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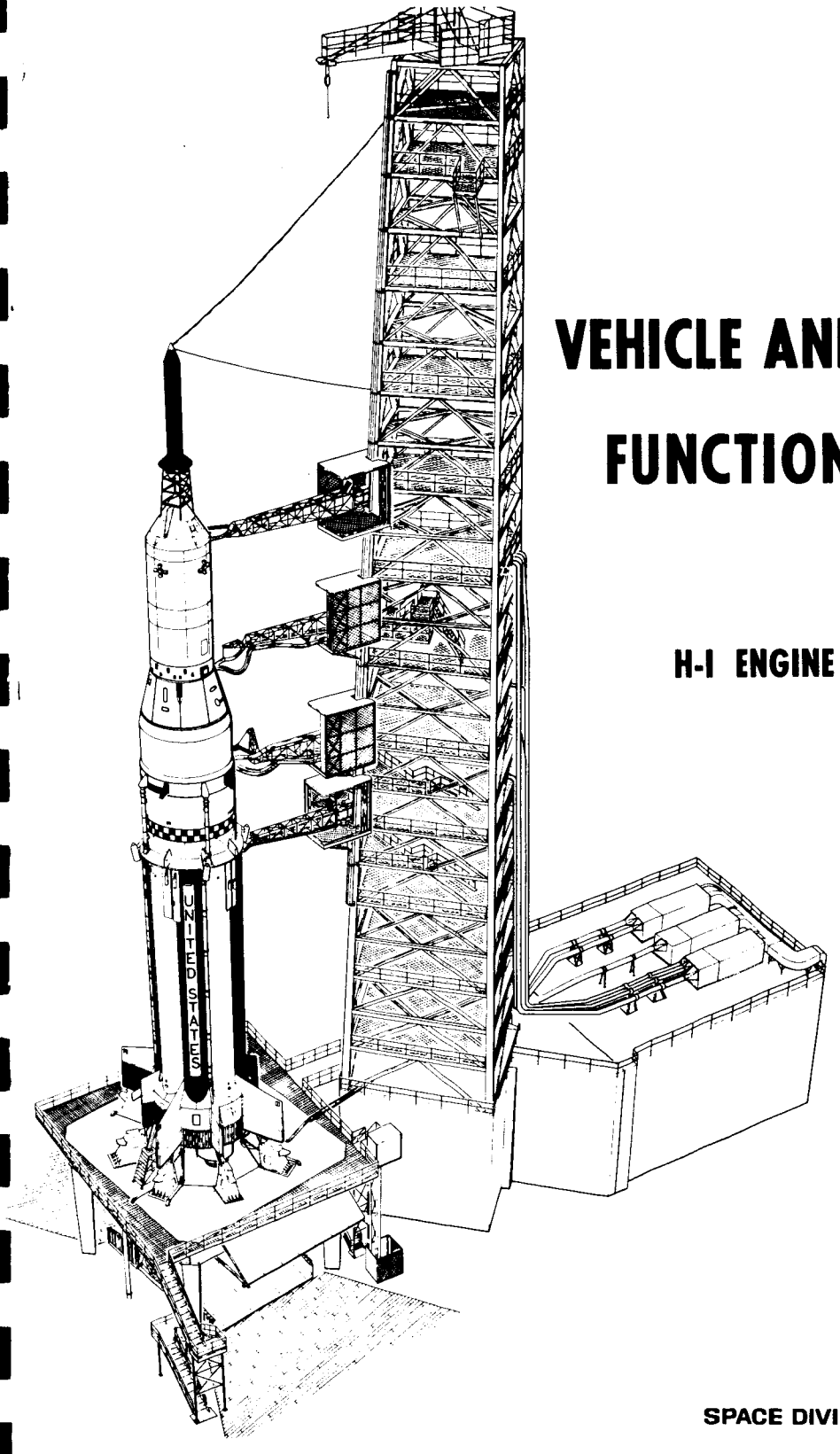

SA-9
VEHICLE AND LAUNCH COMPLEX FUNCTIONAL DESCRIPTION

H-I ENGINE AND HYDRAULIC SYSTEM

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SPACE DIVISION CHRYSLER CORPORATION
HUNTSVILLE OPERATIONS

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HEC-D042
VOLUME VIII

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VEHICLE AND LAUNCH COMPLEX
FUNCTIONAL DESCRIPTION

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FEBRUARY 1964

ENGINEERING COMMUNICATIONS DEPARTMENT

SPACE DIVISION CHRYSLER CORPORATION

HUNTSVILLE OPERATIONS

FOREWORD

This volume has been prepared for the Functional Integration Section, Systems Integration and Operations Branch, Vehicle Systems Division, Propulsion and Vehicle Engineering Laboratory, by Engineering Communications Department, Chrysler Corporation Space Division, under contract number NAS8-4016.

The following series, of which this volume is a part, functionally describes the mechanical and electromechanical systems of Saturn I, SA-9 space vehicle and Launch Complex 37:

Volume I.	RP-1 Fuel System
Volume II.	LOX System
Volume III.	LH_2 System
Volume IV.	Nitrogen and Helium Storage Facility
Volume V.	Pneumatic Distribution System
Volume VI.	Environmental Control System
Volume VII.	Launch Pad Accessories
Volume VIII.	H-1 Engine and Hydraulic System
Volume IX.	RL10A-3 Engine and Hydraulic System
Volume X.	Separation and Flight Termination Systems
Volume XI.	Supplement: Legend and Composite Schematic

Each volume (except Volume XI) contains mechanical schematics and a list of applicable finding numbers.

Volume VIII describes those components that are active during countdown, launch, and flight: it specifically excludes maintenance and checkout procedures. It is intended for use by NASA and prime contractor management and administrative personnel. Only information available by December 5, 1963, has been included.

