R-ASTR-S-67-63
December 15, 1967

GEORGE C. MARSHALL SPACE FLIGHT CENTER
HUNTSVILLE, ALABAMA

TECHNICAL INFORMATION SUMMARY
APOLLO 5 (AS-204/LM-1)
APOLLO SATURN IB
FLIGHT VEHICLE

PREPARED BY:
R-AERO-P
R-ASTR-S
R-P&VE-VNC

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

MSFC - Form 2846 (December 1966)

AS-204/LM-1

TECHNICAL INFORMATION

SUMMARY

This document is prepared jointly by the Marshall Space Flight Center Laboratories R-AERO-P, R-ASTR-S, and R-P&VE-VN. The document presents a brief and concise description of the AS-204/LM-1 Apollo Saturn Space Vehicle. Where necessary, for clarification, additional related information has been included.

It is not the intent of this document to completely define the Space Vehicle or its systems and subsystems in detail. The information presented herein, by text and sketches, describes launch preparation activities, launch facilities, and the space vehicle. This information permits the reader to follow the space vehicle sequence of events beginning a few hours prior to liftoff to its journey into space.

1. Mission Purpose:

The basic purpose of the AS-204/LM-1 mission is to launch and test an unmanned Lunar Module (LM) for verification of crew safety items and to verify the launch vehicle's systems performance in preparation for subsequent operational manned space vehicle missions.

2. Mission Objectives:

Mission Objectives Categories:

The objectives listing is according to the objective category (primary vs. secondary).

Primary Objectives - Are those which are mandatory. Malfunction of launch vehicle systems, ground equipment, or instrumentation which would result in failure to achieve these objectives will cause a "hold" or mission cancellation until the malfunction has been eliminated.

Secondary Objectives - Are those which are desirable but not mandatory. Malfunctions, which would result in failure to attain these objectives, may cause a hold or mission cancellation as indicated in the Mission Rules.

Mission Primary Objectives - AS-204/LM-1 - As listed in the Flight Mission Assignments Document:

a. Verify operation of the following LM subsystems:

-- Ascent Propulsion System (APS).

-- Descent Propulsion System (DPS) (including restart).

-- Structure.

b. Evaluate LM staging.

c. Evaluate S-IVB/IU orbital performance.

Detailed LV Primary Objectives:

Evaluate S-IVB/IU orbital performance.

Specifically:

a. Evaluate the LV attitude control and maneuvering capability.

b. Verify the S-IVB LH_2 and LOX tank boiloff characteristics.

c. Demonstrate nose cone separation from the S-IVB/IU/SLA.

d. Evaluate the operational adequacy of the launch vehicle systems; including guidance and control, electrical, mechanical and instrumentation.

Launch Vehicle - Secondary Objectives:

a. Evaluate S-IVB forward skirt in-flight panel flutter.

b. Evaluate V-2 engine crossover duet temperature experiment.

c. Evaluate S-IVB LH_2 and LOX propellant dump experiment.

d. Evaluate Launch Vehicle orbital coast lifetime capability.

3. Mission Profile:

The Apollo Saturn-204/Lunar Module-1 will be launched at Cape Kennedy, Launch Complex 37, Pad B. Vehicle will be launched on a 90° E of N launch azimuth and will be rolled to a flight azimuth of 72° E of N by the launch vehicle control system based on signals from the control computer. The S-IB phase utilizes a preset time-tilt program to produce a gravity turn trajectory. Guidance commands, during the S-IVB portion of the ascent-to-orbit, will be generated in the Iterative Guidance Mode (IGM) which will navigate and guide the S-IVB/IU/SLA into an 85 x 120 nautical mile elliptical orbit. Insertion should occur 10 seconds after guidance cutoff or 602.26 seconds after liftoff.

Resulting Orbit will be:

Inclination	---	31.6143°
Period	---	88.2785 min.
Apogee	---	123 nautical miles
Perigee	---	88 nautical miles
Velocity	---	7828.77 m/sec.

Shortly after insertion the S-IVB attitude control system will execute maneuvers to place the longitudinal axis of the vehicle along the velocity vector and subsequently will maintain that attitude in an orbital rate mode. The nose cone will be jettisoned and the SLA panels will be deployed after orbital insertion.

The LM will remain attached to the S-IVB/IU/SLA for approximately 45 minutes and the S-IVB/IU will provide attitude stabilization for LM separation.

Approximately 1 1/2 hours after LM separation a S-IVB LOX and LH_2 propellant dump experiment will be performed. This experiment will be completed approximately 4 1/2 hours after orbital insertion.

SA-204/LM-1 S-IVB LOX and LH_2 Propellant Removal Test

The propellant removal test on SA-204/LM-1 will dump LOX and LH_2 propellant through the J-2 engine on the second revolution over Australia during the cold soak of the LM.

At 1 hour and 36 minutes from liftoff, an on-board signal is given which enables this test.

The propellant test does not start for 49 minutes after the on-board signal is given. During this time, the test can be disabled by ground command if necessary.

In preparation for test, (approximately 2 hours and 20 minutes after liftoff), the S-IVB/IU will maneuver to a local vertical attitude - pitch 270°, SLA panels toward earth, yaw 0°, and roll 85°. In order to point the best portion of the IU antenna pattern toward the Carnarvon station, the S-IVB/IU will perform continuous roll during the Propellant Removal Test.

Shortly after 2 hours and 26 minutes into the mission the mainstage control valve in the J-2 engine will be opened and the LOX tank will vent through the engine for 2 minutes. This action will be followed immediately by a similar 3-minute vent of the LH_2 tank. Attitude control in pitch and yaw will be attempted by gimballing the engine for the first 80 seconds of LOX dump after which it will switch back to APS control.

Approximately 20 minutes after the fuel dump test, while the vehicle is over Hawaii, the Launch Vehicle starts a cold helium dump. This dump continues for 22 minutes during which time the vent valves are also open which depletes the tank pressurization helium supply.

Helium which supplies control valve pressure is dumped 4 and 3/4 hours after liftoff while the vehicle is passing over the United States for the third time.

LIST OF FIGURES

LIST OF FIGURES (continued)

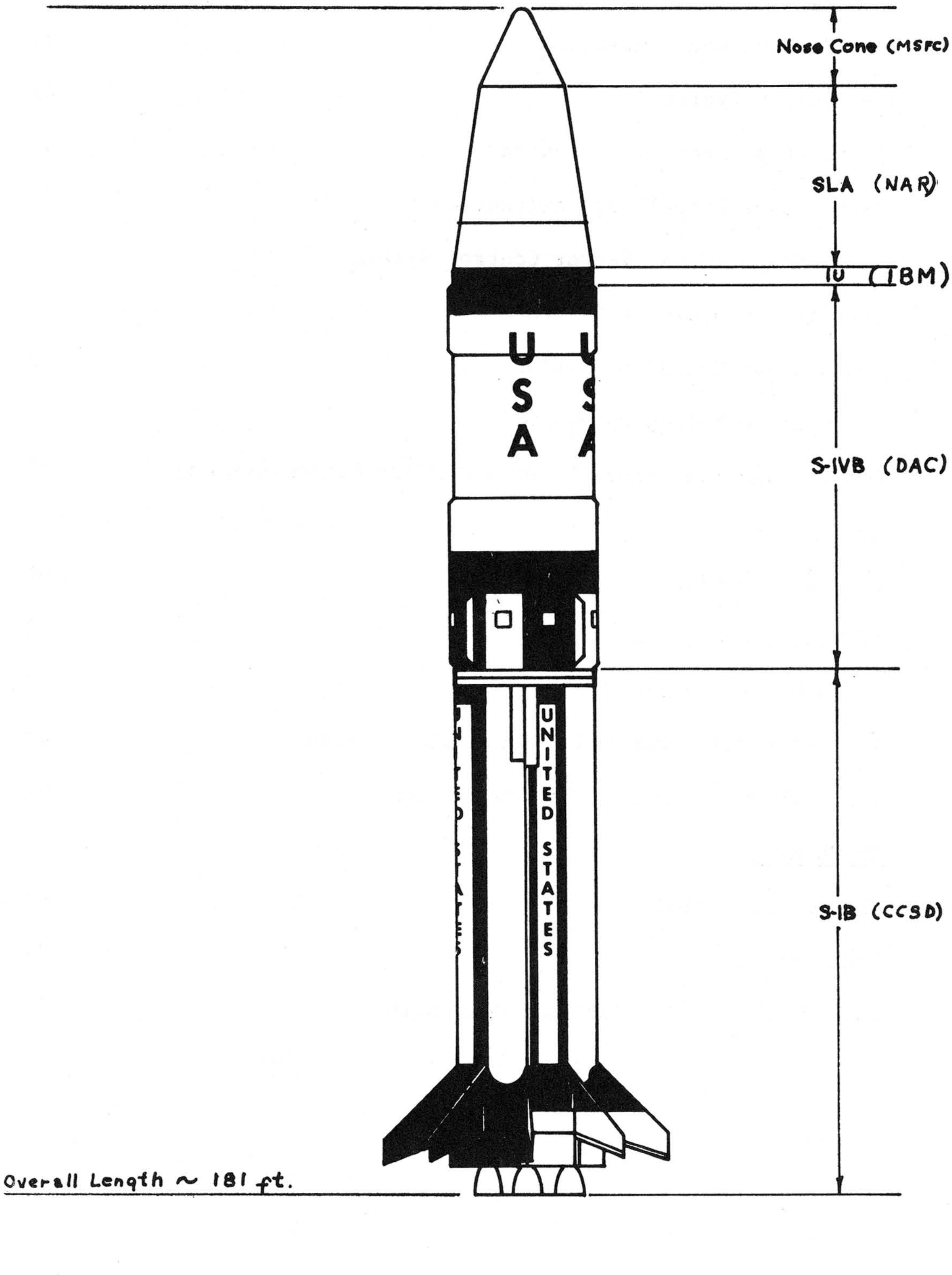


Figure 1

SA-204/LM-1 Profile

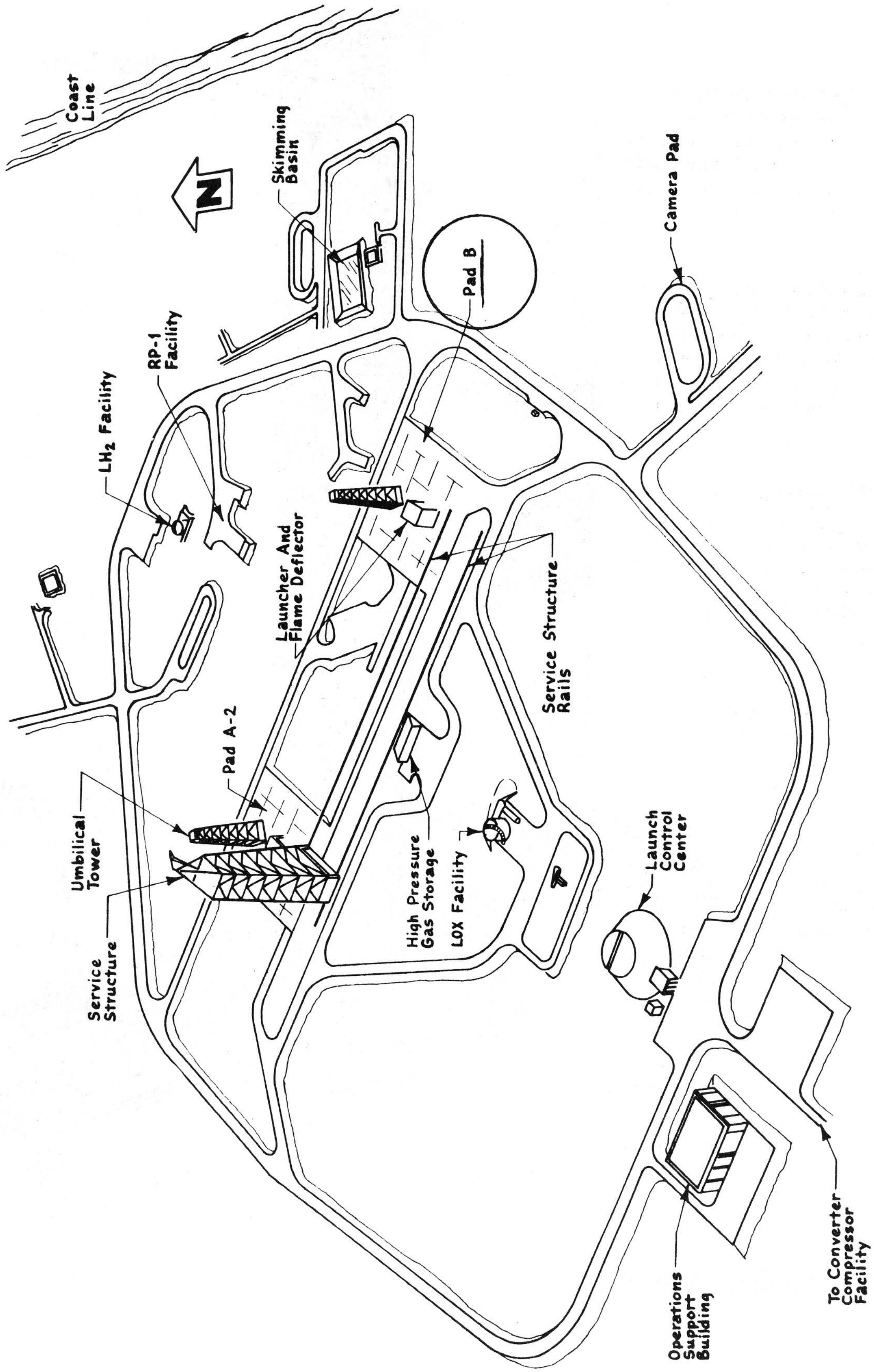
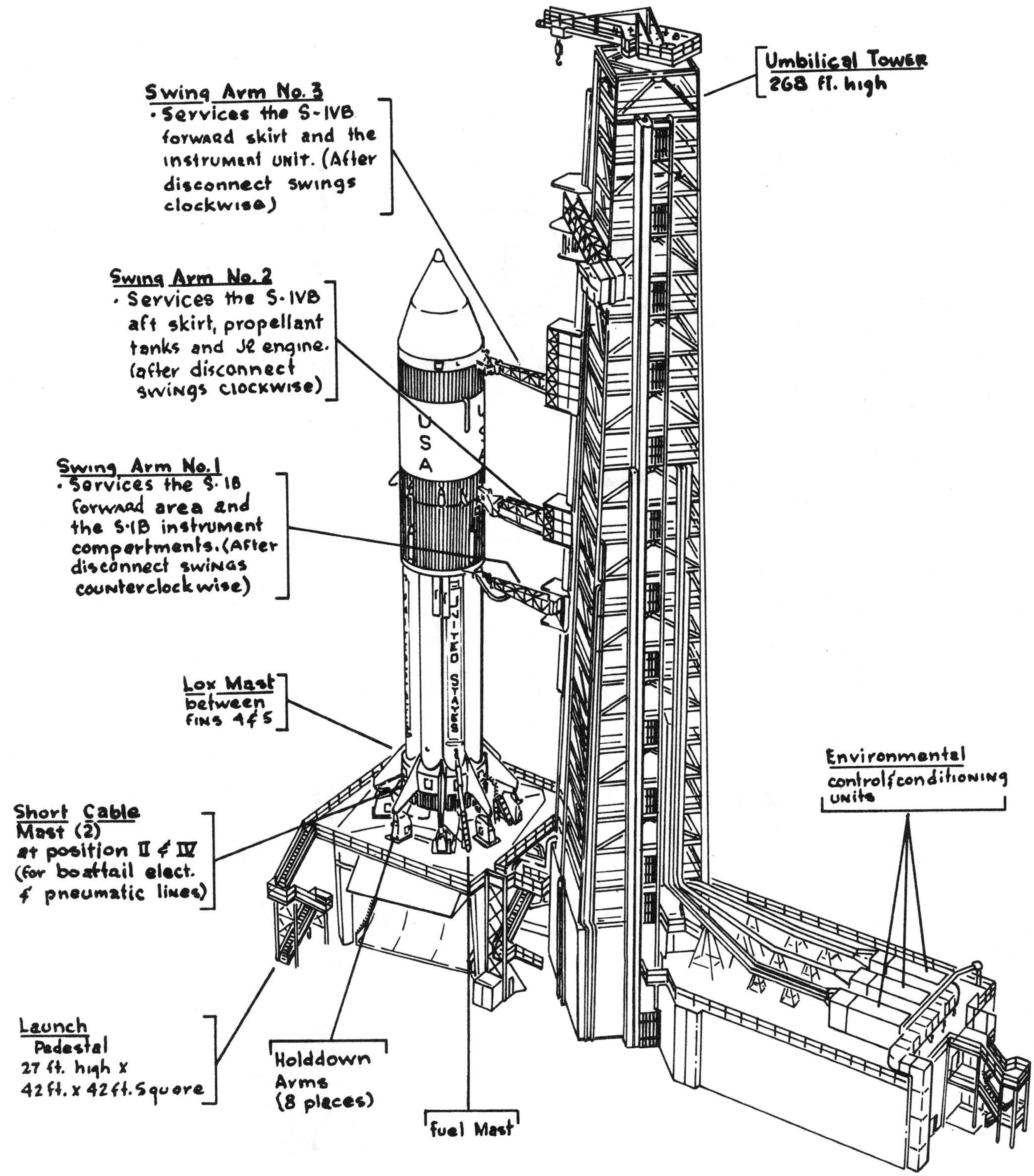


Figure 2

Launch Complex 37



Note: Paint pattern intentionally omitted.

figure 3

LC-37 (Pad B) Configuration

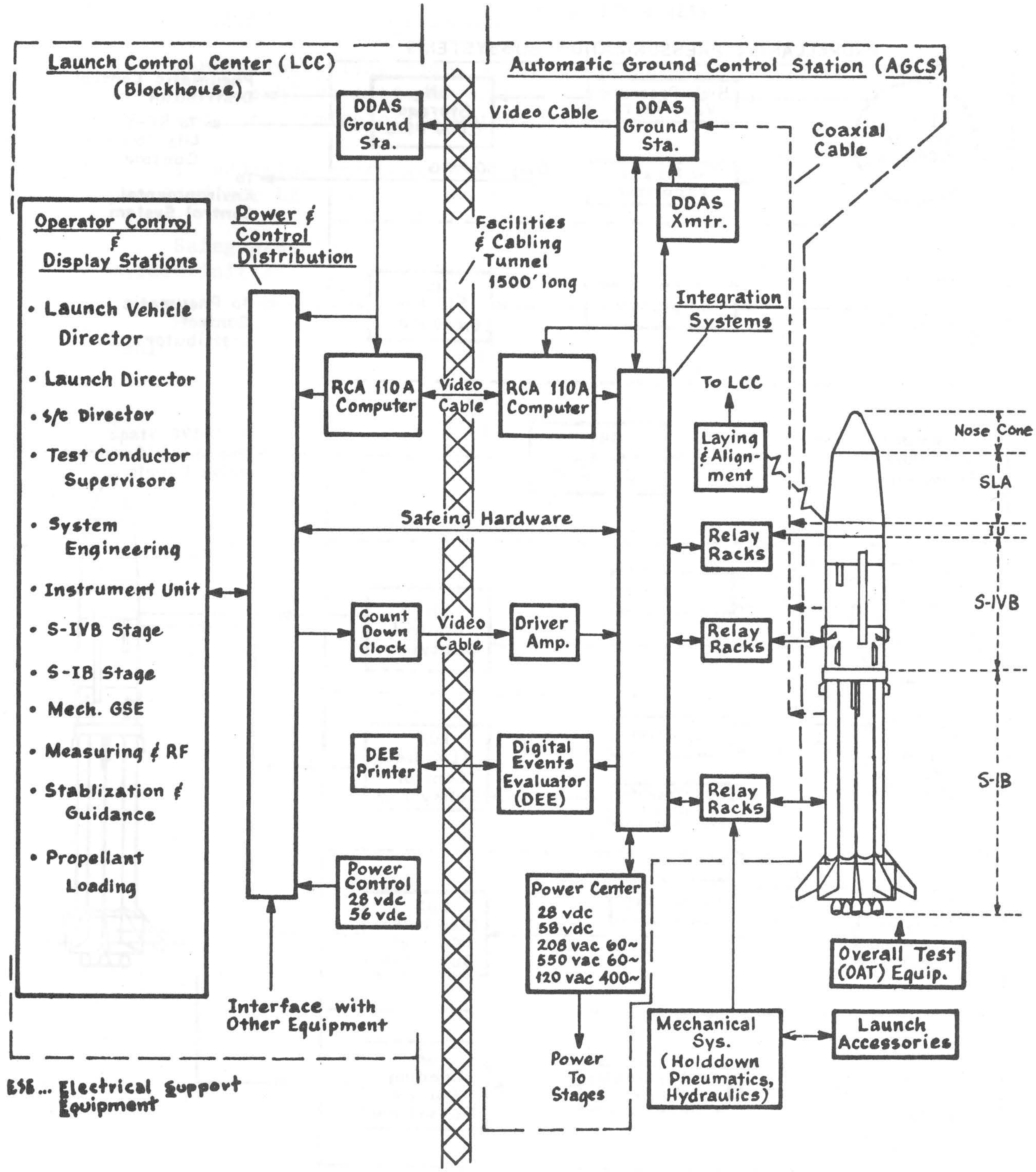


Figure 4

LC-37B Integrated Launch ESE Block Diagram

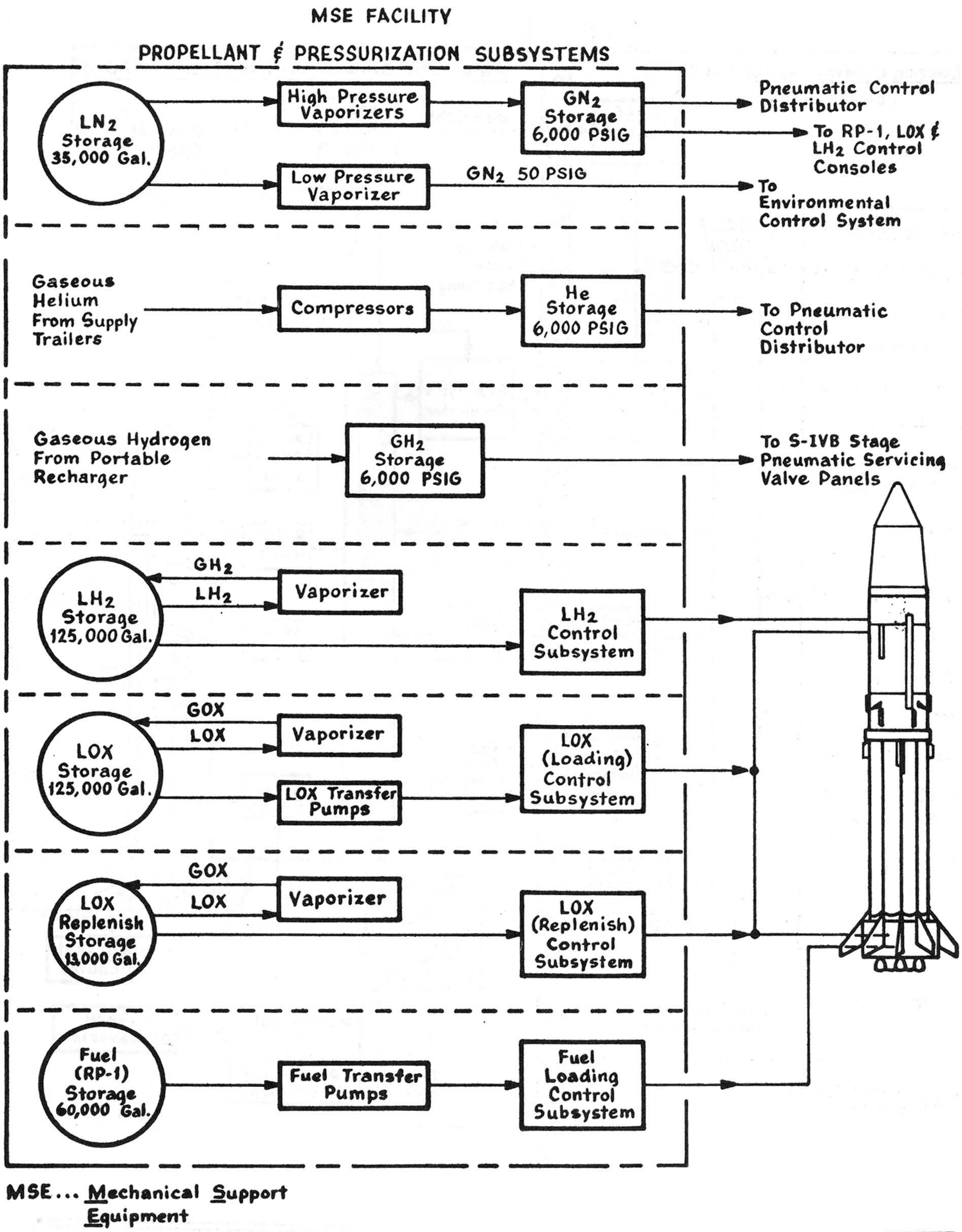


Figure 5

LC-37B Propellant and Pressurization Subsystems

Definition - Flight Sequence Program (AS-204/LM-1)

Four primary Time Bases are used in this Vehicle Flight Sequence Program to achieve optimum vehicle mission with a suitable sequential operation and timing of flight events.

