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SATURN LAUNCH VEHICLE SYSTEMS HANDBOOK

AS-503

SEPTEMBER 3, 1968

PREPARED BY

MARSHALL SPACE FLIGHT CENTER/FLIGHT CONTROL OFFICE

FLIGHT CONTROL DIVISION

MANNED SPACECRAFT CENTER
HOUSTON, TEXAS

1 SLV MISSION PROFILE AS-503
2 SEQUENTIAL SYSTEMS
3 ELECTRICAL POWER SYSTEMS
4 ENVIRONMENTAL CONTROL SYSTEM
5 INSTRU/ COMMUNICATION SYSTEM
6 GUIDANCE AND NAVIGATION SYSTEM
7 CONTROL
8 PROPULSION AND STRUCTURES
9 EMERGENCY DETECTION SYSTEM
10 INTERFACE SYSTEMS

A C K N O W L E D G M E N T

The flight control systems data as presented in this document was prepared by the MSFC Flight Control Team. Team members contributing to this document include Flight Controllers from the following flight control elements:

System Engineering Office, Astrionics Laboratory, International Business Machines Corporation, McDonnell-Douglas Astronautics Company.

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APOLLO

SATURN LAUNCH VEHICLE SYSTEMS HANDBOOK

AS-503

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 AS-503 as of September 3, 1968.

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.

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AS-503 Symbols

To be provided later.

SECTION 1

SLV MISSION PROFILE

1 DESCRIPTION of SLV MISSION AND VEHICLE

The 1967 flight of AS-501 provided an initial demonstration of the flight planning and hardware design of the Saturn V vehicle. The flight of AS-503 will be the first manned flight of this configuration. The primary purpose of this mission will be to demonstrate the capability of the launch vehicle, spacecraft, astronaut crew, and ground support facilities to perform the lunar orbital rendezvous (LOR) mission operations. These capabilities will be shown in an earth orbital mission, figure 1.1.

The Saturn V launch vehicle will rise from pad 39A of Kennedy Space Center (KSC) carrying the S-IVB stage, a lunar module (LM) and a command and service module (CSM) containing a crew of three astronauts. The S-IVB will burn once to establish a 100 n.mi. circular parking orbit. During the second and third revolutions, the CSM will separate, transpose, and dock with the LM/S-IVB. The CSM/LM will then separate from the S-IVB. The S-IVB will then burn a second time, then coast on the outward leg of 109 by 1,800 n.mi. elliptical orbit. The third burn phase will place the S-IVB into an earth escape trajectory. An orbital safing will be conducted after the termination of this third burn.

1.1.1 Launch

The AS-503 vehicle will be launched from the KSC Launch Complex 39A on a launch azimuth of 90°. Shortly after tower clearance, the vehicle will execute a preprogramed pitch and roll maneuver to a trajectory with a 72° east of north flight azimuth.

S-IC stage engine shutdown will be initiated by propellant level sensor actuation. The spent S-IC stage will be separated 1 second later and will impact approximately 350 n.mi. downrange.

After coasting for approximately 3 seconds, the S-II stage ignition occurs. The aft interstage and the launch escape tower are jettisoned approximately 30 seconds later. Engine shutdown for the S-II stage is initiated by the actuation of the low-level propellant sensors. At approximately 520 seconds after liftoff, the S-II will be separated.

1.1.2 S-IVB First Burn

The S-IVB engine start sequence is initiated 0.2 seconds following S-II stage separation. The S-IVB first burn duration is approximately 152 seconds measured from Engine Start command. At the end of the first S-IVB burn, the iterative guidance system will have steered the vehicle into a 100 n.mi. circular orbit.

1.1.3 Parking Orbit Coast

The vehicle will coast in the parking orbit for 4-1/2 hours during which time transposition and docking of the CSM with the LM and the extraction of the LM from the S-IVB stage will occur. A service propulsion system (SPS) ignition to propel the spacecraft onto an intermediate ellipse, for further manned orbital operations, will then take place.

1.1.4 S-IVB Second Burn

Shortly after 4-1/2 hours, when adequate separation distance between the spacecraft and the S-IVB has been assured, the S-IVB stage will reignite and burn for approximately 70 seconds measured from the time of 90 percent thrust. This burn phase will insert the S-IVB/IU into an approximate 109 by 1,800 n.mi. elliptical orbit. Following S-IVB second cutoff, the vehicle will coast in the intermediate orbit for approximately 80 minutes.

1.1.5 S-IVB Third Burn

After the 80-minute coast, the S-IVB will burn for the third time at a constant vehicle attitude for approximately 220 seconds measured from the time of 90 percent thrust. This burn phase will propel the S-IVB/IU onto an earth escape orbit.

1.1.6 Orbital Safing

After third burn cutoff, the S-IVB safing procedures are enabled. The 10- to 20,000 pounds of residual propellants will then be dumped through the main LOX and fuel valves and out of the J-2 engine bell. Propellant tank vents will then be opened. All other high pressure containers will be vented.

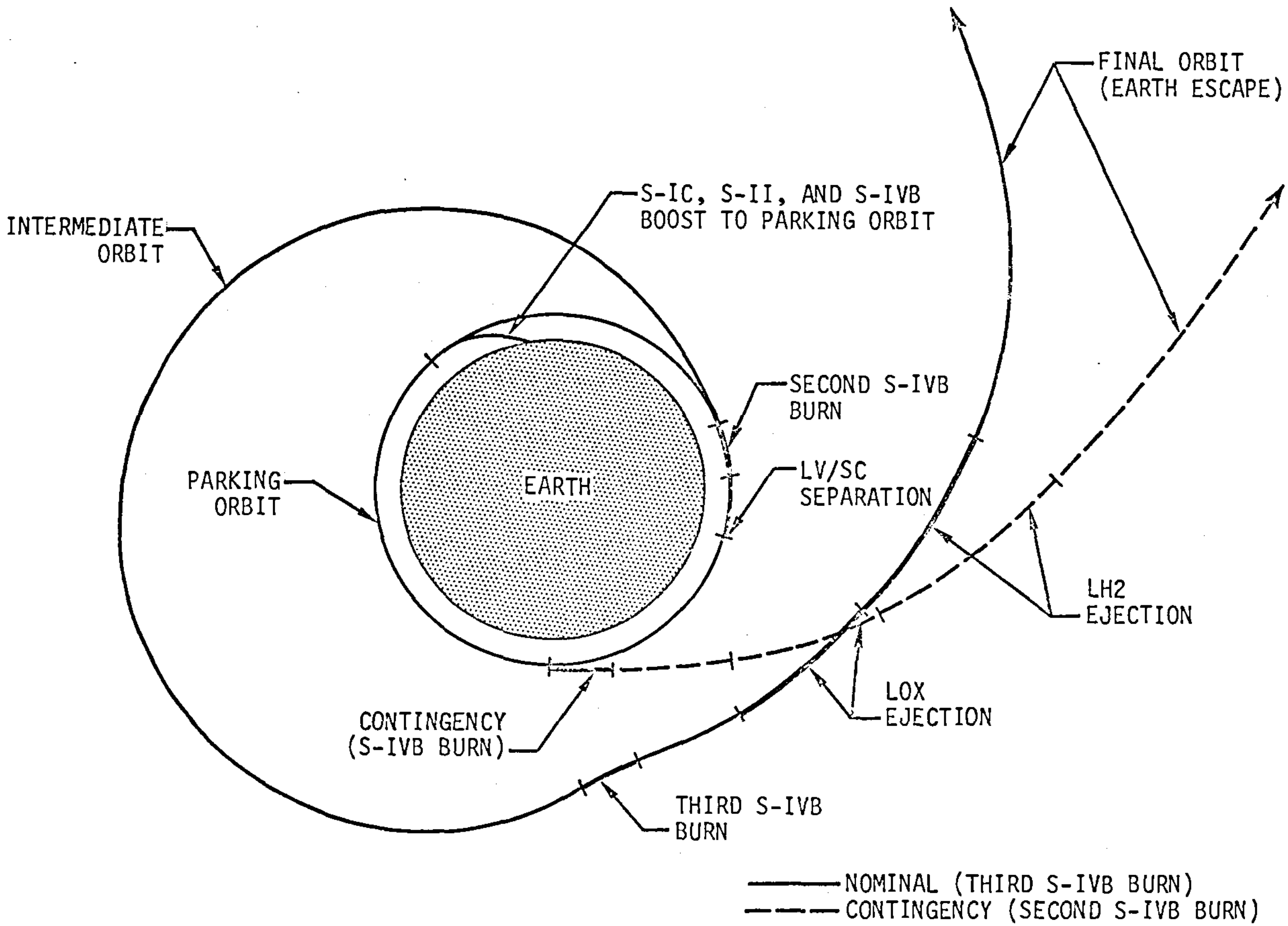

Figure 1.1. AS-503 D Mission Profile

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SECTION 2

SEQUENTIAL SYSTEMS

2.1 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) 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.

2.2 DEFINITION OF TIME BASES FOR TIME SEQUENCING

A. General

The Launch Vehicle Flight Sequence Program contains nine primary time bases and three 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 provide 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 ICD 40M33623, 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.

B. Time Base #1 (T_1)

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

A backup method for starting T_1 is provided should the LVDC fail to receive or recognize the liftoff signal. If T_1 is

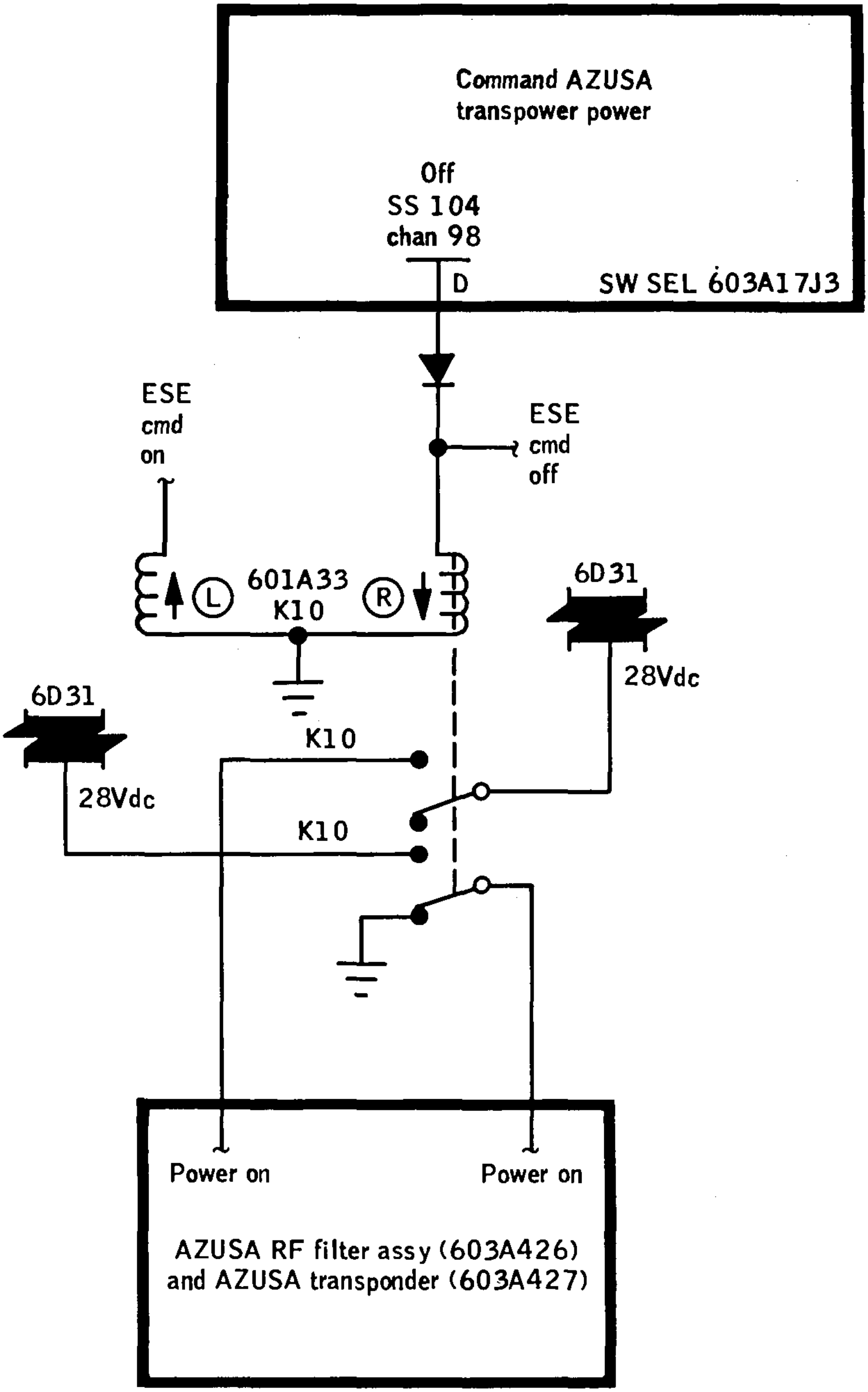

Command AZUSA
transpower power
Off
SS 104
chan 98
D
SW SEL 603A17J3
ESE
cmd
on
ESE
cmd
off
601A33
K10
6D31
28Vdc
6D31
28Vdc
K10
K10
Power on
Power on
AZUSA RF filter assy (603A426)
and AZUSA transponder (603A427)

Figure 2-6

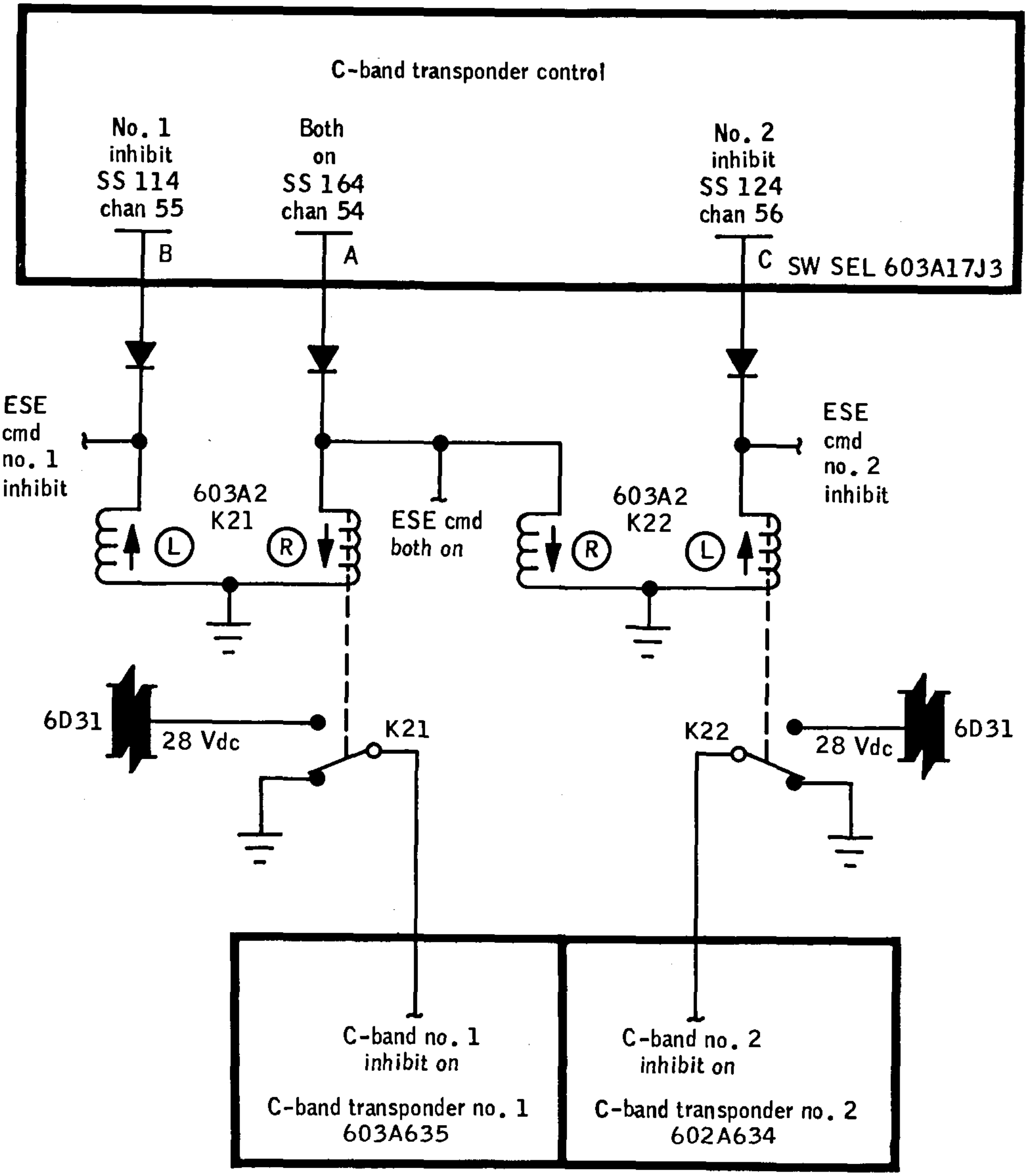

C-band transponder control
No. 1
inhibit
SS 114
chan 55
Both
on
SS 164
chan 54
No. 2
inhibit
SS 124
chan 56
B
A
C
SW SEL 603A17J3
ESE
cmd
no. 1
inhibit
603A2
K21
L
R
ESE cmd
both on
603A2
K22
R
L
ESE
cmd
no. 2
inhibit
6D31
28 Vdc
K21
K22
28 Vdc
6D31
C-band no. 1
inhibit on
C-band transponder no. 1
603A635
C-band no. 2
inhibit on
C-band transponder no. 2
602A634

Figure 2-5

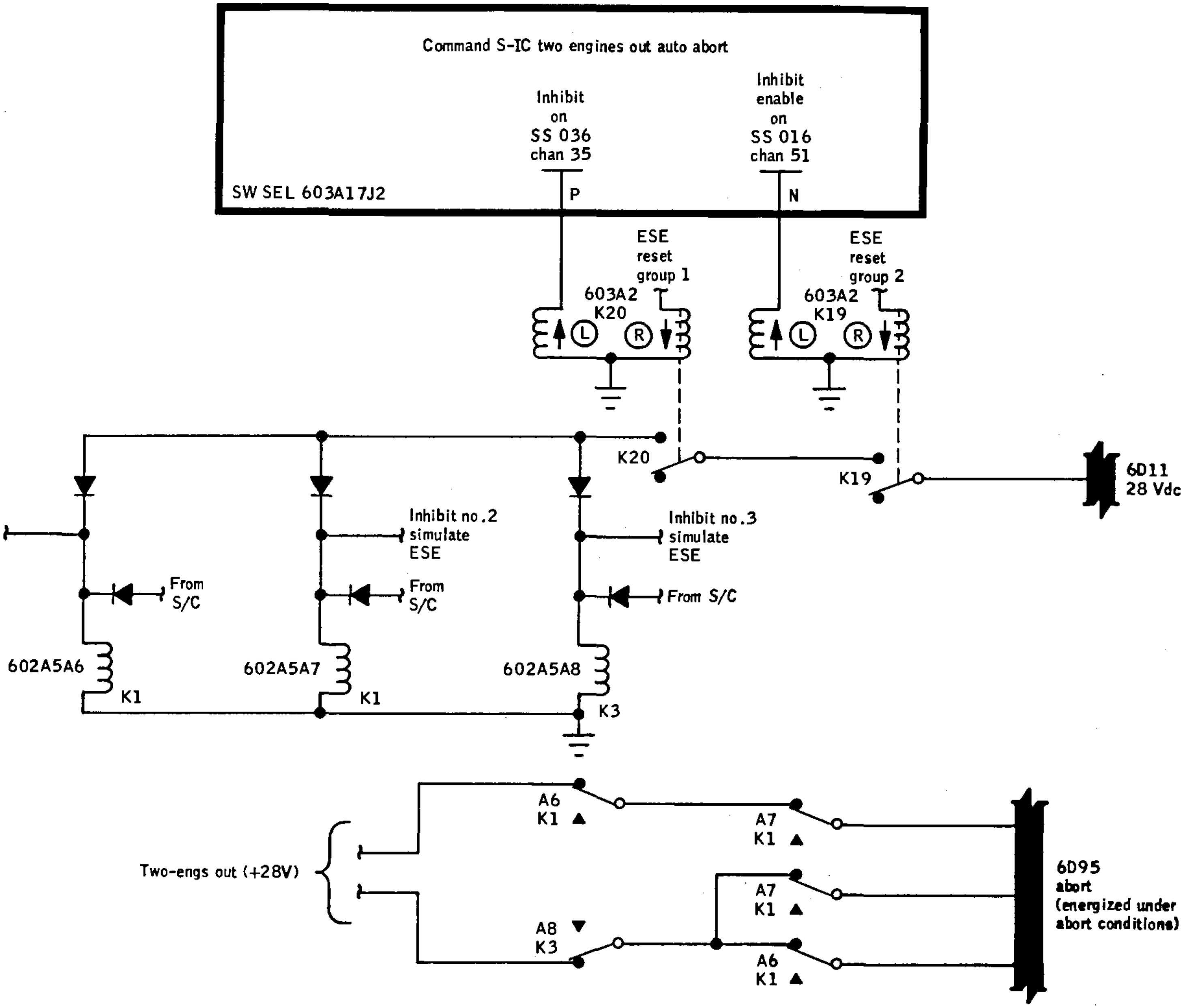
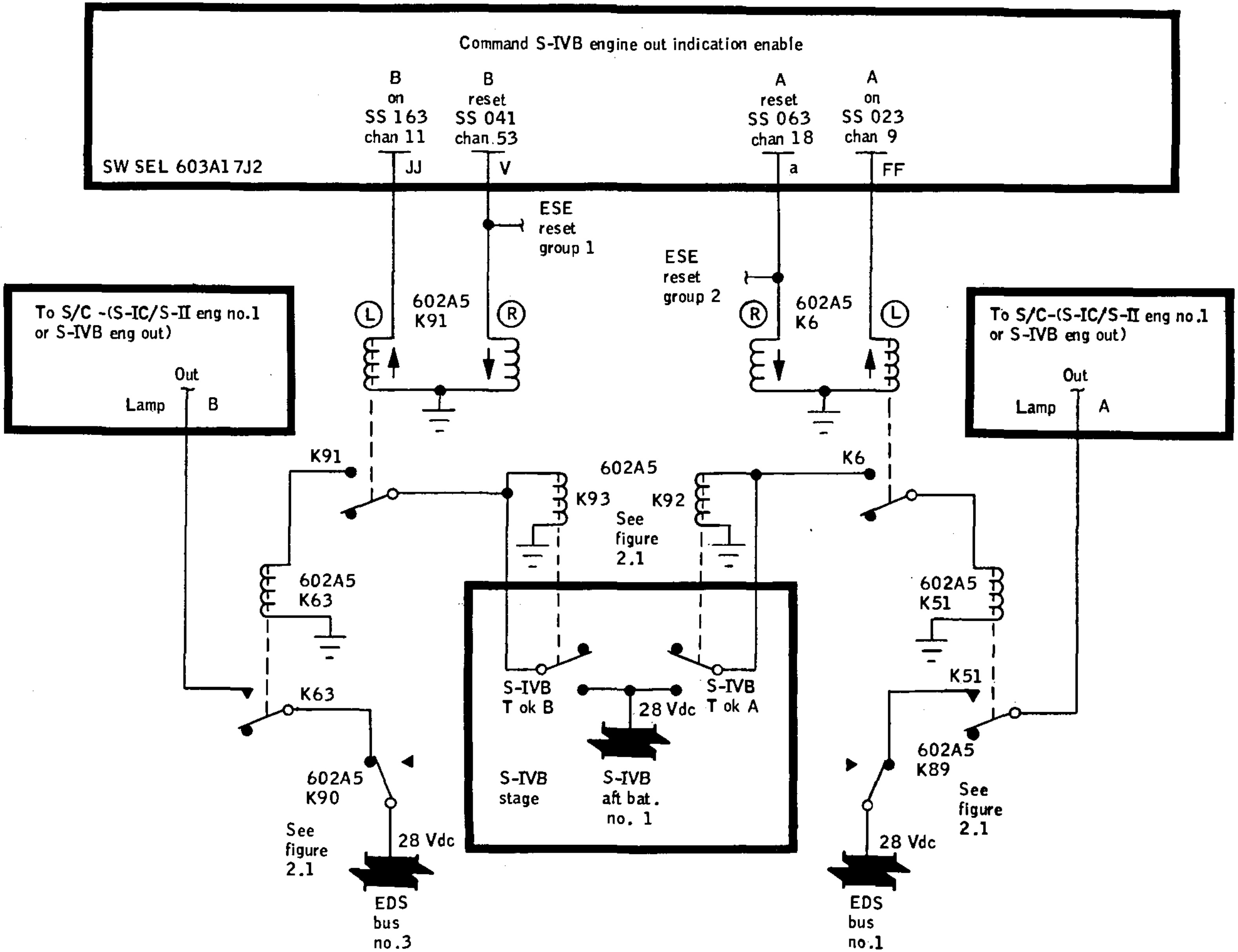

Command S-IC two engines out auto abort
Inhibit
on
SS 036
chan 35
Inhibit
enable
on
SS 016
chan 51
SW SEL 603A17J2
P
N
ESE
reset
group 1
603A2
K20
ESE
reset
group 2
603A2
K19
K20
K19
6D11
28 Vdc
Inhibit no.1
simulate
ESE
Inhibit no.2
simulate
ESE
Inhibit no.3
simulate
ESE
From
S/C
From
S/C
From S/C
602A5A6
K1
602A5A7
K1
602A5A8
K3
A6
K1
A7
K1
A7
K1
Two-engs out (+28V)
A8
K3
A6
K1
6D95
abort
(energized under
abort conditions)

Figure 2-4


Command S-IVB engine out indication enable
B on SS 163 chan 11
B reset SS 041 chan.53
A reset SS 063 chan 18
A on SS 023 chan 9
SW SEL 603A1 7J2
JJ
V
a
FF
ESE reset group 1
ESE reset group 2
To S/C -(S-IC/S-II eng no.1 or S-IVB eng out)
Out
Lamp
B
602A5 K91
L
R
602A5 K6
To S/C-(S-IC/S-II eng no.1 or S-IVB eng out)
Lamp
A
K91
602A5
K6
K93
K92
See figure 2.1
602A5 K63
602A5 K51
S-IVB T ok B
S-IVB T ok A
28 Vdc
K63
K51
602A5 K90
602A5 K89
S-IVB stage
S-IVB aft bat. no. 1
See figure 2.1
28 Vdc
EDS bus no.3
EDS bus no.1
Figure 2.3

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 1g) exists, the LVDC assumes that liftoff 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.

C. 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 downrange accelerometer. If sufficient downrange velocity exists, the LVDC will start Time Base #2 (T_2).

Use of the downrange velocity reading provides a safeguard against starting T_2 on the pad should T_1 be started without liftoff. 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.

D. 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.

E. 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 cutoff command is issued at T_4 + 0.0.

F. 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 + 1.3 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 return to primary Time Base #5 at S-IVB cutoff.

G. 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 interrupt from the engine thrust not okay switch A.
2. J2 engine out "B" LVDA discrete input from the engine thrust not okay 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.

H. Time Base #6 (T_6)

The starting of Time Base #6 will be inhibited in the LVDC. This inhibit (restart inhibit) must be removed prior to the LVDC solving the restart equation by DCS Command. After a predetermined time in Time Base #5 (approximately 15, 113

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seconds) and with the restart inhibit removed, Time Base #5 will be initiated by the LVDC upon solving the restart equation.

I. Alternate Time Base #T6a (T_{6a})

Alternate Time Base T_{6a} will be programed for use should the O_2 - H_2 burner malfunction between the times T_6 + 48.0 seconds and T_6 + 496.9 seconds. This alternate time base will be initiated by the LVDC upon receiving a "O_2 - H_2 Burner Malfunction" signal from the S-IVB stage. The LVDC returns to Time Base (T_6) after completion of the events in Time Base T_{6a}.

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 T_7.

K. Time Base #8 (T_8)

The starting of Time Base #8 will be inhibited in the LVDC. This inhibit (restart inhibit) must be removed by DCS command prior to a predetermined time in Time Base #5 (T6 + 4981.0 seconds) to allow initiation of T_8.

If Time Base #7 has been initiated and the restart inhibit removed, the LVDC will initiate Time Base #8 at 4990.0 seconds after first restart equation convergence (T_6 + 4990.0 seconds).

L. Time Base #8a (T_{8a})

This alternate time base will be programed for use in the event Time Base #6 is not initiated and a second burn of the S-IVB stage is desired.

The starting of Time Base #8a will be inhibited in the LVDC. This inhibit (restart inhibit) must be removed by

DCS command prior to a predetermined time from LVDC restart equation convergence (convergence + 5621.0 seconds). With the inhibit removed and Time Base #6 not having been initiated, T_{8a} will be initiated 5630.4 seconds after equation convergence.

M. Time Base #9 (T_9)

Time Base #9 will start after receiving any two of the four functions monitored by the LVDC, same as Time Base #7 (T_7).

This time base will be programed for use in the nominal sequence as the second orbital coast time base following S-IVB restart.

2.3 FLIGHT SEQUENCE PROGRAM

The flight sequences of events is not incorporated in this handbook since frequent and late changes to the flight program does not lend itself to meeting the scheduled completion date of this document.

Consequently, it is incumbent on the user to obtain an updated copy of the Interface Control Document, MSFC, 40M33623, for this information.

2.4 INTRODUCTION TO SWITCH SELECTOR CONTROL COMMANDS

Switch selector controlled commands, and the channel designation, are organized so that the IU, S-IVB, S-II, and S-IC are independently listed in paragraphs 2.4.1, 2.4.2, 2.4.3, and 2.4.4. Switch selector functions labeled as spares are not wired for use on this mission.

2.4.1 IU Switch Selector Functions (Octal)

CH	CODE	FUNCTION	FIGURE NO.
	000		
37	001	SPARE	
5	002	SPARE	
30	003	SPARE	
74	004	COMMAND FLIGHT CONTROL COMPUTER S-IVB BURN MODE ON "B"	2.1
81	005	COMMAND S-IVB RESTART ALERT OFF	2.1
97	006	SPARE	
63	007	COMMAND CCS COAX SWITCH-FAIL SAFE-HIGH GAIN ANTENNA	2.13
	010		
87	011	SPARE	
111	012	SPARE	
94	013	SPARE	
49	014	SPARE	
14	015	COMMAND IU TAPE RECORDER PLAYBACK OFF	2.7
51	016	COMMAND S-IC TWO ENGINES OUT AUTO-ABORT INHIBIT ENABLE	2.4
39	017	COMMAND IU TAPE RECORDER RECORD ON	2.7
	020		
16	021	COMMAND AUTO-ABORT ENABLE RELAYS RESET	2.12
24	022	COMMAND TELEMETER CALIBRATOR STOP INFLIGHT CALIBRATE	2.9
9	023	COMMAND S-IVB ENGINE OUT INDICATION ENABLE "A" ON	2.3
75	024	COMMAND FLIGHT CONTROL COMPUTER S-IVB BURN MODE OFF "B"	2.1
109	025	COMMAND SENSOR BIAS ON	2.17
82	026	COMMAND IU COMMAND SYSTEM ENABLE	2.11
71	027	SPARE	
	030		
68	031	COMMAND SPACECRAFT CONTROL OF SATURN ENABLE	
57	032	SPARE	
96	033	SPARE	
33	034	COMMAND SWITCH ENGINE CONTROL TO S-II AND S-IC OUTBOARD ENGINE CANT OFF	2.1
7	035	COMMAND FLIGHT CONTROL COMPUTER SWITCH POINT NO. 7	
35	036	COMMAND S-IC TWO ENGINES, OUT AUTO-ABORT INHIBIT	2.4
17	037	COMMAND IU TAPE RECORDER RECORD OFF	2.7

CH	CODE	FUNCTION	FIGURE NO.
	040		
53	041	COMMAND S-IVB ENGINE OUT INDICATION "B" RESET	2.3
23	042	COMMAND TELEMETER CALIBRATOR INFLIGHT CALIBRATE	2.9
31	043	COMMAND FLIGHT CONTROL COMPUTER S-IVB BURN MODE ON "A"	2.1
61	044	COMMAND PCM COAX SWITCH-OMNI ANTENNA	2.13
93	045	SPARE	
102	046	SPARE	
90	047	SPARE	
	050		
69	051	SPARE	
65	052	COMMAND CCS COAX SWITCH-LOW GAIN ANTENNA	2.13
73	053	SPARE	
48	054	COMMAND ENABLE S-II ENGINE OUT INDICATION ENABLE "B" ON	2.1
6	055	SPARE	
52	056	SPARE	
40	057	COMMAND IU TAPE RECORDER PLAYBACK ON	2.7
	060		
38	061	COMMAND ENABLE LAUNCH VEHICLE ENGINES EDS CUTOFF	2.14
44	062	COMMAND FLIGHT CONTROL COMPUTER SWITCH POINT NO. 5	2.2
18	063	COMMAND S-IVB ENGINE OUT INDICATION "A" RESET	2.3
110	064	COMMAND COOLING SYSTEM ELECT ASSY POWER OFF	2.17
92	065	SPARE	
101	066	SPARE	
67	067	SPARE	
	070		
58	071	COMMAND CCS TRANSMITTER INHIBIT ON	2.13
64	072	COMMAND CCS COAX SWITCH-OMNI ANTENNA	2.13
95	073	SPARE	
29	074	COMMAND S-IVB EDS ENGINE CUTOFF DISABLE	
25	075	SPARE	
36	076	SPARE	
8	077	SPARE	
	100		
21	101	COMMAND FLIGHT CONTROL COMPUTER SWITCH POINT NO. 2	2.2
46	102	COMMAND S-IVB ULLAGE THRUST PRESENT OFF	2.8
32	103	SPARE	
98	104	SPARE	2.6
108	105	COMMAND H_2O COOLANT VALVE CLOSED	2.16
76	106	SPARE	
89	107	SPARE	
	110		
66	111	SPARE	
62	112	COMMAND PCM COAX SWITCH-HIGH GAIN ANTENNA	2.13
112	113	COMMAND MEASURING RACK (602A408) POWER OFF	2.15
105	114	SPARE	
12	115	COMMAND FLIGHT CONTROL COMPUTER S-IVB BURN MODE OFF "A"	2.1
41	116	COMMAND INHIBIT EXCESSIVE P, Y & R AUTO-ABORT OFF	2.18
34	117	COMMAND EXCESSIVE ROLL AUTO ABORT INHIBIT ON	2.18

CH	CODE	FUNCTION	FIGURE NO.
	120		
22	121	COMMAND FLIGHT CONTROL COMPUTER SWITCH POINT NO. 3	2.2
19	122	COMMAND IU TAPE RECORDER PLAYBACK REVERSE ON	2.7
45	123	SPARE	
56	124	COMMAND C-BAND TRANSPONDER NO. 2 INHIBIT ON	2.5
91	125	SPARE	
99	126	SPARE	
86	127	COMMAND S-IC OUTBOARD ENGINE CANT OFF "B"	
	130		
84	131	COMMAND S-IC OUTBOARD ENGINE CANT ON "B"	
100	132	SPARE	
60	133	COMMAND PCM COAX SWITCH-FAIL SAFE-LOW GAIN ANTENNA	2.13
88	134	SPARE	
27	135	COMMAND FLIGHT CONTROL COMPUTER SWITCH POINT NO. 9	
42	136	COMMAND ENABLE EXCESSIVE ROLL AUTO ABORT INHIBIT OFF	2.18
2	137	COMMAND EXCESSIVE RATE (P, Y & R) AUTO-ABORT INHIBIT ON	2.18
	140		
4	141	COMMAND FLIGHT CONTROL SWITCH POINT NO. 4	2.2
3	142	COMMAND IU TAPE RECORDER PLAYBACK REVERSE OFF	2.7
10	143	SPARE	
55	144	COMMAND C-BAND TRANSPONDER NO. 1 INHIBIT ON	2.5
107	145	COMMAND WATER COOLANT VALVE OPEN	2.16
77	146	SPARE	
85	147	COMMAND S-IC OUTBOARD ENGINE CANT ON "C"	
	150		
83	151	COMMAND S-IC OUTBOARD ENGINE CANT ON "A"	
79	152	SPARE	
59	153	COMMAND CCS TRANSMITTER INHIBIT OFF	2.13
70	154	SPARE	
47	155	COMMAND FLIGHT CONTROL COMPUTER SWITCH POINT NO. 8	
20	156	COMMAND INHIBIT EXCESSIVE ROLL AUTO-ABORT OFF	2.18
15	157	COMMAND ENABLE EXCESSIVE RATE (P, Y & R) AUTO-ABORT INHIBIT	2.18
	160		
50	161	COMMAND INHIBIT EXCESSIVE ROLL AUTO ABORT	2.18
13	162	COMMAND ENABLE EXCESSIVE P, Y & R AUTO-ABORT INHIBIT OFF	2.18
11	163	COMMAND S-IVB ENGINE OUT INDICATION ENABLE "B" ON	2.3
54	164	COMMAND C-BAND TRANSPONDERS NO. 1 AND NO. 2 ON	2.5
106	165	COMMAND S-I RF ASSEMBLY POWER OFF	2.19
78	166	SPARE	
104	167	SPARE	
	170		
103	171	SPARE	
80	172	S-IVB RESTART ALERT ON	2.1
72	173	SPARE	
28	174	COMMAND S-II ENGINE OUT INDICATION ENABLE "A" ON	2.1
26	175	COMMAND FLIGHT CONTROL COMPUTER SWITCH POINT NO. 1	2.2
43	176	COMMAND S-IVB ULLAGE THRUST PRESENT ON	2.8
1	177	COMMAND Q-BALL POWER OFF	2.10

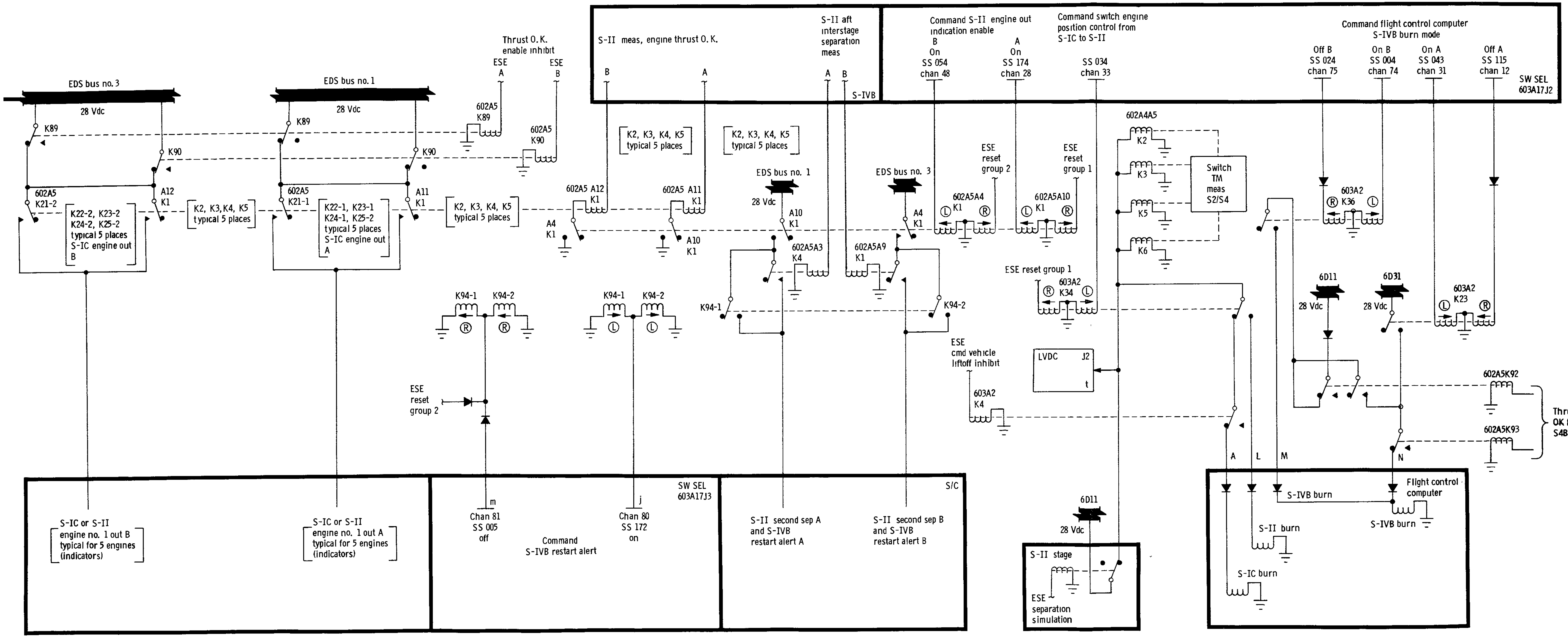
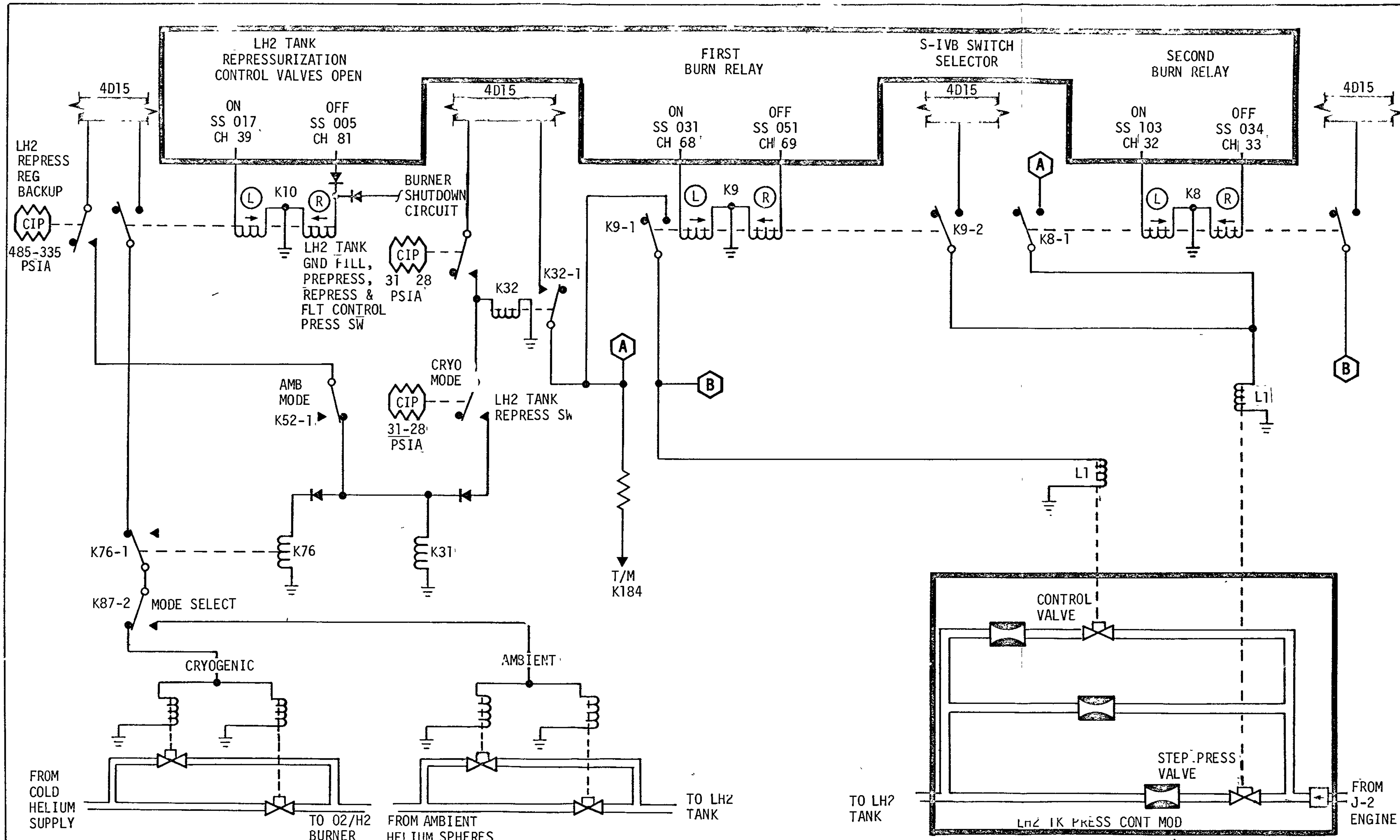
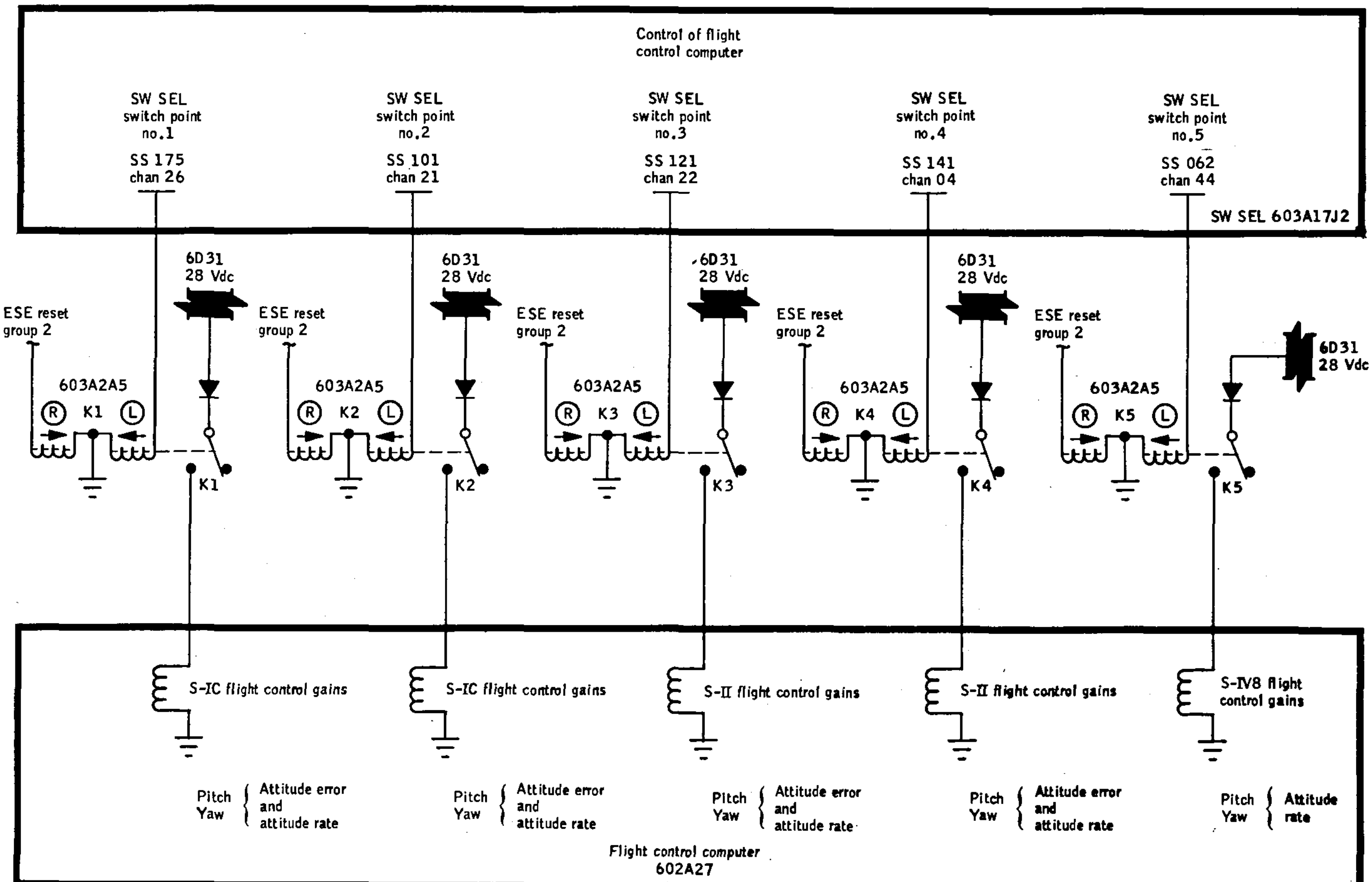

EDS bus no. 3
28 Vdc
K89
K90
602A5
K21-2
A12
K1
K22-2, K23-2
K24-2, K25-2
typical 5 places
S-IC engine out
B
K2, K3, K4, K5
typical 5 places
EDS bus no. 1
28 Vdc
K89
K90
602A5
K21-1
A11
K1
K22-1, K23-1
K24-1, K25-2
typical 5 places
S-IC engine out
A
K2, K3, K4, K5
typical 5 places
Thrust O.K.
enable inhibit
ESE
A
ESE
B
602A5
K89
602A5
K90
S-II meas, engine thrust O.K.
B
A
S-II aft
interstage
separation
meas
A
B
S-IVB
602A5 A12
K1
602A5 A11
K1
A4
K1
A10
K1
K2, K3, K4, K5
typical 5 places
K2, K3, K4, K5
typical 5 places
EDS bus no. 1
28 Vdc
A10
K1
602A5A3
K4
EDS bus no. 3
A4
K1
602A5A9
K1
K94-1
K94-2
K94-1
K94-2
K94-1
K94-2
ESE
reset
group 2
Command S-II engine out
indication enable
B
On
SS 054
chan 48
A
On
SS 174
chan 28
602A5A4
K1
602A5A10
K1
ESE
reset
group 2
ESE
reset
group 1
Command switch engine
position control from
S-IC to S-II
SS 034
chan 33
602A4A5
K2
K3
K5
K6
Switch
TM
meas
S2/S4
ESE reset group 1
603A2
K34
ESE
cmd vehicle
liftoff inhibit
603A2
K4
LVDC
J2
t
Command flight control computer
S-IVB burn mode
Off B
SS 024
chan 75
On B
SS 004
chan 74
On A
SS 043
chan 31
Off A
SS 115
chan 12
SW SEL
603A17J2
603A2
K36
6D11
28 Vdc
6D31
28 Vdc
603A2
K23
602A5K92
602A5K93
Thrust not
OK from
S4B stage
A
L
M
N
S-IC or S-II
engine no. 1 out B
typical for 5 engines
(indicators)
S-IC or S-II
engine no. 1 out A
typical for 5 engines
(indicators)
SW SEL
603A17J3
m
Chan 81
SS 005
off
Command
S-IVB restart alert
j
Chan 80
SS 172
on
S/C
S-II second sep A
and S-IVB
restart alert A
S-II second sep B
and S-IVB
restart alert B
6D11
28 Vdc
S-II stage
ESE
separation
simulation
S-IVB burn
Flight control
computer
S-IVB burn
S-II burn
S-IC burn

Figure 2.1



Commands LH2 Tank Press and Repress Valves

FIGURE 2-27



Control of flight control computer
SW SEL switch point no.1
SS 175 chan 26
SW SEL switch point no.2
SS 101 chan 21
SW SEL switch point no.3
SS 121 chan 22
SW SEL switch point no.4
SS 141 chan 04
SW SEL switch point no.5
SS 062 chan 44
SW SEL 603A17J2
6D31 28 Vdc
ESE reset group 2
603A2A5
R
K1
L
K2
K3
K4
K5
S-IC flight control gains
S-IC flight control gains
S-II flight control gains
S-II flight control gains
S-IV8 flight control gains
Pitch Yaw { Attitude error and attitude rate
Pitch Yaw { Attitude rate
Flight control computer 602A27

Figure 2-2

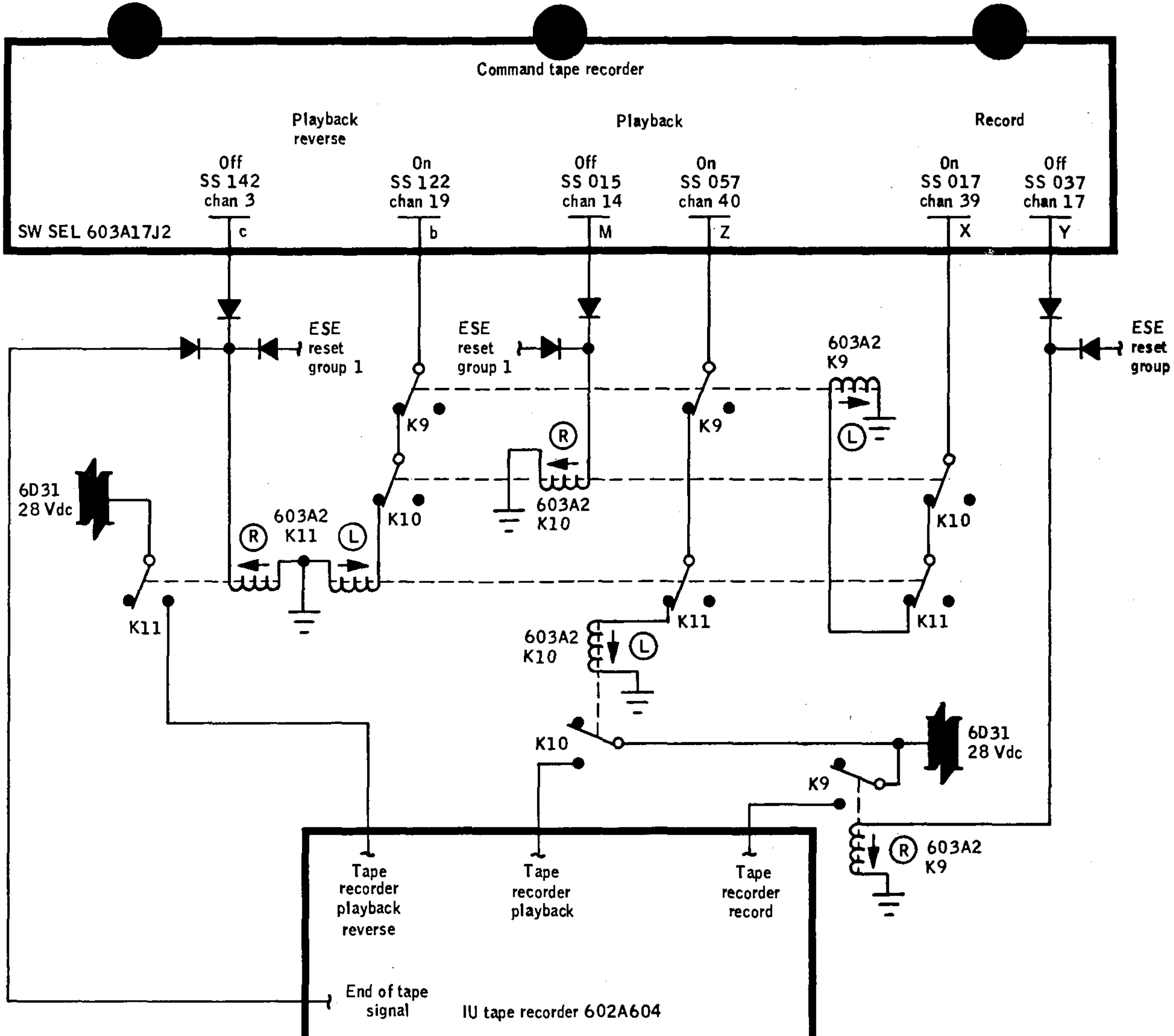

Command tape recorder
Playback reverse
Playback
Record
Off
SS 142
chan 3
On
SS 122
chan 19
Off
SS 015
chan 14
On
SS 057
chan 40
On
SS 017
chan 39
Off
SS 037
chan 17
SW SEL 603A17J2
c
b
M
Z
X
Y
ESE reset group 1
ESE reset group 1
ESE reset group 1
603A2 K9
K9
K9
R
L
603A2 K10
K10
K10
6D31 28 Vdc
603A2 K11
K11
K11
K11
603A2 K10
K10
6D31 28 Vdc
K9
603A2 K9
Tape recorder playback reverse
Tape recorder playback
Tape recorder record
End of tape signal
IU tape recorder 602A604

Figure 2-7

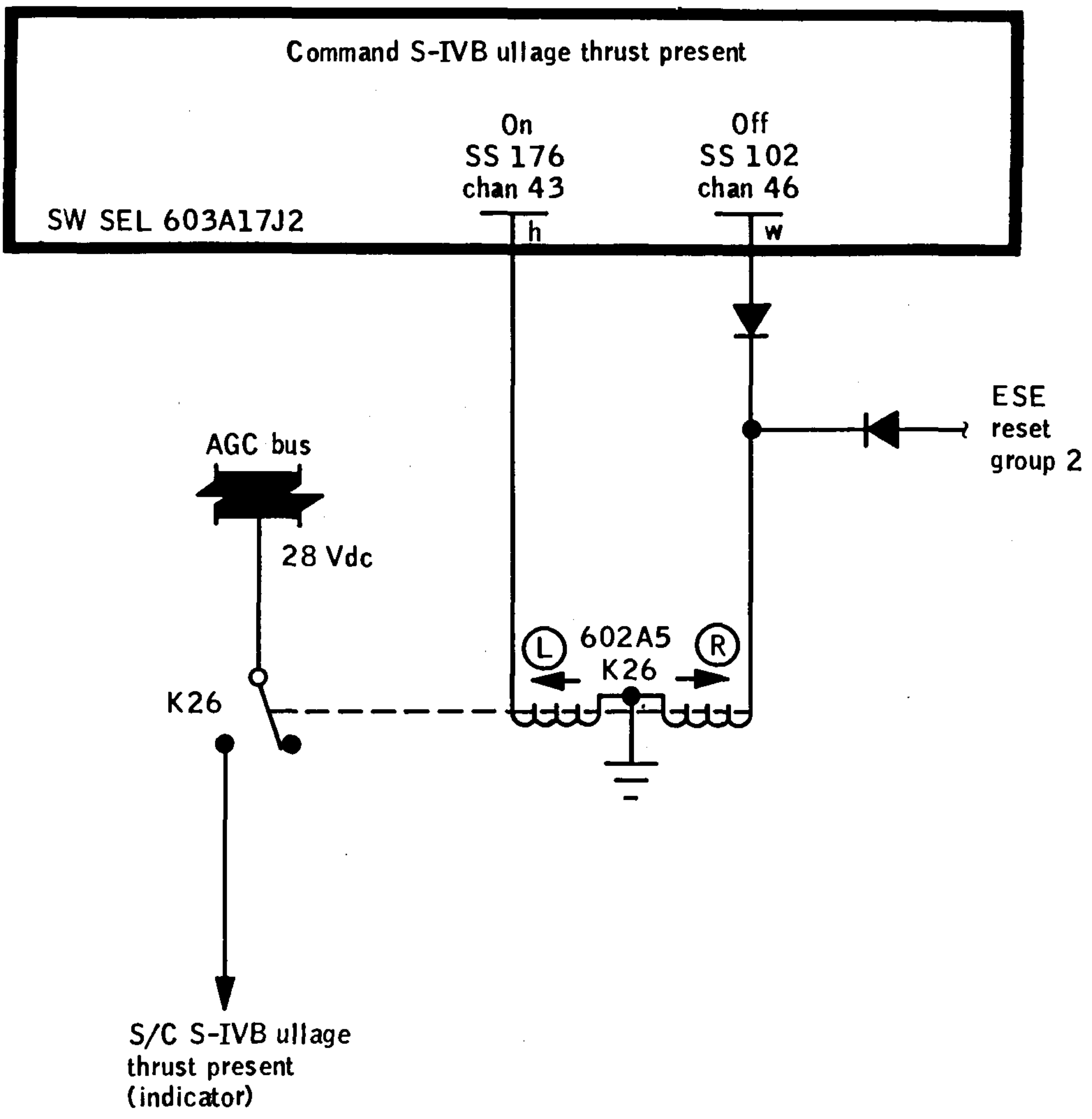

Command S-IVB ullage thrust present
On
SS 176
chan 43
Off
SS 102
chan 46
SW SEL 603A17J2
h
w
ESE
reset
group 2
AGC bus
28 Vdc
L
602A5
K26
R
K26
S/C S-IVB ullage
thrust present
(indicator)

Figure 2-8

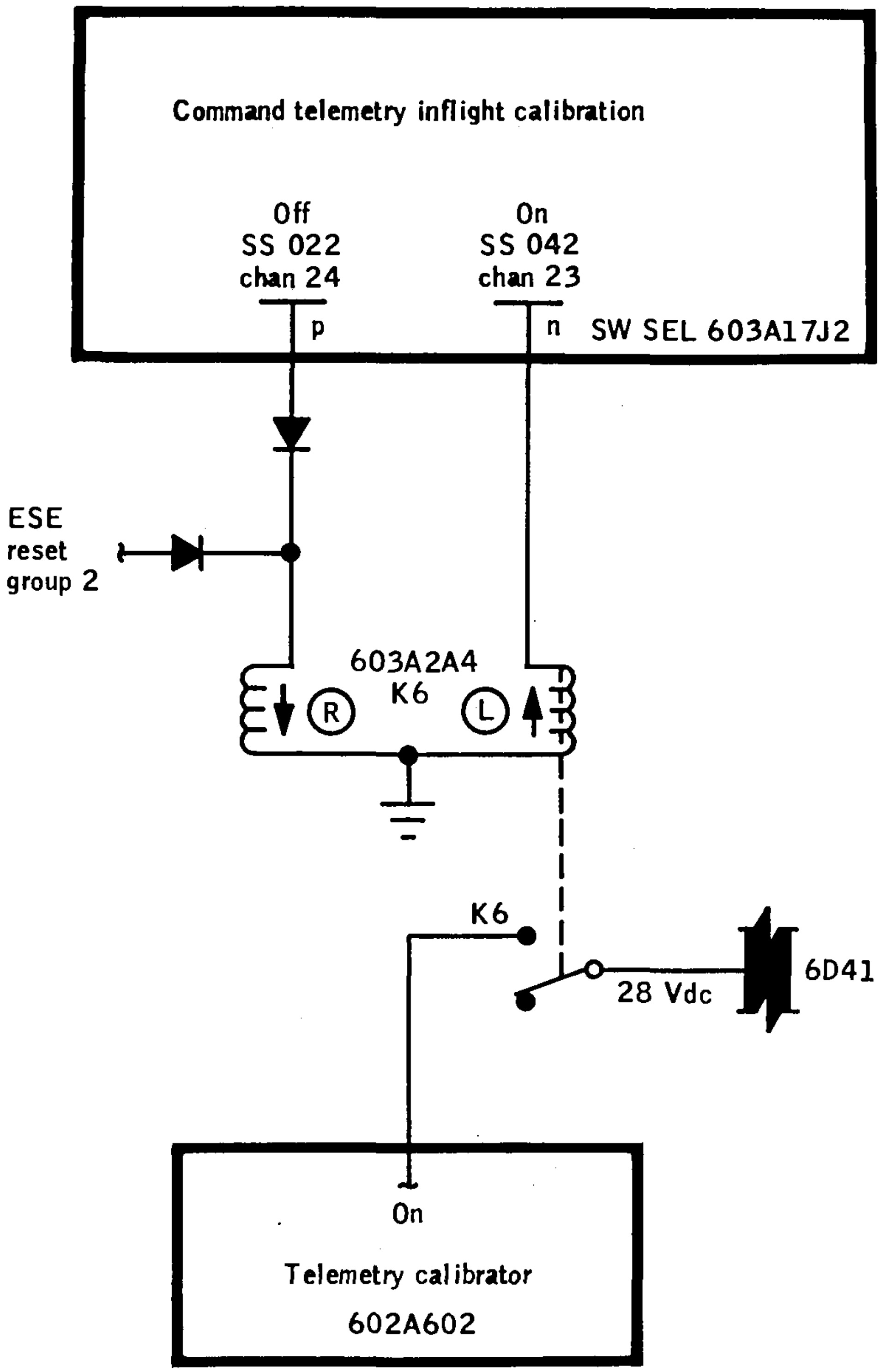

Command telemetry inflight calibration
Off
SS 022
chan 24
On
SS 042
chan 23
p
n
SW SEL 603A17J2
ESE
reset
group 2
603A2A4
K6
R
L
K6
28 Vdc
6D41
On
Telemetry calibrator
602A602

Figure 2.9

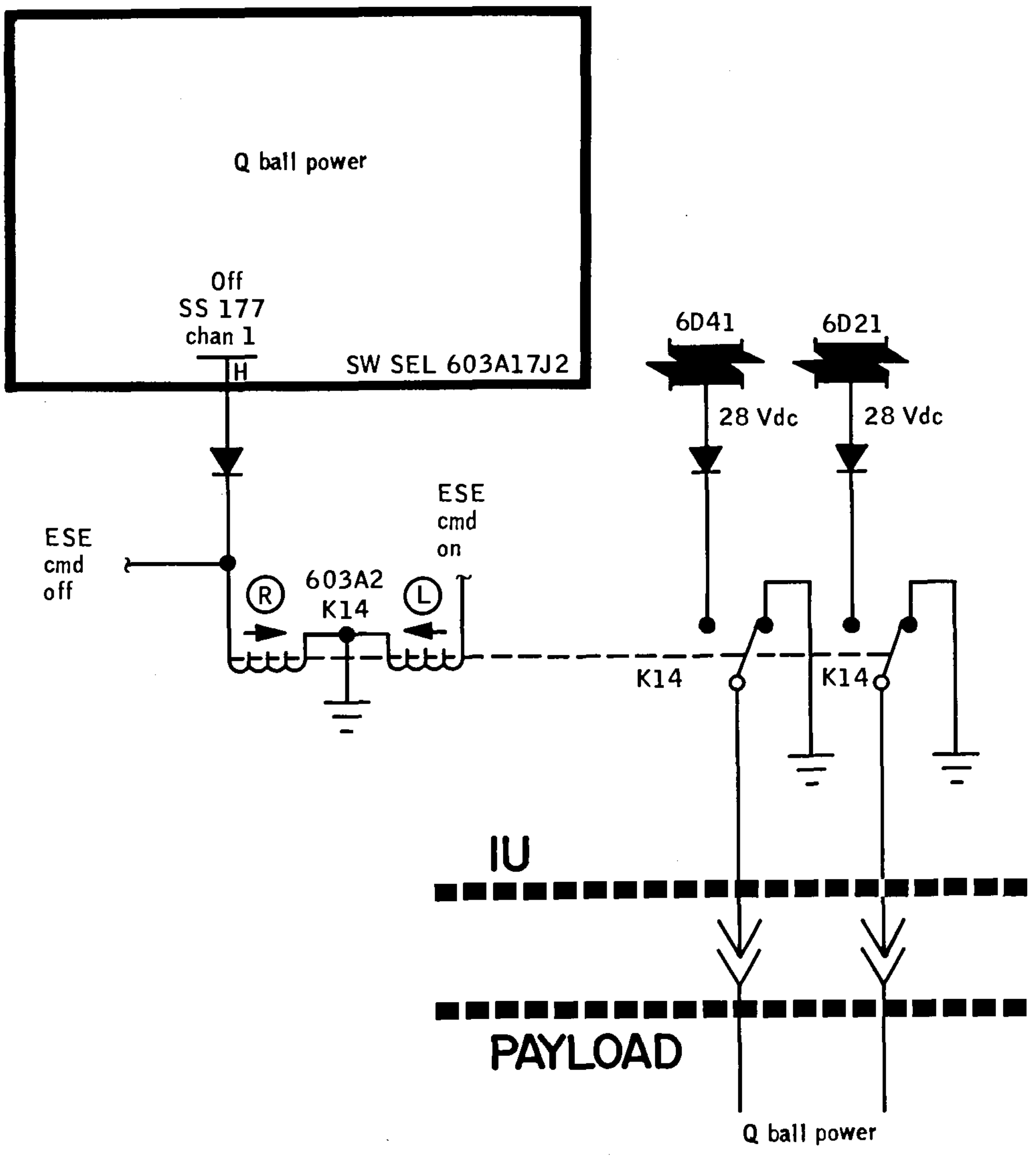

Q ball power
Off
SS 177
chan 1
H
SW SEL 603A17J2
6D41
6D21
28 Vdc
28 Vdc
ESE
cmd
on
ESE
cmd
off
R
603A2
K14
L
K14
K14
IU
PAYLOAD
Q ball power

Figure 2-10

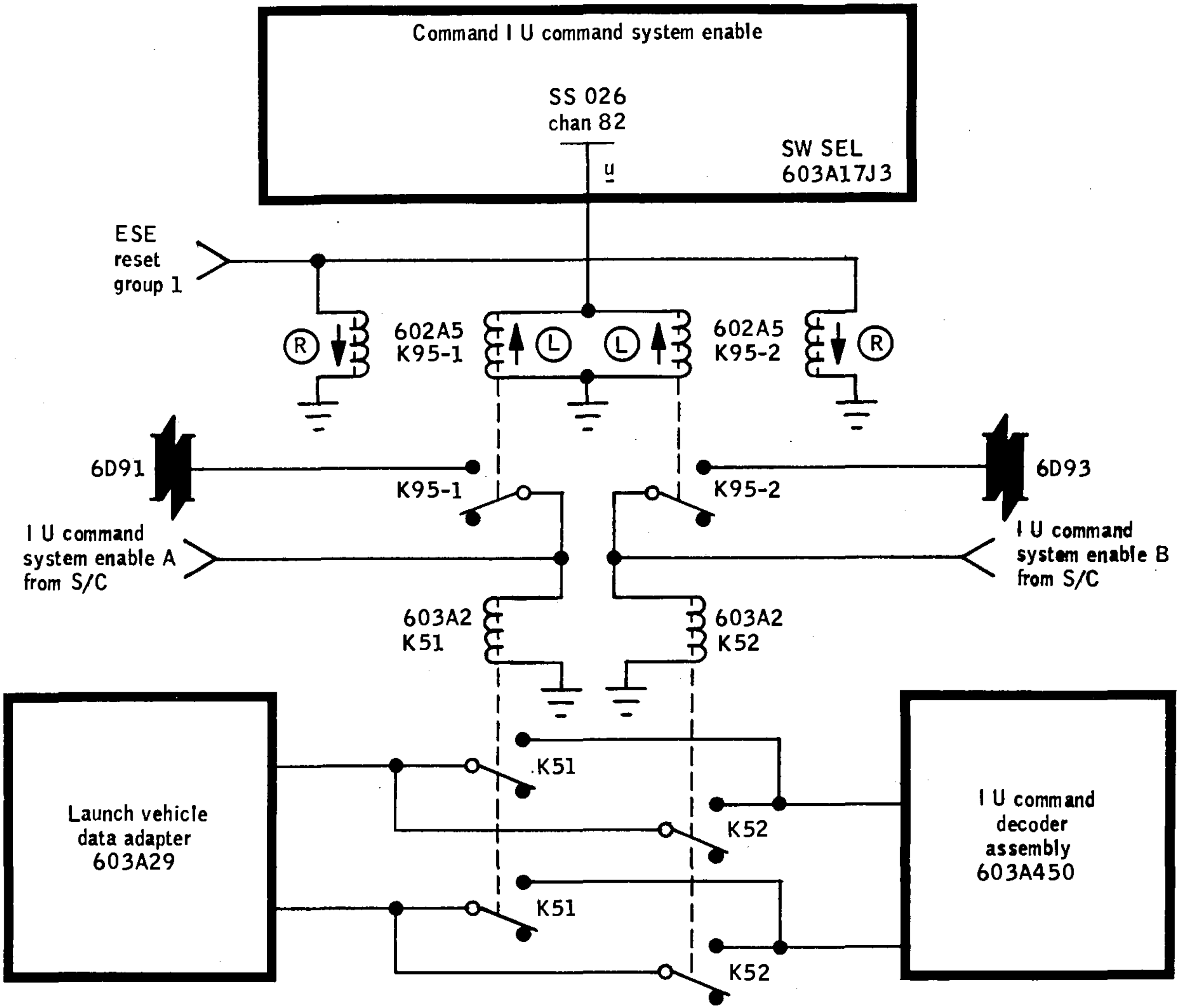

Command I U command system enable
SS 026
chan 82
u
SW SEL
603A17J3
ESE
reset
group 1
602A5
K95-1
602A5
K95-2
R
L
L
R
6D91
K95-1
K95-2
6D93
I U command
system enable A
from S/C
I U command
system enable B
from S/C
603A2
K51
603A2
K52
K51
K52
K51
K52
Launch vehicle
data adapter
603A29
I U command
decoder
assembly
603A450

Figure 2-11

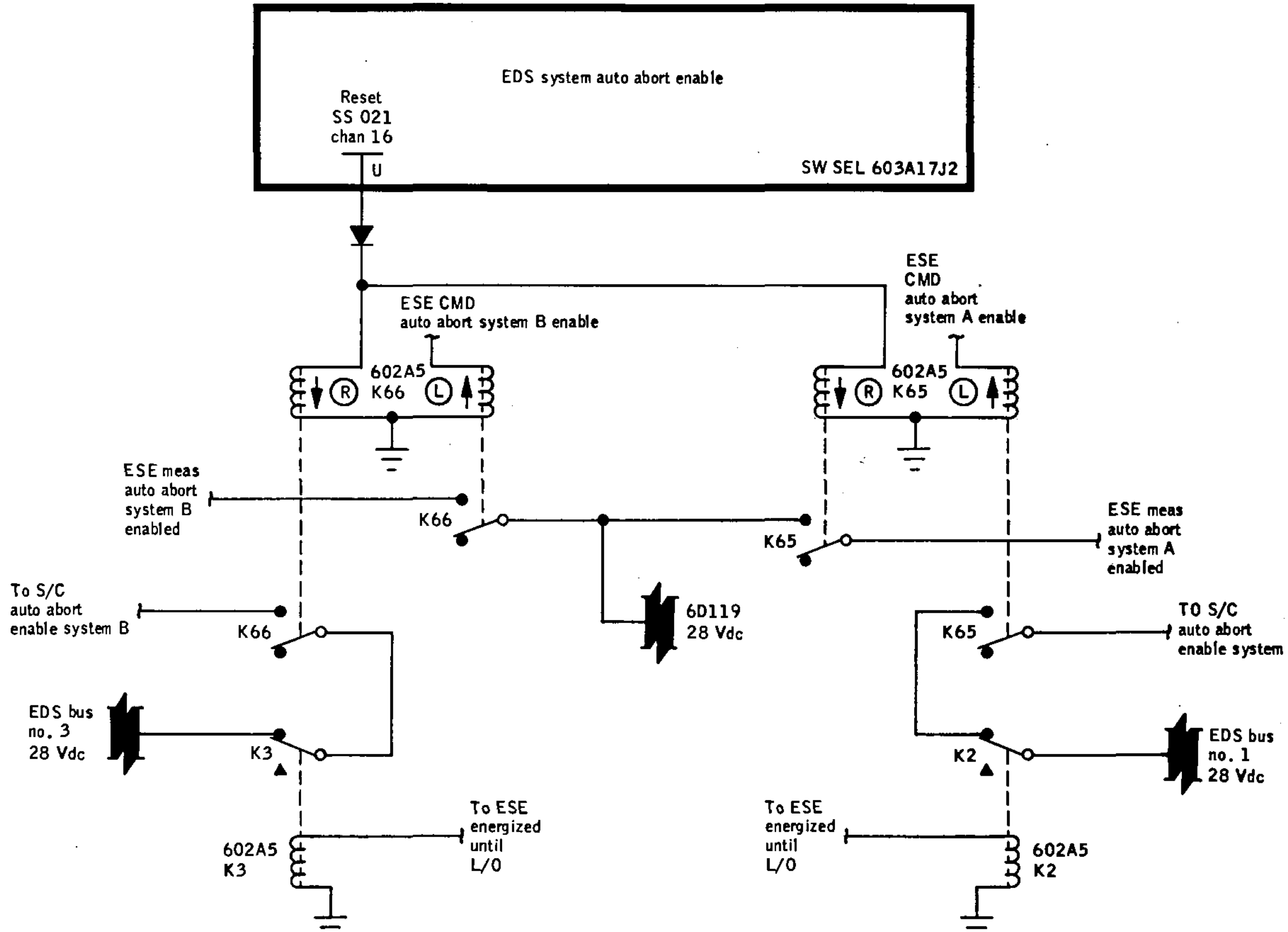

EDS system auto abort enable
Reset
SS 021
chan 16
U
SW SEL 603A17J2
ESE CMD
auto abort system B enable
ESE
CMD
auto abort
system A enable
602A5
K66
602A5
K65
R
L
ESE meas
auto abort
system B
enabled
K66
K65
ESE meas
auto abort
system A
enabled
6D119
28 Vdc
To S/C
auto abort
enable system B
K66
K65
TO S/C
auto abort
enable system A
EDS bus
no. 3
28 Vdc
K3
K2
EDS bus
no. 1
28 Vdc
To ESE
energized
until
L/O
To ESE
energized
until
L/O
602A5
K3
602A5
K2

Figure 2-12

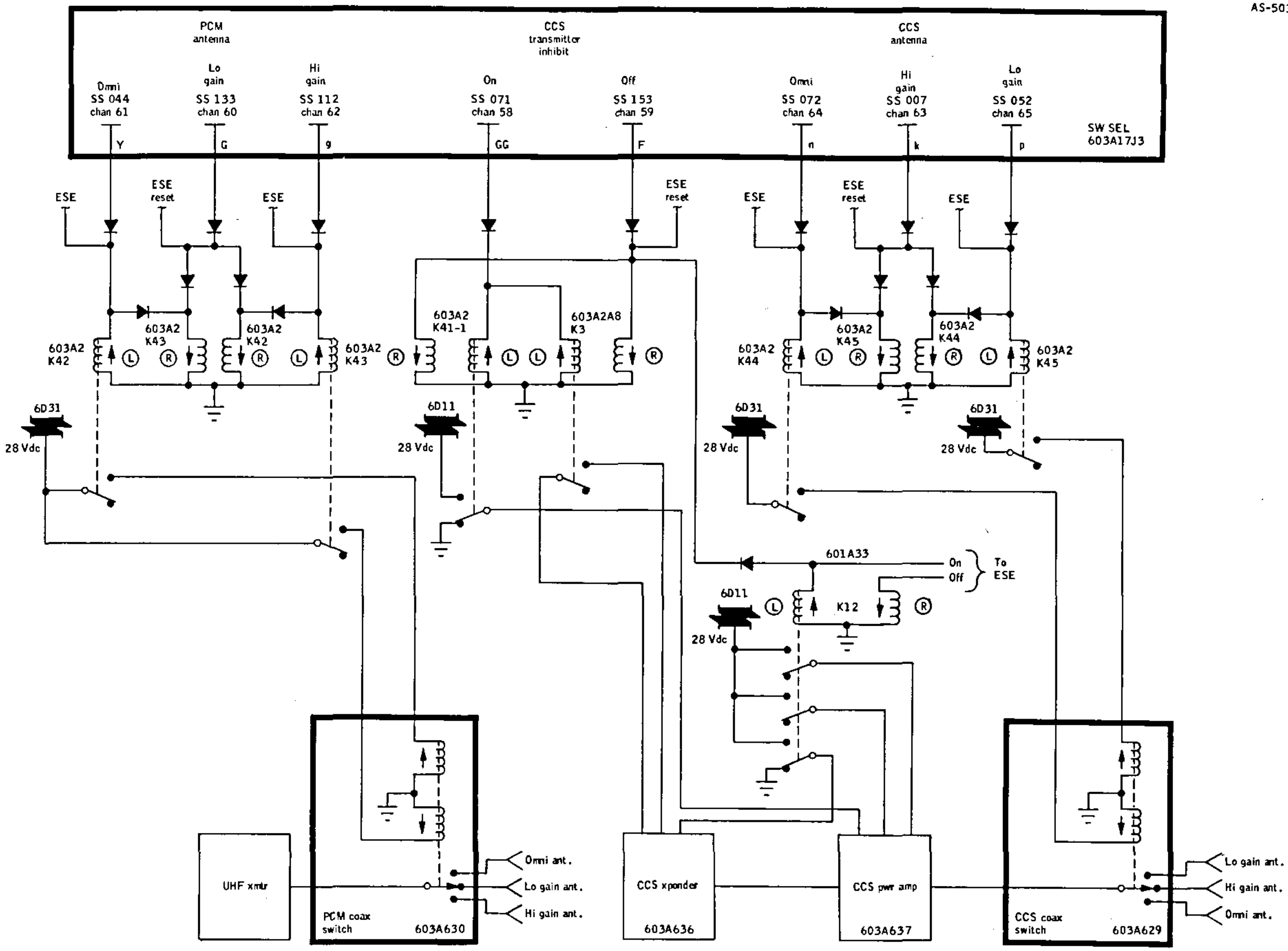


Figure 2.13

2-23

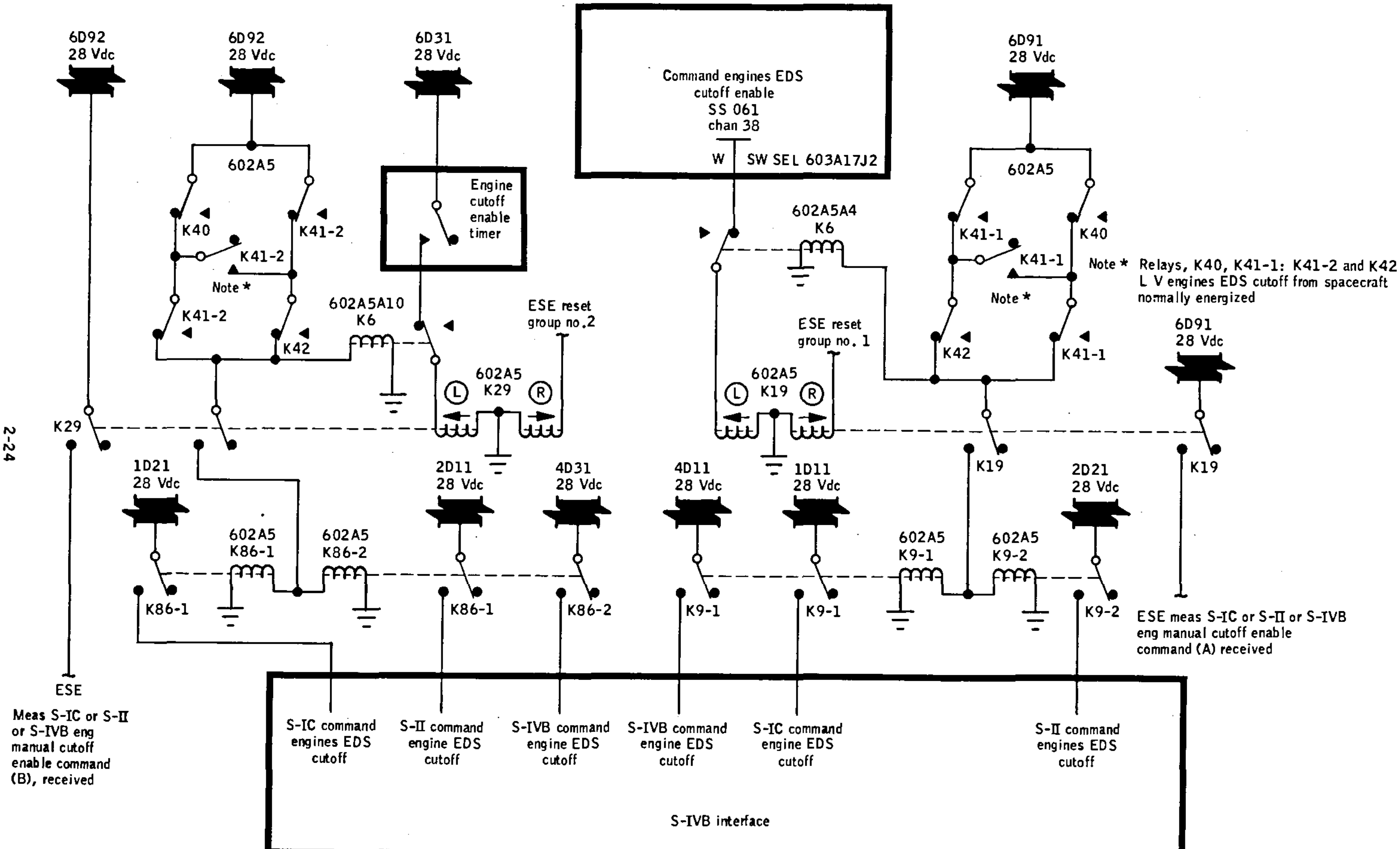

6D92
28 Vdc
6D92
28 Vdc
6D31
28 Vdc
Command engines EDS
cutoff enable
SS 061
chan 38
W
SW SEL 603A17J2
6D91
28 Vdc
602A5
K40
K41-2
K41-2
Note *
K41-2
K42
Engine
cutoff
enable
timer
602A5A10
K6
ESE reset
group no.2
602A5A4
K6
602A5
K41-1
K40
K41-1
Note *
Relays, K40, K41-1: K41-2 and K42,
L V engines EDS cutoff from spacecraft
normally energized
Note *
K42
K41-1
ESE reset
group no. 1
6D91
28 Vdc
602A5
K29
602A5
K19
K29
K19
K19
1D21
28 Vdc
2D11
28 Vdc
4D31
28 Vdc
4D11
28 Vdc
1D11
28 Vdc
2D21
28 Vdc
602A5
K86-1
602A5
K86-2
602A5
K9-1
602A5
K9-2
K86-1
K86-1
K86-2
K9-1
K9-1
K9-2
ESE meas S-IC or S-II or S-IVB
eng manual cutoff enable
command (A) received
ESE
Meas S-IC or S-II
or S-IVB eng
manual cutoff
enable command
(B), received
S-IC command
engines EDS
cutoff
S-II command
engine EDS
cutoff
S-IVB command
engine EDS
cutoff
S-IVB command
engine EDS
cutoff
S-IC command
engine EDS
cutoff
S-II command
engines EDS
cutoff
S-IVB interface

Figure 2-14

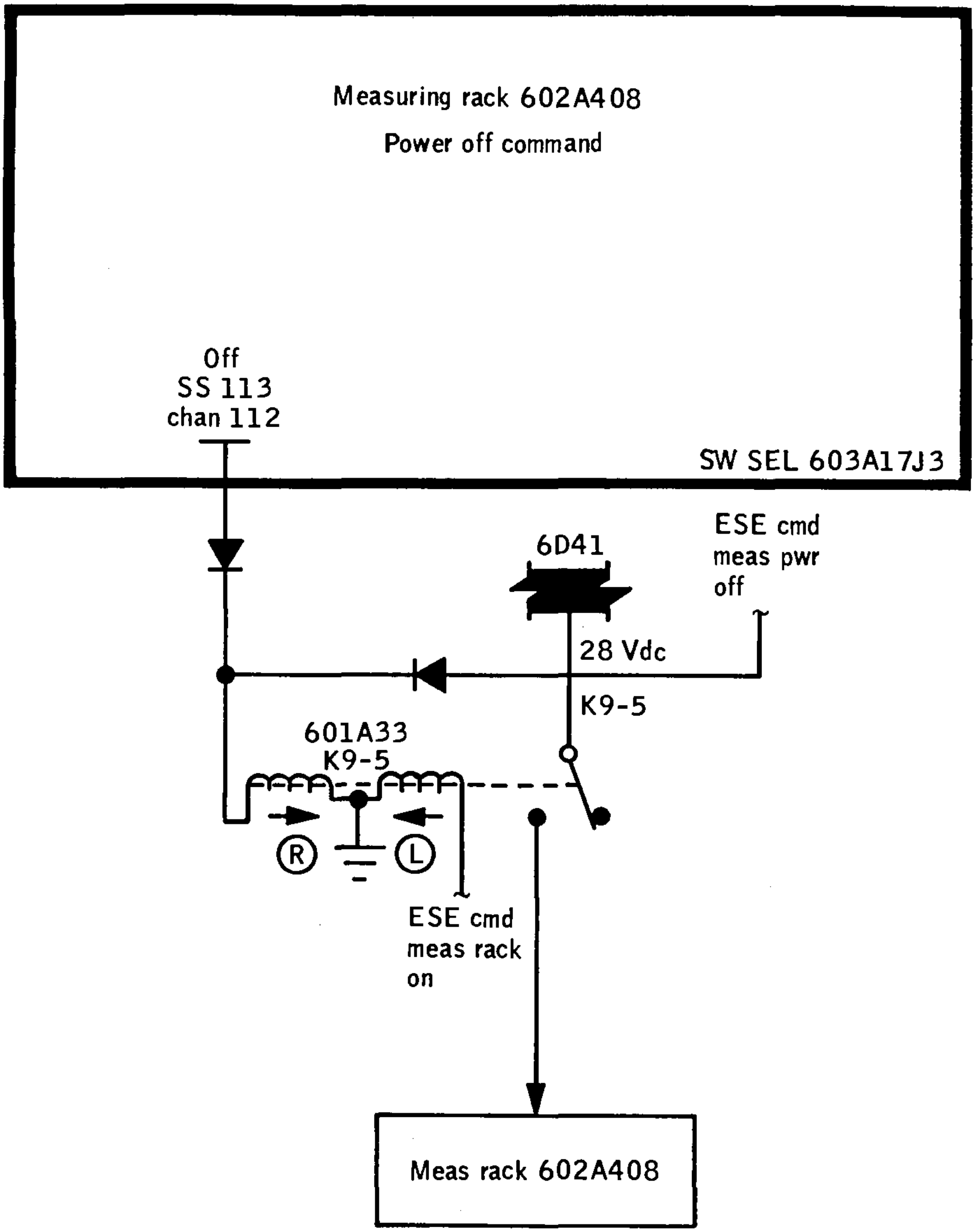

Measuring rack 602A408
Power off command
Off
SS 113
chan 112
SW SEL 603A17J3
6D41
ESE cmd
meas pwr
off
28 Vdc
K9-5
601A33
K9-5
R
L
ESE cmd
meas rack
on
Meas rack 602A408

Figure 2.15

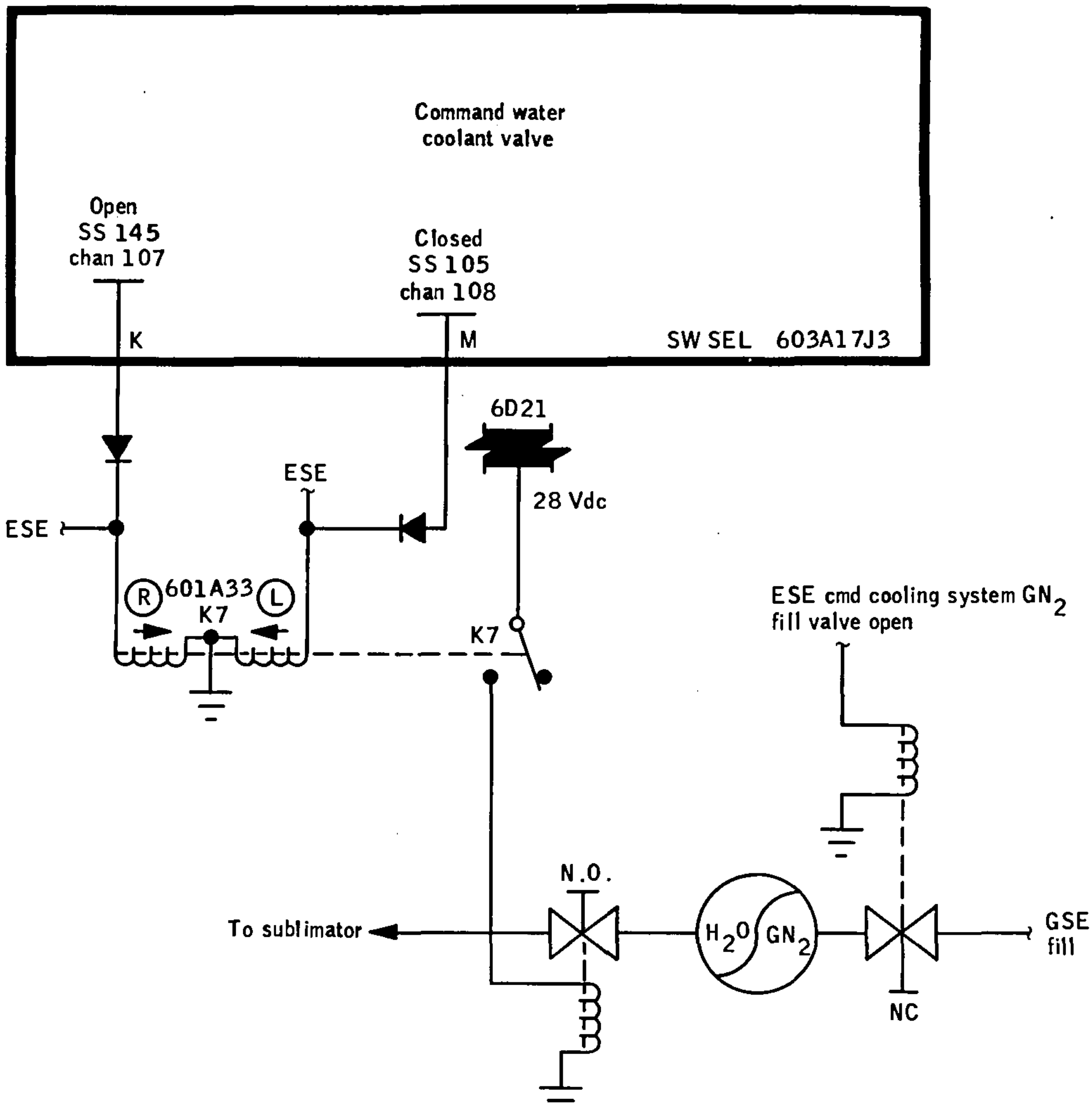

Command water
coolant valve
Open
SS 145
chan 107
Closed
SS 105
chan 108
K
M
SW SEL 603A17J3
6D21
28 Vdc
ESE
ESE
601A33
K7
R
L
K7
ESE cmd cooling system GN_2
fill valve open
N.O.
To sublimator
H_2O
GN_2
GSE
fill
NC