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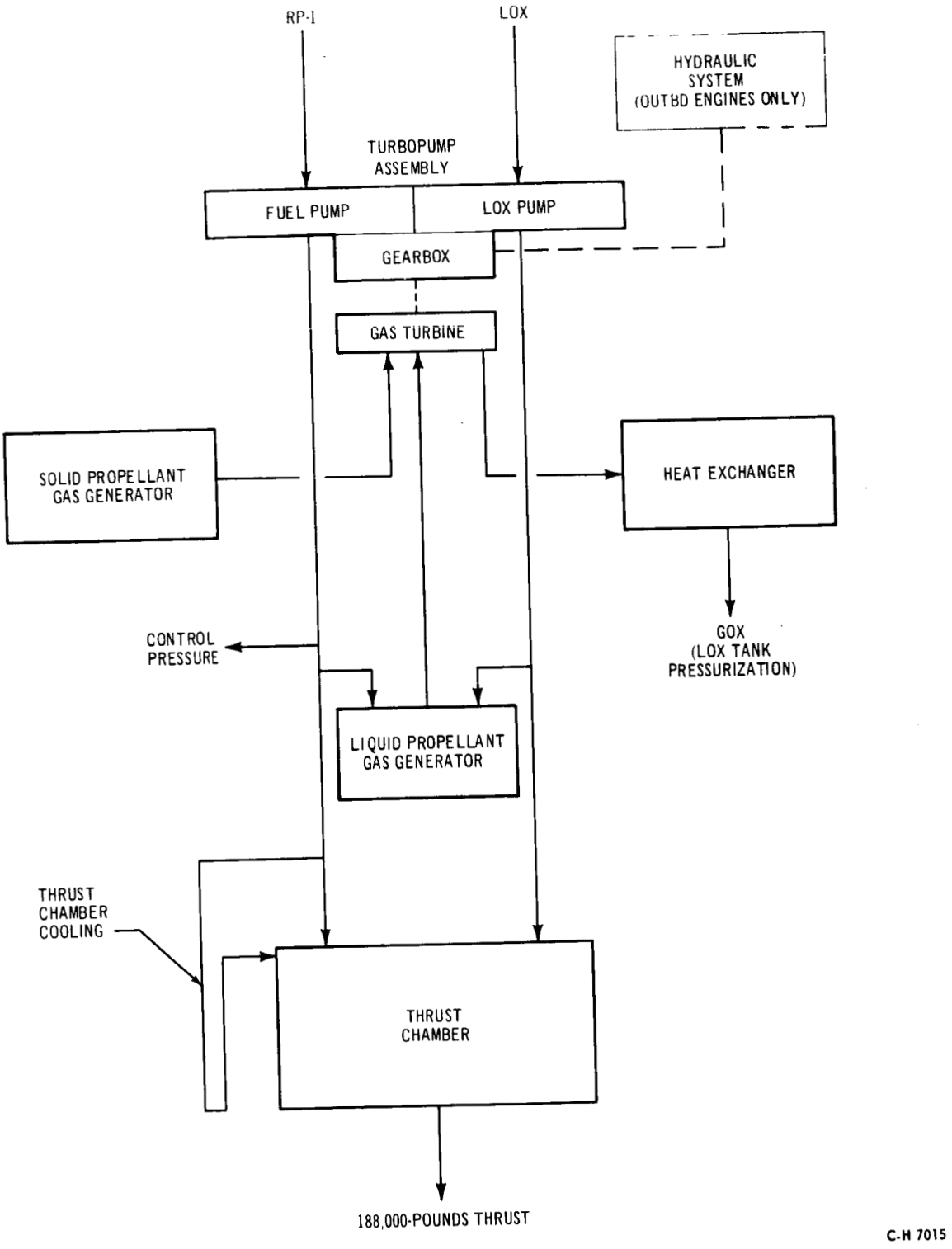

FIGURE 1. H-1 ENGINE BLOCK DIAGRAM

1. ENGINE SYSTEM DESCRIPTION

Eight H-1 engines, using LOX and RP-1 as the propellant, power the S-I stage of SA-9. The H-1 is a single start, fixed thrust engine that develops a nominal sea-level thrust of 188,000 pounds. Four fuel and five LOX containers supply the propellant to the engines through suction lines.

The eight-engine cluster consists of four rigidly mounted inboard engines and four gimbaling outboard engines. Each inboard engine attaches to the thrust structure on a large fin position centerline 32 inches from the vehicle longitudinal axis, canted 3 degrees outward from the vehicle longitudinal axis. Each outboard engine, mounted on a 95-inch radius from the vehicle longitudinal axis 45 degrees from a large fin position centerline, cants at a 6-degree outward angle from the vehicle longitudinal axis. Each outboard engine gimbals ±8 degrees in a square pattern, maintaining the predetermined vehicle trajectory.

The H-1 engines start in pairs 100 milliseconds apart; the inboard engines start first. After approximately 150 seconds of flight, the four inboard engines shut down simultaneously. Approximately six seconds later, the four outboard engines shut down simultaneously.

The engine consists of a turbopump assembly, a liquid propellant gas generator, a solid propellant gas generator, a gas turbine, a thrust chamber, a heat exchanger, valves, purge lines, vents, and drains. In addition, a hydraulic system gimbals each outboard engine. Figure 1 is a block diagram of the system. The schematic on page 25 represents the engine and hydraulic systems.

2. ENGINE SYSTEM OPERATION

2.1. Engine Purges

GN_2 purges, initiated during launch preparations, prevent contaminants from entering the engine.

2.1.1. LOX Pump Seal Purge and Gearbox Pressurization. Both operations, using GN_2 supplied from a common source, commence with control system pressurization prior to propellant loading and continue throughout powered flight. If launch is aborted, the purge is terminated when all LOX has boiled off the turbopump. LOX pump seal purge and gearbox pressurization:

a. Inhibit LOX and lubricant leakage past the turbopump LOX and lubricant seals by applying a positive pressure in the area between these seals.

b. Force any LOX or lubricant that leaks past either seal into the LOX seal drain line or into the lube seal drain line.

c. Improve the lubricant quality at high altitudes by inhibiting turbopump-gearbox lubricant foaming.

GN_2, supplied at 750 psig from Control Pressure Manifold B211 through Manual Valve B214, flows through a ring manifold and into a branch line leading to each engine. Each branch line contains Orifice B305. Downstream from the orifice, a tee divides the line into purge and pressurization lines that lead to the gearbox of Turbopump Assembly B8. GN_2 flows into the LOX and lubrication seal area through the purge line, which contains Orifice B7. Pressurization GN_2 flows into the gearbox through the line that contains Orifice B3 and Check Valve B5. To maintain the desired gearbox pressure, Relief Valve B13 in the lubrication drain manifold cracks at 10 psig.

2.1.2. LOX Dome Purge and Flush. The LOX dome purge has two phases, trickle purge and high-flow-rate purge. The trickle purge provides a slight positive GN_2 pressure in the LOX dome that prevents contaminants from being drawn up through the engine thrust chamber nozzle. The trickle purge, initiated when the thrust chamber covers are removed, continues until just prior to engine ignition, when the second phase starts. The high-flow-rate purge continues during engine operation until it is overcome by main LOX supply line pressure. In case of an abort or other conditions resulting in engine contamination, the LOX dome flush through the LOX dome purge lines begins when pressure decays in the LOX dome. Flushing (with trichloroethylene or oxylene as solvent) is followed by the trickle purge.