In addition to these 4 time bases, one alternate time base is provided for LEM abort capability.

Safeguards have been established wherever necessary to prevent premature initiation of time bases.

Proper establishment of time bases provides a safe and reliable vehicle on the pad and in flight.

If any one of the four primary time bases (T_1, T_2, T_3, or T_4) is not established, subsequent time bases cannot be started and the vehicle mission cannot be completed.

To further increase mission reliability in the absence of normal time base signals, backup methods have been devised to establish these time bases.

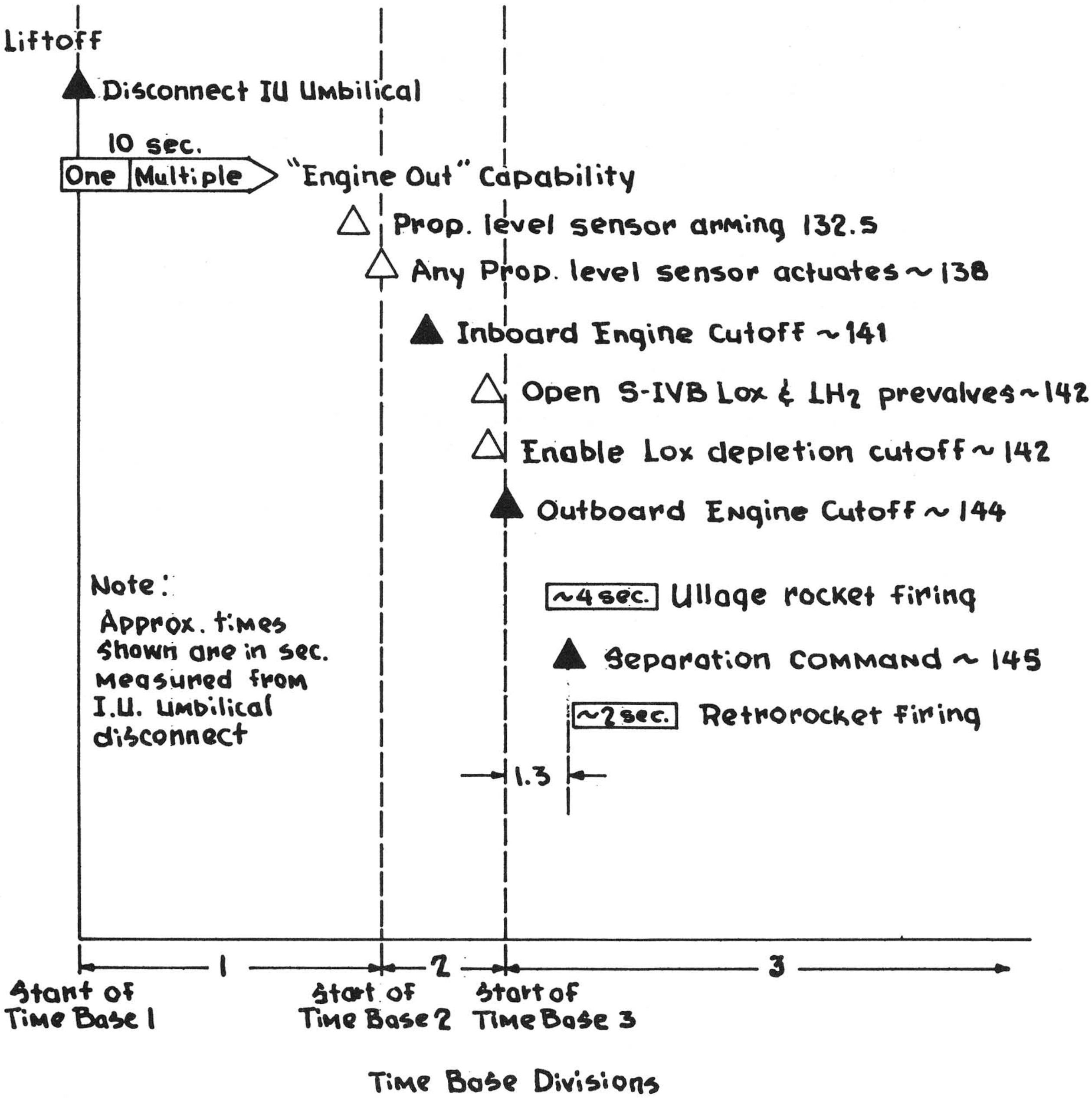


Figure 6

S-IB Stage Flight Sequencing

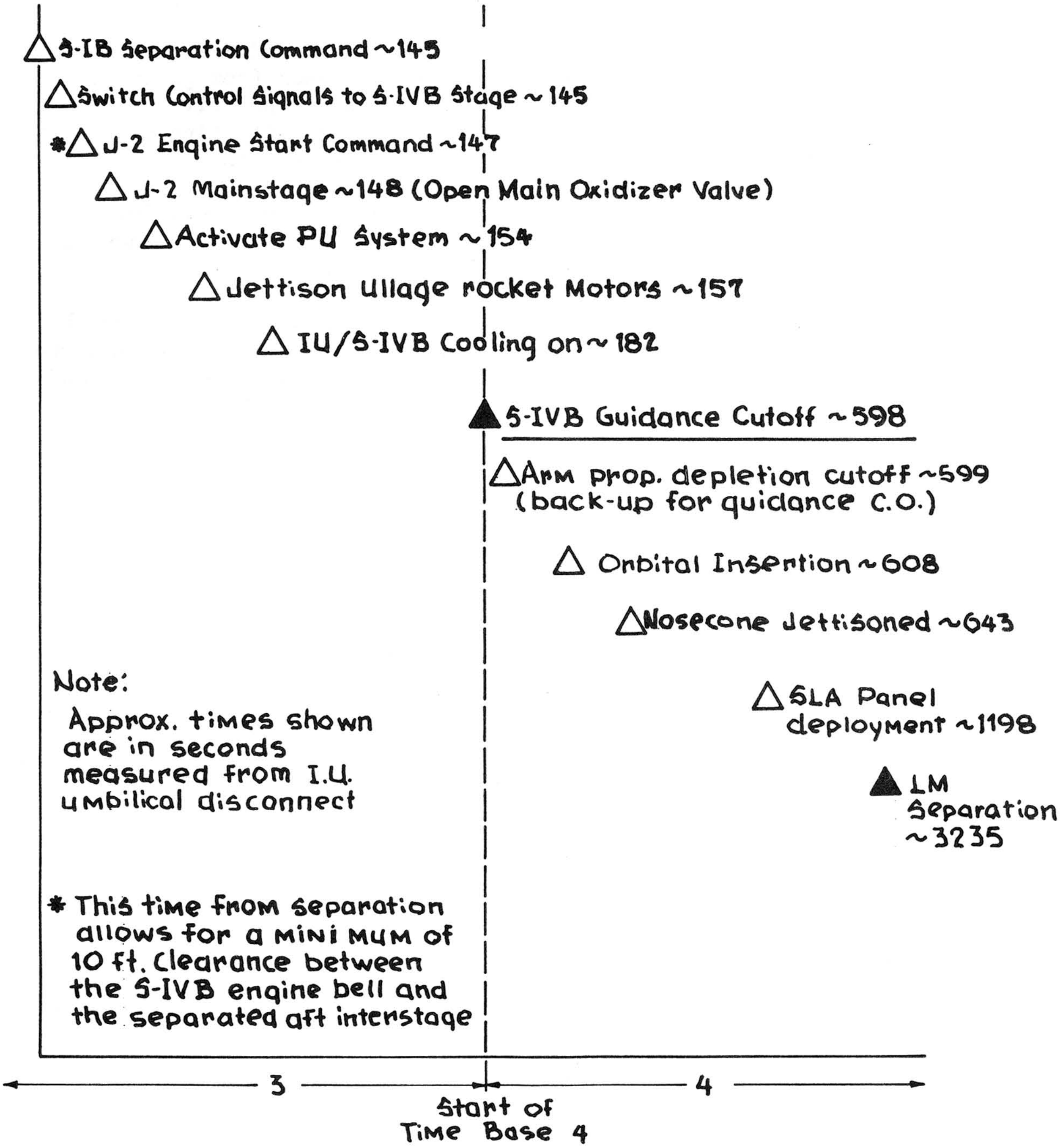


Figure 7

S-IVB Stage Flight Sequencing

LAUNCH VEHICLE SECURE RANGE SAFETY SYSTEMS

The secure range safety systems on the S-IB and S-IVB stages provide a communications link to transmit commands from ground stations to the vehicle during powered flight, and a positive means of terminating the flight of an erratic vehicle by initiating emergency engine cutoff and, if necessary, propellant dispersion.

Each powered stage contains two UHF radio receivers. Both command receivers on each of the two stages respond to the same command signal, each providing a backup system for the other.

The safing and arming device located on each stage is armed by a signal from the blockhouse before vehicle ignition. Following orbital insertion the S-IVB range safety system is "safed" by a command from Range Safety Control to preclude accidental destruct.

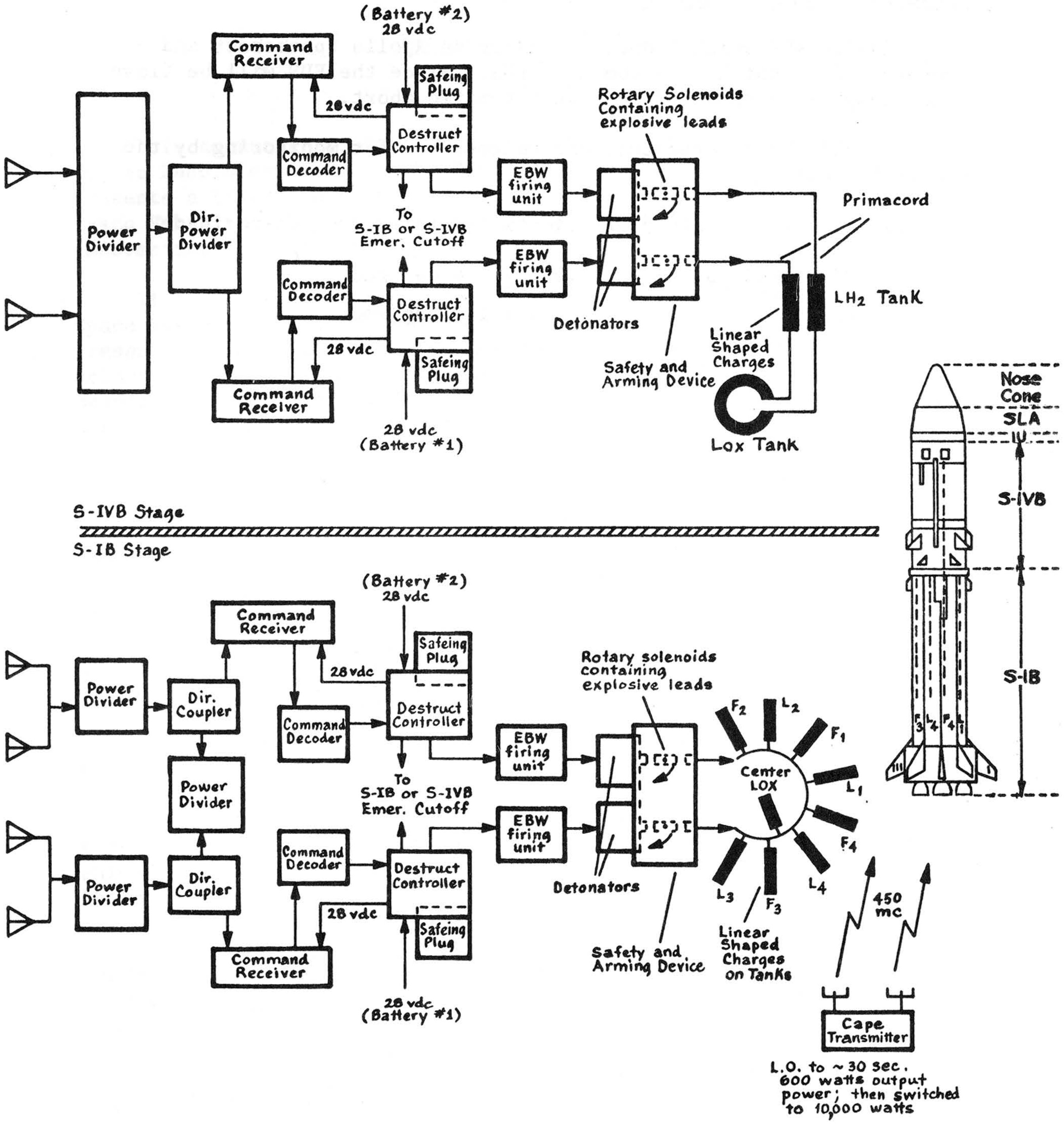


Figure 8

Secure Range Safety System

EMERGENCY DETECTION SYSTEM

Mission AS-204/LM-1 does not carry an Apollo Spacecraft and therefore does not have a complete EDS. Since the EDS will be flown "open loop" it cannot initiate an automatic abort.

All EDS abort parameters are telemetered for monitoring by the Launch Director.

Launch vehicle rate abort limits for telemetry monitoring:

Pitch and yaw	5.0 $\pm$ 0.6 deg/sec.
Roll	20.0 $\pm$ 1.5 deg/sec.

On AS-204/LM-1 the EDS
CANNOT activate an abort
(flown in "open loop" configuration)

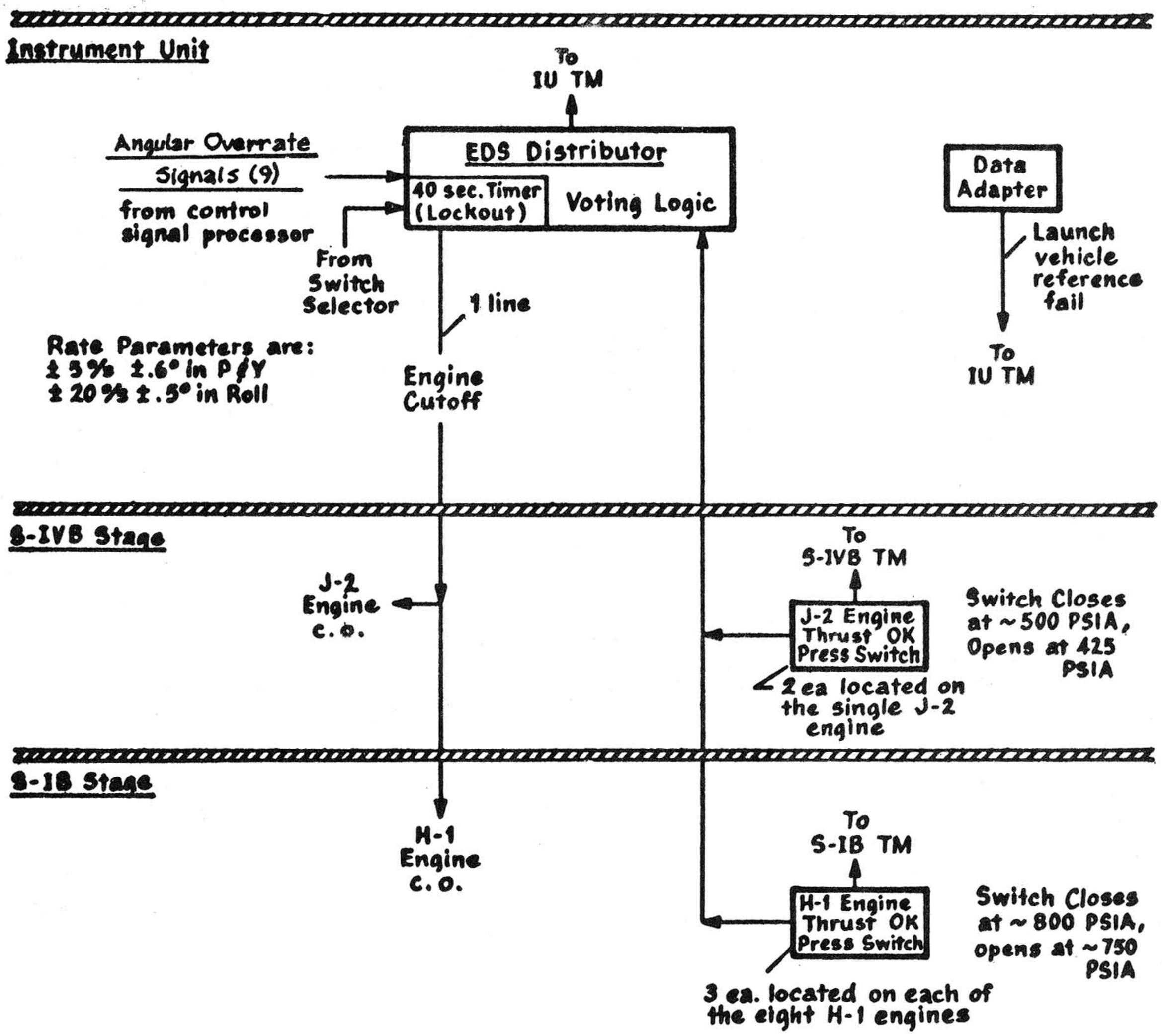
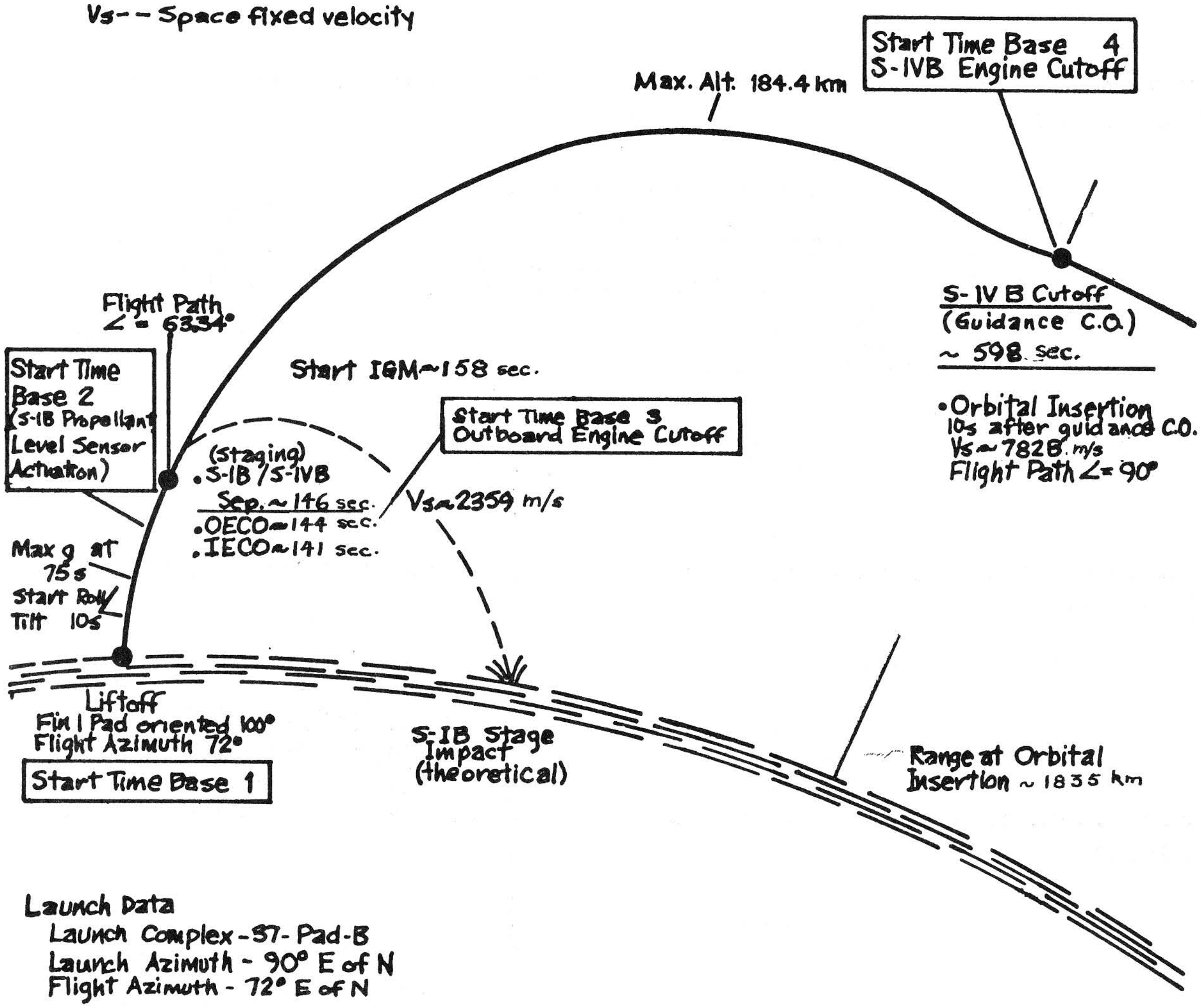


Figure 9

Emergency Detection
System (EDS)

IECO - Inboard Engine Cutoff
OECO - Outboard Engine Cutoff
IGM - Iterative Guidance Mode
Vs - - Space fixed velocity



Launch Data
Launch Complex - 37 - Pad - B
Launch Azimuth - 90° E of N
Flight Azimuth - 72° E of N

Figure 10

Trajectory Information

INTENTIONALLY LEFT BLANK

GUIDANCE AND CONTROL SUBSYSTEMS

Function and Description

Problems to be solved in order to insure mission success involve - navigation, guidance and control.

Figure 11 contains a block diagram of the Guidance and Control Subsystem.

Three accelerometers, mounted on the inner (inertial) gimbal of the stabilized platform, measure the three components of velocity resulting from vehicle propulsion (x, y, z). These acceleration measurements are fed to the Launch Vehicle Data Adapter (LVDA) which serves as an input/output device for the Launch Vehicle Digital Computer (LVDC).

The dual speed resolvers, located at the gimbal pivot points, are used to measure vehicle attitude with respect to the Inertial Platform. These angular outputs are converted into a digital count in the LVDA.

Any maneuver, required to achieve a desired end condition, is determined by the LVDC. The LVDA, acting as the input and output device for LVDC, transforms this data into a form which is compatible with other portions of the system.

The LVDC compares vehicle attitude correction commands with control sensor inputs to develop a control command to the stage engine actuators. The resulting command represents a computed difference between existing and desired attitude angles.

The required resulting action (thrust direction) is obtained by gimballing the engines in the propelling stage, thus changing vehicle direction. In the S-IVB stage, an auxiliary propulsion system is used for roll control since the stage has only one engine. This control is effective during S-IVB powered flight. During coast flight, the auxiliary propulsion system provides complete control of the S-IVB/IU stage.

LVDA output is also routed to stage circuitry via the switch selectors for sequencing purposes.

Changing or introducing new data into the LVDC is made possible through the Instrument Unit command system from ground stations.