Figure 2-16

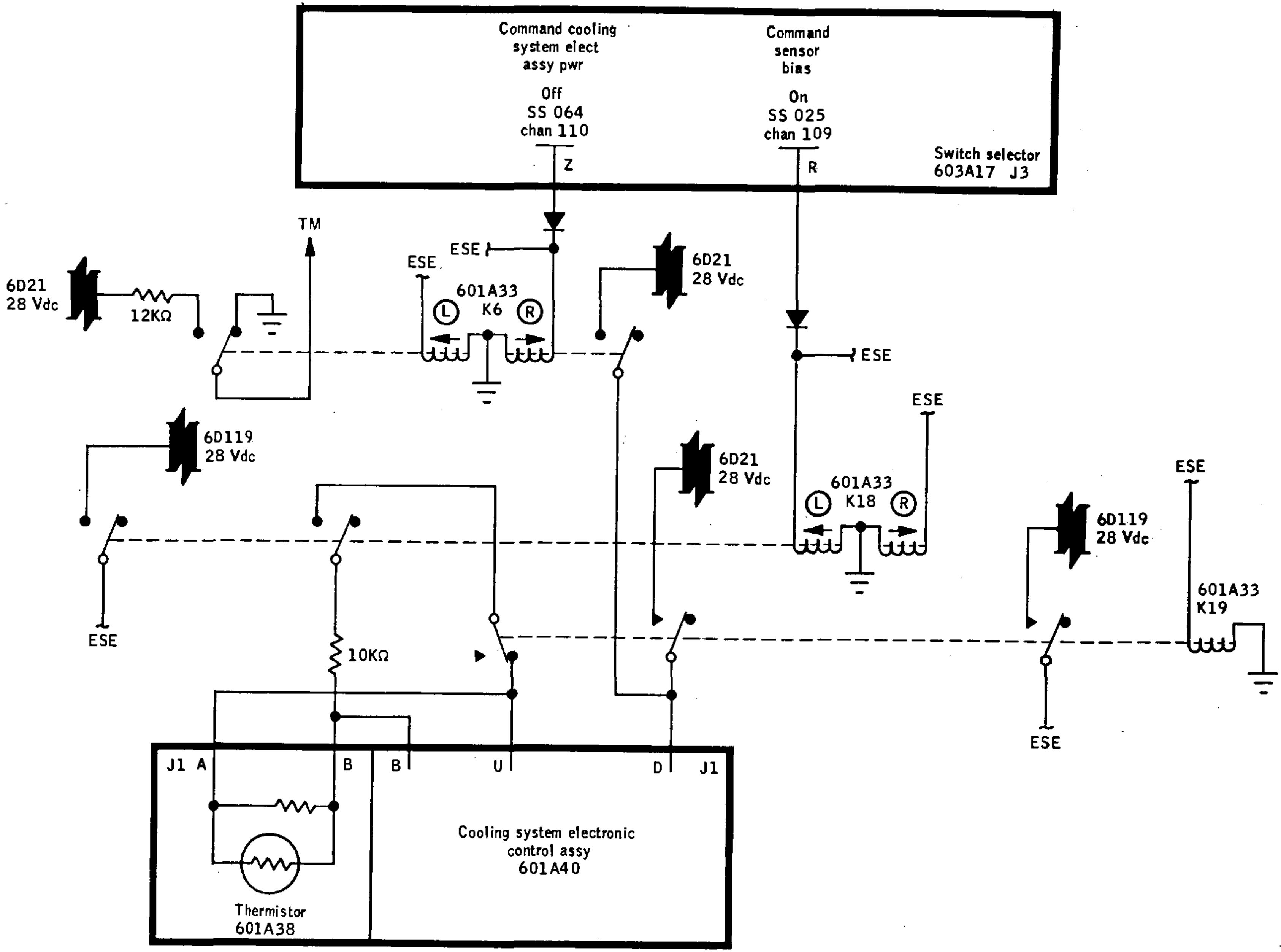
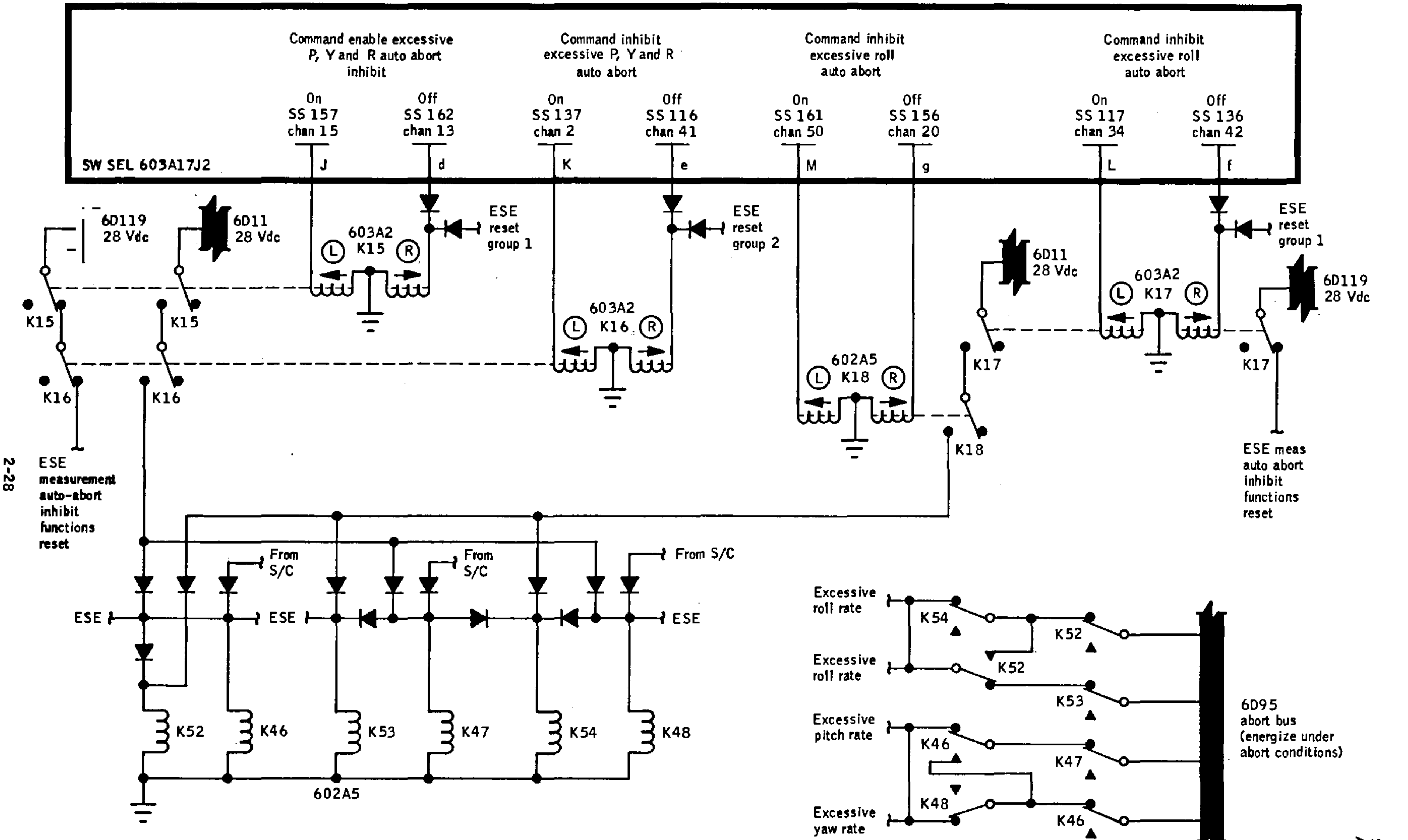

Command cooling
system elect
assy pwr
Off
SS 064
chan 110
Z
Command
sensor
bias
On
SS 025
chan 109
R
Switch selector
603A17 J3
TM
ESE
ESE
601A33
K6
L
R
6D21
28 Vdc
12KΩ
6D21
28 Vdc
ESE
ESE
6D119
28 Vdc
6D21
28 Vdc
601A33
K18
ESE
6D119
28 Vdc
601A33
K19
ESE
10KΩ
ESE
J1 A
B
B
U
D
J1
Cooling system electronic
control assy
601A40
Thermistor
601A38

Figure 2.17



Command enable excessive P, Y and R auto abort inhibit
On SS 157 chan 15
Off SS 162 chan 13
Command inhibit excessive P, Y and R auto abort
On SS 137 chan 2
Off SS 116 chan 41
Command inhibit excessive roll auto abort
On SS 161 chan 50
Off SS 156 chan 20
Command inhibit excessive roll auto abort
On SS 117 chan 34
Off SS 136 chan 42
SW SEL 603A17J2
J
d
K
e
M
g
L
f
6D119 28 Vdc
6D11 28 Vdc
603A2 K15
ESE reset group 1
603A2 K16
ESE reset group 2
602A5 K18
6D11 28 Vdc
603A2 K17
ESE reset group 1
6D119 28 Vdc
K15
K15
K16
K16
K17
K17
K18
ESE measurement auto-abort inhibit functions reset
ESE meas auto abort inhibit functions reset
From S/C
From S/C
From S/C
ESE
ESE
ESE
K52
K46
K53
K47
K54
K48
602A5
Excessive roll rate
Excessive roll rate
Excessive pitch rate
Excessive yaw rate
K54
K52
K52
K53
K46
K47
K48
K46
6D95 abort bus (energize under abort conditions)

Figure 2-18

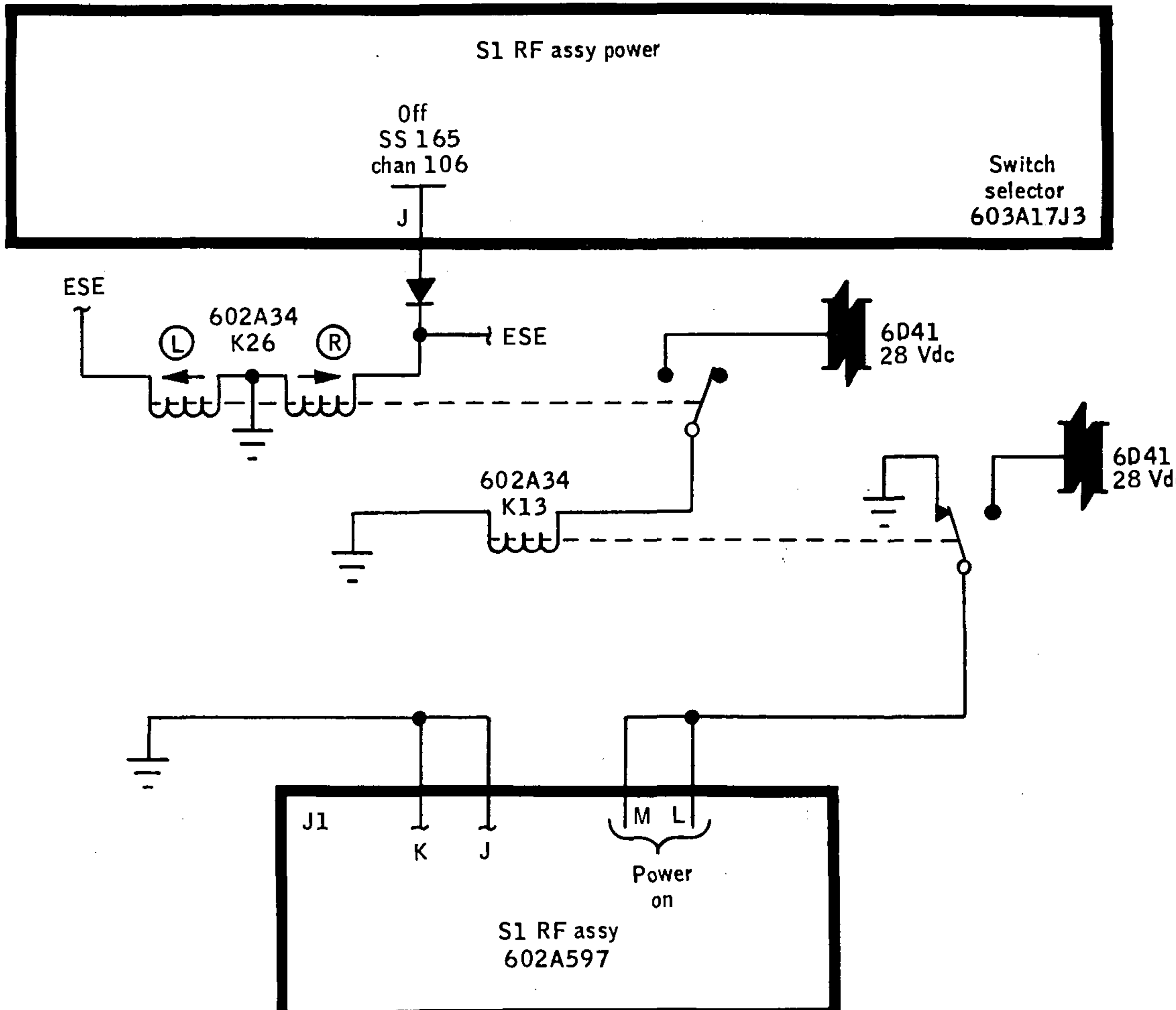

S1 RF assy power
Off
SS 165
chan 106
J
Switch
selector
603A17J3
ESE
602A34
K26
L
R
ESE
6D41
28 Vdc
602A34
K13
6D41
28 Vdc
J1
K
J
M
L
Power
on
S1 RF assy
602A597

Figure 2-19

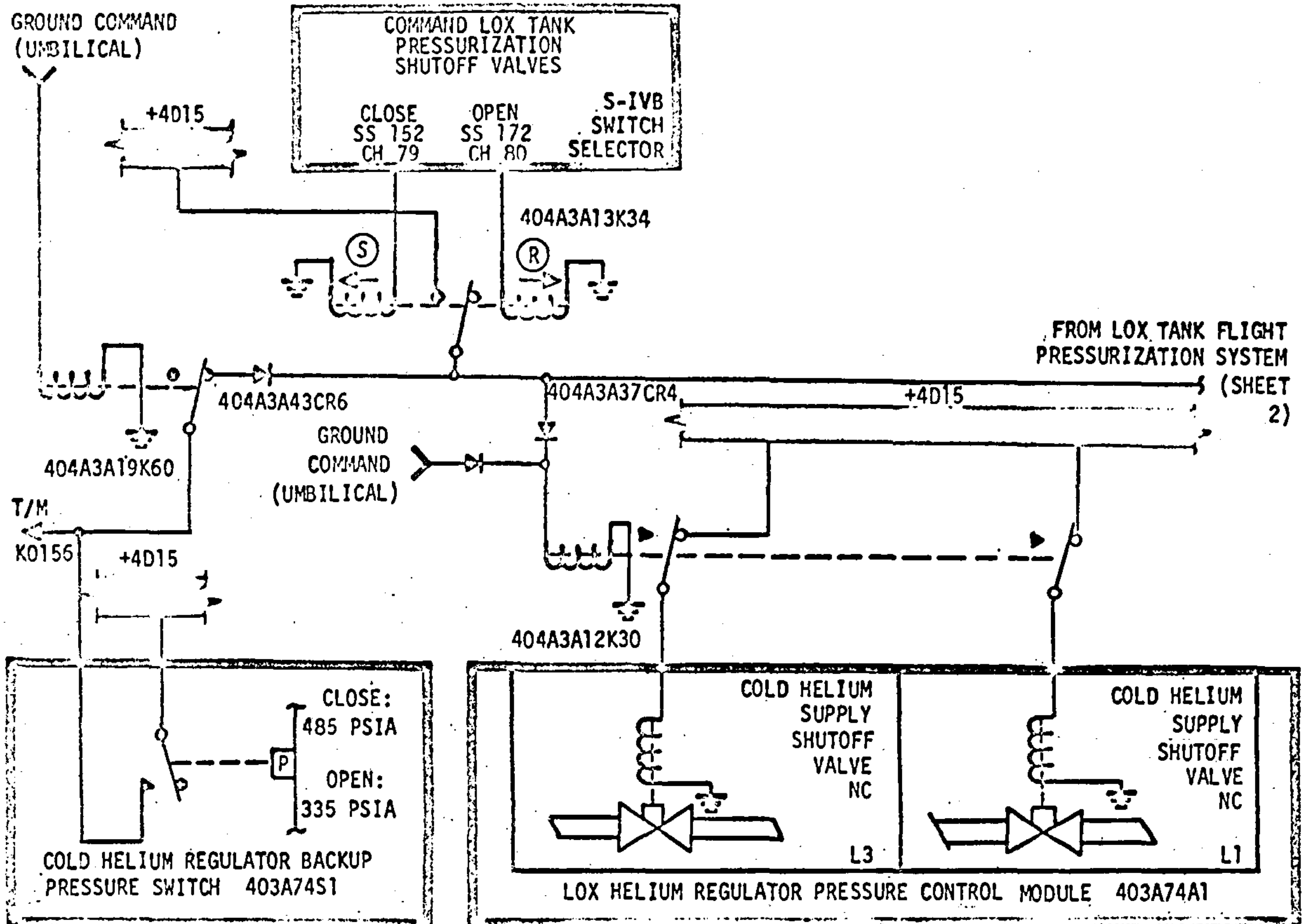
2.4.2 S-IVB Switch Selector Functions (Octal)

CH	Code	Function	Figure No.
	000		
37	001	COMMAND AMBIENT REPRESSURIZATION MODE SELECTOR OFF AND CRYOGENIC ON	Dwg 8.3.2a
5	002	COMMAND PU ACTIVATE ON	2.42
30	003	COMMAND START TANK VENT CONTROL VALVE OPEN ON	Dwg 8.3.8a
74	004	COMMAND BURNER LOX SHUTDOWN VALVE CLOSE ON	Dwg 8.3.2a
81	005	COMMAND LH_2 TANK REPRESS CONTROL VALVE OPEN OFF	2.27, Dwg 8.3.2a
97	006	COMMAND POINT LEVEL SENSOR ARMING	2.34
63	007	COMMAND SPECIAL TM CALIBRATE OFF	2.35
	010		
87	011	COMMAND LH_2 TANK CONTINUOUS VENT VALVE CLOSE OFF	2.24
111	012	COMMAND LH_2 TANK CONTINUOUS VENT ORIFICE SHUTOFF VALVE OPEN ON	2.24
94	013	COMMAND LOX TANK VENT VALVE CLOSE	2.21, Dwg 8.3.3
49	014	COMMAND INFLIGHT CALIBRATION MODE OFF	2.35
14	015	COMMAND ENGINE MAINSTAGE CONTROL VALVE OPEN ON	2.37, Dwg 8.3.8a
51	016	COMMAND HEAT EXCHANGER BYPASS VALVE CONTROL DISABLE	Dwg 8.3.3
39	017	COMMAND LH_2 TANK REPRESS CONTROL VALVE OPEN ON	2.27, Dwg 8.3.2a
	020		
16	021	COMMAND FUEL INJECTION TEMPERATURE OK BYPASS RESET	2.32
24	022	COMMAND ENGINE PUMP PURGE CONTROL VALVE ENABLE ON	2.38
9	023	COMMAND S-IVB ENGINE START ON	2.21
75	024	COMMAND BURNER LOX SHUTDOWN VALVE CLOSE OFF	Dwg 8.3.2a
109	025	COMMAND ENGINE HELIUM CONTROL VALVE OPEN ON	Dwg 8.3.8a
82	026	COMMAND PREVALVES CLOSE ON	2.39, Dwg 8.3.4
71	027	COMMAND BURNER EXCITERS OFF	Dwg 8.3.2a
	030		
68	031	COMMAND FIRST BURN RELAY ON	2.27
57	032	COMMAND FIRE ULLAGE JETTISON ON	2.26
96	033	COMMAND LOX TANK VENT AND NPV VALVES BOOST CLOSE OFF	2.33
33	034	COMMAND SECOND BURN RELAY OFF	2.27
7	035	COMMAND PU INVERTER AND DC POWER ON	2.22
35	036	COMMAND PU FUEL BOILOFF BIAS CUTOFF ON	2.30
17	037	COMMAND PU VALVE HARDOVER POSITION ON	2.30a
	040		

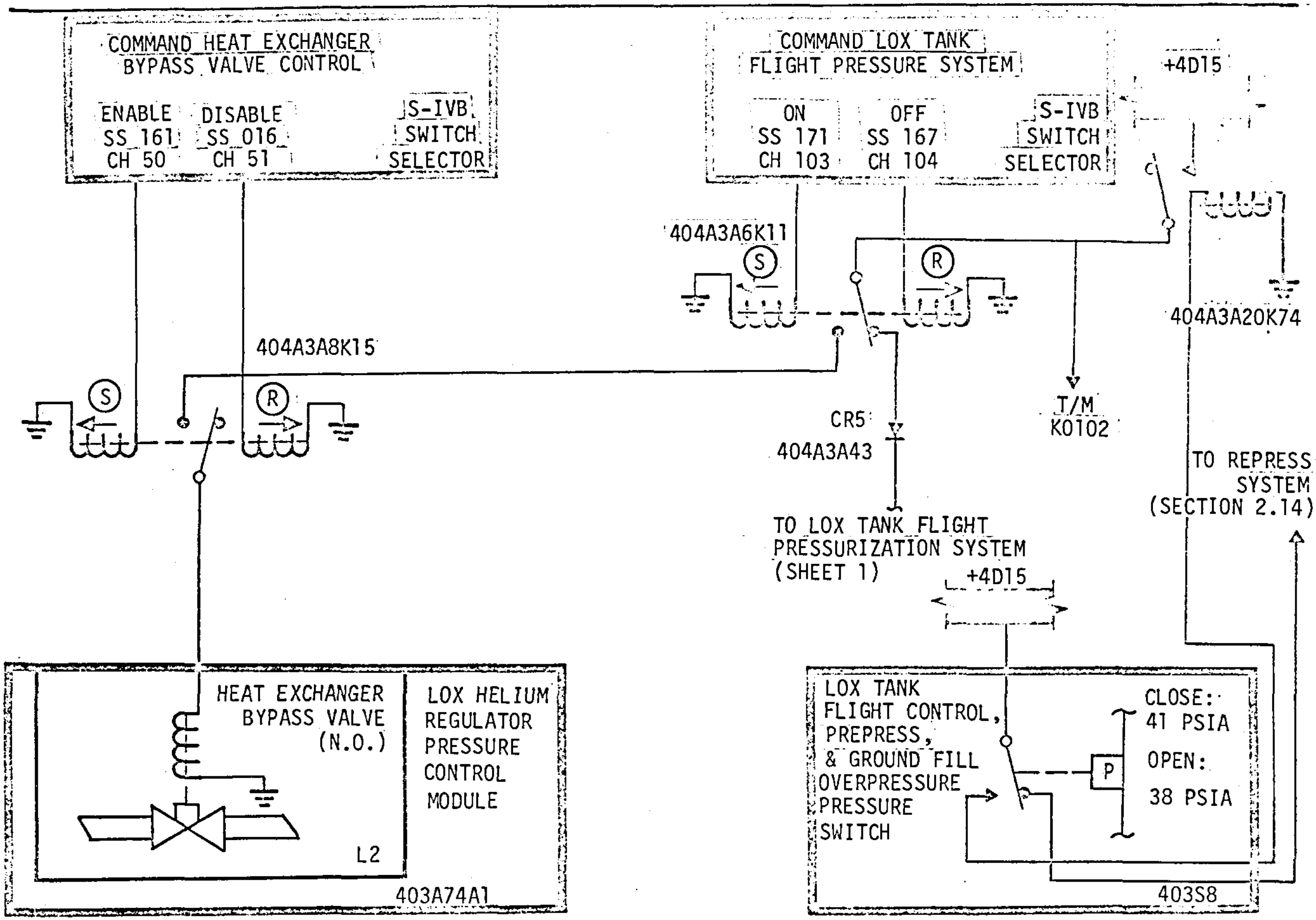
CH	Code	Function	Figure No.
53	041	COMMAND MEASUREMENT TRANSFER MODE POSITION A	2.40, Dwg 8.3.4
23	042	COMMAND LOX CHILLDOWN PUMP OFF	Dwg 8.3.8a
31	043	COMMAND START TANK VENT CONTROL VALVE OPEN OFF	Dwg 8.3.2a
61	044	COMMAND BURNER LH_2 PROPELLANT VALVE CLOSE OFF	2.21, Dwg 8.3.3
93	045	COMMAND LOX TANK VENT VALVE OPEN	2.36, Dwg 8.3.10
102	046	COMMAND S-IVB APS ULLAGE ENGINE RELAY #2 OFF	Dwg 8.3.2a
90	047	COMMAND BURNER LOX SHUTDOWN VALVE OPEN OFF	
	050		
69	051	COMMAND FIRST BURN RELAY OFF	2.27, Dwg 8.3.2
65	052	COMMAND PCM RF ASSEMBLY POWER OFF	
73	053	COMMAND ULLAGE FIRING RESET	2.26
48	054	COMMAND INFLIGHT CALIBRATION MODE ON	2.35
6	055	COMMAND PU ACTIVATE OFF	2.42
52	056	COMMAND MEASUREMENT TRANSFER MODE POSITION B	
40	057	COMMAND ENGINE IGNITION PHASE CONTROL VALVE OPEN	2.41, Dwg 8.3.8a
	060		
38	061	COMMAND LH_2 TANK VENT VALVE OPEN ON	2.23, Dwg 8.3.2
44	062	COMMAND LOX TANK NPV VALVE LATCH ON	2.21, Dwg 8.3.3
18	063	COMMAND PU VALVE HARDOVER POSITION OFF	2.30a
110	064	COMMAND ENGINE HELIUM CONTROL VALVE OPEN OFF	Dwg 8.3.8a
92	065	COMMAND CHILLDOWN SHUTOFF PILOT VALVE CLOSE OFF	2.33, Dwg 8.3.4
101	066	COMMAND S-IVB APS ULLAGE ENGINE RELAY #2 ON	2.36, Dwg 8.3.10
67	067	COMMAND FM/FM TRANSMITTER OFF	2.41
	070		
58	071	COMMAND FUEL CHILLDOWN PUMP ON	2.40, Dwg 8.3.4
64	072	COMMAND LH_2 TANK LATCHING RELIEF VALVE LATCH ON	2.23, Dwg 8.3.2
95	073	COMMAND LOX TANK VENT AND NPV VALVES BOOST CLOSE ON	2.21, Dwg 8.3.3
29	074	COMMAND AUXILIARY HYDRAULIC PUMP FLIGHT MODE OFF	2.25, Dwg 8.3.9
25	075	COMMAND ENGINE PUMP PURGE CONTROL VALVE ENABLE OFF	2.38
36	076	COMMAND AMBIENT REPRESSURIZATION MODE SELECTOR ON AND CRYOGENIC OFF	Dwg 8.3.2a
8	077	COMMAND PU INVERTER AND DC POWER OFF	2.22
	100		
21	101	COMMAND ENGINE PNEUMATIC SYSTEM VENT OPEN OFF	2.37, Dwg 8.3.8a
46	102	COMMAND SINGLE SIDEBAND FM TRANSMITTER ON	2.41

CH	Code	Function	Figure No.
32	103	COMMAND SECOND BURN RELAY ON	2.27, Dwg 8.3.2
98	104	COMMAND POINT LEVEL SENSOR DISARMING	2.34
108	105	COMMAND LH_2 TANK CONTINUOUS VENT RELIEF OVERRIDE SHUTOFF VALVE OPEN OFF	2.21, Dwg 8.3.2
76	106	COMMAND LH_2 TANK VENT VALVE OPEN OFF	2.23, Dwg 8.3.2
89	107	COMMAND BURNER LOX SHUTDOWN VALVE OPEN ON	Dwg 8.3.2a
	110		
66	111	COMMAND FM/FM TRANSMITTER ON	2.41
62	112	COMMAND TM CALIBRATE ON	2.35
112	113	COMMAND LH_2 TANK CONTINUOUS VENT ORIFICE SHUTOFF VALVE OPEN OFF	Dwg 8.3.2
105	114	COMMAND LOX TANK NPV VALVE OPEN ON	2.21, Dwg 8.3.3
12	115	COMMAND S-IVB ENGINE CUTOFF ON	2.28
41	116	COMMAND ENGINE IGNITION PHASE CONTROL VALVE CLOSE	2.31, Dwg 8.3.8a
34	117	COMMAND PU FUEL BOILOFF BIAS CUTOFF.OFF	2.30
	120		
22	121	COMMAND LOX CHILLDOWN PUMP ON	2.40, Dwg 8.3.4
19	122	COMMAND LH_2 TANK LATCHING RELIEF VALVE LATCH OFF	2.23, Dwg 8.3.2
45	123	COMMAND LOX TANK NPV VALVE LATCH OFF	2.21, Dwg 8.3.3
56	124	COMMAND FIRE ULLAGE IGNITION ON	2.26
91	125	COMMAND CHILLDOWN SHUTOFF PILOT VALVE CLOSE ON	2.33, Dwg 8.3.4
99	126	COMMAND LH_2 TANK LATCHING RELIEF VALVE OPEN ON	2.23, Dwg 8.3.2
86	127	COMMAND BURNER AUTOMATIC CUTOFF SYSTEM DISARM	Dwg 8.3.2a
	130		
84	131	COMMAND LH_2 TANK CONTINUOUS VENT VALVE CLOSE ON	2.24, Dwg 8.3.2
100	132	COMMAND LH_2 TANK LATCHING RELIEF VALVE OPEN OFF	2.23, Dwg 8.3.2
60	133	COMMAND BURNER LH_2 PROPELLANT VALVE CLOSE ON	Dwg 8.3.2a
88	134	COMMAND ULLAGE CHARGING RESET	2.26
27	135	COMMAND S-IVB ENGINE START OFF	2.29
42	136	COMMAND S-IVB APS ULLAGE ENGINE RELAY #1 ON	2.26, Dwg 8.3.10
2	137	COMMAND PASSIVATION DISABLE	Dwg 8.3.8a
	140		
4	141	COMMAND LOX TANK REPRESS CONTROL VALVE OPEN OFF	Dwg 8.3.2a
3	142	COMMAND LOX TANK REPRESS CONTROL VALVE OPEN ON	Dwg 8.3.2a
10	143	COMMAND ENGINE READY BYPASS	2.28
55	144	COMMAND CHARGE ULLAGE JETTISON ON	2.26

CH	Code	Function	Figure No.
107	145	COMMAND LH_2 TANK CONTINUOUS VENT RELIEF OVERRIDE SHUTOFF VALVE OPEN ON	2.24, Dwg 8.3.2
77	146	COMMAND LH_2 TANK VENT AND LATCHING RELIEF VALVE BOOST CLOSE ON	2.23, Dwg 8.3.2
85	147	BURNER AUTOMATIC CUTOFF SYSTEM ARM	Dwg 8.3.2a
	150		
83	151	COMMAND PREVALVES CLOSE OFF	2.39, Dwg 8.3.4
79	152	COMMAND LOX TANK PRESSURIZATION SHUTOFF VALVES CLOSE	Dwg 8.3.3
59	153	COMMAND FUEL CHILLDOWN PUMP OFF	2.40, Dwg 8.3.4
70	154	COMMAND BURNER EXCITERS ON	Dwg 8.3.2a
47	155	COMMAND SINGLE SIDEBAND FM TRANSMITTER OFF	2.41
20	156	COMMAND ENGINE PNEUMATIC SYSTEM VENT OPEN ON	2.37, Dwg 8.3.8a
15	157	COMMAND ENGINE MAINSTAGE CONTROL VALVE OPEN OFF	2.37, Dwg 8.3.3a
	160		
50	161	COMMAND HEAT EXCHANGER BYPASS VALVE CONTROL ENABLE	Dwg 8.3.3
13	162	COMMAND S-IVB ENGINE CUTOFF OFF	2.28
11	163	COMMAND FUEL INJECTION TEMPERATURE OK BYPASS	2.32
54	164	COMMAND CHARGE ULLAGE IGNITION ON	2.26
106	165	COMMAND LOX TANK NPV VALVE OPEN OFF	2.21, Dwg 8.3.3
78	166	COMMAND LH_2 TANK VENT AND LATCHING RELIEF VALVE BOOST CLOSE OFF	2.23, Dwg 8.3.2
104	167	COMMAND LOX TANK FLIGHT PRESSURE SYSTEM OFF	Dwg 8.3.3
	170		
103	171	COMMAND LOX TANK FLIGHT PRESSURE SYSTEM ON	Dwg 8.3.3
80	172	COMMAND LOX TANK PRESSURIZATION SHUTOFF VALVES OPEN	Dwg 8.3.3
72	173	COMMAND BURNER LH_2 PROPELLANT VALVE OPEN OFF	Dwg 8.3.2a
28	174	COMMAND AUX HYDRAULIC PUMP FLIGHT MODE ON	2.25, Dwg 8.3.9
26	175	COMMAND BURNER LH_2 PROPELLANT VALVE OPEN ON	Dwg 8.3.2a
43	176	COMMAND S-IVB APS ULLAGE ENGINE RELAY #1 OFF	2.36, Dwg 8.3.10
1	177	COMMAND PASSIVATION ENABLE	Dwg 8.3.8a

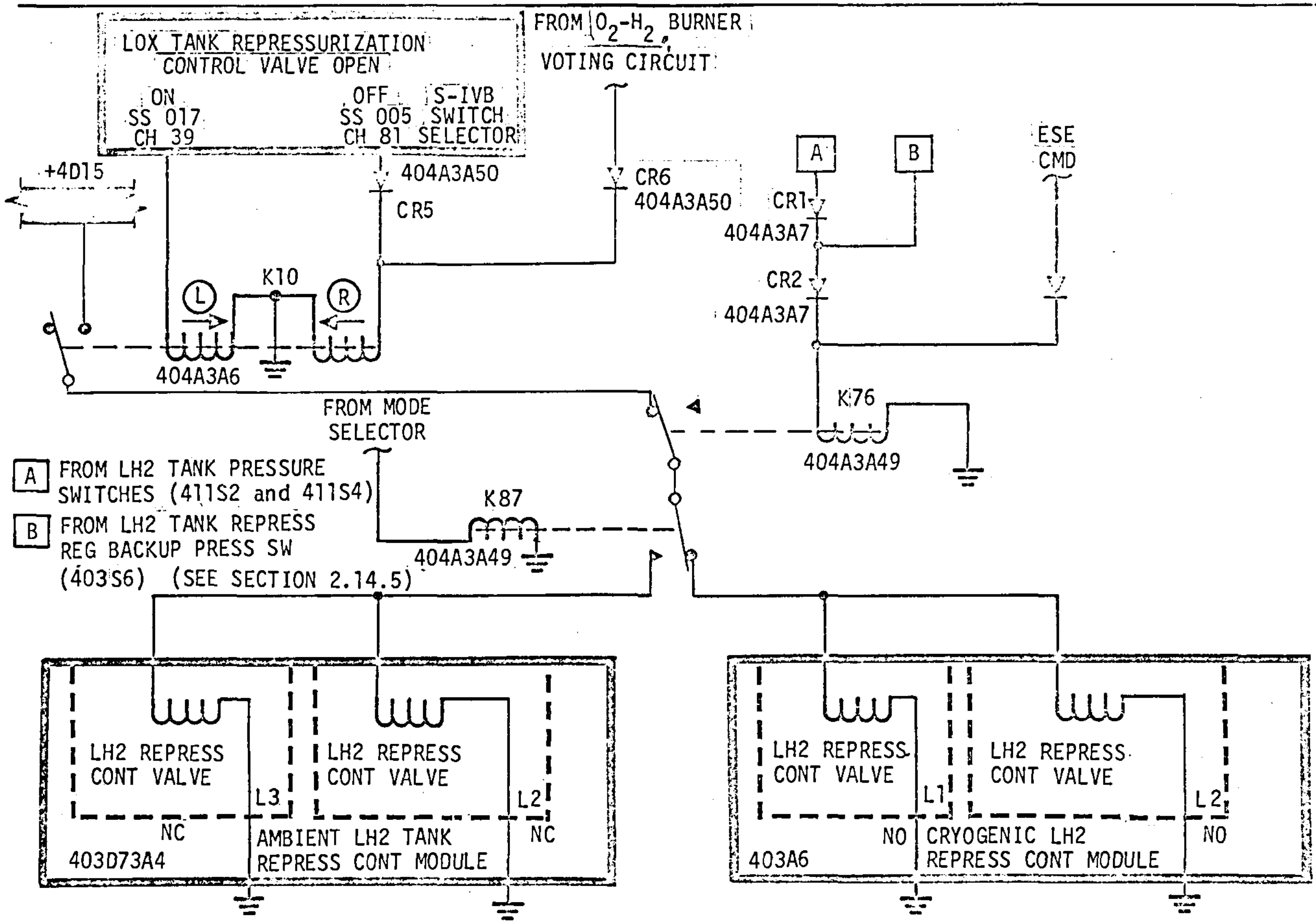


LOX Tank Pressurization Control Schematic (Sheet 1 of 2) FIGURE 2-20

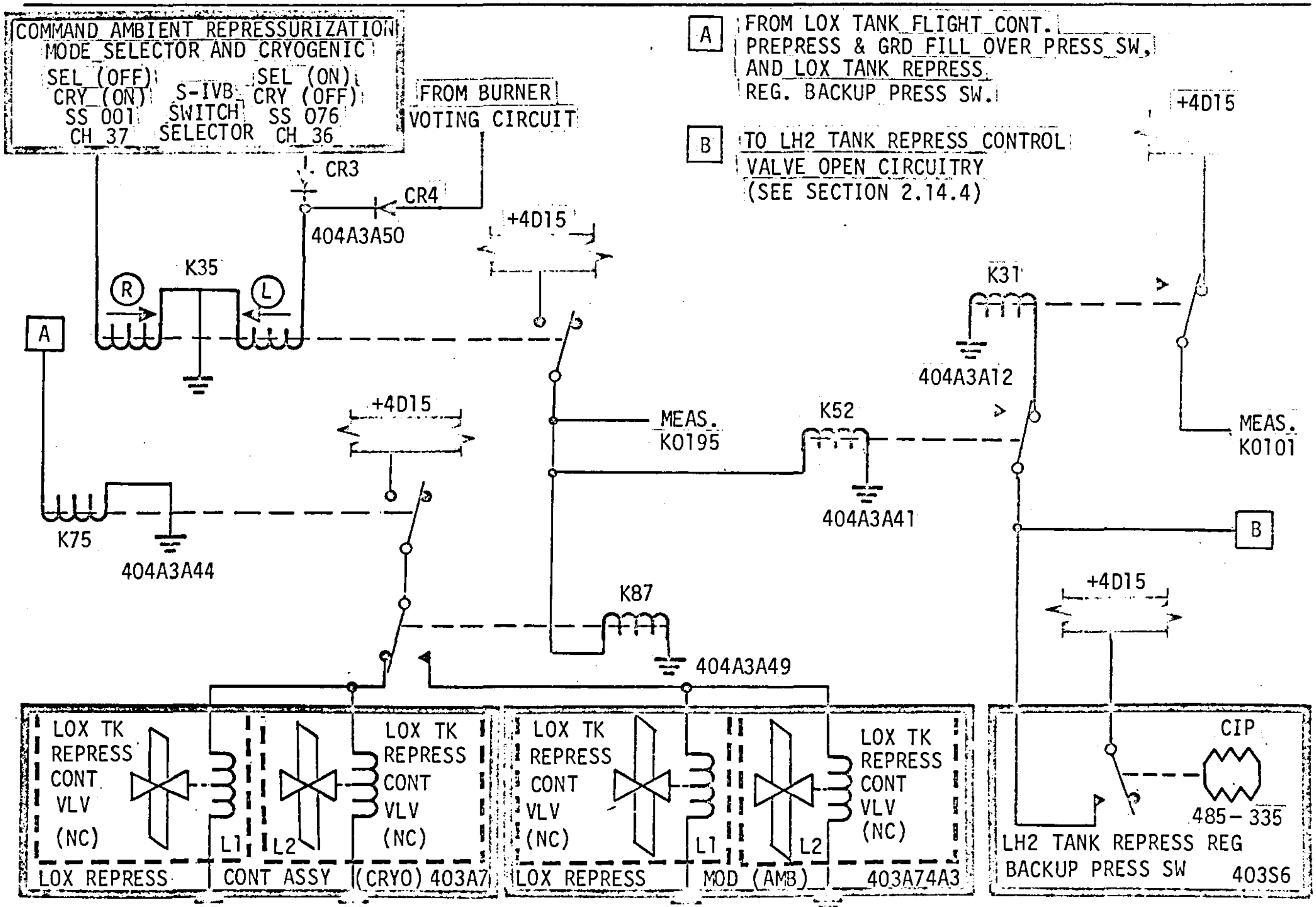


LOX Tank Pressurization Control Schematic (Sheet 2 of 2)

FIGURE 2-20a

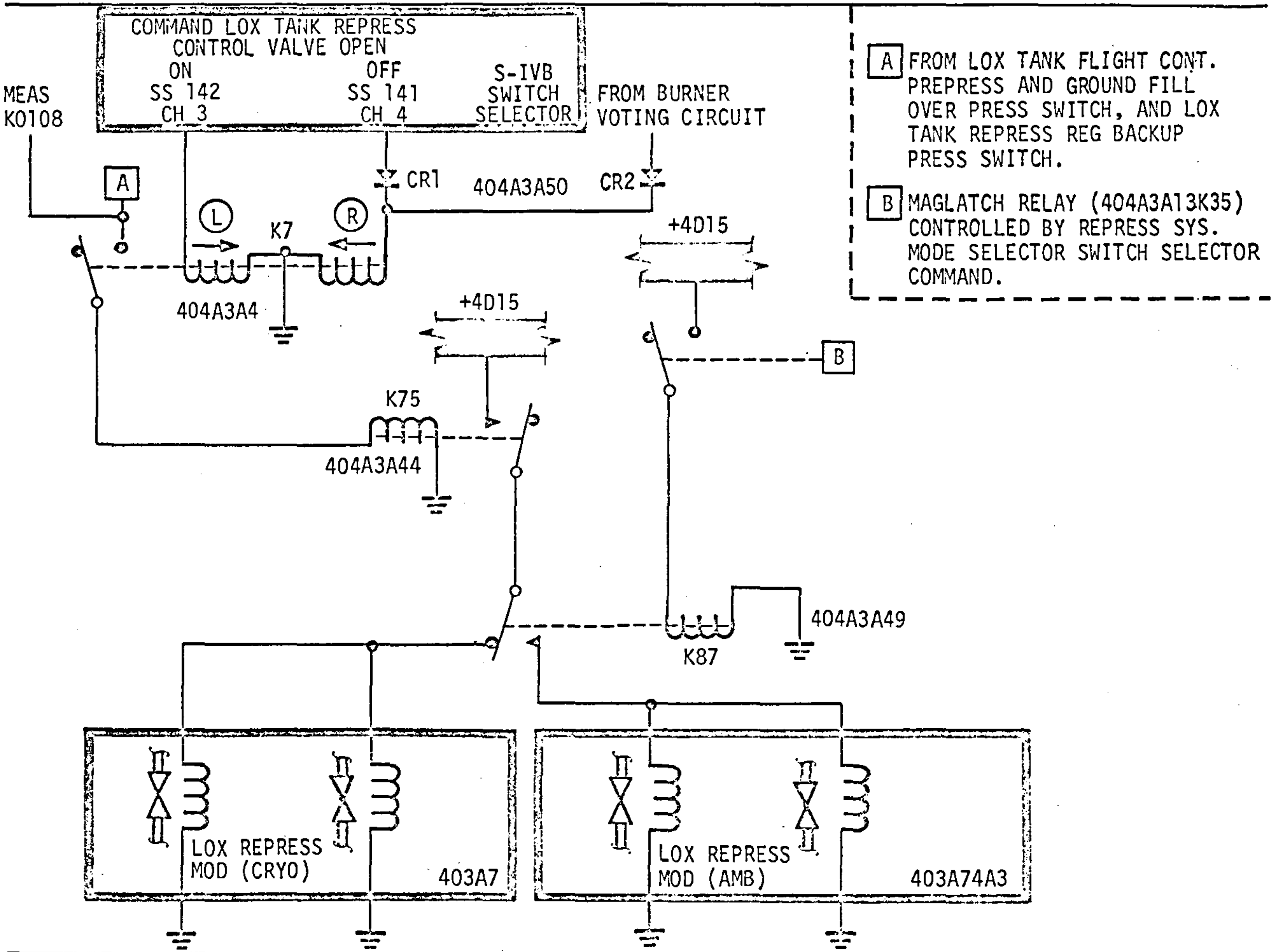


LH2 Tank Repressurization Control Valve



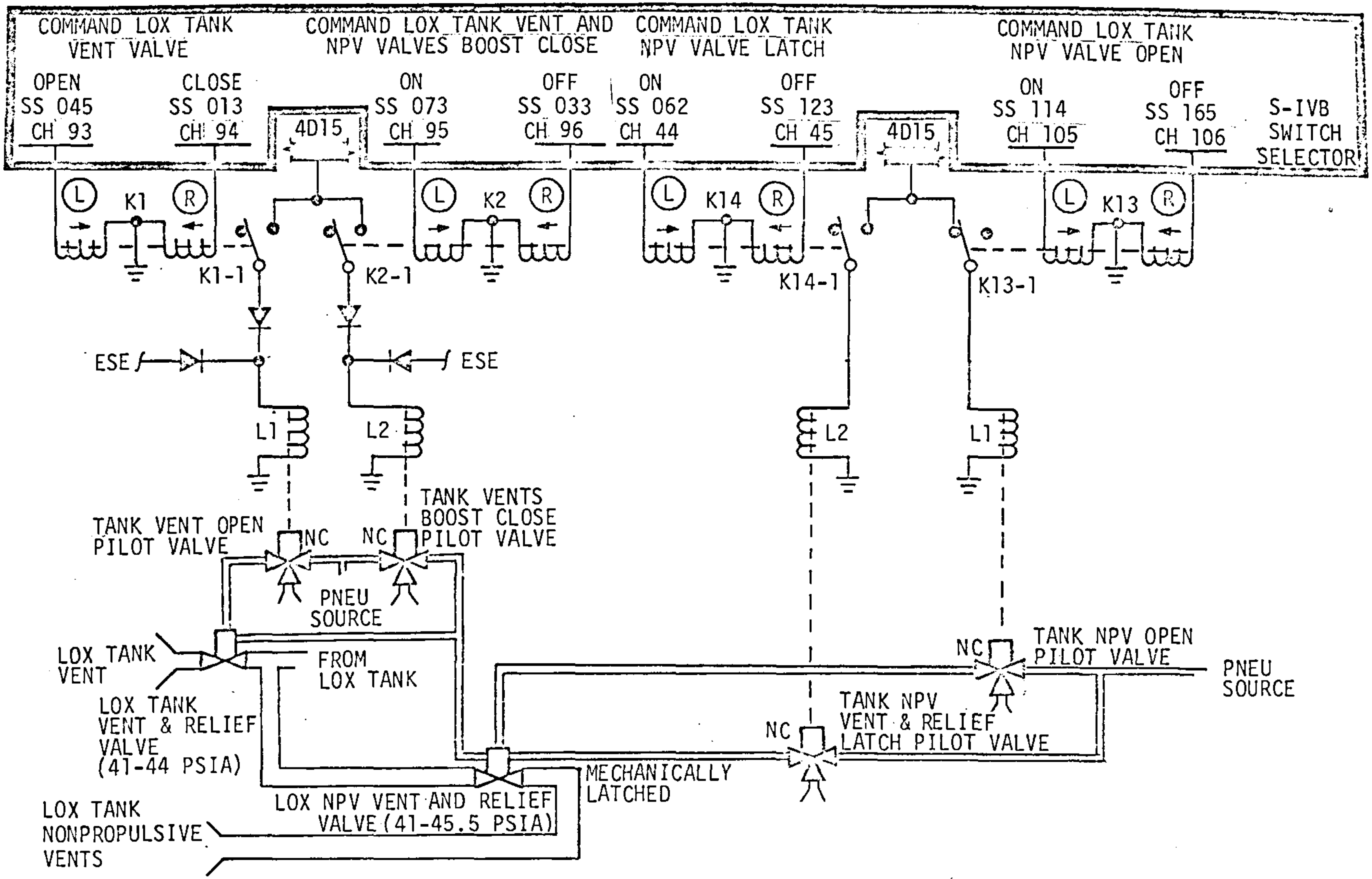
Repressurization System Mode Selector Control

FIGURE 2-20c



LOX Tank Repressurization Control Valve

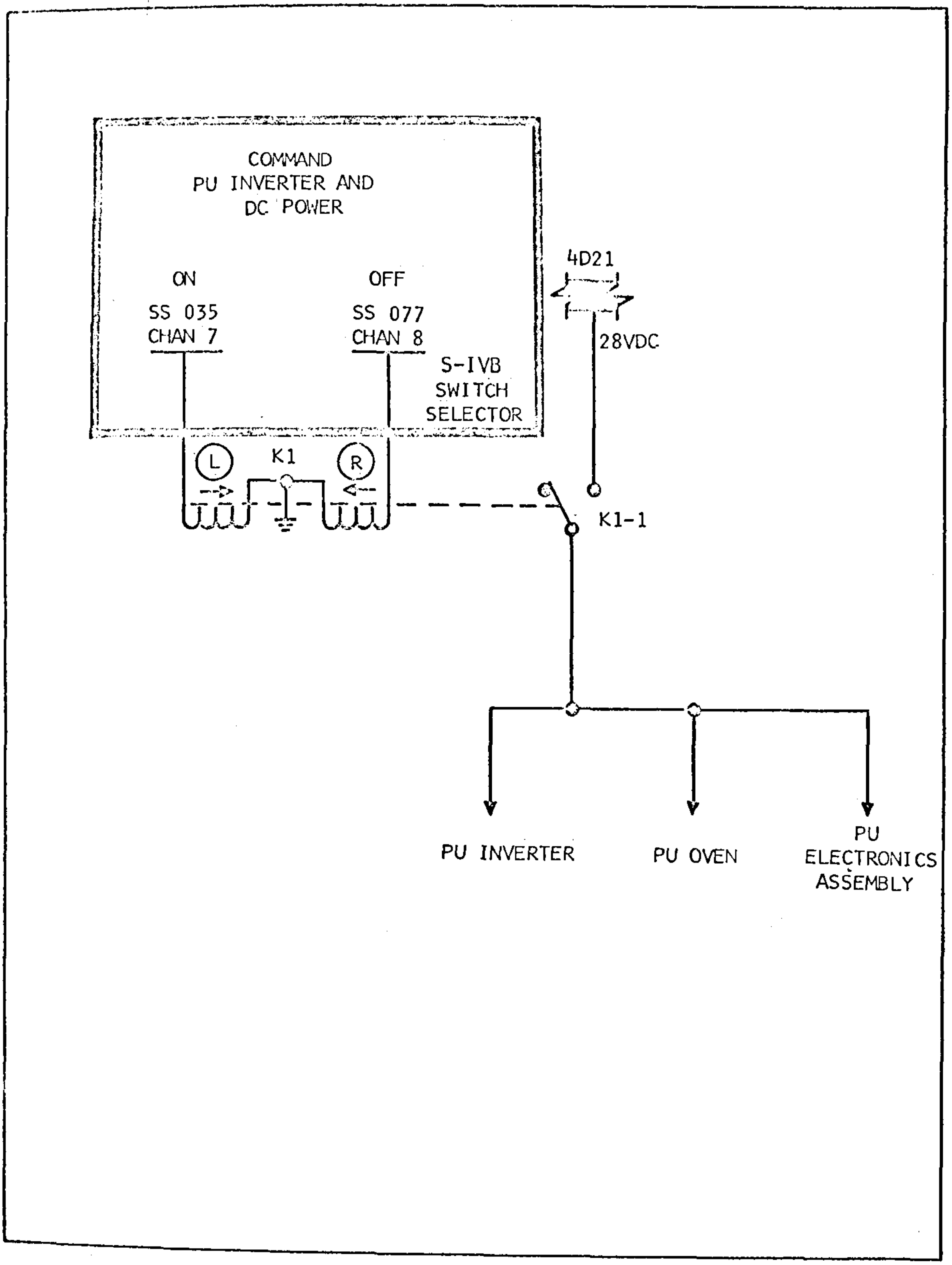
FIGURE 2-20d



CHANNEL 93 WILL OPEN THE VENT VALVE AND NORMALLY ACTUATION OF CHANNEL 94 WILL CAUSE THE VALVE TO CLOSE. TO OPEN THE NPV VENT & RELIEF VALVE AND KEEP IT LATCHED OPEN, CHANNEL 105 IS ACTUATED FOLLOWED BY CHANNEL 44. THIS LATCHES THE VALVE OPEN. NEXT, CHANNEL 106 IS ACTUATED FOLLOWED BY CHANNEL 45. THE VALVE IS NOW MECHANICALLY LATCHED OPEN. NORMALLY ACTUATION OF CHANNEL 105 FOLLOWED BY CHANNEL 106 WILL CLOSE THE VALVE. TO INSURE CLOSURE OF BOTH THE VENT VALVE & THE NPV VENT & RELIEF VALVE, THE BOOST CLOSE COMMAND (CH 95) IS SENT. TWO SECONDS LATER, BOOST CLOSE IS RELEASED BY CHAN 96.

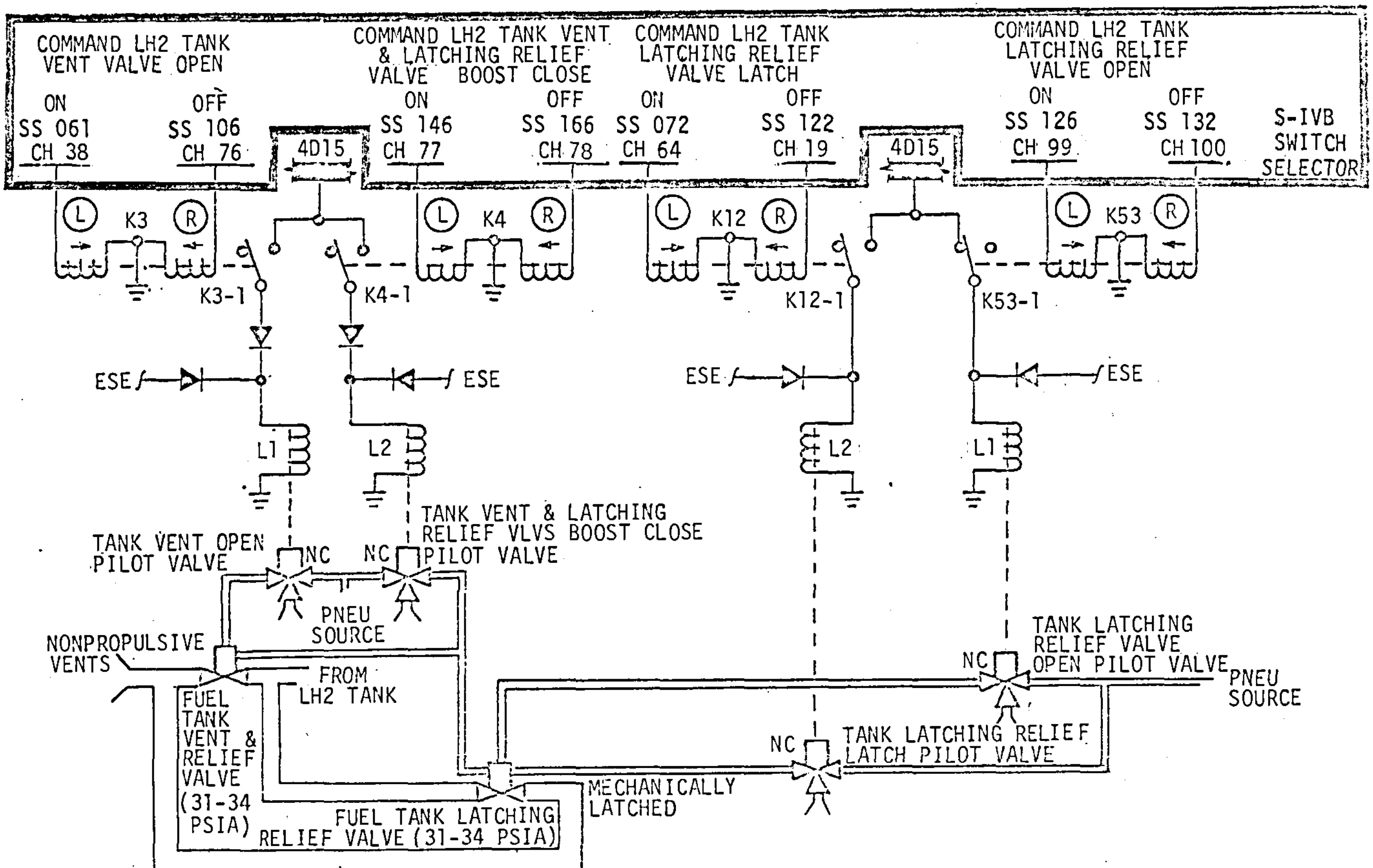
Commands LOX Tank Vent and Relief Valves

FIGURE 2-21



Command PU Inverter And DC Power

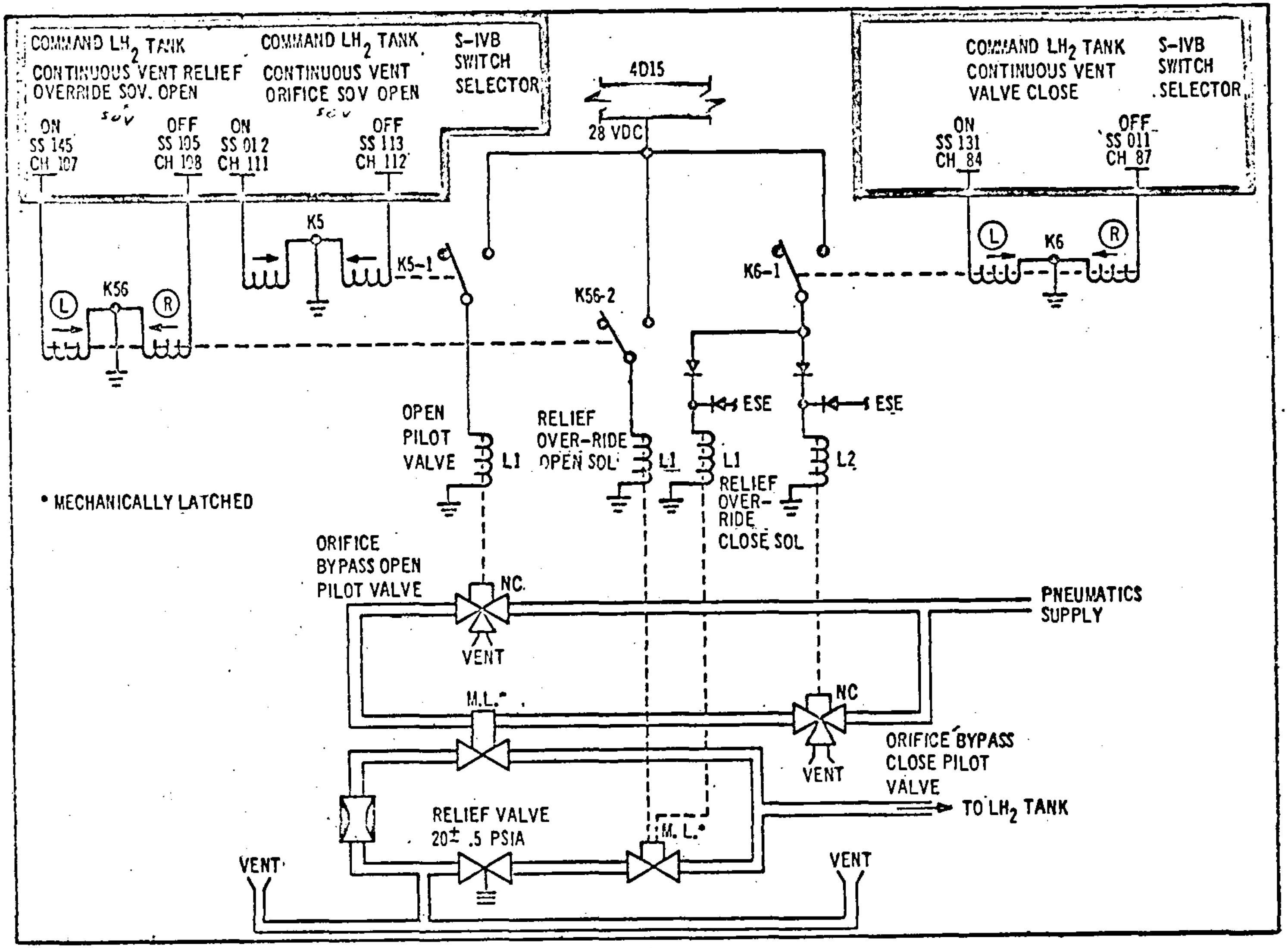
FIGURE 2-22



CHANNEL 38 WILL OPEN THE VENT VALVE AND NORMALLY ACTUATION OF CHANNEL 76 WILL CAUSE THE VALVE TO CLOSE. TO OPEN THE LATCHING RELIEF VALVE AND KEEP IT LATCHED OPEN, CHANNEL 99 IS ACTUATED FOLLOWED BY CHANNEL 64. THIS LATCHES THE VALVE OPEN. NEXT CHANNEL 100 IS ACTUATED FOLLOWED BY CHANNEL 19. THE VALVE IS NOW MECHANICALLY LATCHED OPEN. NORMALLY ACTUATION OF CHANNEL 99 FOLLOWED BY CHANNEL 100 WILL CLOSE THE VALVE. TO INSURE CLOSURE OF BOTH THE VENT VALVE & THE LATCHING RELIEF VALVE, THE BOOST CLOSE COMMAND (CHAN 77) IS SENT. TWO SECONDS LATER BOOST CLOSE IS RELEASED BY CHAN 78.

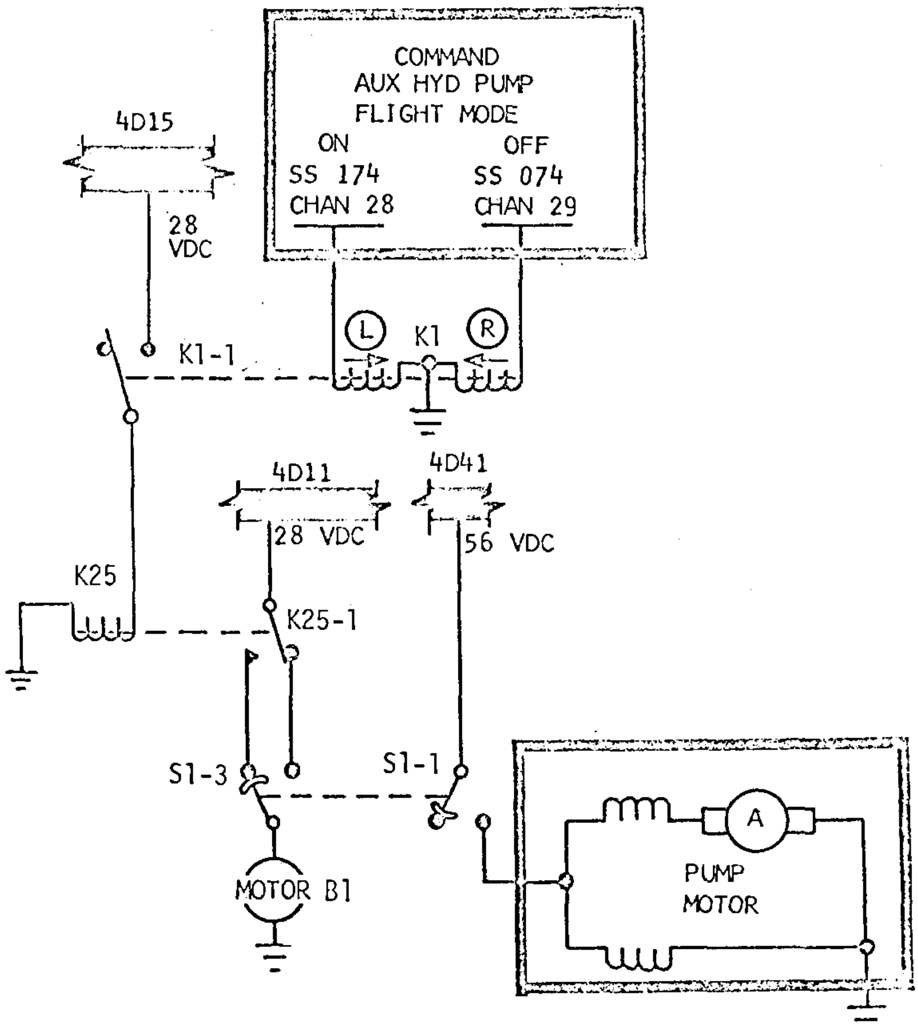
FIGURE 2-23

Commands LH2 Tank Vent and Relief Valves

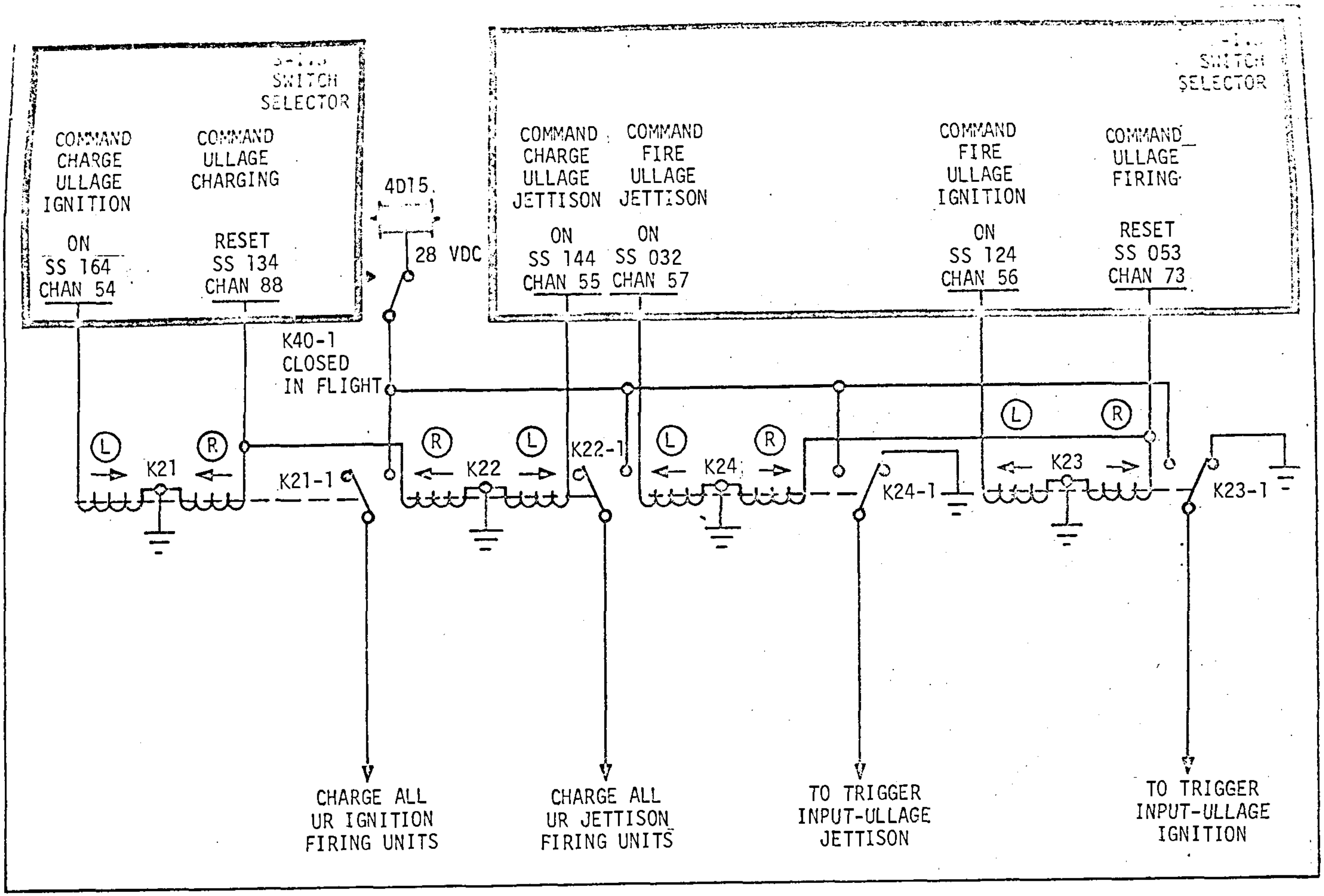


Commands LH2 Tank Continuous Vent Valve Open And Close

FIGURE 2-24

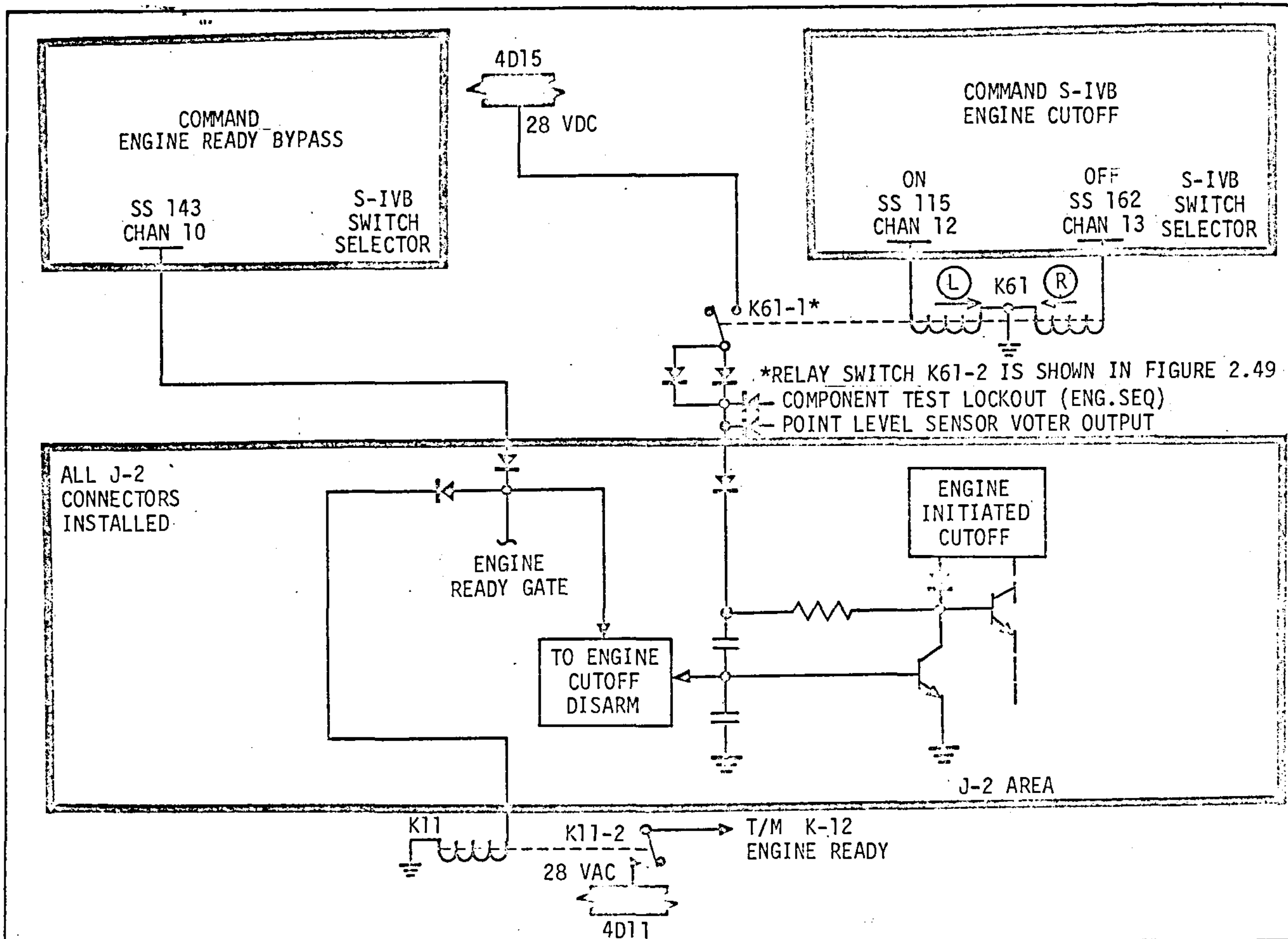


Command Auxiliary Hydraulic Pump Flight Mode



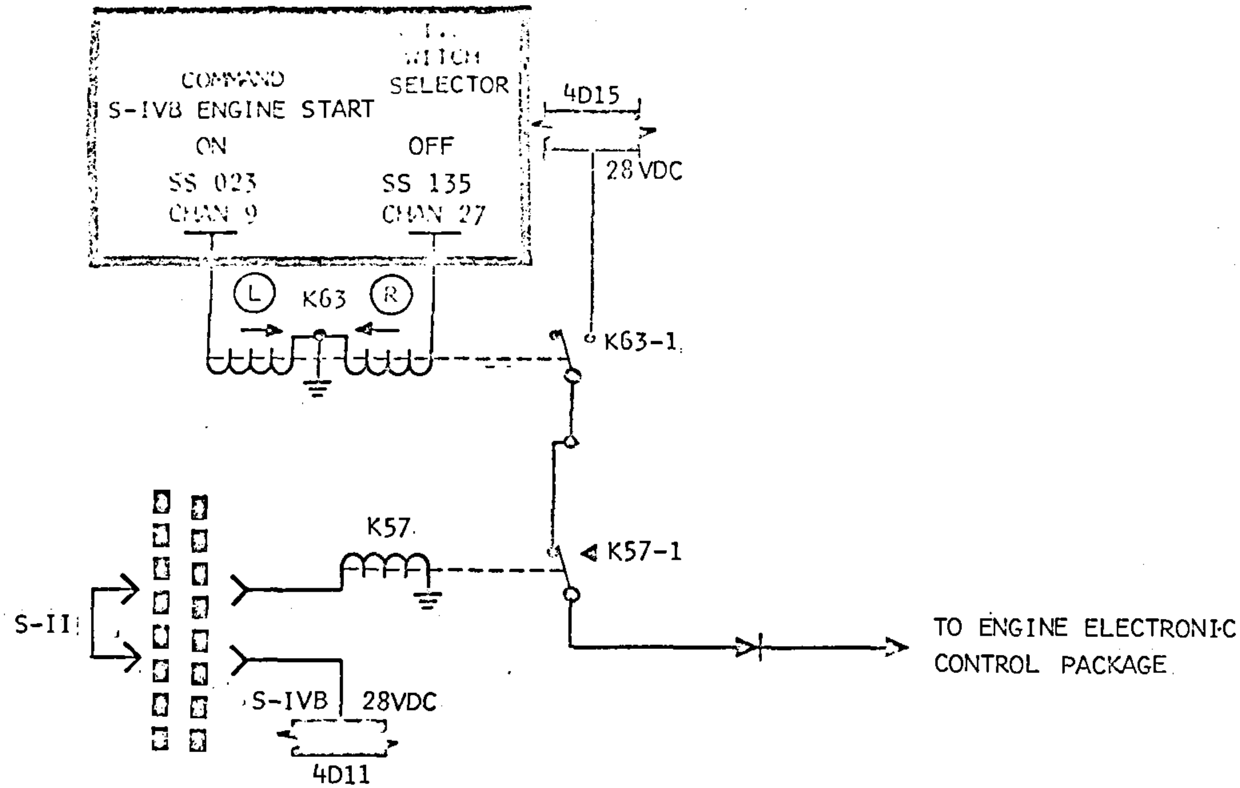
Commands Ullage EBW's Ignition And Jettison

FIGURE 2-26



Commands Engine Ready Bypass And Cutoff

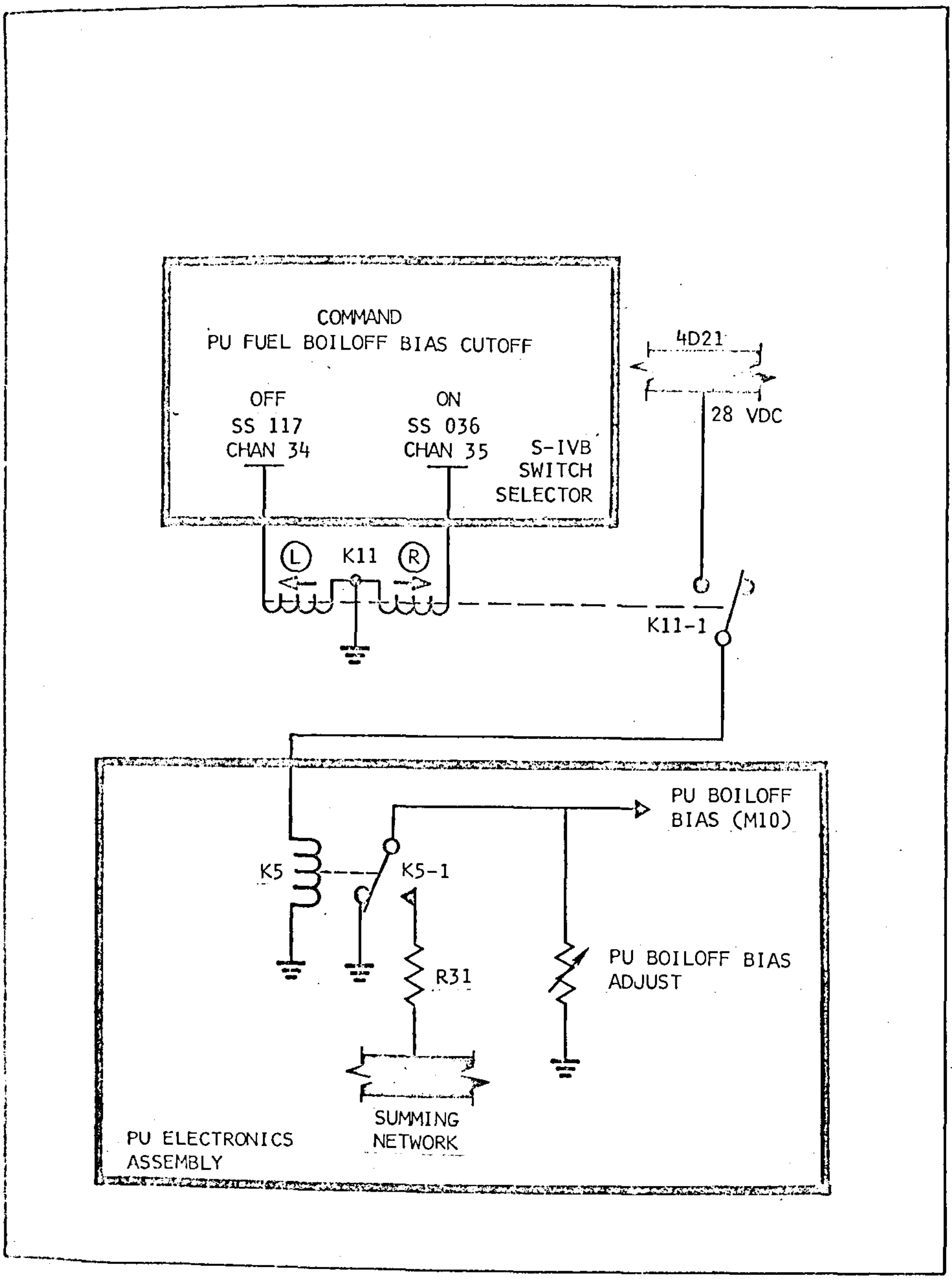
FIGURE 2-28



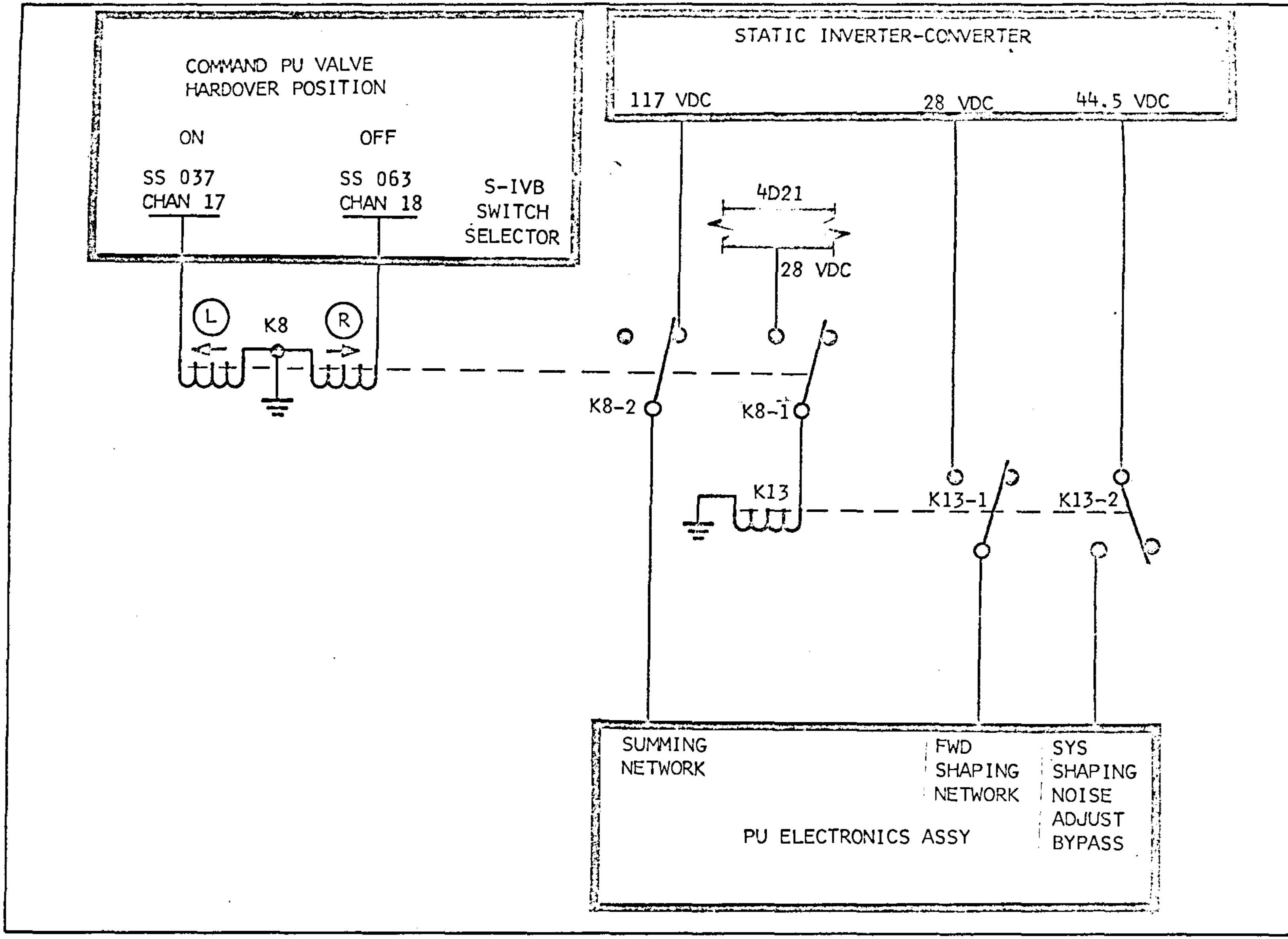
K-57-1 IS SHOWN IN DE-ENERGIZED POSITION.
K-57-1 WILL REMAIN OPEN AS LONG AS STAGING HAS NOT OCCURRED.
AT STAGING, THE S-11 JUMPER OPENS, CLOSING K57-1 AS THE RELAY RELAXES. THE ENGINE START COMMAND NOW HAS CONTINUITY TO THE ENGINE SEQUENCE CONTROLLER.

