072	305	134	243	64
073	304	334	043	95
074	303	074	303	29
075	302	274	103	25
076	301	174	203	36
077	300	374	003	8
100				
101	276	202	175	21
102	275	102	275	46
103	274	302	075	32
104	273	042	335	98
105	272	242	135	108
106	271	142	235	76
107	270	342	035	89
110				
111	266	222	155	66
112	265	122	255	62
113	264	322	055	112
114	263	062	315	105
115	262	262	115	12
116	261	162	215	41
117	260	362	015	34
120				
121	256	212	165	22
122	255	112	265	19
123	254	312	065	45
124	253	052	325	56
125	252	252	125	91
126	251	152	225	99
127	250	352	025	86
130				
131	246	232	145	84
132	245	132	245	100

TABLE 17-II.- SWITCH SELECTOR CROSS-REFERENCE TABLE - Concluded
(IN SEQUENCE BY BINARY CODE FORWARD)

FORWARD		REVERSE		
Octal True	Octal Comp	Octal True	Octal Comp	Channel Number
133	244	332	045	60
134	243	072	305	88
135	242	272	105	27
136	241	172	205	42
137	240	372	005	2
140				
141	236	206	171	4
142	235	106	271	3
143	234	306	071	10
144	233	046	331	55
145	232	246	131	107
146	231	146	231	77
147	230	346	031	85
150				
151	226	226	151	83
152	225	126	251	79
153	224	326	051	59
154	223	066	311	70
155	222	266	111	47
156	221	166	211	20
157	220	366	011	15
160				
161	216	216	161	50
162	215	116	261	13
163	214	316	061	11
164	213	056	321	54
165	212	256	121	106
166	211	156	221	78
167	210	356	021	104
170				
171	206	236	141	103
172	205	136	241	80
173	204	336	041	72
174	203	076	301	28
175	202	276	101	26
176	201	176	201	43
177	200	376	001	1

TABLE 17-III.- SWITCH SELECTOR CROSS-REFERENCE TABLE
(IN SEQUENCE BY BINARY CODE REVERSE)

REVERSE		FORWARD		
Octal (a)	Octal (a)	Octal True	Octal Comp	Channel Number
001	376	177	200	1
002	375			
003	374	077	300	8
004	373			
005	372	137	240	2
006	371			
007	370	037	340	17
010	367			
011	366	157	220	15
012	365			
013	364	057	320	40
014	363			
015	362	117	260	34
016	361			
017	360	017	360	39
020	357			
021	356	167	210	104
022	355			
023	354	067	310	67
024	353			
025	352	127	250	86
026	351			
027	350	027	350	71
030	347			
031	346	147	230	85
032	345			
033	344	047	330	90
034	343			
035	342	107	270	89
036	341			
037	340	007	370	63
040	337	004	373	74
041	336	173	204	72
042	335	104	273	98
043	334	073	304	95
044	333	044	333	61
045	332	133	244	60
046	331	144	233	55
047	330	033	344	96
050	327	024	353	75
051	326	153	224	59
052	325	124	253	56
053	324	053	324	73
054	323	064	313	110
055	322	113	264	112

[a]Underlined data indicates reverse true.

TABLE 17-III.- SWITCH SELECTOR CROSS-REFERENCE TABLE - Continued
(IN SEQUENCE BY BINARY CODE REVERSE)

REVERSE		FORWARD		
Octal (a)	Octal (a)	Octal True	Octal Comp	Channel Number
056	321	164	213	54
057	320	013	364	94
060	317	014	363	49
061	316	163	214	11
062	315	114	263	105
063	314	063	314	18
064	313	054	323	48
065	312	123	254	45
066	311	154	223	70
067	310	023	354	9
070	307	034	343	33
071	306	143	234	10
072	305	134	243	88
073	304	043	334	31
074	303	074	303	29
075	302	103	274	32
076	301	174	203	28
077	300	003	374	30
100	277	002	375	5
101	276	175	202	26
102	275	102	275	46
103	274	075	302	25
104	273	042	335	23
105	272	135	242	27
106	271	142	235	3
107	270	035	342	7
110	267	022	355	24
111	266	155	222	47
112	265	122	255	19
113	264	055	322	6
114	263	062	315	44
115	262	115	262	12
116	261	162	215	13
117	260	015	362	14
120	257	012	365	111
121	256	165	212	106
122	255	112	265	62
123	254	065	312	92
124	253	052	325	65
125	252	125	252	91
126	251	152	225	79
127	250	025	352	109
130	247	032	345	57
131	246	145	232	107
132	245	132	245	100

[a]Underlined data indicates reverse true.

TABLE 17-III.- SWITCH SELECTOR CROSS-REFERENCE TABLE - Concluded
(IN SEQUENCE OF BINARY CODE REVERSE)

REVERSE		FORWARD		
Octal (a)	Octal (a)	Octal True	Octal Comp	Channel Number
133	244	045	332	93
134	243	072	305	64
135	242	105	272	108
136	241	172	205	80
137	240	005	372	81
140	237	006	371	97
141	236	171	206	103
142	235	106	271	76
143	234	071	306	58
144	233	046	331	102
145	232	131	246	84
146	231	146	231	77
147	230	031	346	68
150	227	026	351	82
151	226	151	226	83
152	225	126	251	99
153	224	051	326	69
154	223	066	311	101
155	222	111	266	66
156	221	166	211	78
157	220	011	366	87
160	217	016	361	51
161	216	161	216	50
162	215	116	261	41
163	214	061	316	38
164	213	056	321	52
165	212	121	256	22
166	211	156	221	20
167	200	021	356	16
170	207	036	341	35
171	206	141	236	4
172	205	136	241	42
173	204	041	336	53
174	203	076	301	36
175	202	101	276	21
176	201	176	201	43
177	200	001	376	37

[a]Underlined data indicates reverse true.

17.5 SWITCH SELECTOR NOTES

A. The switch selectors are used by the Launch Vehicle Digital Computer to control, initiate, or terminate functions in each stage. The switch selector is a series of low power transistor switches individually selected and controlled by a coded signal form the digital computer through the data adapter.

B. An 8-bit code for a particular output set by the data adapter appears at each switch selector. The stage select is a specific line to a specific switch selector and its presence is necessary to operate a particular register. Prior to operating any switch selector, a check is made of the complement code return lines. The presence of 28 Vdc on all of the lines indicates that all stage select relays were properly reset on the previous switch selector operation. The computer addresses the switch selector from which an output is desired with the stage select line. The 8-bit code is then set into the selected register. The eight complement lines return to the computer via the data adapter, and the transmitted code is checked. In the event of error detection, the computer pulses the reset line, resetting all registers to all zeros, and then transmits the complement code. Either the code or its complement operates the same relay driver. This gives the switch selector the ability to work around an inoperative relay in the register. With the complement check passed, the computer gives the read command to all selectors at the desired time. This read command allows the switch selector, (or selectors) that have been given a stage select, to drive the addressed output. Addresses in the switch selector registers are automatically reset to zero after the read command. The register may also be reset by the LVDA over the reset line without giving an output.

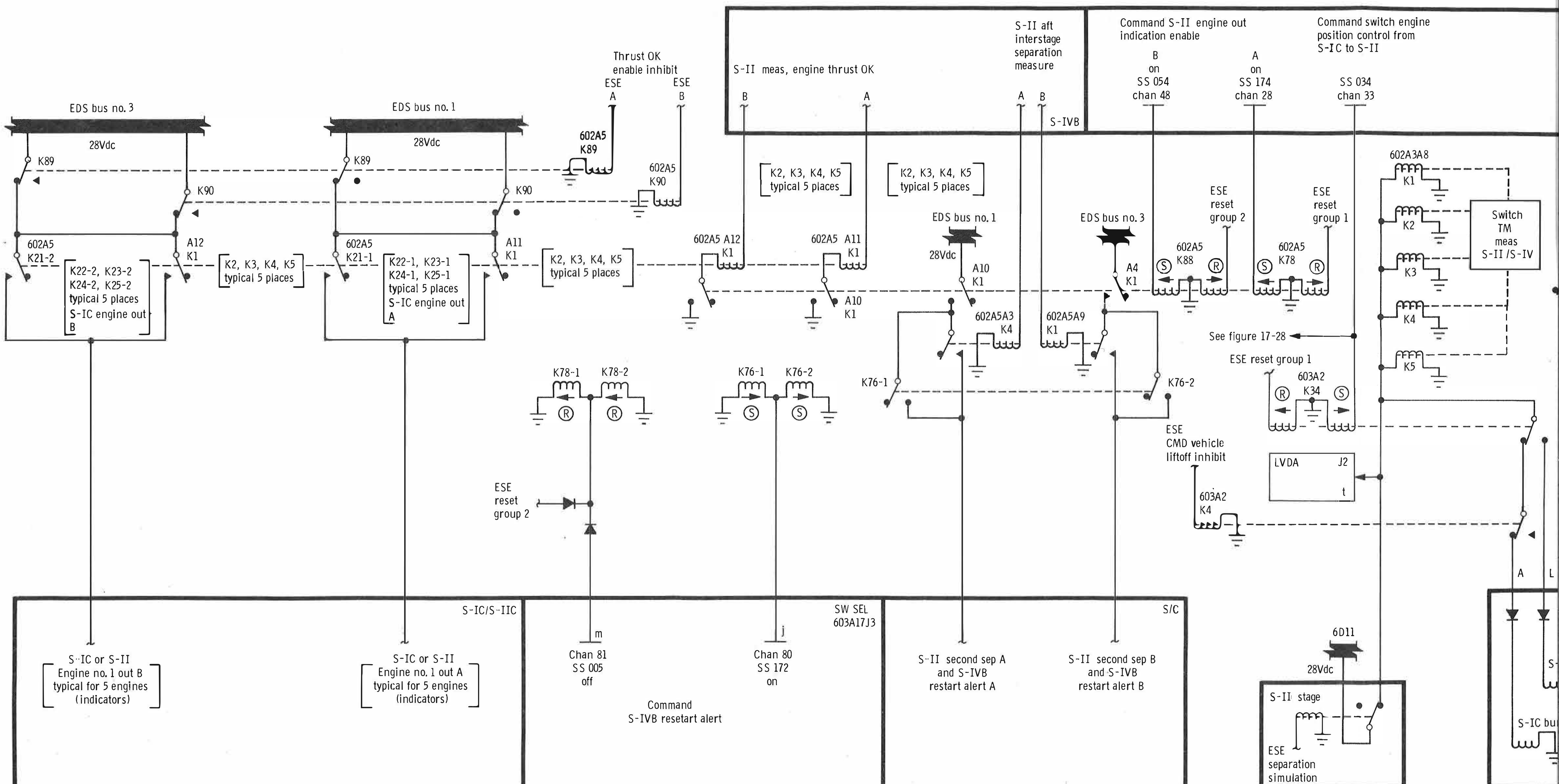


Figure 17-11. - FCC burn mode switching and S-II second plane separation indications.

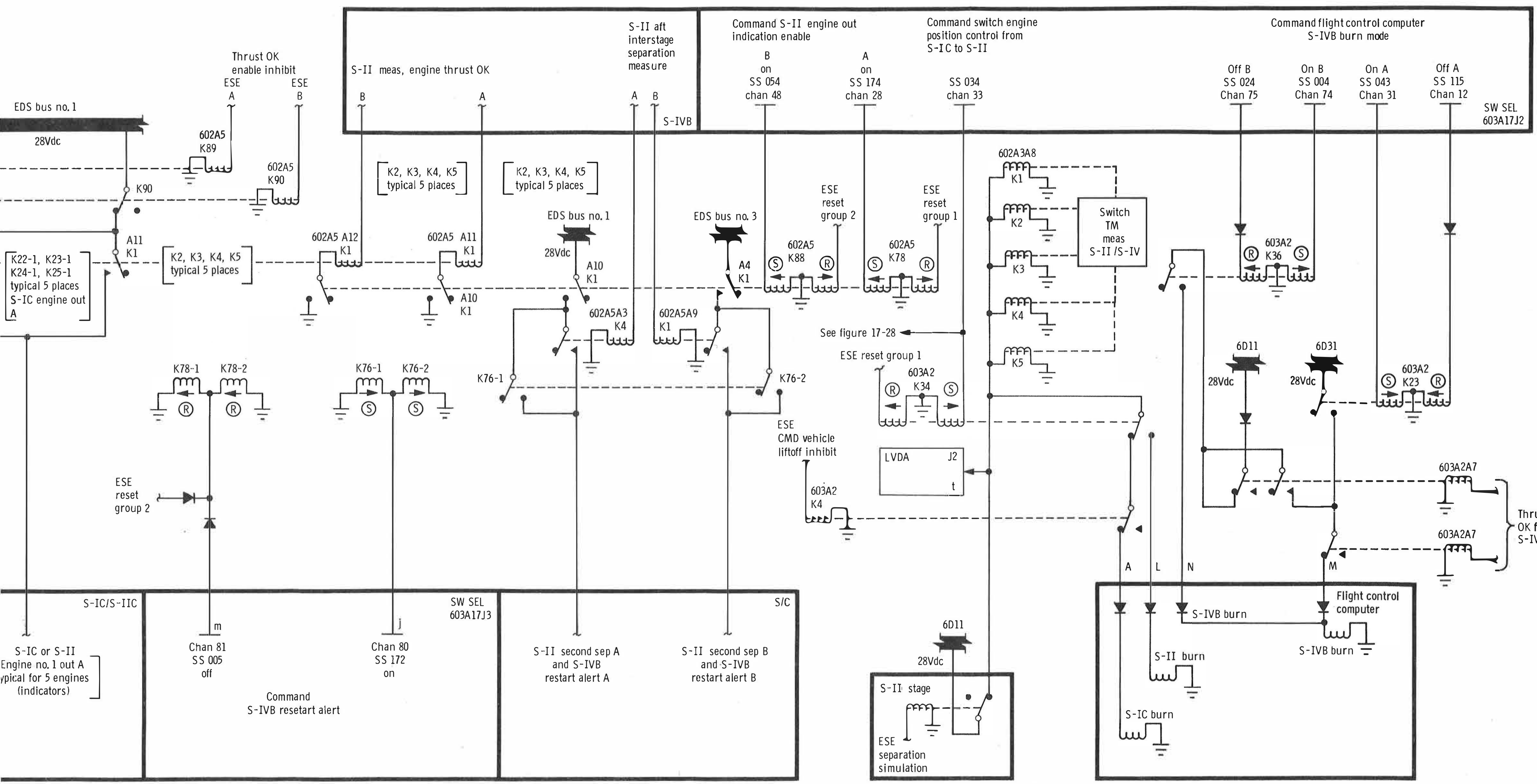


Figure 17-11. - FCC burn mode switching and S-II second plane separation indications.

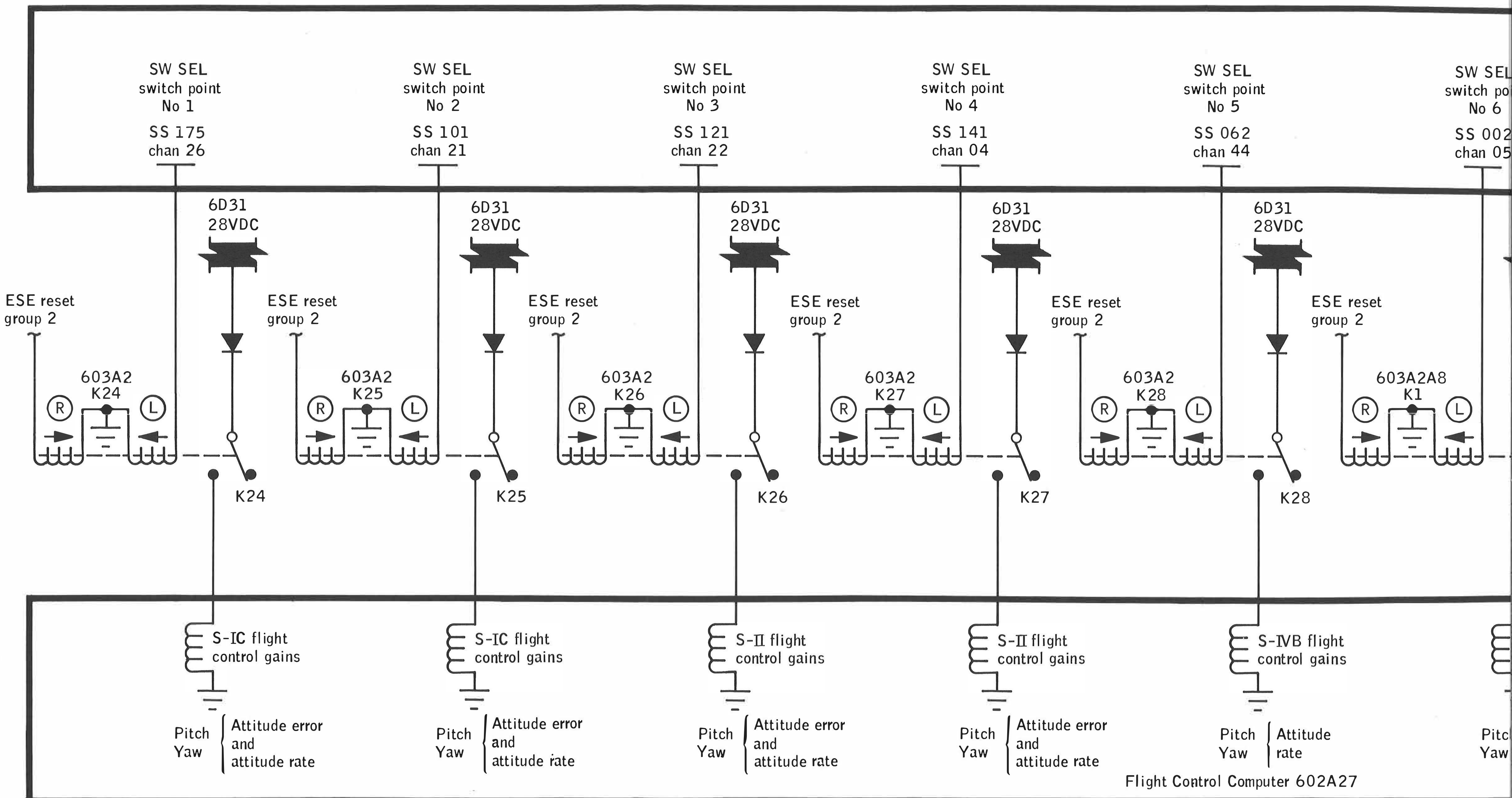


Figure 17-12. - Control of Flight Control Computer.

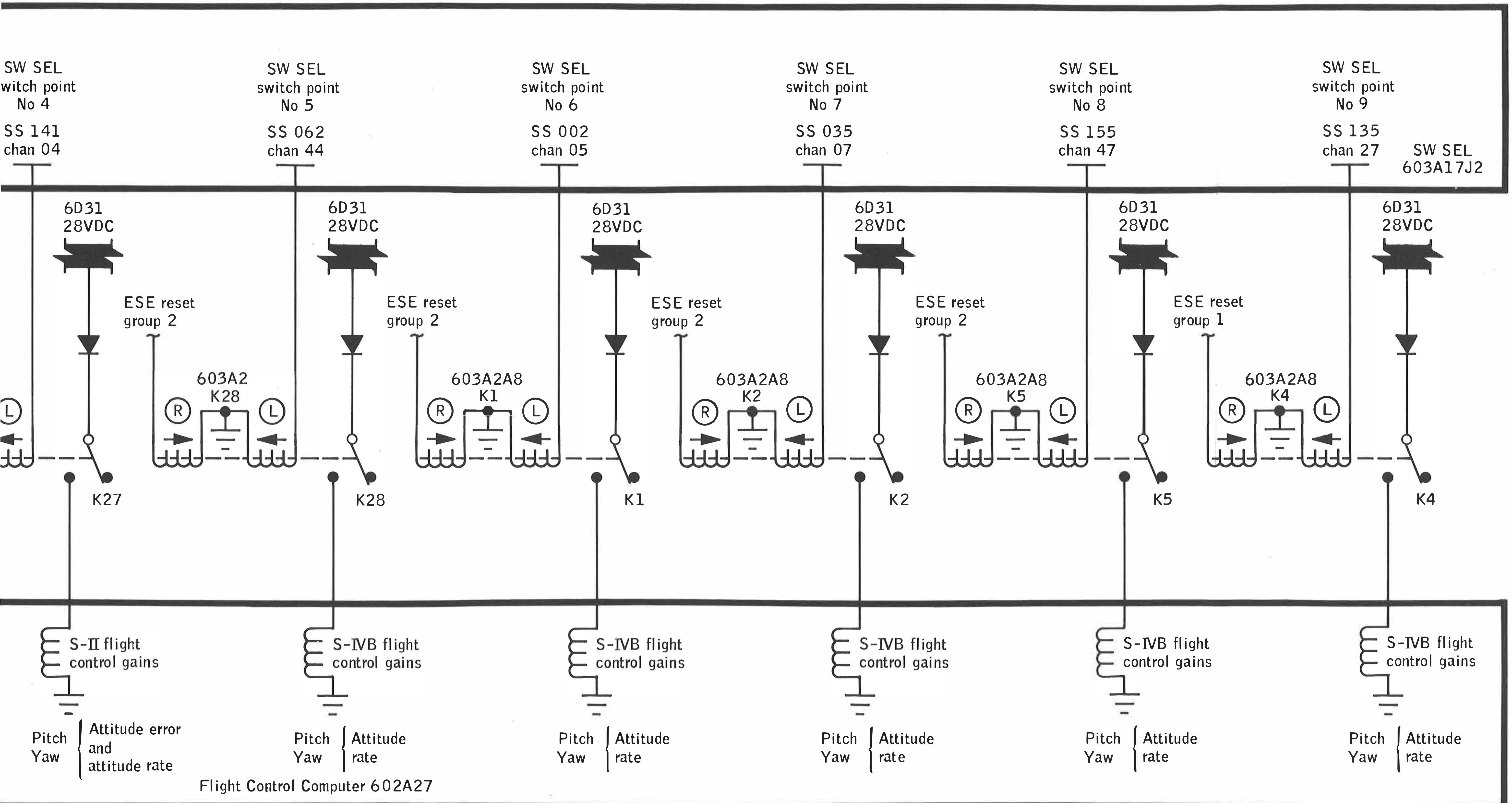


Figure 17-12. - Control of Flight Control Computer.

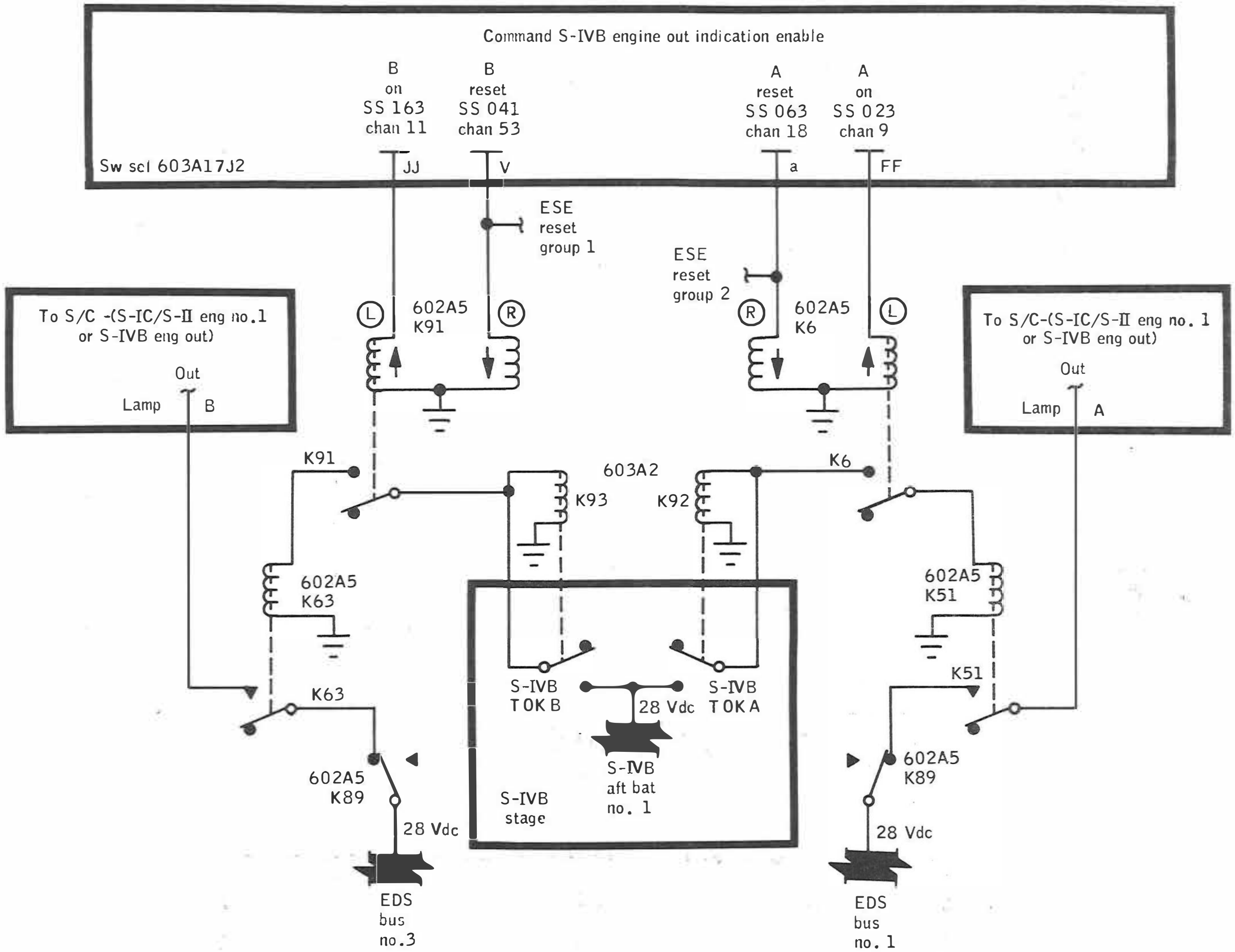


Figure 17-13. - S-IVB engine out indication enable.

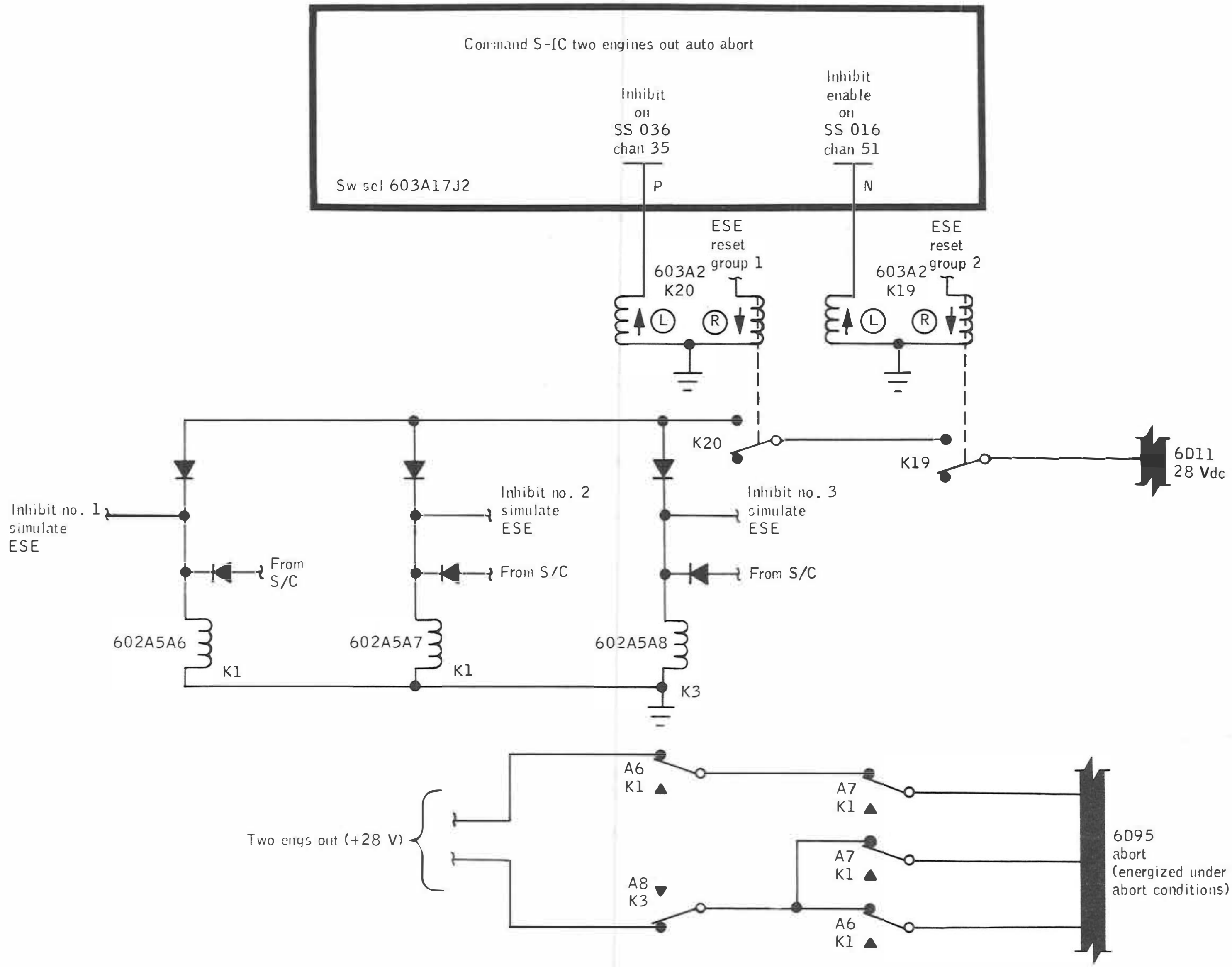


Figure 17-14. - S-IC two engine out auto abort.

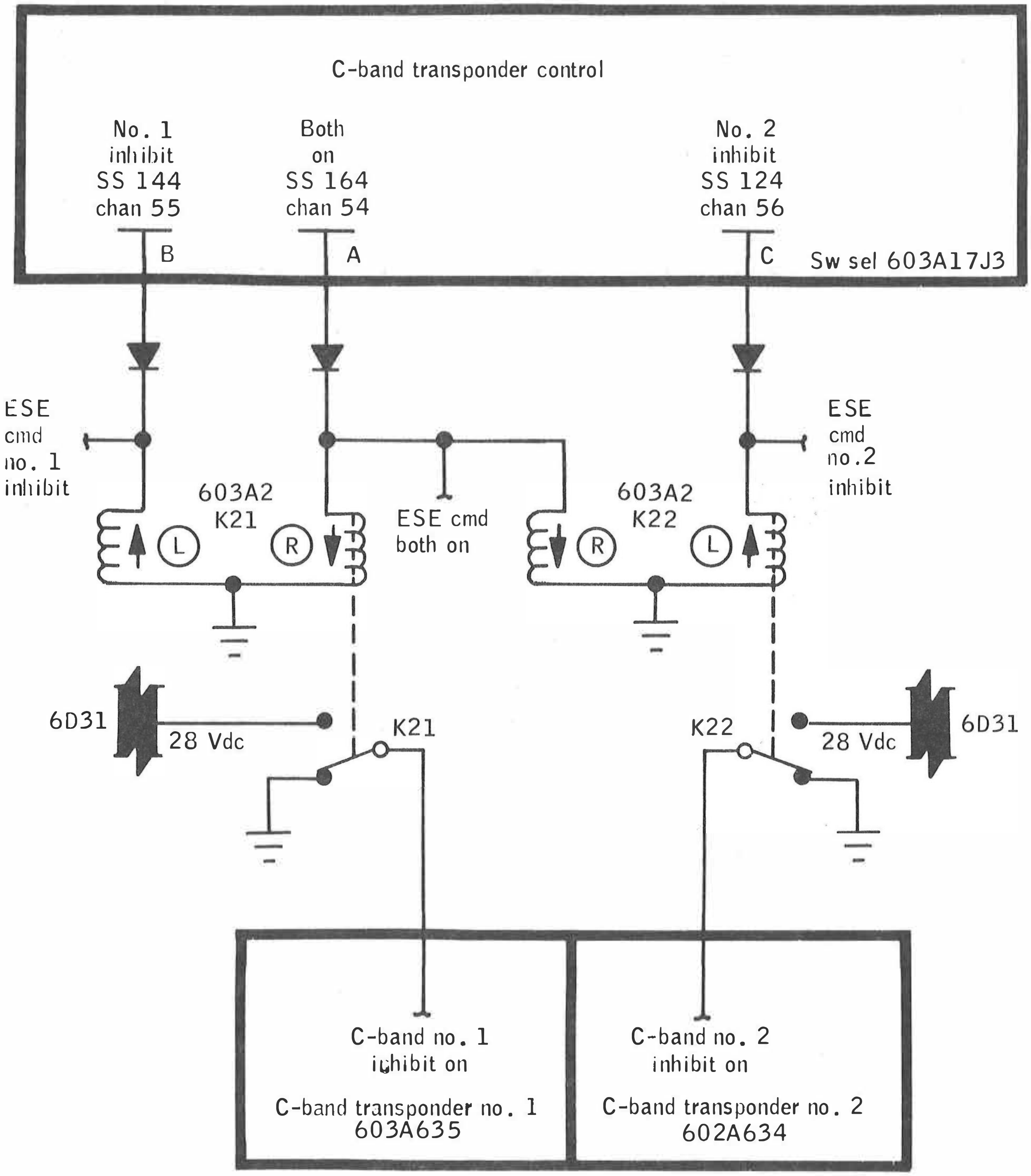


Figure 17-15. - C-band transponder control.

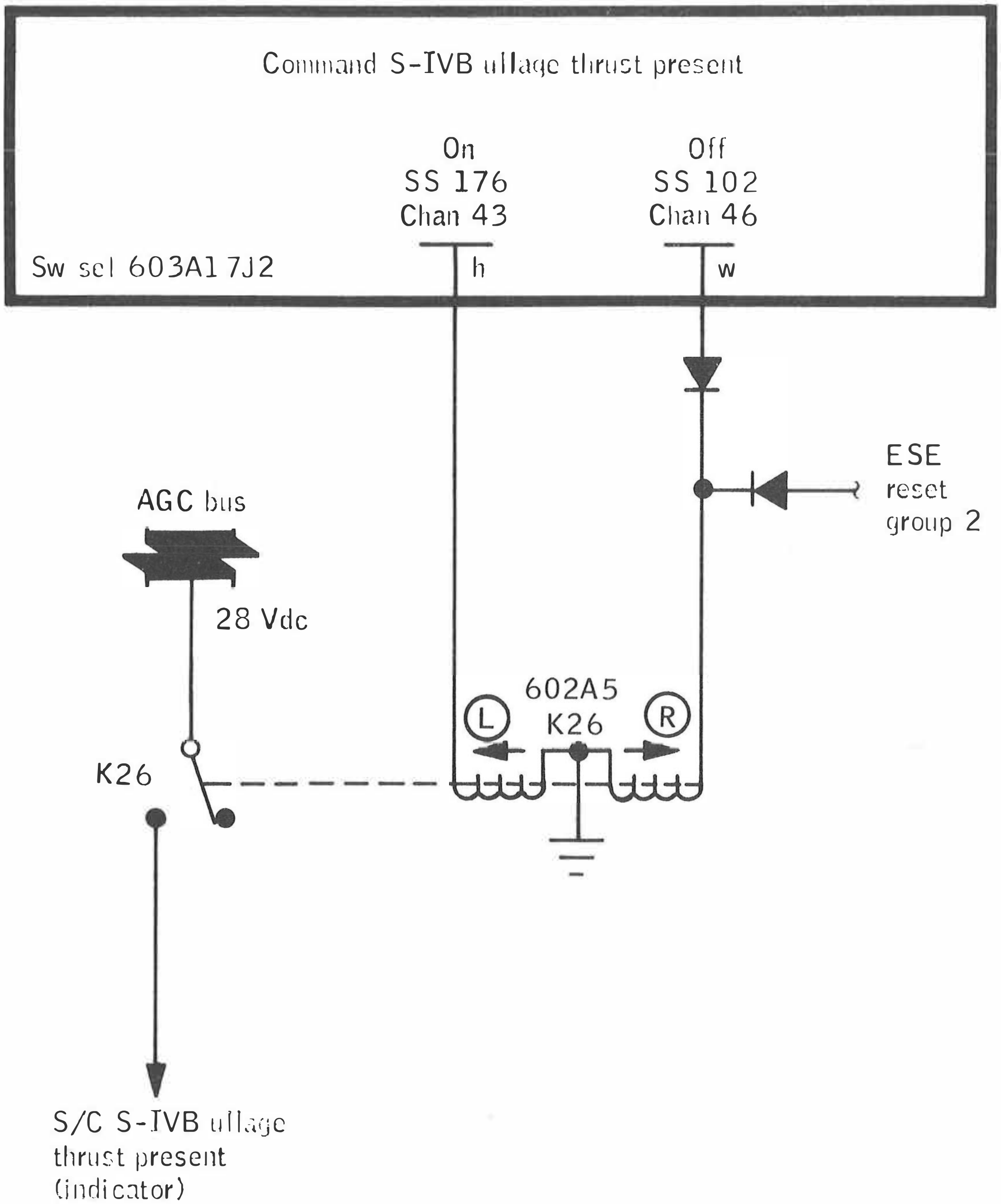


Figure 17-16. - S-IVB ullage thrust present.

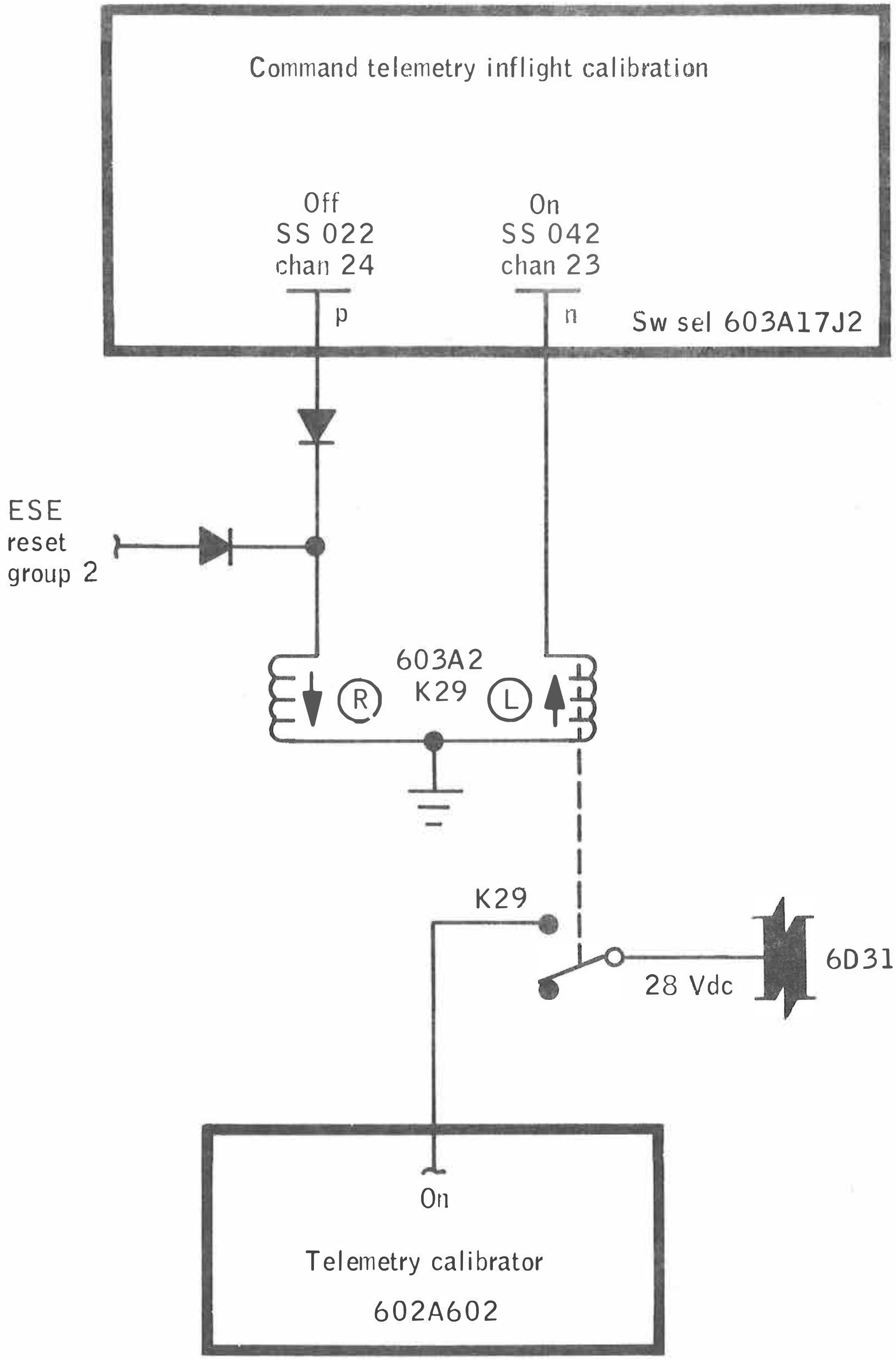


Figure 17-17. - Inflight calibration.

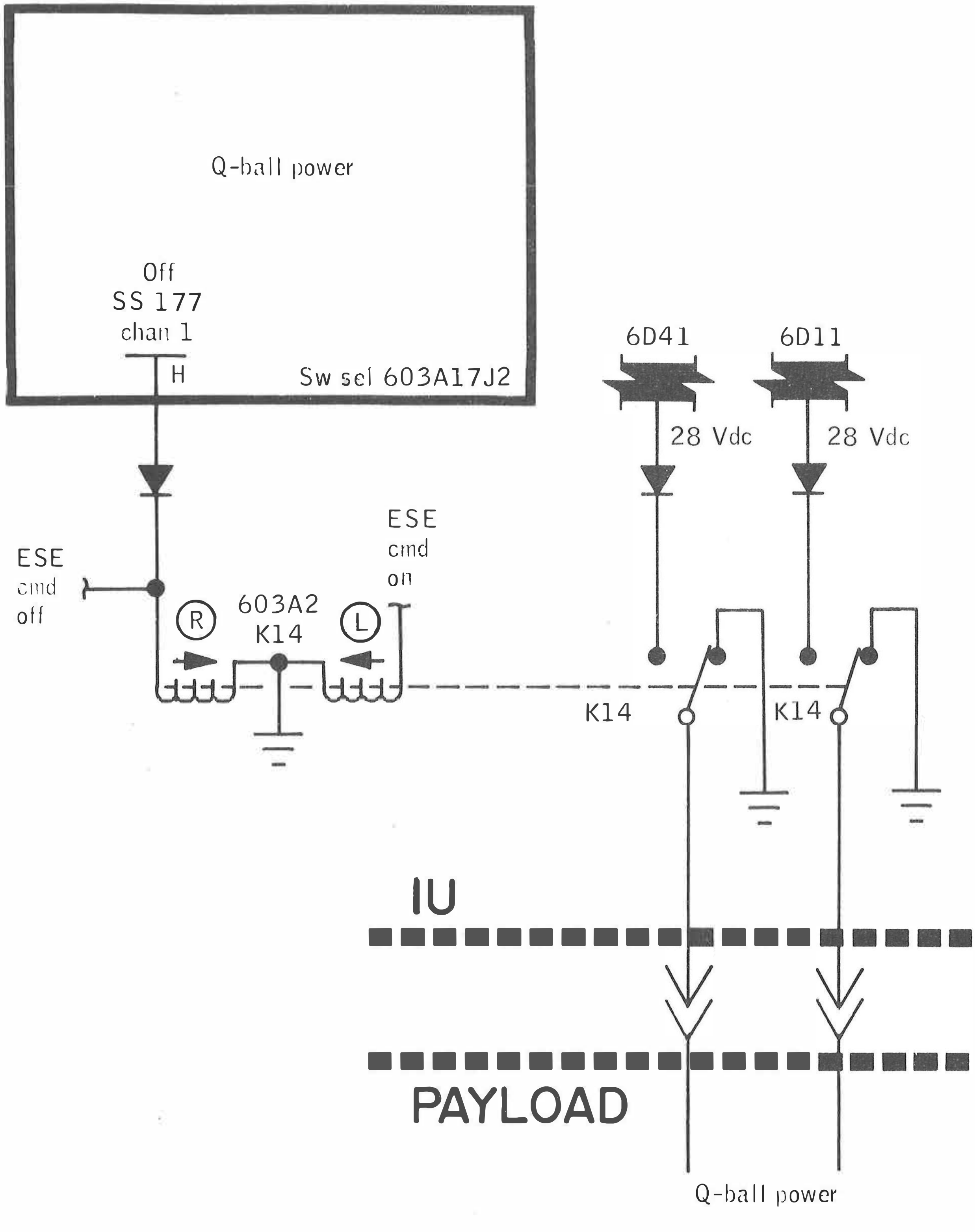


Figure 17-18. - Q-ball power.

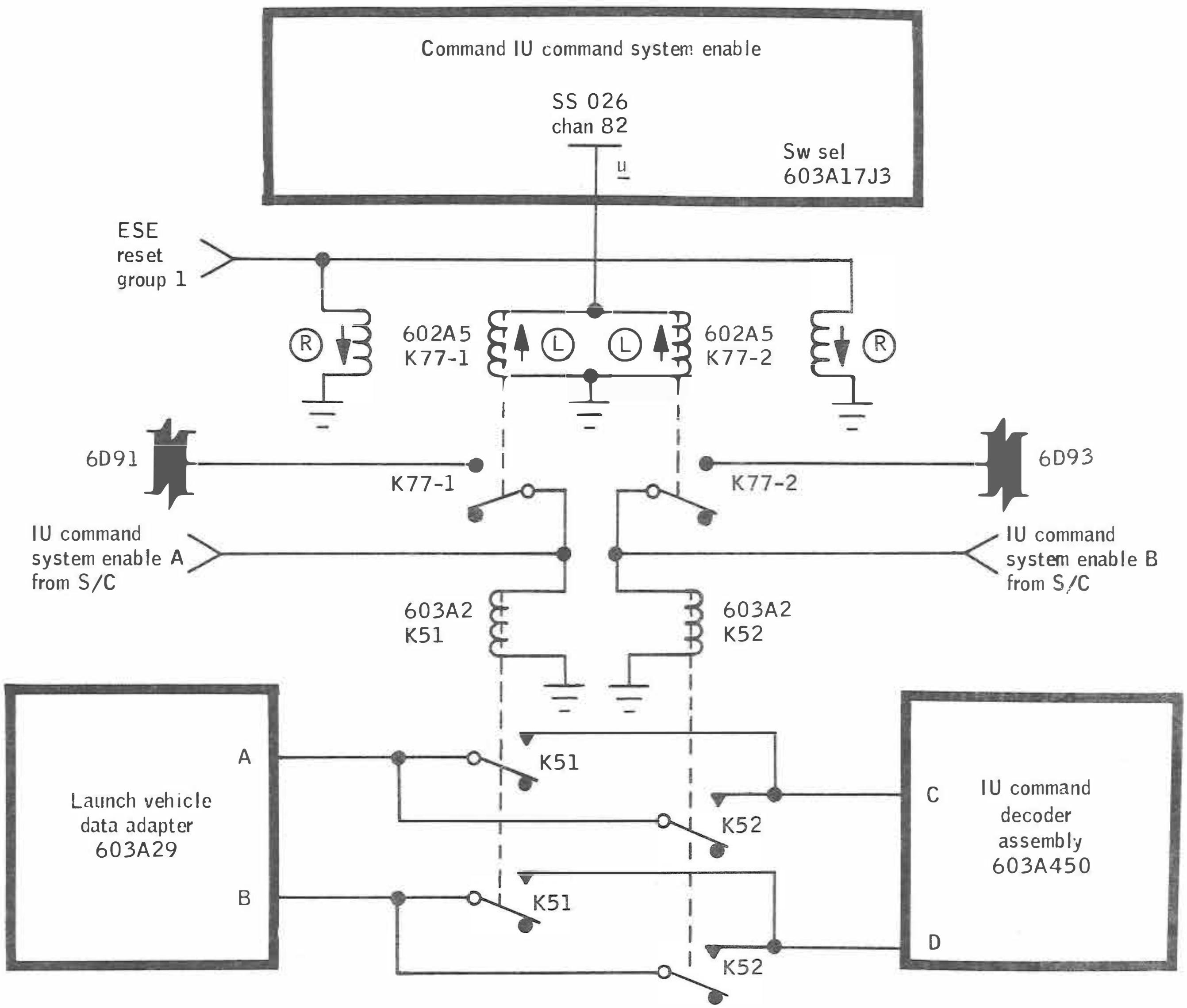


Figure 17-19. - IU Command system enable.

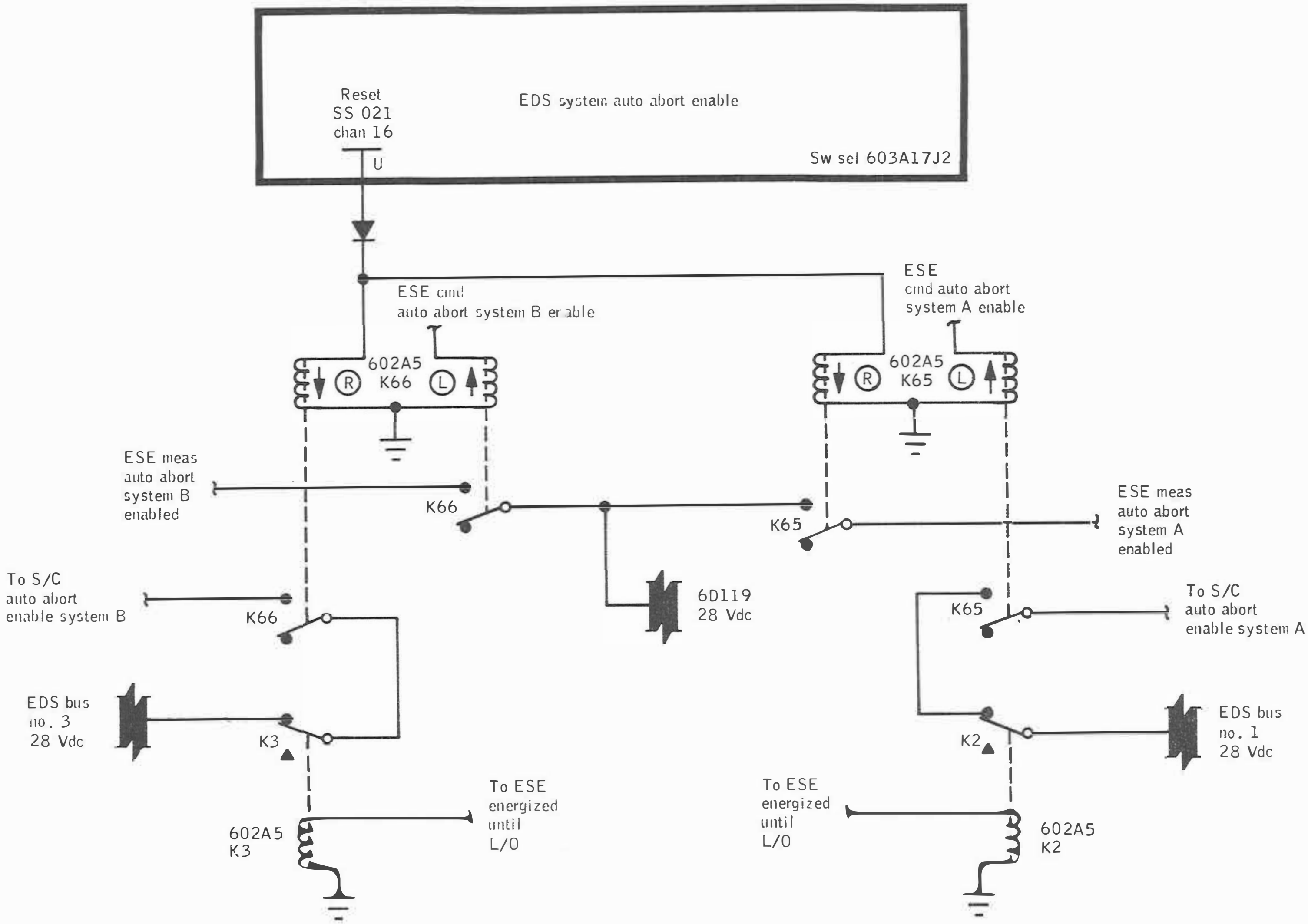


Figure 17-20. - Auto abort enable.