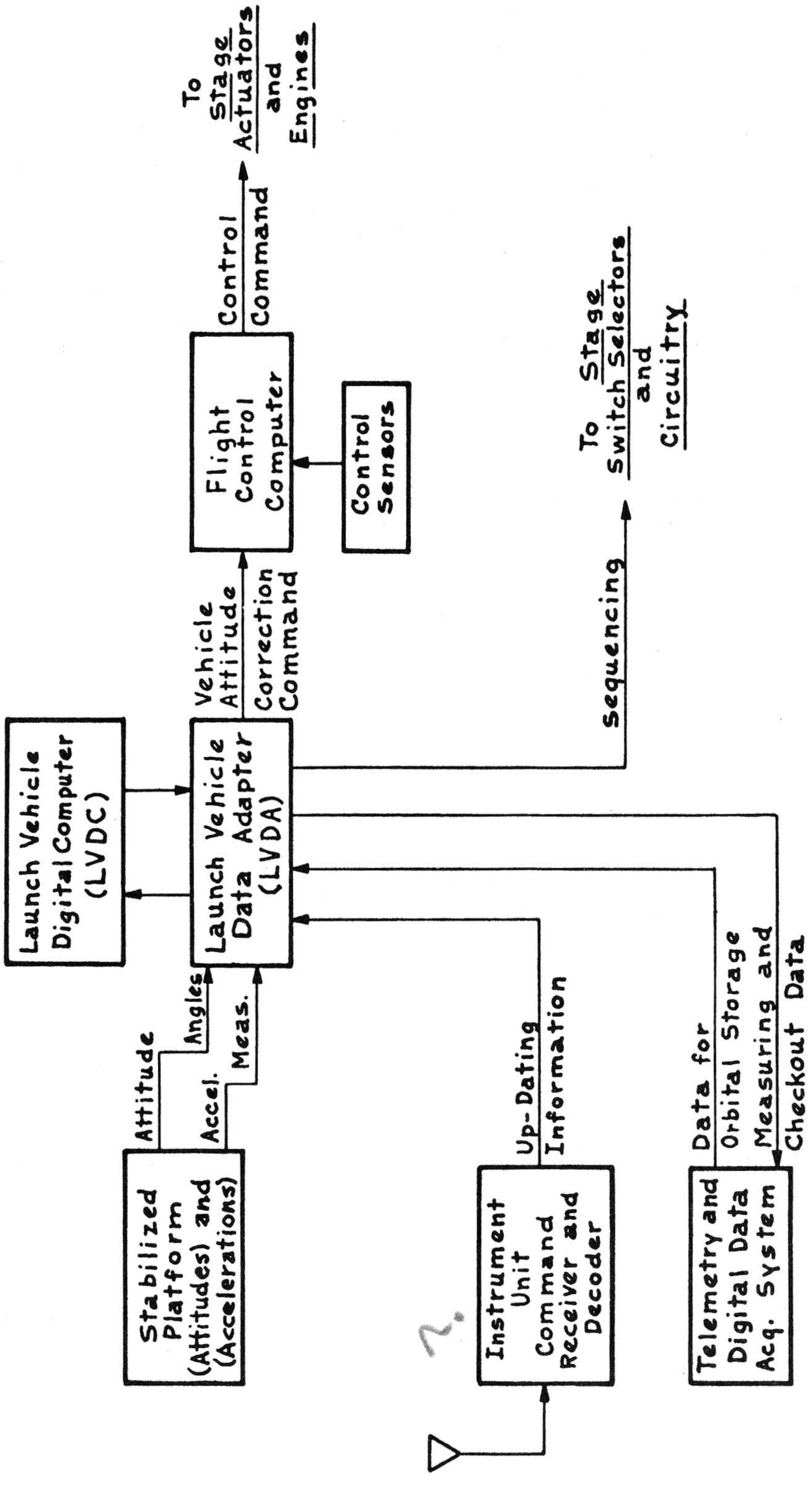


Figure 11

Launch Vehicle Guidance Subsystem

LAUNCH VEHICLE GROUND SUPPORT PLAN (SA-204/LM-1)

Mission Description

The Apollo Mission, SA-204/LM-1 will be the first launch of the uprated Saturn I Launch Vehicle with a fully configured Lunar Module.

Primary purpose of the Launch Vehicle is to insert the LM/S-IVB/IU into an elliptical earth orbit having an 85 nm perigee and a 120 nm apogee and to position the LM for unmanned tests of subsystem operations.

A ground projection of the first six revolutions is shown in Figure 15.

Basic Support

Basic mission support required from the global network are; Tracking, Telemetry Recording, Telemetry Real Time Display and Updata.

Mission Support Planning

For support planning purposes, the mission can be divided into three phases:

1. The Launch Phase - Liftoff to S-IVB cutoff plus 1.5 minutes.

2. Pre-separation Phase - Begins at the end of Launch Phase and is terminated by the initiation of LM separation sequence.

3. Post-separation Phase - Starts with initiation of the Separation Phase and continues for the duration of the LM system life.

For mission planning purposes, LM System life is assumed to be 10 hours.

The mission's secondary objective is to determine the system life of the Launch Vehicle.

Launch Phase

The Apollo Saturn Vehicle, launched from Pad 37B, will have a launch azimuth of 90° and will roll to a flight azimuth of 72° east of true north.

Pre-separation Phase

Following S-IVB cutoff, approximately 598 seconds after liftoff, the S-IVB/IU and the LM are inserted into their earth parking orbit (85 by 120 nm). The vehicle remains in this phase for about 42 minutes which presents the first opportunity for separation. A second opportunity occurs over the United States on the first revolution.

Visibility limit circles for an elevation of 5 degrees are shown in Figure 15 for the primary ground stations for tracking, telemetry and updata.

Whenever the orbital ground projections are within the limit circle, the vehicle will be visible to the stations.

<u>Post-separation Phase</u>

During the second revolution, the S-IVB LOX and LH_2 Propellant Dump Experiment will be activated. This experiment is also described as Propellant Removal Test and S-IVB Stage Passivation.

Figure 12 describes the network coverage constraints for each of the phases described above.

	Launch Phase	Separation Phase	Active Post-Separation Phase
TRACKIG	Continuous Record From Liftoff to S-IVB Cutoff From 2 Independent Systems, and From S-IVB Cutoff for 1.5 Minutes From 1 Syst.	Continuous C-band Cover for at Least 2 Minutes Before Separation Until 2 Minutes After Separation.	C-band Beacon Tracking From 2 Stations per Rev.-180° Apart-For First 4 Revs. and 1 Station/Rev. For Duration of Systems Life.
TELEMETRY	Continuous Record From Liftoff to S-IVB Cutoff by 2 Stations and From S-IVB Cutoff For 1.5 Min. by 1 Station. Continuous Record of S-IB Ballistic Flight From S-IB Cutoff For 2 Min. Continuous Real-Time Flight Control Data From Liftoff to S-IVB Cutoff + 1.5 Minutes.	Continuous Record and Real-Time Flt. Control Data For at Least 2 Min. Before Until 2 Min. After Separation. NOTE; Prior to Separation, Record and Real-Time Data is Provided For at Least 3 Minutes From 1 Station.	Record at Least 3 Minutes From at Least 4 Stations/Rev. Until 4 1/2 Hours Into Mission. Then 2 Sta./Rev. Until End of Estimated Systems Life; Then 1 Sta./Rev. For Duration of Syst. Life. Real-Time Flight Control Data For at Least 3 Min. From 1 Sta./Rev. Until 4 1/2 Hours Into Miss Mission.
UPDATA	Updata Capability From Liftoff Plus 160 Seconds to S-IVB Cutoff +90 Seconds.	Continuous Updata Capability For at Least 2 Minutes Before Separation Until 2 Minutes After Separation.	Updata Capability For At Least 3 Minutes From 1 Station/Rev. Until 4 1/2 Hours Into Mission.

Figure 12

Network Coverage Constraints

COMMUNICATIONS

Command (Data Transfer from Ground to Space Vehicle)

The purpose of the Saturn Instrument Unit Command System is to provide radio frequency digital data transmission between Manned Space Flight Network Stations and the on-board Digital Computer in the Launch Vehicle (LVDC).

Data received by the LVDC is used to update certain vehicle attitude parameters or to perform certain orbital operations in the S-IVB/IU.

Telemetry (Transmission of On-Board Parameters from Space Vehicle to Ground Stations)

Telemetry utilizes a system of sensing devices (transducers) which enables large quantities of physical data to be reduced into electrical intelligence. Various combinations, involving Frequency as well as Pulse Code and Pulse Amplitude Modulation, plus a frequency time-sharing system allows a great amount of data, in vehicle physical parameters, to be relayed to ground stations through limited transmitting paths.

While the vehicle is still on the launch pad, pre-flight telemetry checkout is accomplished by hardwire and umbilical cord transmission.

The 204/LM-1 carries a total of 18 telemetry systems distributed as follows:

- S-IB Stage	4
- S-IVB Stage	5
- IU	4
- LM	5

Tracking (Monitor or Measure Vehicle In-Flight Location by Communication)

Purpose:

- Evaluate Guidance and Control
- Perform Attitude Corrections
- Insure Range Safety

Vehicle 204/LM-1 carries transponders and beacons in the following locations:

Location	System
- S-IB	- ODOP Transponder
- IU	- Two C-Band Radar Beacons - Glotrac Transponder
- LM	- X-Band Rendezvous Radar - Two C-Band Radar Beacons - USB Transponder

INSTRUMENT UNIT - DIGITAL COMMAND SYSTEM CAPABILITY

Function	Description	Periods of Acceptance
LM Abort	Causes LM abort switch selectors and maneuvers.	Enabled at T_3 + 10 sec. until end of mission.
Inhibit	Inhibits certain coast phase attitude maneuvers.	Enabled at T_4 + 15 sec. until end of mission.
Update	Changes the time of initiation of the certain attitude maneuvers.	Enabled at T_4 + 15 sec. until end of mission.
Time Base Update	Time base time is advanced or retarded at the next telemetry loss.	Enabled at T_4 + 15 sec. until end of mission.
Navigation Update	Navigation quantities are reset at the time specified.	Enabled at T_4 + 15 sec. until end of mission.
Generalized Switch Selector	Specified switch selector function is issued at the first opportunity.	Enabled at T_4 + 15 sec. until end of mission.
Sector Dump	Contents of specified memory-sector are telemetered.	Enabled at T_4 + 15 sec. until end of mission.
Telemeter Single Memory Location	Contents of specified memory-sector are telemetered.	Enabled at T_4 + 15 sec. until end of mission.
Terminate	Stop DCS routine and reset for new command.	Enabled at T_4 + 15 sec. until end of mission.

Network Controller

ETR Sites (SRO)

KSC (MLA)
Cape Kennedy (CNV)
Patrick AFB (PAT)
Grand Bahama (GBI)
Antigua (ANT)
Ascension (ASC)
Pretoria (PRE)
Aria

Other DOD Sites

WTR-S. Vandenberg (CAL)
WSMR-White Sands (WHS)

Ship Stations

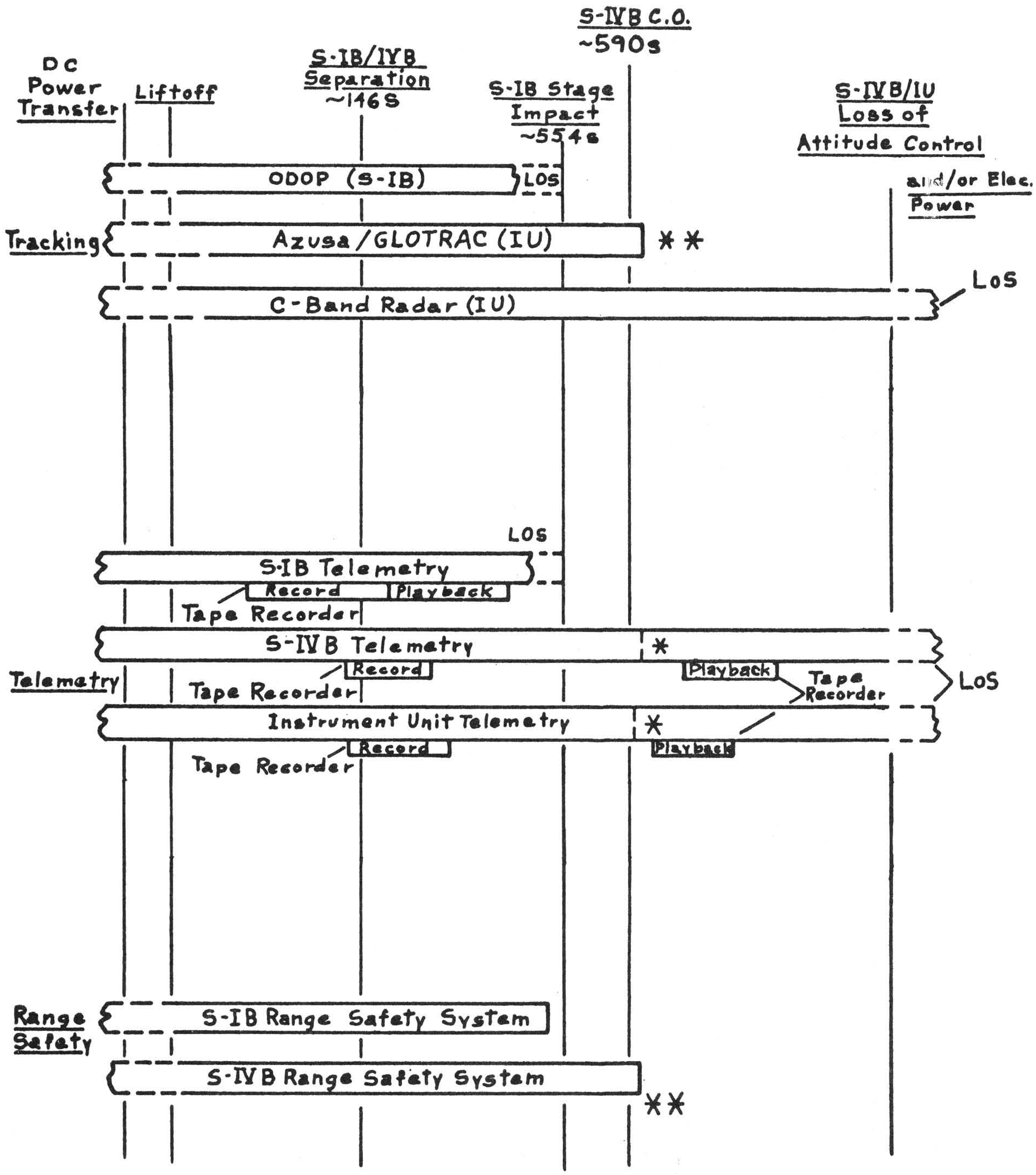
USNS Rose Knot (RKV)
USNS Coastal Sentry (CSQ)
USNS Vanguard (VAN)

NASA Sites

KSC (CIF MIL)
Bermuda (BDA)
Grand Bahama USB (GBM)
Canary Island (CVI)
Tananarive (TAN)
Carnarvon (CRO)
Guam (GWM)
Canton Island (CTN)
Kokee Park (HAW)
Guaymas (GYM)
Corpus Christi (TEX)
Woomera (WOM)
Ascension USB (ACN)
Goldstone (GDS)

Figure 13

TRACKING NETWORK



LOS = Loss of Signal

* = IU SSB off at ~600s, S-IVB SSB off at ~610s.

During orbit the S-IVB tape recorder records between stations and plays back over selected stations.

** Commanded off after S-IV engine cutoff.

Figure 14

Tracking, Telemetry, and Range Safety Coverage

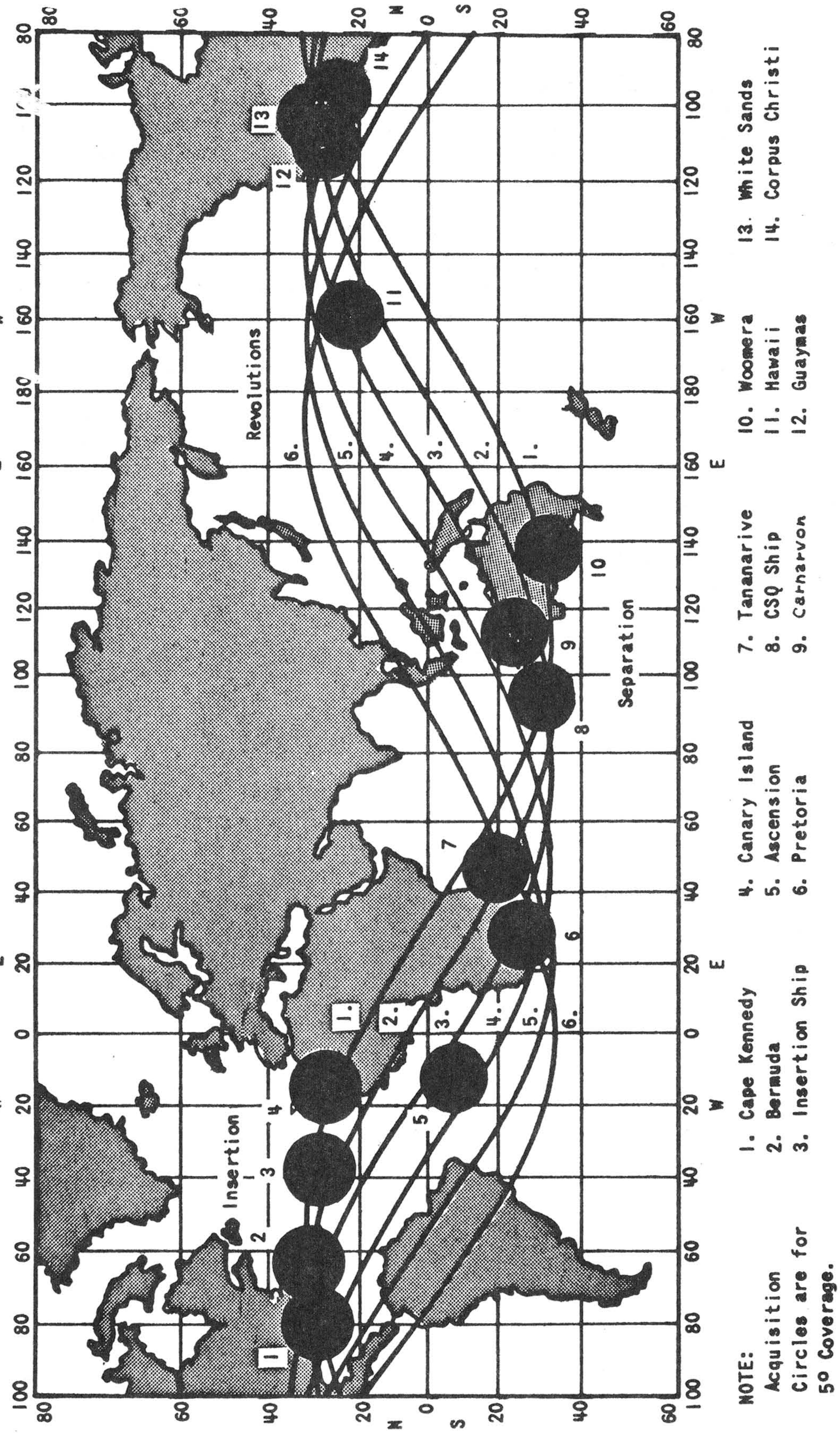


Figure 15

ORBITAL GROUND PROTECTION

SPACE VEHICLE WEIGHT VS. FLIGHT TIME

Propellant consumption during S-IB Stage flight (approximately 144 seconds) is approximately 883,200 pounds and during S-IVB Stage flight (approximately 435 seconds) is 226,400 pounds.

In case one engine of the S-IB Stage malfunctions and is cutoff during flight, the remaining engines will consume the propellant intended for the "dead"engine. Burning time of the stage would increase, and the overall vehicle loss would be minimized.

Vehicle Weight Data (Approximate)	Pounds
Total at S-IB ignition	1,299,000
Total at liftoff	1,285,000
Total at S-IB O.E.C.O.	400,000
Total at S-IVB ignition	296,100
Total of S-IVB cutoff	69,800
Total at nose cone jettison	68,100
Total at LEM separation	36,800

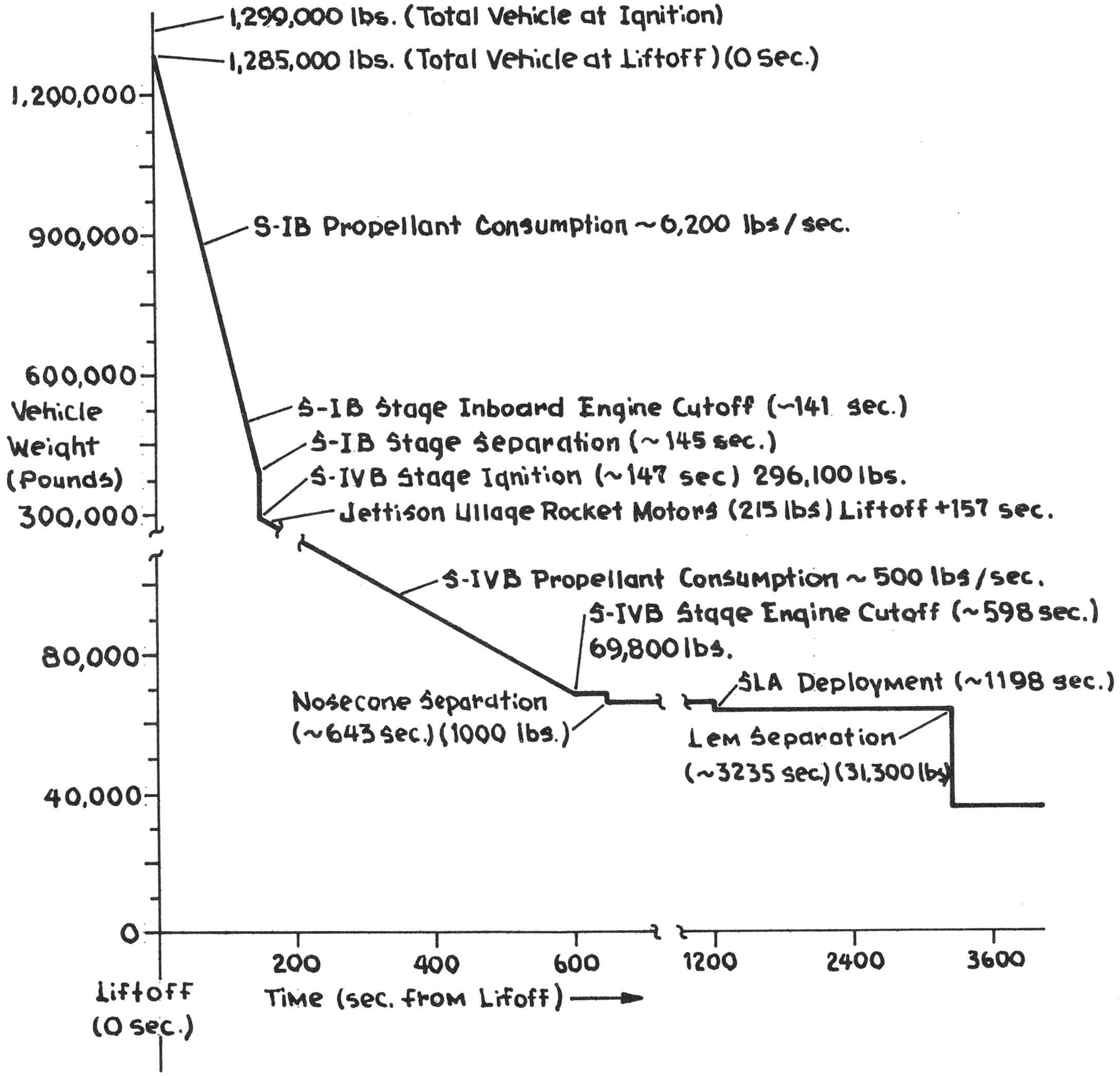


Figure 16

SPACE VEHICLE WEIGHT VS FLIGHT TIME

S-IB STAGE STRUCTURE

The S-IB Stage consists of four 70-inch diameter fuel containers mounted alternately with four 70-inch diameter LOX containers around a 105-inch diameter LOX container. The containers are supported at the base by a thrust structure assembly to which are affixed eight H-1 engines. The spider beam assembly provides the support structure at the forward end of the containers and serves as an adapter for the S-IVB interstage. Eight fins are mounted at the base of the S-IB stage to improve aerodynamic stability, and provide preflight support, and hold-down of the vehicle.

PROPULSION SYSTEM

The first stage of the launch vehicle is powered by a cluster of eight Rocketdyne H-1 engines developing a total sea level thrust of 1,600,000 pounds. Four engines are mounted outboard and four inboard; the four outboard engines are gimballed for vehicle control. The propellants are LOX and RP-1.

