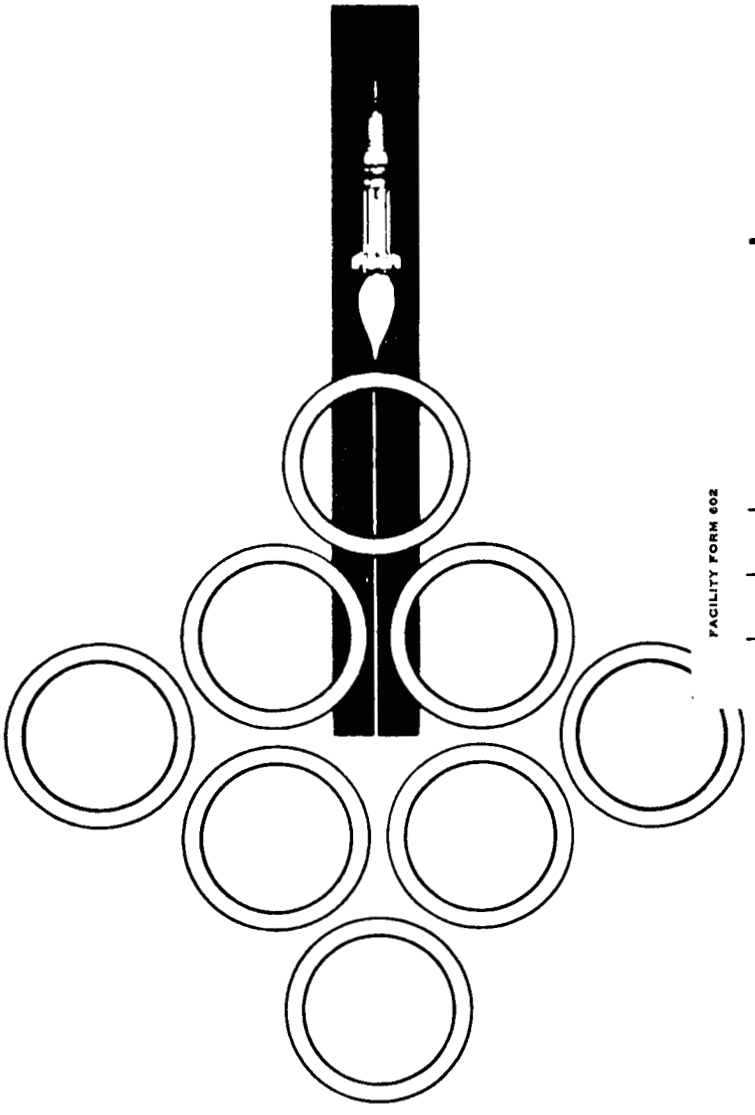

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LAUNCH VEHICLE SA-10 AND LAUNCH COMPLEX 37B FUNCTIONAL SYSTEMS DESCRIPTION

Volume III

LH_2 FUEL SYSTEM FUNCTIONAL DESCRIPTION, INDEX OF FINDING NUMBERS, AND MECHANICAL SCHEMATICS

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SATURN I
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VOLUME III
LH_2 FUEL SYSTEM
FUNCTIONAL DESCRIPTION, INDEX OF FINDING NUMBERS, AND MECHANICAL SCHEMATICS

AUGUST 1964

CHRYSLER CORPORATION SPACE DIVISION - NEW ORLEANS, LOUISIANA

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FOREWORD

This volume is one of a set of eleven volumes that describe mechanical and electro-mechanical systems of the Saturn I, SA-10 launch vehicle and launch complex 37B. The eleven-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. Volume titles are listed below:

Volume I	RP-1 Fuel System
Volume II	LOX System
Volume III	LH_2 Fuel System
Volume IV	Nitrogen and Helium Storage Facility
Volume V	Pneumatic Distribution System
Volume VI	Environmental Conditioning Systems
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

The technical content of this volume reflects up-to-date design information available from the S-I/S-IB Project Engineer, R-P&VE on August 7, 1964.

System mechanical schematics are provided in section 3 to support the functional description of the system. The index of finding numbers in section 2 provides physical and functional descriptions of components identified on the mechanical schematics.

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SECTION 1

FUNCTIONAL DESCRIPTION

1.1 INTRODUCTION

The LH_2 (liquid hydrogen) fuel system as described in this volume is comprised of equipment on launch complex 37B and launch vehicle equipment within the S-IV stage. The launch complex equipment stores LH_2 for fueling the S-IV stage and, during the launch vehicle countdown, loads the S-IV stage with a predetermined quantity of LH_2. Launch complex equipment also drains LH_2 from the stage in the event of a launch cancellation. S-IV stage equipment receives and stores LH_2 supplied from the launch complex and, during vehicle flight, controls the supply of LH_2 to the S-IV stage propulsion system. Figure 1-1 identifies system equipment with respect to both location and functional subsystem arrangement.

This section describes major components and subsystems and describes the operation of the system during an abort-free vehicle countdown, launch, and flight. Specifically excluded from the description are components and subsystems that function as a result of an abortive malfunction or are used exclusively for maintenance of launch complex equipment.

1.2 SYSTEM FUNCTIONS

The LH_2 system has three major functions; it stores LH_2 for fueling the S-IV stage, it transfers LH_2 to and from the S-IV stage, and it controls the supply of LH_2 to the S-IV stage propulsion system.

1.2.1 LH_2 Storage (Figure 1-1) - The storage of LH_2 in the LH_2 storage facility involves three operations; storage facility purge, storage tank filling, and storage tank pressurization. Before the storage tank is filled, the tank and storage facility lines are purged with gaseous nitrogen (GN_2) to prevent the formation of explosive mixtures of air and hydrogen. Following the GN_2 purge, the storage tank is purged with gaseous hydrogen (GH_2) and filled with LH_2 from mobile tankers. Until LH_2 transfer operations are initiated, the LH_2 remains in the storage tank under a pressure of approximately 4 psig.

1.2.2 LH_2 Transfer (Figure 1-1) - There are two types of LH_2 transfer operations; prelaunch operations performed to fuel the S-IV stage, and operations performed in the event of a launch cancellation to drain LH_2 from the S-IV stage and remove residual LH_2 or GH_2 in the transfer lines. The prelaunch and launch cancellation transfer operations are described in the following paragraphs.

1.2.2.1 Prelaunch Operations. Prelaunch operations include S-IV stage propellant tank assembly and transfer line purge, S-IV stage LOX tank pressurization, LH_2 storage tank pressurization, transfer line and S-IV stage cooldown, fill, replenish, and final topping. These operations are initiated and monitored at the LH_2 control

and LH_2 components panels in the launch control center (LCC) and are jointly controlled by Douglas Aircraft Company (DAC) and Launch Operations Control (LOC) propellant loading control equipment in the automatic ground control station (AGCS). Normally, the operations are sequenced automatically; but, mode selection capabilities at the LH_2 control panel allow manual sequencing or simulation of the operations. The S-IV Stage propellant tank assembly and transfer lines are purged to provide an inert atmosphere within the S-IV stage and the transfer line prior to LH_2 transfer. The purge medium is helium (He) supplied from valve panel A (volume V). After passing through the stage and transfer lines, the He is vented to the launch facility burn pond.

The S-IV stage LOX tank is pressurized with He to approximately 48 psig to prevent collapse of the common bulkhead between the LH_2 tank and the LOX tank.

The LH_2 storage tank is pressurized to provide the pressure head necessary for transferring LH_2 from the storage tank to the S-IV stage LH_2 tank. Pressurization is accomplished by means of an LH_2 vaporizer that warms LH_2 drawn from the storage tank and provides gaseous hydrogen (GH_2) for tank pressurization. The storage tank pressurization components control GH_2 flow into the tank and maintain tank pressure at approximately 42 psig throughout LH_2 transfer.

Immediately following storage tank pressurization, cooldown of the transfer line and the S-IV stage is initiated. During this operation, LH_2 flows, at a limited rate, from the storage tank through the LH_2 subcooler and transfer line and into the S-IV stage LH_2 tank. The LH_2 flow precools the transfer line and LH_2 tank to reduce LH_2 vaporization during subsequent LH_2 transfer. The cooldown LH_2 supply continues to flow until the S-IV stage LH_2 tank is 15 percent filled.

When the S-IV stage LH_2 tank is 15 percent filled, main fill transfer is initiated automatically and LH_2 flow from the storage tank to the S-IV stage is increased to approximately 2000 gpm. Main fill continues at this rate until the S-IV stage propellant loading control equipment senses that the LH_2 tank is 92 percent full. At this point in the filling operation, the S-IV stage propellant loading control equipment sends a signal that terminates LH_2 flow through the main fill valve and initiates the replenish operation.

During replenish, LH_2 flows to the S-IV stage through the replenish valve which regulates the LH_2 flowrate to either 20 gpm or 500 gpm. The 500-gpm flow is maintained until the LH_2 tank is 99.25 percent filled as indicated by S-IV stage propellant loading control equipment. At this indication, the replenish valve reduces LH_2 flow to 20 gpm, which is less than enough to compensate for boiloff losses. When the LH_2 tank fuel level falls to the 99-percent-full level, the replenish valve increases LH_2 to 500 gpm and maintains this flowrate until the tank is again filled to the 99.25-percent-full level. The fuel level is repeatedly adjusted between 99.00 and 99.25 percent full until final topping is initiated at approximately T -140 seconds in the prelaunch countdown.

During final topping, the LH_2 tank is filled to the 100-percent-full level and pressurized. LH_2 flow through the replenish valve is increased to, and is maintained at, 500 gpm until the tank is 100 percent filled. S-IV stage propellant loading control equipment then commands closure of the replenish valve, the S-IV stage fill and drain valve, and LH_2 tank vent valves. With closure of the replenish valve, the transfer line vent valve is opened, and the transfer line between the replenish valve and the vehicle is vented to the launch facility burn pond. The S-IV stage LH_2 tank is then pressurized with helium routed from valve panel B (volume V) to S-IV stage LH_2 tank pressurization components. Final topping is complete at approximately T -90 seconds.

At liftoff, all ground connections to the vehicle are released, and the umbilical housings are purged with helium.

1.2.2.2 Launch Cancellation Operations. This group of operations includes LH_2 storage tank venting, S-IV stage LH_2 tank pressurization, S-IV stage LH_2 tank draining, transfer line warmup, and manually controlled GN_2 purging of residual GH_2 from the transfer line (manual inerting).

When a launch is cancelled, LH_2 transfer to the S-IV stage is halted and the LH_2 system is placed in standby status. To prevent further LH_2 transfer to the vehicle, the main fill and replenish transfer valves are closed, and the S-IV stage fill and drain valve is closed.

Upon initiation of S-IV stage LH_2 drain, the LH_2 storage tank pressurization supply is terminated and storage tank pressure is vented to the atmosphere. Simultaneously, the S-IV stage LH_2 tank vent valves are closed and the tank is pressurized with helium. When the LH_2 tank pressurization is complete, the S-IV stage fill and drain valve, main fill valve and replenish valve are opened. The S-IV stage LH_2 tank pressure forces LH_2 from the tank, through the transfer line, and into the LH_2 storage tank.

As LH_2 is drained, transfer line temperature is monitored as a means of detecting LH_2 flow. A temperature increase indicates a reduction of LH_2 flow resulting from depletion of LH_2 in the S-IV stage LH_2 tank. When an increase in transfer line temperature is indicated, the line warmup operation is initiated. LH_2 transfer to the storage tank and further S-IV stage LH_2 tank pressurization are terminated, and the transfer line is vented to the launch facility burn pond. Venting is continued for 3 hours to allow complete vaporization of residual LH_2 and the dissipation of GH_2 vapors. Following line warmup, manual valves are opened to admit a low-pressure GN_2 purge supply to the transfer line. The GN_2 purge eliminates any remaining GH_2 and provides an inert atmosphere within the lines.

1.2.3 S-IV Stage Propulsion System Supply - System equipment in the S-IV stage performs three operations in supplying LH_2 to the stage propulsion system; it controls LH_2 tank pressurization to maintain the structural integrity of the tank and to provide a net positive suction head to the engine turbopumps, it equally distributes LH_2 to the six RL10A-3S engines, and it monitors fuel depletion and provides fuel

mass signals used by the S-IV stage propellant utilization system in initiating engine cutoff.

1.3 SYSTEM DESCRIPTION

1.3.1 Storage Subsystem - The major components within the LH_2 storage subsystem are identified in figure 1-1. The more complex of these components are described below; the remainder are described in the index of finding numbers, on system mechanical schematics and in descriptions of system operations.

1.3.1.1 Pneumatic Control Console (Figure 3-1). The pneumatic control console receives 3500-psig GN_2 from the nitrogen and helium storage facility (volume IV) and provides 750- and 25-psig GN_2 outputs. The 750-psig GN_2 output is used to operate pneumatic valves in the LH_2 storage facility. The GN_2 is routed to the pneumatic valves through solenoid valves which are controlled by signals from the launch control center. The 25-psig GN_2 output is used as a reference pressure for several storage facility control devices and is distributed through restrictive orifices for purging lines and electrical equipment cabinets.

1.3.1.2 Storage Tank Pressurization Components (Figure 3-1). Storage tank pressurization components include an LH_2 vaporizer, pressure controllers, flow regulators, and other associated control devices. These components maintain storage tank ullage pressure at approximately 4 psig during steady state storage conditions and increase the pressure to approximately 42 psig during LH_2 transfer operations. During steady-state conditions, storage tank pressurization is accomplished through controlled venting of LH_2 boiloff within the storage tank. During LH_2 transfer operations, however, additional tank pressurization is provided by LH_2 Vaporizer A3754. The vaporizer receives LH_2 from LH_2 Storage Tank A3753 and provides GH_2 for storage tank pressurization. Excess pressure is vented to the storage facility burn pond. Major components associated with pressurization control are listed and described below.

a. Flow Regulator A3338 - Maintains storage tank pressure at approximately 4 psig during LH_2 storage and storage tank filling operations by controlling the venting of LH_2 boiloff. The regulator position is determined by the differential pressure applied across its actuator.

   The actuator receives 25-psig GN_2 from the pneumatic control console and a varying GN_2 supply from Pneumatic Controller A3551. The pneumatic controller increases control pressure from 3 to 15 psig as storage tank ullage pressure rises and thereby decreases the differential pressure across the regulator actuator. Regulator position is varied until venting is adjusted to maintain storage tank pressure at approximately 4 psig. When storage tank pressure exceeds 4 psig, venting control is transferred to main vent Pneumatic Valve A3304.

b. Flow Regulator A3305 - Controls the flow of LH_2 to Vaporizer A3754 to maintain storage tank pressure at 42 psig during LH_2 transfer operations. Regulator

position is determined by the differential between control pressures applied across the regulator actuator. The actuator receives a constant 25-psig GN_2 supply from the pneumatic control console and a varying GN_2 supply from Pneumatic Controller A3544.

The pneumatic controller senses storage tank ullage pressure and varies differential pressure across the regulator to increase or decrease LH_2 flow through the regulator. As storage tank pressure increases, differential pressure is decreased and LH_2 flow is reduced. When storage tank pressure reaches 42 psig, the regulator is closed to prevent further pressurization. Should the pneumatic controller malfunction, the regulator can be closed by the action of Solenoid Valve A3387 and Pressure Switch A3538. If storage tank ullage pressure increases to 55 psig, the pressure switch actuates and sends a signal that opens the solenoid valve. The solenoid valve vents control pressure from the regulator actuator and allows the regulator to close.

c. Relief Valve A3640 - Provides overpressure protection for the storage tank vent line by relieving excess pressure at 100 psig to the storage facility burn pond.

1.3.1.3 LH_2 Subcooler (Figure 3-1). LH_2 Subcooler A3752 is a tube-in-shell heat exchanger that supercools LH_2 being transferred to the S-IV stage. The subcooler is positioned in the transfer line such that all LH_2 transfer to and from the S-IV stage passes through it, but it is functional only during the replenish and final topping operations. Supercooling is required to prevent excessive in-line vaporization of LH_2 that would otherwise occur due to the low rate of LH_2 transfer during these operations. The subcooler shell is filled with LH_2 drawn from the transfer line, and the LH_2 being transferred to the S-IV stage passes through a coil of tubes submerged in the LH_2 contained in the subcooler shell. Immediately prior to initiation of the replenish operation, Vacuum Pump A3751 reduces the subcooler shell pressure and thereby reduces the temperature of LH_2 coolant in the shell. LH_2 flowing through the transfer line passes through the tube side of the subcooler and is supercooled to approximately -426 F. Other components functionally associated with subcooler operation are described below:

a. Liquid Level Probe A3509 continuously monitors the LH_2 level within the subcooler shell and provides control pressure for regulating LH_2 flow into the shell. The probe is mounted on top of the subcooler and extends downward between the inner wall of the subcooler and the transfer tubes. The probe is sealed at the bottom, and the upper end is connected to a pressure-tight chamber that is pressurized to 45 psig with GN_2.

Chamber pressure drops as the LH_2 level rises and increases as the LH_2 level drops. Thus, the chamber pressure is indicative of the LH_2 level and is used as a control pressure for regulating the flow of LH_2 to the subcooler shell.