Ground-supplied GN_2 flows through Coupling-Half B304 into a ring manifold with separate branch lines that lead to each engine. The branch lines carry GN_2 through Check Valve B45, into the LOX pump discharge line, and into the LOX dome. Because the purge pressure is lower than the cracking pressure of Check Valve B24, no GN_2 flows to Heat Exchanger B30.

2.1.3. Gas Generator LOX Injector Manifold Purge. This purge removes fuel vapor from the LOX injector manifold of the liquid propellant gas generator and prevents solid propellant gas generator combustion products from contaminating the manifold prior to LOX arrival. The purge starts just before engine ignition and terminates when LOX pressure buildup closes Check Valve B12. If a launch is aborted, this purge starts immediately after engine cutoff and continues until spent Solid Propellant Gas Generator B20 is removed.

Ground source GN_2 at 300 psig, supplied through Coupling-Half B301, flows through a ring manifold into eight branch lines, through Check Valve B12 in each line, into the LOX injector manifold, and out the turbine exhaust duct.

2.1.4. Thrust Chamber Fuel Injector Manifold Purge. This purge, initiated just before engine ignition, prevents LOX from entering the fuel injector manifold during engine ignition. The purge is also part of the engine decontamination procedures.

GN_2 from a ground source flows through Coupling-Half B303, into a ring manifold, and to branch lines that lead to the fuel injector manifold on each engine. Two tees and an L-fitting divide the line into three radial lines, each containing Check Valve B37. The GN_2 passes through the check valves, into the injector manifold, and out the thrust chamber. During prelaunch operations, the ground supply shutoff valve terminates the purge. During the engine starting sequence, after the firing command, pressure builds up in the fuel injector manifold and closes the check valves to end the purge.

2.2. Launch Preparations

During launch preparations, several steps must be taken to prepare the H-1 engines for flight. After the vehicle has been erected on the launch pedestal, all explosive devices are installed on the engine. These devices include Solid Propellant Gas Generator B20, Initiator B11, Conax Valve B2, and Hypergol Container B36.

Coupling-Half B17 provides a means of filling Fuel Additive Blender Unit (FABU) B15 with Oronite 262, which, when blended with fuel in the FABU during engine operation, lubricates the gearbox of Turbopump Assembly B8. Coupling-Half B31 permits the fuel jacket of Thrust Chamber B28 to be filled with RP-1.

2.3. Start

Engine start begins with the ignition command and continues until steady-state engine operation has been accomplished. The start sequence begins with ignition of the solid propellant gas generator that drives the turbopump assembly, supplying propellant to the engine thrust chamber where hypergol initiates ignition. Propellant, bled off the main engine supply and burned in the liquid propellant gas generator, provides gas that supplements and finally replaces the action of the solid propellant gas generator.

To avoid undue structural loading, the H-1 engines start in pairs at 100-millisecond intervals, on signals from the ignition sequencer: first, engines 5 and 7 start, then engines 6 and 8, then 2 and 4, and finally 1 and 3. Thrust OK Pressure Switch B41 sends a signal to GSE for liftoff when the fuel supply line pressure reaches 810 psia.

An electrical signal from the start sequencer in the LCC fires Initiators B11. The initiators ignite the propellant in Solid Propellant Gas Generator B20, providing high pressure gas for approximately 200 milliseconds (until the engine reaches steady-state operation). These gases are forced through part of Liquid Propellant Gas Generator B22 to Gas Turbine B19, which accelerates the LOX and fuel pumps through a gear train in Turbopump Assembly B8.

The turbopump draws fuel from the suction line and forces it through Orifice B4 and the fuel discharge line to the inlet side of normally-closed Main Fuel Valve B39. Fuel in the fuel discharge line enters a feeder line that (for valve control, gearbox lubrication, engine ignition, and pump cavitation prevention) branches into the following:

a. A bleed line containing Orifice B48 and leading back to the fuel suction line.

b. Closed Fuel Igniter Valve B46.

c. Closed Main LOX Valve B49 through Orifice B1.

d. Conax Valve B2.

LOX from the pump volute passes into the LOX discharge line and to the inlet side of normally-closed Main LOX Valve B49. A bleed line between the LOX discharge line and the suction line allows some LOX recirculation, preventing pump cavitation.

Turbopump Assembly B8 acceleration increases the pressure in the fuel feeder line. This pressure is applied to Main LOX Valve B49 control through Orifice B1. Spring force in the main LOX valve is overcome when the feeder line fuel pressure reaches approximately 230 psig. The valve begins to open, allowing LOX to flow through the LOX discharge line, LOX dome, and LOX injector nozzles into Thrust Chamber B28. In addition, LOX flows through the LOX bootstrap line containing Orifice B21 to the closed Control Valve Assembly B23.

When the main LOX valve has opened approximately 80 percent, a mechanical linkage opens Fuel Igniter Valve B46, allowing fuel to flow to Hypergol Container B36 and to the inlet port of normally-closed Ignition Monitor Valve B38. Burst diaphragms in the hypergol container rupture when fuel pressure reaches 300 psig, allowing hypergol, followed by fuel, to flow through the fuel injection nozzles into Thrust Chamber B28. The hypergol and fuel ignite on contact with the previously injected LOX, causing primary ignition.

Primary ignition causes pressure buildup within the thrust chamber, the fuel injector manifold, and the control line from the manifold to Ignition Monitor Valve B38 and Control Valve B23. When the fuel injector manifold pressure reaches approximately 15 psig, the ignition monitor valve opens, allowing fuel from Fuel Igniter Valve B46 to exert opening pressure on Main Fuel Valve B39. When fuel pressure overcomes spring force, the main fuel valve opens and fuel flows into the fuel manifold. From the manifold, fuel flows through the thrust chamber fuel jacket, the fuel injector manifold, and into the thrust chamber. Since LOX is already present and ignition has occurred, this fuel will burn, increasing engine thrust.

As fuel flows through the fuel manifold, some fuel flows through Orifice B32 to Gas Generator Control Valve Assembly B23. As thrust buildup continues, combustion chamber pressure is exerted on the control of the gas generator control valve. When this pressure reaches approximately 115 psig, the control valve opens, allowing LOX and fuel to flow into Liquid Propellant Gas Generator B22; they are there ignited by the hot gases of Solid Propellant Gas Generator B20. Two redundant Auto-Igniters B42 provide a secondary ignition source in the liquid propellant gas generator.