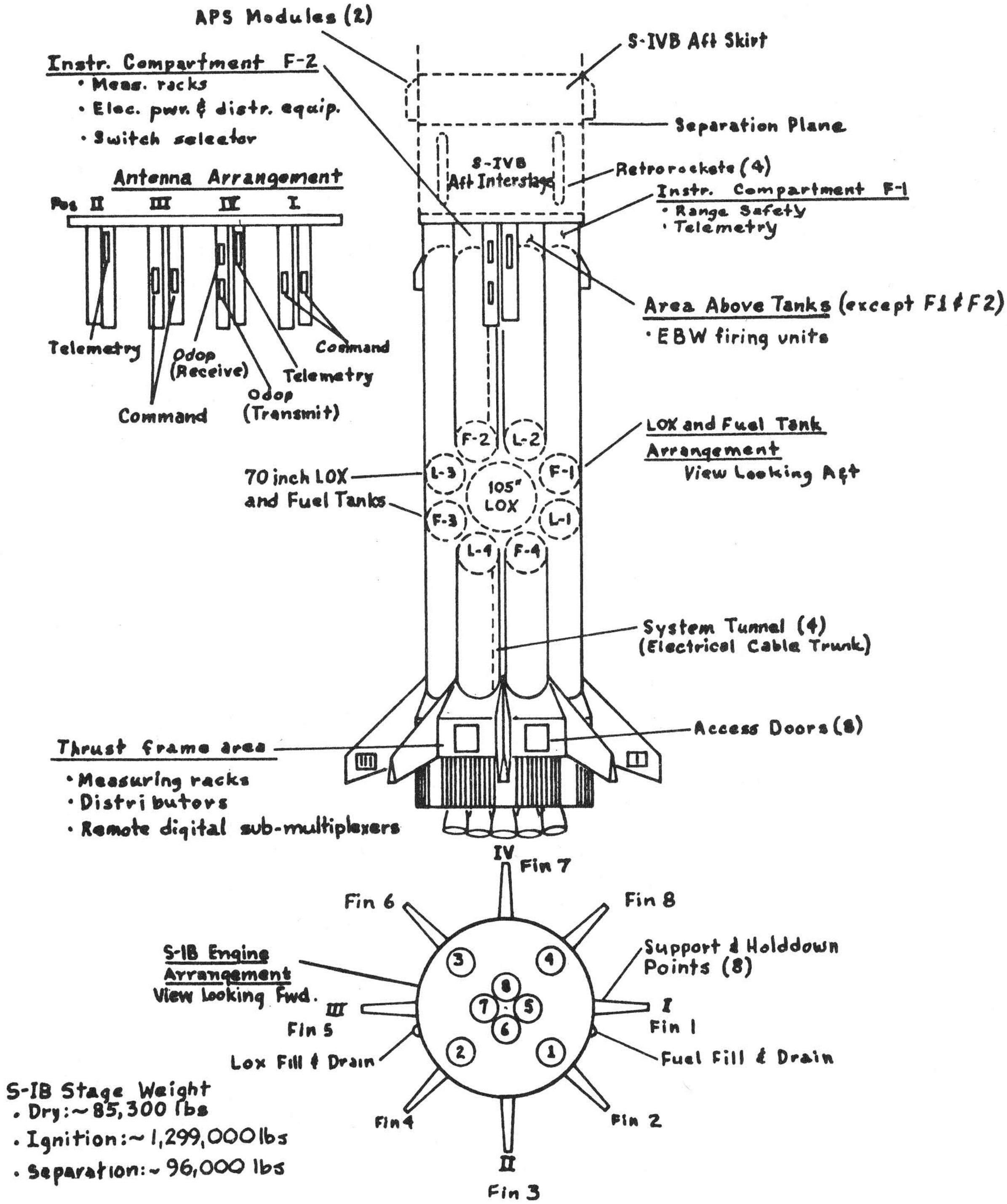


Figure 17

S-IB Stage Configuration

H-1 ENGINE OPERATION

A start signal ignites the solid propellant gas generator (SPGG) which accelerates the LOX and RP-1 pumps. Increasing fuel pressure opens the main LOX valve which, in turn, opens the sequence valve permitting fuel pressure to rupture the hypergolic cartridge. Primary ignition occurs when the RP-1 and hypergolic fluid contact LOX in the thrust chamber. The injector fuel pressure opens the main RP-1 valve and provides propellant flow to the liquid propellant gas generator (LPGG) which sustains turbine operation.

The digital computer initiates inboard engine cutoff 3.1 seconds after the propellant level sensor actuation. Outboard engine cutoff is normally initiated by the LOX depletion probes, with the fuel depletion probes, the digital computer, and the thrust OK switches providing backup capabilities. Both cutoff signals are routed through the S-IB Stage switch selector. The cutoff signal opens the explosively actuated Conax valve equalizing the RP-1 pressure at the main LOX valve. The valve closes to interrupt fuel flow and terminate engine operation.

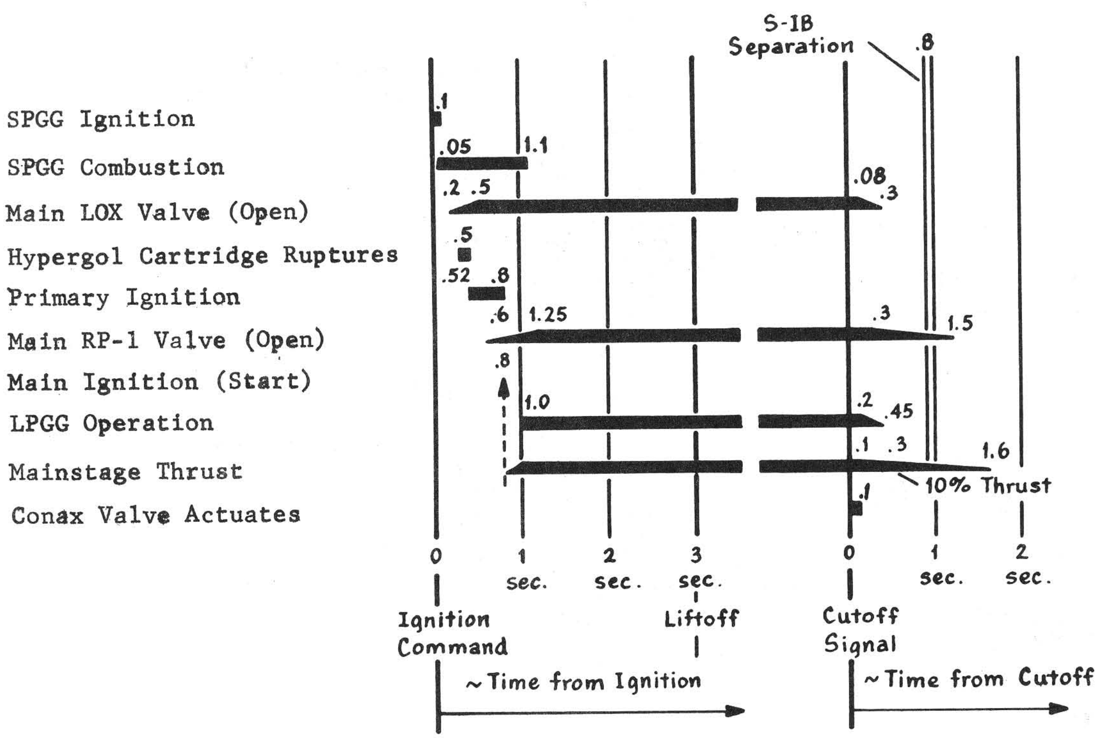


Figure 18

H-1 Operational Sequence

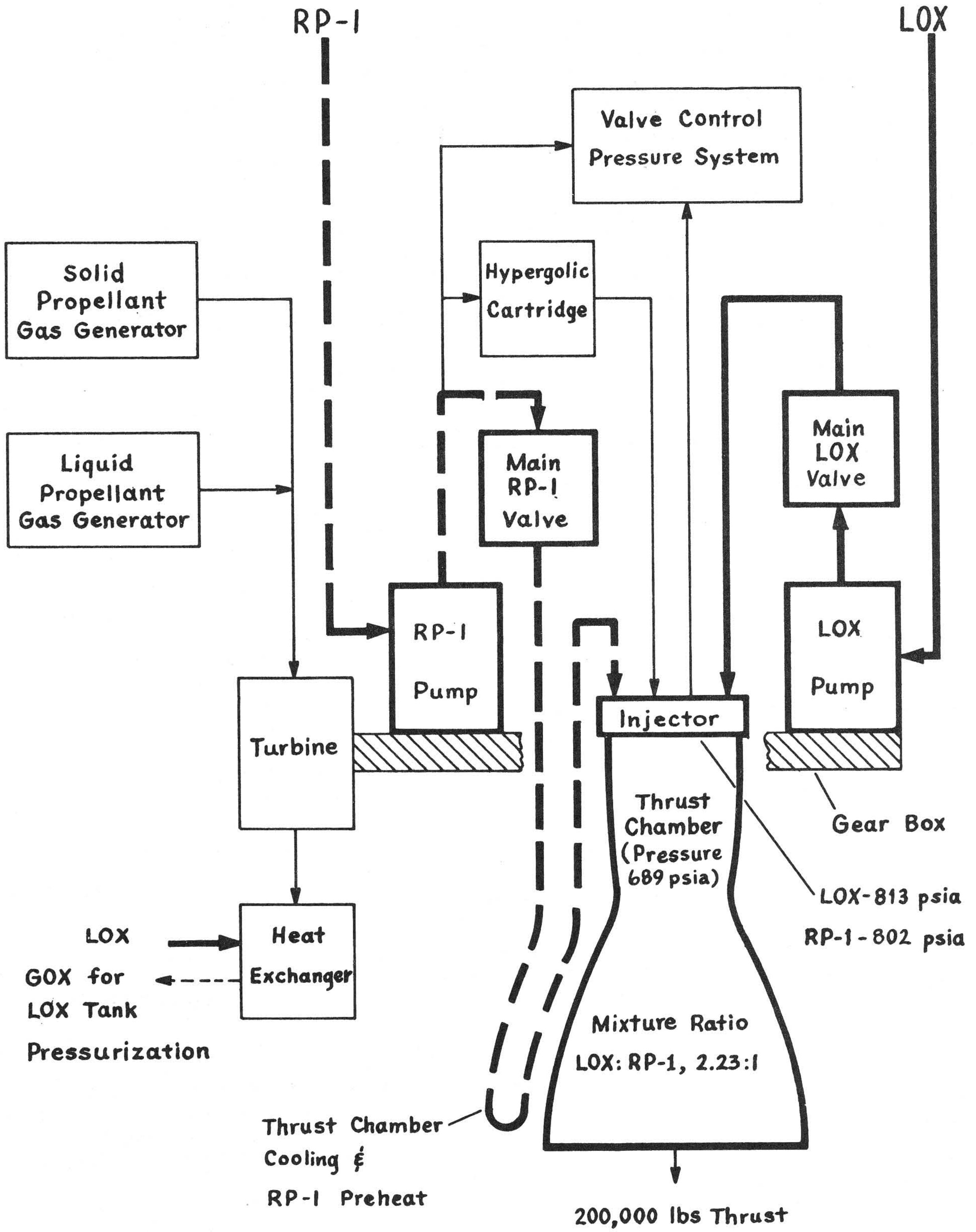
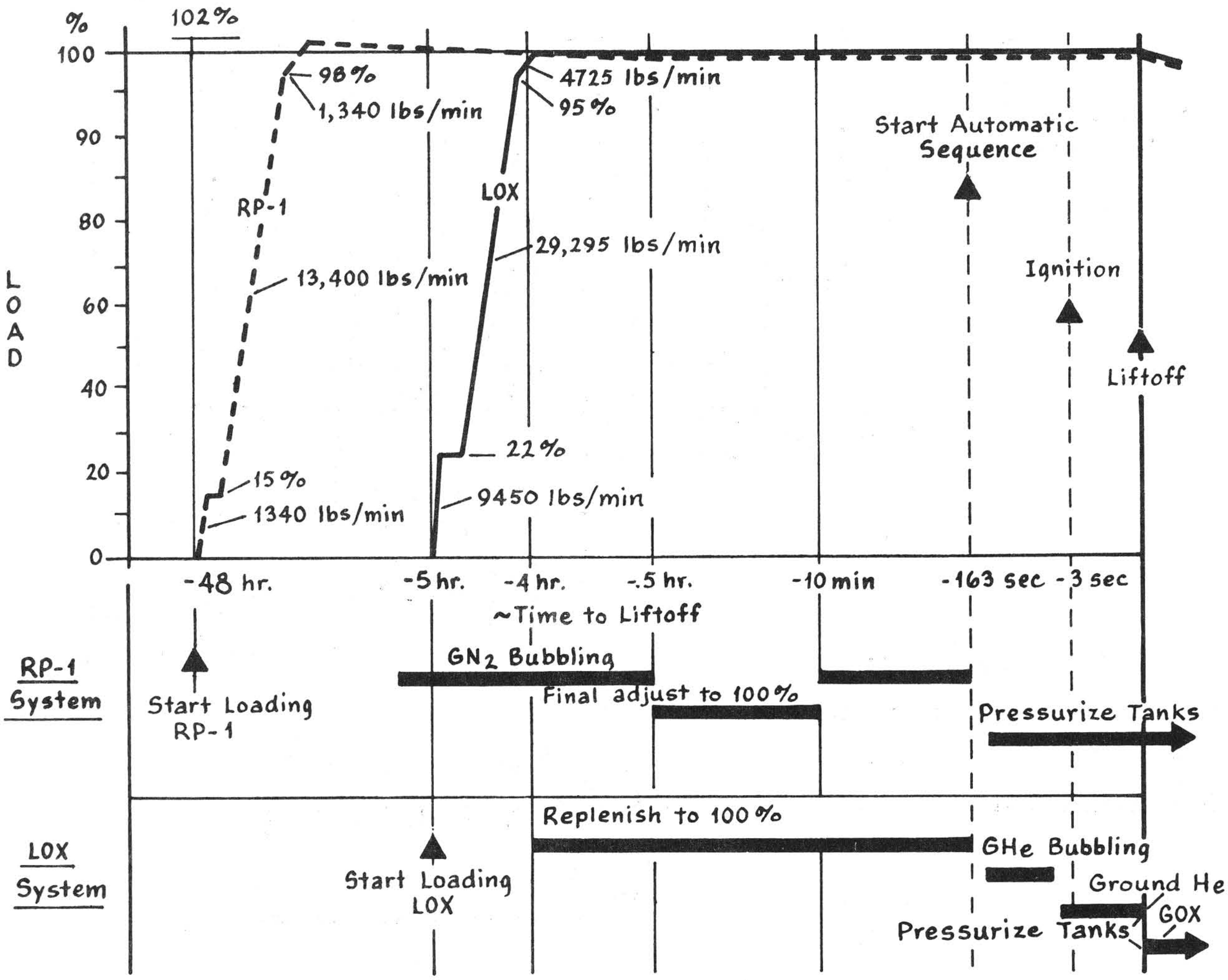


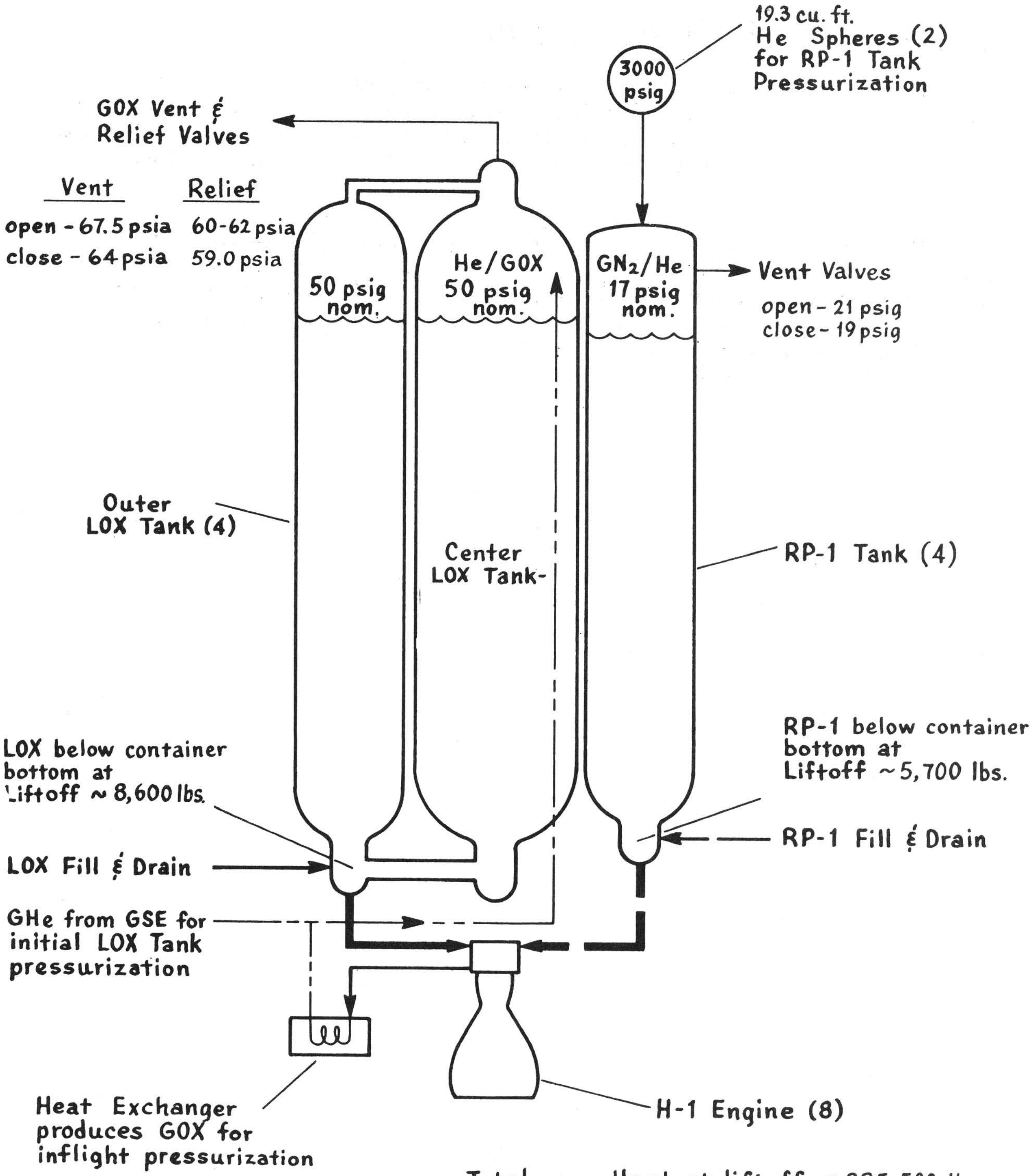
Figure 19

H-1 Engine System

S-IB STAGE PROPELLANT SYSTEM

The S-IB Stage propellant system is composed of five LOX tanks, four RP-1 tanks, propellant lines, control valves, vents, and pressurization subsystems. The sumps of each group of tanks are interconnected to provide uniform propellant levels and pressures. Loading of LOX and RP-1 tanks is controlled by ground computers. After the RP-1 has been loaded and just before the start of LOX loading, ground source GN_2 is bubbled through the RP-1 suction lines to prevent temperature stratification. At the start of the automatic sequence the RP-1 tanks are pressurized with ground source GN_2. During S-IB burn, fuel tank pressurization is maintained by GHe from two 19.3 cubic foot spheres located above two of the fuel tanks. Ground source helium is bubbled through the LOX lines and tanks at the start of the automatic sequence to prevent temperature stratification in the engine LOX suction lines. Prior to engine ignition the bubbling is discontinued and the LOX tanks are pressurized with helium from a ground source. After liftoff, the LOX tank pressurization is maintained with GOX converted from LOX in the heat exchanger.





Total propellant at liftoff ~ 895,500 lbs.
Total propellant consumed after liftoff ~ 883,200 lbs.

Figure 20

S-IB Stage
Propellant System

S-IB STAGE THRUST VECTOR CONTROL SYSTEM

Each of the four outboard H-1 engines is gimbal mounted on the stage thrust structure to provide engine thrust vectoring for vehicle attitude control and steering. Two hydraulic actuators are utilized to gimbal each engine in response to signals from the Flight Control Computer located in the Instrument Unit.

The actuators are part of an independent hydraulic system on each gimballed engine. Hydraulic fluid flows to the actuators from the high pressure accumulator and returns to the low pressure reservoir. The electric motor driven auxiliary pump operates only during prelaunch checkout of the thrust vector control system.

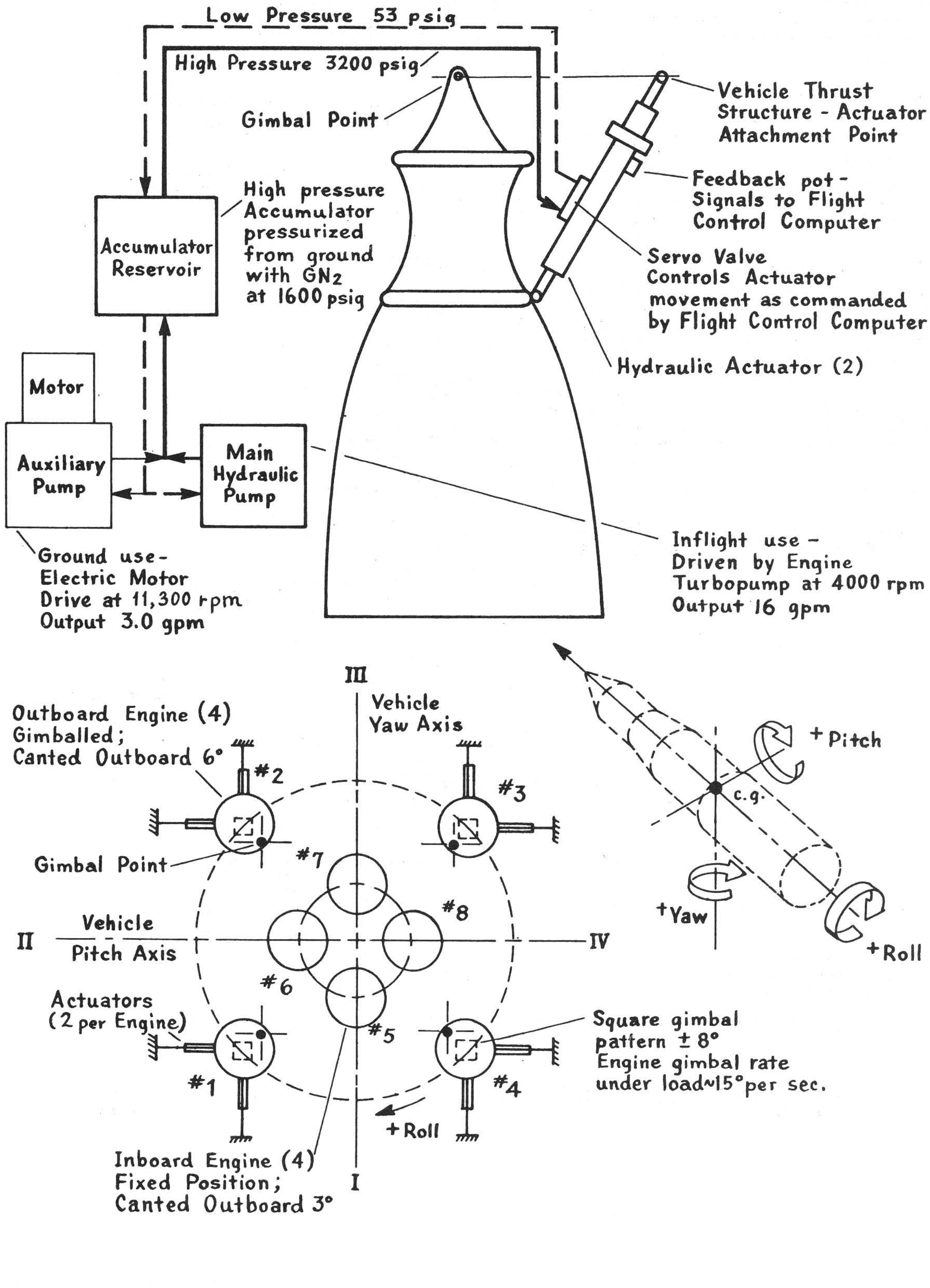


Figure 21

S-IB Stage Thrust Vector Control System

Summary of Measurements	
Inflight	S-IB-204
1 Acceleration	3
2 Acoustics	1
3 Temperature	90
4 Pressure	101
5 Jib	62
6 RFET/M	2
7 Signals	99
8 Level	18
9 Voltage, Current, Freq.	26
10 Angular Velocity	3
11 Strain	26
12 Speed	8
Total	439
LCC (Blockhouse)	165