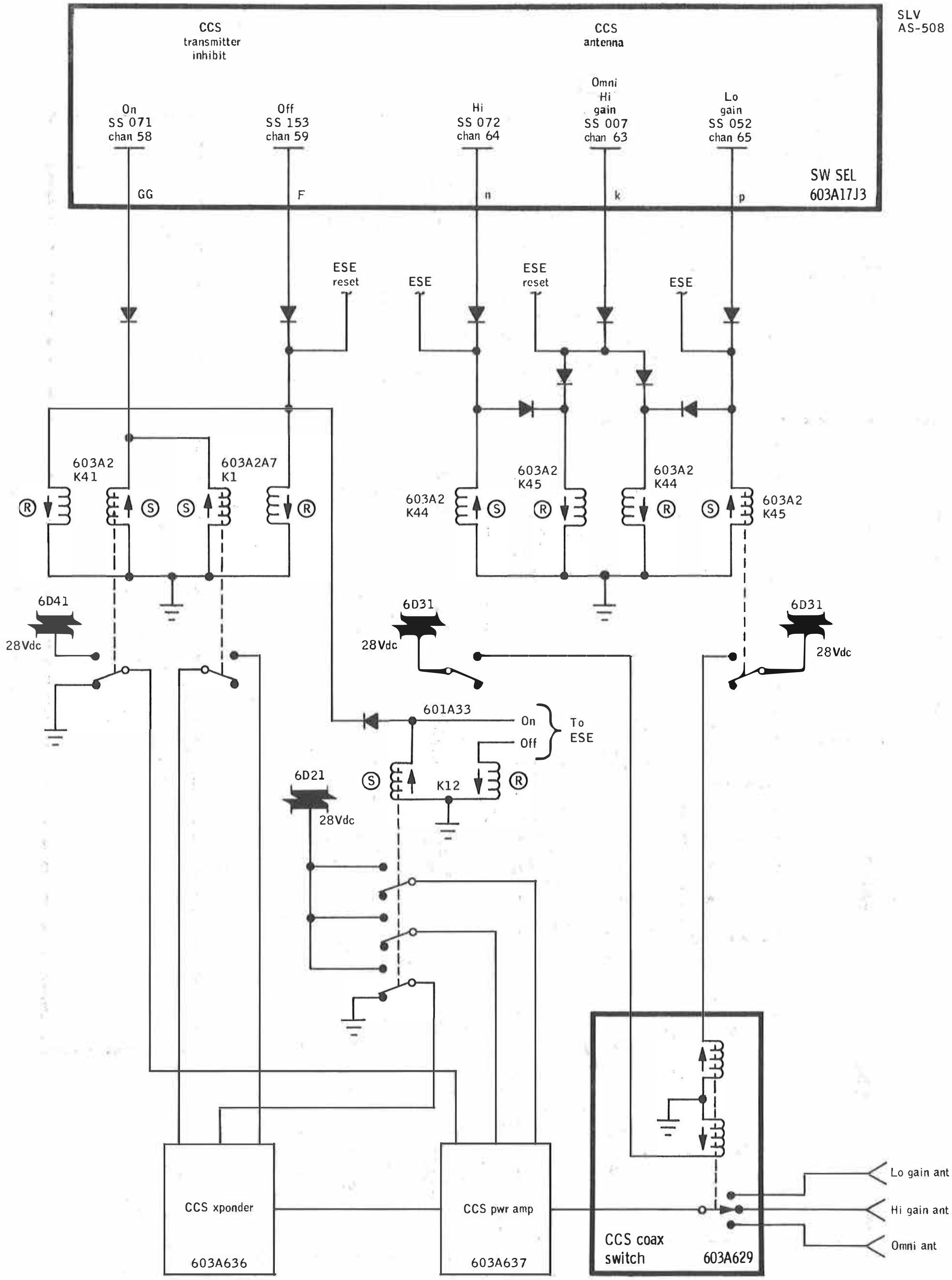


Figure 17-21. - CCS antenna switching.

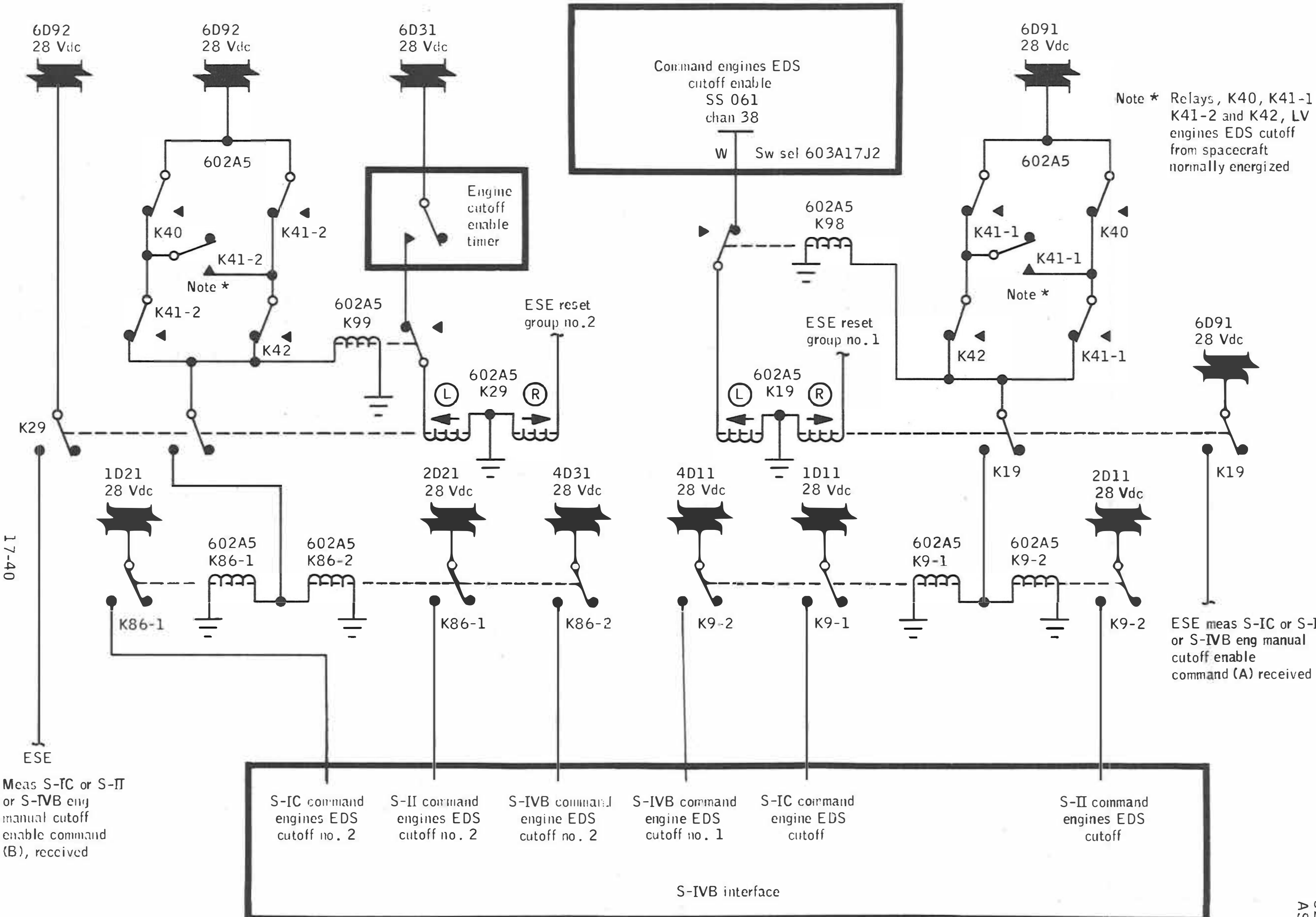


Figure 17-22. - Engines EDS cutoff enable.

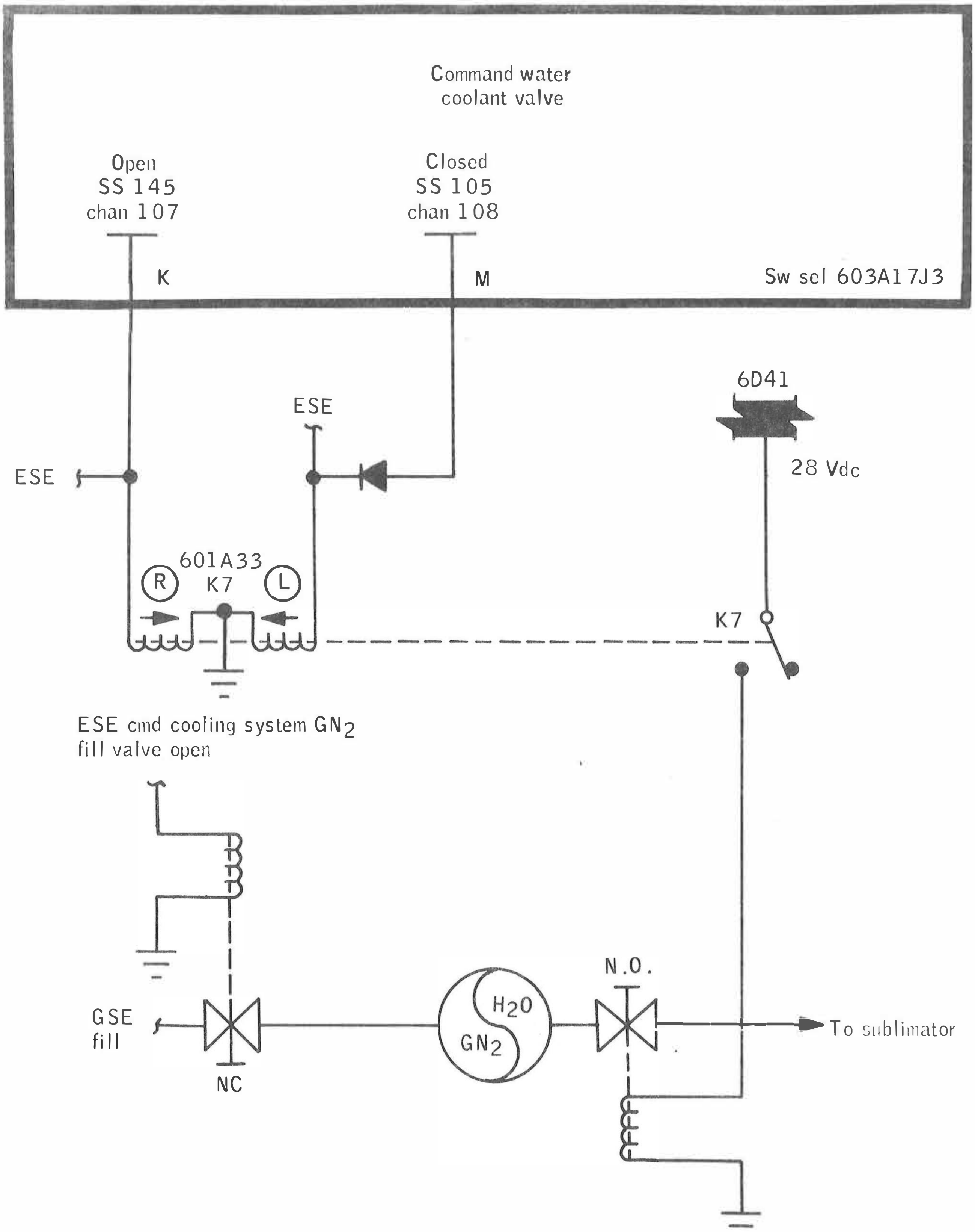


Figure 17-23. - Water valve control.

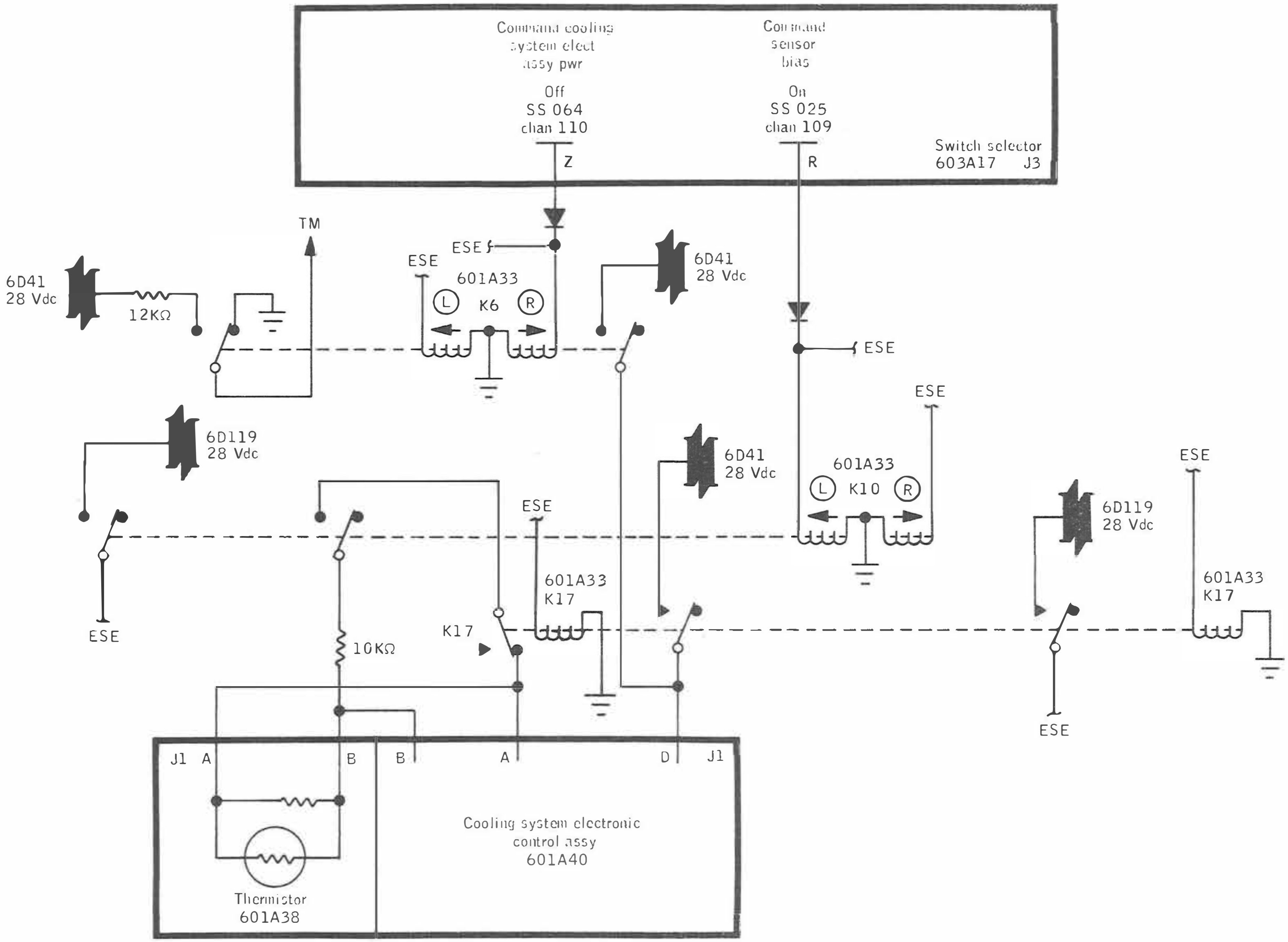


Figure 17-24. - IU cooling system electrical power.

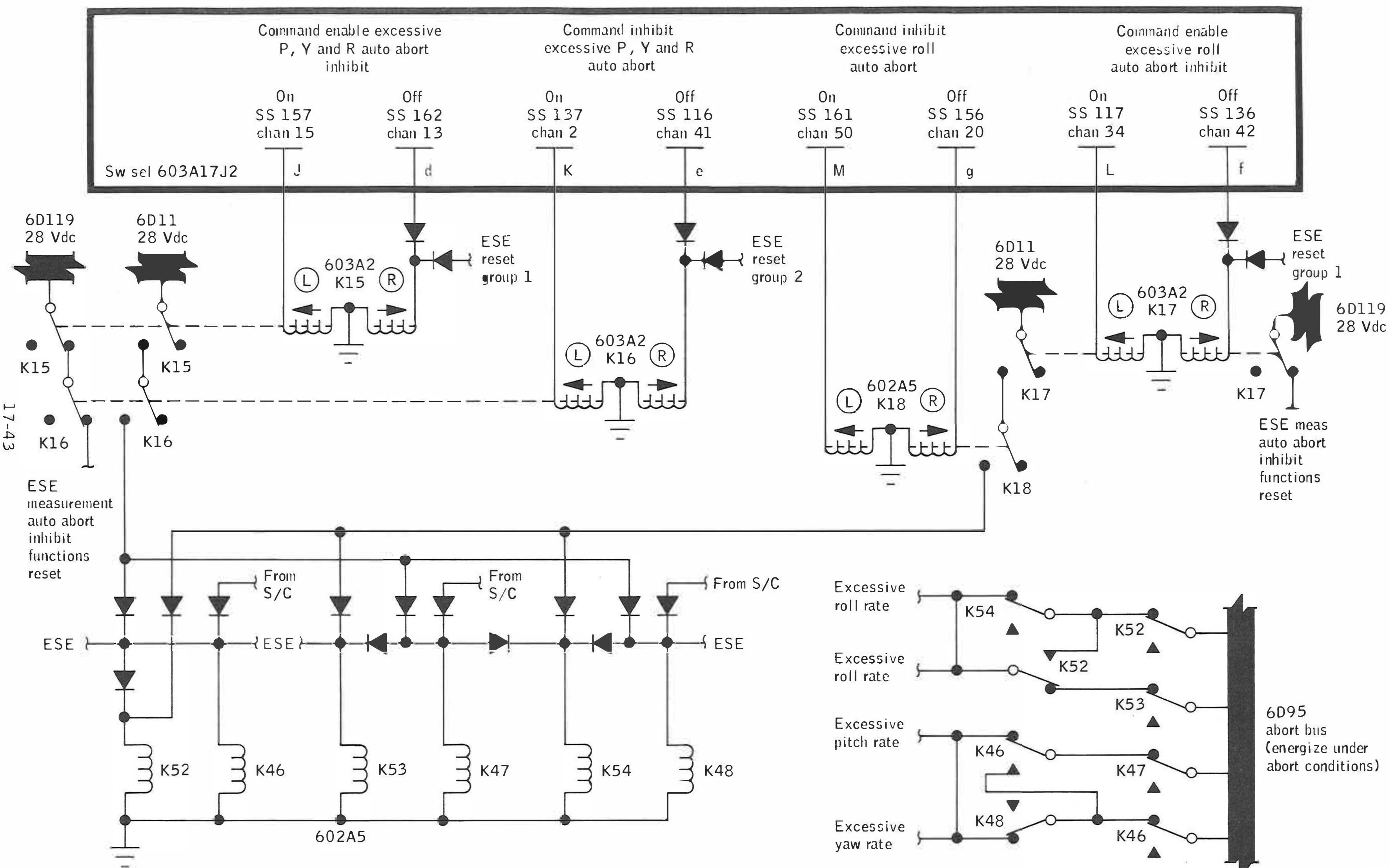


Figure 17-25. - EDS P, Y, and R automatic abort.

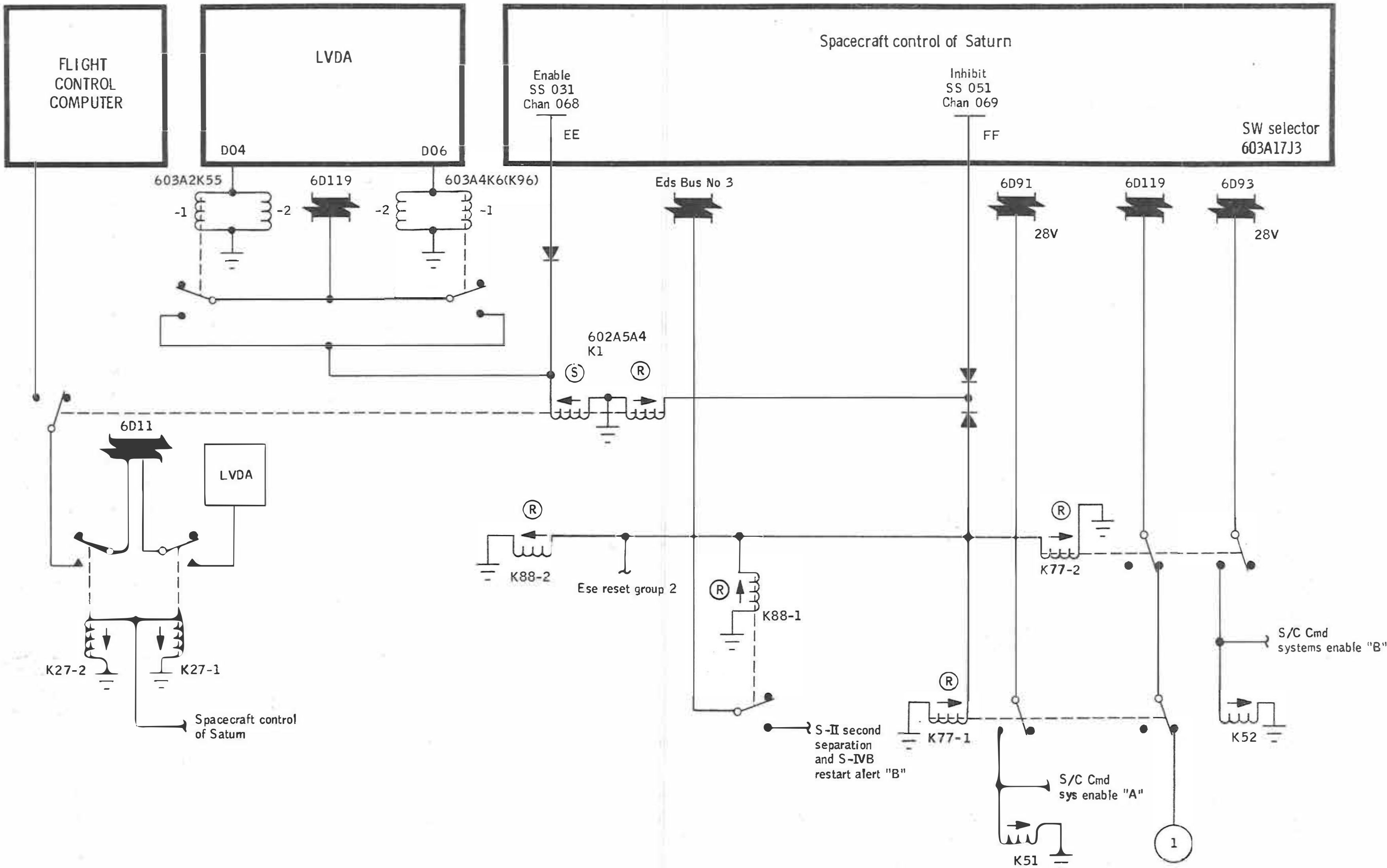


Figure 17-26. - Spacecraft control of Saturn.

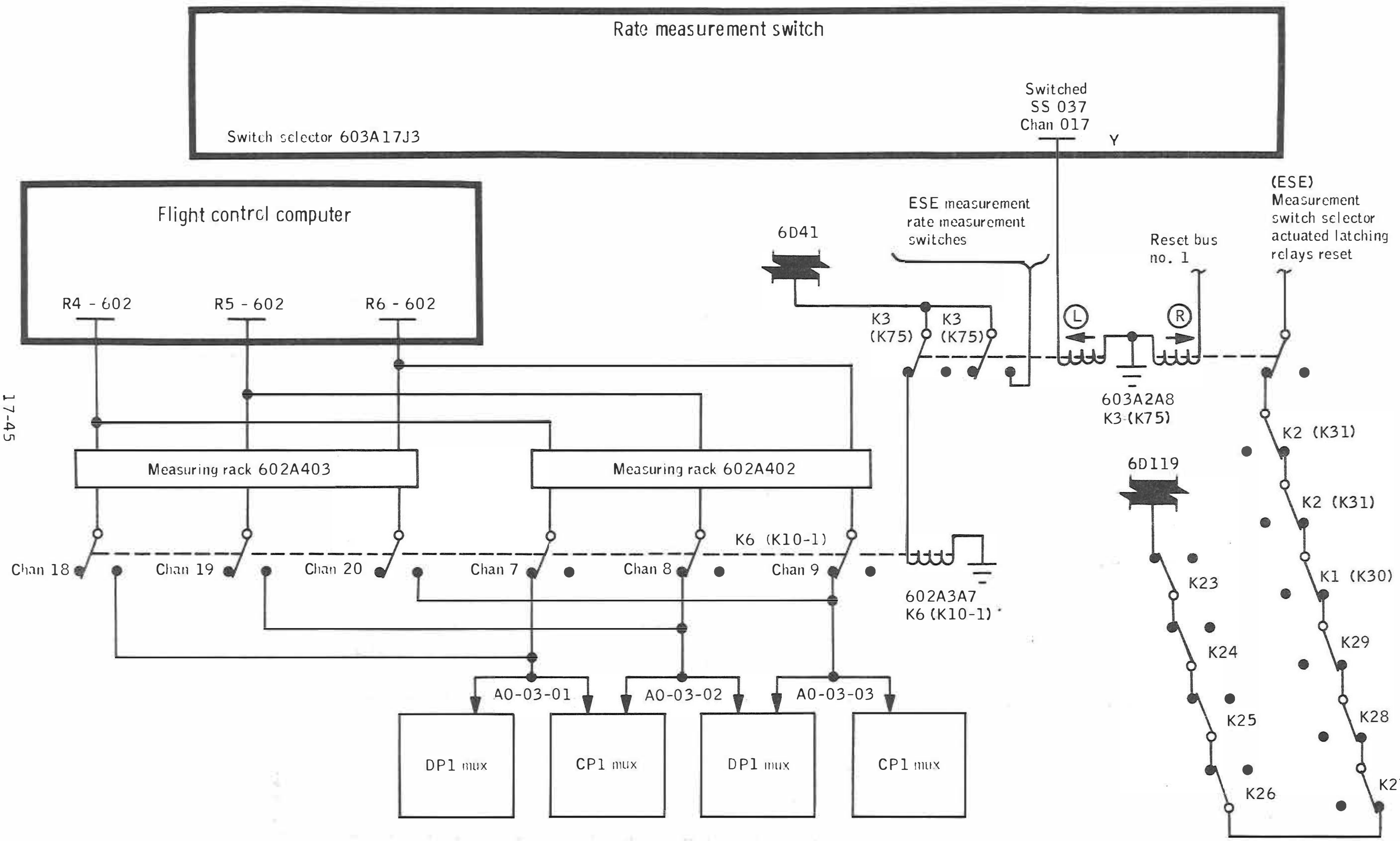


Figure 17-27. - Rate measurement switch.

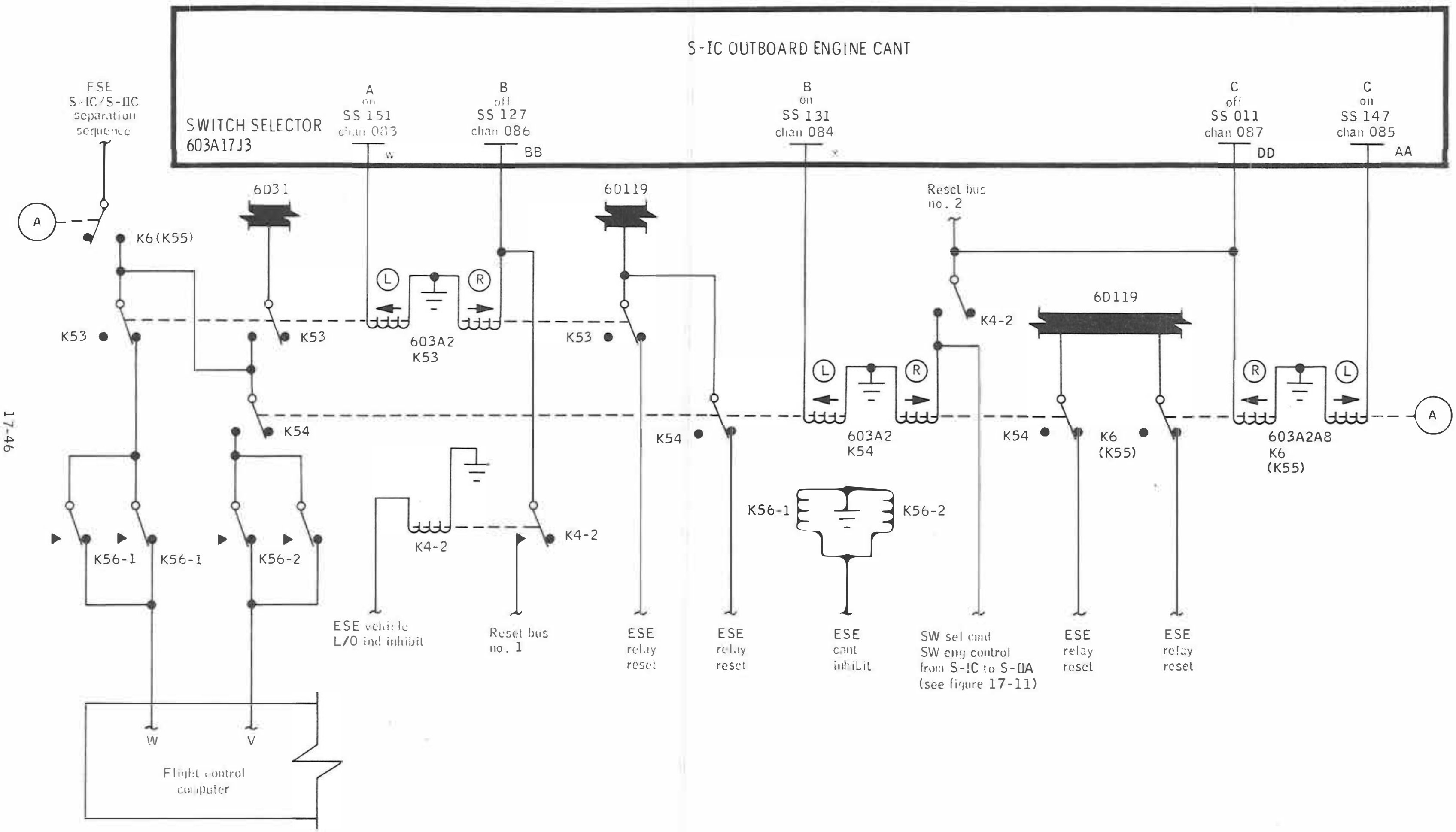
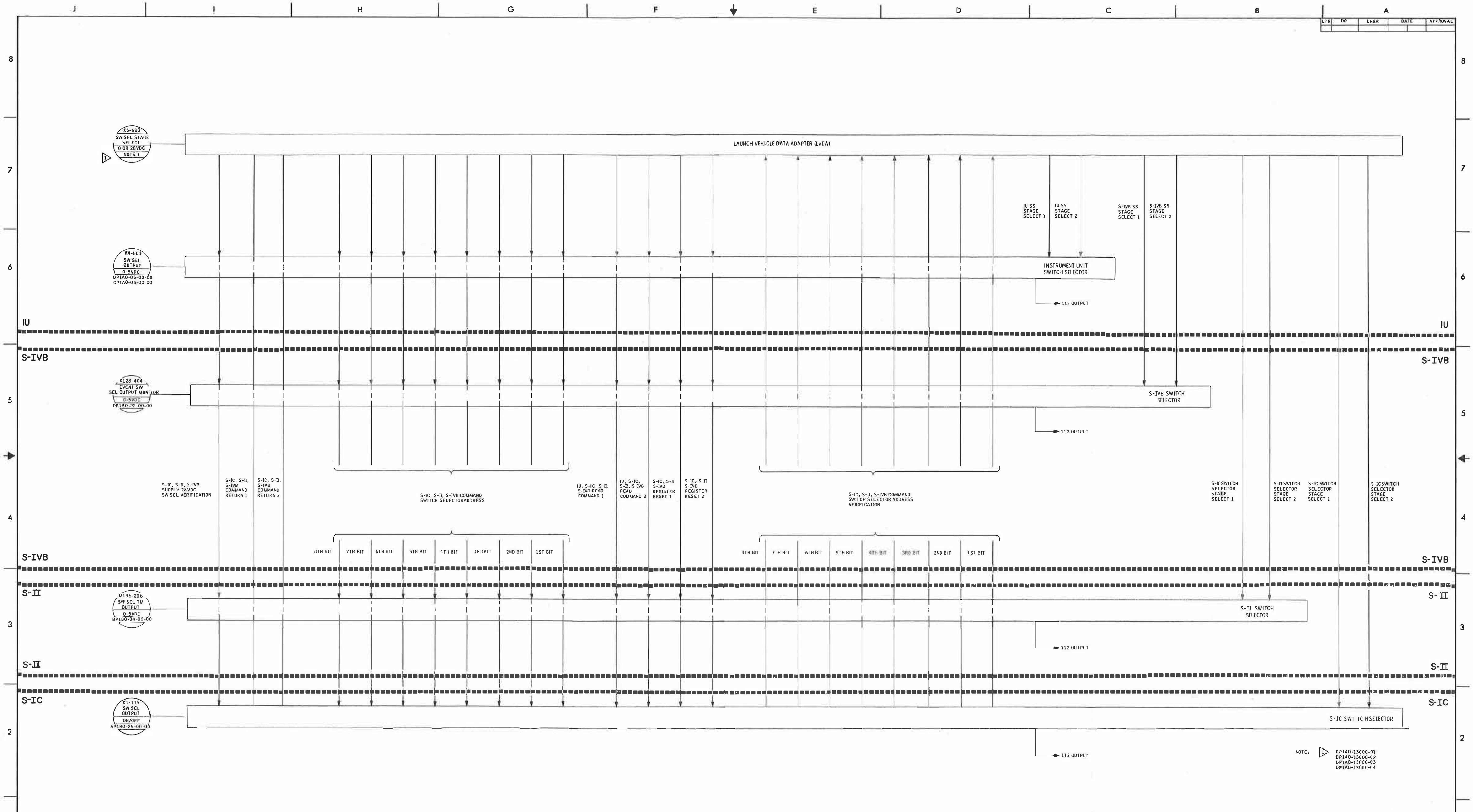


Figure 17-28. - Command S-IC outboard engines cant.



LTR	DR	ENGR	DATE	APPROVAL

NATIONAL AERONAUTICS & SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER - HOUSTON, TEXAS

SEQUENTIAL SYSTEM INTERFACE

SIGNATURES	DATE
DR [signature]	[illegible]
DSGN [signature]	[illegible]
QC [signature]	[illegible]
ENGR [signature]	[illegible]
APP [signature]	[illegible]
FEC [signature]	[illegible]
AUTH [signature]	[illegible]

SLV AS-508 | SIZE J | DWG NO 17.5.1

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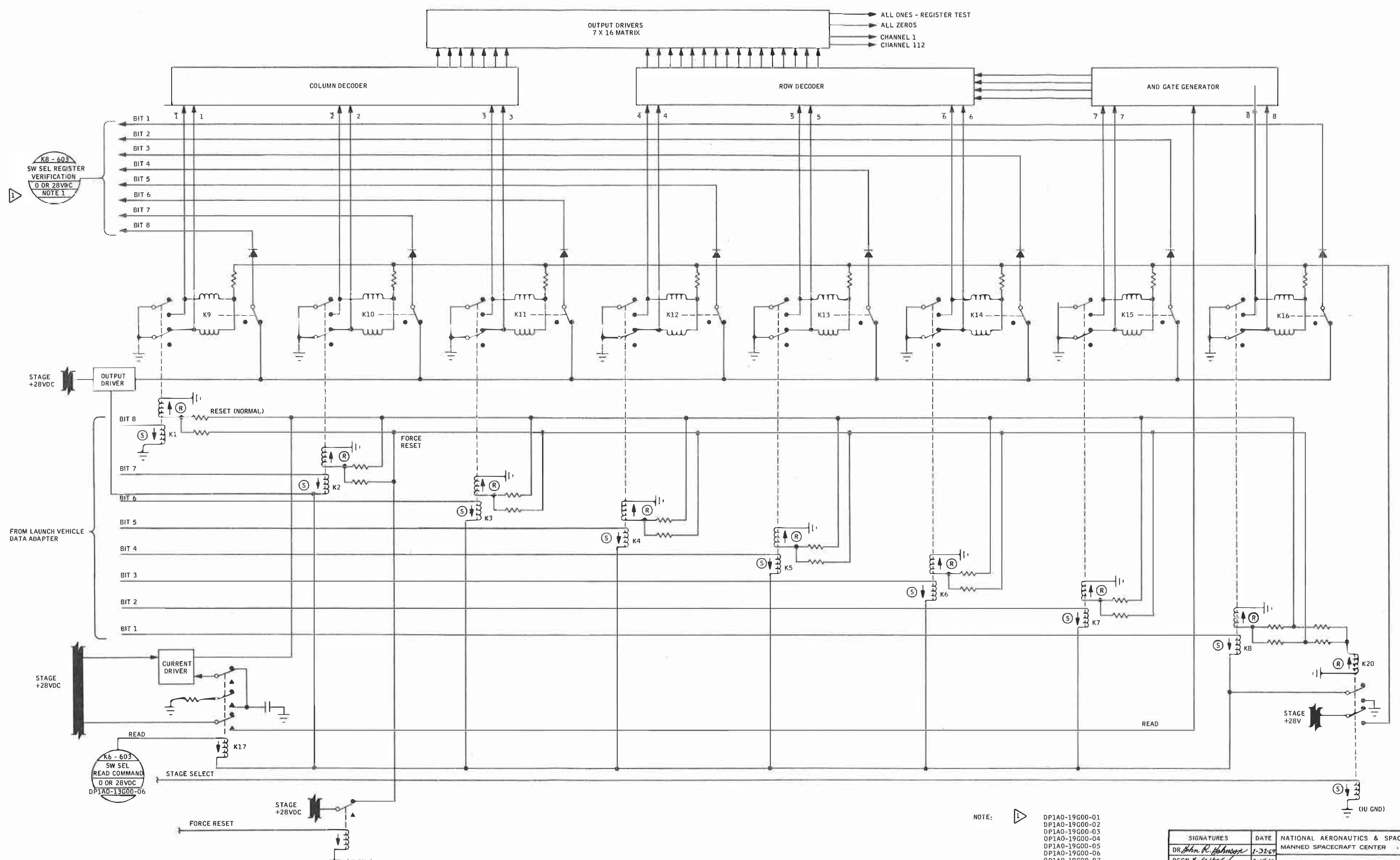

NOTE: 1 DP1A0-19G00-01
DP1A0-19G00-02
DP1A0-19G00-03
DP1A0-19G00-04
DP1A0-19G00-05
DP1A0-19G00-06
DP1A0-19G00-07
DP1A0-19G00-08

SIGNATURES	DATE
DR John R. Johnson	1-31-69
DSGN [illegible]	3-14-69
QC Betty M. [illegible]	3-14-69
ENGR [illegible]	3-12-69
APP C. [illegible]	3/13/69
FEC [illegible]	3/14/69
AUTH [illegible]	[illegible]

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SEQUENTIAL-SWITCH SELECTOR MOD II

SLV AS-508 | SIZE F | DWG NO 17.5.2

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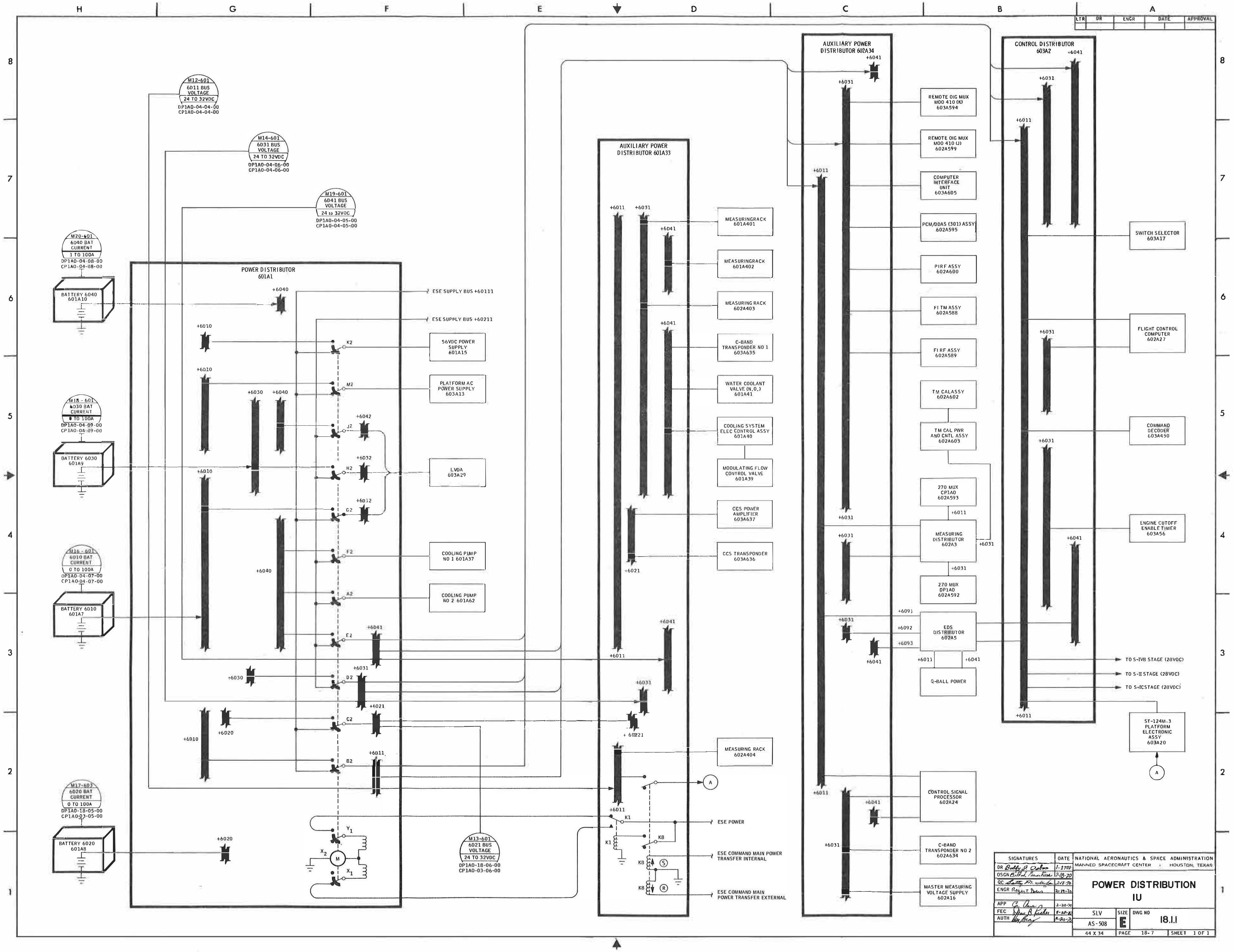
18 IU ELECTRICAL POWER SYSTEMS


POWER DISTRIBUTOR 601A1
AUXILIARY POWER DISTRIBUTOR 601A33
AUXILIARY POWER DISTRIBUTOR 602A34
CONTROL DISTRIBUTOR 603A2
M12-601 6011 BUS VOLTAGE 24 TO 32VDC DP1A0-04-04-00 CP1A0-04-04-00
M14-601 6031 BUS VOLTAGE 24 TO 32VDC DP1A0-04-06-00 CP1A0-04-06-00
M19-601 6041 BUS VOLTAGE 24 to 32VDC DP1A0-04-05-00 CP1A0-04-05-00
M20-601 6040 BAT CURRENT 1 TO 100A DP1A0-04-08-00 CP1A0-04-08-00
M18-601 6030 BAT CURRENT 0 TO 100A DP1A0-04-09-00 CP1A0-04-09-00
M16-601 6010 BAT CURRENT 0 TO 100A DP1A0-04-07-00 CP1A0-04-07-00
M17-603 6020 BAT CURRENT 0 TO 100A DP1A0-18-05-00 CP1A0-03-05-00
M13-601 6021 BUS VOLTAGE 24 TO 32VDC DP1A0-18-06-00 CP1A0-03-06-00
BATTERY 6040 601A10
BATTERY 6030 601A9
BATTERY 6010 601A7
BATTERY 6020 601A8
ESE SUPPLY BUS +60111
ESE SUPPLY BUS +60211
56VDC POWER SUPPLY 601A15
PLATFORM AC POWER SUPPLY 603A13
LVDA 603A29
COOLING PUMP NO 1 601A37
COOLING PUMP NO 2 601A62
MEASURING RACK 601A401
MEASURING RACK 601A402
MEASURING RACK 602A403
C-BAND TRANSPONDER NO 1 603A635
WATER COOLANT VALVE (N.O.) 601A41
COOLING SYSTEM ELEC CONTROL ASSY 601A40
MODULATING FLOW CONTROL VALVE 601A39
CCS POWER AMPLIFIER 603A637
CCS TRANSPONDER 603A636
MEASURING RACK 602A404
ESE POWER
ESE COMMAND MAIN POWER TRANSFER INTERNAL
ESE COMMAND MAIN POWER TRANSFER EXTERNAL
REMOTE DIG MUX MOD 410 (K) 603A594
REMOTE DIG MUX MOD 410 (J) 602A599
COMPUTER INTERFACE UNIT 603A605
PCM/DDAS (301) ASSY 602A595
PIRF ASSY 602A600
FI TM ASSY 602A588
FI RF ASSY 602A589
TM CAL ASSY 602A602
TM CAL PWR AND CNTL ASSY 602A603
270 MUX CP1A0 602A593
MEASURING DISTRIBUTOR 602A3
270 MUX DP1A0 602A592
EDS DISTRIBUTOR 602A5
Q-BALL POWER
CONTROL SIGNAL PROCESSOR 602A24
C-BAND TRANSPONDER NO 2 602A634
MASTER MEASURING VOLTAGE SUPPLY 602A16
SWITCH SELECTOR 603A17
FLIGHT CONTROL COMPUTER 602A27
COMMAND DECODER 603A450
ENGINE CUTOFF ENABLE TIMER 603A56
ST-124M-3 PLATFORM ELECTRONIC ASSY 603A20
TO S-IVB STAGE (28VDC)
TO S-II STAGE (28VDC)
TO S-IC STAGE (28VDC)
LTR DR ENGR DATE APPROVAL
SIGNATURES DATE
DR 1-27-70
DSGN 2-18-70
QC 2-18-70
ENGR 2-19-70
APP 2-20-70
FEC 2-20-70
AUTH 2-20-70
NATIONAL AERONAUTICS & SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER HOUSTON, TEXAS
POWER DISTRIBUTION
IU
SLV
AS-508
SIZE E
DWG NO 18.1.1
44 X 34
PAGE 18-7
SHEET 1 OF 1

SECTION 18

IU ELECTRICAL POWER SYSTEMS

18.1 GENERAL NOTES

A. Electrical power for the Saturn launch vehicle is provided by batteries in each stage to operate the functions of that stage. In this manner, complete power isolation is maintained between stages. Grounds are also isolated except for a single point interconnection.

B. All batteries on the Saturn launch vehicle are 28 volts except those used for chilldown inverters and auxiliary hydraulic pumps which are 56 Vdc.

C. All power distribution is at 28 Vdc (except auxiliary hydraulic pump and chilldown). Where ac or voltages other than 28 Vdc are required, the conversion is within and as a part of the using equipment.

18.1.1 IU Electrical System

A. Electrical power for the IU stage is provided by four silver oxide/zinc primary cell batteries located in the stage. The batteries are designated as follows:

Battery	Voltage	Capacity
+6D10	28 ± 2 Vdc	350 ampere-hours
+6D20	28 ± 2 Vdc	350 ampere-hours
+6D30	28 ± 2 Vdc	350 ampere-hours
+6D40	28 ± 2 Vdc	350 ampere-hours

Each battery contains 19 active and 1 spare cell. The electrolyte is potassium hydroxide (KOH).

B. At approximately T-50 seconds, all power distribution in the IU is transferred from ground power to the IU batteries. The transfer switches are disabled at umbilical release.

TABLE 18-I.- IU ELECTRICAL LOAD DISTRIBUTION

Item	Total current	6D10 current	6D20 current	6D30 current	6D40 current
Switch selector	0.07	0.07			
5-volt measuring voltage supply	0.46			0.46	
56-volt power supply	4.30	4.30			
Q-ball transducer	0.50	0.25			0.25
Coolant pump	18.96				18.96
Water control valve	1.17				1.17
Control signal processor	3.00	1.00		1.00	1.00
Flight control computer					
S-IC burn	2.38	1.19		1.19	
S-II burn	3.16	1.58		1.58	
S-IVB burn	2.14	1.07		1.07	
S-IVB coast	1.50	0.75		0.75	
LVDC/LVDA	17.52	5.84		5.84	5.84
Platform ac power supply	5.86	5.86			
Platform electronics assembly	0.43	0.43			
Computer interface unit	0.30			0.30	
Measuring rack A401	1.08			1.08	
Measuring rack A402	1.18				1.18
Measuring rack A403	1.28			1.28	
Measuring rack A404	1.74	1.74			
270 Multiplexer (CP1)	0.10	0.10			
270 Multiplexer (DP1)	0.10			0.10	
410 Multiplexer (J)	0.30			0.30	
410 Multiplexer (K)	0.30			0.30	
F1 telemeter assembly	0.58			0.58	
PCM/DDAS telemeter assembly	0.89			0.89	
F1 RF transmitter assembly	3.72			3.72	
P1 PCM RF transmitter assembly	3.75			3.75	
Telemetry calibrator power and control assembly	0.45			0.45	
C-band transponder #1	0.69				0.69
C-band transponder #2	0.69			0.69	
CCS power amplifier	3.18		3.18		
CCS transponder	0.95		0.95		
Command decoder	0.08	0.08			
Totals					
S-IC burn		20.86	4.13	22.03	29.09
S-II burn		21.00	4.13	22.42	28.84
S-IVB burns		20.49	4.13	21.91	28.84
S-IVB coast		20.17	4.13	21.59	28.84

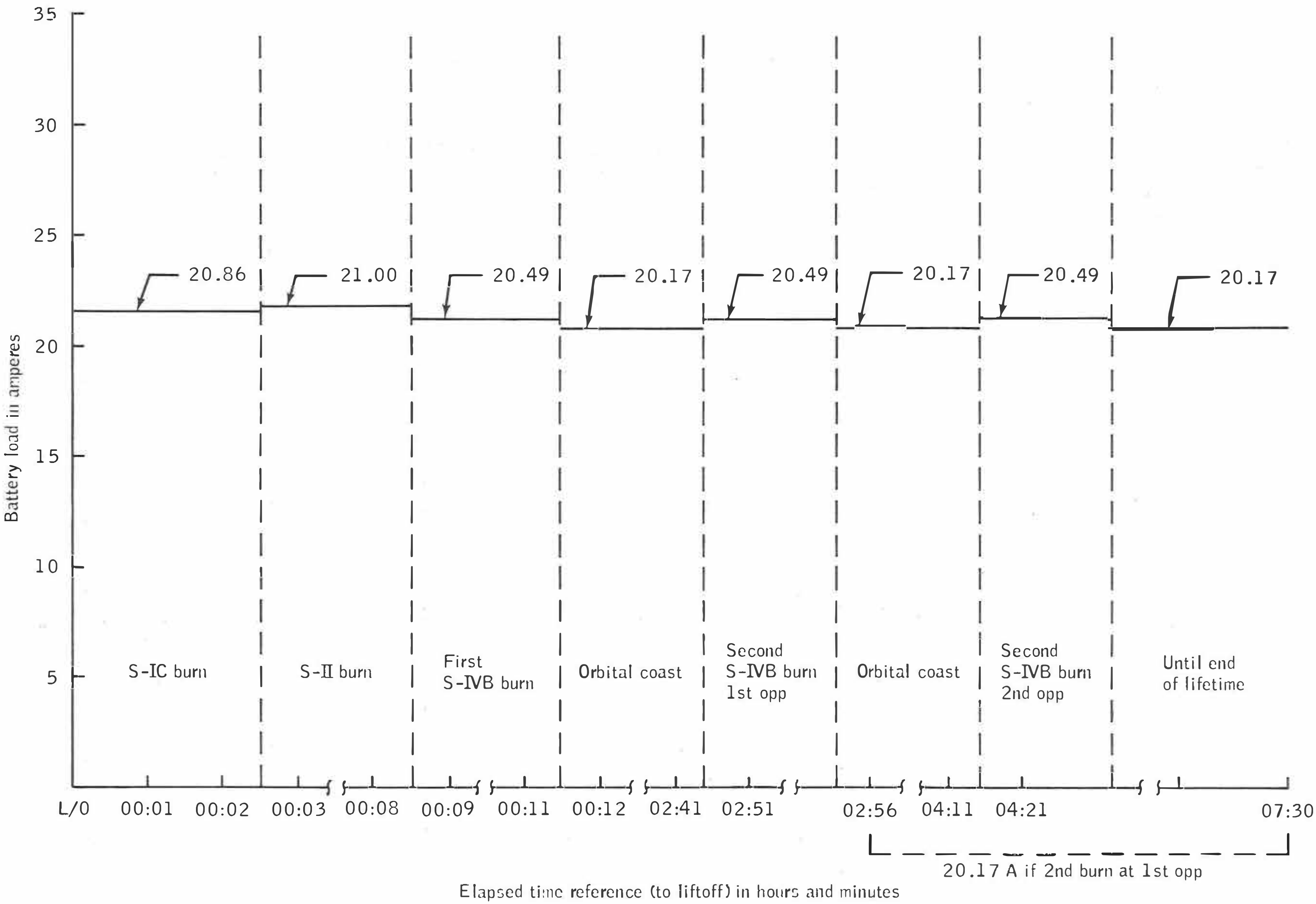


Figure 18-1. - IU battery no. 1 composite load profile.

