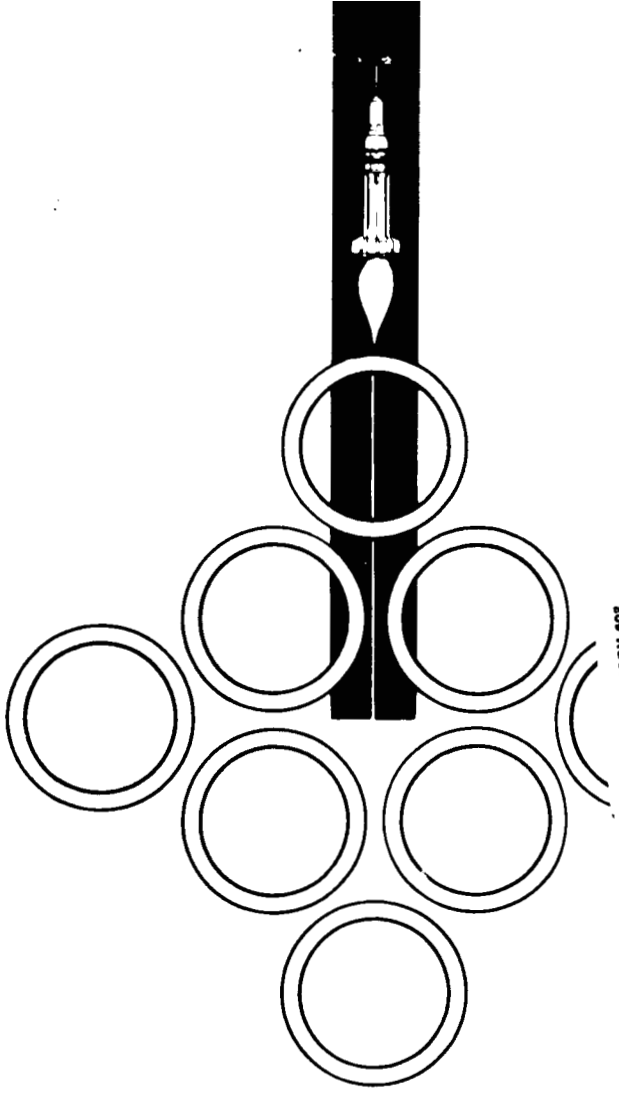

ENGINEERING DEPARTMENT

TECHNICAL MANUAL

SDES-64-414

Saturn I

LAUNCH VEHICLE SA-8 AND LAUNCH COMPLEX 37B FUNCTIONAL SYSTEMS DESCRIPTION

Volume VIII

H-1 ENGINE AND HYDRAULIC SYSTEM FUNCTIONAL DESCRIPTION, INDEX OF FINDING NUMBERS, AND MECHANICAL SCHEMATICS

SPACE DIVISION CHRYSLER CORPORATION

SDES-64-414

SATURN I
LAUNCH VEHICLE SA-8
AND
LAUNCH COMPLEX 37B
FUNCTIONAL SYSTEMS DESCRIPTION

VOLUME VIII
H-I ENGINE AND HYDRAULIC SYSTEM FUNCTIONAL DESCRIPTION, INDEX OF FINDING NUMBERS AND MECHANICAL SCHEMATICS

APRIL 1964

CHRYSLER CORPORATION SPACE DIVISION - NEW ORLEANS, LOUISIANA

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FOREWORD

This volume is part of a ten-volume set that describes the mechanical and electromechanical systems of the Saturn I launch vehicle SA-8 and launch complex 37B that function either during the prelaunch countdown or in the event of a launch abort. The mechanical and electromechanical systems of the launch vehicle that function during flight or flight abort are also described.

The ten-volume set is prepared for the Functional Integration Section, Systems Integration and Operations Branch, Vehicle Systems Division, P&VE Laboratory, MSFC, by Systems Engineering Branch, Chrysler Corporation Space Division under Contract NAS 8-4016.

This volume describes the H-1 engine and hydraulic system of the S-I stage of launch vehicle SA-8. The information is presented in three sections: functional description, index of finding numbers, and mechanical schematic. The technical content reflects the functional system design information available on February 2, 1964.

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

SECTION 1

FUNCTIONAL DESCRIPTION

1.1 ENGINE SYSTEM GENERAL DISCUSSION

A cluster of eight H-1 engines powers the S-I stage of launch vehicle SA-8. These engines are supplied with propellants from four RP-1 and five LOX tanks. The H-1 is a single-start, constant-thrust engine with a nominal sea-level thrust rating of 188,000 pounds.

The eight-engine cluster consists of four inboard engines located at a radius of 32 inches from the vehicle longitudinal axis and four outboard engines located at a radius of 95 inches from the same axis. (See figure 3-1).

The inboard engines are mounted at a fixed cant of three degrees outward from the vehicle longitudinal axis. The outboard engines are mounted at a cant of six degrees outward from the vehicle longitudinal axis, and allow gimballing of ± 8 degrees square pattern, unrestricted travel. The inboard engines 5, 6, 7 and 8 are located on fin position center lines I, II, III and IV respectively. The outboard engines 1, 2, 3 and 4 are offset 45 degrees from the fin position centerlines. (See figure 3-1).

To avoid undue structural loading, the H-1 engines are started in pairs 100 miliseconds apart; the inboard engines are started first. A signal from the start sequencer located in the launch control center starts the first pair of engines, 5 and 7. One hundred miliseconds later, engines 6 and 8 are started. Engines 2 and 4 are started 100 miliseconds afterward; then engines 1 and 3 are started. Powered flight lasts approximately 150 seconds and termination begins when the four inboard engines are simultaneously shut down. Approximately six seconds later, the four outboard engines are shutdown.

The engine system consists of the turbopump assembly, gas generator, thrust chamber, heat exchanger, engine valves, purge lines, and engine vents and drains. In addition, each outboard engine has an individual hydraulic system to provide power for gimballing. Figure 1-1 graphically illustrates the engine start and shutdown sequences. Figure 3-1 schematically represents the engine and hydraulic system.

1.2 ENGINE OPERATION

1.2.1 Prelaunch Operations - Prelaunch operations are performed prior to engine start. The fuel jacket on Thrust Chamber B28 is filled with fuel through Coupling Half B31, and Fuel Additive Blender Unit B15 is filled with oronite through Coupling Half B17. In addition, pyrotechnic devices are installed. Solid propellant Turbine Spinner B20 containing Turbine Spinner Initiators B11 is bolted to Gas Generator Combustor Assembly B22, and two Auto-Ignitors B42 are installed inside the combustor assembly. Finally, Conax Valve B2 is installed and the engine is ready to be started.

1.2.2 Engine Start - Engine start begins with primary ignition and continues until normal inflight operation has been established. During this period turbopump operation is initiated by a solid propellant charge, engine ignition occurs, and various valves are positioned. In addition, a bootstrap operation is established in which LOX and fuel are bled off the main engine supply, burned in the gas generator, and the products of combustion are used to continue driving the turbopump.

Engine start occurs when an electrical signal from the start sequencer in the launch control center fires two Turbine Spinner Initiators B11. The initiators ignite the solid propellant of Turbine Spinner B20. The resultant high-pressure combustion gases are forced through part of Gas Generator Combustor Assembly B22 to Gas Turbine B19. The gas turbine accelerates the LOX and fuel pumps through a gear train in the gearbox of Turbopump Assembly B8.