Two capacitance-type, point-level sensors, mounted near the bottom of the probe, sense the LH_2 level and send signals to transducer cabinet indicators for local monitoring of the LH_2 level. Level Sensor A3511 provides a high level indication when submerged in LH_2 and Liquid Level Sensor A3512 provides a low level indication when the LH_2 level recedes below it. Liquid Level Sensor A3511 is also electrically interlocked with Solenoid Valve A3386. Actuation of Solenoid Valve A3386 closes subcooler inlet Flow Regulator A3309. and shuts off LH_2 flow into the subcooler shell.

b. Pneumatic Controller A3513 and Flow Regulator A3309 function together to maintain a constant LH_2 level within the subcooler. The controller senses pressure variations in Liquid Level Probe A3509 and provides proportional increases or decreases in control pressure applied to the flow regulator. The flow regulator controls LH_2 flow from the transfer line into the subcooler. The controller receives a 25-psig GN_2 supply from the pneumatic control console and regulates control pressure applied to the flow regulator between 3 and 15 psig. An increase in LH_2 level reduces the controller output pressure. The reduced output pressure increases differential pressure applied across the flow regulator actuator and thereby reduces LH_2 flow through the flow regulator. A decrease in LH_2 level causes a corresponding decrease in the differential pressure applied to the flow regulator, thereby increasing LH_2 flow through the regulator. Thus, increases or decreases in LH_2 coolant level are compensated for by LH_2 flow regulation through the flow regulator.

c. Pneumatic Controllers A3515 and A3514 provide an alternate means for controlling the LH_2 level adjustments through Flow Regulator A3309. These two controllers substitute for Pneumatic Controller A3513 and Liquid Level Probe A3509, which can be isolated by closing Manual Valve A3412. Pneumatic Controller A3515 senses subcooler LH_2 level and regulates control pressure applied to Pneumatic Controller A3514 which, in turn, regulates the positioning of Flow Regulator A3309. Pneumatic Controller A3515 senses LH_2 level by sensing the differential pressure between the upper and lower taps on the subcooler shell. Upper-tap pressure is applied to the pneumatic controller through Manual Valves A3384 and A3406, and lower-tap pressure is applied through Manual Valves A3385 and A3407. In proportion to the applied differential pressure, Pneumatic Controller A3515 reduces a 25-psig GN_2 supply from the pneumatic control console and provides a 15- to 3-psig control pressure for control of Pneumatic Controller A3514. Pneumatic Controller A3514 also receives a 25-psig GN_2 input from the pneumatic control console and, in proportion to the control pressure applied from Pneumatic Controller A3515, applies a 3- to 15-psig control pressure to Flow Regulator A3309.

d. Flow Regulator A3342 regulates GH_2 flow from the subcooler to Vacuum Pump A3751 during vacuum pump operation to maintain a set subcooler shell pressure. The flow regulator receives 25-psig GN_2 control pressure from the pneumatic console and a variable control pressure of 3- to 15-psig GN_2 from Pneumatic Controller A3554. The differential between these control pressures determines the regulator position.

The pneumatic controller actuator senses, as control pressure, subcooler shell pressure over a range of 0 to 15 psig. In proportion to the applied shell pressure, the pneumatic controller reduces 25-psig GN_2 from the pneumatic control console to a 3- to 15- psig control pressure for positioning Flow Regulator A3342. As Vacuum Pump A3751 reduces the subcooler shell pressure, the control pressure applied to the flow regulator is reduced, thereby reducing GH_2 flow through the flow regulator. Conversely, an increase in subcooler shell pressure causes an increase in GH_2 flow through the flow regulator.

e. Temperature Probe A3585 and Temperature Indicator A3584 provide local monitoring of vacuum line temperature.

f. Temperature Probe A3587 and Temperature Indicator A3586 provide local monitoring of vacuum pump inlet temperature.

g. Pressure Transducer A3547 provides subcooler pressure monitor signals to a vacuum indicator on the LCC LH_2 monitor panel.

h. Subcooler Inlet Temperature Probe A3574 measures line temperature upstream from Subcooler A3752. Measuring instruments associated with the probe measure the vapor pressure inside the probe and provide a temperature indication as a function of vapor pressure. Temperature Indicator A3571 permits local monitoring of line temperature and is used for calibration of Temperature Transducer A3572. Temperature Transducer A3572 provides subcooler inlet temperature monitor signals to a temperature indicator on the LH_2 monitor panel. Temperature is measured over a range of -403 to -430 F.

i. Subcooler discharge Temperature Probe A3583 and Temperature Gage A3582 function together to provide local monitoring of subcooler discharge temperature over a range of -403 F to -430 F.

j. Temperature Probe A3580, Temperature Gage A3576, and Pressure Switch A3578 function together to monitor the transfer line discharge temperature. (See figure 3-2.) Temperature Gage A3576 provides local monitoring of transfer line temperature and is used for calibrating Pressure Switch A3578. Pressure Switch A3578 provides transfer line temperature monitor signals to the LCC temperature recorder and a temperature indicator on the LCC LH_2 monitor panel.

1.3.2 Transfer Subsystem (Figure 3-2) - LH_2 transfer between the LH_2 storage facility and the S-IV stage LH_2 tank is controlled by the main fill and topping control transfer line valve complex within the umbilical tower. Major components within this valve complex are: Main fill Pneumatic Valve A3911, replenish Pneumatic Valve A3910, transfer line vent Pneumatic Valve A3912, and helium heat exchanger LH_2 inlet Pneumatic Valve A3917. The pneumatic valves are controlled by individual solenoid valves that route 750-psig GN_2 control pressure from valve panel B (volume

V) to the appropriate side of the pneumatic valve actuators. The solenoids are controlled by the transfer sequence signals originated at LH_2 control subsystem equipment in the LCC and the AGCS. Each pneumatic valve is equipped with a position indicator switch that is electrically interlocked with an indicator on the LCC LH_2 components panel to provide continuous monitoring of valve position.

a. Main fill transfer Pneumatic Valve A3911 - Opened during the main fill transfer operation and allows a 2000-gpm LH_2 flow to the S-IV stage LH_2 tank.

b. Replenish Pneumatic Valve A3910 - A three-position valve that controls LH_2 transfer flow during the replenish operation. One valve position provides a 500-gpm LH_2 flow and the second valve position limits LH_2 flow to 20 gpm. During the replenish operation, the valve is alternately positioned to the 500-gpm and 20-gpm positions by Solenoid Valves A3923 and A3922 to maintain the S-IV stage LH_2 tank between 99 and 99.25 percent full.

c. Pneumatic Valve A3917 - Directs part of the LH_2 supply being transferred to the S-IV stage to the helium heat exchanger (volume V) for use as a coolant supply.

d. Pneumatic Valve A3912 - Opened upon termination of LH_2 transfer operations to vent GH_2 from the transfer line to the launch facility burn pond. During LH_2 transfer operations, the valve remains closed.

e. Pressure Transducers A3900 and A3916 - Monitor main fill and topping control line pressure during LH_2 transfer operations and provide pressure monitor signals to a pressure indicator on the LH_2 monitor panel. The differential pressure ranges from 0 to 30 psig.

f. Relief Valve A3932 - Provides overpressure protection for the main fill and topping control lines by venting the lines to the launch area burn pond when line pressure reaches 92 ($\pm$ 2) psig.

1.3.3 Control Subsystem - The control subsystem consists of equipment in the launch control center, the automatic ground control station, and the electrical equipment house. These three areas and the control subsystem equipment within each area are identified in figure 1-1.

1.3.3.1 Launch Control Center (LCC). Control subsystem equipment in the LCC consists of the panels and control equipment necessary for initiating, monitoring, and controlling LH_2 transfer operations. Equipment descriptions are provided below:

a. Relay Distributor Assemblies - A relay distributor assembly is mounted in each of the two propellant loading racks to provide a point for power distribution from the LCC to the storage and launch areas.

b. LH_2 Timer Assembly - Contains time relays for use in automatic sequences and power switching relays for controlling system power busses and associated components.

c. LH_2 Control Panel - Provides controls for initiating operations and provides indicators for monitoring operations. The controls and indicators are described below.

(1) Power ON-OFF Switch - Controls electric power to other LH_2 control panel components.

(2) FUNCTION SELECTOR SWITCH - A four-position switch used for selecting one of four modes of system operation: off, operate, simulate, or manual. With the switch at the OPERATE position, the LH_2 system is set for automatic operation, which requires only the momentary depression of sequence buttons to initiate automatic sequencing of system operations. At the SIMULATE position, the switch also provides for automatic sequencing of system operations, but without LH2 transfer. This mode is used only to verify the operation of system components. When turned to the MANUAL position, the switch transfers individual control of system components to controls on the LH_2 components panel. At the OFF position, the switch stops all transfer operations.

(3) CONTROL RETURN Switch - Used to return control of transfer operations to S-IV stage propellant loading control equipment when required.

(4) Prerequisite Indicators - The indicators are mounted across the top of the panel. As each prerequisite is completed, a particular indicator will light. When all the prerequisites are met, and the S-IV stage LH_2 tank is ready for filling, the STANDBY indicator will light in the FILL sequence group of indicators.

(5) FILL, SECURE, and DRAIN Pushbutton Switches - Used to simulate the fill, secure, and drain sequences as required. The fill sequence may be initiated only after the fill sequence STANDBY indicator and the prerequisite indicator lamps are lighted. Progress of the sequence may be monitored on indicators located to the right of the FILL push-button. The secure and drain sequence are monitored in a like manner.

d. LH_2 DC Power Panel - Provides dc power to propellant loading racks No. 6 and No. 7.

e. LH_2 Distributor Assembly - Provides a distribution point for electrical power and control circuits.

f. LH_2 Monitor Panel - Provides ten gages for monitoring various system conditions in the storage facility, launch area, and the vehicle.

(1) Filter Differential Pressure Gage - Indicates the pressure drop across transfer line Filter A3905 (figure 3-2).

(2) Transfer Line Pressure Gage - Indicates the LH_2 pressure in the transfer line.

(3) Transfer Line Outlet Temperature Gage - Indicates the transfer line temperature of LH_2 leaving the storage area.

(4) Vehicle Vent Pressure Gage - Indicates the vehicle vent pressure in the vent stack.

(5) Subcooler Level Gage - Indicates the LH_2 coolant supply level in in Subcooler A3752 (figure 3-1).

(6) Subcooler Inlet Line Pressure Gage - Indicates subcooler shell pressure being maintained by Vacuum Pump A3751 (figure 3-1).

(7) Subcooler Inlet Line Temperature Gage - Indicates the temperature of the LH_2 entering the tube side of Subcooler A3752 (figure 3-1).

(8) Storage Tank Level Gage - Indicates the level of LH_2 in Storage Tank A3753 (figure 3-1).

(9) Storage Tank Pressure Gage - Indicates the storage tank ullage pressure. The measurement range is 0 to 100 psig.

(10) Vehicle Tank Pressure Gage - Indicates the ullage pressure in the S-IV stage LH_2 tank.

g. LH_2 Components Panel - Provides manual control and visual monitoring of individual component operation. Manual control of components is attained by positioning the FUNCTION SELECTOR switch on the LH_2 control panel to the MANUAL position. Indicators on the panel show the condition or position of the various components.

h. S-IV Stage Propellant Loading Control Panels - These panels provide controls for manual operation of system components within the umbilical tower and the S-IV stage, and provide indicators for monitoring component operation.

1.3.3.2 Automatic Ground Control Station (AGCS). Control subsystem equipment in the AGCS consists of an LH_2 dc power panel, an LH_2 control distributor and S-IV stage propellant loading control equipment. Functional descriptions are given below:

a. LH_2 DC Power Panel - A rack-mounted assembly that contains indicating fuses for monitoring system power busses, and power switching relays for switching power to associated busses.

b. LH_2 Control Distributor - Contains the terminal distributors, cable connections and circuit switching relays necessary to transfer power from the LH_2 power panel to remotely located valves.

c. S-IV Stage Propellant Loading Control Equipment - Consists of power distribution and control circuits necessary for the operation and control of system components within the umbilical tower and the S-IV stage.

1.3.3.3 Electrical Equipment House (EEH). Control subsystem equipment in the EEH consists of two control distributors, and LH_2 dc power panel, and an LH_2 monitor panel, all located in rack No. 1. EEH equipment is described below.

a. Control Distributors - Contain terminal connections and other equipment necessary to make cable connections and distribute signals to and from the LCC and storage area equipment.

b. LH_2 DC Power Panel - Contains indicating fuses for monitoring system power busses, and switching relays for switching power to associated busses.

c. LH_2 Monitor Panel - Provides a means for visually monitoring liquid level and ullage presssure within the LH_2 storage tank. The three components mounted on the panel perform the following functions:

(1) Storage Tank Level Indicator - Indicates the level of LH_2 in Storage Tank A3753 (figure 3-1).

(2) Storage Tank Pressure Indicator - Indicates storage tank ullage pressure.

(3) Fill Valve Control Switch - Used to control the position of the storage tank fill Pneumatic Valve A3302 (figure 3-1) during tank filling operations.

1.3.4 S-IV Stage LH_2 Subsystem - Major components of the S-IV stage LH_2 subsystem identified in figure 1-1 are described below.

1.3.4.1 LH_2 Tank (Figure 3-2). LH_2 Tank E102 is part of the S-IV stage propellant tank assembly which is comprised of the LH_2 tank and a LOX tank. The LH_2 tank is mounted above and is physically separated from the LOX tank by a common bulkhead. During prelaunch operations, the LH_2 tank is filled with approximately 28,000 gallons of LH_2. During vehicle flight, the tank supplies LH_2 to the six RL10A-3S engines through individual suction lines.

Capacitance-type Mass Sensor E102, which extends from the top to the bottom of the tank, provides continuous monitoring of fuel mass. The Mass Sensor is a probe consists of two coaxial, cylindrical elements. Each element forms one plate of a capactor that is in one leg of a balanced bridge network in the S-IV Stage Propellant Utilization (PU) system. Variations in LH_2 mass during prelaunch fueling and inflight depletion of LH_2 cause a proportional change in probe capacitance which unbalances the bridge network. The error signal resulting from the unbalanced condition drives servomotors which drive ganged potentiometers to provide feedback signals indicative of LH_2 mass. These signals provide constant monitoring of LH_2 mass during prelaunch fuel loading operations and vehicle flight. A similar arrangement of a capacitance probe and a balanced bridge are used in the S-IV stage LOX system to monitor LOX mass (volume II).

During prelaunch fueling operations, the LH_2 mass feedback signals are used to control LH_2 loading operations. During vehicle flight, the signals serve two functions: they feed telemetry channels for ground monitoring of in-flight LH_2 depletion, and they are compared with LOX mass signals to determine and regulate the proportional rate of LOX and LH_2 consumption by the RL10A-3S engines. (Refer to volume IX for information concerning the RL10A-3S engine LOX and LH_2 mixture ratio.)

1.3.4.2 Fill and Drain Valve (Figure 3-2). Fill and drain Pneumatic Valve E113 controls LH_2 flow into the LH_2 tank during prelaunch fueling operations and is opened in the event of a launch cancellation to drain LH_2 from the tank. Valve actuation is controlled by Solenoid Valves E321 and E322 in response to control signals from S-IV stage propellant loading control equipment in the LCC and the AGCS.

1.3.4.3 Tank Pressurization Components (Figure 3-2). Tank pressurization components include valves, orifices, and pressure switches that jointly control the admission of pressurants to the LH_2 tank from ground support equipment or vehicle supplies and protect the tank from overpressurization. Functions of major components within this group are described below.

a. Vent and relief Pneumatic Valves E114 and E115 relieve excess LH_2 tank pressure and are pneumatically opened to vent the tank during prelaunch filling operations.

b. Solenoid Valves E209 and E210 control pneumatic pressure for opening vent and relief Pneumatic Valves E114 and E115.

c. Solenoid Valve E211 controls pneumatic pressure for closing vent and relief Pneumatic Valves E114 and E115.

d. Solenoid Valve E257 is opened during S-I stage powered flight to pressurize the LH_2 tank with helium from the S-IV stage control pressure system (volume V).

e. Electropneumatic Valves E254 and E255 are opened to provide stepped increases in GH_2 or helium flow into the LH_2 tank to compensate for in-flight decay in LH_2 tank pressure.

f. Pressure Switch E276 monitors LH_2 tank pressure and controls a helium pressurization supply solenoid valve in valve panel B (volume V) to maintain LH_2 tank pressure between 35 to 38 psia during prelaunch pressurization of the tank.

g. Pressure Switch E277 monitors LH_2 tank pressure during S-I stage powered flight and controls tank pressurization supply Solenoid Valves E255 and E257 to maintain tank pressure between 30 and 32 psia.

h. Pressure Switch E278 monitors tank pressure immediately prior to vehicle liftoff and provides a signal to the LCC to indicate whether or not the tank is sufficiently pressurized for liftoff. If tank pressure is below 33.5 (± 0.5) psia the switch signals insufficient tank pressure for liftoff.

i. Pressure Switch E279 actuates and opens tank pressurization Electropneumatic Valve E254 to increase pressurant flow into the LH_2 tank when tank pressure decays to 27.5 (± 0.5) psia.

j. Differential pressure Switch E275 monitors the differential between LH_2 tank and LOX tank pressures and maintains the differential below 4 (± 1) psid by initiating a release of LH_2 tank pressure through vent and relief Pneumatic Valve E115 and E114.

1.4 SYSTEM OPERATIONS

1.4.1 Storage - Storage operations include storage facility purge, storage tank filling, and storage tank pressurization.

1.4.1.1 Storage Facility Purge. The storage facility purge is initiated prior to storage tank filling to prevent the formation of explosive mixtures of air and hydrogen in the storage tank and associated lines. The purge requires external sources of GN_2 and GH_2. The GN_2 source is attached to storage facility couplings and GN_2 flows into storage tank and associated lines. The storage tank is purged by repeatedly filling it with GN_2 and evacuating it until the oxygen content of the tank atmosphere is less than 1.5 percent per unit volume. The GN_2 purge is followed by a warm GH_2 purge which expels the GN_2 and provides a pure GH_2 atmosphere within the tank.

1.4.1.2 Storage Tank Filling. LH_2 is transported to the launch complex in mobile tankers and is subsequently pumped from the tankers into the storage tank. During the filling operations, storage tank pressure is maintained at approximately 4 psig; excess pressure is vented to atmosphere. The filling operation is continued until the tank contains approximately 125,000 gallons of LH_2.

1.4.1.3 Storage Tank Pressurization. After the storage tank has been filled, it is pressurized to 4 psig with GH_2 and held at that pressure until the initiation of LH_2 transfer operations. Prior to the initiation of the main fill operation, however, the tank pressure is increased to, and maintained at approximately 42 psig. This increase in tank pressure provides the pressure head necessary to transfer LH_2 through the transfer lines and into the S-IV stage LH_2 tank.