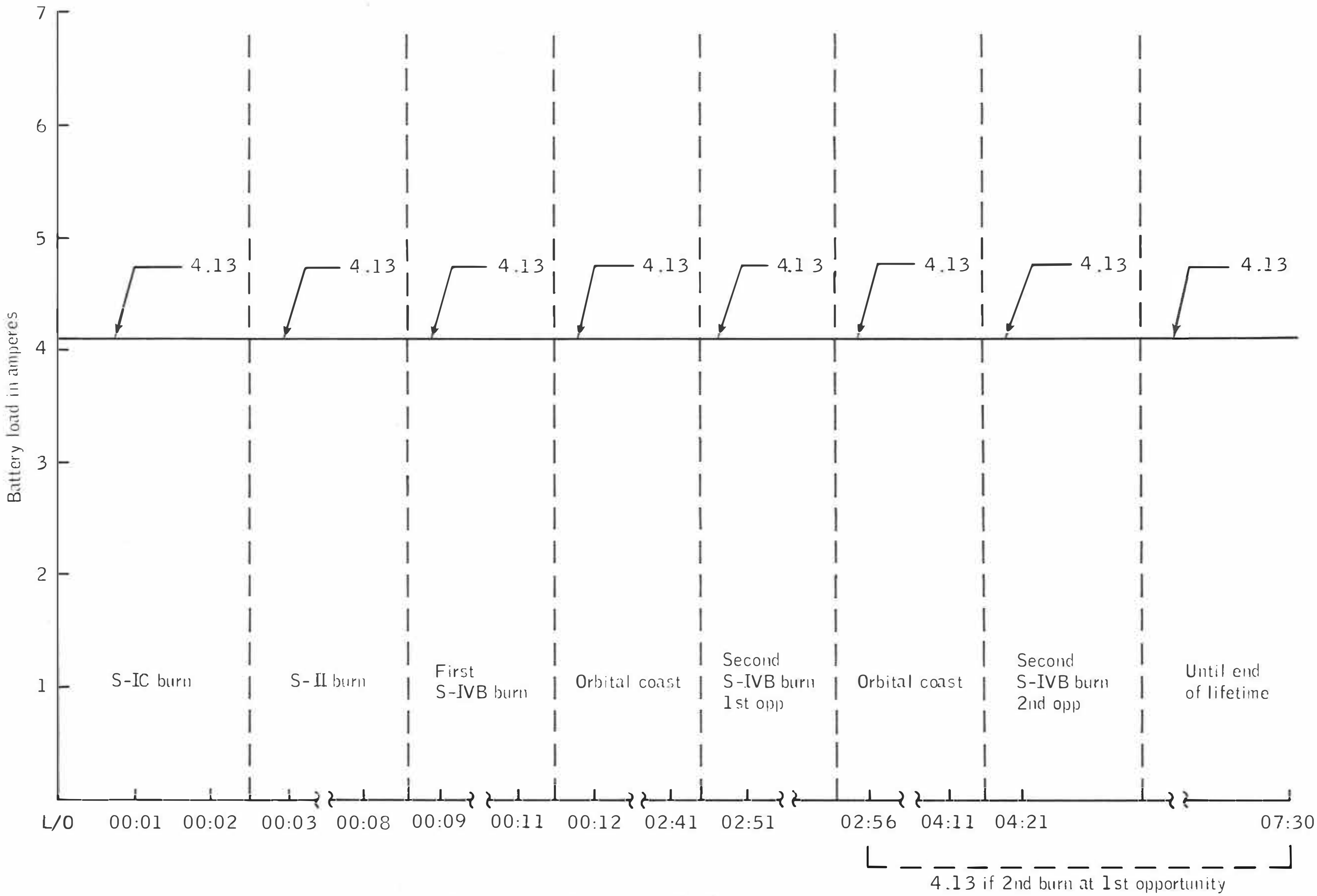


Figure 18-2. - IU battery no. 2 composite load profile.

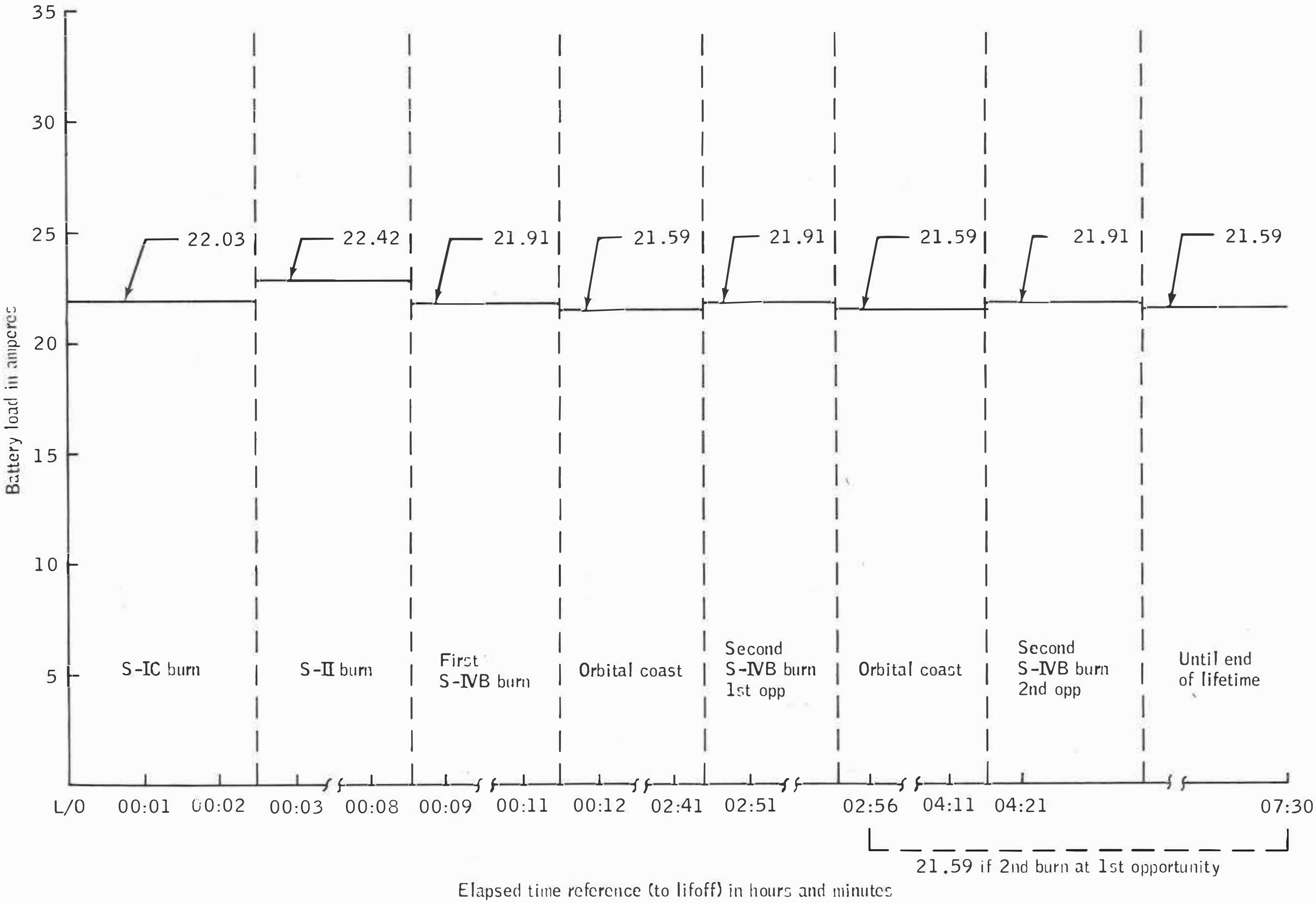


Figure 18-3. - IU battery no. 3 composite load profile.

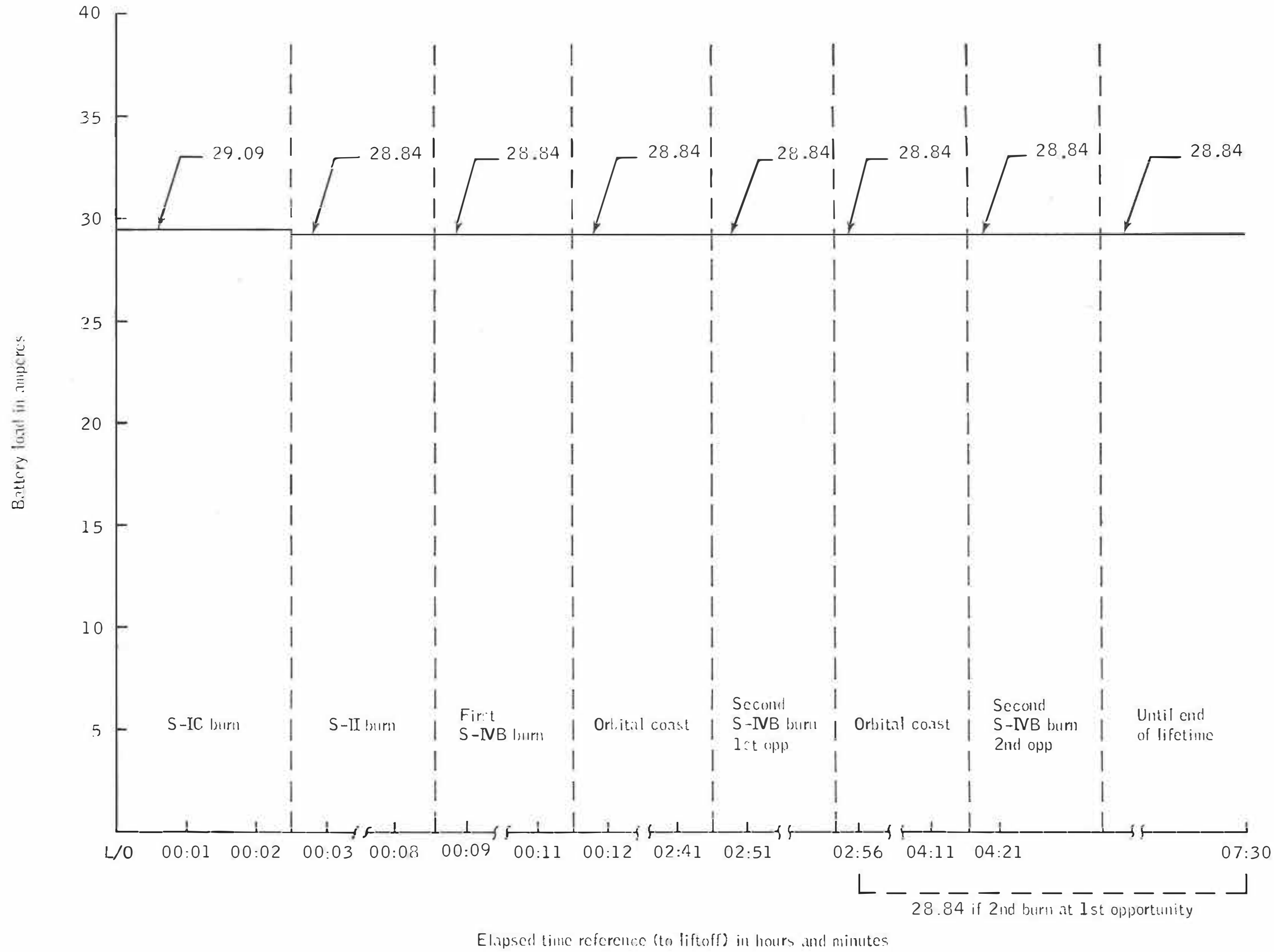


Figure 18-4. - IU battery no. 4 composite load profile.

19 DIGITAL COMMAND SYSTEMS

SECTION 19

DIGITAL COMMAND SYSTEMS

19.1 PURPOSE

The purpose of the Saturn Instrument Unit (IU) command system is to provide a radio frequency/digital transmission link from various Manned Space Flight Network (MSFN) stations to the onboard Launch Vehicle Digital Computer (LVDC). This input data will be used to update guidance information, to command certain vehicle functions such as stage switch selector operations, and to review data in certain locations of the LVDC memory.

The command is transmitted in the S-band using a carrier frequency of 2101.8 MHz. The command is FM modulated on a 70 kHz subcarrier, which in turn is PM modulated on the 2101.8 MHz carrier. The signal from the ground station is received through the S-band transponder of the Saturn Command and Communications System in the IU. The receiver portion of the transponder separates the transmitted message from the carrier and subcarrier and feeds the resulting baseband signal to the IU command decoder where decoding is accomplished. From the decoder, the data is sent through the Launch Vehicle Data Adapter (LVDA) to the Launch Vehicle Digital Computer (LVDC).

19.1.1 Modulation Techniques

The techniques employed by the ground stations for baseband modulation is phase-shift keyed (PSK). A stable 1 kHz tone is generated in the modulator and used as a phase synchronizing signal. A coherent 2 kHz tone is biphase modulated so that the binary digits are phase analogous. The 2 kHz tone is modulated at a 1 kHz rate. A binary one is being transmitted during the 1 millisecond period when the 2 kHz tone is in phase with the 1 kHz reference starting at the point where the 1 kHz waveform is crossing zero and has a positive slope. The 1 kHz tone and the phase modulated 2 kHz tone are algebraically summed to produce the composite waveform. This composite waveform is then FM modulated on a 70 kHz subcarrier which in turn is PM modulated on the 2101.8 MHz carrier for transmission to the vehicle. (See Figure 19-1.)

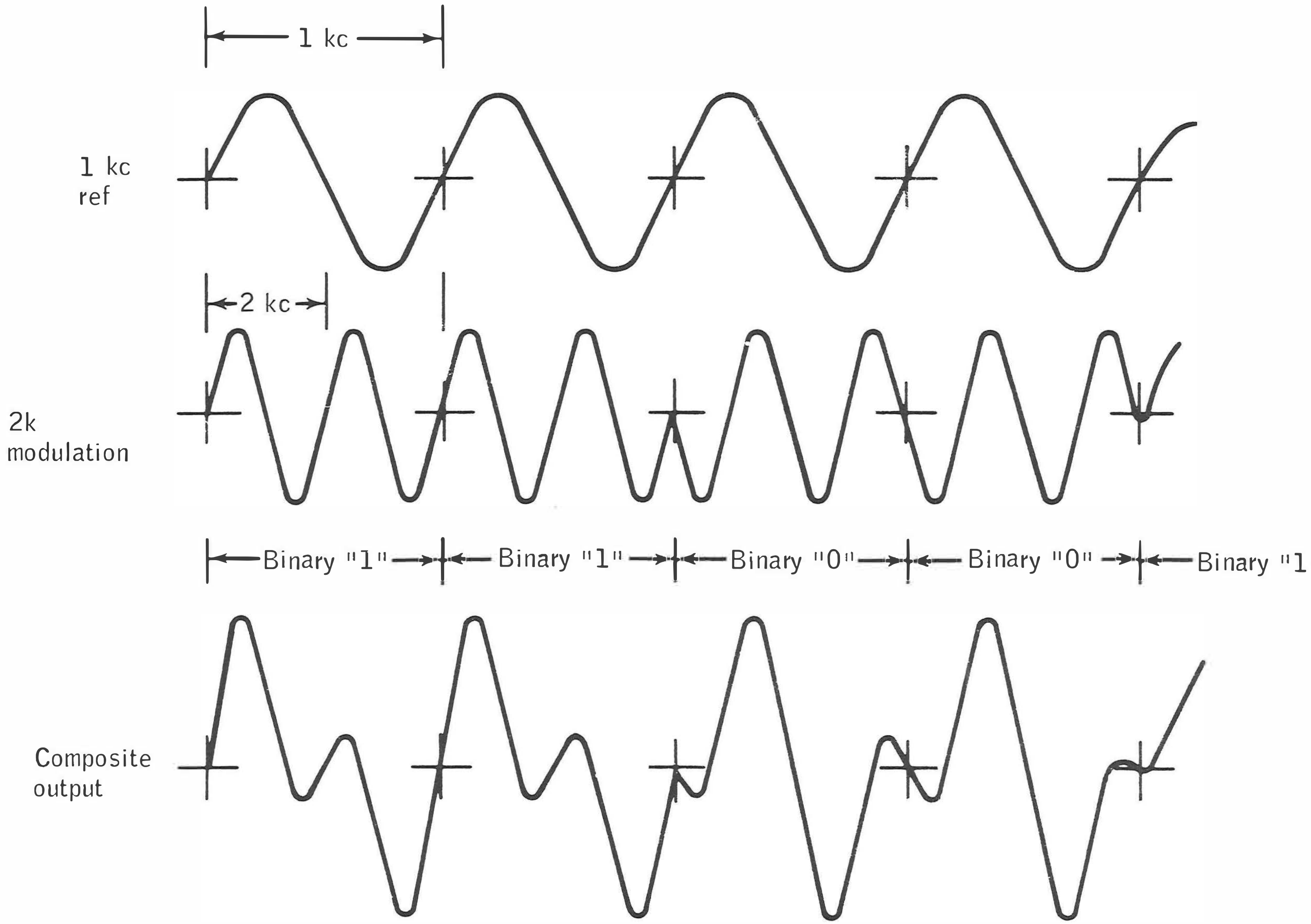


Figure 19-1.- PSK waveforms.

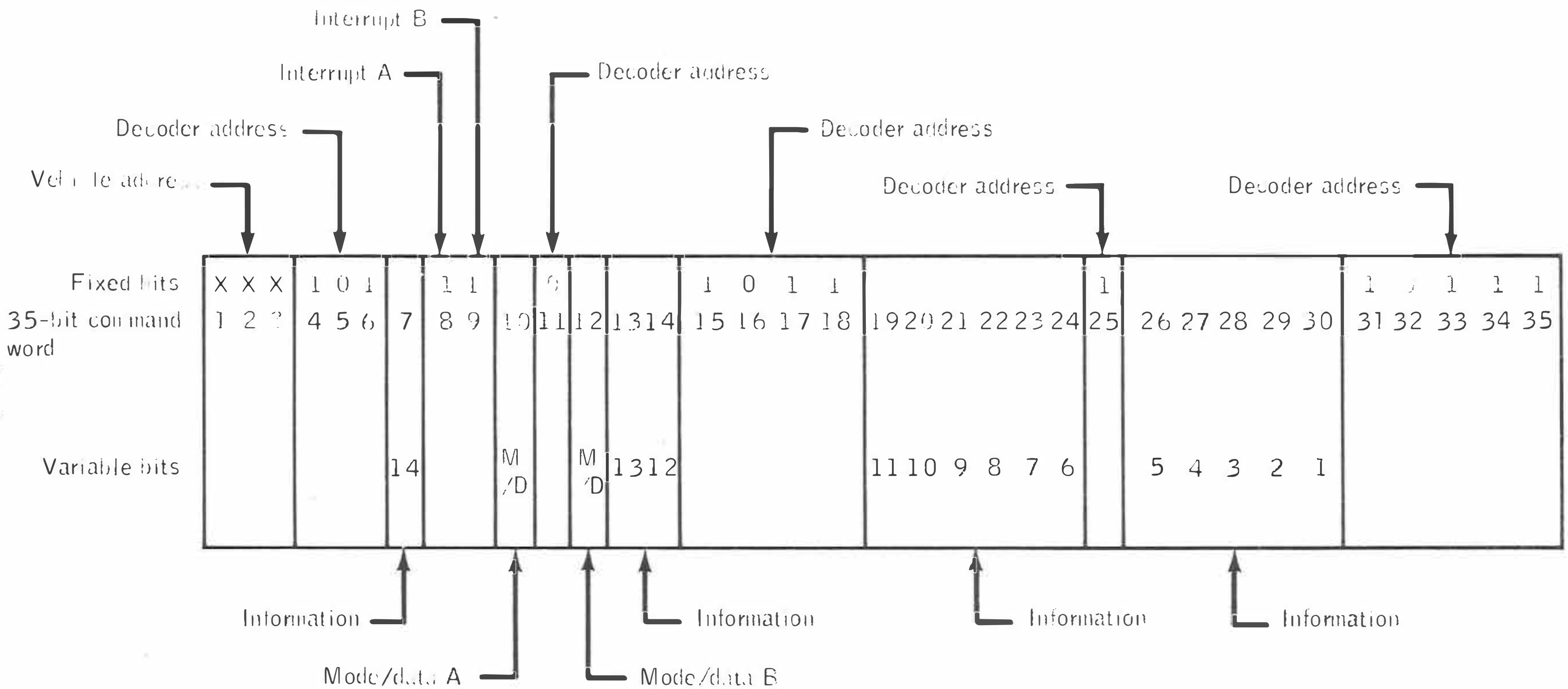
19.2 COMMAND WORD FORMAT

The first three bits of the word are called vehicle address bits and are 111 for the IU command system on all Saturn flights. The 14 decoder address bits are distributed throughout the command word. These bits are compared with a prewired address in the decoder and are used to perform error checking.

The 18 information bits are used to convey binary data to the LVDC. (All data for the LVDC are processed by the LVDA, which is the input-output device for the LVDC.)

The LVDC data bits are divided into functional groups. The first two bits are called "interrupt" bits and the next two are called "mode/data" bits. The remaining 14 bits are data to the LVDC. The interrupt bits are always binary "ones" and are combined in the LVDA to produce a single interrupt bit from the LVDA to the LVDC. The mode/data bits are binary "ones" or "zeros" depending on whether the particular command message is a mode command word or a data command word. The other 14 bits represent the binary coded data wherein the message will be presented in the "true" and "complement" form.

Each of the 35 updata bits of the command word is encoded into five sub-bits (total of 175 sub-bits per command word). Each sub-bit is 1 millisecond in duration, which is exactly the period of the 1 kHz waveform. Each updata bit, consequently, is 5 milliseconds in duration because the system operates NRZ with no dead time between sub-bits. (See Figure 19-2.)



Bit 1 transmitted first
Bit 35 transmitted last

Figure 19-2. - Command word format.

19.3 COMMAND DECODER OPERATION

The operation of the main decoder is best explained by the use of the block diagram in Drawing 19.3.1 and the flow diagram in Figure 19-3. During dead time between messages, a continuous stream of sub-bit "1's" is being transmitted. These sub-bits are fed to the sub-bit decoder where they are written into the five-bit shift register. Each sub-bit, as it leaves the sub-bit demodulator, is 200 microseconds in duration.

The leading edge of this 200-microsecond waveform is differentiated and used as the shift pulse for the five-bit shift register. The bits are written into the register by the differentiated trailing edge.

The shift register has 10 outputs (two for each position) resulting in 2^5 (32) possible sub-bit patterns. Each of three sub-bit comparators "X", "1", and "0" have five wires connected to the five-bit shift register, one wire to each position.

During intervals when no messages are being transmitted, all sub-bit "1's" are transmitted; however, the comparators have no output. The first three data bits of a transmitted message are designated as "vehicle address" and are sub-bit coded as "X's". Since the message sub-bits are bracketed by continuous sub-bit "1's", the "X" comparator is initially enabled by the output from OR 6 through OR 3 and the five-bit counter is inhibited by AND 1; permitting an "X" comparison at any time the five-bit shift register pattern is correct.

The first "X" bit comparison generates a 1 millisecond pulse which is differentiated; the leading edge passes through AND 2 and resets the five-bit counter and the three-bit counter. The trailing edge of the pulse advances the three-bit counter one count and starts the missing-bit clock.

The missing-bit clock is essentially two monostable multivibrators which, if a proper message is being received, will provide a continuous output from OR 6. This is accomplished by alternately triggering the multivibrators. The "on" cycle of the multivibrators (5.4 ms) is adjusted to be slightly greater than the duration of each data bit (5.0 ms). Thus the "off" multivibrator is triggered "on" 400 microseconds before the "on" multivibrator completes its cycle, and OR 6 will always have at least one input. When the missing-bit clock starts, the output of OR 6 will: (1) open AND 1 enabling the three-bit counter, (2) inhibit AND 2 preventing the next "X" comparison from generating a reset, and (3) inhibit through OR 3 the "X" comparator.

As the next five sub-bits are written into the five-bit shift register, they are counted by the five-bit counter. When the counter reaches a count of five, the output passes through OR 3, thus enabling an "X" comparison. A valid "X" comparison will generate a 200 microsecond pulse. The trailing edge of this pulse will advance the three-bit counter to the count-of-two state and will also keep the missing-bit clock running. The count-of-two output from the three-bit counter will (1) clear the 32-bit shift register (the cleared state of this register is whenthere is a "0" stored in the "0" side of all 32 stages), (2) send a reset pulse to the 32-bit counter, and (3) send a reset pulse to the output flip-flop. After the third "X" bit has been recognized, the count-of-three output from the three-bit counter will provide a direct-coupled signal to AND 3 and AND 4. As long as this signal is present, AND 3 and AND 4 are "open"; that is, they will allow valid "0" and "1" bits to pass through.

The next 32 bits will be coded with "0's" and "1's" as required. Each time a count of five state is reached by the 5-bit counter, a comparison is made to determine if the bit is a "0" or a "1". If it is a "0" or a "1", a pulse will be produced at the output of OR 5, thus keeping the missing-bit clock running. These 32 bits will also be shifted and written into the 32-bit shift register and counted by the 32-bit counter. Upon the count of 32, a 1-millisecond monostable multivibrator is triggered "on". This signal opens AND 5 and allows an address comparison to be made. If the address is correct, a signal will pass through AND 5 and trigger the output gate flip-flop (a bistable multivibrator) to its "set" state. In addition, the two 60-millisecond monostable multivibrator will be triggered "on", providing an indication to telemetry that the address was valid. Two multivibrators are used for reliability.

The "set" output of the flip-flop also resets the three-bit counter (through OR 4) and provides an enabling voltage to the 18 data output drivers. The binary information stored in the 18 data stages of the 32-bit shift register is thus transferred in parallel from the LVDA. When the LVDC accepts these data bits from the LVDA, a reset pulse acknowledging receipt is sent through the LVDA to the decoder. This pulse will pass through OR 8 and will clear the 32-bit shift register, reset the output flip-flop (thus disabling the 18 data output drivers), and trigger two 60-millisecond monostable multivibrators. The outputs of these two multivibrators are sent to telemetry to indicate receipt of the LVDC reset pulse. If, for some reason, the LVDC reset pulse does not arrive prior to the beginning of the next message, the second "X" bit of vehicle address will provide an output from the three-bit counter to reset the decoder circuits.

TABLE 19-I.- COMMAND TM DATA SUMMARY

Measurement	Function	Information Obtained
J69-603 J70-603	Address Verification Pulse Presence/Absence of Onboard Decoder Response to Uplink Command	The presence or absence of the AVP is required to determine if the command was accepted or rejected by the onboard decoder.
J71-603 J72-603	Computer Reset Pulse Presence/Absence of LVDC Response to Uplink Command	The presence or absence of the CRP is required by the ground computer to determine validity of command words. If the CRP is absent the uplink will be repeated.
J76-603	CCS AGC	The presence of this voltage give an accurate measurement of the received signal strength, and provides a indication that phase lock has occurred.
J77-603	On/Off Status of Prime Updata Carrier (2101.8 MHz)	The lock/no lock status of the prime carrier is used to determine that the updata link is valid (vehicle in range and capable of receiving commands).
J78-603	On/Off Status of Uplink Command Subcarrier (70 kHz)	Lock/no lock status of 70 kHz subcarrier. The 70 kHz subcarrier must be in lock prior to initiating a command. NOTE: If the prime carrier or the subcarrier is not in lock S/C reject will result from an attempted uplink.

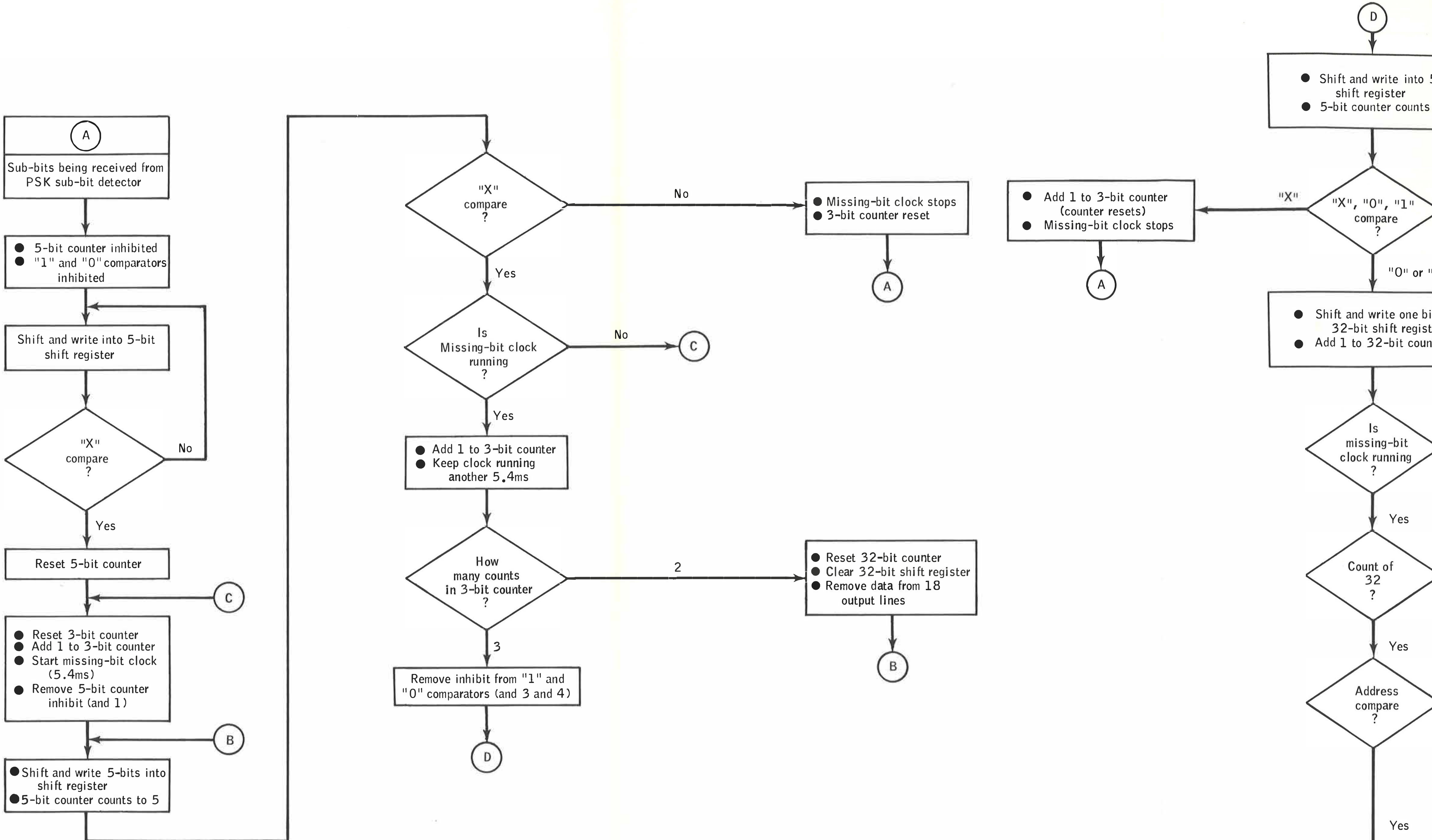


Figure 19-3.- Command decoder logic flow.

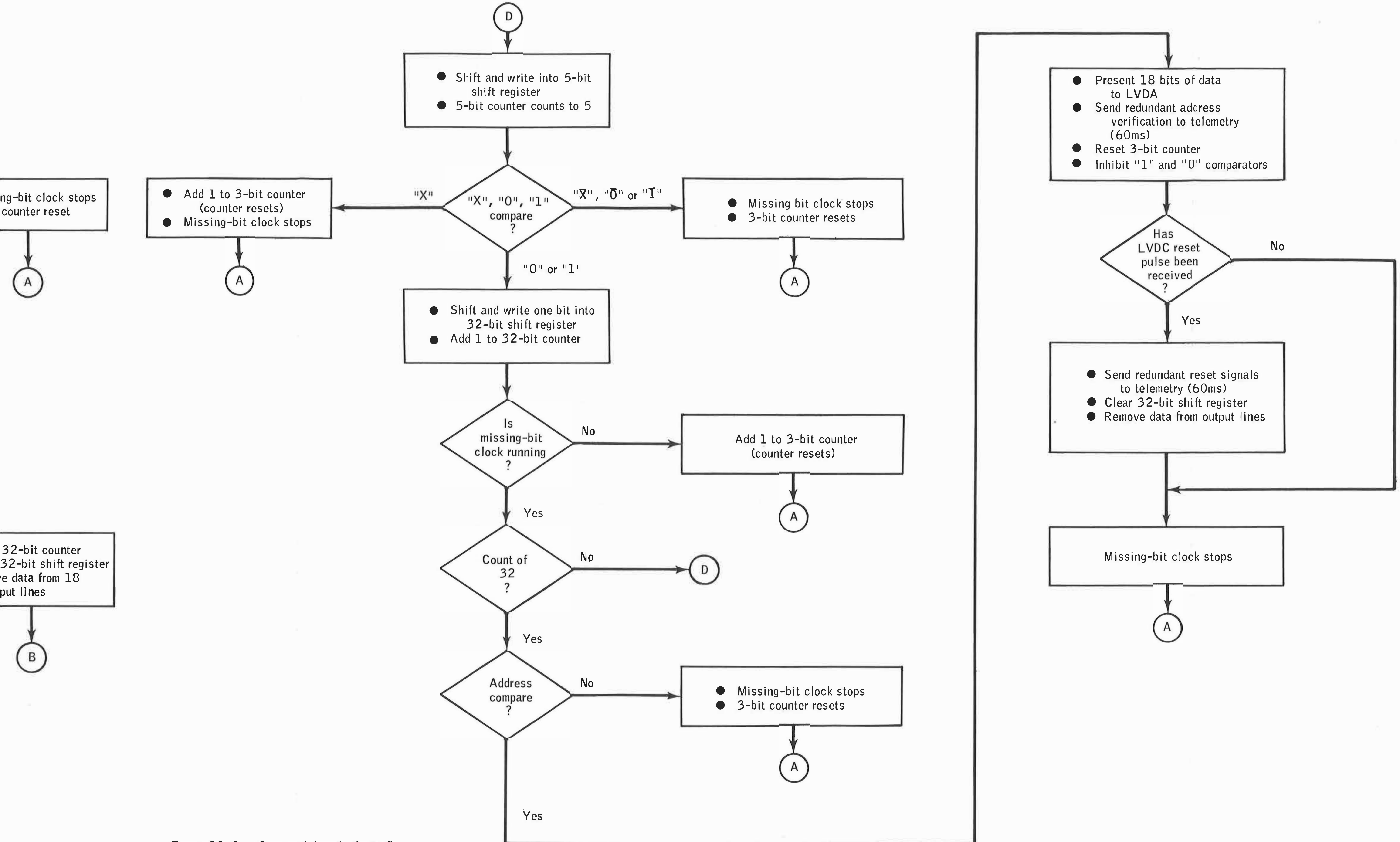


Figure 19-3.- Command decoder logic flow.

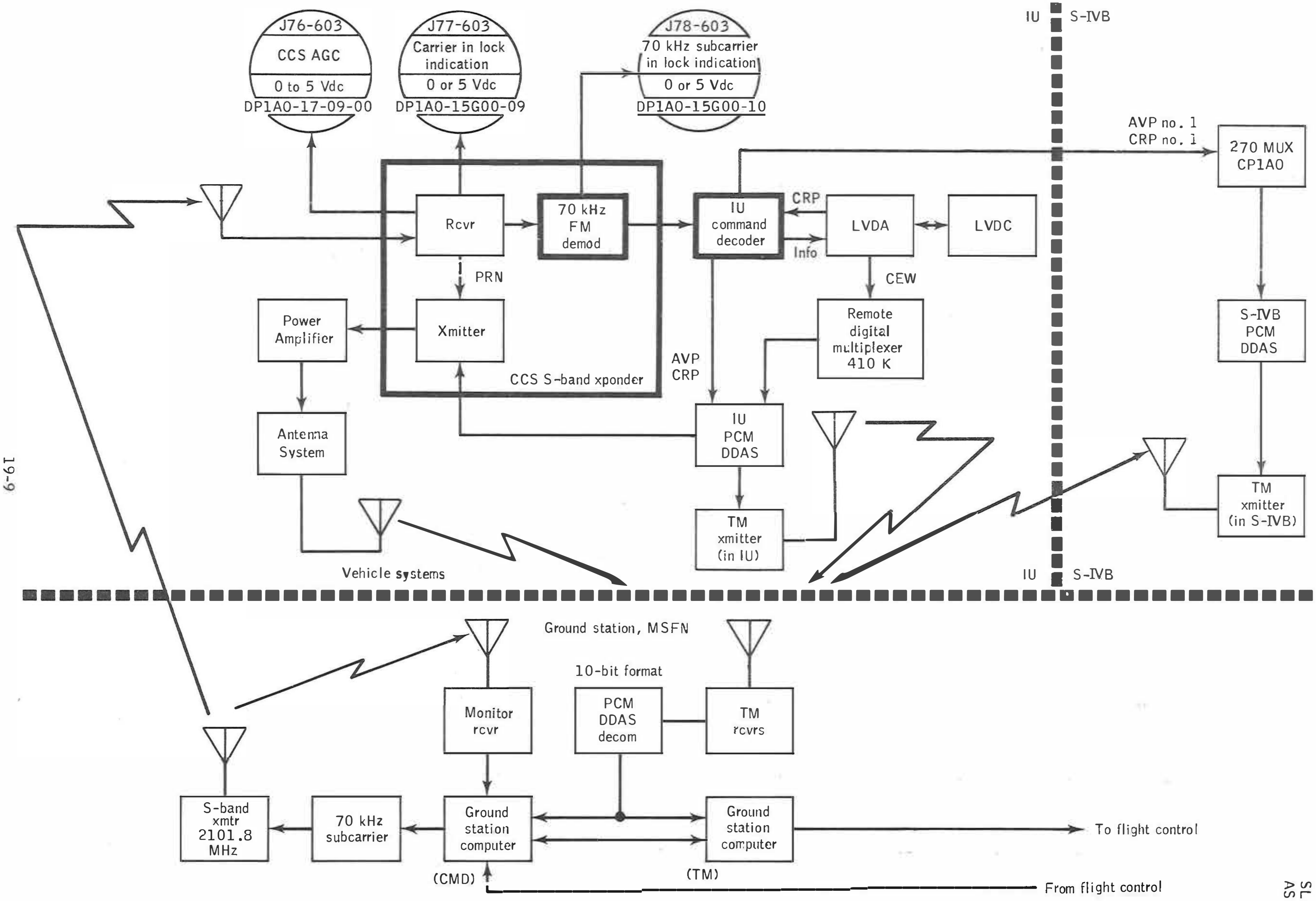


Figure 19-4.- S-V IU command system.

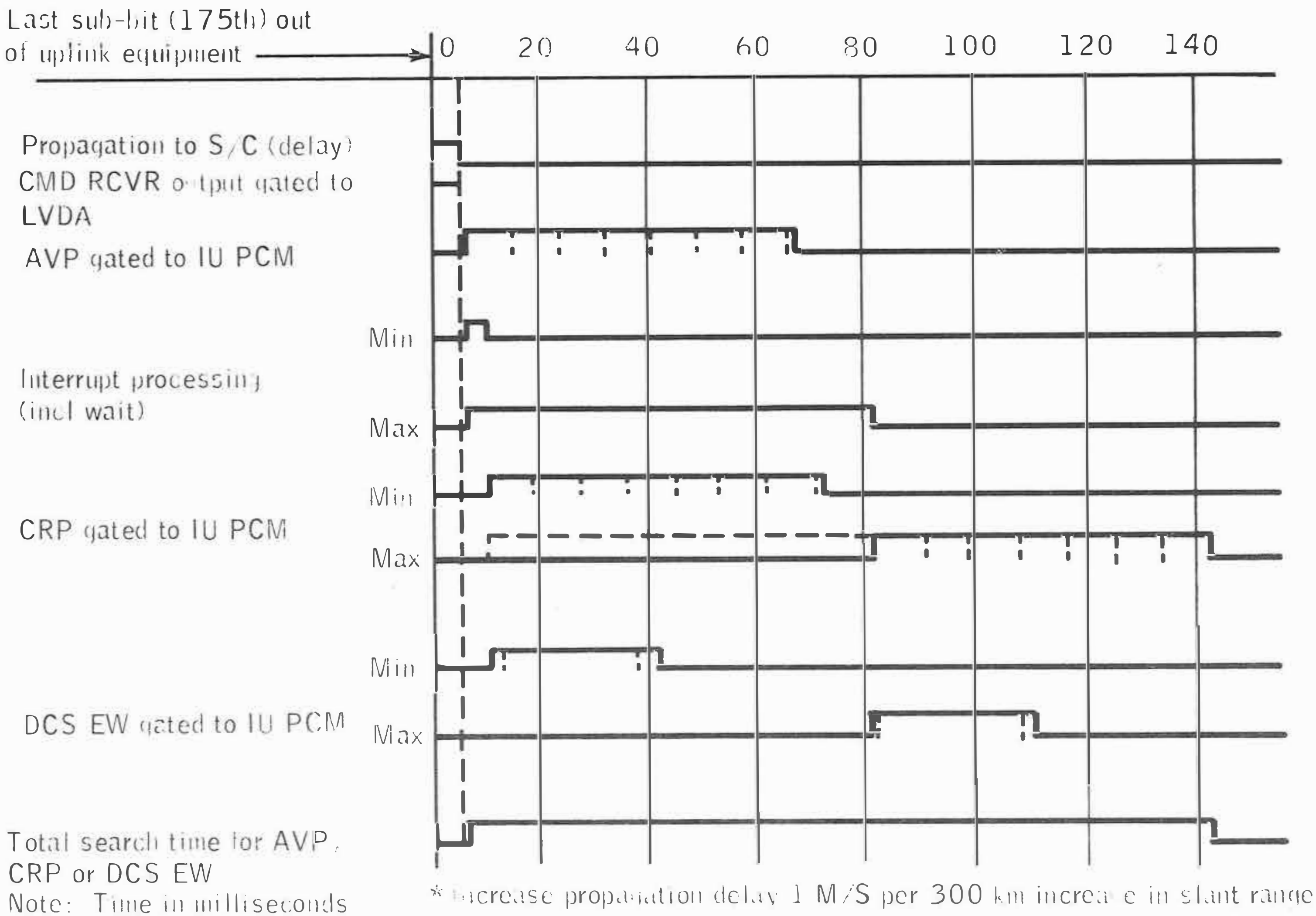
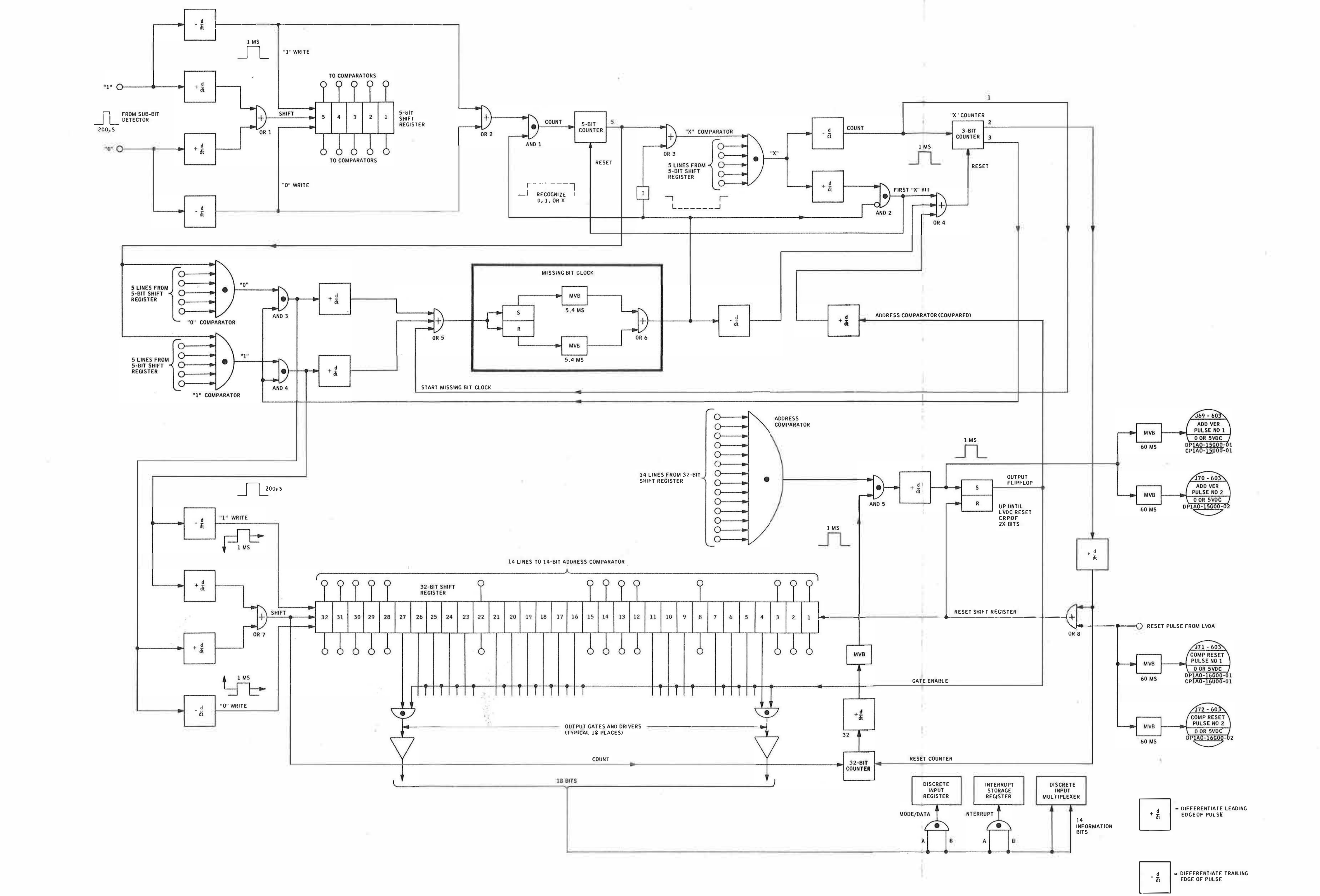


Figure 19-5.- Onboard processing timeline.



SIGNATURES	DATE	NATIONAL AERONAUTICS & SPACE ADMINISTRATION MANNED SPACECRAFT CENTER · HOUSTON, TEXAS
DR		COMMAND DECODER
DSGN		
QC		
ENGR		
APP		SLV — AS-508
FEC		SIZE E — DWG NO 19.3.1
AUTH		44 X 34 — PAGE 19-11 — SHEET 1 OF 1

20 GUIDANCE AND NAVIGATION

SECTION 20

GUIDANCE AND NAVIGATION

20.1 BOOST PHASE GUIDANCE

A. During boost, the S-IC will be programed to initiate a roll maneuver to properly align the vehicle with the flight azimuth. This maneuver is controlled by the LVDC and begins at lift-off + 10.7 seconds.

The roll maneuver is required to align S-IC location 1 (at LC39A, location 1 is aligned to 90°) to the flight azimuth.

B. A pitch maneuver is also programed during S-IC boost beginning at liftoff + 10.7 seconds. The pitch maneuver is preprogramed in the LVDC and pitch angle is determined as a function of time. When pitch attitude reaches the required value, that attitude is held until approximately 40 seconds after S-II ignition.

C. Active guidance (IGM) of the vehicle begins at about S-II ignition + 40 seconds. The guidance system during S-II powered flight will position the vehicle to a specified velocity, flightpath angle and altitude. When these conditions are satisfied, the guidance program will freeze when the S-II is cut off and will continue for 6.5 seconds.

D. The attitude hold continues until after J-2 ignition. The second active guidance period directs the S-IVB/IU to the proper altitude, velocity, and attitude for orbit insertion conditions.

E. LVDC/LVDA Operational Parameters
Meas No. H60-603, Channel No. DP1A0 - 8K00, 9K00, 10K00, 11K00, and DP1A0 - 23K00, 24K00, 25K00, 26K00.