Gas Turbine B19 operates on combined high-pressure gases of Solid Propellant Gas Generator B20 and Liquid Propellant Gas Generator B22 for approximately 200 milliseconds (until the solid propellant has burned completely). The liquid propellant gas generator drives the turbine for the remainder of engine operation.

2.4. Steady-State Operation

This phase begins when all engine valves are open and the propellant is burning at the desired rate. Thrust OK Pressure Switch B41 monitors engine thrust by sensing pressure in the fuel line downstream from Main Fuel Valve B39, initiating a signal to GSE before liftoff and a signal to cut off the engine when thrust decays below a set value.

Fuel flows from Turbopump Assembly B8, through Main Fuel Valve B39, and into the thrust chamber fuel manifold that distributes the fuel to the fuel jacket down-tubes extending the entire length of the engine. The fuel flows through these tubes to a collector ring, through the fuel jacket up-tubes, the fuel injector, and into the combustion chamber. This routing cools the thrust chamber walls and increases engine efficiency by heating fuel.

During steady-state operation, LOX is supplied from a branch line downstream from Main LOX Valve B49, through three Orifices B29, to Heat Exchanger B30. This LOX is evaporated and used for LOX container pressurization (described in Volume II).

Fuel for turbopump assembly gearbox lubrication flows from the fuel feeder line through Conax Valve B2 to FABU B15, where it mixes with Oronite. The fuel-oronite mixture flows through a lubrication line containing Filter B14 into the gearbox located in Turbopump Assembly B8, where it cools and lubricates the various components. The fuel-oronite mixture circulates through the gearbox and discharges overboard through the lubrication drain line that contains Relief Valve B13. The relief valve maintains continuous gearbox pressurization, preventing excessive discharge rates at high altitudes.

2.5. Shutdown

Normal engine cutoff is initiated by a signal (described in Volume X) from the guidance computer in the instrument unit. This signal detonates two explosive charges within Conax Valve B2. The explosive force moves a piston that shears a metal diaphragm in the valve body, allowing pressurized fuel to flow to the closing control of Main LOX Valve B49. This pressure counteracts the existing fuel pressure on the opening control of the valve, allowing the internal valve spring to close the valve and thus stop LOX flow to the thrust chamber and liquid propellant gas generator.

When the main LOX valve has closed approximately 20 percent, a mechanical linkage closes Fuel Igniter Valve B46. The pressure that was holding Main Fuel Valve B39 open is then removed, allowing the main fuel valve to close. The flow of fuel to the thrust chamber and the gas generator terminates; however, because fuel shutoff lags LOX shutoff, a fuel-rich cutoff occurs. This

type of cutoff prevents an explosive shutdown in both the thrust chamber and the liquid propellant gas generator.

2.6. Drain

Drain and vent lines on each engine carry away leakage of combustible liquids or gases from individual components.

Three drain lines--a lube, a LOX seal, and a lube seal line--lead from the gearbox of Turbopump Assembly B8. In addition, two lines drain LOX from Main LOX Valve B49; three lines drain fuel from Main Fuel Valve B39; and single lines drain Fuel Igniter Valve B46, Ignition Monitor Valve B38, and Gas Generator Control Valve B23.

The entire engine may be drained of fuel and LOX, when necessary, through Fuel Drain Coupling B18, LOX Volute Drain Cap Assembly B9, Fuel Volute Drain Cap Assembly B10, Fuel Jacket Drain Screws B26, and Fuel Drain Plug B43.

3. HYDRAULIC SYSTEM DESCRIPTION

A hydraulic gimbal control system, part of each outboard engine, provides vehicle guidance. Each independent, closed-loop system consists basically of two hydraulic actuators, a main pump, an auxiliary pump and motor, and an accumulator-reservoir assembly.

4. HYDRAULIC SYSTEM OPERATION

4.1. Fill

Accumulator-Reservoir and Manifold Assembly B86 is charged with GN_2 from a ground source through High Pressure Charging Valve B88 before filling the system with hydraulic fluid. Hydraulic fluid, supplied from a ground source through Coupling-Half B84, is forced through Filter B85, into the accumulator-reservoir, and through the system. Excess hydraulic fluid used in the purging operation returns to the ground source through Coupling-Half B90.

4.2. Prelaunch

Auxiliary Pump B80, driven by electric Motor B81, supplies the necessary hydraulic pressure for engine gimbaling during prelaunch operations. Check Valve B79 protects Main Pump B75 from high pressure fluid during auxiliary pump operation; Check Valve B82 protects the auxiliary pump from high pressure fluid during main pump operation. After all engines have reached steady-state operation, auxiliary pump operation terminates.

Accumulator-Reservoir and Manifold Assembly B86 includes various monitoring devices. Differential Pressure Indicator B78 senses the pressure drop

across Filter B85. If the pressure drop exceeds a predetermined amount, a red button in the indicator extends, providing a visual indication of a clogged filter. Thermal Switch B96 protects electric Motor B81 from overheating by cutting off power to the motor if its temperature rises above a safe level.

The following devices operate both on the ground and throughout powered flight: Thermal Switch B93 transmits a signal if the fluid temperature increases above a predetermined value; Pressure Transducer B92 monitors pressure in the accumulator (high pressure side); and Potentiometer B87 monitors fluid level in the reservoir (low pressure side).

4.3. Flight

Main Pump B75, mounted on an accessory drive pad and driven by the engine turbopump, draws fluid from the low pressure (return) side of Accumulator-Reservoir and Manifold Assembly B86. As turbopump speed increases, fluid pressure increases to approximately 3200 psi, causing hydraulic fluid to flow through Check Valve B79 and Filter B85 into the high pressure side of the accumulator-reservoir. The fluid flows under pressure from the accumulator-reservoir into Servoactuator Assemblies B94 and B95. When the servovalve in each actuator receives a command from the guidance system, it diverts high pressure fluid against one or the other side of the actuator piston, causing extension or retraction of the actuator arms and thus gimbaling the engines. In this way the guidance system controls engine thrust direction. Displaced fluid from the actuators is returned to the low pressure side of the accumulator-reservoir.

Two relief valves protect the system against excessive pressures: High-Pressure Relief Valve B89 protects the accumulator and the high pressure side of the system by venting fluid into the reservoir and low pressure side of the system; Low-Pressure Relief Valve B91 protects the reservoir and low pressure side of the system by venting fluid to atmosphere.