Commands S-IVB Engine Start

FIGURE 2-29

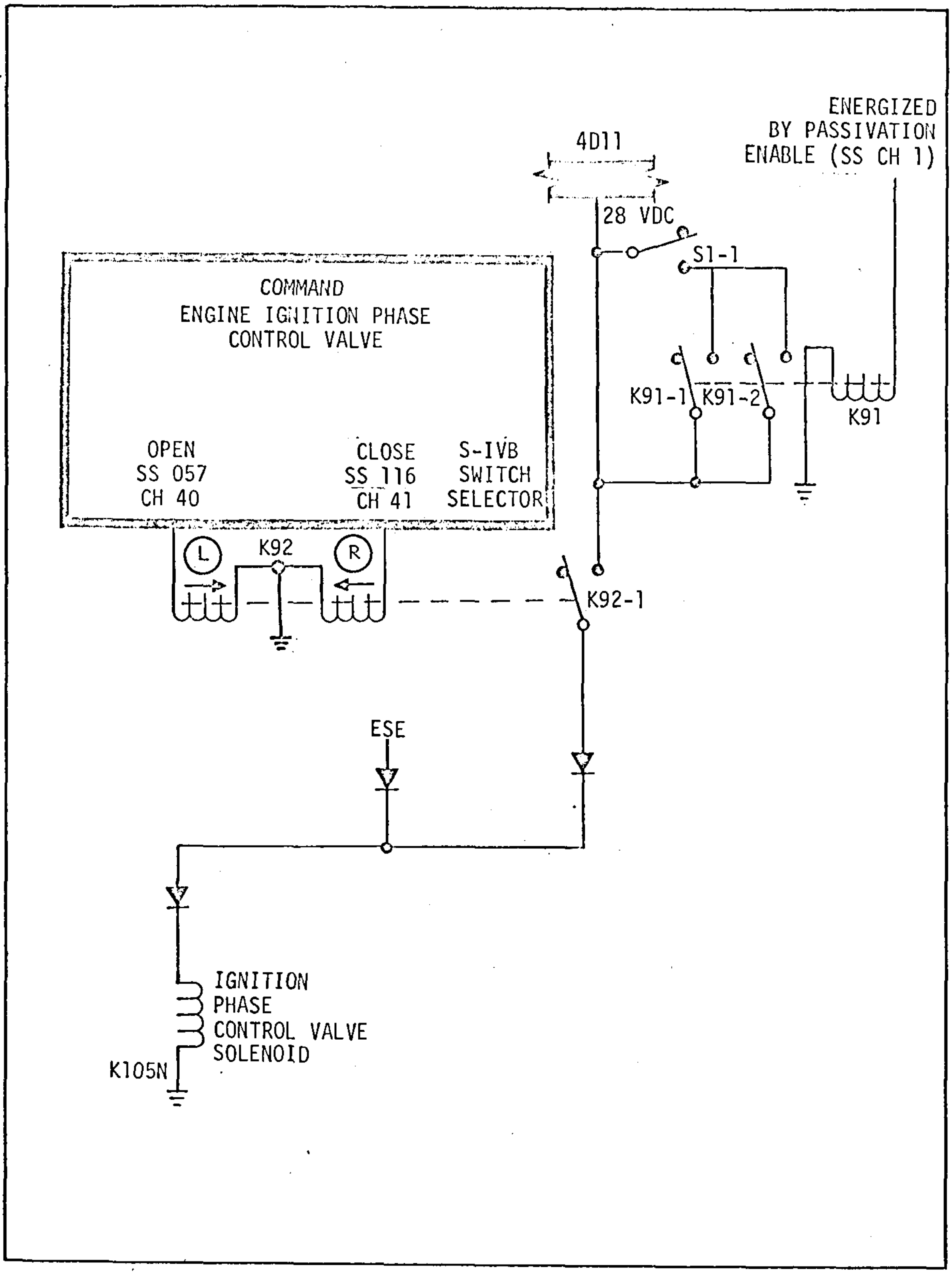


Command PU Fuel Boiloff Bias Cutoff

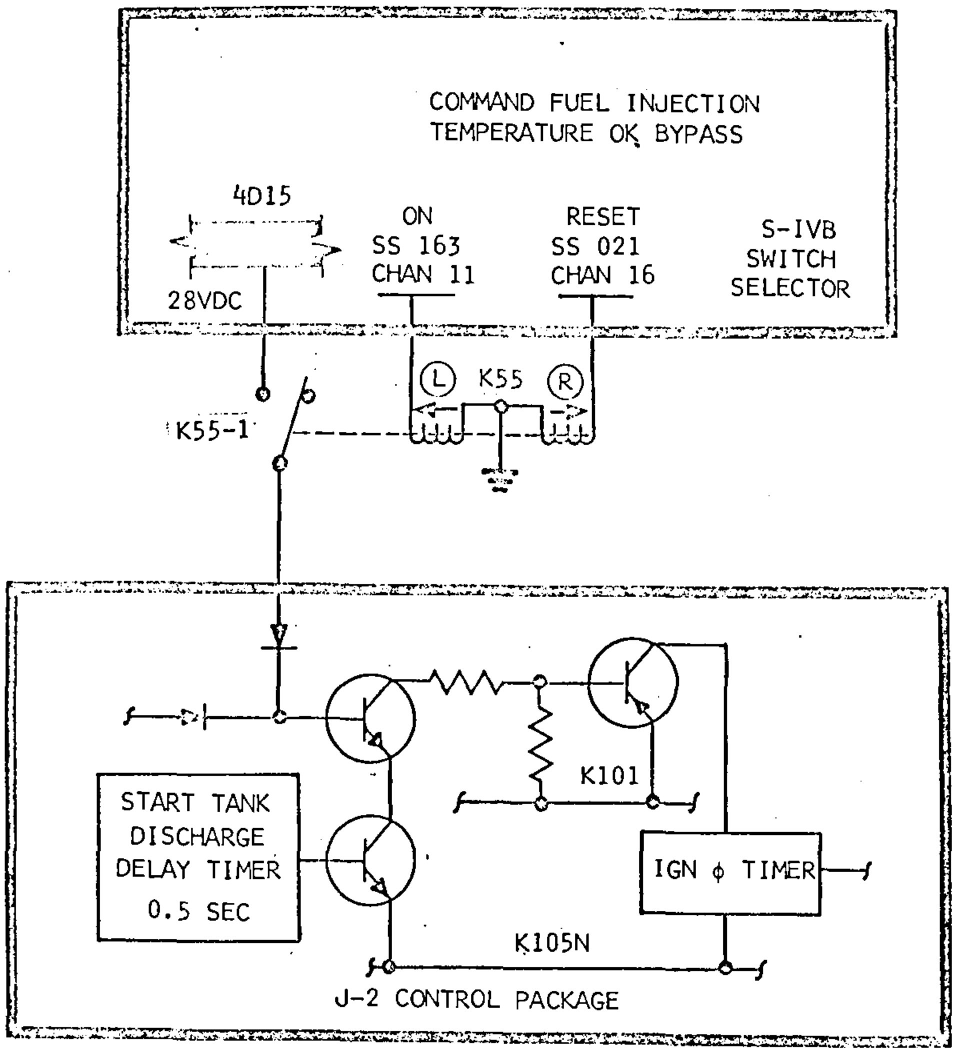


Command PU Valve Hardover Position

FIGURE 2-31

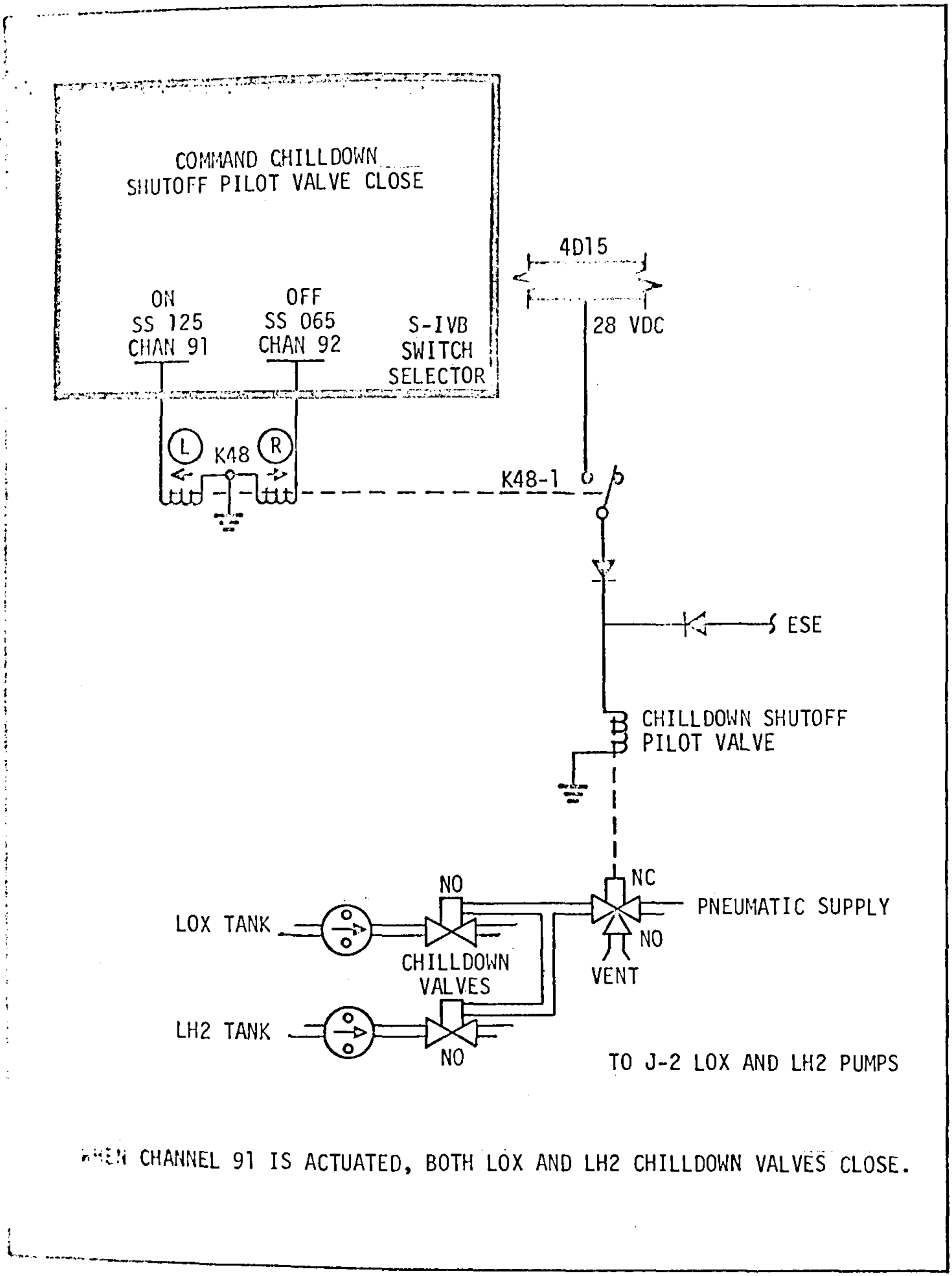


Command Ignition Phase
Cont Valve



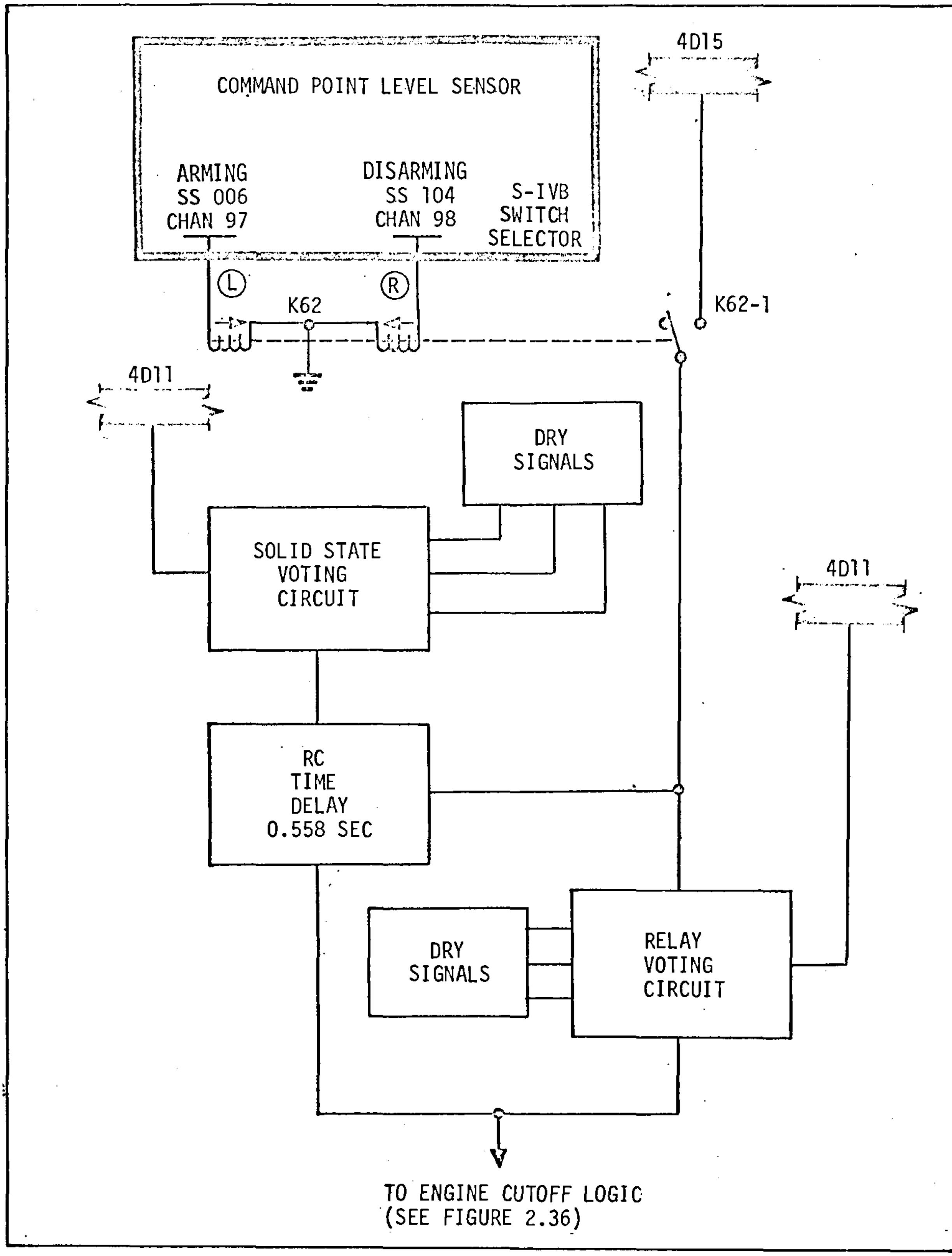
Command Fuel Injection Temperature OK Bypass

FIGURE 2-33



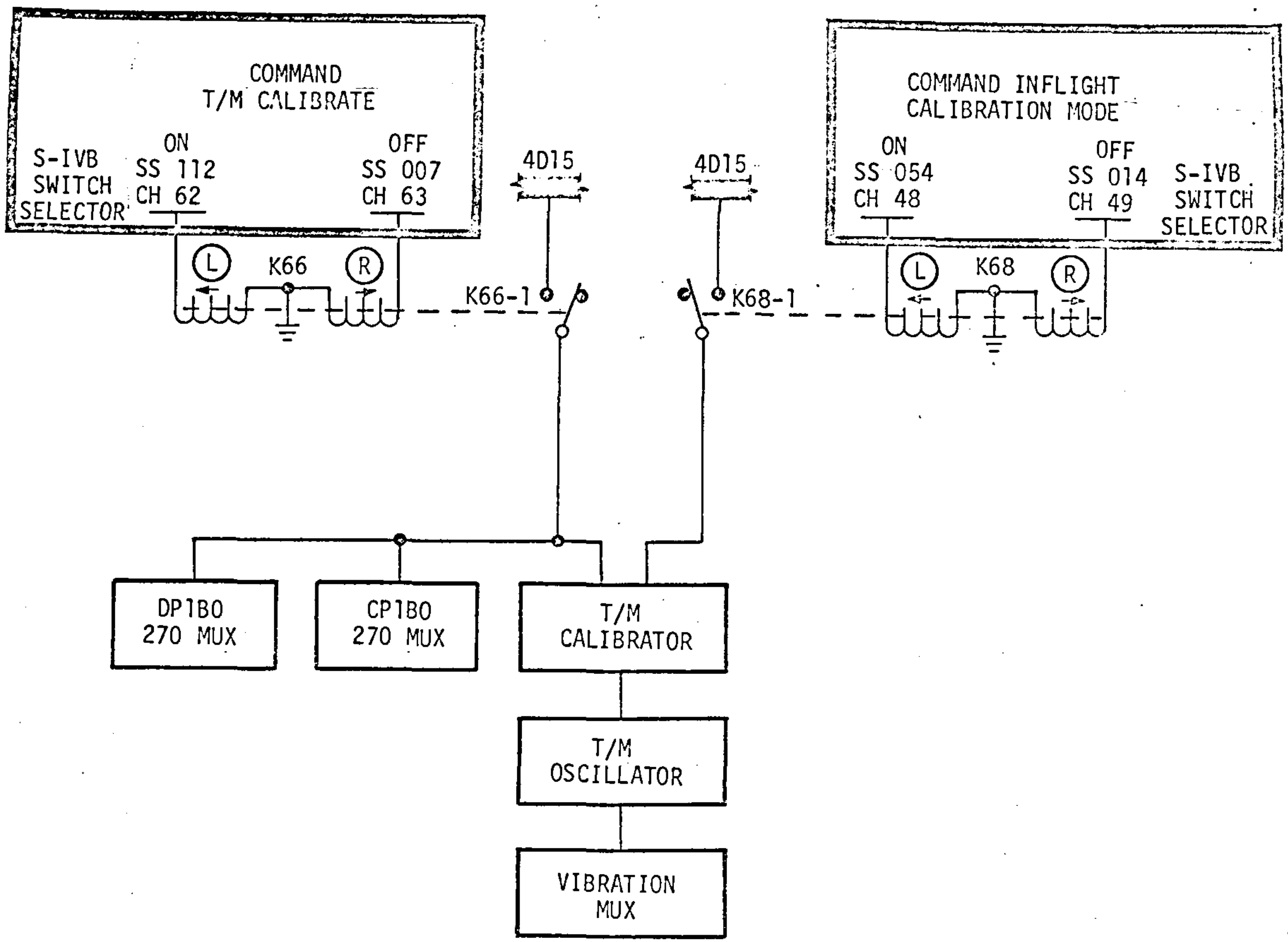
Command Chilldown Shutoff Pilot Valve Close

FIGURE 2-34



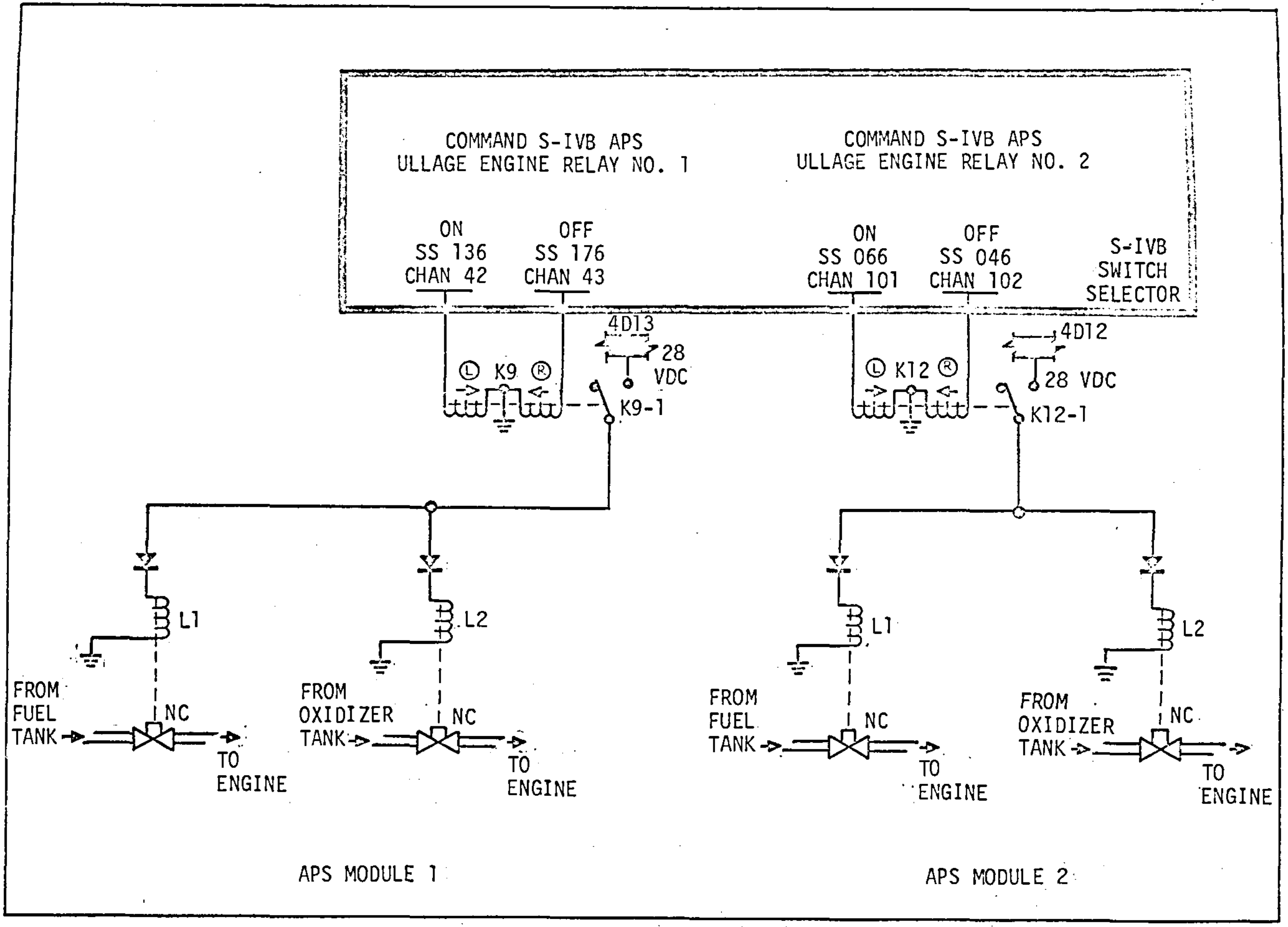
Command Point Level Sensor

FIGURE 2-35



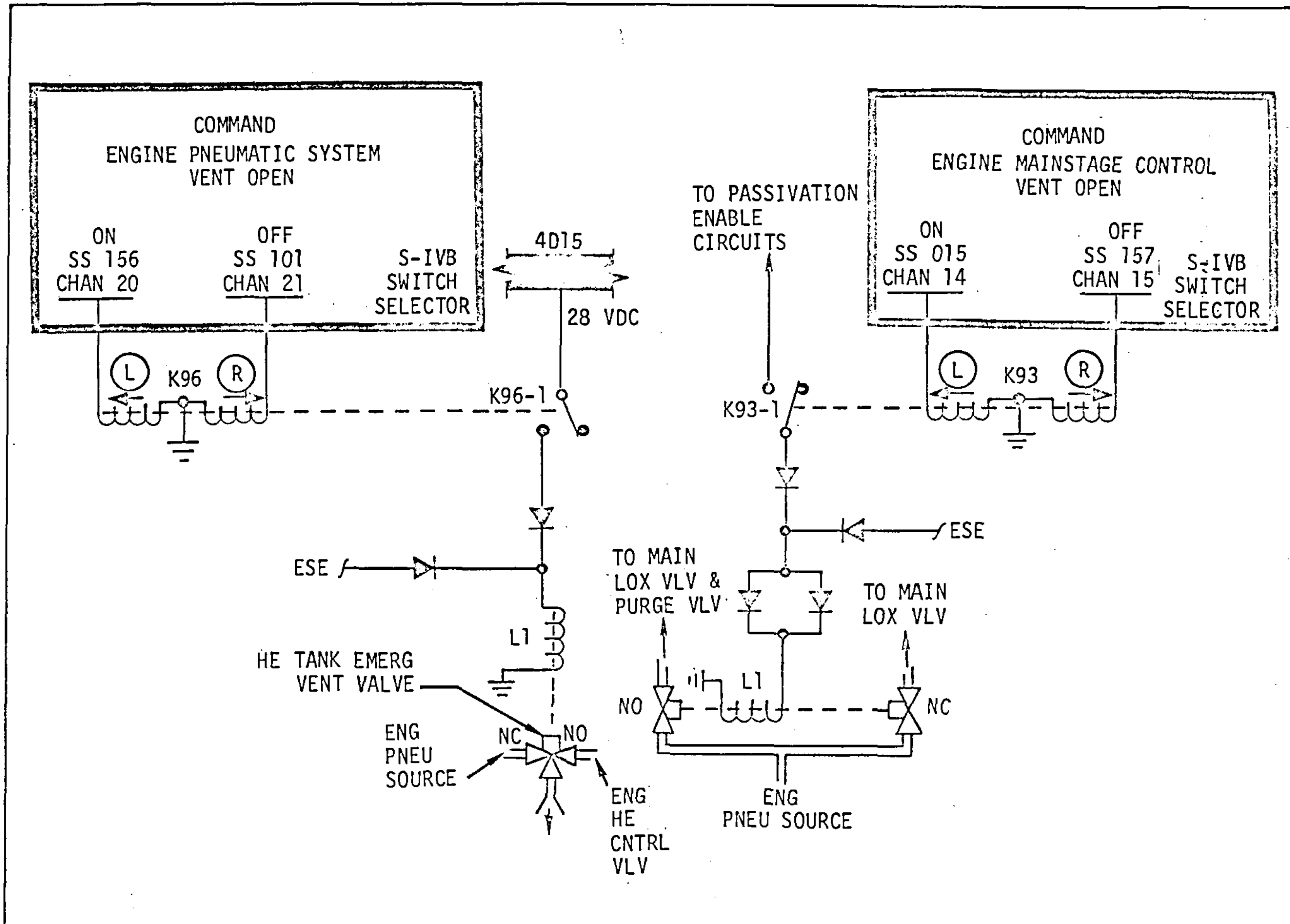
Commands TM Calibrate and Inflight Relays

FIGURE 2-36



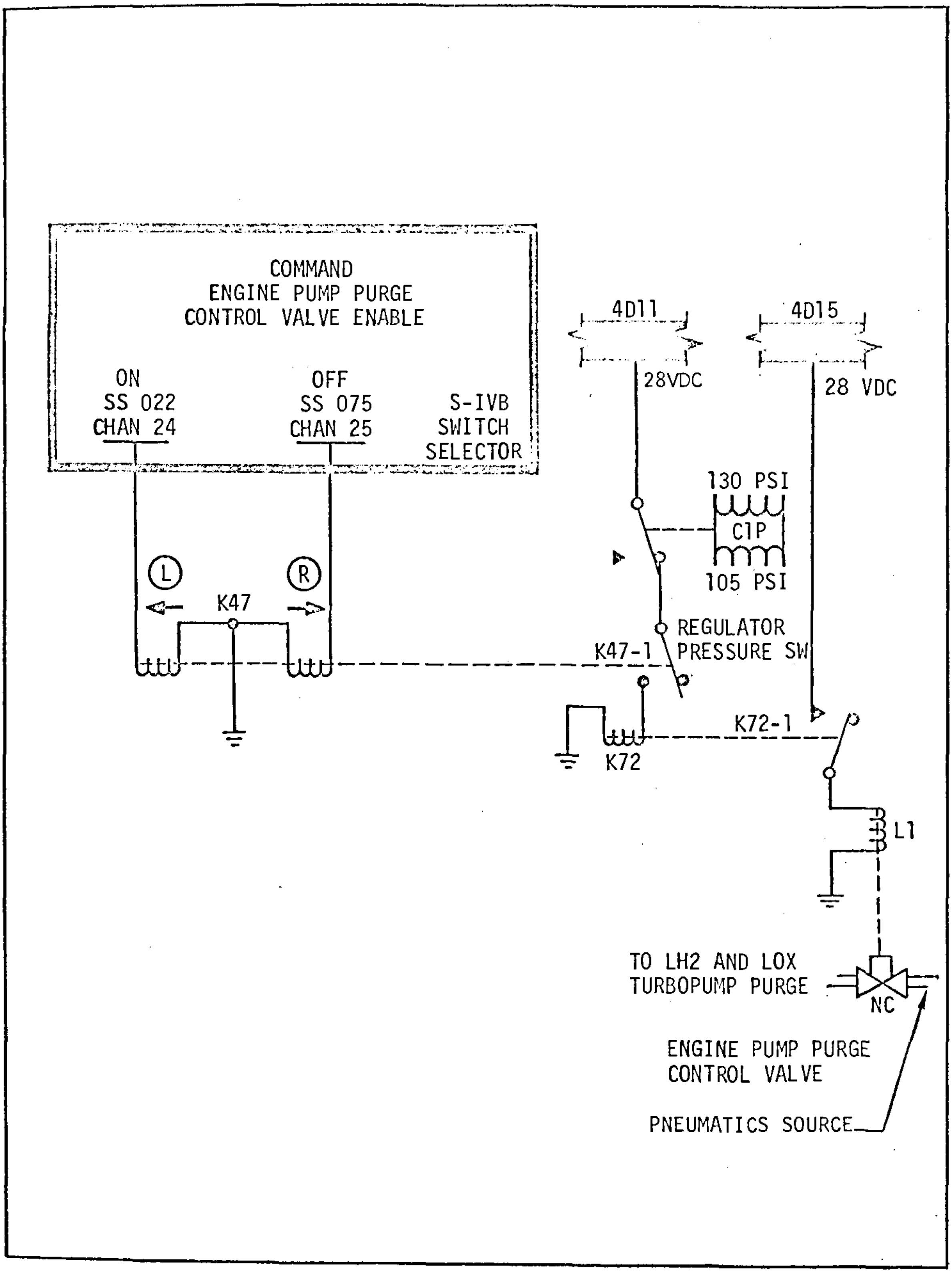
Commands S-IVB Ullage Engines No. 1 And No. 2

FIGURE 2-37



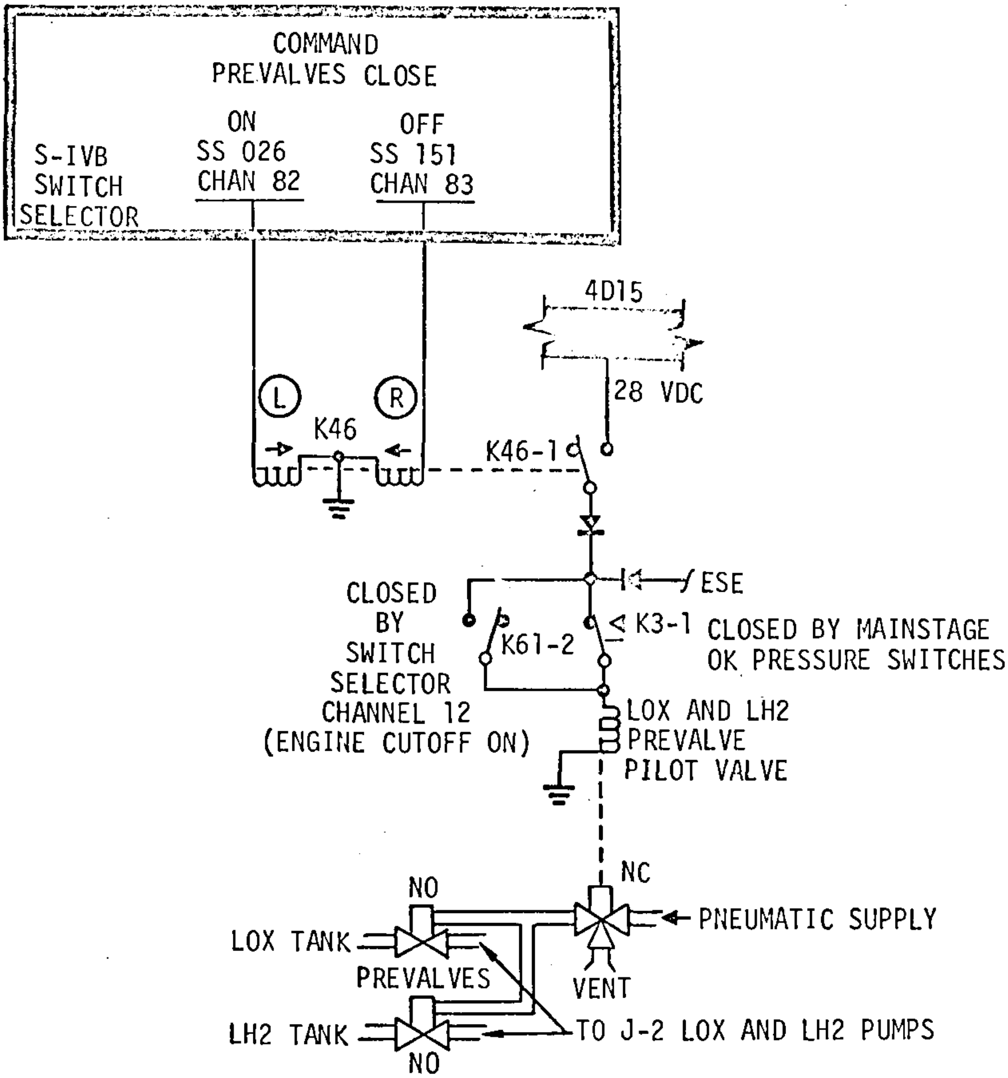
Commands LOX Chilldown Pump Purge Control and Dump Valves

FIGURE 2-38



Command Engine Pump Purge Control Valve Enable

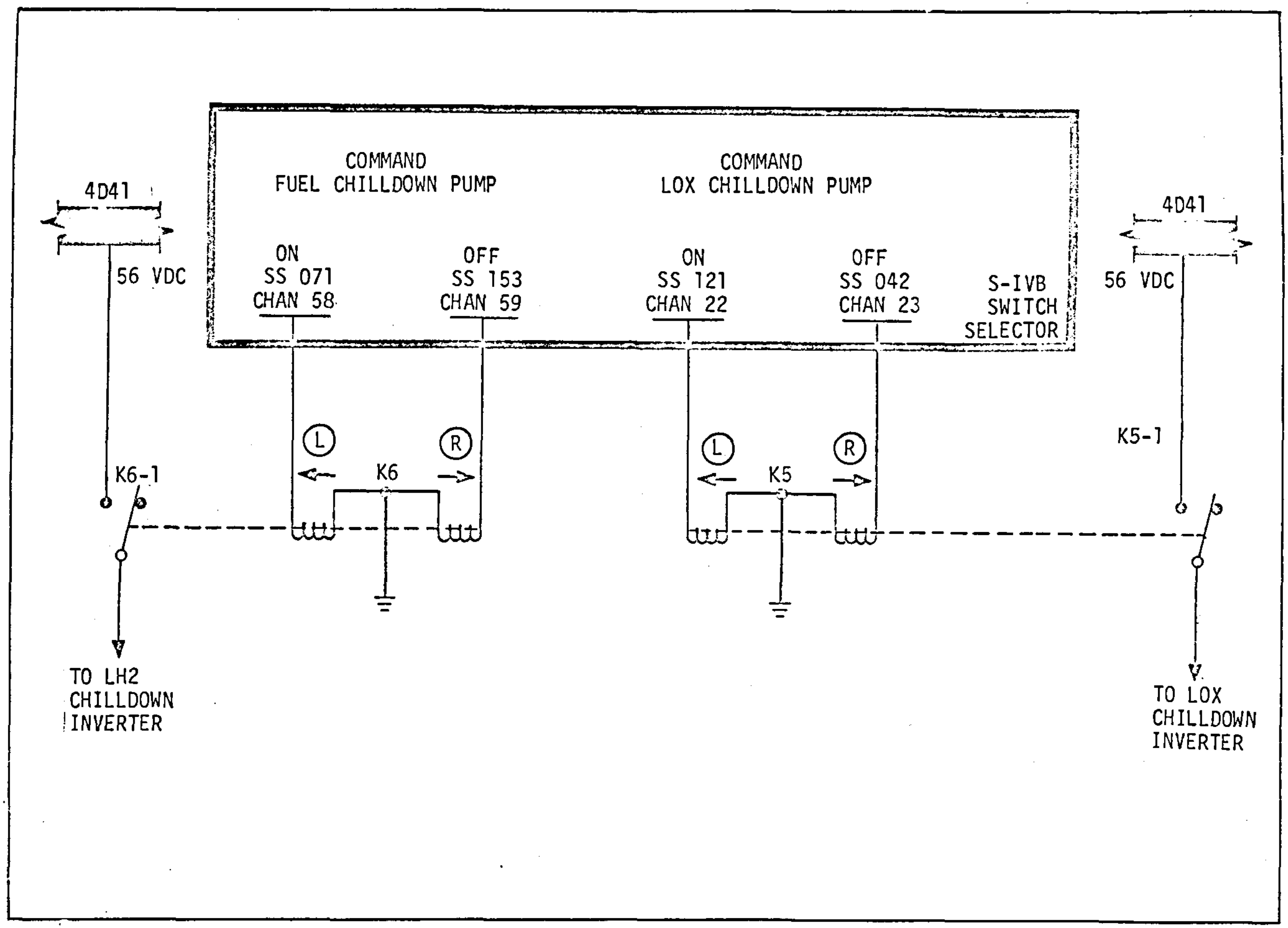
FIGURE 2-39



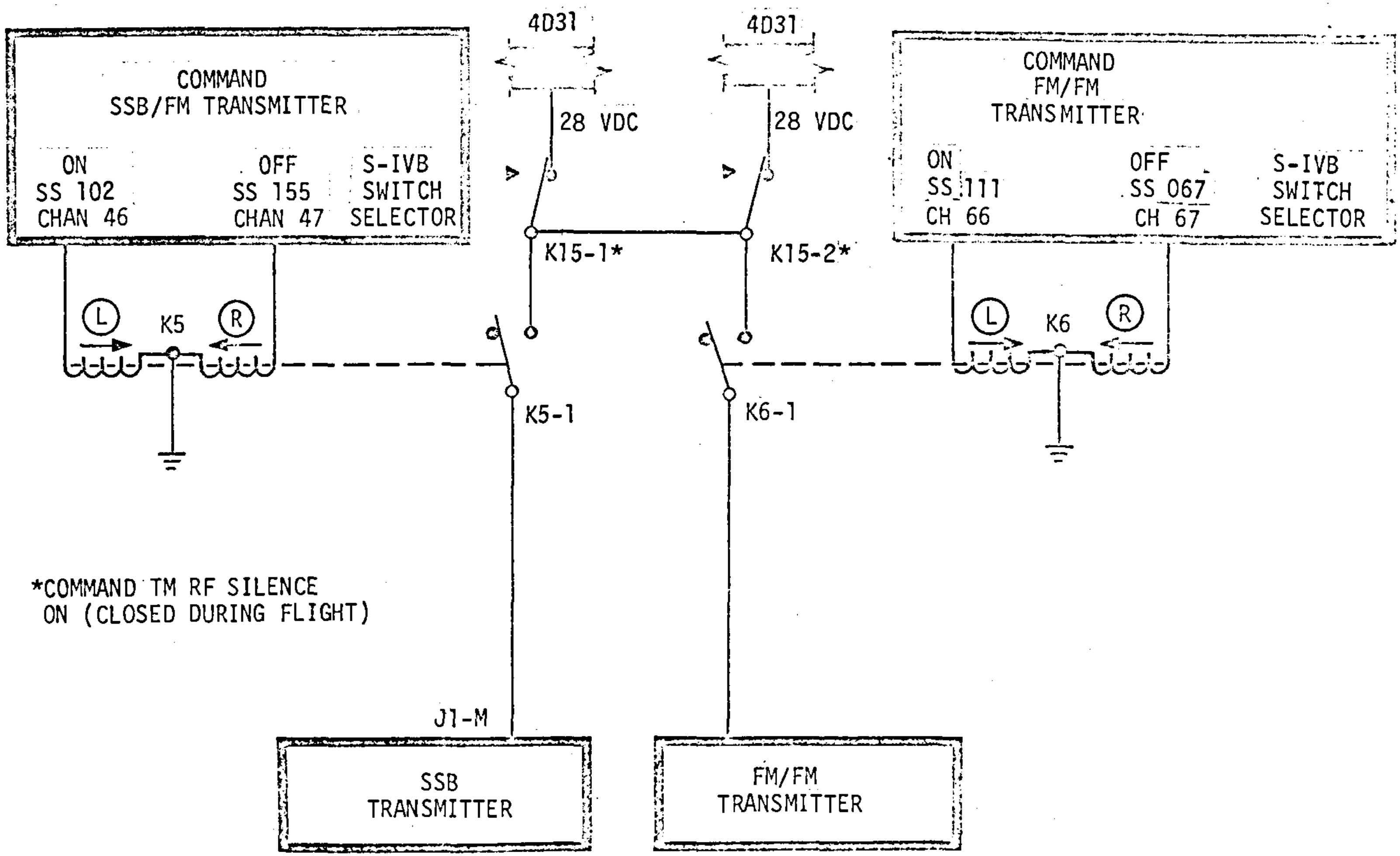
WHEN CHANNEL 82 IS ACTIVATED, BOTH LOX AND LH2 PREVALVES CLOSE

Command Prevalves Close

FIGURE 2-40

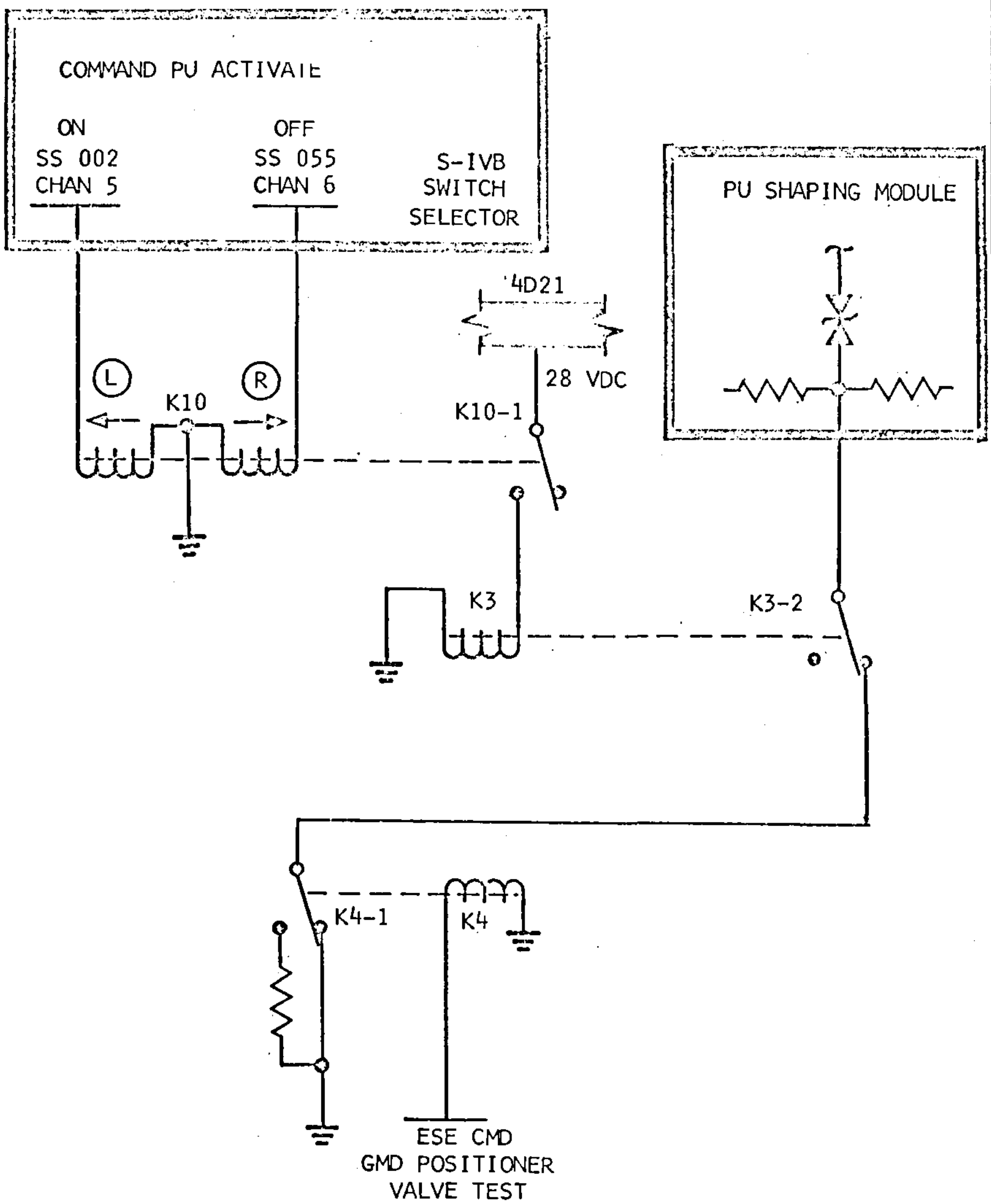


Commands Fuel and LOX Chilldown Pump.



Command Single Sideband FM Transmitter

FIGURE 2-42



PU ACTIVATE REMOVES THE DISABLING GROUND AND ALLOWS THE PU TO OPERATE AS A SELF COMPENSATIVE SERVO SYSTEM.

Command PU Activate

FIGURE 2-43

2.4.3 S-II Switch Selector Functions (Octal)

CH	Code	Function	Figure No.
	000		
37	001	SPARE	
5	002	COMMAND S-II/S-IVB SEPARATION	2.54
30	003	COMMAND START PAM-FM/FM CALIBRATION	2.55
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	2.47
14	015	SPARE	
51	016	SPARE	
39	017	SPARE	
	020		
16	021	SPARE	
24	022	COMMAND S-II ULLAGE TRIGGER	2.54
9	023	COMMAND STOP PAM FM/FM CALIBRATION	2.68
75	024	SPARE	
109	025	SPARE	
82	026	SPARE	
71	027	COMMAND START DATA RECORDERS	2.45
	030		
68	031	SPARE	
57	032	SPARE	
96	033	SPARE	
33	034	COMMAND S-II ENGINE START	2.49
7	035	COMMAND S-II LH_2 STEP PRESSURIZATION	2.48
35	036	SPARE	
17	037	SPARE	
	040		
53	041	SPARE	
23	042	COMMAND S-II SECOND PLANE SEPARATION	2.54
31	043	COMMAND S-II ENGINES CUTOFF RESET	2.59
61	044	SPARE	
93	045	SPARE	
102	046	SPARE	
90	047	COMMAND MEASUREMENT CONTROL SWITCH NO. 2 ACTUATE	2.43
	050		
69	051	SPARE	
65	052	SPARE	

CH	Code	Function	Figure No.
73	053	SPARE	
48	054	COMMAND S-II LH_2 RECIRCULATION PUMPS OFF	2.49
6	055	COMMAND S-II START PHASE LIMITER CUTOFF ARM RESET	2.46
52	056	SPARE	
40	057	SPARE	
	060		
38	061	S-II LH_2 TANK HIGH PRESS VENT MODE	
44	062	SPARE	
18	063	COMMAND CUTOFF S-II ENGINES	2.46
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	COMMAND S-II START PHASE LIMITER CUTOFF ARM	2.46
36	076	SPARE	
8	077	COMMAND S-II/S-IVB ORDNANCE ARM	2.54
	100		
21	101	SPARE	
46	102	SPARE	
32	103	COMMAND ACTIVATE PU SYSTEM	2.56
98	104	SPARE	
108	105	SPARE	
76	106	SPARE	
89	107	SPARE	
	110		
66	111	COMMAND START RECORDER TIMERS	2.45
62	112	SPARE	
112	113	SPARE	
105	114	SPARE	
12	115	COMMAND S-II HYDRAULIC ACCUMULATORS UNLOCK	2.50
41	116	SPARE	
34	117	SPARE	
	120		
22	121	SPARE	
19	122	COMMAND PREVALVES LOCKOUT RESET	2.46
45	123	SPARE	

CH	Code	Function	Figure No.
56	124	SPARE	
91	125	SPARE	
99	126	PREVALVES CLOSE ARM	
86	127	SPARE	
	130		
84	131	SPARE	
100	132	SPARE	
60	133	SPARE	
88	134	COMMAND CHILLDOWN VALVES CLOSE	2.44
27	135	SPARE	
42	136	COMMAND S-II LH_2 DEPLETION SENSOR CUTOFF ARM	2.46
2	137	SPARE	
	140		
4	141	SPARE	
3	142	COMMAND S-II LOX DEPLETION SENSOR CUTOFF ARM	2.46
10	143	SPARE	
55	144	SPARE	
107	145	SPARE	
77	146	SPARE	
85	147	SPARE	
	150		
83	151	SPARE	
79	152	SPARE	
59	153	SPARE	
70	154	SPARE	
47	155	SPARE	
20	156	COMMAND ENGINES READY BYPASS	2.47
15	157	SPARE	
	160		
50	161	SPARE	
13	162	SPARE	
11	163	COMMAND S-II ORDNANCE ARM	2.54
54	164	SPARE	
106	165	SPARE	
78	166	SPARE	
104	167	COMMAND STOP DATA RECORDERS	2.45
	170		
103	171	SPARE	
80	172	SPARE	
72	173	SPARE	
28	174	SPARE	
26	175	SPARE	
43	176	SPARE	
1	177	SPARE	

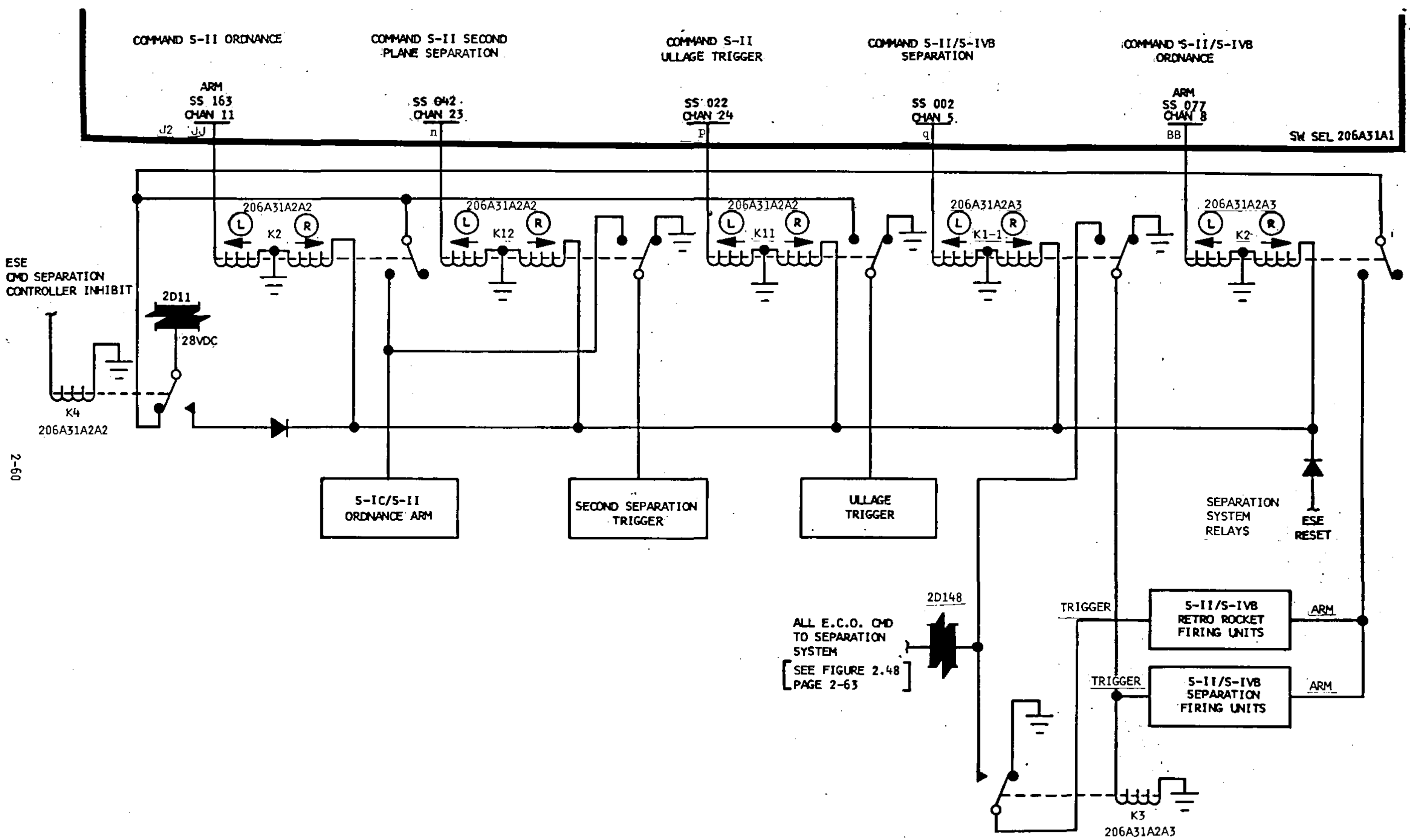

COMMAND S-II ORDNANCE
COMMAND S-II SECOND PLANE SEPARATION
COMMAND S-II ULLAGE TRIGGER
COMMAND S-II/S-IVB SEPARATION
COMMAND S-II/S-IVB ORDNANCE
ARM SS 163 CHAN 11
SS 042 CHAN 23
SS 022 CHAN 24
SS 002 CHAN 5
ARM SS 077 CHAN 8
J2 JJ
n
p
q
BB
SW SEL 206A31A1
206A31A2A2
K2
206A31A2A2
K12
206A31A2A2
K11
206A31A2A3
K1-1
206A31A2A3
K2
ESE CMD SEPARATION CONTROLLER INHIBIT
2D11
28VDC
K4
206A31A2A2
S-IC/S-II ORDNANCE ARM
SECOND SEPARATION TRIGGER
ULLAGE TRIGGER
SEPARATION SYSTEM RELAYS
ESE RESET
2D148
ALL E.C.O. CMD TO SEPARATION SYSTEM
SEE FIGURE 2.48 PAGE 2-63
TRIGGER
S-II/S-IVB RETRO ROCKET FIRING UNITS
ARM
TRIGGER
S-II/S-IVB SEPARATION FIRING UNITS
ARM
K3
206A31A2A3

FIGURE 2-43

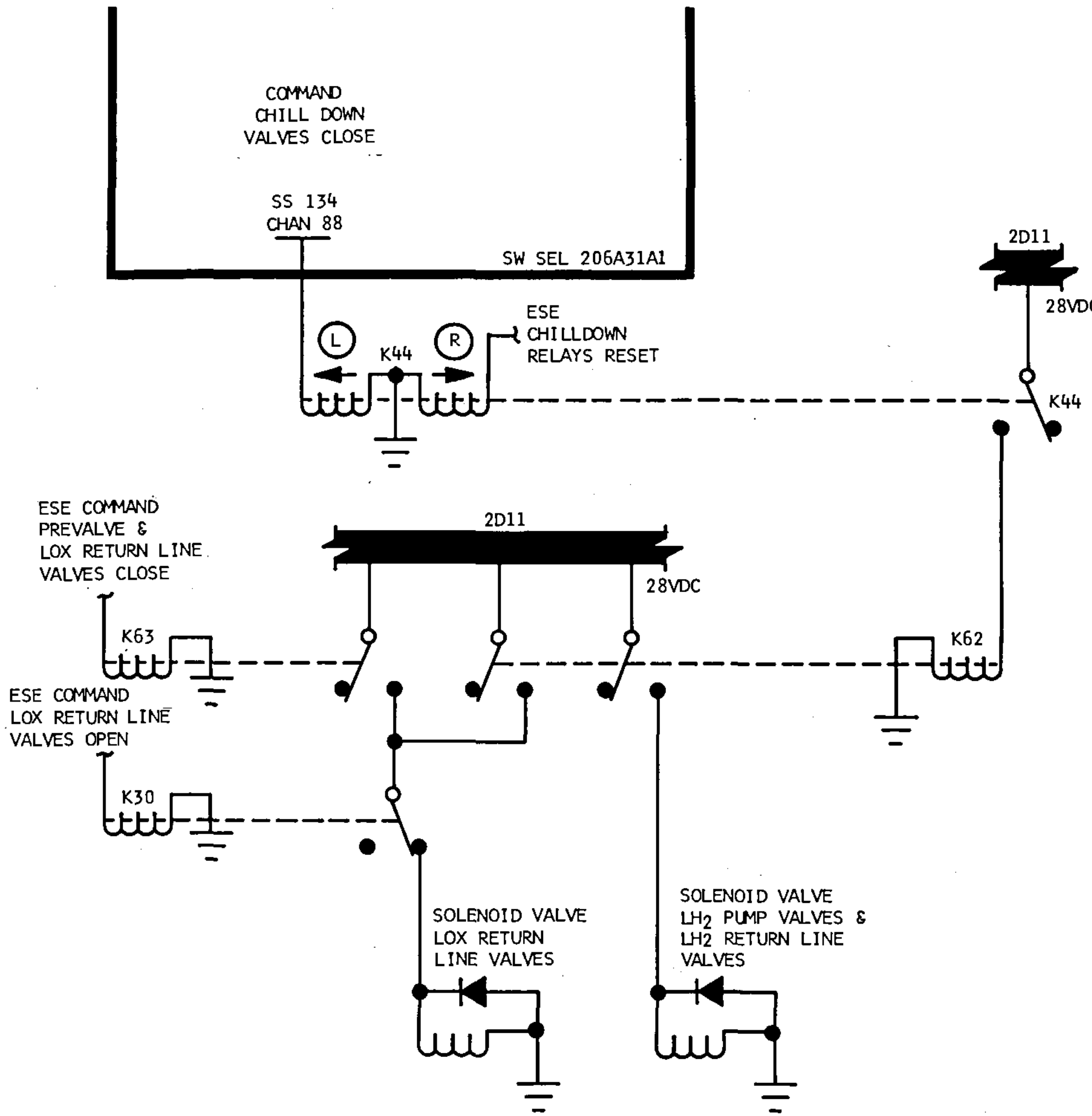

COMMAND
CHILL DOWN
VALVES CLOSE
SS 134
CHAN 88
SW SEL 206A31A1
2D11
28VDC
L
R
K44
ESE
CHILLDOWN
RELAYS RESET
K44
ESE COMMAND
PREVALVE &
LOX RETURN LINE
VALVES CLOSE
2D11
28VDC
K63
K62
ESE COMMAND
LOX RETURN LINE
VALVES OPEN
K30
SOLENOID VALVE
LOX RETURN
LINE VALVES
SOLENOID VALVE
LH2 PUMP VALVES &
LH2 RETURN LINE
VALVES

FIGURE 2-44

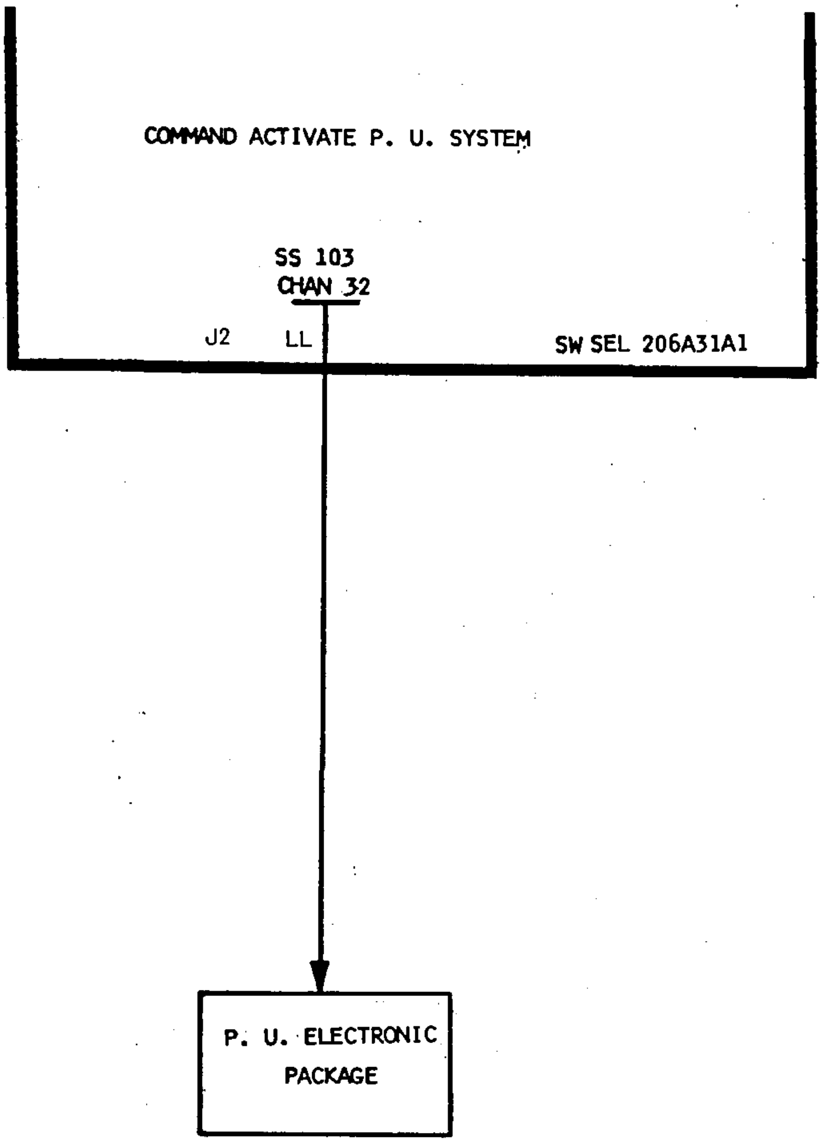
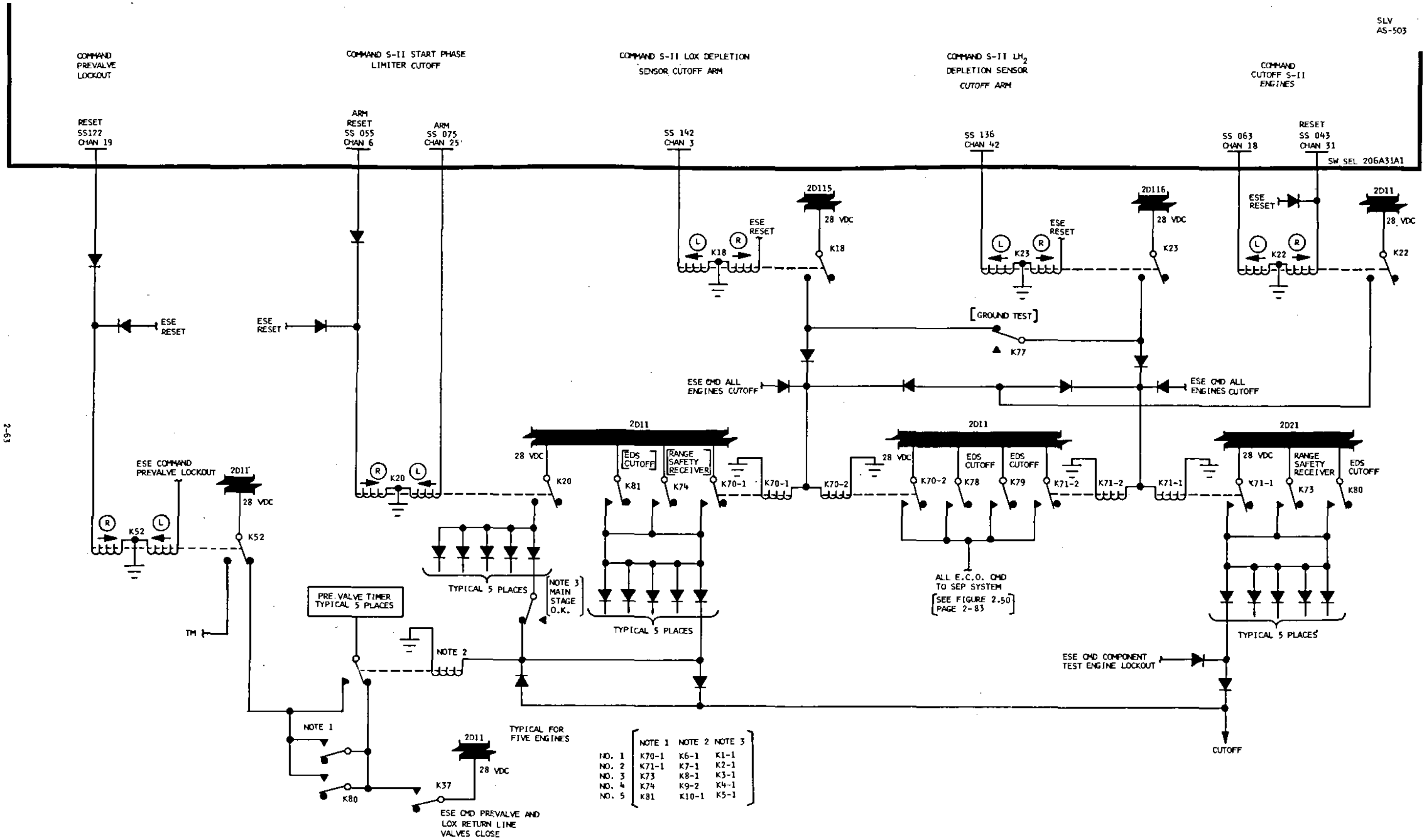

COMMAND ACTIVATE P. U. SYSTEM
SS 103
CHAN 32
J2
LL
SW SEL 206A31A1
P. U. ELECTRONIC
PACKAGE

FIGURE 2-45



	NOTE 1	NOTE 2	NOTE 3
NO. 1	K70-1	K6-1	K1-1
NO. 2	K71-1	K7-1	K2-1
NO. 3	K73	K8-1	K3-1
NO. 4	K74	K9-2	K4-1
NO. 5	K81	K10-1	K5-1

FIGURE 2-46

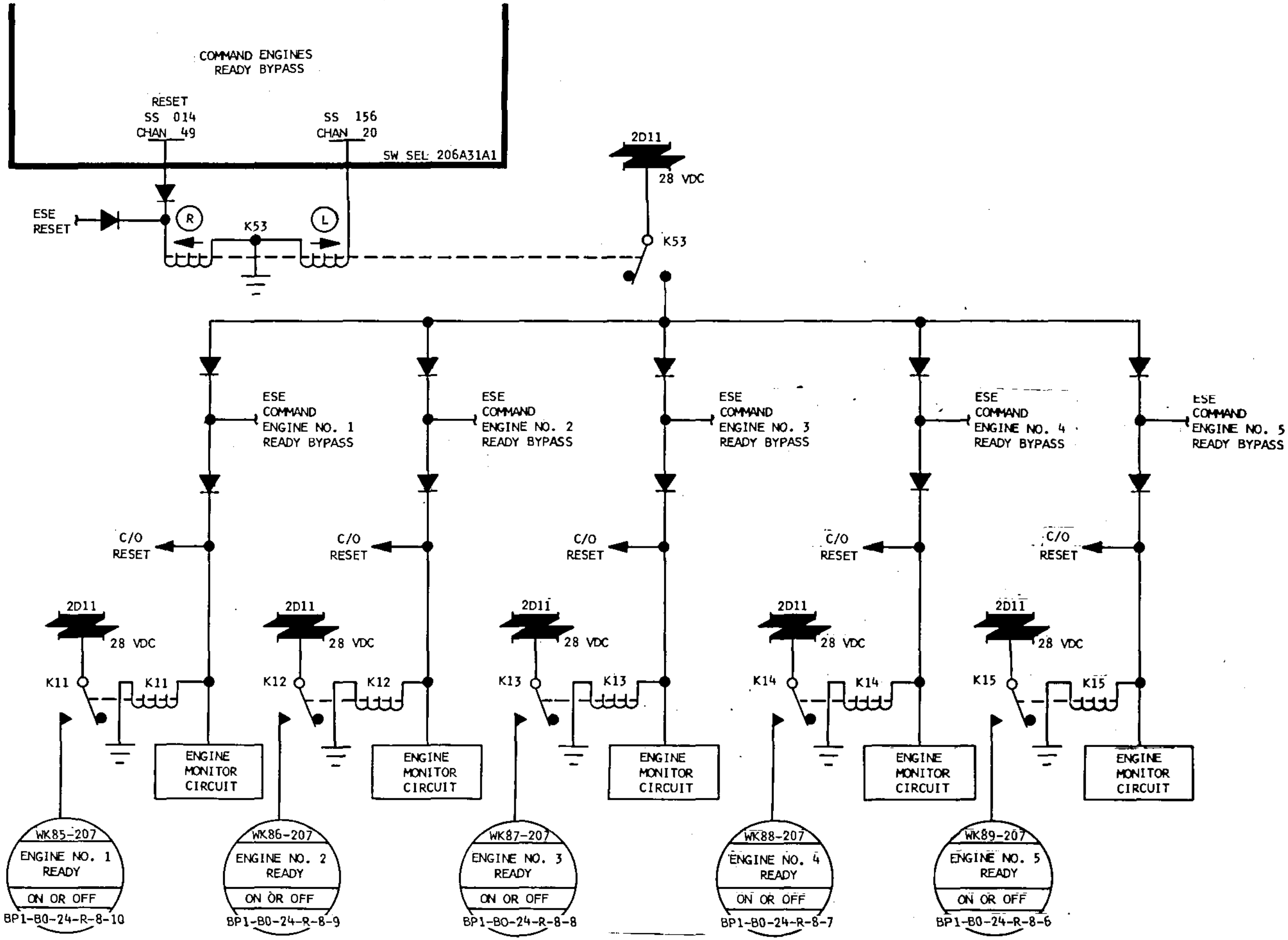

COMMAND ENGINES READY BYPASS
RESET
SS 014
CHAN 49
SS 156
CHAN 20
SW SEL 206A31A1
ESE RESET
R
K53
L
2D11
28 VDC
K53
ESE COMMAND ENGINE NO. 1 READY BYPASS
ESE COMMAND ENGINE NO. 2 READY BYPASS
ESE COMMAND ENGINE NO. 3 READY BYPASS
ESE COMMAND ENGINE NO. 4 READY BYPASS
ESE COMMAND ENGINE NO. 5 READY BYPASS
C/O RESET
C/O RESET
C/O RESET
C/O RESET
C/O RESET
2D11
28 VDC
K11
K11
2D11
28 VDC
K12
K12
2D11
28 VDC
K13
K13
2D11
28 VDC
K14
K14
2D11
28 VDC
K15
K15
ENGINE MONITOR CIRCUIT
ENGINE MONITOR CIRCUIT
ENGINE MONITOR CIRCUIT
ENGINE MONITOR CIRCUIT
ENGINE MONITOR CIRCUIT
WK85-207
ENGINE NO. 1 READY
ON OR OFF
BP1-B0-24-R-8-10
WK86-207
ENGINE NO. 2 READY
ON OR OFF
BP1-B0-24-R-8-9
WK87-207
ENGINE NO. 3 READY
ON OR OFF
BP1-B0-24-R-8-8
WK88-207
ENGINE NO. 4 READY
ON OR OFF
BP1-B0-24-R-8-7
WK89-207
ENGINE NO. 5 READY
ON OR OFF
BP1-B0-24-R-8-6

FIGURE 2-47

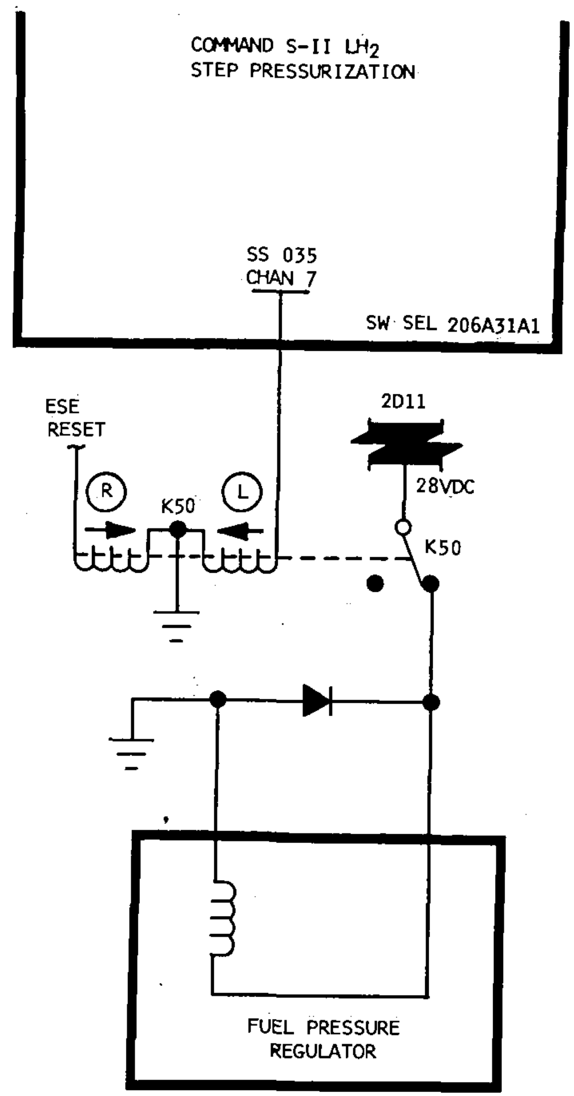

COMMAND S-II LH2
STEP PRESSURIZATION
SS 035
CHAN 7
SW SEL 206A31A1
ESE
RESET
R
K50
L
2D11
28VDC
K50
FUEL PRESSURE
REGULATOR

FIGURE 2-48

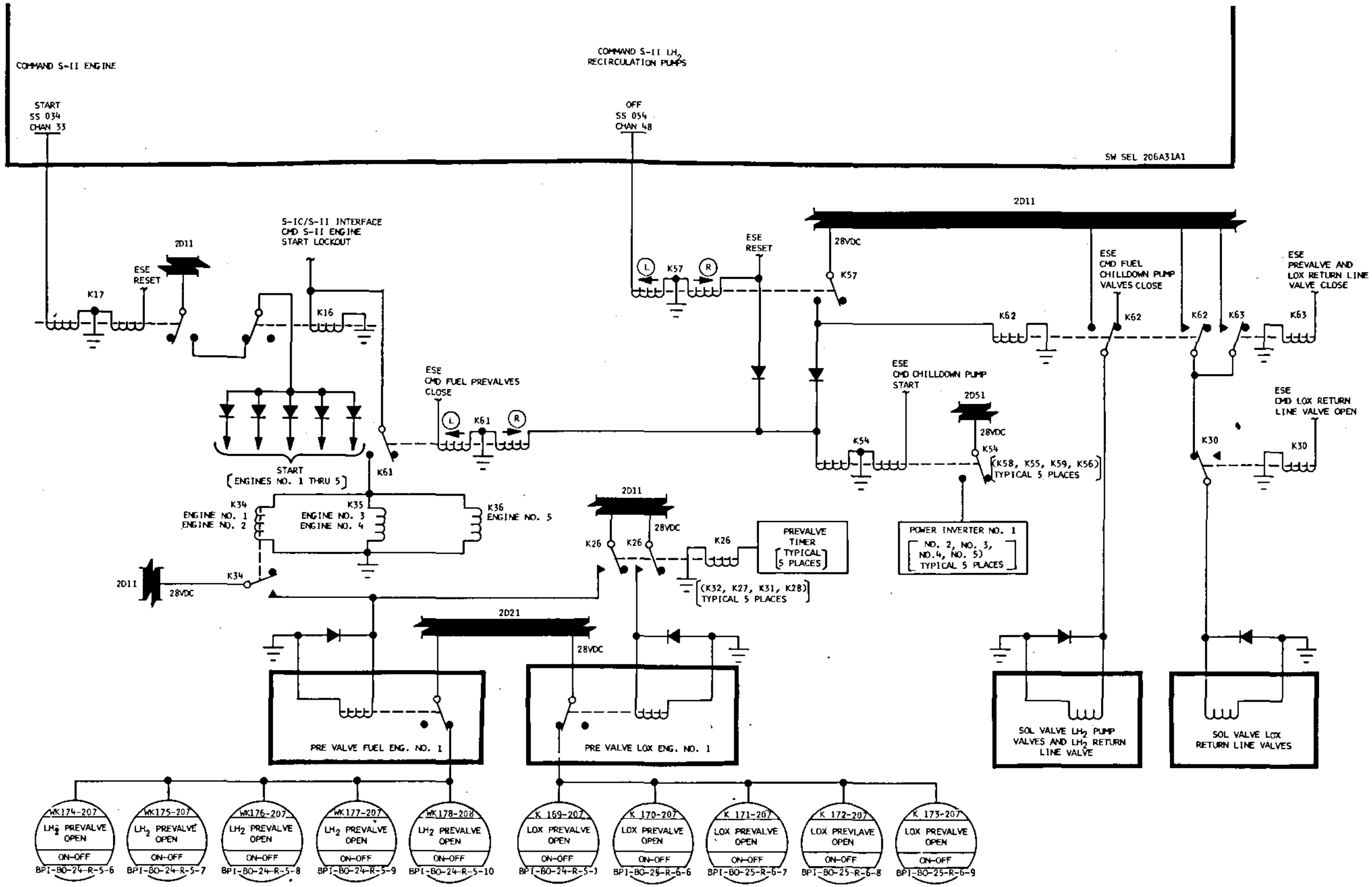

COMMAND S-II ENGINE
COMMAND S-II LH2 RECIRCULATION PUMPS
START SS 034 CHAN 33
OFF SS 054 CHAN 48
SW SEL 206A31A1
2D11
ESE RESET
K17
S-IC/S-II INTERFACE CMD S-II ENGINE START LOCKOUT
K16
ESE CMD FUEL PREVALVES CLOSE
K61
START [ENGINES NO. 1 THRU 5]
K34 ENGINE NO. 1 ENGINE NO. 2
K35 ENGINE NO. 3 ENGINE NO. 4
K36 ENGINE NO. 5
28VDC
K57
28VDC
ESE CMD FUEL CHILLDOWN PUMP VALVES CLOSE
ESE PREVALVE AND LOX RETURN LINE VALVE CLOSE
K62
K63
ESE CMD CHILLDOWN PUMP START
2D51
K54
(K58, K55, K59, K56) TYPICAL 5 PLACES
ESE CMD LOX RETURN LINE VALVE OPEN
K30
K26
PREVALVE TIMER [TYPICAL 5 PLACES]
(K32, K27, K31, K28) TYPICAL 5 PLACES
POWER INVERTER NO. 1 [NO. 2, NO. 3, NO. 4, NO. 5) TYPICAL 5 PLACES]
2D21
PRE VALVE FUEL ENG. NO. 1
PRE VALVE LOX ENG. NO. 1
SOL VALVE LH2 PUMP VALVES AND LH2 RETURN LINE VALVE
SOL VALVE LOX RETURN LINE VALVES
WK174-207 LH2 PREVALVE OPEN ON-OFF BPI-BO-24-R-5-6
WK175-207 LH2 PREVALVE OPEN ON-OFF BPI-BO-24-R-5-7
WK176-207 LH2 PREVALVE OPEN ON-OFF BPI-BO-24-R-5-8
WK177-207 LH2 PREVALVE OPEN ON-OFF BPI-BO-24-R-5-9
WK178-208 LH2 PREVALVE OPEN ON-OFF BPI-BO-24-R-5-10
K 169-207 LOX PREVALVE OPEN ON-OFF BPI-BO-24-R-5-J
K 170-207 LOX PREVALVE OPEN ON-OFF BPI-BO-25-R-6-6
K 171-207 LOX PREVALVE OPEN ON-OFF BPI-BO-25-R-6-7
K 172-207 LOX PREVLAVE OPEN ON-OFF BPI-BO-25-R-6-8
K 173-207 LOX PREVALVE OPEN ON-OFF BPI-BO-25-R-6-9

FIGURE 2-49

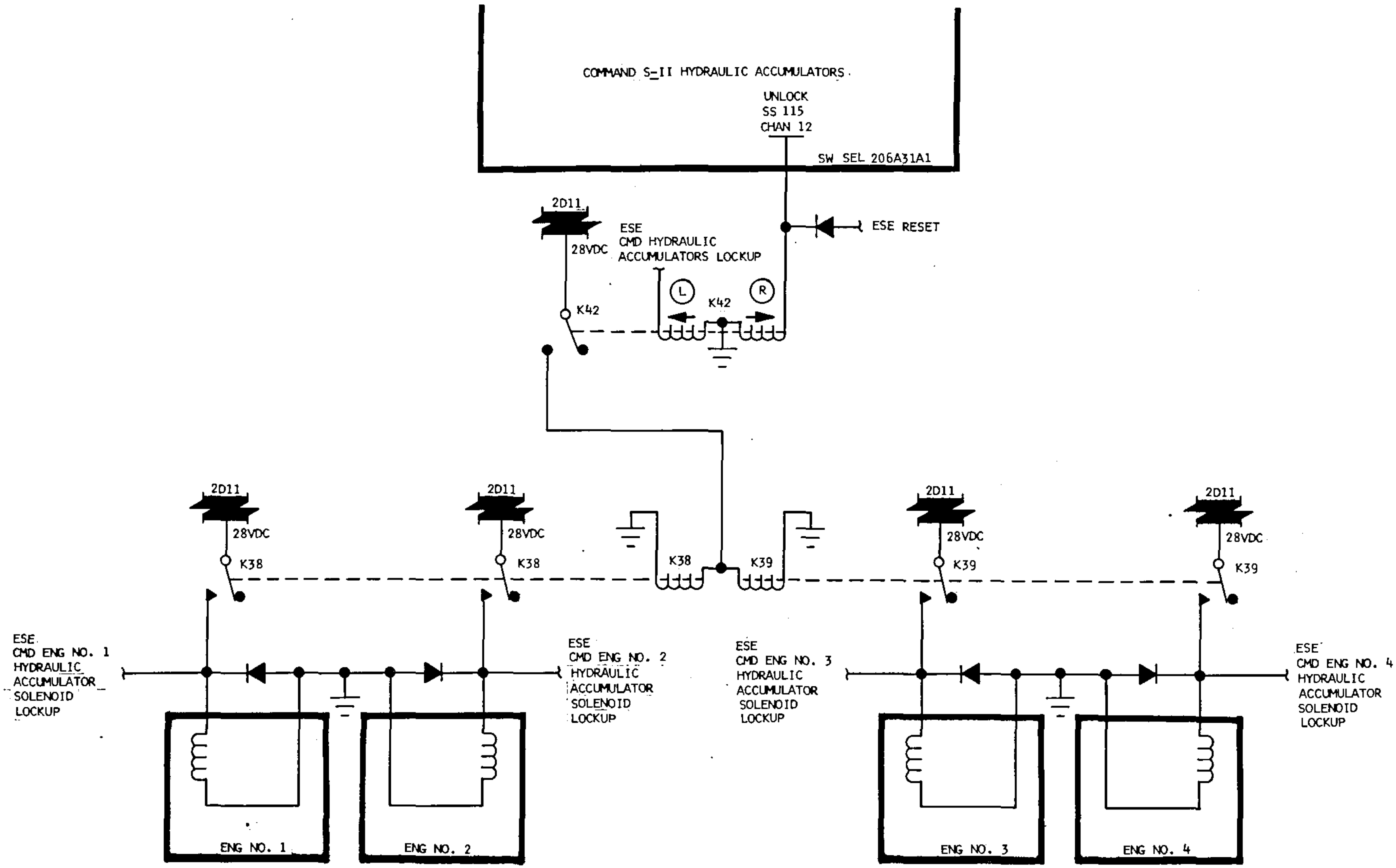

COMMAND S-II HYDRAULIC ACCUMULATORS
UNLOCK
SS 115
CHAN 12
SW SEL 206A31A1
2D11
28VDC
ESE
CMD HYDRAULIC
ACCUMULATORS LOCKUP
ESE RESET
L
R
K42
K42
2D11
28VDC
K38
K39
ESE
CMD ENG NO. 1
HYDRAULIC
ACCUMULATOR
SOLENOID
LOCKUP
ESE
CMD ENG NO. 2
HYDRAULIC
ACCUMULATOR
SOLENOID
LOCKUP
ESE
CMD ENG NO. 3
HYDRAULIC
ACCUMULATOR
SOLENOID
LOCKUP
ESE
CMD ENG NO. 4
HYDRAULIC
ACCUMULATOR
SOLENOID
LOCKUP
ENG NO. 1
ENG NO. 2
ENG NO. 3
ENG NO. 4

FIGURE 2-50

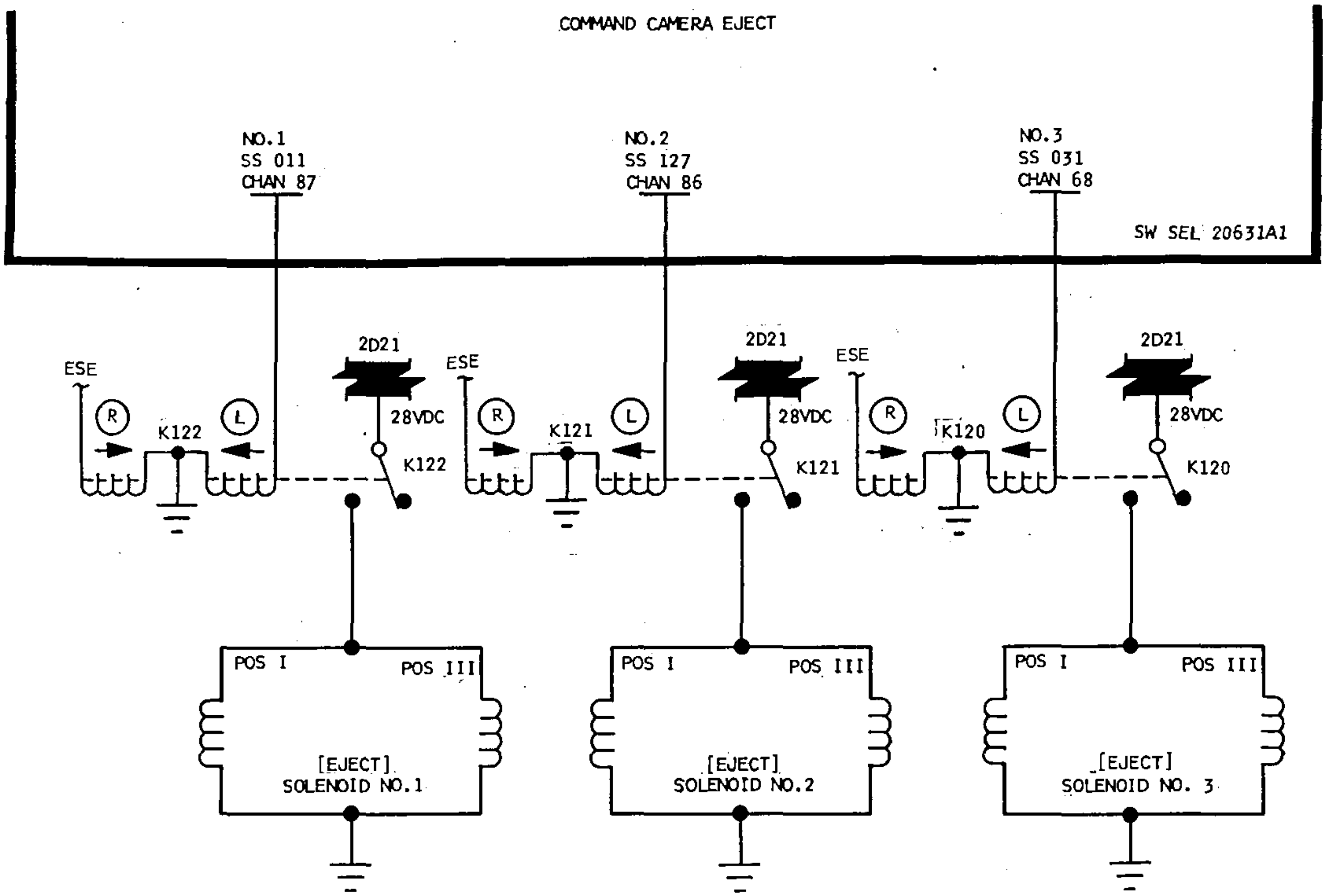

COMMAND CAMERA EJECT
NO.1
SS 011
CHAN 87
NO.2
SS 127
CHAN 86
NO.3
SS 031
CHAN 68
SW SEL 20631A1
ESE
R
K122
L
2D21
28VDC
K122
ESE
R
K121
L
2D21
28VDC
K121
ESE
R
K120
L
2D21
28VDC
K120
POS I
POS III
[EJECT]
SOLENOID NO.1
POS I
POS III
[EJECT]
SOLENOID NO.2
POS I
POS III
[EJECT]
SOLENOID NO. 3

FIGURE 2-51

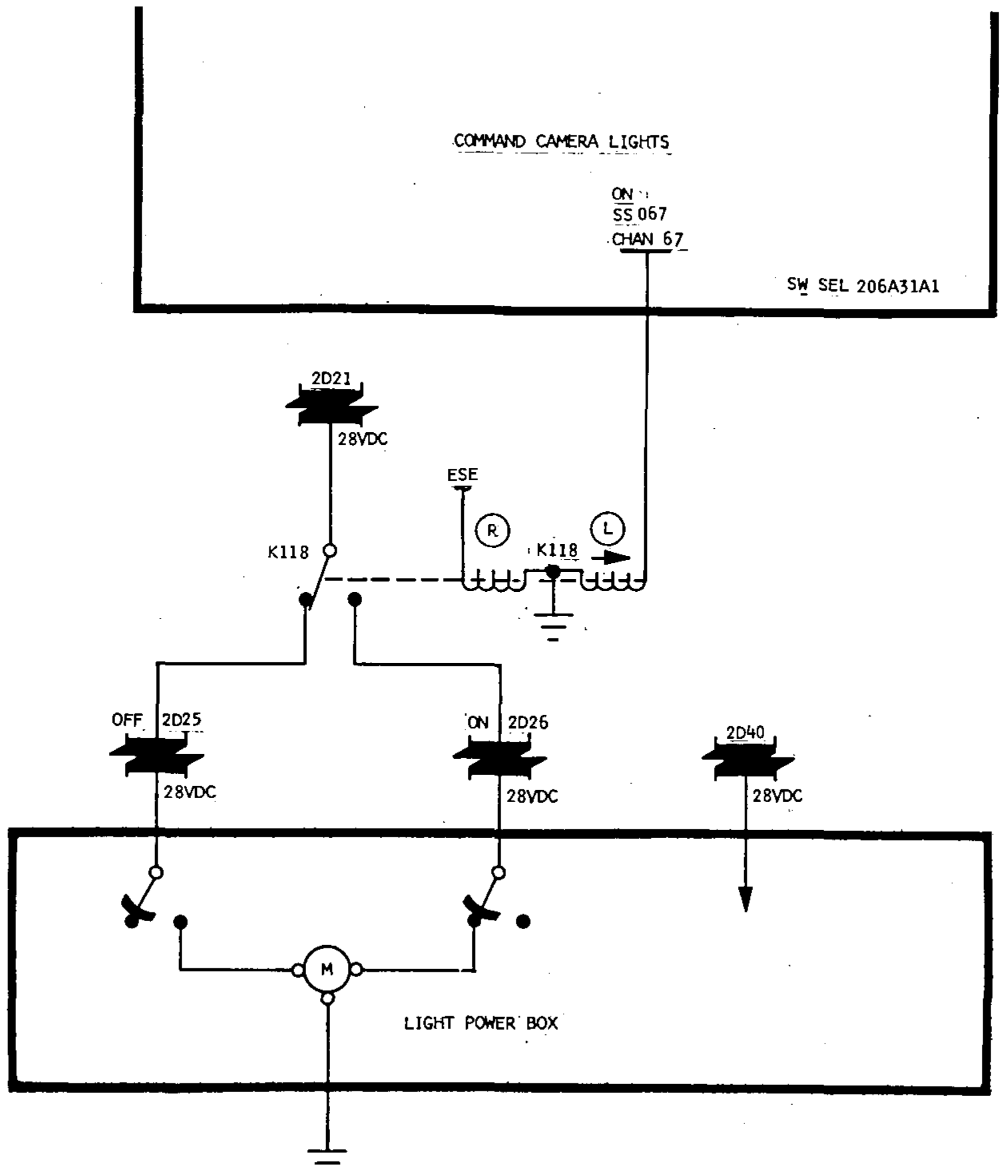

COMMAND CAMERA LIGHTS
ON
SS 067
CHAN 67
SW SEL 206A31A1
2D21
28VDC
ESE
R
L
K118
K118
OFF
2D25
28VDC
ON
2D26
28VDC
2D40
28VDC
M
LIGHT POWER BOX

FIGURE 2-52

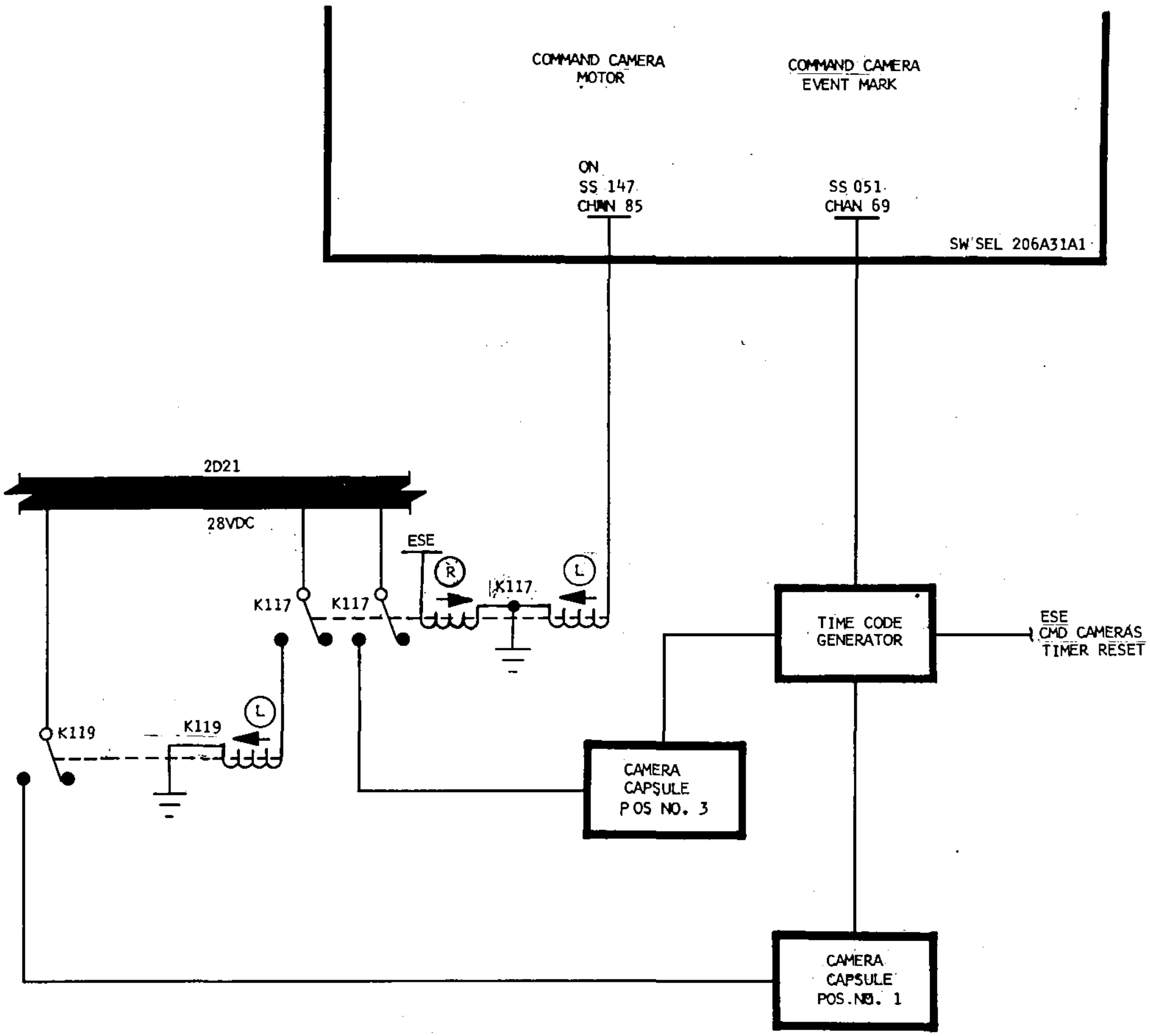
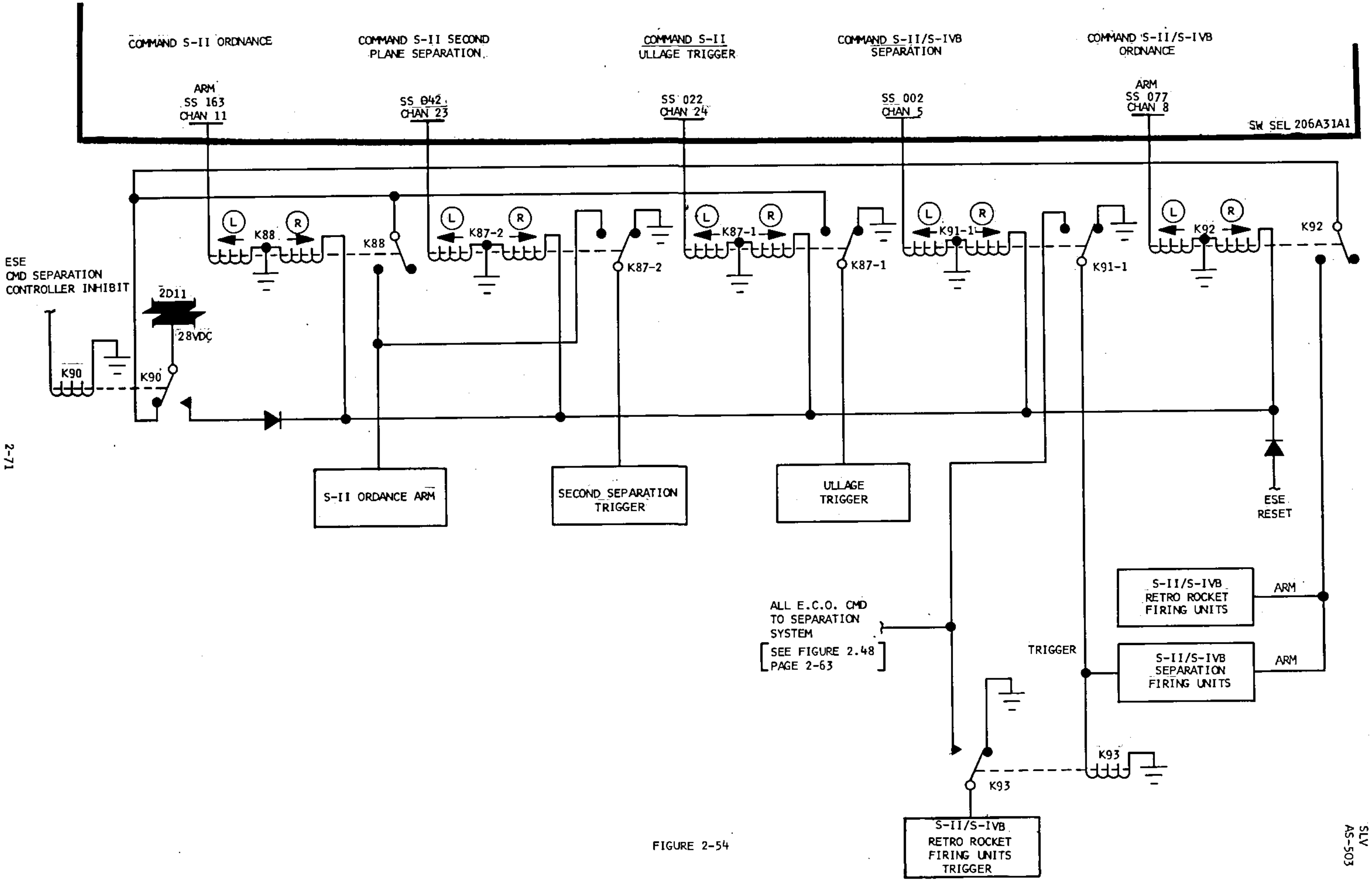

COMMAND CAMERA
MOTOR
COMMAND CAMERA
EVENT MARK
ON
SS 147
CHAN 85
SS 051
CHAN 69
SW SEL 206A31A1
2D21
28VDC
ESE
R
K117
L
K117
K117
TIME CODE
GENERATOR
ESE
CMD CAMERAS
TIMER RESET
K119
K119
L
CAMERA
CAPSULE
POS NO. 3
CAMERA
CAPSULE
POS.NO. 1

FIGURE 2-53



COMMAND S-II ORDNANCE
COMMAND S-II SECOND PLANE SEPARATION
COMMAND S-II ULLAGE TRIGGER
COMMAND S-II/S-IVB SEPARATION
COMMAND S-II/S-IVB ORDNANCE
ARM SS 163 CHAN 11
SS 042 CHAN 23
SS 022 CHAN 24
SS 002 CHAN 5
ARM SS 077 CHAN 8
SW SEL 206A31A1
K88
K87-2
K87-1
K91-1
K92
ESE CMD SEPARATION CONTROLLER INHIBIT
2D11
28VDC
K90
S-II ORDANCE ARM
SECOND SEPARATION TRIGGER
ULLAGE TRIGGER
ESE RESET
S-II/S-IVB RETRO ROCKET FIRING UNITS
ARM
TRIGGER
S-II/S-IVB SEPARATION FIRING UNITS
ALL E.C.O. CMD TO SEPARATION SYSTEM
SEE FIGURE 2.48 PAGE 2-63
K93
S-II/S-IVB RETRO ROCKET FIRING UNITS TRIGGER

FIGURE 2-54

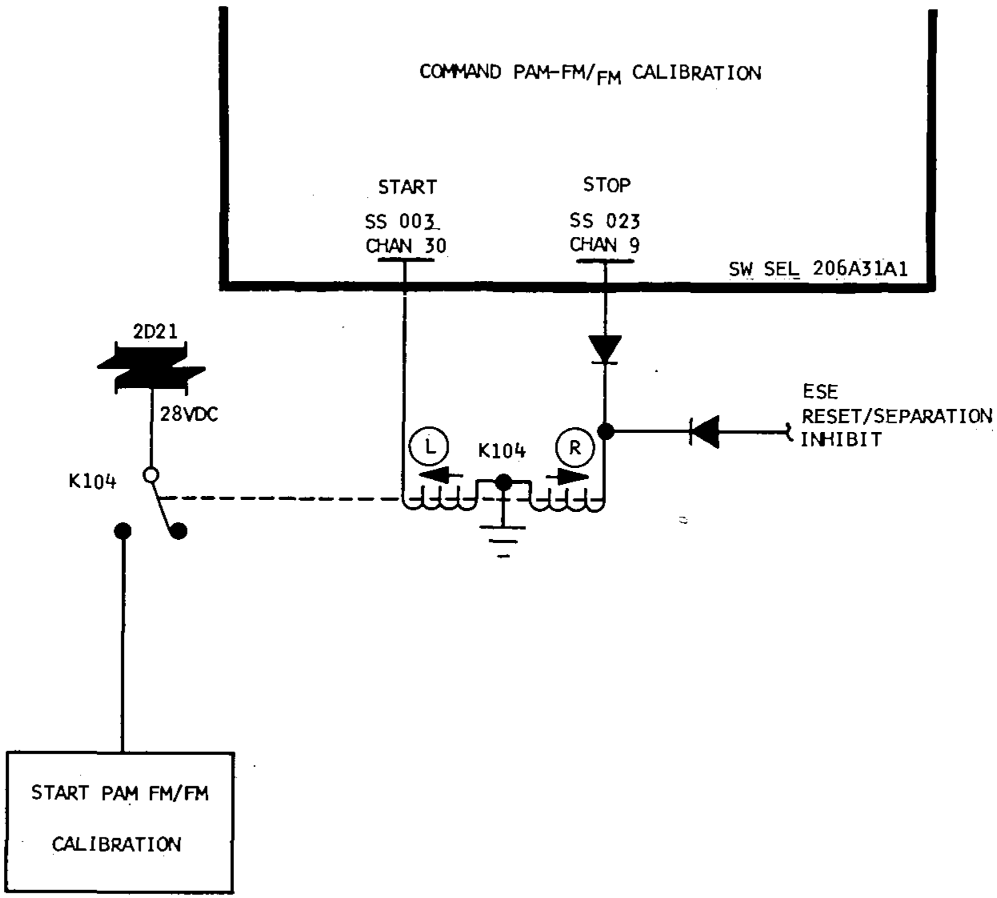

COMMAND PAM-FM/FM CALIBRATION
START
SS 003
CHAN 30
STOP
SS 023
CHAN 9
SW SEL 206A31A1
2D21
28VDC
K104
L
K104
R
ESE
RESET/SEPARATION
INHIBIT
START PAM FM/FM
CALIBRATION