1.4.2 Preparation For LH_2 Transfer

1.4.2.1 Preoperational System Checkout. Following the storage tank filling operations and prior to the initiation of LH_2 transfer operations, a preoperational check is made of the LH_2 pneumatic control console, storage facility purge supplies, and electrical power supplies. In addition, system manual valves are set up for LH_2 transfer operations.

a. Manual Valve Checkout (Figures 3-1 and 3-2). System manual valves are positioned as follows:

(1) Storage tank Manual Valves A3324 and A3380 are opened.

(2) Storage tank pressurization Manual Valves A3301, A3369 and A3370 are opened.

(3) Subcooler Manual Valve A3412 is opened.

(4) LH_2 transfer line Manual Valves A3303 and A3379 are opened.

(5) Manual Valve A3372 is opened.

(6) All other manual valves are closed.

b. Pneumatic Control Console Checkout (Figure 3-1). The LH_2 pneumatic control console is placed into operation and checked out as follows:

(1) Manual Valves A3712, A3713, A3714, A3715, A3720 and A3771 are opened.

(2) Manual Vent Valves A3716, A3717, A3718, A3719, A3721, A3722, A3723 and A3724 are closed.

(3) Pressure Gages A3700, A3701, A3702, and A3703 must indicate 3500, 750, 120, and 25 psig, respectively. Downstream Pressure Regulators A3704, A3705 and A3706 may be adjusted to provide the correct indications of line pressure at Gages A3701, A3702, and A3703, respectively. Line pressure measured by Gage A3700 must be be adjusted at the nitrogen and helium storage facility (volume IV).

(4) With correct pressures indicated at the pressure gages, the operation of Pressure Switches A3725 and A3711 is verified at the LCC LH_2 control panel. Pressure Switch A3725 actuates on rising pressure of 600 (± 20) psig and lights the STORAGE FACILITY 750-PSI indicator on the LH_2 control panel. Pressure Switch A3711 actuates on a rising pressure of 21.4 (± 0.5) psig and lights the STORAGE FACILITY 25 PSI indicator on the LH_2 control panel.

c. GN_2 Purge Supply Checkout. The S-IV stage and umbilical tower equipment must be placed in a state of readiness for purging, and GN_2 purge supplies to various storage facility components must be pressure-checked and analyzed for oxygen content. Pressure checks are made with a portable manometer, and oxygen content is measured with a portable oxygen analyzer. Purge checks are made as follows:

(1) The vehicle vent stack purge is checked through Manual Valve A3375.

(2) The launch area transducer cabinet purge is checked through a quick-disconnect fitting located in the top of the cabinet.

(3) The storage tank steady-state vent line purge is checked through Manual Valve A3416.

(4) The subcooler transducer cabinet purge is checked through a quick-disconnect coupling located in the top of the cabinet.

d. Electrical Power Checkout. Electrical power must be available to LH_2 system equipment in the EEH, LCC, AGCS, and the storage facility and launch facility burn ponds. Power availability is indicated by LH_2 control panel indicators as follows:

(1) The AGCS & STORAGE FACILITY indicator lights when ac power is available to AGCS and storage facility components.

(2) The STORAGE FACILITY, LCC, AGCS, TOWER S-IV & VEHICLE S-IV indicators light when dc power is available to areas that correspond with the indicator placards.

(3) The TOWER S-IV, S-IV 750 PSI, and STORAGE FACILITY 25 PSI & STORAGE FACILITY 750 PSI indicators light when pneumatic control pressure is available from the LH_2 pneumatic control console. The availability of pneumatic control pressure also indicates the availability of power to EEH equipment.

(4) The STORAGE & LAUNCH FACILITIES indicator lights when power is available at the launch area and storage facility burn ponds.

1.4.2.2 S-IV Stage LH_2 Tank and Transfer Line Purge. Following the preoperational checkout, the LH_2 system is conditioned and powered for performance of the prelaunch countdown. A standby period is initiated to permit the Douglas Aircraft Company (DAC) to check out and purge the S-IV stage and the LH_2 transfer line. During this standby period, system control is transferred from the LCC LH_2 control panel to the DAC operated S-IV stage propellant loading control panels.

a. Control of transfer line vent Pneumatic Valve A3308 (figure 3-1) is transferred to S-IV stage propellant loading control panels from the LCC LH_2 control panel by setting the CONTROL RETURN switch and turning the FUNCTION SELECTOR switch to the MANUAL position. The S-IV status STANDBY light is lighted during this sequence.

b. The S-IV stage LOX tank is pressurized with helium to 29 (± 1) psia. This pressure is maintained until LH_2 tank purging is complete to prevent collapse of the common bulkhead between the LOX and LH_2 tanks.

c. During the standby period, LH_2 tank E102 and the LH_2 transfer line receive a 50-minute helium purge that is initiated by a solenoid valve in valve panel B (volume V). (See figure 3-2.) Helium flows from valve panel B into the S-IV stage LH_2 tank through Quick-Disconnect Couplings A3155 and E250. From the LH_2 tank, the helium flows through fill and drain Pneumatic Valve E113, Quick-Disconnect Couplings E100 and A3159, Electropneumatic Valve A3150, Filter A3905, and to Subcooler A3752 (figure 3-1) through either main fill Pneumatic Valve A3911 or replenish Pneumatic Valve A3910. From the main fill valve or the replenish valve, the purge supply is also routed to the helium heat exchanger (volume V) through Pneumatic Valve A3917. The helium purge supply is vented to the storage facility burn pond through transfer line vent Pneumatic Valve A3308 (figure 3-1) and to the launch facility burn pond through the helium heat exchanger and Pneumatic Valve A3912.

d. As the LH_2 tank and transfer lines are purged, the umbilical vent line and Quick-Disconnect Couplings A2389 and E105 are purged with a 50-psig helium supply routed from valve panel A (volume V) through Check Valve A2388. (See figure 3-2.) This purge supply is also routed through Check Valve A3166 to purge the umbilical fill line. A second 50-psig helium purge supply from valve panel A is routed through Orifices A3167 and A3168 to purge Electropneumatic. Valve A3150 and Quick-Disconnect Coupling A3159. These purges are continued through the transfer line cooldown operation. The umbilical fill line purge removes GH_2 boiloff during the cooldown operation and provides and inert atmosphere in the fill line prior to the cooldown operation. The coupling purge displaces GH_2 which might escape from the couplings during LH_2 transfer.

e. During the standby period purge operations, the LH_2 transfer lines are checked for helium content, and when they are found to contain 99 percent helium, system control is transferred from S-IV stage propellant loading control panels to the LCC LH_2 control panel. The S-IV CONTROL RETURN indicator on the LH_2 control panel goes out to signal the transfer of system control.

1.4.3 Prelaunch LH_2 Transfer

1.4.3.1 Initial Setup. Following DAC checkout and purge of the S-IV stage and transfer lines, LH_2 transfer operations are initiated at the LCC LH_2 control panel by setting the FUNCTION SELECTOR SWITCH to AUTO and pressing the FILL pushbutton.

This setup initiates automatic sequencing of the prelaunch transfer operations described in paragraph 1.2.2.

1.4.3.2 System Interlocks. Various LH_2 system operations are interlocked such that a given operation or a given set of conditions automatically initiates or controls another operation. These interlock functions are numbered and described here for reference. In subsequent descriptions of transfer operations the interlocks are identified by the numbers assigned below.

1. Transfer line fill Pneumatic Valve A3306 is closed unless transfer line output temperature is -406 F or less.

2. Transfer line fill Pneumatic Valve A3306, replenish Pneumatic Valve A3910 and main fill Pneumatic Valve A3911 are closed unless the S-IV stage LOX tank is pressurized. A signal from S-IV stage propellant loading control equipment indicates LOX tank pressurization.

3. Transfer line fill Pneumatic Valve A3306 and transfer line cooldown Pneumatic Valve A3307 close with the opening of transfer line vent Pneumatic Valve A3308.

4. Replenish Pneumatic Valve A3910 and Main fill Pneumatic Valve A3911 close with an S-IV stage LH_2 tank overpressure indication.

5. Replenish Pneumatic Valve A3910 and main fill Pneumatic Valve A3911 close with an S-IV stage LH_2 tank overfill indication.

6. Umbilical line vent Pneumatic Valve A3912 is interlocked closed by S-IV stage propellant loading control equipment with the opening of replenish Pneumatic Valve A3910, main fill Pneumatic Valve A3911, or S-IV stage fill drain Pneumatic Valve E113.

7. Transfer line fill Pneumatic Valve A3306 is closed with the closing of S-IV stage vent Pneumatic Valves E114 and E115.

8. Transfer line helium purge Solenoid Valve A3318 or transfer line high-pressure helium purge Solenoid Valve A3344 are closed with the opening of either subcooler LH_2 inlet Flow Regulator A3309 or helium heat exchanger LH_2 inlet Pneumatic Valve A3917.

9. LH_2 storage tank pressure less than 30 psig causes transfer line helium purge Solenoid Valve A3318 or transfer line high-pressure helium purge Solenoid Valve 3344 to close.

10. LH_2 storage tank main vent Pneumatic Valve A3304 is closed when LH_2 storage tank pressure is equal to or less than 2 psig, or when LH_2 storage tank pressurization Flow Regulator A3305 and transfer line fill Pneumatic Valve A3306 are closed.

1.4.3.3 S-IV Stage LOX Tank Pressurization. When the LH_2 control panel FILL pushbutton is pressed, a command signal is sent to S-IV stage propellant loading control equipment (figure 1-1) to initiate S-IV stage LOX tank pressurization. The command signal also lights the LH_2 control panel PRESSURIZE LOX TANK indicator. LOX tank pressurization to approximately 45 psia prevents collapse of the common bulkhead between the LOX tank and the LH_2 tank as LH_2 is loaded into the LH_2 tank. The LH_2 control panel PRESSURIZED COMPLETE indicator lights when pressurization is complete. (Details of the LOX tank pressurization sequence are covered in volume II.)

1.4.3.4 LH_2 Storage Tank Pressurization (Figure 3-1). When the S-IV stage LOX tank pressurization sequence is complete, the fill sequence automatically progresses to LH_2 storage tank pressurization. The sequence occurs as follows:

a. The LH_2 control panel PRESSURIZE STORAGE TANK indicator lamp lights.

b. Interlock functions 1 and 2 are in effect. (Refer to paragraph 1.4.3.2.)

c. Vaporizer inlet Flow Regulator A3305 is opened by Pneumatic Controller A3544 and Solenoid Valve A3387. Valve opening is monitored by the LH_2 components panel TANK PRESSURIZATION OPEN indicator. LH_2 from the storage tank passes through Manual Valve A3301 and Flow Regulator A3305 to Vaporizer A3754 where it is converted to GH_2 for storage tank pressurization.

d. Relief Valve A3641 vents excess line pressure to the tank pressurization line, downstream from Vaporizer A3754, to maintain a maximum differential pressure of 20 psi across the vaporizer and pneumatic flow regulator.

e. Flow through Flow Regulator A3305 is reduced by Pneumatic Controller A3544 as tank pressure rises. The flow regulator is completely closed when storage tank ullage pressure reaches 42 psig. Pressure Switch A3537 actuates and lights the LCC LH_2 control panel PRESSURIZATION COMPLETE indicator when storage tank pressure rises to 30 psig. Simultaneously, the PRESSURIZE STORAGE TANK indicator goes out. Pressure Switch A3538 actuates at an increasing ullage pressure of 55 psig to remove power from Solenoid Valve A3387. The closing of Solenoid Valve A3387 provides redundancy for Pneumatic Controller A3544 by ensuring that Flow Regulator A3305 is completely closed.

f. A continued ullage pressure rise to 60 psig results in the actuation of Pressure Switch A3539. The switch supplies power to Solenoid Valves A3395 and A3396 which open Pneumatic Valve A3304. Excess tank pressure is vented through Pneumatic Valve A3304 and Check Valve A3365 to the storage facility burn pond. Ullage pressure is maintained at approximately 42 psig for the duration of LH_2 transfer.

1.4.3.5 Transfer Line and S-IV Stage Cooldown (Figures 3-1 and 3-2). Thirty seconds after Flow Regulator A3305 is opened, the transfer line and S-IV stage cooldown sequence is initiated automatically. The sequence occurs as follows:

a. The LH_2 control panel COOLDOWN FILL LINE indicator lights.

b. Interlock functions 1, 2, 3, 4, 5, and 6 are in effect. (Refer to paragraph 1.4.3.2.)

c. Transfer line cooldown Pneumatic Valve A3307, subcooler inlet Flow Regulator A3309, and helium heat exchanger inlet Pneumatic Valve A3917 are opened. LH_2 flows from Storage Tank A3753 through Manual Valve A3303, Pneumatic Valve A3307, the tube side of Subcooler A3752, and into the subcooler shell through Flow Regulator A3309. LH_2 flow through the subcooler continues through the transfer line via Manual Valve A3379 and is admitted to the helium heat exchanger (volume V) through Pneumatic Valve A3917. The GH_2 vented from the helium heat exchanger is routed to the launch facility burn pond through Check Valve A3377.

d. Five minutes after Pneumatic Valves A3307 and A3917 and Flow Regulator A3309 are opened, main fill Pneumatic Valve A3911 is opened. Replenish Pneumatic Valve A3910, S-IV stage fill and drain Pneumatic Valve E113, and S-IV stage LH_2 tank vent Pneumatic Valves E114 and E115 are opened when LH_2 is detected in the helium heat exchanger. LH_2 then flows through the main fill and replenish valves and into S-IV stage LH_2 tank E102. LH_2 boiloff within the tank is vented to the launch facility burn pond through vent Pneumatic Valves E114 and E115, Quick-Disconnect Couplings E105 and A2389, and Check Valve A3376.

e. The transfer line and S-IV stage cooldown continues until the LH_2 tank is 15 percent filled. At this point in the sequence, S-IV stage propellant loading control equipment generates a command that opens transfer line fill Pneumatic Valve A3306 and lights the COOLDOWN COMPLETED indicator on the LH_2 control panel. Simultaneously, the COOLDOWN FILL LINE indicator goes out. Transfer line fill Pneumatic Valve A3306 remains open as long as the S-IV stage LH_2 tank is at least 15 percent filled.

1.4.3.6 Main Fill (Figures 3-1 and 3-2). The command signal that lights the LH_2 control panel COOLDOWN COMPLETED indicator also initiates the main fill transfer operation. The sequence proceeds automatically as follows:

a. The LH_2 control panel MAIN FILL indicator lights.

b. Interlock functions 1, 2, 3, 4, 6, and 7 are in effect. (Refer to paragraph 1.4.3.2.)

c. Transfer line fill Pneumatic Valve A3306 is open and transfer line cooldown Pneumatic Valve A3307 is closed. Valve positions are monitored by the pertinent OPEN and CLOSED indicators on the LH_2 components panel. LH_2 flows from Storage Tank A3753 through Manual Valve A3303, transfer line fill Pneumatic Valve A3306, Subcooler A3752, Manual Valve A3379, main fill and replenish Pneumatic Valves A3911 and A3910, Filter A3905. Electropneumatic Valve A3150, Quick-Disconnect Couplings A3159 and E100, and fill and drain Pneumatic Valve E113, into S-IV stage LH_2 tank E102. The filling rate is approximately 2000 gpm.

d. When the LH_2 tank is 92 percent filled, S-IV stage propellant loading control equipment initiates a start command to subcooler Vacuum Pump Motor A3939 which operates Vacuum Pump A3571. The 92% TANK LEVEL indicator on the LH_2 components panel lights and subcooler operations begin as follows:

(1) Liquid Level Probe A3509 senses a low subcooler liquid level and supplies a high-pressure signal to pneumatic Pressure Controller A3513. The controller output pressure passes through Manual Valve A3412 and opens subcooler inlet Flow Regulator A3309 to admit LH_2 to the subcooler shell from the transfer line. As the LH_2 level rises within the shell, Liquid Level Probe A3509 supplies a lower pressure signal to pneumatic Controller A3513. A continued drop in controller output over a range of 15 to 3 psig gradually reduces LH_2 flow through Flow Regulator A3309, and thereby controls the amount of LH_2 admitted to the subcooler shell.

(2) Liquid Level Sensor A3511 actuates when the subcooler is overfilled and energizes Solenoid Valve A3386. The solenoid valve vents control pressure applied to Flow Regulator A3309, and the flow regulator closes, thereby terminating LH_2 flow into the subcooler shell.

(3) Vacuum Pump A3751 reduces the subcooler shell pressure. The resulting pressure drop lowers the coolant temperature sufficiently to supercool transfer line LH_2 to approximately -426 F.

e. When the LH_2 tank is 95 percent filled, main fill Pneumatic Valve A3911 is closed by Solenoid Valve A3906. This action is initiated by a DAC command that energizes Solenoid Valve A3906 and lights the LH_2 components panel 95% TANK LEVEL indicator. Redundancy in terminating the main fill operation is provided by a circuit that delays the DAC command for 15 seconds and closes transfer line fill Pneumatic Valve A3306 if main fill Pneumatic Valve A3911 fails to close within 15 seconds after the DAC command is applied to Solenoid Valve A3906. The LH_2 control panel MAIN FILL indicator goes out when main fill Pneumatic Valve A3911 is closed.