4.4. Drain

The system is drained through Low-Pressure Coupling-Half B90. Drain plugs are provided in Servoactuator Assemblies B94 and B95. The element of Filter B85 can be removed for cleaning. Nitrogen pressure in the accumulator-reservoir assembly can be released through High-Pressure Charging Valve B88. Main Pump B75 and Auxiliary Pump B80 are provided with Seepage Plug Assemblies B76. Case Drain Filter B97 removes contaminants generated by the auxiliary pump before the fluid is returned to the reservoir.

LIST OF FINDING NUMBERS

* FINDING NUMBER	NO. REQD	COMPONENT	REMARKS	VENDOR	DRAWING NUMBER	ELEC SYM
B1	8	Bolt, Restrictor	Orifice	Rocketdyne P/N 307404		
B2-1	1	Valve, Conax		Rocketdyne P/N NA5-26594		1A8
B2-2	1	Valve, Conax		Rocketdyne P/N NA5-26594		2A8
B2-3	1	Valve, Conax		Rocketdyne P/N NA5-26594		3A8
B2-4	1	Valve, Conax		Rocketdyne P/N NA5-26594		4A8
B2-5	1	Valve, Conax		Rocketdyne P/N NA5-26594		5A8
B2-6	1	Valve, Conax		Rocketdyne P/N NA5-26594		6A8
B2-7	1	Valve, Conax		Rocketdyne P/N NA5-26594		7A8
B2-8	1	Valve, Conax		Rocketdyne P/N NA5-26594		8A8
B3	8	Orifice		Rocketdyne P/N DO4-1.2		
B4	8	Orifice		Rocketdyne P/N RD-251-4013		
B5-1 through B5-4	4	Valve, Check		Rocketdyne P/N NA5-26260-1B		

*Location: A=Ground; B=S-I Stage; C=S-IV Stage; G=Instrument Unit; H=Payload.

FINDING NUMBER	NO. REQD	COMPONENT	REMARKS	VENDOR	DRAWING NUMBER	ELEC SYM
B5-5 through B5-8	4	Valve, Check		Rocketdyne P/N NA5-28049-1A		
B6						
B7	8	Orifice		Rocketdyne P/N DO4-1.2		
B8-1	1	Turbopump Assembly		Rocketdyne P/N 456405-31		1A1
B8-2	1	Turbopump Assembly		Rocketdyne P/N 458412		2A1
B8-3	1	Turbopump Assembly		Rocketdyne P/N 456405-31		3A1
B8-4	1	Turbopump Assembly		Rocketdyne P/N 456405-31		4A1
B8-5	1	Turbopump Assembly		Rocketdyne P/N 456405-11		5A1
B8-6	1	Turbopump Assembly		Rocketdyne P/N 456405-11		6A1
B8-7	1	Turbopump Assembly		Rocketdyne P/N 456405-11		7A1
B8-8	1	Turbopump Assembly		Rocketdyne P/N 456405-11		8A1
B9	8	Drain Cap Assembly (LOX Volute)		AN929A3C		

FINDING NUMBER	NO. REQD	COMPONENT	REMARKS	VENDOR	DRAWING NUMBER	ELEC SYM
B10	8	Drain Cap Assembly, (Fuel Volute)		AN929A3C		
B11	16	Initiator		Rocketdyne P/N NA5-26737		
B12-1 through B12-4	4	Valve, Check		Rocketdyne P/N NA5-26051		
B12-5 through B12-8	4	Valve, Check		Rocketdyne P/N NA5-28051		
B13	8	Valve, Relief		Rocketdyne P/N 456419		
B14	8	Filter		Rocketdyne P/N NA5-26723-1A		
B15-1	1	Blender-Unit, Fuel-Additive		Rocketdyne P/N 454075-11		1A3
B15-2	1	Blender-Unit, Fuel-Additive		Rocketdyne P/N 454075-11		2A3
B15-3	1	Blender-Unit, Fuel-Additive		Rocketdyne P/N 454075-11		3A3
B15-4	1	Blender-Unit, Fuel-Additive		Rocketdyne P/N 454075-11		4A3
B15-5	1	Blender-Unit, Fuel-Additive		Rocketdyne P/N 454075-11		5A3
B15-6	1	Blender-Unit, Fuel-Additive		Rocketdyne P/N 454075-11		6A3

FINDING NUMBER	NO. REQD	COMPONENT	REMARKS	VENDOR	DRAWING NUMBER	ELEC SYM
B15-7	1	Blender-Unit, Fuel-Additive		Rocketdyne P/N 454075-11		7A3
B15-8	1	Blender-Unit, Fuel-Additive		Rocketdyne P/N 454075-11		8A3
B16						
B17	8	Coupling-Half		Rocketdyne P/N 340234-4		
B18	8	Coupling-Half (Fuel Drain)		Rocketdyne P/N 340234-8		
B19	8	Gas-Turbine		Rocketdyne P/N 454204		
B20-1	1	Gas-Generator, Solid-Propellant		Rocketdyne P/N 651240-41		1A6
B20-2	1	Gas-Generator, Solid-Propellant		Rocketdyne P/N 651240-41		2A6
B20-3	1	Gas-Generator, Solid-Propellant		Rocketdyne P/N 651240-41		3A6
B20-4	1	Gas-Generator, Solid-Propellant		Rocketdyne P/N 651240-41		4A6
B20-5	1	Gas-Generator, Solid-Propellant		Rocketdyne P/N 651240-41		5A6
B20-6	1	Gas-Generator, Solid-Propellant		Rocketdyne P/N 651240-41		6A6

FINDING NUMBER	NO. REQD	COMPONENT	REMARKS	VENDOR	DRAWING NUMBER	ELEC SYM
B20-7	1	Gas-Generator, Solid-Propellant		Rocketdyne P/N 651240-41		7A6
B20-8	1	Gas-Generator, Solid-Propellant		Rocketdyne P/N 651240-41		8A6
B21	8	Orifice		Rocketdyne P/N RD-251-4012		
B22-1 through B22-4	4	Gas-Generator Combustor Assembly	Liquid Propellant Gas Generator	Rocketdyne P/N 307269-31		
B22-5 through B22-8	4	Gas-Generator Combustor Assembly	Liquid Propellant Gas Generator	Rocketdyne P/N 307269-21		
B23-1	1	Valve, Control	Gas Generator Control Valve	Rocketdyne P/N 303600		
B23-2	1	Valve, Control	Gas Generator Control Valve	Rocketdyne P/N 302600		
B23-3 through B23-8	6	Valve, Control	Gas Generator Control Valve	Rocketdyne P/N 303600		
B24-1 through B24-4	4	Valve, Check		Rocketdyne P/N NA5-20032-T2		
B24-5 through B24-8	4	Valve, Check		Rocketdyne P/N NA5-26032-T2		
B25						
B26	32	Screw	Fuel Jacket Drain Screw	AN501A10-4		