Turbopump Assembly B8 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. At this point, some fuel is diverted through a branch line as a supply for valve control, gearbox lubrication, and engine ignition.

From the branch line a bleed line connects the fuel discharge line to the fuel suction line. Prior to engine start, any air trapped in the fuel discharge line will be bled back to the fuel suction line through Orifice B48. The bleed line has no function after engine start.

When Conax Valve B2 is in the normal position, fuel from the branch line flows through to Fuel Additive Blender Unit B15. Here, the fuel mixes with Oronite; and the fuel-Oronite mixture flows through a lube line containing Filter B14 to the gearbox located in Turbopump Assembly B8. The fuel-Oronite mixture cools and lubricates the assembly components, and then discharges overboard through the lube drain line that includes Relief Valve B13. The relief valve maintains continous gearbox pressurization by preventing excessive discharge rates at high attitudes.

Another fuel path leads to Sequence Valve B46 and through Orifice B1 to Main LOX Valve B49. Prior to application of fuel control pressure to the main LOX valve, Turbopump Assembly B8 draws LOX from the suction line and forces it through the LOX discharge line to the inlet side of the normally closed main LOX valve. The line between the LOX discharge and the LOX suction line bleeds any air or LOX vapor from the LOX discharge line into the LOX suction line before engine start. The bleed line has no function after engine start. As turbopump acceleration causes pressure buildup in the fuel discharge line, increasing pressure is applied to overcome spring pressure in Main LOX Valve B49. When the discharge line fuel pressure reaches approximately 230 psig, this valve begins to open. LOX flows through the LOX discharge line, LOX dome, and LOX injector nozzles into the Thrust Chamber B28. LOX also flows from branch lines in the LOX discharge line to three-coil Heat Exchanger Assembly B30 and the LOX bootstrap line, containing Orifice B21, to Gas Generator Control Valve Assembly B23.

When Main LOX Valve B49 has opened approximately 80 percent, a mechanical linkage opens Sequence Valve B46. Opening the sequence valve allows fuel to flow to Hypergol Container Assembly B36 and to the inlet port of normally closed Ignition Monitor Valve B38.

The hypergol-container burst-diaphrams rupture when fuel pressure reaches 300 psig; thereby allowing hypergol, followed by fuel, to flow through the ignition fuel spray nozzles and then into Thrust Chamber B28. The hypergol and fuel ignite on contact with previously injected LOX causing primary ignition.

Primary ignition produces pressure buildup within Thrust Chamber B28, the fuel injector manifold, and the control line from the manifold to Ignition Monitor Valve B38 and Gas Generator Control Valve Assembly B23. When the fuel-injector-manifold pressure reaches approximately 15 psig, Ignition Monitor Valve B38 opens and fuel channeled from Sequence Valve B46 exerts pressure on Main Fuel Valve B39. When fuel pressure overcomes spring pressure, 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 Thrust Chamber B28. Since LOX is already present and ignition has occurred, main stage operation now begins.

As fuel flows from the fuel manifold to the thrust chamber fuel jacket, the fuel bootstrap line allows some fuel to flow 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 assembly. When this pressure reaches approximately 115 psig, the gas generator control valve assembly opens allowing LOX and fuel to flow into Gas Generator Combustor Assembly B22 where they are ignited by the hot gases of Turbine Spinner B20. Two Auto-Igniters B42 provide a redundant secondary ignition source in the gas generator to insure starting of the bootstrap cycle.

Gas Turbine B19 operates on combined Turbine Spinner B20 and Gas Generator Combustor Assembly B22 high-pressure gases for approximately 200 milliseconds. The turbine spinner then ceases operation. The gas generator continues to power the gas turbine for the remainder of engine operation.

Once bootstrap operation has been established, the engine operates independently. This independent operation is called "bi-propellant operation."

1.2.3 Bi-Propellant Operation - At this time all engine valves are open and the propellant lines are discharging at desired flow rates. The fuel flows through the fuel manifold and into the walls of Thrust Chamber B28. In the thrust chamber, the fuel cools the chamber walls. Next, the fuel flows into the fuel injector manifold for injection into the thrust chamber.

Main propellant ignition results in a pressure buildup in the thrust chamber. Thurst O.K. Pressure Switch B41 monitors this thrust buildup by measuring a corresponding pressure buildup in the fuel line downstream from Main Fuel Valve B39.

During bi-propellant operation, LOX is supplied from a branch line downstream from Main LOX Valve B49 to Heat Exchanger Assembly B30 through three Orifices B29. This LOX is vaporized and routed through Check Valve B173 to provide in-flight LOX tank pressurization. Check Valve B24 in the heat exchanger assembly supply line prevents pre-flight helium from backing up into the engine.

1.2.4 Engine Shutdown. Approximately 150 seconds after engine ignition, a signal from the flight computer in the instrument unit initiates engine cutoff. This signal detonates two explosive charges within Conax Valve B2. The explosive force moves a piston that shears a metal diaphram in the valve body, thereby 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 and allows the internal valve spring pressure to close the valve. Now, LOX flow to Thrust Chamber B28 and Gas Generator Combustor Assembly B22 stops.

After Main LOX Valve B49 has closed approximately 20 percent, Sequence Valve B46 closes. 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 Thrust Chamber B28 and Gas Generator Combustor Assembly B22 terminates. This time-lag between LOX and fuel shutoff provides a fuel-rich cutoff that prevents an explosive shutdown in both the thrust chamber and gas generator.

1.2.5 Engine Purges - Several GN_2 purges are initiated during the launch preparation sequence to prevent contaminants from entering the engine.

1.2.5.1 LOX Pump Seal Purge and Gearbox Pressurization. The LOX Pump seal aids in preventing LOX or lubricant leakage past the turbopump LOX and lube seals by applying a positive pressure in the area between these seals. LOX and lubricant leakage into this area will be kept separate by the GN_2 pressure and drained overboard through separate engine LOX and lube seal drain lines. Gearbox pressurization is required to prevent the turbopump gearbox lubricant from foaming at high altitudes. Gearbox pressurization is also used prior to launch to detect any fuel leakage past the turbopump fuel seal by forcing the leakage out the lube drain line. LOX pump seal purge and gearbox pressurization are described together since both use GN_2 from a common source. Both operations commence with S-I stage control system pressurization and continue throughout launch preparations, engine starting, and launch. If a launch is aborted, purging is required until all LOX has boiled off from the turbopump.

GN_2 is supplied from the control pressure system and flows through Manual Valve B214 to a ringline manifold. From the ringline manifold GN_2 flows into separate branch lines leading to each engine Turbopump Assembly B8. Each branch line contains Orifice B305 and a tee downstream from the orifice which divides the line into a purge line and a pressurization line. Purge nitrogen flows through the purge line through Orifice B7, and into the LOX and lube seal areas. The purge nitrogen is then vented through the LOX and lube seal drain lines. Pressurization nitrogen flows through the pressurization line through Orifice B3 and Check Valve B5 and into the

gearbox. Relief Valve B13 in the lube drain line maintains the desired pressure in the gearbox by not venting GN_2 through the lube drain line until the desired level of pressurization has been reached.