1.4.3.7 Replenish (Figure 3-2). The replenish operation is initiated automatically with the closing of main fill Pneumatic Valve A3911. The operation proceeds as follows:

a. The LH_2 control panel REPLENISH indicator lights.

b. Interlock functions 1, 2, 3, 4, 5, 6, and 7 are in effect. (Refer to paragraph 1.4.3.2.)

c. Replenish Pneumatic Valve A3910 and fill and drain Pneumatic Valve E113 are held open by signals from S-IV stage propellant loading control equipment. S-IV stage vent Pneumatic Valves E114 and E115 are held open by signals from Launch Operations Control (LOC) automatic circuitry in the AGCS.

d. LH_2 flows into S-IV stage LH_2 tank E102 through Manual Valve A3379, replenish Pneumatic Valve A3910, Filter A3905, Electropneumatic Valve A3150, Quick-Disconnect Couplings A3159 and E100, and fill and drain Pneumatic Valve E113. LH_2 flow through the replenish valve is maintained at approximately 500 gpm until the LH_2 tank is 99.25 percent filled.

e. When the LH_2 tank is 99.25 percent filled, S-IV stage propellant loading control equipment energizes Solenoid Valve A3922 and deenergizes Solenoid Valve A3923. The solenoid valve action repositions replenish Pneumatic Valve A3910 to provide a 20-gpm LH_2 flow. Because the reduced replenish flowrate is less than the LH_2 boiloff rate, the tank LH_2 level drops to the 99-percent-full level.

f. When S-IV stage propellant loading control senses this level drop, replenish Pneumatic Valve A3910 is repositioned to resume LH_2 replenish at 500 gpm. The replenish flow is repeatedly cycled between 500 gpm and 20 gpm until final topping is initiated.

1.4.3.8 Final Topping (Figure 3-2). LH_2 tank final topping is initiated 10 seconds after the S-I stage firing command is given at T -150 seconds. LOX tank prepressurization is initiated at T -150 seconds, and LH_2 tank prepressurization is initiated at T -140 seconds. The topping operation occurs as follows:

a. System interlock functions 1, 2, 3, 4, 5, 6, and 7 are in effect. (Refer to paragraph 1.4.3.2.)

b. LH_2 tank vent Pneumatic Valves E114 and E115 are closed by Solenoid Valves E209 and E210 at T -140 seconds. Position-feedback signals from the pneumatic valves initiate a 3000-psig helium prepressurization supply from valve panel B (volume V). The prepressurization supply is admitted to the LH_2 tank through Quick-Disconnect Couplings A3155 and E250 and Check Valve E251 and subsequently increases tank ullage pressure to approximately 36 psia.

c. Upon initiation of final topping, Solenoid Valve A3923 positions replenish Pneumatic Valve A3910 to provide a 500-gpm LH_2 flow into the LH_2 tank.

d. At T -135 seconds, Solenoid Valve E211 is opened to ensure that vent Pneumatic Valves E114 and E115 are closed and at T -130 seconds, E211 is closed.

e. LH_2 tank (E102) is 100 percent filled at T -90 seconds. S-IV stage propellant loading control equipment closes replenish Pneumatic Valve A3910 and fill and drain Pneumatic Valve E113. The LH_2 control panel REPLENISH COMPLETED indicator and the LH_2 components panel 100% TANK LEVEL indicator are lighted.

f. When tank pressure reaches 37.25 (± 0.75) psia, Pressure Switch E276 actuates and provides a signal that terminates the helium prepressurization supply from valve panel B. Switch deactuation at 35.75 (± 0.75) psia reinitiates the pressurization supply if tank pressure should drop before vehicle launch.

g. When the LH_2 tank is completely filled and pressurized, transfer line vent Pneumatic Valve A3912 is opened by Solenoid Valve A3925. LH_2 in the transfer line is vented to the launch facility burn pond through Check Valve A3378.

h. The position-feedback signal from transfer line vent Pneumatic Valve A3912 opens a solenoid valve in valve panel A (volume V) to initiate a 50-psig He purge supply that is coupled into the umbilical fill line and the umbilical vent line.

i. When S-IV stage propellant loading control equipment senses that the LH_2 tank is 100 percent filled, Vacuum Pump A3751 is stopped, subcooler inlet Flow Regulator A3309 is closed by Solenoid Valve A3386, and helium heat exchanger LH_2 inlet Pneumatic Valve A3917 is closed by Solenoid Valve A3931. (See figure 3-1.) If the subcooler inlet flow regulator and the heat exchanger LH_2 inlet valve fail to close within 10 seconds after the closing command is given, transfer line fill Pneumatic Valve A3306 is closed to terminate LH_2 flow.

j. At vehicle liftoff, swing arms No. 2 and No. 3 disconnect all S-IV stage connections to ground complex fill, vent, and pressurization lines, and the S-IV stage propellant loading control equipment closes transfer line vent Pneumatic Valve A3912.

1.4.4 Launch Cancellation - If a launch cancellation occurs during or after prelaunch LH_2 transfer, LH_2 is drained from the S-IV stage LH_2 tank and transferred back to the LH_2 storage tank. The system prerequisites for draining are the same as the prerequisites for prelaunch LH_2 transfer with one exception: S-IV stage propellant loading control equipment places the S-IV stage in a drain status. When the prerequisites have been satisfied and the S-IV stage is ready for draining, the S-IV stage propellant loading control equipment generates a signal that lights the LH_2 control panel DRAIN STANDBY indicator. The drain sequence proceeds automatically when the LH_2 control panel DRAIN pushbutton is pressed. The DRAIN STANDBY indicator goes out and the DRAIN SEQUENCE indicator lights. The sequence occurs as follows:

1.4.4.1 Initial Setup (Figure 3-1). A drain command from the S-IV stage propellant loading control equipment is applied to Solenoid Valves A3386 and A3931 to close subcooler LH_2 inlet Flow Regulator A3309 and helium heat exchanger LH_2 inlet Pneumatic Valve A3917 (figure 3-2), respectively. If either A3309 or A3917 does not close within 10 seconds after the command is applied, transfer line fill Pneumatic Valve A3306 is closed to prevent further LH_2 flow from the storage tank.

1.4.4.2 LH_2 Storage Tank Venting (Figure 3-1). Before LH_2 can be transferred from the S-IV stage to LH_2 Storage Tank A3753, storage tank pressure must be vented. The venting operation is initiated by the drain command.

a. The VENT STORAGE TANK indicator lamp on the LH_2 control panel is lighted.

b. Interlock function 6 is in effect. (Refer to paragraph 1.4.3.2.)

c. Vaporizer inlet Flow Regulator A3305 is closed by Solenoid Valve A3387 to prevent further storage tank pressurization.

d. Replenish Pneumatic Valve A3910 is closed by Solenoid Valves A3923 and A3922. and main fill Pneumatic Valve A3911 is closed by Solenoid Valve A3906. (See figure 3-2.) Closure of these valves prevents further draining of the S-IV stage LH_2 tank. If closure is not effected within 15 seconds after the closing command is given, transfer line fill Pneumatic Valve A3306 is closed and fill and drain Pneumatic Valve E113 is opened.

e. An S-IV stage LH_2 drain sequence secure signal is relayed to S-IV stage propellant loading control equipment, and an S-IV LOX tank pressurization signal is relayed to LOC control equipment.

f. A closed position-feedback signal from Flow Regulator A3305 opens vent Pneumatic Valve A3304. The valve position is monitored by the appropriate indicator on the LH_2 components panel. The storage tank is vented to the storage area burn pond through Pneumatic Valve A3304 and Check Valve A3365.

g. Pressure Switch A3535 actuates when tank pressure drops to 2 psig and lights the VENT COMPLETED indicator on the LCC LH_2 control panel.

1.4.4.3 S-IV Stage LH_2 Tank Pressurization. As the LH_2 storage tank is being vented, the S-IV stage LH_2 tank is pressurized. When the storage tank pressure drops to 8 psig or less, as sensed by Pressure Switch A3536 (figure 3-1), the following sequence occurs:

a. The PRESSURIZE S-IV TANK indicator on the LH_2 control panel is lighted.

b. Interlock functions 3, and 6 are in effect (Refer to paragraph 1.4.3.2.)

c. Vent Pneumatic Valves E114 and E115 are closed to prepare the LH_2 tank for pressurization. (See figure 3-2.) A closed-position feedback signal from the vent valves energizes a solenoid valve in valve panel B to initiate a 1000-psig helium pressurization supply. The pressurization supply enters the LH_2 tank through Quick-Disconnect Couplings A3155 and E250 and Check Valve E251.

1.4.4.4 LH_2 Tank Draining (Figures 3-1 and 3-2). LH_2 tank draining is initiated when tank ullage pressure increases to a minimum of 17 psig. The LH_2 control panel PRESSURIZED COMPLETE indicator lights, and the drain sequence occurs as follows:

a. Interlock functions 3 and 6 are in effect. (Refer to paragraph 1.4.3.2.)

b. Main fill Pneumatic Valve A3911 and fill and drain Pneumatic Valve E113 are opened. If closed, transfer line fill Pneumatic Valve A3306 is also opened.

c. The LH_2 control panel DRAIN indicator is lighted.

d. LH_2 flows from the S-IV stage LH_2 tank through fill and drain Pneumatic Valve E113, Quick-Disconnect Couplings E100 and A3159, Electropneumatic Valve A3150, Filter A3905, main fill Pneumatic Valve A3911, Manual Valve A3379, Subcooler A3752, transfer line fill Pneumatic Valve A3306, and into the storage tank through Manual Valve A3303.

e. Temperature Switch A3775 actuates when transfer line temperature increases to -406 F and signals the completion of draining by lighting the LH_2 control panel DRAIN COMPLETED indicator.

1.4.4.5 Transfer Line Warmup (Figures 3-1 and 3-2). Transfer line warmup is initiated when the transfer line inlet temperature increases to -406 F. The sequence occurs as follows:

a. The LH_2 control panel LINE WARM-UP indicator is lighted.

b. Interlock functions 3 and 6 are in effect. (Refer to paragraph 1.4.3.2.)

c. Transfer line fill Pneumatic Valve A3306 and main fill Pneumatic Valve A3911 are closed.

d. System control is returned to S-IV stage propellant loading control equipment when a closed-position feedback signal is received from main fill Pneumatic Valve A3911.

e. The LH_2 tank prepressurization supply from valve panel B is terminated.

f. Transfer line vent Pneumatic Valve A3308 is opened to vent the transfer line to the storage facility burn pond.

g. Vent Pneumatic Valve A3304 is closed by the closed-position feedback signal from transfer line fill Pneumatic Valve A3306, or when the storage tank ullage pressure drops to 2 psig.

h. The transfer line is vented for 3 hours before line vent Pneumatic Valve A3308 is closed.

i. Automatic sequencing terminates at this point in the sequence, and the LH_2 control panel LINE WARM-UP indicator goes out.

1.4.4.6 Manual Inerting (Figures 3-1 and 3-2). Manual inerting of the transfer line and LH_2 storage facility is initiated at the closure of line vent Pneumatic Valve A3308. The READY FOR INERTING indicator on the LH_2 control panel is lighted and the sequence occurs as follows:

a. Solenoid Valve A3318 is closed by a signal from the LH_2 components panel.

b. Manual Valves A3301, A3303, and A3343 are closed.

c. Manual Valves A3336 and A3337 are opened to supply low-pressure GN_2 to the transfer line. The GN_2 supplied at Coupling A3937 passes through Manual Valve A3337, Orifice A3606, Manual Valve A3336, and Check Valve A3348 to the transfer line.

d. Helium heat exchanger LH_2 inlet Pneumatic Valve A3917 is opened for 1 hour. Subcooler inlet Flow Regulator A3309 is opened for 5 minutes. The helium heat exchanger and Subcooler A3732 are purged by GN_2 supplied to the transfer line.

e. Steady-state vent Flow Regulator A3338 is opened by Pneumatic Controller A3551 to vent Storage Tank A3753. Tank pressure may be maintained at a positive pressure of approximately 0.5 psig by adjusting Pneumatic Controller A3551.

1.4.5 S-IV Stage Propulsion System Supply

1.4.5.1 LH_2 Tank Pressurization (Figure 3-2). LH_2 tank pressurization provides necessary structural integrity to the S-IV stage propellant tank assembly and provides a net positive LH_2 suction head to the RL10A-3S engine fuel pumps.

a. The S-IV stage LH_2 tank E102 is pressurized to a nominal pressure of 36.5 psia during LH_2 replenish operations. Pressurization is initiated by commands from S-IV stage propellant loading control equipment when the tank is 95 percent filled. Immediately prior to liftoff, Pressure Switch E278 signals inadequate tank pressure for liftoff if tank pressure drops to 33.5 (± 0.5) psia, and the launch is halted. However, if pressure is 34.5 (± 0.5) psia, the pressure switch signals minimum pressure for liftoff and the launch operations are continued. To maintain tank pressure between 37.25 (± 0.75) psia and 35.75

psia, Pressure Switch E276 controls the opening of pressurization solenoid valve in valve panel B.

b. LH_2 tank pressure remains substantially constant during S-I stage powered flight until the LH_2 prestart command is initiated. An appreciable pressure drop occurs, however, during LH_2 chilldown of the RL10A-3S engine. Pressure Switch E277 opens Solenoid Valve E257 and Electropneumatic Valve E255 to admit make-up pressure to the LH_2 tank from the S-IV stage control pressure system if pressure drops to 30.5 (± 0.5) psia. Helium at 3000 psig, supplied through Solenoid Valve E257, Check Valve E258, Orifices E259 and E253, Electropneumatic Valve E255, and Orifice E256, increases tank pressure to 31.5 (± 0.5) psia and make-up pressurization stops. Pressure Switch E277 maintains tank pressurization between 30.5 (± 0.5) psia and 31.5 (± 0.5) psia until chilldown operations are completed. A system interlock function at approximately 4.6 seconds after separation of the S-I stage and the S-IV stage renders the make-up pressurization system inoperative for the remainder of S-IV stage powered flight. Additional LH_2 tank pressurization is also provided, as required, by the action of LH_2 tank Pressure Switch E279. Pressure Switch E279 actuates Electropneumatic Valve E254 at a tank ullage pressure of 27.5 (± 0.5) psia and remains operative until the propellant utilization (PU) system commands Electropneumatic Valve E254 to remain open during the latter period of S-IV stage powered flight. The pressure switch is rendered inoperative as long as the ullage pressure remains above 29.5 (± 0.5) psia. Electropneumatic Valve E254 provides helium for tank pressurization until 4.6 seconds after S-I and S-IV stage separation when the make-up pressurization system is rendered inoperative.

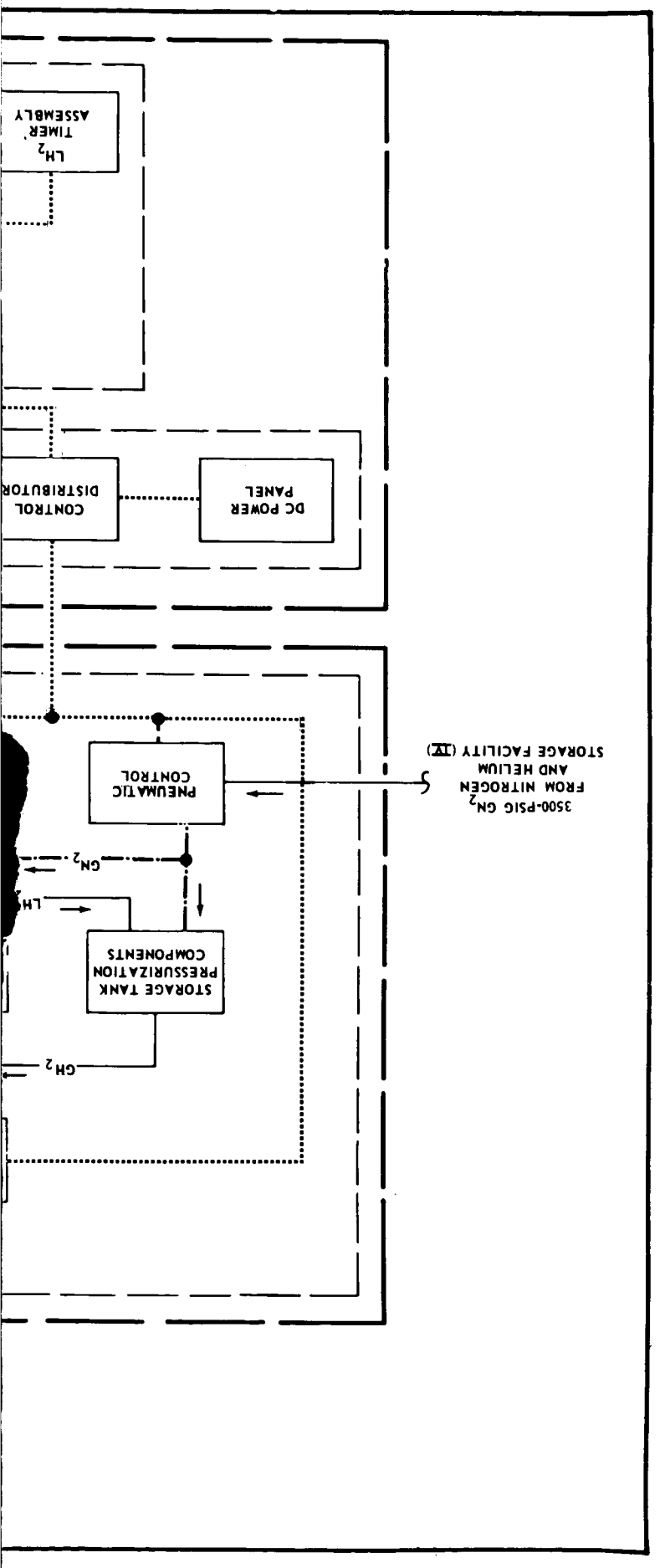
c. After engine ignition, LH_2 tank pressurization is supplied by 340-psia GH_2 from RL10A-3S engine LH_2 tank pressurization lines. The pressure is reduced to approximately 34 psia by Orifice E253 to maintain adequate tank pressure as LH_2 is depleted. Electropneumatic Valve E255 admits additional GH_2 to the LH_2 tank through Orifice E256 upon receipt of a signal from Pressure Switch E277 that indicates a tank pressure drop below 30.5 (± 0.5) psia. Pressure Switch E277 controls the opening and closing of the electropneumatic valve to maintain LH_2 tank pressure at 30.5 (± 0.5) psia until approximately 370 seconds after RL10A-3S engine ignition.