FINDING NUMBER	NO. REQD	COMPONENT	REMARKS	VENDOR	DRAWING NUMBER	ELEC SYM
B27	4	Aspirator		Rocketdyne P/N 204600		
B28-1	1	Thrust-Chamber		Rocketdyne P/N 205198		
B28-2	1	Thrust-Chamber		Rocketdyne P/N 204598		
B28-3	1	Thrust-Chamber		Rocketdyne P/N 205198		
B28-4	1	Thrust-Chamber		Rocketdyne P/N 205198		
B28-5 through B28-8	4	Thrust-Chamber		Rocketdyne P/N 206076		
B29	24	Orifice		Rocketdyne P/N 303384		
B30-1	1	Heat Exchanger Assembly		Rocketdyne P/N 303351		
B30-2	1	Heat Exchanger Assembly			60C27611-1	
B30-3	1	Heat Exchanger Assembly		Rocketdyne P/N 303351		
B30-4	1	Heat Exchanger Assembly		Rocketdyne P/N 303351		
B30-5 through B30-8	4	Heat Exchanger Assembly			60C27611-1	

FINDING NUMBER	NO. REQD	COMPONENT	REMARKS	VENDOR	DRAWING NUMBER	ELEC SYM
B31	8	Coupling-Half		Rocketdyne P/N 340234-8		
B32	8	Orifice		Rocketdyne P/N RD-251-4005		
B33 through B35 are not functionally applicable to this system.						
B36-1	1	Hypergol Container Assembly		Rocketdyne P/N 201967		1A7
B36-2	1	Hypergol Container Assembly		Rocketdyne P/N 201967		2A7
B36-3	1	Hypergol Container Assembly		Rocketdyne P/N 201967		3A7
B36-4	1	Hypergol Container Assembly		Rocketdyne P/N 201967		4A7
B36-5	1	Hypergol Container Assembly		Rocketdyne P/N 201967		5A7
B36-6	1	Hypergol Container Assembly		Rocketdyne P/N 201967		6A7
B36-7	1	Hypergol Container Assembly		Rocketdyne P/N 201967		7A7
B36-8	1	Hypergol Container Assembly		Rocketdyne P/N 201967		8A7
B37-1 through B37-4	12	Valve, Check		Rocketdyne P/N NA5-28049-1B		

FINDING NUMBER	NO. REQD	COMPONENT	REMARKS	VENDOR	DRAWING NUMBER	ELEC SYM
B37-5 through B37-8	12	Valve, Check		Rocketdyne P/N NA5-28049-1A		
B38	8	Valve, Pneumatic	Ignition Monitor Valve Normally Closed (NC)	Rocketdyne P/N 554838		
B39-1	1	Valve, Butterfly	Main Fuel Valve NC	Rocketdyne P/N 405444		1A19
B39-2	1	Valve, Butterfly	Main Fuel Valve NC	Rocketdyne P/N 405444		2A19
B39-3	1	Valve, Butterfly	Main Fuel Valve NC	Rocketdyne P/N 405444		3A19
B39-4	1	Valve, Butterfly	Main Fuel Valve NC	Rocketdyne P/N 405444		4A19
B39-5	1	Valve, Butterfly	Main Fuel Valve NC	Rocketdyne P/N 405444		5A19
B39-6	1	Valve, Butterfly	Main Fuel Valve NC	Rocketdyne P/N 405444		6A19
B39-7	1	Valve, Butterfly	Main Fuel Valve NC	Rocketdyne P/N 405444		7A19
B39-8	1	Valve, Butterfly	Main Fuel Valve NC	Rocketdyne P/N 405444		8A19
B40						
B41-1	1	Switch, Pressure	Thrust OK Pressure Switch Actuates @ 810 ±8 psia	Southwestern Industries P/N PS-5807-810	60C27818	1A11

FINDING NUMBER	NO. REQD	COMPONENT	REMARKS	VENDOR	DRAWING NUMBER	ELEC SYM
B41-2	1	Switch, Pressure	Thrust OK Pressure Switch Actuates @ 810 ± 8 psia	Southwestern Industries P/N PS-5807-810	60C27818	2A11
B41-3	1	Switch, Pressure	Thrust OK Pressure Switch Actuates @ 810 ± 8 psia	Southwestern Industries P/N PS-5807-810	60C27818	3A11
B41-4	1	Switch, Pressure	Thrust OK Pressure Switch Actuates @ 810 ± 8 psia	Southwestern Industries P/N PS-5807-810	60C27818	4A11
B41-5	1	Switch, Pressure	Thrust OK Pressure Switch Actuates @ 810 ± 8 psia	Southwestern Industries P/N PS-5807-810	60C27818	5A11
B41-6	1	Switch, Pressure	Thrust OK Pressure Switch Actuates @ 810 ± 8 psia	Southwestern Industries P/N PS-5807-810	60C27818	6A11
B41-7	1	Switch, Pressure	Thrust OK Pressure Switch Actuates @ 810 ± 8 psia	Southwestern Industries P/N PS-5807-810	60C27818	7A11
B41-8	1	Switch, Pressure	Thrust OK Pressure Switch Actuates @ 810 ± 8 psia	Southwestern Industries P/N PS-5807-810	60C27818	8A11
B42	16	Auto-Igniter		Rocketdyne P/N 651139		
B43	8	Plug, Drain	Fuel Drain Plug	AN814-4CL		
B44						
B45	8	Valve, Check		Rocketdyne P/N NA5-26032T1L		
B46-1	1	Valve, Cam-Actuated	Fuel Igniter Valve NC	Rocketdyne P/N 403520		1A5