TABLE 20-I.- LVDC TELEMETRY NOMENCLATURE, TAGS AND SCALING

NAME	MCC ABBR	HOSC ABBR	RTCC WORD NO.	MCC PCM	HOSC PCM	MCC SCALING	HOSC SCALING
TIME SINCE GRR	TAS	TASEC	01-3	2000	0400	DATA BIT 11 = 1 SEC	SIGN +15
X-COMPONENT OF SPACE-FIXED POSITION	XS	XS	02-4	2110	0422	DATA BIT 3 = 1 M DATA BIT 3 = 16 M*	SIGN +23 SIGN +27
Y-COMPONENT OF SPACE-FIXED POSITION	YS	YS	03-4	2120	0424	DATA BIT 3 = 1 M DATA BIT 3 = 16 M*	SIGN +23 SIGN +27
Z-COMPONENT OF SPACE-FIXED POSITION	ZS	ZS	04-4	2070	0416	DATA BIT 3 = 1 M DATA BIT 3 = 16 M*	SIGN +23 SIGN +27
X-COMPONENT OF SPACE-FIXED VELOCITY	XDS	XDS	05-3	2230	0446	DATA BIT 12 = 1 M/S	SIGN +14
Y-COMPONENT OF SPACE-FIXED VELOCITY	YDS	YDS	06-3	2240	0450	DATA BIT 12 = 1 M/S	SIGN +14
Z-COMPONENT OF SPACE-FIXED VELOCITY	ZDS	ZDS	07-3	2220	0444	DATA BIT 12 = 1 M/S	SIGN +14
TOTAL SPACE-FIXED VELOCITY	VS	V	08-2	2250	0452	DATA BIT 12 = 1 M/S	SIGN +14
TIME IN TIME BASE	TBX	TB	09-2	6060	1414	DATA BIT 11 = 1 SEC	SIGN +15
TIME IN TIME BASE UPDATED	TBXU	TBB	18-2	2060	0414	DATA BIT 11 = 1 SEC	SIGN +15
TIME-TO-GO S-IVB CUTOFF	TTG	IGTSTR	10-2	2540	0530	DATA BIT 16 = 1 SEC	SIGN +10
YAW GUIDANCE ANGLE	XZ	CHIZ	13-2	6000	1400	DATA BIT 26 = 180 DEG	SIGN +0
ROLL GUIDANCE ANGLE	XX	CHIX	11-2	6010	1402	DATA BIT 26 = 180 DEG	SIGN +0
PITCH GUIDANCE ANGLE	XY	CHIY	12-2	6020	1404	DATA BIT 26 = 180 DEG	SIGN +0
X-TOTAL ACTUAL GIMBAL ANGLE (ROLL)	θX	TLTHTX	14-2	6040	1410	DATA BIT 26 = 180 DEG	SIGN +0
Y-TOTAL ACTUAL GIMBAL ANGLE (PITCH)	θY	TLTHTY	15-2	6050	1412	DATA BIT 26 = 180 DEG	SIGN +0
Z-TOTAL ACTUAL GIMBAL ANGLE (YAW)	θZ	TLTHTZ	16-2	6030	1406	DATA BIT 26 = 180 DEG	SIGN +0
TIME OF TIME BASE INITIATE	TBXI	TI	17-2	6740	1570	DATA BIT 11 = 1 SEC	SIGN +15
TIME TO GO TO RESTART PREP	TTGO	TTGO	10-2	6120	1424	DATA BIT 11 = 1.000 SEC	SIGN +0
SECOND AND FOURTH TTG	T2I	IGT2I	40-2	6360	1474	DATA BIT 16 = 1 SEC	SIGN +10
DEVIATION IN S-IVB CUTOFF TIME	ΔT4	DT4	19-2	2210	0442	DATA BIT 18 = 1 SEC	SIGN +8
GUIDANCE MODE WORD 1	GMW1	MC25	34-4	6440	1510	DATA BITS 1→26	
GUIDANCE MODE WORD 2	GMW2	MC26	35-4	6400	1500	DATA BITS 1→26	
GUIDANCE STATUS WORD	GSW	MC24	36-3	6430	1506	DATA BITS 3→26	
ORBITAL STATUS WORD	OSW	MC28	37-3	2430	0506	DATA BITS 3→26	
ORBITAL MODE WORD	OMW	MC27	38-4	2440	0510	DATA BITS 1→26	
ERROR MONITOR REGISTER	EMR	EMRR	39-4	6470	1516	DATA BITS 1→26	
RADIUS VECTOR	1/R		48-3	2130	0426	DATA BIT 48 = 1 METER^{-1}	
SINGLE WORD DUMP HEADER WORD (SFS #2)	SWD HW	N/A	WD99A	6221	1445		
SINGLE WORD DUMP DATA WORD (SFS #2)	SWD DW	N/A	WD99A	6231	1447	WORDS 1 THRU 7	
VEHICLE ALTITUDE	ALT	ONALT	31-3	2670	0556	DATA BIT 7 = 1 M	SIGN +19
TIME TO GO IN FIRST IGM	T1I	IGT1I	41-2	2400	0500	DATA BIT 16 = 1 SEC	SIGN +10
DISCRETE INPUT REGISTER	DIN	DI	30-3	6550	1532	BITS D3→D26	
DISCRETE OUTPUT REGISTER	DOR	DORSW	28-2	6450	1512	BITS D11→D26	
THIRD AND FIFTH IGM TIME TO GO	T3I	IGT3I	42-2	2550	0532	DATA BIT 16 = 1 SEC	SIGN +10
ACCELERATION	F/M	FOVM	33-2	2314	2452	DATA BIT 26 = 1 M/S^2	SIGN +6
STEERING PITCH	SMCP	SMCY	44-2	2752	4572	DATA BIT 25 = 90 DEG	SIGN +0
STEERING YAW	SMCY	SMCZ	43-2	2742	4570	DATA BIT 25 = 90 DEG	SIGN +0
FLIGHT PATH ANGLE	θT	IGTHAT	32-2	2720	0564	DATA BIT 25 = 90 DEG	SIGN +0
MINOR LOOP CHI Z	MLXZ	MLCHIZ	46-2	6600	1540	DATA BIT 25 = 90 DEG	SIGN +0
MINOR LOOP CHI X	MLXX	MLCHIX	47-2	6610	1542	DATA BIT 25 = 90 DEG	SIGN +0
MINOR LOOP CHI Y	MLXY	MLCHIY	45-2	6620	1544	DATA BIT 25 = 90 DEG	SIGN +0
BEGIN TELEMETRY CYCLE**	BTC	CCCNT		6770	1576	BTC/COUNTER T1 = 1	
COMMAND ERROR WORD**	CEW	CEW		6131	1427	N/A	
COMMAND STATUS WORD MODE**	CSWM			2061	1415	N/A	
COMMAND STATUS WORD DATA**	CSWD			2771	0577	N/A	
SECTOR DUMP HEADER WORD (SFS #1)	SDHW	N/A	WD99B	2561	0535	N/A	
SECTOR DUMP DATA WORD (SFS #1)	SDDW	N/A	WD99B				
INTERNAL CONTROL REGISTER	ICR	ICR	29-4	6460	1514	DATA BITS 1→26	

*The scaling on these items will be changed as indicated at second S-IVB cutoff. Uplink and downlink scaling in the ground system must be changed at this time.

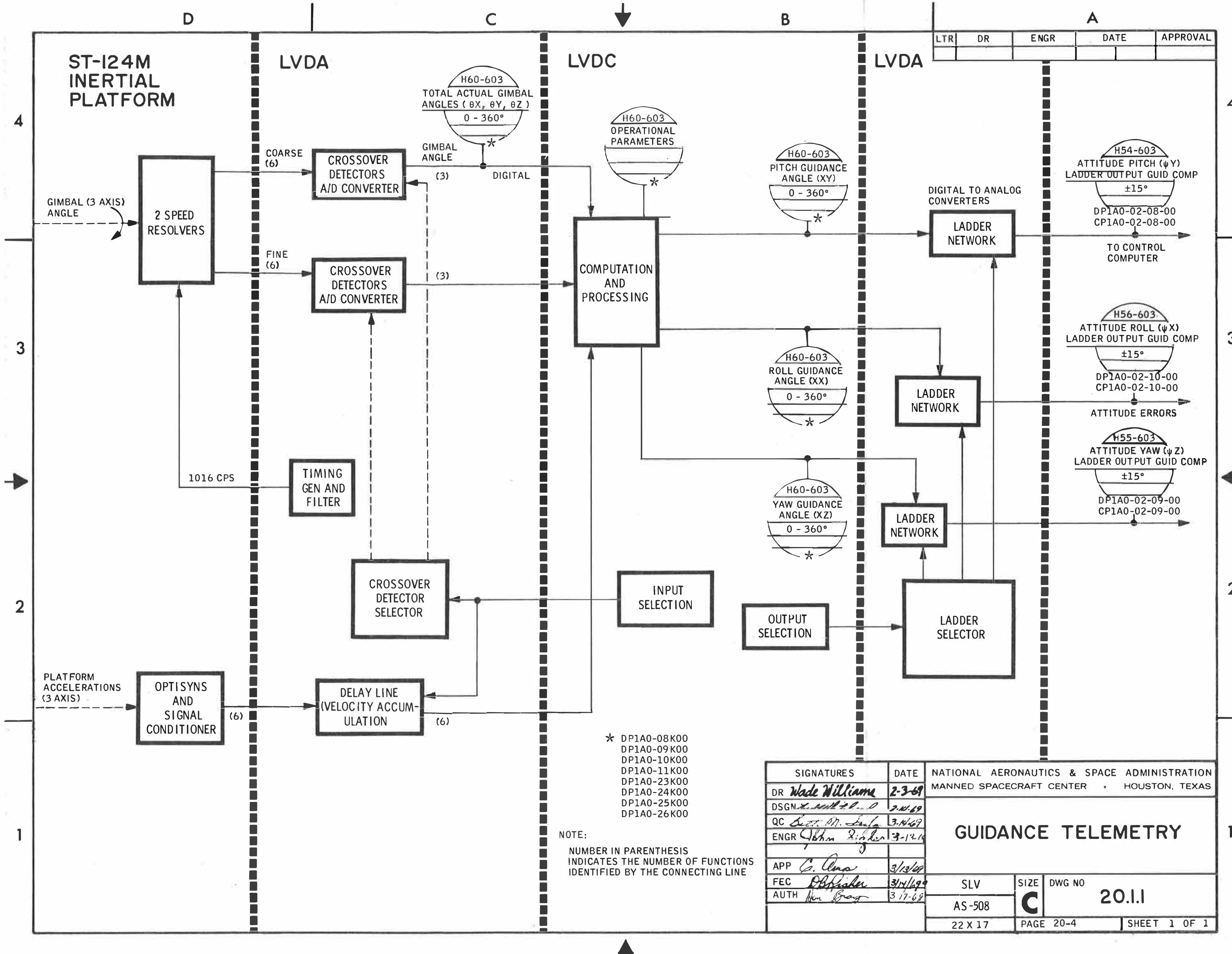
**Special processing - RSDP only.

TABLE 20-1.- LVDC TELEMETRY NOMENCLATURE, TAGS, AND SCALING - Concluded

NAME	MCC ABBR	HOSC ABBR	RTCC WORD NO.	MCC PCM	HOSC PCM	MCC SCALING	HOSC SCALING
Z_S COMPONENT OF MEASURED VELOCITY	$\dot{Z}_M$	$\dot{Z}_M$	54-3	2044	2410	DATA BIT 12 = 1 M/S	SIGN +14
X_S COMPONENT OF MEASURED VELOCITY	$\dot{X}_M$	$\dot{X}_M$	55-3	2054	2412	DATA BIT 12 = 1 M/S	SIGN +14
Y_S COMPONENT OF MEASURED VELOCITY	$\dot{Y}_M$	$\dot{Y}_M$	56-3	2064	2414	DATA BIT 12 = 2 M/S	SIGN +14
SECTOR DUMP DATA WORD							
WORD 10				2701	0561		
WORD 11				2711	0563		
WORD 12				2721	0565		
WORD 13				2731	0567		
WORD 14				2741	0571		
WORD 15				2751	0573		
WORD 16				2761	0575		

ORBIT TARGET UPDATE QUANTITY	MCC ABBR	HOSC ABBR	MEMORY LOCATION MODULE	SECTOR	ADDRESS	MCC SCALING	HOSC SCALING
INCLINATION OF TARGET PLANE (SFS #1 WD17)	i	INC	4	14	371	DATA BIT 25 = 90° = .5 PIRAD	SIGN +0, DEG
DESCENDING NODE OF TARGET PLANE (SFS #1 WD18)	θN	THN	4	14	372	DATA BIT 25 = 90° = .5 PIRAD	SIGN +0, DEG
ECCENTRICITY OF TRANSFER ELLIPSE (SFS #1 WD19)	eN	ECC	4	14	373	DATA BIT 26 = 1 (NO UNITS)	SIGN +0, DEG
ENERGY OF TRANSFER ELLIPSE (SFS #1 WD20)	C3	C3	4	14	374	DATA BIT 1 = 2 M^2/S^2	SIGN +21, M^2S^2
TRUE ANOMALY OF DESCENDING NODE (SFS #1 WD21)	αD	ALPHAD	4	14	375	DATA BIT 25 = 90° = .5 PIRAD	SIGN +0, DEG
TRUE ANOMALY OF INJECTION RADIUS VECTOR (SFS #1 WD22)	φ'	F	4	14	376	DATA BIT 25 = 90° = .5 PIRAD	SIGN +0, DEG
TIME TO INITIATE TB6 (SFS #1 WD23)	TRP	TRP	4	14	377	DATA BIT 11 = 1 SEC	SIGN +15, SEC
NAV UPDATE QUANTITY							
Z-COMPONENT OF SPACE-FIXED VELOCITY (SFS #1 WD26)	ZDNU	ZDS	4	15	371	DATA BIT 12 = 1 M/S	SIGN +14, M/S
X-COMPONENT OF SPACE-FIXED VELOCITY (SFS #1 WD27)	XDNU	XDS	4	15	372	DATA BIT 12 = 1 M/S	SIGN +14, M/S
Y-COMPONENT OF SPACE-FIXED VELOCITY (SFS #1 WD28)	YDNU	YDS	4	15	373	DATA BIT 12 = 1 M/S	SIGN +14, M/S
Z-COMPONENT OF SPACE-FIXED POSITION (SFS #1 WD29)	ZNU	ZS	4	15	374	DATA BIT 3 = 1 M DATA BIT 3 = 16 M*	SIGN +23, M SIGN +27, M
X-COMPONENT OF SPACE-FIXED POSITION (SFS #1 (WD30)	XNU	XS	4	15	375	DATA BIT 3 = 1 M DATA BIT 3 = 16 M*	SIGN +23, M SIGN +27, M
Y-COMPONENT OF SPACE-FIXED POSITION (SFS #1 WD31)	YNU	YS	4	15	376	DATA BIT 3 = 1 M DATA BIT 3 = 16 M*	SIGN +23, M SIGN +27, M
TIME OF NAV UPDATE	TNU	NUPTIM	4	15	377	DATA BIT 11 = 1 SEC	SIGN +15, SEC
NAME							
MANEUVER NO. 1			2	6	200	DATA BIT 11 = 1 SEC	SIGN +15, SEC
MANEUVER NO. 2			2	6	201	DATA BIT 11 = 1 SEC	SIGN +15, SEC
MANEUVER NO. 3			2	6	202	DATA BIT 11 = 1 SEC	SIGN +15, SEC
MANEUVER NO. 4			2	6	203	DATA BIT 11 = 1 SEC	SIGN +15, SEC
MANEUVER NO. 5			2	6	204	DATA BIT 11 = 1 SEC	SIGN +15, SEC
MANEUVER NO. 6			2	6	205	DATA BIT 11 = 1 SEC	SIGN +15, SEC
MANEUVER NO. 7			2	6	206	DATA BIT 11 = 1 SEC	SIGN +15, SEC

*The scaling on these items will be changed as indicated at second S-IVB cutoff. Uplink and downlink scaling in the ground system must be changed at this time.



SIGNATURES	DATE
DR Wade Williams	2-3-69
DSGN	3-14-69
QC	3-14-69
ENGR John	3-12-69
APP	3/13/69
FEC	3/14/69
AUTH	3-17-69

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GUIDANCE TELEMETRY

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20.2 ORBITAL PHASE GUIDANCE

A. The guidance system during parking orbit will provide capability for various attitude maneuvers. The normal configuration will point vehicle position 1 down and the longitudinal axis perpendicular to the radius vector.

B. Orbit navigation will be accomplished by integrating the equations of motions. The drag gravitation and venting assumed characteristics are programed as a function of attitude and position of the vehicle. For example, the platform gimbal angles are sampled every 8 seconds to resolve the vent acceleration from the body-fixed system into the space-fixed system.

C. During times between the programed ground sites the onboard system will perform the normal navigation functions and will telemeter real-time data. During the dark periods the LVDC will perform checks in a self-test routine and store the data for transmittal when over the ground stations. The data that may be accumulated (in addition to CIU data) during the self-test is radiated in a manner to impose no restrictions on the real-time data. There will be no loss of mission control data as a result of compressed data operations.

20.3 GUIDANCE AND NAVIGATION ALIGNMENT

A. During prelaunch, the ST-124M platform is held aligned to the local geodetic vertical by a set of gas bearing leveling pendulums. The pendulum output is amplified in the platform, and then transmitted to the ground equipment alignment amplifier. The alignment amplifier provides a signal to the torque drive amplifier and then to the platform gyro torque generator. The vertical alignment system will level the platform to an accuracy of ±3 arc seconds.

B. The azimuth alignment is accomplished by means of a theodolite on the ground and two prisms (one fixed and one servo-driven) on the platform. The theodolite maintains the azimuth orientation of the movable prism and the ground-based digital computer computes a mission azimuth and programs the inner gimbal to its mission azimuth. The laying system has an accuracy of ±20 arc seconds.

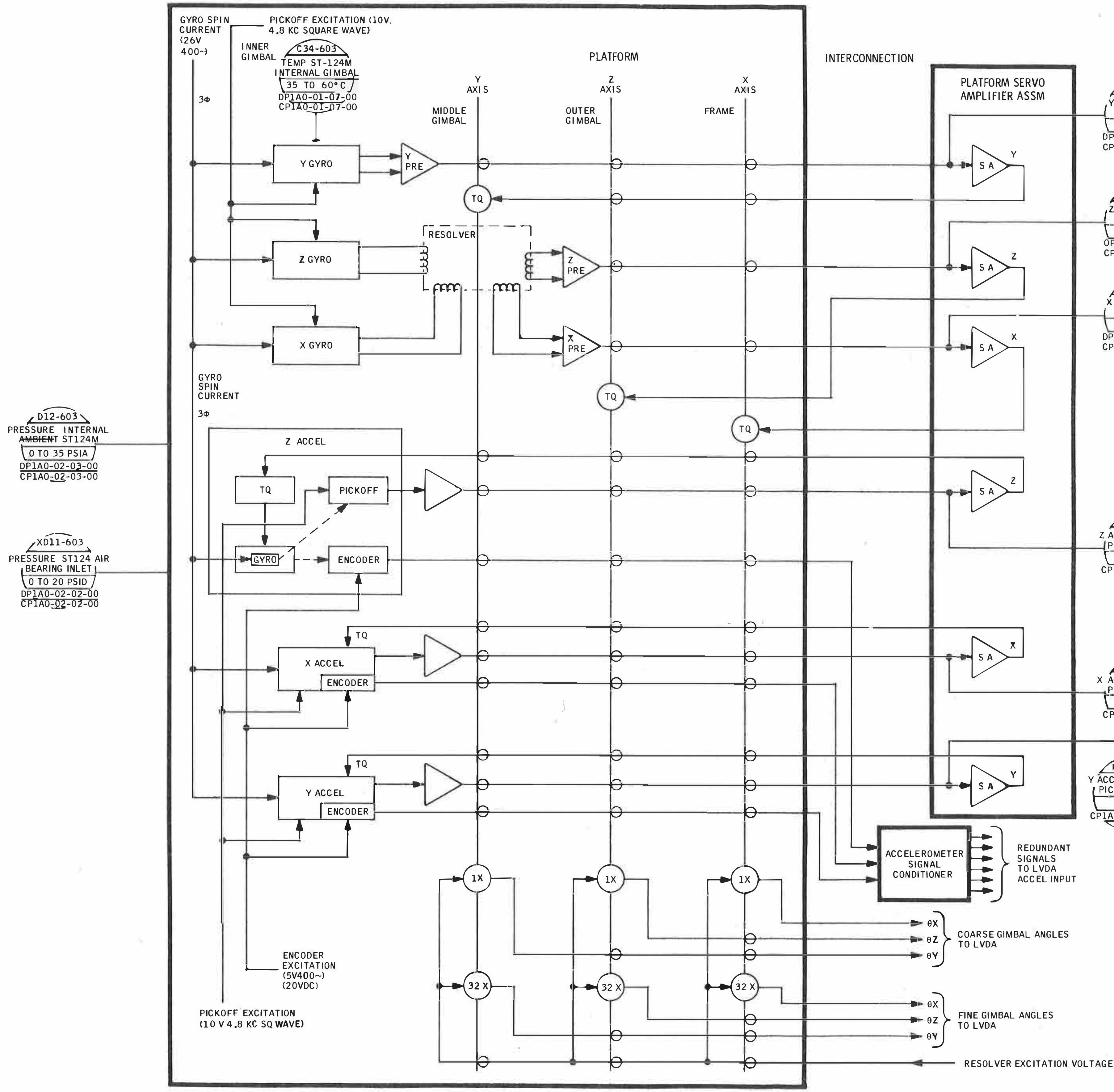
C. At approximately liftoff minus 17 seconds, the platform is released to maintain an inertial reference initiated at the launch point. At this point, the LVDC begins navigation using velocity accumulations derived from the ST-124M inertial platform.

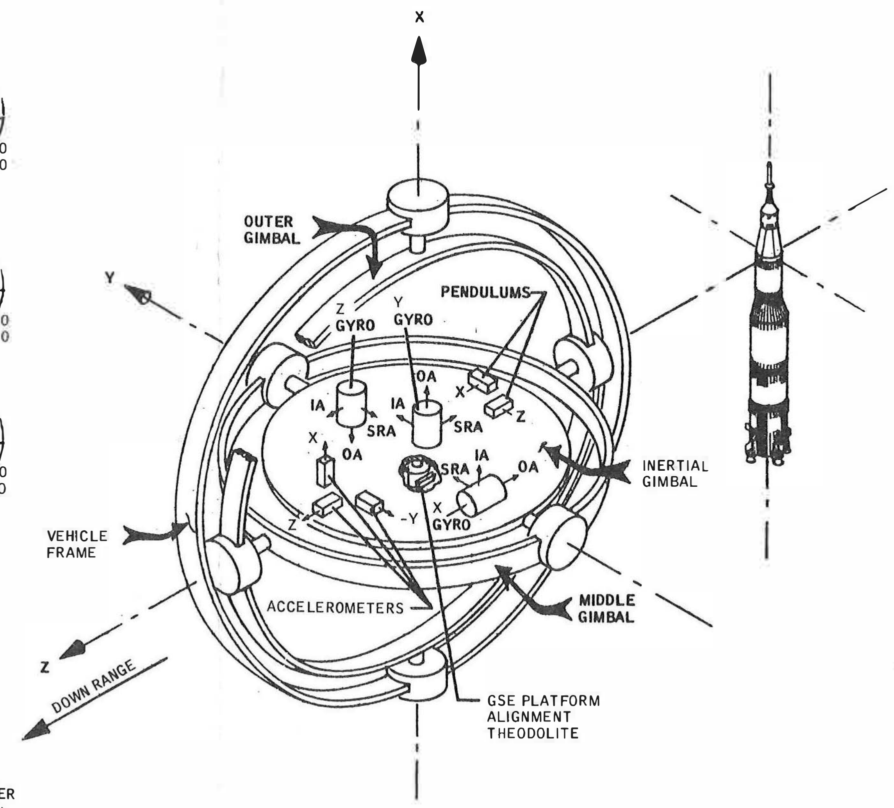
20.4 GYRO AND ACCELEROMETER SERVOSYSTEM

The gyro and accelerometer servoloops use a 4.8 kHz suppressed carrier modulation system with the signal generator outputs being amplified and demodulated on the gimbals of the inertial platform. The dc signal from the detector output is transferred from the platform to the platform electronic assembly. The dc signal is shaped, remodulated at 4.8 kHz amplified, and then demodulated prior to entering the dc power bridge. This power bridge provides a current source drive for the direct axis dc gimbal torquer.

20.5 ACCELEROMETER SIGNAL CONDITIONER

The accelerometer signal conditioner accepts the velocity signal from the accelerometer optical encoders and shapes them before they are passed on to the LVDA/LVDC. Each accelerometer requires four shapers; a sine shaper and cosine shaper for the active channel and a sine shaper and cosine shaper for the redundant channel. Also included are four buffer amplifiers for each accelerometer; one for each sine and cosine output.





ST-124-M3-GIMBAL CONFIGURATION

GIMBAL	INNER	MIDDLE	OUTER
AXIS	Y	Z	X
GIMBAL LIMITS	NOT LIMITED	±45°	NOT LIMITED
VEHICLE AXIS	PITCH	YAW	ROLL

LTR	DR	ENGR	DATE	APPROVAL

SIGNATURES	DATE
DR Wade Williams	2-7-68
DSGN [signature]	3-14-69
QC [signature]	3-4-69
ENGR [signature]	3-12-69
APP [signature]	3/13/69
FEC [signature]	3/13/69
AUTH [signature]	[illegible]

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GUIDANCE-INERTIAL PLATFORM

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20.6 LAUNCH VEHICLE DATA ADAPTER

A. The Launch Vehicle Data Adapter (LVDA) is the input-output unit that accompanies the Launch Vehicle Digital Computer (LVDC). The data adapter can perform a variety of input-output functions and is compatible with the information rate and interface requirements of IU equipment with which it must interconnect. The data adapter is divided into the following distinct parts:

1. A digital section which buffers and manipulates digital quantities.
2. An analog section which converts analog-to-digital and digital-to-analog.
3. The power supplies which serve the data adapter, computer, and memory are contained in the data adapter. These power supplies are duplexed for reliability; thus, each supply must be capable of supplying the full current load for that voltage. Voltage sequencing is provided where required, and power supply lines can be switched to permit single channel computer operation.
4. Communication with the Launch Vehicle Digital Computer is carried out through 512 kbps serial transmission. The process input-output instruction permits the specification of either input or output operations, and addresses the device to be affected. A single 26-bit word is transferred to the computer accumulator or from the accumulator to memory.

B. Data Adapter Internal Functions

Although the routing of data is an important data adapter function, the data adapter must also process much of the data it transmits. The internal operation of the data adapter is broken down into three main categories:

1. The control of data flow, including temporary storage;
2. The transformation of data into a form which is compatible with the characteristics of the receiving equipment.
3. The performance of certain simple computational and logical operations on the data.

The following functions are typical of those included in the first category:

- The storage of telemetry data from the computer and data adapter in the buffer registers.
- The temporary storage of telemetry scanner addresses during orbital checkout.
- The transmission of guidance data from the computer to the analog control computer.

Operations which required a change in the form of the data include (typical of those in the second category):

- Digital-to-analog, analog-to-digital, and signal level conversions.
- The formation of 40-bit launch computer and telemetry words from 26-bit computer words.
- Buffering of communications between the computer and the ground-based launch computer to reconcile the difference in clock rates.

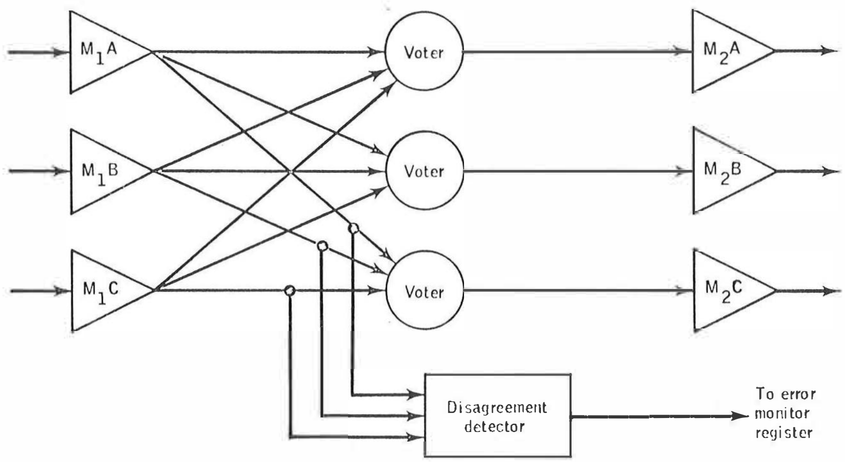
The data adapter contributes to the efficient operation of the computer by performing many simple, though time consuming, logical and computational tasks, such as (typical of those functions performed in the third category):

- Keeping track of real time.
- Decoding of operand addresses in process input-output operations.

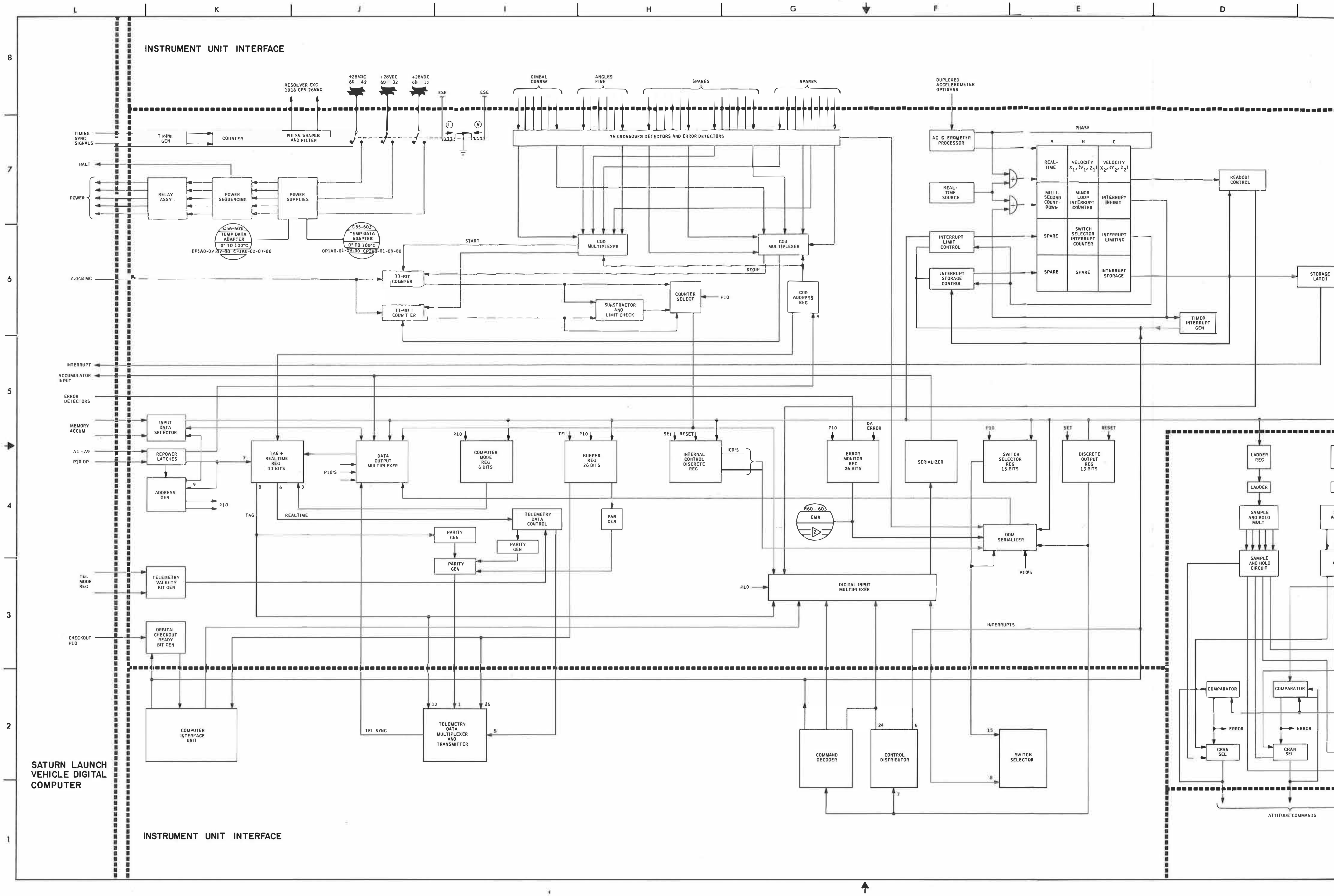
C. Launch Vehicle Digital Computer, data adapter redundancy, and triple modular redundancy (TMR) is used in the logic portion of the Launch Vehicle Digital Computer and Launch Vehicle Data Adapter. The three redundant circuit channels are voted upon following selected stage's outputs. Thus, even if one of the three outputs of a TMR stage is incorrect, the input to the next stage will be correct.

D. Disagreement Detector

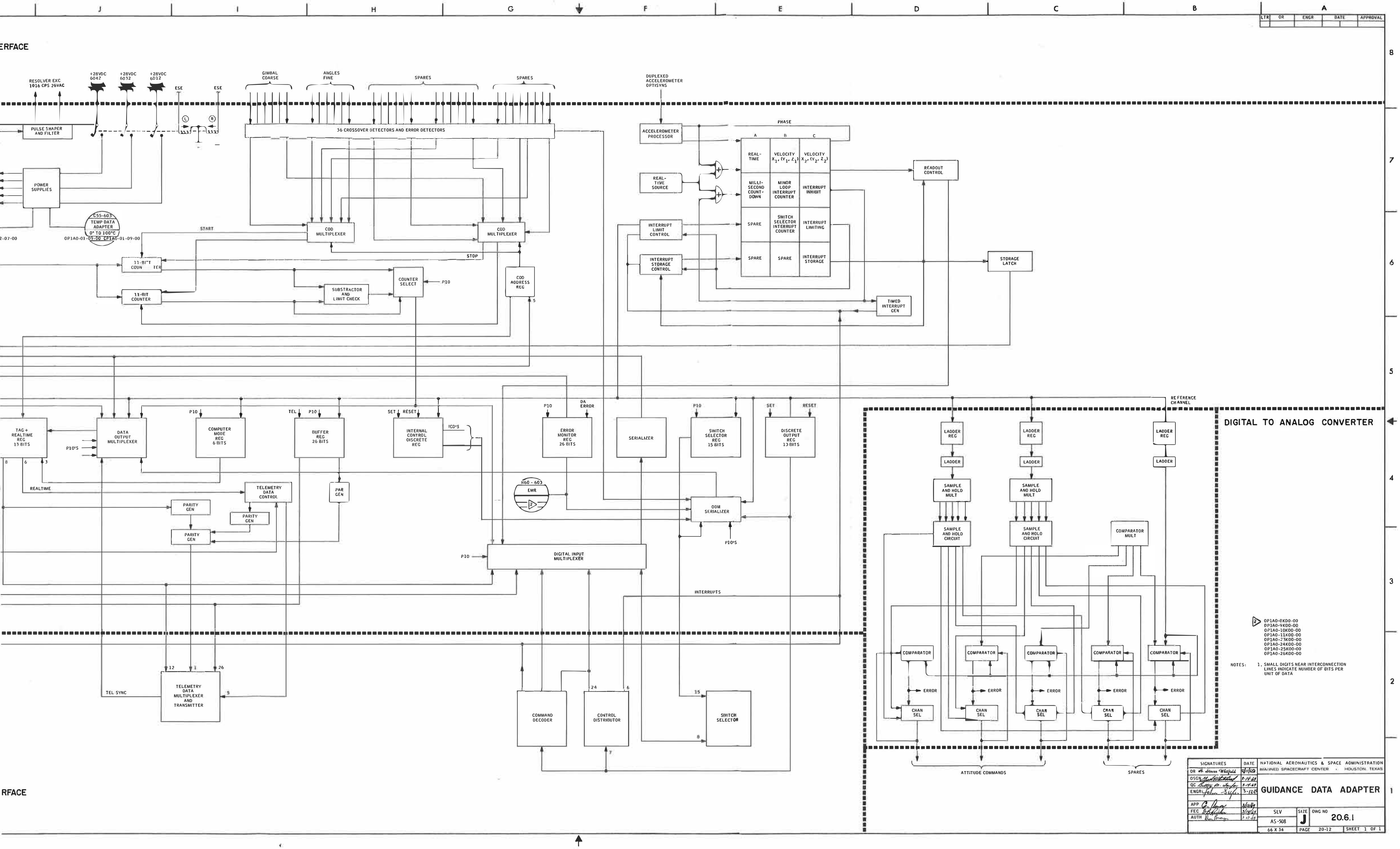
In TMR, each required circuit module is constructed three times to give three channels of data flow. If any one of the modules M_1A, M_1B, or M_1C should fail, one of the module output signals will be in error. The disagreement detector will note a disagreement among the three signals and set an error indication latch. The outputs of the three voters, however, will be the same as the majority of the inputs, so with one input error, the voter outputs will be identical and correct. By voting between stages, the identical stage in two channels must fail before a significant failure has occurred.



The Launch Vehicle Digital Computer memory system has two individual memories which can be used in parallel (duplex). In the duplex mode, information is read out of both memories from cores and by means of a selection network, just one memory output will be used. If the selected memory should contain an error (parity or timing), the information from the other memory would be used with the correct information being read back into both memories. Thus, the computer can correct its own memory errors.



INSTRUMENT UNIT INTERFACE
RESOLVER EXC 1016 CPS 26VAC
+28VDC 6D 42
+28VDC 6D 32
+28VDC 6D 12
ESE
ESE
GIMBAL COARSE
ANGLES FINE
SPARES
SPARES
DUPLEXED ACCELEROMETER OPTISYNS
TIMING SYNC SIGNALS
TIMING GEN
COUNTER
PULSE SHAPER AND FILTER
36 CROSSOVER DETECTORS AND ERROR DETECTORS
ACCELEROMETER PROCESSOR
PHASE
A
B
C
REAL-TIME
VELOCITY X1, (Y1, Z1)
VELOCITY X2, (Y2, Z2)
MILLI-SECOND COUNT-DOWN
MINOR LOOP INTERRUPT COUNTER
INTERRUPT INHIBIT
SPARE
SWITCH SELECTOR INTERRUPT COUNTER
INTERRUPT LIMITING
SPARE
SPARE
INTERRUPT STORAGE
REAL-TIME SOURCE
INTERRUPT LIMIT CONTROL
INTERRUPT STORAGE CONTROL
READOUT CONTROL
STORAGE LATCH
TIMED INTERRUPT GEN
HALT
POWER
RELAY ASSY
POWER SEQUENCING
POWER SUPPLIES
C56-603 TEMP DATA ADAPTER 0° TO 100°C
DP1A0-02-07-00 CP1A0-02-07-00
C55-603 TEMP DATA ADAPTER 0° TO 100°C
DP1A0-01-09-00 CP1A0-01-09-00
START
STOP
COD MULTIPLEXER
COD MULTIPLEXER
2.048 MC
11-BIT COUNTER
11-BIT COUNTER
SUBSTRACTOR AND LIMIT CHECK
COUNTER SELECT
P10
COD ADDRESS REG
INTERRUPT
ACCUMULATOR INPUT
ERROR DETECTORS
MEMORY ACCUM
A1 - A9
P10 OP
INPUT DATA SELECTOR
REPOWER LATCHES
ADDRESS GEN
TAG + REALTIME REG 13 BITS
TAG
REALTIME
P10'S
DATA OUTPUT MULTIPLEXER
COMPUTER MODE REG 6 BITS
TEL
BUFFER REG 26 BITS
SET
RESET
INTERNAL CONTROL DISCRETE REG
ICO'S
DA ERROR
ERROR MONITOR REG 26 BITS
SERIALIZER
SWITCH SELECTOR REG 15 BITS
DISCRETE OUTPUT REG 13 BITS
TELEMETRY DATA CONTROL
PARITY GEN
PARITY GEN
PARITY GEN
PAR GEN
R60-603
EMR
DDM SERIALIZER
P10'S
TEL MODE REG
TELEMETRY VALIDITY BIT GEN
DIGITAL INPUT MULTIPLEXER
CHECKOUT P10
ORBITAL CHECKOUT READY BIT GEN
INTERRUPTS
LADDER REG
LADDER
SAMPLE AND HOLD MULT
SAMPLE AND HOLD CIRCUIT
COMPARATOR
COMPARATOR
ERROR
ERROR
CHAN SEL
CHAN SEL
ATTITUDE COMMANDS
COMPUTER INTERFACE UNIT
TEL SYNC
TELEMETRY DATA MULTIPLEXER AND TRANSMITTER
COMMAND DECODER
CONTROL DISTRIBUTOR
SWITCH SELECTOR
SATURN LAUNCH VEHICLE DIGITAL COMPUTER
INSTRUMENT UNIT INTERFACE



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GUIDANCE DATA ADAPTER

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20.7 LAUNCH VEHICLE DIGITAL COMPUTER

A. The LVDC is a serial machine using a random access magnetic core memory. It uses microminiature packaging techniques and triple modular reliability. Glass delay lines are used for the serial arithmetic registers and for the storage of the instruction counter.

B. Memory words are 28 bits in length which includes two parity bits. The memory consists of eight identical 4096-word memory modules which are operated in duplex pairs for high reliability.

C. The LVDC operates on a basic clock time of 512 kbps. Standard machine cycle time of the LVDC is approximately 82 microseconds. This standard cycle time is based on an add or subtract arithmetic function.

Five status words are telemetered from the LVDC through the LVDA. The presence of a bit in the positions identified will be interpreted in accordance with the formats on the following pages.

*

ERROR MONITOR REGISTER

LVDC 10 BIT OCTAL	FCO 8 BIT OCTAL	BIT DESCRIPTION
S	D26	COMPUTER FAILURE
1	D25	MEMORY "B" FAILURE
2	D24	MEMORY "A" FAILURE
3	D23	
4	D22	
5	D21	
6	D20	
7	D19	
8	D18	
9	D17	
10	D16	
11	D15	
12	D14	
13	D13	
14	D12	
15	D11	
16	D10	
17	D9	LADDER "A" FAILURE
18	D8	
19	D7	
20	D6	
21	D5	
22	D4	
23	D3	
24	D2	
25	D1	

LVDC 10 BIT OCTAL	FCO 8 BIT OCTAL	BIT DESCRIPTION
S	D26	ACCEL REASONABLENESS FAILURE, Z (A)
1	D25	ACCEL REASONABLENESS FAILURE, Z (B)
2	D24	ACCEL REASONABLENESS FAILURE, X (A)
3	D23	ACCEL REASONABLENESS FAILURE, X (B)
4	D22	ACCEL REASONABLENESS FAILURE, Y (A)
5	D21	ACCEL REASONABLENESS FAILURE, Y (B)
6	D20	GIMBAL ANGLE REASONABLENESS FAILURE, Z (BACKUP)
7	D19	GIMBAL ANGLE REASONABLENESS FAILURE, Z (FINE)
8	D18	GIMBAL ANGLE REASONABLENESS FAILURE, X (BACKUP)
9	D17	GIMBAL ANGLE REASONABLENESS FAILURE, X (FINE)
10	D16	GIMBAL ANGLE REASONABLENESS FAILURE, Y (BACKUP)
11	D15	GIMBAL ANGLE REASONABLENESS FAILURE, Y (FINE)
12	D14	GIMBAL ANGLE DISAGREEMENT (> ZERO)
13	D13	GIMBAL ANGLE DISAGREEMENT (= ZERO)
14	D12	GIMBAL ANGLE DISAGREEMENT COUNTER "A" FAILED
15	D11	GIMBAL ANGLE DISAGREEMENT COUNTER "B" FAILED
16	D10	LADDER "A" FAILURE (LADDER "B" SELECTED)
17	D9	SWITCH SELECTOR CHANNEL "B" SELECTED
18	D8	EXPANDED ACCELEROMETER ZERO TEST
19	D7	UNACCEPTABLE ZERO READING OF Y ACCELEROMETER
20	D6	COD MULTIPLEXER "A" BAD
21	D5	COD MULTIPLEXER "B" BAD
22	D4	UNACCEPTABLE ZERO READING OF Z ACCELEROMETER
23	D3	UNACCEPTABLE ZERO READING OF X ACCELEROMETER
24	D2	SPARE
25	D1	SPARE

LVDC 10 BIT OCTAL	FCO 8 BIT OCTAL	BIT DESCRIPTION
S	D26	GUIDANCE REFERENCE RELEASE (GRR) (INT 7) (START TB0)
1	D25	LIFTOFF (START TB1) (DIN 24)
2	D24	START PITCH AND ROLL MANEUVER (INITIATE S-IC GUIDANCE)
3	D23	STOP ROLL
4	D22	SPARE
5	D21	STOP PITCH (S-IC TIME TILT ARREST)
6	D20	S-IC INBOARD ENGINE CUTOFF (START TB2)
7	D19	S-IC OUTBOARD ENGINE CUTOFF (START TB3) (INT 5) or (DIN 18)
8	D18	S-IC INBOARD ENGINE OUT (DIN 11) } ENGINE FAILURE ONLY
9	D17	S-IC OUTBOARD ENGINE OUT (DIN 14) } ENGINE FAILURE ONLY
10	D16	SPARE
11	D15	S-II SKIRT SEPARATION (DIN 15)
12	D14	BEGIN FIRST PHASE IGM GUIDANCE (S-II FIRST IGM PHASE BEFORE EMRC)
13	D13	BEGIN SECOND PHASE IGM (AFTER EMRC)
14	D12	START TB4 OR TB4a (S-II CUTOFF)
15	D11	S-II OUTBOARD ENGINE OUT (DIN 21) } ENGINE FAILURE ONLY
16	D10	S-II INBOARD ENGINE OUT (DIN 13) } ENGINE FAILURE ONLY
17	D9	S-II/S-IVB SEPARATION (DIN 10)
18	D8	
19	D7	BEGIN S-IVB IGM - BEFORE EMRC (NOMINAL AND EARLY STAGING)
20	D6	FIRST S-IVB ENGINE ON COMMAND
21	D5	S-IVB IGM AFTER EMRC (EARLY STAGING)
22	D4	START TERMINAL GUIDANCE (FIRST BURN)
23	D3	FIRST S-IVB CUTOFF COMMAND
24	D2	BEGIN TIME BASE 5 (T_5) (S-IVB C/O)
25	D1	START S-IVB CHILLDOWN SEQUENCE (START TB6)

GUIDANCE MODE WORD 2

LVDC 10 BIT OCTAL	FCO 8 BIT OCTAL	BIT DESCRIPTION
S	D26	S-IVB ENGINE ON COMMAND (SECOND BURN)
1	D25	SPARE
2	D24	SPARE
3	D23	START TERMINAL GUIDANCE (SECOND BURN)
4	D22	SECOND S-IVB CUTOFF COMMAND
5	D21	SPARE
6	D20	START TB7
7	D19	S/C INIT OF S-IVB CUTOFF (DIN 17 OR 22)
8	D18	S/C CONTROL AFTER GUIDANCE FAILURE
9	D17	START TB4 S/C INITIATION OF S-II/S-IVB SEPARATION (DIN 17 or 22)
10	D16	SPARE
11	D15	SPARE
12	D14	SPARE
13	D13	SPARE
14	D12	LUNAR IMPACT CMD RCVD
15	D11	STEERING MISALIGNMENT CORRECTION (SMC) RESET DURING PERIODS OF NO SMC CALCULATIONS.
16	D10	O_2 - H_2 BURNER MALFUNCTION 1 (T_{6A})
17	D9	TLC - SIMULTANEOUS MEMORY FAILURE (INT 9)
18	D8	GUIDANCE REFERENCE FAILURE (D04 AND D06)
19	D7	TLI INHIBITED (SECOND OPPORTUNITY) (DIN 6)
20	D6	TLI INHIBITED (FIRST OPPORTUNITY) (DIN 6)
21	D5	START TB6C
22	D4	START TB6 (S-IVB IGNITION SEQUENCE START) (DIN 20)
23	D3	O_2 - H_2 BURNER MALFUNCTION (TB6b)
24	D2	SPARE
25	D1	PREFLIGHT ABORT

ORBITAL MODE WORD

LVDC 10 BIT OCTAL	FCO 8 BIT OCTAL	BIT DESCRIPTION
S	D26	POWERED FLIGHT DCS INHIBIT REMOVED
1	D25	TB8 ENABLE DCS CMD ENABLE
2	D24	SPARE
3	D23	SPARE
4	D22	COMM MAN IN TB8
5	D21	PCM AND CCS ANT - LOW GAIN
6	D20	PCM AND CCS ANT - HIGH GAIN
7	D19	PCM AND CCS ANT - OMNI
8	D18	NAVIGATION UPDATE ACCEPTED
9	D17	TIME BASE UPDATE ACCEPTED
10	D16	TRACK LOCAL HORIZ
11	D15	INERTIAL HOLD IN PROGRESS
12	D14	S/C IN CONTROL OF SATURN
13	D13	TD&E ENABLE (TB6 INHIBITED BY DCS CMD)
14	D12	TARGET UPDATE RECEIVED
15	D11	START TB8
16	D10	CONT RET FROM S/C (ATT HOLD W/R TO LOCAL REF)
17	D9	CONT RET FROM S/C (ATT HOLD W/R TO INERTIAL REF)
18	D8	H_2O CONTROL VALVE LOGIC ACTIVE
19	D7	INHIBIT MAN 3
20	D6	INHIBIT MAN 4
21	D5	INHIBIT MAN 5
22	D4	INHIBIT MAN 9
23	D3	INHIBIT MAN 10
24	D2	INHIBIT MAN 11
25	D1	INHIBIT MAN 13

LVDC TIME

LVDC 10 BIT OCTAL	FCO 8 BIT OCTAL	BIT DESCRIPTION
S	D26	32 768 SECONDS
1	D25	16 384
2	D24	8 192
3	D23	4 096
4	D22	2 048
5	D21	1 024
6	D20	512
7	D19	256
8	D18	128
9	D17	64
10	D16	32
11	D15	16
12	D14	8
13	D13	4
14	D12	2
15	D11	1
16	D10	
17	D9	
18	D8	
19	D7	
20	D6	
21	D5	
22	D4	
23	D3	
24	D2	
25	D1	

LVDC POSITIONS

LVDC 10 BIT OCTAL	FCO 8 BIT OCTAL	BIT DESCRIPTION		
SIGN	D26	SIGN (0 = POSITIVE; 1 = NEGATIVE)		
1	D25	4 194 304	METERS	67 108 864
2	D24	2 097 152		33 554 432
3	D23	1 048 576		16 777 216
4	D22	524 288		8 388 608
5	D21	262 144		4 194 304
6	D20	131 072		2 097 152
7	D19	65 536		1 048 576
8	D18	32 768		524 288
9	D17	16 384		262 144
10	D16	8 192		131 072
11	D15	4 096		65 536
12	D14	2 048		32 768
13	D13	1 024		16 384
14	D12	512		8 192
15	D11	256		4 096
16	D10	128		2 048
17	D9	64		1 024
18	D8	32		512
19	D7	16		256
20	D6	8		128
21	D5	4		64
22	D4	2		32
23	D3	1		16
24	D2			8
25	D1			4
		PARKING ORBIT		WAITING ORBIT

LVDC SPACE FIXED POSITIONS

Conversion from octal to engineering units (kilometers). This conversion assumes a fill of one zero to left of LVDC MSB. The data provides for the eight MSB LVDC downlink bits.

OCTAL	ENGR	OCTAL	ENGR	OCTAL	ENGR	OCTAL	ENGR
- +	K	- +	K	- +	K	- +	K
000 000	0000	330 050	2621	260 120	5243	207 171	7930
377 001	66	327 051	2687	257 121	5308	206 172	7995
376 002	131	326 052	2753	256 122	5374	205 173	8061
375 003	197	325 053	2818	255 123	5439	204 174	8126
374 004	262	324 054	2884	254 124	5505	203 175	8192
373 005	328	323 055	2949	253 125	5570	202 176	8258
372 006	393	322 056	3015	252 126	5636	201 177	8323
371 007	459	321 057	3080	251 127	5702		
370 010	524	320 060	3164	250 130	5767		
367 011	590	317 061	3211	247 131	5833		
366 012	655	316 062	3277	246 132	5898		
365 013	721	315 063	3342	245 133	5964		
364 014	786	314 064	3408	244 134	6029		
363 015	852	313 065	3473	243 135	6095		
362 016	918	312 066	3539	242 136	6160		
361 017	983	311 067	3604	241 137	6226		
360 020	1048	310 070	3670	240 140	6291		
357 021	1114	307 071	3736	237 141	6357		
356 022	1180	306 072	3801	236 142	6423		
355 023	2294	305 073	3867	235 143	6488		
354 024	1311	304 074	3932	234 144	6554		
353 025	1376	303 075	3998	233 145	6619		
352 026	1442	302 076	4063	232 146	6685		
351 027	1507	301 077	4129	231 147	6750		
350 030	1572	300 100	4194	230 150	6816		
347 031	1638	277 101	4260	227 151	6881		
346 032	1704	276 102	4325	226 152	6947		
345 033	1769	275 103	4391	225 153	7012		
344 034	1835	274 104	4456	224 154	7078		
343 035	1901	273 105	4522	223 155	7143		
342 036	1966	272 106	4588	222 156	7209		
341 037	2032	271 107	4653	221 157	7274		
340 040	2097	270 110	4719	220 160	7340		
337 041	2163	267 111	4784	217 161	7406		
336 042	2282	266 112	4850	216 162	7471		
335 043	2294	265 113	4915	215 163	7537		
334 044	2359	264 114	4980	214 164	7602		
333 045	2425	263 115	5046	213 165	7668		
332 046	2490	262 116	5112	212 166	7733		
331 047	2556	261 117	5177	211 167	7799		
				210 170	7864		

LVDC VELOCITY

LVDC 10 BIT OCTAL	FCO 8 BIT OCTAL	BIT DESCRIPTION
SIGN	D26	SIGN (0 = POSITIVE; 1 = NEGATIVE)
1	D25	8 192 METERS/SECOND
2	D24	4 096
3	D23	2 048
4	D22	1 024
5	D21	512
6	D20	256
7	D19	128
8	D18	64
9	D17	32
10	D16	16
11	D15	8
12	D14	4
13	D13	2
14	D12	1
15	D11	.5
16	D10	
17	D9	
18	D8	
19	D7	
20	D6	
21	D5	
22	D4	
23	D3	
24	D2	
25	D1	

LVDC SPACE FIXED VELOCITY

Conversion from octal to engineering units (meters/second). This conversion assumes a fill of one zero to left of LVDC MSB. The data provides for the eight MSB LVDC downlink bits also with a fill bit to left.