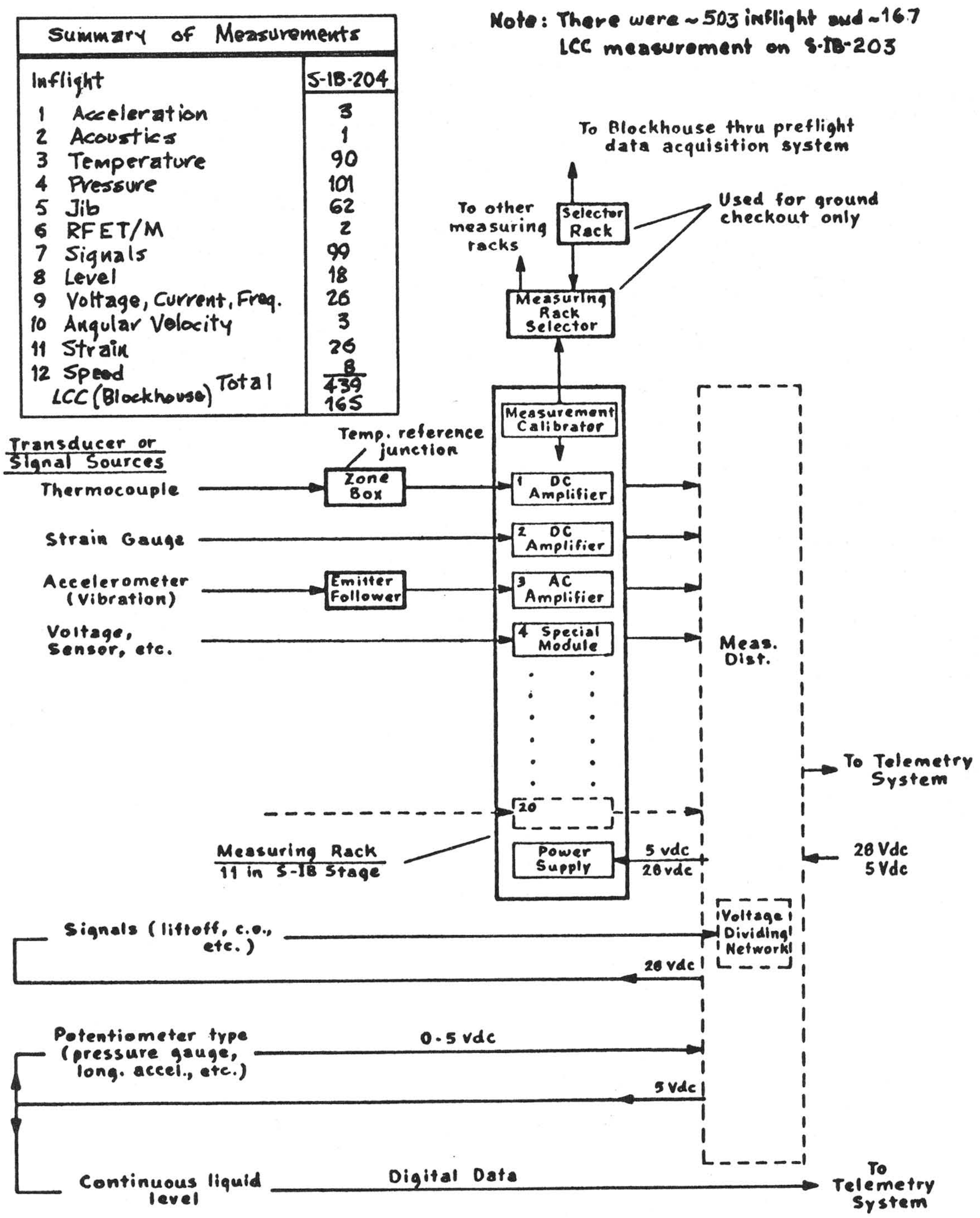


Figure 22

S-IB Stage Measuring System

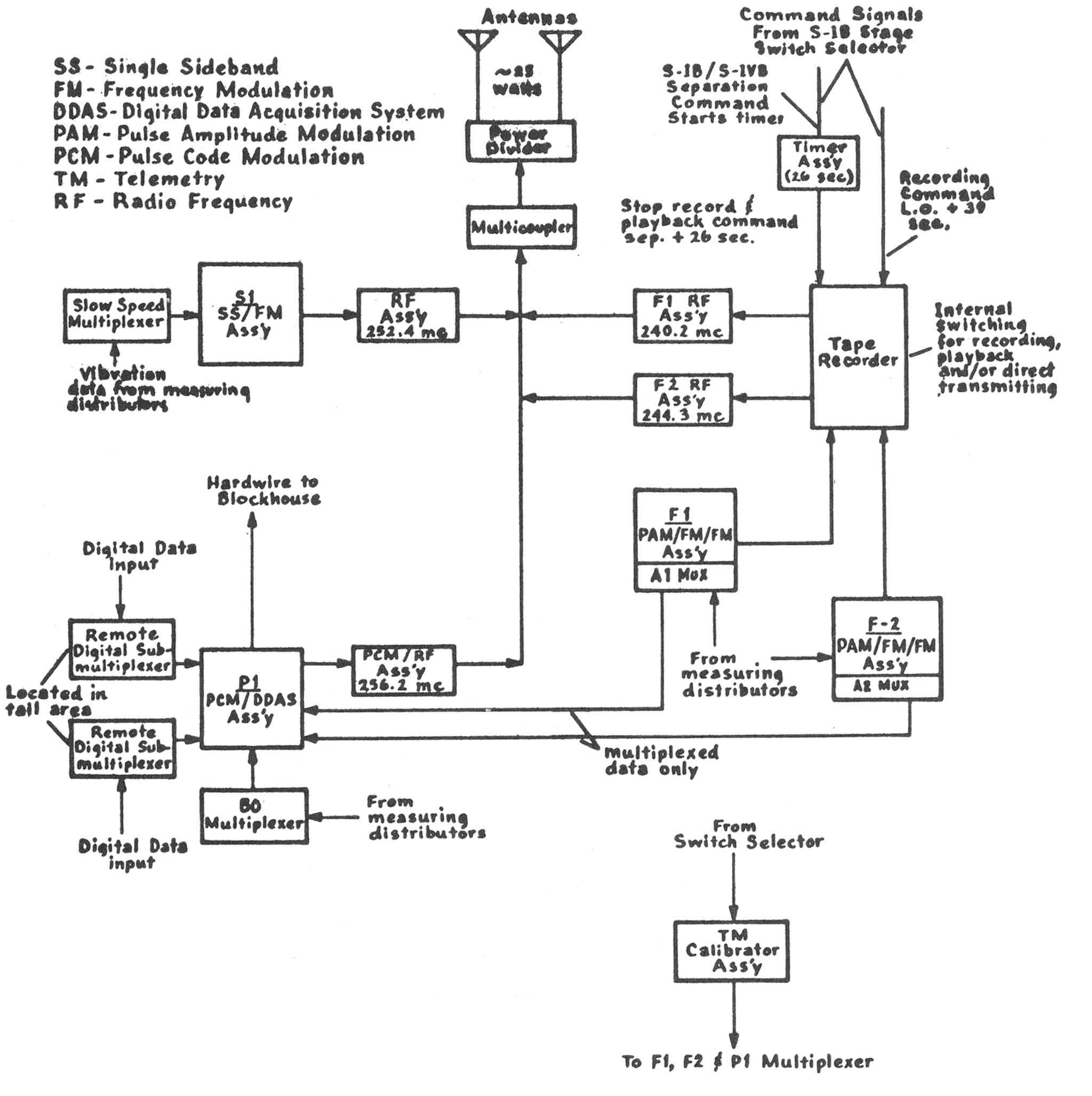


Figure 23

S-IB Stage Telemetry System

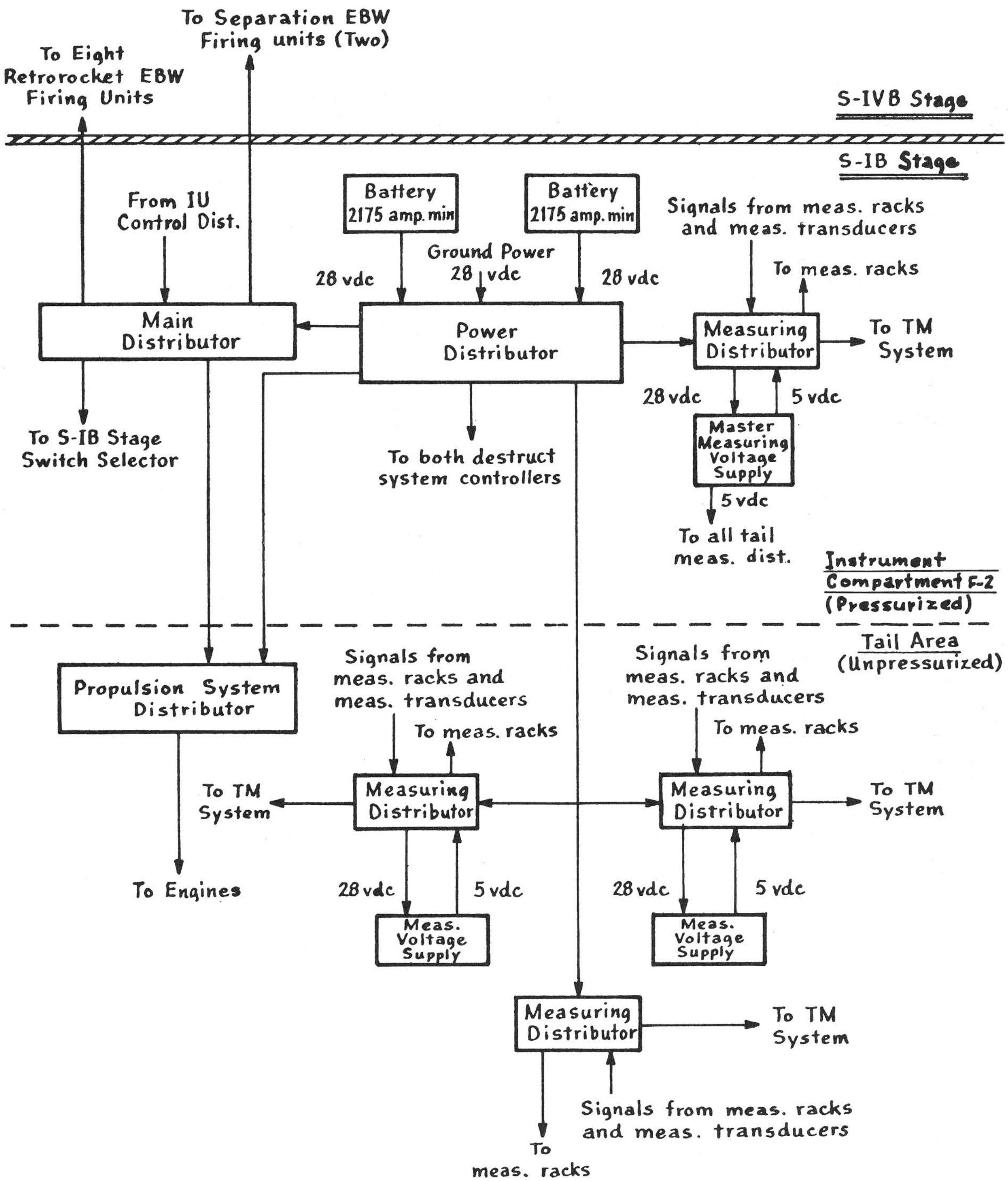


Figure 24

S-IB Stage Electrical Power and Distribution System

INTENTIONALLY LEFT BLANK

S-IVB STAGE STRUCTURE

The S-IVB Stage consists basically of an aft interstage, an aft skirt, a thrust structure, a divided propellant container and a forward skirt.

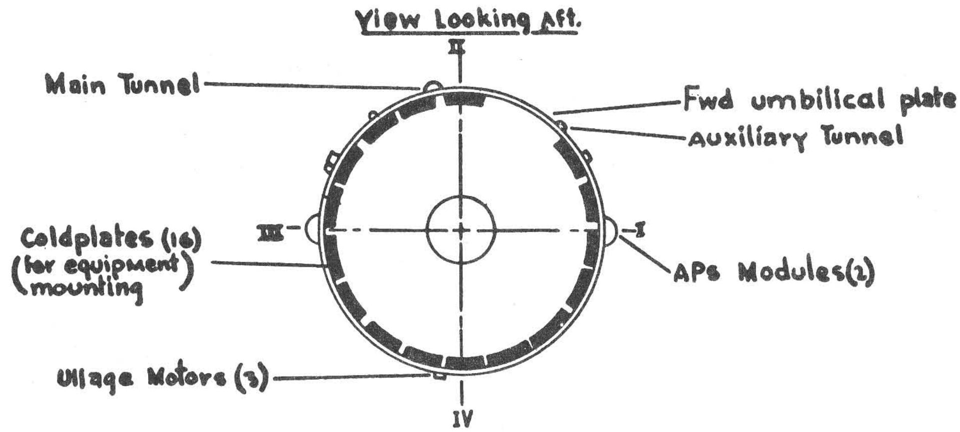
Aft Interstage The aft interstage, also referred to as the S-IB/S-IVB interstage, is a semimonocoque structure which supports the S-IVB Stage, the Instrument Unit and the Apollo Spacecraft payload prior to the S-IB/S-IVB separation. The aft interstage provides mounting facilities for retro-motors. Four Thiokol TE-29-IB solid propellant retro-motors equally spaced circumferentially provide thrust to impart a negative acceleration to the S-IB Stage and the aft interstage after the explosive skin cutting separation at the aft interstage/aft skirt interface.

Aft Skirt The aft skirt is a semimonocoque structure which attaches to the end of the cylindrical portion of the propellant container. The aft skirt houses electrical and electronic components as noted in figure 25. Three Thiokol TX-280 solid propellant motors equally space circumferentially provide a positive acceleration to the S-IVB Stage to settle propellants for J-2 engine start. The aft skirt also provides mounting hardware for two attitude control modules diametrically opposed. Each module contains three TAPCO 150-pound thrust (vacuum) hypergolic (MMH and N_2O_4) rocket engines.

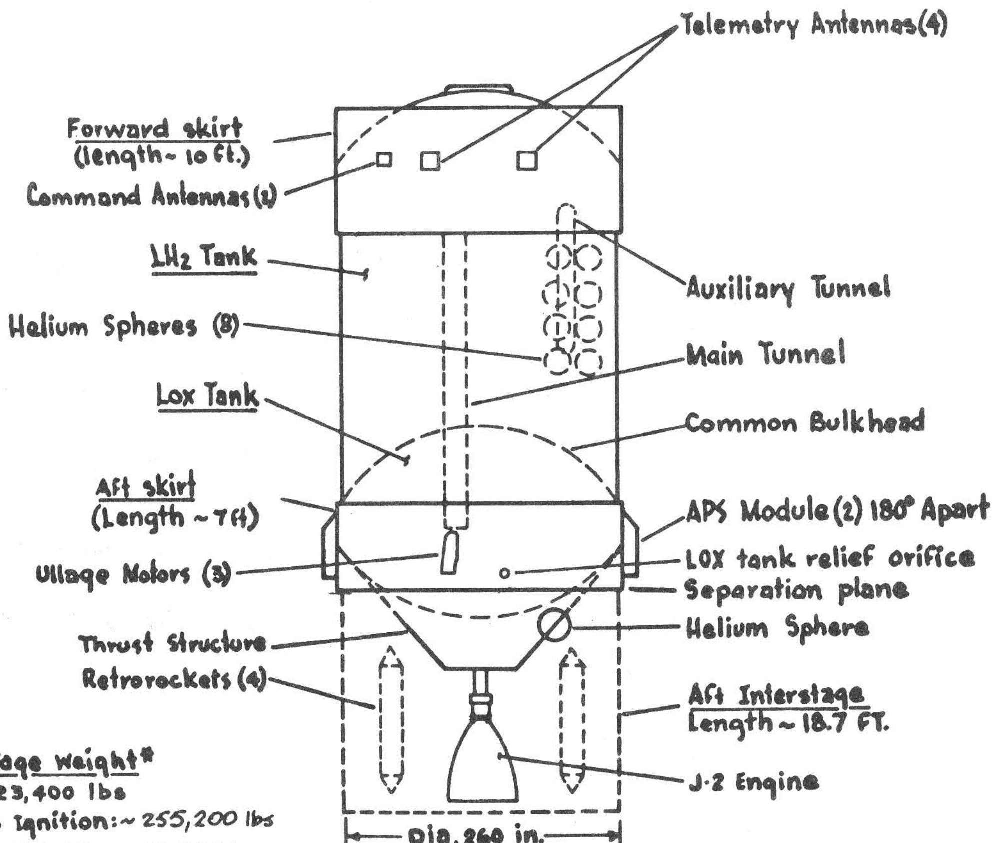
Thrust Structure The thrust structure is a truncated cone with longitudinal stiffeners. The forward end (large diameter) of the cone attaches tangentially to the aft bulkhead of the propellant container. The thrust structure provides attachment points for the engine gimbal mount and the hydraulic actuators. A single J-2 rocket engine of 200,000 pound nominal thrust (vacuum) is installed on the centerline of the S-IVB Stage.

Propellant Container The propellant container is an internally insulated cylinder with hemispherical bulkheads at each end. An internal hemispherical bulkhead with the concave side facing aft divides the propellant container into an aft section for LOX and a forward section for liquid hydrogen. Eight cold helium spheres located in the hydrogen tank provide LOX tank pressurization. An ambient spherical helium bottle mounted on the engine thrust structure provides pneumatic control pressurization throughout the vehicle pressure system. The ambient helium bottle on AS-204 has been increased from .5 cu. ft. to 4.5 cu. ft. to provide pressurization for propellant venting exercises during orbit.

Forward Skirt The forward skirt is a semimonocoque cylindrical structure which attaches to the forward end of the cylindrical portion of the propellant container and supports the Instrument Unit and the payload. The forward skirt houses electrical and electronic components (most mounted on coldplates) and provides external mounting for telemetry and command antennas.



Stage Length: ~ 59 ft.
Including 8 in. protrusion of LH_2 tank beyond S-IVB/IU mating surface



S-IVB Stage Weight*
- Dry: ~ 23,400 lbs
- At S-IVB Ignition: ~ 255,200 lbs
- At S-IVB Cutoff: ~ 29,500 lbs

*Excludes wt. of aft interstage

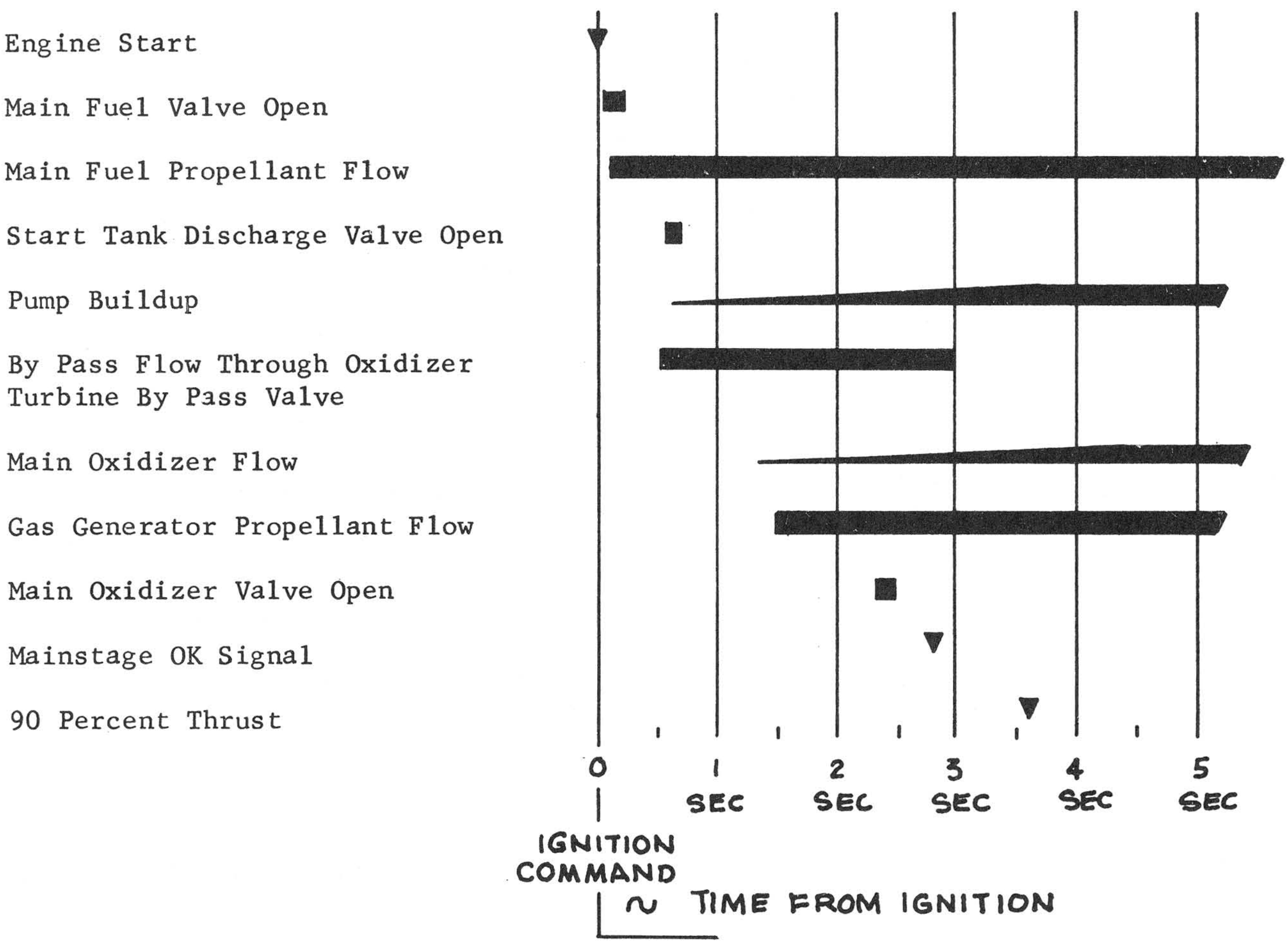
Figure 25

S-IVB Stage Configuration

J-2 ENGINE OPERATION S-IVB

The operating cycle of the J-2 Engine consists of prestart, start, steady-state operation and cutoff sequences. During prestart, LOX and LH_2 flow through the engine to temperature-condition the engine components, and to assure the presence of propellant in the turbopumps for starting. Following a timed cooldown period, the start signal is received by the sequence controller which energizes various control solenoid valves to open the propellant valves in the proper sequence. The sequence controller also energizes spark plugs in the gas generator and thrust chamber to ignite the propellant. In addition, the sequence controller releases GH_2 from the start tank. The GH_2 provides the initial drive for the turbopumps that deliver propellant to the gas generator and the engine. The propellant ignites, gas generator output accelerates the turbopumps, and engine thrust increases to main stage operation. At this time, the spark plugs are de-energized and the engine is in steady-state operation.

Steady-state operation is maintained until a cutoff signal is received by the sequence controller. The sequence controller de-energizes the solenoid valves which in turn close the engine propellant valves in the proper sequence. As a result, engine thrust decays and the cutoff sequence is complete.