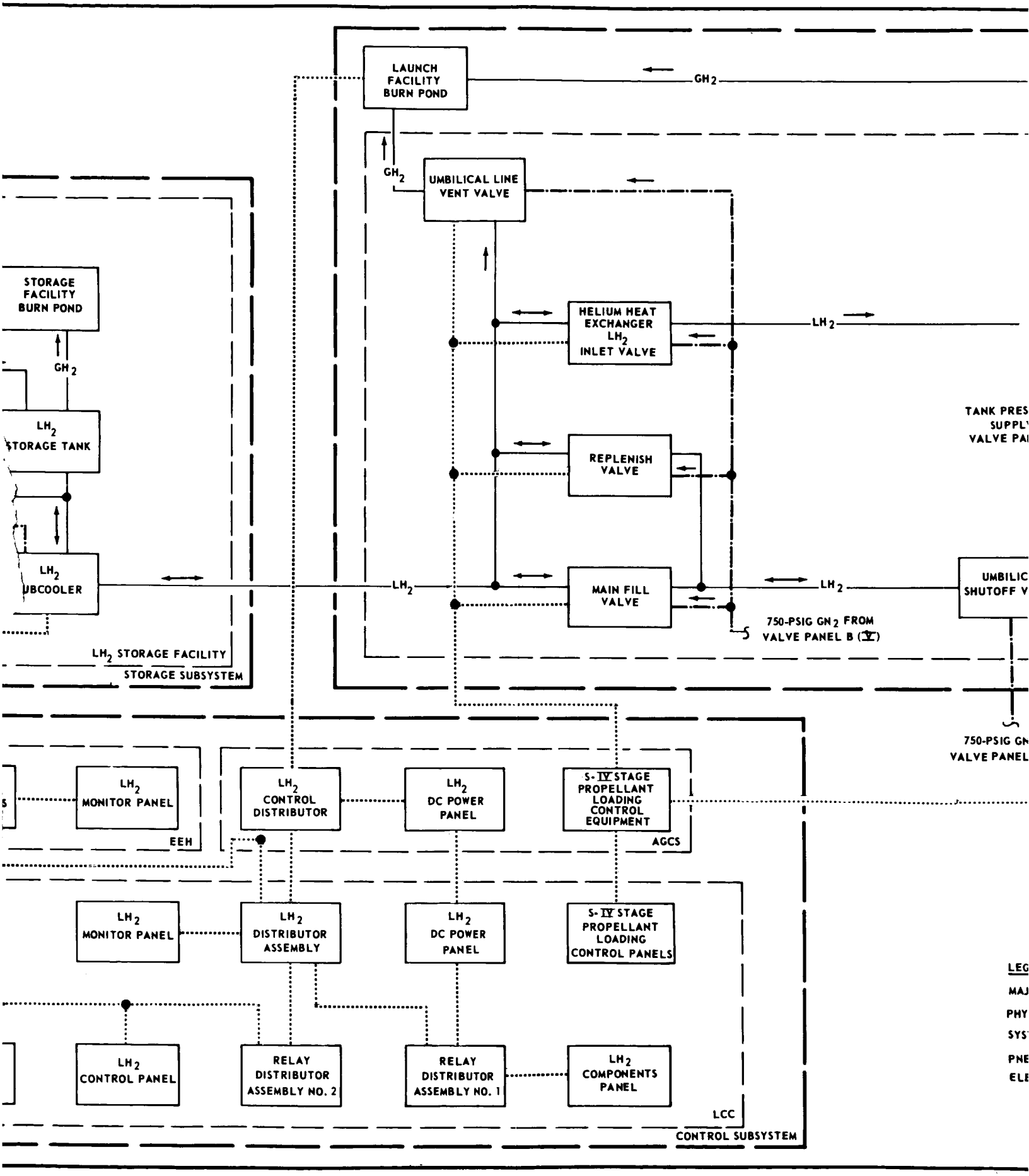
d. Additional LH_2 tank pressurization is required during the last 100 seconds of powered flight to ensure that a net positive suction head is maintained at the RL10A-3S engine turbopump inlets. At approximately 370 seconds after engine ignition, a propellant utilization system command opens Electropneumatic Valve E254 to admit additional GH_2 from the engine LH_2 tank pressurization lines to the LH_2 tank. GH_2 at approximately 340 psia is applied to Orifice E 252 and the flow through the orifice increases tank pressure approximately 10 psig. For the remainder of S-IV stage powered flight LH_2 tank pressurization is maintained by Electropneumatic Valve E254 and Orifices E252 and E253.

e. During flight differential Pressure Switch E275 prevents the possible collapse of the common bulkhead between the LOX and LH_2 tanks due to excessive LH_2 tank pressure. When LH_2 tank pressure exceeds LOX tank pressure by 4 (± 0.1) psid, Differential Pressure Switch E275 actuates and sends a signal that energizes Solenoid Valve E209. Control pressure flow through the solenoid valve opens vent Pneumatic Valve E115, to reduce LH_2 tank pressure.

f. Vent Pneumatic Valves E114 and E115 provide LH_2 tank overpressure protection by relieving excess pressure at 44 psia. The valves reseat at 41 psia.

1.4.5.2 LH_2 Consumption (Figure 3-2). LH_2 consumption is initiated at RL10A-3S engine chilldown. The fuel inlet shutoff Pneumatic Valves E1 (volume IX) are opened during S-I and S-IV stage separation to supply LH_2 to the RL10A-3S engines. LH_2 flows from the LH_2 tank, through each of six suction lines and fuel inlet shutoff Pneumatic Valves E1 to each RL10A-3S engine turbopump inlet. During engine operation the LH_2 mass flowrate to each engine is approximately 5.88 pounds per second. Mass Sensor E107 senses LH_2 mass and provides continuous monitor signals to the S-IV stage PU system. When LH_2 depletes to approximately 83 pounds of residual fuel, the S-IV stage PU system initiates engine cutoff.


LH2 TIMER ASSEMBLY
CONTROL DISTRIBUTOR
DC POWER PANEL
PNEUMATIC CONTROL
3500-PSIG GN2 FROM NITROGEN AND HELIUM STORAGE FACILITY (IX)
GN2
LH2
STORAGE TANK PRESSURIZATION COMPONENTS
GH2


LAUNCH FACILITY BURN POND
GH_2
GH_2
UMBILICAL LINE VENT VALVE
STORAGE FACILITY BURN POND
GH_2
HELIUM HEAT EXCHANGER LH_2 INLET VALVE
LH_2
TANK PRES
SUPPL
VALVE PA
LH_2 STORAGE TANK
REPLENISH VALVE
LH_2 UBCOOLER
LH_2
MAIN FILL VALVE
LH_2
UMBILIC
SHUTOFF V
750-PSIG GN_2 FROM VALVE PANEL B (V)
LH_2 STORAGE FACILITY
STORAGE SUBSYSTEM
750-PSIG GN
VALVE PANEL
LH_2 MONITOR PANEL
LH_2 CONTROL DISTRIBUTOR
LH_2 DC POWER PANEL
S-IV STAGE PROPELLANT LOADING CONTROL EQUIPMENT
EEH
AGCS
LH_2 MONITOR PANEL
LH_2 DISTRIBUTOR ASSEMBLY
LH_2 DC POWER PANEL
S-IV STAGE PROPELLANT LOADING CONTROL PANELS
LEG
MAJ
PHY
SYS
PNE
ELE
LH_2 CONTROL PANEL
RELAY DISTRIBUTOR ASSEMBLY NO. 2
RELAY DISTRIBUTOR ASSEMBLY NO. 1
LH_2 COMPONENTS PANEL
LCC
CONTROL SUBSYSTEM

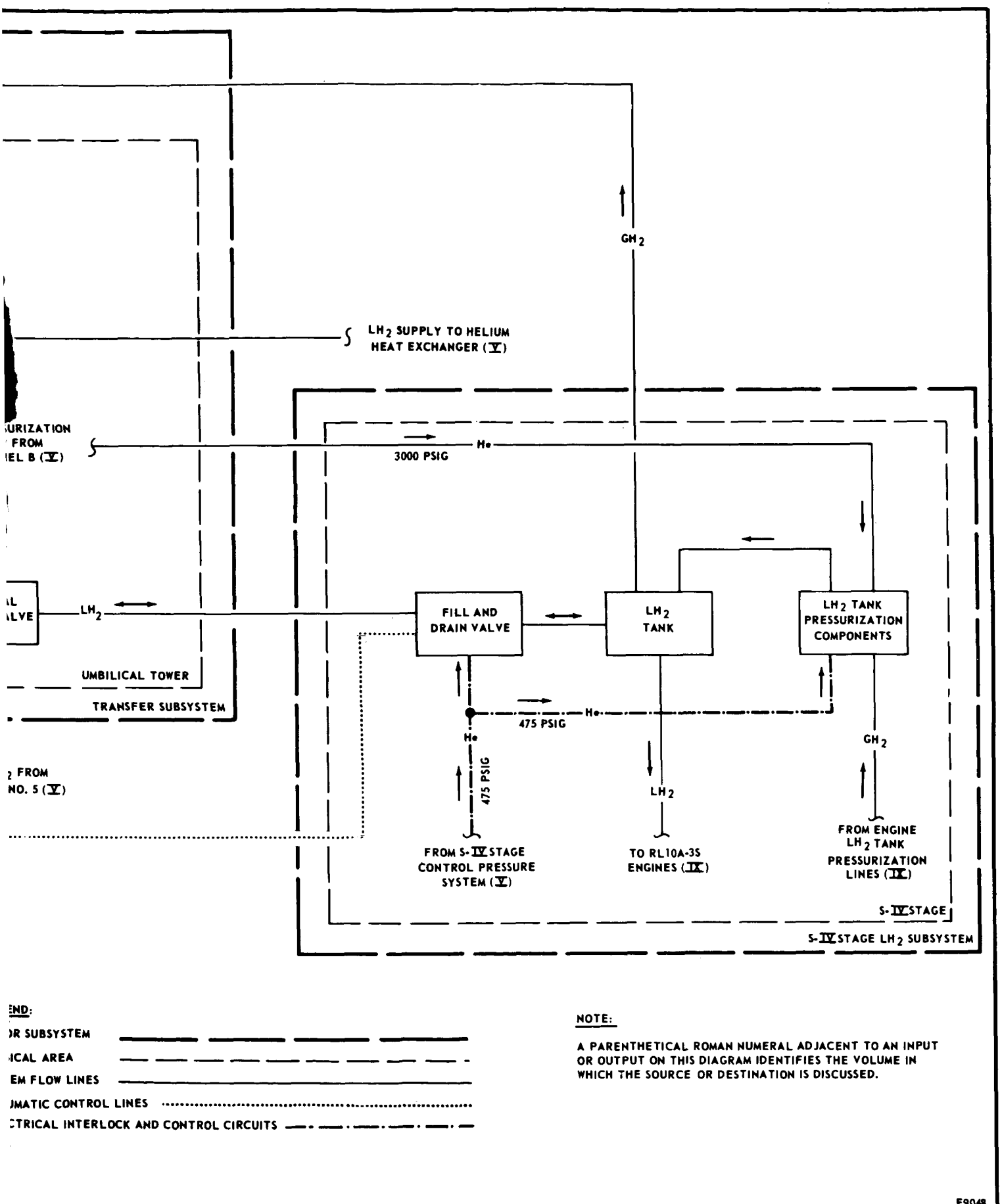


Figure 1-1. Launch Vehicle SA-10 and Launch Complex 37B LH_2 Fuel System-Block Diagram

SECTION 2

INDEX OF FINDING NUMBERS

This section contains an alphameric list by finding number, of LH_2 fuel system components that function during a prelaunch countdown, during vehicle flight, or in the event of a launch cancellation. The finding numbers listed identify components on system schematics provided in section 3. 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 alphameric 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 only during a maintenance operation, or part of another functional system.

The letter prefix of a finding number identifies the component location with respect to either the launch complex or an area of the launch vehicle. The letter prefixes used in this eleven-volume set are listed below.

FINDING NUMBER PREFIX	DESIGNATED AREA
A	Launch complex
B	S-I stage
E	S-IV stage
G	Instrument unit
H	Payload

Finding Number	Reqd	Component	Remarks	Vendor	Drawing Number	Elec. Sym.
A2388	1	Valve, Check				
A2389	1	Coupling, Quick-Disconnect	GH_2 vent			
A2390 through A3149 are not functionally applicable to this system.						
A3150	1	Valve, Electropneumatic	Shutoff	Hadley Valve	A75M-05605	
A3151 through A3154 are not functionally applicable to this system.						
A3155	1	Coupling, Quick-Disconnect				
A3156 through A3158 are not functionally applicable to this system.						
A3159	1	Coupling, Quick-Disconnect	LH_2 supply		D57M-04852	
A3160 through A3165 are not functionally applicable to this system.						
A3166	1	Valve, Check	1/2 in.		3871261-501	
A3167	1	Orifice	Valve purge		75M06713-2	
A3168	1	Orifice	0.010 in. dia., 0.1 scfm flowrate		75M06686-3	
A3169 through A3300 are not functionally applicable to this system.						

Finding Number	Reqd	Component	Remarks	Vendor	Drawing Number	Elec. Sym.
A3301	1	Valve, Manual	3-in., shutoff	Pacific Valves, Inc. Model G-710YJ-10K-WE	10464405	
A3302	1	Valve, Pneumatic	2-in., NC, main fill	The Annin Co. Model 1720	10464408	
A3303	1	Valve, Manual	6-in.	Pacific Valve, Inc. Model G-710YJ-10K-WE	10464407	
A3304	1	Valve, Pneumatic	8-in., NC, vent	The Annin Co. Model 1620B	10464411	
A3305	1	Regulator, Flow	1-1/2-in., NC; 25 psig actuator pressure, 3 to 15 psig signal pressure	The Annin Co. Model 1760	10464410	
A3306	1	Valve, Pneumatic	6-in., NC	Pacific Valves, Inc. Model G-710YJC-10K-WE	10464401	
A3307	1	Valve, Pneumatic	1-1/2-in., NC	The Annin Co. Model 1720	10464402	
A3308	1	Valve, Pneumatic	1-1/2-in., NC, line vent	The Annin Co. Model 1620	10464403	
A3309	1	Regulator, Flow	1-in., NC, 25-psig actuator pressure, 3-to15-psig signal pressure	The Annin Co. Model 1760	10464416	
A3310 through A3317 are not functionally applicable to this system.						
A3318	1	Valve, Solenoid	1/2-in., 2-way, 2-position, NC	Marotta Valve Corp. Model MV-185	10464427	
A3319 is not functionally applicable to this system.						
A3320	1	Valve, Manual	2-in., shutoff	The Annin Co. Model 1710	10464409	

Finding Number	Reqd	Component	Remarks	Vendor	Drawing Number	Elec. Sym.
A3321 is not functionally applicable to this system.						
A3322	1	Valve, Manual	1/2-in., shutoff	Hills Mc Canna Co. Model S-303-S6-T	10464552	
A3323	1	Valve, Manual	3-in., shutoff	Hills Mc Canna Co. Model S-303-S6-T	10464562	
A3324	1	Valve, Manual	6-in., shutoff	Vacuum Research Co. Model VG-6N5	10464550	
A3325	1	Valve, Manual	1/2-in., shutoff	Vacuum Electronics Engr. Co. Model L62P	10464551	
A3326	1	Valve, Manual	1/2-in., shutoff	Vacuum Electronics Engr. Co. Model L62P	10464551	
A3327	1	Valve, Manual	1/2-in., shutoff	Hills Mc Canna Co. Model S-303-S6-T	10464552	
A3328	1	Valve, Manual	1/2-in., shutoff	Hills Mc Canna Co. Model S-303-S6-T	10464552	
A3329	1	Valve, Manual	1/2-in., shutoff	Hills Mc Canna Co. Model S-303-S6-T	10464552	
A3330	1	Valve, Manual	2-in., shutoff	The Annin Co. Model 1710	10464404	
A3331	1	Valve, Manual	2-in., shutoff	The Annin Co. Model 1710	10464404	
A3332	1	Valve, Manual	2-in., shutoff	The Annin Co. Model 1710	10464404	
A3333	1	Valve, Manual	2-in., shutoff	The Annin Co. Model 1710	10464404	

Finding Number	Reqd	Component	Remarks	Vendor	Drawing Number	Elec. Sym.
A3334	1	Valve, Manual	1/2-in., vent	Vacuum-Electronics Engr. Co. Model L62P	10464551	
A3335	1	Valve, Manual	1/2-in., drain	Hills Mc Canna Co. Model S-303-S6-T	10464552	
A3336	1	Valve, Manual	1/2-in., shutoff	Hills Mc Canna Co. Model S-303-S6-T	10464552	
A3337	1	Valve, Manual	1/2-in., shutoff	Hills Mc Canna Co. Model S-303-S6-T	10464552	
A3338	1	Regulator, Flow	3-in., NC; 25-psig actuator pressure, 3-to 15-psig signal pressure	The Annin Co. Model 1660	10464418	
A3339 is not functionally applicable to this system.						
A3340	1	Valve, Manual	1/2-in., shutoff	Hills Mc Canna Co. Model S-303-S6-T	10464552	
A3341	1	Valve, Manual	1/2-in., vent	Hills Mc Canna Co. Model S-303-S6-T	10464552	
A3342	1	Regulator, Flow	2-in., NC; 25-psig actuator pressure, 3-to 15-psig signal pressure	The Annin Co. Model 1760	10464417	
A3343	1	Valve, Manual	1/2-in., shutoff	Hills Mc Canna Co. Model S-303-S6-T	10464552	
A3344	1	Valve, Solenoid	1/2-in., 2-way, 3-position, NC	Marotta Valve Corp. Model MV-182C	10464421	
A3345	1	Regulator, Pressure	1/2-in.; 50-psig input, 2-psig output	Fisher Governor Co. Model 45-L	10464420	
A3346	1	Valve, Manaul	1/4-in., vent	Robbins Aviation, Inc. Model SSKG250-4T	10464559	