1.2.5.2 LOX Dome Purge. The LOX dome purge has two modes of operation. The first mode is the LOX dome bypass purge. This purge keeps a slight positive GN_2 pressure in the LOX dome to prevent contaminants from being drawn upwards through the engine thrust chamber nozzle and into the injector plate and LOX dome. The purge also keeps moisture out of this area. The LOX dome bypass purge is initiated prior to propellant tanking and continues until just prior to engine ignition. At this time, the second mode, LOX dome purge, starts and the GN_2 pressure and flow rate are increased. The LOX dome purge continues during engine operation until it is overcome by increased LOX pressure in the LOX dome. If the launch is aborted, the LOX dome purge resumes as soon as LOX pressure in the LOX dome decreases below purge pressure.

GN_2 flows from a ground source through short cable mast No. 2 and into a ringline manifold through Quick-Disconnect Coupling Halves B304. From the ringline manifold, separate branch lines lead to each engine. The GN_2 flows into each branch line, through Check Valve B45, and into the heat exchanger LOX supply line. At this point GN_2 is prevented from flowing into Heat Exchanger Assembly B30 because purge pressure is lower than the cracking pressure of Check Valve B24. From the heat exchanger supply line the GN_2 flows into the LOX pump discharge line and into the LOX dome. Although GN_2 can enter the LOX bootstrap line from the LOX pump discharge line, it can go only as far as the closed LOX poppet valve in Gas Generator Control Valve Assembly B23.

1.2.5.3 Gas Generator - LOX Injector Manifold Purge. The gas generator - LOX injector manifold purge prevents turbine spinner combustion products and other contaminants from contaminating the gas generator - LOX injector manifold prior to the arrival of LOX at the manifold. The purge starts just before engine ignition and is terminated by LOX pressure buildup in the manifold. If a launch is aborted, this purge starts immediately following engine cutoff and continues until after the removal of spent Turbine Spinner B20.

Ground source GN_2 flows through short cable mast No. 4 to Quick-Disconnect Coupling Half B301 and into a ringline manifold. From the ringline manifold a separate branch line leads to each individual gas generator - LOX injector manifold. Each branch line has a Check Valve B12 where the line connects to the LOX injector manifold. The GN_2 flows into each branch line through Check Valve B12 and into the LOX injector manifold. From the LOX injector manifold, the GN_2 is exhausted through the gas turbine exhaust duct. The purge is terminated by LOX pressure buildup in the LOX injector manifold which flows into the purge line and closes the check valve. This occurs just prior to bi-propellant ignition in Gas Generator Combustor Assembly B22.

1.2.5.4 Thrust Chamber Fuel Injector Manifold Purge. The thrust chamber fuel injector manifold purge prevents LOX from entering the fuel injector manifold during engine ignition. The purge is initiated just before engine ignition.

GN_2 from a ground source flows through short cable mast No. 2 to Quick-Disconnect Coupling Half B303 and into a ringline manifold. From the ringline manifold, separate branch lines lead to a manifold on each engine. From this manifold, three branch lines connect to the engine fuel injector manifold. The three branch lines which enter the fuel injector manifold are approximately 120 degrees apart. Each branch line contains Check Valve B37. The GN_2 flows from the ringline manifold through each branch line and into the manifold on each engine. At this point the GN_2 flow is divided into the three branch lines and enters the fuel injector manifold through the check valves. Once inside the fuel injector manifold, the GN_2 passes through the injector plate and is vented out Thrust Chamber B28. After engine starting sequence, pressure buildup in the fuel injector manifold closes the check valves and shuts off the GN_2 flow. The ground supply is then shut off, terminating the purge.

1.2.6 Engine Drain Operation. The engine is equipped with manual drains that allow it to be drained in the event of a launch cancellation and a vent and drain system that provides for in-flight disposal of combustable fluids leakage.

1.2.6.1 Ground Drain Operation. In the event of launch cancellation, the fuel suction line, fuel pump volute, fuel discharge line, and fuel branch line are drained through Coupling Half B18. The fuel pump volute can also be drained through Cap Assembly B10, and the fuel discharge line upstream from Main Fuel Valve B39 can be drained through Drain Plug B43. The fuel bootstrap line is drained through Coupling Half B31. The fuel manifold and thrust chamber fuel jacket are drained through four Drain Plugs B26 located on the collector ring at the base of Thrust Chamber B28. Fuel Additive Blender Unit B15 is drained through Drain Plug B16.

1.2.6.2 Inflight Drain Operation. During engine operation, drain lines carry any combustible fluids leakage clear of the engine area. Fuel and lubricant leakage is isolated from LOX leakage by means of separate drain lines. Three drain lines lead from Turbopump Assembly B8: the LOX seal drain, the lube seal drain, and the lube drain. On inboard engines the LOX seal drain is routed to Manifold B47 which also receives leakage from two LOX drain lines located on Main LOX Valve B49. From the manifold a single line drains LOX leakage over board. On outboard engines, LOX leakage is conducted to a common drain line and then drained overboard. Manifold B44 receives fuel and lubricant leakage from six separate lines and drains it overboard through a single line. The six lines are: the lube seal drain, the gas generator control valve assembly drain, the fuel drain from the main LOX valve, and three drain lines from Main Fuel Valve B39.

Three other lines drain leakage from the engine area. These are the lube drain line from the turbopump gearbox, and the fuel drain lines from Ignition Monitor Valve B38 and Sequence Valve B46. On outboard engines, all leakage is dumped into the engine thrust chamber from a common point on the edge of Aspirator B27. On inboard engines, the leakage is ducted to aerodynamic fairings (one for each inboard engine) on the exterior of the vehicle where it is dumped into the turbine exhaust.

1.3 HYDRAULIC SYSTEM GENERAL DISCUSSION

A hydraulic system, which constitutes part of each outboard engine, provides power for vehicle attitude control through engine gimballing. Each independent, closed-loop system consists of two hydraulic actuators, a main pump, auxiliary pump and motor, and an accumulator reservoir assembly.

1.4 HYDRAULIC SYSTEM OPERATION

1.4.1 Filling Operation - Accumulator Reservoir Assembly B86 is charged with GN_2 from a ground source through High-Pressure Charging Valve B88 before the system is filled with hydraulic fluid. The system is then filled with hydraulic fluid through high-pressure Quick-Disconnect Coupling Half B84, purged, and bled. Hydraulic fluid is supplied from a ground source and is forced through Filter B85, into the accumulator reservoir assembly, and through the system. Excess hydraulic fluid used in the purging operation is returned to the ground source through low-pressure Quick-Disconnect Coupling Half B90.

1.4.2 Prelaunch Operation - Ground operation of the hydraulic system is accomplished by electrically operated Auxiliary Pump B80, driven by electric Motor Assembly B81, which supplies the necessary hydraulic pressure for engine gimballing. Check Valve B79 protects Hydraulic Pump B75 from high-pressure fluid during auxiliary pump operation. The auxiliary pump is protected by Check Valve B82 from high-pressure fluid during the main Hydraulic Pump B75 operation. After all engines have reached mainstage operation, auxiliary pump operation terminates.