FIGURE 2-55

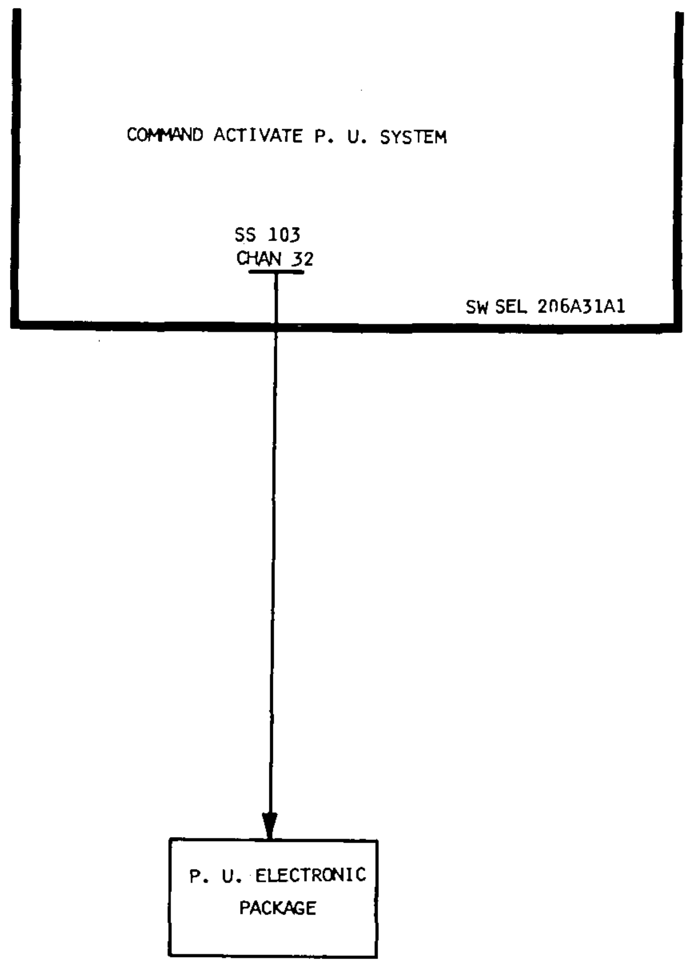

COMMAND ACTIVATE P. U. SYSTEM
SS 103
CHAN 32
SW SEL 206A31A1
P. U. ELECTRONIC
PACKAGE

FIGURE 2-56

2.4.4 S-IC Switch Selector Functions (Octal)

CH	Code	Function	Figure No.
	000		
37	001	SPARE	
5	002	COMMAND FUEL PRESSURIZING VALVE NO. 2 OPEN AND TAPE RECORDER RECORD	2.60
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	SPARE	
51	016	SPARE	
39	017	SPARE	
	020		
16	021	SPARE	
24	022	SPARE	
9	023	COMMAND OUTBOARD ENGINE CUTOFF ENABLE	2.59
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	COMMAND FUEL PRESSURIZING VALVE NO. 4 OPEN	2.60
35	036	SPARE	
17	037	COMMAND TWO ADJACENT OUTBOARD ENGINES OUT CUTOFF ENABLE	2.59
	040		
53	041	SPARE	
23	042	SPARE	
31	043	SPARE	
61	044	SPARE	
93	045	SPARE	
102	046	SPARE	
90	047	SPARE	

CH	Code	Function	Figure No.
	050		
69	051	SPARE	
65	052	SPARE	
73	053	SPARE	
48	054	SPARE	
6	055	COMMAND FUEL PRESSURIZING VALVE NO. 3 OPEN	2.60
52	056	SPARE	
40	057	SPARE	
	060		
38	061	SPARE	
44	062	SPARE	
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	COMMAND INBOARD ENGINE CUTOFF ENABLE START OF TIME BASE NO. 2	2.54
	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	COMMAND SEPARATION CAMERA ON	2.60a
41	116	SPARE	
34	117	SPARE	
	120		
22	121	SPARE	
19	122	COMMAND S-IC/S-II SEPARATION (NO. 2)	
45	123	SPARE	

*

CH	Code	Function	Figure No.
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	COMMAND S-IC TELEMETER CALIBRATE ON	2.58
	140		
4	141	COMMAND LOX TANK STROBE LIGHTS OFF	2.60a
3	142	COMMAND MULTIPLE ENGINE CUTOFF ENABLE	2.59
10	143	COMMAND SEPARATION AND RETRO EBW NO. 1 ARM	2.60
55	144	SPARE	
107	145	SPARE	
77	146	SPARE	
85	147	SPARE	
	150		
83	151	SPARE	
79	152	SPARE	
59	153	SPARE	
70	154	SPARE	
47	155	SPARE	
20	156	COMMAND SEPARATION AND RETRO EBW NO. 2 ARM	
15	157	COMMAND S-IC/S-II SEPARATION (NO. 1)	2.60
	160		
50	161	SPARE	
13	162	COMMAND S-IC TELEMETRY MEASUREMENT SWITCH OVER	2.57
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	COMMAND S-IC TELEMETER CALIBRATE OFF	2.58

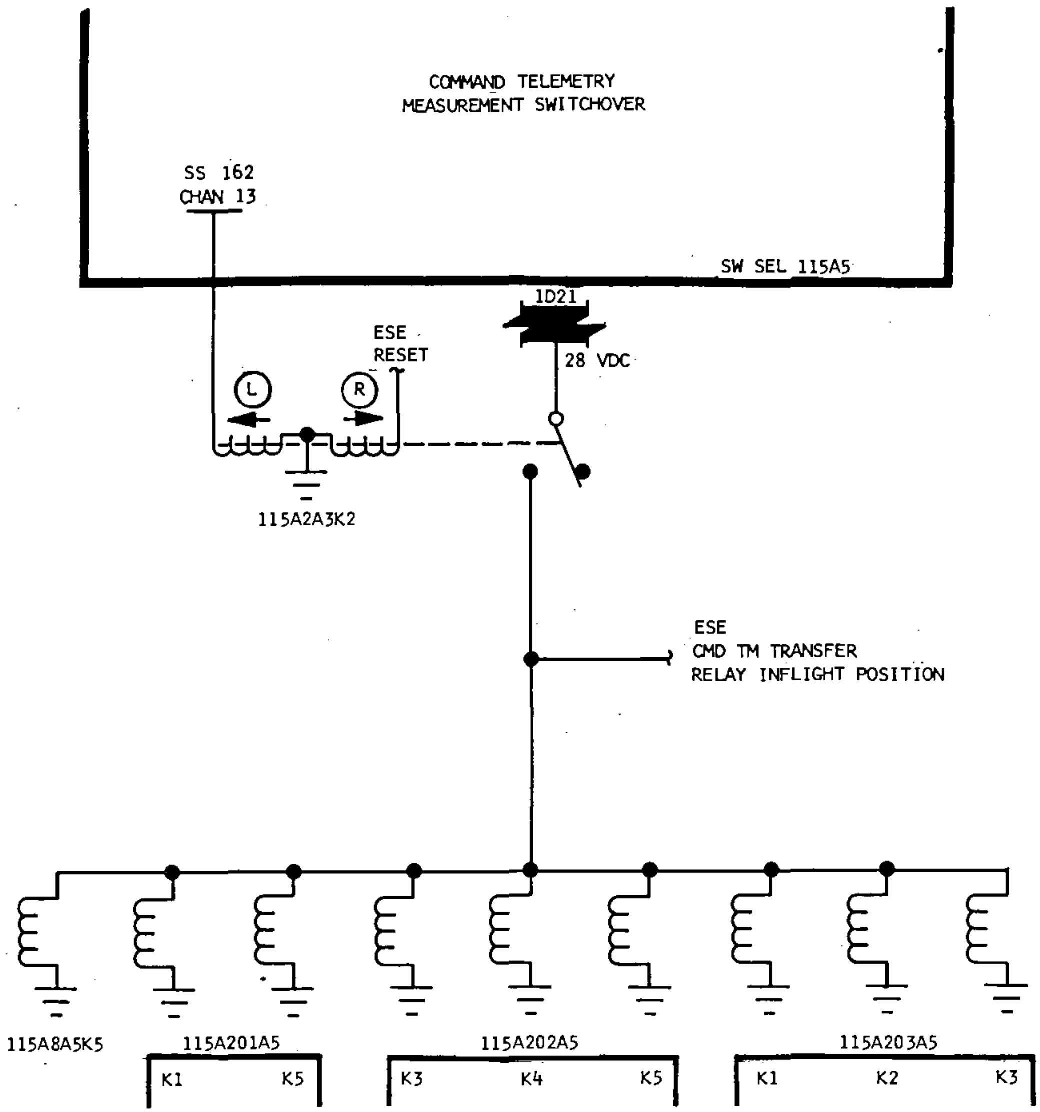

COMMAND TELEMETRY
MEASUREMENT SWITCHOVER
SS 162
CHAN 13
SW SEL 115A5
1D21
28 VDC
ESE
RESET
L
R
115A2A3K2
ESE
CMD TM TRANSFER
RELAY INFLIGHT POSITION
115A8A5K5
115A201A5
K1
K5
115A202A5
K3
K4
K5
115A203A5
K1
K2
K3

FIGURE 2-57

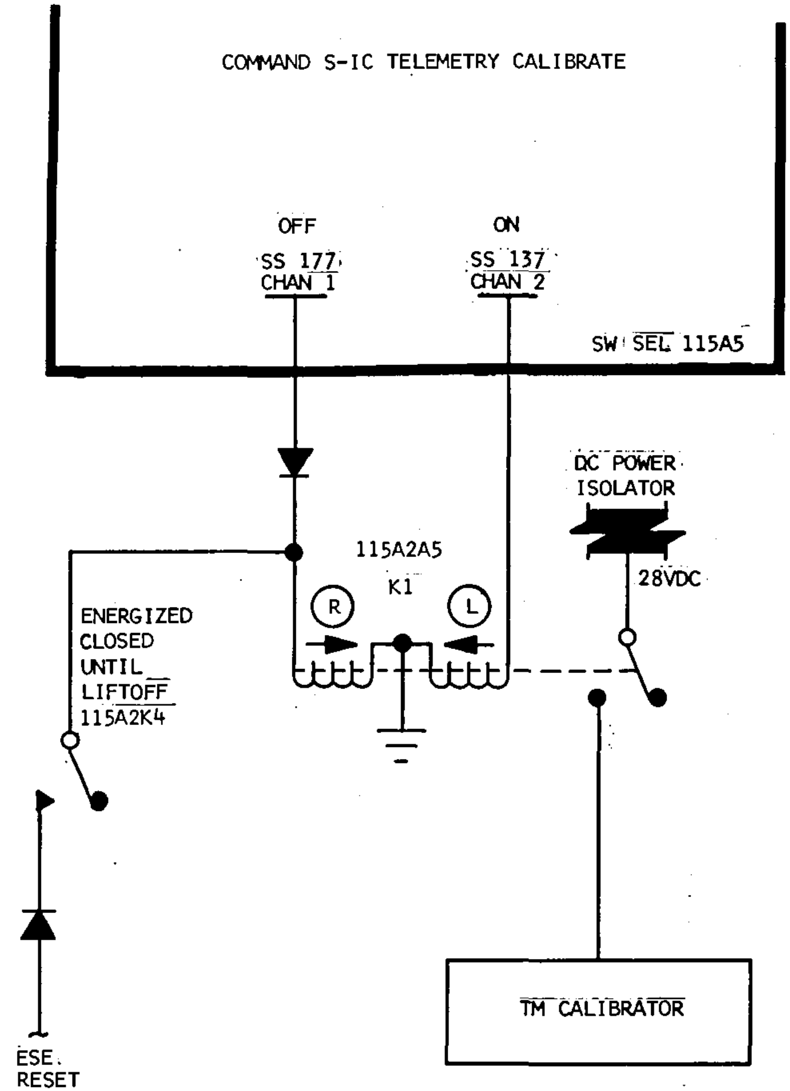

COMMAND S-IC TELEMETRY CALIBRATE
OFF
SS 177
CHAN 1
ON
SS 137
CHAN 2
SW SEL 115A5
DC POWER
ISOLATOR
115A2A5
K1
R
L
28VDC
ENERGIZED
CLOSED
UNTIL
LIFTOFF
115A2K4
ESE
RESET
TM CALIBRATOR

FIGURE 2-58

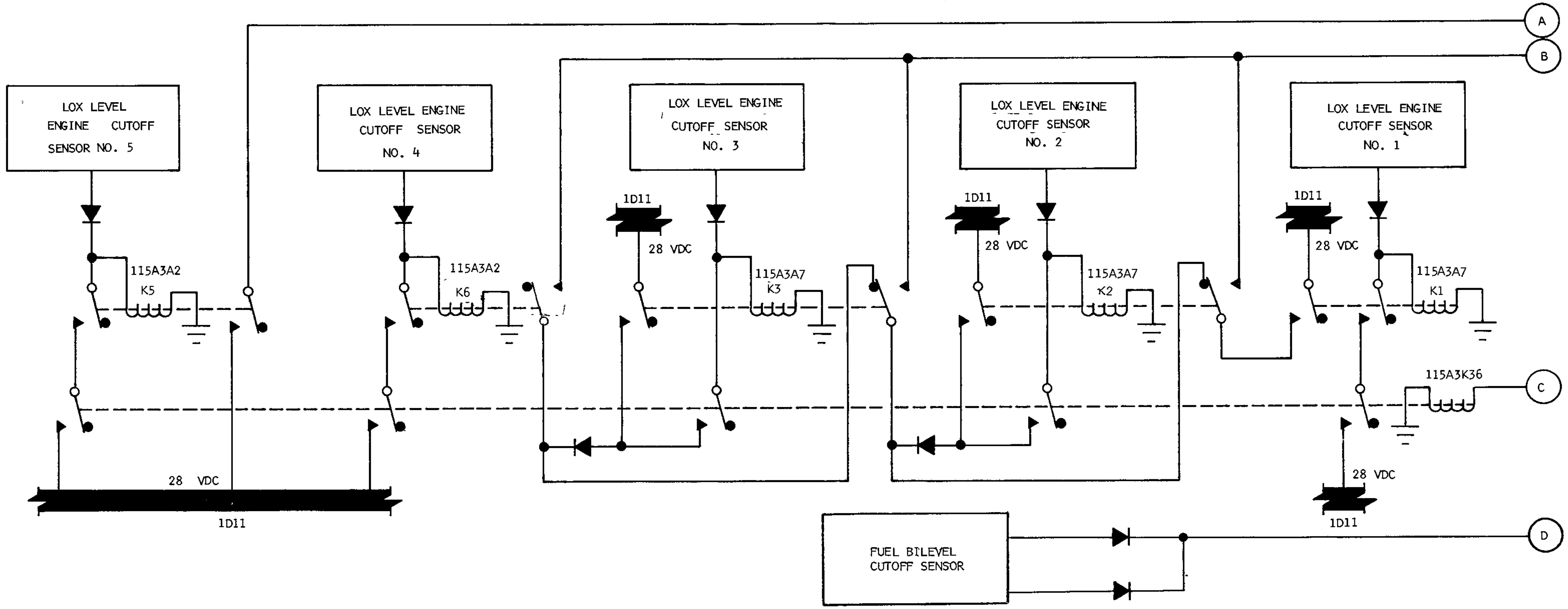


FIGURE 2-59 (1 OF 2)

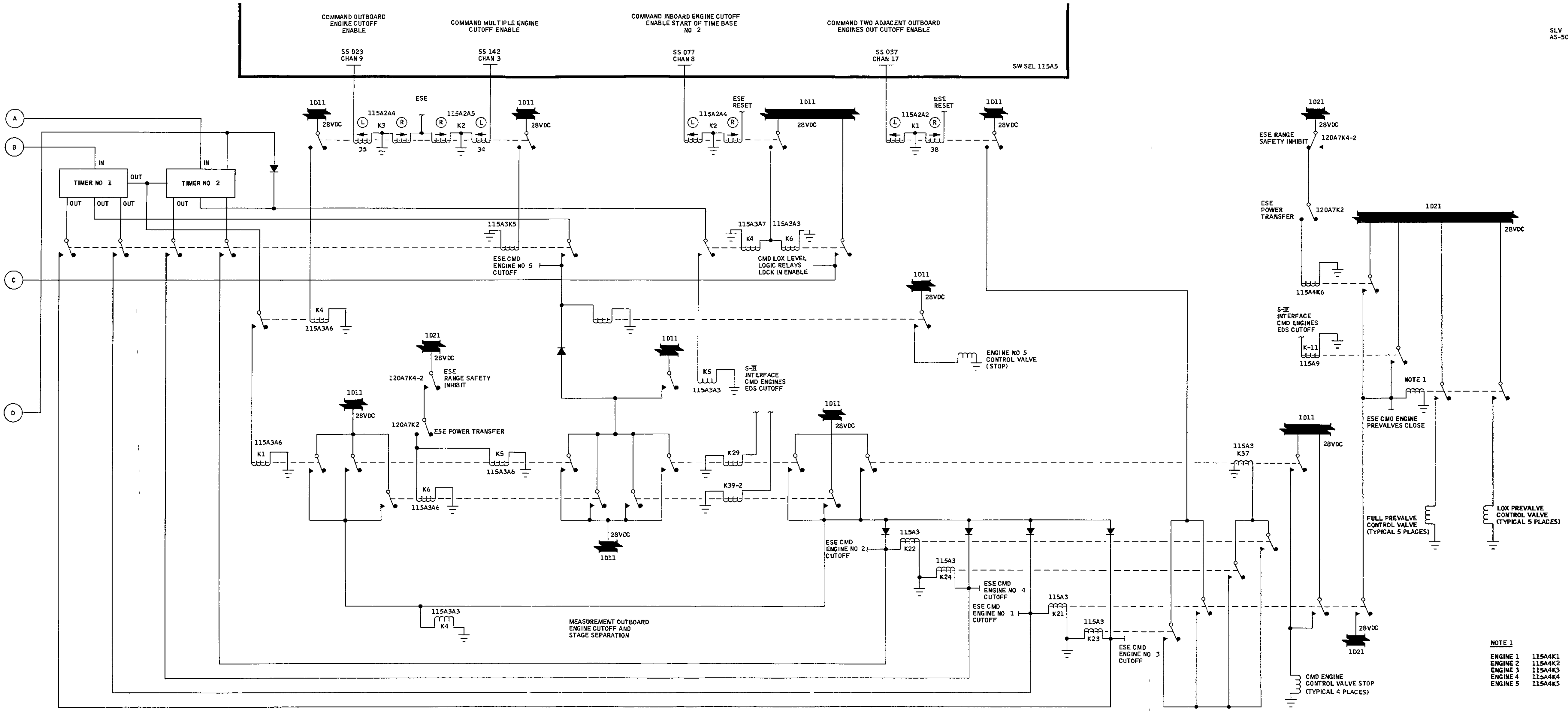


FIGURE 2-59 (2 OF 2)

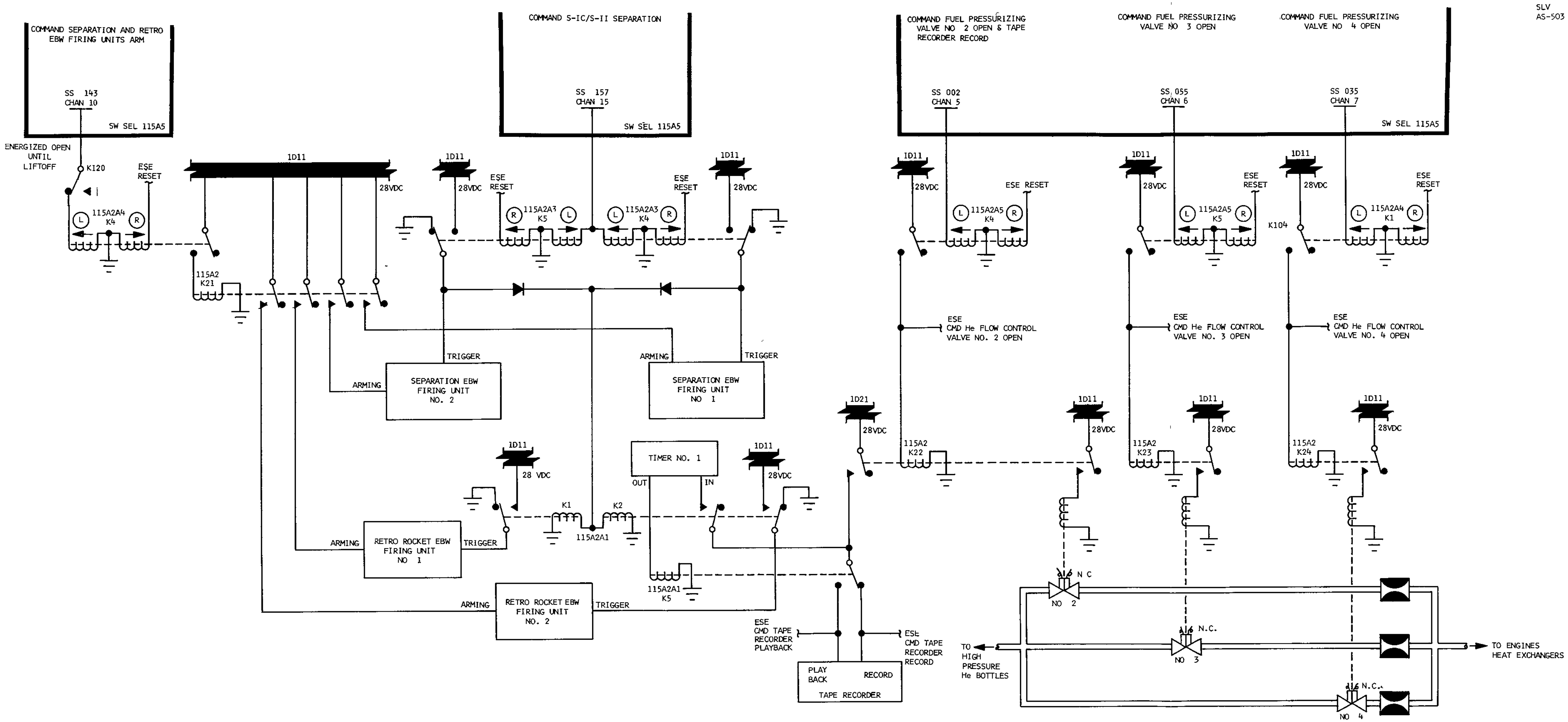
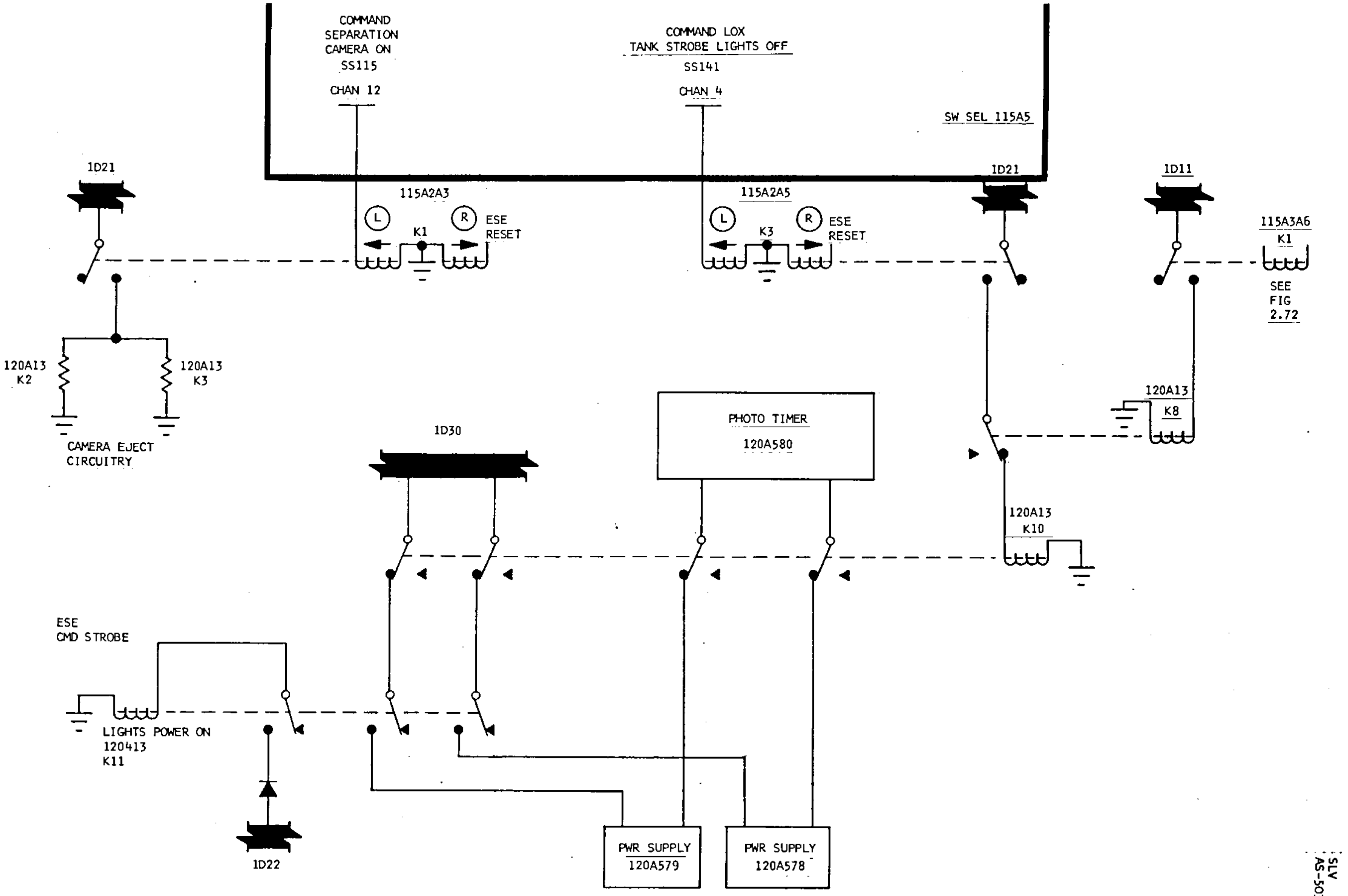

COMMAND SEPARATION AND RETRO EBW FIRING UNITS ARM
SS 143 CHAN 10
SW SEL 115A5
COMMAND S-IC/S-II SEPARATION
SS 157 CHAN 15
SW SEL 115A5
COMMAND FUEL PRESSURIZING VALVE NO 2 OPEN & TAPE RECORDER RECORD
SS 002 CHAN 5
COMMAND FUEL PRESSURIZING VALVE NO 3 OPEN
SS 055 CHAN 6
COMMAND FUEL PRESSURIZING VALVE NO 4 OPEN
SS 035 CHAN 7
SW SEL 115A5
ENERGIZED OPEN UNTIL LIFTOFF
K120
ESE RESET
115A2A4 K4
1D11
28VDC
115A2 K21
115A2A3 K5
115A2A3 K4
115A2A5 K4
115A2A5 K5
115A2A4 K1
K104
ESE CMD He FLOW CONTROL VALVE NO. 2 OPEN
ESE CMD He FLOW CONTROL VALVE NO. 3 OPEN
ESE CMD He FLOW CONTROL VALVE NO. 4 OPEN
TRIGGER
ARMING
SEPARATION EBW FIRING UNIT NO. 2
SEPARATION EBW FIRING UNIT NO 1
1D21
115A2 K22
115A2 K23
115A2 K24
TIMER NO. 1
OUT
IN
28 VDC
K1
K2
115A2A1
RETRO ROCKET EBW FIRING UNIT NO 1
RETRO ROCKET EBW FIRING UNIT NO. 2
115A2A1 K5
ESE CMD TAPE RECORDER PLAYBACK
ESE CMD TAPE RECORDER RECORD
PLAY BACK
RECORD
TAPE RECORDER
N C
N.C.
NO 2
NO 3
NO 4
TO HIGH PRESSURE He BOTTLES
TO ENGINES HEAT EXCHANGERS

FIGURE 2-60



COMMAND SEPARATION CAMERA ON
SS115
CHAN 12
COMMAND LOX TANK STROBE LIGHTS OFF
SS141
CHAN 4
SW SEL 115A5
1D21
115A2A3
L
K1
R
ESE RESET
115A2A5
L
K3
R
ESE RESET
1D21
1D11
115A3A6
K1
SEE FIG 2.72
120A13
K2
120A13
K3
CAMERA EJECT CIRCUITRY
1D30
PHOTO TIMER
120A580
120A13
K8
120A13
K10
ESE
CMD STROBE
LIGHTS POWER ON
120413
K11
1D22
PWR SUPPLY
120A579
PWR SUPPLY
120A578

FIGURE 2-60A

2.5 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 2-I lists by channel number. Table 2-II lists by forward octal true. Table 2-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 2-III includes an underscore beneath the principal form corresponding to the normally expected bit pattern.

TABLE 2-I.- SWITCH SELECTOR CROSS-REFERENCE TABLE
(IN SEQUENCE BY CHANNEL NUMBER)

Channel Number	FORWARD Octal True	FORWARD Octal Comp	REVERSE Octal True	REVERSE 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 2-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 2-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 2-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	044	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 2-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 2-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 2-III.- SWITCH SELECTOR CROSS-REFERENCE TABLE
(IN SEQUENCE BY BINARY CODE REVERSE)

REVERSE		FORWARD		
Octal Comp	Octal True	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

TABLE 2-III.- SWITCH SELECTOR CROSS-REFERENCE TABLE - Continued
(IN SEQUENCE BY BINARY CODE REVERSE)

REVERSE		FORWARD		
Octal Comp	Octal True	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

*

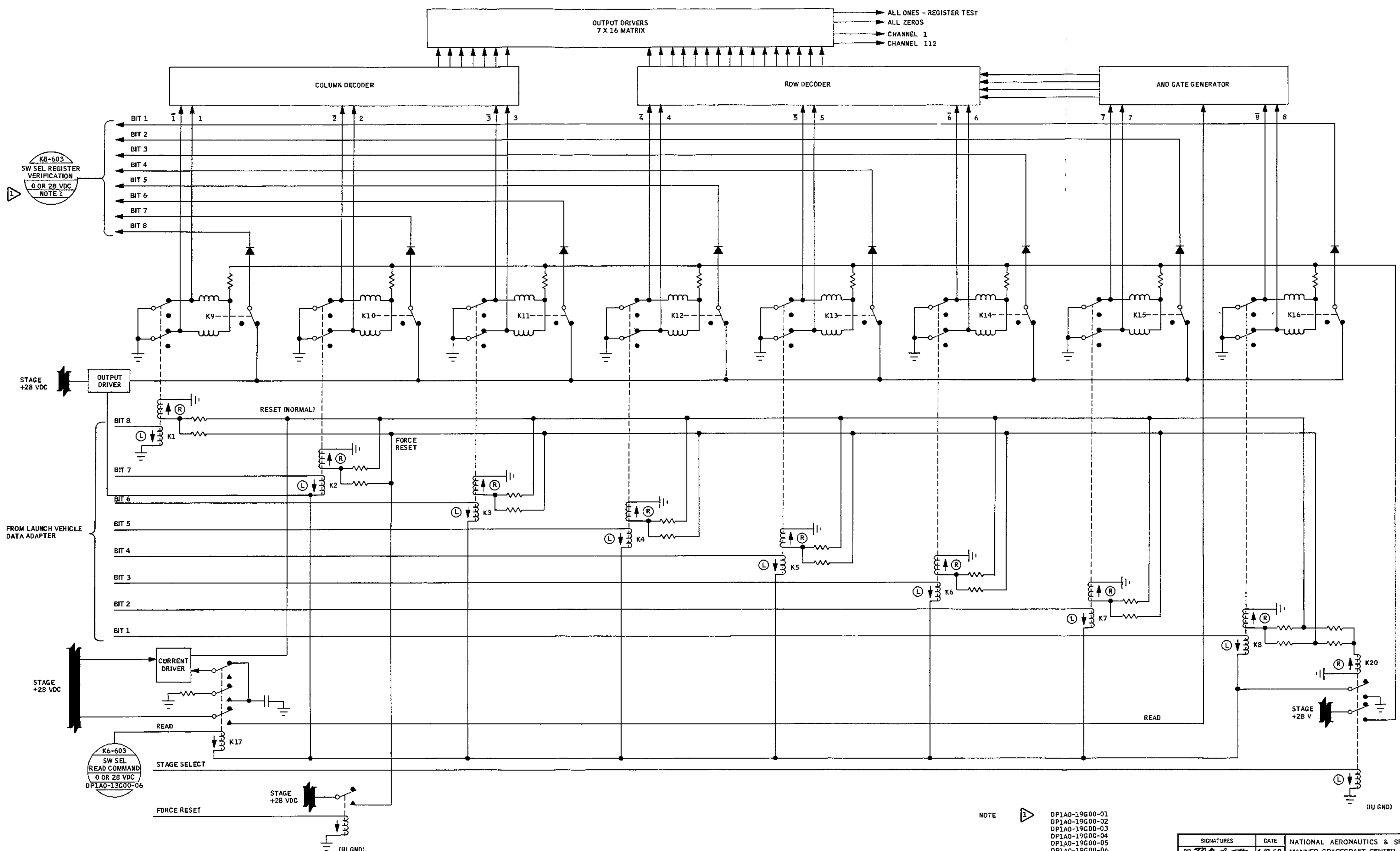
TABLE 2-III.- SWITCH SELECTOR CROSS-REFERENCE TABLE - Concluded
(IN SEQUENCE OF BINARY CODE REVERSE)

REVERSE		FORWARD		
Octal Comp	Octal True	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

2.6 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 from 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.



NOTE 1 DP1A0-19G00-01
DP1A0-19G00-02
DP1A0-19GDD-03
DP1A0-19G00-04
DP1A0-19G00-05
DP1A0-19G00-06
DP1AD-19G00-07
DP1A0-19G00-08

SIGNATURES	DATE
DR	4 19 68
DSGN	8-6 1968
QC	8 16 68
ENGR	8/22/68
APP	8-23 68
FEC	9/3/68
AUTH	9-3 68

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SEQUENTIAL-SWITCH SELECTOR MOD II

SLV AS-503 | SIZE F | DWG NO 2.6.2
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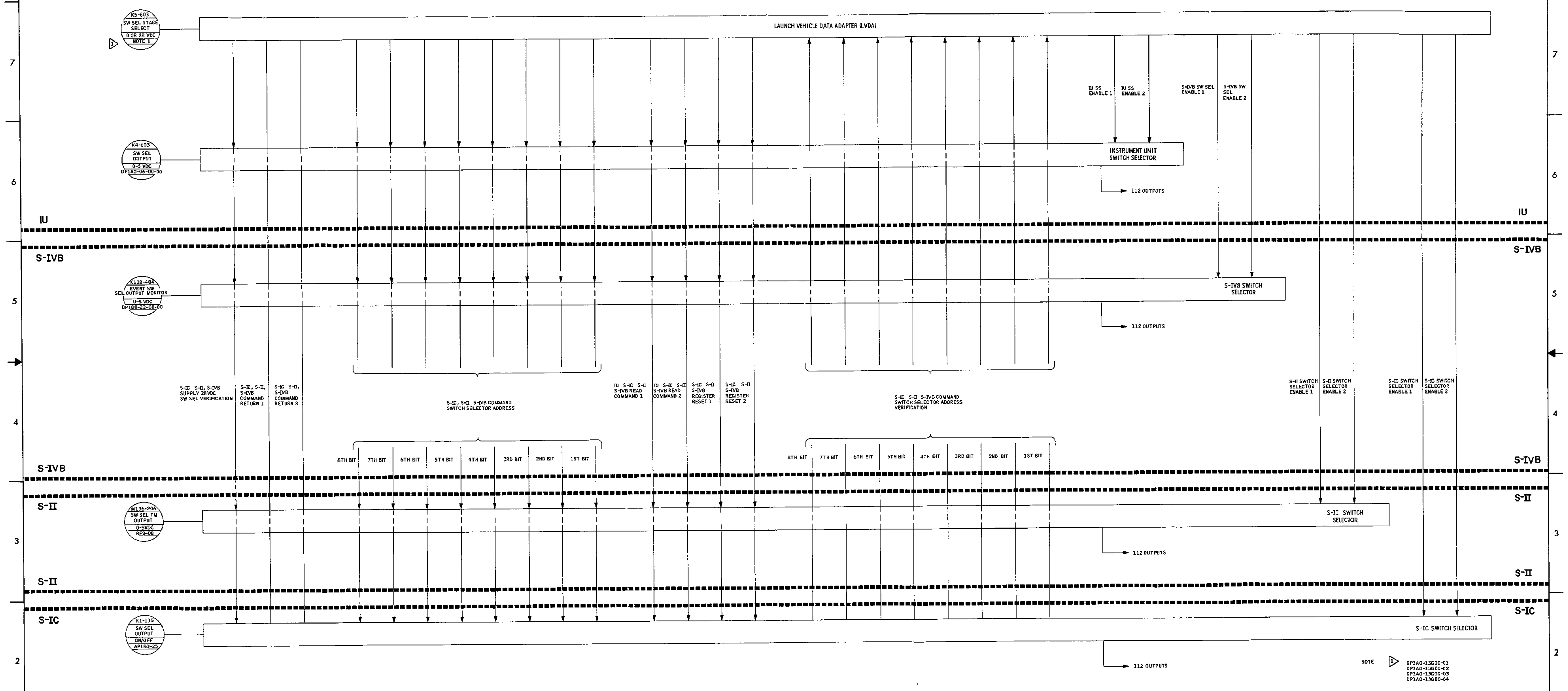

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SEQUENTIAL SYSTEM INTERFACE

SLV AS503 | SIZE J | DWG NO 261

55 X 34 | PAGE 2-92 | SHEET OF

SECTION 3

ELECTRICAL POWER SYSTEMS

3.1 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 56V.

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.

3.2 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 3-I.- IU ELECTRICAL LOAD DISTRIBUTION

Item	Total 28 Vdc Current	Total 28 Vdc Current	6D10 Current	6D20 Current	6D30 Current	6D40 Current
LVDA/LVDC - Boost	17.54	491.12	5.85		5.85	5.85
- Orbit	17.52	490.56	5.84		5.84	5.84
Switch Selector	0.07	1.96	0.07			
Flight Control Computer						
S-IC Burn	2.37	66.36	0.79		0.79	0.79
S-II Burn	3.16	88.48	1.05		1.05	1.05
S-IVB Burn	2.13	59.64	0.71		0.71	0.71
Orbit	1.50	42.00	0.50		0.50	0.50
Control Signal Processor	3.00	84.00	1.00		1.00	1.00
Total Platform Requirement	11.14	311.92	11.14			
5-Vdc Converter	0.46	12.82			0.46	
Command Decoder	0.08	2.24	0.08			
Q-Ball (S-IC Burn Only)	0.50	14.00		0.25		0.25
245 Multiplexer	0.15	4.20				0.15
SS Telemetry Assembly	0.57	15.96				0.57
SS RF Assembly	3.72	104.16				3.72
F1 Telemetry Assembly (B-1)	0.58	16.24			0.58	
F1 RF Assembly	3.72	104.16			3.72	
270 Multiplexer (F2)	0.10	2.80		0.10		
F2 Telemetry Assembly (A-3)	.70	19.60		.70		
F2 RF Assembly	3.72	104.16		3.72		
410 Multiplexer (J, 603A599)	0.30	8.40			0.30	
410 Multiplexer (K, 603A594)	0.30	8.40			0.30	
270 Multiplexer (PCM)	0.10	2.80			0.10	
PCM/DDAS (301) Assembly	0.89	24.92			.89	
PCM RF Assembly (VHF)	3.75	105.00			3.75	
PCM UHF Assembly	5.96	166.88				5.96
CIU	0.30	8.40			0.30	
CCS Transponder & Power Amplifier	4.13	115.64	4.13			

TABLE 3-I.- IU ELECTRICAL LOAD DISTRIBUTION — Concluded

Item	Total 28 Vdc Current	Total 28 Vdc Current	6D10 Current	6D20 Current	6D30 Current	6D40 Current
TM Cal PCU	0.45	12.60				0.45
Tape Recorder	1.25	35.00	1.25			
C-Band Transponder #1 (603A635) (50% Standby, 50% 2000 prf)	0.89	24.92	0.89			
C-Band Transponder #2 (602A634) (50% standby, 50% 2000 prf)	0.89	24.92				0.89
Measuring Rack						
#601A401	1.16	32.48	1.16			
#601A402	1.21	33.88	1.21			
#602A403	1.28	35.84		1.28		
#602A404	1.09	30.52		1.09		
#602A405	1.27	35.56				1.27
#602A406	1.22	34.16				1.22
#602A407	1.28	35.84				1.28
#602A408	0.38	10.64				0.38
#602A409	1.15	32.20				1.15
#603A669	0.93	26.04				0.93
ECS						
Temperature Control Unit	0.34	9.52		0.34		
Water S/O Valve (S-IC Burn Only)	1.75	49.00		1.75		
Pump	18.96	530.88		18.96		
Heater						
#601A69	5.00	35.00	5.00			
#603A75	5.00	35.00		5.00		
#603A76	5.00	35.00			5.00	
#603A77	5.00	35.00			5.00	
#601A66	5.00	35.00			5.00	
#601A67	5.00	35.00				5.00
#601A68	5.00	35.00				5.00
Totals						
S-IC Burn	139.49	3905.72	32.57	33.19	37.88	35.86
S-II Burn	138.03	3864.84	32.83	31.19	38.14	35.87
S-IVB Burn	137.00	3836.00	32.49	31.19	37.80	35.53
Orbit	136.35	3817.80	32.27	31.14	37.58	35.31

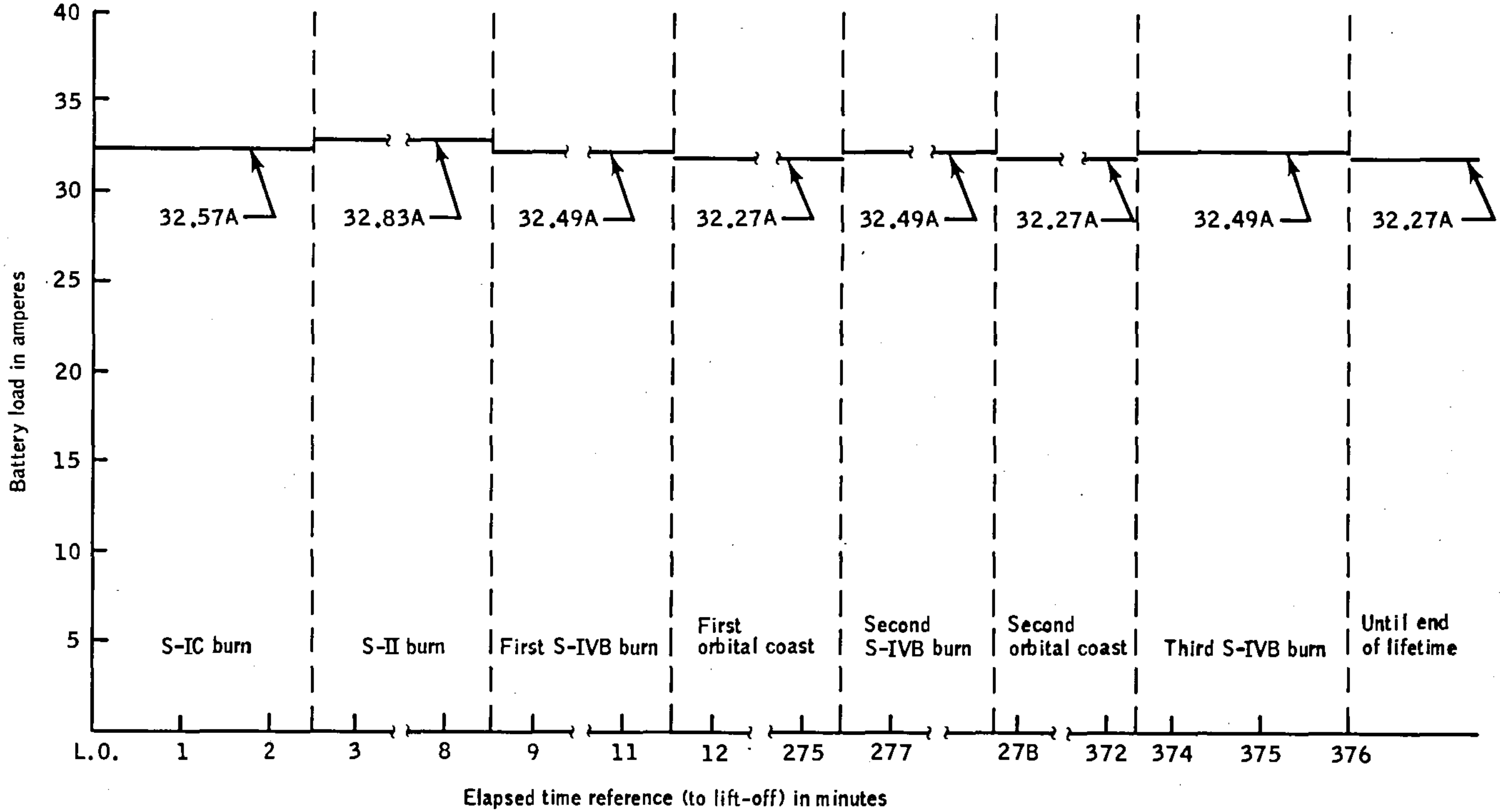


Figure 3-1.- IU battery no. 1 composite load profile.

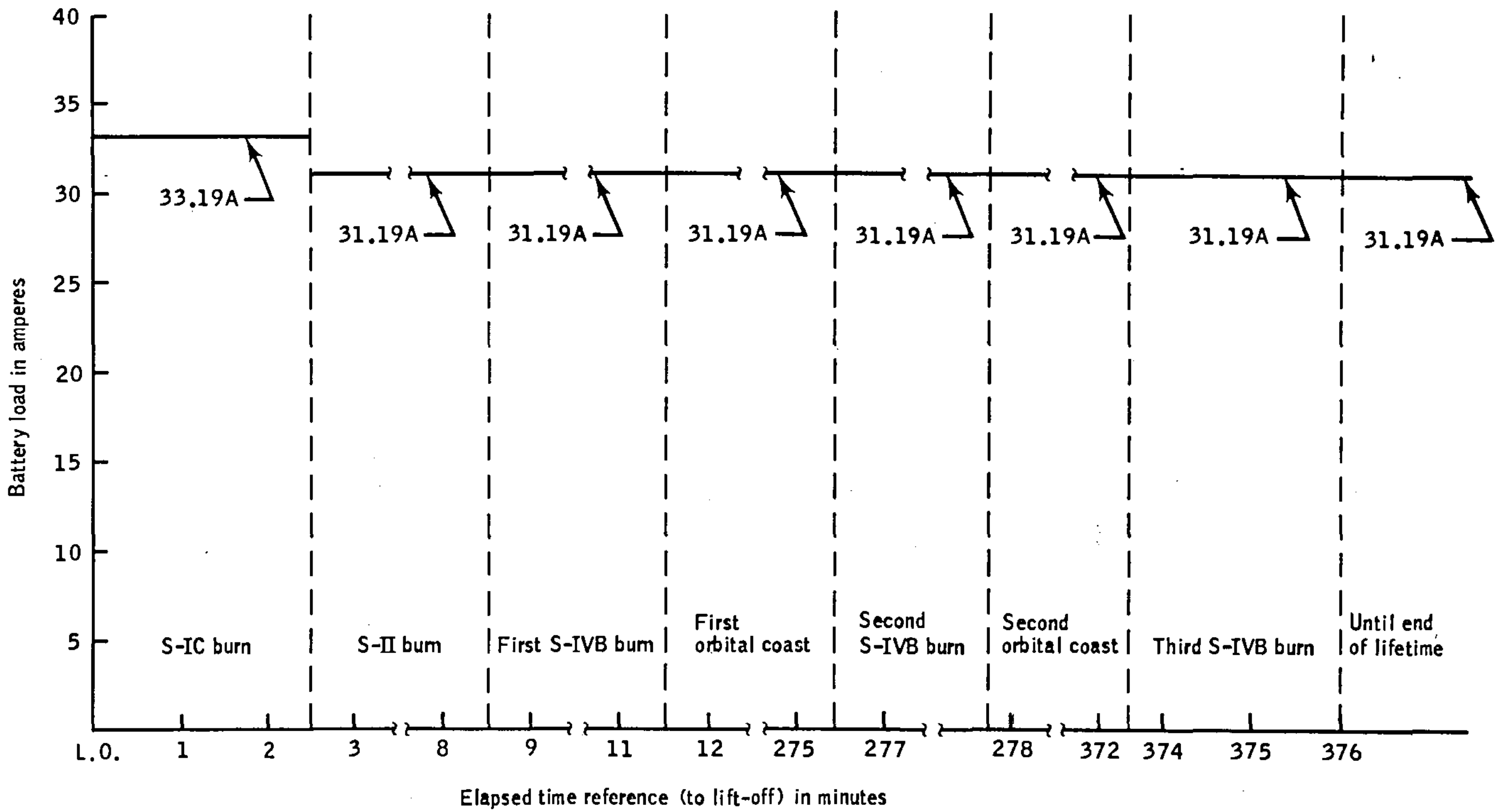


Figure 3-2.- IU battery no. 2 composite load profile.

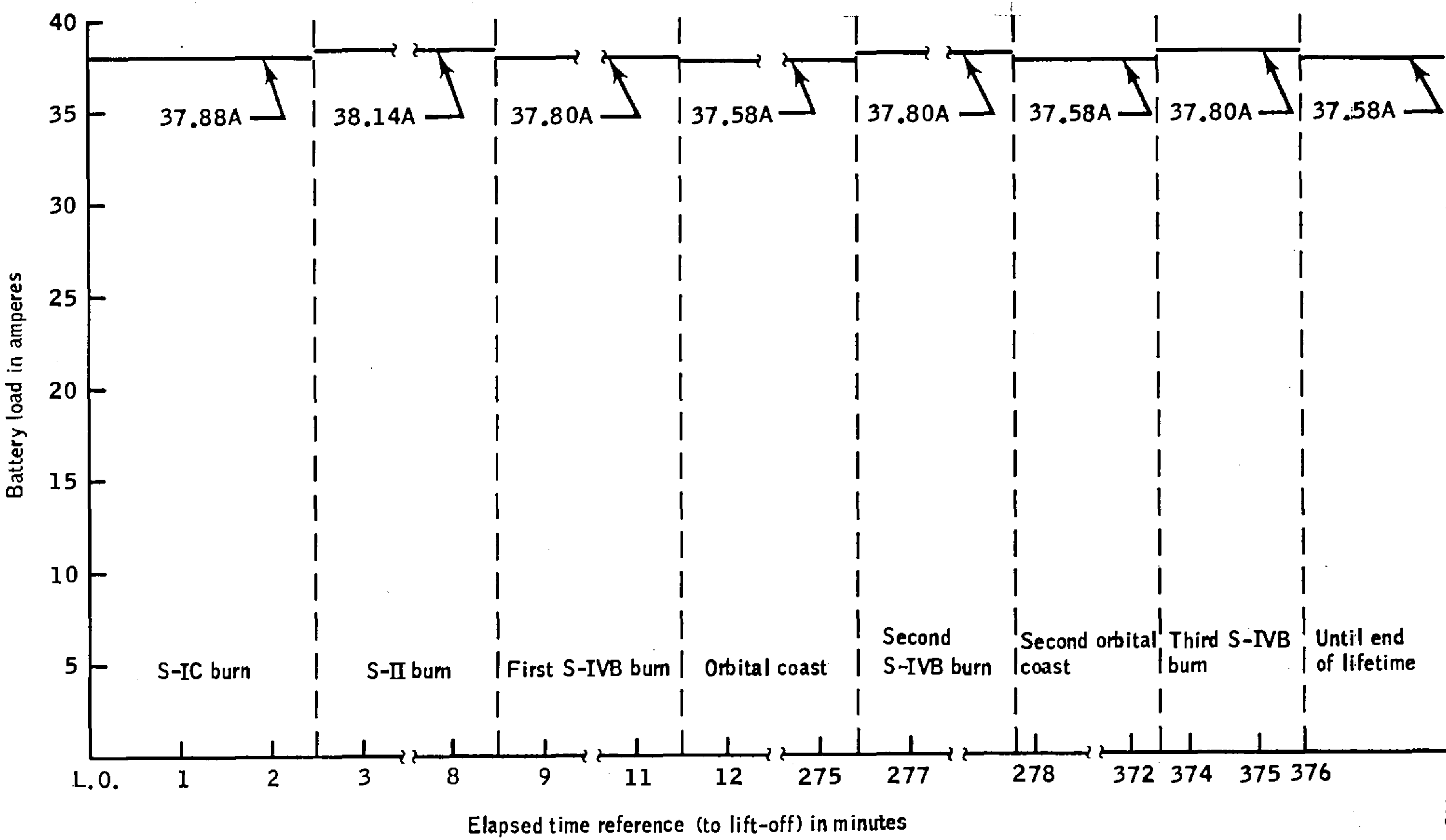


Figure 3-3.- IU battery no. 3 composite load profile.

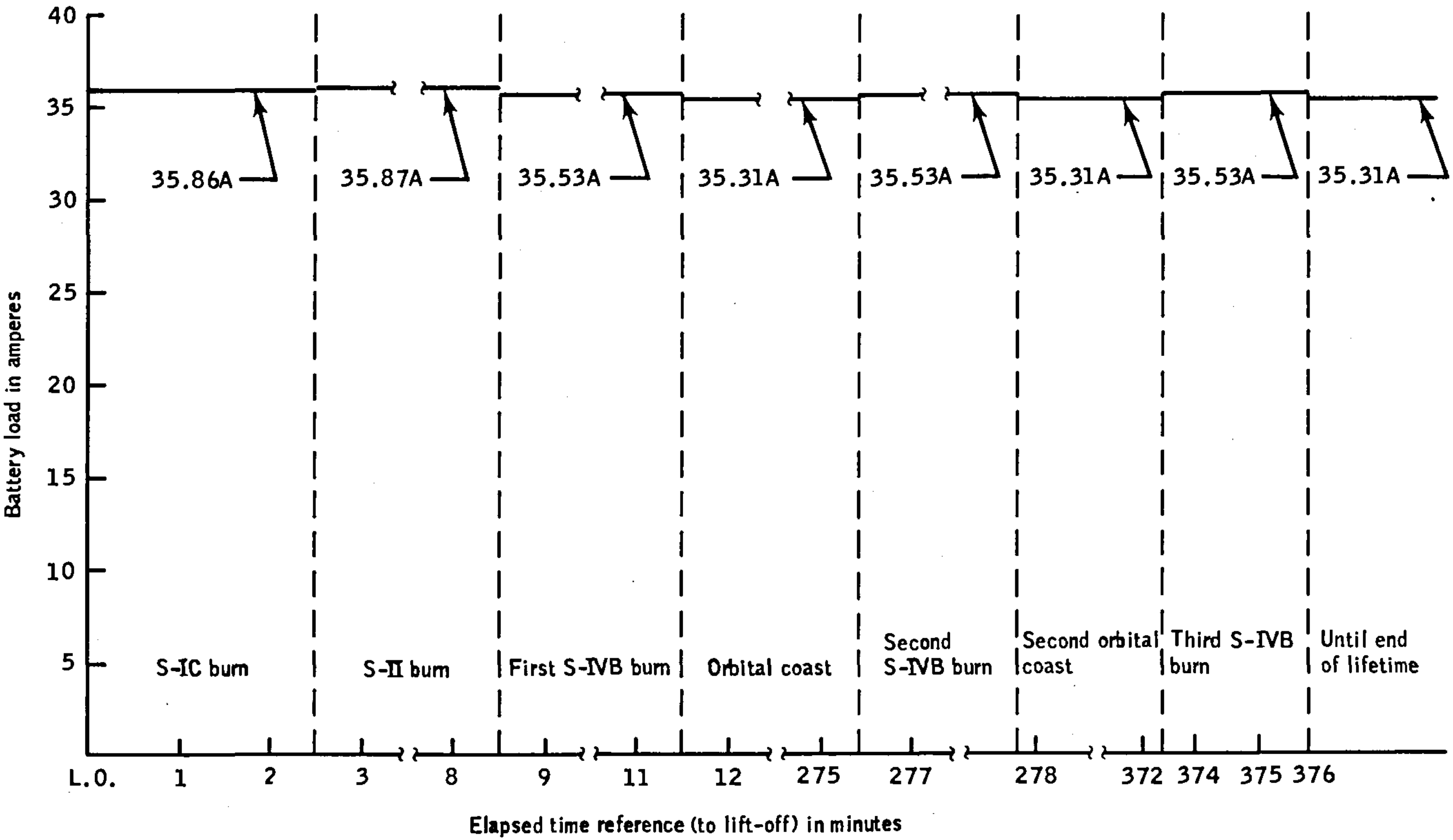


Figure 3-4.- IU battery no. 4 composite load profile.

3.3 S-IVB ELECTRICAL SYSTEM (Drawing 3.3.1)

A. Electrical power for the S-IVB stage is provided by four batteries located in the forward and aft skirts of the stage. The battery descriptions and expected usage are as follows:

Battery	Location	Voltage	Capacity	Expected Usage
Fwd #1	Fwd Skirt	28 ±2 Vdc	300 ampere-hrs	82* ampere-hrs
Fwd #2	Fwd Skirt	28 ±2 Vdc	25 ampere-hrs	9 ampere-hrs
Aft #1	Aft Skirt	28 ±2 Vdc	300 ampere-hrs	24 ampere-hrs
Aft #2	Aft Skirt	56 ±4 Vdc	78 ampere-hrs	63 ampere-hrs

*Does not include SSB/FM and FM/FM kit loads.

TABLE 3-II.- S-IVB ELECTRICAL LOAD DISTRIBUTION

FORWARD BATTERY #1 (Figure 3.5)

FUNCTION	CURRENT AMPS
PCM/FM System Group	5.85
PCM RF System Group	5.00
Fwd 5V Excit Mod #1	0.21
Aft 5V Excit Mod	0.01
Fwd Battery #1 Heater	15.0
Fwd Battery #2 Heater	3.0
Range Safety System #1	0.34
O_2-H_2 Burner Voter Regulator	0.095
Switch Selector Power	0.04
SSB/FM Transmitter Group	4.5
FM/FM Transmitter Group	4.0

FORWARD BATTERY #2 (Figure 3.6)

FUNCTION	CURRENT AMPS
Range Safety System No. 2	0.34
PU dc and Inverter	4.0
Fwd 5V Excit Mod No. 2	0.005

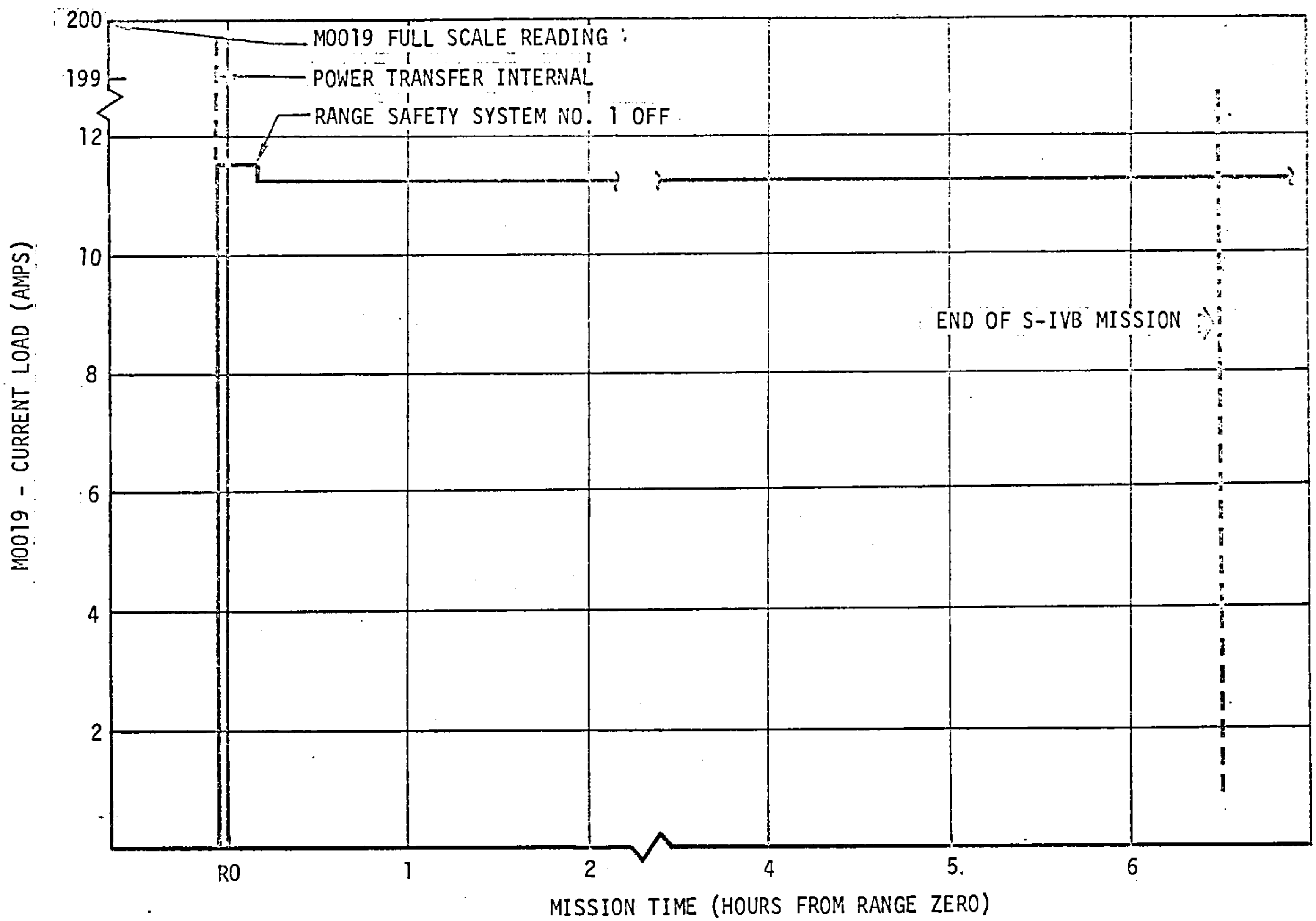
AFT BATTERY NO. 1 (Figure 3.7)

FUNCTION	CURRENT AMPS
LOX Chilldown Pump Purge Control Valve	0.3
Battery Heater Aft 1	14.0
Battery Heater Aft 2	13.8
Prevalves	1.5
LOX Flight Press System	3.0
Charge Ullage Ignition	1.5
Fire Ullage Ignition	1.5
Chilldown Shutoff Valves	1.5
J-2 Engine Cont Power (Coast)	0.75
J-2 Engine Cont Power (Start)	13.2

TABLE 3-II.- S-IVB ELECTRICAL LOAD DISTRIBUTION - Concluded

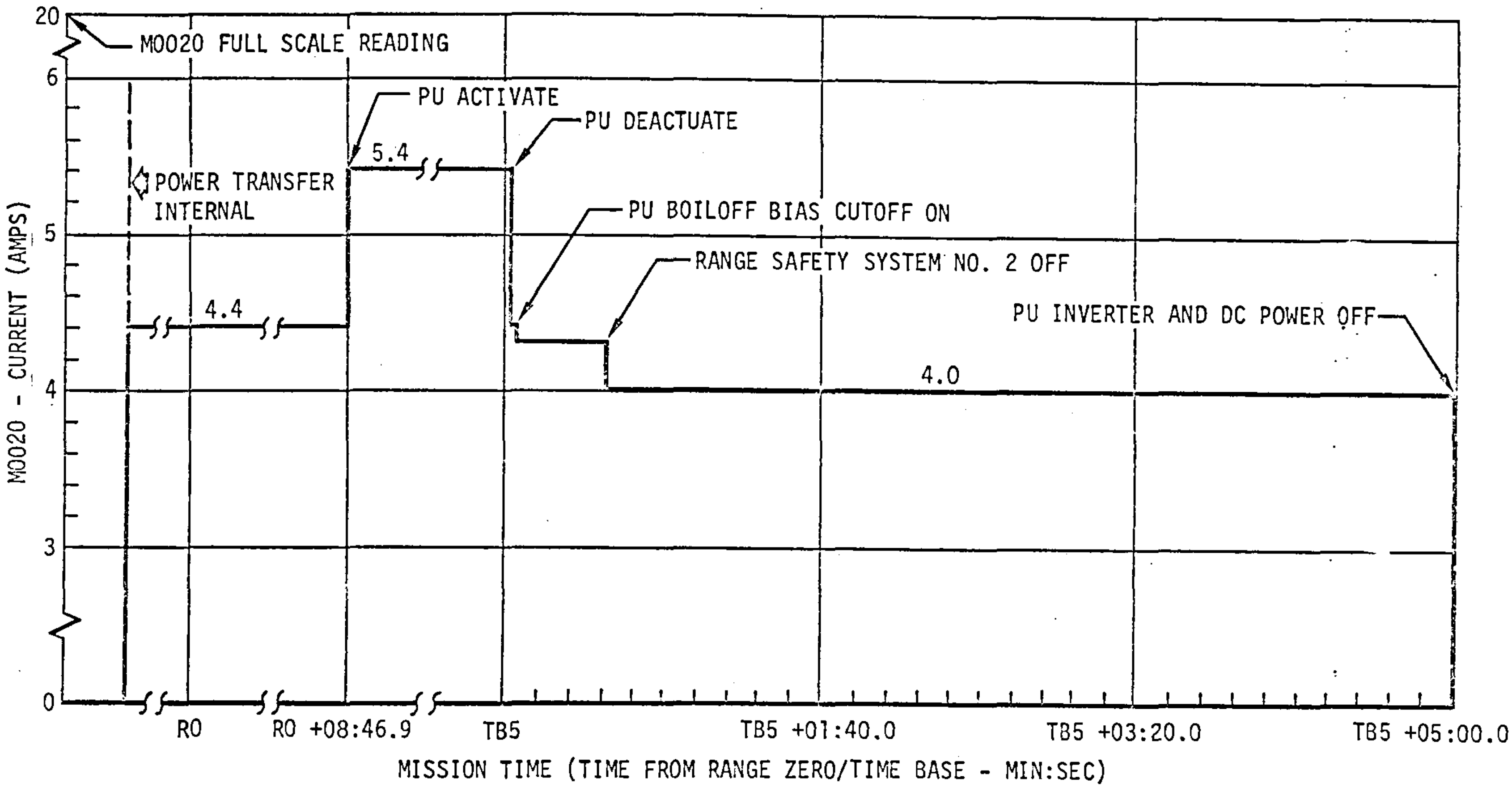
FUNCTION	CURRENT AMPS
J-2 Engine Cont Power (Burn)	5.7
Ignition Power	0.01
Ignition Power (Start Sequence)	21.4
LOX Tank Flight Press	3.0
First Burn Relay	6.00
Charge Ullage Jettison	4.00
Fire Ullage Jettison	1.5
LH_2 Cont Vent Open	1.5
Eng Pump Purge Valve Open	1.5
LH_2 Cont Vent Close	1.5
Eng Burn No. 2 Relay On	4.95
Coast Period	0.10
LH_2 Repress Valve Open	3.0
LOX Repress Valve Open	3.0
Auxiliary Propulsion System*	20.0 (max)
O_2-H_2 Burner Exciters	2.5
AFT BATTERY NO.2 (Figure 3.8)	
LOX Chilldown Inverter	18.0
LH_2 Chilldown Inverter	25.0
Aux Hyd Pump Flight Mode	45

*Includes operation of No. 1 and No. 2 70 lb ullage engines



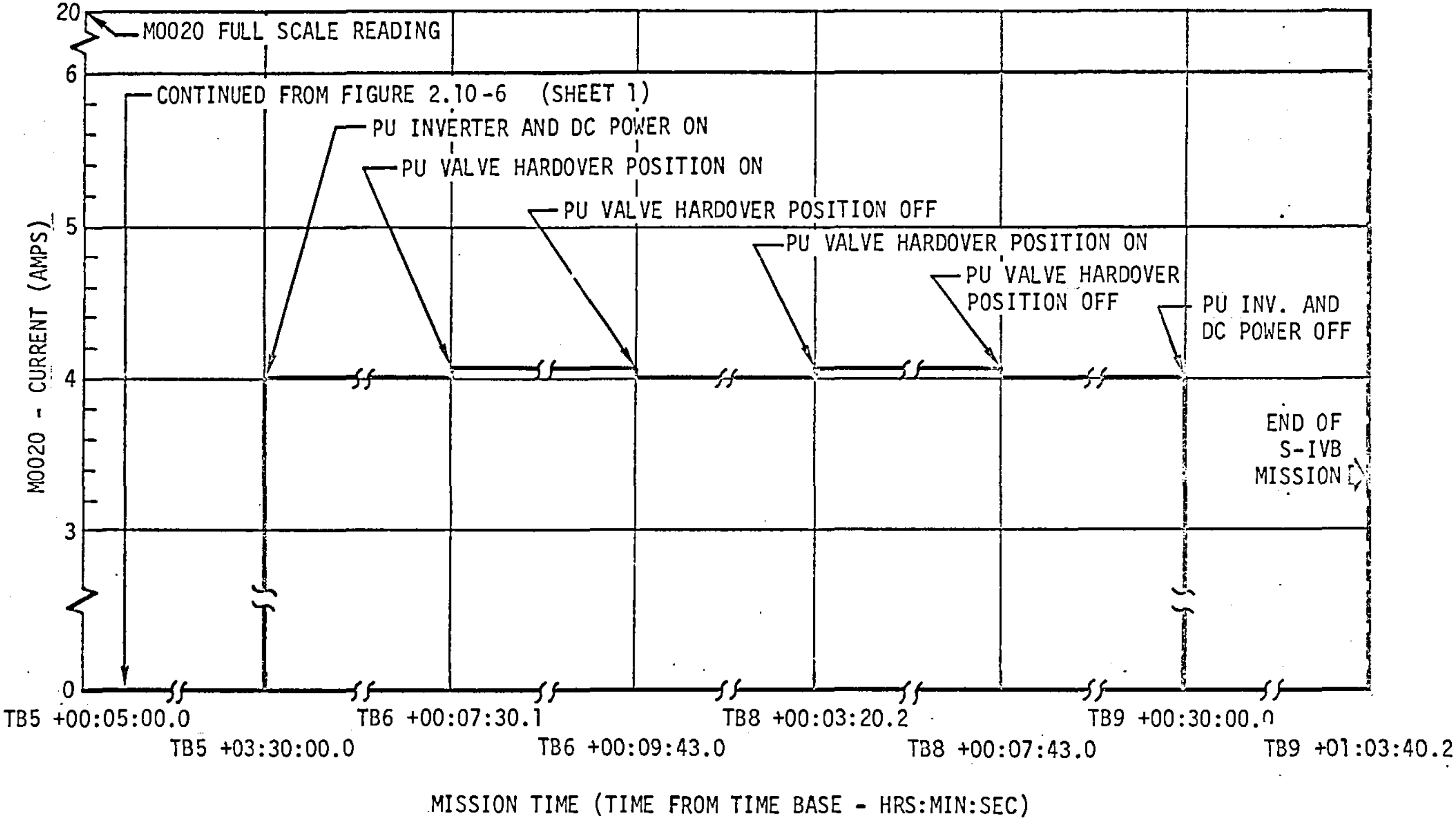
Forward Battery No. 1 - Current Profile

FIGURE 3.5



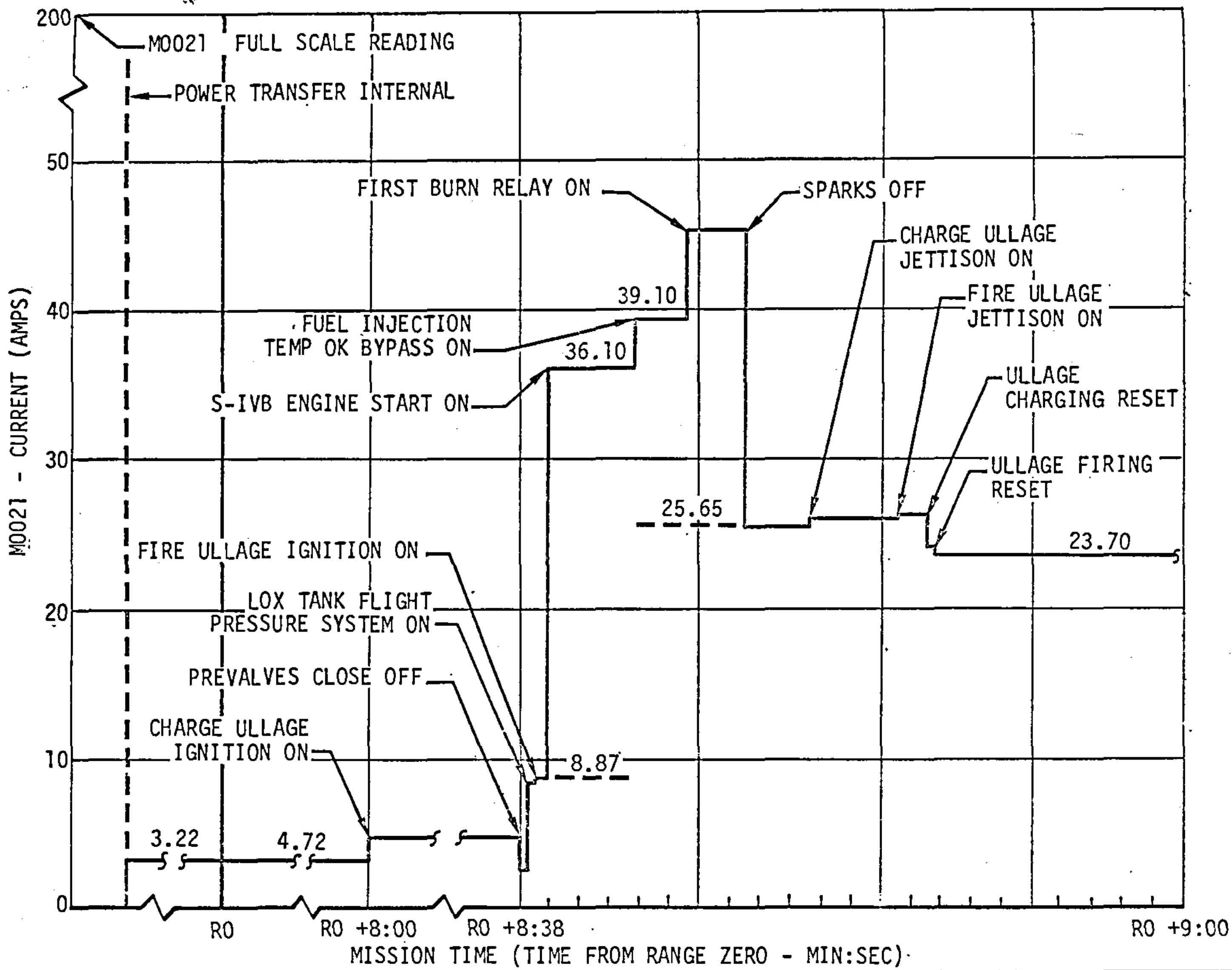
Forward Battery No. 2 - Current Profile (Sheet 1 of 2)

FIGURE 3.6

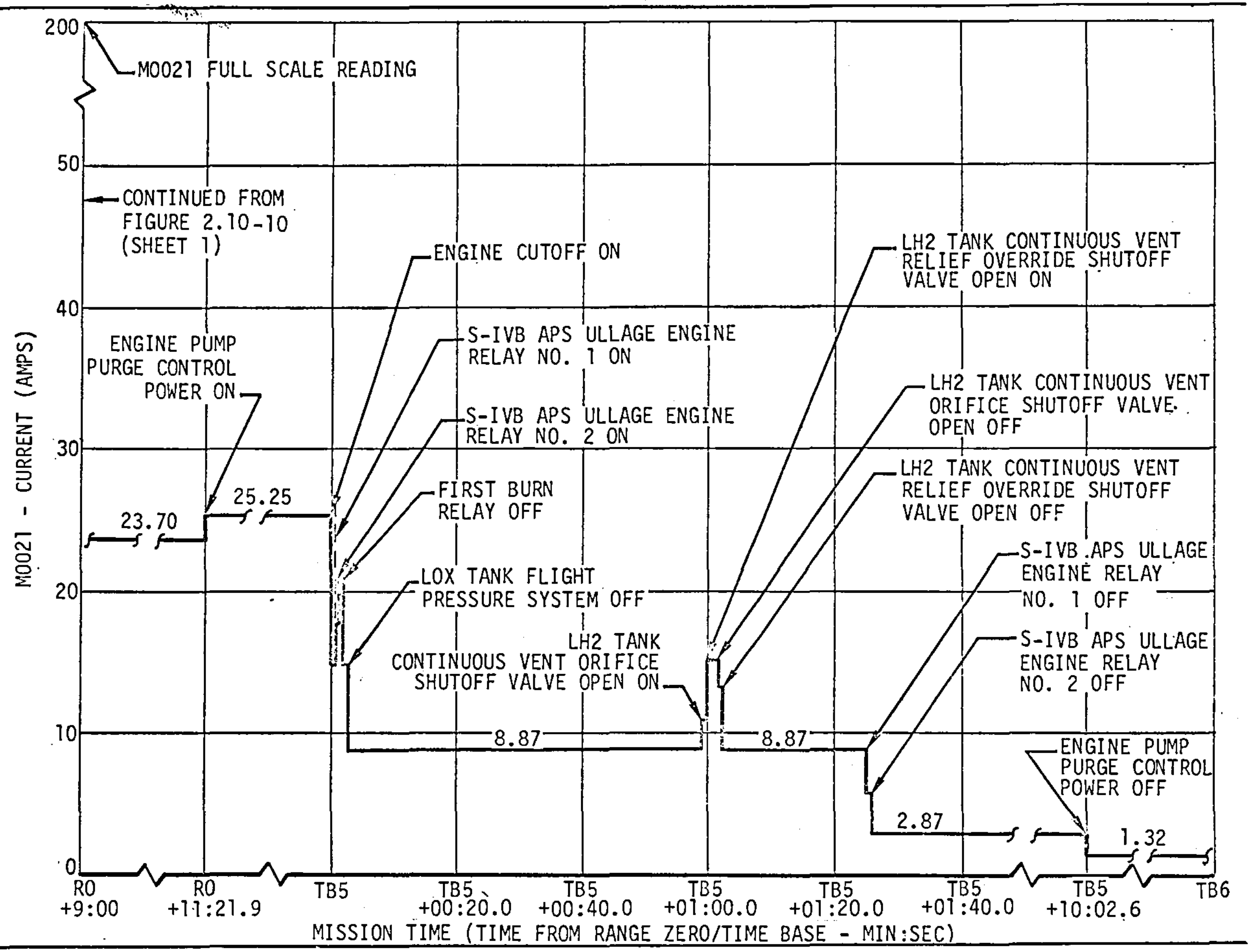


Forward Battery No. 2 - Current Profile (Sheet 2 of 2)

FIGURE 3.6a

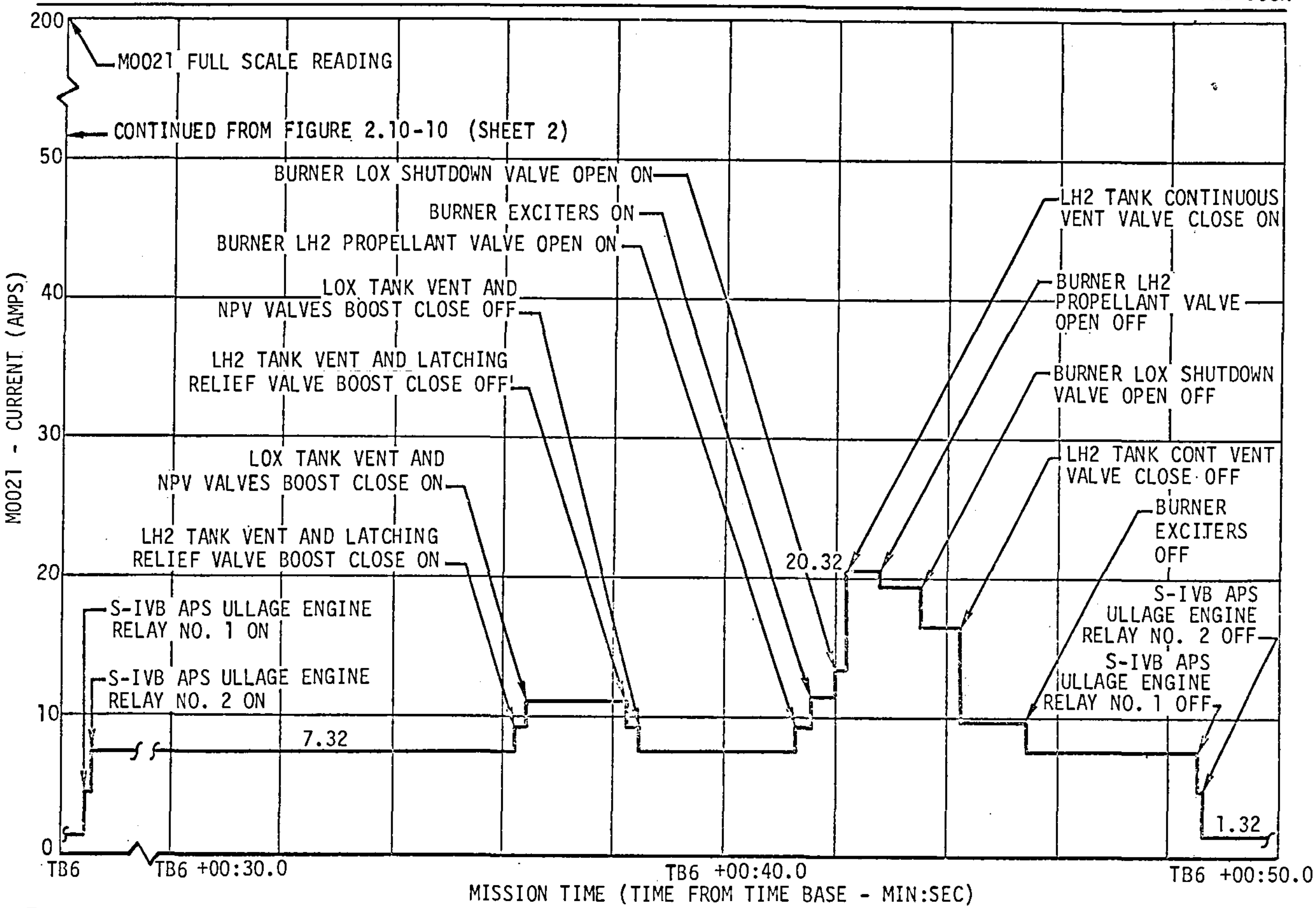


Aft Battery No. 1 - Current Profile (Sheet 1 of 9)



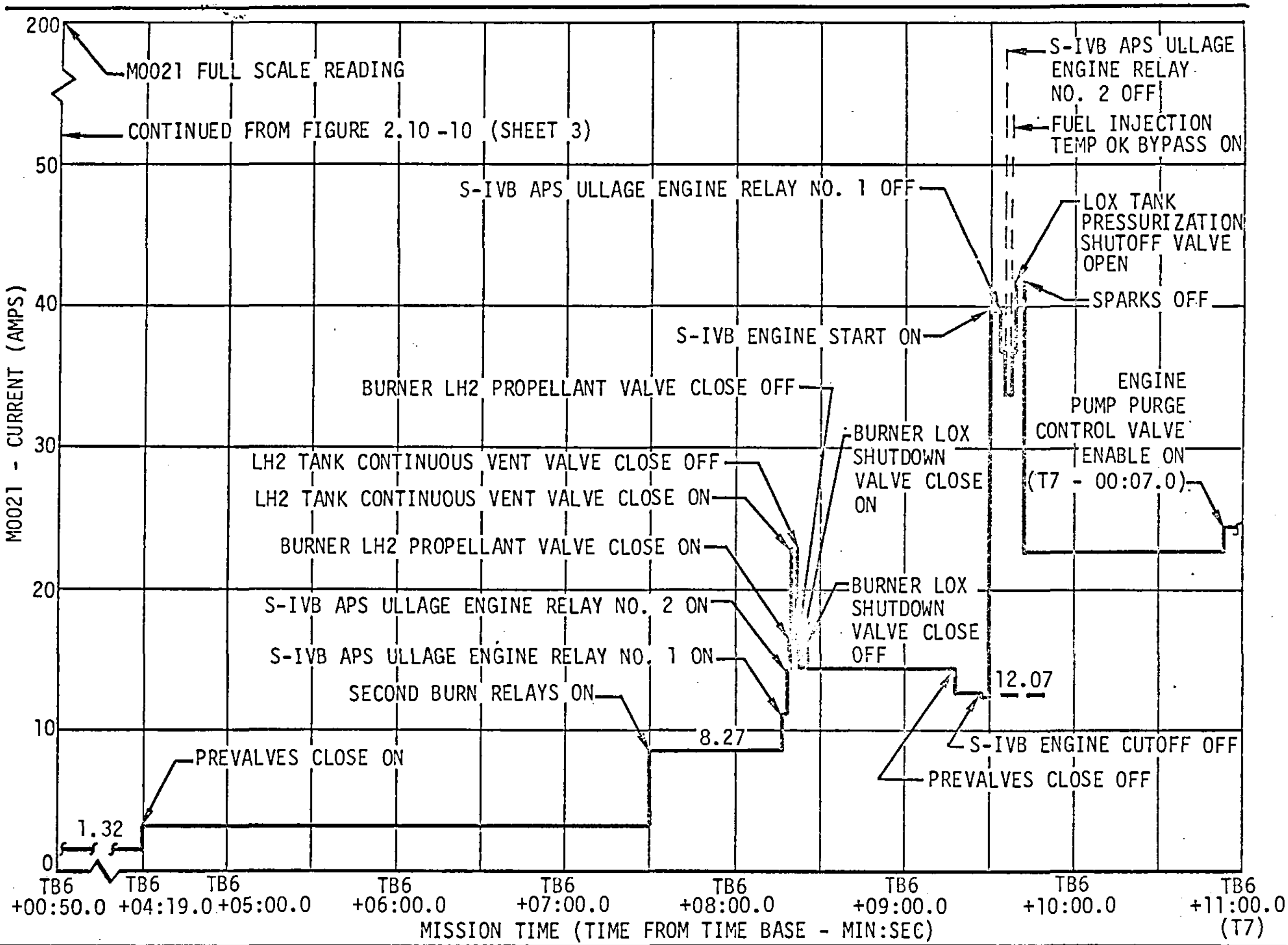
Aft Battery No. 1 - Current Profile (Sheet 2 of 9)

FIGURE 3.7a



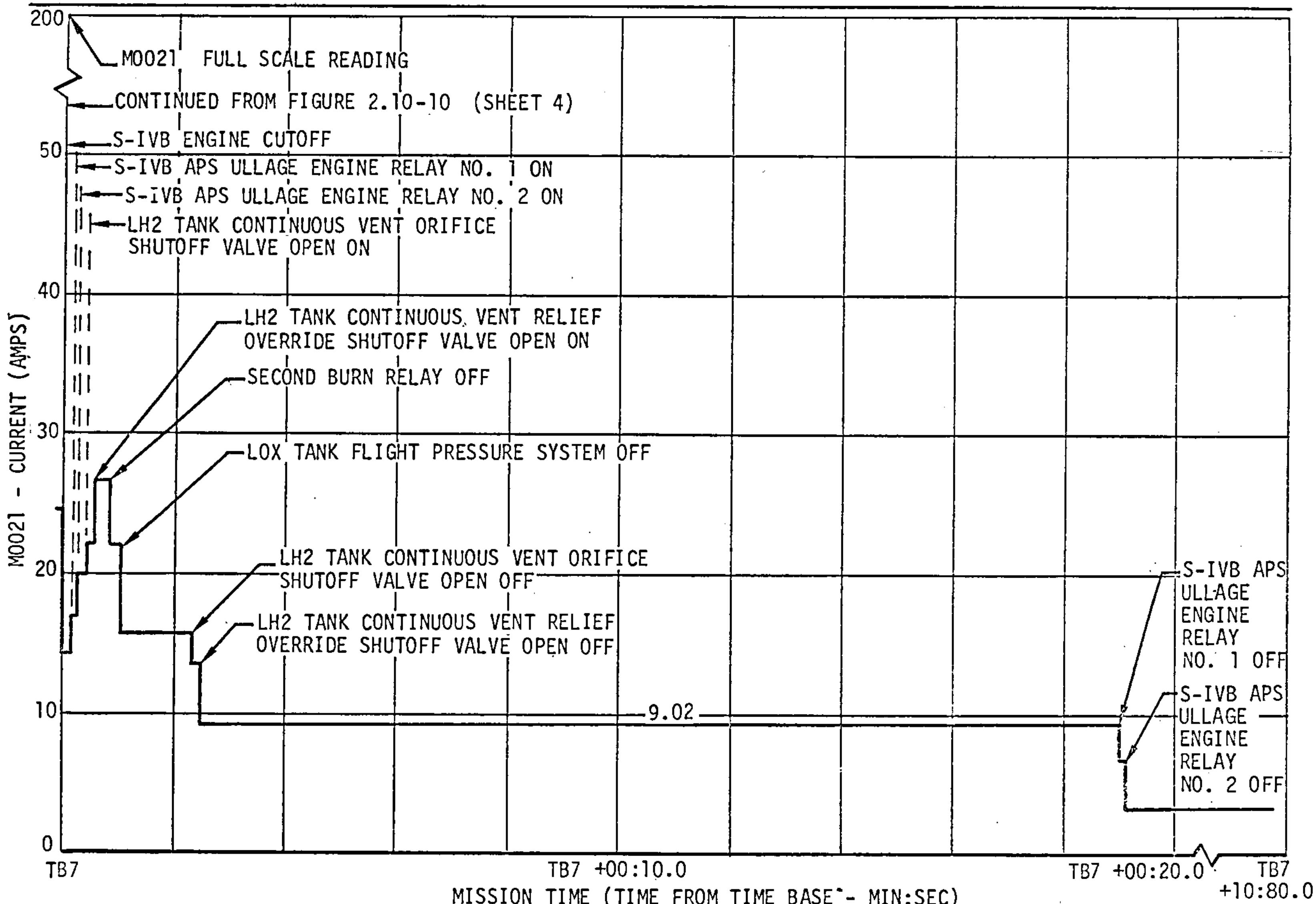
Aft Battery No. 1 - Current Profile (Sheet 3 of 9)

FIGURE 3.7b



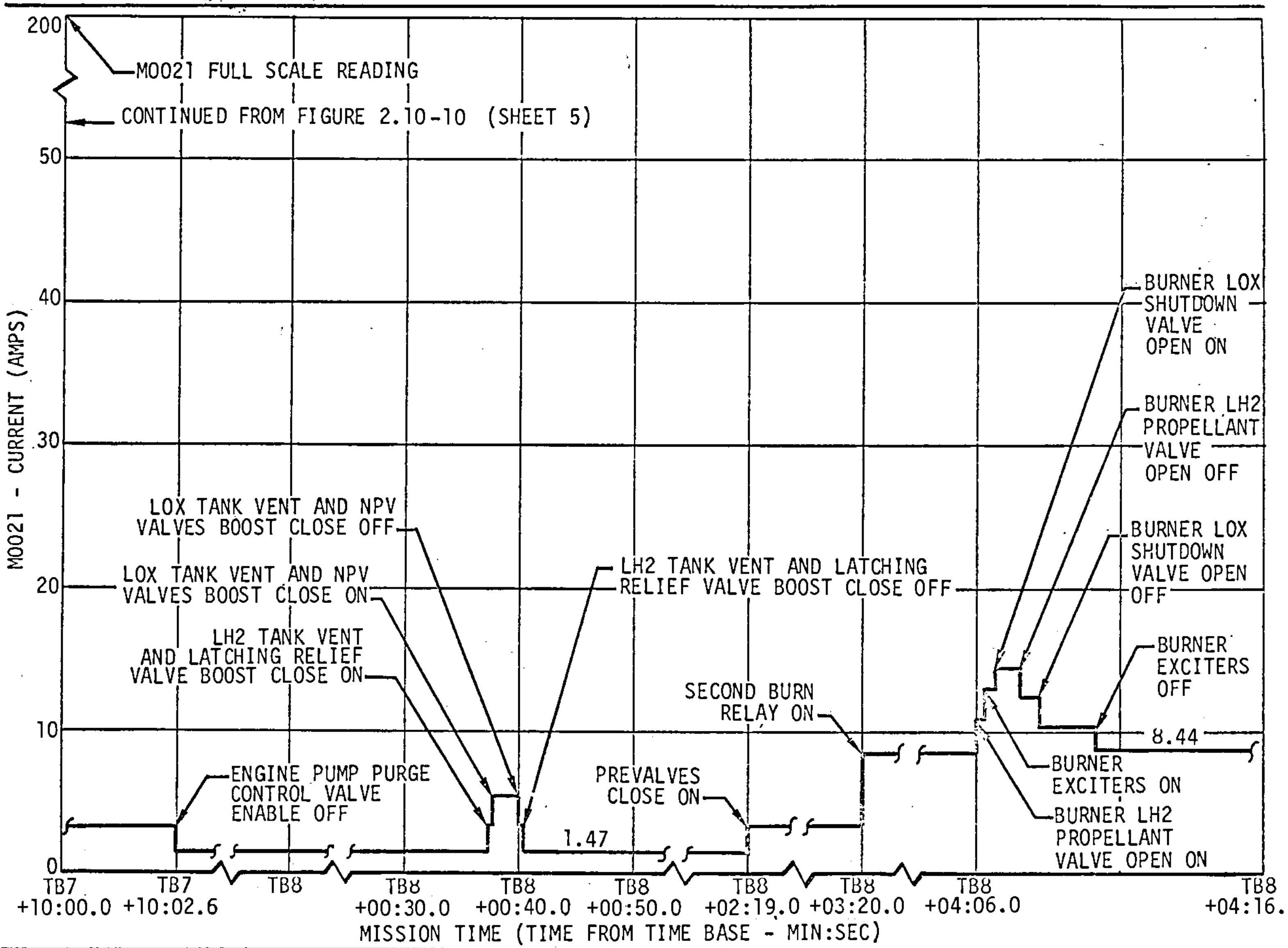
Aft Battery No. 1 - Current Profile (Sheet 4 of 9)

