NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

BELL AEROSYSTEMS - A textron COMPANY

TITLE

LUNAR LANDING TRAINING VEHICLE SERVICE AND MAINTENANCE MANUAL

REPORT NO. 7260-954002

25 AUGUST 1969

MANNED SPACECRAFT CENTER

HOUSTON, TEXAS

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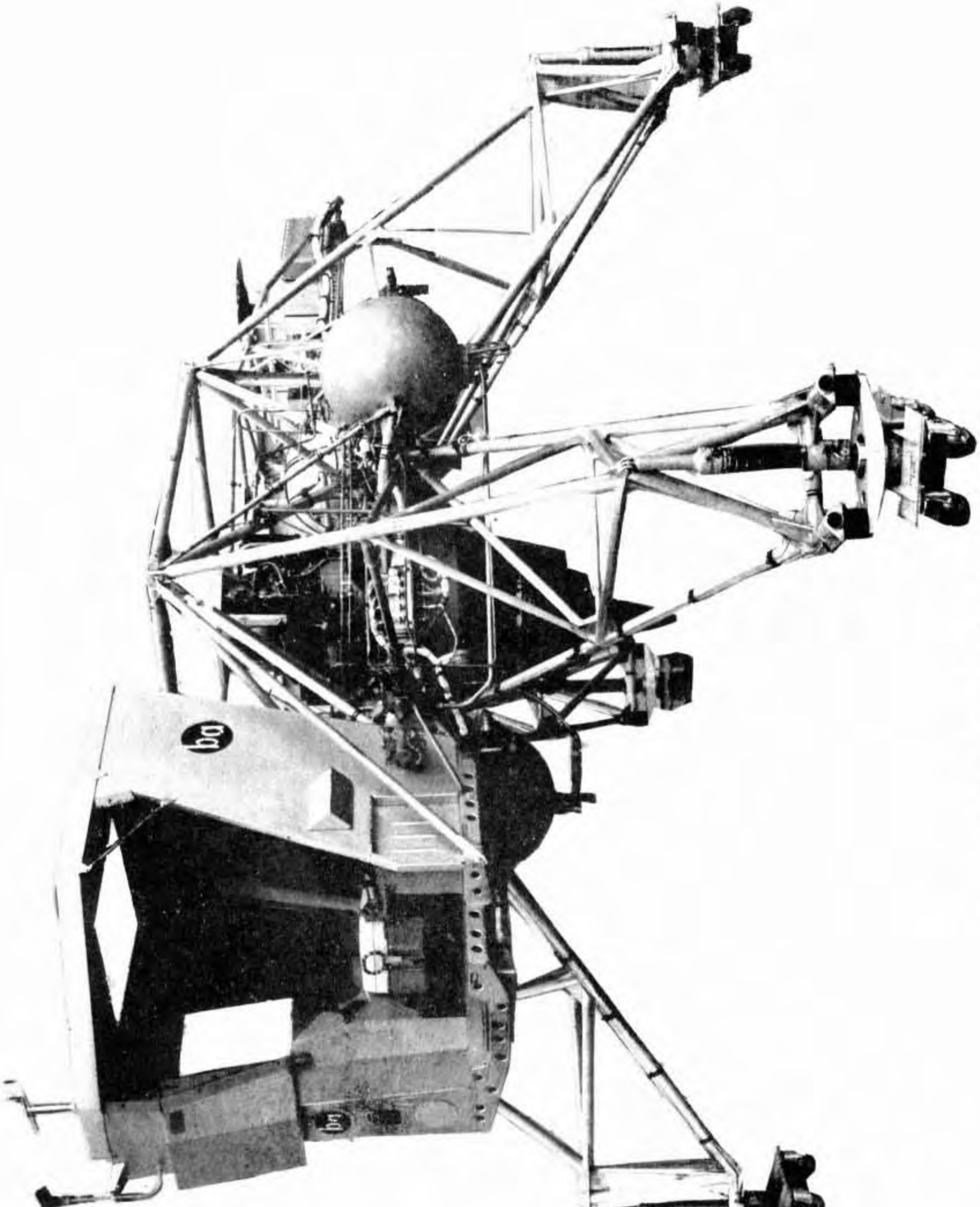

Figure 1-1. Lunar Landing Training Vehicle

SECTION I

GENERAL INFORMATION

1-1. GENERAL

1-2. The Lunar Landing Training Vehicle (hereafter referred to as either the LLTV or Vehicle), figure 1-1, has been designed and manufactured by Bell Aerosystems Company, Model 7260, under Contract NAS 9-6657 for the National Aeronautcs and Space Administration. The vehicle capabilities provide potential moon landing astronauts a simulated lunar gravity and atmospheric environment and also trains the astronauts to cope and react to the operational problems involved in the final phases of a lunar landing and the initial phases of a lunar takeoff. Areas of training, using the LLTV, include the controls, displays, visibility, orientation systems, propulsion, and dynamics in flight and landing. The LLTV operates in free flight to simulate the lunar gravity and atmospheric environment by compensating for aerodynamic drag forces and moments and excessive (earth) gravitational forces.