OCTAL	ENGR	OCTAL	ENGR	OCTAL	ENGR	OCTAL	ENGR
– +	M/S	– +	M/S	– +	M/S	– +	M/S
000 000	0000	330 050	5120	260 120	10240	210 170	15360
377 001	128	327 051	5248	257 121	10368	207 171	15488
376 002	256	326 052	5376	256 122	10496	206 172	15616
375 003	384	325 053	5504	255 123	10624	205 173	15744
374 004	512	324 054	5632	254 124	10752	204 174	15872
373 005	640	323 055	5760	253 125	10880	203 175	16000
372 006	768	322 056	5888	252 126	11008	202 176	16128
371 007	896	321 057	6061	251 127	11136	201 177	16256
370 010	1024	320 060	6144	250 130	11264		
367 011	1152	317 061	6272	247 131	11392		
366 012	1280	316 062	6400	246 132	11520		
365 013	1308	315 063	6528	245 133	11648		
364 014	1536	314 064	6656	244 134	11776		
363 015	1664	313 065	6784	243 135	11904		
362 016	1792	312 066	6912	242 136	12032		
361 017	1920	311 067	7040	241 137	12160		
360 020	2048	310 070	7168	240 140	12288		
357 021	2176	307 071	7296	237 141	12416		
356 022	2034	306 072	7424	236 141	12544		
355 023	2432	305 073	7552	235 143	12672		
354 024	2560	304 074	7680	234 144	12800		
353 025	2688	303 075	7808	233 145	12928		
352 026	2816	302 076	7936	232 146	13056		
351 027	2944	301 077	8064	231 147	13184		
350 030	3072	300 100	8192	230 150	13312		
347 031	3200	277 101	8320	227 151	13440		
346 032	3328	276 102	8448	226 152	13568		
345 033	3456	275 103	8576	225 153	13696		
344 034	3584	274 104	8704	224 154	13824		
343 035	3712	273 105	8832	223 155	13952		
342 036	3840	272 106	8960	222 156	14080		
341 037	3968	271 107	9088	221 157	14208		
340 040	4096	270 110	9216	220 160	14336		
337 041	4224	267 111	9344	217 161	14464		
336 042	4352	266 112	9472	216 162	14592		
335 043	4480	265 113	9600	215 163	14720		
334 044	4608	264 114	9728	214 164	14848		
333 045	4736	263 115	9856	213 165	14976		
332 046	4864	262 116	9984	212 166	15104		
331 047	4992	261 117	10112	211 167	15232		

LVDC ANGLES

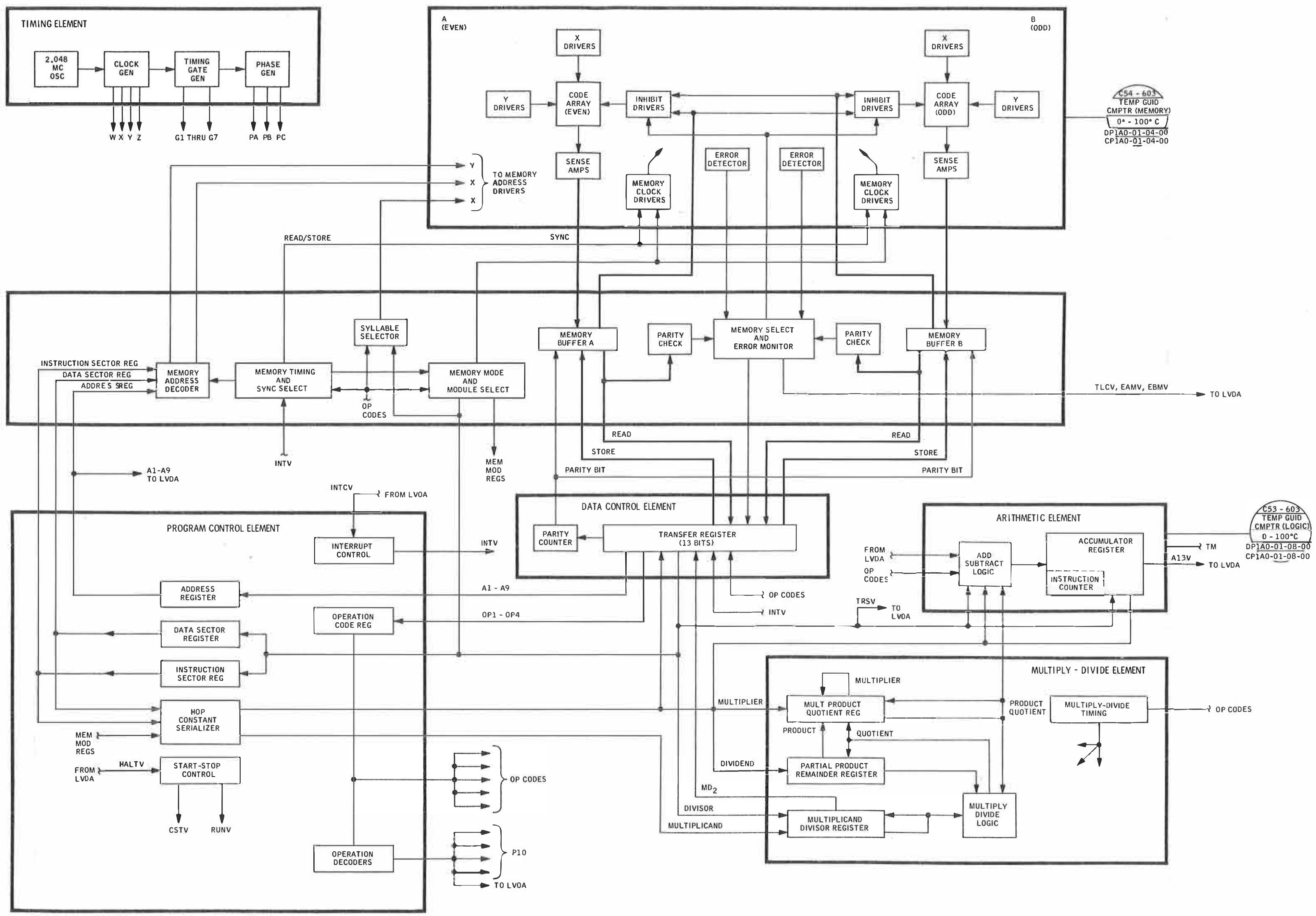
LVDC 10 BIT OCTAL	FCO 8 BIT OCTAL	BIT DESCRIPTION	
S	D26	180	DEGREES
1	D25	90	
2	D24	45	
3	D23	22.5	
4	D22	11.25	
5	D21	5.625	
6	D20	2.812 5	
7	D19	1.406 25	
8	D18	.703 125	
9	D17	.351 562 5	
10	D16	.175 781 25	
11	D15	.087 890 625	
12	D14	.043 945 312	
13	D13	.021 972 656	
14	D12	.010 986 328	
15	D11	.005 493 164	
16	D10	.002 746 582	
17	D9	.001 373 291	
18	D8	.000 686 645	
19	D7	.000 343 323	
20	D6	.000 171 661	
21	D5	.000 085 831	
22	D4	.000 042 915	
23	D3	.000 021 457	
24	D2	.000 010 728	
25	D1	.000 005 364	

Conversion from octal to engineering units (degrees). This conversion assumes a fill of one zero to the left of the LVDC MSB. The data provides for the eight MSB LVDC downlink bits also with a fill of zero to left.

OCT	DEG	OCT	DEG	OCT	DEG	OCT	DEG	OCT	DEG	OCT	DEG
000	000	060	68	140	135	220	203	300	270	360	338
001	1	061	69	141	136	221	204	301	271	361	339
002	3	062	70	142	138	222	205	302	273	362	340
003	4	063	72	143	139	223	207	303	274	363	342
004	6	064	73	144	141	224	208	304	276	364	343
005	7	065	75	145	142	225	210	305	277	365	345
006	8	066	76	146	143	226	211	306	278	366	346
007	10	067	77	047	145	227	212	307	280	367	347
010	11	070	79	050	146	230	214	310	281	370	349
011	13	071	80	151	148	231	215	311	283	371	350
012	14	072	82	152	149	232	217	312	284	372	352
013	15	073	83	153	150	233	218	313	285	373	353
014	17	074	84	154	152	234	219	314	287	374	354
015	18	075	86	155	153	235	221	315	288	375	356
016	20	076	87	156	155	236	222	316	290	376	357
017	21	077	89	157	156	237	224	317	291	377	359
020	23	100	90	160	158	240	225	320	293		
021	24	101	91	161	159	241	226	321	294		
022	25	102	93	162	160	242	228	322	295		
023	27	103	94	163	162	243	229	323	297		
024	28	104	96	164	163	244	231	324	298		
025	30	105	97	165	165	245	232	325	300		
026	31	106	98	166	166	246	233	326	301		
027	32	107	100	167	167	247	235	327	302		
030	34	110	101	170	169	250	236	330	304		
031	35	111	103	171	170	251	238	331	305		
032	37	112	104	172	172	252	239	332	307		
033	38	113	105	173	173	253	240	333	308		
034	39	114	107	174	174	254	242	334	309		
035	41	115	108	175	176	255	243	335	311		
036	42	116	110	176	177	256	245	336	312		
037	44	117	111	177	179	257	246	337	314		
040	45	120	113	200	180	260	248	340	315		
041	46	121	114	201	181	261	249	341	316		
042	48	122	115	202	183	262	250	342	318		
043	49	123	117	203	184	263	252	343	319		
044	51	124	118	204	186	264	253	344	321		
045	52	125	120	205	187	265	255	345	322		
046	53	126	121	206	188	266	256	346	323		
047	55	127	122	207	189	267	257	347	325		
050	56	130	124	210	191	270	259	350	326		
051	58	131	125	211	193	271	260	351	328		
052	59	132	127	212	194	272	262	352	239		
053	60	133	128	213	195	273	263	353	330		
054	62	134	129	214	197	274	264	354	332		
055	63	135	131	215	198	275	266	355	333		
056	65	136	132	216	200	276	267	356	335		
057	66	137	134	217	201	277	269	357	336		

TIME TO GO TO S-IVB CUTOFF

LVDC 10 BIT OCTAL	FCO 8 BIT OCTAL	BIT DESCRIPTION
SIGN	D26	
1	D25	512
2	D24	256
3	D23	128
4	D22	64
5	D21	32
6	D20	16
7	D19	8
8	D18	4
9	D17	2
10	D16	1
11	D15	.5
12	D14	.25
13	D13	.125
14	D12	.062 5
15	D11	.031 25
16	D10	
17	D9	
18	D8	
19	D7	
20	D6	
21	D5	
22	D4	
23	D3	
24	D2	
25	D1	



SIGNATURES	DATE
DR Wade Williams	1-29-69
DSGN	3-14-69
QC	3-14-69
ENGR	3-12-69
APP	
FEC	3-14-69
AUTH	

NATIONAL AERONAUTICS & SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER • HOUSTON, TEXAS

GUIDANCE-DIGITAL COMPUTER

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21 CONTROL

SECTION 21

CONTROL

21.1 DEFINITION OF THE CONTROL SYSTEM

The control system is composed of all the equipment which is necessary to control the thrust vector of the launch vehicle engines during the active boost phases and maintain proper vehicle attitude during orbital coast phases. The major components of the control system are the Flight Control Computer, the Control EDS Rate Gyro Package, and the Control Signal Processor. The major interfaces of the control system are with the Launch Vehicle Data Adapter, the IU Switch Selector, the S-IC, S-II and S-IVB Engine Actuators and the Control Relay Package for the Auxiliary Propulsion System.

21.2 CONTROL SYSTEM OPERATION

A. The prime component of the control system is the Flight Control Computer (FCC). The FCC is an analog computer which accomplishes two primary functions:

1. It solves and instruments the vehicle thrust vector equation:

Pitch: $\beta_{pc} = a_{op}\psi_p + a_{1p}\dot{\phi}_p$

Yaw: $\beta_{yc} = a_{oy}\psi_y + a_{1y}\dot{\phi}_y$

Roll: $\beta_{rc} = a_{or}\psi_r + a_{1r}\dot{\phi}_r$

where

β_{pc}, β_{yc}, β_{rc}	is commanded thrust direction
a_o	is control system attitude error gain
a_1	is control system attitude rate gain
ψ_p, ψ_y, ψ_r	is vehicle attitude error
$\dot{\phi}_p$, $\dot{\phi}_y$, $\dot{\phi}_r$	is vehicle attitude rate

This equation calculates the angle which must exist between the thrust vector (axis of engine thrust) and the longitudinal axis of the vehicle in order to maintain stable flight along the desired trajectory. The FCC outputs control signals to the individual actuators in accordance with the following equations:

$\beta_{p1c} = \beta_{pc} - \beta_{rc}/\sqrt{2}$

$\beta_{p2c} = \beta_{pc} + \beta_{rc}/\sqrt{2}$

$\beta_{p3c} = \beta_{pc} - \beta_{rc}/\sqrt{2}$

$\beta_{p4c} = \beta_{pc} + \beta_{rc}/\sqrt{2}$

$\beta_{y1c} = \beta_{yc} + \beta_{rc}/\sqrt{2}$

$\beta_{y2c} = \beta_{yc} - \beta_{rc}/\sqrt{2}$

$\beta_{y3c} = \beta_{yc} + \beta_{rc}/\sqrt{2}$

$\beta_{y4c} = \beta_{yc} - \beta_{rc}/\sqrt{2}$

where β_{p1c} is the commanded pitch motion for engine number one, et cetera.

2. It provides control signals to the APS engines to establish and maintain vehicle attitude during coasting flight. These control signals are represented by the following equations which give error command (ε) to the pseudo-rate modulator (spatial amplifier):

Pitch: $\varepsilon_p = a_{op}\psi_p + a_{1p}\dot{\phi}_p$

Yaw-Roll Mixed: $\varepsilon_{y-r} = a_{oy}\psi_y - a_{or}\psi_r + a_{1y}\dot{\phi}_y - a_{1r}\dot{\phi}_r$

$\varepsilon_{y+r} = a_{oy}\psi_y + a_{or}\psi_r + a_{1y}\dot{\phi}_y + a_{1r}\dot{\phi}_r$

The following table illustrates the polarity of the signal required to cause each engine to fire:

Error Signal	Engine On
a. $+\varepsilon_p$	I_p (+p)
b. $-\varepsilon_p$	III_p (-p)
c. $+\varepsilon_{y-r}$	III_{II} (+y, -r)
d. $-\varepsilon_{y-r}$	III_{IV} (-y, +r)
e. $+\varepsilon_{y+r}$	I_{II} (+y, +r)
f. $-\varepsilon_{y+r}$	I_{IV} (-y, -r)

B. The FCC has the following modes of operation (exclusive of GSE test configurations):

1. S-IC Burn
2. S-II Burn
3. S-IVB Burn
4. S-IVB Coast
5. Spacecraft Control

This mode switching of the FCC performs the function of routing the input signals through the proper filters and amplifiers and routing the engine control signals to the appropriate stage actuators. The FCC is put into the S-IC Burn Mode with a GSE command prior to liftoff. At liftoff, relay K4-2 (Drawing 21.1.2) is deenergized applying 28 Vdc to the FCC in order to maintain the S-IC Burn Mode configuration. The S-II Burn Mode is achieved with a switch selector command which energizes relay K34 (Drawing 21.1.2) applying 28 Vdc to the S-II Burn Mode circuitry. Power is removed from the S-II Burn Mode circuits by the physical separation of the S-II stage from the S-IVB stage. The S-IVB Burn Mode is achieved with two switch selector commands which energize relays K23 and K36 (Drawing 21.1.2). These commands operate in conjunction with relays K92 and K93 which are driven from the S-IVB main stage Thrust OK switches to provide 28 Vdc to the S-IVB Burn Mode circuitry. This configuration is used to provide redundancy in achieving S-IVB burn and S-IVB coast configurations. The FCC is configured for the S-IVB Coast Mode by the removal of the 28 Vdc to the S-IVB Burn Mode circuitry. This is accomplished with two switch selector commands which reset relays K23 and K36 with the S-IVB Thrust OK switches operating to back up these switch selector commands.

C. The vehicle control requirements are different during the various phases of flight. The function and characteristics of each mode follow.

1. S-IC Burn Mode (Drawing 21.2.2)

   The function of the control system during S-IC stage burn is to maintain stable aerodynamic flight. The FCC accepts attitude error signals from the guidance system (LVDC/LVDA) which are obtained from a time-tilt guidance program. Attitude rate signals are input from the Control Signal Processor which conditions the outputs from the Control EDS Rate Gyro Package for use by the FCC. These attitude error and rate signals attempt to maintain the vehicle in a zero angle-of-attack attitude. Filters are included in all of these signal channels to control the effects of vehicle bending and fuel sloshing on the control system, to control the effects of sampling rate and quantitation of the attitude error signals, and to maintain proper control system stability. The gains of the attitude error and rate signals are controlled with switch selector functions known as Flight Control Computer switch points.

2. S-II Burn Mode (Drawing 21.2.2)

   The function of the control system during S-II stage burn is to direct the vehicle along the desired guidance trajectory. The attitude errors are obtained from an active guidance program which begins just after LES tower jettison. The attitude rate signals used are the same as described above for the S-IC stage. A different set of filters are used in the control signal channels because the vehicle dynamics characteristics have changed with the jettisoning of the S-IC stage.

3. S-IVB Burn Mode (Drawing 21.2.3)

   The function of the control system during S-IVB stage burn is to direct the vehicle along the guidance trajectory. The attitude error and rate signals are the same as described above for the S-II stage. A different set of filters is used because of the change in vehicle dynamic characteristics with the jettisoning of the S-II stage. There is only one engine on the S-IVB stage so attitude control in the roll axis is not possible. Roll control is achieved with the auxiliary propulsion system (APS) during S-IVB burn.

4. S-IVB Coast Mode (Drawing 21.2.3)

   The function of the control system during the S-IVB Coast Mode is to establish and maintain the desired vehicle attitudes in the pitch, yaw and roll planes. The inputs to the FCC are attitude error signals from the guidance system and attitude rate signals from the rate gyros. The FCC spatial amplifiers convert these analog inputs into variable width and frequency pulses which are suitable for the APS. The APS engines are fired whenever the summation of attitude errors and rates fall outside the OFF zone of the pseudo-rate modulator curves. The control system can be directed to perform attitude maneuvers during orbital coast by the guidance system by means of the attitude error commands. No filters are required for S-IVB coast as the vehicle bending and fuel sloshing effects are negligible during orbital coast. The purpose of the OFF zone or deadband for the APS is to prevent overcorrecting the vehicle's attitude which would result in excessive usage of the APS propellants. A schematic of the auxiliary propulsion system showing temperature and pressure measurements may be found in another section of this handbook.

5. Spacecraft Control Mode

The function of the control system during the spacecraft control mode is to respond to the attitude error commands from the spacecraft. The inputs to the Flight Control Computer are the attitude error signals from the spacecraft and attitude rate signals from the rate gyros. The spacecraft attitude error signals replace the guidance system attitude error signals and are used in an identical fashion as the guidance system. During S-IVB coast mode, the spacecraft attitude error signals are limited to a predetermined limit by the FCC. The gain of the error channels is changed from 3.75 in LVDC to 10 in S/C control.

21.2.1 Control System Redundancy

A. Control EDS Rate Gyro Package

There are three identical gyros in each of the three axes sensing the vehicle's attitude rates. Two of the three output signals for each axis are compared in the control signal processor. If the two signals agree within prescribed tolerances, one of these signals is used in the FCC. If the two signals are not within the prescribed tolerance, the signal from the third gyro is sent to the FCC.

B. Flight Control Computer

1. S-IC and S-II Stage Circuits

The S-IC and S-II stages each have five propulsive engines, the outer four of which can be gimbaled in the pitch and yaw axes by two hydraulic actuators at each engine. Each actuator is driven by a servoamplifier within the FCC. These circuits are not redundant but backup is provided by the fact that there are four individual actuator loops for each axis. Should one actuator loop fail, the other three loops in that axis will compensate with larger excursions since the total vehicle movement is being sensed and fed back to the FCC via the rate gyros and stable platform. Mechanical feedback is used in both the S-IC and S-II actuator servo loops.

2. S-IVB Burn Circuits (See Table 21-I)

All circuits in the FCC used for S-IVB Burn are redundant. Each of the three attitude error and rate inputs is divided into three separate channels which exist up to the servo amplifier comparator. A comparison of two of the three channels is made and one of these signals drives the actuator if the comparison is satisfactory. If the comparison is unsatisfactory, the third channel is used to drive the actuator. Mechanical feedback is used in the S-IVB actuator servo loops. The roll axis is handled in the same manner except that spatial amplifiers and comparators are used with the output driving the APS relay packages rather than an actuator.

3. S-IVB Coast Circuits

All circuits in the FCC used for S-IVB Coast are also redundant. Each of the three attitude error and rate inputs is divided into three separate channels which exist up to the spatial amplifier comparator. A comparison of two of the three channels is made and one of these signals drives the APS relay package if the comparison is satisfactory. If the comparison is unsatisfactory the third channel is used to drive the APS relay package.

21.2.2 Control System General Notes

A. Flight Control Computer

B. Control Signal Processor

	S-IC	S-II	S-IVB
C. Engine Actuators			
1. Max Engine Displacement	±5.17°	±7.29°	±7°
2. Max Actuator Drive Rate	5°/sec	9.6°/sec	8°/sec
D. APS	Pitch	Yaw	Roll
1. Deadband	±1.0°*	±1.0°*	±1.0°*
2. Maneuvering Rate Ledge	0.3°/sec*	0.3°/sec*	0.5°/sec*
3. Engine Thrust	150 lb	150 lb	150 lb

21.2.3 Control Signal Processor Characteristics

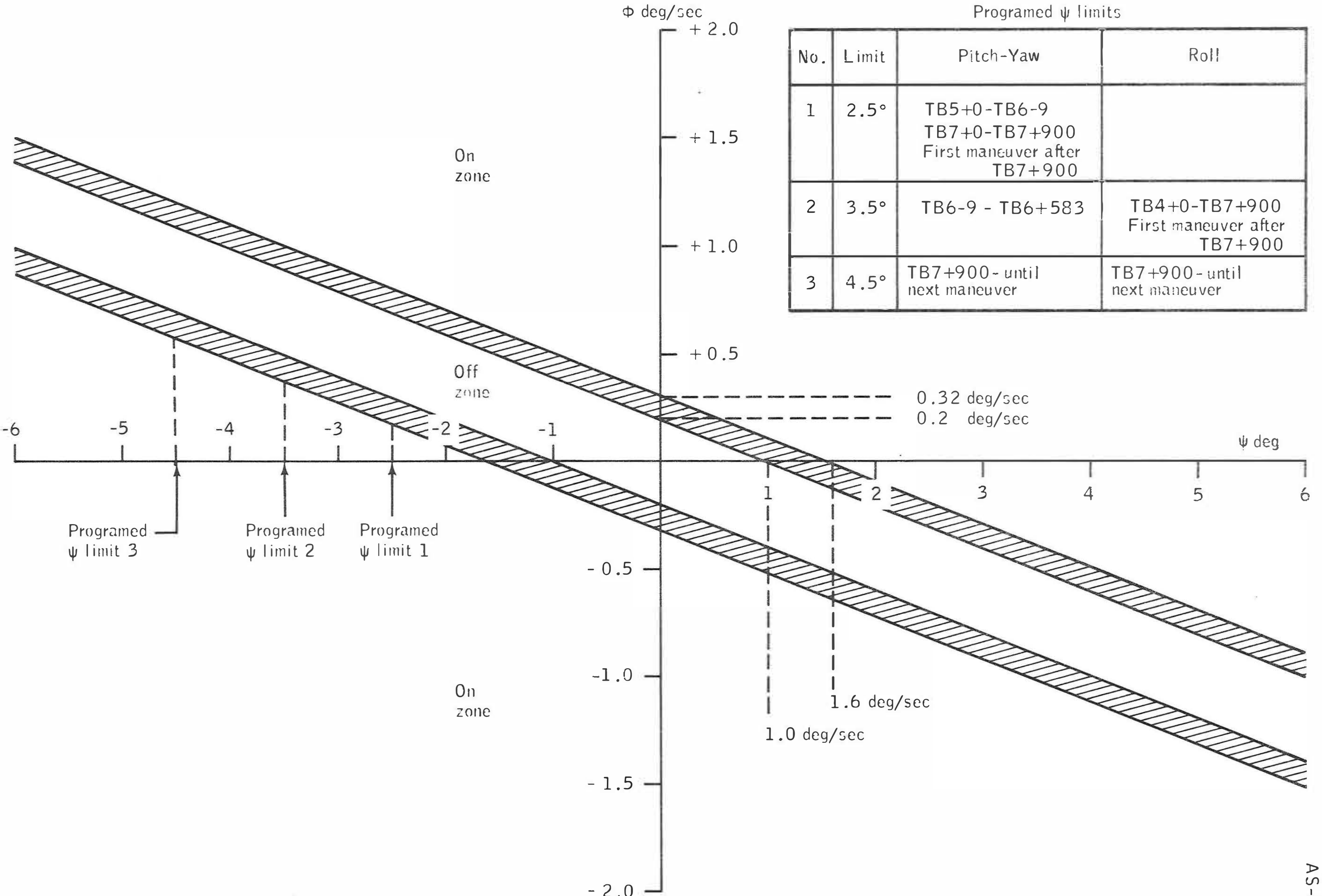
Input Power required	28 ± 4 Vdc
Rate Gyros	
Scale Factor	0.5656 V P-P/deg/sec
Range	±20 deg/sec 11.31 V. P-P
Control Signal Processor Output	
Scale Factor	4.5 Vdc/deg/sec
Range	±10 deg/sec 45 Vdc
Comparison Circuit	
Switchover Point	7.4 V Diff ±1.65 deg/sec
Tolerance	±10%
EDS Rate Switch Parameters	
$\dot{\phi}$ YAW, PITCH	
Activate point	+4.0/sec ±0.55°/sec -4.0/sec ±0.55°/sec
$\dot{\phi}$ ROLL	
Activate point	±20.0°/sec ±1.3°/sec

*The deadband and rate ledge are variable, see figure 21.1.

TABLE 21-I.- FCC AMPLIFIER CONFIGURATION

		$\dot{\phi}P$			$\dot{\phi}Y$			$\dot{\phi}R$			$\dot{\psi}P$			$\dot{\psi}Y$			$\dot{\psi}R$		
		DC	Servo	Spatial	DC	Servo	Spatial	DC	Servo	Spatial	DC	Servo	Spatial	DC	Servo	Spatial	DC	Servo	Spatial
S-IC and S-II		90			89			91			48 116			34 117			49 115		
	Eng 1		104			78													
	2		105			79													
	3		108			82													
	4		110			84				I/II									I/II
S-IVB burn	Active		105			79		32		66/72	55	105		46	79		53		66/72
	Ref		104			78		31		65/71	48	104		34	78		49		65/71
	Standby		108			82		33		67/73	54	108		47	82		52		67/73
S-IVB coast	Active	116		61	90		66/72	32		66/72	55		61	46		66/72	53		66/72
	Ref	117		60	89		65/71	31		65/71	48		60	34		65/71	49		65/71
	Standby	115		62	91		67/73	33		67/73	54		62	47		67/73	52		67/73

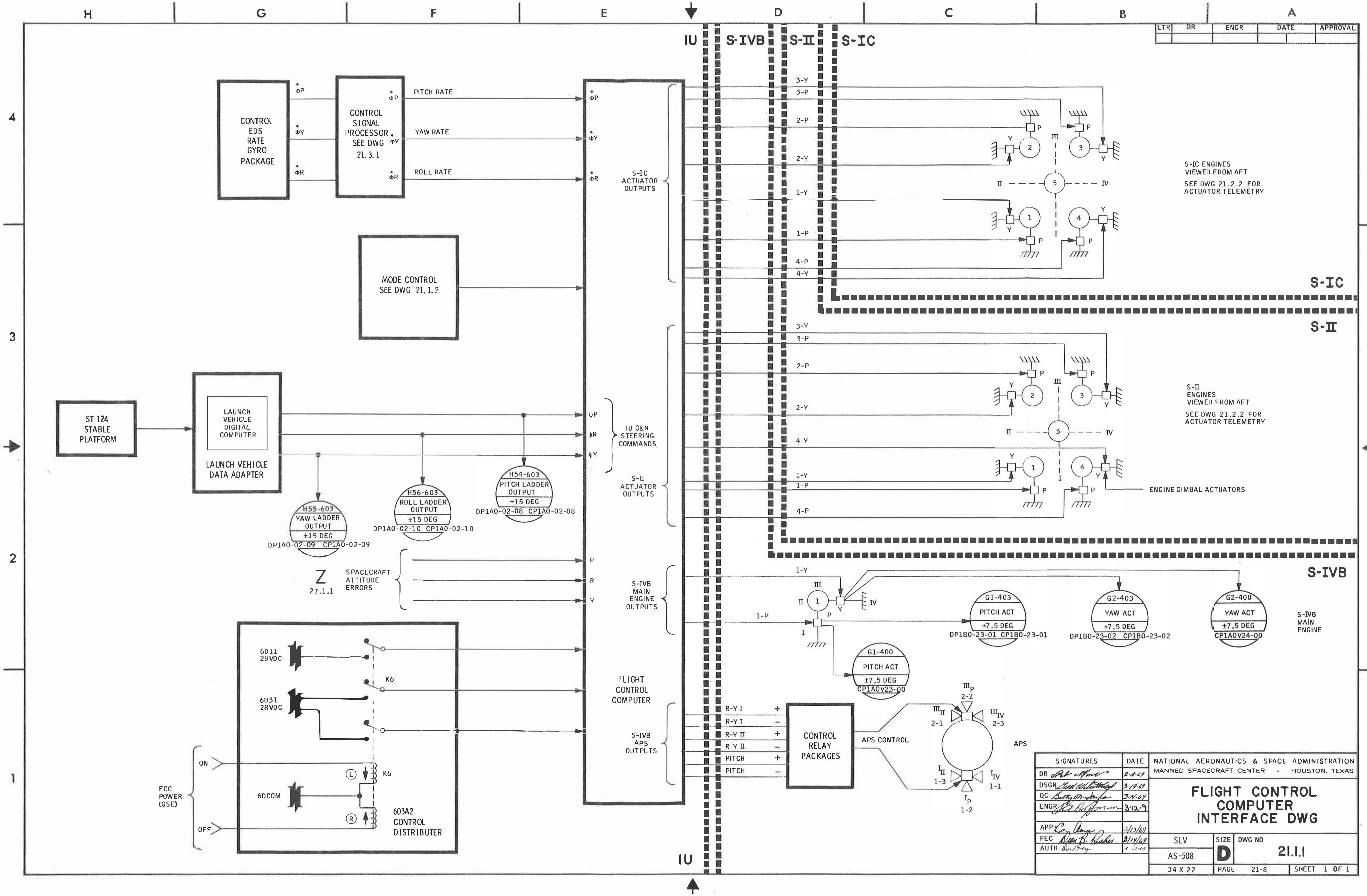
EXAMPLE: If dc amp 90, $\dot{\phi}P$ S-IC/S-II fails there will be $\dot{\phi}Y$ switchover during S-IVB coast.

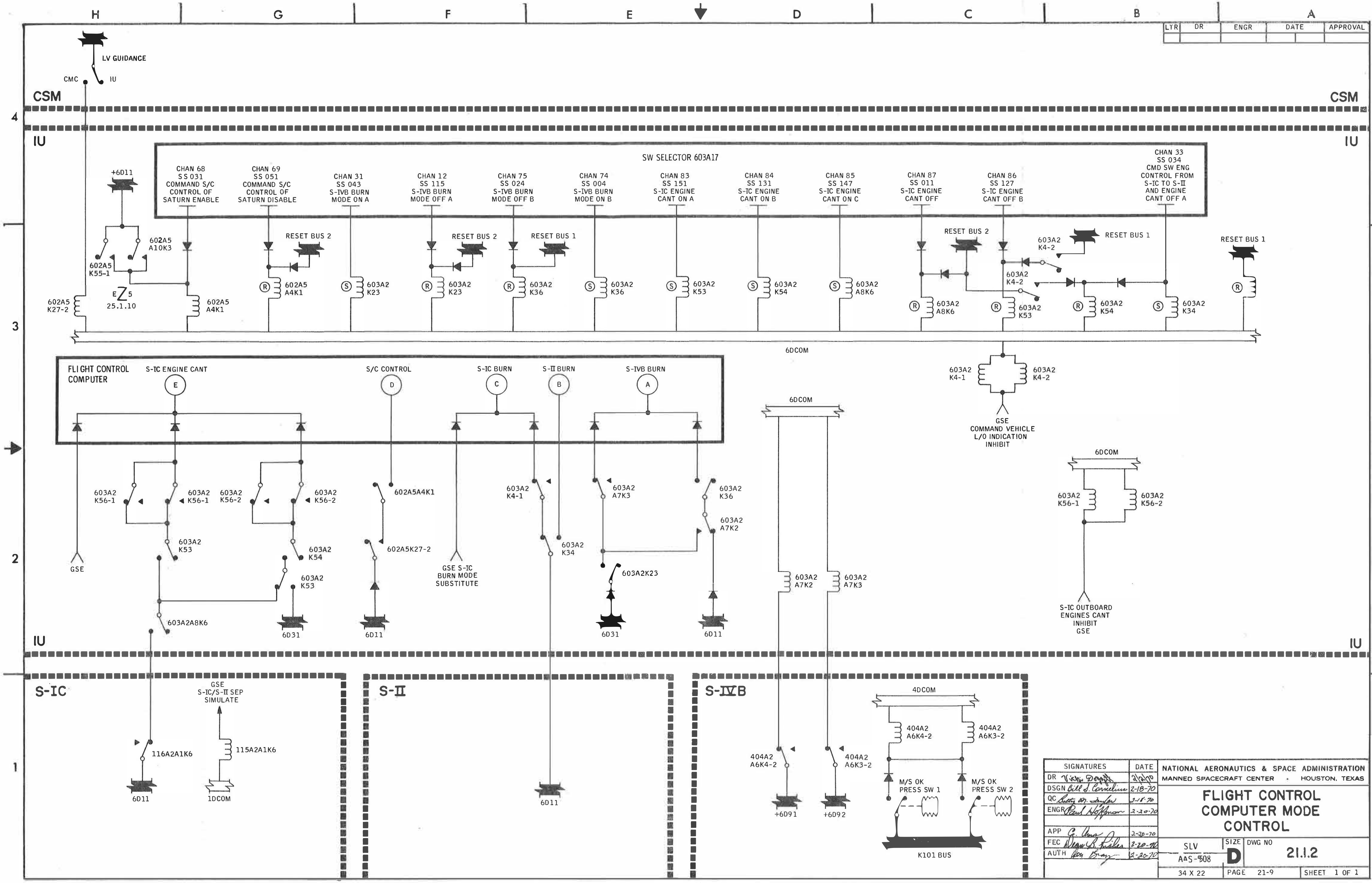


Programed ψ limits

No.	Limit	Pitch-Yaw	Roll
1	2.5°	TB5+0-TB6-9 TB7+0-TB7+900 First maneuver after TB7+900	
2	3.5°	TB6-9 - TB6+583	TB4+0-TB7+900 First maneuver after TB7+900
3	4.5°	TB7+900- until next maneuver	TB7+900- until next maneuver

Figure 21-1. - APS pseudo rate modulator characteristics.


H G F E D C B A
IU
S-IVB
S-II
S-IC
CONTROL EDS RATE GYRO PACKAGE
CONTROL SIGNAL PROCESSOR SEE DWG 21.3.1
PITCH RATE
YAW RATE
ROLL RATE
S-IC ACTUATOR OUTPUTS
MODE CONTROL SEE DWG 21.1.2
ST 124 STABLE PLATFORM
LAUNCH VEHICLE DIGITAL COMPUTER
LAUNCH VEHICLE DATA ADAPTER
IU G&N STEERING COMMANDS
S-II ACTUATOR OUTPUTS
H55-603 YAW LADDER OUTPUT ±15 DEG DP1A0-02-09 CP1A0-02-09
H56-603 ROLL LADDER OUTPUT ±15 DEG DP1A0-02-10 CP1A0-02-10
H54-603 PITCH LADDER OUTPUT ±15 DEG DP1A0-02-08 CP1A0-02-08
Z 27.1.1
SPACECRAFT ATTITUDE ERRORS
S-IVB MAIN ENGINE OUTPUTS
6D11 28VDC
6D31 28VDC
K6
FLIGHT CONTROL COMPUTER
S-IVB APS OUTPUTS
FCC POWER (GSE)
ON
OFF
6DCOM
603A2 CONTROL DISTRIBUTER
S-IC ENGINES VIEWED FROM AFT
SEE DWG 21.2.2 FOR ACTUATOR TELEMETRY
S-II ENGINES VIEWED FROM AFT
SEE DWG 21.2.2 FOR ACTUATOR TELEMETRY
ENGINE GIMBAL ACTUATORS
G1-403 PITCH ACT ±7.5 DEG DP1B0-23-01 CP1B0-23-01
G2-403 YAW ACT ±7.5 DEG DP1B0-23-02 CP1B0-23-02
G2-400 YAW ACT ±7.5 DEG CP1A0V24-00
G1-400 PITCH ACT ±7.5 DEG CP1A0V23-00
S-IVB MAIN ENGINE
R-Y I
R-Y II
PITCH
CONTROL RELAY PACKAGES
APS CONTROL
APS
LTR DR ENGR DATE APPROVAL
SIGNATURES DATE
DR 2-4-69
DSGN 3-14-69
QC 3-14-69
ENGR 3-12-69
APP 3/13/69
FEC 3/14/69
AUTH
NATIONAL AERONAUTICS & SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER • HOUSTON, TEXAS
FLIGHT CONTROL COMPUTER INTERFACE DWG
SLV
AS-508
34 X 22
SIZE D
DWG NO 21.1.1
PAGE 21-8
SHEET 1 OF 1


H
G
F
E
D
C
B
A
LTR
DR
ENGR
DATE
APPROVAL
LV GUIDANCE
CMC
IU
CSM
IU
SW SELECTOR 603A17
CHAN 68 SS 031 COMMAND S/C CONTROL OF SATURN ENABLE
CHAN 69 SS 051 COMMAND S/C CONTROL OF SATURN DISABLE
CHAN 31 SS 043 S-IVB BURN MODE ON A
CHAN 12 SS 115 S-IVB BURN MODE OFF A
CHAN 75 SS 024 S-IVB BURN MODE OFF B
CHAN 74 SS 004 S-IVB BURN MODE ON B
CHAN 83 SS 151 S-IC ENGINE CANT ON A
CHAN 84 SS 131 S-IC ENGINE CANT ON B
CHAN 85 SS 147 S-IC ENGINE CANT ON C
CHAN 87 SS 011 S-IC ENGINE CANT OFF
CHAN 86 SS 127 S-IC ENGINE CANT OFF B
CHAN 33 SS 034 CMD SW ENG CONTROL FROM S-IC TO S-II AND ENGINE CANT OFF A
+6D11
602A5 A10K3
602A5 K55-1
25.1.10
602A5 K27-2
602A5 A4K1
RESET BUS 2
RESET BUS 1
603A2 K23
603A2 K36
603A2 K53
603A2 K54
603A2 A8K6
603A2 K4-2
603A2 K34
6DCOM
FLIGHT CONTROL COMPUTER
S-IC ENGINE CANT
S/C CONTROL
S-IC BURN
S-II BURN
S-IVB BURN
603A2 K4-1
GSE COMMAND VEHICLE L/O INDICATION INHIBIT
603A2 K56-1
603A2 K56-2
602A5A4K1
602A5K27-2
603A2 A7K3
603A2 A7K2
603A2K23
GSE
GSE S-IC BURN MODE SUBSTITUTE
603A2A8K6
6D31
6D11
S-IC OUTBOARD ENGINES CANT INHIBIT GSE
S-IC
S-II
S-IVB
GSE S-IC/S-II SEP SIMULATE
116A2A1K6
115A2A1K6
1DCOM
4DCOM
404A2 A6K4-2
404A2 A6K3-2
+6D91
+6D92
M/S OK PRESS SW 1
M/S OK PRESS SW 2
K101 BUS
SIGNATURES
DATE
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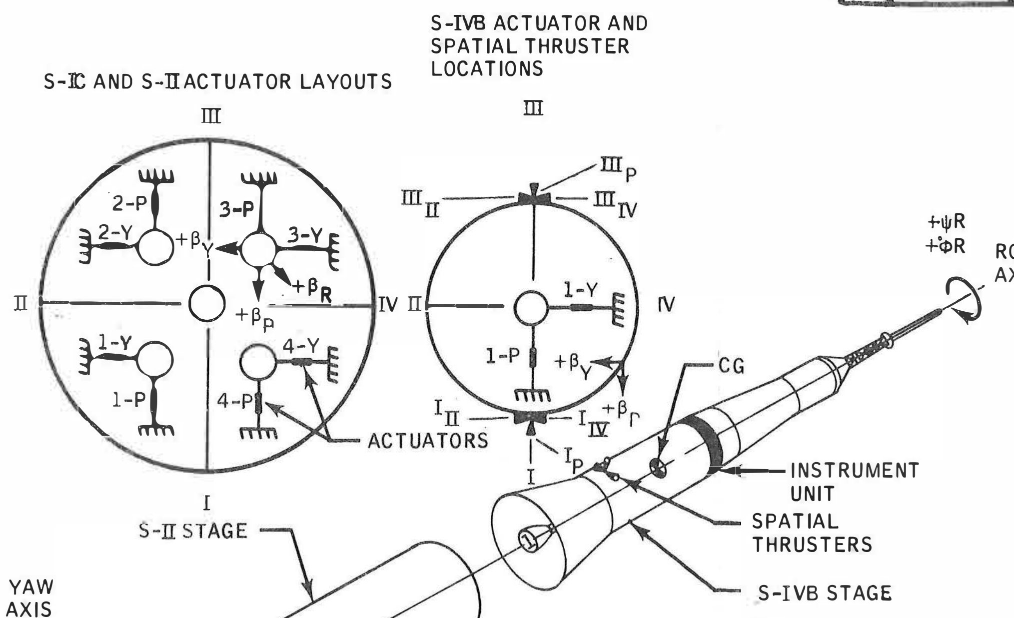
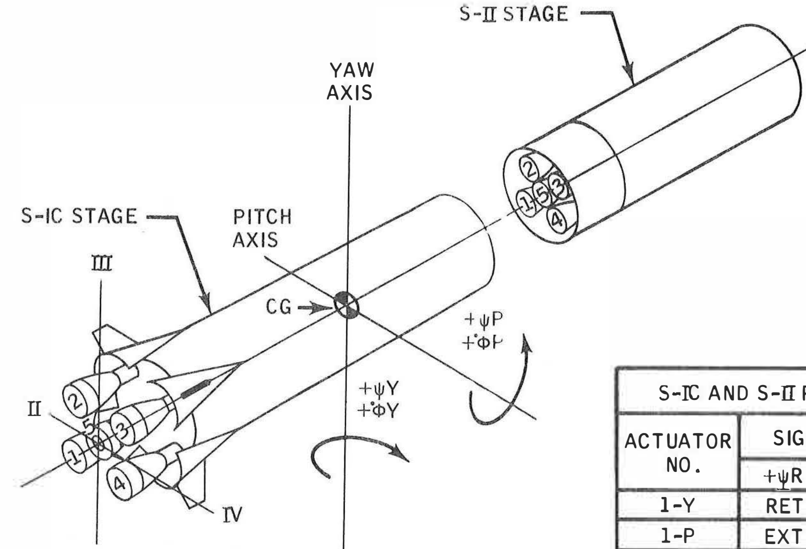
MANNED SPACECRAFT CENTER · HOUSTON, TEXAS
FLIGHT CONTROL COMPUTER MODE CONTROL
DSGN 2-18-70
QC 2-18-70
ENGR 2-20-70
APP 2-20-70
FEC 2-20-70
AUTH 2-20-70
SLV
AAS-508
SIZE D
DWG NO 21.1.2
34 X 22
PAGE 21-9
SHEET 1 OF 1

LTR	ENGR	REVISION	DATE	APPROVAL

NOTES:

1. ALL SIGNAL ARROWS INDICATE POSITIVE VEHICLE MOVEMENTS.
2. VEHICLE PITCHES OVER POSITION 1.
3. ENGINE ACTUATOR LAYOUTS SHOWN AS VIEWED FROM AFT END OF VEHICLE.
4. DIRECTIONS AND POLARITIES SHOWN ARE TYPICAL FOR ALL STAGES.
5. + β INDICATES ENGINE DEFLECTION REQUIRED TO CORRECT FOR POSITIVE VEHICLE MOVEMENT.
6. CG = CENTER OF GRAVITY
   F = NOZZLES ON
   EXT = ACTUATOR EXTENDED
   RET = ACTUATOR RETRACTED
   β = THRUST VECTOR ANGULAR DEFLECTION





S-IC AND S-II POLARITY TABLE			
ACTUATOR NO.	SIGNAL AND ACTION		
	+ψR	+ψY	+ψP
1-Y	RET	RET	
1-P	EXT		RET
2-Y	EXT	RET	
2-P	RET		EXT
3-Y	RET	EXT	
3-P	EXT		EXT
4-Y	EXT	EXT	
4-P	RET		RET

S-IVB POLARITY TABLE				
ACTUATOR NO.	SIGNAL AND ACTION			
	+ψR	-ψR	+ψY	+ψP
1-Y			EXT	
1-P				RET
THRUSTER NO				
I_{IV}		F		
I_P				
I_{II}	F			
III_{II}		F		
III_P				
III_{IV}	F			

CONDITIONS DURING COAST						
	+ψR	-ψR	+ψY	-ψY	+ψP	-ψP
I_{IV}		F		F		
I_P					F	
I_{II}	F		F			
III_{II}		F	F			
III_P						F
III_{IV}	F			F		

PHYSICAL AND FUNCTION RELATIONSHIP OF THE SATURN V CONTROL SYSTEM COMPONENTS

SIGNATURES	DATE
DR Wade Williams	2-5-69
DSGN Fred Whitehead	3-14-69
QC Betty M. Taylor	3-14-69
ENGR E. Hoffman	3-12-69
APP C. Owens	3/13/69
FEC Dean L. Fisher	3/14/69
AUTH Roy Bray	3-17-69

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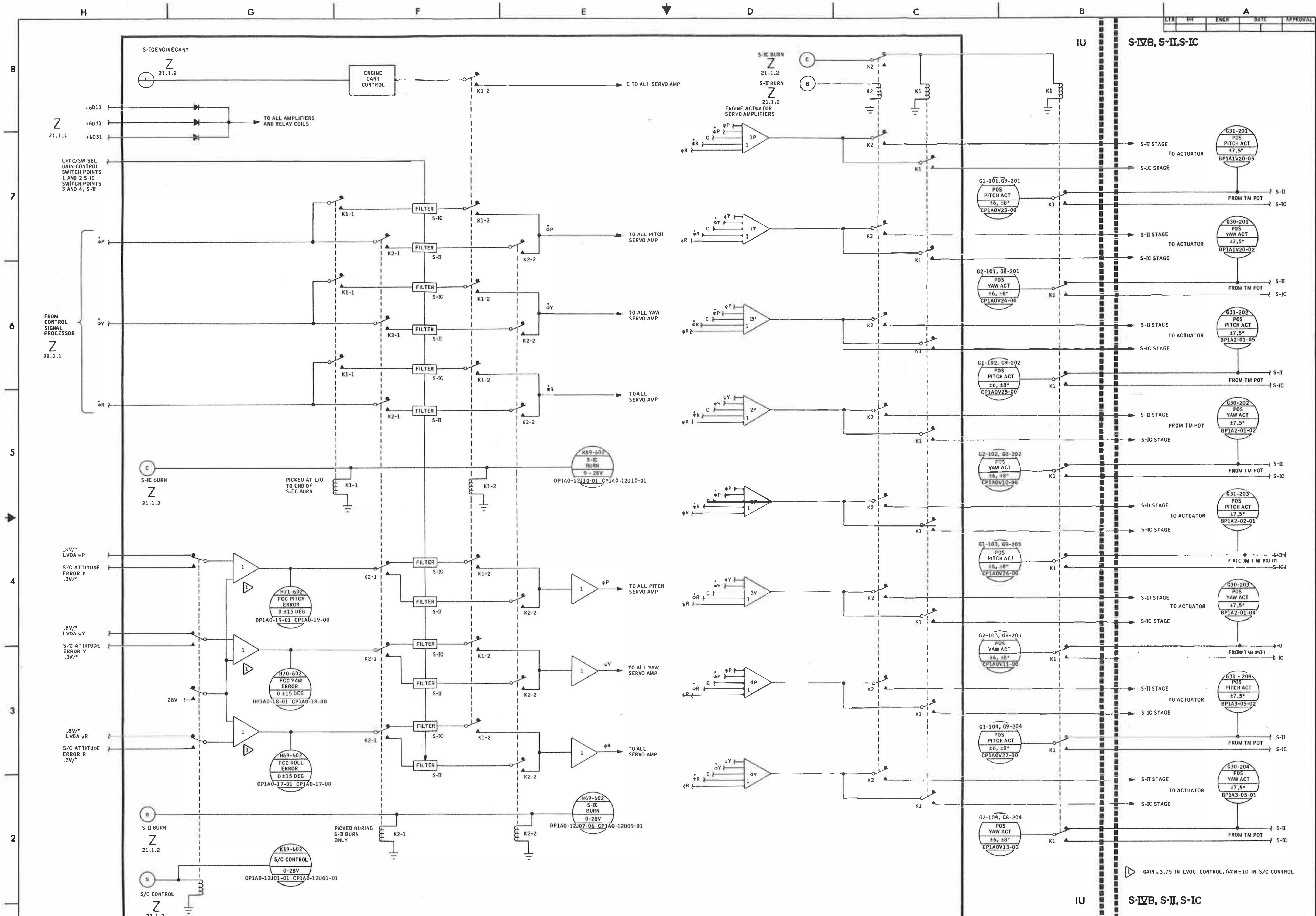
SATURN V CONTROL SYSTEM

SLV	SIZE	DWG. NO.
AS-508	C	21.2.1
16 X 21	PAGE 21-10	SHEET 1 OF 1



SIGNATURES	DATE
OR [signature]	2-3-69
DSGN [signature]	3-14-69
QC [signature]	3-14-69
ENGR [signature]	3-12-69
APP [signature]	3/13/69
FEC [signature]	3/14/69
AUTH [signature]	3-?-69