FIGURE 3.7c

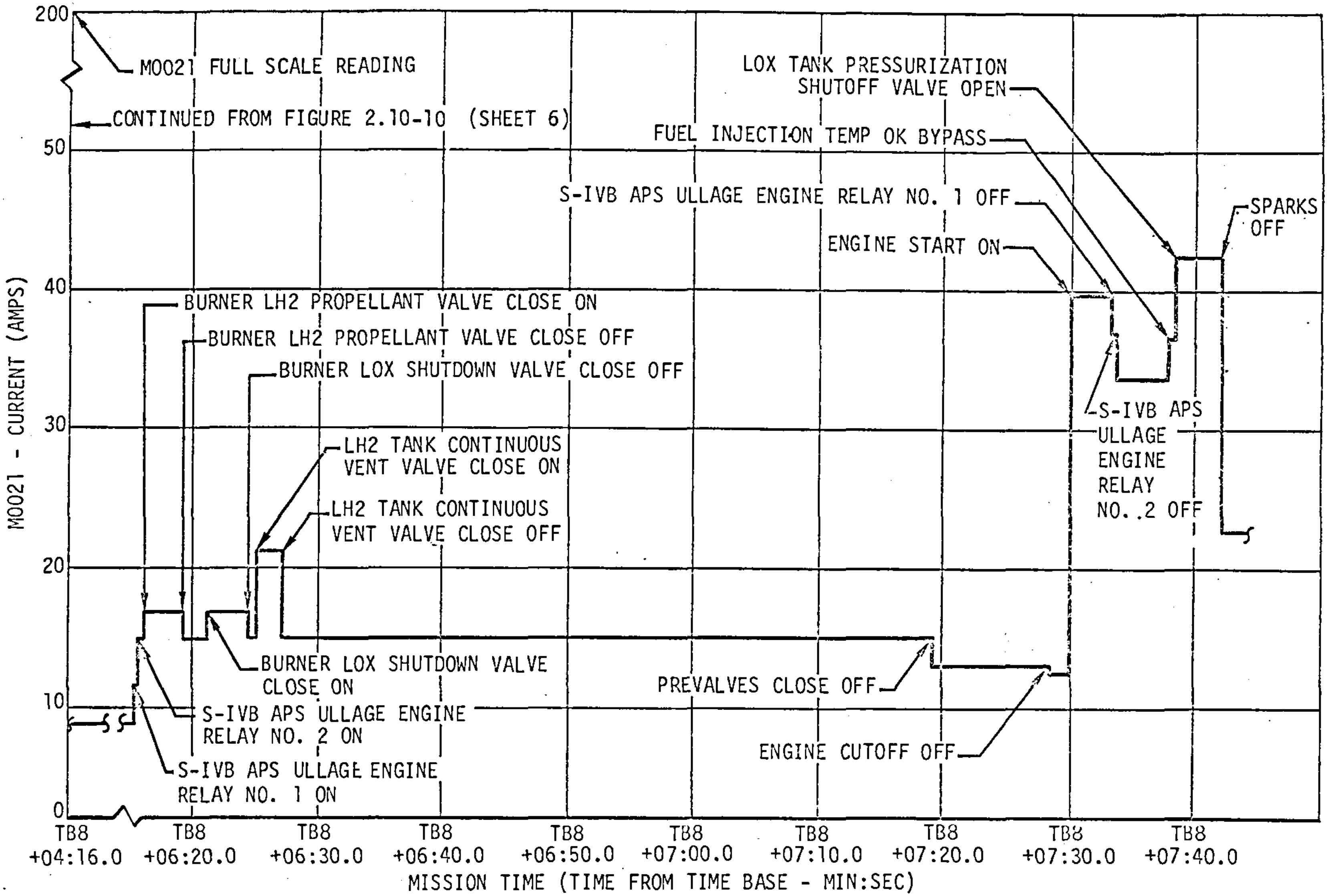


Aft Battery No. 1 - Current Profile (Sheet 5 of 9)

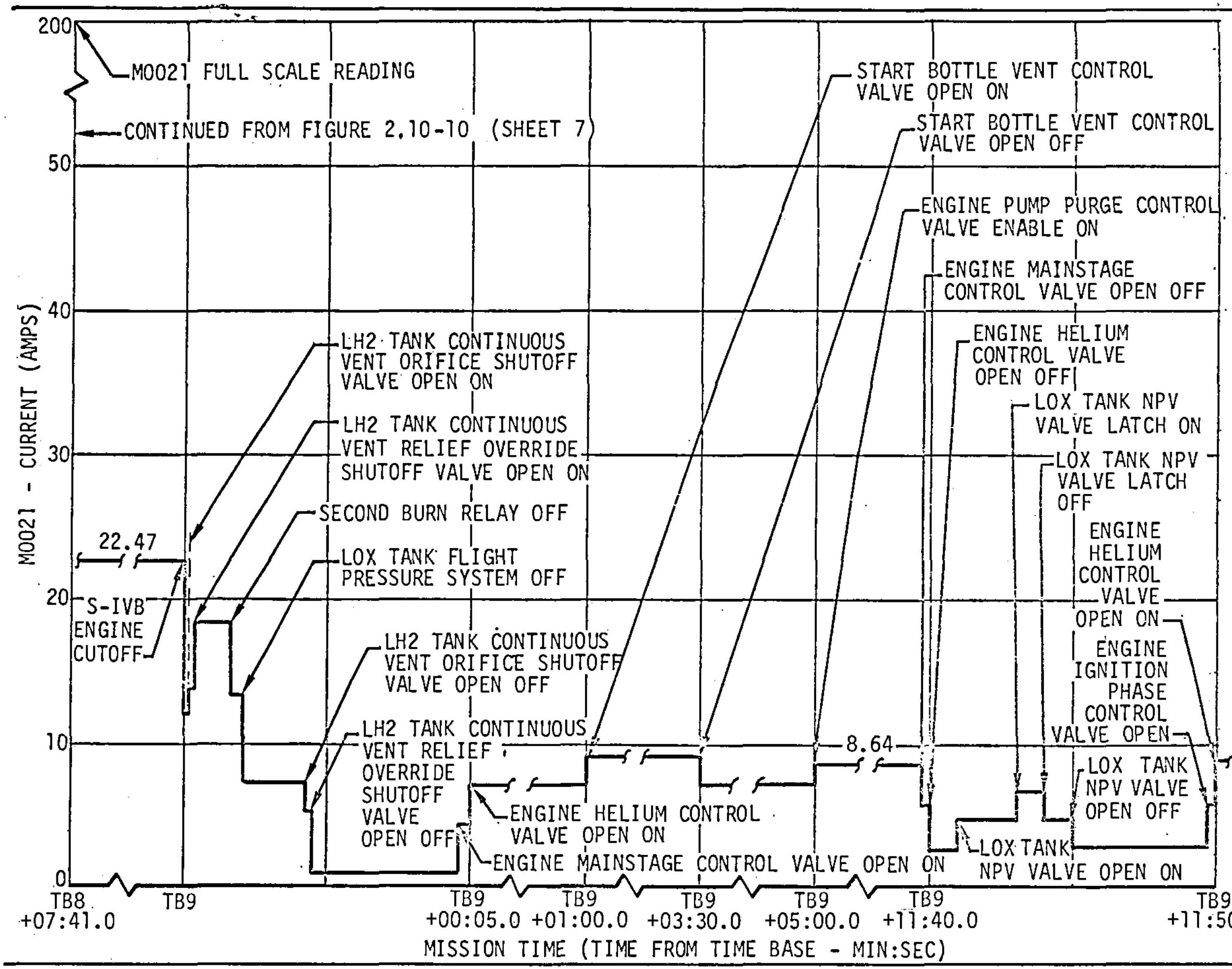
FIGURE 3.7d



Aft Battery No. 1 - Current Profile (Sheet 6 of 9)

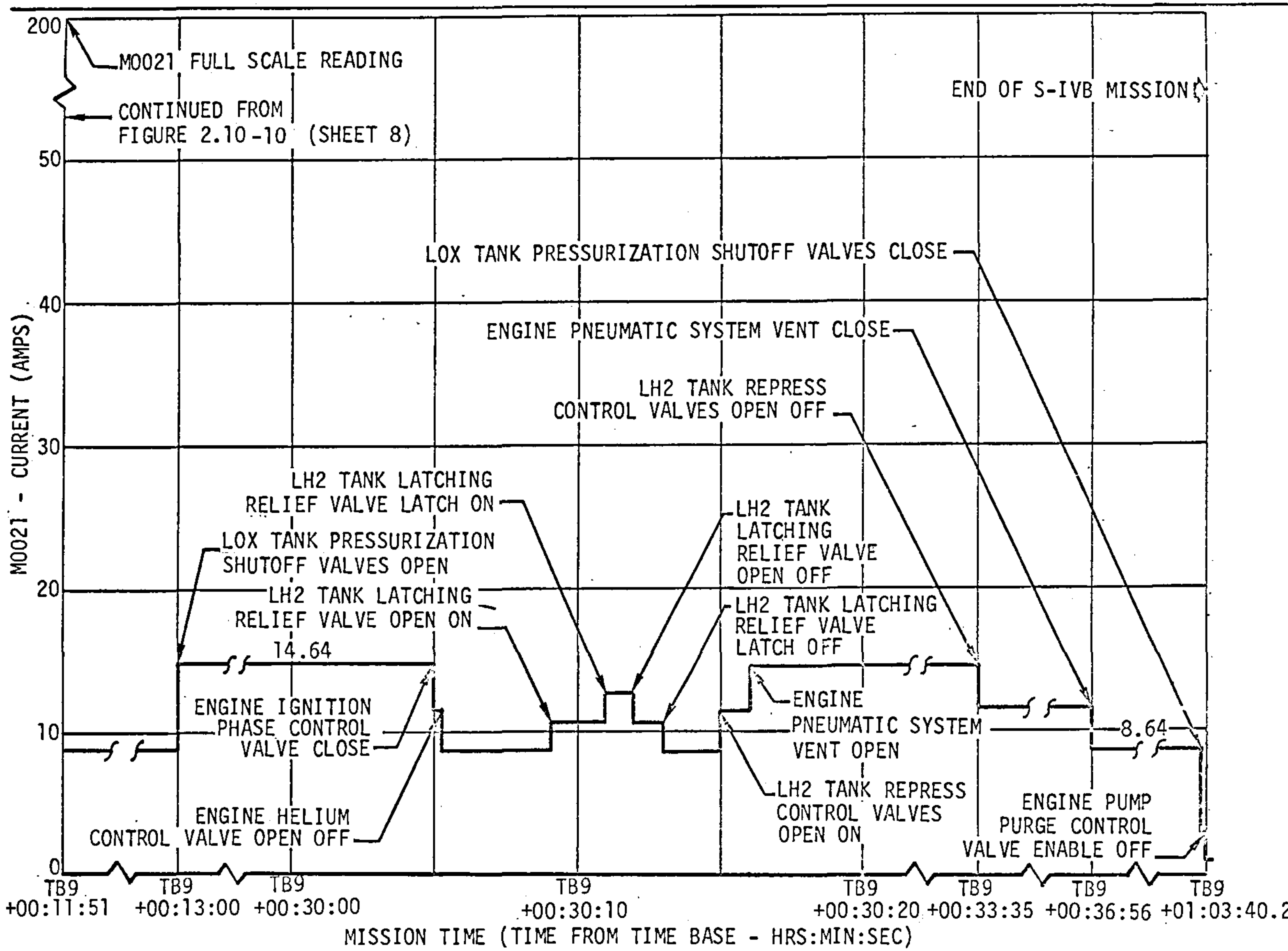


Aft Battery No. 1 - Current Profile (Sheet 7 of 9)



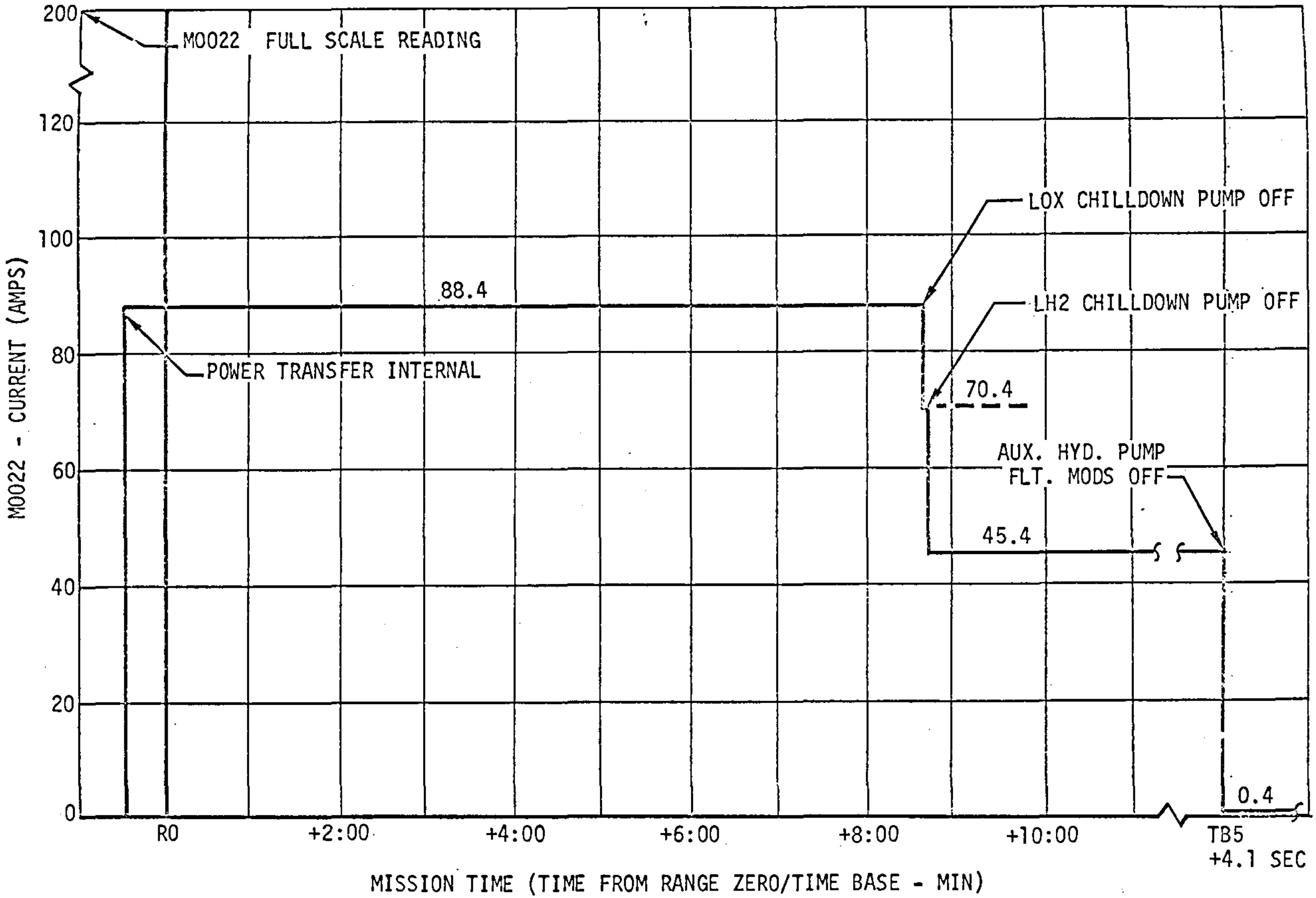
Aft Battery No. 1 - Current Profile (Sheet 8 of 9)

FIGURE 3.7g



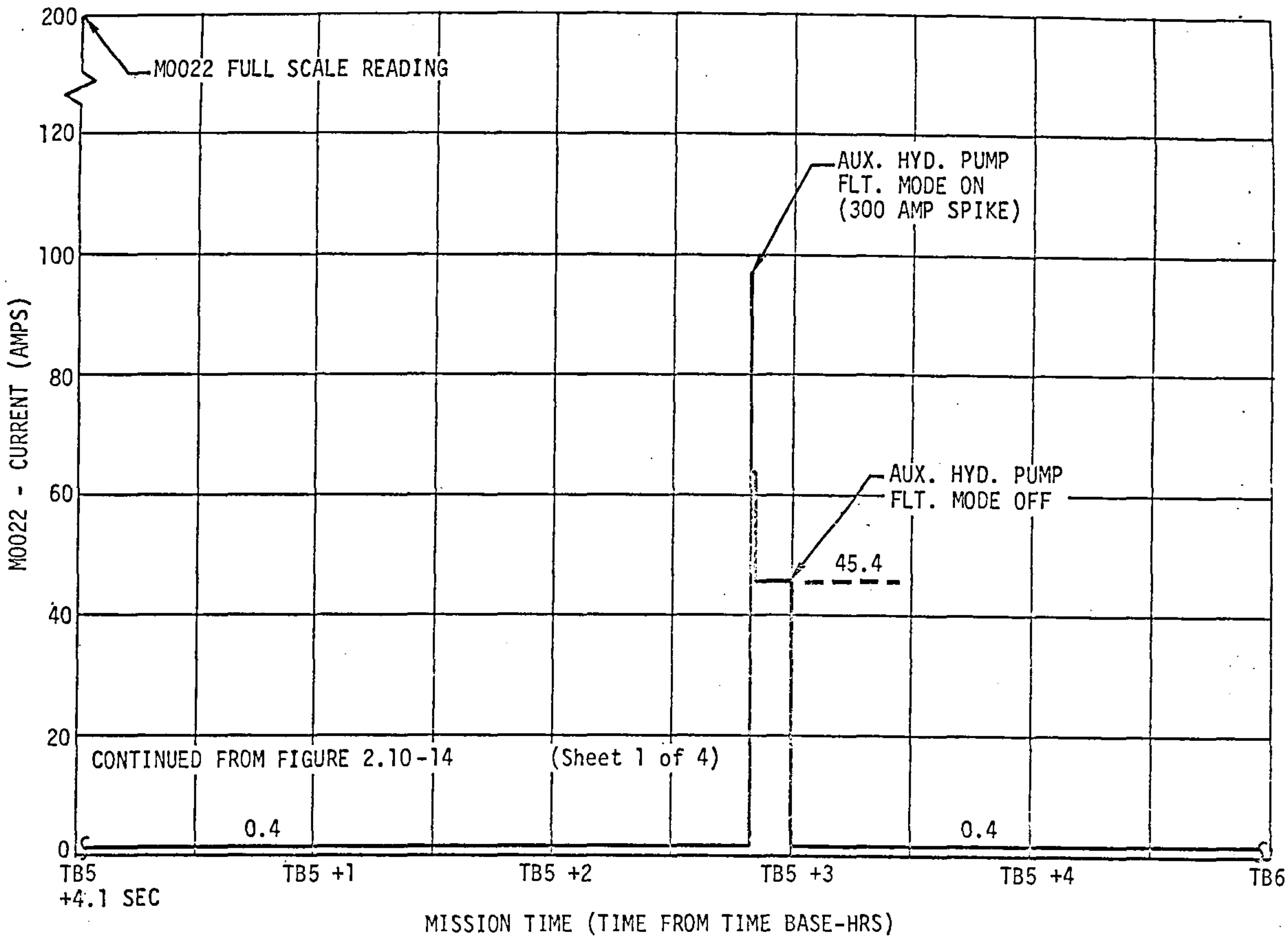
Aft Battery No. 1 - Current Profile (Sheet 9 of 9)

FIGURE 3.7h



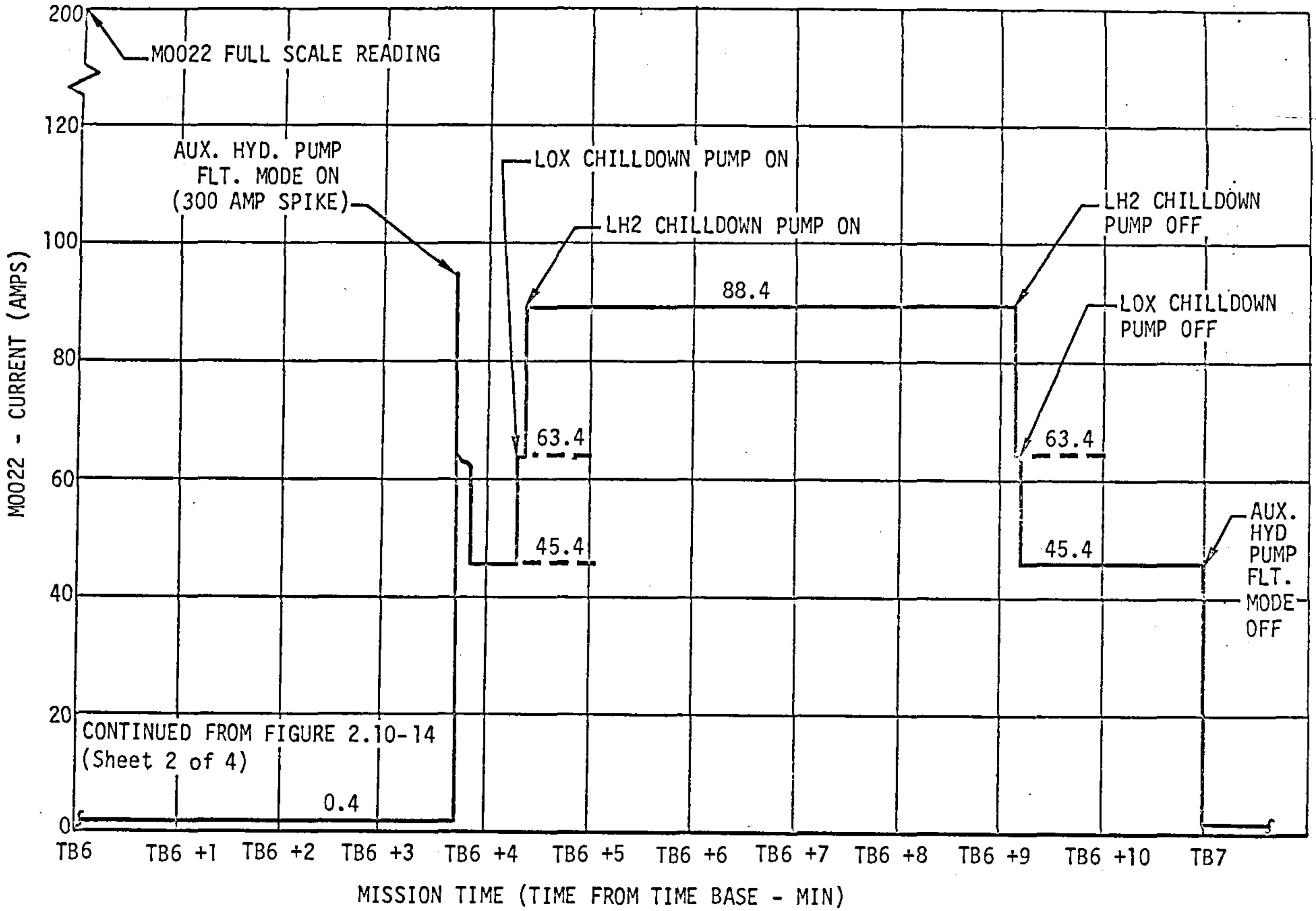
Aft Battery No. 2 - Current Profile (Sheet 1 of 4)

FIGURE 3.8



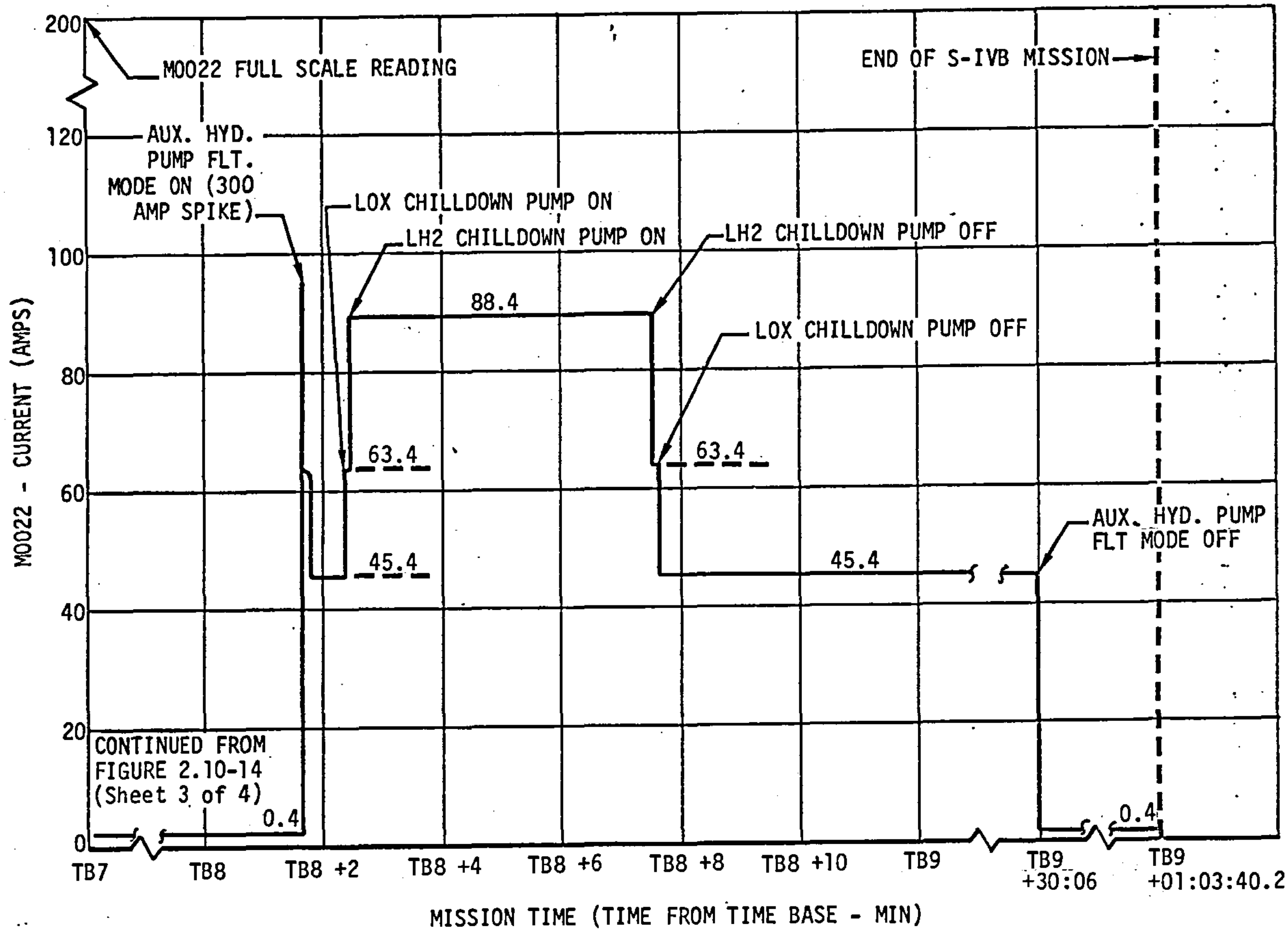
Aft Battery No. 2 - Current Profile (Sheet 2 of 4)

FIGURE 3.8a



Aft Battery No. 2 - Current Profile (Sheet 3 of 4)

FIGURE 3.8b

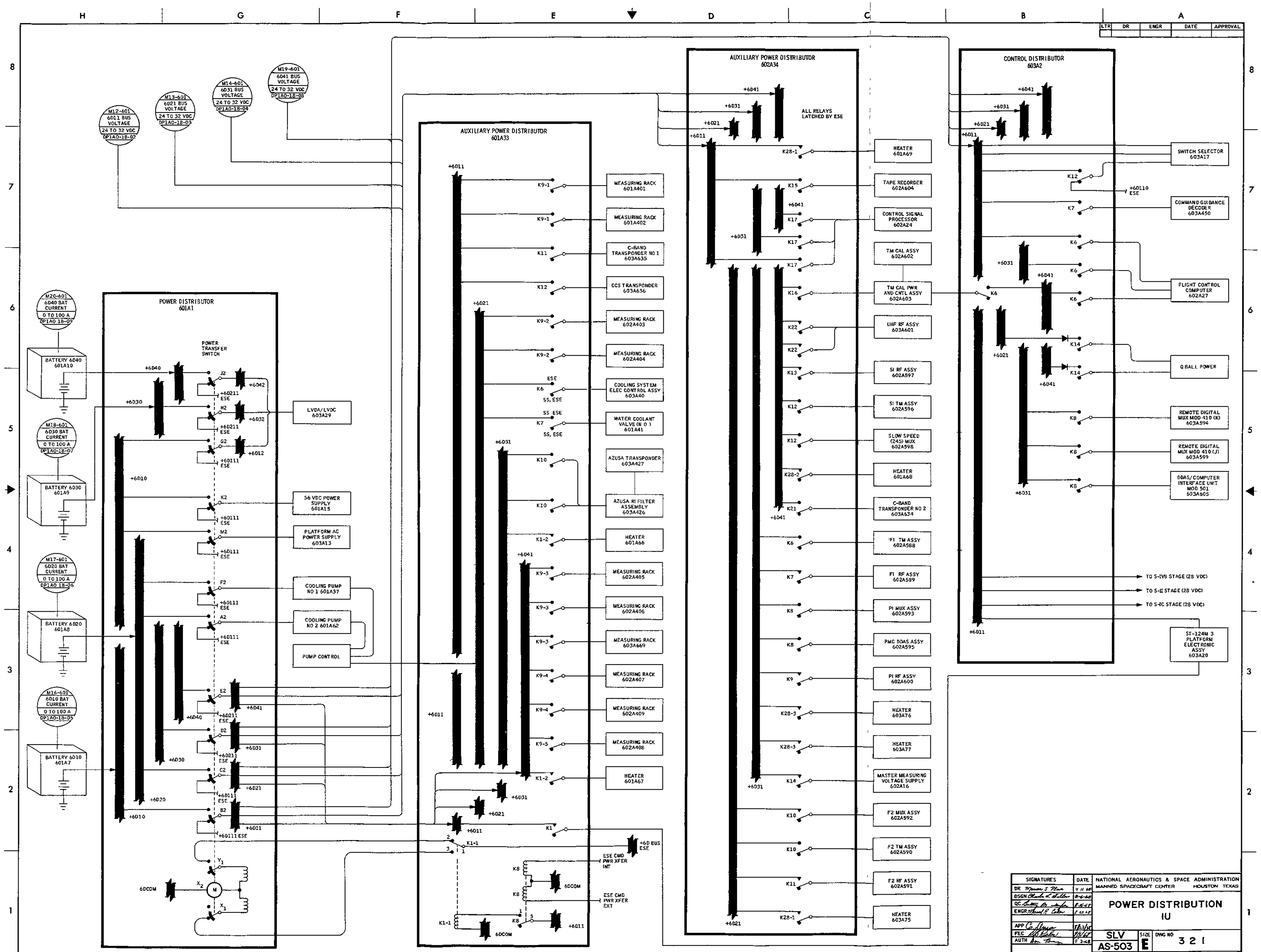


Aft Battery No. 2 - Current Profile (Sheet 4 of 4)

FIGURE 3.8c

therefore, receive a constant flow as system sphere pressure changes.

F. Electrical/electronic equipment in the S-IVB forward skirt area is thermally conditioned by a heat transfer subsystem using a circulating coolant for intermediate heat transport. Principle components of the subsystem, located in the S-IVB stage forward skirt area, are a coolant distribution subsystem and cold plates, figure 4-3. In the flight configuration, thermally conditioned coolant is supplied to the S-IVB thermo-conditioning system by the IU environmental control system. The electrical/electronic equipment is attached to the cold plates and dissipates heat by conduction through the equipment's mounting feet to the cold plates and coolant. The coolant consists of a 60 percent methyl alcohol and 40 percent distilled water solution that contains a corrosion inhibitor. It is supplied through quick disconnect fittings at the IU/S-IVB interface at a flow rate of 3,500 ±175 pounds/hour and is maintained within temperature limits of +40 to +60°F. Operating pressure at the supply interface is 42 psia, and the nominal subsystem differential pressure is 14.25 psi at the given flow rate.



SIGNATURES	DATE
DR	
DSGN	
QC	
ENGR	
APP	
FEC	
AUTH	

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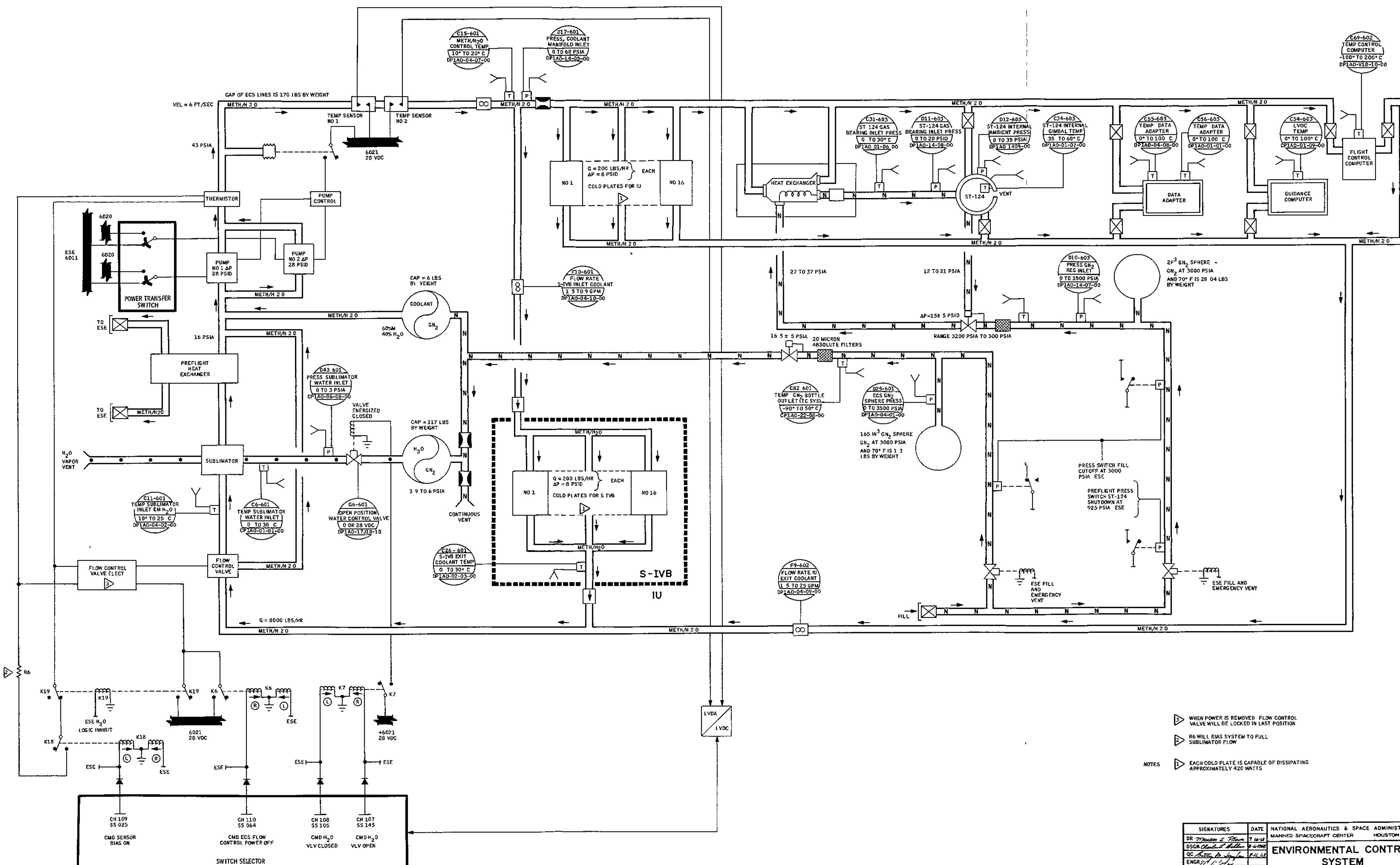
POWER DISTRIBUTION
IU

SLV AS-503 | SIZE E | DWG NO 3 2 1
44 X 34 | PAGE 3-5 | SHEET OF



SIGNATURES	DATE	NATIONAL AERONAUTICS & SPACE ADMINISTRATION MANNED SPACECRAFT CENTER HOUSTON TEXAS
DR	7-16-68	ENVIRONMENTAL CONTROL SYSTEM IU/S-IVB
DSGN	8-6-1968	
QC	8-16-68	
ENGR		
APP		
FEC	9/3/68	SLV AS-503 — SIZE J — DWG NO 41.1
AUTH	9/3/68	49 50 X 34 — PAGE 4-4 — SHEET 1 OF 1

SECTION 4

ENVIRONMENTAL CONTROL SYSTEM

4.1 ENVIRONMENTAL CONTROL SYSTEM 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 stabilized platform. The main components of the system are an inflight sublimator, a water accumulator, a methanol/water 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 internal battery power is applied to the stage. The methanol/water accumulator provides a constant pressure at the pump inlet. As the coolant circulates through the system it absorbs heat from the cold plates, the ST-124 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 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 $59 \pm 1^{\circ}F$.

C. At liftoff T_1 + 5.0 seconds the LVDC/LVDA commands "Sensor Bias ON," driving the flow control valve to the full sublimator flow position. At T_1 + 75.0 seconds the LVDC/LVDA commands "Cooling System Electronic Assembly Power OFF" disabling the flow control valve electronics leaving the flow control valve in the full sublimator flow position for the remainder of the mission.

At T_3 + 29.8 seconds, liftoff + 180 seconds, the LVDC/LVDA program commands the water valve open allowing water 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 later enabled allowing the operation of the thermal switches sensing the temperature of the coolant to cause the temperature of the coolant to cause the LVDC/LVDA program to cycle the water valve open or closed to maintain proper environmental temperature 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 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 platform 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,

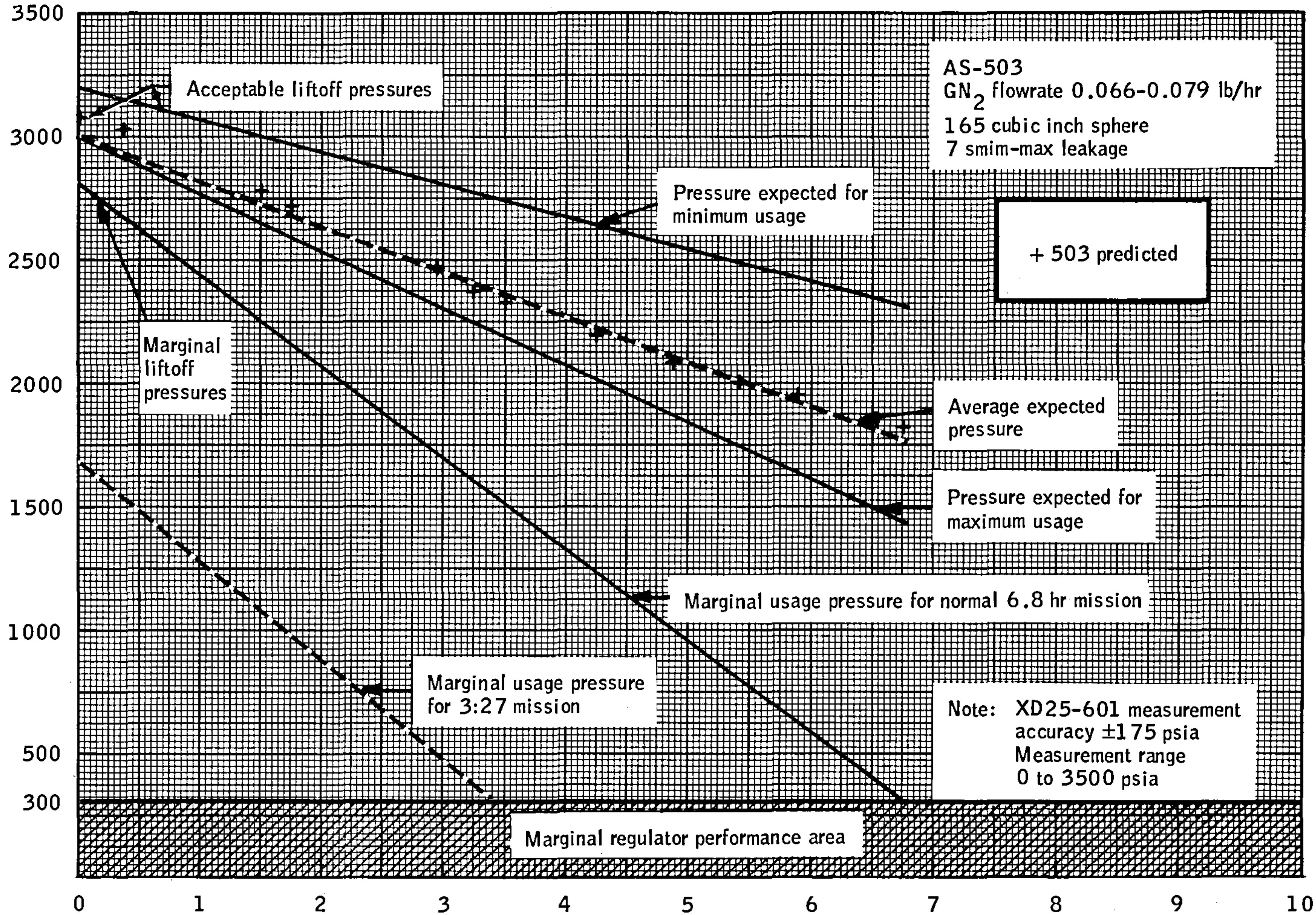


Figure 4-1.-TCS GN_2 usage.

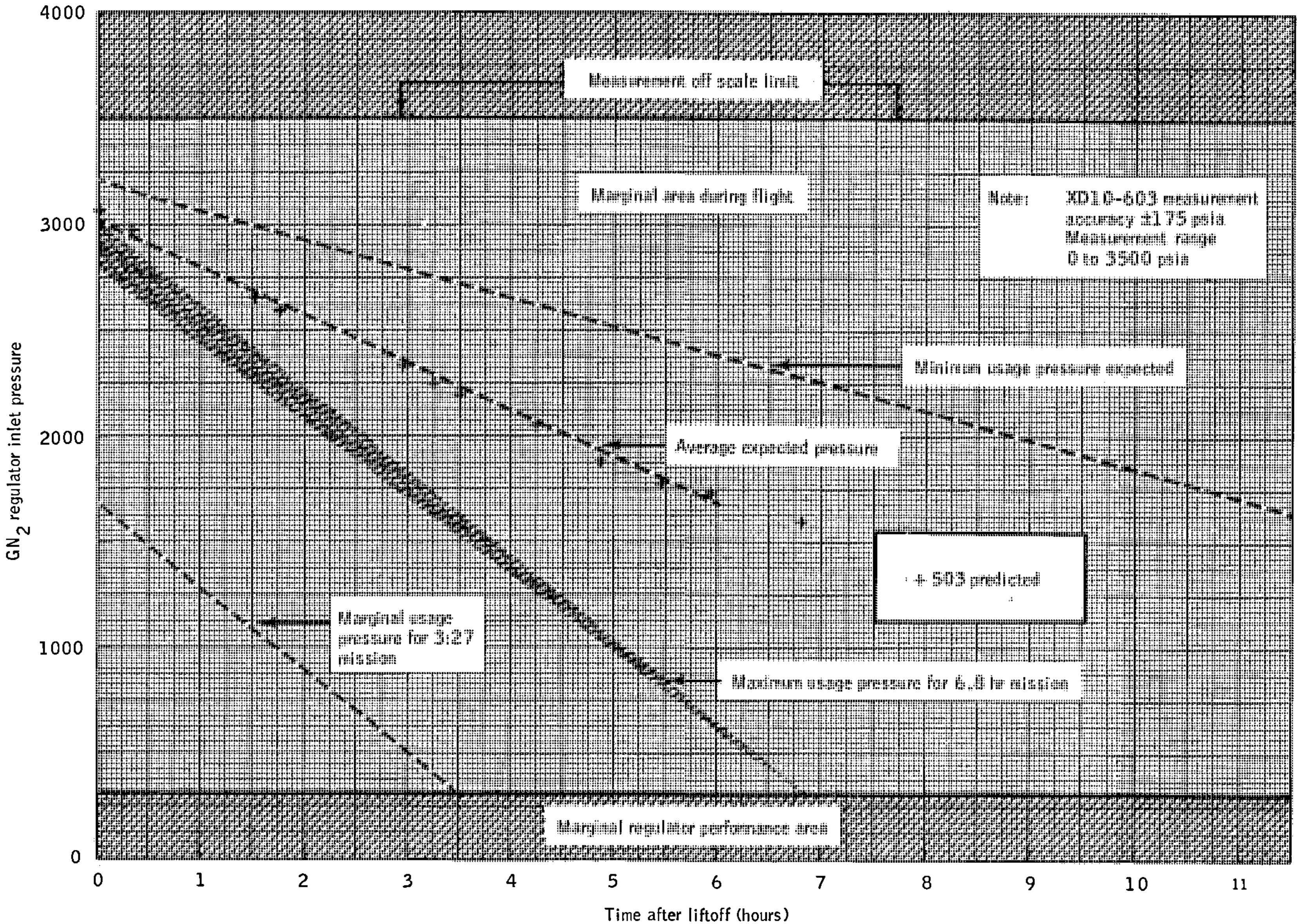


Figure 4-2.-XD10-603 gas bearing GN_2 usage.

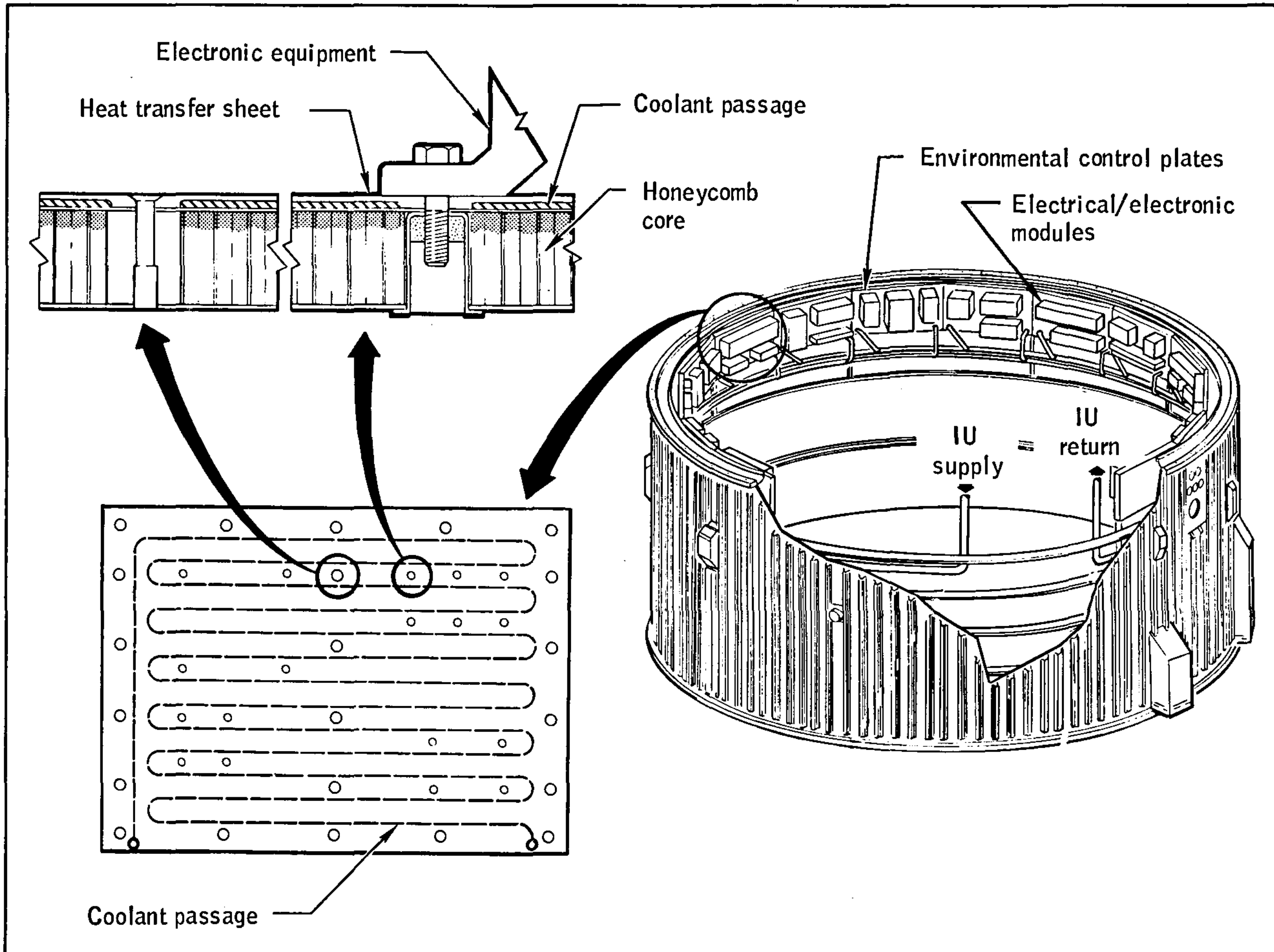


Figure 4-3.- S-IVB environmental control system.

SECTION 5
INSTRUMENTATION/COMMUNICATION SYSTEM

5.1 DIGITAL COMMAND SYSTEM

5.1.1 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.

5.1.2 General

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).

5.1.3 Modulation Techniques

The technique employed by the ground stations for base line 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 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 modulated on a 70 kHz subcarrier which in turn is PM modulated on the 2101.8 MHz carrier for transmission to the vehicle.

5.1.4 MSFN Command Loads

It is planned that MCC will be responsible for origination and transfer of all vehicle messages to the ground installations. In normal operation this transfer is made by way of a high-speed data communication system. A 100 word-per-minute teletype will serve as a backup for the HSD system. In addition, data via communication satellite will be provided for later missions.

5.1.5 Decoder Bit Coding and Timing

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 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 word. The other 14 bits represents the binary coded data within the message, and 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. 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 total time for a 35-bit message transmission is 5 x 35 = 175 milliseconds since there also is no dead time between updata bits. The updata bit rate is, therefore, 200 bits per second. During the intervals when no messages are being transmitted, all sub-bit "1's" are transmitted; however, the comparators have no output.

5.1.6 Data Verification

The IU command system requires a high probability that a correct command will be received by the vehicle. This high probability is obtained by the use of several different techniques.

A. To transpose a "1" bit to a "0" bit, every one of the five sub-bits must be complemented in multiples of five in sync with the bit rate.

B. The 17 address bits must be correct or the message is rejected.

C. The 18 information bits must be present.

D. The LVDC checks and comparisons must be verified and a computer reset pulse originated to signal the ground station for transmission of the next command.

To complete the verification loop, the ground command system must receive an indication of successful acceptance by the LVDC within a specified time, depending upon processing and loop delays or the command is considered to be rejected.

5.1.7 TM Data for Command System Analysis

Selected TM data from the onboard and from the ground system is returned to MCC to assist in system performance predictions.

Sense points for the TM pickup of onboard data is shown in figure 5.7 and figure 5.11. For ground generated data, points of origin are shown in figure 5.6.

5.2 TELEMETRY SYSTEMS

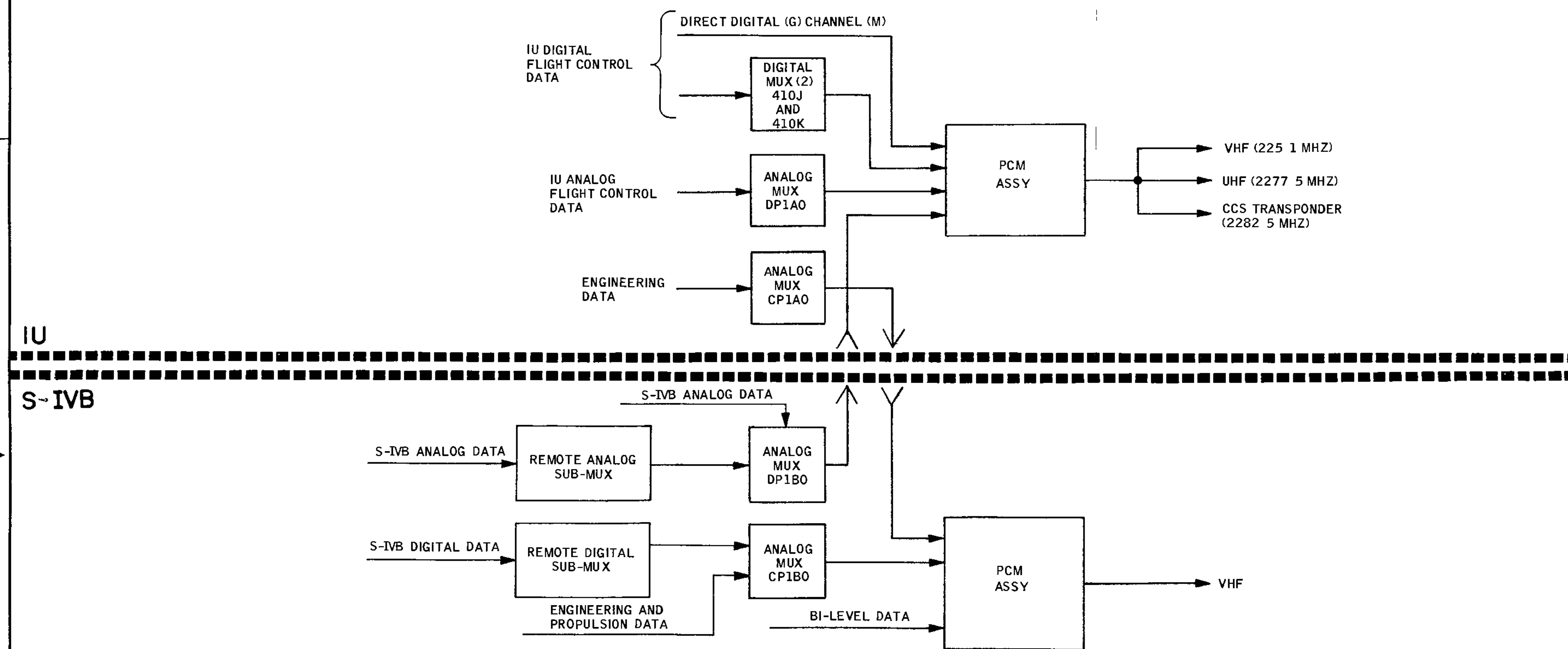
A. Each stage of the launch vehicle has an independent measuring and telemetry system with flight control measurements on redundant lines between the IU and S-IVB stages. Before launch, coaxial cables from each stage telemetry system supply digital data to the checkout facility. During flight, the telemetry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

B. The Saturn vehicle contains the following telemetry systems:

LINK	MODULATION	USE	FREQ	POWER OUTPUT
IU/S-IVB composite PCM flow diagram (see Drawing No. 5.2.1)				
IU (see Drawing No. 5.2.2)				
DP-1	PCM/FM	Operational and Digital information	255.1 MHz	20 W
DF-1	FM/FM	Engineering data	250.7 MHz	20 W
DF-2	PAM/FM/FM	Engineering data	245.3 MHz	20 W
DS-1	SS/FM	Vibration and Structure data	259.7 MHz	20 W
DP-1A	PCM/FM	Parallel to DP-1	2277.5 MHz	20 W
DP-1B	CCS	Parallel to DP-1	2282.5 MHz	20 W
S-IVB (see Drawing No. 5.2.3)				
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 No. 5.2.4)				
BF-1	PAM/FM/FM	Engineering data	241.5 MHz	20 W
BF-2	PAM/FM/FM	Engineering data	234.0 MHz	20 W
BF-3	PAM/FM/FM	Engineering data	229.9 MHz	20 W
BP-1	PCM/FM	Operational and Digital information	248.6 MHz	20 W
BS-1	SS/FM	Engineering data	227.2 MHz	20 W
BS-2	SS/FM	Engineering data	236.2 MHz	20 W

LINK	MODULATION	USE	FREQ	POWER OUTPUT
S-IC (see Drawing No. 5.2.5)				
AF-3	PAM/FM/FM	Engineering data	231.9 MHz	20 W
AF-2	PAM/FM/FM	Engineering data	252.4 MHz	20 W
AF-1	PAM/FM/FM	Engineering data	240.2 MHz	20 W
AS-1	SS/FM	Engineering data	235.0 MHz	20 W
AS-2	SS/FM	Engineering data	256.2 MHz	20 W
AP-1	PCM/FM	Operational and Digital information	244.3 MHz	20 W

LTR	DR	ENGR	DATE	APPROVAL



SIGNATURES	DATE
DR	4/18/68
DSGN	8/6/1968
QC	8-16-68
ENGR	8-23-68
APP	9-23-68
FEC	9/3/68
AUTH	9-3-68

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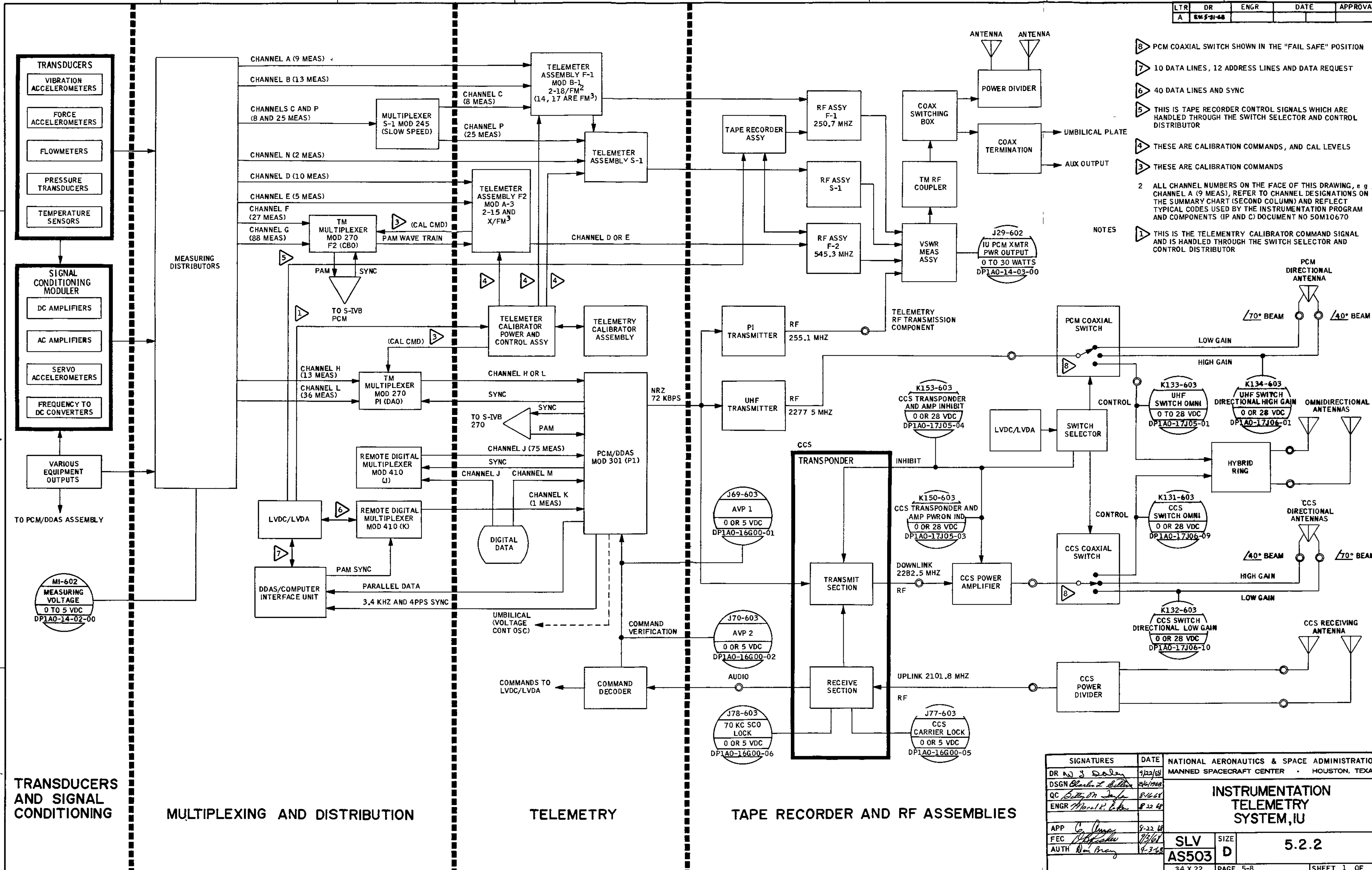
TELEMETRY COMPOSITE S-IVB / IU PCM FLOW DIAGRAM

SLV AS503 | SIZE C | NO 5.2.1

22 X 17 | PAGE 5-7 | SHEET 1 OF 1

MSC Form 1616 C (REV OCT 65)



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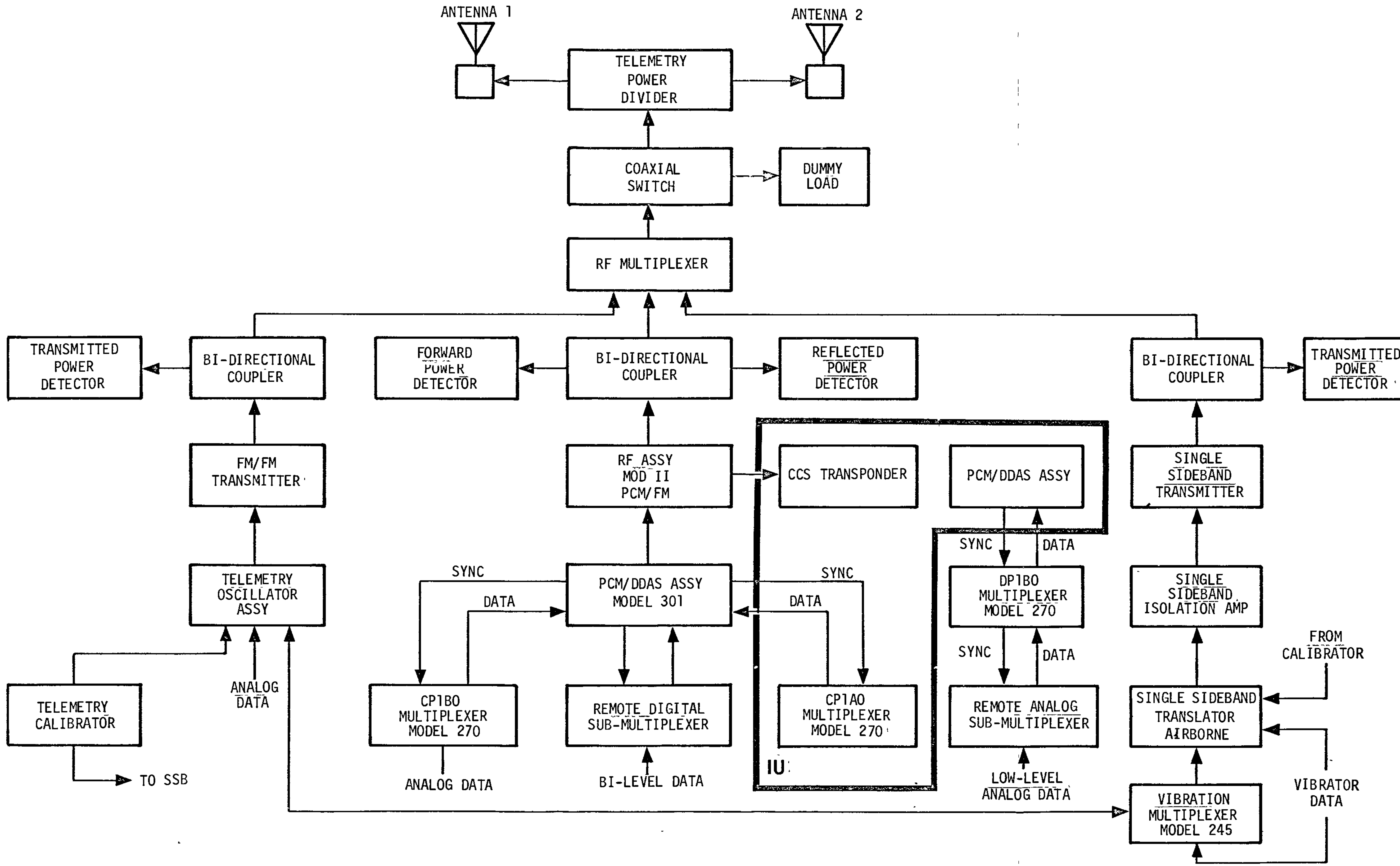
INSTRUMENTATION TELEMETRY SYSTEM, IU

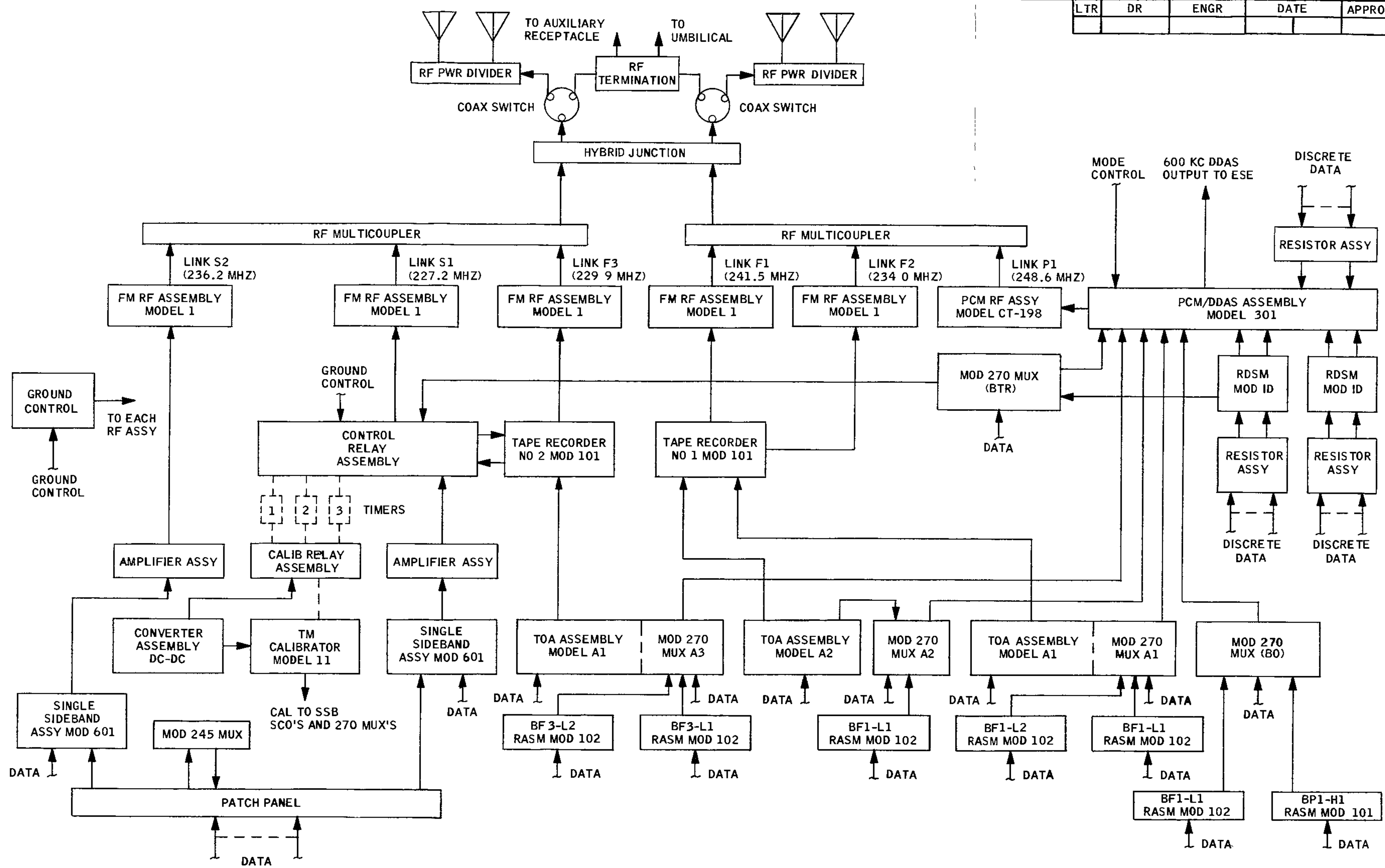
SLV AS503 — SIZE D — 5.2.2

34 X 22 — PAGE 5-8 — SHEET 1 OF 1

MSC Form 1616 D (REV OCT 65)



Instrumentation - S-IVB Telemetry System



LTR	DR	ENGR	DATE	APPROVAL

SIGNATURES	DATE
DR	4-19-68
DSGN	8/6/1968
QC	8-16-68
ENGR	8-22-68
APP	8-22-68
FEC	9/3/68
AUTH	9-3-68

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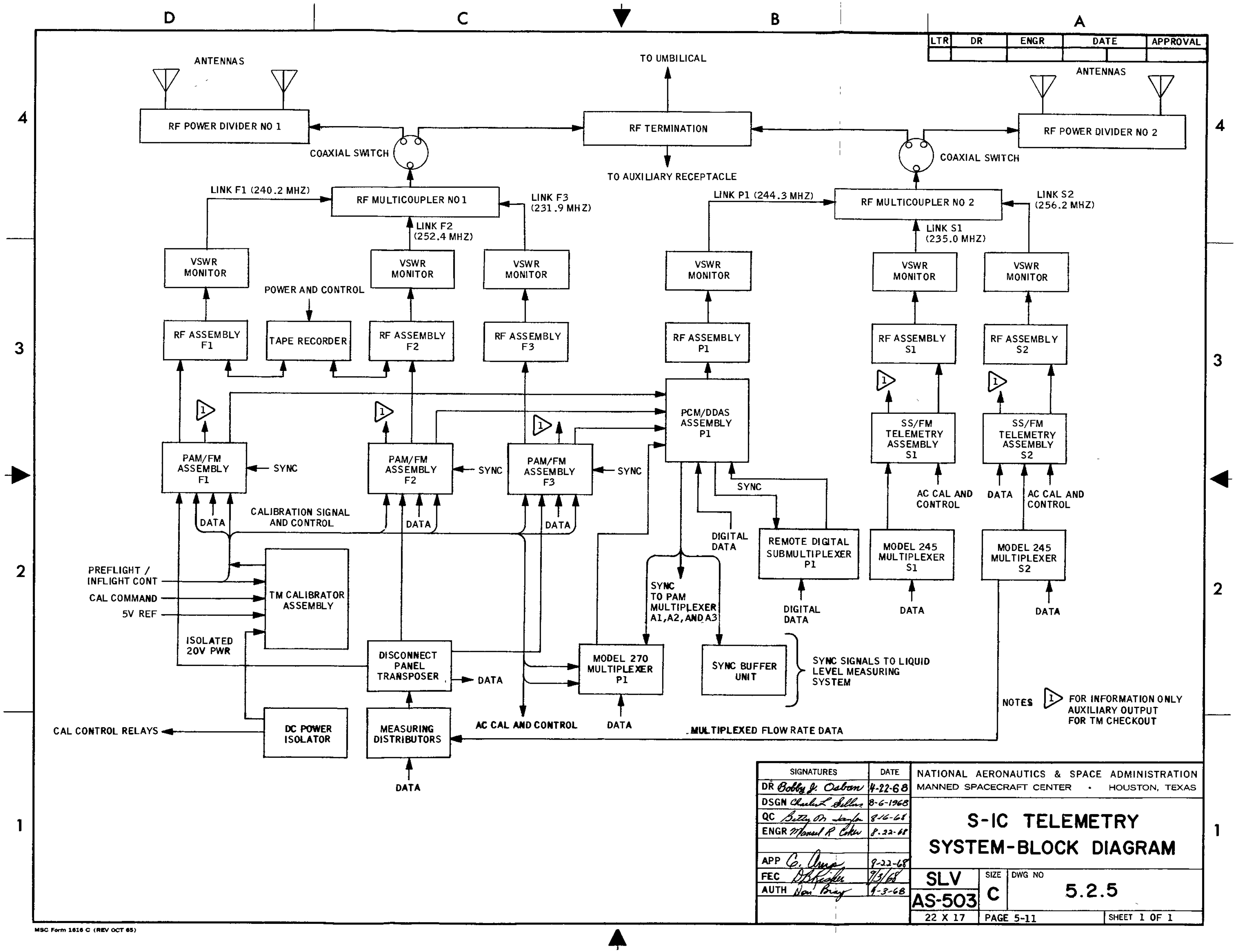
S-II TELEMETRY SYSTEM-BLOCK DIAGRAM

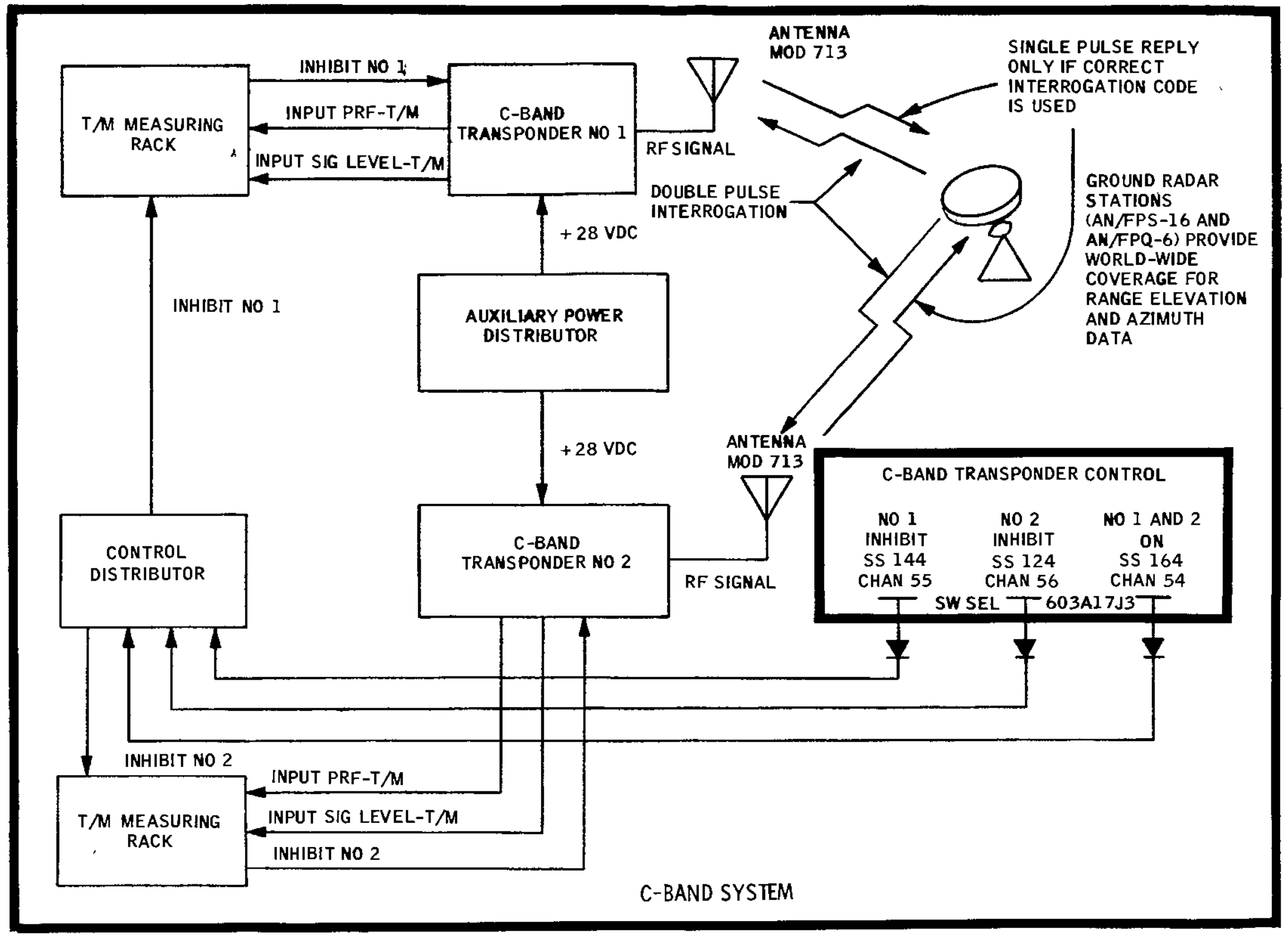
SLV AS-503 | SIZE C | DWG NO. 5.2.4

22 X 17 | PAGE 5-10 | SHEET 1 OF 1

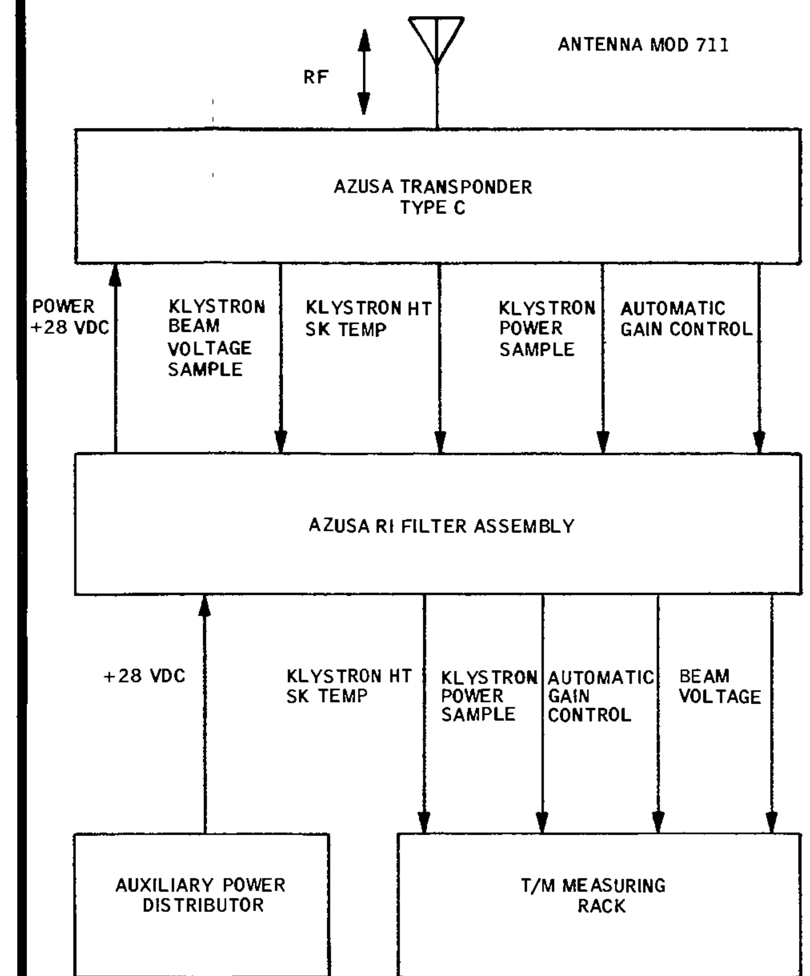


MSC Form 1616 C (REV OCT 65)

LTR	DR	ENGR	DATE	APPROVAL



C-BAND SYSTEM



1. TRACKING STATIONS LOCATED AT CAPE KENNEDY AND GRAND BAHAMA PROVIDE REAL TIME COVERAGE FOR INITIAL BOOST PHASE OF FLIGHT
2. AZUSA TRACKING INFORMATION IS PROCESSED TO PROVIDE IMPACT PREDICTION DATA TO THE RANGE SAFETY CONTROL OFFICER

AZUSA SYSTEM

SIGNATURES	DATE
DR Kenneth R. Williams	4/19/68
DSGN Charles L. Sellers	8/6/1968
QC Betty M. Sawyer	8-16-68
ENGR Manuel R. Coker	8-28-68
APP C. Umsay	8-23-68
FEC D.B. Kesler	9/3/68
AUTH Don Brainy	9-3-68

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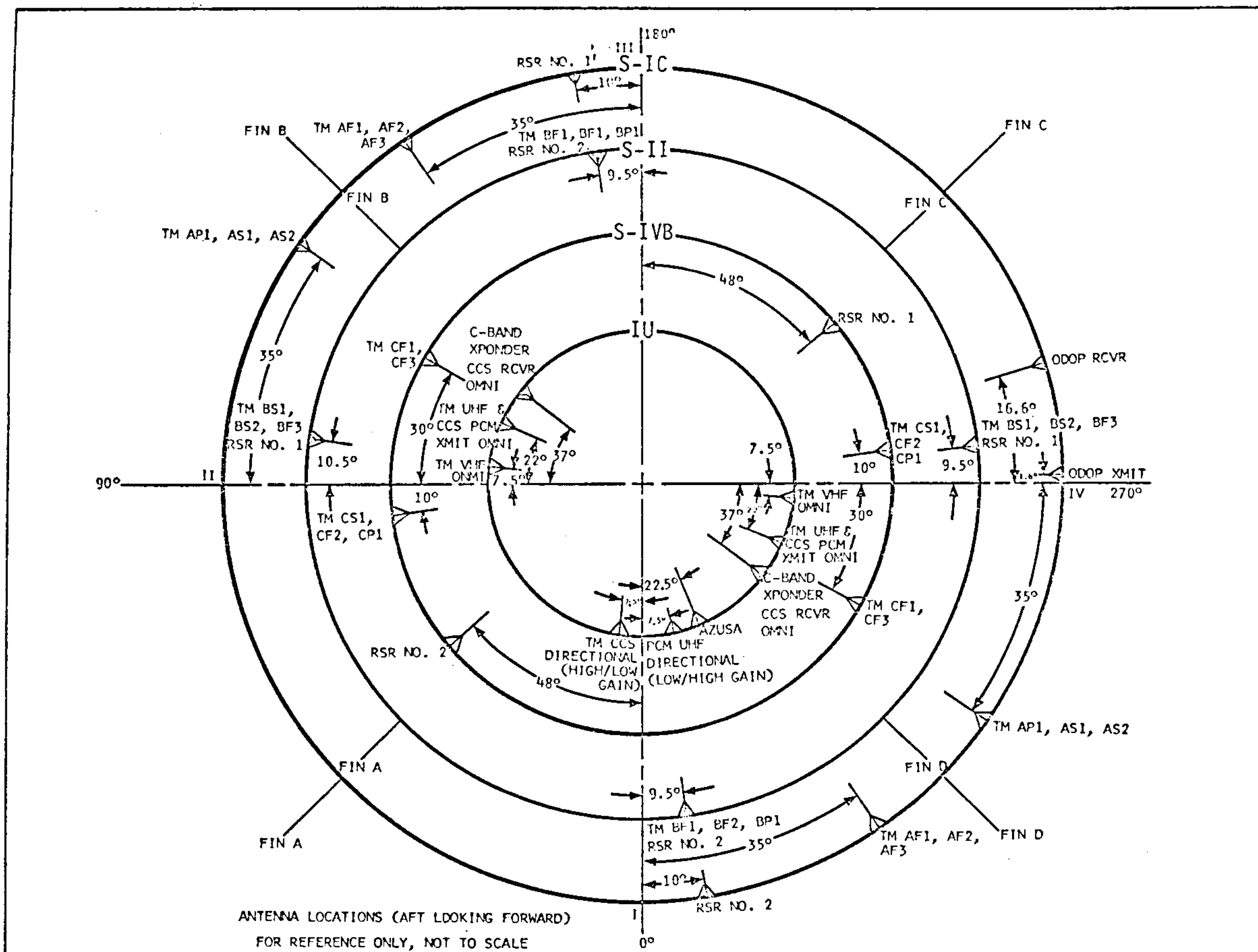
INSTRUMENTATION TRACKING SYSTEM SIGNAL FLOW

SLV AS503 | SIZE C | DWG NO 5.2.6

22 X 17 | PAGE 5-12 | SHEET 1 OF 1



Antenna Locations Aft Looking Forward (For Reference Only - Not to Scale)

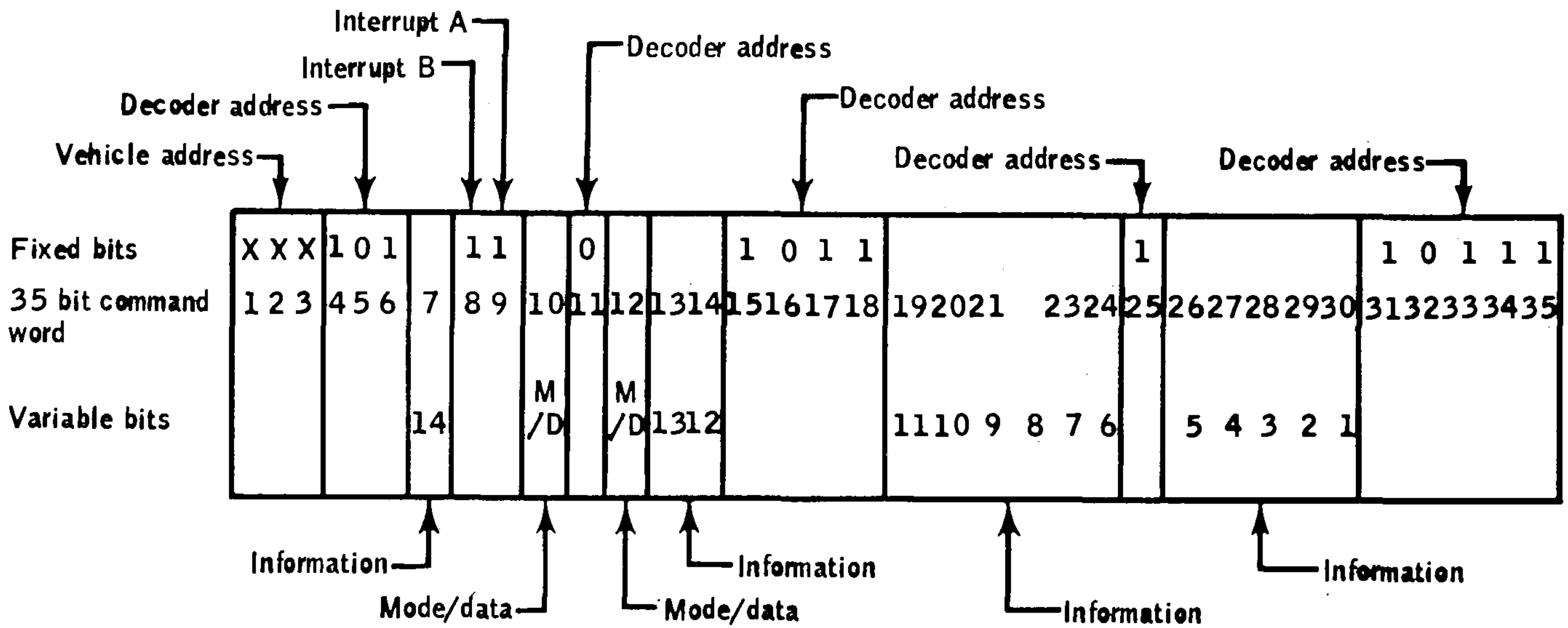
FIGURE 5.1

5.3 DESCRIPTION OF THE S-IVB TAPE RECORDER

There is no tape recorder in the S-IVB stage.

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. PRESSURE/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 LOADS. IF THE CRP IS ABSENT THE UPLINK WILL BE REPEATED.
J76-603	CCS AGC	
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	LOCK/NO LOCK STATUS OF 70 kHz SUBCARRIER. THE 70 kHz SUBCARRIER MUST BE IN LOCK PRIOR TO INITIATING A COMMAND. IF THE PRIME CARRIER OR THE SUBCARRIER IS NOT IN LOCK S/C REJECT WILL RESULT FROM AN ATTEMPTED UPLINK.

Figure 5-2.- Command TM data summary.



Bit 1 transmitted first
Bit 35 transmitted last

Figure 5.3.- Command word format.

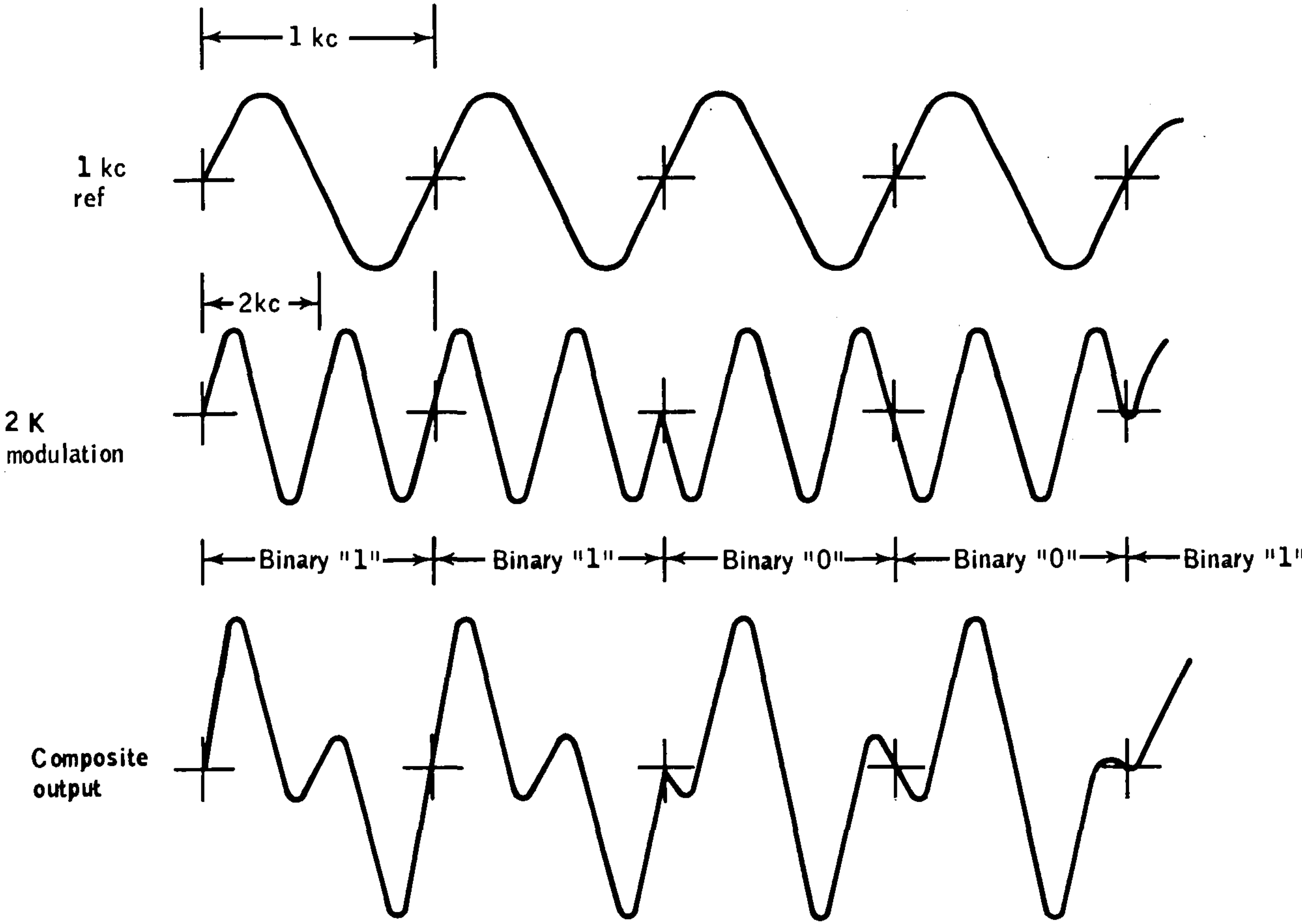


Figure 5.4.- PSK waveforms.

ITEM		FUNCTION	INFORMATION OBTAINED
1	UDL SUBC 70 kHz	ON/OFF STATUS OF UPLINK COMMAND/BACKUP VOICE SUBCARRIER	THE STATUS OF THE 70 kHz SUBCARRIER MUST BE KNOWN PRIOR TO INITIATING A COMMAND OR UTILIZING IT FOR BACKUP VOICE.
3	PRN UPLINK	ON/OFF STATUS OF UPLINK MODULATION OF THE BASEBAND.	THE PRESENCE (ON)/ABSENCE (OFF) OF MODULATION ON THE UPLINK BASEBAND WILL REFLECT THE PRESENCE OF THE TRANSMITTED PRN RANGING CODE. THE INFORMATION IS REQUIRED TO DETERMINE IF PROBLEMS ENCOUNTERED ARE ASSOCIATED WITH THE S/C OR THE GROUND SYSTEMS.
11	PCM SUBC LOCK (PM) 1.024 kHz	LOCK/NO LOCK STATUS OF PM DOWNLINK PCM SUBCARRIER DEMODULATOR.	THE STATUS OF THE PM DOWNLINK PCM SUBCARRIER DEMODULATOR IS REQUIRED IN ORDER TO DETERMINE QUALITY OF THE DOWNLINK DATA DUE TO MARGINAL LOOK ANGLES, CIRCUIT MARGINS AND TO FACILITATE S/C HANDOVER.
12	PCM SUBC LOCK (PM)	LOCK/NO LOCK STATUS OF FM DOWNLINK PCM SUBCARRIER DEMODULATOR.	THE LOCK/NO LOCK STATUS OF THE FM PCM DOWNLINK SUBCARRIER DEMODULATOR IS REQUIRED TO DETERMINE QUALITY OF DOWNLINK DATA.

Figure 5-5.- Ground generated events for command evaluation.