1.4.3 Flight Operation. Hydraulic Pump B75, driven by an accessory drive pad on the engine turbopump, draws fluid from the low-pressure (return) side of Accumulator Reservoir Assembly B86. As the turbopump speed increases, fluid pressure increases to approximately 3200 psi, causing the hydraulic fluid to flow through Check Valve B79 and Filter B85 into the high-pressure side of the accumulator reservoir assembly. The fluid flows under pressure from the accumulator into Hydraulic Actuators B94 and B95.

When the electro-hydraulic servo valve in each actuator receives a command from the guidance system, it diverts the high-pressure fluid against one side or the other of the actuator piston, causing extension or retraction of the actuator arms, thus providing gimballing action of the engines. Displaced fluid from Hydraulic Actuators B94 and B95 is returned to the low-pressure side of Accumulator Reservoir Assembly B86.

The hydraulic system is monitored by various switches and indicators within Accumulator Reservoir Assembly B86. Differential Pressure Indicator B78 is calibrated to trip a spring-loaded button when the pressure drop across Filter B85 exceeds a predetermined level. An extended button indicates the presence of a dirty or clogged filter. Thermal Switch B93 transmits a signal if the fluid temperature increases above a predetermined value. The hydraulic fluid pressure in the high-pressure accumulator is monitored by High-Pressure Transducer B92. The fluid level of

the reservoir is monitored at all times by Potentionmeter B87. Thermal Switch B96 protects electric Motor Assembly B81 from overheating by cutting off power to the motor if the temperature of the motor rises above a safe level.

The hydraulic system is protected against excessive pressures by Relief Valves B89 and B91. High-pressure Relief Valve B89 protects Accumulator Reservoir Assembly B86 and the high-pressure side of the system by allowing high-pressure fluid to vent into the low-pressure side of the accumulator reservoir assembly. The low-pressure (return) side of the system is protected by low-pressure Relief Valve B91 which vents excess fluid to the atmosphere. During flight, the low-pressure relief valve is capped and is inoperative.

1.4.4 Drain Operation. The system is drained through low-pressure Quick-Disconnect Coupling B90. Drain plugs are provided in Actuators B94 and B95 for draining purposes. Filter B85 can be removed for cleaning. Nitrogen pressure in Accumulator Reservoir Assembly B86 can be released through High-Pressure Charging Valve B88. Hydraulic Pump B75 and Auxiliary Pump B80 are provided with Seepage Plugs B76. Bleed Valves B83 and B98 are provided for both the high-and-low-pressure sides of the accumulator reservoir assembly, the hydraulic pump, and the auxiliary pump.

Case Drain Filter B97 filters any auxiliary-pump-generated contaminant before the fluid is returned to the reservoir.

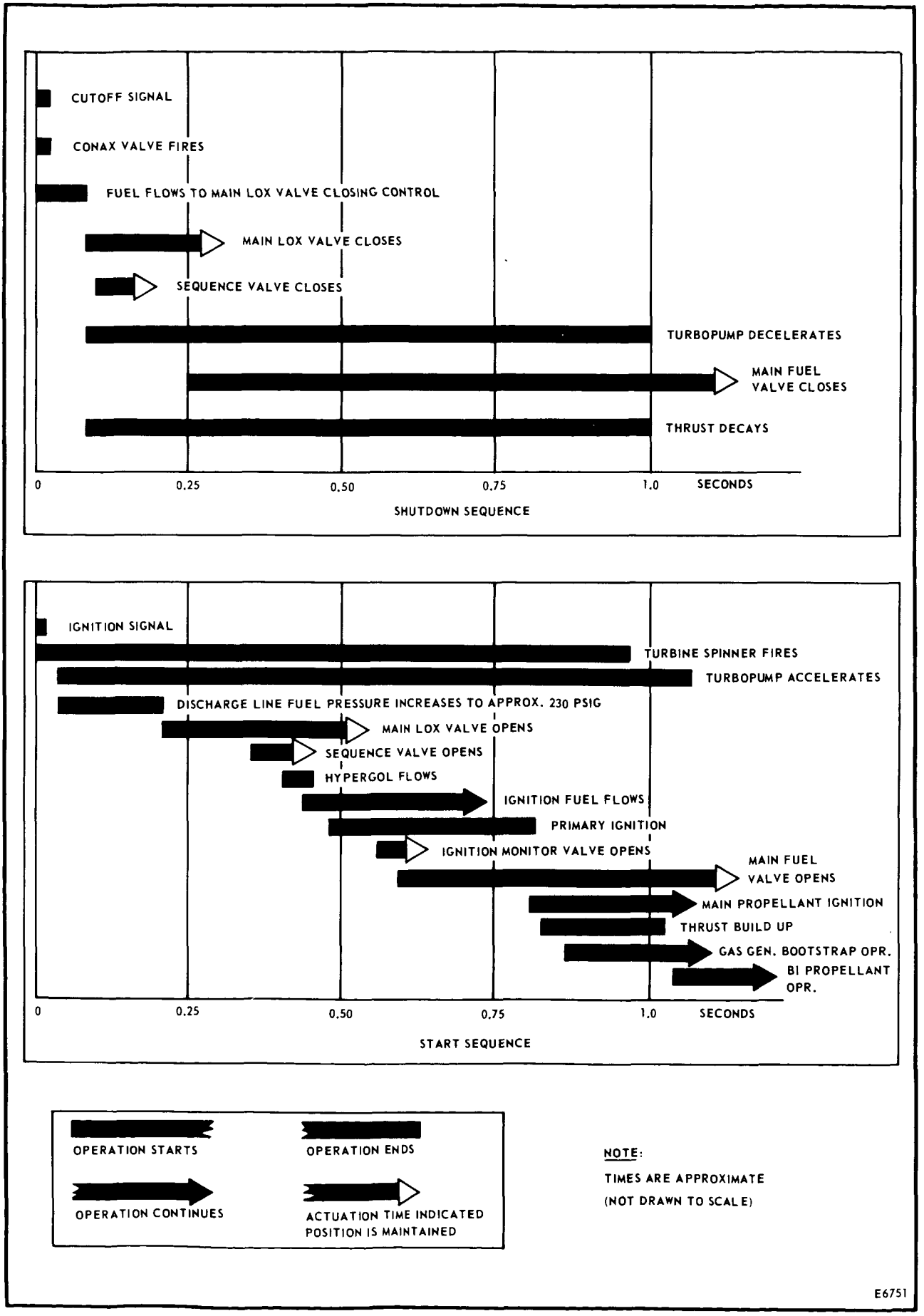

Figure 1-1. H-1 Engine Start and Shutdown Sequences

SECTION 2

INDEX OF FINDING NUMBERS

This section contains an alpha-numerical list, by finding number, of H-1 engine and hydraulic system components that function during a prelaunch countdown, during vehicle flight, or in the event of a launch abort. The finding numbers listed identify components on the system schematic diagram provided in section III. Additional columns in the index of finding numbers provide such pertinent information as component description and function, part number, and the supplier's name and part number. A break will occur in the alpha-numeric sequence of finding numbers when a component, or component series is: non-functional during the countdown; functional only in the event of a malfunction; functional in terms of a maintenance operation only; or part of another functional system.

The significance of finding number alphabetical prefixes used in this ten-volume set is explained below.