Finding Number	Reqd	Component	Remarks	Vendor	Drawing Number	Elec. Sym.
A3347	1	Valve, Manual	1/4-in., vent	Robbins Aviation, Inc. Model SSKG250-4T	10464559	
A3348	1	Valve, Check	1/2-in., 2 psig cracking pressure	William Powell Co. Model 70-2341-KD	10464553	
A3349	1	Valve, Check	2-in., 0.05 psig cracking pressure	Chapman Valve Mfg. Co., Model PD-117948	10464554	
A3350	1	Valve, Manual	1/4-in., vent	Robbins Aviation, Inc. Model SSKG250-4T	10464559	
A3351	1	Valve, Manual	1/4-in., shutoff	Robbins Aviation, Inc. Model SSKG250-4T	10464559	
A3352	1	Valve, Manual	1/4-in., shutoff	Robbins Aviation, Inc. Model SSKG250-4T	10464559	
A3353	1	Valve, Manual	1/4-in., shutoff	Robbins Aviation, Inc. Model SSKG250-4T	10464559	
A3354	1	Valve, Manual	1/4-in., shutoff	Robbins Aviation, Inc. Model SSKG250-4T	10464559	
A3355 is not functionally applicable to this system.						
A3356	1	Valve, Manual	1/4-in., vent	Robbins Aviation, Inc. Model SSKG250-4T	10464559	
A3357	1	Valve, Manual	1/4-in., shutoff	Robbins Aviation, Inc. Model SSKG250-4T	10464559	
A3358	1	Valve, Manual	1/4-in., shutoff	Robbins Aviation, Inc. Model SSKG250-4T	10464559	
A3359	1	Valve, Manual	1/4-in., shutoff	Robbins Aviation, Inc. Model SSKG250-4T	10464559	

Finding Number	Reqd	Component	Remarks	Vendor	Drawing Number	Elec. Sym.
A3360	1	Valve, Manual	1/4-in., shutoff	Robbins Aviation, Inc. Model SSKG250-4T	10464559	
A3361	1	Valve, Manual	1/4-in., shutoff	Robbins Aviation, Inc. Model SSKG250-4T	10464559	
A3362	1	Valve, Manual	1/4-in., shutoff	Robbins Aviation, Inc. Model SSKG250-4T	10464559	
A3363	1	Valve, Manual	1/4-in., shutoff	Robbins Aviation, Inc. Model SSKG250-4T	10464559	
A3364	1	Valve, Manual	1/4-in., shutoff	Robbins Aviation, Inc. Model SSKG250-4T	10464559	
A3365	1	Valve, Check	8-in., 1 psig cracking pressure	Chapman Valve Mfg. Co. Model PB-117946	10464555	
A3366 is not functionally applicable to this system.						
A3367	1	Valve, Manual	1/4-in., vent	Robbins Aviation, Inc. Model SSKG250-4T	10464559	
A3368	1	Valve, Manual	1/2-in., NC, vent			
A3369	1	Valve, Manual	1/4-in., shutoff	Robbins Aviation, Inc. Model SSKG250-4T	10464559	
A3370	1	Valve, Manual	1/4-in., shutoff	Robbins Aviation, Inc. Model SSKG250-4T	10464559	
A3371	1	Valve, Manual	1/4-in., vent	Robbins Aviation, Inc. Model SSKG250-4T	10464559	

Finding Number	Reqd	Component	Remarks	Vendor	Drawing Number	Elec. Sym.
A3372	1	Valve, Manual	1/4-in., shutoff	Robbins Aviation, Inc. Model SSKG250-4T	10464559	
A3373	1	Valve, Manual	1/4-in., shutoff	Robbins Aviation, Inc. Model SSKG250-4T	10464559	
A3374 is not functionally applicable to this system.						
A3375	1	Valve, Manual	1/2-in., shutoff			
A3376	1	Valve, Check	10-in., 2-psig cracking pressure	Chapman Valve Mfg. Co. Model PB-117408	10464556	
A3377	1	Valve, Check	8-in.	Chapman Valve Mfg. Co. Model PB-117946	10464555	
A3378	1	Valve, Check	2-in.	Chapman Valve Mfg. Co. Model PB-117948	10464554	
A3379	1	Valve, Manual	6-in., shutoff	Pacific Valves, Inc. Model G-710YJ-10K-WE	10464424	
A3380	1	Valve, Manual	6-in., shutoff	Vacuum Research Co. Model VG-6N5	10464550	
A3381	1	Valve, Manual	1/4-in., vent and calibration	Robbins Aviation, Inc. Model SSKG250-4T	10464559	
A3382	1	Valve, Check	3-in., 1-psig cracking pressure.	Chapman Valve Mfg. Co. Model PB-117947	10464563	
A3383	1	Valve, Check	1/2-in.	William Powell Co. Model 70-2341	10464564	

Finding Number	Reqd	Component	Remarks	Vendor	Drawing Number	Elec. Sym.
A3384	1	Valve, Manual	1/4-in., shutoff	Robbins Aviation, Inc. Model SSKG250-4T	10464559	
A3385	1	Valve, Manual	1/4-in., shutoff	Robbins Aviation, Inc. Model SSKG250-4T	10464559	
A3386	1	Valve, Solenoid	3-way, 2-position; NC	Marotta Valve Corp. Model MV-74TB	10464413	
A3387	1	Valve, Solenoid	3-way, 2-position; NC	Marotta Valve Corp. Model MV-74TB	10464413	
A3388	1	Valve, Solenoid	3-way, 2-position; NC	Marotta Valve Corp. Model MV-74TB	10464413	
A3389	1	Valve, Solenoid	3-way, 2-position; N. O.	Marotta Valve Corp. Model MV-74TB	10464413	
A3390	1	Valve, Solenoid	3-way, 2-position; NC	Marotta Valve Corp. Model MV-74TB	10464413	
A3391	1	Valve, Solenoid	3-way, 2-position; N. O.	Marotta Valve Corp. Model MV-74TB	10464413	
A3392	1	Valve, Solenoid	3-way, 2-position; NC	Marotta Valve Corp. Model MV-74TB	10464413	
A3393	1	Valve, Solenoid	3-way, 2-position; N. O.	Marotta Valve Corp. Model MV-74TB	10464413	
A3394	1	Valve, Solenoid	3-way, 2-position; NC	Marotta Valve Corp. Model MV-74TB	10464413	
A3395	1	Valve, Solenoid	3-way, 2-position; N. O.	Marotta Valve Corp. Model MV-74TB	10464413	

Finding Number	Reqd	Component	Remarks	Vendor	Drawing Number	Elec. Sym.
A3396	1	Valve, Solenoid	3-way, 2-position, NC	Marotta Valve Corp. Model MV-74TB	10464413	
A3397	1	Valve, Solenoid	3-way, 2-position, N. O.	Marotta Valve Corp. Model MV-74TB	10464413	
A3398	1	Valve, Solenoid	3-way, 2-position, NC	Marotta Valve Corp. Model MV-74TB	10464413	
A3399	1	Valve, Manual	1/4-in., shutoff	Robbins Aviation, Inc. Model SSKG 250-4T	10464559	
A3400 is not functionally applicable to this system.						
A3401	1	Valve, Manual	1/4-in., shutoff	Robbins Aviation, Inc. Model SSKG250-4T	10464559	
A3402	1	Valve, Check	1/2-in., 0.1 psig cracking pressure	Circle Seal Products Inc., Model 119T-4PP	10464566	
A3403	1	Valve, Manual	1/4-in., vent	Robbins Aviation, Inc. Model SSKG250-4T	10464559	
A3404 is not functionally applicable to this system.						
A3405	1	Valve, Manual	1/4-in., shutoff	Robbins Aviation, Inc. Model SSKG250-4T	10464559	
A3406	1	Valve, Manual	1/4-in., shutoff	Robbins Aviation, Inc. Model SSKG250-4T	10464559	
A3407	1	Valve, Manual	1/4-in., shutoff	Robbins Aviation, Inc. Model SSKG250-4T	10464559	

Finding Number	Reqd	Component	Remarks	Vendor	Drawing Number	Elec. Sym.
A3408	1	Valve, Manual	1/4-in., vent	Robbins Aviation, Inc. Model SSKG250-4T	10464559	
A3409	1	Valve, Manual	1/4-in., shutoff	Robbins Aviation, Inc. Model SSKG250-4T	10464559	
A3410	1	Valve, Manual	1/4-in., vent	Robbins Aviation, Inc. Model SSKG250-4T	10464559	
A3411	1	Valve, Check	1/2-in.	Circle Seal Products Co., Inc., Model 859T-12BB	10464565	
A3412	1	Valve, Manual	1/4-in., shutoff	Robbins Aviation, Inc. Model SSKG250-4T	10464559	
A3413	1	Valve, Manual	1/4-in., shutoff	Robbins Aviation, Inc. Model SSKG250-4T	10464559	
A3414	1	Limiter, Differential Pressure	1-1/2-psig set pressure		10466187	
A3415	1	Valve, Manual	1/4-in., 3-way, 2-position, shutoff		10466188	
A3416	1	Valve, Manual	1/4-in., drain	Robbins Aviation, Inc. Model SSKG250-4T	10464559	
A3417	1	Valve, Manual	1-in., drain	Hills Mc Canna Co. Model S-303-S6-T	10464567	
A3418 through A3501 are not functionally applicable to this system.						
A3502	1	Transducer, Differential Pressure	0 to 1-psid nominal range		10465305	

Finding Number	Reqd	Component	Remarks	Vendor	Drawing Number	Elec. Sym.
A3503 is not functionally applicable to this system.						
A3504	1	Gage, Liquid Level	125,000 gallon normal indication, 0- to 130,000-range	Barton Model 199 P Unit Model 200 indicator	10466009	
A3505 is not functionally applicable to this system.						
A3506	1	Gage, Compound	30-in. Hg vacuum, 60-psig range		10466007	
A3507	1	Transducer, Pressure	0- to 50-psig range	Fairchild Controls Corp. Model 990550-2	10465306	
A3508 is not functionally applicable to this system.						
A3509	1	Probe, Liquid Level	10- to 40-psig internal pressure, 100 to 0 percent subcooler LH_2 level		10462814	
A3510 is not functionally applicable to this system.						
A3511	1	Sensor, Liquid Level	Actuates at 100 percent LH_2 level		10466011	
A3512	1	Sensor, Liquid Level	Actuates at 0 percent LH_2 level		10466011	
A3513	1	Controller, Pneumatic	10- to 40-psig input, 15- to 3-psig output	Bristol Series 624	10466004	
A3514	1	Controller, Pneumatic	13- to 15-psig input 15- to 3-psig output	Bristol Series 624	10466017	

Finding Number	Reqd	Component	Remarks	Vendor	Drawing Number	Elec. Sym.
A3515	1	Controller, Pneumatic	100 to 0 percent LH_2 level 2- to 0-in. H_20 actuating press., 3- to 15-psig output	Barton Model 274 Transmitter Model 199 P Unit	10466010	
A3516 through A3531 are not functionally applicable to this system.						
A3532	1	Gage, Pressure	0- to 100-psig range		10466006	
A3533	1	Transducer, Pressure	0- to 100-psig range	Fairchild Controls Inc. Model 990550-2	10465306	
A3534 is not functionally applicable to this system.						
A3535	1	Switch, Pressure	Actuates at 2 psig decreasing pressure		10466005-1	
A3536	1	Switch, Pressure	Actuates at 6 psig decreasing pressure		10466005-2	
A3537	1	Switch, Pressure	Actuates at 30 psig increasing pressure		10466005-3	
A3538	1	Switch, Pressure	Actuates at 55 psig increasing pressure		10466005-4	
A3539	1	Switch, Pressure	Actuates at 60 psig increasing pressure		10466005-5	
A3540	1	Switch, Pressure	Actuates at 15 psig increasing pressure		10466024	
A3541 is not functionally applicable to this system.						

Finding Number	Reqd	Component	Remarks	Vendor	Drawing Number	Elec. Sym.
A3542	1	Transducer, Pressure	0- to 20-psig range	Fairchild Controls, Inc. Model 990550-2	10465306	
A3543 is not functionally applicable to this system.						
A3544	1	Controller, Pneumatic	0- to 100-psig input, 15- to 3-psig output	Bristol Series 624	10466001	
A3545 and A3546 are not functionally applicable to this system.						
A3547	1	Transducer, Pressure	0- to 20-psia range	Fairchild Controls, Inc. Model 990550-2	10465306	
A3548 and A3549 are not functionally applicable to this system.						
A3550	1	Gage, Pressure	2 psig normal reading, 0- to 60-psig range		10466027	
A3551	1	Controller, Pneumatic	0- to 5-psig actuating press., 25-psig input.	Bristol Series 624	10466003	
A3552	1	Snubber	Set at 10 psig	Sprague Eng. Corp. Model S-214-10	10466014	
A3553 is not functionally applicable to this system.						
A3554	1	Controller, Pneumatic	0- to 15-psig input, 3- to 15-psig output	Bristol Series 624	10466002	
A3555 through A3570 are not functionally applicable to this system.						

Finding Number	Reqd	Component	Remarks	Vendor	Drawing Number	Elec. Sym.
A3571	1	Indicator, Temperature	Pressure-operated, 0- to 150-psia range; -430- to -403-F range		10466008	
A3572	1	Transducer, Temperature	Pressure-operated, 0- to 150-psia; -430- to -403-F range	Fairchild Controls Inc. Model 990550-2	10465306	
A3573 is not functionally applicable to this system.						
A3574	1	Probe, Temperature			10466016	
A3575	1	Switch, Temperature	Pressure-operated, actuates at 100 psig increasing pressure-equivalent to -406 F		10466025-1	
A3576	1	Gage, Temperature	Pressure-operated, 0 to 150 psig range			
A3577 is not functionally applicable to this system.						
A3578	1	Switch, Pressure	0- to 100-psia range, temperature indicating			
A3579 is not functionally applicable to this system.						
A3580	1	Probe, Temperature			10466016	
A3581	1	Switch, Pressure	100 psig actuating pressure, temperature indicating			
A3582	1	Gage, Temperature	Pressure-operated, 0- to 50-psia, -430- to -403 -F range.		10466008	

Finding Number	Reqd	Component	Remarks	Vendor	Drawing Number	Elec. Sym.
A3583	1	Probe, Temperature			10466016	
A3584	1	Indicator, Temperature	Pressure-operated, 0-to 150-psia, -430- to -403 -F range		10466008	
A3585	1	Probe, Temperature			10466023	
A3586	1	Indicator, Temperature	Pressure-operated, 0-to 150-psia, -430- to -403-F range		10466008	
A3587	1	Probe, Temperature				
A3588	1	Switch, Temperature				
A3589 through 3600 are not functionally applicable to this system.						
A3601	1	Orifice	0.116 in.-dia., 5-scfm flowrate			
A3602	1	Orifice	0.052-in.-dia., 1-scfm flowrate			
A3603	1	Orifice	0.182-in.-dia., 20-scfm flowrate at 50 psig			
A3604	1	Orifice	0.037-in.-dia., 5-scfm flowrate at 50 psig			
A3605	1	Orifice	0.116-in.-dia., 8-scfm flowrate			

Finding Number	Reqd	Component	Remarks	Vendor	Drawing Number	Elec. Sym.
A3606	1	Orifice	0.228-in.-dia., 20-scfm flowrate			
A3607	1	Orifice	0.037-in.-dia., 0.5-scfm flowrate			
A3608	1	Orifice	0.037-in.-dia., 0.5-scfm flowrate			
A3609	1	Orifice	0.037-in.-dia., 0.5-scfm flowrate			
A3610	1	Orifice	0.0156-in.-dia., 0.1-scfm flowrate			
A3611 through A3621 are not functionally applicable to this system.						
A3622	1	Transducer, Vacuum			10466012	
A3623	1	Transducer, Vacuum			10466012	
A3624	1	Transducer, Vacuum			10466012	
A3625 through A3639 are not functionally applicable to this system.						
A3640	1	Valve, Relief	Relieves at 100 psig	Manning, Maxwell, & Moore, Inc.	10464412	
A3641	1	Valve, Relief	Relieves at 20 psid	Manning, Maxwell, & Moore, Inc.	10464415	

Finding Number	Reqd	Component	Remarks	Vendor	Drawing Number	Elec. Sym.
A3642	1	Valve, Relief	Relieves at 100 psig	Manning, Maxwell, & Moore, Inc.	10464414	
A3643	1	Valve, Relief	Relieves at 100 psig	Manning, Maxwell, & Moore, Inc.	10464414	
A3644	1	Valve, Relief	Relieves at 100 psig	Manning, Maxwell, & Moore, Inc.	10464414	
A3645	1	Valve, Relief	Relieves at 5 psig	Manning, Maxwell, & Moore, Inc.	10464419	
A3646	1	Valve, Relief	1-in., relieves at 100 psig	Manning, Maxwell, & Moore, Inc.	10464414	
A3647	1	Valve, Relief	Relieves at 100 psig	Manning, Maxwell, & Moore, Inc.	10464414	
A3648 through A3699 are not functionally applicable to this system.						
A3700	1	Gage, Pressure	3500-psig normal reading, 0- to 10,000-psig range	U.S. Gauge Company	10437648	
A3701	1	Gage, Pressure	750-psig normal reading, 0- to 1500-psig range	U.S. Gauge Company	10437688	
A3702	1	Gage, Pressure	120-psig normal reading, 0- to 300-psig range	U.S. Gauge Company	10437687	
A3703	1	Gage, Pressure	25-psig normal reading, 0- to 60-psig range	U.S. Gauge Company	10437686	
A3704	1	Regulator, Pressure	3500-psig inlet, 750-psig outlet	Grove Valve & Regulator Co. Model No. 94X	10437651	