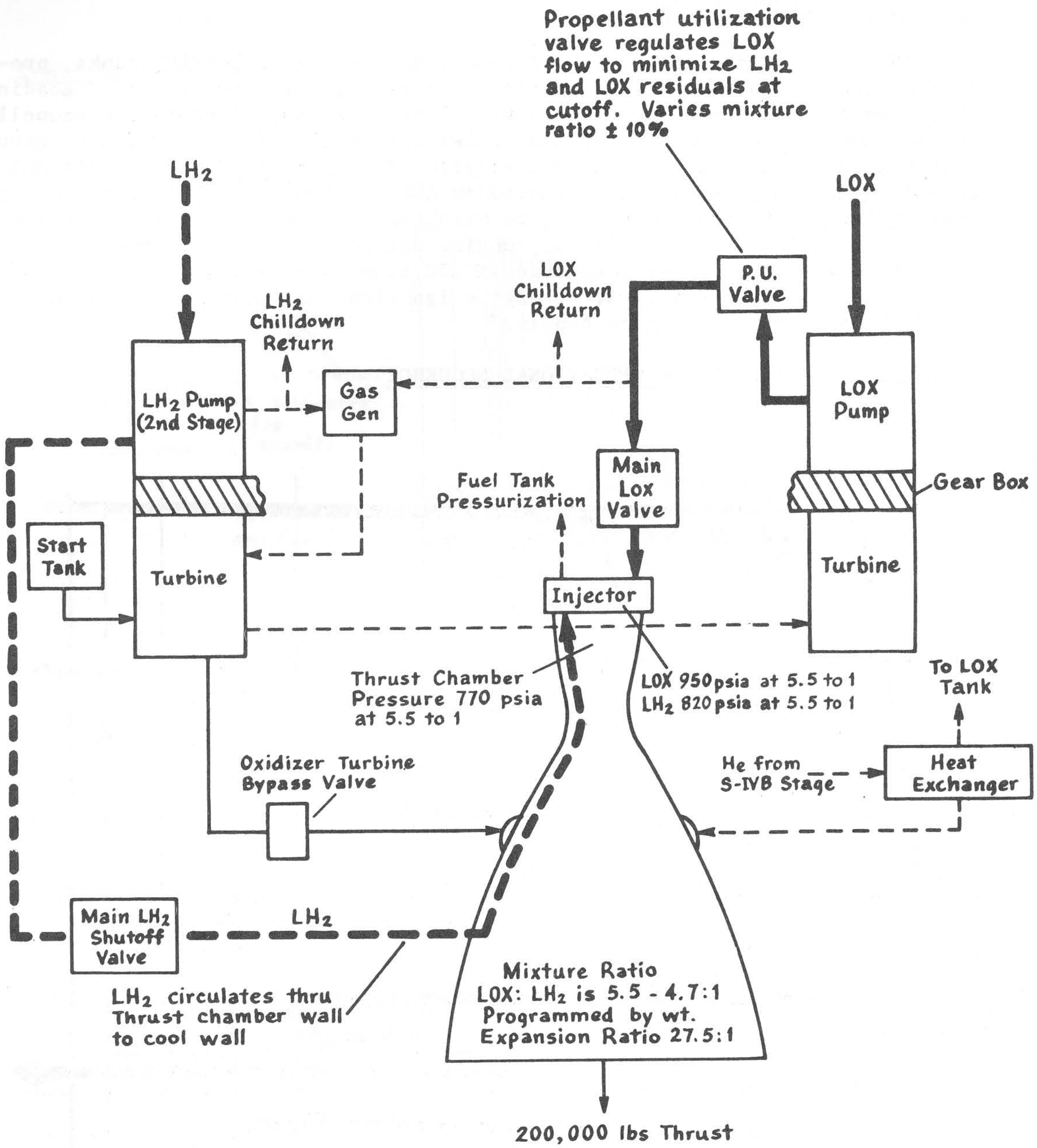


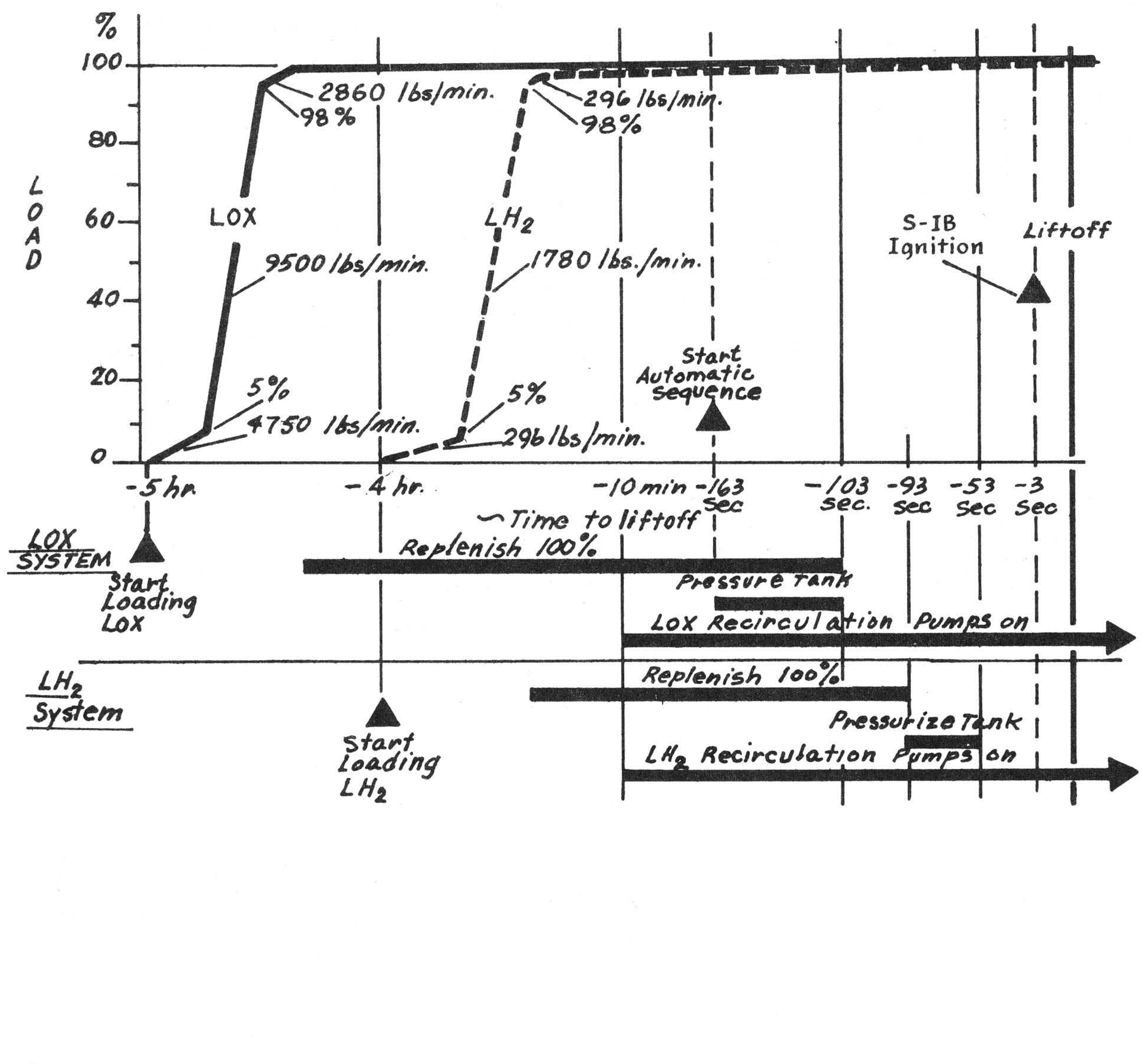
Figure 26

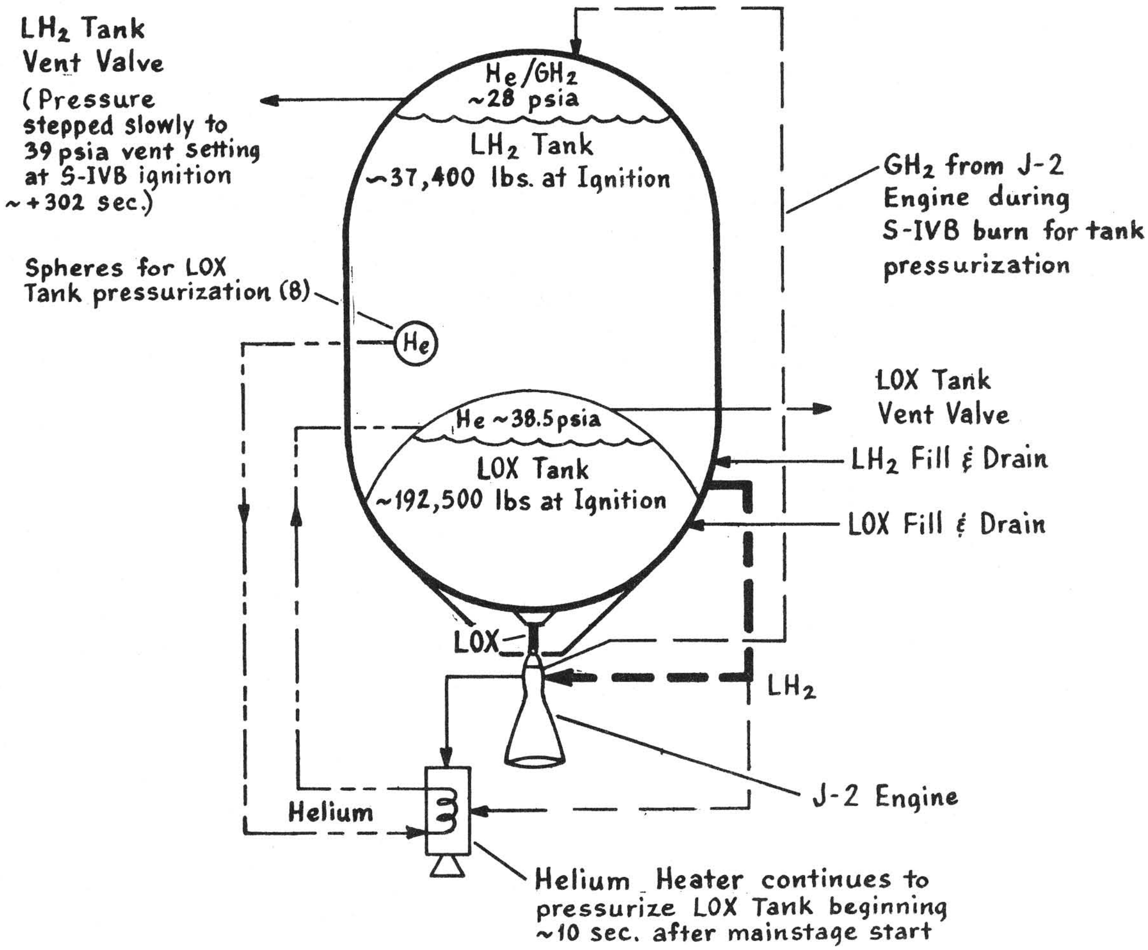
J-2 Engine System

S-IVB STAGE PROPELLANT SYSTEM

The S-IVB propellant system is composed of integral LOX/LH_2 tanks, propellant lines, control valves, vents, and pressurization subsystems. Loading of the propellant tanks and flow of propellants is controlled by the propellant utilization system. Both propellant tanks are initially pressurized by ground source cold helium. LOX tank pressurization during S-IVB Stage burn is maintained by helium supplied from spheres in the LH_2 tank, which is expanded by passing through the helium heater, to maintain positive pressure across the common tank bulkhead and to satisfy engine net positive suction head. The LH_2 pressurization strengthens the stage in addition to satisfying net positive suction head requirements. After engine ignition the pressure is maintained by GH_2 tapped from the engine supply.

S-IVB PROPELLANT LOAD AND OPERATIONAL SEQUENCE





LH$_2$ Tank contains ~1500 lbs at J-2 engine cutoff. LOX remaining at J-2 engine cutoff ~ 3,000 lbs.

Total propellant at liftoff ~230,700 lbs.
Total propellant consumed after liftoff ~226,400 lbs.

Figure 27

S-IVB Stage Propellant System

PROPELLANT UTILIZATION SYSTEM

The propellant utilization (PU) system controls loading and engine mixture ratios (LOX to LH_2) to ensure balanced consumption of LOX and LH_2.

Probes mounted in the LOX and LH_2 containers monitor the mass of the propellants during powered flight. At PU activation (5.0 seconds after J-2 ignition), the probes sense the LOX overload and commands the engine to burn at the high rate engine mixture ratio of 5.5:1. When the high mixture ratio is removed, the PU system will then command the engine to burn the reference mixture ratio of 4.7:1, striving for simultaneous depletion of LOX and LH_2 for maximum stage performance.

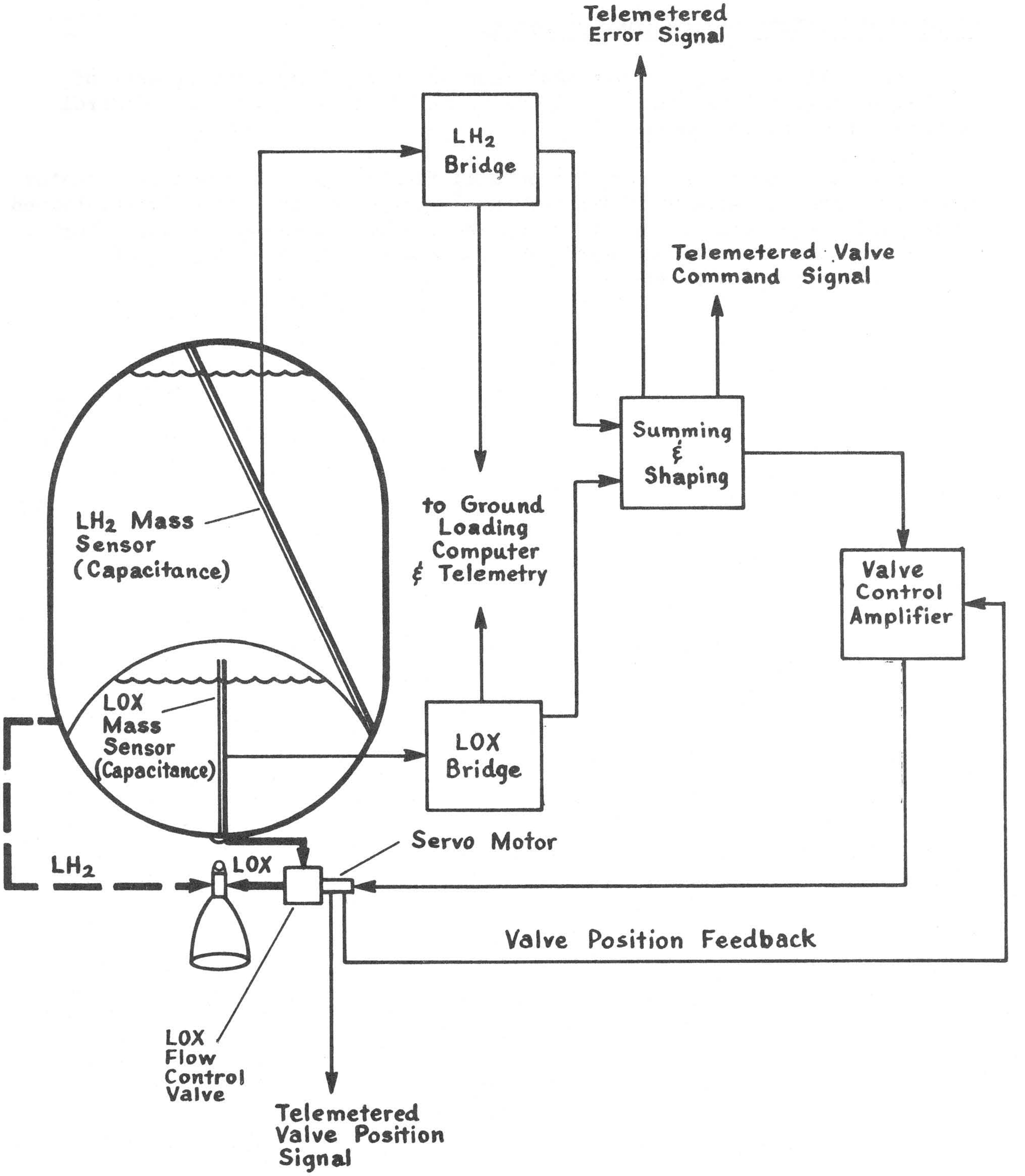


Figure 28

S-IVB Stage Propellant Utilization System

S-IVB STAGE THRUST VECTOR CONTROL SYSTEM

The single J-2 engine is gimbal mounted on the longitudinal axis of the S-IVB Stage. Power for gimballing is supplied by a hydraulic control system mounted on the engine.

Pitch and yaw control, during powered flight, is maintained by actuator control of the engine thrust vector. Roll control of the stage is maintained by properly sequencing the pulse-fired hypergolic propellant thrust motors in the APS. When the stage enters the coast mode, the APS thrust motors control the stage in all three axes.

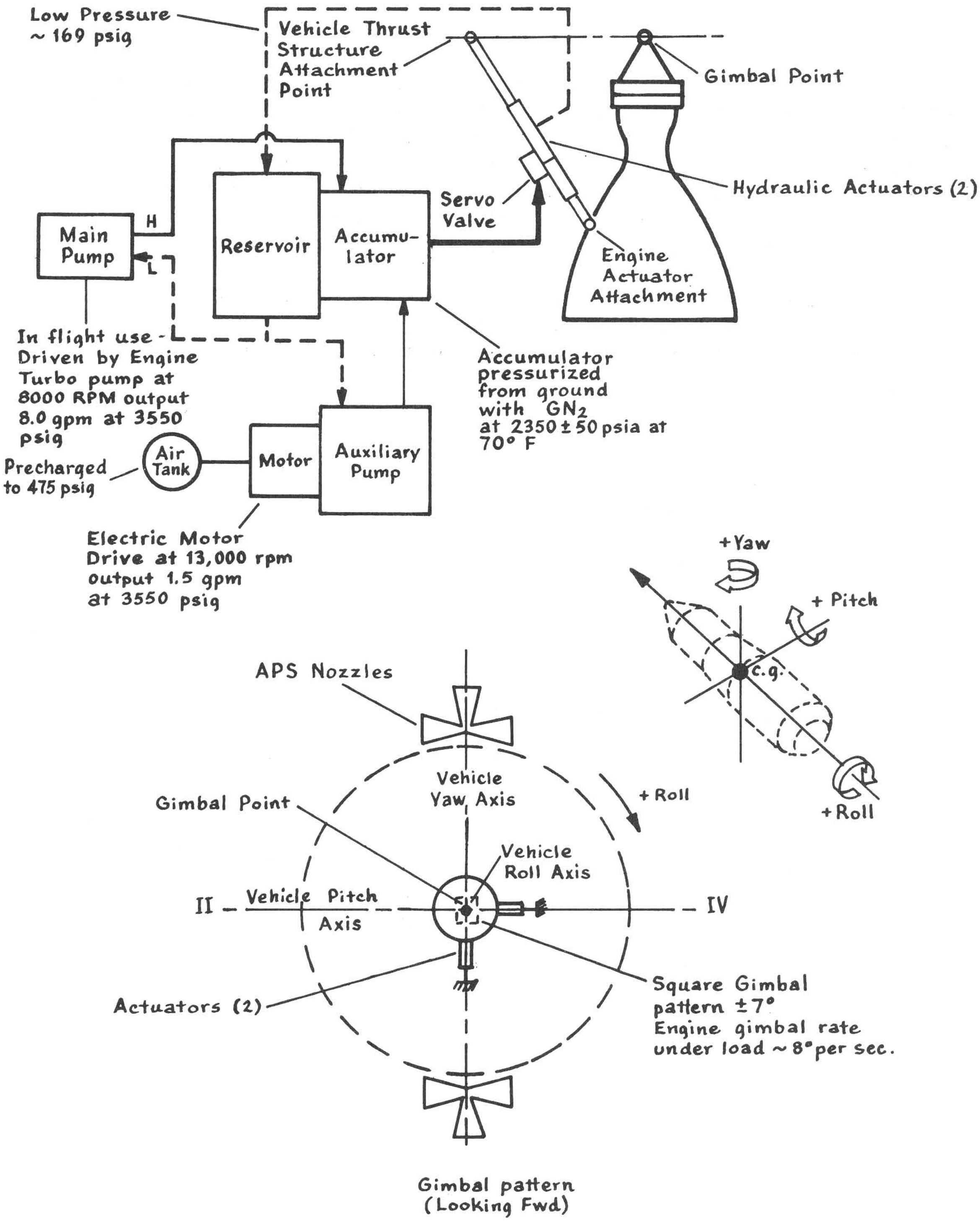


Figure 29

S-IVB Stage Thrust Vector Control System

AUXILIARY PROPULSION SYSTEM

The APS consists of two self-contained attitude control modules mounted 180 degrees apart on the aft skirt of the S-IVB stage. Each attitude control module contains three thrust motors which use hypergolic propellant (nitrogen tetroxide (N_2O_4) and monomethylhydrazine (MMH). The thrust motors are pulse-fired and produce 150 pounds of thrust each. No ignition system is required since the fuel and oxidizer are hypergolic.

The thrust motors provide pitch, yaw, and roll control during the S-IVB coast mode, and roll control during S-IVB powered flight. Pitch and yaw control during powered flight is provided by the J-2 engine system.

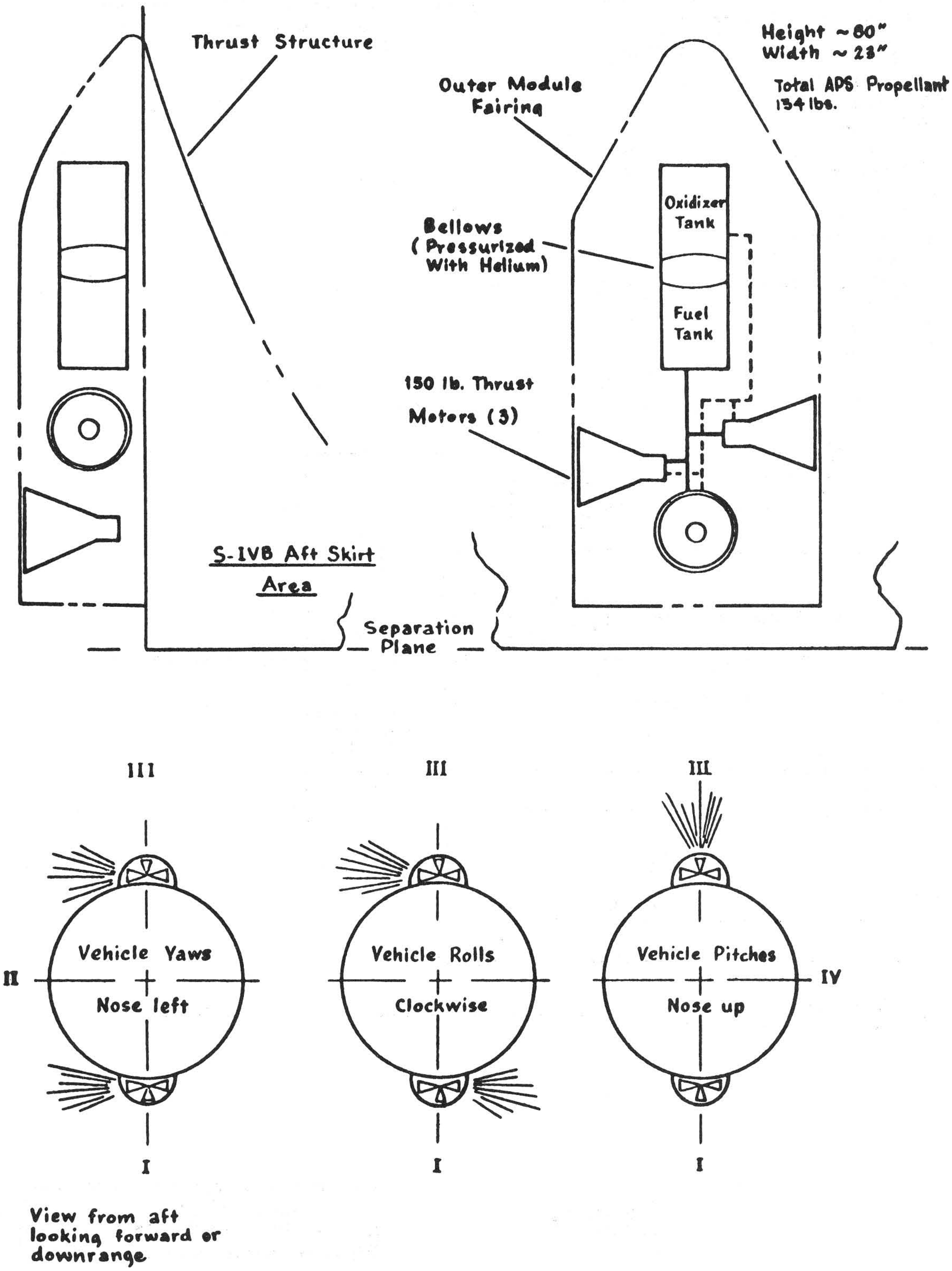


Figure 3.0

Auxiliary Propulsion System

Summary of Measurements	
Inflight	S-IVB-204
1 Acceleration	1
2 Acoustics	6
3 Temperature	145
4 Pressure	130
5 Vibration	30
6 Flow	4
7 Position	8
8 Miscellaneous	30
9 Level	6
10 Voltage, Current, Freq.	45
11 Signal	74
12 Speed	2
13 Strains	32
Total	513
LCC (Blockhouse)	~ 125

Note: There were ~ 590 Inflight and ~151 LCC measurements on S-IVB-203

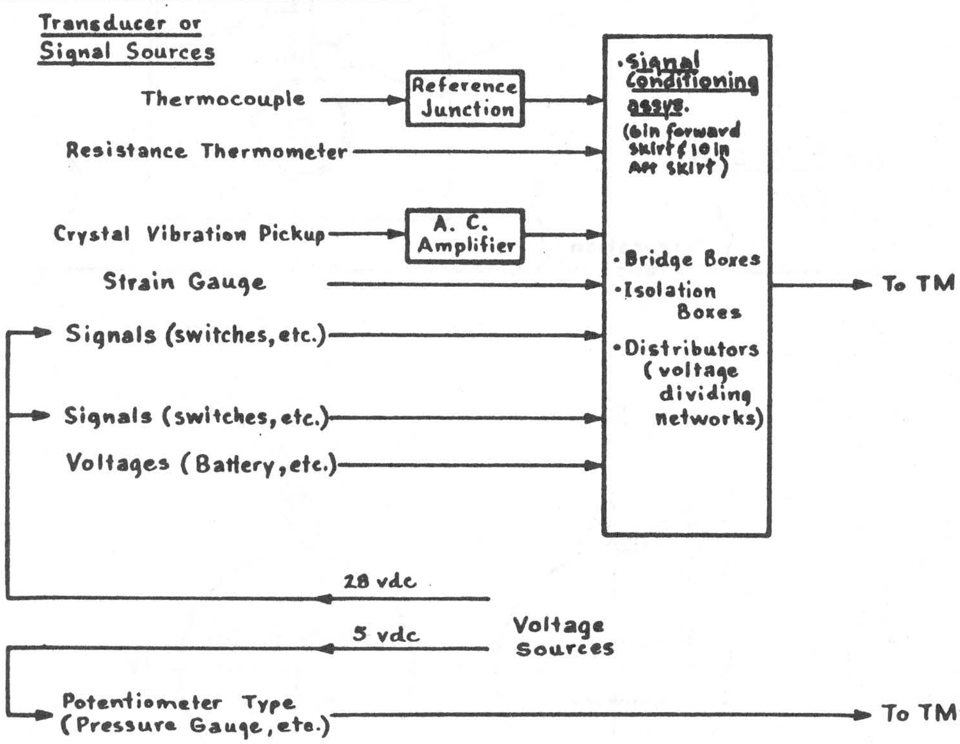


Figure 31

S-IVB Stage Measuring System

Telemetry Measuring Distribution			
System	Data Channels		
	Continuous	Multiplexed	Digital Inputs
F 1	10	200	-
F 2	11	260	-
F 3	8	243	-
P 1	-	95	33
S 1	8	40	-
Totals	37	838	33
Grand Total = 908			