FINDING NUMBER	NO. REQD	COMPONENT	REMARKS	VENDOR	DRAWING NUMBER	ELEC SYM
B46-2	1	Valve, Cam-Actuated	Fuel Igniter Valve NC	Rocketdyne P/N 403520		2A5
B46-3	1	Valve, Cam-Actuated	Fuel Igniter Valve NC	Rocketdyne P/N 403520		3A5
B46-4	1	Valve, Cam-Actuated	Fuel Igniter Valve NC	Rocketdyne P/N 403520		4A5
B46-5	1	Valve, Cam-Actuated	Fuel Igniter Valve NC	Rocketdyne P/N 403520		5A5
B46-6	1	Valve, Cam-Actuated	Fuel Igniter Valve NC	Rocketdyne P/N 403520		6A5
B46-7	1	Valve, Cam-Actuated	Fuel Igniter Valve NC	Rocketdyne P/N 403520		7A5
B46-8	1	Valve, Cam-Actuated	Fuel Igniter Valve NC	Rocketdyne P/N 403520		8A5
B47						
B48	8	Orifice		Rocketdyne P/N NA5-24002T123		
B49-1	1	Valve, Butterfly	Main LOX Valve NC	Rocketdyne P/N 405967		1A4
B49-2	1	Valve, Butterfly	Main LOX Valve NC	Rocketdyne P/N 405405		2A4
B49-3	1	Valve, Butterfly	Main LOX Valve NC	Rocketdyne P/N 405967		3A4

FINDING NUMBER	NO. REQD	COMPONENT	REMARKS	VENDOR	DRAWING NUMBER	ELEC SYM
B49-4	1	Valve, Butterfly	Main LOX Valve NC	Rocketdyne P/N 405967		4A4
B49-5	1	Valve, Butterfly	Main LOX Valve NC	Rocketdyne P/N 405967		5A4
B49-6	1	Valve, Butterfly	Main LOX Valve NC	Rocketdyne P/N 405967		6A4
B49-7	1	Valve, Butterfly	Main LOX Valve NC	Rocketdyne P/N 405967		7A4
B49-8	1	Valve, Butterfly	Main LOX Valve NC	Rocketdyne P/N 405967		8A4
B50 through B74 are not functionally applicable to this system.						
B75	4	Pump, Variable-Displacement	Main Pump 18 gpm @ 4300 rpm	American Brake Shoe Co. P/N APGV-24K	20M85035	
B76	8	Seepage Plug Assembly	5/8 in. dia.		20M85056	
B77						
B78	4	Indicator, Differential-Pressure	Actuates @ 80 ±10 psid	Aircraft Porous Media Inc. P/N AC-2100-1180NT	20M85074	
B79	4	Valve, Check		Parker Aircraft Co. P/N H61C0572-G	20M85080-3	
B80	4	Pump, Variable-Delivery	Auxiliary Pump 3.5 gpm @ 11,000 rpm	Vickers Inc. P/N PV006L012B	20M85064	

FINDING NUMBER	NO. REQD	COMPONENT	REMARKS	VENDOR	DRAWING NUMBER	ELEC SYM
B81-1	1	Motor Assembly	200 vac, 3-ph, 400 cps	U.S. Electric Motors P/N 406930	20M85065	1A9
B81-2	1	Motor Assembly	200 vac, 3-ph, 400 cps	U.S. Electric Motors P/N 406930	20M85065	2A9
B81-3	1	Motor Assembly	200 vac, 3-ph, 400 cps	U.S. Electric Motors P/N 406930	20M85065	3A9
B81-4	1	Motor Assembly	200 vac, 3-ph, 400 cps	U.S. Electric Motors P/N 406930	20M85065	4A9
B82	4	Valve, Check		Parker Aircraft Co. P/N H61C0572-8	20M85109-1	
B83	24	Valve, Bleeder		Fluid Regulators Corp. P/N 7579-S	20M85009	
B84	4	Coupling-Half, Quick-Disconnect		Aeroquip Corp. P/N 340246-8	20M85082	
B85	4	Filter		Bendix Filter Div. P/N 043581	20M85087	
B86	4	Accumulator-Reservoir and Manifold Assembly	Hydraulic Fluid, GN_2	Cadillac Gage Co. P/N 20296	20M85062	
B87	4	Potentiometer		Servonic Instruments Inc. P/N H204	20M85093	
B88	4	Valve, Manual, Quick-Disconnect	High Pressure Charging Valve 1600 psig GN_2	Cadillac Gage Co. P/N 18659		
B89	4	Valve, Relief	High Pressure Relief Valve Cracks @ 3800 ± 100 psig Reseats @ 3400 psig min.	Fluid Regulators Corp. P/N C485-02	20M85078	

FINDING NUMBER	NO. REQD	COMPONENT	REMARKS	VENDOR	DRAWING NUMBER	ELEC SYM
B90	4	Coupling-Half, Quick-Disconnect		Aeroquip Corp. P/N 370250-12	20M85081	
B91	4	Valve, Relief	Low Pressure Relief Valve Cracks @ 100 ± 10 psig Reseats @ 75 psig min.	Parker Aircraft Co. P/N H60C0661	20M85077	
B92-1	1	Transducer, Pressure		Servonic Instruments Inc. P/N 104-855	20M85079	1A426
B92-1	1	Transducer, Pressure		Servonic Instruments Inc. P/N 104-855	20M85079	2A425
B92-3	1	Transducer, Pressure		Servonic Instruments Inc. P/N 104-855	20M85079	3A426
B92-4	1	Transducer, Pressure		Servonic Instruments Inc. P/N 104-855	20M85079	4A425
B93-1	1	Switch, Thermal	Opens @ 200 ± 10°F Closes @ 155 ± 10°F	Texas Instruments Inc. P/N 21400	60C27739	1A10
B93-2	1	Switch, Thermal	Opens @ 200 ± 10°F Closes @ 155 ± 10°F	Texas Instruments Inc. P/N 21400	60C27739	2A10
B93-3	1	Switch, Thermal	Opens @ 200 ± 10°F Closes @ 155 ± 10°F	Texas Instruments Inc. P/N 21400	60C27739	3A10
B93-4	1	Switch, Thermal	Opens @ 200 ± 10°F Closes @ 155 ± 10°F	Texas Instruments Inc. P/N 21400	60C27739	4A10
B94-1	1	Servoactuator Assembly		Moog Servocontrols Inc. P/N 010-26306	50M01609	1A14
B94-2	1	Servoactuator Assembly		Moog Servocontrols Inc. P/N 010-26306	50M01609	2A12