Finding Number	Reqd	Component	Remarks	Vendor	Drawing Number	Elec. Sym.
A3705	1	Regulator, Pressure	750-psig inlet, 120-psig outlet	Grove Valve & Regulator Co. Model No. 94X	10437651	
A3706	1	Regulator, Pressure	120-psig inlet, 25-psi outlet	Moore Products Co. Model 42H50	10437679	
A3707	1	Filter	10-micron	Permanent Filter Corp. P/N 10813	10437650	
A3708	1	Valve, Relief	Cracks at 900 (±50) psig, reseats at 750 psig min	Republic Manufacturing Co. P/N 625B-9-6	10437652	
A3709	1	Valve, Relief	Cracks at 120 psig, reseats at 100 psig min	Republic Manufacturing Co. P/N 625B-3-6	10437680	
A3710	1	Valve, Relief	Cracks at 35 (±5) psig, reseats at 25 psig min	Republic Manufacturing Co. P/N 625-2-8	10437681	
A3711	1	Switch, Pressure	Actuates at 21.5 (±0.5) psig, deactuates within 1.5 psig of actuation press.	Southwestern Industries Inc. P/N PS-3700A-4	10437682	
A3712	1	Valve, Manual	5/16-in., shutoff	Robbins Aviation P/N SSNA-375A-6T	10437684	
A3713	1	Valve, Manual	5/16-in., shutoff	Robbins Aviation P/N SSNA-375A-6T	10437684	
A3714	1	Valve, Manual	5/16-in., shutoff	Robbins Aviation P/N SSNA-375A-6T	10437684	
A3715	1	Valve, Manual	5/16-in., shutoff	Robbins Aviation P/N SSNA-375A-6T	10437684	
A3716	1	Valve, Manual	1/4-in., vent	Futurecraft Corp. P/N 30205	10437647	

Finding Number	Reqd	Component	Remarks	Vendor	Drawing Number	Elec. Sym.
A3717	1	Valve, Manual	1/4-in., vent	Futurecraft Corp. P/N 30205	10437647	
A3718	1	Valve, Manual	1/4-in., vent	Futurecraft Corp. P/N 30205	10437647	
A3719	1	Valve, Manual	1/4-in., vent	Futurecraft Corp. P/N 30205	10437647	
A3720	1	Valve, Manual	5/16-in., shutoff	Robbins-Aviation P/N SSNA-375A-6T	10437684	
A3721	1	Valve, Manual	1/4-in., vent	Futurecraft Corp. P/N 30205	10437647	
A3722	1	Valve, Manual	1/4-in., vent	Futurecraft Corp. P/N 30205	10437647	
A3723	1	Valve, Manual	1/4-in., vent	Futurecraft Corp. P/N 30205	10437647	
A3724	1	Valve, Manual	1/4-in., vent	Futurecraft Corp. P/N 30205	10437647	
A3725	1	Switch, Pressure	Actuates at 600 (±20) psig, deactuates at 50 psig less than actuation pressure	Southwestern Industries P/N PS-5100A	10437683	
A3726 through A3749 are not functionally applicable to this system.						
A3750	1	Pump, Vacuum	8-in. bore, 5-in. stroke	F. J. Stokes Model 412-10		
A3751	1	Pump, Vacuum	8-in. bore, 5-in. stroke	Air Products & Chemicals, Inc.	10463950	

Finding Number	Reqd	Component	Remarks	Vendor	Drawing Number	Elec. Sym.
A3752	1	Subcooler	Supercools LH_2 to -426 F			
A3753	1	Storage Tank, LH_2	125,000-gallon capacity	Air Products & Chemical, Inc.		
A3754	1	Vaporizer				
A3755 through A3770 are not functionally applicable to this system.						
A3771	1	Valve, Manual	5/16-in., shutoff			
A3772 is not functionally applicable to this system.						
A3900	1	Transducer, Pressure	1/4-in., 0- to 100-psia range	Douglas Aircraft Co. P/N 7870467-511		
A3901 through A3904 are not functionally applicable to this system.						
A3905	1	Filter	4-in.; 98 percent of 72 micron particles, 100 per cent of 125 micron particles	Douglas Aircraft Co. 1A38763-1		
A3906	1	Valve, Solenoid	1/4-in.; 4-way, 2-position, NC 750-psig	Douglas Aircraft Co. P/N 3863940-501		
A3907 through A3909 are not functionally applicable to this system.						
A3910	1	Valve, Pneumatic	2-in., 3-position, NC, replenish	Douglas Aircraft Co. P/N 7864354-1		

Finding Number	Reqd	Component	Remarks	Vendor	Drawing Number	Elec. Sym.
A3911	1	Valve, Pneumatic	4-in., NC; main fill	Douglas Aircraft Co. P/N 7864253-1		
A3912	1	Valve, Pneumatic	2-in., NC, line vent	Douglas Aircraft Co. P/N 7864252-1		
A3913 through A3915 are not functionally applicable to this system.						
A3916	1	Transducer, Pressure	1/4-in., 0 to 100 psia range	Douglas Aircraft Co. P/N 7870467-511		
A3917	1	Valve, Pneumatic	1-1/2-in., NC	Douglas Aircraft Co. P/N 7866052-1		
A3918 through A3921 are not functionally applicable to this system.						
A3922	1	Valve, Solenoid	1/4-in., 4-way, 2-position; NC, 750-psig	Douglas Aircraft Co. P/N 3863940-501		
A3923	1	Valve, Solenoid	1/4-in., 4-way, 2-position; NC, 750-psig	Douglas Aircraft Co. P/N 3863940-501		
A3924 is not functionally applicable to this system.						
A3925	1	Valve, Solenoid	1/4-in., 4-way, 2-position; NC, 750-psig	Douglas Aircraft Co. P/N 3863940-501		
A3926 through A3930 are not functionally applicable to this system.						
A3931	1	Valve, Solenoid	1/4-in., 4-way, 2-position; NC, 750-psig	Douglas Aircraft Co. P/N 386940-501		

Finding Number	Reqd	Component	Remarks	Vendor	Drawing Number	Elec. Sym.
A3932	1	Valve, Relief	1-in., relieves at 92 (± 2) psig, reseats at 84 (± 2) psig	Douglas Aircraft Co. P/N 3865757-1		
A3933 through A3935 are not functionally applicable to this system.						
A3936	1	Coupling				
A3937	1	Coupling				
A3938	1	Motor	15-hp	U. S. Electrical Motors, Inc. Type J	10462945	
A3939	1	Motor	15-hp	U. S. Electrical Motors, Inc. Type J	10462945	
A3940	1	Coupling				
A3941	1	Coupling				
A3942	1	Coupling				
A3943	1	Coupling				
A3944	1	Orifice	1/2-in.	Douglas Aircraft Co.		
A3945	1	Pressure Switch		Douglas Aircraft Co.		

Finding Number	Reqd	Component	Remarks	Vendor	Drawing Number	Elec. Sym.
A3946	1	Coupling				
A3947	1	Coupling				
A3948	1	Coupling				
A3949	1	Transducer, Differential Pressure				
A3950 through E99 are not functionally applicable to this system.						
E100	1	Coupling, Quick-Disconnect		Douglas Aircraft Co. P/N 7851805-1		
E101 is not functionally applicable to this system.						
E102	1	Tank, LH_2	4274-cu-ft	Douglas Aircraft Co.		
E103 and E104 are not functionally applicable to this system.						
E105	1	Coupling, Quick-Disconnect		Douglas Aircraft Co. P/N 7851802-1		
E106	4	Vortex Eliminator	100-and 150-mesh	Douglas Aircraft Co. P/N 5851798-1		
E107	1	Sensor, Mass		Douglas Aircraft Co.		

Finding Number	Reqd	Component	Remarks	Vendor	Drawing Number	Elec. Sym.
E108 through E112 are not functionally applicable to this system.						
E113	1	Valve, Pneumatic	3-in., NC	Douglas Aircraft Co. P/N 7851806-501		
E114	1	Valve, Pneumatic	NC, 475 (± 25)-psig, vent and relief; relieves at 44 psia, reseats at 41 psia.	Douglas Aircraft Co. P/N 7851795-1		
E115	1	Valve, Pneumatic	NC, 475 (± 25)-psig, vent and relief; relieves at 44 psia, reseats at 41 psia.	Douglas Aircraft Co. P/N 7851795-1		
E116 through E208 are not functionally applicable to this system.						
E209	1	Valve, Solenoid	3-way, 2-position, NC	Douglas Aircraft Co. P/N 7851827-1		
E210	1	Valve, Solneoid	3-way, 2-position, NC	Douglas Aircraft Co. P/N 7851827-1		
E211	1	Valve, Solenoid	3-way, 2-position, NC	Douglas Aircraft Co. P/N 7851827-1		
E212 through E249 are not functionally applicable to this system.						
E250	1	Coupling, Quick-Disconnect		Douglas Aircraft Co. P/N 7851861-1		
E251	1	Valve, Check	1-to 2-psig cracking press.	Douglas Aircraft Co. P/N 7851859-1		
E252	1	Orifice	0.209-in.-dia.	Douglas Aircraft Co. P/N 4884302-523		

Finding Number	Reqd	Component	Remarks	Vendor	Drawing Number	Elec. Sym.
E253	1	Orifice	0.257-in.-dia.	Douglas Aircraft Co. P/N 4884302-521		
E254	1	Valve, Electropneumatic		Douglas Aircraft Co. P/N 7851858-1		
E255	1	Valve, Electropneumatic		Douglas Aircraft Co. P/N 7851858-1		
E256	1	Orifice	0.397-in.-dia.	Douglas Aircraft Co. P/N 4884302-525		
E257	1	Valve, Solenoid	2-way, 2-position, NC	Douglas Aircraft Co. P/N 7851825-1		
E258	1	Valve, Check	5- to 10-psig cracking press.	Douglas Aircraft Co. P/N 7851822-1		
E259	1	Orifice	0.140-in.-dia	Douglas Aircraft Co. P/N S-4851838-4		
E260 through E274 are not functionally applicable to this system.						
E275	1	Switch, Differential Pressure	Actuates at 4 (± 0.3) psid	Douglas Aircraft Co. P/N 7851831-1		
E276	1	Switch, Pressure	Actuates at 37.25 (± 0.75) psia, deactuates at 35.75 (±0.75) psia	Douglas Aircraft Co. P/N 7851860-501		
E277	1	Switch, Pressure	Actuates at 31.5 (±0.5) psi, deactuates at 30.5 (±0.5) psia	Douglas Aircraft Co. P/N 7851860-1		
E278	1	Switch, Pressure	Actuates at 34.5 (± 0.5) psia, deactuates at 33.5 (± 0.5) psia	Douglas Aircraft Co. P/N 7851860-505		

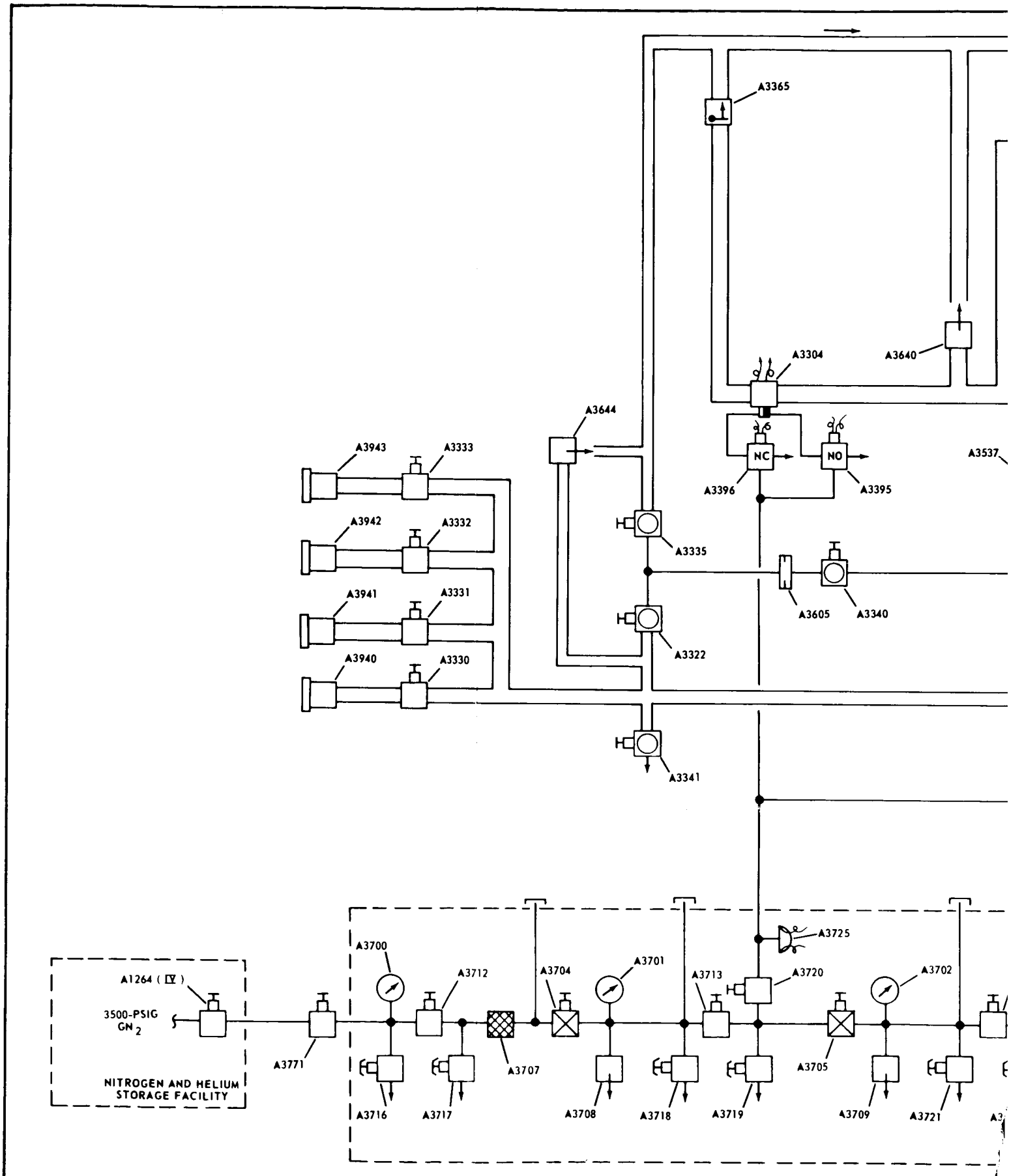
Finding Number	Reqd	Component	Remarks	Vendor	Drawing Number	Elec. Sym.
E279	1	Switch, Pressure	Actuates at 29.5 (± 0.5) psia, deactuates at 27.5 (± 0.5) psia	Douglas Aircraft Co. P/N 7851860-507		
E280 through E320 are not functionally applicable to this system.						
E321	1	Valve, Solenoid				
E322	1	Valve, Solenoid				

SECTION 3

MECHANICAL SCHEMATICS

This section contains mechanical schematics that show the functional arrangement of LH_2 fuel system components listed in section 2.

For a definition of the mechanical symbols used, see MSFC-STD-162A.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A3605
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A3341
A3725
A3700
A3712
A3704
A3701
A3713
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GN 2
NITROGEN AND HELIUM
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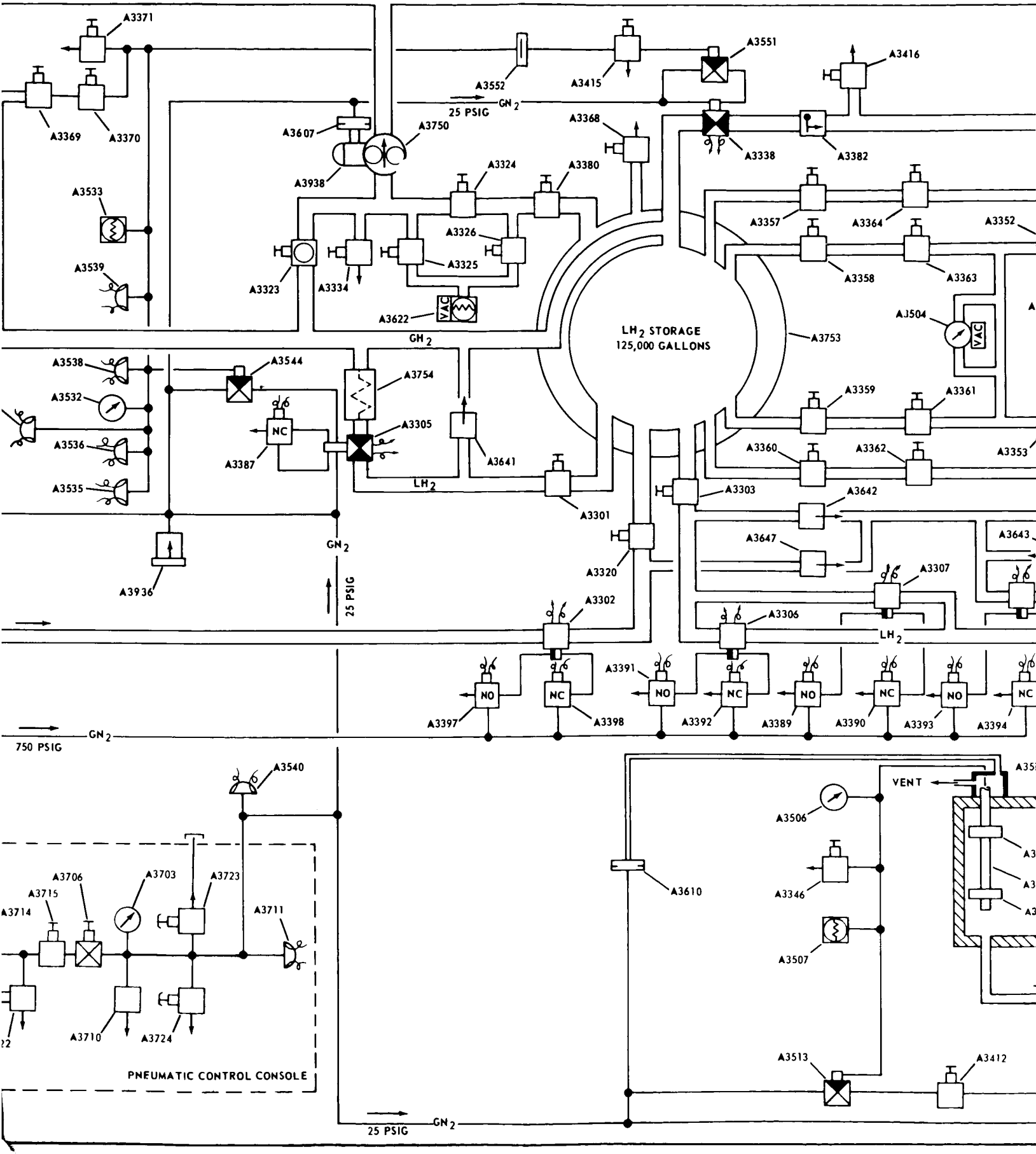
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A3622
VAC
A3380
A3552
A3415
A3551
A3416
25 PSIG
GN2
A3368
A3338
A3382
A3357
A3364
A3352
A3358
A3363
A3504
VAC
LH2 STORAGE
125,000 GALLONS
A3753
GH2
A3538
A3532
A3536
A3535
A3544
A3754
A3305
NC
A3387
A3641
LH2
A3359
A3361
A3360
A3362
A3353
A3303
A3642
A3301
A3647
A3643
A3320
A3307
A3302
A3306
LH2
GN2
25 PSIG
A3936
750 PSIG
GN2
NO
NC
A3397
A3398
A3391
A3392
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A3390
A3393
A3394
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A3706
A3715
A3714
A3703
A3723
A3711
A3710
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VENT
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A3610
A3346
A3507
A3513
A3412
25 PSIG
GN2