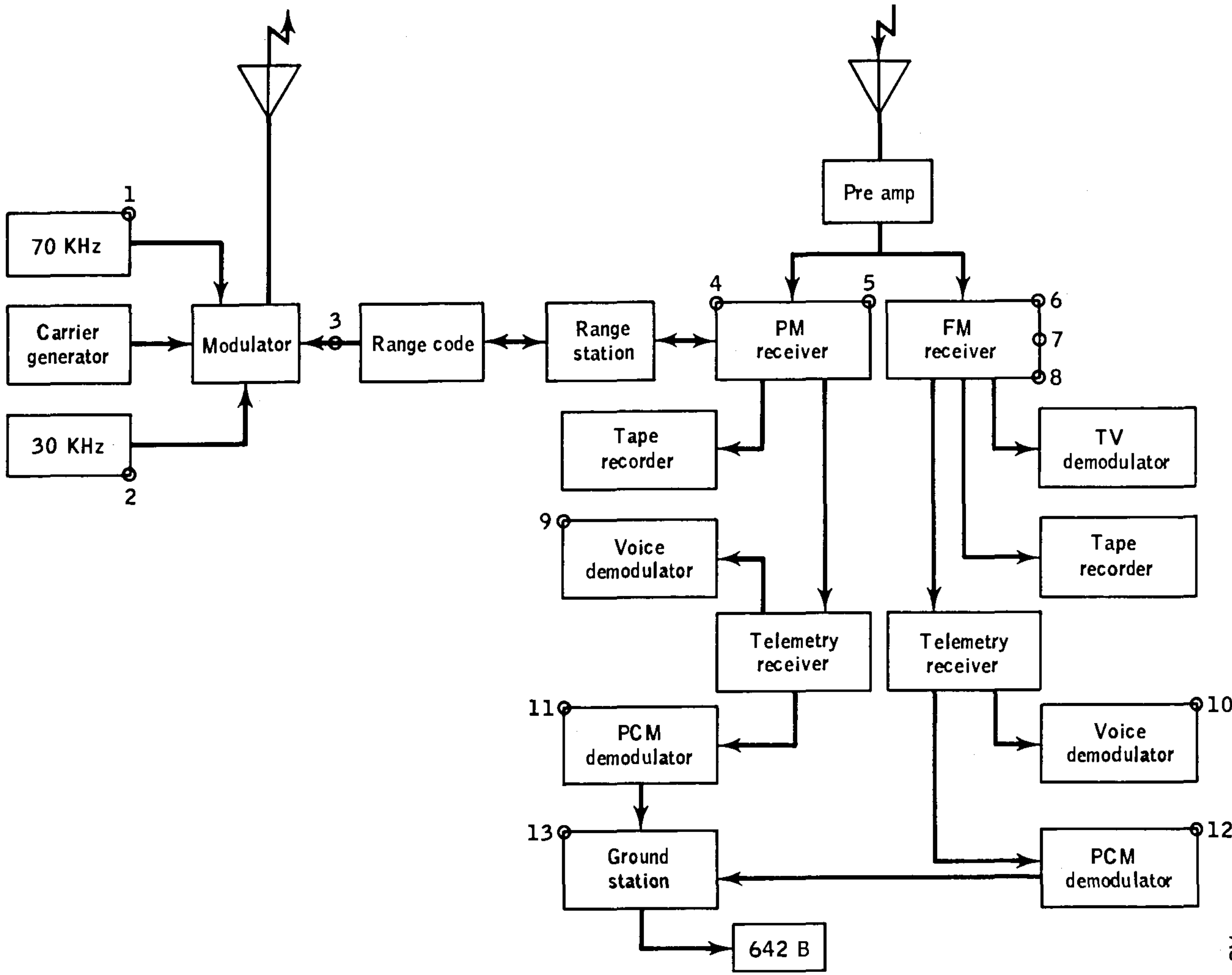
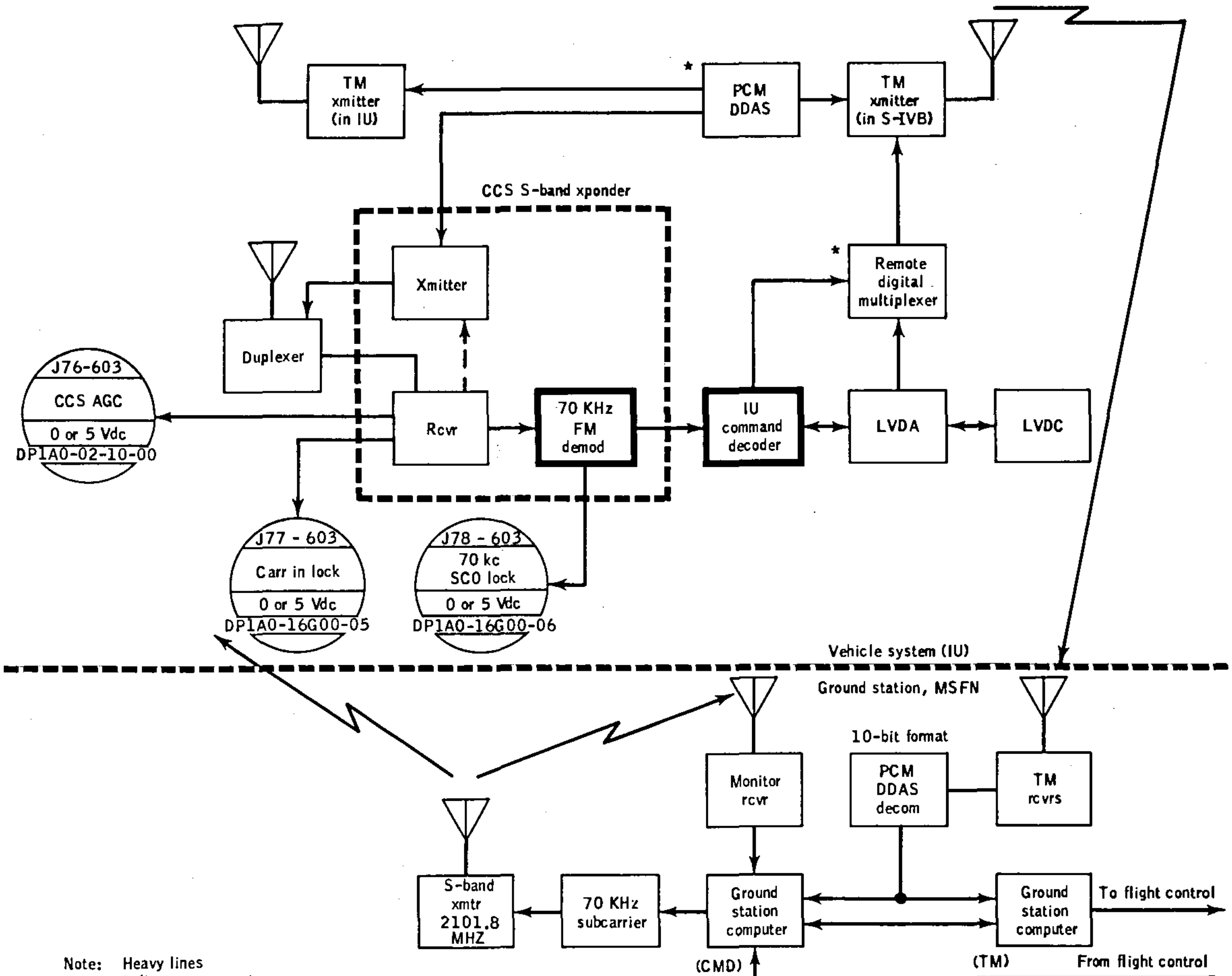


Figure 5.6.- Schematic of ground generated events.



Note: Heavy lines indicate components of the IU command system

*PCM DDAS references IU or IVB.
The IVB multiplexer is an analogue MUX

Figure 5.7.- S-V IU command system.

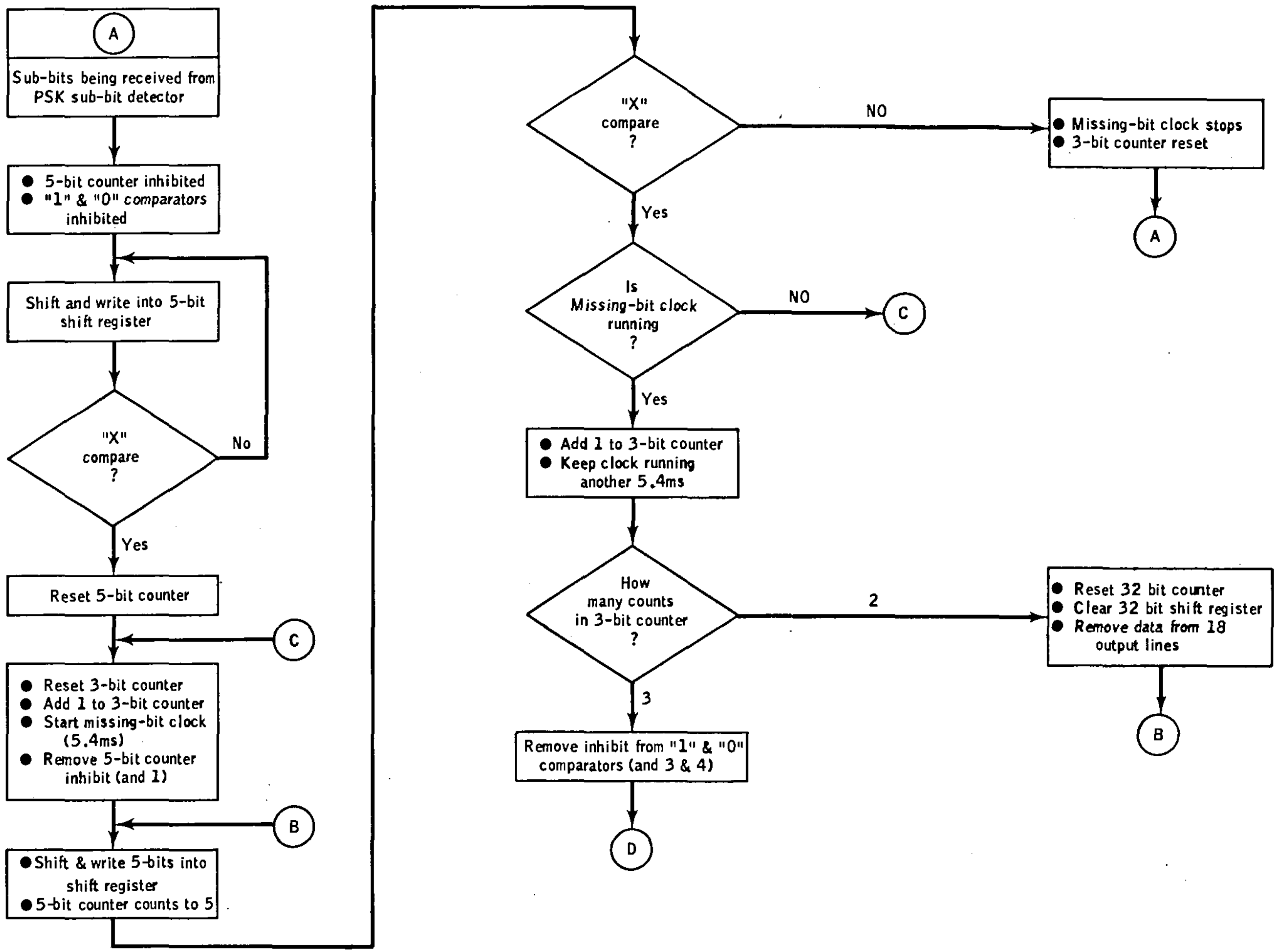


Figure 5.8.- Flow diagram - main decoder (part 1).

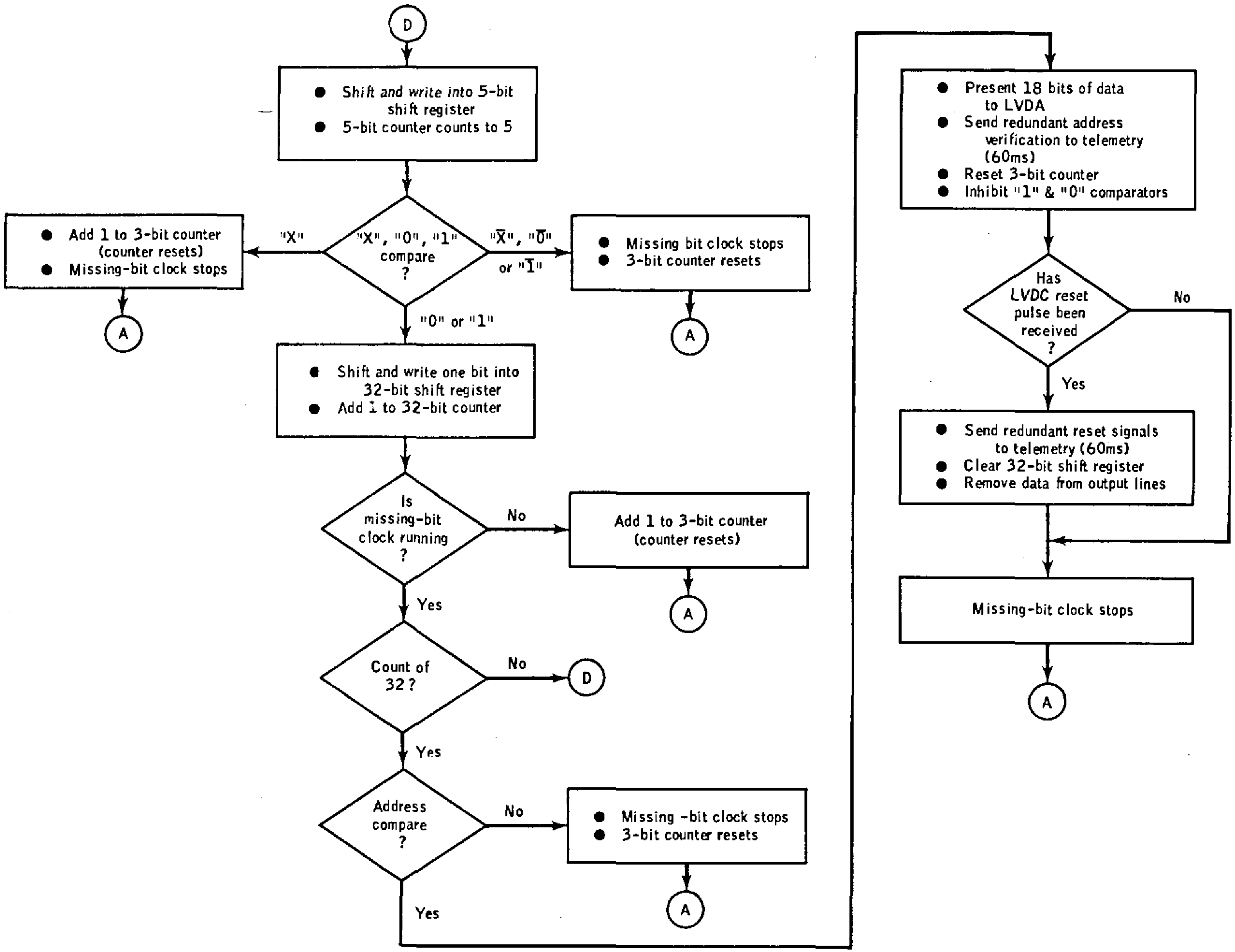


Figure 5.9.- Flow diagram main decoder (part II).

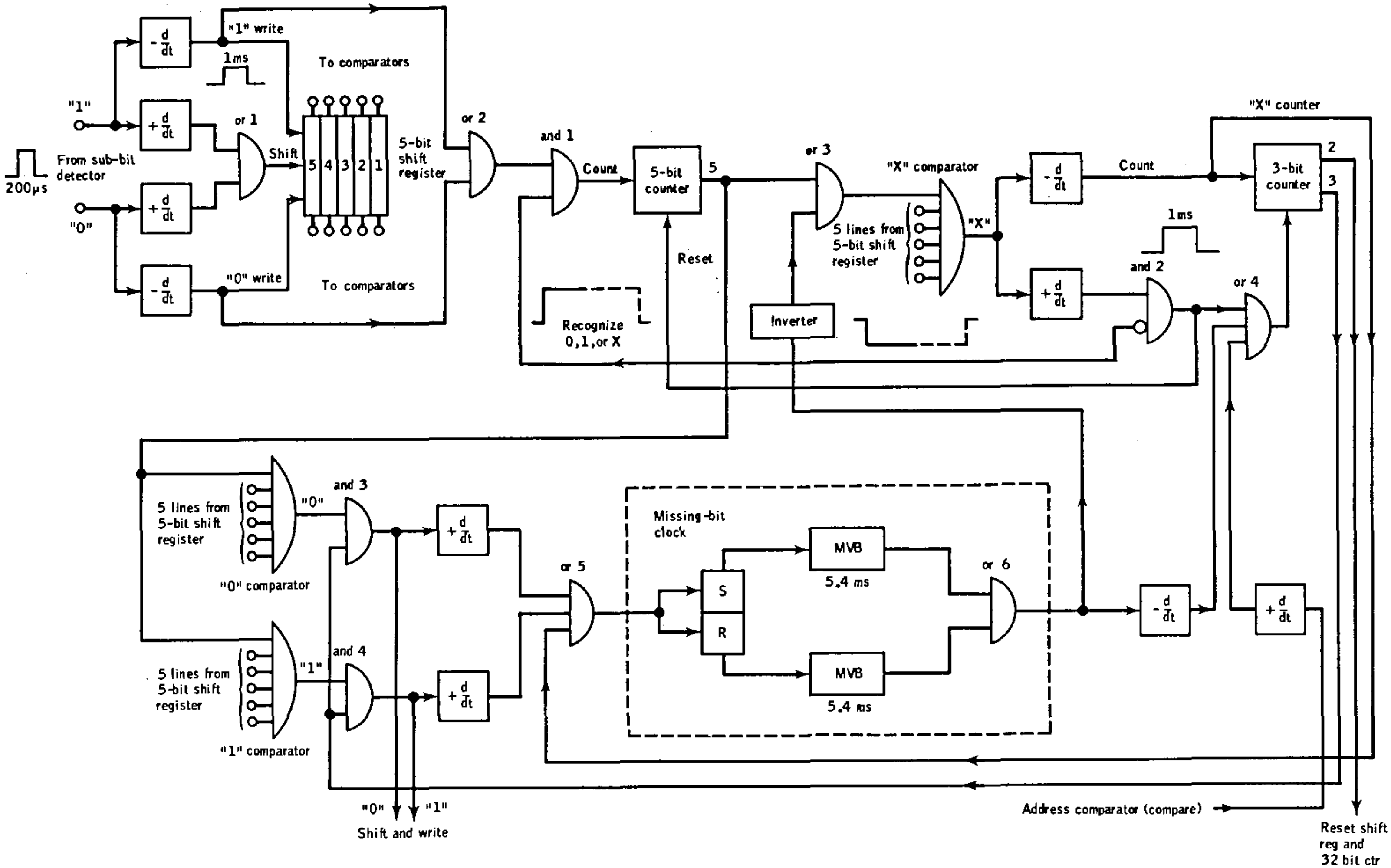


Figure 5.10.- Block diagram main decoder (part I).

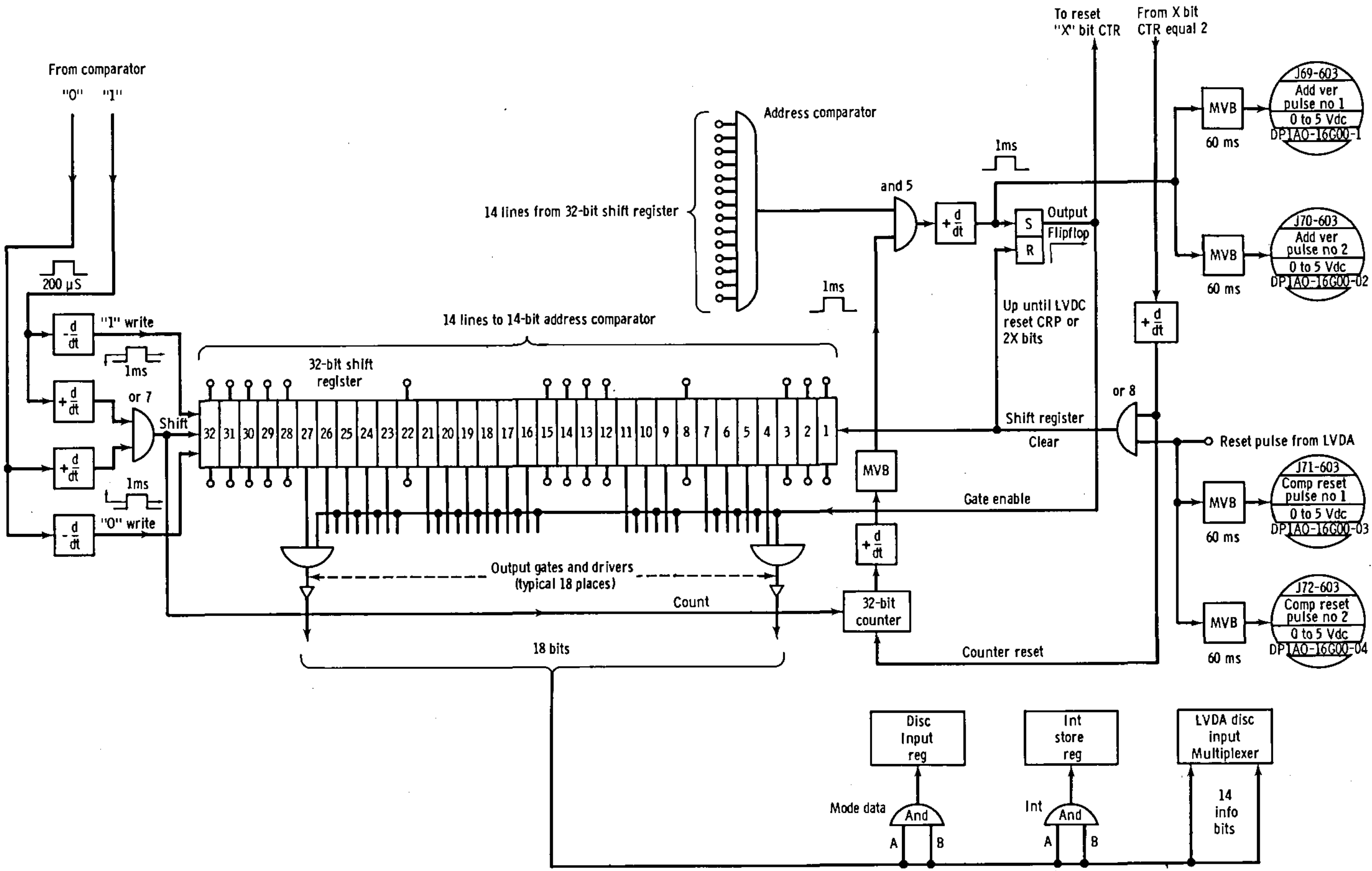


Figure 5.11. - Block diagram main decoder (part II).

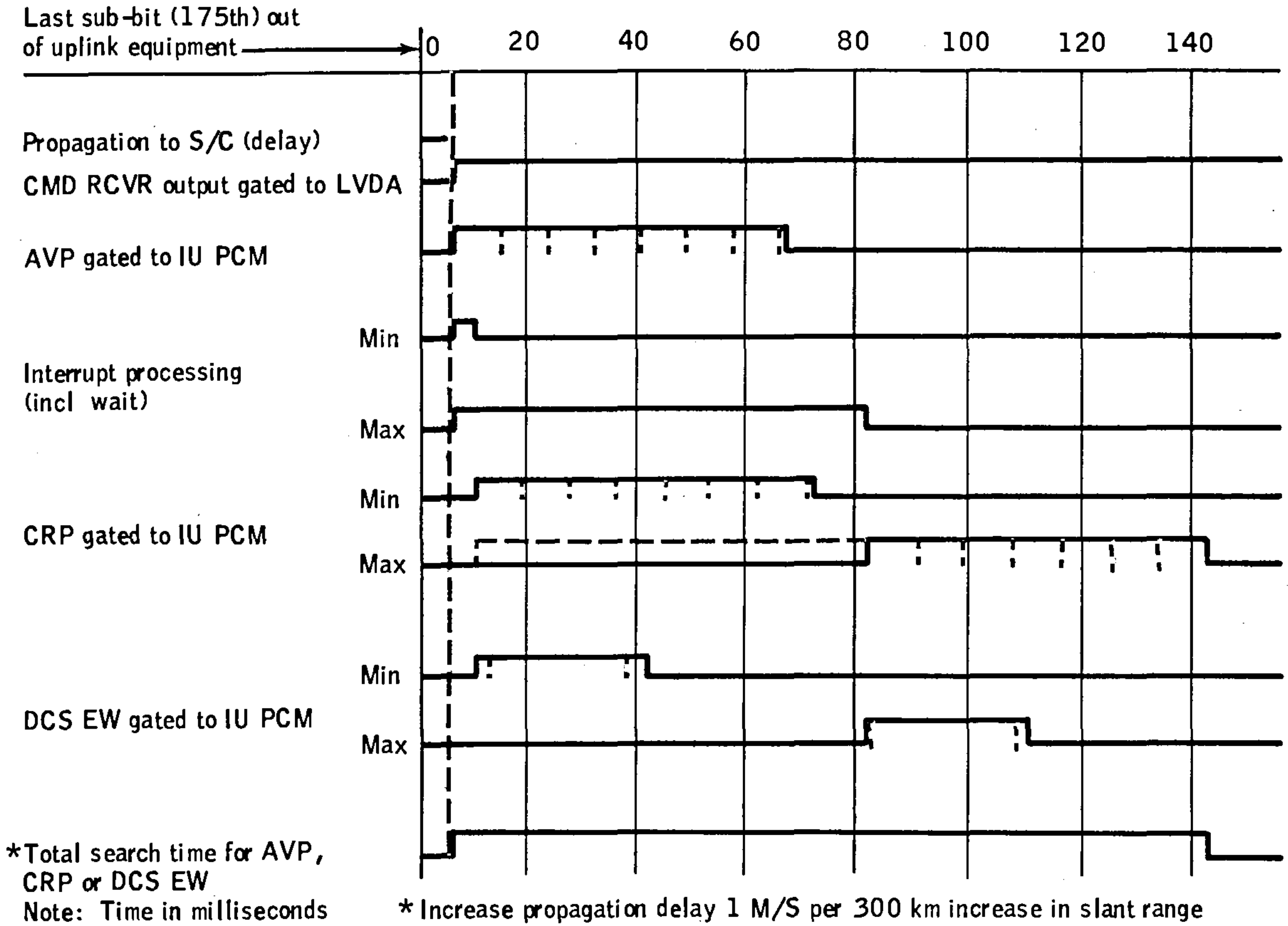


Figure 5.12.- On board processing timeline.

SECTION 6

GUIDANCE AND NAVIGATION SYSTEM

6.1 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 liftoff + 12 seconds.

The roll maneuver is required to align S-IC location 1 (at LC39A, location 1 is aligned to 90°) to the flight azimuth of 72°.

B. A pitch maneuver is also programed during S-IC boost beginning at liftoff + 12 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 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 is frozen for staging and the S-II is cut off.

D. The attitude hold then continues until about 10 seconds after J-2 ignition. The second active guidance period directs the S-IVB/IU to the proper altitude, velocity and attitude for the AS-503 mission 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 6-I.- LVDC TELEMETRY NOMENCLATURE, TAGS AND SCALING

NAME	MCC ABBR	HOSC ABBR	PIO	MCC PCM	HOSC PCM	MCC SCALING	HOSC SCALING
TIME SINCE GRR	TAS	TASEC	000	2000	0400	DATA BIT 11 = 1 SEC	SIGN +15
X-COMPONENT OF SPACE-FIXED POSITION	XS	XS	044	2110	0422	DATA BIT 3 = 1 M DATA BIT 3 = 16 M*	SIGN +23 SIGN +27
Y-COMPONENT OF SPACE-FIXED POSITION	YS	YS	050	2120	0424	DATA BIT 3 = 1 M DATA BIT 3 = 16 M*	SIGN +23 SIGN +27
Z-COMPONENT OF SPACE-FIXED POSITION	ZS	ZS	034	2070	0416	DATA BIT 3 = 1 M DATA BIT 3 = 16 M*	SIGN +23 SIGN +27
X-COMPONENT OF SPACE-FIXED VELOCITY	XDS	XDS	114	2230	0446	DATA BIT 12 = 1 M/S	SIGN +14
Y-COMPONENT OF SPACE-FIXED VELOCITY	YDS	YDS	120	2240	0450	DATA BIT 12 = 1 M/S	SIGN +14
Z-COMPONENT OF SPACE-FIXED VELOCITY	ZDS	ZDS	110	2220	0444	DATA BIT 12 = 1 M/S	SIGN +14
TOTAL SPACE-FIXED VELOCITY	VS	V	124	2250	0452	DATA BIT 12 = 1 M/S	SIGN +14
TIME IN TIME BASE	TBX	TB	031	6060	1414	DATA BIT 11 = 1 SEC	SIGN +15
TIME IN TIME BASE UPDATED	TBXU	TBB	030	2060	0414	DATA BIT 11 = 1 SEC	SIGN +15
TIME-TO-GO S-IVB CUTOFF	TTG	IGTSTR	460	2540	0530	DATA BIT 16 = 1 SEC	SIGN +10
YAW GUIDANCE ANGLE	XZ	CHIZ	001	6000	1400	DATA BIT 26 = 180 DEG	SIGN +0
ROLL GUIDANCE ANGLE	XX	CHIX	005	6010	1402	DATA BIT 26 = 180 DEG	SIGN +0
PITCH GUIDANCE ANGLE	XY	CHIY	011	6020	1404	DATA BIT 26 = 180 DEG	SIGN +0

TABLE 6-I.- LVDC TELEMETRY NOMENCLATURE, TAGS AND SCALING - Continued

NAME	MCC ABBR	HOSC ABBR	PIO	MCC PCM	HOSC PCM	MCC SCALING	HOSC SCALING
X-TOTAL ACTUAL GIMBAL ANGLE	θX	TLTHTX	021	6040	1410	DATA BIT 26 = 180 DEG	SIGN +0
Y-TOTAL ACTUAL GIMBAL ANGLE	θY	TLTHTY	025	6050	1412	DATA BIT 26 = 180 DEG	SIGN +0
Z-TOTAL ACTUAL GIMBAL ANGLE	θZ	TLTHTZ	015	6030	1406	DATA BIT 26 = 180 DEG	SIGN +0
TIME OF TIME BASE INITIATE	TBXI	TI	561	6740	1570	DATA BIT 11 = 1 SEC	SIGN +15
TIME TO GO TO RESTART PREP	TLQ1	TTGO	101	6200	1440	DATA BIT 26 = 1,000	SIGN +0
SECOND AND FOURTH TTG	T2I	IGT2I	171	6360	1474	DATA BIT 16 = 1 SEC	SIGN +10
DEVIATION IN S-IVB CUTOFF TIME	ΔT4	DT4	104	2210	0442	DATA BIT 18 = 1 SEC	SIGN +8
GUIDANCE MODE WORD 1	GMW1	MC25	421	6440	1510	N/A	
GUIDANCE MODE WORD 2	GMW2	MC26	401	6400	1500	N/A	
GUIDANCE STATUS WORD	GSW	MC24	415	6430	1506	N/A	
ORBITAL STATUS WORD	OSW	MC28	414	2430	0506	N/A	
ORBITAL MODE WORD	OMW	MC27	420	2440	0510	N/A	
ERROR MONITOR REGISTER	EMR	EMRR	435	6470	1516	N/A	

NAME	MCC ABBR	HOSC ABBR	PIO	MCC PCM	HOSC PCM	MCC SCALING	HOSC SCALING
SINGLE WORD DUMP HEADER WORD	SWD HW	N/A	111	6221	1445		
SINGLE WORD DUMP DATA WORD	SWD DW	N/A	115	6231	1447		

NAME	MEMORY LOCATION MODULE	SECTOR	ADDRESS	MCC SCALING	HOSC SCALING
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

TABLE 6-I.- LVDC TELEMETRY NOMENCLATURE, TAGS AND SCALING - Continued

NAME	MCC ABBR	HOSC ABBR	PIO	MCC PCM	HOSC PCM	MCC SCALING
SECTOR DUMP HEADER WORD	SDHW	N/A	470	2561	0535	N/A
WORD 1			474	2571	0537	
WORD 2			500	2601	0541	
WORD 3			504	2611	0543	
WORD 4			510	2621	0545	
WORD 5			514	2631	0547	
WORD 6			520	2641	0551	
WORD 7			524	2651	0553	
WORD 8			530	2661	0555	
WORD 9			534	2671	0557	
WORD 10			540	2701	0561	
WORD 11			544	2711	0563	
WORD 12			550	2721	0565	
WORD 13			554	2731	0567	
WORD 14			560	2741	0571	
WORD 15			564	2751	0573	
WORD 16			570	2761	0575	

TABLE 6-I.- LVDC TELEMETRY NOMENCLATURE, TAGS AND SCALING - Continued

NAV UPDATE QUANTITY	MCC ABBR	HOSC ABBR	MEMORY LOCATION MODULE	SECTOR	ADDRESS	MCC SCALING	HOSC SCALING
Z-COMPONENT OF SPACE-FIXED VELOCITY	ZDNU	ZDS	4	15	371	DATA BIT 12 = 1 M/S	SIGN +14, M/S
X-COMPONENT OF SPACE-FIXED VELOCITY	XDNU	XDS	4	15	372	DATA BIT 12 = 1 M/S	SIGN +14, M/S
Y-COMPONENT OF SPACE-FIXED VELOCITY	YDNU	YDS	4	15	373	DATA BIT 12 = 1 M/S	SIGN +14, M/S
Z-COMPONENT OF SPACE-FIXED POSITION	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	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	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 S	SIGN +15, S

TABLE 6-I.- LVDC TELEMETRY NOMENCLATURE, TAGS AND SCALING - Continued

ORBIT TARGET UPDATE QUANTITY	MCC ABBR	HOSC ABBR	MEMORY LOCATION MODULE	SECTOR	ADDRESS	MCC SCALING	HOSC SCALING
INCLINATION OF TARGET PLANE	i	INC	4	14	371	DATA BIT 25 = 90 DEG = .5 PIRAD	SIGN +0, DEG
DESCENDING NODE OF TARGET PLANE	θN	THN	4	14	372	DATA BIT 25 = 90 DEG = .5 PIRAD	SIGN +0, DEG
ECCENTRICITY OF TRANSFER ELLIPSE	eN	ECC	4	14	373	DATA BIT 26 = 1 (NO UNITS)	SIGN +0, DEG
ENERGY OF TRANSFER ELLIPSE	C3	C3	4	14	374	DATA BIT 5 = 1 M^2/S^2	SIGN +21, M^2/S^2
TRUE ANOMALY OF DESCENDING NODE	αD	ALPHAD	4	14	375	DATA BIT 25 = 90 DEG = .5 PIRAD	SIGN +0, DEG
TRUE ANOMALY OF INJECTION RADIUS VECTOR	φ'	F	4	14	376	DATA BIT 25 = 90 DEG = .5 PIRAD	SIGN +0, DEG
TIME TO INITIATE TB6	TRP	TRP	4	14	377	DATA BIT 11 = 1 SEC	SIGN +15, SEC

TABLE 6-I.- LVDC TELEMETRY NOMENCLATURE, TAGS AND SCALING - Concluded

SLV AS-503

NAME	MCC ABBR	HOSC ABBR	PIO	MCC PCM	HOSC PCM	MCC SCALING	HOSC SCALING
VEHICLE ALTITUDE	ALT	ONALT	534	2670	0556	DATA BIT 7 = 1 M	SIGN +19
TIME TO GO IN FIRST IGM	T1I	IGT1I	400	2400	0500	DATA BIT 16 = 1 SEC	SIGN +10
DISCRETE INPUT REGISTER	DIN	DI	465	6550	1532	N/A	
DISCRETE OUTPUT REGISTER	DOR	DORSW	425	6450	1512	N/A	
THIRD AND FIFTH IGM TIME TO GO	T3I	IGT3I	464	2550	0532	DATA BIT 16 = 1 SEC	SIGN +10
ACCELERATION	F/M	FOVM	144	2314	2462	DATA BIT 20 = 1 M/S^2	SIGN +6
STEERING PITCH	SMCP	SMCY	564	2752	4572	DATA BIT 25 = 90 DEG	SIGN +0
STEERING YAW	SMCY	SMCZ	560	2742	4570	DATA BIT 25 = 90 DEG	SIGN +0
FLIGHT PATH ANGLE	θT	IGTHAT	550	2720	0564	DATA BIT 25 = 90 DEG	SIGN +0
MINOR LOOP CHI Z	MLXZ	MLCHIZ	501	6600	1540	DATA BIT 25 = 90 DEG	SIGN +0
MINOR LOOP CHI X	MLXX	MLCHIX	505	6610	1542	DATA BIT 25 = 90 DEG	SIGN +0
MINOR LOOP CHI Y	MLXY	MLCHIY	511	6620	1544	DATA BIT 25 = 90 DEG	SIGN +0
BEGIN TELEMETRY CYCLE	BTC	CCCNT	575	6770	1576	N/A	

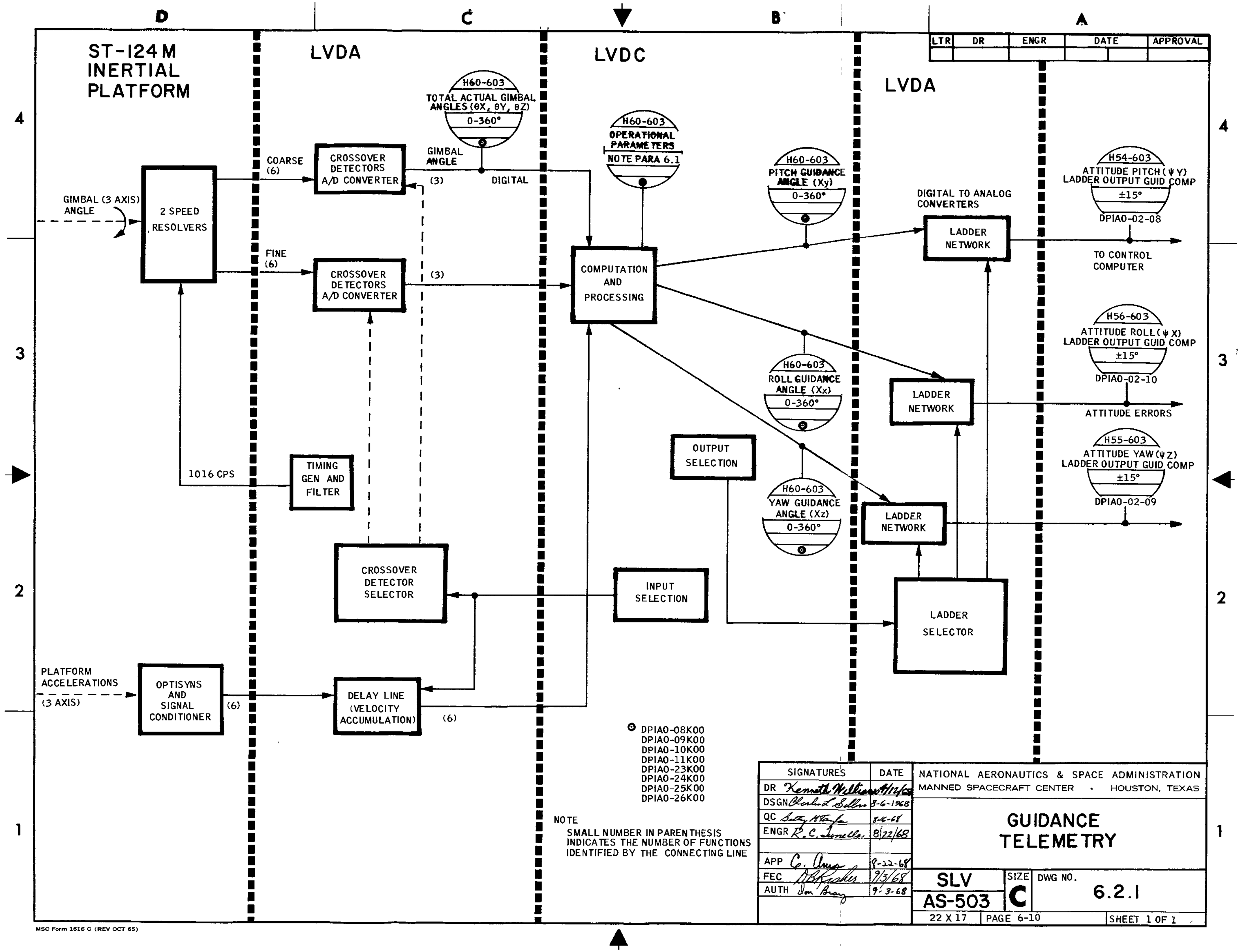
* The scaling on these items will be changed as indicated at second S-IVB cutoff. Uplink and downlink scaling in the ground system must be changed at this time.

6.2 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 but will not 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.


D
C
B
A
4
3
2
1
LTR
DR
ENGR
DATE
APPROVAL
ST-124M INERTIAL PLATFORM
LVDA
LVDC
LVDA
GIMBAL (3 AXIS) ANGLE
2 SPEED RESOLVERS
COARSE (6)
FINE (6)
CROSSOVER DETECTORS A/D CONVERTER
CROSSOVER DETECTORS A/D CONVERTER
(3)
(3)
GIMBAL ANGLE
DIGITAL
H60-603
TOTAL ACTUAL GIMBAL ANGLES (θX, θY, θZ)
0-360°
H60-603
OPERATIONAL PARAMETERS
NOTE PARA 6.1
COMPUTATION AND PROCESSING
H60-603
PITCH GUIDANCE ANGLE (Xy)
0-360°
H60-603
ROLL GUIDANCE ANGLE (Xx)
0-360°
H60-603
YAW GUIDANCE ANGLE (Xz)
0-360°
DIGITAL TO ANALOG CONVERTERS
LADDER NETWORK
LADDER NETWORK
LADDER NETWORK
H54-603
ATTITUDE PITCH (ψY)
LADDER OUTPUT GUID COMP
±15°
DPIA0-02-08
TO CONTROL COMPUTER
H56-603
ATTITUDE ROLL (ψX)
LADDER OUTPUT GUID COMP
±15°
DPIA0-02-10
ATTITUDE ERRORS
H55-603
ATTITUDE YAW (ψZ)
LADDER OUTPUT GUID COMP
±15°
DPIA0-02-09
1016 CPS
TIMING GEN AND FILTER
OUTPUT SELECTION
CROSSOVER DETECTOR SELECTOR
INPUT SELECTION
LADDER SELECTOR
PLATFORM ACCELERATIONS (3 AXIS)
OPTISYNS AND SIGNAL CONDITIONER
(6)
DELAY LINE (VELOCITY ACCUMULATION)
(6)
DPIA0-08K00
DPIA0-09K00
DPIA0-10K00
DPIA0-11K00
DPIA0-23K00
DPIA0-24K00
DPIA0-25K00
DPIA0-26K00
NOTE
SMALL NUMBER IN PARENTHESIS INDICATES THE NUMBER OF FUNCTIONS IDENTIFIED BY THE CONNECTING LINE
SIGNATURES
DATE
DR
DSGN 8-6-1968
QC 8-16-68
ENGR 8/22/68
APP 8-22-68
FEC
AUTH 9-3-68
NATIONAL AERONAUTICS & SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER · HOUSTON, TEXAS
GUIDANCE TELEMETRY
SLV AS-503
SIZE C
DWG NO. 6.2.1
22 X 17
PAGE 6-10
SHEET 1 OF 1
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6.3 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.

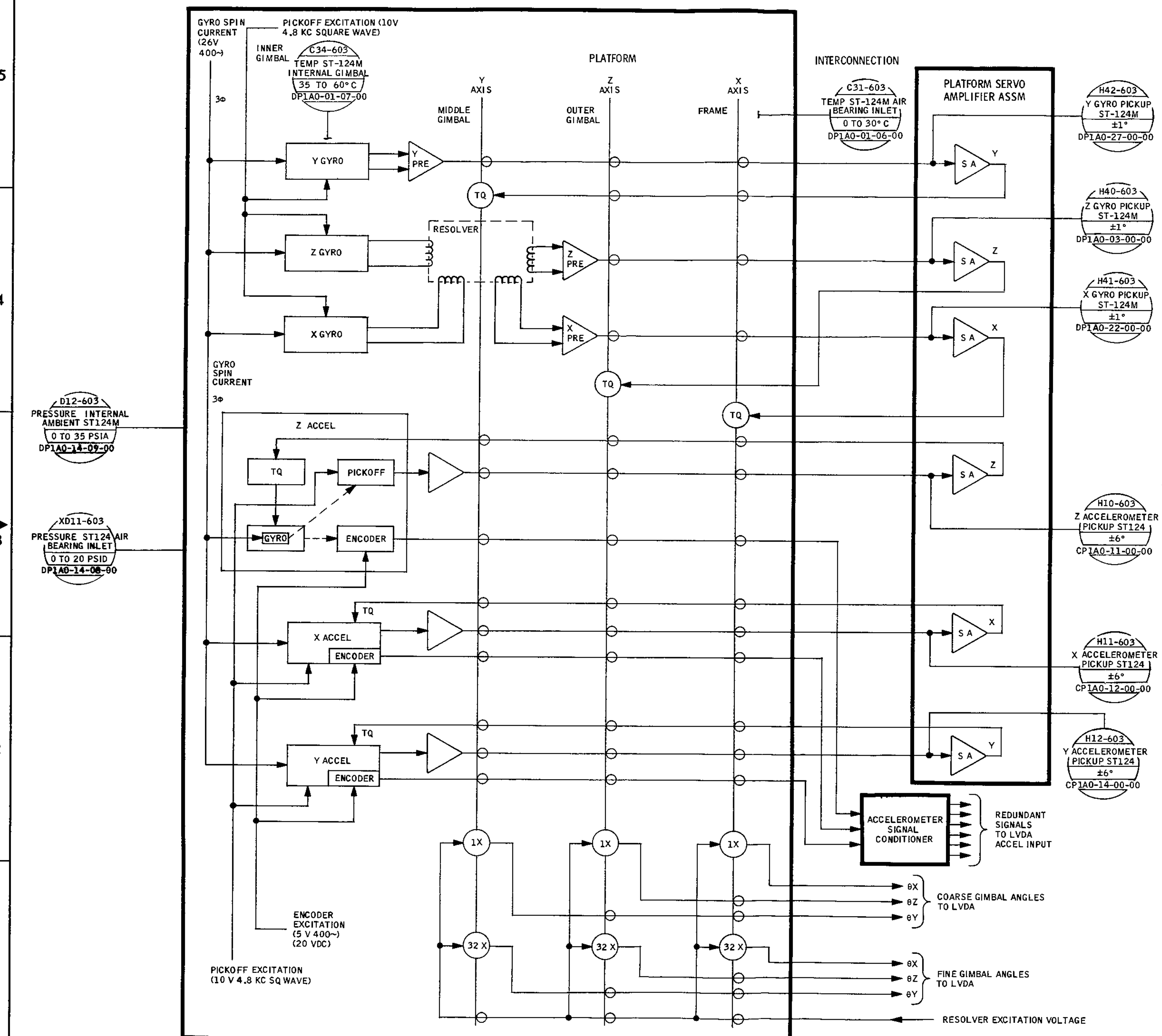
C. At approximately liftoff minus 17 seconds, the platform is released to maintain an inertial reference initiated at the launch point. At this point, the LVDC begins navigation using velocity accumulations derived from the ST-124M inertial platform.

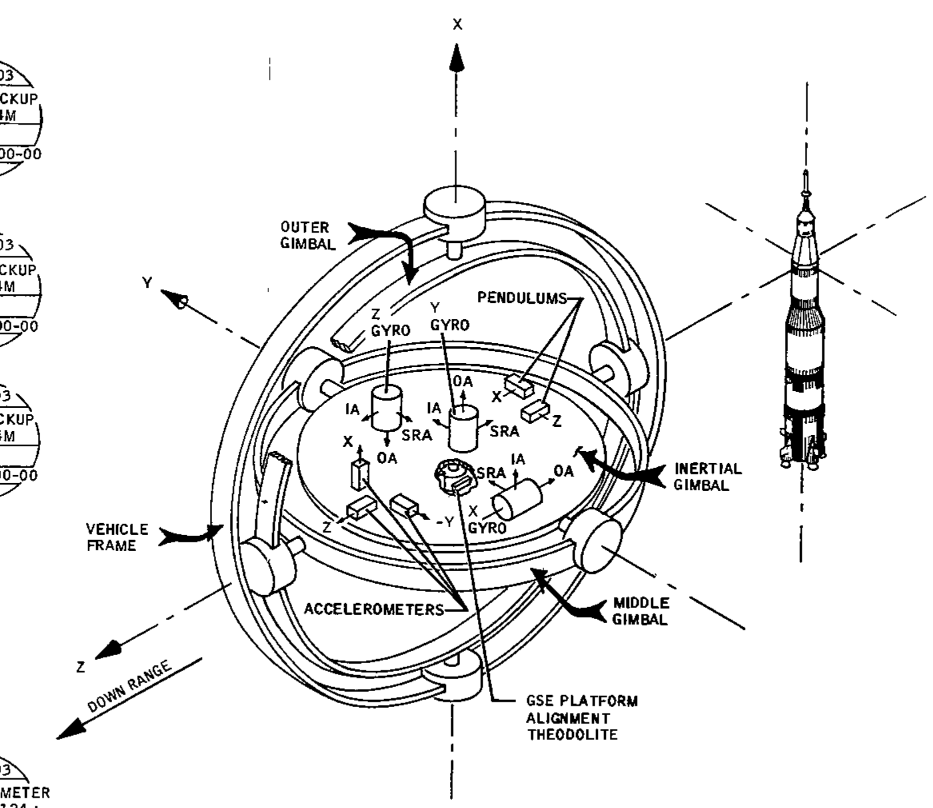
6.4 GYRO AND ACCELEROMETER SERVOSYSTEM

A. 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.

6.5 ACCELEROMETER SIGNAL CONDITIONER

A. The accelerometer signal conditioner accepts the velocity signals 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 [signature]	4/29/68
DSGN [signature]	8/6/1968
QC [signature]	8-16-68
ENGR [signature]	8/22/68
APP [signature]	8-22-68
FEC [signature]	9/3/68
AUTH [signature]	9-3-68

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GUIDANCE-INERTIAL PLATFORM

SLV AS 503 | SIZE D | DWG NO 6.5.1

34 X 22 | 6-14 | SHEET

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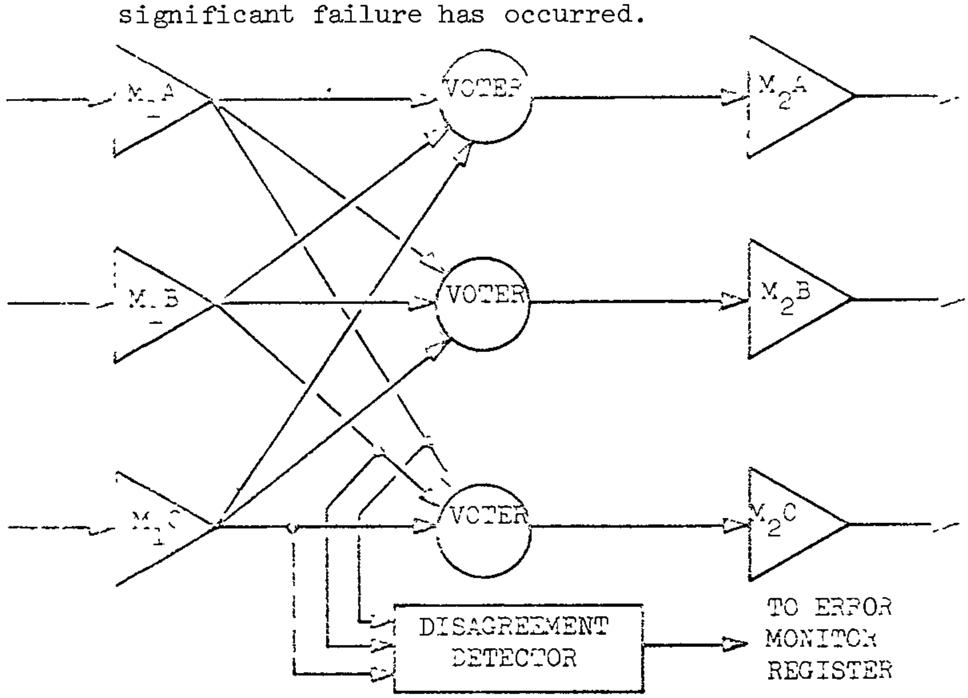
*

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.

6.6 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 or 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:

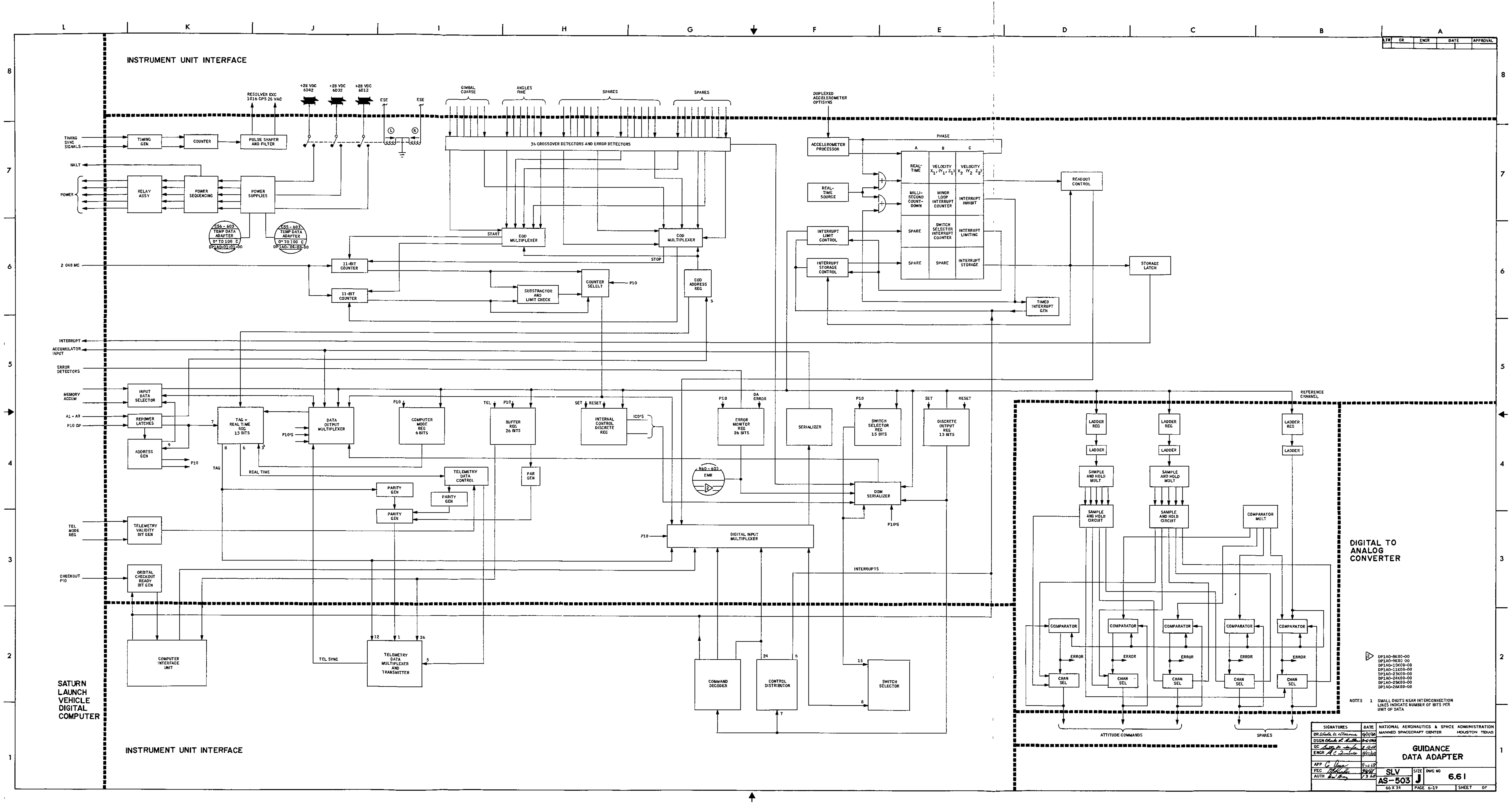
1. The storage of telemetry data from the computer and data adapter in the buffer registers.
2. The temporary storage of telemetry scanner addresses during orbital checkout.
3. The transmission of guidance data from the computer to the analog control computer.

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

1. Digital-to-analog, analog-to digital, and signal level conversions.
2. The formation of 40-bit launch computer and telemetry words from 26-bit computer words.
3. 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):

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



INSTRUMENT UNIT INTERFACE
SATURN LAUNCH VEHICLE DIGITAL COMPUTER
DIGITAL TO ANALOG CONVERTER
TIMING SYNC SIGNALS
TIMING GEN
COUNTER
PULSE SHAPER AND FILTER
RESOLVER EXC 1016 CPS 26 VAC
+28 VDC 6042
+28 VDC 6032
+28 VDC 6012
ESE
HALT
POWER
RELAY ASSY
POWER SEQUENCING
POWER SUPPLIES
GIMBAL COARSE
ANGLES FINE
SPARES
36 CROSSOVER DETECTORS AND ERROR DETECTORS
START
STOP
CDU MULTIPLEXER
CDU ADDRESS REG
2.048 MC
11-BIT COUNTER
SUBSTRACTOR AND LIMIT CHECK
COUNTER SELECT
DUPLEXED ACCELEROMETER OPTISYNS
ACCELEROMETER PROCESSOR
PHASE
REAL-TIME SOURCE
REAL-TIME
VELOCITY
MILLI-SECOND COUNT-DOWN
MINOR LOOP INTERRUPT COUNTER
INTERRUPT INHIBIT
SPARE
SWITCH SELECTOR INTERRUPT COUNTER
INTERRUPT LIMITING
INTERRUPT STORAGE
INTERRUPT LIMIT CONTROL
INTERRUPT STORAGE CONTROL
READOUT CONTROL
STORAGE LATCH
TIMED INTERRUPT GEN
INTERRUPT
ACCUMULATOR INPUT
ERROR DETECTORS
MEMORY ACCUM
INPUT DATA SELECTOR
A1 + A9
P10 CP
REPOWER LATCHES
ADDRESS GEN
TAG + REAL TIME REG 13 BITS
DATA OUTPUT MULTIPLEXER
COMPUTER MODE REG 6 BITS
BUFFER REG 26 BITS
INTERNAL CONTROL DISCRETE REG
ERROR MONITOR REG 26 BITS
SERIALIZER
SWITCH SELECTOR REG 15 BITS
DISCRETE OUTPUT REG 13 BITS
REAL TIME
TELEMETRY DATA CONTROL
PARITY GEN
PAR GEN
EMR
DDM SERIALIZER
TEL MODE REG
TELEMETRY VALIDITY BIT GEN
DIGITAL INPUT MULTIPLEXER
INTERRUPTS
CHECKOUT P10
ORBITAL CHECKOUT READY BIT GEN
COMPUTER INTERFACE UNIT
TEL SYNC
TELEMETRY DATA MULTIPLEXER AND TRANSMITTER
COMMAND DECODER
CONTROL DISTRIBUTOR
SWITCH SELECTOR
REFERENCE CHANNEL
LADDER REG
LADDER
SAMPLE AND HOLD MULT
SAMPLE AND HOLD CIRCUIT
COMPARATOR MULT
COMPARATOR
ERROR
CHAN SEL
ATTITUDE COMMANDS
SPARES
DP1A0-8K00-00
DP1A0-9K00-00
DP1A0-10K00-00
DP1A0-11K00-00
DP1A0-23K00-00
DP1A0-24K00-00
DP1A0-25K00-00
DP1A0-26K00-00
NOTES 1 SMALL DIGITS NEAR INTERCONNECTION LINES INDICATE NUMBER OF BITS PER UNIT OF DATA
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MANNED SPACECRAFT CENTER HOUSTON TEXAS
GUIDANCE DATA ADAPTER
SLV AS-503
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6.61
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6.7 LAUNCH VEHICLE DIGITAL COMPUTER

A. The LVDC is a serial machine using a random access magnetic core memory. It uses micro-miniature 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.

Six 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 SLV AS-503

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	

MODE CODE 24 GUIDANCE STATUS WORD SLV AS-503

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
17	D9	SWITCH SELECTOR CHANNEL "B" SELECTED
18	D8	
19	D7	
20	D6	COD MULTIPLEXER A BAD
21	D5	COD MULTIPLEXER B BAD
22	D4	Z ACCELEROMETER 0 READING
23	D3	X ACCELEROMETER 0 READING
24	D2	
25	D1	

MODE CODE 25 | GUIDANCE MODE WORD 1 | SLV AS-503

LVDC 10 BIT OCTAL	FCO 8 BIT OCTAL	BIT DESCRIPTION
S	D26	GUIDANCE REFERENCE RELEASE (GRR) (INT 7) (START TBO)
1	D25	LIFTOFF (START TB1) (DIN 24)
2	D24	START PITCH & ROLL
3	D23	STOP ROLL
4	D22	
5	D21	STOP PITCH
6	D20	START (TB2)
7	D19	S-IC OUTBOARD ENGINE CUTOFF (START TB3) (INT 5)
8	D18	S-IC INBOARD ENGINE OUT (DIN 11)
9	D17	S-IC OUTBOARD ENGINE OUT (DIN 14)
10	D16	
11	D15	S-II SKIRT SEPARATION (DIN 15)
12	D14	BEGIN FIRST PHASE IGM GUIDANCE (S-II FIRST BURN)
13	D13	S-II ENGINE MIXTURE RATIO CHANGE (EMRC) (2ND PHASE IGM)
14	D12	S-II CUTOFF (START TB4)
15	D11	S-II OUTBOARD ENGINE OUT (DIN 21)
16	D10	S-II INBOARD ENGINE OUT (DIN 13)
17	D9	S-II/S-IVB SEPARATION (DIN 10)
18	D8	
19	D7	
20	D6	FIRST S-IVB IGNITION
21	D5	START 3RD PHASE IGM
22	D4	START S-IVB TERMINAL GUIDANCE
23	D3	FIRST S-IVB CUTOFF COMMAND
24	D2	BEGIN TIME BASE 5 (T_5)
25	D1	START S-IVB CHILLDOWN SEQUENCE (START TB6)

MODE CODE 26 GUIDANCE MODE WORD 2 SLV AS-503

LVDC 10 BIT OCTAL	FCO 8 BIT OCTAL	BIT DESCRIPTION
S	D26	START S-IVB REIGNITION (SECOND BURN)
1	D25	S-IVB REIGNITION (THIRD BURN)
2	D24	
3	D23	
4	D22	SECOND S-IVB CUTOFF COMMAND
5	D21	
6	D20	START TB7
7	D19	S/C INIT OF S-IVB CUTOFF (DIN 17 OR 22)
8	D18	CONTROL COMPUTER SWITCHED TO S/C (DIN 9)
9	D17	S/C INITIATION OF S-II/S-IVB SEPARATION (DIN 17 OR 22)
10	D16	
11	D15	
12	D14	
13	D13	
14	D12	
15	D11	STEERING MISALIGNMENT CORRECTION (SMC)
16	D10	O_2 - H_2 BURNER MALFUNCTION 1 (T_{6A})
17	D9	TLC - SIMULTANEOUS MEMORY FAILURE (INT 9)
18	D8	GUIDANCE FAILURE (D04)
19	D7	
20	D6	START S-IVB REIGNITION SEQUENCE (THIRD BURN)
21	D5	START S-IVB REIGNITION SEQUENCE (THIRD BURN - NO SECOND BURN)
22	D4	THIRD S-IVB CUTOFF COMMAND
23	D3	BEGIN TIME BASE 9
24	D2	
25	D1	PREFLIGHT ABORT

MODE CODE 27 ORBITAL MODE WORD SLV AS-503

LVDC 10 BIT OCTAL	FCO 8 BIT OCTAL	BIT DESCRIPTION
S	D26	POWERED FLIGHT DCS INHIBIT REMOVED
1	D25	
2	D24	
3	D23	
4	D22	
5	D21	PCM & CCS ANT - LOW GAIN
6	D20	PCM & CCS ANT - HIGH GAIN
7	D19	PCM & CCS ANT - OMNI
8	D18	NAVIGATION UPDATE RECEIVED
9	D17	TIME BASE UPDATE RECEIVED
10	D16	TRACK LOCAL HORIZ - POS I DOWN (MAN 2, 4, 6, 9, 10, 12)
11	D15	TRACK LOCAL HORIZ IN RETRO ATT - POS I UP (MAN 5)
12	D14	BEGIN ORBITAL SAFING SEQUENCE (SET AT TB9 + T19FS IN ORBITAL GUIDANCE)
13	D13	INERTIAL ATTITUDE HOLD IN PROGRESS (MAN 1, 3, 7, 8, 11)
14	D12	
15	D11	
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)
19	D7	INHIBIT MANEUVER 3 (DCS INHIBIT #1)
20	D6	INHIBIT MANEUVER 4 (DCS INHIBIT #2) PROGRAMED INITIALLY SET
21	D5	INHIBIT MANEUVER 5 (DCS INHIBIT #3)
22	D4	RESTART MANEUVER INHIBIT SET (PROGRAMED INITIALLY SET)
23	D3	
24	D2	
25	D1	

MODE CODE 28 | ORBITAL STATUS WORD | SLV AS-503

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	
13	D13	
14	D12	
15	D11	
16	D10	
17	D9	
18	D8	
19	D7	
20	D6	COD MULTIPLEXOR A BAD
21	D5	COD MULTIPLEXOR B BAD
22	D4	
23	D3	
24	D2	
25	D1	

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 −	OCTAL +	ENGR K	OCTAL −	OCTAL +	ENGR K	OCTAL −	OCTAL +	ENGR K	OCTAL −	OCTAL +	ENGR 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 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	

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	142	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

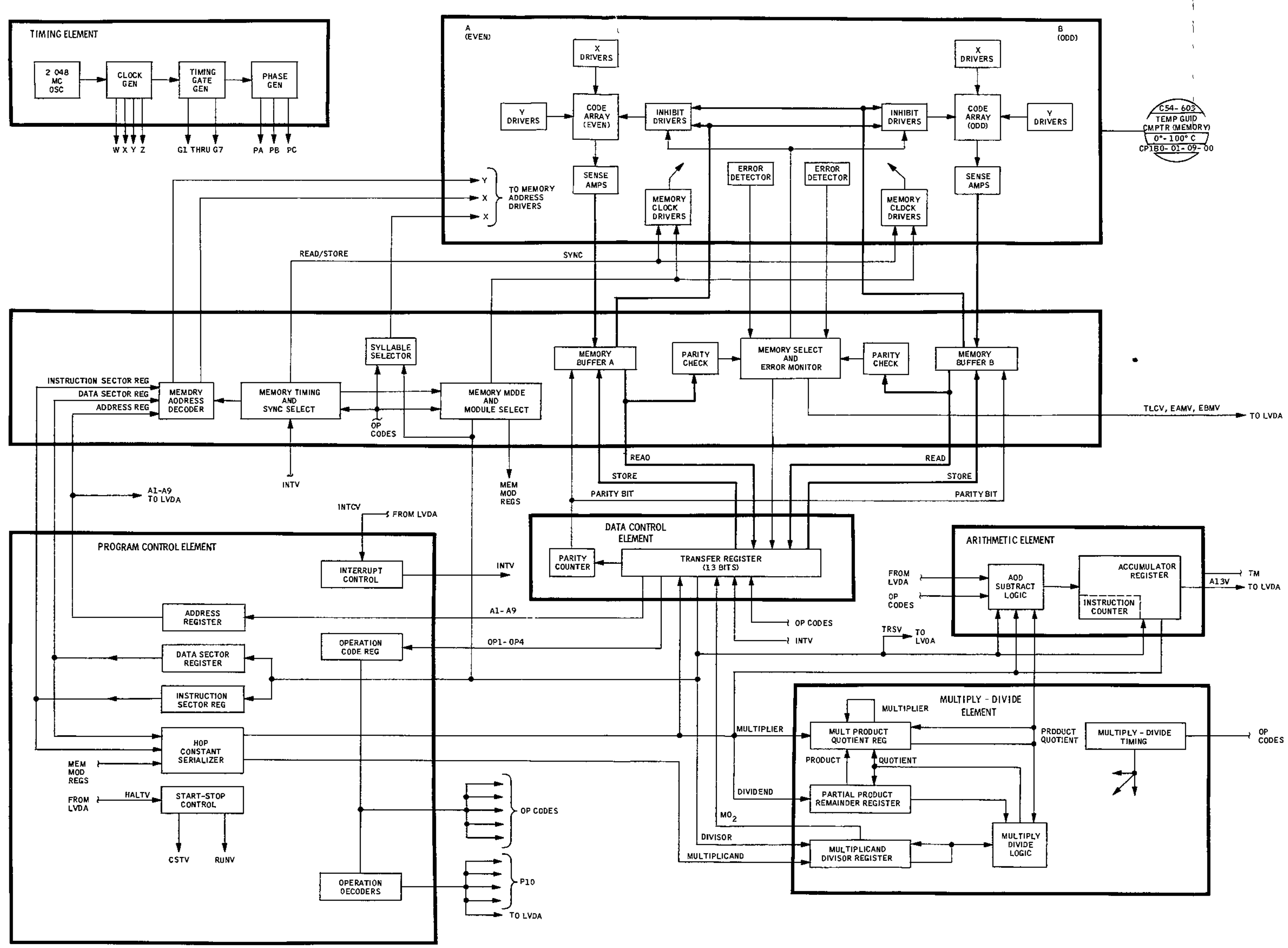
LVDC 10 BIT OCTAL	FCO 8 BIT OCTAL	BIT DESCRIPTION	
S	D26	180	DEGREES
1	D25	90	
2	D24	45	
3	D23	22.5	
4	D22	11.25	
5	D21	5.625	
6	D20	2.812 5	
7	D19	1.406 25	
8	D18	.703 125	
9	D17	.351 562 5	
10	D16	.175 781 25	
11	D15	.087 890 625	
12	D14	.043 945 312	
13	D13	.021 972 656	
14	D12	.010 986 328	
15	D11	.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	045	227	212	307	280	367	347
010	11	070	79	150	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	373	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	155	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	352	328		
052	59	132	127	212	194	272	262	352	329		
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	6/18/68
DSGN	6/6/1968
QC	8.11.68
ENGR	8/12/68
APP	8-22-68
FEC	9/3/68
AUTH	9-3-68

NATIONAL AERONAUTICS & SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER HOUSTON TEXAS

GUIDANCE–DIGITAL COMPUTER

SLV AS-503 | SIZE F | DWG NO 6.7.1

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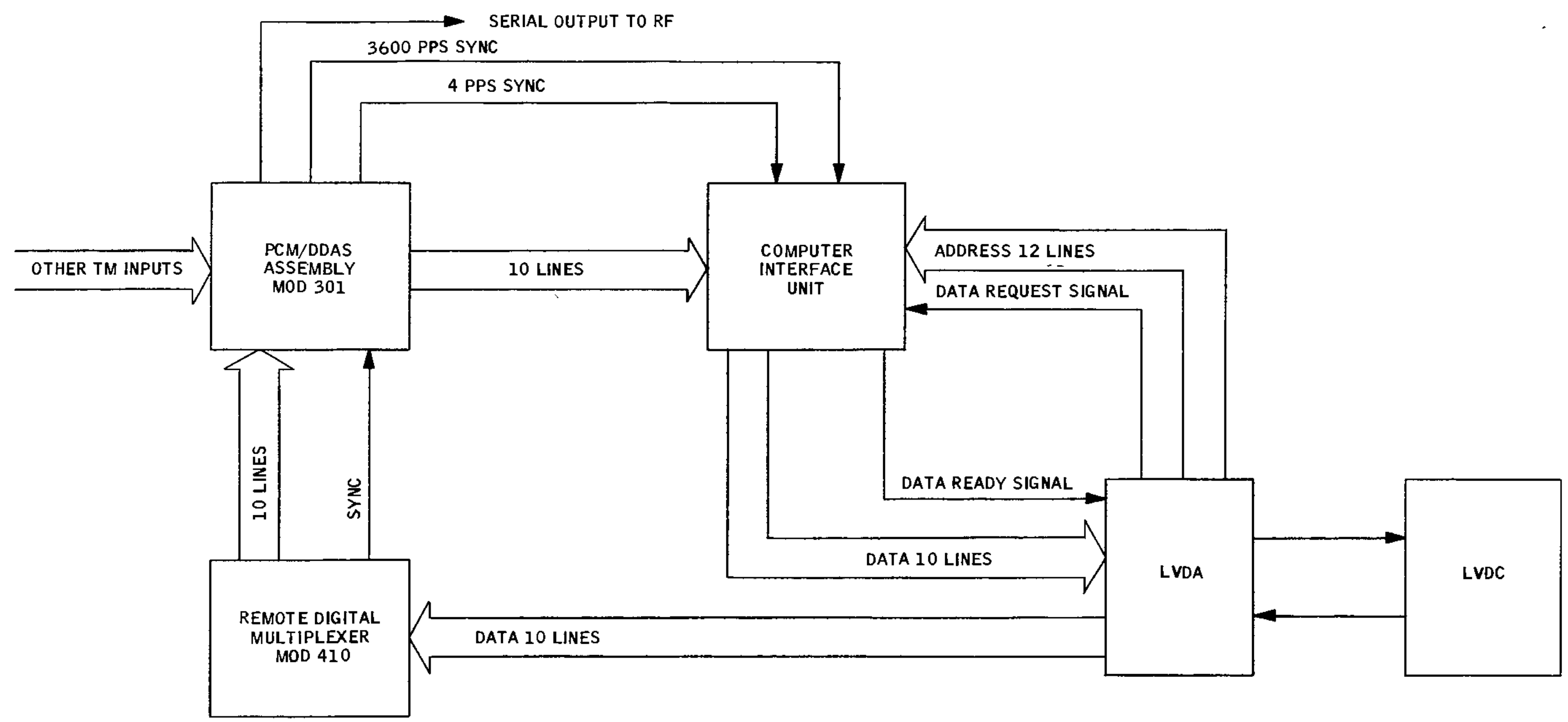
17' 1514 3570



LTR	DR	ENGR	DATE	APPROVAL

SIGNATURES	DATE
DR Linda George	4-17-68
DSGN	8-6-68
QC	8 16 68
ENGR	8/22/68
APP	8/22/68
FEC	9/3/68
AUTH	9-3-68

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

GUIDANCE-COMPUTER INTERFACE UNIT

SLV AS503	SIZE C	DWG NO. 6.7.2
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6.8 NOTES - CIU

A. Selective transfer of measurement values from the IU Telemetry systems to the LVDA is accomplished through the computer interface assembly. This assembly contains the timing and comparison logic necessary to separate the selected channel from the IU PCM format.

B. The LVDA signifies the specific data channel to be transferred by means of a 12-bit channel address. Upon receipt of a "data-request" signal from the LVDA, the computer interface assembly initiates a transfer sequence which consists of:

- Awaiting the next appearance of the signified channel in the PCM/DDAS format
- Writing the data sample into a 10-bit holding register within the assembly
- Providing a "data-ready" signal to the LVDA indicating that the selected data is available.

C. For as long as the "data-request" signal remains at the request level, subsequent samples of the selected channels are transferred into the holding register as they appear in the format of the PCM/DDAS assembly. When the LVDA returns the "data-request" signal to the standby level, the last value transferred remains in the holding register until another transfer sequence is initiated.

D. When the LVDA receives the "data-ready" signal, it branches to a subroutine which operates to transfer the data from the telemetry output register to the LVDA. Synchronization between the telemetry system and the LVDA is accomplished in the following manner: Each time the telemetry receives an address from the LVDA, followed by a valid "data-request" signal, it recognizes this input as the initiation of new data seeking cycle as well as a signal to read in the data.

*

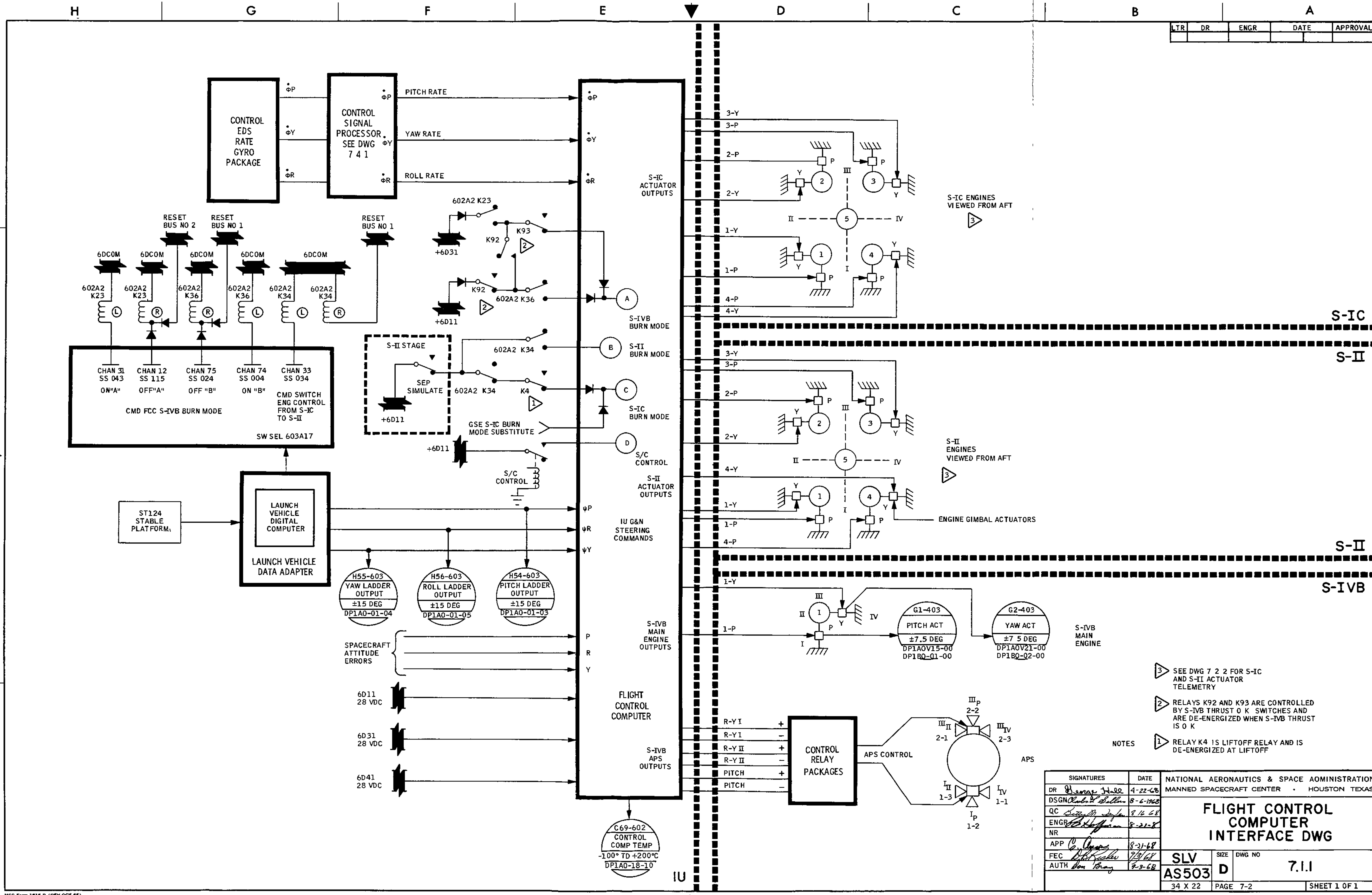
Upon this recognition by telemetry, it first resets its output data register and then begins seeking the data requested by the LVDA. The LVDA and LVDC insures that a new address with a valid read bit is not generated until data from the telemetry output register has been received in response to the previous address.

* SECTION 7

CONTROL

7.1 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 fo 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.



CONTROL EDS RATE GYRO PACKAGE
CONTROL SIGNAL PROCESSOR SEE DWG 7 4 1
PITCH RATE
YAW RATE
ROLL RATE
RESET BUS NO 2
RESET BUS NO 1
RESET BUS NO 1
6DCOM
602A2 K23
602A2 K36
602A2 K34
CHAN 31 SS 043 ON "A"
CHAN 12 SS 115 OFF "A"
CHAN 75 SS 024 OFF "B"
CHAN 74 SS 004 ON "B"
CHAN 33 SS 034
CMD SWITCH ENG CONTROL FROM S-IC TO S-II
CMD FCC S-IVB BURN MODE
SW SEL 603A17
+6D31
+6D11
K92
K93
602A2 K36
S-II STAGE
SEP SIMULATE
602A2 K34
K4
GSE S-IC BURN MODE SUBSTITUTE
S/C CONTROL
ST124 STABLE PLATFORM
LAUNCH VEHICLE DIGITAL COMPUTER
LAUNCH VEHICLE DATA ADAPTER
H55-603 YAW LADDER OUTPUT ±15 DEG DP1A0-01-04
H56-603 ROLL LADDER OUTPUT ±15 DEG DP1A0-01-05
H54-603 PITCH LADDER OUTPUT ±15 DEG DP1A0-01-03
SPACECRAFT ATTITUDE ERRORS
6D11 28 VDC
6D31 28 VDC
6D41 28 VDC
S-IC ACTUATOR OUTPUTS
S-IVB BURN MODE
S-II BURN MODE
S-IC BURN MODE
S/C CONTROL
S-II ACTUATOR OUTPUTS
IU G&N STEERING COMMANDS
S-IVB MAIN ENGINE OUTPUTS
FLIGHT CONTROL COMPUTER
S-IVB APS OUTPUTS
C69-602 CONTROL COMP TEMP -100° TO +200°C DP1A0-18-10
IU
S-IC ENGINES VIEWED FROM AFT
S-IC
S-II
S-II ENGINES VIEWED FROM AFT
ENGINE GIMBAL ACTUATORS
S-II
S-IVB
G1-403 PITCH ACT ±7.5 DEG DP1A0V15-00 DP1B0-01-00
G2-403 YAW ACT ±7.5 DEG DP1A0V21-00 DP1B0-02-00
S-IVB MAIN ENGINE
R-Y I
R-Y I
R-Y II
R-Y II
PITCH
PITCH
CONTROL RELAY PACKAGES
APS CONTROL
APS
NOTES
3 SEE DWG 7 2 2 FOR S-IC AND S-II ACTUATOR TELEMETRY
2 RELAYS K92 AND K93 ARE CONTROLLED BY S-IVB THRUST O K SWITCHES AND ARE DE-ENERGIZED WHEN S-IVB THRUST IS O K
1 RELAY K4 IS LIFTOFF RELAY AND IS DE-ENERGIZED AT LIFTOFF
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FLIGHT CONTROL COMPUTER INTERFACE DWG
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7.2 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 (drawing 7.1.1) 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 7.1.1) 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 7.1.1). 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.

Spacecraft Control Mode is achieved by command from the spacecraft. The spacecraft can assume control during S-IVB coast only.

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 7.2.2)
   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 7.2.2)
   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 dynamic characteristics have changed with the jettisoning of the S-IC stage.
3. S-IVB Burn Mode (Drawing 7.2.3) (Figure 7.1)
   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.

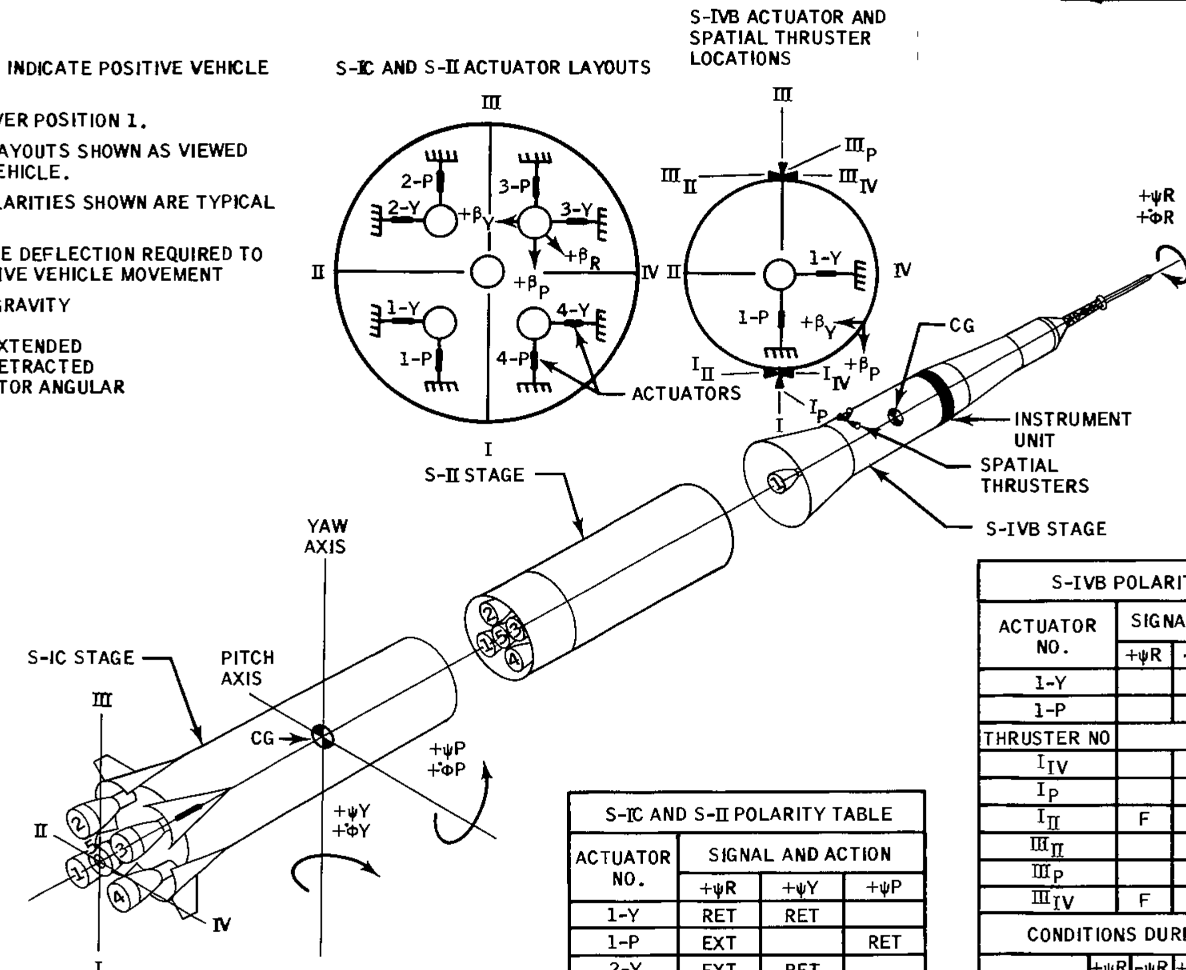
4. S-IVB Coast Mode (Drawing 7.2.3) (Fig 7.2 and 7.3)
The function of the control system during the S-IVB Coast Mode is to establish and maintain the desired vehicle attitudes in the pitch, yaw and roll planes. The inputs to the FCC are attitude error signals from the guidance system and attitude rate 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, figures 7.4, 7.5, 7.6. 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 Section 8 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.

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. $+\beta$ 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		
	$+\psi R$	$+\psi Y$	$+\psi P$
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			
	$+\psi R$	$-\psi R$	$+\psi Y$	$+\psi P$
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						
	$+\psi R$	$-\psi R$	$+\psi Y$	$-\psi Y$	$+\psi P$	$-\psi P$
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

LTR	ENGR	REVISION	DATE	APPROVAL

SIGNATURES	DATE
DR	5-23
DSGN	8/6/68
QC	8-16-68
ENGR	8-21-68
APP	8-21-68
FEC	9/5/68
AUTH	9-3-68

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SATURN V CONTROL SYSTEM

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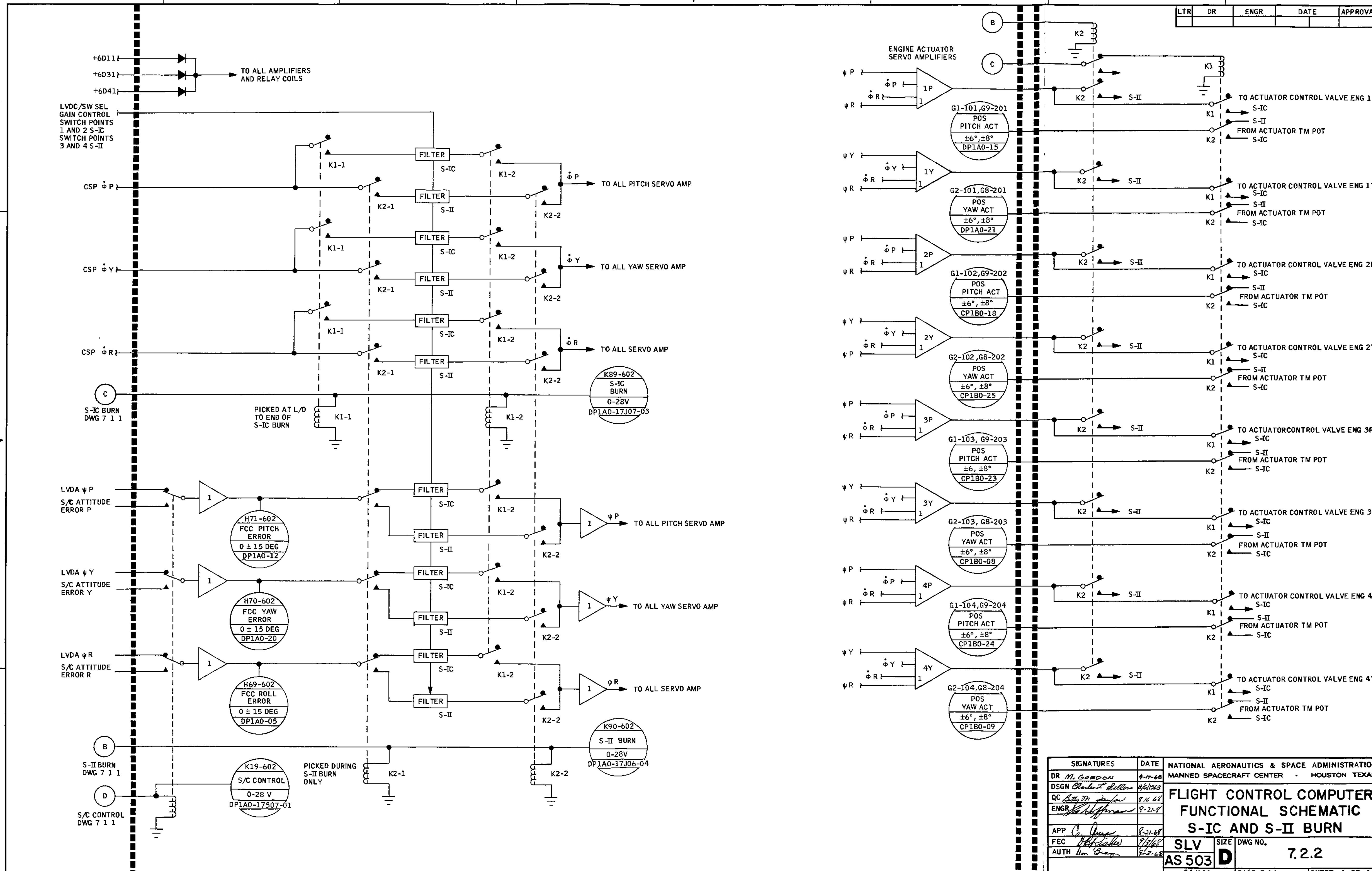

SIGNATURES		DATE
DR	M. Gordon	4-17-68
DSGN	Charles L. Sellers	8/6/1968
QC	[signature]	8 16 68
ENGR	[signature]	9-21-68
APP	[signature]	8-21-68
FEC	[signature]	9/3/68
AUTH	Don Bray	9-3-68

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

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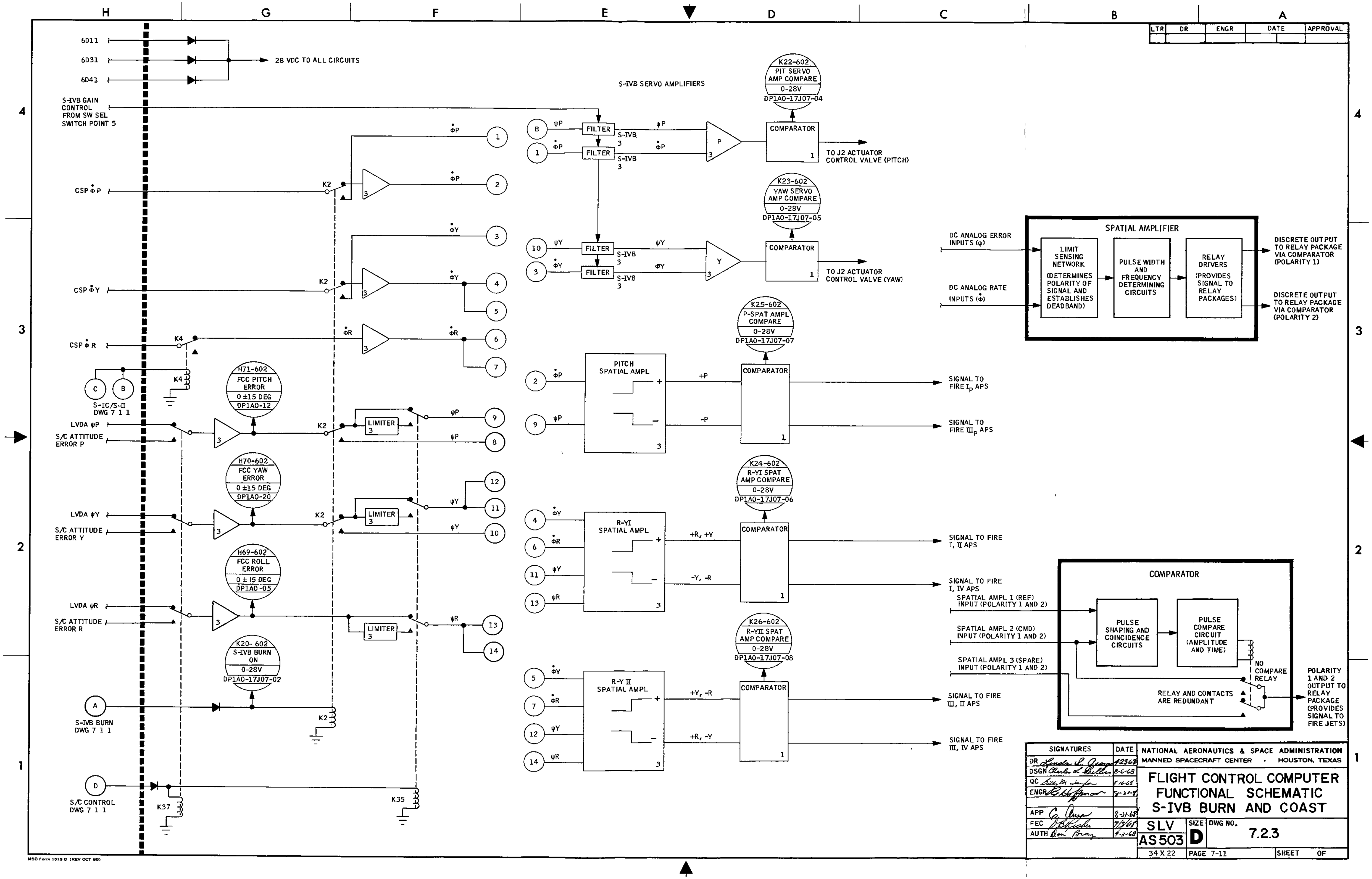

6D11
6D31
6D41
28 VDC TO ALL CIRCUITS
S-IVB GAIN CONTROL FROM SW SEL SWITCH POINT 5
S-IVB SERVO AMPLIFIERS
K22-602 PIT SERVO AMP COMPARE 0-28V DP1A0-17J07-04
K23-602 YAW SERVO AMP COMPARE 0-28V DP1A0-17J07-05
FILTER
S-IVB 3
COMPARATOR
TO J2 ACTUATOR CONTROL VALVE (PITCH)
TO J2 ACTUATOR CONTROL VALVE (YAW)
CSP Φ̇P
CSP Φ̇Y
CSP Φ̇R
K2
K4
S-IC/S-II DWG 7 1 1
H71-602 FCC PITCH ERROR 0 ±15 DEG DP1A0-12
H70-602 FCC YAW ERROR 0 ±15 DEG DP1A0-20
H69-602 FCC ROLL ERROR 0 ± 15 DEG DP1A0-05
K20-602 S-IVB BURN ON 0-28V DP1A0-17J07-02
LVDA ψP
S/C ATTITUDE ERROR P
LVDA ψY
S/C ATTITUDE ERROR Y
LVDA ψR
S/C ATTITUDE ERROR R
LIMITER 3
S-IVB BURN DWG 7 1 1
S/C CONTROL DWG 7 1 1
K37
K35
K25-602 P-SPAT AMPL COMPARE 0-28V DP1A0-17J07-07
PITCH SPATIAL AMPL
SIGNAL TO FIRE I_P APS
SIGNAL TO FIRE III_P APS
K24-602 R-YI SPAT AMP COMPARE 0-28V DP1A0-17J07-06
R-YI SPATIAL AMPL
+R, +Y
-Y, -R
SIGNAL TO FIRE I, II APS
SIGNAL TO FIRE I, IV APS
K26-602 R-YII SPAT AMP COMPARE 0-28V DP1A0-17J07-08
R-Y II SPATIAL AMPL
+Y, -R
+R, -Y
SIGNAL TO FIRE III, II APS
SIGNAL TO FIRE III, IV APS
SPATIAL AMPLIFIER
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)
COMPARATOR
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)
LTR DR ENGR DATE APPROVAL
SIGNATURES DATE
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FLIGHT CONTROL COMPUTER FUNCTIONAL SCHEMATIC S-IVB BURN AND COAST
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7.3 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 servo-amplifier 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

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.