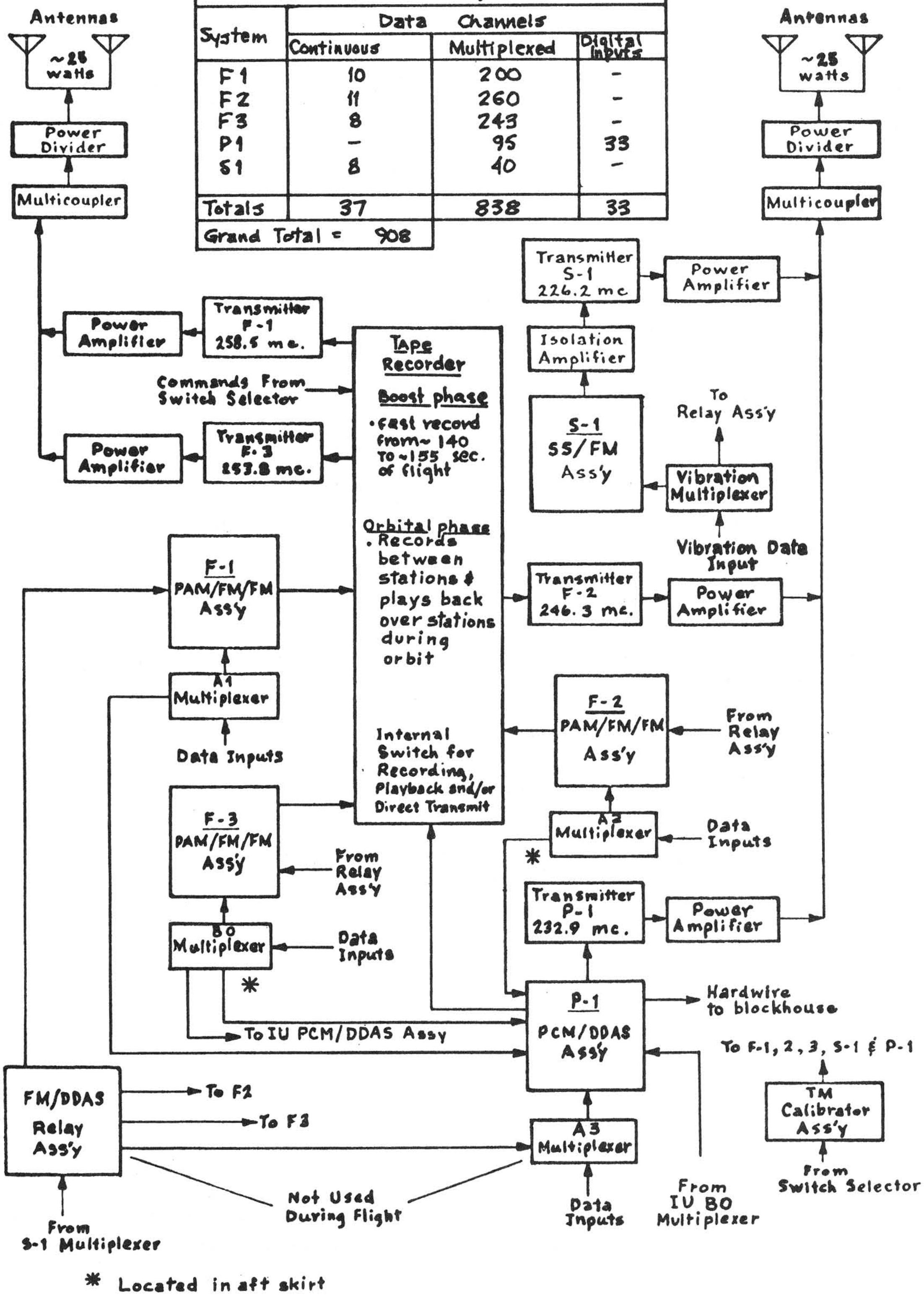


Figure 32

S-IVB Stage telemetry System

Note : Most Forward Interstage Components Are Mounted On Coldplates

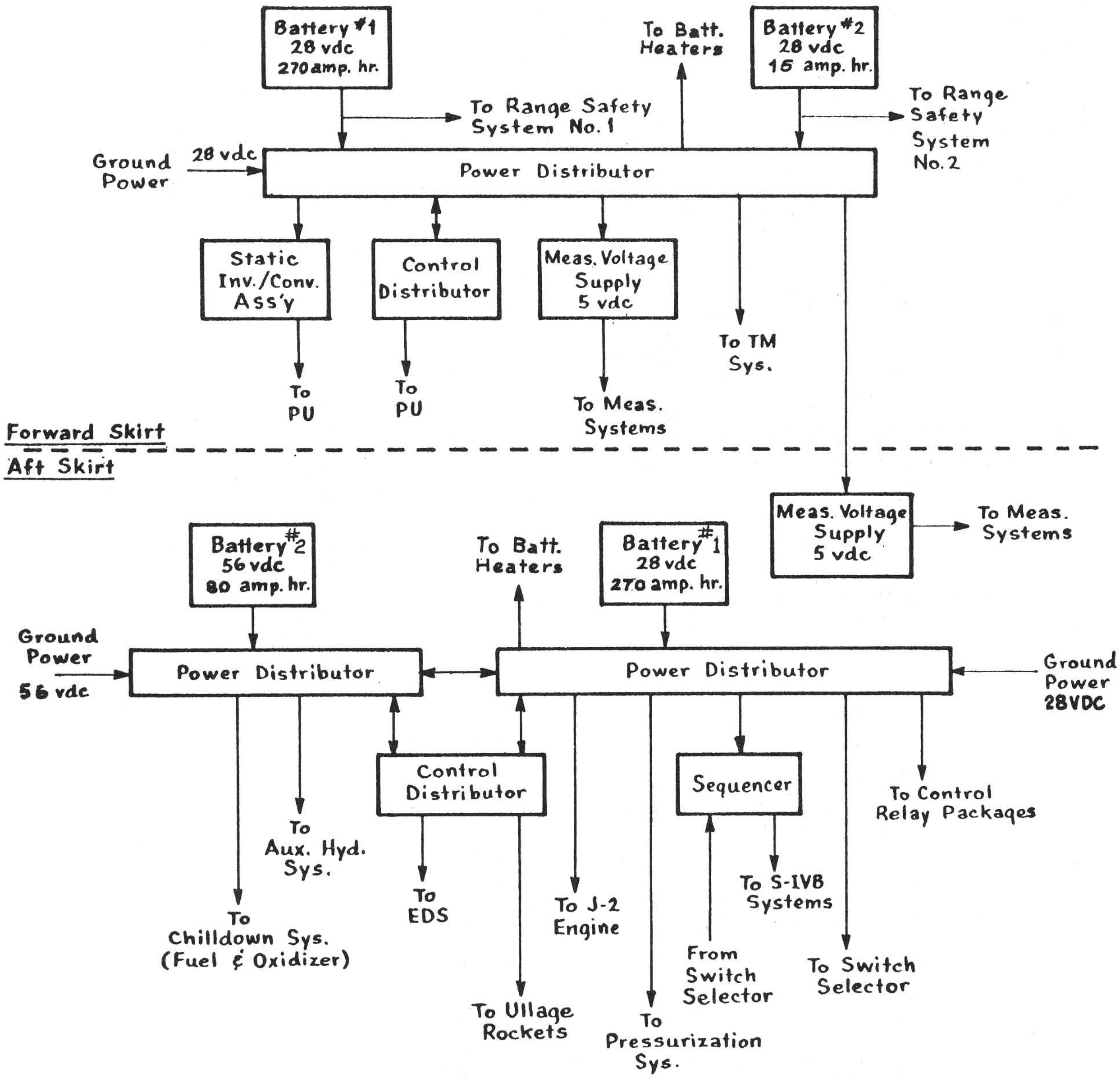


Figure 33

S-IVB Stage Electrical Power and Distribution System

INTENTIONALLY LEFT BLANK

INSTRUMENT UNIT

The IU consists of three arc segments (Nos. 601, 602, and 603), joined with splice plates bolted to the skin and the channel ring segments, to form a single, sandwiched, honeycomb construction 260 inches in diameter and 36 inches high.

Brackets are bonded to the inner skin to provide mounting surface for 16 cold plates which are each 30 inches square.

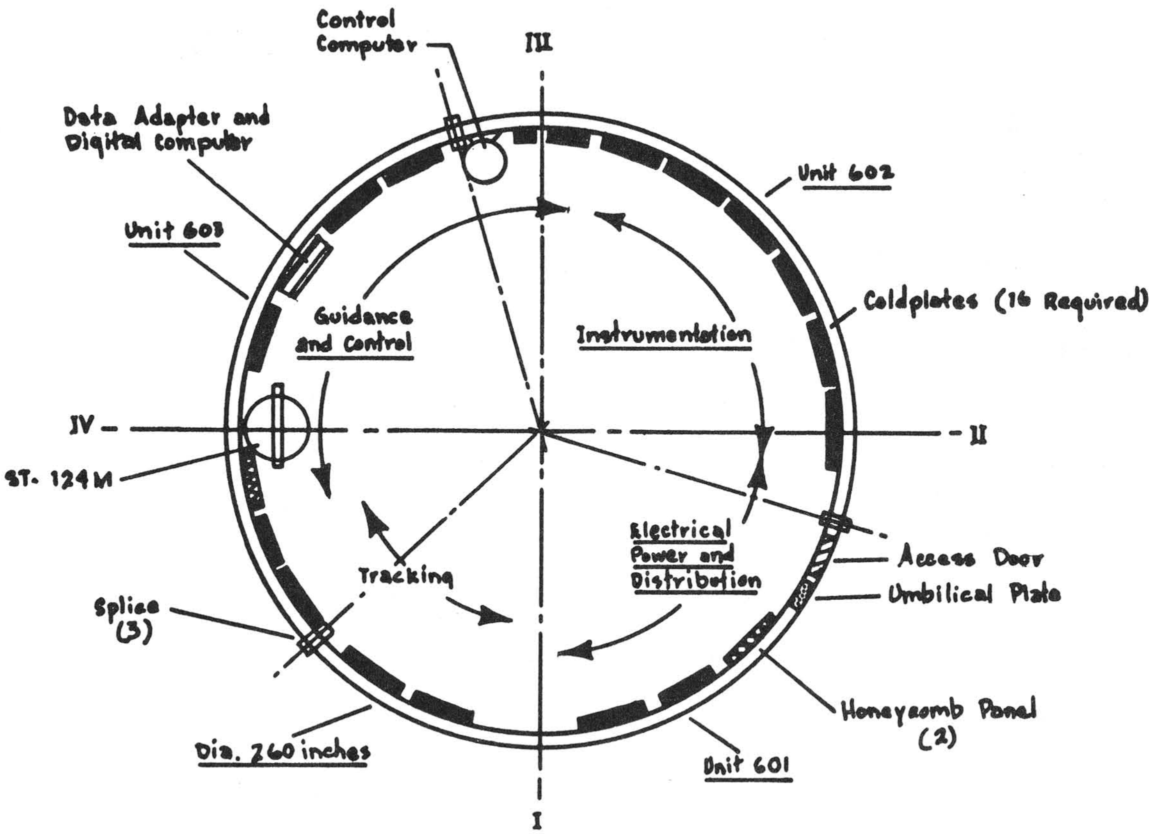
A coolant is circulated through the cold plates to dissipate the heat generated by the electrical components.

This arrangement provides clearance for the Lunar Module landing gear and for the forward bulkhead of the S-IVB hydrogen tank which extends into the IU.

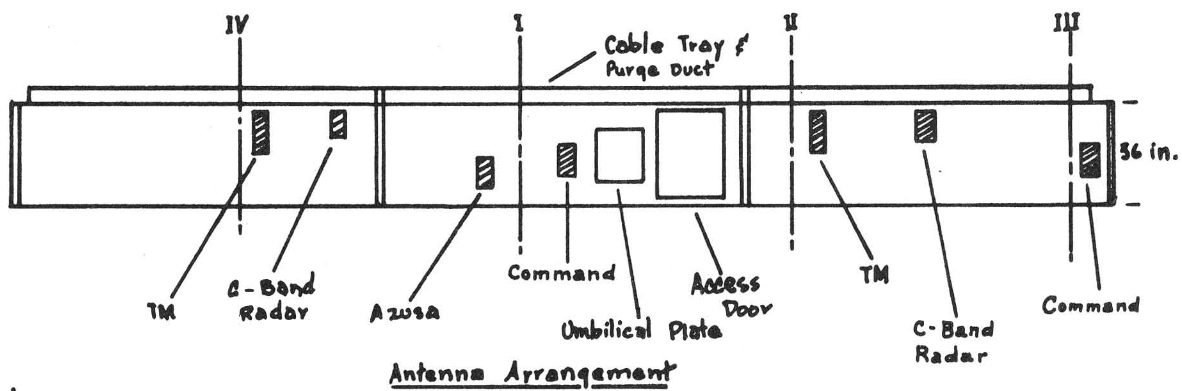
A honeycomb-constructed access door in segment 601 provides access to components within after the IU is assembled as a part of the space vehicle.

In order to maintain a temperature range of 60 to 80 degrees Fahrenheit, a temperature controlled atmosphere is forced into the IU and S-IVB forward skirt prior to launch. As a purging medium, compressed air is used up to thirty minutes prior to propellant loading after which the air is replaced with a nitrogen purge.

The compartment purge will be disconnected at vehicle liftoff by retraction of the IU umbilical service arm.



View Looking Aft.



Antenna Arrangement

Weight

- Dry: ~ 4,600 lbs
- Serviced: ~ 4,600 lbs
- At S-IVB cutoff: ~ 4,600 lbs

Figure 34

Instrument Unit Configuration

Summary of Measurements	
Inflight	**S-IU-204**
1 Acceleration	4
2 Acoustics	1
3 Temperature	67
4 Pressure	10
5 Vibration	23
6 Flow	11
7 Position	13
8 Guidance and Control	46
9 RF and Telemetry	20
10 Voltage, Current, Freq.	24
11 Signal	64
12 Angular Velocity	32
Total	315
LCC (Blockhouse)	~172

Note: There were ~ 362 Inflight and ~ 224 LCC measurements on S-IU-203

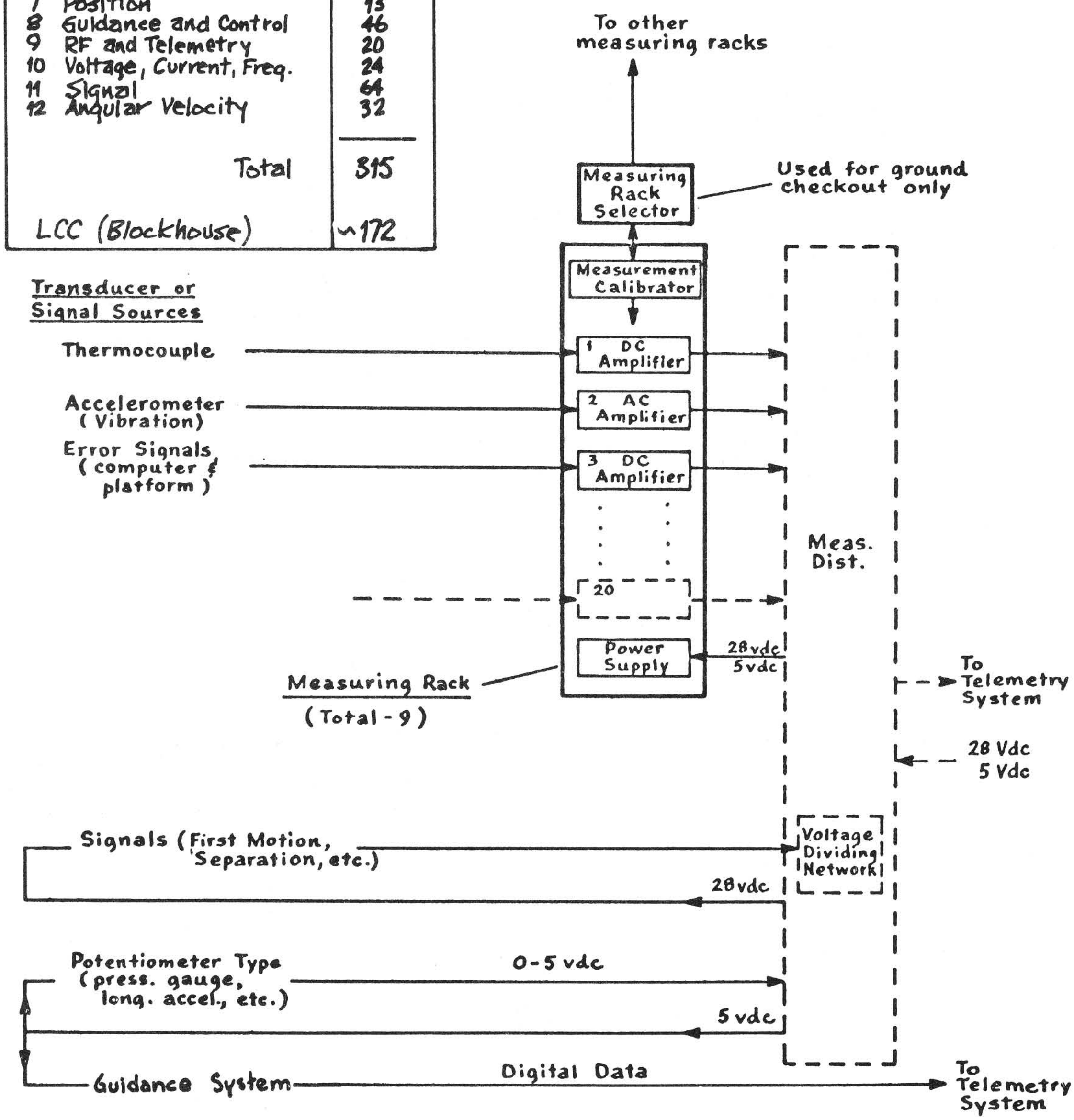


Figure 35

Instrument Unit Measuring System

Telemetry Channel Assignment		
	Data Channels	
System	Continuous	Multiplexed
F 1	9	11
F 2	10	230
P 1	–	200
S 1	6	23
RDSM	–	280
Totals	25	744
Grand Total	769	

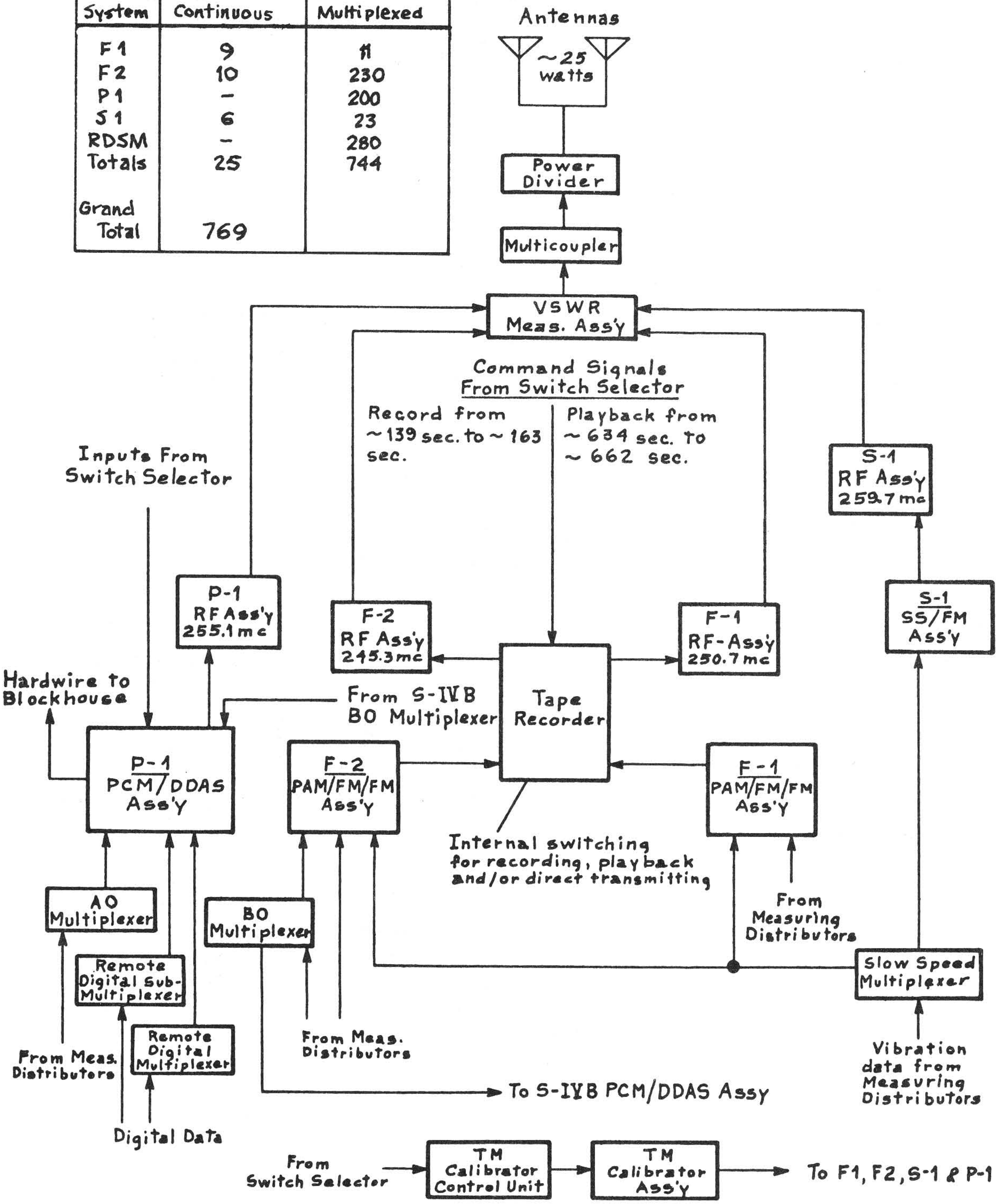


Figure 36

Instrument Unit Telemetry System

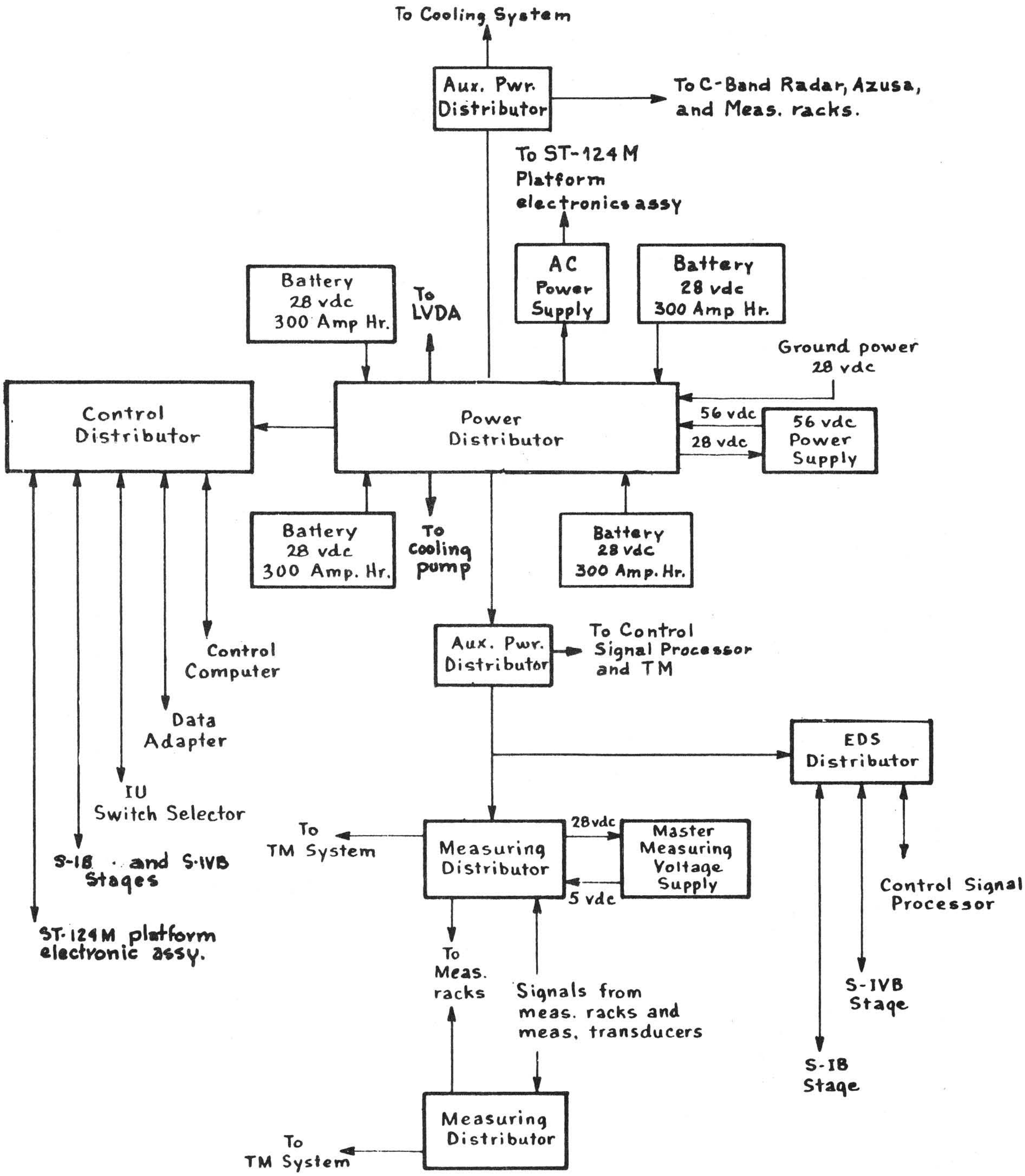


Figure 37

Instrument Unit Electrical Power and Distribution System

ENVIRONMENTAL CONTROL SYSTEM

The Environmental Control System (ECS) controls the thermal environment for the IU and S-IVB electronics equipment and also conditions the GN_2 supplied to the gas bearings of the ST-124 inertial platform.