FINDING NUMBER PREFIX	DESIGNATED AREA
A	Ground Support components
B	S-I stage components
C	S-IV stage components
G	Instrument Unit
H	Payload

Finding Number	Reqd	Component	Remarks	Vendor	Drawing Number	Elec. Sym.
B1	8	Orifice	0.116 in dia; main LOX valve opening control line	Rocketdyne P/N 307404		
B2-1	1	Valve, Conax	NC, 2-way, self-contained, pyrotechnic-actuated	Rocketdyne P/N NA5-26594		1A8
B2-2	1	Valve, Conax	NC, 2-way, self-contained, pyrotechnic-actuated	Rocketdyne P/N NA5-26594		2A8
B2-3	1	Valve, Conax	NC, 2-way, self-contained, pyrotechnic-actuated	Rocketdyne P/N NA5-26594		3A8
B2-4	1	Valve, Conax	NC, 2-way, self-contained, pyrotechnic-actuated	Rocketdyne P/N NA5-26594		4A8
B2-5	1	Valve, Conax	NC, 2-way, self-contained, pyrotechnic-actuated	Rocketdyne P/N NA5-26594		5A8
B2-6	1	Valve, Conax	NC, 2-way, self-contained, pyrotechnic-actuated	Rocketdyne P/N NA5-26594		6A8
B2-7	1	Valve, Conax	NC, 2-way, self-contained, pyrotechnic-actuated	Rocketdyne P/N NA5-26594		7A8
B2-8	1	Valve, Conax	NC, 2-way, self contained, pyrotechnic-actuated	Rocketdyne P/N NA5-26594		8A8
B3	8	Orifice	0.013 in. dia; gearbox pressurizing	Rocketdyne P/N D04-1.2		
B4	8	Orifice	2.70 in. nom dia; fuel discharge line	Rocketdyne P/N RD251-4013		
B5	8	Valve, Check	1/4 in.; gearbox pressurizing	Rocketdyne P/N NA5-28049		

Finding Number	Reqd	Component	Remarks	Vendor	Drawing Number	Elec. Sym.
B6 is not functionally applicable to this system.						
B7	8	Orifice	0.013 in. dia.; LOX seal purge	Rocketdyne P/N D04-1.2		
B8-1	1	Turbopump Assembly	Rated flow: 3257.4 gpm LOX and 2007.6 gpm fuel at 6506 rpm	Rocketdyne P/N 456405-21		1A1
B8-2	1	Turbopump Assembly	Rated flow: 3257.4 gpm LOX and 2007.6 gpm fuel at 6506 rpm	Rocketdyne P/N 456405-21		2A1
B8-3	1	Turbopump Assembly	Rated flow: 3257.4 gpm LOX and 2007.6 gpm fuel at 6506 rpm	Rocketdyne P/N 456405-21		3A1
B8-4	1	Turbopump Assembly	Rated flow: 3257.4 gpm LOX and 2007.6 gpm fuel at 6506 rpm	Rocketdyne P/N 456405-21		4A1
B8-5	1	Turbopump Assembly	Rated flow: 3257.4 gpm LOX and 2007.6 gpm fuel at 6506 rpm	Rocketdyne P/N 456405-21		5A1
B8-6	1	Turbopump Assembly	Rated flow: 3257.4 gpm LOX and 2007.6 gpm fuel at 6506 rpm	Rocketdyne P/N 456405-21		6A1
B8-7	1	Turbopump Assembly	Rated flow: 3257.4 gpm LOX and 2007.6 gpm fuel at 6506 rpm	Rocketdyne P/N 456405-21		7A1
B8-8	1	Turbopump Assembly	Rated flow: 3257.4 gpm LOX and 2007.6 gpm fuel at 6506 rpm	Rocketdyne P/N 456405-51		8A1
B9 is not functionally applicable to this system.						
B10	8	Cap Assembly	3/16 in. tube cap, drilled for safety chain; fuel volute drain	AN 929A3C		

Finding Number	Reqd	Component	Remarks	Vendor	Drawing Number	Elec. Sym.
B11-1	2	Initiator, Turbine Spinner	Actuated by 500 volts ac at 1.5 amps minimum	Rocketdyne NA5-26737		1A6
B11-2	2	Initiator, Turbine Spinner	Actuated by 500 volts ac at 1.5 amps minimum	Rocketdyne NA5-26737		2A6
B11-3	2	Initiator, Turbine Spinner	Actuated by 500 volts ac at 1.5 amps minimum	Rocketdyne NA5-26737		3A6
B11-4	2	Initiator, Turbine Spinner	Actuated by 500 volts ac at 1.5 amps minimum	Rocketdyne NA5-26737		4A6
B11-5	2	Initiator, Turbine Spinner	Actuated by 500 volts ac at 1.5 amps minimum	Rocketdyne NA5-26737		5A6
B11-6	2	Initiator, Turbine Spinner	Actuated by 500 volts ac at 1.5 amps minimum	Rocketdyne NA5-26737		6A6
B11-7	2	Initiator, Turbine Spinner	Actuated by 500 volts ac at 1.5 amps minimum	Rocketdyne NA5-26737		7A6
B11-8	2	Initiator, Turbine Spinner	Actuated by 500 volts ac at 1.5 amps minimum	Rocketdyne NA5-26737		8A6
B12	8	Valve, Check	3/8 in., gas generator LOX injector manifold purge	Rocketdyne P/N 554121		
B13	8	Valve, Relief	Relieves at 2 to 10 psig; lube drain relief	Rocketdyne P/N 304537		
B14	8	Filter	Rated flow: 5 gpm at approx 722 psig; rated at 40 micron	Rocketdyne P/N NA 5-26723A		
B15-1		Fuel Additive Blender Unit	111 cu in. capacity: Oronite 262	Rocketdyne P/N 454075-11		1A3

Finding Number	Reqd	Component	Remarks	Vendor	Drawing Number	Elec. Sym.
B15-2	1	Fuel Additive Blender Unit	111 cu in. capacity, Oronite 262	Rocketdyne P/N 454075-11		2A3
B15-3	1	Fuel Additive Blender Unit	111 cu in. capacity; Oronite 262	Rocketdyne P/N 454075-11		3A3
B15-4	1	Fuel Additive Blender Unit	111 cu in. capacity; Oronite 262	Rocketdyne P/N 454075-11		4A3
B15-5	1	Fuel Additive Blender Unit	111 cu in. capacity; Oronite 262	Rocketdyne P/N 454075-11		5A3
B15-6	1	Fuel Additive Blender Unit	111 cu in. capacity; Oronite 262	Rocketdyne P/N 454075-11		6A3
B15-7	1	Fuel Additive Blender Unit	111 cu in. capacity; Oronite 262	Rocketdyne P/N 454075-11		7A3
B15-8	1	Fuel Additive Blender Unit	111 cu in. capacity; Oronite 262	Rocketdyne P/N 454075-11		8A3
B16	8	Plug, Drain	1/4 in. plug, drilled for lockwire	AN 814-4DL		
B17	8	Coupling Half	Bulkhead mounting; self sealing, Oronite 262 fill	Aeroquip Corp., Aircraft Div. P/N 340234-4		
B18	8	Coupling Half	Bulkhead mounting, self sealing, fuel drain	Aeroquip Corp., Aircraft Div. P/N 340234-8		
B19	8	Gas Turbine	Impulse-type, two stage; develops 3793 bhp	Rocketdyne P/N 454204		
B20-1	1	Turbine Spinner	Gas generating solid propellant	Rocketdyne P/N 651240-31		1A6