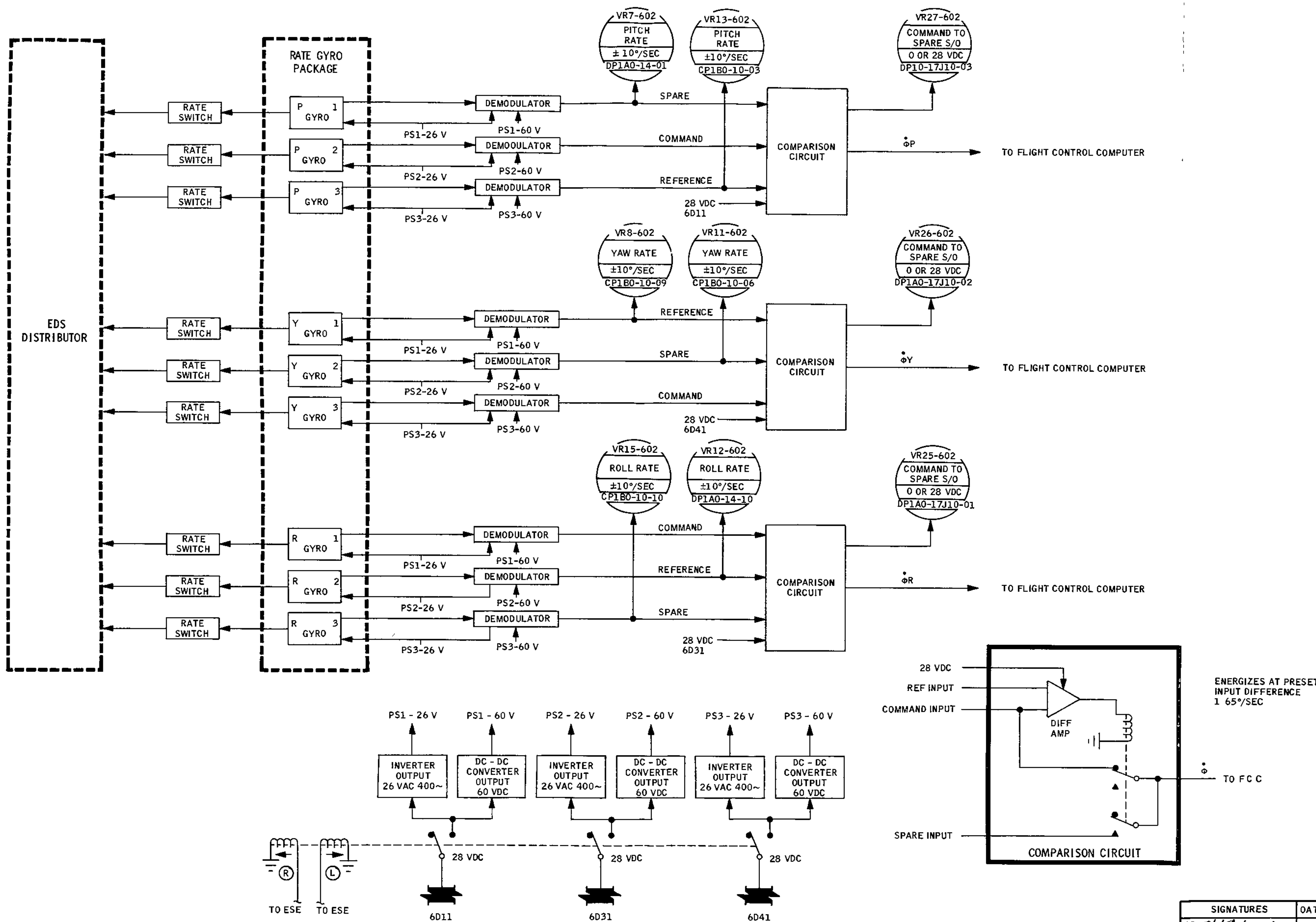
7.4 CONTROL SYSTEM GENERAL NOTES

A. Flight Control Computer

B. Control Signal Processor

C. Engine Actuators	S-IC	S-II	S-IVB
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



SIGNATURES	DATE
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DSGN	8/6/1968
QC	8-16-68
ENGR	8-21-68
APP	8-21-68
FEC	9/3/68
AUTH	9-3-68

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CONTROL SIGNAL PROCESSOR BLOCK DIAGRAM

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LTR | DR | ENGR | DATE | APPROVAL

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SECTION 8

PROPULSION AND STRUCTURES

8.1 S-IC STAGE

8.1.1 Propulsion and Structures (General Description)

The S-IC is a cylindrical booster 138 feet long, 33 feet in diameter, and has a gross weight at liftoff of approximately 4.7 million pounds. The stage is powered by five F-1 rocket engines, each developing 1.5 million pounds of thrust. One engine, mounted on the vehicle longitudinal centerline, is fixed. The remaining four engines are mounted equidistant on a 364-inch diameter circle about the center engine and are capable of being gimbaled through a plus or minus 5° square pattern for thrust vector control. During the boost period, the five F-1 engines consume approximately 4.3 million pounds of propellants, LOX and RP-1.

The F-1 engine is a single-start, turbopump-fed, fixed-thrust, gimbaled, bipropellant, liquid rocket system. The engine has a single bell shaped thrust chamber with expansion ratio of 16:1. The thrust chamber is regeneratively fuel cooled through the 10:1 expansion area tubular walled construction. An extension nozzle is used to increase the expansion area from a ratio of 10:1 to 16:1. This expansion nozzle is cooled through an inner wall by exhaust gases from the engine pump turbine.

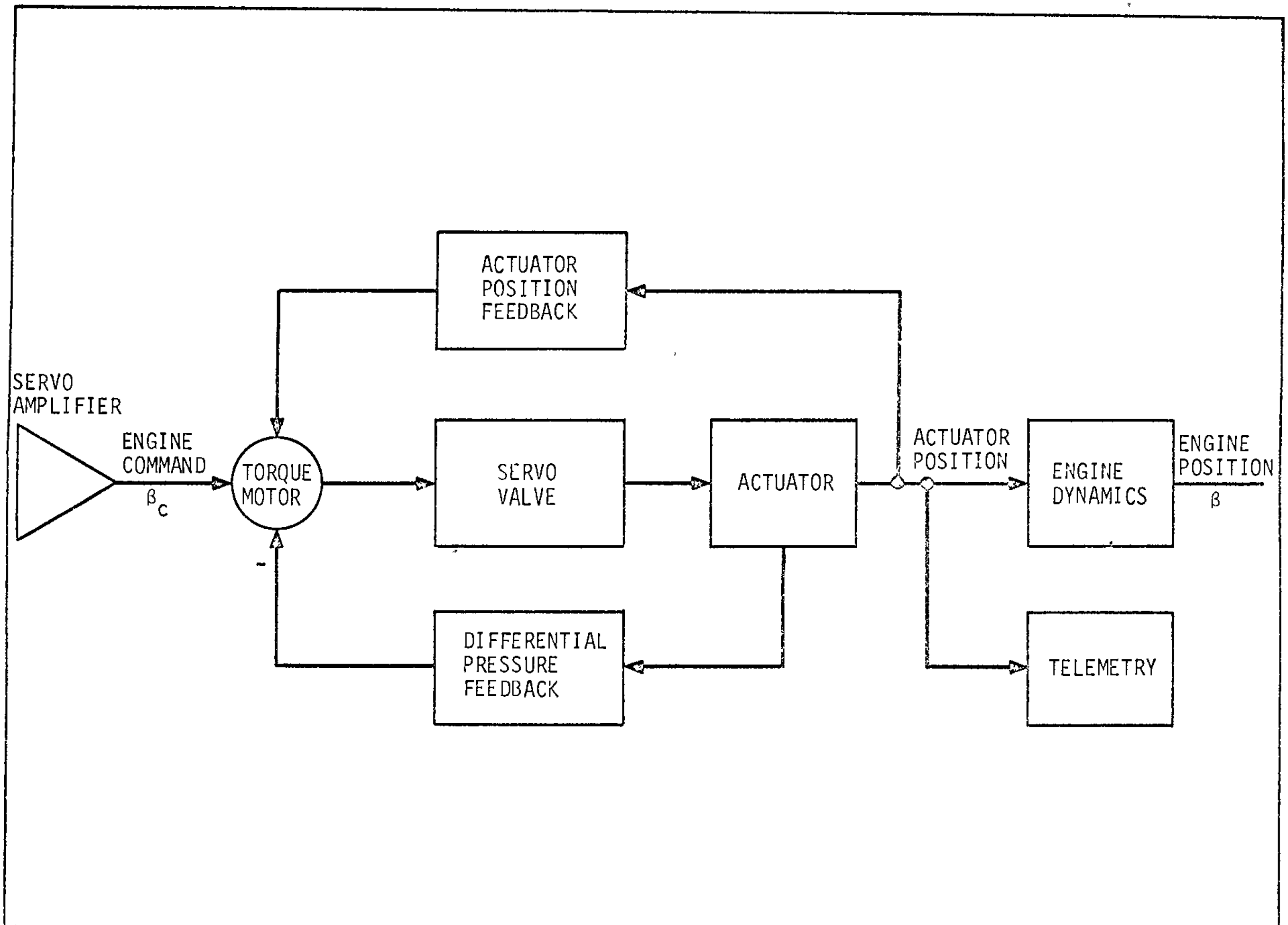
The propellants are stored in separate containers in a tandem arrangement with the LOX tank on top. Both tanks are cylindrical structures closed at each end by an ellipsoidal bulkhead. The LOX and RP-1 tank volumes are 47,000 and 29,000 cubic feet, respectively. Anti-slosh and anti-vortex baffles are provided in both tanks. Inflight pressurization is provided for maintenance of the required pump inlet pressures.

The S-IC instrumentation system provides the capability for measuring approximately 900 stage performance parameters.

The signals collected from individual transducers and sensors are processed onboard and transmitted to the ground by six separate telemetry links. The telemetry links include three PAM/FM/FM, two SS/FM and one PCM/FM. The signals are radiated over four antennas. The PCM system is also used for direct wire ground telemetering of digital data acquisition system (DDAS) measurements.

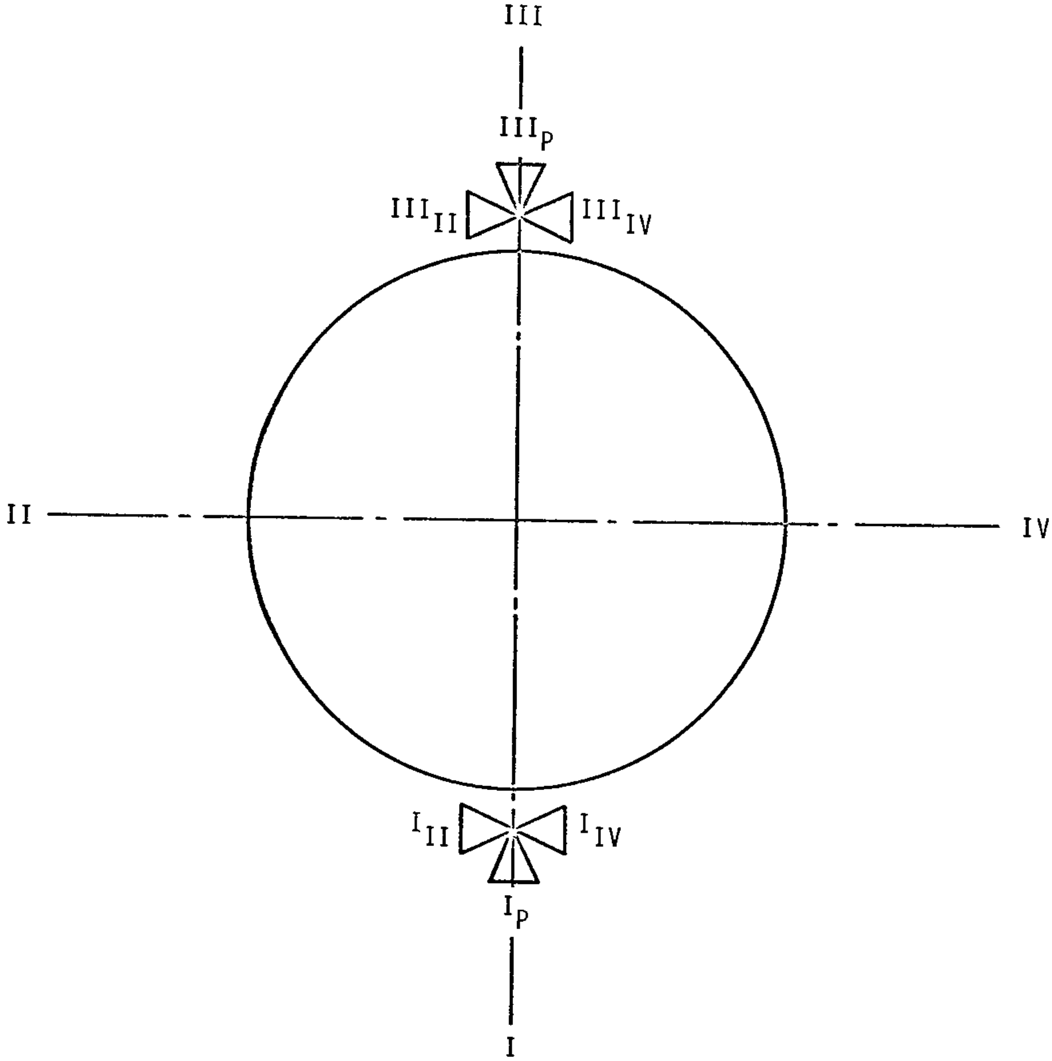
Other systems aboard the S-IC include eight retrorockets for retarding the stage during S-IC/S-II separation, an emergency flight termination system which accomplishes engine cutoff followed by tank rupture for propellant dispersion, and electrical power distribution system, and flight control system components which execute steering commands issued by the instrument unit.

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 the AS-503 S-IC stage. The system is proposed to decrease the likelihood of a pogo oscillation by injecting helium into the LOX prevalve cavity of each engine such that the cavity acts as a vibration damper, thereby lowering the natural frequency of the LOX liquid column.



Thrust Vector Control System

FIGURE 7.1



VIEW LOOKING FORWARD

I_{IV}	= 1 =	1-1		VARIOUS ENGINE NOMENCLATURE
I_P	= 2 =	1-2		
I_{II}	= 3 =	1-3		
III_{II}	= 4 =	2-1		
III_P	= 5 -	2-2		
III_{IV}	= 6 =	2-3		

Auxiliary Attitude Control System Engine Orientation

FIGURE 7.2

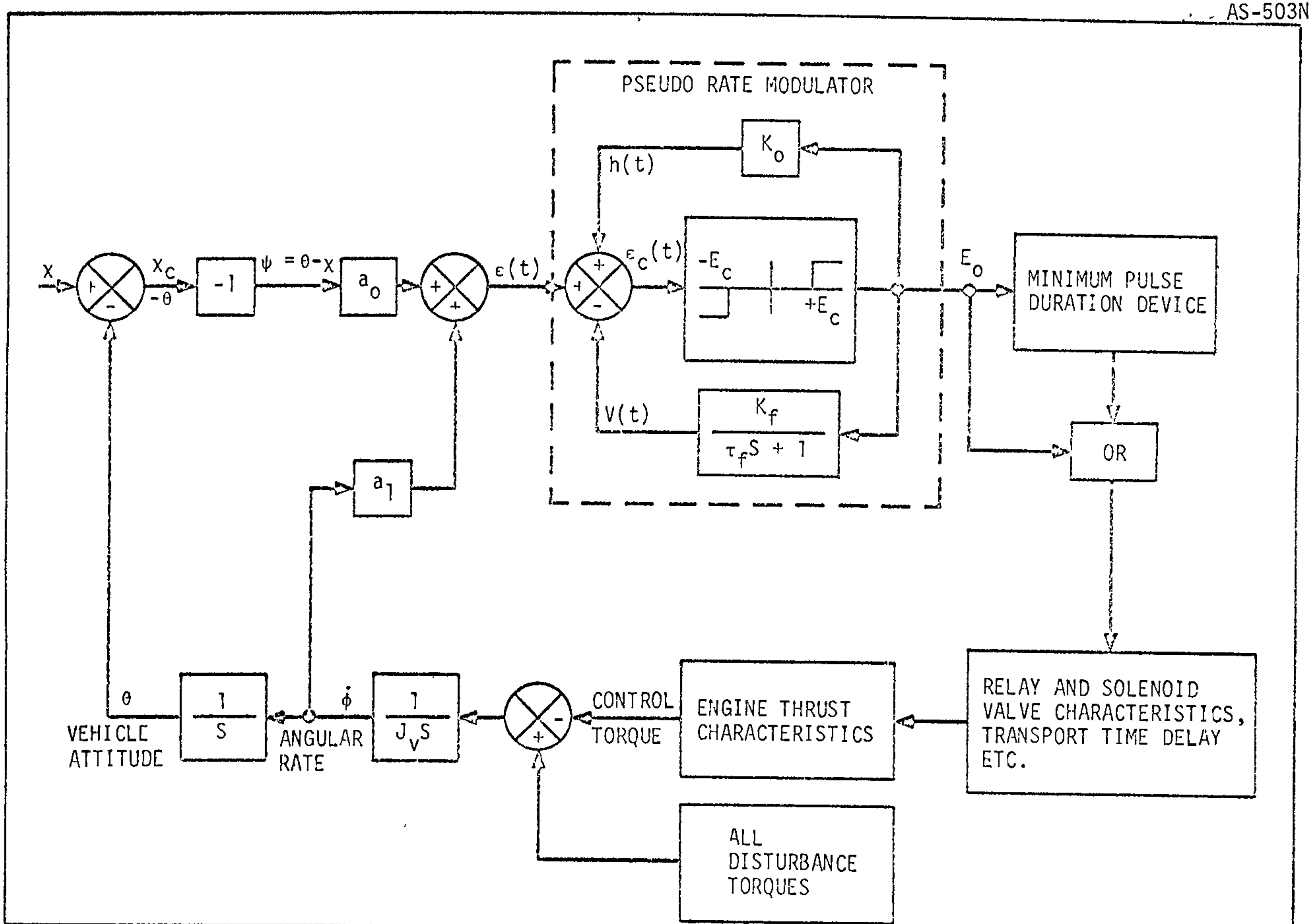
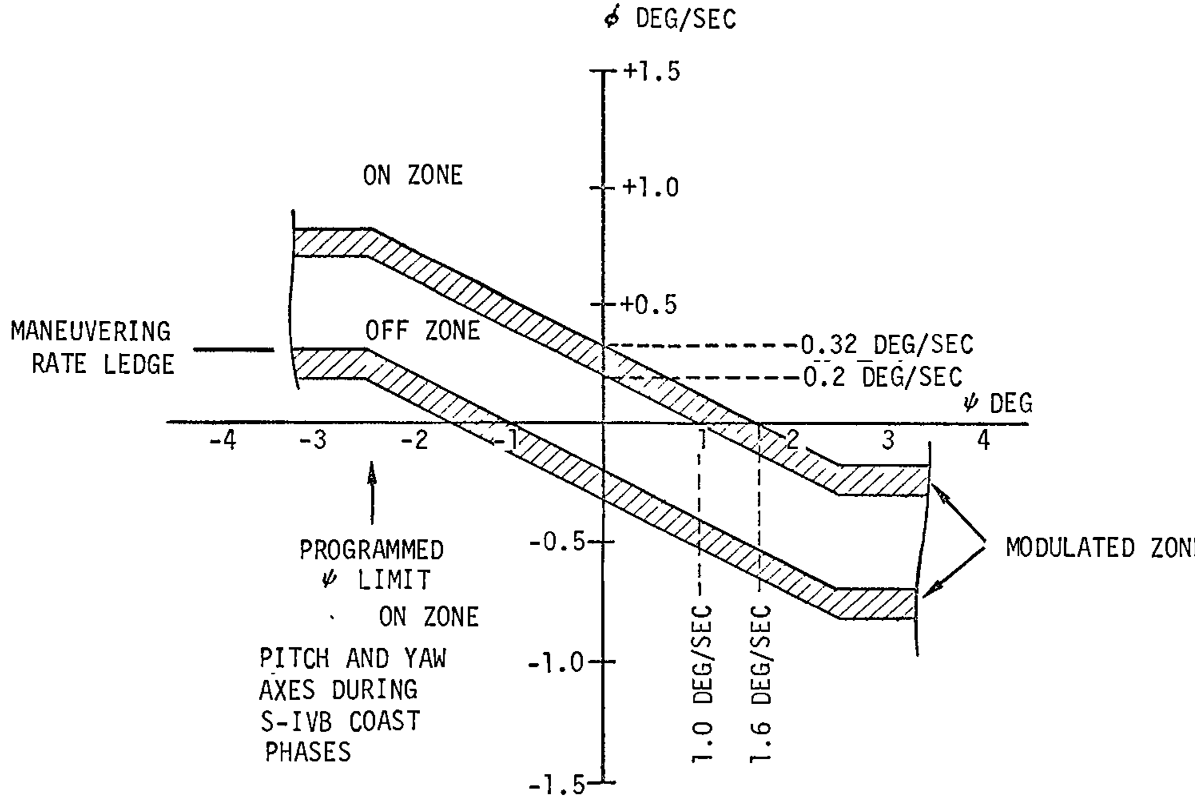


FIGURE 7.3

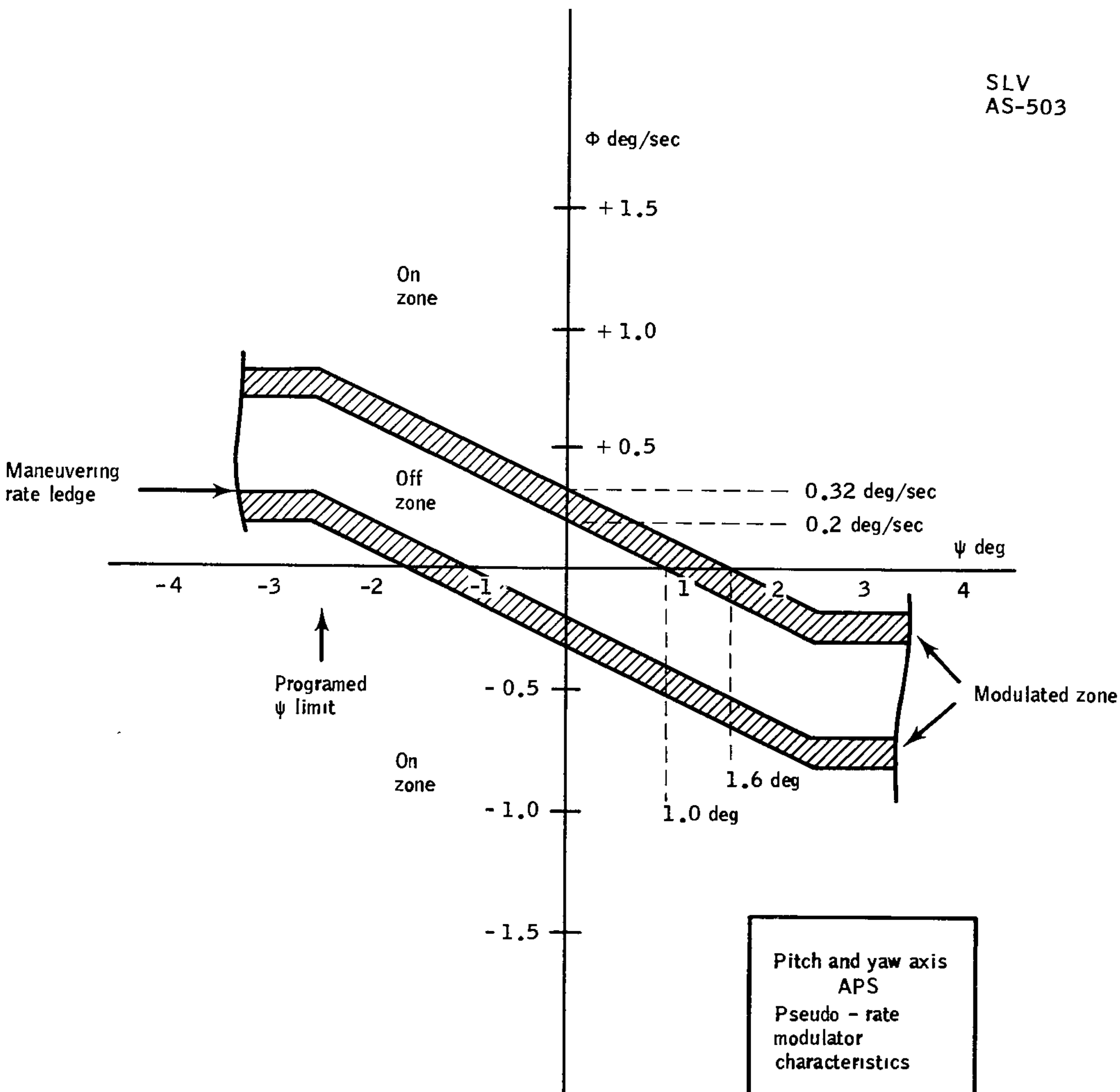
Auxiliary Attitude Control System Schematic



APS Pseudo-Rate Modulator Characteristics

FIGURE 7.4

SLV
AS-503



Pitch and yaw axis
APS
Pseudo - rate
modulator
characteristics

AS-503

Figure 7-5

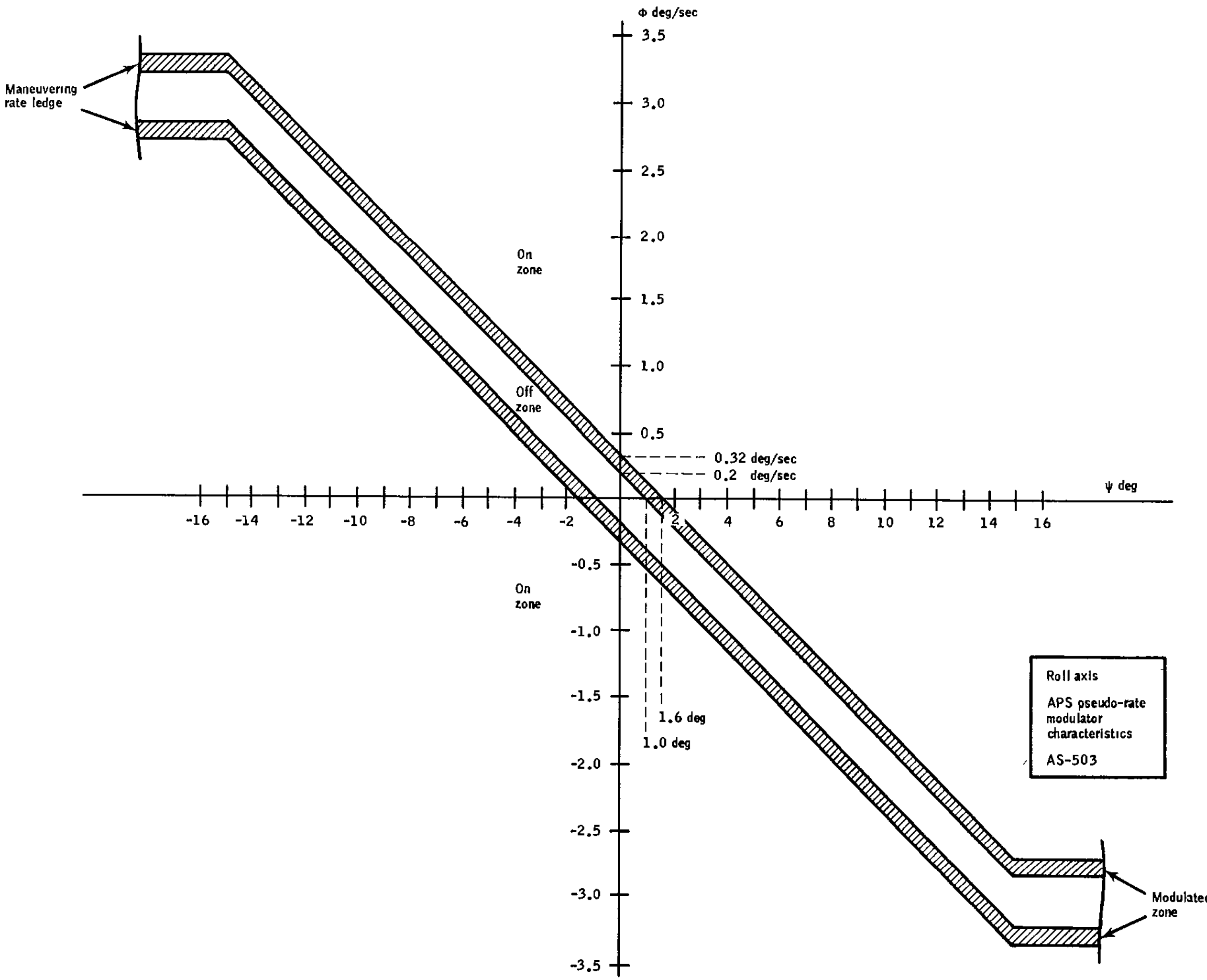

Φ deg/sec
3.5
3.0
2.5
2.0
1.5
1.0
0.5
-0.5
-1.0
-1.5
-2.0
-2.5
-3.0
-3.5
ψ deg
-16
-14
-12
-10
-8
-6
-4
-2
2
4
6
8
10
12
14
16
Maneuvering rate ledge
On zone
Off zone
On zone
0.32 deg/sec
0.2 deg/sec
1.6 deg
1.0 deg
Modulated zone
Roll axis
APS pseudo-rate modulator characteristics
AS-503

Figure 7-6

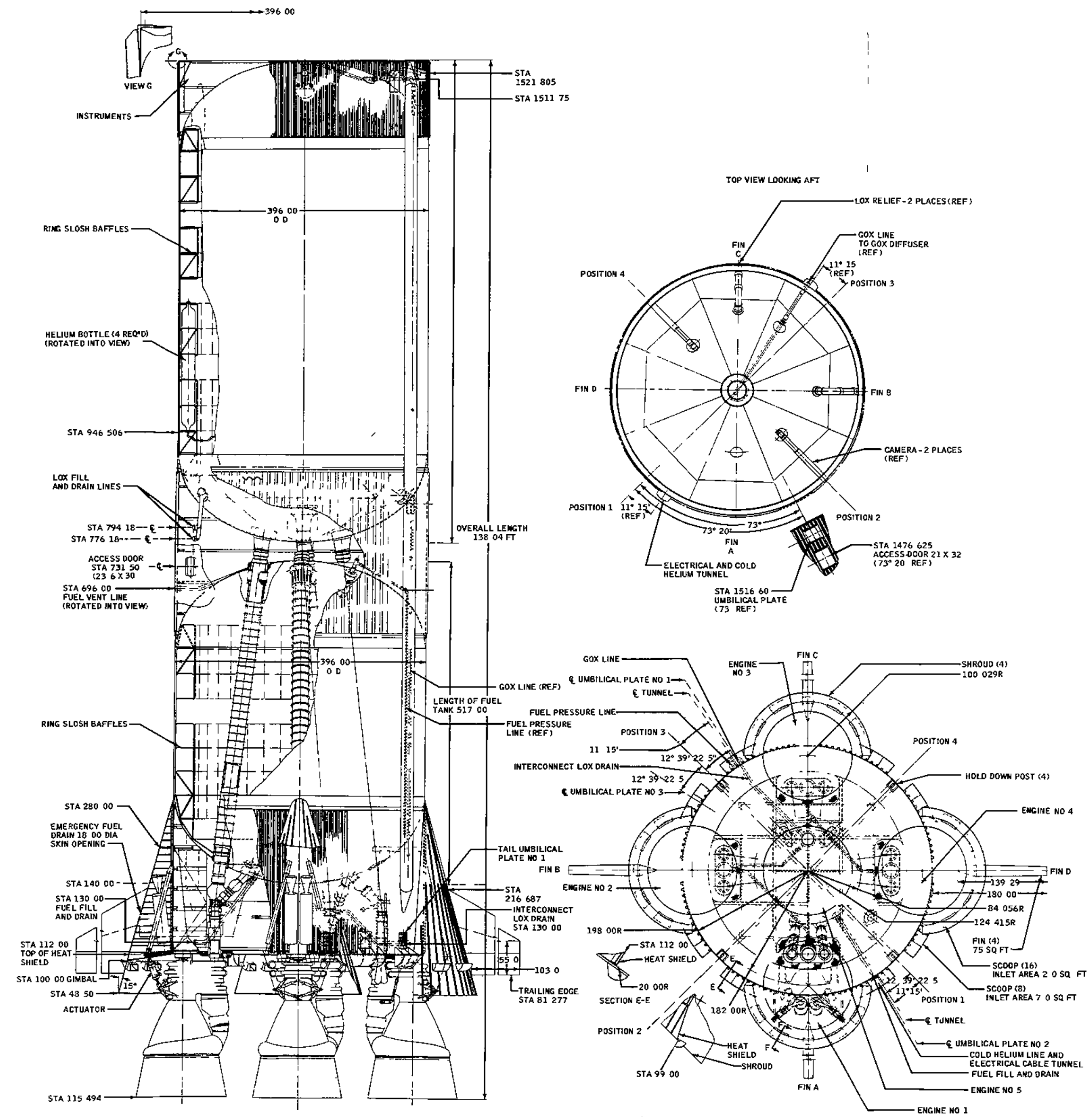
7.5 CONTROL SIGNAL PROCESSOR CHARACTERISTICS

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	± 5.0°/sec ± 0.55°/sec*
	± 3.0°/sec ± 0.55°/sec*
$\dot{\phi}$ ROLL	
Activate point	± 20.0°/sec ± 1.3°/sec

*$\dot{\phi}$ Yaw, $\dot{\phi}$ Pitch activate points switched from ± 5°/sec to ± 3°/sec at liftoff plus 2:14.9.



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DSGN		
QC		
ENGR		
APP		
FEC		
AUTH		

PROPULSION S-IC STRUCTURE

SLV AS-503 | SIZE E | DWG NO 811

44 X 34 | PAGE 8-3 | SHEET OF

8.1.2 Staging (General Description)

A. Subsystems

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.

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 the 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.

3. Confined Detonating Fuse

A confined detonating fuse CDF) manifold is used to transfer the detonation 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 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 case.

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.

5. S-II Ullage Rockets

Eight 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 3.25 seconds and develops a thrust of 22,700 lbs (in vacuum). Two pyrogen initiators are mounted on each ullage rocket and complete the ordnance train required for rocket ignition.

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.

B. Operation

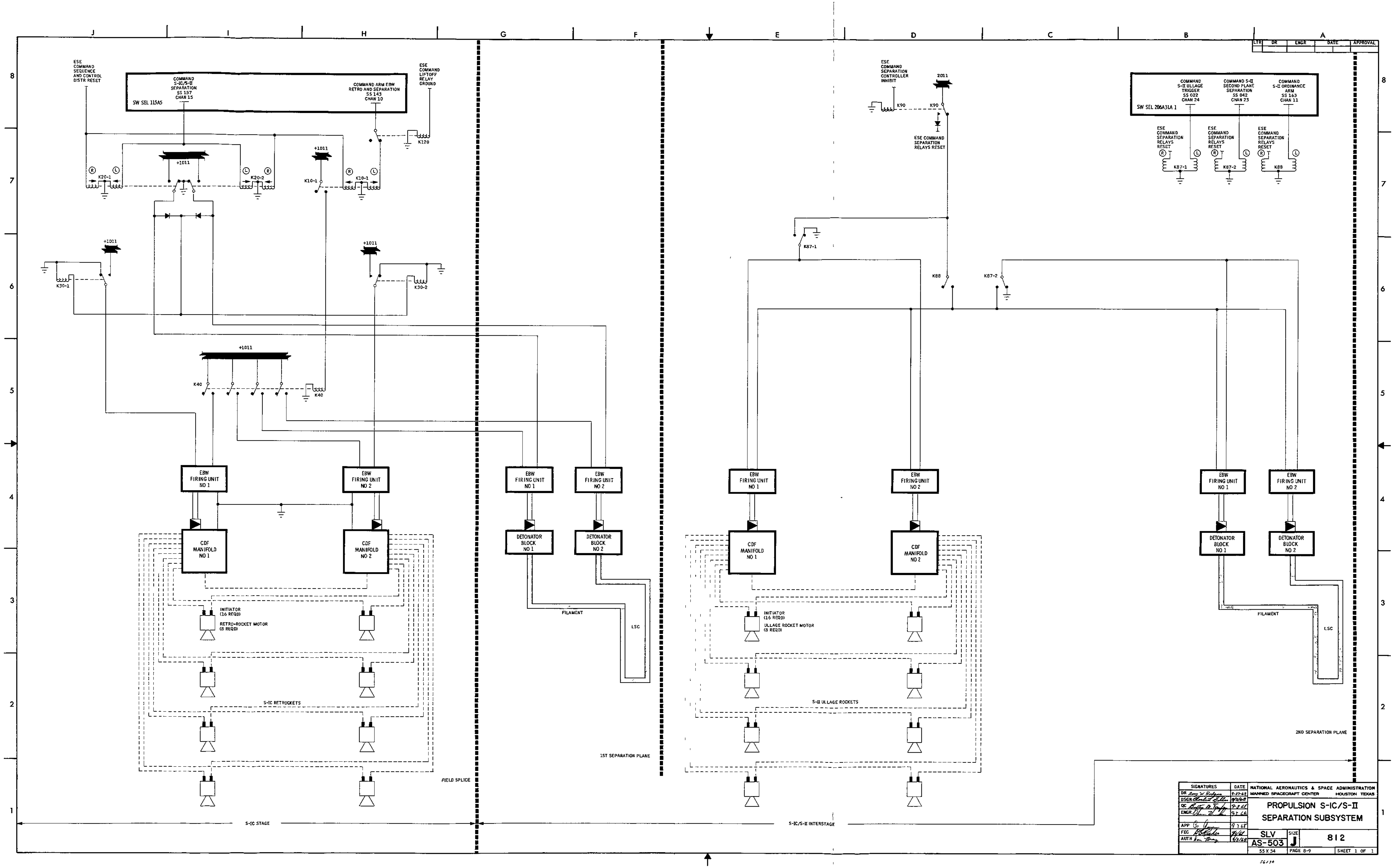
Physical separation is initiated by the Instrument Unit (IU) at the end of S-IC boost phase, following shutdown of the five F-1 engine. Separation requires the performance of the following major functions in the sequence described.

1. EBW firing units armed

A ground latched interlock renders the EBW firing units inoperative while the vehicle is on the launch pad. This interlock is released with umbilical disconnect during liftoff, and the sybsystem is reset to flight condition. At approximately 9 seconds after inboard engine cutoff the IU sends out the command to arm the S-IC/S-II separation ordnance. The ordnance arm command is routed through the S-II switch selector to both the S-IC stage electrical circuitry, to supply plus 28 Vdc to the EBW firing units for first plane separation and retrorocket ignition, and to the S-II stage electrical circuitry to supply plus 28 Vdc to the EBW firing units for ullage rocket ignition and second plane separation. The firing units use this energy to charge the internal storage capacitors to 2300 volts to provide the firing pulse for rocket ignition and LSC detonation.

2. S-IC engine cutoff
   Cutoff of the center F-1 engine is enabled by the Launch Vehicle Digital Computer at approximately 136 seconds after liftoff. The four outboard F-1 engines shutdown is enables at approximately 144 seconds after liftoff.
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.
4. First plane separation and S-IC retrorocket ignition.
   First plane separation is initiated immediately after

S-II ullage rocket ignition at approximately 149 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.


ESE COMMAND SEQUENCE AND CONTROL DISTR RESET
COMMAND S-IC/S-II SEPARATION SS 157 CHAN 15
COMMAND ARM EBW RETRO AND SEPARATION SS 143 CHAN 10
ESE COMMAND LIFTOFF RELAY GROUND
SW SEL 115A5
K120
+1011
K20-1
K20-2
K10-1
K30-1
K30-2
K40
EBW FIRING UNIT NO 1
EBW FIRING UNIT NO 2
CDF MANIFOLD NO 1
CDF MANIFOLD NO 2
INITIATOR (16 REQD)
RETRO-ROCKET MOTOR (8 REQD)
S-IC RETROROCKETS
FIELD SPLICE
DETONATOR BLOCK NO 1
DETONATOR BLOCK NO 2
FILAMENT
LSC
1ST SEPARATION PLANE
ESE COMMAND SEPARATION CONTROLLER INHIBIT
2011
K90
ESE COMMAND SEPARATION RELAYS RESET
K87-1
K88
K87-2
ULLAGE ROCKET MOTOR (8 REQD)
S-II ULLAGE ROCKETS
COMMAND S-II ULLAGE TRIGGER SS 022 CHAN 24
COMMAND S-II SECOND PLANE SEPARATION SS 043 CHAN 23
COMMAND S-II ORDINANCE ARM SS 163 CHAN 11
SW SEL 206A31A 1
K89
2ND SEPARATION PLANE
S-IC STAGE
S-IC/S-II INTERSTAGE
SIGNATURES
DATE
NATIONAL AERONAUTICS & SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER HOUSTON TEXAS
PROPULSION S-IC/S-II SEPARATION SUBSYSTEM
SLV AS-503
SIZE J
812
55 X 34
PAGE 8-9
SHEET 1 OF 1

8.1.3 RP-1 Pressurization

A. Fuel Conditioning

Fuel conditioning is required to prevent fuel stratification. At T-5.0 hours, GN_2 bubbling is initiated by opening a solenoid valve in the ground GN_2 distribution console and allowing GN_2 at 150 psig to be injected into the fuel suction ducts near the fuel pump inlets of each F-1 engine. Bubbling is terminated when the fuel tank prepressurization command is given.

B. Tank Prepressurization

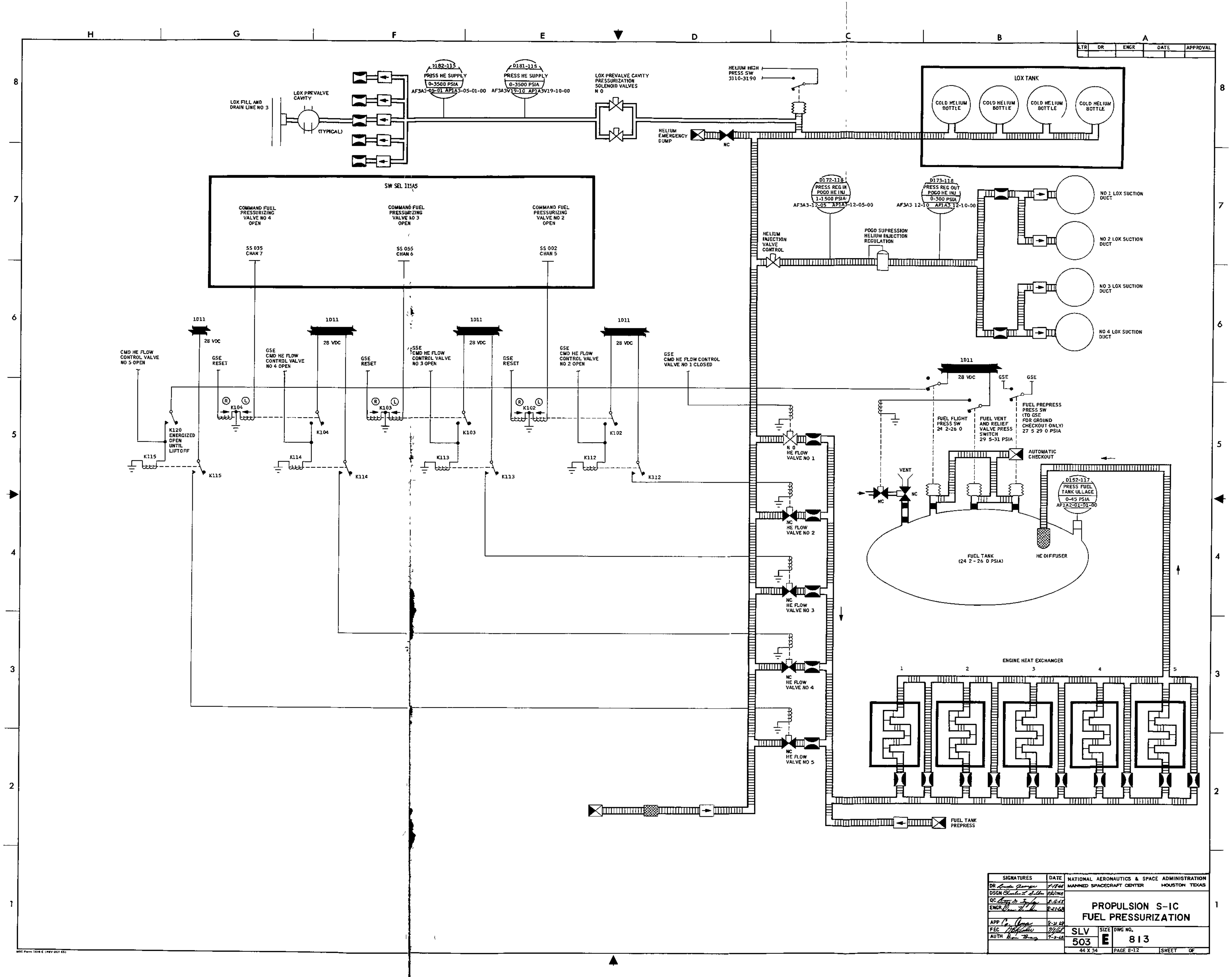
Prepressurization of the fuel tank is required prior to engine ignition to insure the necessary net positive suction head pressure at the engine pump inlets. Prepressurization of the fuel tank is initiated at T-1.5 minutes. The fuel tank vent valve is closed, the ground GN_2 bubbling valve is closed, 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 approximently T-50 seconds.

C. Flight Pressurization

During S-IC powered flight, ullage pressure is maintained by helium supplied from helium cylinders. Flight pressurization is initiated at liftoff, 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 24.2 psia and 26.0 psia. The following pressurization valve sequence is programed and is based on predetermined helium requirements as a function of flight time.

1. Valve No. 2 is opened at 49.5 seconds from liftoff.
2. Valve No. 3 is opened at 95.3 seconds from liftoff.
3. Valve No. 4 is opened at 133.5 seconds from liftoff.

Valve No. 5 operates independently and is controlled by the fuel tank pressure switch which operates at pressures between 26 and 24.2 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 psia 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.


LOX TANK
COLD HELIUM BOTTLE
SW SEL 115A5
COMMAND FUEL PRESSURIZING VALVE NO 4 OPEN
COMMAND FUEL PRESSURIZING VALVE NO 3 OPEN
COMMAND FUEL PRESSURIZING VALVE NO 2 OPEN
HELIUM EMERGENCY DUMP
NO 1 LOX SUCTION DUCT
NO 2 LOX SUCTION DUCT
NO 3 LOX SUCTION DUCT
NO 4 LOX SUCTION DUCT
28 VDC
GSE RESET
FUEL TANK (24 2 - 26 0 PSIA)
HE DIFFUSER
AUTOMATIC CHECKOUT
ENGINE HEAT EXCHANGER
HE FLOW VALVE NO 1
HE FLOW VALVE NO 2
HE FLOW VALVE NO 3
HE FLOW VALVE NO 4
HE FLOW VALVE NO 5
FUEL TANK PREPRESS
NATIONAL AERONAUTICS & SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER HOUSTON TEXAS
PROPULSION S-IC
FUEL PRESSURIZATION
SLV 503
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813
44 X 34
PAGE 8-12

8.1.4 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:

- LOX conditioning
- Tank prepressurization
- Flight pressurization

A. LOX Conditioning

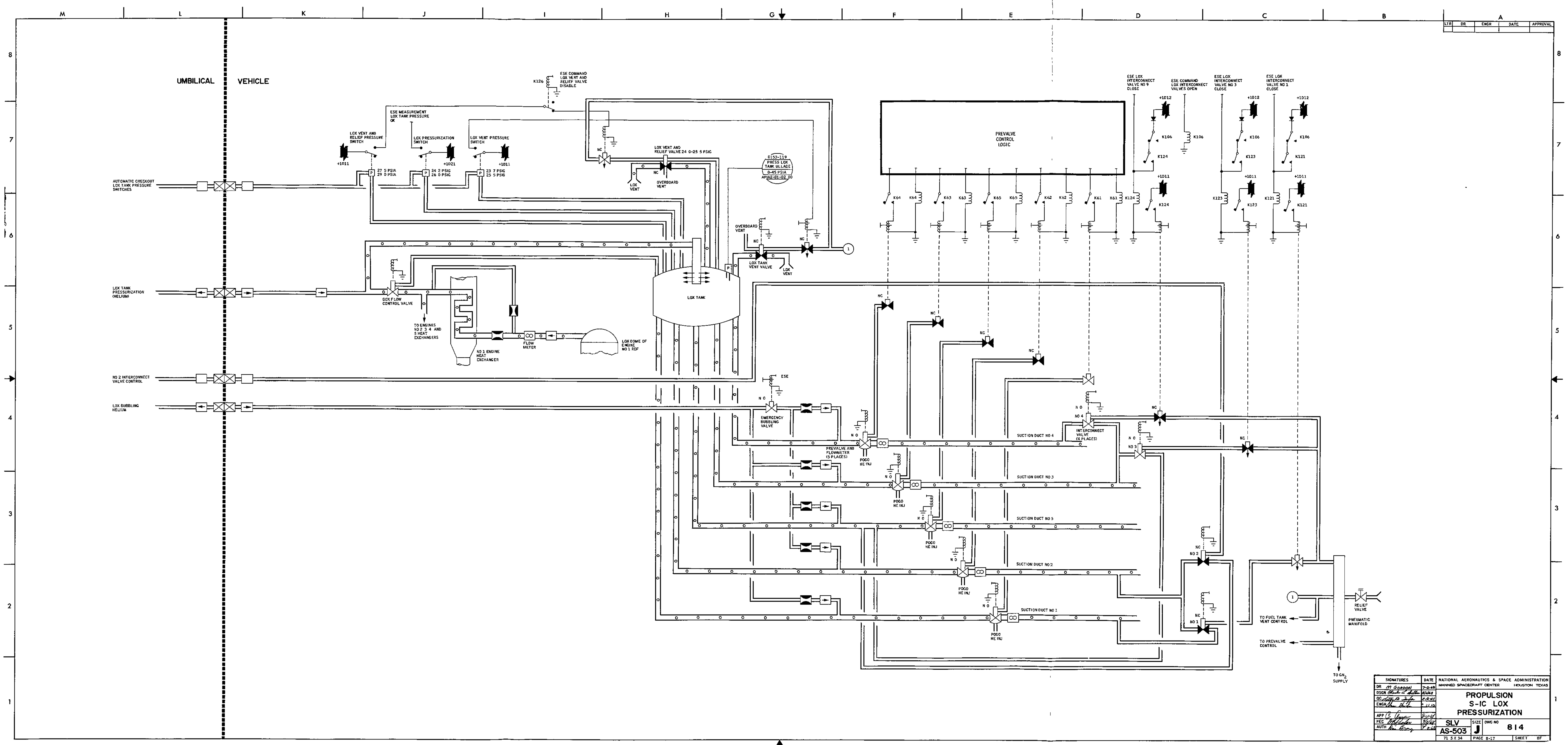
LOX conditioning is necessary to prevent geysering in the suction ducts and to provide the LOX pump inlet with a uniform density oxidizer. The conditioning is accomplished by both helium bubbling and thermal pumping. In order to establish a path for thermal recirculation, the suction ducts are interconnected 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. 3 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, or if the temperatures of the LOX in the suction ducts should increase excessively, helium gas will be bubbled into all five suction ducts. Should premature closure of the prevalves occur, interconnect valve No. 3 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.

B. Prepressurization

Prepressurization of the LOX tank is required prior to liftoff 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 and 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 45 seconds will be required for prepressurization. Engine ignition at T-7 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 pressurization until liftoff.



SIGNATURES	DATE
DR M Gordon	7-2-68
DSGN	8/6/68
QC	8-6-68
ENGR	8-21-68
APP	8-21-68
FEC	9/3/68
AUTH	

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PROPULSION S-IC LOX PRESSURIZATION

SLV AS-503 | SIZE J | DWG NO 814

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*

C. Flight Pressurization

Flight pressurization of the LOX tank is required to provide the necessary LOX pressure at the engine pump inlets. At engine ignition command, the turbopumps begin to supply LOX to the LOX dome of each thrust chamber. 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 mainstage, 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 certain minimum GOX flow and is designed to maintain LOX tank ullage pressure at about 20.5 psia subsequent to liftoff. During the time period between engine ignition and liftoff, minimum flow occurs through the GOX flow control valve. Until liftoff this flow is supplemented by the prepressurization described above and the tank is maintained at about 26 psia. After liftoff and throughout the flight, the GOX flow control valve maintains LOX tank ullage pressure at about 20.5 psia by modulating GOX flow between an optimized range of 30 to 50 pounds per second (with a maximum flow capacity of 70 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 No. 1 will assure primary control of tank venting until approximately T+65 seconds. This switch, which actuates at 29.0 psia and deactuates at 27.5 psia, will open the LOX tank vent valve. As the vehicle gains altitude, the external ambient pressure decreases, and between approximately T+64 and T+75 seconds, either flight vent pressure switch No. 1 or No. 2 may cause venting. Flight vent pressure switch No. 2 which actuates at 25.5 psig and deactuates at 23.7 psig, will operate the LOX tank vent valve after T+75 seconds when the external ambient pressure has decreased to such an extent that flight vent pressure switch No. 2 assumes primary control of the venting operation, should venting be required. Should the pressure switches or solenoid valves which operate the LOX vent valve malfunction, the LOX tank vent and relief valve will mechanically relieve tank pressure between 25.5 and 24.0 psig.

8.1.5 S-IC Pneumatic Control System

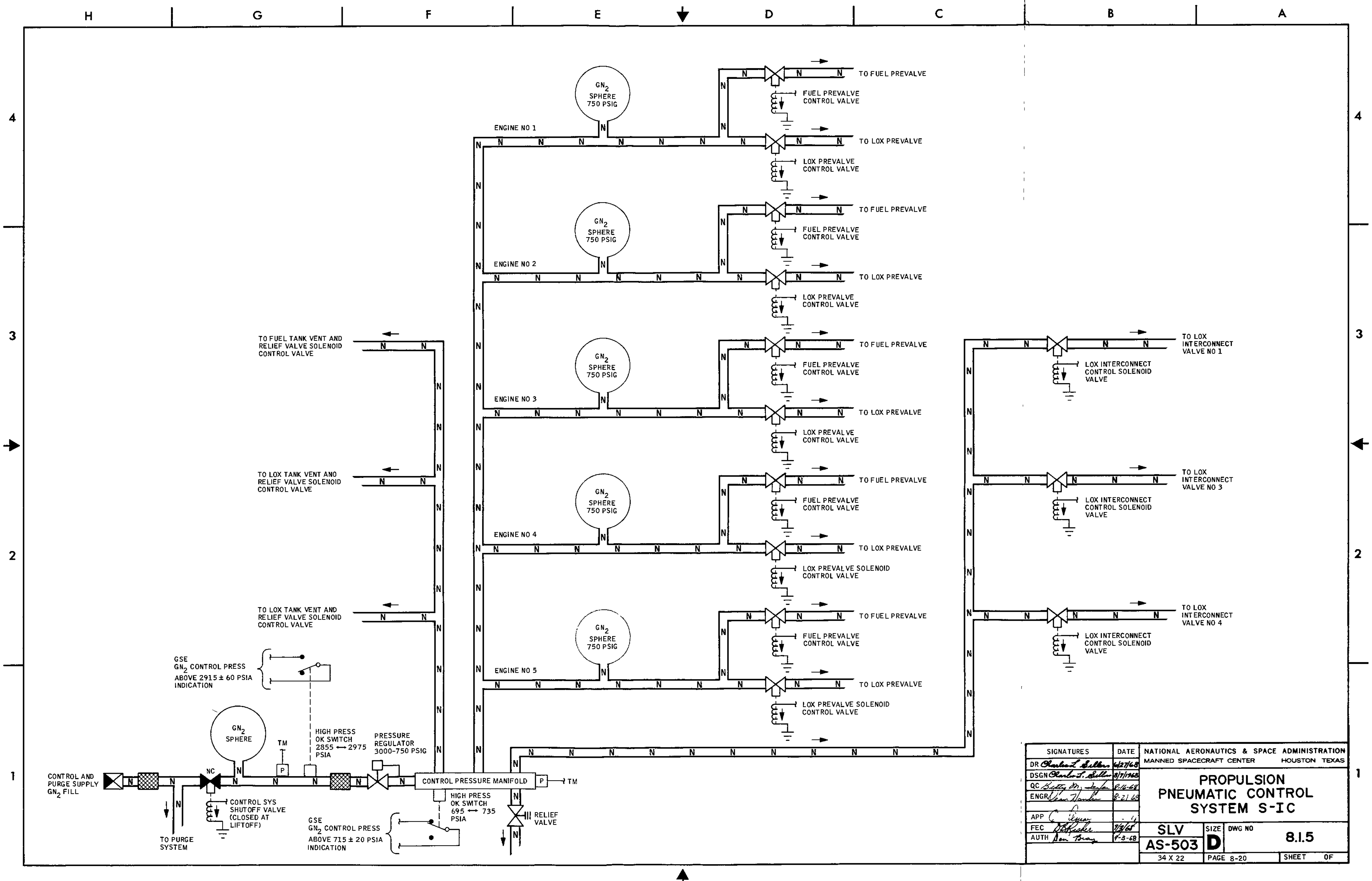
Prior to pressurization of the 3000 psig (1.27 cu ft) GN_2 storage sphere, the normally closed GN_2 solenoid valve must be in the open position. Ground supplied gaseous nitrogen is introduced through a GN_2 storage self-sealing quick disconnect coupling, GN_2 pressurization filter, and GN_2 solenoid valve into the sphere. The sphere is pressurized to approximately 1500 psig prior to propellant tanking. Pressurization to approximately 3000 psig occurs at T-30 minutes. The GN_2 solenoid valve is closed shortly before liftoff 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 actuation 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. Also, the helium fill control solenoid valve is energized open to allow gaseous nitrogen to close the helium fill shutoff valve.

*

Gaseous nitrogen is routed from the pressure manifold to the prevalve control manifold which feeds five 750 psig GN_2 storage spheres. Each sphere feeds two normally closed LOX and fuel prevalve control solenoid valves. The LOX prevalve control solenoid valve, when energized, opens and allows gaseous nitrogen to close the normally open LOX prevalve and flowmeter assembly, and the fuel prevalve control solenoid valve opens and allows gaseous nitrogen to close the two normally open fuel prevalve and flowmeter assemblies. A fuel prevalve control orifice is located in the line between the solenoid valve and the fuel prevalves so the fuel prevalves will close after the LOX prevalve, thus maintaining the desired fuel-rich shutoff.

The GN_2 storage 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 liftoff and remain closed to isolate the two systems during flight.



H
G
F
E
D
C
B
A
4
3
2
1
GN2 SPHERE 750 PSIG
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 LOX INTERCONNECT VALVE NO 1
TO LOX INTERCONNECT VALVE NO 3
TO LOX INTERCONNECT VALVE NO 4
LOX INTERCONNECT CONTROL SOLENOID VALVE
TO FUEL TANK VENT AND RELIEF VALVE SOLENOID CONTROL VALVE
TO LOX TANK VENT AND RELIEF VALVE SOLENOID CONTROL VALVE
GSE GN2 CONTROL PRESS ABOVE 2915 ± 60 PSIA INDICATION
GN2 SPHERE
NC
TM
P
HIGH PRESS OK SWITCH 2855 ↔ 2975 PSIA
PRESSURE REGULATOR 3000-750 PSIG
CONTROL PRESSURE MANIFOLD
CONTROL AND PURGE SUPPLY GN2 FILL
TO PURGE SYSTEM
CONTROL SYS SHUTOFF VALVE (CLOSED AT LIFTOFF)
GSE GN2 CONTROL PRESS ABOVE 715 ± 20 PSIA INDICATION
HIGH PRESS OK SWITCH 695 ↔ 735 PSIA
RELIEF VALVE
N
SIGNATURES
DATE
DR
DSGN
QC
ENGR
APP
FEC
AUTH
NATIONAL AERONAUTICS & SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER
HOUSTON TEXAS
PROPULSION PNEUMATIC CONTROL SYSTEM S-IC
SLV AS-503
SIZE D
DWG NO 8.1.5
34 X 22
PAGE 8-20
SHEET OF

8.1.6 F-1 Engines

A. General Description

Five F-1 engines are used on the S-IC stage of the Saturn AS-503 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 uses RP-1 as the hydraulic fluid during flight. The fuel is bled from the 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.

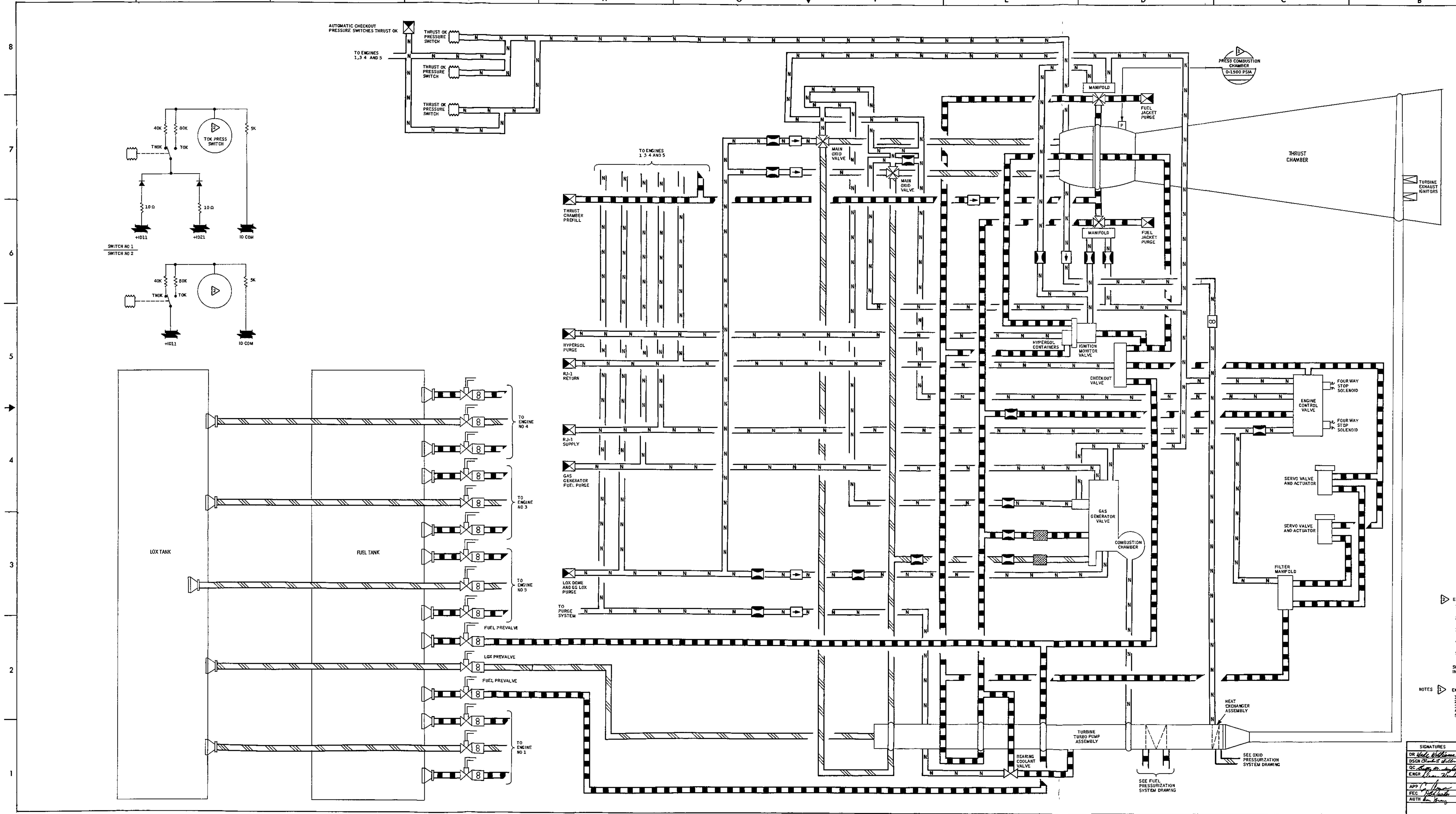
Ground support equipment is required to start the engine, but once started it is self sustaining. The F-1 engine system consists of a gas generator, a turbopump assembly, a dual media heat exchanger, a thrust chamber, a nozzle extension, a checkout valve, a four-way control valve, two main LOX valves,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

B. Start Sequence and Mainstage 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 de-energized. 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 the 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 heat exchanger, and out 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 dishcarge 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 $\pm$ 30 psig, the igniter fuel poppet opens and allows fuel pressure to build up against the hypergol cartridge burst diaphram. The hypergol diaphram bursts 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 rough combustion or low thrust.



2▷

ENG	SWITCH 1	SWITCH 2
1	K33-115 AP1B0-19R05-01	K34-115 AP1B0-19R05-02
2	K36-115 AP1B0-19R05-04	K37-115 AP1B0-19R05-05
3	K39-115 AP1B0-19R05-07	K40-115 AP1B0-19R05-08
4	K42-115 AP1B0-19R05-10	K46-115 AP1BU-19R02-01
5	K45-115 AP1B0-19R02-03	K46-115 AP1B0-19R02-04

SWITCHES 1 AND 2 MONITORED BY FLIGHT CONTROLLER IN REALTIME

NOTES 1▷

ENG	MEASUREMENT	TM CHANNEL
1	D8-101	AP1B0V07 10-00
2	D8-102	AP1B0V08 01-00
3	D8-103	AP1B0V09-03-00
4	D8-104	AP1B0V09-04-00
5	D8-105	AP1B0V10-06-00

SIGNATURES	DATE
DR	7-1-68
DSGN	8/6/1968
QC	9-16-68
ENGR	8 21 68
APP	8/21/68
FEC	7/3/68
AUTH	9-3-68

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PROPULSION FI ENGINE MECHANICAL SYSTEM S-IC

SLV AS-503 | SIZE J | DWG NO 8.1.6

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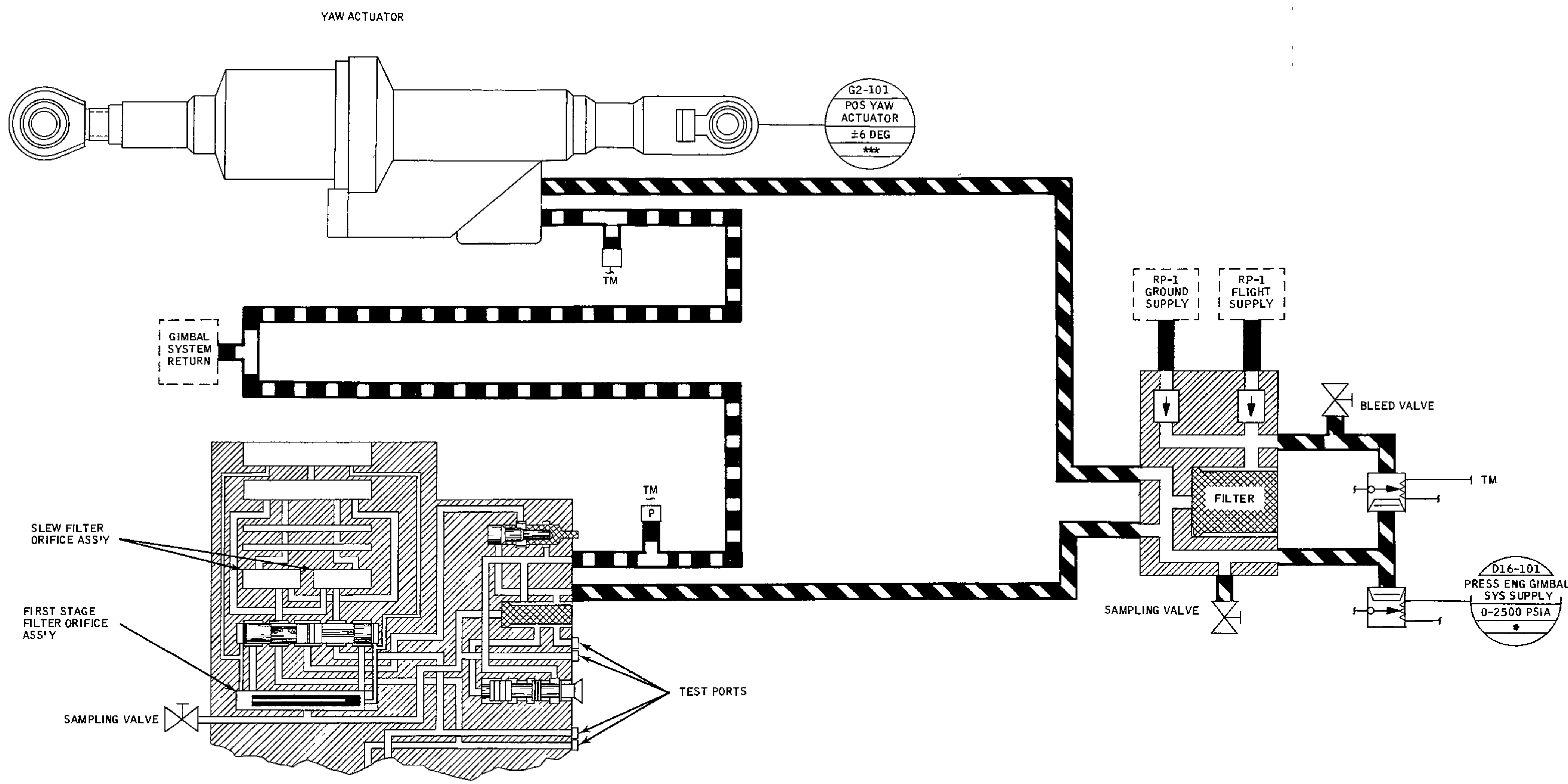
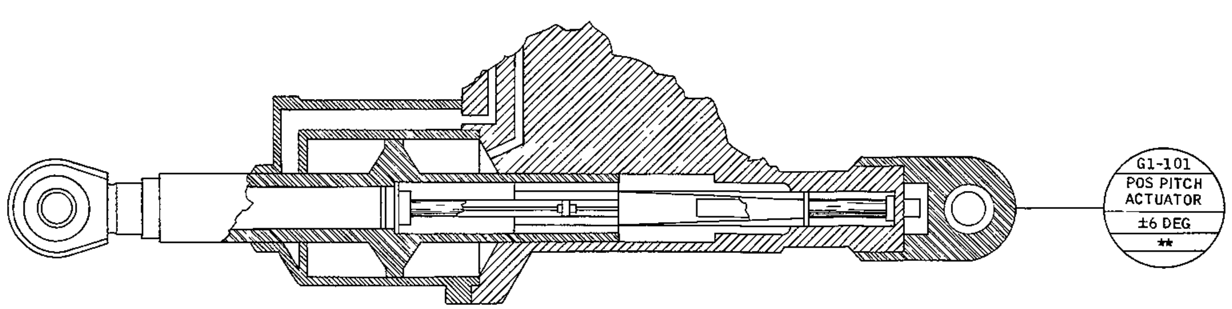
8.1.7 S-IC Hydraulic System

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 (RJ-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.

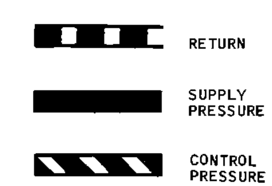




PITCH ACTUATOR

*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	CP1B0V09-00-00

LEGEND



SIGNATURES	DATE
DR	4/24/68
DSGN	8/6/1968
QC	8-16-68
ENGR	8-21-68
APP	8-21-68
FEC	9/3/68
AUTH	9-3-68

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PROPULSION HYDRAULIC SYSTEM S-IC

SLV 503 | SIZE D | DWG NO. 8.17

34 X 22 | PAGE 8-27 | SHEET OF

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8.2 S-II STAGE

8.2.1 Propulsion and Structures (General Description)

The S-II stage measures 81.5 feet in length and is 33 feet in diameter. It has a gross weight at liftoff of about 1.0 million pounds. The stage is powered by five J-2 rocket engines utilizing liquid oxygen and liquid hydrogen as propellants. Each engine develops a nominal vacuum thrust of approximately 200,000 pounds. The four outer J-2 engines are equally spaced on a 210-inch diameter circle, and are capable of being gimbaled through a plus or minus 7.3° square pattern for thrust vector control. The fifth engine is mounted on the stage center line and is fixed. During their burn period, the engines consume approximately 930,000 pounds of propellants.

The J-2 engine is a high specific impulse (I_{sp}) engine featuring a tubular wall, bell shaped thrust chamber with a 27.5:1 expansion ratio. Two independently driven turbopumps, both powered in series by a single gas generator, supply LOX and LH_2 to the thrust chamber. The gas generator operates on the same propellants as the engine.

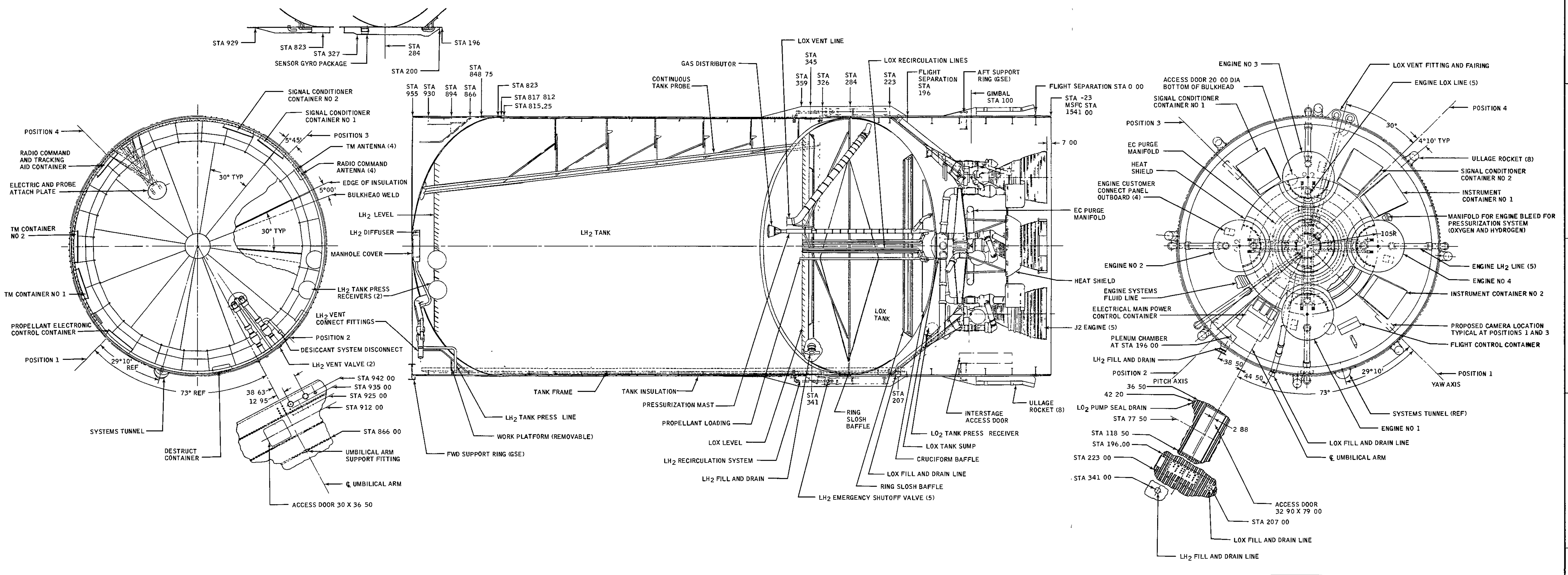
The propellants are stored in an integral container. The LOX and LH_2 compartments are separated by a common insulated bulkhead. The LOX and LH_2 tanks have volumes of 12,600 and 27,700 cubic feet respectively. The tank pressurization system is designed to assure adequate propellant inlet pressures to the turbopumps.

The stage instrumentation system transmits over 700 measurements to ground receiving stations for real time and postflight vehicle performance evaluation. Six telemetry links are employed: three PCM/FM/FM for relatively low frequency measurements, two SS/FM for relatively high frequency measurements and one PCM/FM for digital measurements. The PCM link is also used for ground telemetering by direct wire of DDAS system measurements required for automatic checkout. A tape recorder is used to record certain S-II/S-IVB separation data for playback.

Stage separation system components located on the S-II stage include a controller for sequencing separation events, eight ullage rockets to provide propellant settling during engine start, and linear shaped charges which physically sever structure at both separation planes.

Other systems aboard the stage are sensors for an emergency detection system, a propellant recirculation system for chill-down of propellant lines, flight control system elements for executing steering commands issued by the Instrument Unit, and electrical power system and a flight termination system.

LTR	DR	ENGR	DATE	APPROVAL



SIGNATURES	DATE	NATIONAL AERONAUTICS & SPACE ADMINISTRATION MANNED SPACECRAFT CENTER • HOUSTON TEXAS
DR Betty M. [illegible]	8-30-68	
DSGN Clarence [illegible]	9-3-68	**PROPULSION S-II STRUCTURE**
QC [illegible]	9-3-68	
ENGR [illegible]	9-3-68	
APP [illegible]	9-3-68	
FEC [illegible]	9/3/68	SLV AS-503 — SIZE J — DWG NO 8.2.1
AUTH [illegible]	9-3-68	
		44 X 21 25 — PAGE 8-30 — SHEET 1 OF 1

MSC Form 1616 E (REV OCT 65)

8.2.2 Staging Systems Operation (General Description)

A. Second-plane Separation

To be supplied.

B. S-II/S-IVB 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:

1. EBW Firing Units Armed

A ground latched interlock renders the EBW firing units inoperative while the vehicle is on the launch pad. The interlock is released with umbilical disconnect during liftoff, and the subsystem is reset to flight condition. At approximately 482 seconds after liftoff, 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 both 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, and the S-IVB stage electrical circuitry to supply plus 28 Vdc to the EBW firing units for ullage rocket 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 MDF detonation.

2. S-II Engine Cutoff
3. Separation

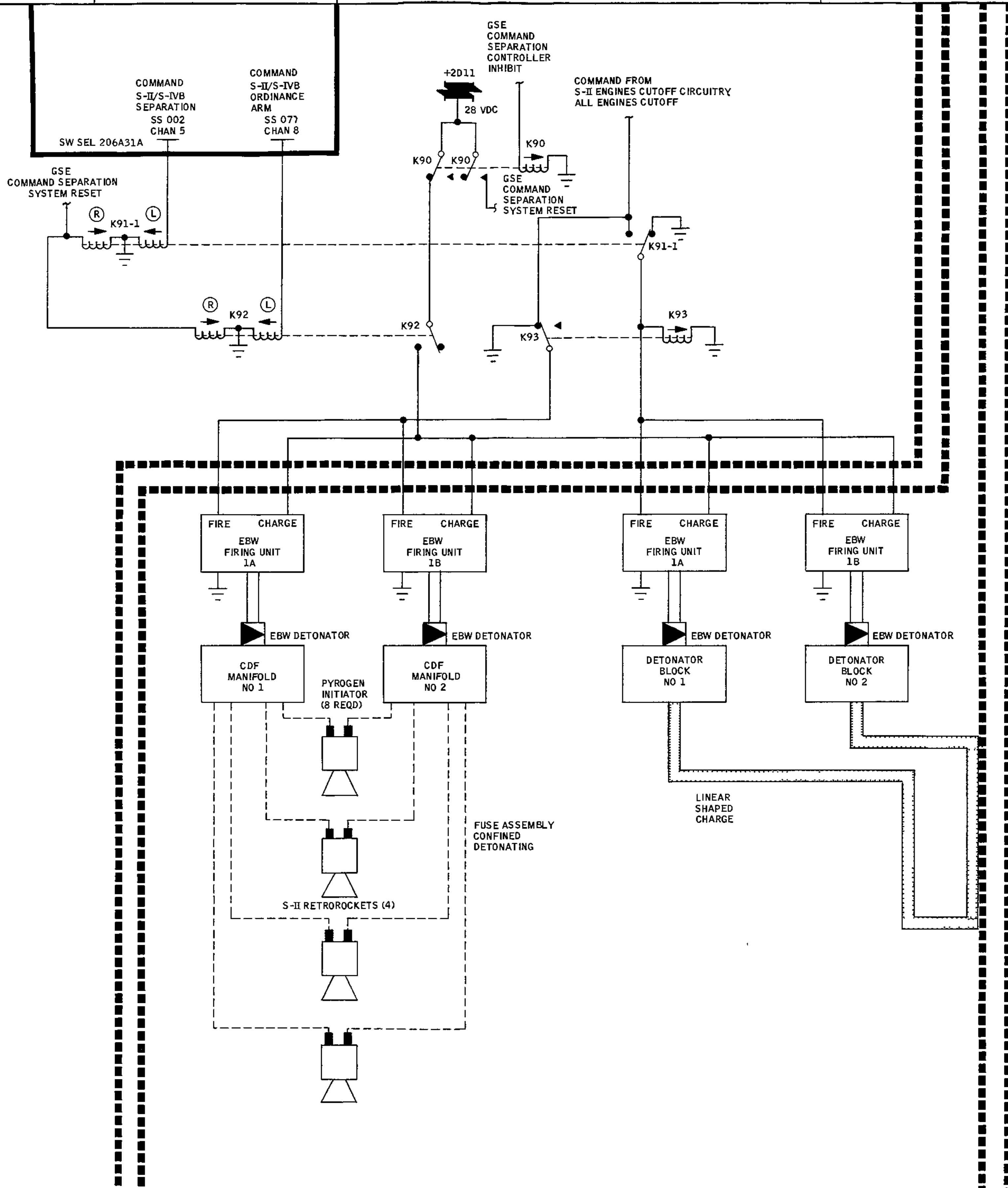
Separation is initiated at approximately 518.7 seconds after liftoff. The separation command is routed through the S-II switch selector to the S-II electrical circuitry to trigger the ordnance train for separation and retro-rocket ignition.

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 after separation. Each retrorocket has a burning time of 1.54 seconds and develops a thrust of 34,810 pounds vacuum thrust.

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.

The mild detonating fuse is used to sever the vehicle structure during separation. Two trains of MDF 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.



LTR	DR	ENGR	DATE	APPROVAL

SIGNATURES	DATE
DR M D Smith	4-19-68
DSGN Charles L. Sullivan	8/4/1968
QC Betty M. Taylor	8 16 68
ENGR	8 21 68
APP	8-21-68
FEC	9/3/68
AUTH	9-3-68

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PROPULSION
S-II/S-IVB SEPARATION SUBSYSTEM

SLV AS-503 | SIZE D | DWG NO 8.2.2

34 X 22 | PAGE 8-34 | SHEET

8.2.3 S-II LH_2 Pressurization

A. Prepressurization

Prepressurization is initiated in the terminal countdown sequence at approximately T-97 seconds and continues until umbilical disconnect. 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 Ghe at minus 275°F 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 S-IC launch.

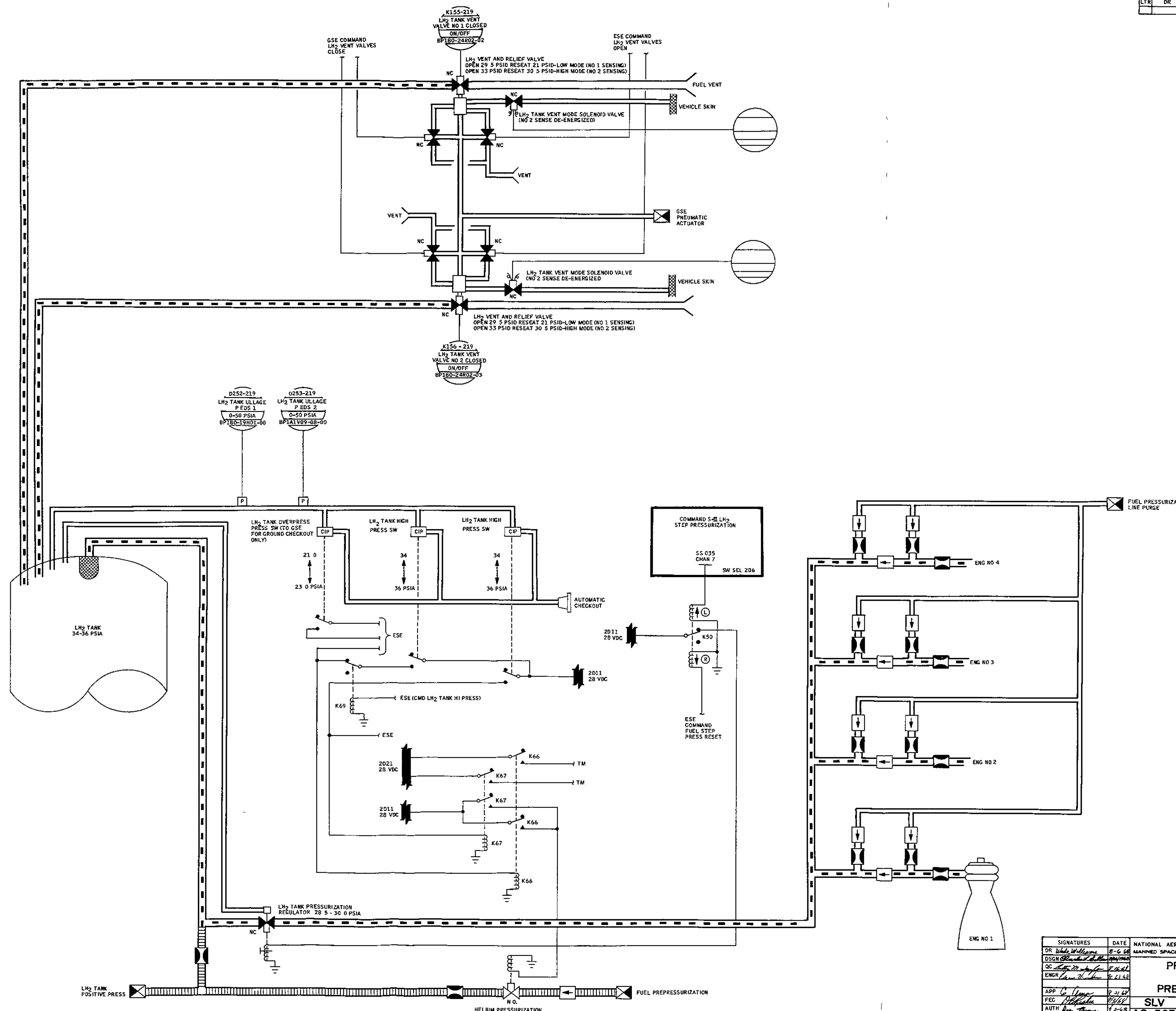
B. Interim Pressurization

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 27.0 to 29.5 psid until S-IC engine cutoff.

C. At T_3 + 0.11 seconds, the normally closed solenoid valves will be deactivated to place the vent valves in the high pressure vent mode, this 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 supplied from the engines.

After S-II engine ignition, liquid hydrogen is preheated in the regenerative cooling tubes of the engine, and tapped off from the thrust chamber injector manifold in the form of GH_2 to serve as a pressurizing medium. The ullage pressure drop in the fuel tank is sensed by the pressure regulator which opens the pressurization line and permits 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 250 seconds after

S-II engine ignition, 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 30.5 to 33.0 psia to compensate for the loss of head pressure caused by the lowering of the fuel level in the tank.



SIGNATURES	DATE
DR Wade Williams	8-6 68
DSGN	8/6/1968
QC	8 16 68
ENGR	8 21 68
APP	8 21 68
FEC	9/3/68
AUTH	9 3-68

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PROPULSION S-II LH_2 PRESSURIZATION

SLV AS-503 | SIZE E | DWG NO 8.2.3

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8.2.4 LOX Pressurization

A. LOX Conditioning

LOX conditioning is necessary to provide LOX at the LOX pump inlet at uniform temperature and density.

Conditioning of LOX is initiated at the start of LOX fill and continues to approximately 10 seconds before S-II ignition. Conditioning is accomplished by recirculating the LOX down the suction ducts, through the LOX pumps on the engines, into the return lines and back into the LOX tank. LOX recirculation is started by self-induced thermopumping or, when necessary, by thermopumping induced by injecting gaseous helium. Thermopumping is self-started by the heat differential present in the uninsulated return lines. The heat absorbed by the LOX during this cycle maintains thermal pumping. Recirculation is terminated by closing the return line valves and LOX bleed valves.

Provisions for injecting ground supplied gaseous helium to start thermopumping are available during LOX fill and until umbilical disconnect. The helium is injected through bosses into the return lines by opening the helium injection control valve. Chilled helium may be used to further decrease LOX temperature.

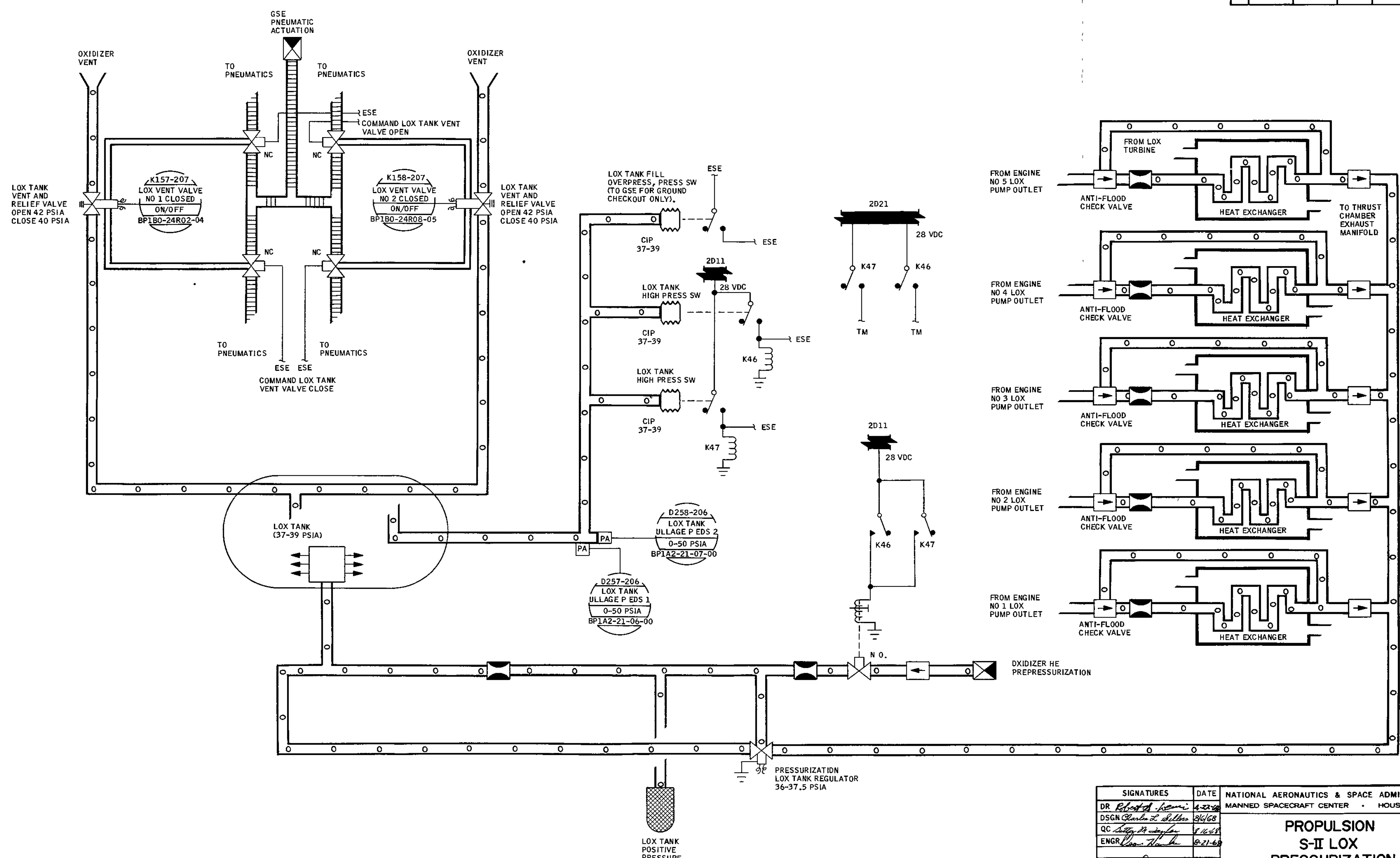
B. Tank Prepressurization

Prepressurization of the LOX tank is required prior to liftoff to provide the required NPSH for engine start and starts at approximately T-187 seconds and continues until liftoff. The command to open the prepressurization valve, to begin prepressurization, is interlocked with the closed indication of the LOX tank vent valves. 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 37.5 psig the pressurization valve is closed by the two tank pressure switches.

The S-IC ignition command closes the disconnect valve and initiates umbilical line bleed. Ground helium remains available for use until liftoff. Ullage pressure provided at liftoff is maintained by LOX boiloff throughout the interim period between umbilical disconnect and S-II ignition.

C. Flight Pressurization

Pressurization of the LOX tank during S-II powered flight is by gaseous oxygen supplied by heating LOX bleed from the LOX pump outlet and is initiated at S-II ignition and continues until engine cutoff. After S-II ignition the gas generator exhaust passes through the heat exchanger. When the LOX turbine discharge pressure reaches a pressure differential of 100 psid, the LOX antiflood heat exchanger valve permits LOX bleed from the LOX pump outlet, to pass into the heat exchanger. Flow of GOX produced at the heat exchanger is regulated by the GOX regulator control valve, varying according to LOX tank ullage pressure required, as sensed by the reference pressure line. At approximately 250 seconds after engine start, the GOX regulator control valve is actuated to its full open position and remains in this position the remainder of S-II powered flight. When the GOX regulator is actuated to its full open position, LOX tank pressure increases to a nominal 40 psia.