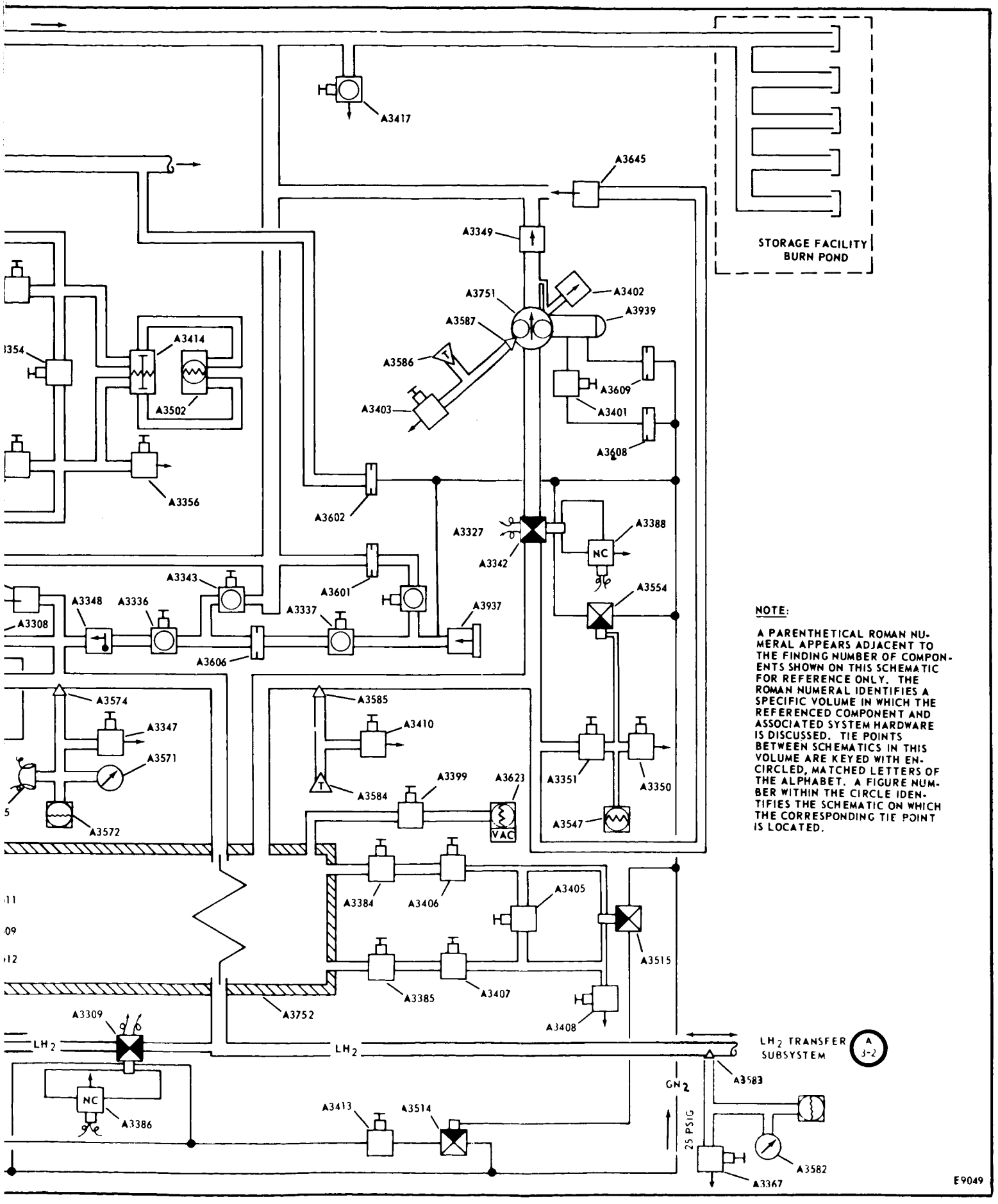
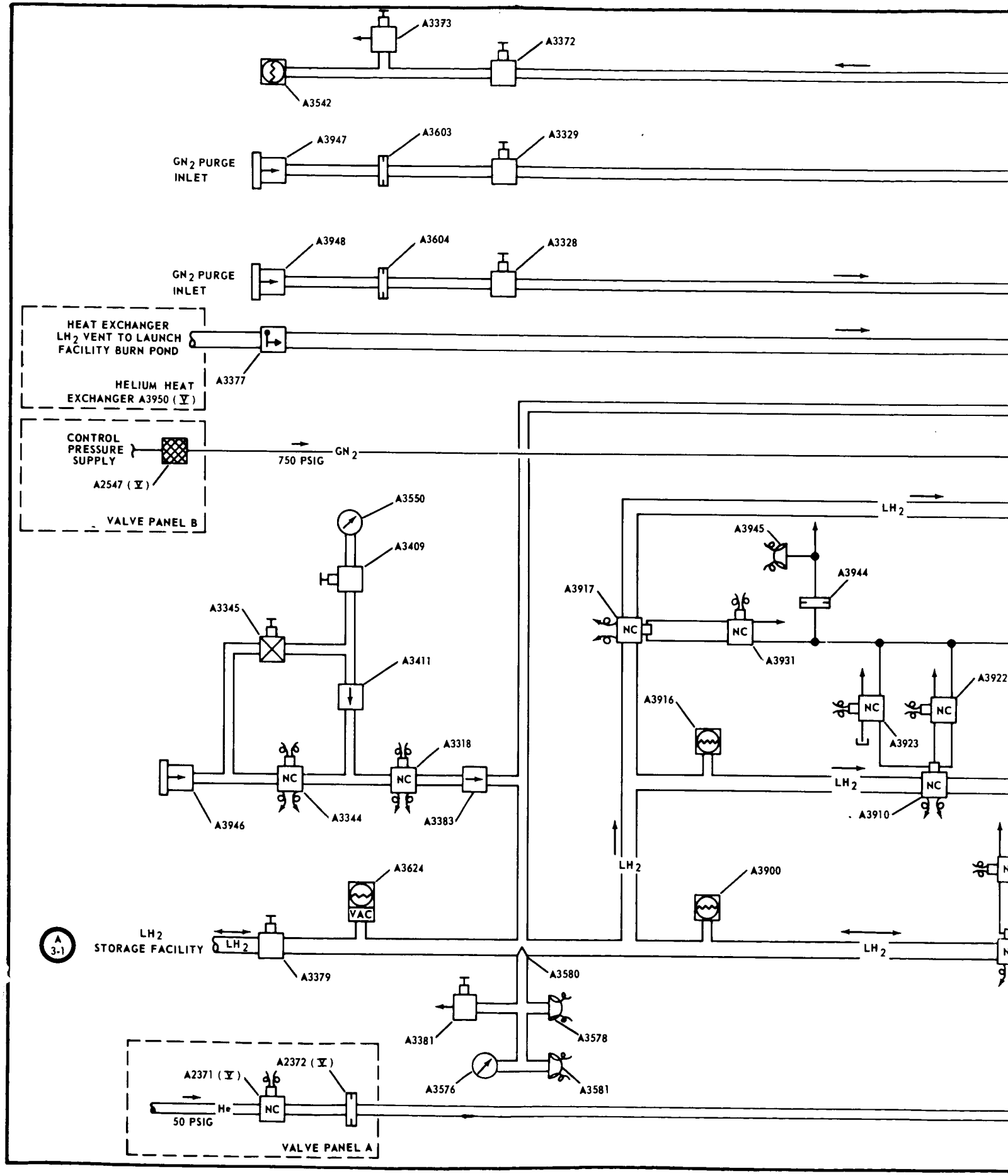


Figure 3-1. Launch Complex 37B LH_2 Fuel Storage Facility-Mechanical Schematic


A3373
A3372
A3542
GN2 PURGE INLET
A3947
A3603
A3329
GN2 PURGE INLET
A3948
A3604
A3328
HEAT EXCHANGER LH2 VENT TO LAUNCH FACILITY BURN POND
A3377
HELIUM HEAT EXCHANGER A3950 (V)
CONTROL PRESSURE SUPPLY
A2547 (V)
750 PSIG
GN2
VALVE PANEL B
A3550
A3409
A3345
A3411
A3318
NC
A3946
A3344
A3383
LH2
A3945
A3944
A3917
A3931
A3922
A3916
A3923
A3910
A3624
VAC
A3900
A3-1
LH2 STORAGE FACILITY
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A3578
A3576
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A2371 (V)
A2372 (V)
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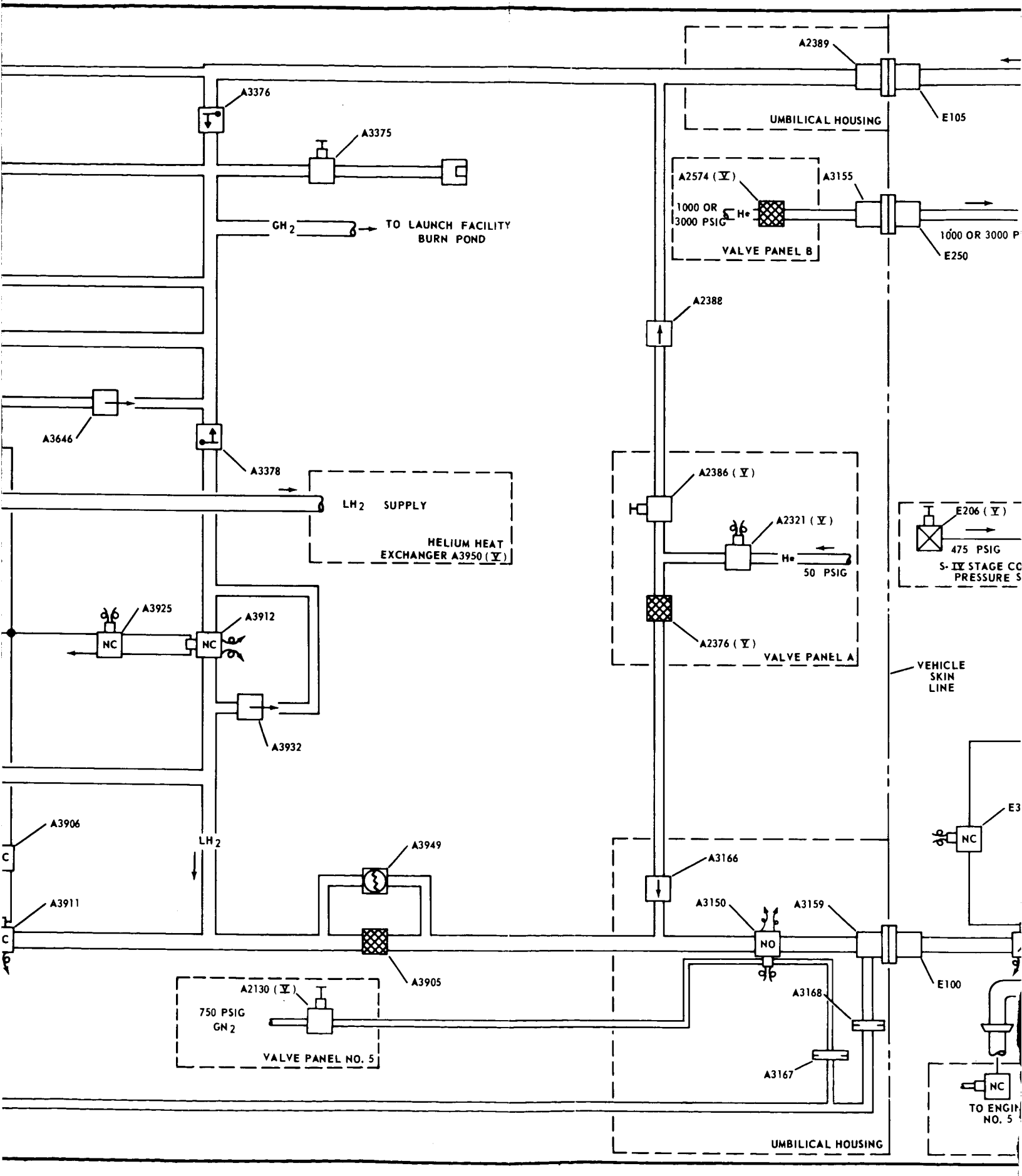
50 PSIG
VALVE PANEL A


A2389
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A3375
UMBILICAL HOUSING
E105
A2574 (Y)
A3155
1000 OR 3000 PSIG
He
VALVE PANEL B
1000 OR 3000 P
E250
GH2
TO LAUNCH FACILITY BURN POND
A2388
A3646
A3378
LH2 SUPPLY
HELIUM HEAT EXCHANGER A3950 (Y)
A2386 (Y)
A2321 (Y)
E206 (Y)
475 PSIG
He
50 PSIG
S-IV STAGE CO
PRESSURE S
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A3912
NC
NC
A2376 (Y)
VALVE PANEL A
VEHICLE SKIN LINE
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A3906
LH2
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E100
A3905
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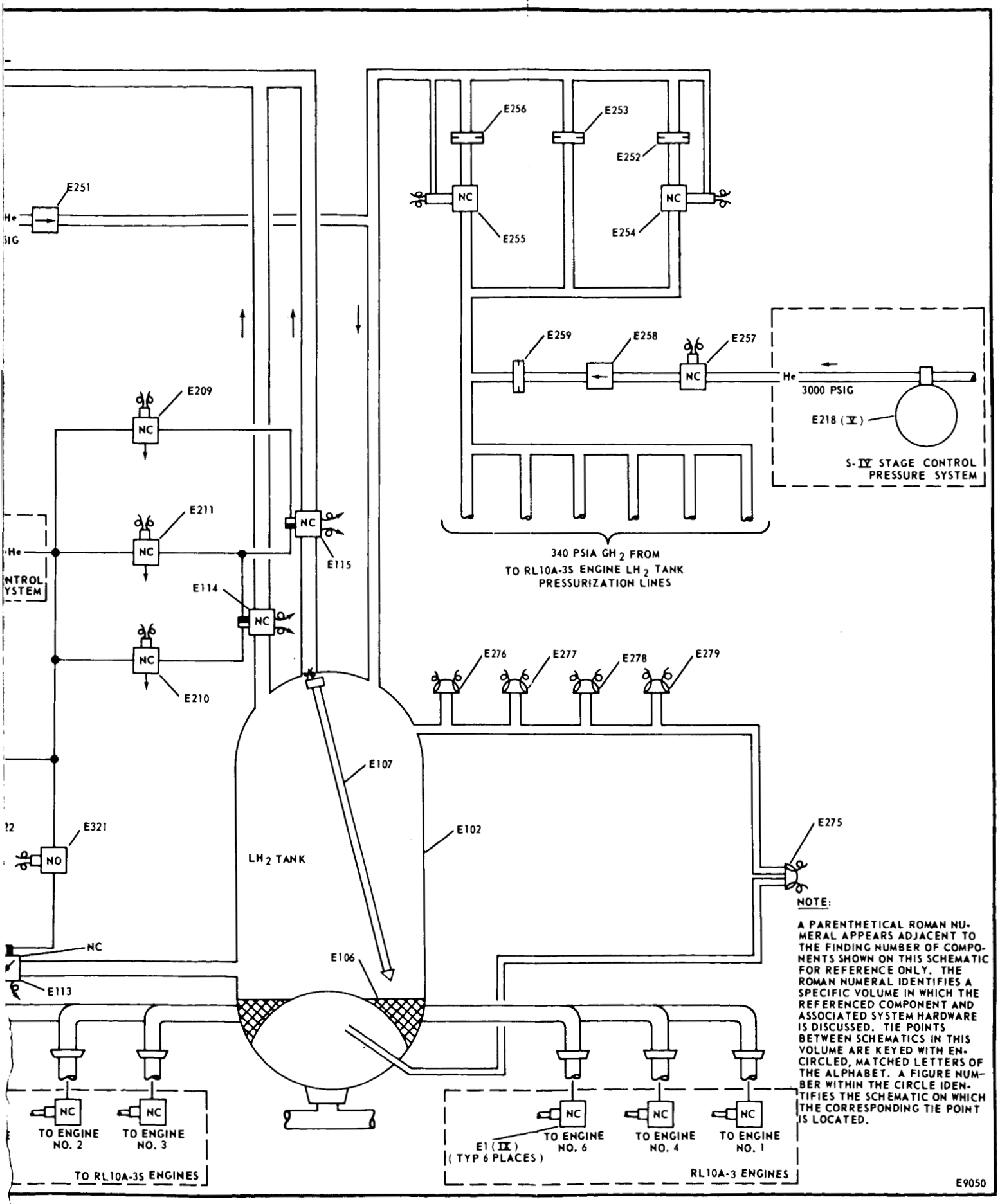
TO ENGI
NO. 5
UMBILICAL HOUSING

Figur



3-2. Launch Complex 37B LH_2 Transfer Subsystem and S-IV Stage LH_2 Subsystem-Mechanical Schematic