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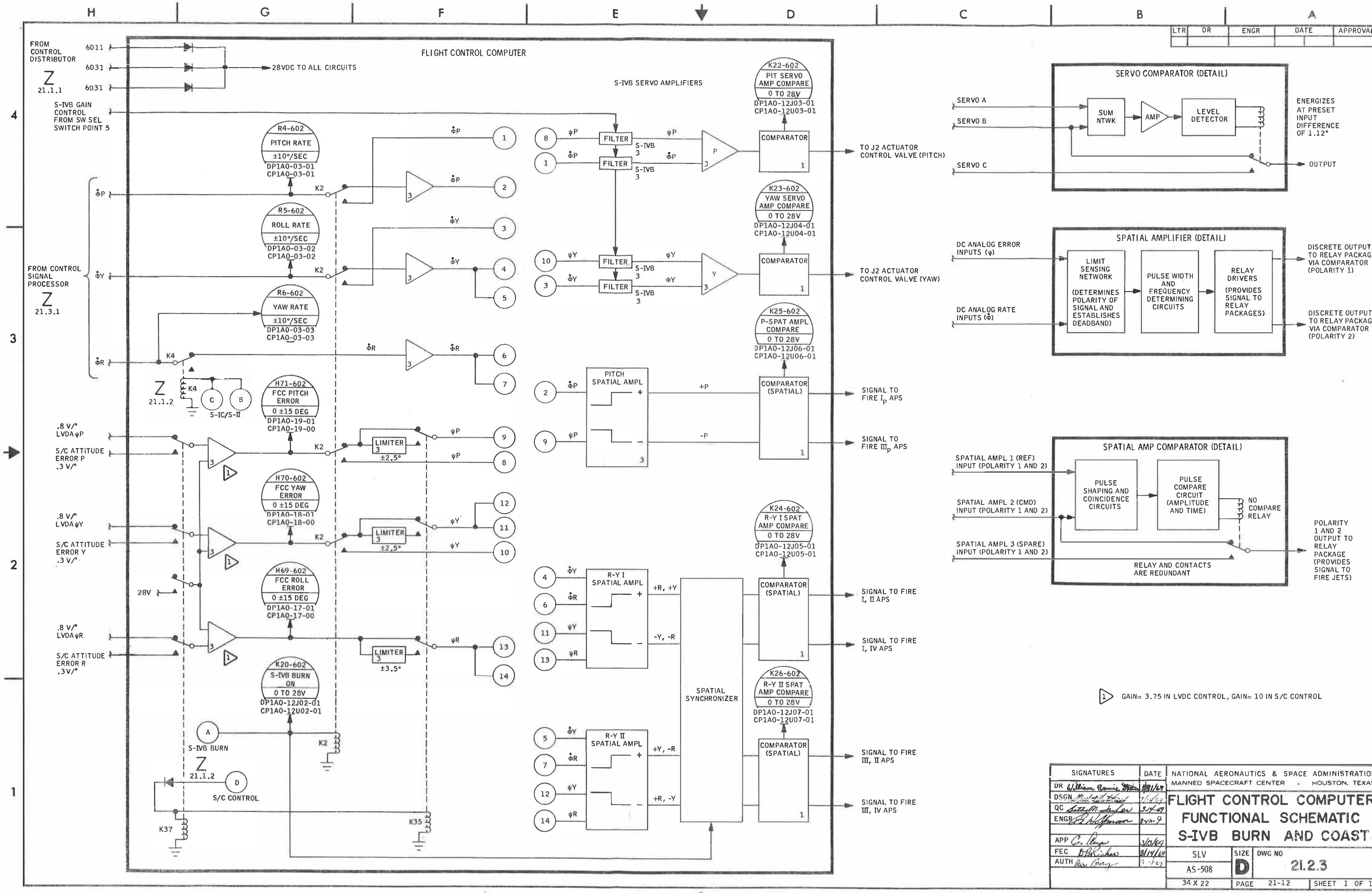
FLIGHT CONTROL COMPUTER FUNCTIONAL SCHEMATIC S-IC AND S-II BURN

SLV AS-508 | SIZE E | DWG NO 21.2.2

44 X 34 | PAGE 21-11 | SHEET 1 OF 1



FLIGHT CONTROL COMPUTER
FROM CONTROL DISTRIBUTOR
6D11
6D31
6D31
Z 21.1.1
28VDC TO ALL CIRCUITS
S-IVB GAIN CONTROL FROM SW SEL SWITCH POINT 5
S-IVB SERVO AMPLIFIERS
R4-602 PITCH RATE ±10°/SEC DP1A0-03-01 CP1A0-03-01
R5-602 ROLL RATE ±10°/SEC DP1A0-03-02 CP1A0-03-02
R6-602 YAW RATE ±10°/SEC DP1A0-03-03 CP1A0-03-03
FROM CONTROL SIGNAL PROCESSOR
Z 21.3.1
K2
K4
Z 21.1.2
S-IC/S-II
H71-602 FCC PITCH ERROR 0 ±15 DEG DP1A0-19-01 CP1A0-19-00
H70-602 FCC YAW ERROR 0 ±15 DEG DP1A0-18-01 CP1A0-18-00
H69-602 FCC ROLL ERROR 0 ±15 DEG DP1A0-17-01 CP1A0-17-00
K20-602 S-IVB BURN ON 0 TO 28V DP1A0-12J02-01 CP1A0-12U02-01
.8 V/° LVDAψP
S/C ATTITUDE ERROR P .3 V/°
.8 V/° LVDAψY
S/C ATTITUDE ERROR Y .3 V/°
28V
.8 V/° LVDAψR
S/C ATTITUDE ERROR R .3V/°
LIMITER ±2.5°
LIMITER ±2.5°
LIMITER ±3.5°
S-IVB BURN
Z 21.1.2
S/C CONTROL
K37
K35
FILTER
S-IVB
K22-602 PIT SERVO AMP COMPARE 0 TO 28V DP1A0-12J03-01 CP1A0-12U03-01
K23-602 YAW SERVO AMP COMPARE 0 TO 28V DP1A0-12J04-01 CP1A0-12U04-01
K25-602 P-SPAT AMPL COMPARE 0 TO 28V DP1A0-12J06-01 CP1A0-12U06-01
K24-602 R-Y I SPAT AMP COMPARE 0 TO 28V DP1A0-12J05-01 CP1A0-12U05-01
K26-602 R-Y II SPAT AMP COMPARE 0 TO 28V DP1A0-12J07-01 CP1A0-12U07-01
COMPARATOR
COMPARATOR (SPATIAL)
TO J2 ACTUATOR CONTROL VALVE (PITCH)
TO J2 ACTUATOR CONTROL VALVE (YAW)
PITCH SPATIAL AMPL
R-Y I SPATIAL AMPL
R-Y II SPATIAL AMPL
SPATIAL SYNCHRONIZER
SIGNAL TO FIRE I_P APS
SIGNAL TO FIRE III_P APS
SIGNAL TO FIRE I, II APS
SIGNAL TO FIRE I, IV APS
SIGNAL TO FIRE III, II APS
SIGNAL TO FIRE III, IV APS
SERVO COMPARATOR (DETAIL)
SERVO A
SERVO B
SERVO C
SUM NTWK
AMP
LEVEL DETECTOR
ENERGIZES AT PRESET INPUT DIFFERENCE OF 1.12°
OUTPUT
SPATIAL AMPLIFIER (DETAIL)
DC ANALOG ERROR INPUTS (ψ)
DC ANALOG RATE INPUTS (Φ̇)
LIMIT SENSING NETWORK (DETERMINES POLARITY OF SIGNAL AND ESTABLISHES DEADBAND)
PULSE WIDTH AND FREQUENCY DETERMINING CIRCUITS
RELAY DRIVERS (PROVIDES SIGNAL TO RELAY PACKAGES)
DISCRETE OUTPUT TO RELAY PACKAGE VIA COMPARATOR (POLARITY 1)
DISCRETE OUTPUT TO RELAY PACKAGE VIA COMPARATOR (POLARITY 2)
SPATIAL AMP COMPARATOR (DETAIL)
SPATIAL AMPL 1 (REF) INPUT (POLARITY 1 AND 2)
SPATIAL AMPL 2 (CMD) INPUT (POLARITY 1 AND 2)
SPATIAL AMPL 3 (SPARE) INPUT (POLARITY 1 AND 2)
PULSE SHAPING AND COINCIDENCE CIRCUITS
PULSE COMPARE CIRCUIT (AMPLITUDE AND TIME)
NO COMPARE RELAY
RELAY AND CONTACTS ARE REDUNDANT
POLARITY 1 AND 2 OUTPUT TO RELAY PACKAGE (PROVIDES SIGNAL TO FIRE JETS)
1 GAIN= 3.75 IN LVDC CONTROL, GAIN= 10 IN S/C CONTROL
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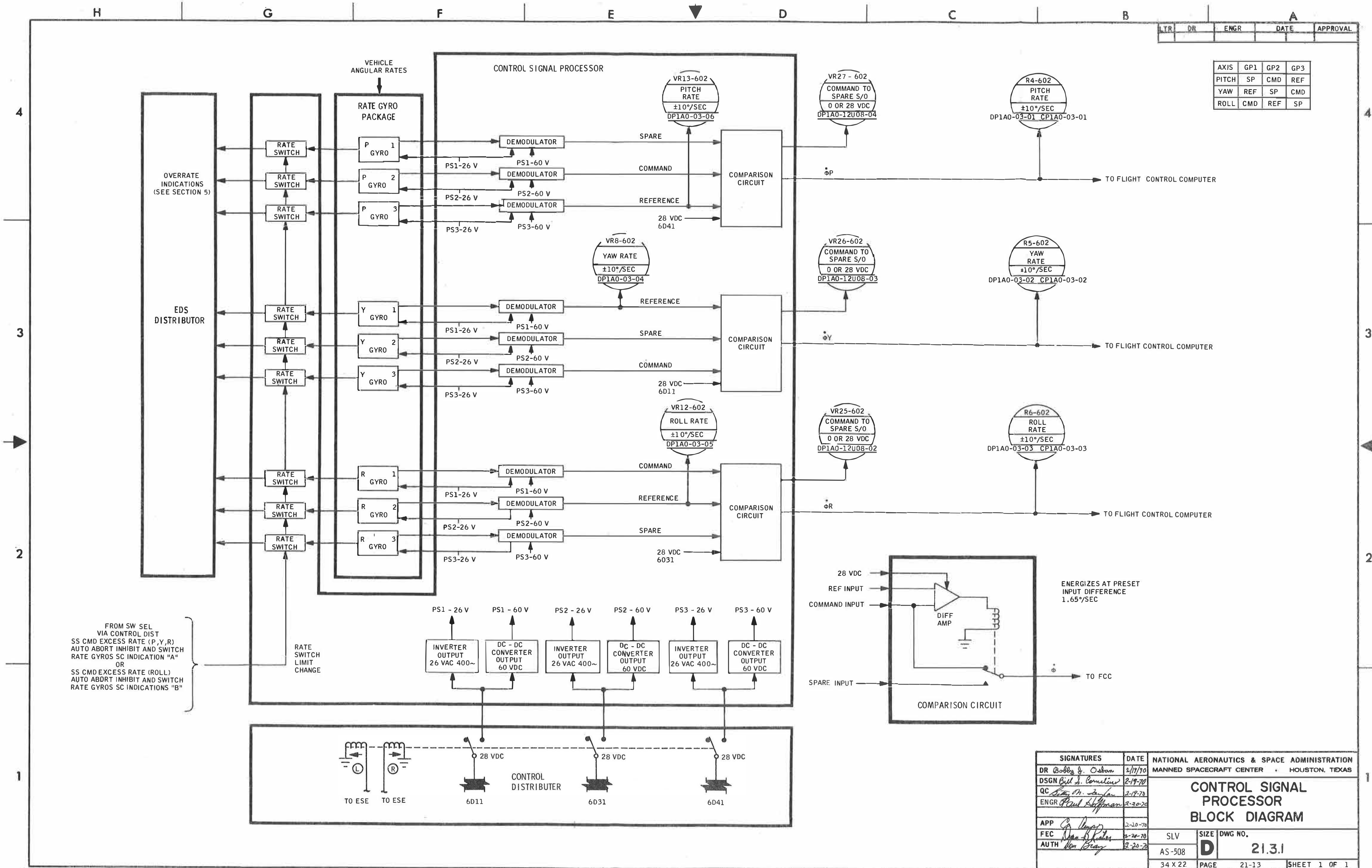
FLIGHT CONTROL COMPUTER FUNCTIONAL SCHEMATIC S-IVB BURN AND COAST
SLV AS-508
SIZE D
DWG NO 21.2.3
34 X 22
PAGE 21-12
SHEET 1 OF 1



AXIS	GP1	GP2	GP3
PITCH	SP	CMD	REF
YAW	REF	SP	CMD
ROLL	CMD	REF	SP

LTR	DR	ENGR	DATE	APPROVAL

SIGNATURES	DATE
DR Bobby J. Osborn	2/19/70
DSGN Bill S. Cornelius	2-19-70
QC Betty M. Taylor	2-19-70
ENGR Paul Hoffman	2-20-70
APP	2-20-70
FEC	2-20-70
AUTH	2-20-70

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CONTROL SIGNAL PROCESSOR BLOCK DIAGRAM

SLV AS-508 | SIZE D | DWG NO. 21.3.1

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MSC Form 1616 D (REV OCT 65)

22 IU
ENVIRONMENTAL
CONTROL SYSTEMS

SECTION 22

IU ENVIRONMENTAL CONTROL SYSTEM

22.1 GENERAL NOTES

A. The environmental control system (ECS) controls the thermal environment for the IU and S-IVB electronics equipment and also conditions the GN_2 supplied to the gas bearings of the ST-124 inertial platform. The main components of the system are an inflight sublimator, a water accumulator, a coolant accumulator, cold plates, and GN_2 storage spheres. The coolant solution used in the ECS is 60 percent methanol/40 percent water.

B. During preflight operation, the coolant pump begins operating as soon as external battery power is applied to the stage. The coolant accumulator provides a constant pressure at the pump inlet. As the coolant circulates through the system, it absorbs heat from the cold plates, ST-124 inertial platform, LVDA, and LVDC. The absorbed heat is transferred to GSE equipment through the preflight heat exchanger. The temperature sensor (thermistor) senses the coolant temperature and transmits a signal to the electronic control assembly (ECA). The ECA actuates the modulating flow control valve so that part of the coolant flow bypasses the heat exchanger. Through the action of the sensor, ECA, and the valve, coolant temperature is maintained at $59 \pm 1°F$. When power is applied to the IU, the modulating flow control valve is put in the full sublimator flow position for the mission.

C. At TB3 + 19.4 seconds, lift-off + 3 minutes, the LVDC/LVDA program commands "Water Valve Open," allowing water to flow from the water accumulator to the sublimator. The water absorbs the heat from the circulating methanol/water coolant, and the vapor from the sublimation is vented overboard. The LVDC/LVDA "program control" of the water valve is enabled at lift-off + 8 minutes allowing the LVDC/LVDA to test two discretes from two thermal switches every 5 minutes. The onboard program decides if the water valve should be commanded open or closed, thus maintaining proper environmental temperature control of the IU and upper S-IVB electrical components.

D. GN_2 is utilized to pressurize the methanol/water accumulator (15 psia) and the water accumulator (5 psia). GN_2 pressure within the methanol/water accumulator assures that the coolant pump will not cavitate in the rarified atmosphere of space. The water accumulator is pressurized with GN_2 to insure that the water will flow from the accumulator to the sublimator.

E. The ECS supplies conditioned GN_2 to the gas bearings of the ST-124 inertial platform during preflight and inflight operations. GN_2 is supplied from a sphere through the pressure regulator and flows to a heat exchanger where the GN_2 is conditioned by the methanol/water coolant. The conditioned GN_2 then flows to the ST-124 inertial platform's gas bearings. A reference pressure line routes gas bearing pressure from the platform back to the pressure regulator. The reference pressure causes the pressure regulator to increase its output when the platform bearing pressure falls below rated pressure and to decrease the output when the bearing pressure rises above the rated pressure. The gas bearings, therefore, receive a constant flow as system sphere pressure changes.

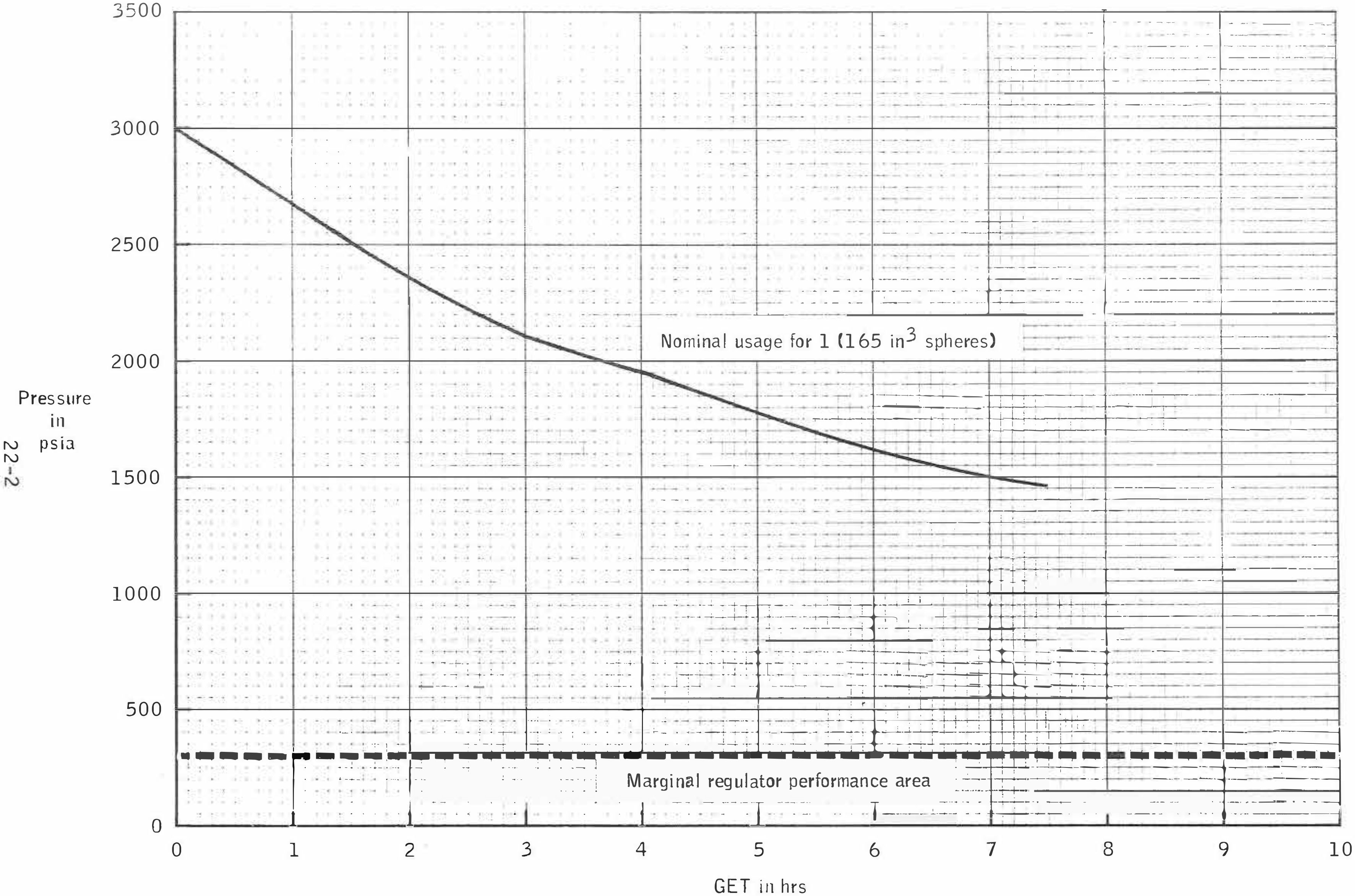


Figure 22-1. - TCS GN_2 sphere pressure (D25-601).

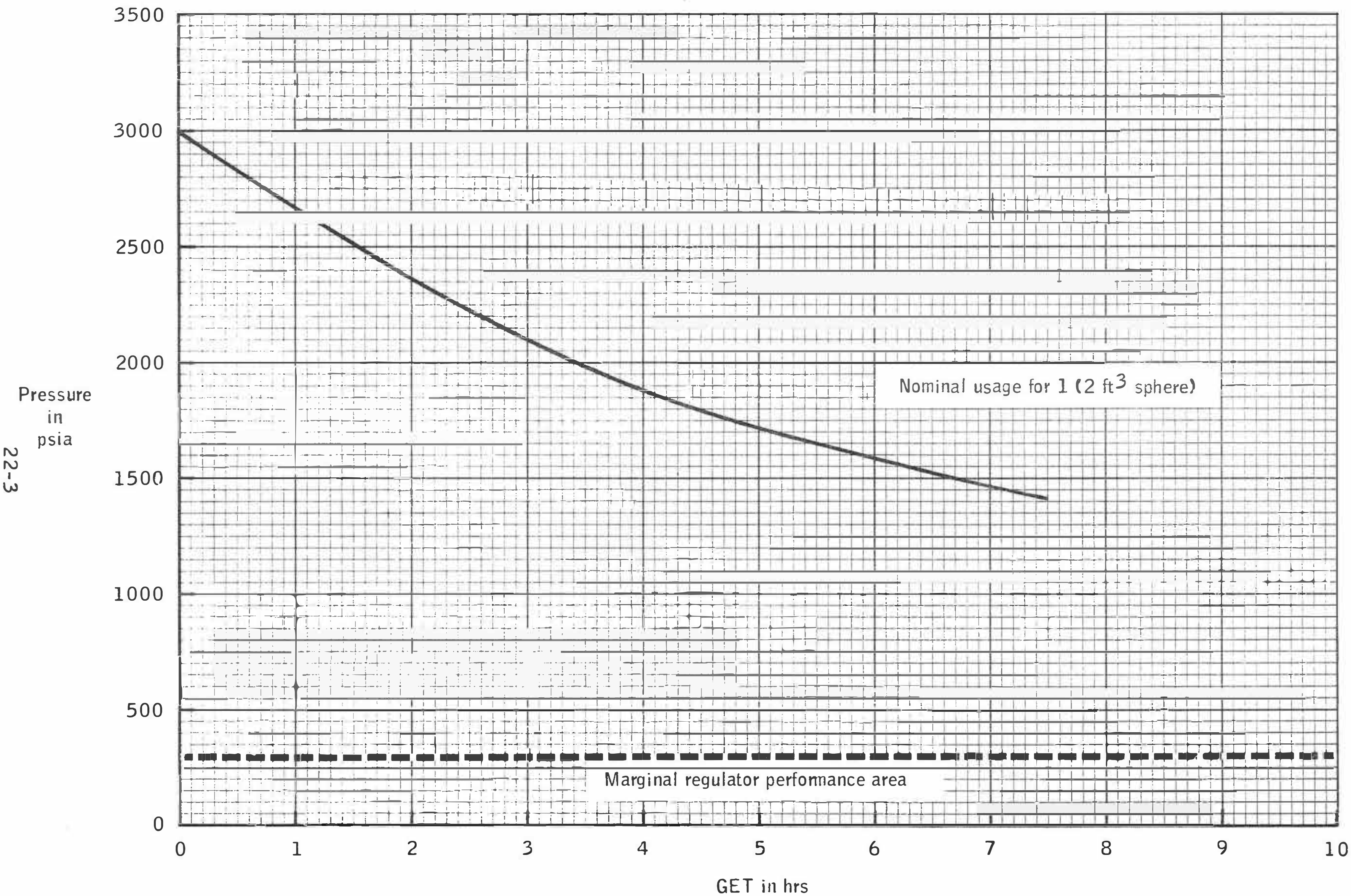
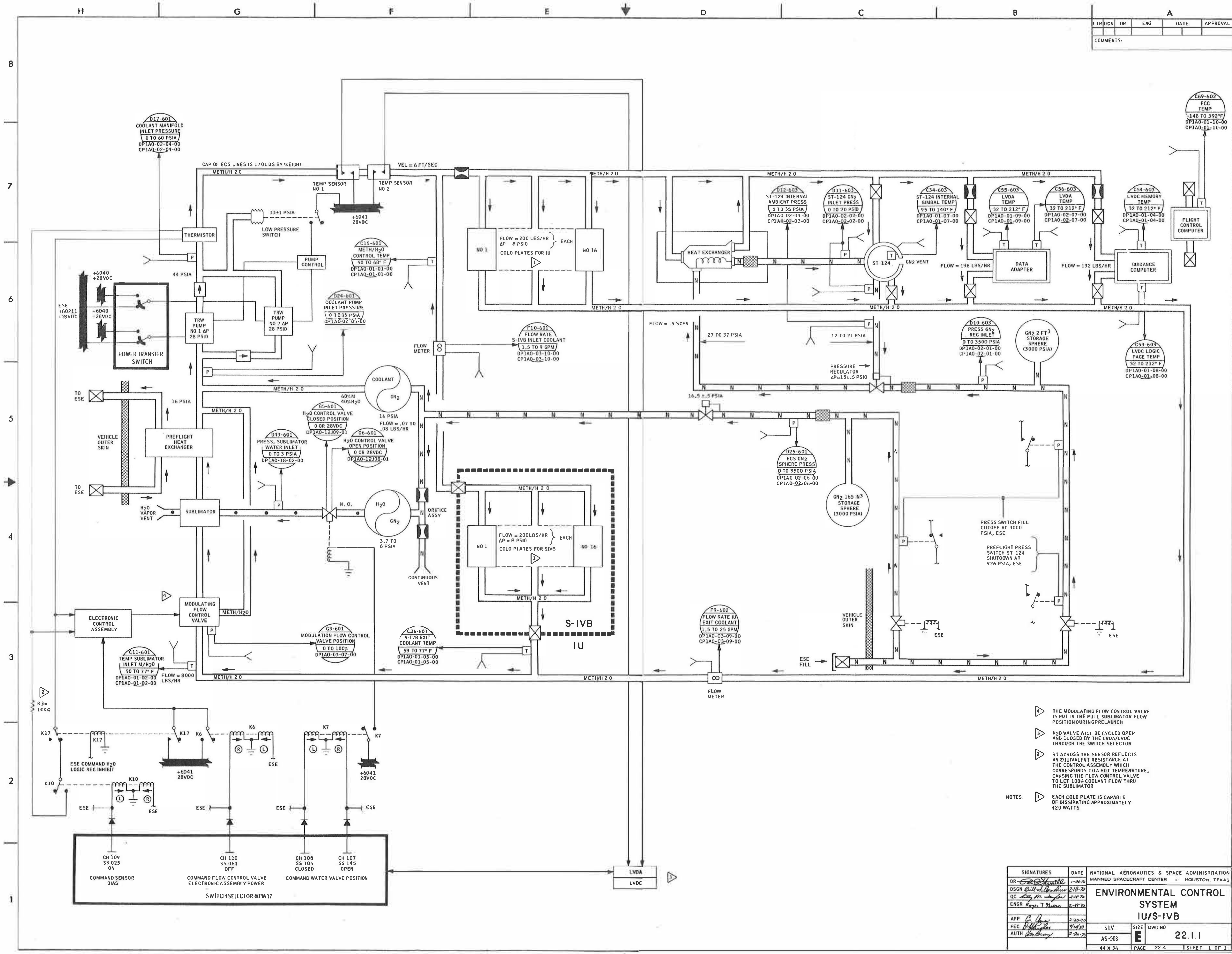


Figure 22-2. - GBS GN_2 sphere pressure (D10-603).



CAP OF ECS LINES IS 170 LBS BY WEIGHT
VEL = 6 FT/SEC
METH/H 2 0
TEMP SENSOR NO 1
TEMP SENSOR NO 2
D17-601 COOLANT MANIFOLD INLET PRESSURE 0 TO 60 PSIA DP1A0-02-04-00 CP1A0-02-04-00
THERMISTOR
33±1 PSIA
LOW PRESSURE SWITCH
+6041 28VDC
PUMP CONTROL
C15-601 METH/H2O CONTROL TEMP 50 TO 68° F DP1A0-01-01-00 CP1A0-01-01-00
44 PSIA
D24-601 COOLANT PUMP INLET PRESSURE 0 TO 35 PSIA DP1A0-02-05-00
TRW PUMP NO 1 ΔP 28 PSID
TRW PUMP NO 2 ΔP 28 PSID
POWER TRANSFER SWITCH
ESE +6021 +28VDC
+6040 +28VDC
FLOW METER
F10-601 FLOW RATE S-IVB INLET COOLANT 1.5 TO 9 GPM DP1A0-03-10-00 CP1A0-03-10-00
FLOW = 200 LBS/HR ΔP = 8 PSID EACH
COLD PLATES FOR IU
NO 1
NO 16
COOLANT
GN2
60%M 40%H2O
16 PSIA
FLOW = .07 TO .08 LBS/HR
TO ESE
VEHICLE OUTER SKIN
PREFLIGHT HEAT EXCHANGER
G5-601 H2O CONTROL VALVE CLOSED POSITION 0 OR 28VDC DP1A0-12J09-01
G6-601 H2O CONTROL VALVE OPEN POSITION 0 OR 28VDC DP1A0-12J08-01
D43-601 PRESS, SUBLIMATOR WATER INLET 0 TO 3 PSIA DP1A0-18-02-00
H2O VAPOR VENT
SUBLIMATOR
N.O.
H2O
3.7 TO 6 PSIA
ORIFICE ASSY
CONTINUOUS VENT
FLOW = 200LBS/HR ΔP = 8 PSID EACH
COLD PLATES FOR SIVB
S-IVB
IU
MODULATING FLOW CONTROL VALVE
ELECTRONIC CONTROL ASSEMBLY
G3-601 MODULATION FLOW CONTROL VALVE POSITION 0 TO 100% DP1A0-03-07-00
C26-601 S-IVB EXIT COOLANT TEMP 59 TO 77° F DP1A0-01-05-00 CP1A0-01-05-00
C11-601 TEMP SUBLIMATOR INLET M/H2O 50 TO 77° F DP1A0-01-02-00 CP1A0-01-02-00
FLOW = 8000 LBS/HR
R3= 10KΩ
K17
K6
K7
K10
ESE COMMAND H2O LOGIC REG INHIBIT
+6041 28VDC
ESE
CH 109 SS 025 ON COMMAND SENSOR BIAS
CH 110 SS 064 OFF COMMAND FLOW CONTROL VALVE ELECTRONIC ASSEMBLY POWER
CH 108 SS 105 CLOSED
CH 107 SS 145 OPEN
COMMAND WATER VALVE POSITION
SWITCH SELECTOR 603A17
LVDA
LVDC
HEAT EXCHANGER
D12-603 ST-124 INTERNAL AMBIENT PRESS 0 TO 35 PSIA DP1A0-02-03-00 CP1A0-02-03-00
D11-603 ST-124 GN2 INLET PRESS 0 TO 20 PSID DP1A0-02-02-00 CP1A0-02-02-00
C34-603 ST-124 INTERNAL GIMBAL TEMP 95 TO 140° F DP1A0-01-07-00 CP1A0-01-07-00
C55-603 LVDA TEMP 32 TO 212° F DP1A0-01-09-00 CP1A0-01-09-00
C56-603 LVDA TEMP 32 TO 212° F DP1A0-02-07-00 CP1A0-02-07-00
C54-603 LVDC MEMORY TEMP 32 TO 212° F DP1A0-01-04-00 CP1A0-01-04-00
C69-602 FCC TEMP -148 TO 392° F DP1A0-01-10-00 CP1A0-01-10-00
FLIGHT CONTROL COMPUTER
ST 124
GN2 VENT
FLOW = 198 LBS/HR
DATA ADAPTER
FLOW = 132 LBS/HR
GUIDANCE COMPUTER
FLOW = .5 SCFM
27 TO 37 PSIA
12 TO 21 PSIA
D10-603 PRESS GN2 REG INLET 0 TO 3500 PSIA DP1A0-02-01-00 CP1A0-02-01-00
GN2 2 FT3 STORAGE SPHERE (3000 PSIA)
C53-603 LVDC LOGIC PAGE TEMP 32 TO 212° F DP1A0-01-08-00 CP1A0-01-08-00
PRESSURE REGULATOR ΔP=15±.5 PSID
16.5 ±.5 PSIA
D25-601 ECS GN2 SPHERE PRESS 0 TO 3500 PSIA DP1A0-02-06-00 CP1A0-02-06-00
GN2 165 IN3 STORAGE SPHERE (3000 PSIA)
PRESS SWITCH FILL CUTOFF AT 3000 PSIA, ESE
PREFLIGHT PRESS SWITCH ST-124 SHUTDOWN AT 926 PSIA, ESE
F9-602 FLOW RATE IU EXIT COOLANT 1.5 TO 25 GPM DP1A0-03-09-00 CP1A0-03-09-00
VEHICLE OUTER SKIN
ESE FILL
FLOW METER
4 THE MODULATING FLOW CONTROL VALVE IS PUT IN THE FULL SUBLIMATOR FLOW POSITION DURING PRELAUNCH
3 H2O VALVE WILL BE CYCLED OPEN AND CLOSED BY THE LVDA/LVDC THROUGH THE SWITCH SELECTOR
2 R3 ACROSS THE SENSOR REFLECTS AN EQUIVALENT RESISTANCE AT THE CONTROL ASSEMBLY WHICH CORRESPONDS TO A HOT TEMPERATURE, CAUSING THE FLOW CONTROL VALVE TO LET 100% COOLANT FLOW THRU THE SUBLIMATOR
NOTES: 1 EACH COLD PLATE IS CAPABLE OF DISSIPATING APPROXIMATELY 420 WATTS
SIGNATURES DATE
DR 1-30-70
DSGN Bill L. Cornelius 2-18-70
QC 2-18-70
ENGR Roger T Beers 2-19-70
APP 2-20-70
FEC 2-20-70
AUTH 2-20-70
NATIONAL AERONAUTICS & SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER - HOUSTON, TEXAS
ENVIRONMENTAL CONTROL SYSTEM IU/S-IVB
SLV AS-508
SIZE E
DWG NO 22.1.1
44 X 34
PAGE 22-4
SHEET 1 OF 1
LTR OCN DR ENG DATE APPROVAL
COMMENTS:

23 IU
INSTRUMENTATION
AND TELEMETRY

SECTION 23

IU INSTRUMENTATION AND TELEMETRY

23.1 TELEMETRY SYSTEMS

A. Each stage of the launch vehicle has an independent measuring and telemetry system with flight control measurements on redundant lines between the IU and S-IVB stages. Before launch, coaxial cables from each stage telemetry system supply digital data to the checkout facility. During flight, the telemetry data is radiated from separate antenna systems on each stage.

B. The Saturn vehicle contains the following telemetry systems:

Link	Modulation	Use	Frequency	Power Output
IU/S-IVB composite PCM flow diagram (see Drawing 23.1.1)				
IU (see Drawing 23.1.2)				
DP-1	PCM/FM	Operational and digital information	245.3 MHz	20 W
DF-1	FM/FM	Engineering data	250.7 MHz	20 W
DP-1B	CCS	Parallel to DP-1	2282.5 MHz	20 W
S-IVB (see Drawing 23.1.3)				
CP-1	PCM/FM	Engineering data	258.5 MHz	20 W
CS-1	SS/FM	Vibration and structure data	253.8 MHz	20 W
S-II (see Drawing 10.1.1)				
BF-1	FM/FM	Engineering data	241.5 MHz	20 W
BF-2	FM/FM	Engineering data	234.0 MHz	20 W
BP-1	PCM/FM	Operational and digital information	248.6 MHz	20 W
S-IC (see Drawing 5.1.1)				
AF-1	FM/FM	Engineering data	256.2 MHz	20 W
AP-1	PCM/FM	Operational and digital information	244.3 MHz	20 W

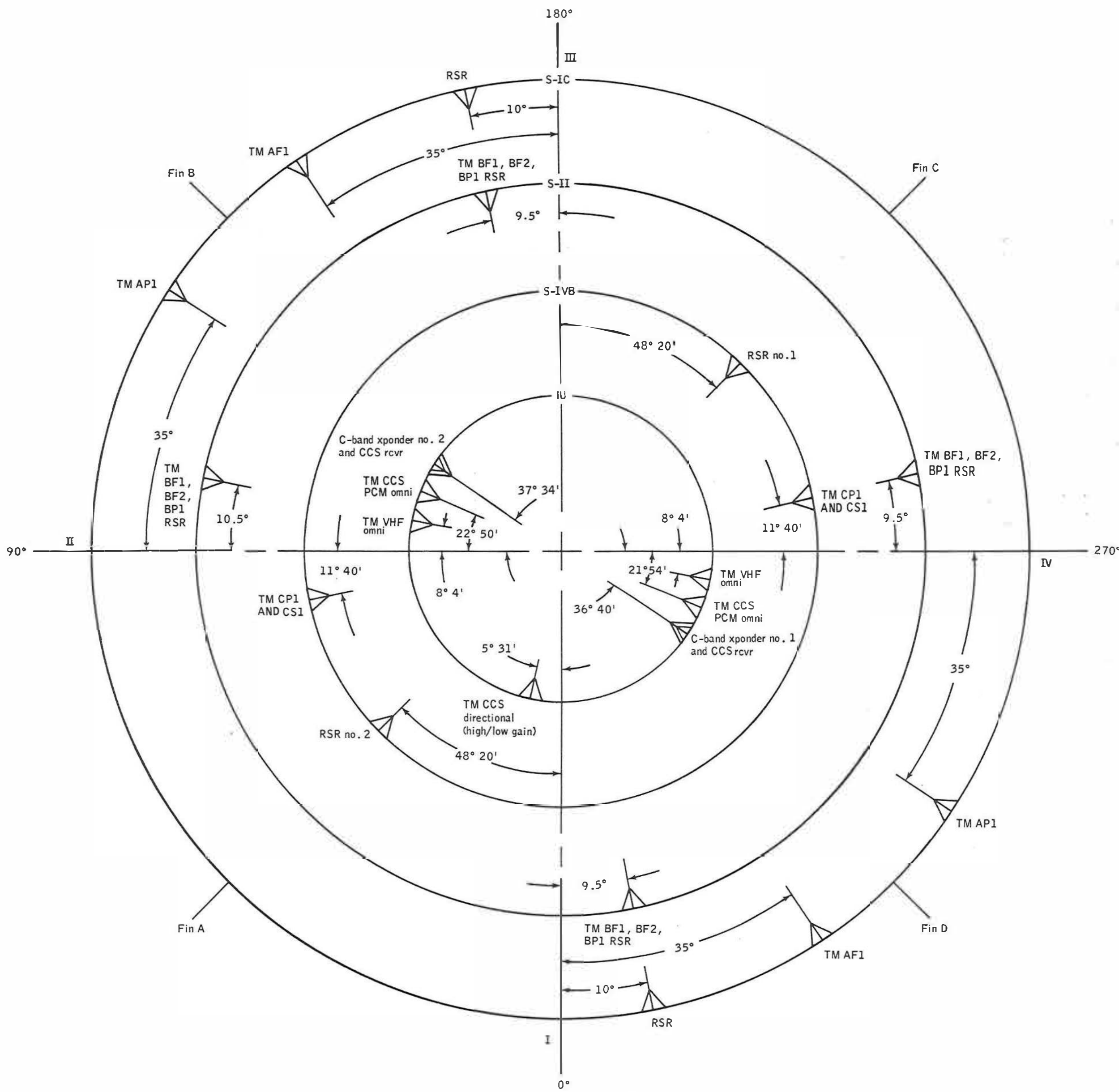


Figure 23-1. - SLV antenna location diagram (aft looking forward).

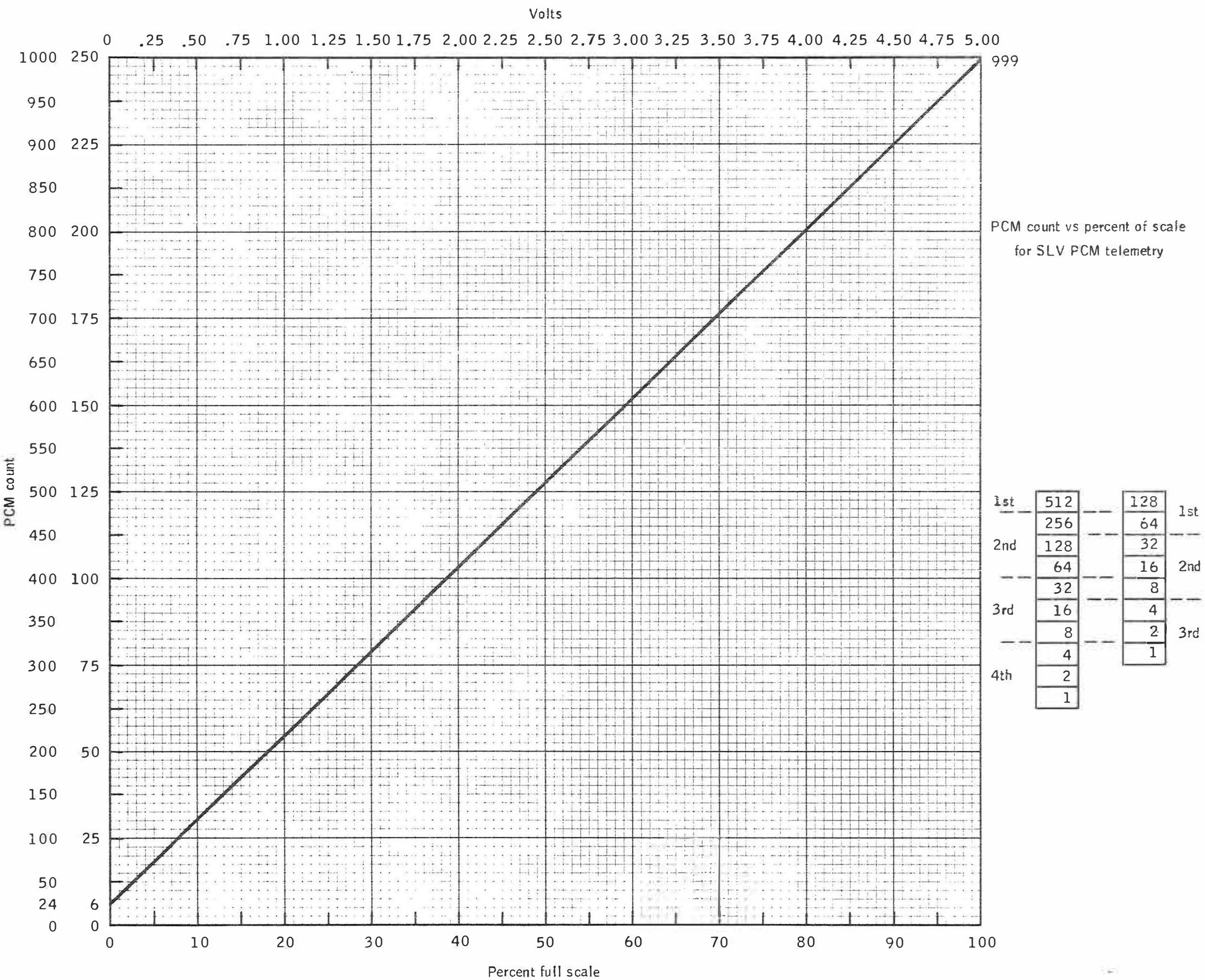
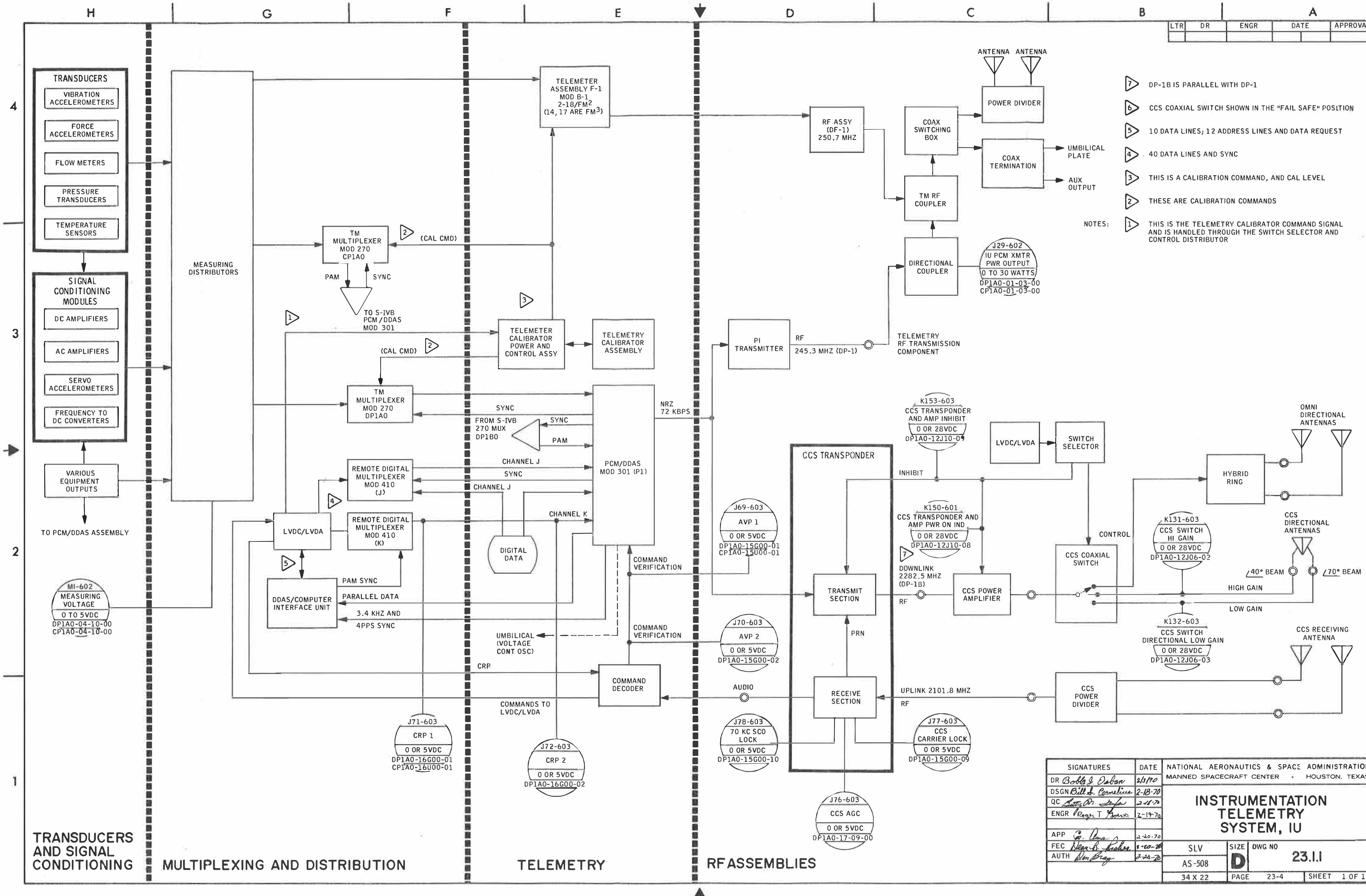
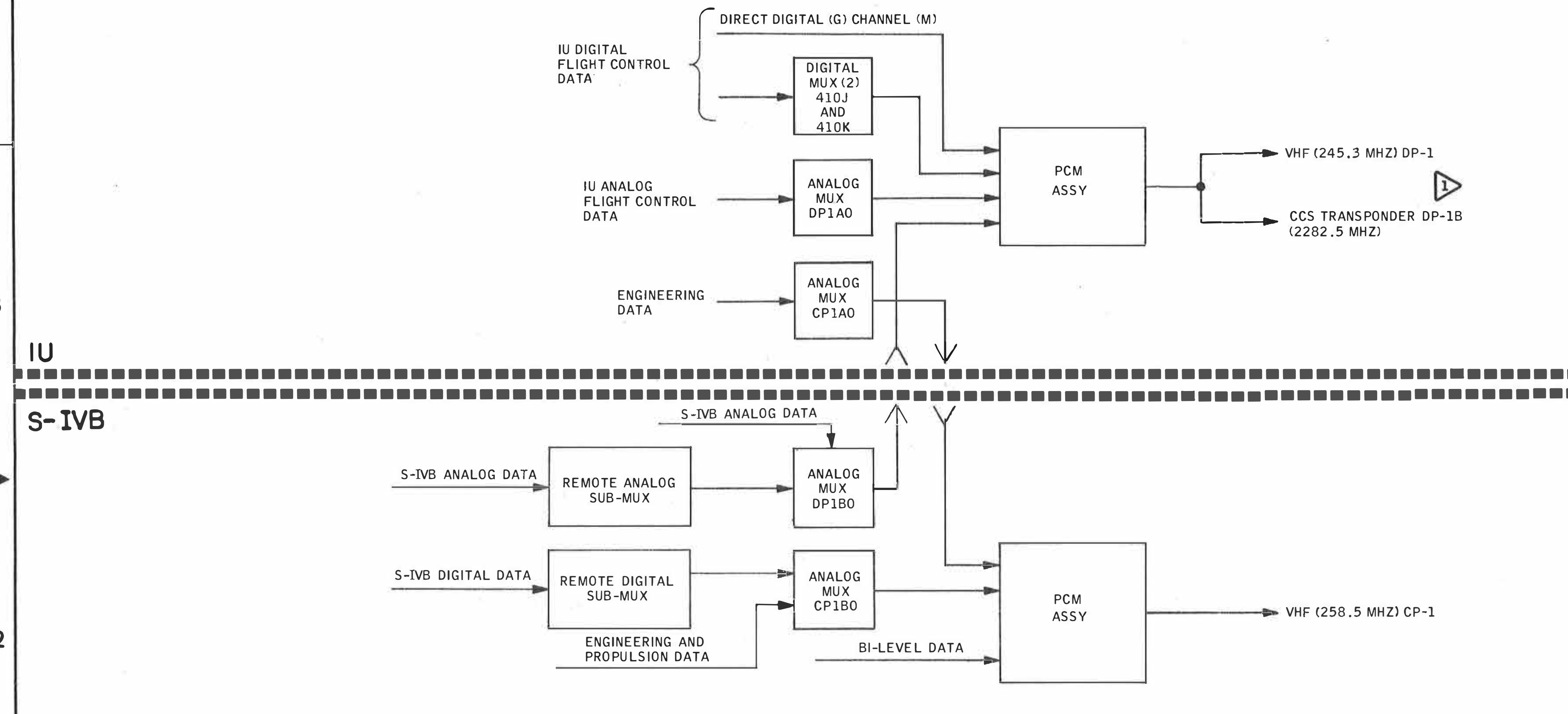


Figure 23-2. - PCN count conversion chart.



H G F E D C B A
LTR DR ENGR DATE APPROVAL
TRANSDUCERS
VIBRATION ACCELEROMETERS
FORCE ACCELEROMETERS
FLOW METERS
PRESSURE TRANSDUCERS
TEMPERATURE SENSORS
SIGNAL CONDITIONING MODULES
DC AMPLIFIERS
AC AMPLIFIERS
SERVO ACCELEROMETERS
FREQUENCY TO DC CONVERTERS
VARIOUS EQUIPMENT OUTPUTS
TO PCM/DDAS ASSEMBLY
MI-602 MEASURING VOLTAGE 0 TO 5VDC DP1A0-04-10-00 CP1A0-04-10-00
MEASURING DISTRIBUTORS
TM MULTIPLEXER MOD 270 CP1A0
(CAL CMD)
PAM SYNC
TO S-IVB PCM/DDAS MOD 301
TM MULTIPLEXER MOD 270 DP1A0
SYNC
FROM S-IVB 270 MUX DP1B0
REMOTE DIGITAL MULTIPLEXER MOD 410 (J)
REMOTE DIGITAL MULTIPLEXER MOD 410 (K)
CHANNEL J
CHANNEL K
LVDC/LVDA
DDAS/COMPUTER INTERFACE UNIT
PAM SYNC
PARALLEL DATA
3.4 KHZ AND 4PPS SYNC
DIGITAL DATA
J71-603 CRP 1 0 OR 5VDC DP1A0-16G00-01 CP1A0-16U00-01
J72-603 CRP 2 0 OR 5VDC DP1A0-16G00-02
TELEMETER ASSEMBLY F-1 MOD B-1 2-18/FM2 (14,17 ARE FM3)
TELEMETER CALIBRATOR POWER AND CONTROL ASSY
TELEMETRY CALIBRATOR ASSEMBLY
PCM/DDAS MOD 301 (P1)
NRZ 72 KBPS
COMMAND VERIFICATION
UMBILICAL (VOLTAGE CONT OSC)
CRP
COMMAND DECODER
COMMANDS TO LVDC/LVDA
AUDIO
J69-603 AVP 1 0 OR 5VDC DP1A0-15G00-01 CP1A0-15U00-01
J70-603 AVP 2 0 OR 5VDC DP1A0-15G00-02
J78-603 70 KC SCO LOCK 0 OR 5VDC DP1A0-15G00-10
RF ASSY (DF-1) 250.7 MHZ
PI TRANSMITTER
RF 245.3 MHZ (DP-1)
TELEMETRY RF TRANSMISSION COMPONENT
ANTENNA ANTENNA
POWER DIVIDER
COAX SWITCHING BOX
COAX TERMINATION
UMBILICAL PLATE
AUX OUTPUT
TM RF COUPLER
DIRECTIONAL COUPLER
J29-602 IU PCM XMTR PWR OUTPUT 0 TO 30 WATTS DP1A0-01-03-00 CP1A0-01-03-00
CCS TRANSPONDER
K153-603 CCS TRANSPONDER AND AMP INHIBIT 0 OR 28VDC DP1A0-12J10-09
INHIBIT
K150-601 CCS TRANSPONDER AND AMP PWR ON IND 0 OR 28VDC DP1A0-12J10-08
DOWNLINK 2282.5 MHZ (DP-1B)
RF
TRANSMIT SECTION
PRN
RECEIVE SECTION
UPLINK 2101.8 MHZ
RF
J77-603 CCS CARRIER LOCK 0 OR 5VDC DP1A0-15G00-09
J76-603 CCS AGC 0 OR 5VDC DP1A0-17-09-00
CCS POWER AMPLIFIER
LVDC/LVDA
SWITCH SELECTOR
CONTROL
CCS COAXIAL SWITCH
HYBRID RING
OMNI DIRECTIONAL ANTENNAS
K131-603 CCS SWITCH HI GAIN 0 OR 28VDC DP1A0-12J06-02
CCS DIRECTIONAL ANTENNAS
40° BEAM
70° BEAM
HIGH GAIN
LOW GAIN
K132-603 CCS SWITCH DIRECTIONAL LOW GAIN 0 OR 28VDC DP1A0-12J06-03
CCS RECEIVING ANTENNA
CCS POWER DIVIDER
7 DP-1B IS PARALLEL WITH DP-1
6 CCS COAXIAL SWITCH SHOWN IN THE "FAIL SAFE" POSITION
5 10 DATA LINES; 12 ADDRESS LINES AND DATA REQUEST
4 40 DATA LINES AND SYNC
3 THIS IS A CALIBRATION COMMAND, AND CAL LEVEL
2 THESE ARE CALIBRATION COMMANDS
NOTES: 1 THIS IS THE TELEMETRY CALIBRATOR COMMAND SIGNAL AND IS HANDLED THROUGH THE SWITCH SELECTOR AND CONTROL DISTRIBUTOR
TRANSDUCERS AND SIGNAL CONDITIONING
MULTIPLEXING AND DISTRIBUTION
TELEMETRY
RF ASSEMBLIES
SIGNATURES DATE
DR 2/3/70
DSGN 2-18-70
QC 2-18-70
ENGR 2-19-70
APP 2-20-70
FEC 2-20-70
AUTH 2-20-70
NATIONAL AERONAUTICS & SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER • HOUSTON, TEXAS
INSTRUMENTATION TELEMETRY SYSTEM, IU
SLV
AS-508
SIZE D
DWG NO 23.1.1
34 X 22
PAGE 23-4
SHEET 1 OF 1



NOTE: 1 DP-1B IS PARALLEL TO DP-1

SIGNATURES	DATE
DR Wade Williams	2-10-69
DSGN	3-14-69
QC	3/14/69
ENGR M. R. Coker	3-14-69
APP	3/13/69
FEC	3/14/69
AUTH	3-17-69

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TELEMETRY COMPOSITE S-IVB / IU PCM FLOW DIAGRAM

SLV AS-508 | SIZE C | NO. 23.1.2

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MSC Form 1616 C (REV OCT 65)

24 TRACKING

24.1 GENERAL

The purposes of tracking the space vehicles are to determine vehicle trajectory for mission control, post-flight evaluation, and to provide range safety.