FINDING NUMBER	NO. REQD	COMPONENT	REMARKS	VENDOR	DRAWING NUMBER	ELEC SYM
B94-3	1	Servoactuator Assembly		Moog Servocontrols Inc. P/N 010-26306	50M01609	3A14
B94-4	1	Servoactuator Assembly		Moog Servocontrols Inc. P/N 010-26306	50M01609	4A12
B95-1	1	Servoactuator Assembly		Moog Servocontrols Inc. P/N 010-26306	50M01609	1A12
B95-2	1	Servoactuator Assembly		Moog Servocontrols Inc. P/N 010-26306	50M01609	2A14
B95-3	1	Servoactuator Assembly		Moog Servocontrols Inc. P/N 010-26306	50M01609	3A12
B95-4	1	Servoactuator Assembly		Moog Servocontrols Inc. P/N 010-26306	50M01609	4A14
B96	4	Switch, Thermal			Part of 20M85065	
B97	4	Filter, Case-Drain	2 gpm	Aircraft Porous Media Inc. P/N AC-4913E-1	20M85085	
B98	4	Valve, Bleeder		Fluid Regulators Corp. P/N 7409-S	20M85086	
B99 through B163 are not functionally applicable to this system.						
B164	8	Valve, Check	2-3/4 in.dia.	Precision Equipment Co. P/N 126060-2	20M30046	
B165 through B213 are not functionally applicable to this system.						

FINDING NUMBER	NO. REQD	COMPONENT	REMARKS	VENDOR	DRAWING NUMBER	ELEC SYM
B214	1	Valve, Needle, Three-Way	Manual Valve	Benton Corp. P/N B-17500	60C27547	
B215 through B300 are not functionally applicable to this system.						
B301	1	Quick-Disconnect Coupling Assembly	Coupling-Half 1 in., 300 psig GN_2	E. B. Wiggins P/N 6005R92A16	20M30165	
B303	1	Quick-Disconnect Coupling Assembly	Coupling-Half 1.25 in., 490 psig GN_2	E. B. Wiggins P/N 7005R11A20	20M30166	
B304	2	Quick-Disconnect Coupling Assembly	Coupling-Half 1 in.	E. B. Wiggins P/N 6005R92A16	20M30165	
B305	8	Orifice	Tapered .042 to .108 in. id, .186 in. od		20M00991	

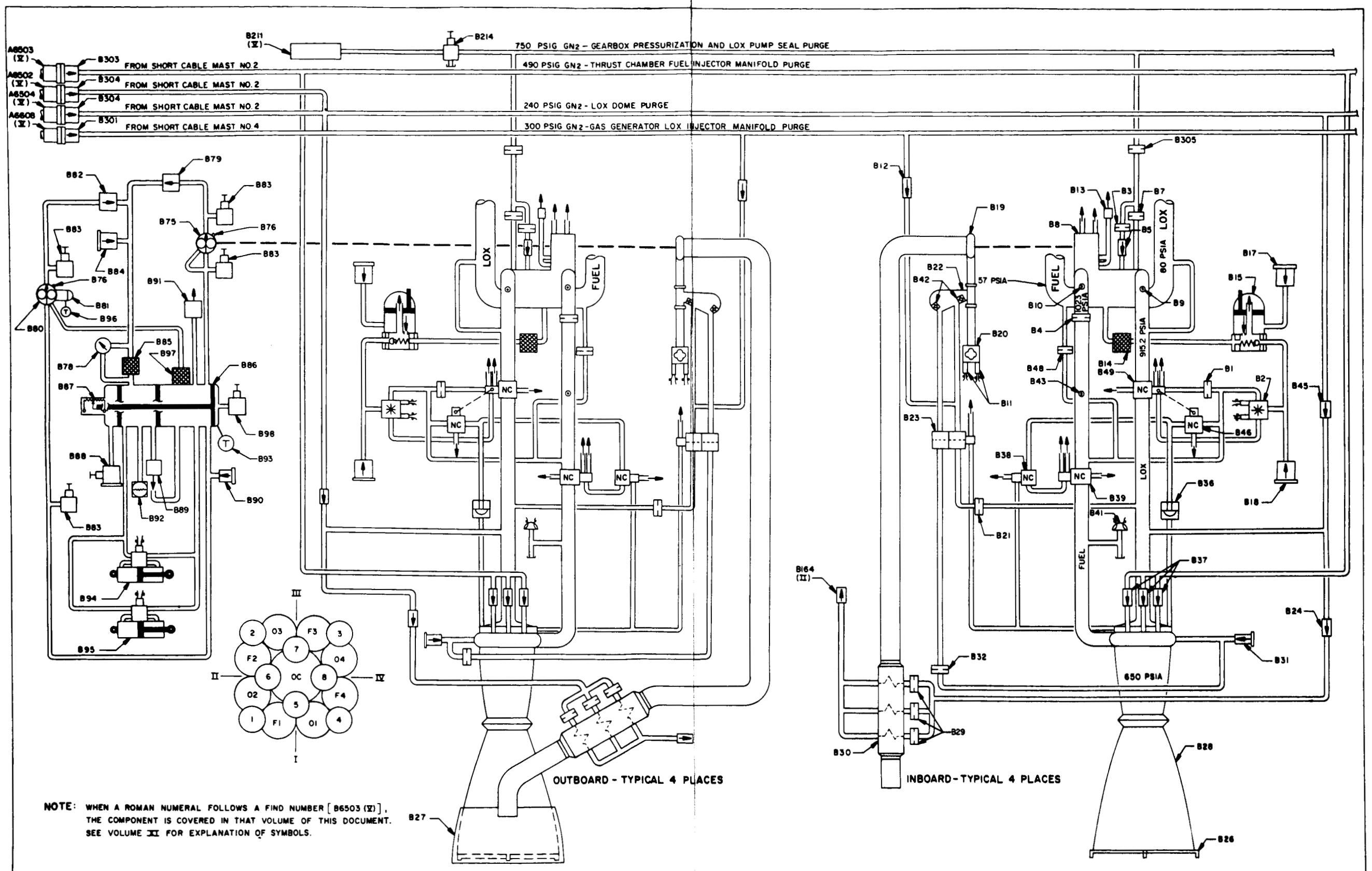

FIGURE 2. H-I ENGINE AND HYDRAULIC SYSTEM SCHEMATIC

HEC-D042
VOLUME VIII

APPROVAL

SA-9
VEHICLE AND LAUNCH COMPLEX
FUNCTIONAL DESCRIPTION

H-1 ENGINE AND HYDRAULIC SYSTEM

W. S. G. Davis
Special Projects Group

C. L. Balfour
Applied Communications
Engineering Section

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Branch

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