SIGNATURES	DATE
DR	4-22-68
DSGN	8/6/68
QC	8-16-68
ENGR	8-21-68
APP	8-31-68
FEC	9/4/68
AUTH	9-3-68

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PROPULSION S-II LOX PRESSURIZATION

SLV AS-503 SIZE D DWG NO. 8.2.4

34 X 22 PAGE 8-40 SHEET OF

LTR	DR	ENGR	DATE	APPROVAL

MSC Form 1616 D (REV OCT 65)

8.2.5 S-II Pneumatic Control System

A. Countdown through liftoff

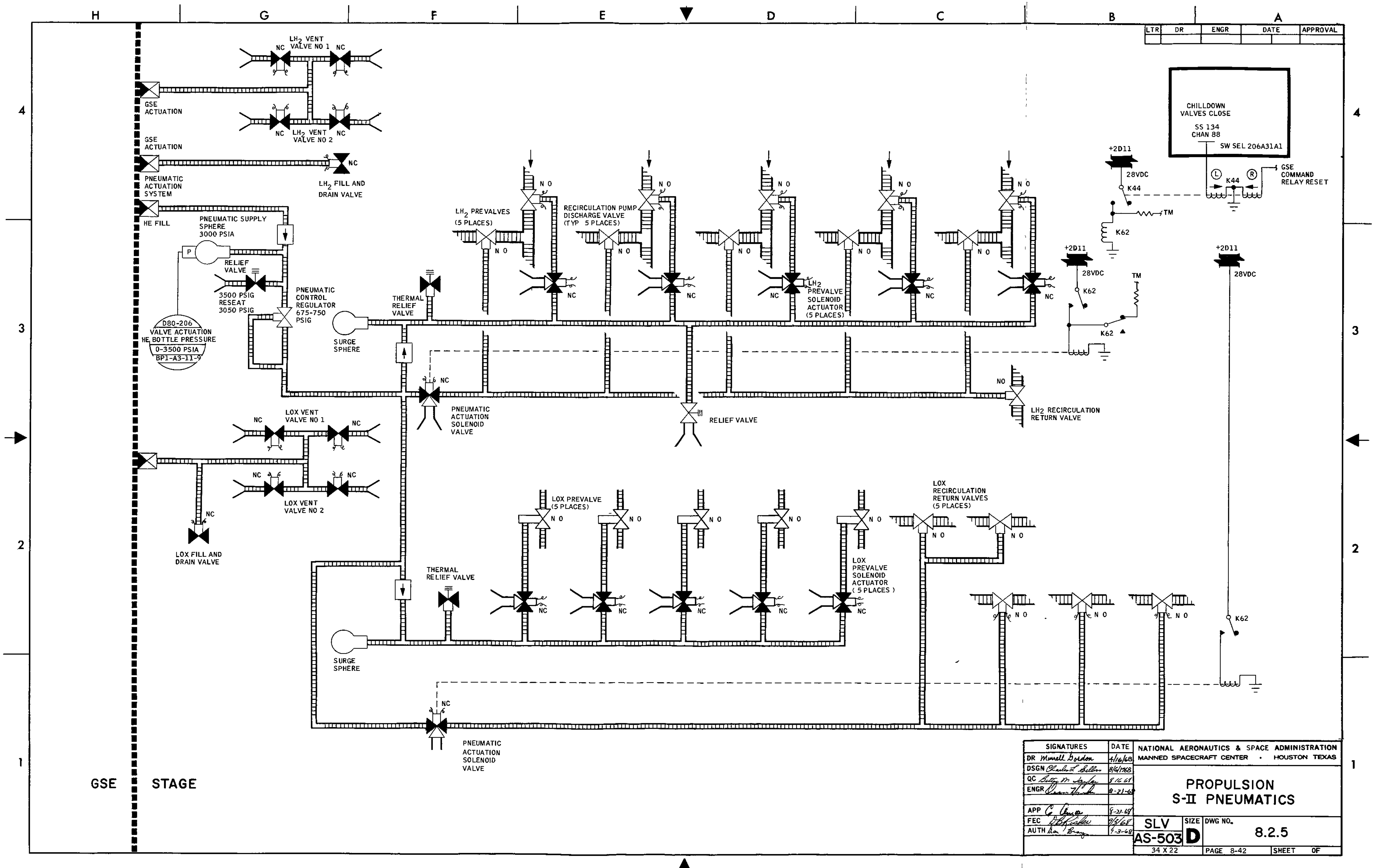
The S-II pneumatic subsystem is prepressurized with helium at ambient temperature and 1500 psig at approximately T-6.5 hours. The LH_2 prevalves are actuated at the closed position. The LH_2 and LOX recirculation valves and the LOX prevalves are left in their normally open position. The subsystem is 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 LOX and LH_2 recirculation valves to their closed positions until commanded by the switch selector.

B. Liftoff Through S-IC Boost

Pressure is maintained to hold the LH_2 prevalves in the closed position until 0.5 seconds prior to S-IC/S-II separation. At that time, the built-in solenoids of the LH_2 prevalves are actuated, allowing the LH_2 prevalves to open.

C. Staging and S-II Burn

The low pressure helium receivers contain sufficient pressure for prevalve actuation in the event of engine failure.



SIGNATURES	DATE
DR Murrell Gordon	4/16/68
DSGN	8/6/1968
QC	8-16-68
ENGR	8-21-68
APP	8-21-68
FEC	9/3/68
AUTH	9-3-68

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PROPULSION
S-II PNEUMATICS

SLV AS-503 | SIZE D | DWG NO. 8.2.5

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8.2.6 J-2 Engine System

A. General Description

The engine system consists of five single start J-2 engines. The J-2 engine is a 200,000 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.

B. Operational Description

START - All five engines are started simultaneously upon receipt of a command from the switch selector.

STEADY STATE - All five engines operate at approximately 100 percent thrust during mainstage operation and use a nominal 5:1 propellant mixture ratio.

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.

MALFUNCTION DETECTION - Each engine is provided with a system to detect malfunctions and to effect a safe shutdown. A cutoff signal is given to an individual engine prior to attainment of main stage operation if the required signal is not received from the ignition monitor. 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.

C. Engine Purges

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. After partial pressurization, the ground supply valve is closed and the helium tank is vented through the normally closed helium tank emergency vent control solenoid valve. This procedure is repeated three times to insure adequate purging.

START TANK PURGE AND PRECHILL - Following the helium tank purge, the start tank is purged in the same manner as the helium tank, 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.

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 -200°F with cold helium through this same purge and preconditioning route.

*

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:

1. Seal cavity of LH_2 pump, with flow passing 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.
2. Seal cavity of LH_2 turbine, with flow passing through a turbopump check valve and LH_2 turbine seal cavity purge orifice. Purge gas exits through overboard bleed lines.
3. Seal cavity of LOX pump, with flow passing through a turbopump check valve and LOX turbine seal cavity purge orifice. Purge gas exits through overboard bleed lines.
4. LH_2 injection of gas generator, with flow passing 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.

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 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.

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 during static testing and is not performed during flight.

NOTE

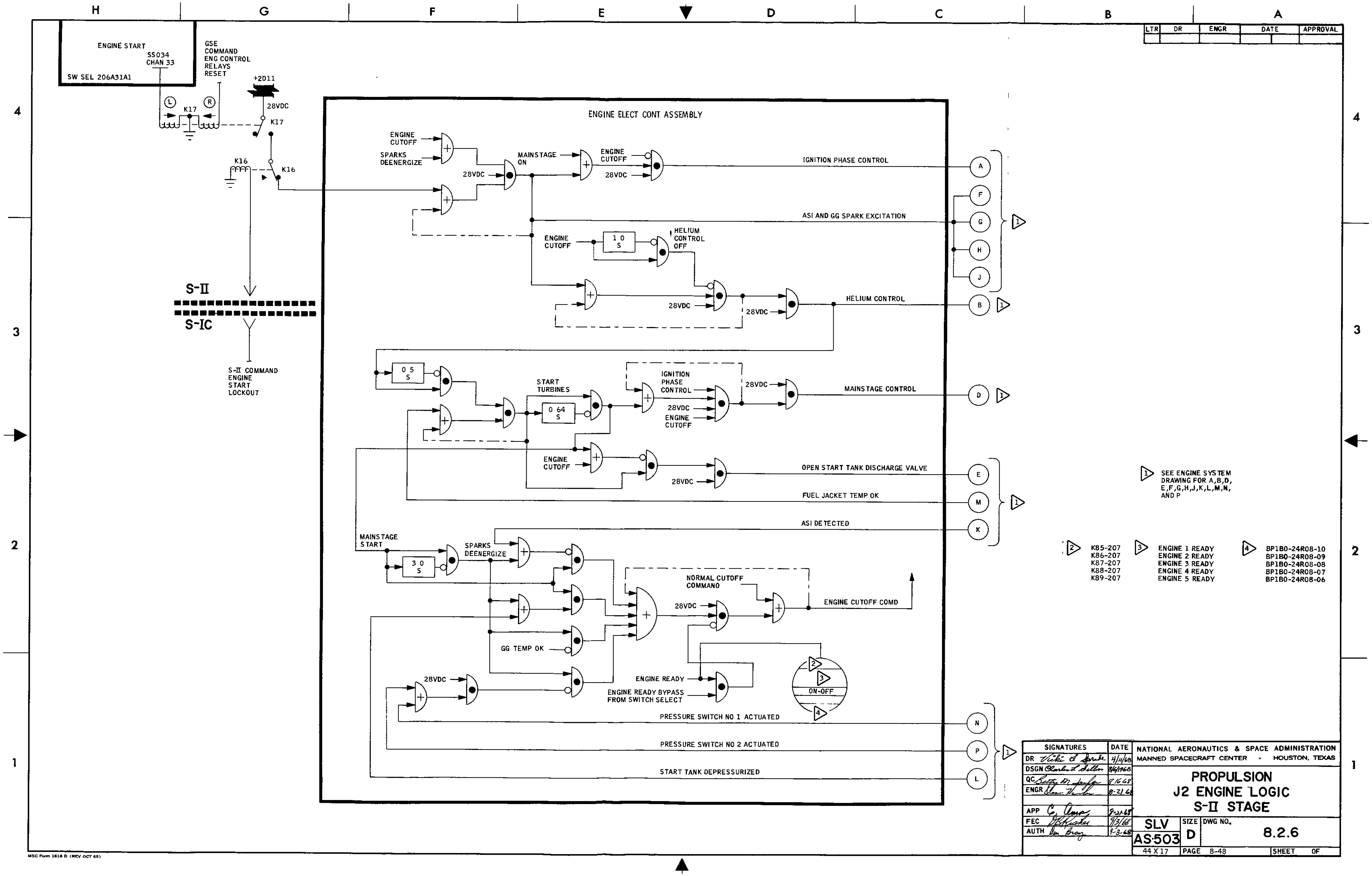
For J-2 engine data, further information may be obtained from the Rocketdyne publication, "Preliminary Technical Engine Data Manual," R-3825-1. (CONFIDENTIAL)

D. Propellant Management System - 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.

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 continuous probe. During loading operations, the signal from each probe is transmitted from the onboard propellant management electronics to a ground checkout and display. Backup sensors to the probes are provided for both the LH_2 and LOX systems. 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.

PROPELLANT UTILIZATION - During flight, the signals from the LH_2 and LOX tank continuous capacitance probes are transmitted through LH_2 airborne electronics package and LOX airborne electronics package to both the telemetry system and the airborne computer which compare the signals, and provide an error signal to the propellant utilization valve on each LOX pump. Based on this error signal, the propellant utilization valves are positioned to minimize residual propellants at cutoff and assure a fuel rich cutoff. This is accomplished by varying the amount of LOX delivered to the engines. The propellant utilization valves are installed at the turbopump outlet and control propellant mixture ratio by varying the amount of LOX returned from the outlet to the inlet of the pump.



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PROPULSION J2 ENGINE LOGIC S-II STAGE

SIGNATURES	DATE
DR	4/11/68
DSGN	8/6/1968
QC	8-16-68
ENGR	8-21-68
APP	8-21-68
FEC	9/3/68
AUTH	9-3-68

SLV AS-503 | SIZE D | DWG NO. 8.2.6

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8.2.7 S-II Hydraulic System

A. General Description

The S-II hydraulic system provides attitude control by gimbaling one or more of 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 or individually in accordance with electrical input signals. The primary components are the main hydraulic pump, auxiliary pump, auxiliary pump electric motor, accumulator reservoir manifold assembly, and two servoactuators.

B. System Fill

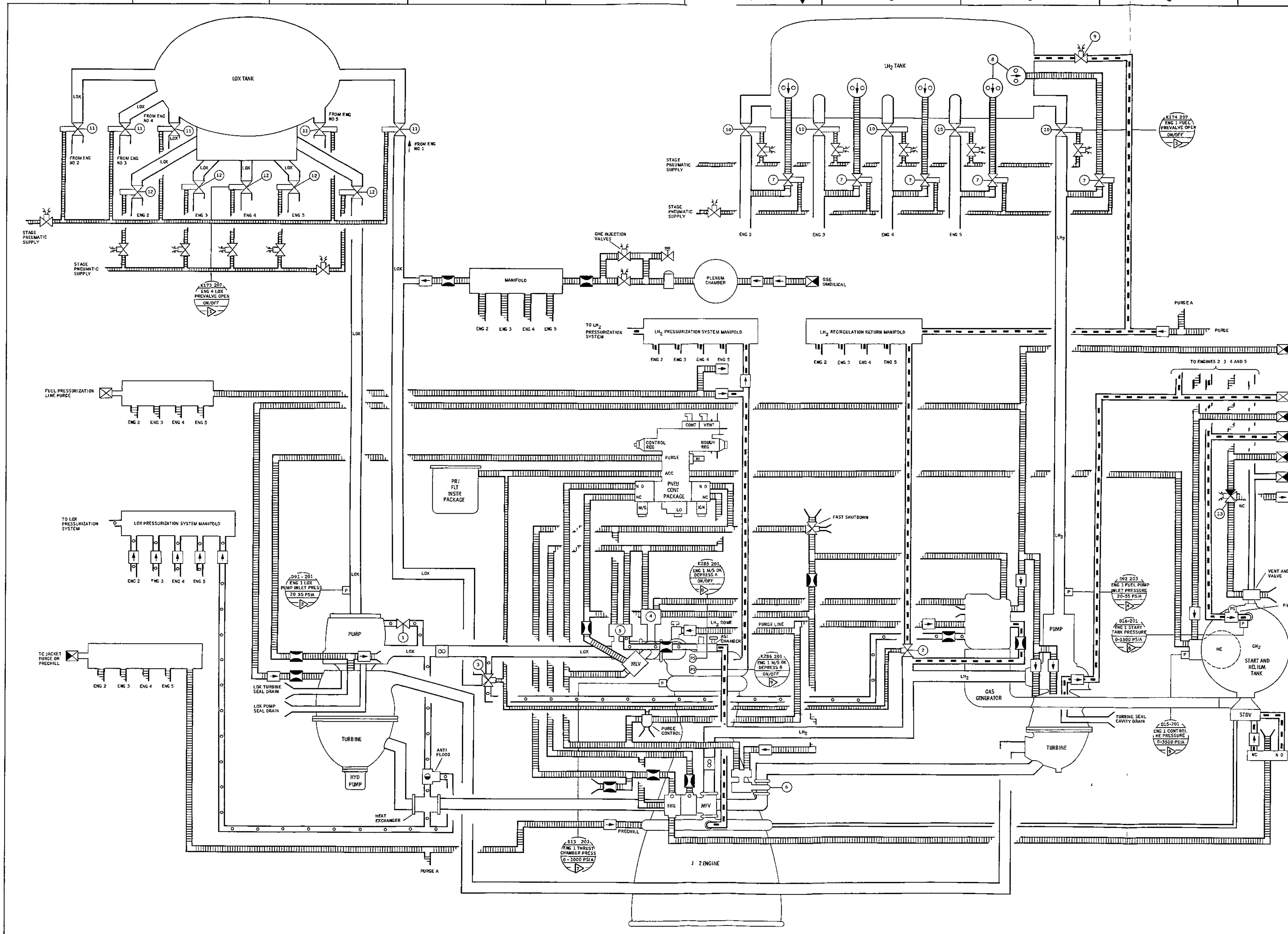
The engine gimbal actuation system is filled with hydraulic oil (MIL-H-5606A) from a low pressure ground source through the high pressure service self-sealing quick disconnect coupling. The low pressure service self-sealing quick disconnect coupling is also connected to the ground source to allow the return of fluid to GSE during preflight purging and flushing operations. The manually controlled prefiltration bypass valves on the servoactuator assemblies are actuated to the bypass position prior to initiation of system flush to prevent contamination of the hydraulic actuators. The accumulator is precharged with GN_2 through the GN_2 fill valve. Fluid is circulated through the system by auxiliary pump. When sampling tests indicate that the contamination level of the fluid is acceptable, the prefiltration bypass valves are actuated to the flight position, the auxiliary pump is stopped, the main hydraulic pump is manually rotated, and the servoactuators are driven full strok to complete the filling and bleeding operations.

C. Operational Phase

For the purpose of this description, preflight operation shall begin with propellant loading and end with S-IC/S-II stage sepration.

PRELFIGHT OPERATION - Prior to propellant loading, each hydraulic system is filled with hydraulic fluid at low pressure through the hydraulic fluid fill self-sealing quick disconnect coupling. During and following propellant loading, the hydraulic system fluid is intermittently recirculated by the electrically driven auxiliary pump in order to prevent the fluid from freezing. Recirculation is terminated just prior to S-IC ignition command. Recirculation is not necessary during S-IC burn, due to the short duration of S-IC burn. The accumulator reservoir manifold assembly contains an accumulator and a reservoir. The reservoir receives fluid from the servoactuators during engine operation and supplies low pressure fluid to the auxiliary and main hydraulic pumps. Prior to launch the accumulator is filled from the pressurized auxiliary pump flow. Just prior to liftoff, this fluid is stored under high pressure in the accumulator by closing both hydraulic lockup valves which are contained in the accumulator reservoir manifold assembly. These valves are controlled by an independent lockup control solenoid valve. The engines remain in the "null" position during countdown, except during gimbal checks. These checks are made between 20 and 30 minutes prior to liftoff.

INFLIGHT OPERATION - After S-IC/S-II stage separation, an S-II switch selector command unlocks the accumulator lockup valves, releasing high pressure fluid to each of the two servoactuators. This fluid provides gimbaling power prior to main hydraulic pump operation. The main hydraulic pump is driven directly from the accessory drive pad of the engine LOX pump. During S-II main stage operation, the main hydraulic pump supplies high pressure fluid to the servoactuators per engine, one for the pitch axis and one for the yaw axis. Each servoactuator contains a servo-valve which controls the position of the hydraulic actuator in accordance with electrical signals transmitted from the flight control system.



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

NOTES	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	D13-201	E1 THRUST CHAMBER P	BP1B0V23 06 00
	D13-202	E2 THRUST CHAMBER P	BP1B0V18-01 00
	D13-203	E3 THRUST CHAMBER P	BP1B0V23-05 00
	D13-204	E4 THRUST CHAMBER P	BP1B0V07-10 00
	D13-205	E5 THRUST CHAMBER P	BP1B0V06 06 00
6	D16 201	E1 START TANK P	BP1A3 01-04-00
	D16-202	E2 START TANK P	BP1A2 16-00-00
	D16 203	E3 START TANK P	BP1A2 02-02-00
	D16 204	E4 START TANK P	BP1A3 02-02-00
	D16-205	E5 START TANK P	BP1A3 02 03-00
5	D15-201	E1 HELIUM TANK P	BP1A3 21 09 00
	D15 202	E2 HELIUM TANK P	BP1A2-16 03 00
	D15-203	E3 HELIUM TANK P	BP1A2 21 02 00
	D15-204	E4 HELIUM TANK P	BP1A3 17-03 00
	D15-205	E5 HELIUM TANK P	BP1A3-17-08 00
4	D92-201	E1 ENGINE INLET LH_2 P	BP1A1V25 00-00
	D92 202	E2 ENGINE INLET LH_2 P	BP1A2 20 09 00
	D92 203	E3 ENGINE INLET LH_2 P	BP1A2 01 07-00
	D92 204	E4 ENGINE INLET LH_2 P	BP1A3 12 04 00
	D92 205	E5 ENGINE INLET LH_2 P	BP1B0V07 04 00
3	K174 207	E1 LH_2 PREVALVE OPEN	BP1B0 24R05 06
	K175 207	E2 LH_2 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	D91 201	E1 ENGINE INLET LOX P	BP1A3-19 00 00
	D91 202	E2 ENGINE INLET LOX P	BP1A2 20 06-00
		E2 ENGINE INLET LOX P	BP1A2 16 02 00
	D91-204	E4 ENGINE INLET LOX P	BP1A3 21 06-00
	D91-205	E5 ENGINE INLET LOX P	BP1A3 25 00-00
	D91-203		
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

SIGNATURES	DATE
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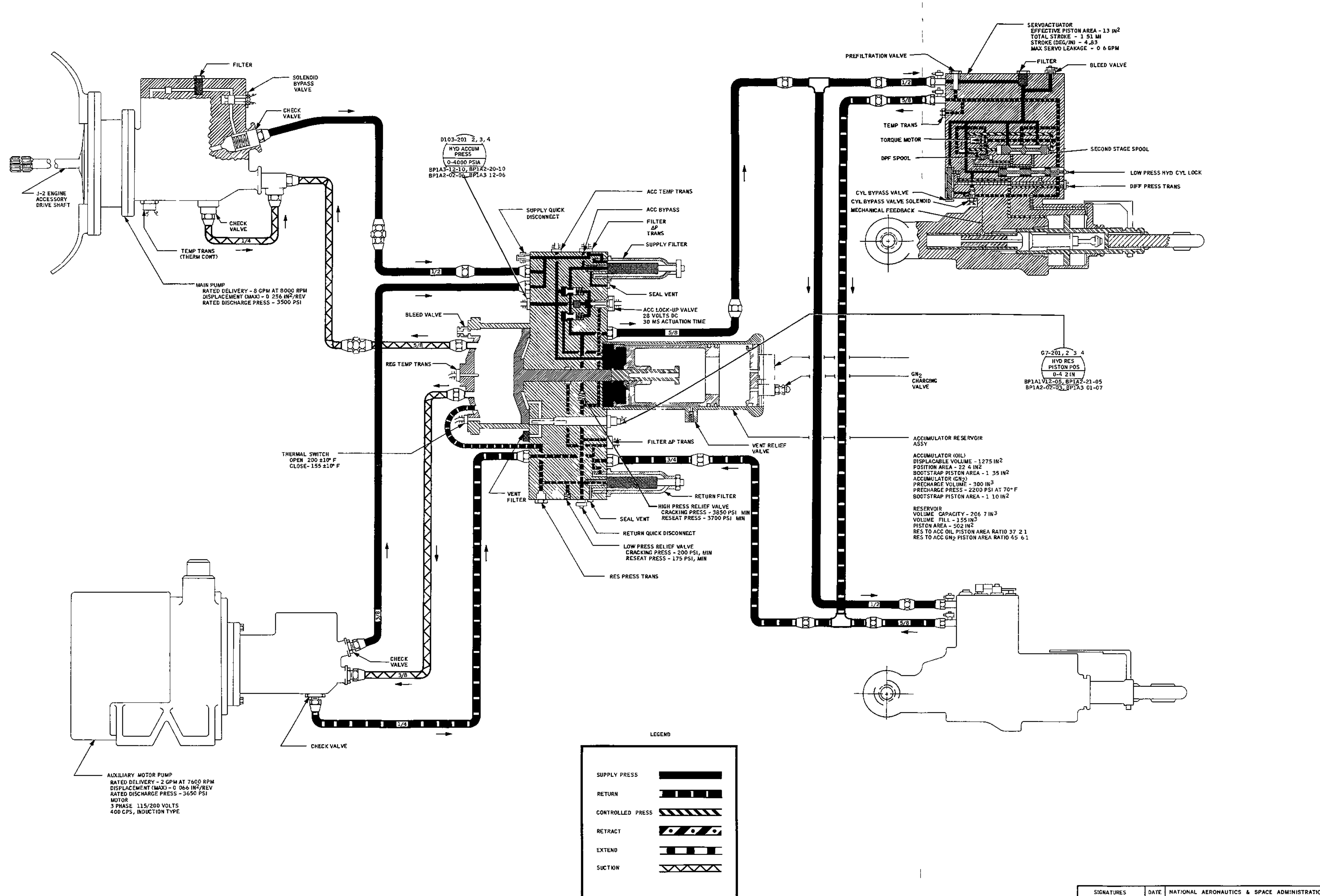
DSGN [signature]	9/3/68
QC [signature]	9-3-68
ENGR [signature]	9-?-68
APP [signature]	9-3-68
FEC [signature]	9/3/68
AUTH [signature]	9-3-68

NATIONAL AERONAUTICS & SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER HOUSTON TEXAS

PROPULSION, J-2 ENGINE SYSTEM, S-II STAGE

SLV AS-503 | SIZE J | DWG NO 827

60 5 X 38 25 | PAGE 8-52 | SHEET OF



SIGNATURES	DATE
DR M GORDON	6-28-68
DSGN Charles L Sellers	8/6/1968
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S-II ENGINE GIMBAL SYSTEM

SLV AS-503 | SIZE J | DWG NO 8.2.8

44 X 34 | PAGE 8-53 | SHEET OF

8.3 S-IVB STAGE

8.3.1 Propulsion (General Description)

The AS-503 S-IVB stage is a three-burn vehicle and incorporates provisions to condition and/or maintain the propulsion system for each start and burn. The propulsion system consists of a bipropellant J-2 engine, a fuel supply tank, an oxidizer supply tank and a propellant utilization system (PU). The fuel and oxidizer tanks incorporate separate pressurization systems, venting systems and chilldown systems, which condition the propellants to insure proper engine start and burn. The above systems, plus other supporting systems are further defined in the appropriate subsection.

On the Saturn V vehicle there is an additional propulsive requirement to maintain the propellants settled at the pump inlets when the J-2 engine is inoperative. This requirement is satisfied using two systems. The first is a high thrust (140-pound) short duration burn system employing two hypergolic engines, one located in each APS module (see subsection 8.3.11). This system is used during the transition periods when the J-2 engine is shut down or started up. The second is the low thrust (minimum of 6 pounds) continuous vent system. This system utilizes vented LH_2 tank boiloff gas to supply the propulsive force. This very low acceleration is maintained during the orbital coast period. This continuous vent system is further described in subsection 8.3.4.

8.3.2 Structures (General Description)

The S-IVB structure of the Saturn V vehicle consists of a forward skirt assembly, propellant tank assembly, aft skirt assembly, thrust structure assembly, and aft interstage assembly, drawing 8.3.0.

A. Aft Interstage Assembly

A truncated cone of aluminum skin panels, 260 inches in diameter at the forward end, 396.750 inches in diameter at the aft end, and 227.5 inches long. It is externally stringer-stiffened with extruded attach angles at each end; the forward attach angle is bolted to the aft skirt. The S-IVB/S-II separation is forward of the interstage.

B. Aft Skirt

A cylindrical section structure of aluminum skin panels, 260 inches in diameter and 85.5 inches long. It is stiffened by external stringers, extruded attach angles at the forward end, and an ordnance separation frame at the aft end.

C. Thrust Structure Assembly

A truncated cone, fabricated of aluminum skins, formed, chem-milled, riveted to stringers and frames and attach angles at the large end, and fastened to the cast aluminum engine mount at the smaller end. The thrust structure is bolted to attach angles on the LOX tank dome and provides the attach point for the J-2 engine and distributes the J-2 engine and distributes the J-2 engine thrust over the entire tank circumference.

D. Propellant Tank Assembly

Consists of the forward dome, cylindrical tank wall, and LOX tank assembly. The LOX tank assembly consists of the aft dome and the common bulkhead which isolates the LH_2 tank from the LOX tank. The forward dome and aft dome are similarly constructed of nine pie-shaped segments of sheet aluminum structure, which is formed, etch-milled, and welded together. Both domes have attach flanges in the center for an access door in the forward dome, and the

LOX tank sump in the aft dome. The cylindrical tank center section is fabricated from seven aluminum skins with a waffle pattern mechanically milled on the interior surface skin, which is formed, seam welded together, then welded to attach rings at both ends. The common bulkhead is constructed of a 1-3/4-inch fiberglass honeycombed core, bonded between two hemispherical domes. The domes are fabricated by welding a contoured center plate with nine fusion welded aluminum etch-milled skin segments to circumferential rings. The domes are then bonded to the honeycomb and welded to the aft dome.

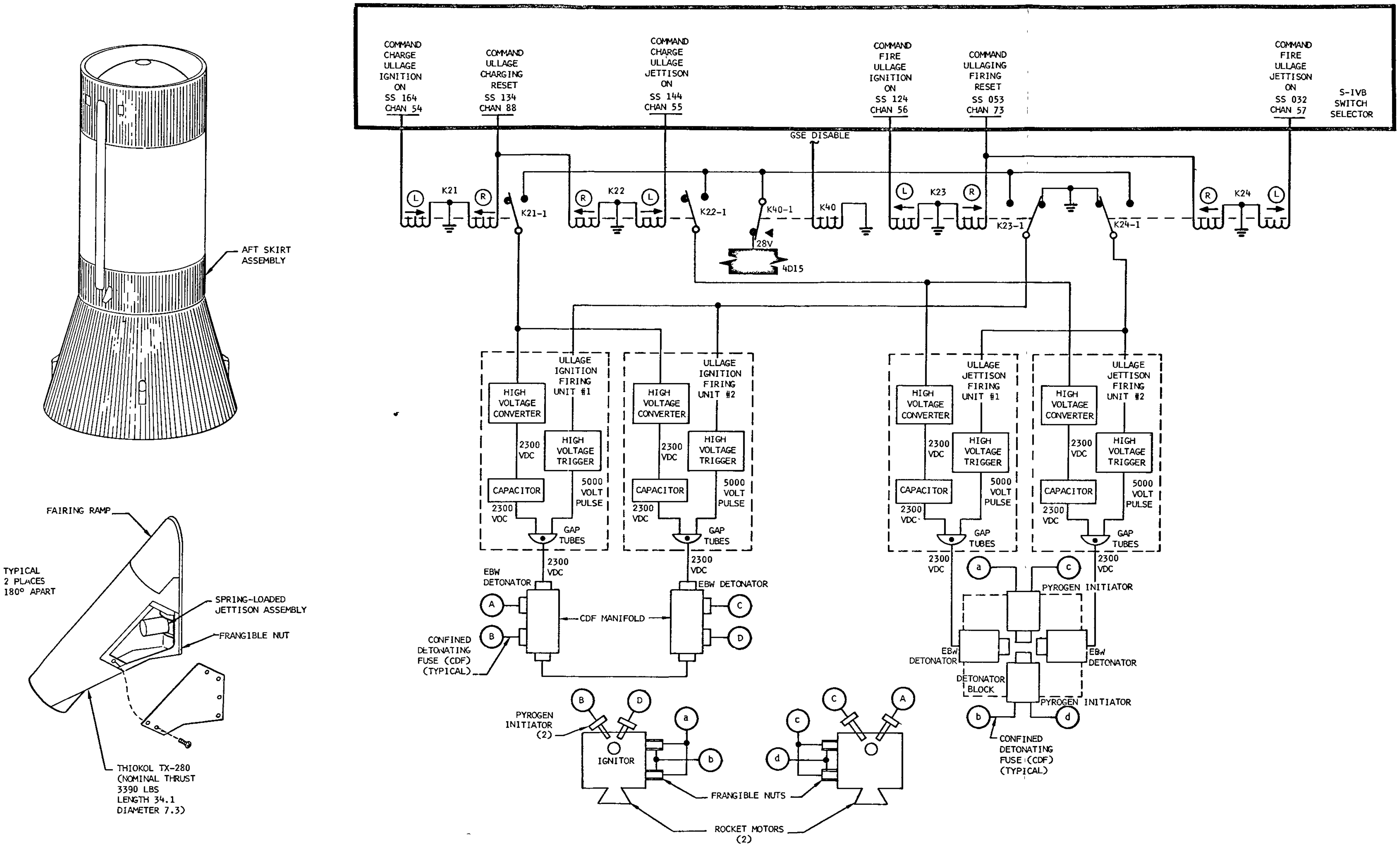
E. Forward Skirt Assembly

A cylindrical structure fabricated of aluminum skins, 260 inches in diameter and 122 inches in length. It is stiffened by external stringers and has attach angles at both ends. The forward skirt is bolted to the forward end of the tank assembly and the instrument unit is bolted to the forward end of the skirt.

8.3.3 Staging (General Description)

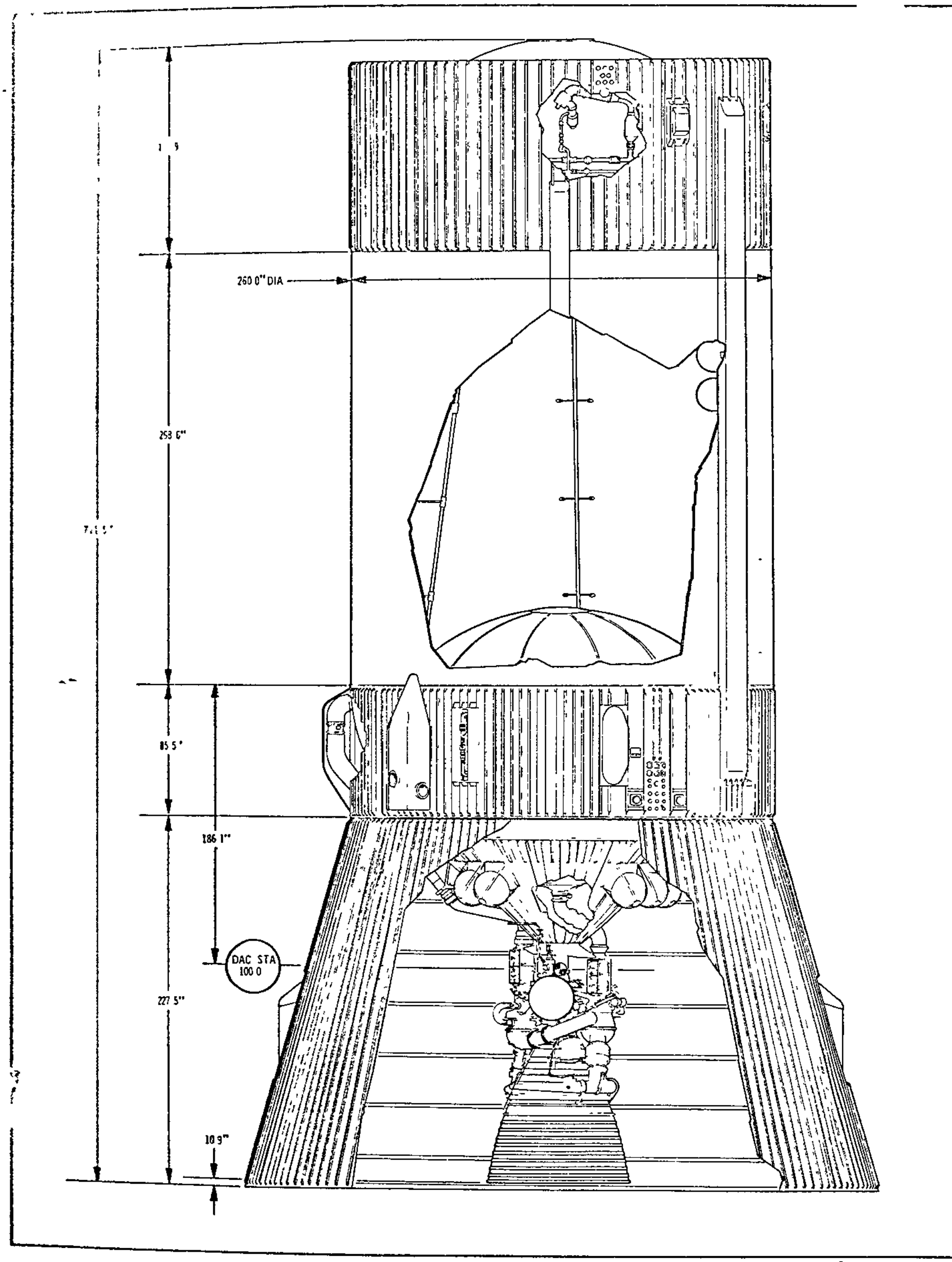
Several systems are employed to cause the physical separation between the S-II and the S-IVB stages. These systems receive commands from the instrument unit via the S-II and/or S-IVB switch selectors.

The propellant settling, as activated by the S-IVB switch selector, is the solid propellant ullage rocket system. The ullage rockets are ignited during the physical separation process to provide for propellant settling of the S-IVB stage. After the J-2 engine ignites, the spent ullage rockets and their fairings are jettisoned (Drawing 8.3.1.)



Propulsion - S-IVB Ullage and Ignition Systems

DRAWING 8.3.1



Propulsion - S-IVB Stage Structure Layout

Two commands are required to either ignite the rockets or to jettison them. This command process is as follows:

- The IU issues a charge command which provides 28 Vdc to a relaxation oscillator in the exploding bridge wire (EBW) firing unit. The oscillator output is amplified, stepped-up by transformer action, and rectified to charge the storage element and place a 2300 Vdc potential across a gap tube. This charging process requires a maximum of 1.5 seconds.
- The IU then issues a firing command which provides 28 Vdc to another amplifier in the firing unit which provides a 5000 volt trigger voltage to the gap tube causing the 2300 Vdc stored energy to be applied to either the ignition ordnance or jettison ordnance.

Discharge of the EBW firing units ignites the redundant ordnance items leading to the direct ignition of the solid engine propellants or firing of the frangible nuts, thereby releasing the holding bolts.

8.3.4 LH2 Pressurization (Drawings 8.3.2 and 8.3.2a)

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 rapid fill phase, LH_2 is supplied at the rate of 3000 gpm. 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 fuel tank is prepressurized to 28 to 31 psia. 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 31-34 psia. If this occurs, or if at any other flight time venting occurs, the gases will vent through the non-propulsive vent.

During engine firing, GH_2 is bled from the J-2 engine tapoff at 750 psia and at -260° F to maintain adequate LH_2 tank pressure. Pressure is controlled by the fuel tank pressurization control module.

During burn, the flight control pressure switch is enabled and senses ullage pressure. This pressure switch controls tank pressure within 31 psia and 28 psia by sending a signal to the pressurization control module when tank pressure exceeds 31 psia, thus closing the control valve and decreasing pressurization flow. When tank pressure falls below 28 psia a signal is sent to the pressurization control module, opening the control solenoid valve and increasing pressurant flow.

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 (8-15 lbf) on the vehicle to maintain the proper propellant position.

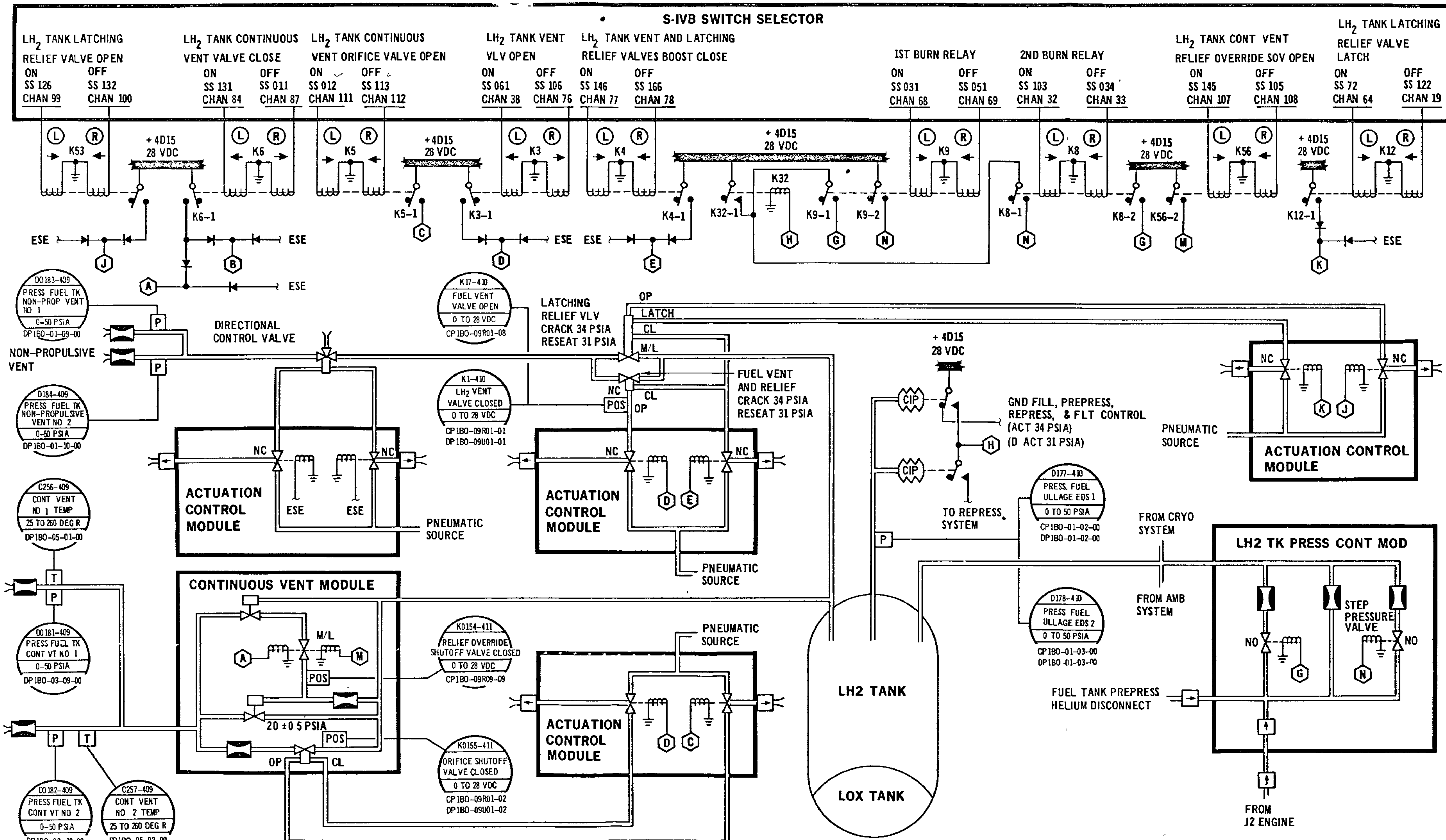
The dual repressurization system pressurizes the stage propellant tanks to flight conditions for restart of the J-2 engine.

Repressurization for first start is accomplished by the cryogenic repress system. The O_2/H_2 burner provides the heat to expand the cold helium used to pressurize the propellant tanks prior to first J-2 engine restart.

The burner utilizes LOX and LH_2 from the main tanks. A thrust of 16 to 30 pounds is obtained, and is directed approximately through the center of gravity of the vehicle. The O_2/H_2 burner heats cold helium for use as the oxidizer and fuel tank pressurant. The nine cold helium spheres are located in the LH_2 tank, and contain helium initially charged to 3100 psia at $-420°$ F. The pressure is reduced to 385 $\pm$25 psig by the LOX tank pressure control module. Cryogenic repress control modules are located in each supply line. The solenoid valves in the module are controlled by a signal from the respective tank flight control pressure switches which are sensing tank ullage pressures.

The ambient helium repressurization system provides second restart repressurization as well as backup for the cryogenic repress system.

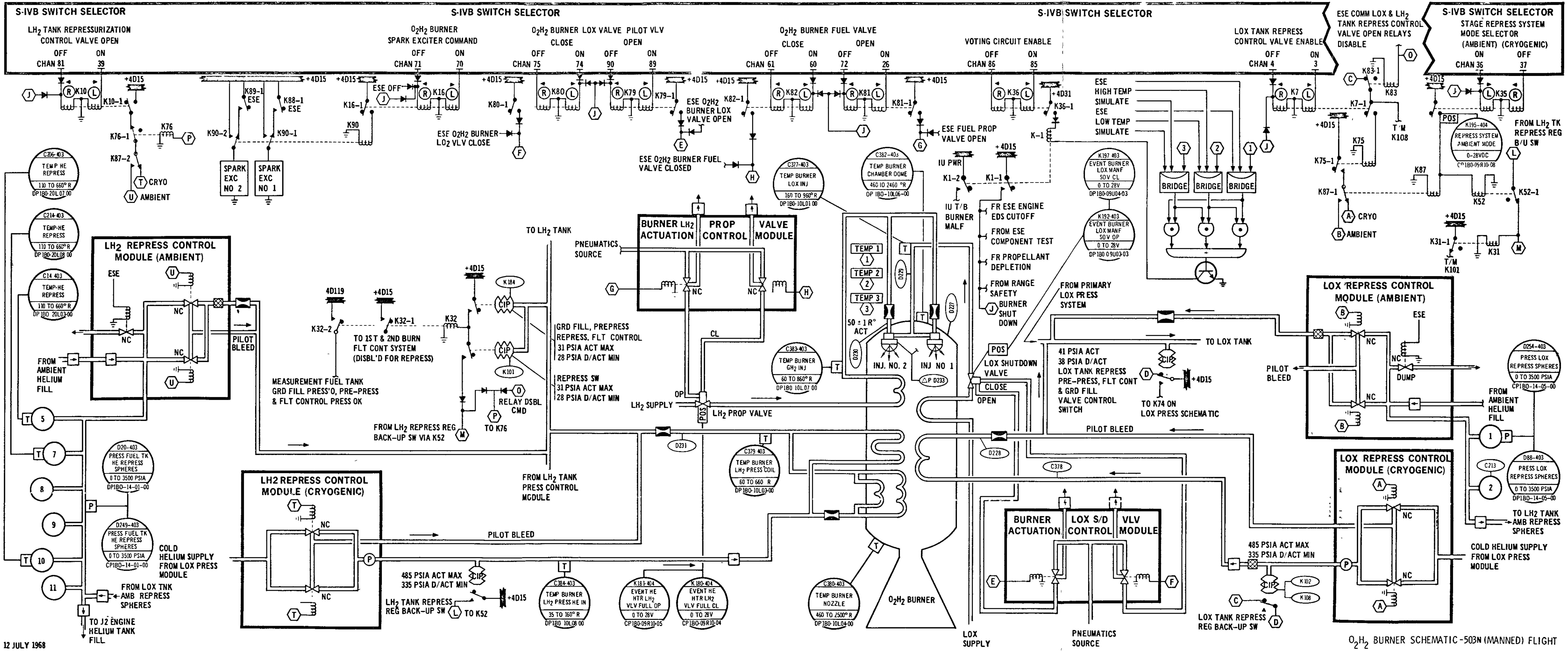
The ambient repress system operates late in the restart preparations sequence. If helium from the ambient system is required for the first restart (due to a malfunction in the cryo repress system or for makeup gas), it is supplied through an independent control module for each propellant tank. Two spheres are provided for LOX tank repressurization and six spheres are provided for LH_2 tank repressurization. The LOX tank repressurization bottles are tied in to the LH_2 tank repressurization bottles through check valves. This allows the LOX tank bottles to aid in the repressurization of the LH_2 tank.



12 JULY 1968

LH_2 PRESSURIZATION SYSTEM SCHEMATIC-503N(MANNED)FLIGHT

DRAWING 8.3.2



O_2H_2 BURNER SCHEMATIC-503N (MANNED) FLIGHT

DRAWING 8.3.2a

8.3.5 LOX Pressurization (Drawing 8.3.3)

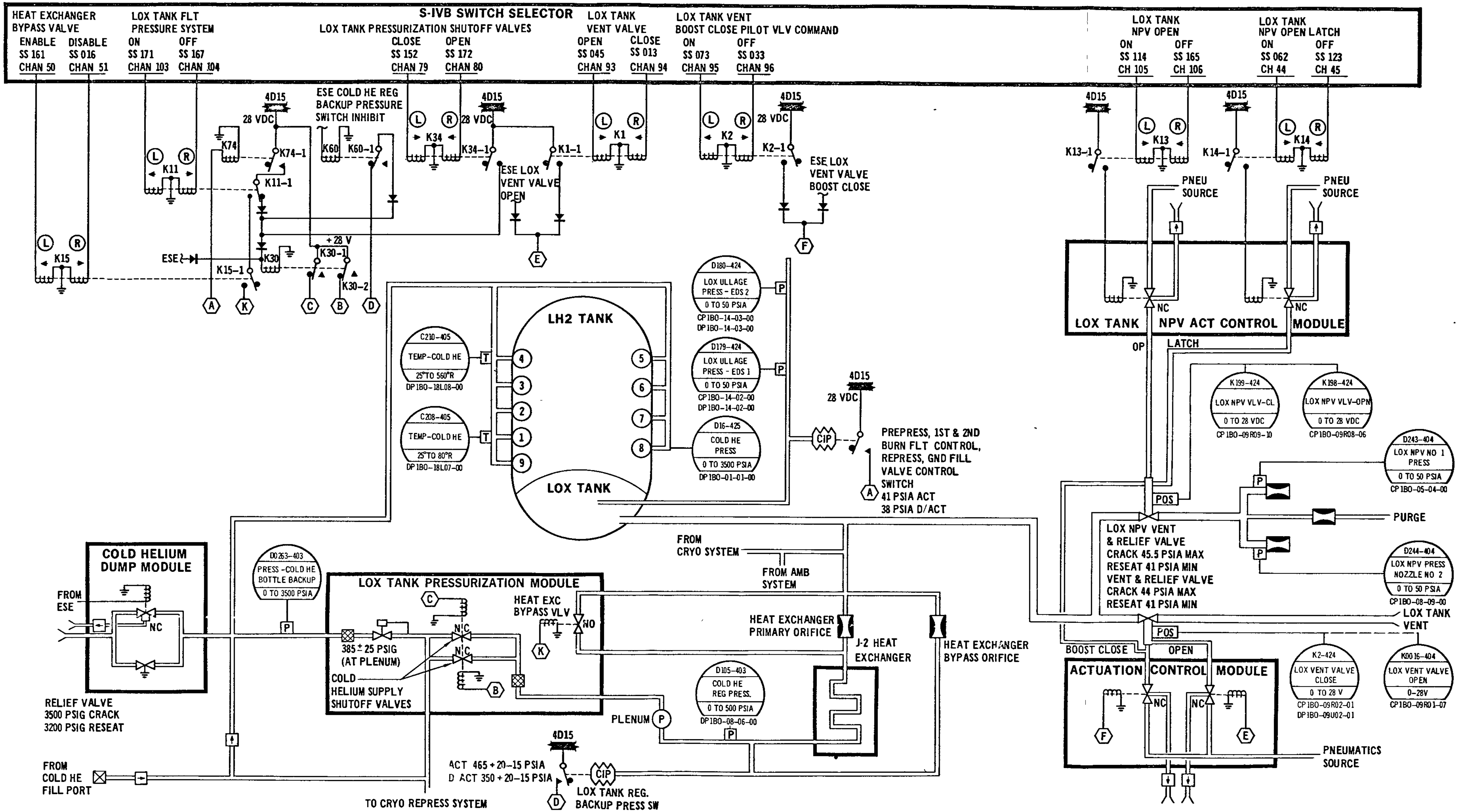
The oxidizer tank pressurization is accomplished by using the LOX pressurization control module. At the beginning of LOX tank fill, the vent and relief valve is opened. During rapid fill, LOX is supplied to the tank at a maximum rate of 1000 gpm and is then reduced to 200 gpm during slow fill. When slow fill is complete, the vent and relief valve is closed and prepressurization begins until desired pressure has been reached.

The LOX tank is prepressurized to 38 to 41 psia by the cold helium flow from the GSE and controlled by the cold helium shutoff valves. Cold helium for inflight pressurization is stored in eight spheres charged to 3100 to ± 100 psia at -420° F located in the LH_2 tank. The flight control pressure switch (sensing tank ullage pressure) controls prepressurization by opening and closing the onboard cold helium shutoff valves for cold helium pressurant flow, and in this way acts as a regulator. Normally, the cold helium regulator backup pressure switch picks up at 450 to 485 psia and closes the cold helium shutoff valves and drops out at 335 to 370 psia and opens the cold helium shutoff valves. In case of regulator failure during flight, the regulator backup pressure switch acts in a bang-bang mode. During prepressurization and boost, the backup pressure switch is deactivated. After engine ignition, the flight pressure switch is changed over from control of the onboard cold helium shutoff valves to control of the heat exchanger bypass valve. The cold helium shutoff valves cycle to the open position allowing cold helium to flow from the cold helium supply through the regulator, reducing pressure to 385 ± 25 psia through the shutoff valves, 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 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 insufficient 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 allowing the cold helium shutoff valves to go to their normally closed position.

Between first and second burn, the LOX tank pressurization system is deactivated during the two coast periods between burns. There is a vent system similar to the LH_2 tank in that there is a vent and relief valve and a non-propulsive vent and relief valve as a 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 the two restarts, the LOX tank is repressurized to the flight control pressure switch settings, 38 to 41 psia. This is accomplished as described in paragraph 8.3.4.



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LOX PRESSURIZATION SYSTEM SCHEMATIC–503N (MANNED)FLIGHT

DRAWING 8.3.3

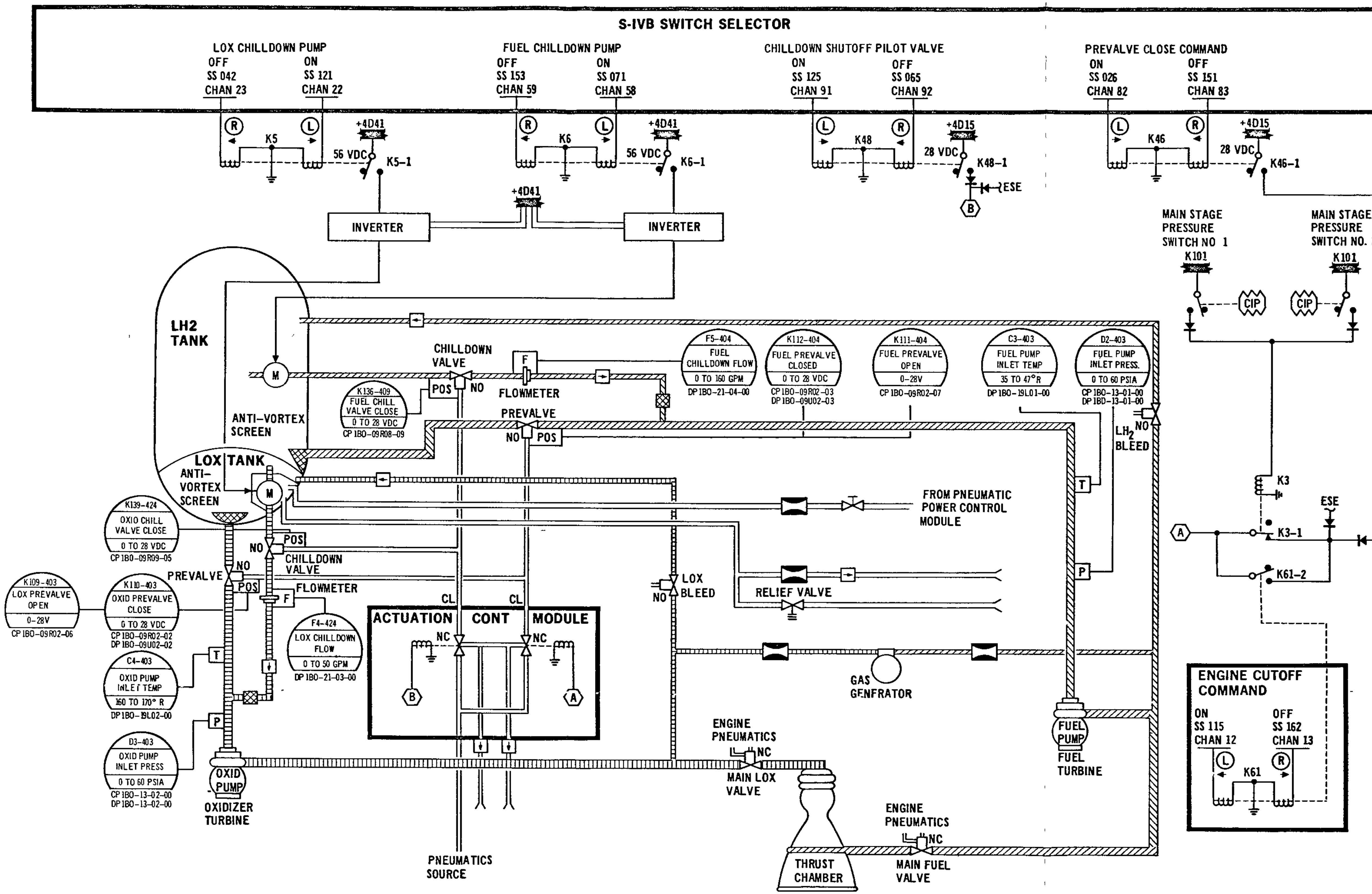
8.3.6 Propellant Chilldown Subsystem (Drawing 8.3.4)

Chilldown of the LOX and LH_2 subsystems 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 propellant bleed valves, and back to the tanks through return lines.

The forward flow chilldown subsystems are activated during ground operation prior to liftoff 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 and subsequent burn repressurizations, 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.



12 JULY 1968

CHILLDOWN SYSTEM SCHEMATIC-503N(MANNED)FLIGHT

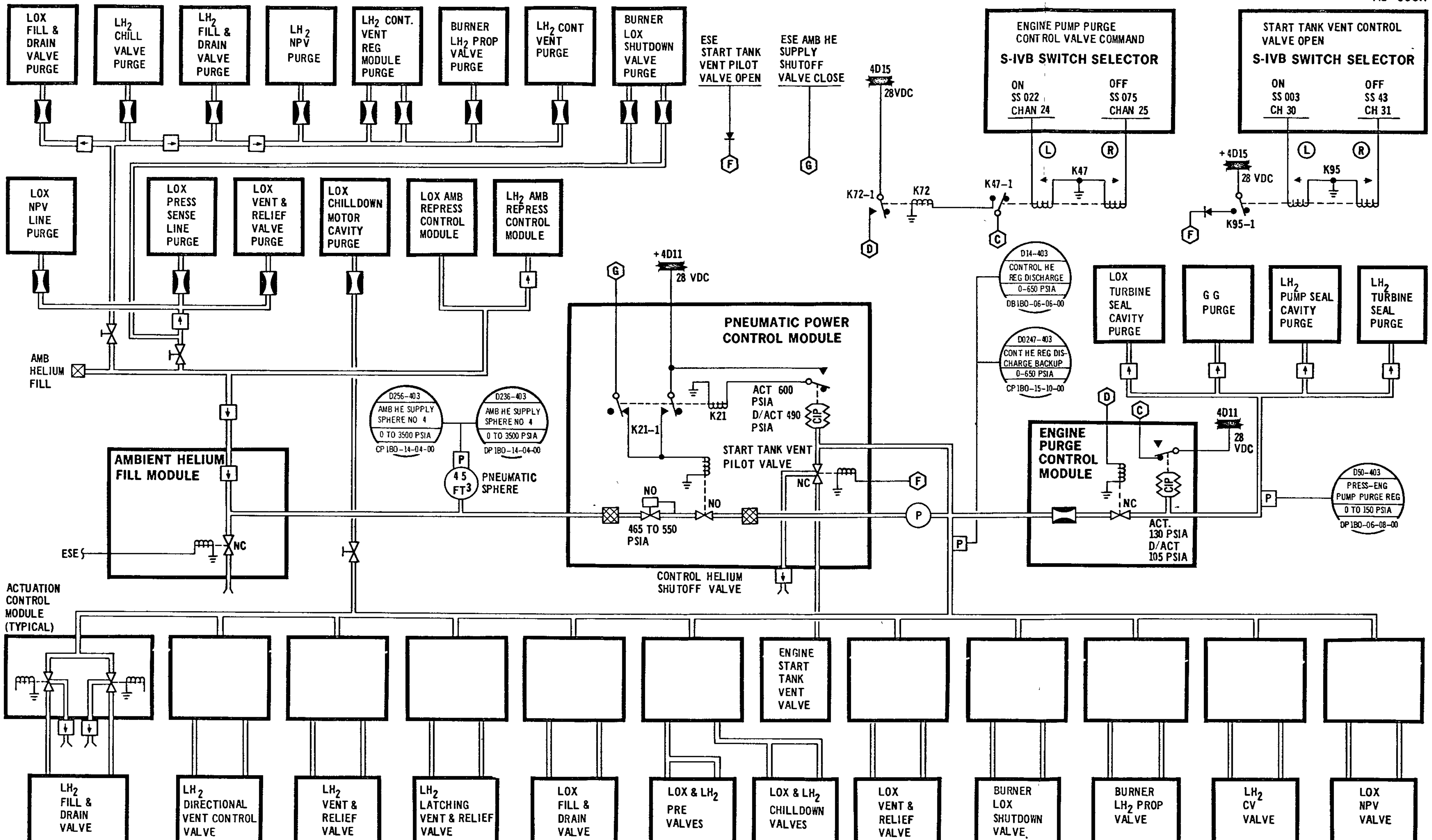
DRAWING 8.3.4

8.3.7 <u>Pneumatic Control System</u> (Drawing 8.3.5)

The pneumatic control system provides supply pressure for all stage pneumatically operated valves with the exception of J-2 engine valves. A pneumatic power control module filters ambient helium flowing from the ambient helium sphere and regulates the sphere pressure of 3,100 ± 100 psia at 70 ± 10°F down to 490 ± 25 psia. This pressure is used as indicated below:

A. LH_2 nonpropulsive vent valves actuation
B. LH_2 vent directional control valve actuation
C. LH_2 continuous vent orifice shutoff valve actuation
D. LOX tank vent control valve actuation
E. LOX and LH_2 prevalves and chilldown shutoff valves actuation
F. LOX and LH_2 fill and drain valves actuation
G. O_2/H_2 burner propellant valves actuation
H. J-2 engine GH_2 start system vent valve actuation
I. LOX chilldown pump motor enclosure purge
J. LOX and LH_2 turbopump turbines and gas generator purge.

Items A. through J. 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 again open.



12 JULY 1968

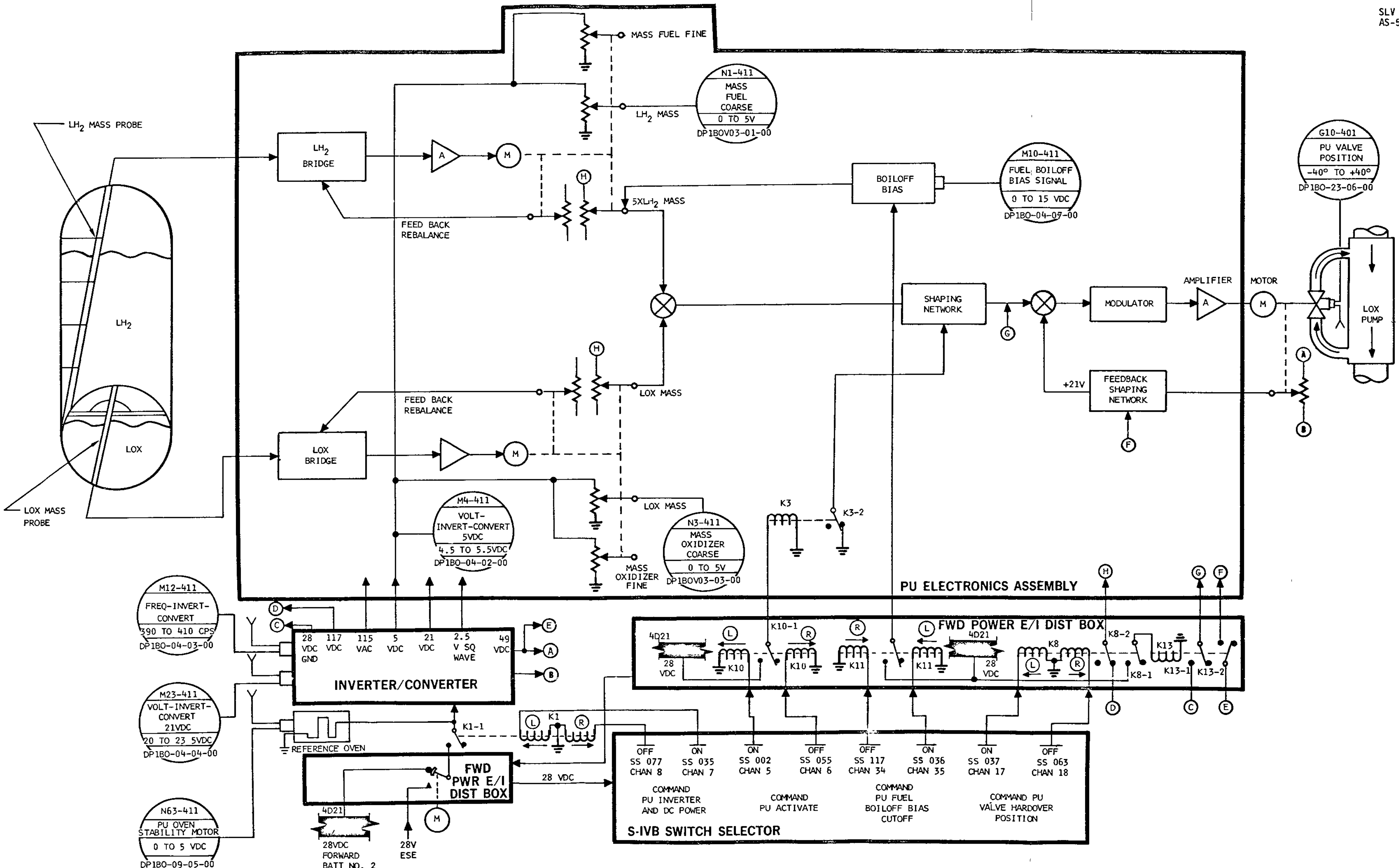
PNEUMATIC SYSTEM SCHEMATIC 503N(MANNED) FLIGHT

DRAWING 8.3.5

8.3.8 Propellant Utilization (Drawing 8.3.6)

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 assembly. The signals from the 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 can be maintained to less than 575 lb (0.25%) total usable load.

The sum of the LH_2 and LOX potentiometers are fed to a shaping network. The amplified, modulated signal is applied to a mixture ratio 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.



PROPULSION - S-IVB PROPELLANT UTILIZATION SYSTEM

DRAWING 8.3.6

8.3.9 J-2 Engine (Drawings 8.3.7, 8.3.8 and 8.3.8a)

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 LOX dome.

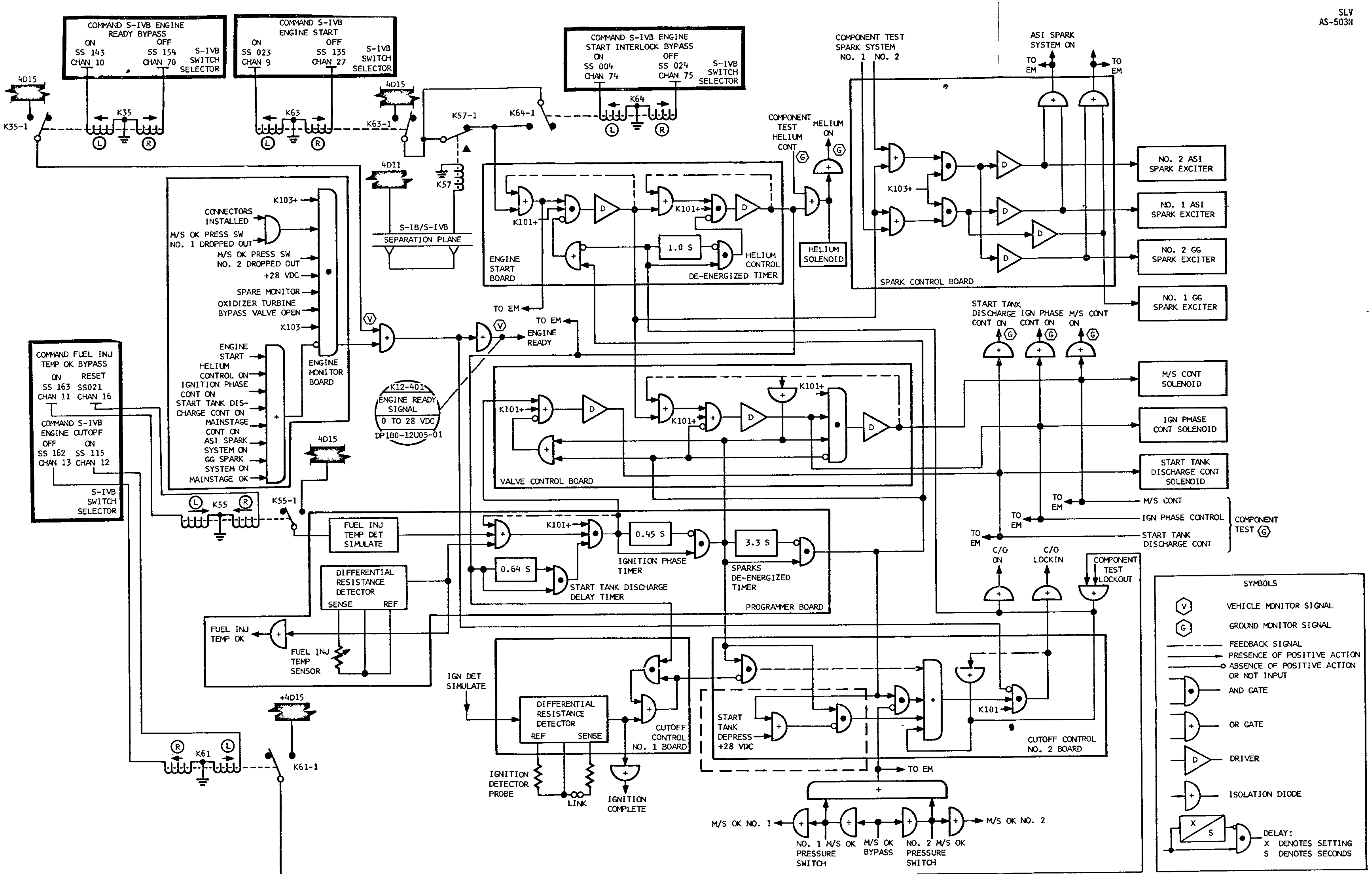
C. Ignition phase control solenoid which opens the ASI LOX valve allowing LOX to flow to the ASI chamber, the main LH_2 valve allowing LH_2 to flow through the thrust chamber tubes and injector, and to the ASI chamber.

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 mainstage operation, and purge pressure in the LOX dome to prevent the entry of hydrogen.

Upon expiration of a pre-determined 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 up the propellant turbopumps. The signal also activates the ignition phase timer which, upon expiration, de-energizes the start tank solenoid, closing the start tank discharge valve, and simultaneously, 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.

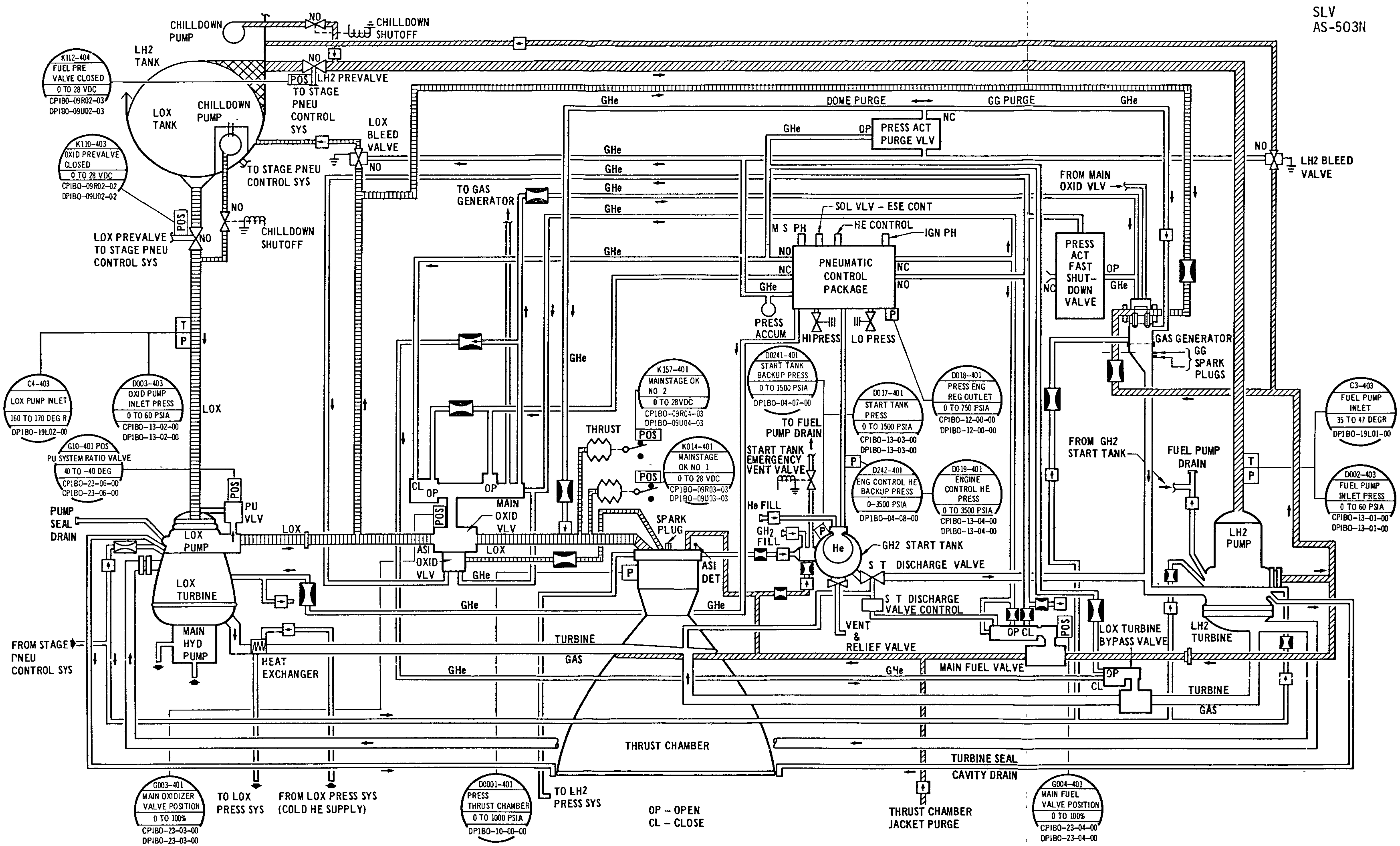
During steady-state first burn, the start tank which provided energy for start is refilled from a gas tapoff on the engine LH_2 injector and a liquid tapoff on the main fuel line downstream of the LH_2 propellant valve.

When an engine cutoff signal is received by the electrical control package, it de-energizes the main stage and ignition phase solenoid valves and energizes the helium control solenoid de-energize 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 de-energize timer, the helium control solenoid de-energizes, thereby venting the helium in the pneumatic control low pressure systems and the LOX and LH_2 bleed valves open.

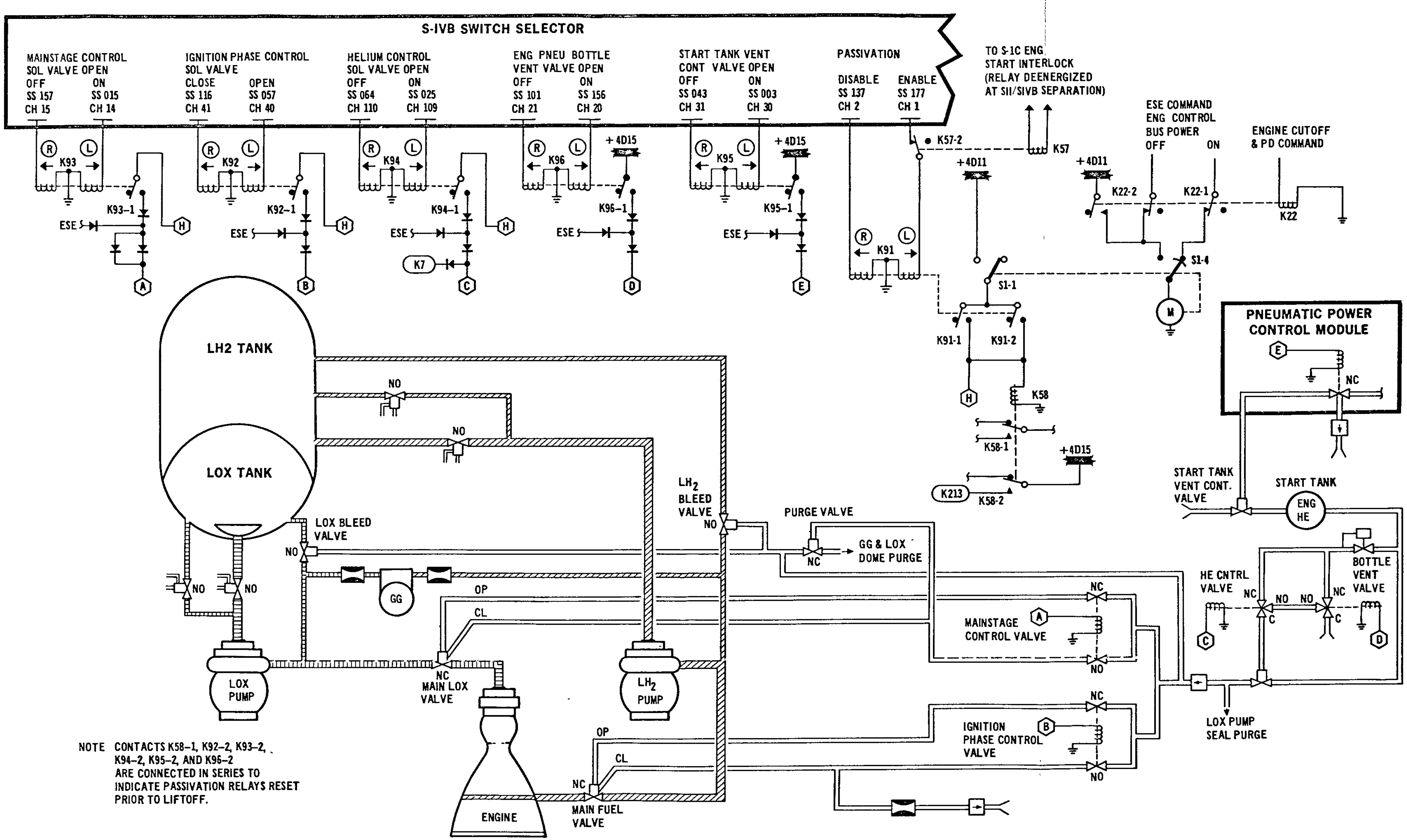


Propulsion - S-IVB J-2 Engine Electronic System

DRAWING 8.3.7



J-2 Engine System Schematic 503 Flight
DRAWING 8.3.8



NOTE CONTACTS K58-1, K92-2, K93-2, K94-2, K95-2, AND K96-2 ARE CONNECTED IN SERIES TO INDICATE PASSIVATION RELAYS RESET PRIOR TO LIFTOFF.

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ORBITAL SAFING SCHEMATIC 503N (MANNED) FLIGHT

DRAWING 8.3.8a

8.3.10 Hydraulics System (Drawing 8.3.9)

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, closedloop, hydraulic system, figure 8.3.9. Gimbal forces, provided by two electro-hydraulic 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 actuators can extend or retract separately or in unison.

The hydraulic system consists of five major components mounted on the engine and/or stage structure and are connected by metal tubing and teflon-lined flexible hoses, drawing 8.1.7.

The five major components include:

A. Engine-driven hydraulic pump

B. Auxiliary pump

C. Accumulator-reservoir assembly

D. Yaw servoactuator

E. Pitch servoactuator

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.

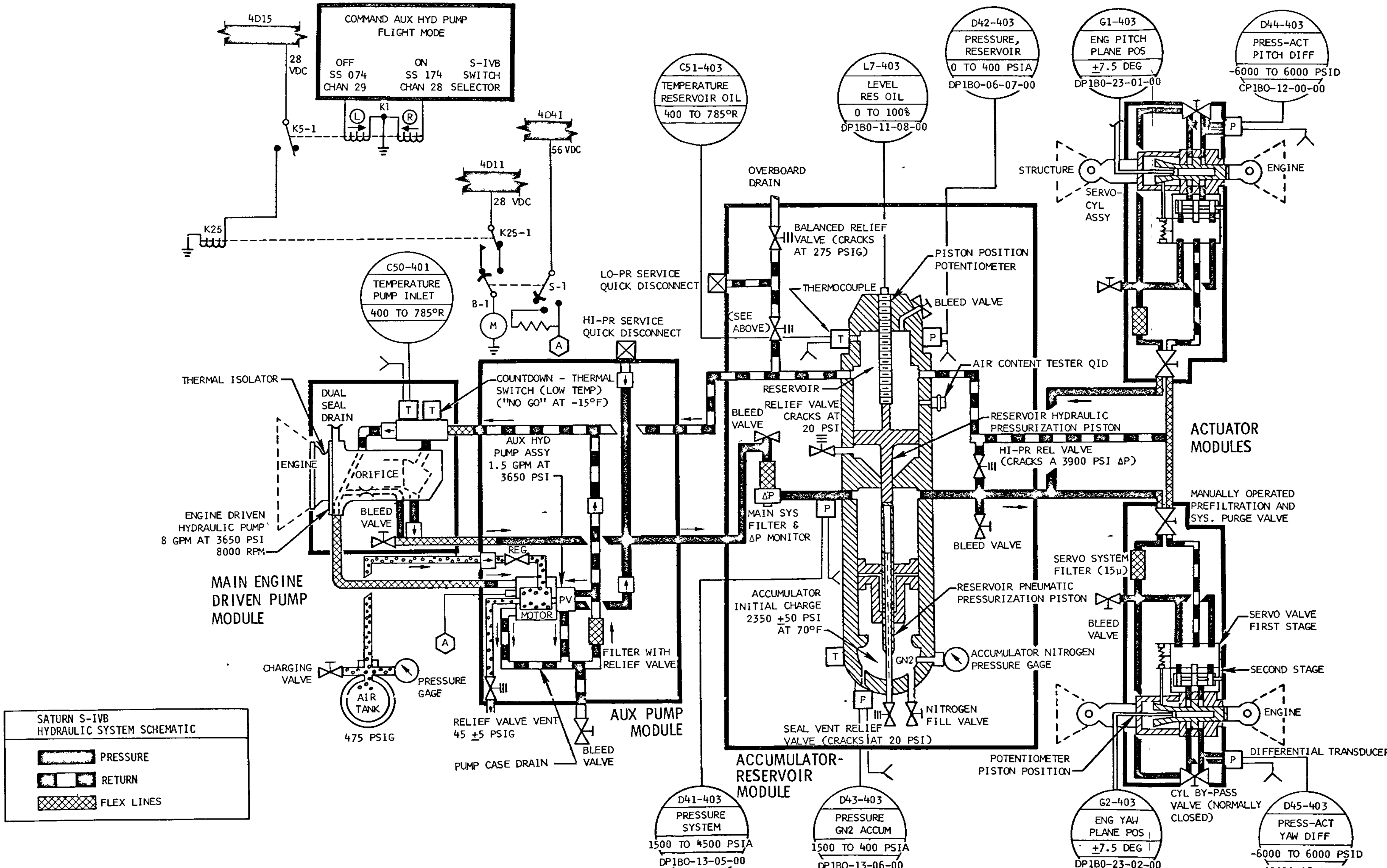
3.10.1 Engine-driven (main) hydraulic pump.- The engine-driven hydraulic pump provides the high flow rate required to gimbal the engine at a rate as high as 15 deg/sec. The pump is a yoke-type, variable displacement pump with a flow rate of 8 gpm at 8,000 rpm and 3,550 psia nominal pressure. The pump, mounted on the

LOX turbine gas collector dome accessory pad, is powered by a crown-spline quill shaft extending from the turbine shaft to the pump.

8.3.10.2 Auxiliary hydraulic pump.- The auxiliary hydraulic pump is a fixed angle, variable delivery pump with a rated flow of 1.5 gpm at a minimum of 3,500 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 and transfers motor-generated heat to the hydraulic fluid. This heat thermal conditions the fluid during prelaunch propellant loading operations and during the orbital coast phase. For the coast phase, the pump turns on 172 minutes after first burn cutoff and operates for 8 minute heating and circulating the fluid.

8.3.10.3 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, acts as the system fluid heat sink, 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



Propulsion - S-IVB Hydraulic System

FIGURE 8.3.9

2,350 $\pm$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.

8.3.10.4 Pitch and yaw servoactuators.- Two servoactuators, located 90° apart with respect to the longitudinal axis of the S-IVB stage provide pitch and yaw control.

The hydraulic servoactuators are piston type, linear, double acting units capable of delivering 42,000 lbf at a pressure of 3,650 psia in the extend or retract position. They are positioned by commands from the instrument unit and can operate separately or in unison. Mechanical feedback on each actuator indicates the position of the piston.

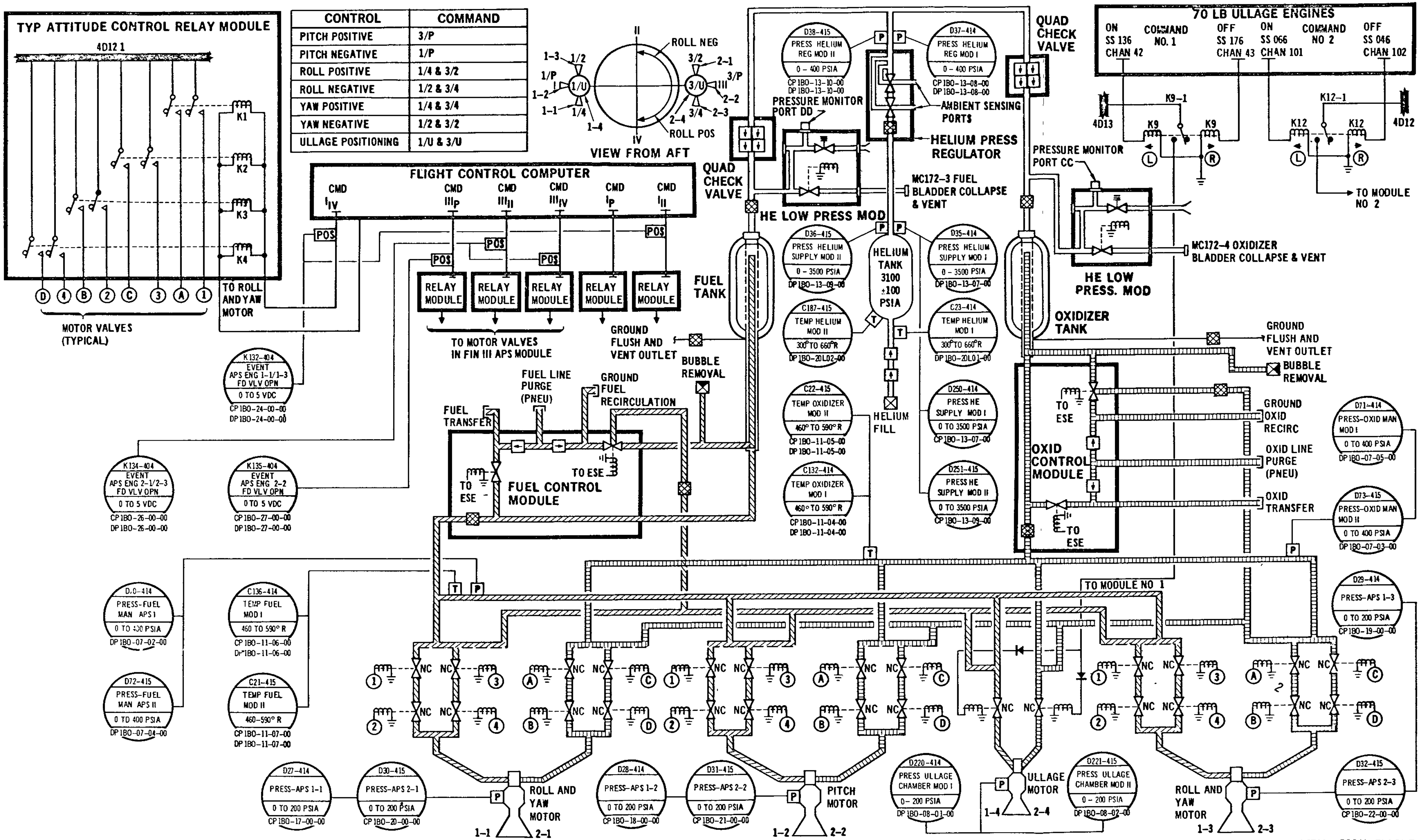
8.3.11 Auxiliary Propulsion (Drawing 8.3.10)

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 placed 180° 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 lb attitude control engines and one 70 lb ullage settling engine.

The APS modules receive command signals from the IU and performs 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 and third burn start).

The instrument unit provides all firing commands. These commands actuate fuel and oxidizer solenoid valves to release hypergolic propellants to the engines. Roll deviation is corrected by firing an engine in each module, both simultaneously in opposite directions. Yaw correction is accomplished by firing two engines simultaneously, one in each of the modules, in the direction opposite the error. Pitch correction is provided by firing one of the two APS pitch engines in the direction opposing the error. (Pitch and yaw corrections are provided by the APS only when the S-IVB stage, J-2 main engine is in the non-operational mode.) The engines operate in short pulse type bursts ranging from 65 milliseconds 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 87 seconds, through the engine cutoff transient decay and the activation of the LH_2 tank propulsive vent system. The ullage engines also fire for 17 sec after second cutoff. This assures that the LOX and LH_2 propellants are positioned aft in the S-IVB stage tanks during coast. The APS ullage rockets are again energized at the end of the two coast periods 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 another propulsive system and is explained in subsection 8.3.3.



CONTROL	COMMAND
PITCH POSITIVE	3/P
PITCH NEGATIVE	1/P
ROLL POSITIVE	1/4 & 3/2
ROLL NEGATIVE	1/2 & 3/4
YAW POSITIVE	1/4 & 3/4
YAW NEGATIVE	1/2 & 3/2
ULLAGE POSITIONING	1/U & 3/U

AUXILIARY PROPULSION SYSTEM - 503N FLIGHT

DRAWING 8.3.10

Figure 9.1

To be provided later.

* SECTION 9

EMERGENCY DETECTION SYSTEM

9.1 GENERAL NOTES

To be provided later.

9.2 SC-SLV INTERFACE REQUIREMENTS

To be provided later.

Figure 9.2
To be provided later.

Drawing 9.2.1

To be provided later.

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Drawing 9.2.2

To be provided later.

Drawing 9.2.3

To be provided later.

Drawings 9.2.5 through 9.2.10
To be provided later.

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Drawing 9.3.1

To be provided later.

9.3 S-IVB RANGE SAFETY SYSTEM

The flight termination system 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.

9.3.1 Range Safety (Drawings 9.3.1 and 9.3.2)

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 eleven characters. Each character consists of two simultaneous tone pairs in the range of 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 a "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 output 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° of clutch travel by the solenoid. At the 90° 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° 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 receiver and 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 system from internal to external power position, thus cutting off power to the range safety flight termination system and thereby returning it to safe state.

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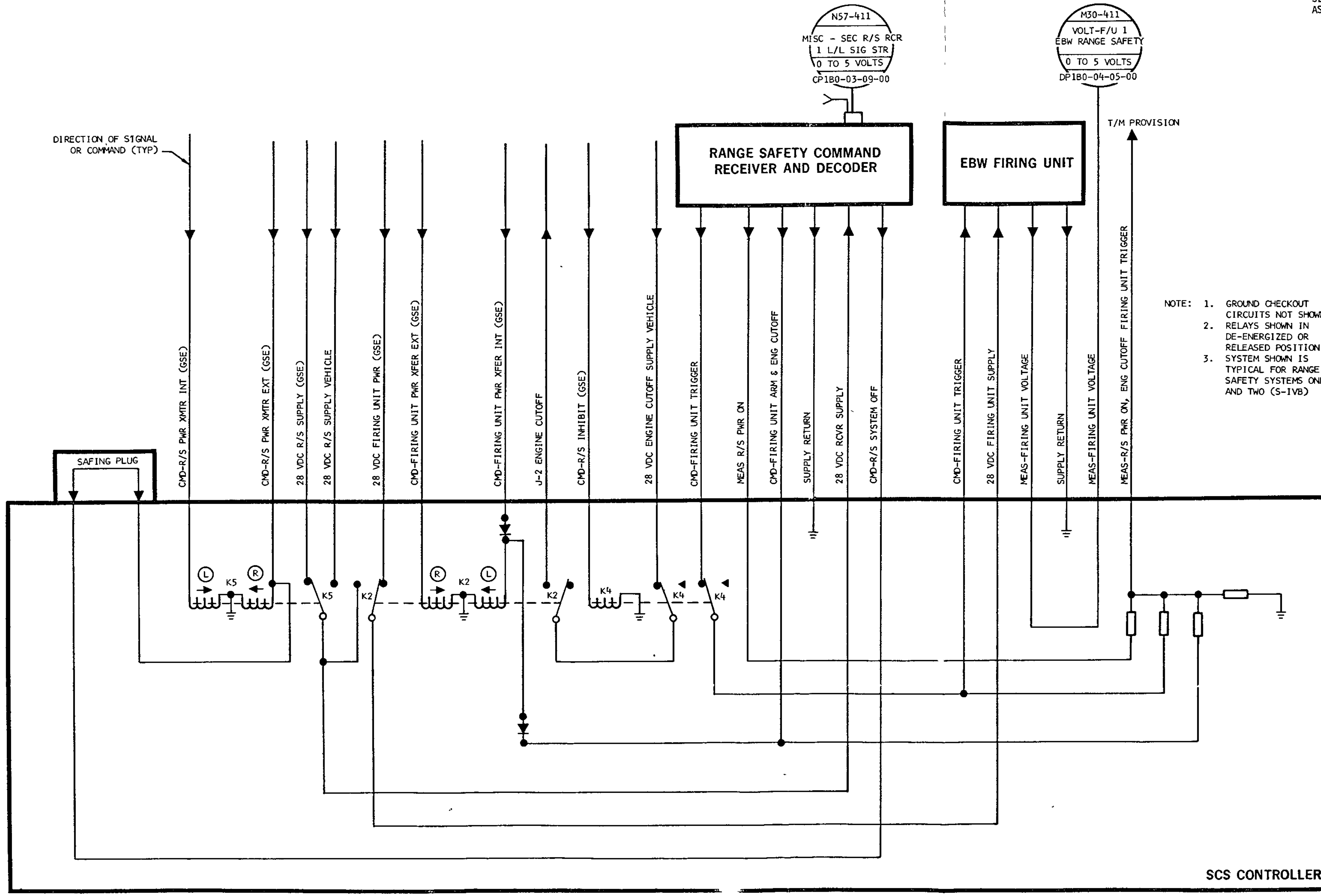
Drawing 9.2.4

To be provided later.



S-IVB Range Safety System

* SECTION 10

INTERFACE SYSTEM

This section will be provided at a later date.