Several tracking systems are used to determine the trajectory during powered ascent and orbital flight. Consolidation of this tracking data provides the best possible trajectory information and increased missi..n reliability through redundant data.

24.1.1 Tracking Stations

The C-band radar network provides one of the tracking systems used to monitor the flightpath of the Saturn vehicle. The C-band radar network is comprised of both land-based and ship-based stations. These stations provide a global tracking capability.

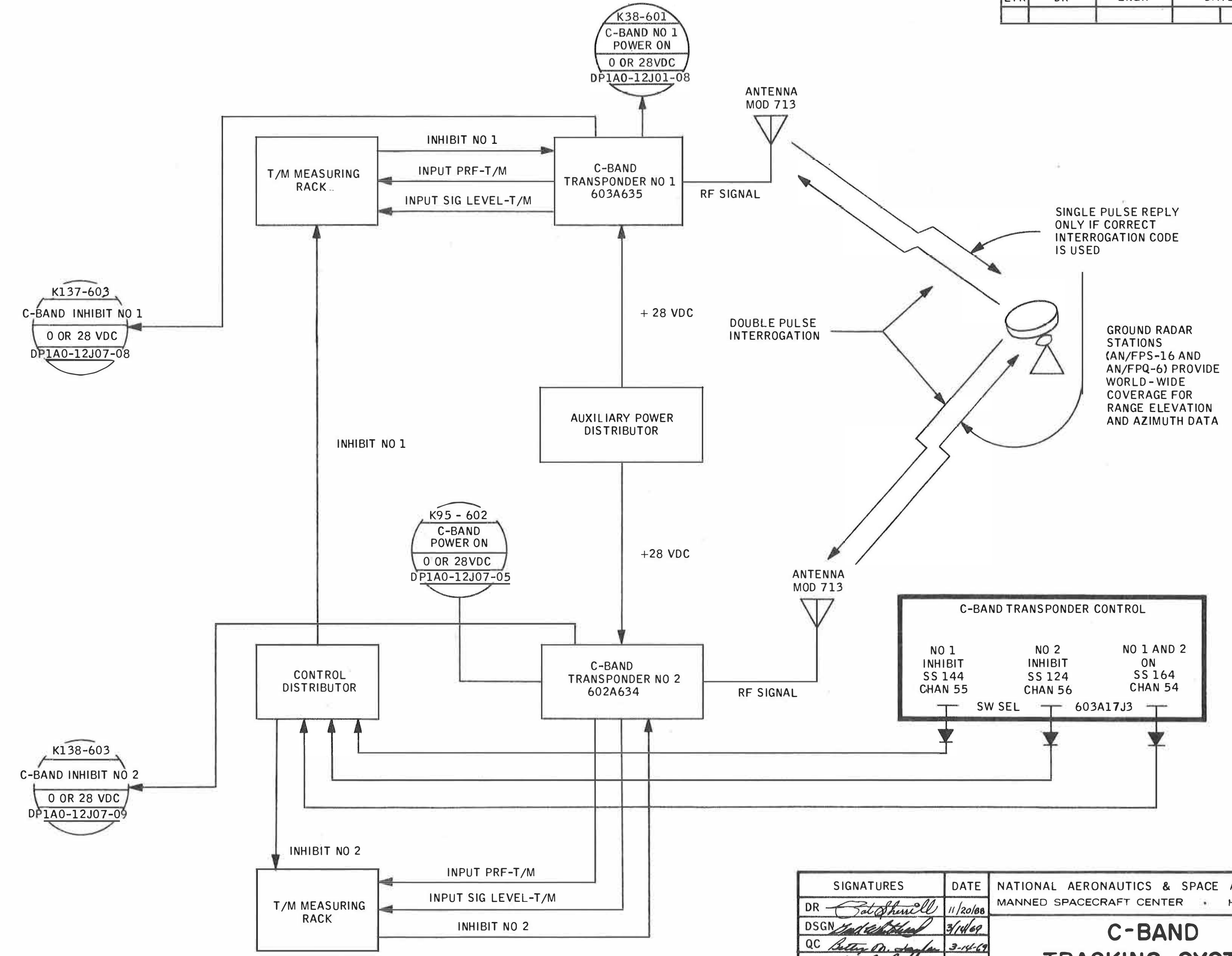
The primary C-band equipments used at these stations are the An/FPS-16 and the AN/FPQ-6 radar systems. These are high precision, C-band, monopulse tracking radars designed specifically for missile tracking. They are sited to provide launch vehicle position and velocity in real time. The transmitted RF energy may be either single pulse, for skin track, or coded pulse, for beacon track. This capability permits switching to skin track if the transponder should fail.

The radar station determines the position of the vehicle by measuring range, azimuth angle, and elevation angle. Range is determined from pulse travel time, and angle tracking is accomplished by amplitude-comparison monopulse techniques.

24.1.2 C-Band Transponders

To aid vehicle tracking and to increase the range and accuracy of the C-band radar, several C-band transponders are mounted on the Saturn vehicle. The transponders located in the IU are mounted 180 degrees apart and operate simultaneously. The transponder set receives either a coded or single pulse interrogation signal and transmits a single reply on an offset frequency, but in the same frequency band. The system has a calculated range of approximately 6500 miles. Drawing 24.1.1 shows a block diagram of the C-band radar tracking system.

LTR	DR	ENGR	DATE	APPROVAL



SIGNATURES	DATE
DR	11/20/68
DSGN	3/14/69
QC	3-14-69
ENGR	3-13-69
APP	3/13/69
FEC	3/14/69
AUTH	3-17-69

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C-BAND TRACKING SYSTEM SIGNAL FLOW

SLV AS-508	SIZE C	DWG NO 24.1.1
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25 EMERGENCY DETECTION SYSTEM

SECTION 25

EMERGENCY DETECTION SYSTEM

25.1 INTRODUCTION

25.1.1 General Description

The emergency detection system (EDS) will be flown on this mission in a closed loop configuration and will be fully functional.

The EDS protects against loss of launch vehicle thrust and/or excessive vehicle rate that could endanger the spacecraft during launch. The automatic system may be disabled at any time from the spacecraft or at a specific time by the onboard LVDC. This will be accomplished prior to S-IC inboard engine out and will not be re-enabled after that time.

The EDS employs redundant components and generally involves triple redundant circuits with voting logic.

The majority of the system is located in the SLV while control and indicator items are included in the command module.

Two types of aborts are possible with the EDS.

A. Auto Aborts are initiated by loss of two or more S-IC engines or excessive vehicle rates.

B. Manual Aborts are initiated by the flight crew based on spacecraft indications.

25.1.2 EDS Circuit Logic

A. EDS Power (Drawing 25.1.1)

B. S-IC Two Engine Out Auto Abort (Drawing 25.1.2)

C. Overrate Abort Logic (Drawing 25.1.3)

D. Auto Abort Deactivate Logic (Drawing 25.1.4)

E. Abort Initiate Logic (Drawing 25.1.5)

F. Spacecraft Initiated Abort Logic (Drawing 25.1.6)

G. S-IC Engine Cutoff Logic (Drawing 25.1.7)

H. S-II Engine Cutoff Logic (Drawing 25.1.8)

I. S-IVB Cutoff Logic (Drawing 25.1.9)

J. Spacecraft Indication (Drawing 25.1.10)

25.1.3 General

The EDS is armed by receipt of the liftoff signal (deenergizing K90 and K91) as shown on Drawing 25.1.6. These signals arm the spacecraft Abort logic. The liftoff signal is backed up by the manual Abort Enable push button in the spacecraft.

The general data flow for the EDS is along the following pattern. Signals indicating either an Auto Abort condition or a launch vehicle malfunction warning are generated in the SLV. These signals are transmitted to the Apollo spacecraft where the abort is either automatically or manually initiated. The MESC contains the logic for determining the type of Abort. The Abort initiating signal also transmits a command to the SLV stages to shut down any running engines.

25.1.4 Auto Abort

Once enabled, the EDS will initiate an Auto Abort if the Abort bus (6D95) is energized by application of 28 Vdc. This bus appears on Drawing 25.1.2, 25.1.3, and 25.1.5.

The Abort bus may be energized automatically in two ways. The first is shown on Drawing 25.1.2. The relay configuration indicates a two-of-three voting technique operating on the thrust OK switches located in the S-IC Stage. The voting is accomplished in the IU while the three triple redundant thrust OK switches and their associated wiring are located in the S-IC. Any time that two engines fall below 89 percent thrust, the thrust OK switches will open and the voting circuitry will apply 28 Vdc to 6D95 and initiate an Abort, if the Auto Abort system is enabled.

The Abort bus may also be energized by indication of excessive rates in any of the three axes (pitch, yaw or roll). These triple redundant indications are shown on Drawing 25.1.3 and again two of the three gyros in any one axis are required to initiate an Abort if the Auto Abort system is enabled.

The Auto Abort capability may be completely disabled from the spacecraft at any time. It also can be disabled by the switch selector and will be just prior to S-IC engine cutoff on this mission. Relays K46-1,2,3; K47-1,2,3 and K43-1,2,3 on Drawings 25.1.2, 25.1.3, and 25.1.4 accomplish the disabling.

The Abort bus when energized, applies triple redundant signals to the spacecraft where logic circuits decide if the Abort should use the launch escape tower or the service module propulsion system. The circuitry is shown on Drawings 25.1.5 and 25.1.6.

When the spacecraft recognizes the Abort condition, the relay logic starts the SLV/CSM separation sequence and will turn off any booster engines that may be running.

NOTE

Engine cutoff is inhibited prior to L/O + 30 seconds. See paragraph 25.1.6.

The sequence is inhibited by deengerizing relays K20-1, K20-2, and K20-4, shown on Drawings 25.1.6 and 25.1.7. Note that this is normally in the operational condition and an Abort results in dropping of the relays.

25.1.5 Spacecraft EDS Indications

A portion of the EDS circuitry is not used for the generation of Auto Abort signals. This circuitry supplies indications to the spacecraft to assist the flight crew in determining Abort situations. The flight crew may then initiate a manual abort.

The indicator lamps and the associated logic is shown on Drawing 25.1.10. The indicators include:

A. S-IC/S-II/S-IVB engine out
B. Excess launch vehicle rate
C. Launch vehicle attitude reference
D. Abort request (from spacecraft updata link or range safety shutdown)
E. Excess angle-of-attack.

25.1.6 SLV Engine Cutoff Logic

Engine cutoff logic is shown in Drawings 25.1.7 (S-IC), 25.1.8 (S-II) and 25.1.9 (S-IVB). Initiation of an Abort (either auto or manual) in the spacecraft will cause relays K20-1, 2, 4 to deenergize and in turn energize K9 and K10. Relays K9 and K10 send EDS cutoff commands to the S-IC, S-II and S-IVB stages. Engine shutdown is inhibited prior to liftoff plus 30 seconds by the EDS timer which closes relays K19-1, 2 at that time. The timer is backed up by a switch selector function at 30 seconds.

25.1.7 EDS Notes

A. EDS buses 6D91, 6D92, 6D93, are armed with main power buses 6D11, 6D31, and 6D41 unless disabled by EDS GSE.
B. Spacecraft EDS buses 1, 2, 3 are energized by the flight crew.
C. Loss of IU battery 1/bus 6D11 will cause loss of IU switch selector and loss of EDS switching functions. Critical functions are backed up by timers or spacecraft switches.
D. All EDS circuits crossing the IU/SC interface are deadfaced simultaneously at CM/SM separation by pyrotechnic circuit interrupters at the CM/SM umbilical.
E. Abort circuitry across the IU/SC interface is normally energized. A loss of signal indicates Abort or launch vehicle shutdown.
F. EDS Ready indication indicates that GSE bus 6D195 is not energized. Bus 6D195 may be energized by the following occurrences:
   1. Spacecraft cutoff (3 ckts)
   2. Excessive rates indications (9 ckts)
   3. Abort bus (1 ckt)
   4. EDS unsafe (2 ckts)
G. Relay numbers enclosed in parentheses are part of the EDS Intercenter Control Document numbering system. Relay numbers not enclosed are stage relay designations.

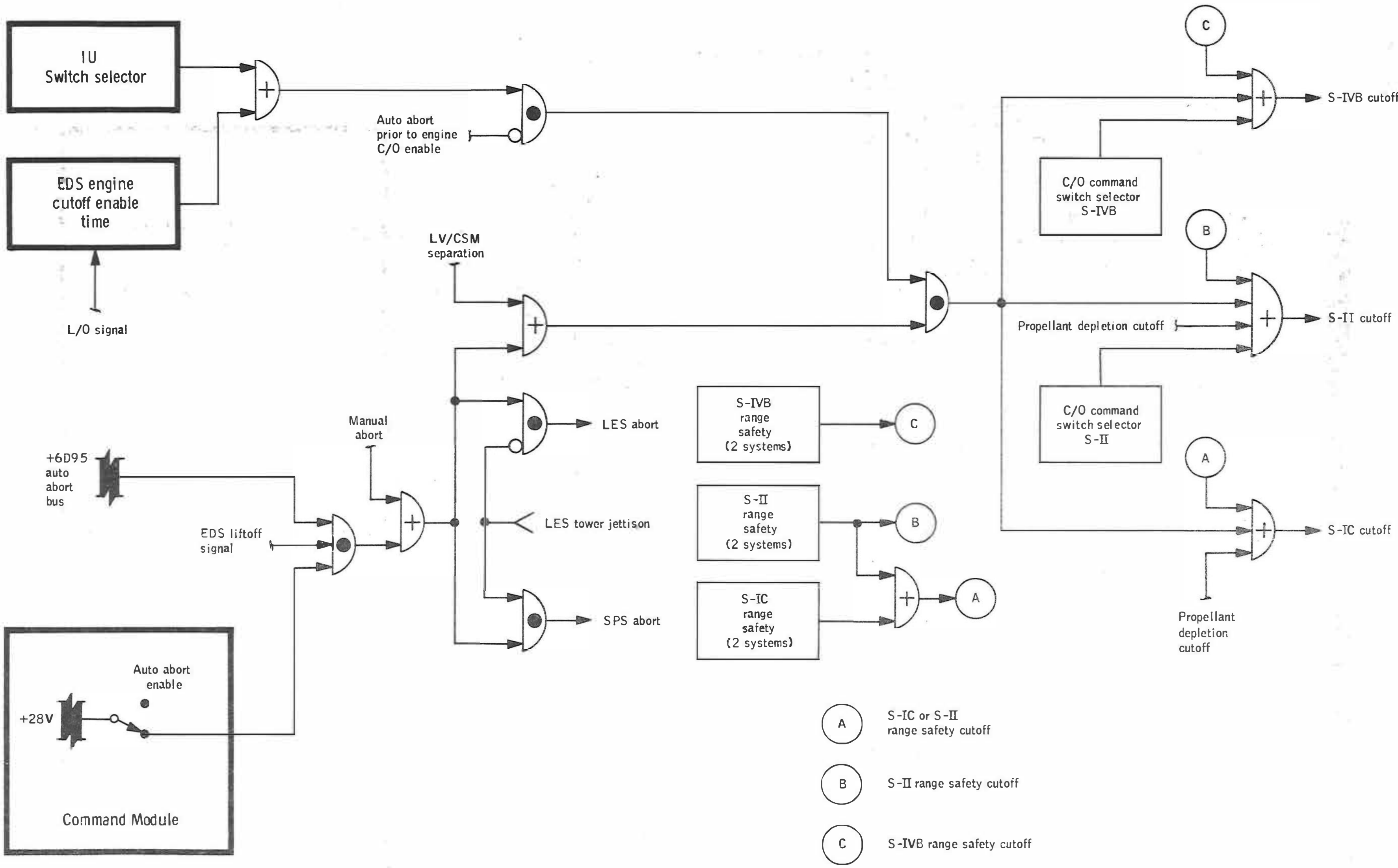


Figure 25-1. - Logic flow engine cutoff and separation.

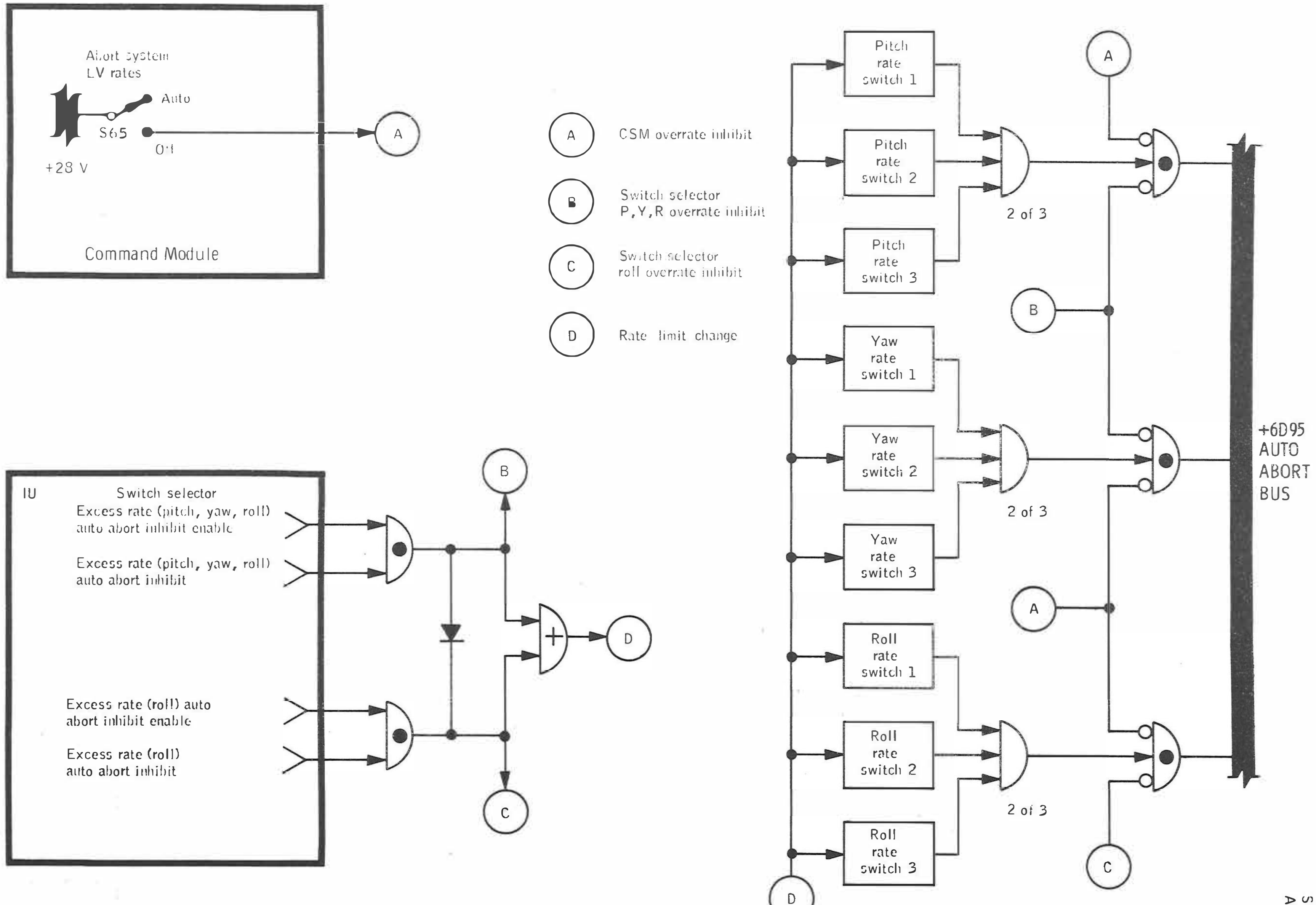


Figure 25-2.- Logic flow - overrate abort.

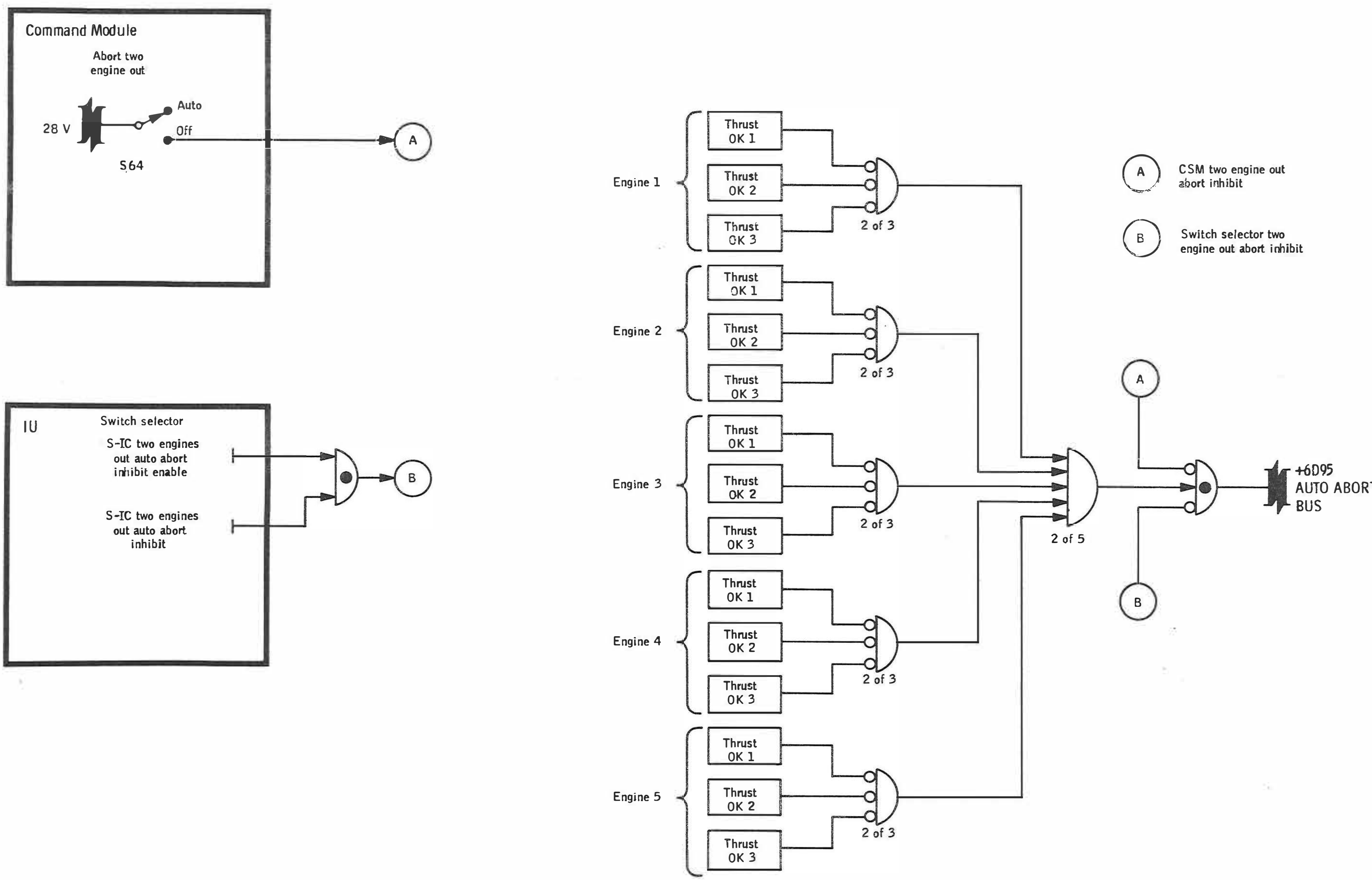
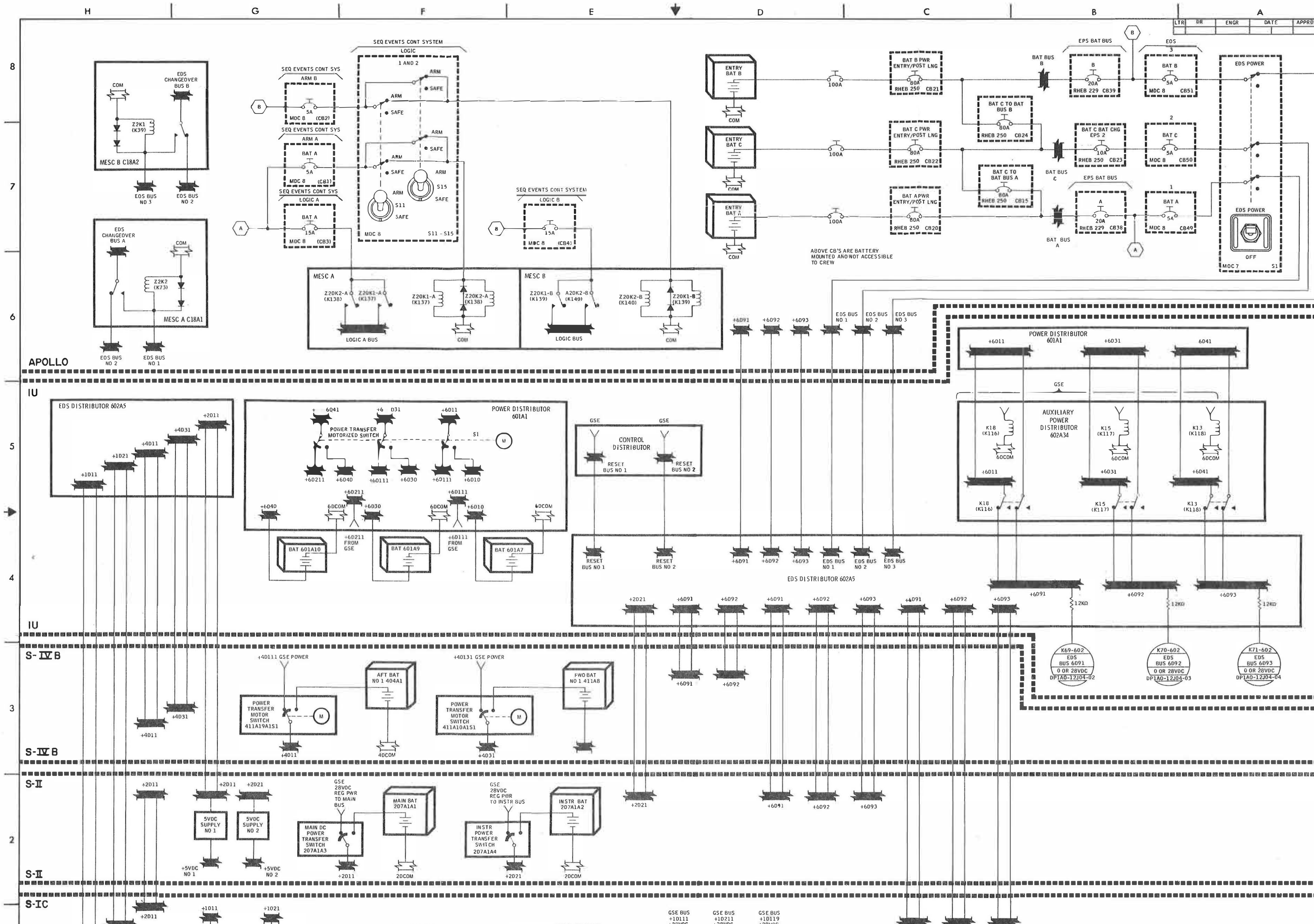
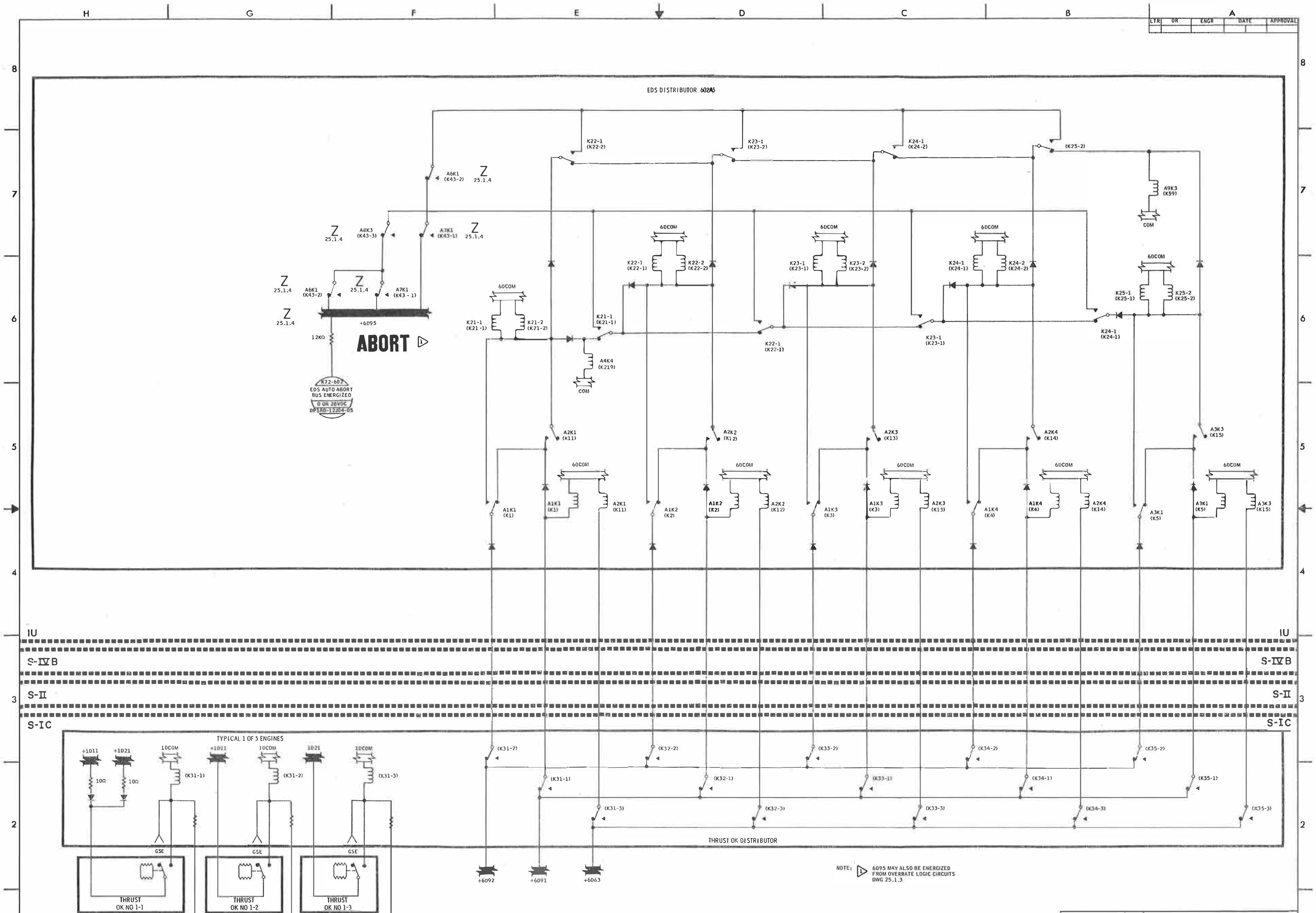


Figure 25-3.- Logic flow two engine out abort.



SIGNATURES	DATE	NATIONAL AERONAUTICS & SPACE ADMINISTRATION MANNED SPACECRAFT CENTER · HOUSTON, TEXAS
DR Vicki Doggett	1/29/70	
DSGN Bill S. Cornelius	2-18-70	
QC	2-18-70	
ENGR	2-20-70	**EDS VEHICLE POWER**
APP	2-20-70	SLV AS-508 · SIZE E · DWG NO 25.1.1
FEC	2-20-70	44 X 34 · PAGE 25-6 · SHEET 1 OF 1
AUTH	2-20-70	



ENG	MEAS	CHAN	MEAS	CHAN	MEAS	CHAN
1	K33-115	AP180-19R05-01	K34-115	AP180-19R05-02	K35-115	AP180-19R05-03
2	K36-115	AP180-19R05-04	K37-115	AP180-19R05-05	K38-115	AP180-19R05-06
3	K39-115	AP180-19R05-07	K40-115	AP180-19R05-08	K41-115	AP180-19R05-09
4	K42-115	AP180-19R05-10	K43-115	AP180-19R06-01	K44-115	AP180-19R06-02
5	K45-115	AP180-19R06-03	K46-115	AP180-19R06-04	K47-115	AP180-19R06-05

SIGNATURES	DATE
DR	2/1/70
DSGN	2-18-70
QC	2-18-70
ENGR	2-20-70
APP	2-20-70
FEC	2/20/70
AUTH	2-20-70

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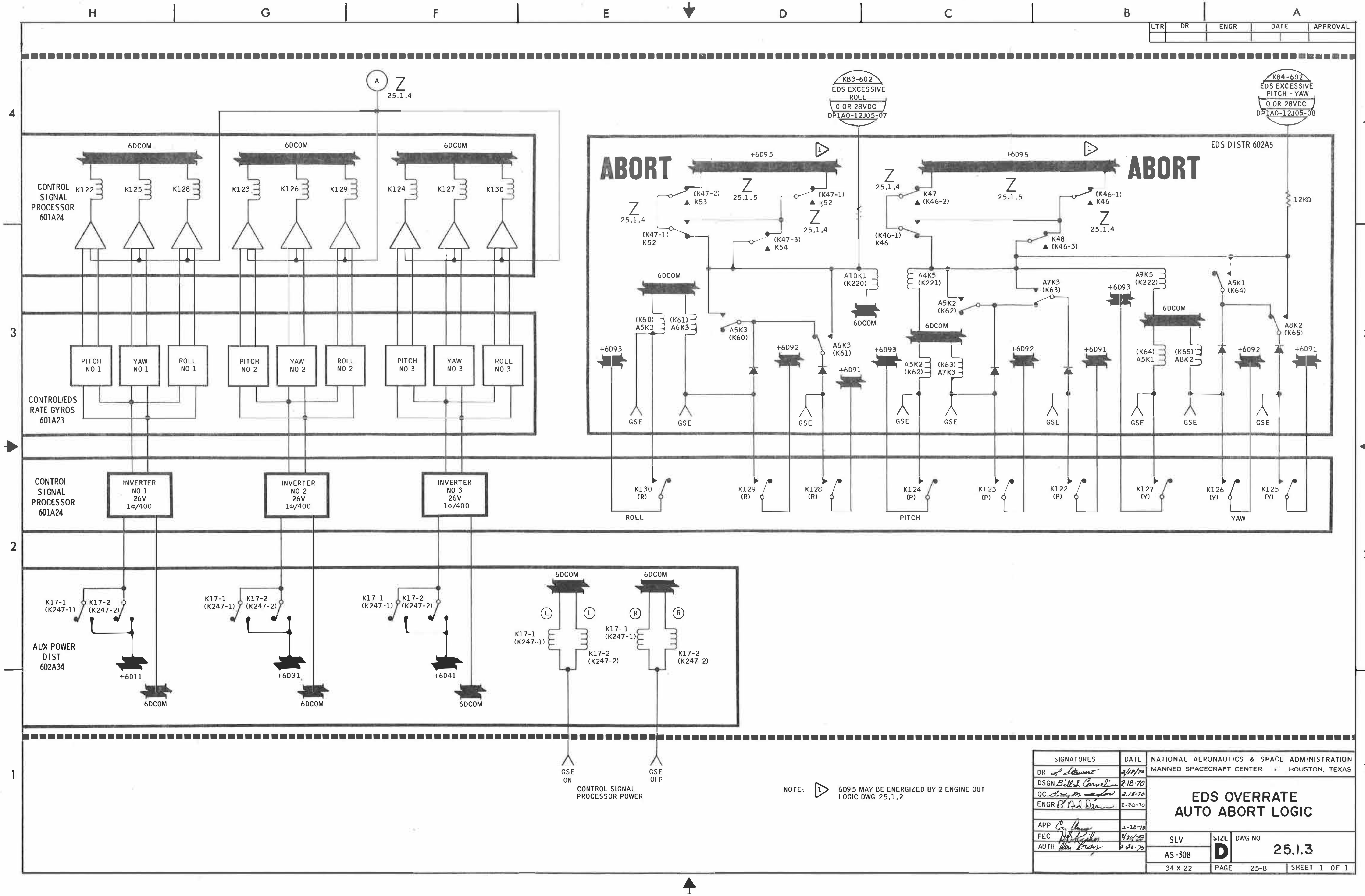
EDS
S-IC TWO ENGINE OUT AUTO-ABORT VOTING LOGIC

SLV AS-508 | SIZE E | DWG NO 25.1.2

44 X 34 | PAGE 25-7 | SHEET 1 OF 1



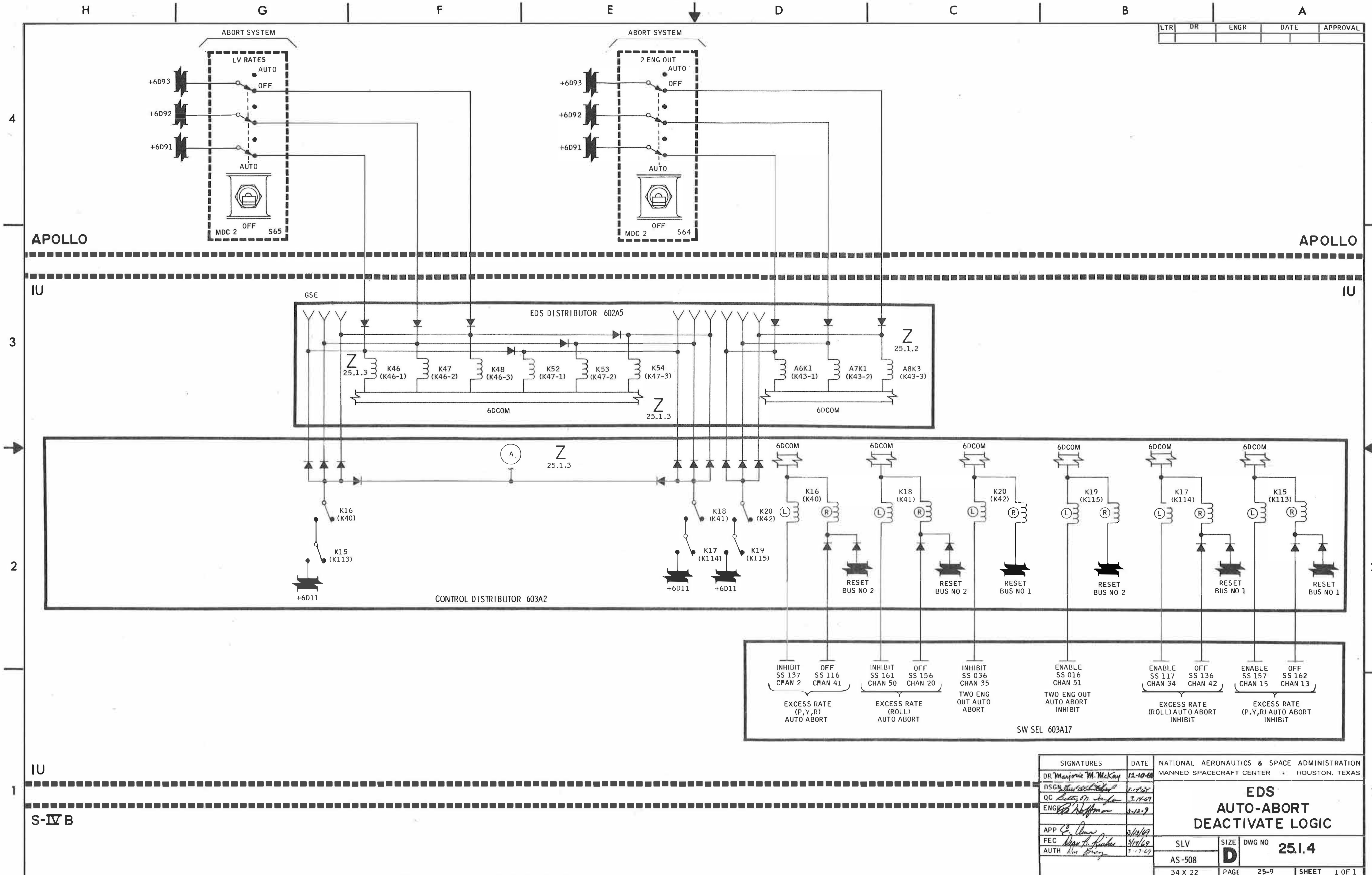
NOTE: 1 6D95 MAY BE ENERGIZED BY 2 ENGINE OUT LOGIC DWG 25.1.2

SIGNATURES	DATE
DR	2/18/70
DSGN	2-18-70
QC	2-18-70
ENGR	2-20-70
APP	2-20-70
FEC	2-20-70
AUTH	2-20-70

NATIONAL AERONAUTICS & SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER · HOUSTON, TEXAS

EDS OVERRATE AUTO ABORT LOGIC

SLV AS-508 | SIZE D | DWG NO 25.1.3
34 X 22 | PAGE 25-8 | SHEET 1 OF 1



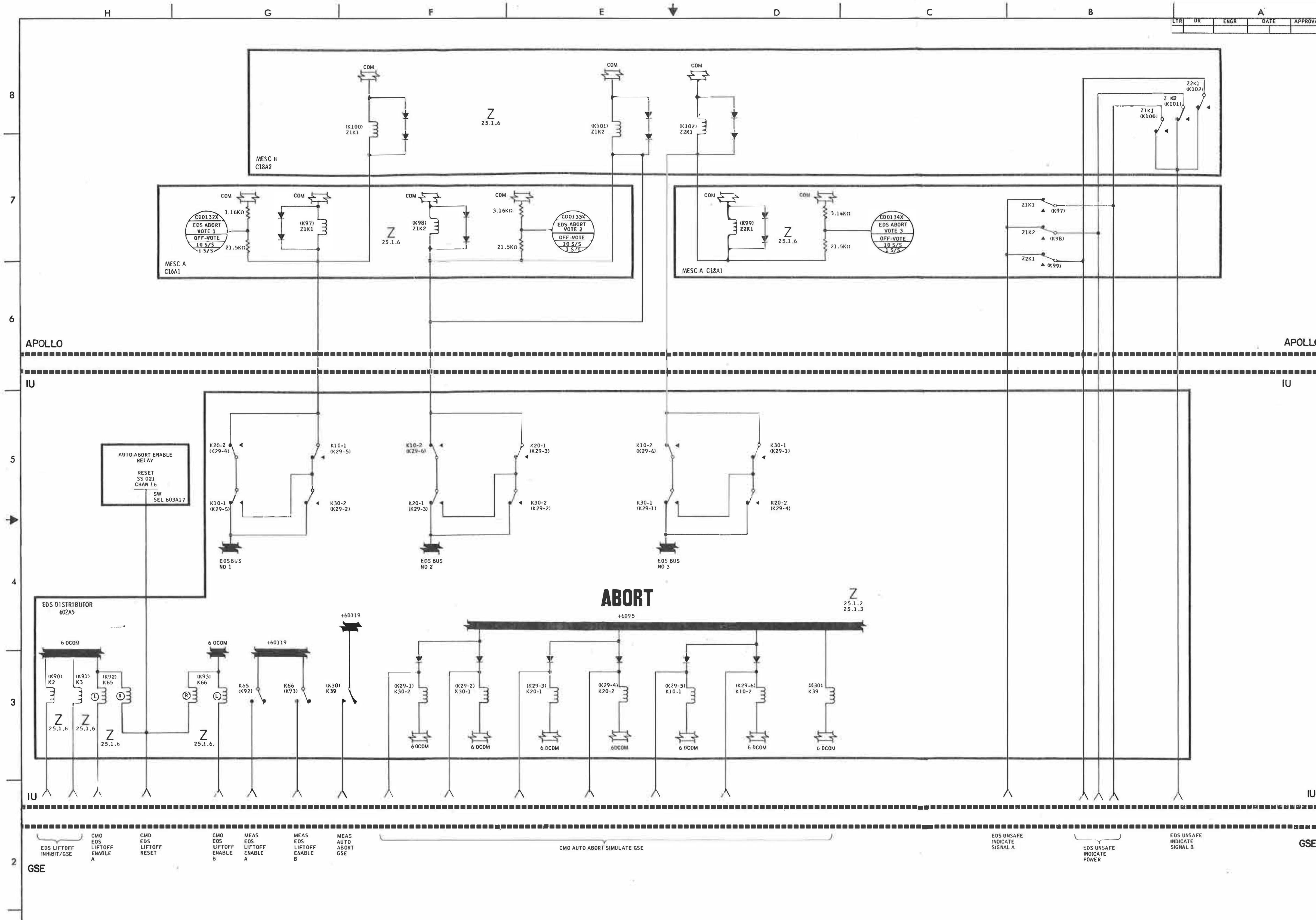
LTR	DR	ENGR	DATE	APPROVAL

SIGNATURES	DATE
DR Marjorie M. McKay	12-10-68
DSGN	3-14-69
QC Betty M. Taylor	3-14-69
ENGR	3-12-9
APP	3/14/69
FEC	3/14/69
AUTH	3-17-69

NATIONAL AERONAUTICS & SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER • HOUSTON, TEXAS

EDS AUTO-ABORT DEACTIVATE LOGIC

SLV AS-508 | SIZE D | DWG NO 25.1.4
34 X 22 | PAGE 25-9 | SHEET 1 OF 1



SIGNATURES	DATE
DR Wade Williams	2-5-69
DSGN	3-14-69
QC	3-13-69
ENGR	3-12-9
APP	3/13/69
FEC	3/19/69
AUTH	3-17-69

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EDS ABORT INITIATE LOGIC

SLV AS-508 | SIZE E | DWG NO 25.1.5

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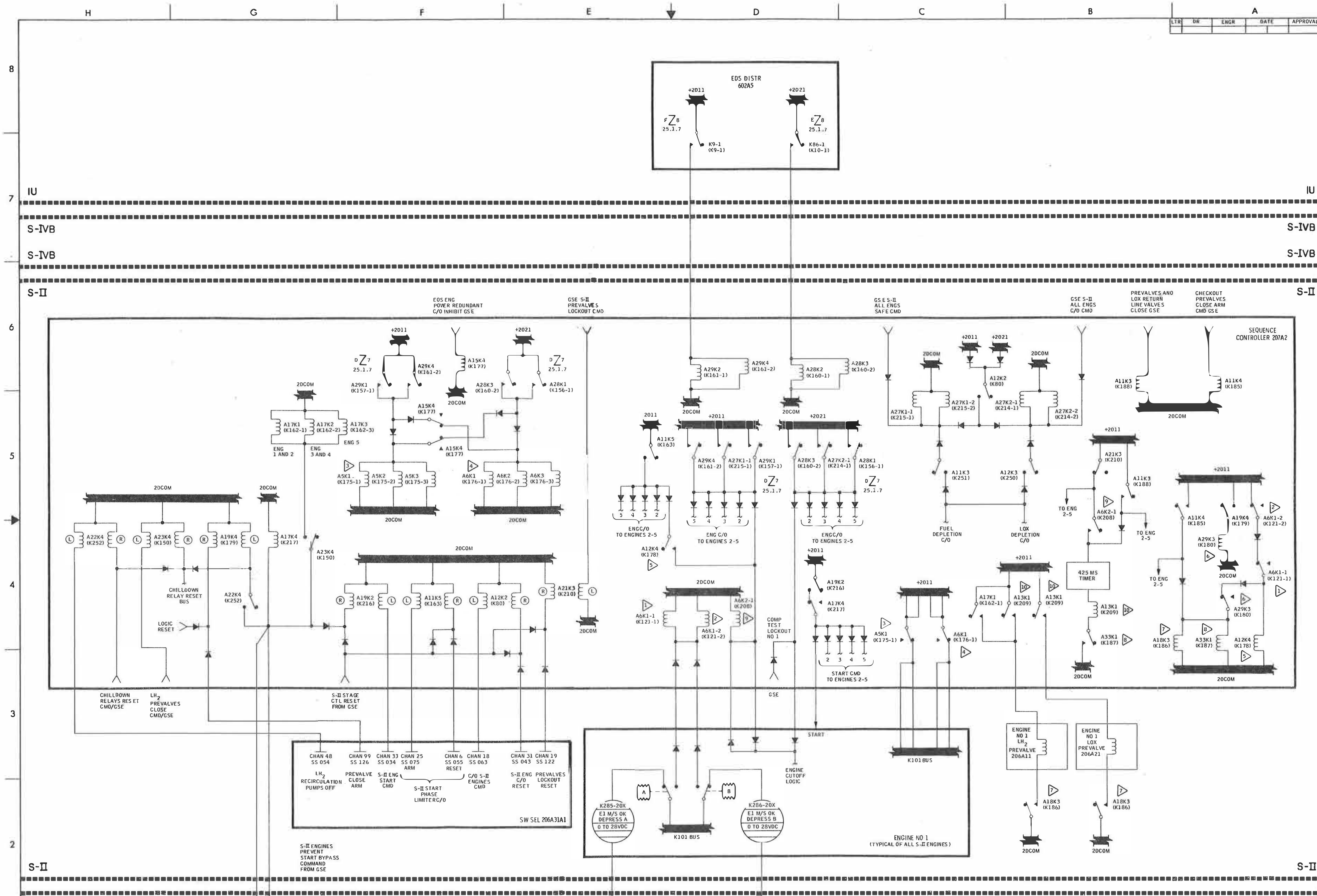

ENG	K121-1	K121-2	K175-1	K176-1
1	A6K1-1	A6K1-2	A5K1	A6K1
2	A7K1-1	A7K1-2	A5K1	A6K1
3	A8K1-1	A8K1-2	A5K2	A6K2
4	A9K1-1	A9K1-2	A5K2	A6K2
5	A10K1-1	A10K1-2	A5K3	A6K3