Finding Number	Reqd	Component	Remarks	Vendor	Drawing Number	Elec. Sym.
B20-2	1	Turbine Spinner	Gas generating solid propellant	Rocketdyne P/N 651240-31		2A6
B20-3	1	Turbine Spinner	Gas generating solid propellant	Rocketdyne P/N 651240-31		3A6
B20-4	1	Turbine Spinner	Gas generating solid propellant	Rocketdyne P/N 651240-31		4A6
B20-5	1	Turbine Spinner	Gas generating solid propellant	Rocketdyne P/N 651240-31		5A6
B20-6	1	Turbine Spinner	Gas generating solid propellant	Rocketdyne P/N 651240-31		6A6
B20-7	1	Turbine Spinner	Gas generating solid propellant	Rocketdyne P/N 651240-31		7A6
B20-8	1	Turbine Spinner	Gas generating solid propellant	Rocketdyne P/N 651240-31		8A6
B21	8	Orifice	0.320 in. nom dia; LOX bootstrap line	Rocketdyne P/N RD251-4012		
B22	8	Gas Generator Combustor Assembly	Chamber press.: 612.1 psia	Rocketdyne P/N 307350		
B23-1 thru B23-3	3	Gas Generator Control Valve Assembly	NC; Operating press.: 275 psia	Rocketdyne P/N 303775		
B23-4	1	Gas Generator Control Valve Assembly	NC; Operating press.: 275 psia	Rocketdyne P/N 303600		
B23-5 thru B23-7	3	Gas Generator Control Valve Assembly	NC; Operating press.: 275 psia	Rocketdyne P/N 303775		

Finding Number	Reqd	Component	Remarks	Vendor	Drawing Number	Elec. Sym.
B23-8	1	Gas Generator Control Valve Assembly	NC; Operating press.: 275 psia	Rocketdyne P/N 303600		
B24	8	Valve, Check	3/4 in.; heat exchanger LOX line	Rocketdyne P/N NA5-26032T2L		
B25 is not functionally applicable to this system.						
B26	32	Plugs Drain	1/4 in., fillister head, 10-32 thread; fuel jacket drain	AN501A10-4		
B27-1 thru B27-3	3	Aspirator	Outboard engines only	Rocketdyne P/N 204586		
B27-4	1	Aspirator	Outboard engines only	Rocketdyne P/N 204600		
B28-1 thru B28-3	3	Thrust Chamber	Outboard engines	Rocketdyne P/N 206078		
B28-4	1	Thrust Chamber	Outboard engines	Rocketdyne P/N 205198		
B28-5 thru B28-7	3	Thrust Chamber	Inboard engines	Rocketdyne P/N 206076		
B28-8	1	Thrust Chamber	Inboard engine	Rocketdyne P/N 206076-11		
B29	24	Orifice	0.102 (+ 0.000, - 0.001) in dia; heat exchanger LOX	Part of 10438000	20M01029	
B30	8	Heat Exchanger Assembly	LOX to GOX conversion	Government Furnished Equipment (GFE)	1043800	

Finding Number	Reqd	Component	Remarks	Vendor	Drawing Number	Elec. Sym.
B31	8	Coupling Half	Bulkhead mounting; self sealing; fuel jacket fill	Aeroquip Corp. Aircraft Div P/N 340234-8		
B32	8	Orifice	0.600 in. nom dia; fuel bootstrap line	Rocketdyne P/N RD251-4005		
B33 through B35 are not functionally applicable to this system.						
B36-1	1	Hypergol Container Assembly	Hypergol flame temp 1200F; energy release 18,300 btu/lb	Rocketdyne P/N 205181		1A7
B36-2	1	Hypergol Container Assembly	Hypergol flame temp 1200F; energy release 18,300 btu/lb	Rocketdyne P/N 205181		2A7
B36-3	1	Hypergol Container Assembly	Hypergol flame temp 1200F; energy release 18,300 btu/lb	Rocketdyne P/N 205181		3A7
B36-4	1	Hypergol Container Assembly	Hypergol flame temp 1200F; energy release 18,300 btu/lb	Rocketdyne P/N 205181		4A7
B36-5	1	Hypergol Container Assembly	Hypergol flame temp 1200F; energy release 18,300 btu/lb	Rocketdyne P/N 205181		5A7
B36-6	1	Hypergol Container Assembly	Hypergol flame temp 1200F; energy release 18,300 btu/lb	Rocketdyne P/N 205181		6A7
B36-7	1	Hypergol Container Assembly	Hypergol flame temp 1200F; energy release 18,300 btu/lb	Rocketdyne P/N205181		7A7
B36-8	1	Hypergol Container Assembly	Hypergol flame temp 1200F; energy release 18,300 btu/lb	Rocketdyne P/N 205181		8A7
B37	24	Valve, Check	1/4 in.; fuel injector purge	Rocketdyne P/N NA5-28049		

Finding Number	Reqd	Component	Remarks	Vendor	Drawing Number	Elec. Sym.
B38	8	Valve, Ignition Monitor	1/4 in., 3-way, NC; main fuel valve central	Rocketdyne P/N 554838		
B39-1 thru B39-7	7	Valve, Main Fuel	NC; butterfly-type W/4.25 in. dia gate	Rocketdyne P/N 405444		
B39-8	1	Valve, Main Fuel	NC; butterfly-type W/4.25 in. dia gate	Rocketdyne P/N 406222		
B40 is not functionally applicable to this system.						
B41-1	1	Switch, Pressure	Diaphragm actuated toggle mechanism; thrust OK	Southwestern Ind. Inc. P/N PS-5807	60C20278	1A11
B41-2	1	Switch, Pressure	Diaphragm actuated toggle mechanism; thrust OK	Southwestern Ind. Inc. P/N PS-5807	60C20278	2A11
B41-3	1	Switch, Pressure	Diaphragm actuated toggle mechanism; thrust OK	Southwestern Ind. Inc. P/N PS-5807	60C20278	3A11
B41-4	1	Switch, Pressure	Diaphragm actuated toggle mechanism; thrust OK	Southwestern Ind. Inc. P/N PS-5807	60C20278	4A11
B41-5	1	Switch, Pressure	Diaphragm actuated toggle mechanism; thrust OK	Southwestern Ind. Inc. P/N PS-5807	60C20278	5A11
B41-6	1	Switch, Pressure	Diaphragm actuated toggle mechanism; thrust OK	Southwestern Ind. Inc. P/N PS-5807	60C20278	6A11
B41-7	1	Switch, Pressure	Diaphragm actuated toggle mechanism; thrust OK	Southwestern Ind. Inc. P/N PS-5807	60C20278	7A11
B41-8	1	Switch, Pressure	Diaphragm actuated toggle mechanism; thrust OK	Southwestern Ind. Inc. P/N PS-5807	60C20278	8A11