Main components of the system consist of:

- Coolant Pump
- Inflight Sublimator
- Water Accumulator
- Methanol/Water Reservoir (60% Methanol - 40% Water)
- Cold Plates (16 Required)
- GN_2 Storage Sphere
- Heat Exchanger (Preflight)

Preflight Operation

Coolant Pump begins operation as soon as power is applied to the stage.

Methanol/Water Reservoir provides a constant pressure at pump inlet.

The coolant, circulating through the system, absorbs heat from the ST-124 Platform, the LVDC, the LVDA and from the system cold plates in the IU and S-IVB.

Heat absorbed is transferred to Ground Support Equipment via the preflight heat exchanger.

A temperature sensor (thermistor) monitors the coolant temperature and controls actuation of the flow control valve by signal transmission to the electronic control assembly. This temperature monitor, and ECS action to control coolant flow maintains a coolant temperature of $59 \pm 1°F$.

Inflight Operation

Approximately 3 minutes after liftoff, a signal activates the solenoid control valve permitting water to flow from the water accumulator to the sublimator. The water absorbs heat from the coolant (methanol/water) and the steam from the sublimator is vented overboard.

GN_2 is utilized to pressurize the methanol/water reservoir (15 psia) and the water accumulator (5 psia). Pressure within the reservoir assures that the coolant pump will not cavitate in the space atmosphere.

The water accumulator pressure insure flow from the accumulator to the sublimator.

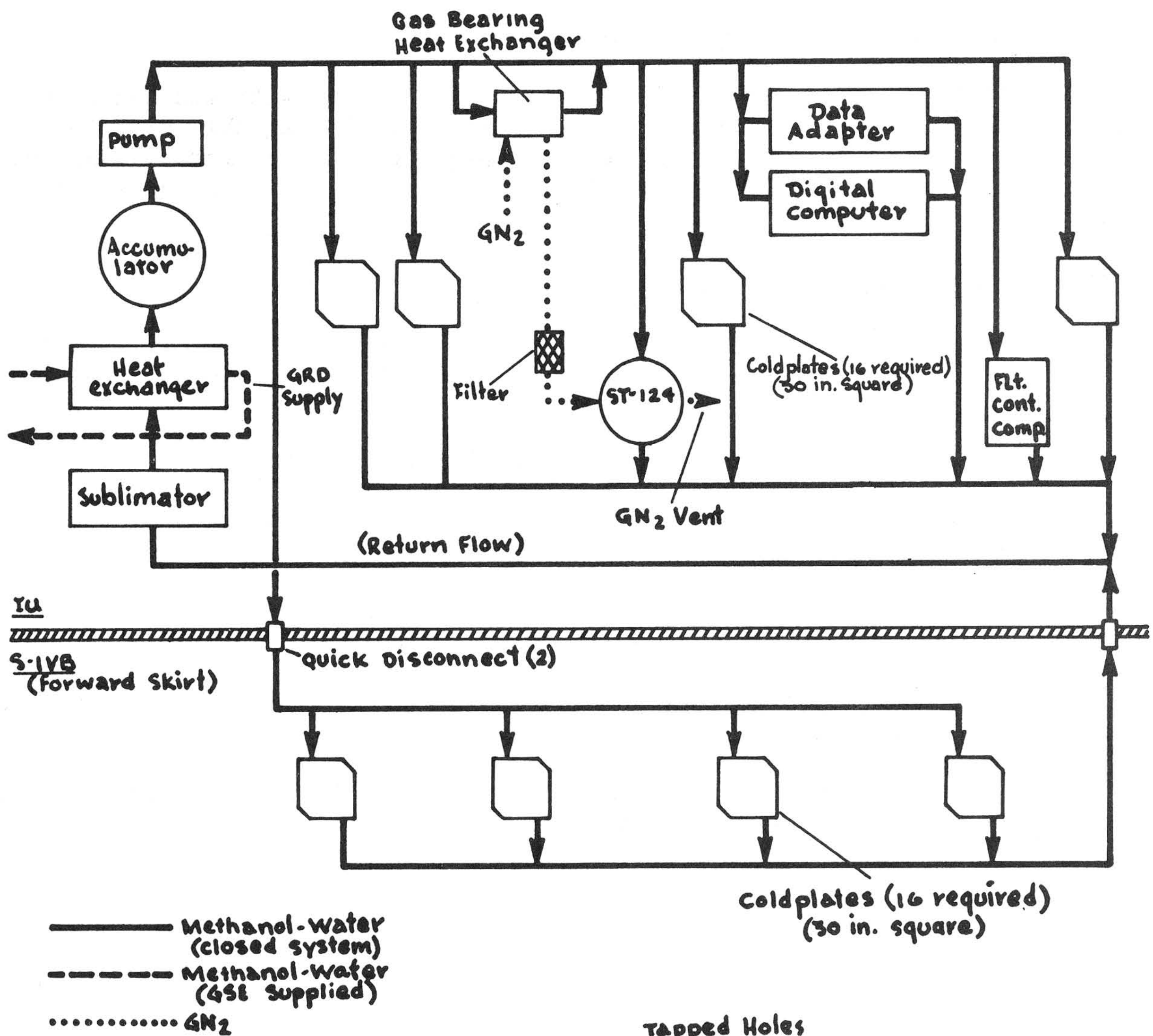
GN_2 Supply

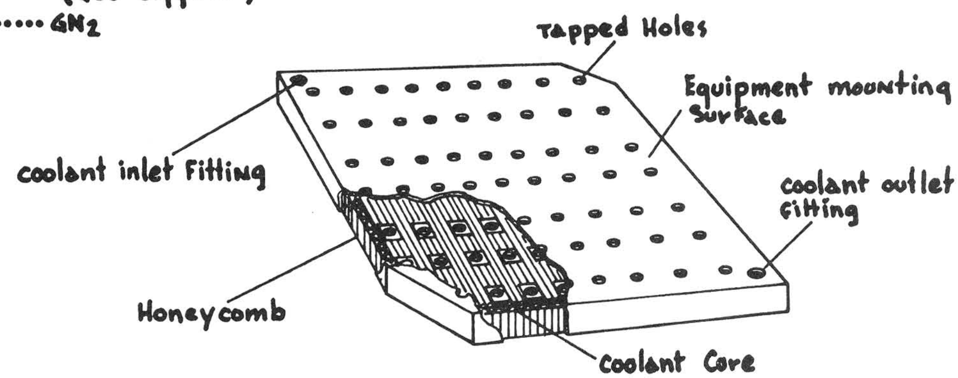
The ECS supplies conditioned GN_2 to the gas bearings of the ST-124 platform during preflight and inflight operations.

GN_2 flows to a heat exchanger where it is conditioned by the methanol/water coolant.

Conditioned GN_2 then flows to the ST-124 platform gas bearings.

A reference pressure line routes gas bearing pressure from the ST-124 platform back to the regulator thus maintaining a constant flow as GN_2 sphere pressure changes.





Typical Coldplate

Figure 38

IU/S-IVB Environmental Control System

SPACECRAFT LUNAR MODULE ADAPTER (SLA)

The SLA is designed to transport the Lunar Module, with landing gear retracted, for approximately 50 minutes after liftoff. At this time the Launch Vehicle assumes an inertial attitude in preparation for separation. At approximately T + 54 minutes, separation of the LM from the S-IVB/IU takes place over carnarvon.

INTERFACE-IU/SPACECRAFT JETTISON CONTROLLER

The Spacecraft Jettison Controller (SJC) is used to separate the nose cone from the SLA, deploy the SLA panels, and to initiate LM/SLA Separation.

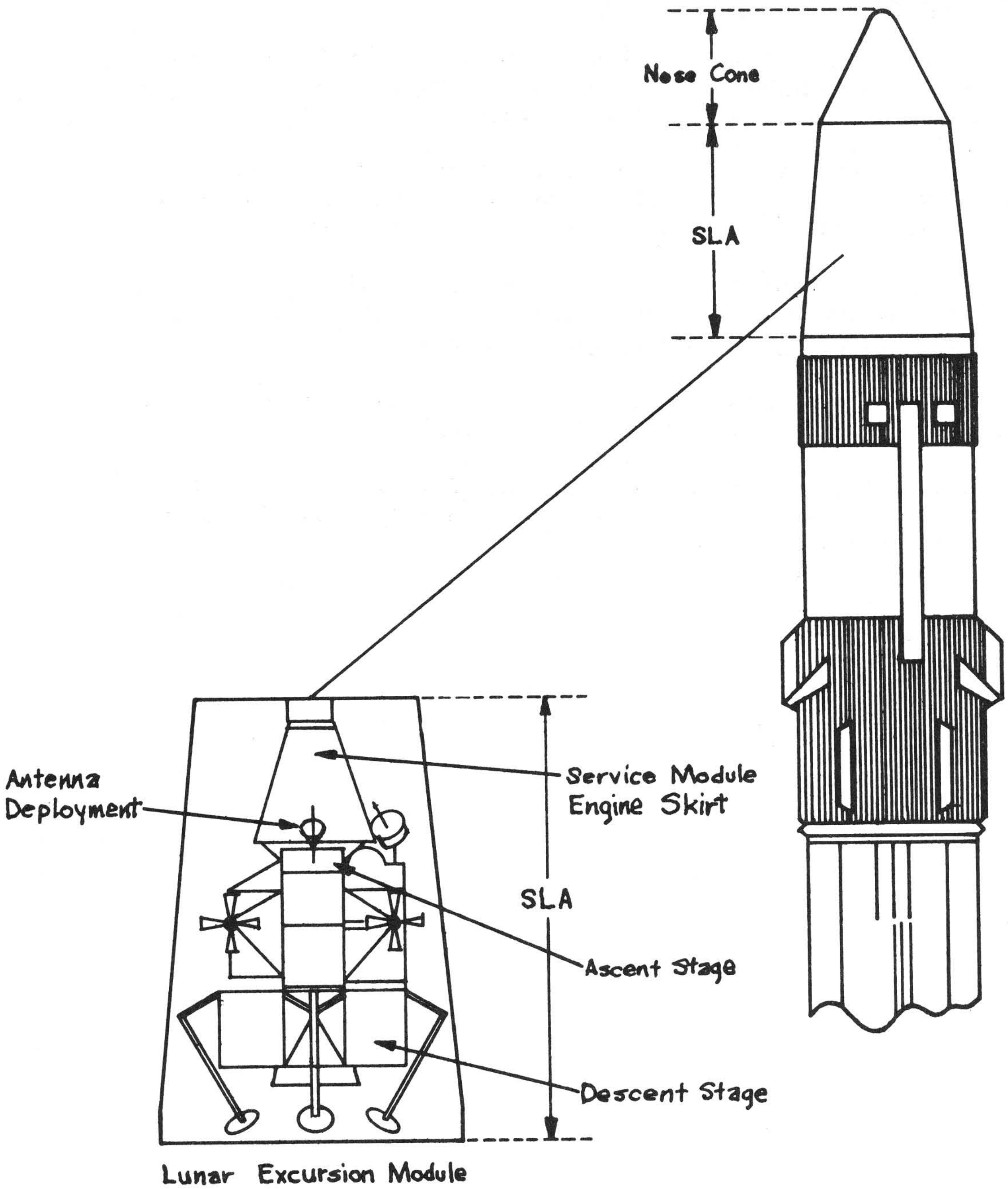
As a programmed function of LVDC, the IU Switch Selector issues two redundant commands to initiate the nose cone SLA Separation Sequence.

This signal is applied through relay logic to redundant pyro initiators which start the nose cone SLA separation sequence.

At a programmed time after nose cone separation, the LVDC issues two redundant Switch Selector Commands to the SJC to deploy SLA panels.

This signal is applied through relay logic to redundant pyro initiators to start the SLA Panel Deploy Sequence.

LM/SLA Separation Sequence is a function of the LM Mission Programmer rather than the IU/LVDC and Switch Selector.



Note: LEM Landing Gear will not be included on AS-204/LM-1 Mission.

Figure 39

Spacecraft Lunar Module Adapter (SLA)

LUNAR MODULE

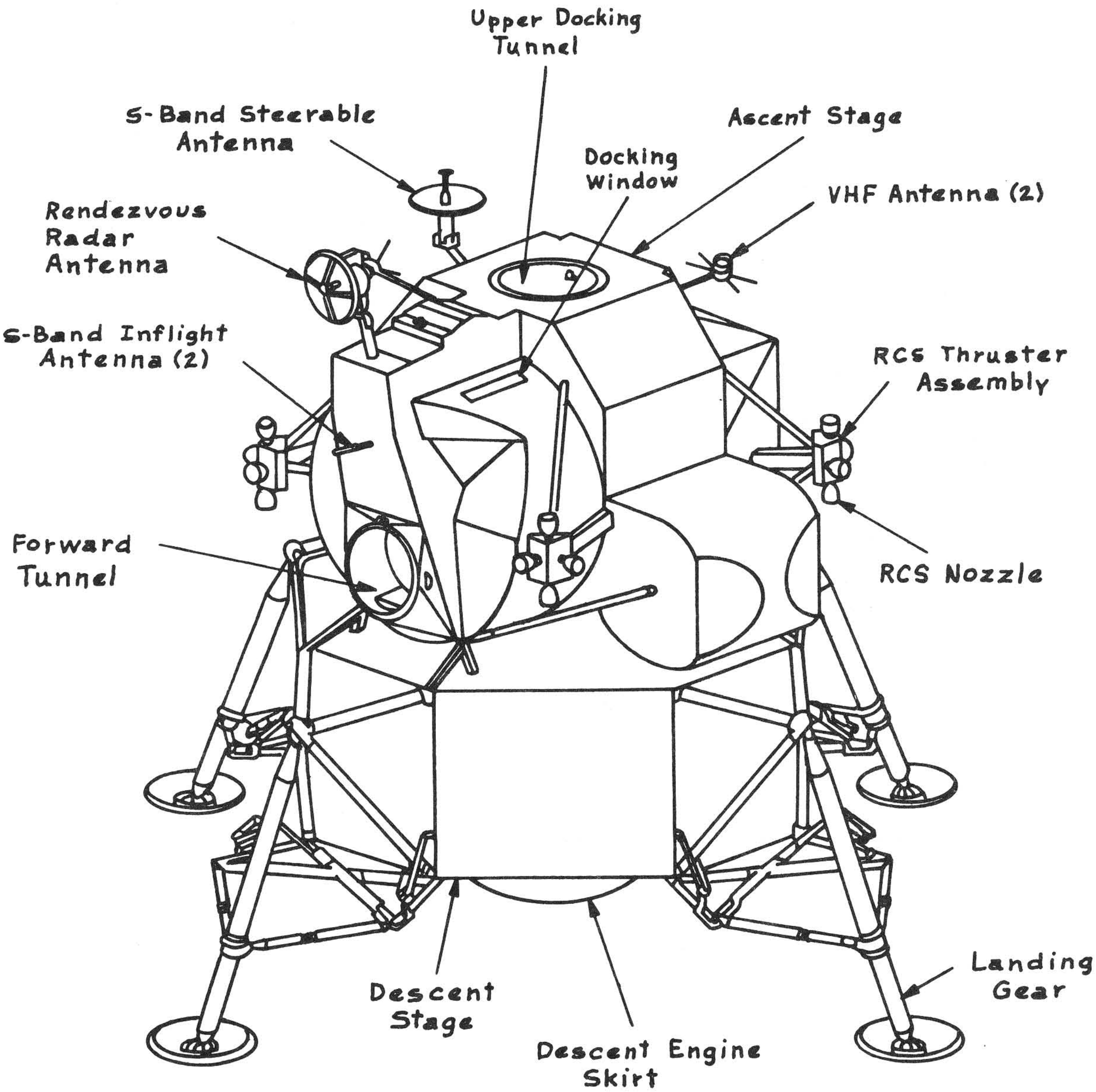
The Lunar Module for mission 204/LM-1 will be an unmanned, remotely controlled version of the same module to be used by the astronauts for their descent to, and return from, the moon.

The LM consists of an ascent stage with a two-man cockpit equipped with most of the instrumentation intended for the actual Lunar mission, plus the Ascent Propulsion System (APS).

The Descent System, with its Descent Propulsion System (DPS), is mounted on four-legged landing gear. It should be noted that LEM landing gear will not be included on this mission.

This landing system may be retracted to permit conveyance of the LM within the Spacecraft/LM Adapter (SLA).

Also included among items to be tested will be the spent S-IVB stage which will be purged and tested in anticipation of its future use as an orbital workshop.



Note: LEM Landing Gear will not be included on AS-204/LM-1 Mission.

Figure 40

Lunar Module

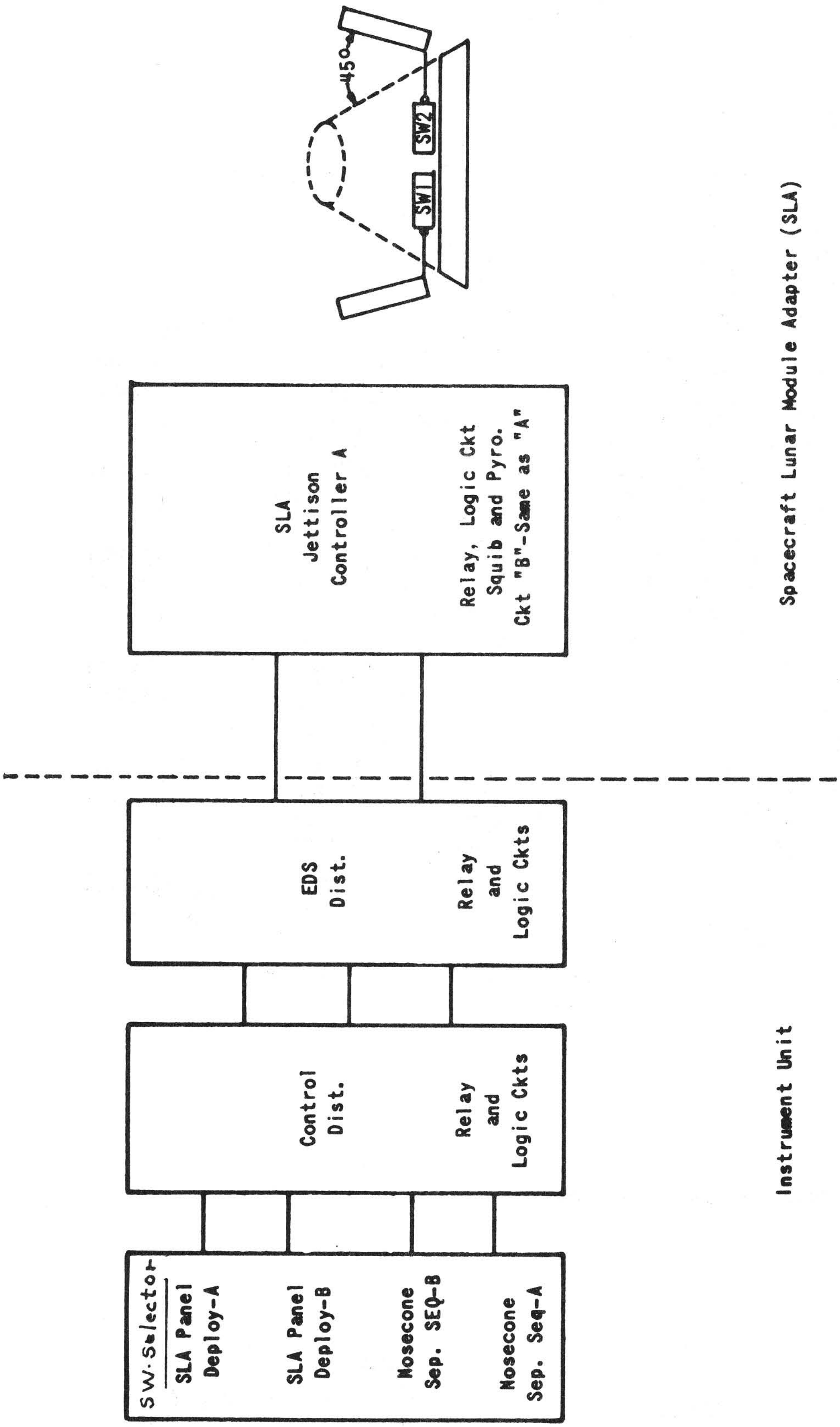


Figure 41

Interface - IU/SLA Jettison Controller

DISTRIBUTION - TECHNICAL INFORMATION SUMMARY

DIR	Dr. von Braun
DIR-T	Dr. Rees
DEP-T	Mr. Neubert
PA	Mr. Jones (2)
I-DIR	Gen. O'Connor Dr. Mrazek Dr. Farish (50)
I-I/IB-MGR	Col. Teir
I-I/IB-E	Mr. Huff (2)
I-I/IB-G	Mr. Dunlap (3)
I-I/IB-T	Mr. Fikes (3)
I-I/IB-SI/IB	Mr. Thompson (3)
I-I/IB-U	Mr. Simmons (3)
I-I/IB-E	Mr. Germany (2)
I-V-MGR	Dr. Rudolph
I-V-E	Mr. Bell (2)
I-K	Mr. Montgomery (10)
I-E-A	Mrs. Watson (25)
I-MO-MGR	Dr. Speer
I-MO-F	Mr. Casey (10)
I-MO-O	Mr. Kurtz (5)
I-MO-OE	Mr. Beutjer (6) Mr. Ladner (5)
I-RL (MSC Liaison)	Mr. Hamilton (200)
I-MICH-MGR	Mr. Stevenson (10)
R-DIR	Mr. Weidner (2)
R-OM	Mr. Fellows (5)
R-TO	Mr. Richard (2)
R-SSL-DIR	Dr. Stuhlinger
R-AERO-F	Mr. Martin (2)
R-AERO-FP	Mr. Fletcher
R-AERO-P	Mr. Teague (60)
R-ASTR	Dist. - E
R-P&VE	Dist. - E
R-ASTR-GS	Mr. Kelley (5)
R-ASTR-NF	Mr. Kalange (8)
R-COMP-RP	Mr. Cochran (6)
R-ME-DIR	Mr. Kuers (10)
R-QUAL-J	Mr. Klauss (10) Mr. Crews
R-TEST-S	Mr. Driscoll (5)
KSC (LVO-5)	Mr. Williams (250)
IBM Dept. M77 3N1 VAB KSC	Mr. P. Grovier (20)
MSFC/DAC Thru R-ASTR-BV/DAC	Mr. French (25)
DAC/H	Mr. P. Thelander (5) Mr. J. Tobias
IBM-H	Mr. C.L. Martin (25) Mr. Robin (10) Mr. Oppenheim (1) Mr. Kinser (2) Mr. H.D. Jensen (2)
CCSD/M	Mr. Juengling (5) Mr. Beverly
MS-IL	Library (2)

Additional copies may be obtained from the following personnel:

R-AERO-P	Mr. R. Teague, 876-4443	Bldg. 4200/408
R-ASTR-S	Mr. F. Hammers, 876-1860	Bldg. 4487/AA-211
R-P&VE-VNC	Mr. O. E. Moon, 876-5585	Bldg 4610/1091