ENG	SW A MEAS NO	SW A CHANNEL	SW B MEAS NO	SW B CHANNEL
1	K285-201	BP180-25R01-01	K286-201	BP180-25R01-06
2	K285-202	BP180-25R01-02	K286-202	BP180-25R01-07
3	K285-203	BP180-25R01-03	K286-203	BP180-25R01-08
4	K285-204	BP180-25R01-04	K286-204	BP180-25R01-09
5	K285-205	BP180-25R01-05	K286-205	BP180-25R01-10

ENG	K178	K180	K186	K187	K208	K209
1	A12K4	A29K3	A18K3	A33K1	A6K2-1	A13K1
2	A13K4	A29K3	A20K3	A33K2	A7K2-1	A15K3
3	A18K4	A28K4	A24K3	A33K3	A8K2-1	A13K2
4	A24K4	A28K4	A26K3	A33K4	A9K2-1	A15K2
5	A27K3	A29K5	A32K1	A33K5	A10K2-1	A13K3

SIGNATURES	DATE
DR	1/28/70
DSGN Bill J. Cornelius	2-18-70
QC	2-18-70
ENGR B. Red Dean	2-20-70
APP	2-20-70
FEC	2-20-70
AUTH	2-20-70

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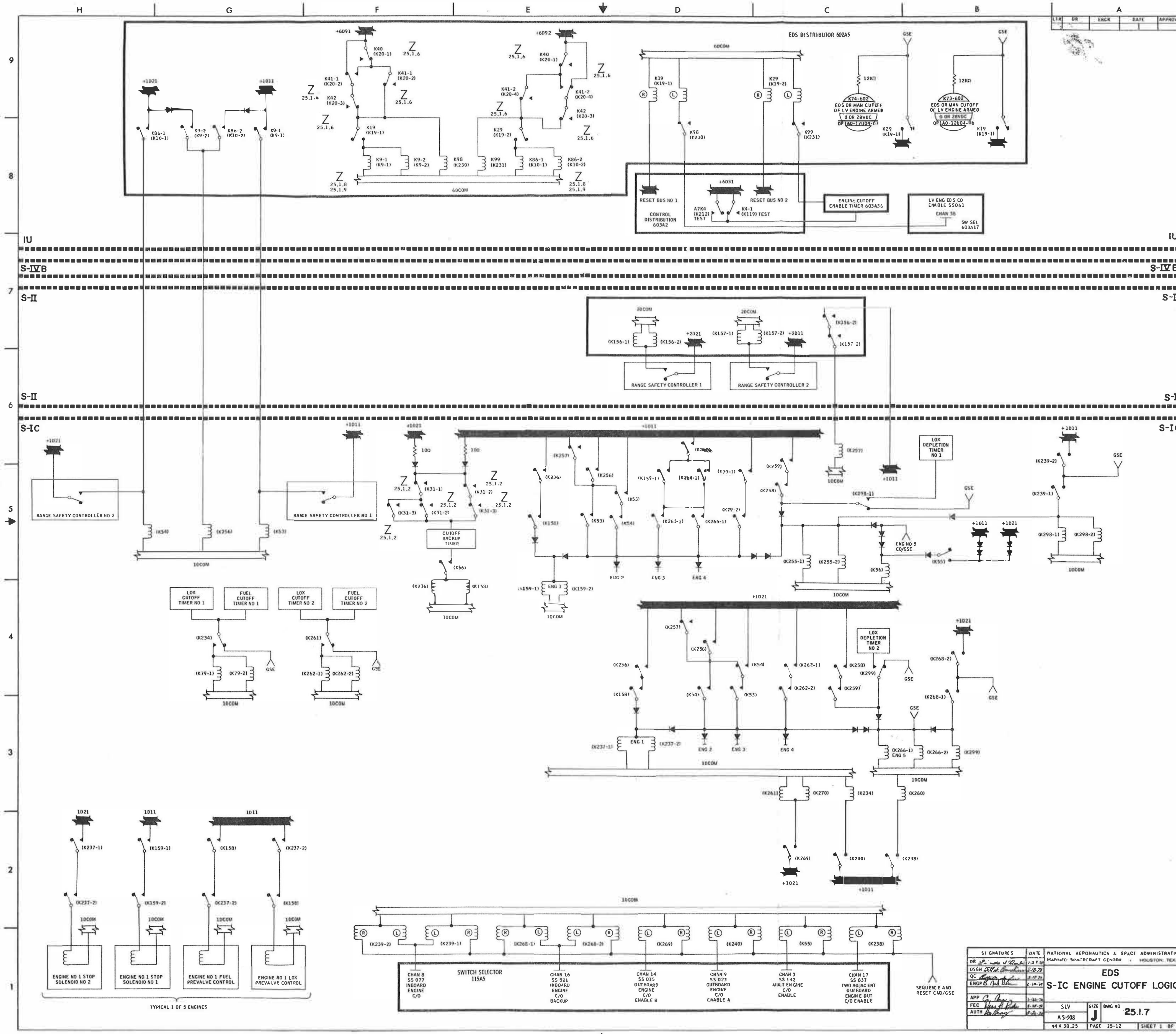
EDS
S-II ENGINE CUTOFF LOGIC

SLV AS-508 | SIZE E | DWG NO 25.1.8
44 X 34 | PAGE 25-13 | SHEET 1 OF 1



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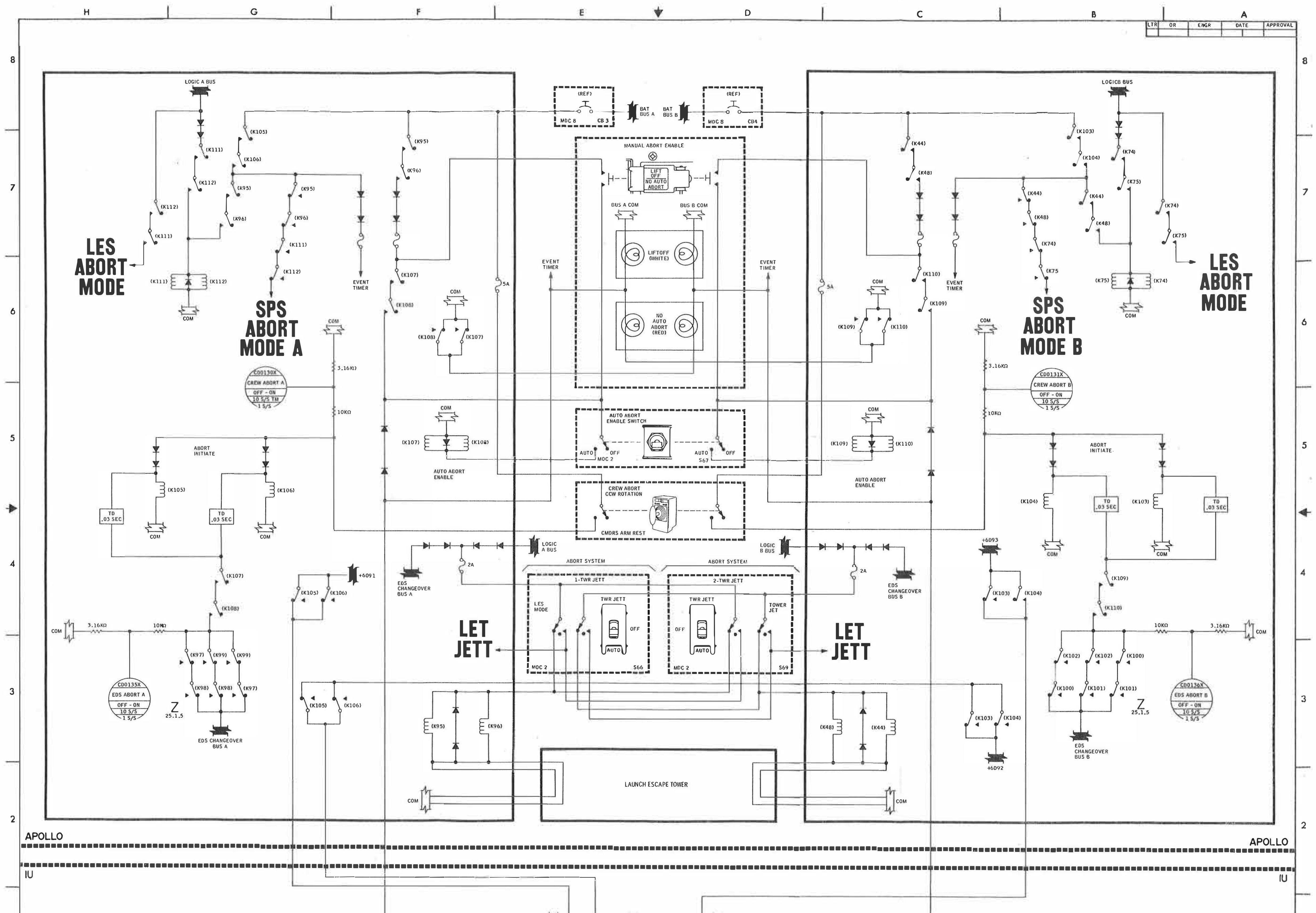
EDS
S-IC ENGINE CUTOFF LOGIC

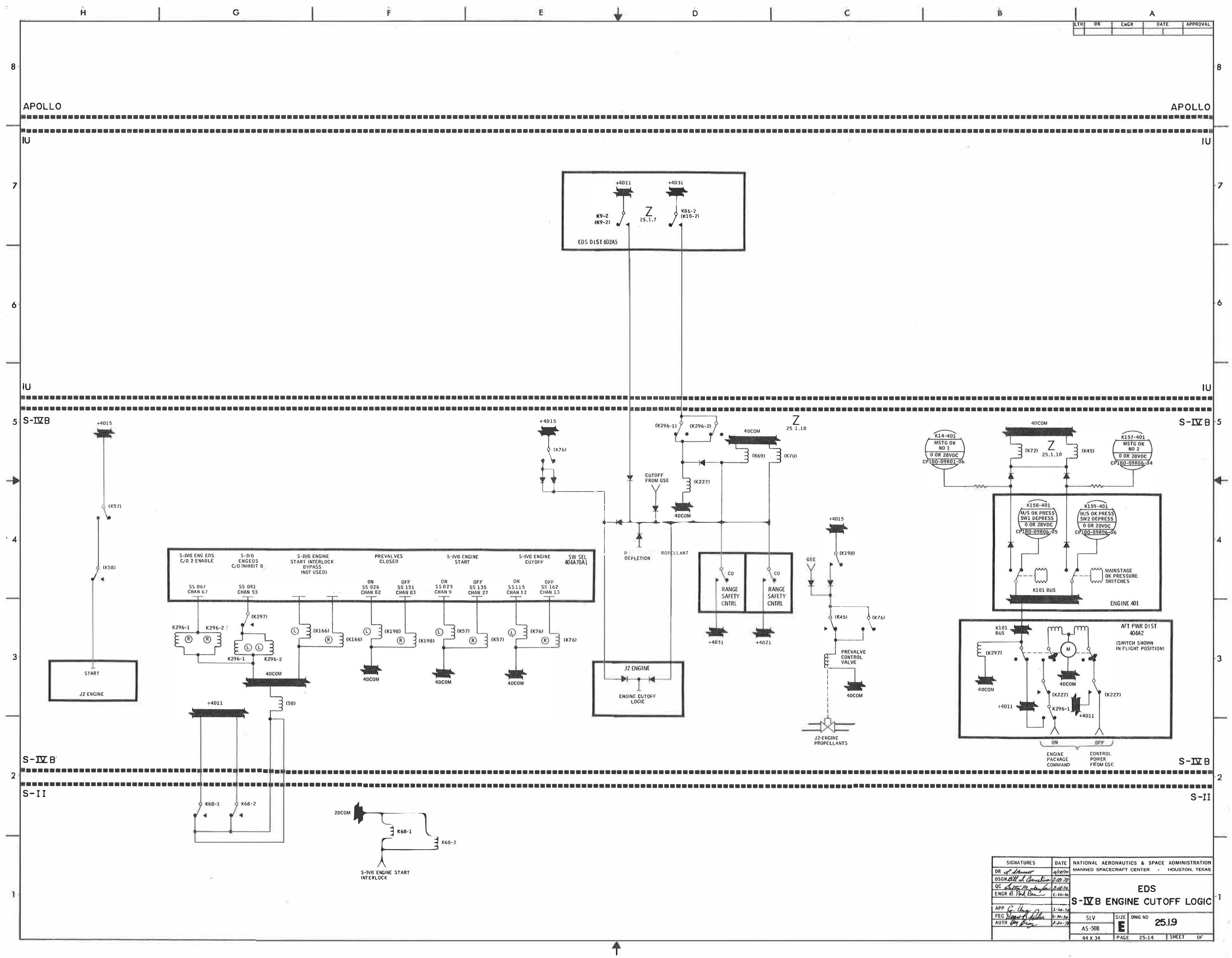
SIGNATURES	DATE
DR	
DSGN	2-18-70
QC	
ENGR	2-20-70
APP	
FEC	
AUTH	

SLV AS-508 · SIZE J · DWG NO 25.1.7

44 X 38.25 · PAGE 25-12 · SHEET 1 OF 1



SIGNATURES	DATE	NATIONAL AERONAUTICS & SPACE ADMINISTRATION MANNED SPACECRAFT CENTER · HOUSTON, TEXAS		
DR Vicki Doggett	1/29/70	EDS SPACECRAFT INITIATED ABORT LOGIC		
DSGN Bill S. Cornelius	2-18-70			
QC	2-18-70			
ENGR B. Ned Dean	2-20-70			
APP	3-20-70	SLV	SIZE	DWG NO
FEC	4-1-70	AS-508	E	25.1.6
AUTH	2-24-70	44 X 34	PAGE 25-11	SHEET 1 OF 1



SIGNATURES	DATE
DR	2/18/70
DSGN	2-18-70
QC	
ENGR	2-20-70
APP	2-20-70
FEC	2-20-70
AUTH	2-20-70

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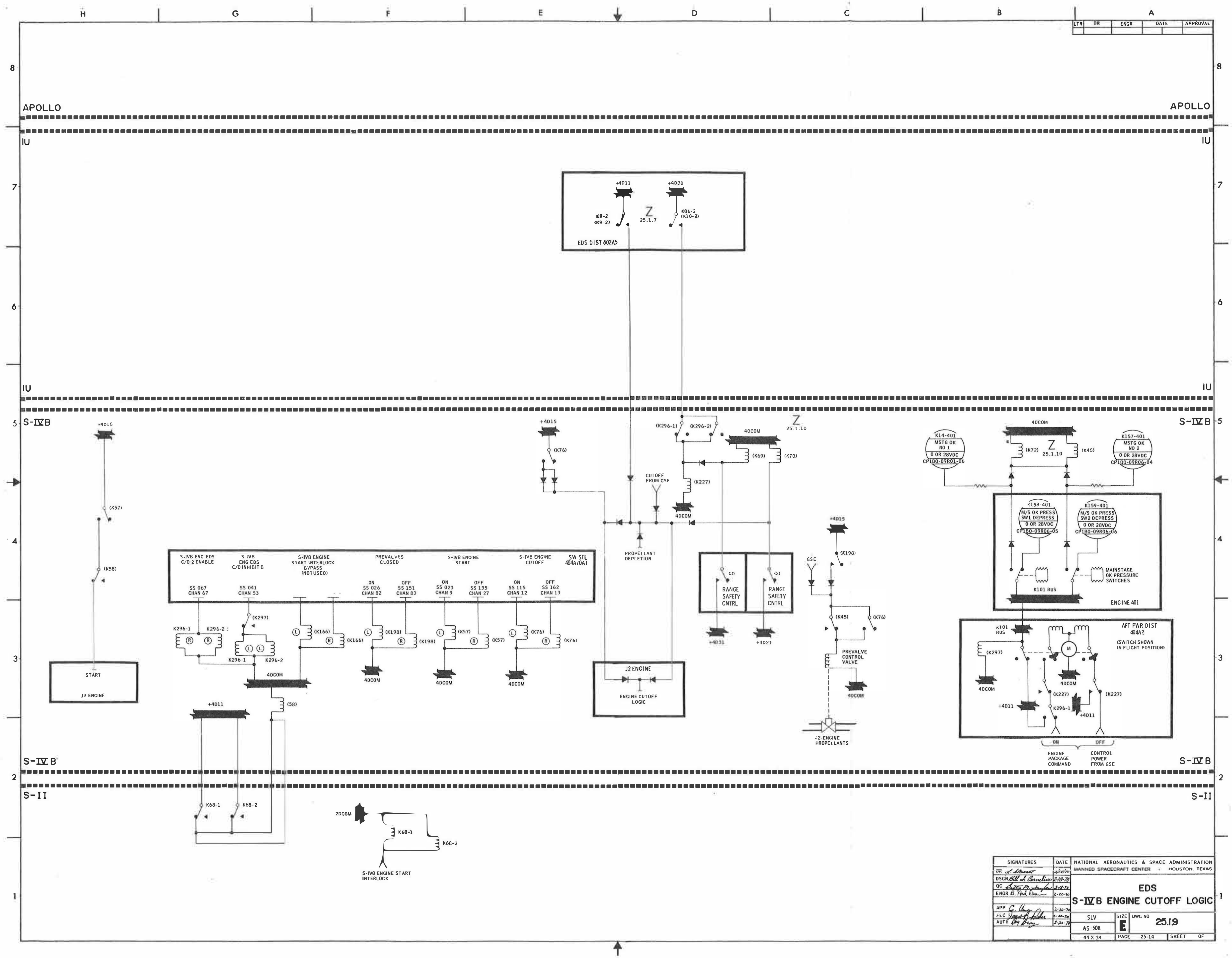
EDS
S-IVB ENGINE CUTOFF LOGIC

SLV AS-508 | SIZE E | DWG NO 25.1.9

44 X 34 | PAGE 25-14 | SHEET OF



APOLLO
IU
S-IVB
S-II
EDS DIST 602A5
+4D11
+4D31
K9-2 (K9-2)
K86-2 (K10-2)
25.1.7
25.1.10
+4D15
(K57)
(K58)
START
J2 ENGINE
S-IVB ENG EDS C/O 2 ENABLE
S-IVB ENG EDS C/O INHIBIT B
S-IVB ENGINE START INTERLOCK BYPASS (NOT USED)
PREVALVES CLOSED
S-IVB ENGINE START
S-IVB ENGINE CUTOFF
SW SEL 404A/0A1
SS 067 CHAN 67
SS 041 CHAN 53
ON SS 026 CHAN 82
OFF SS 151 CHAN 83
ON SS 023 CHAN 9
OFF SS 135 CHAN 27
ON SS 115 CHAN 12
OFF SS 162 CHAN 13
(K297)
K296-1
K296-2
40COM
(58)
(K166)
(K198)
(K57)
(K76)
K68-1
K68-2
2DCOM
S-IVB ENGINE START INTERLOCK
(K296-1)
(K296-2)
(K69)
(K70)
(K227)
CUTOFF FROM GSE
PROPELLANT DEPLETION
J2 ENGINE
ENGINE CUTOFF LOGIC
RANGE SAFETY CNTRL
CO
+4D21
GSE
(K45)
PREVALVE CONTROL VALVE
J2-ENGINE PROPELLANTS
K14-401 MSTG OK NO 1 0 OR 28VDC CP180-09R01-06
K157-401 MSTG OK NO 2 0 OR 28VDC CP180-09R06-04
(K72)
K158-401 M/S OK PRESS SW1 DEPRESS 0 OR 28VDC CP180-09R06-05
K159-401 M/S OK PRESS SW2 DEPRESS 0 OR 28VDC CP180-09R06-06
MAINSTAGE OK PRESSURE SWITCHES
K101 BUS
ENGINE 401
AFT PWR DIST 404A2
(SWITCH SHOWN IN FLIGHT POSITION)
M
ON
OFF
ENGINE PACKAGE COMMAND
CONTROL POWER FROM GSE
SIGNATURES
DATE
NATIONAL AERONAUTICS & SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER · HOUSTON, TEXAS
DR
DSGN
QC
ENGR
APP
FEC
AUTH
EDS
S-IVB ENGINE CUTOFF LOGIC
SLV
AS-508
SIZE E
DWG NO 25.1.9
44 X 34
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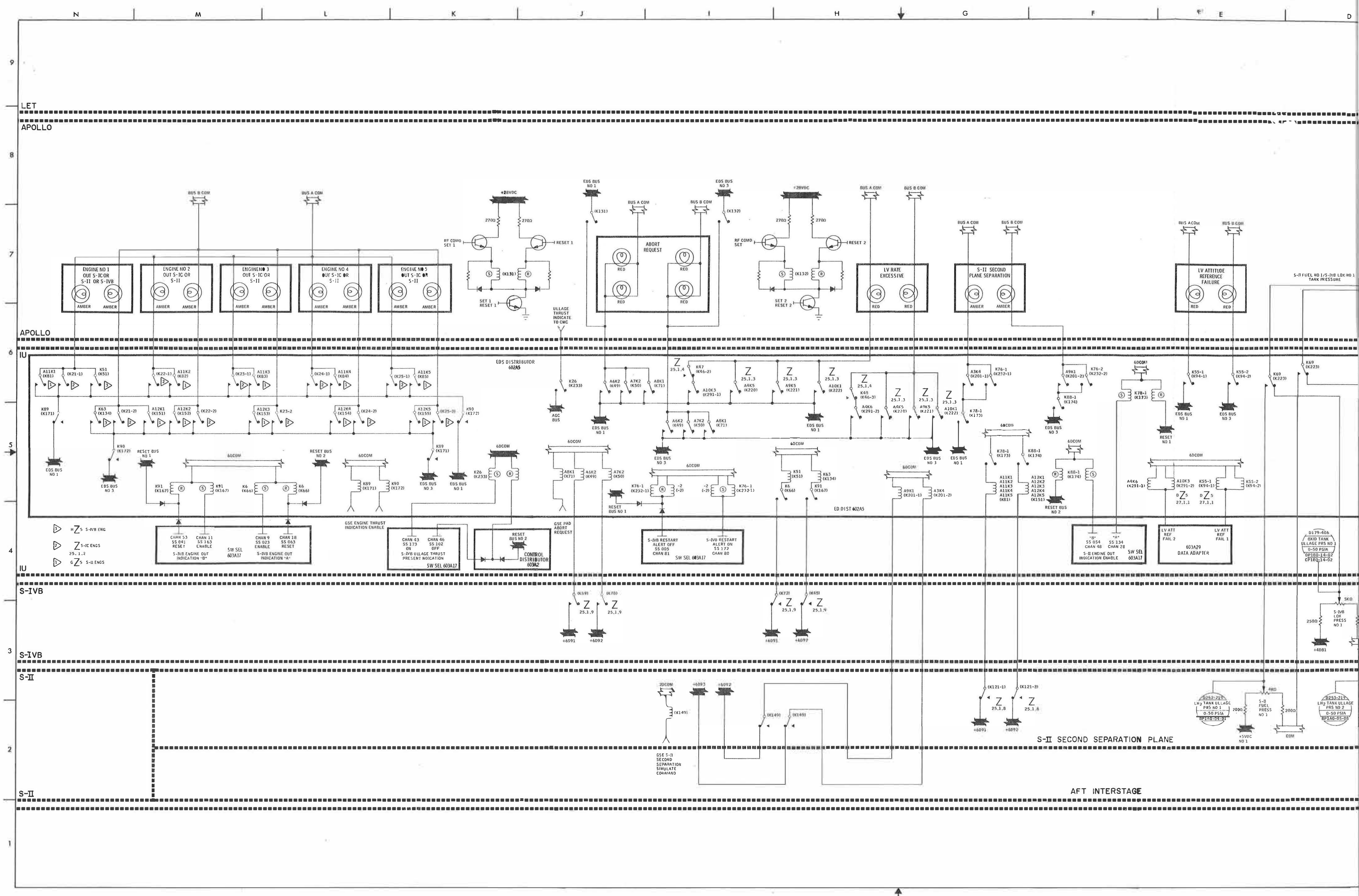
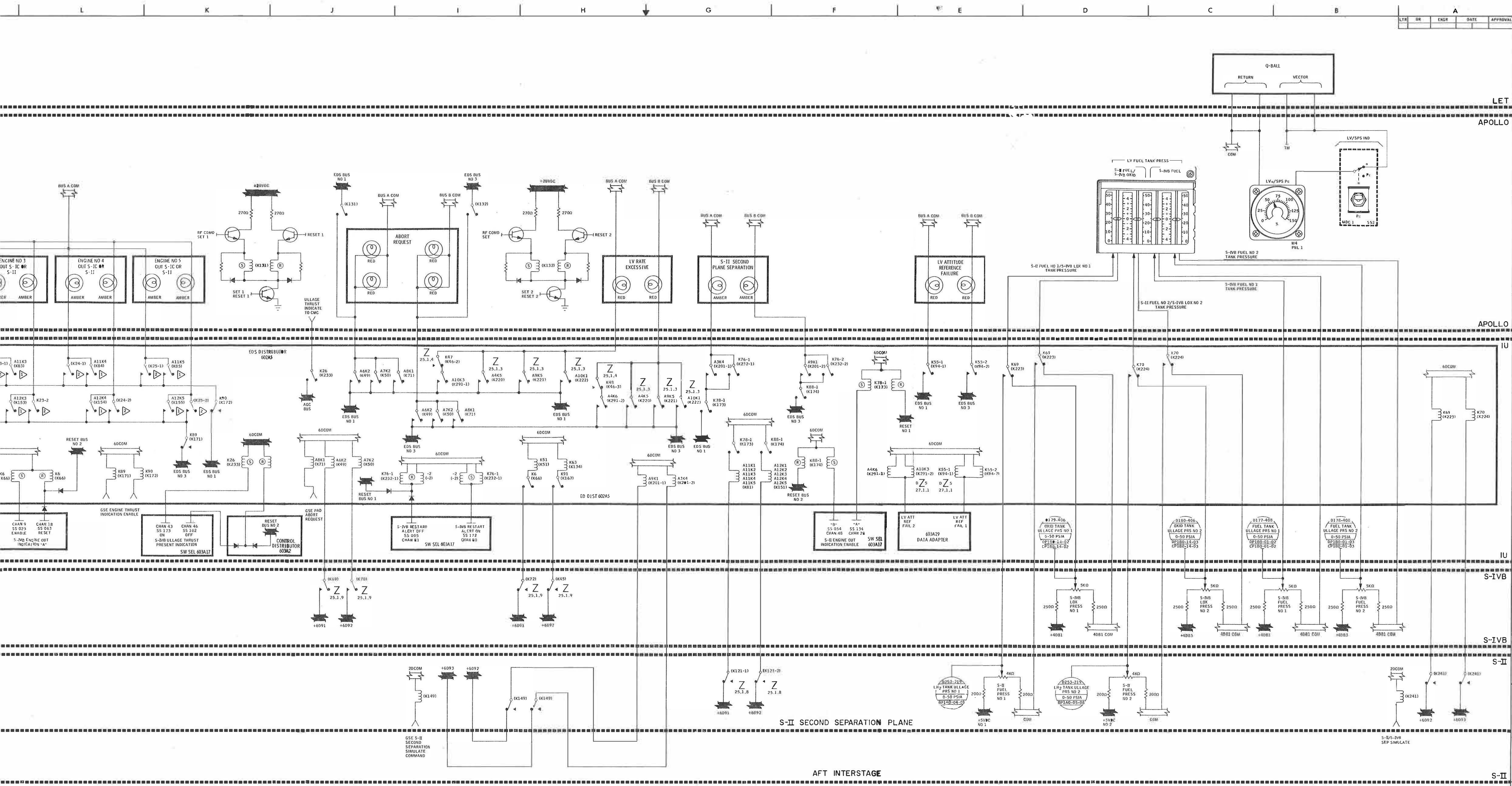
SHEET OF



LET
APOLLO
ENGINE NO 1 OUT S-IC OR S-II OR S-IVB
ENGINE NO 2 OUT S-IC OR S-II
ENGINE NO 3 OUT S-IC OR S-II
ENGINE NO 4 OUT S-IC OR S-II
ENGINE NO 5 OUT S-IC OR S-II
AMBER
+28VDC
ABORT REQUEST
RED
LV RATE EXCESSIVE
S-II SECOND PLANE SEPARATION
LV ATTITUDE REFERENCE FAILURE
ULLAGE THRUST INDICATE TO CMC
IU
EDS DISTRIBUTOR 602A5
EDS BUS NO 1
EDS BUS NO 3
RESET BUS NO 1
RESET BUS NO 2
60COM
GSE ENGINE THRUST INDICATION ENABLE
GSE PAD ABORT REQUEST
SW SEL 603A17
CONTROL DISTRIBUTOR 603A2
603A29 DATA ADAPTER
ED DIST 602A5
S-IVB
S-II
S-II SECOND SEPARATION PLANE
AFT INTERSTAGE



SIGNATURES	DATE	NATIONAL AERONAUTICS & SPACE ADMINISTRATION MANNED SPACECRAFT CENTER · HOUSTON, TEXAS
DR Vicki Doggett	1/2/70	EDS SPACECRAFT INDICATIONS
DSGN Bill S. Cornelius	2-18-70	
QC		
ENGR		
APP		SLV AS-508
FEC		SIZE J
AUTH		DWG NO 25.1.10
		77 X 38.25 · PAGE 25-15 · SHEET 1 OF 1

26 RANGE
SAFETY SYSTEM

SECTION 26

RANGE SAFETY SYSTEM

26.1 GENERAL

The flight termination system consists of an identical range safety system on the S-IC, S-II and S-IVB, each of which consists of a range safety antenna subsystem; two secure command receivers, two range safety controllers, two secure range safety decoders, two exploding bridgewire (EBW) firing units, two EBW detonators and a common safe and arm device that connects the subsystems to the tank-cutting charge. Electrical power for all elements appearing in duplicate is supplied from separate stage batteries.

26.1.1 Range Safety

The antenna subsystem consists of two folded-sleeve antennas mounted on diametrically opposite sides of the stage. Longitudinally, both antennas are mounted at the midsection of the forward skirt. The two antennas are individually connected to a hybrid ring power divider by coaxial cables of equal phase length. The power divider is a 3-db hybrid ring in a strip line assembly that separately supplies sum and difference signals to a directional power divider.

The directional power divider is essentially a 24-db directional coupler and a power divider combined into one strip-line assembly. Its function is to provide a means of applying a secure closed loop checkout signal to the receivers from the GSE. Two outputs of the directional power divider are separately applied to two secure command receivers.

The antenna radiation pattern coverage is basically omnidirectional, providing adequate gain over 96 percent of the spherical solid angle representing ground station look angles during powered flight. The station losses are approximately 3-db and the subsystem VSWR is 1.5:1.

Each secure command receiver is a double conversion, crystal controlled, solid-state, super-heterodyne frequency-modulated (FM) receiver having two isolated audio outputs of a nominal 1-volt rms level with a bandpass characteristic of approximately 300 cps to 250 kcs. The receiver has an internal power supply to provide power, isolation, and regulation.

Commands to the secure system consist of a message format of two words; an address word and a command word. The address word consists of nine characters; the command word consists of two characters. Thus, the total message comprises 11 characters. Each character consists of two simultaneous tone pairs in the range 7.35 to 13.65 kcs as follows:

Command	10th Character Tones	11th Character Tones
A. Destruct	1 and 2	1 and 3
B. Fuel Cutoff	2 and 3	2 and 4
C. MSCO/ASCO (Saturn Spare No. 1)	4 and 5	4 and 6
D. Spare No. 2	3 and 4	3 and 5
E. Safe	5 and 6	5 and 7

The decoder accepts the demodulated tone pairs from one of the audio outputs of the receiver. Seven tone filters and seven threshold detectors detect the presence of a particular tone and establish a decision level. The data is processed through 21 AND gates to the input of a code plug. The code plug sets up the chosen code-of-the-day configuration and unscrambles the code for use by the sequencer register which determines if the address is correct and sets up the enabling circuits to accept the command. If the address is wrong in timing or sequence, the enable circuits are inhibited and the unit resets to wait another address. If the address is correct, the command word is processed through the filters and enables the closing of the appropriate relays which supply 28 Vdc power to the controller.

The code plug supplied with the decoder is the "test" plug and will be exchanged for a code-of-the-day plug upon arming of the vehicle.

The receiver and decoder are supplied by 28 Vdc from either a ground source (external) or by an internal source. The source used is determined by the setting of a relay in the range safety controller.

The range safety controller is a relay package that controls the input to the receiver power supply and the ouput of the receiver and provides inputs (charge and fire) to two range safety EBW firing units.

Output of each EBW firing unit is fed to the EBW detonators on one side of an electromechanical safe and arm device. When in SAFE position, the device prevents accidental activation of the range safety ordnance devices during prelaunch activities. The safe and arm device arms the range safety flight termination system on command by aligning two explosive leads with explosive trains. The tank-cutting charge leads are connected to the various destruct ordnance devices located on the S-IVB stage. The safe and arm device consists of a 28 Vdc solenoid-operated unidirectional shaft that contains two explosive charges placed in SAFE or ARM position when the solenoid is activated. The shaft is mechanically attached to the solenoid by a ratchet and is powered through 90 degrees of clutch travel by the solenoid. At the 90 degree point, power is removed from the solenoid by a CAM-operated microswitch. The solenoid then returns to the starting position, because of the ratchet action of the clutch and is held in this position by a spring-loaded detent. Each subsequent application of power causes the shaft to rotate 90 degrees clockwise. SAFE to ARM to SAFE, et cetera. Prior to launch, the safe and arm device is set to ARM position by ground support equipment in the blockhouse. After umbilical disconnect during launch, there is no control of the safe and arm device.

Ground initiated commands are transmitted in the form of tone signals. The tone signals are received by the receiver and decoded by a decoder network which energizes relays in the range safety controller. The relays supply 28 Vdc for the destruct arm cutoff, destruct, and turnoff events.

The destruct arm/cutoff command word activates a relay in the range safety controller. The controller relay activates the engine cutoff circuits in the sequencer thereby cutting off the engine. At the same time, power is supplied to the range safety EBW firing unit storage circuits, charging the units. The system is then ready for a destruct command.

As a result of the destruct command word, 28 Vdc is routed from the range safety receiver controller to the trigger circuit in the EBW firing units, thus ending the stage flight and dumping the remaining propellants overboard. If no destruct command is generated (successful launch), the turnoff command word is initiated. Controller response to this command energizes a series of relays, switching the S-IVB system from internal to external power position, thus cutting off power to the range safety flight termination system of the S-IVB and thereby returning it to safe state.

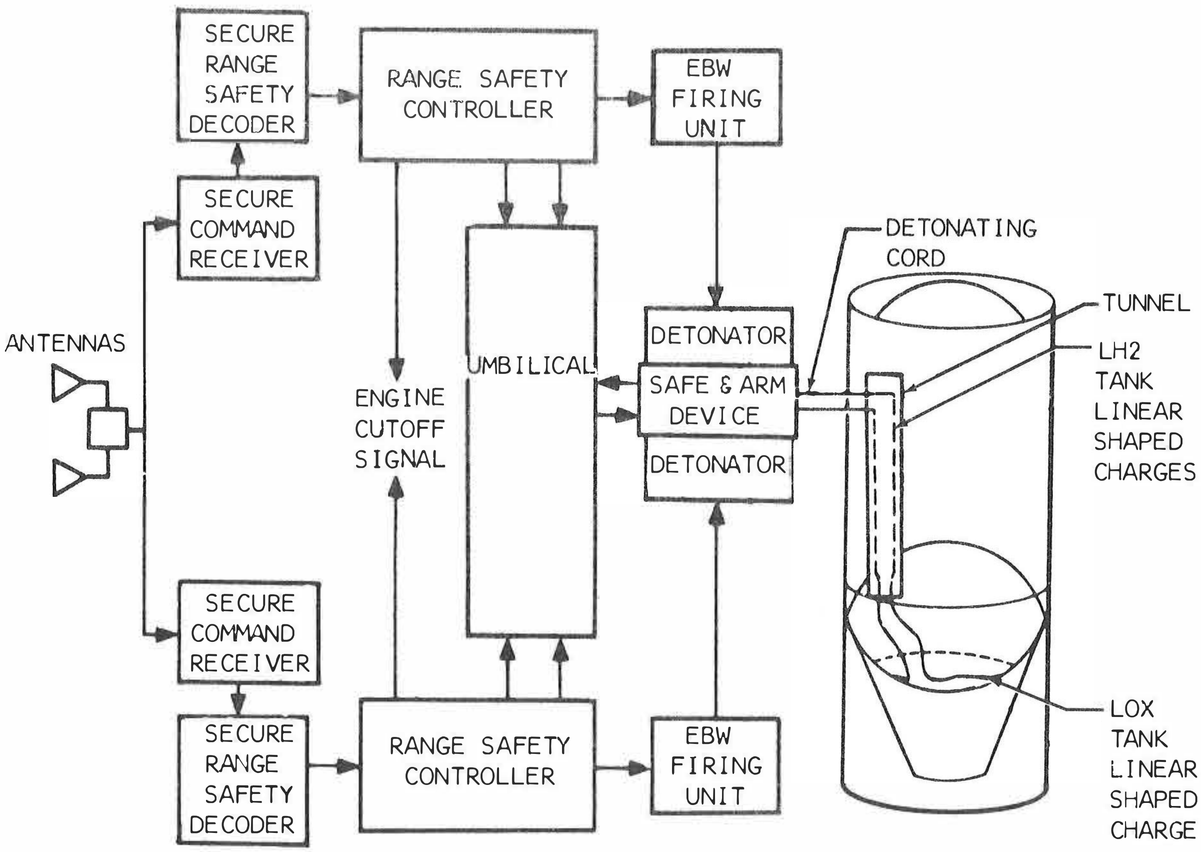
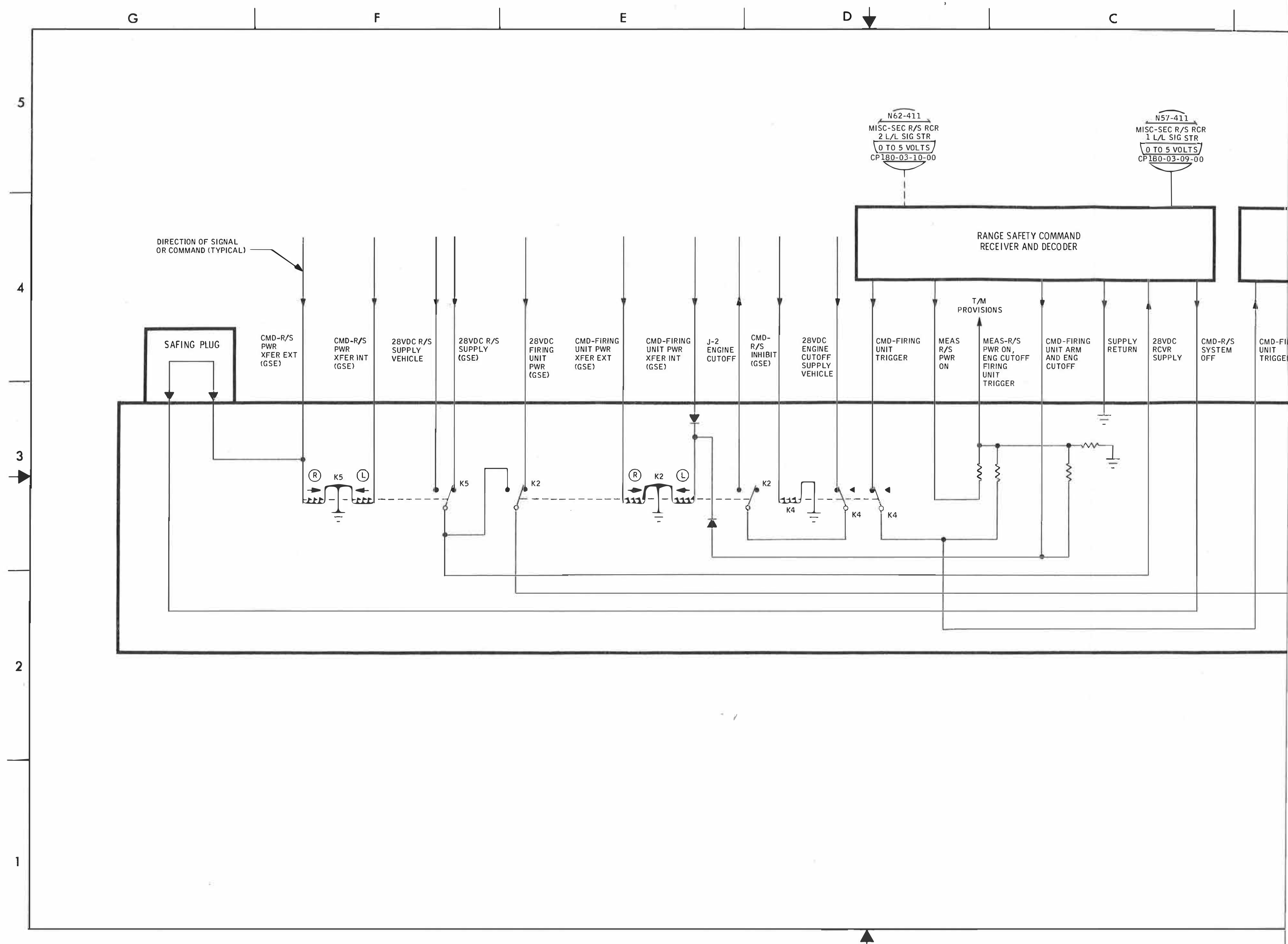
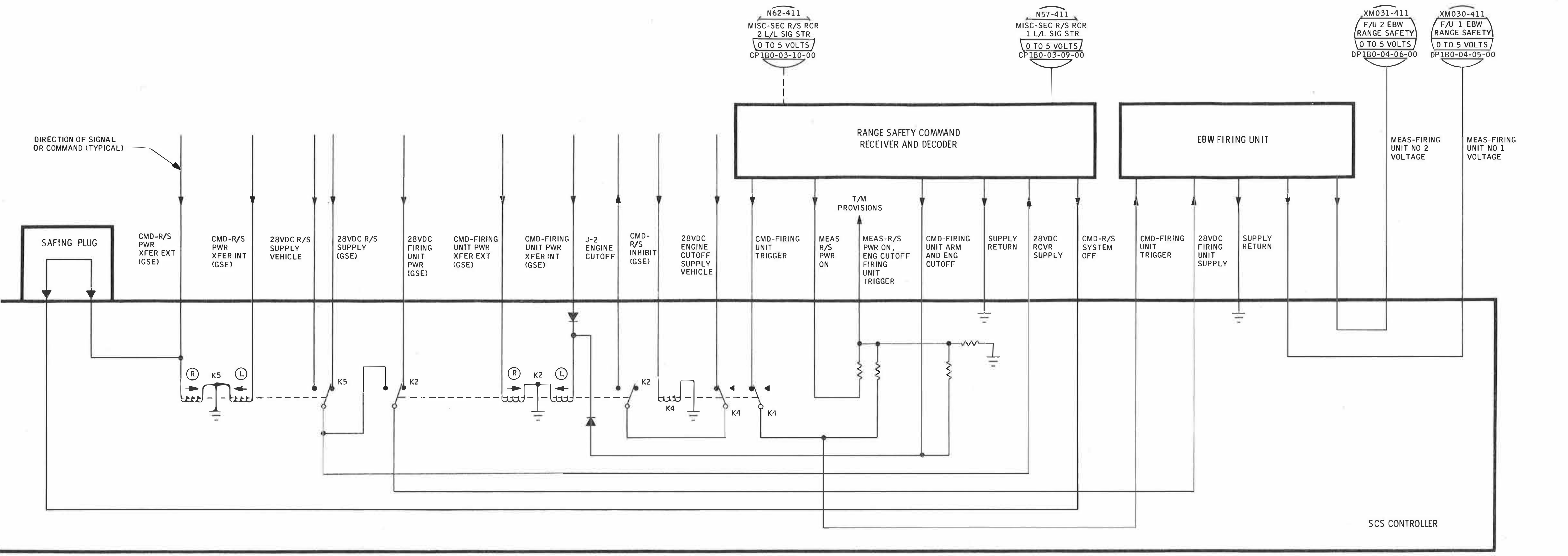


Figure 26-1.- S-IVB range safety system data flow.
(typical for all stages)


G
F
E
D
C
5
4
3
2
1
N62-411
MISC-SEC R/S RCR
2 L/L SIG STR
0 TO 5 VOLTS
CP180-03-10-00
N57-411
MISC-SEC R/S RCR
1 L/L SIG STR
0 TO 5 VOLTS
CP180-03-09-00
RANGE SAFETY COMMAND RECEIVER AND DECODER
DIRECTION OF SIGNAL OR COMMAND (TYPICAL)
T/M PROVISIONS
SAFING PLUG
CMD-R/S PWR XFER EXT (GSE)
CMD-R/S PWR XFER INT (GSE)
28VDC R/S SUPPLY VEHICLE
28VDC R/S SUPPLY (GSE)
28VDC FIRING UNIT PWR (GSE)
CMD-FIRING UNIT PWR XFER EXT (GSE)
CMD-FIRING UNIT PWR XFER INT (GSE)
J-2 ENGINE CUTOFF
CMD-R/S INHIBIT (GSE)
28VDC ENGINE CUTOFF SUPPLY VEHICLE
CMD-FIRING UNIT TRIGGER
MEAS R/S PWR ON
MEAS-R/S PWR ON, ENG CUTOFF FIRING UNIT TRIGGER
CMD-FIRING UNIT ARM AND ENG CUTOFF
SUPPLY RETURN
28VDC RCVR SUPPLY
CMD-R/S SYSTEM OFF
K5
K2
K4

LTR	DCN	DR	ENG	DATE	APPROVAL

COMMENTS:



NOTES:

1. GROUND CHECKOUT CIRCUITS NOT SHOWN
2. RELAYS SHOWN IN DEENERGIZED OR RELEASED POSITION
3. SYSTEM SHOWN IS TYPICAL FOR RANGE SAFETY SYSTEMS ONE AND TWO (S-IVB)

SIGNATURES	DATE
DR	2/19/70
DSGN	2-18-70
QC	2-18-70
ENGR	2-19-70
APP	2-20-70
FEC	2-20-70
AUTH	2-20-70

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S-IVB RANGE SAFETY SYSTEM

SLV	SIZE	DWG NO
AS-508	D	26.1.1
38.5 X 21.25	PAGE 26-4	SHEET 1 OF 1

27 SPACECRAFT/IU
INTERFACE

SECTION 27

SPACECRAFT/IU INTERFACE

27.1 GENERAL

Several launch vehicle functions are controlled by the CSM. Drawing 27.1.1 presents the following items: S-II/S-IVB LV Stage, Launch Vehicle Guidance, Translunar Inject, Up TLM, CMC control of S-IVB injection sequence start, and CMC control of S-IVB cutoff.

27.1.1 S-II/S-IVB LV Stage

This switch will cause early S-II/S-IVB staging if it is thrown during TB3. If the switch is thrown during TB4 or TB6 (after TB6 + 560), it will cause S-IVB cutoff.

27.1.2 Launch Vehicle Guidance

If the IU has S/C Control Enable, TB5 or TB7, or Guidance Reference Fail during powered phases, the astronauts can control the launch vehicle attitude.

27.1.3 Translunar Inject

If the Translunar Inject switch is in the SAFE position at TB6 initiate or during selected times in TB6, the translunar burn will be inhibited.

27.1.4 Up TLM

When the spacecraft is attached, the crew has control of the IU command system. If commanding is required during the time the spacecraft is attached, the Up TLM switch must be in ACCEPT. After separation, the command system is enabled by stage circuitry.

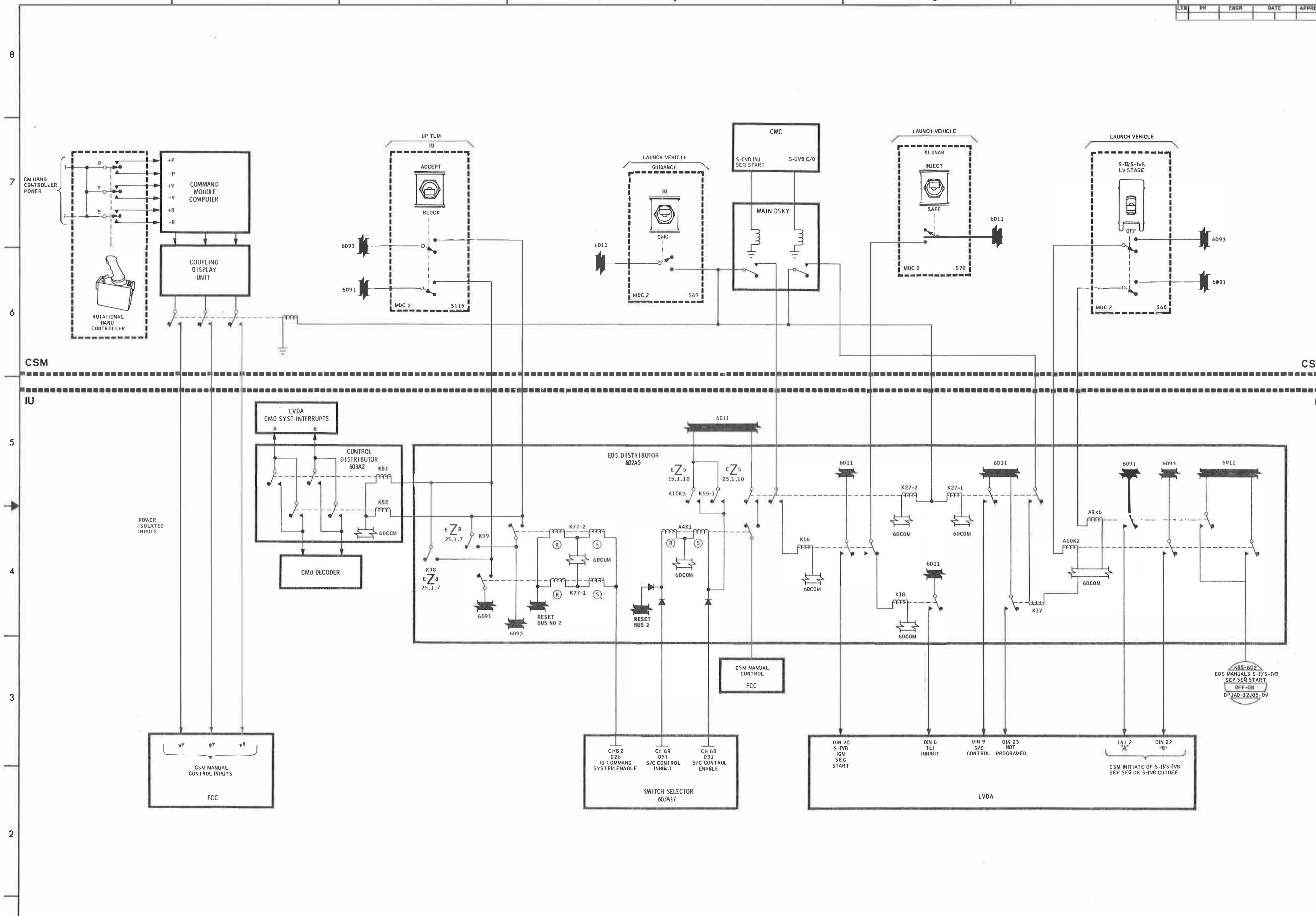
Additional interface items are in Sections 17 and 25 of this handbook.

27.1.5 S-IVB Injection Sequence Start

If the Launch Vehicle Guidance switch is in the CMC position the S/C can initiate the injection (restart) sequence (LVDC DIN 20).

27.1.6 S-IVB Cutoff

If the Launch Vehicle Guidance switch is in the CMC position the S/C can issue an S-IVB cutoff signal (LVDC DIN 23, the LVDC will not honor this discrete input on AS-508).



SIGNATURES	DATE	NATIONAL AERONAUTICS & SPACE ADMINISTRATION MANNED SPACECRAFT CENTER · HOUSTON, TEXAS
DR		SPACECRAFT/IU INTERFACE
DSGN		
QC		
ENGR		
APP		
FEC		
AUTH		

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APOLLO

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UNIVERSAL SATURN LAUNCH VEHICLE SYSTEMS HANDBOOK

AS-508 AND SUBSEQUENT VEHICLES

FEBRUARY 20, 1970

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