Finding Number	Reqd	Component	Remarks	Vendor	Drawing Number	Elec. Sym.
B42	16	Auto-Igniter	Squibless type;	Rocketdyne P/N 651139		
B43	8	Plug, Drain	1/4 in. plug, drilled for lockwire; fuel discharge line	AN814-4CL		
B44	8	Manifold, Fuel Drain	Inboard and outboard engines	Chrysler Corp. Space Div., Michoud Operations	20C50113	
B45	8	Valve, Check	1/2 in.; LOX dome purge	Rocketdyne P/N NA5-26032T1L		
B46-1	1	Valve, Sequence	NC; cam actuated	Rocketdyne P/N 403520		1A5
B46-2	1	Valve, Sequence	NC; cam actuated	Rocketdyne P/N 403520		2A5
B46-3	1	Valve, Sequence	NC; cam actuated	Rocketdyne P/N 403520		3A5
B46-4	1	Valve, Sequence	NC; cam actuated	Rocketdyne P/N 403520		4A5
B46-5	1	Valve, Sequence	NC; cam actuated	Rocketdyne P/N 403520		5A5
B46-6	1	Valve, Sequence	NC; cam actuated	Rocketdyne P/N 403520		6A5
B46-7	1	Valve, Sequence	NC; cam actuated	Rocketdyne P/N 403520		7A5
B46-8	1	Valve, Sequence	NC; cam actuated	Rocketdyne P/N 403520		8A5

Finding Number	Reqd	Component	Remarks	Vendor	Drawing Number	Elec. Sym.
B47	4	Manifold, LOX Drain	Inboard engines only	Chrysler Corp., Space Division Michoud Operations	20C50124	
B48	8	Orifice	0.060 in. dia; fuel bleed line	Rocketdyne P/N NA5-24002-123		
B49-1	1	Valve, Main LOX	NC; butterfly-type w/ 4.25 in. dia gate	Rocketdyne P/N 405967		1A4
B49-2	1	Valve, Main LOX	NC; butterfly-type w/ 4.25 in. dia gate	Rocketdyne P/N 405967		2A4
B49-3	1	Valve, Main LOX	NC; butterfly-type w/ 4.25 in. dia gate	Rocketdyne P/N 405967		3A4
B49-4	1	Valve, Main LOX	NC; butterfly-type w/ 4.25 in. dia gate	Rocketdyne P/N 405967		4A4
B49-5	1	Valve, Main LOX	NC; butterfly-type w/ 4.25 in. dia gate	Rocketdyne P/N 405967		5A4
B49-6	1	Valve, Main LOX	NC; butterfly-type w/ 4.25 in. dia gate	Rocketdyne P/N 405967		6A4
B49-7	1	Valve, Main LOX	NC; butterfly-type w/ 4.25 in. dia gate	Rocketdyne P/N 405967		7A4
B49-8	1	Valve, Main LOX	NC; butterfly-type w/ 4.25 in. dia gate	Rocketdyne P/N 405967		8A4
B50 through B74 are not functionally applicable to this system.						
B75	4	Pump, Hydraulic	Rated flow: 18 gpm at 4300 rpm	American Brake Shoe Co. Model No. APGV-24K	20C85035	

Finding Number	Reqd	Component	Remarks	Vendor	Drawing Number	Elec. Sym.
B76	8	Plug, Seepage	Fabricated from epoxy resin w/ sponge seepage core		20C85056	
B77 is not functionally applicable to this system.						
B78	4	Indicator, Differential Pressure	Actuating press.: 80 (± 10) psid	Aircraft Porous Media, Inc. P/N AC-2100-118ONT	20C85074	
B79	4	Valve, Check	Cracking press.: 2 to 8 psid operating pres.: 3200 psig	Parker Aircraft Co. P/N 362-0846-8	20C85109-3	
B80	4	Auxiliary Pump Assembly	Rated flow: 3.5 gpm at 11,000 rpm	Vickers Incorp. Model No. PV006L012B	20C85064	
B81-1	1	Motor Assembly	200 volts, 3 phase, 400 cycles	U. S. Electric Motors P/N 406930	20C85065	1A9
B81-2	1	Motor Assembly	200 volts, 3 phase, 400 cycles	U. S. Electric Motors P/N 406930	20C85065	2A9
B81-3	1	Motor Assembly	200 volts, 3 phase, 400 cycles	U. S. Electric Motors P/N 406930	20C85065	3A9
B81-4	1	Motor Assembly	200 volts, 3 phase, 400 cycles	U. S. Electric Motors P/N 406930	20C85065	4A9
B82	4	Valve, Check	Cracking press.: 2 to 8 psid operating press.: 3200 psig	Parker Aircraft Co. P/N 362-0846-6	20C85109-1	
B83	24	Valve, Bleed	Operating press.: 3200 psig	Fluid Regulators Corp. P/N 7579-5	20C85009	
B84	4	Coupling Half, Quick Disconnect	Operating press.: 3200 psig	Aeroquip Corp. P/N 340246-8	20C85082	

Finding Number	Reqd	Component	Remarks	Vendor	Drawing Number	Elec. Sym.
B85	4	Filter	Rated flow: 10 gpm at 3200 psig; rated at 17 microns absolute, 2 microns nom	Bendix Filter Div. P/N 043581	20C85087	
B86-1	1	Accumulator Reservoir Assembly	Hydraulic fluid, GN_2	Cadillac Gage Co. P/N 20296	20C85062	1A10
B86-2	1	Accumulator Reservoir Assembly	Hydraulic fluid, GN_2	Cadillac Gage Co. P/N 20296	20C85062	2A10
B86-3	1	Accumulator Reservoir Assembly	Hydraulic fluid, GN_2	Cadillac Gage Co. P/N 20296	20C85062	3A10
B86-4	1	Accumulator Reservoir Assembly	Hydraulic fluid, GN_2	Cadillac Gage Co. P/N 20296	20C85062	4A10
B87-1	1	Potentionmeter	Wire wound; linear actuating	Servonic Instruments Inc. P/N G-156	20C85093	1A463
B87-2	1	Potentionmeter	Wire wound; linear actuating	Servonic Instruments Inc. P/N G-156	20C85093	2A461
B87-3	1	Potentionmeter	Wire wound; linear actuating	Servonic Instruments Inc. P/N G-156	20C85093	3A463
B87-4	1	Potentionmeter	Wire wound; linear actuating	Servonic Instruments Inc. P/N G-156	20C85093	4A461
B88	4	Valve, High-Pressure Charging	1600 psig GN_2	Cadillac Gage Co. P/N 18659		
B89	4	Valve, Relief	Relieves at 3800 (± 100) psig; reseats at 3400 psig min	Fluid Regulators Corp. P/N C485-02	20C85078	
B90	4	Coupling Half, Quick-Disconnect	Operating press.: 125 psig	Aeroquip Corp. P/N 370250-12	20C85081	

Finding Number	Reqd	Component	Remarks	Vendor	Drawing Number	Elec. Sym.
B91	4	Valve, Relief	Relieves at 100 (± 10) psig; reseats at 75 psig min	Parker Aircraft Co. P/N H60C0661	20C85077	
B92-1	1	Transducer, High-Pressure	Press. range: 0 to 4000 psig	Servonic Instruments, Inc. P/N H-204	20C85079	1A427
B92-2	1	Transducer, High-Pressure	Press. range: 0 to 4000 psig	Servonic Instruments, Inc. P/N H-204	20C85079	2A426
B92-3	1	Transducer, High-Pressure	Press. range: 0 to 4000 psig	Servonic Instruments, Inc. P/N H-204	20C85079	3A427
B92-4	1	Transducer, High-Pressure	Press. range: 0 to 4000 psig	Servonic Instruments, Inc. P/N H-204	20C85079	4A426
B93-1	1	Switch, Thermal	Opens at 200 (± 10) F; recloses at 155 (± 10) F	Texas Instruments, Inc. P/N 21400	20C85016	1A10
B93-2	1	Switch, Thermal	Opens at 200 (± 10) F; recloses at 155 (± 10) F	Texas Instruments, Inc. P/N 21400	20C85016	2A10
B93-3	1	Switch, Thermal	Opens at 200 (± 10) F; recloses at 155 (± 10) F	Texas Instruments, Inc. P/N 21400	20C85016	3A10
B93-4	1	Switch, Thermal	Opens at 200 (± 10) F; recloses at 155 (± 10) F	Texas Instruments, Inc. P/N 21400	20C85016	4A10
B94-1	1	Actuator, Hydraulic	Operating press.: 3200 psig; pitch control	Moog Servocontrols, Inc. P/N 010-28482	50C01173	1A14
B94-2	1	Actuator, Hydraulic	Operating press.: 3200 psig; pitch control	Moog Servocontrols, Inc. P/N 010-28482	50C01173	2A12
B94-3	1	Actuator, Hydraulic	Operating press.: 3200 psig; pitch control	Moog Servocontrols, Inc. P/N 010-28482	50C01173	3A14

Finding Number	Reqd	Component	Remarks	Vendor	Drawing Number	Elec. Sym.
B94-4	1	Actuator, Hydraulic	Operating press.: 3200 psig; pitch control	Moog Servocontrols, Inc. P/N 010-28482	50C01173	4A12
B95-1	1	Actuator, Hydraulic	Operating press.: 3200 psig; yaw control	Moog Servocontrols, Inc. P/N 010-28482	50C01173	1A12
B95-2	1	Actuator, Hydraulic	Operating press.: 3200 psig; yaw control	Moog Servocontrols, Inc. P/N 010-28482	50C01173	2A14
B95-3	1	Actuator, Hydraulic	Operating press.: 3200 psig; yaw control	Moog Servocontrols, Inc. P/N 010-28482	50C01173	3A12
B95-4	1	Actuator, Hydraulic	Operating press.: 3200 psig; yaw control	Moog Servocontrols, Inc. P/N 010-28482	50C01173	4A14
B96	4	Switch, Thermal	NC Contacts: open at 350(± 18F,) reclose at 310 (± 18) F	U. S. Electric Motors Inc. Part of P/N406930	Part of 20C85065	1A9J2
B97	4	Filter, Case Drain	Rated flow: 2 gpm at 100 psig; rated at 17 microns max	Aircraft Porous Media, Inc. P/N AC-4913E-1	20C85085	
B98	4	Valve, Bleed	Operating press.: 53 psig	Fluid Regulators Corp. P/N 7409-5	20C85086	
B99 through 172 are not functionally applicable to this system.						
B173	8	Valve, Check		Precision Equipment Co P/N 126060	20C30046	
B174 through B213 are not functionally applicable to this system.						
B214	1	Valve, Manual	1/4 in., 3-way, needle	Benton Corp. P/N B-15600	1041087	

Finding Number	Reqd	Component	Remarks	Vendor	Drawing Number	Elec. Sym.
B215 through B300 are not functionally applicable to this system.						
B301	1	Coupling Half, Quick-Disconnect	1 in.	E. B. Wiggins Co. P/N 6005R92A16	20C30165	
B302 is not functionally applicable to this system.						
B303	1	Coupling Half, Quick-Disconnect	1-1/4 in.	E. B. Wiggins Co. P/N 7005R11A20	20C30166	
B304	2	Coupling Half, Quick-Disconnect	1 in.	E. B. Wiggins Co. P/N 6005R92A16	20C30165	
B305	8	Orifice	0.042 (+ 0.002, -0.000) in. dia		20C00991	

SECTION 3

MECHANICAL SCHEMATICS

This section contains a mechanical schematic that shows the functional arrangement of H-I engine and hydraulic system components listed in section II

For a definition of the mechanical symbols used, see MSFC-STD-162A.

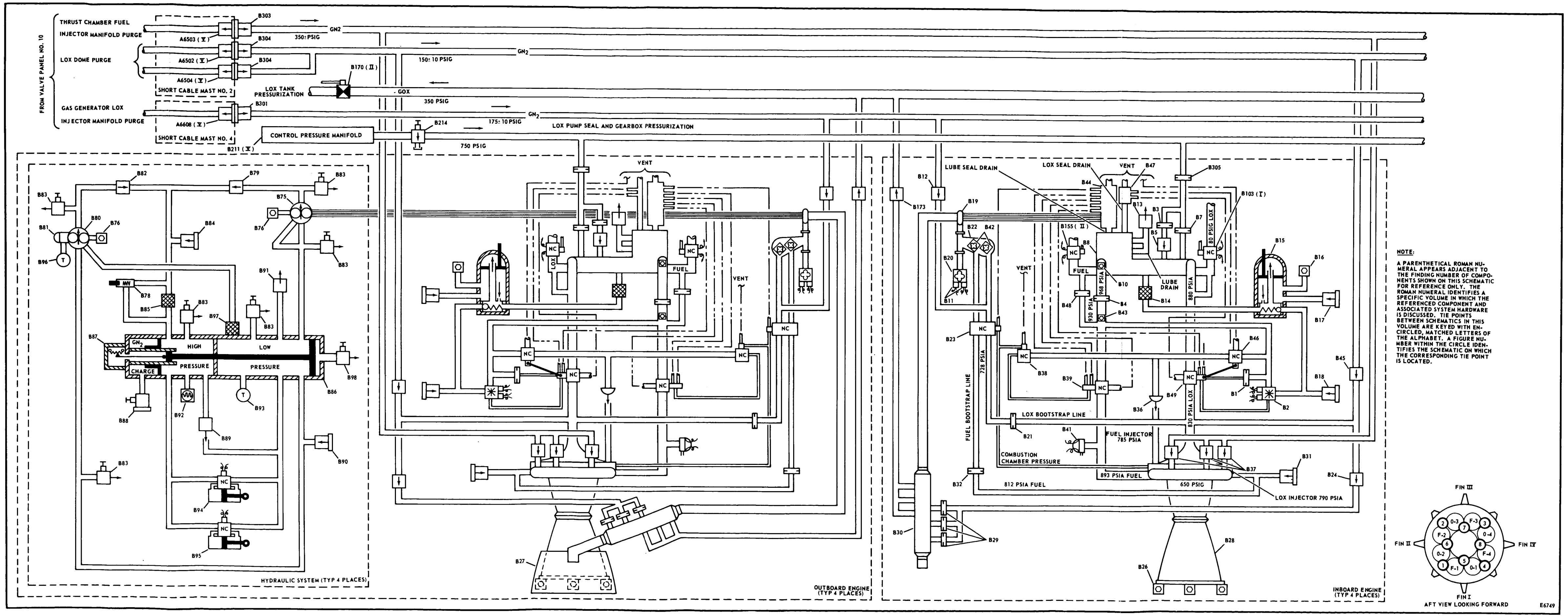

Figure 3-1. H-1 Engine and Hydraulic System

APPENDIX A

LISTING OF LAUNCH VEHICLE SA-8 AND LAUNCH COMPLEX 37B VOLUMES

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