1-3. SCOPE OF MANUAL

1-4. This service and maintenance manual has been prepared for use by skilled, trained personnel, as an aid in servicing and maintaining the LLTV. It contains all necessary information and instructions for transporting, erecting, flight line servicing and maintenance.

1-5. PUBLICATIONS

1-6. Table 1-1 lists the publications to be used in conjunction with this manual that are applicable to the operation, servicing, and maintenance of the LLTV.

TABLE 1-1. APPLICABLE DOCUMENTS

DOCUMENT NO.	DOCUMENT TITLE
	Bell Aerosystems Company
Handbooks and Manuals	
7260-954001	LLTV Flight Manual
7260-954003	LLTV Weight and Balance Handbook
7260-954004	LLTV Avionic Test Cart Operational Manual
Ground Run Checklists	
7260-931001	Rocket Operational Ramp Checklist
7260-931003	Pilot ACS Familiarization on CG Fixture
7260-931004	Jet Engine Run Ramp Checklist
Flight Checkout Inspection and Servicing Checklists	
7260-931005	Vehicle Preflight Checklist
7260-931006	Avionic System Preflight Checklist
7260-931007	Instrumentation System Preflight Checklist
7260-931009	Radar System Preflight Checklist
7260-931012	Vehicle Turnaround Preflight Checklist
7260-931016	Avionic System Turnaround Preflight Checklist
7260-931010	Vehicle Postflight Checklist
Flight Checklists	
7260-931008	Pilot Flight Checklist
7260-931011	Flight Controller Checklist
7260-931014	Mission Plan
7260-931015	Data Reduction Plan

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7260-931015	Data Reduction Plan

TABLE 1-1. APPLICABLE DOCUMENTS (Continued)

DOCUMENT NO.	DOCUMENT TITLE
	General Electric Company
G.E. SEI-157	CF 700-2C Turbofan Engine Operating Instructions
G.E. SEI-158	CF 700-2C Turbofan Engine Maintenance Manual
G.E. SEI-133	CF 700-2C Turbofan Engine Operation, Maintenance and Overhaul Manual
	Scott Aviation Company
35-30-78	Scott Overhaul Manual
QCP 20-5	Control of High Pressure Type Cylinders Airline Oxygen Equipment Catalog.
	Weber Aircraft Company
Weber Seat Manual Manual DR 5773-1	Operation; Periodic Inspection and Maintenance; and Overhaul Instructions for LLRV/LLTV Pilot Ejection Seat and Fixed Rail Assembly
	and
	Packing and Inspection Procedure for LLRV/LLTV Pilot Personnel Parachute Assemblies
	Ryan Aeronautical Company
Ryan 54764-1	Support Manual for Model 547 Doppler Velocity Sensor
Ryan 54764-2	Handbook Operation Instructions Flight Data System for LLTV
Ryan 54764-3	Support Manual for Model 547 Thrust-To-Weight Indicator
Ryan 60264-1	Support Manual for Model 602 Radar Altimeter
	Cubic Corporation
N/A	Operation and Maintenance Manual for Model TR-31 -- UHF Transceiver

1-7. DESCRIPTION

1-8. The LLTV is a vertically rising free-flight lunar landing training vehicle that simulates lunar gravity and lunar atmospheric environment. The LLTV operates in free flight on earth with compensation for aerodynamic drag and movement, and earth gravitational forces.

1-9. The LLTV is manned by a crew of one and propelled by a jet engine and a rocket propulsion system.

1-10. During a lunar landing simulation, the jet engine remains essentially vertical regardless of the attitude of the vehicle, and the jet thrust supports five-sixths of the vehicle's weight. The remaining one-sixth of the weight is supported by hydrogen-peroxide lift rockets that are mounted on the main frame and tilt with the vehicle. The attitudes and accelerations are similar to those that will be experienced on the moon where gravity is one-sixth that on earth. The pilot controls the descent by means of two lift rockets. Sixteen attitude rockets provide attitude control.

1-11. VEHICLE STRUCTURE

1-12. The primary airframe structure consists of a pyramid-shaped tublar structure with four truss-type legs. The cockpit section extends forward between the two front legs and the equipment platform, similarly positioned, extends rearward. The jet engine is mounted in a gimbal ring at the center of the vehicle. The general arrangement and configuration is shown in figure 4-1.

1-13. MAJOR STRUCTURAL COMPONENTS - The major structural components of the vehicle are: center body, engine mounted, gimbal ring, peroxide tanks, fuel

(JP4) tanks, cockpit structure, equipment structure, and leg installation/ shock struts. These components are briefly described in the following paragraphs.

1-14. CENTER BODY - The center body structure consists of an upper and a lower frame connected by diagonal tubes. Refer to section IV and Drawing No. 7260-152001 for more detailed information.

1-15. ENGINE MOUNT - The engine mount is a built-up sheet metal ring, the inner surface of which is contoured to form the outer wall of the engine fan inlet. The engine is attached to the mount at the two points of the lower surface and by a steady rest at the top of the forward fitting. Refer to section IV and Drawing No. 7161-421032 for more detailed information.

1-16. GIMBAL RING - The gimbal ring is a machined aluminum ring that supports the engine mount that is supported by the center body. The gimbal ring is capable of supporting two ground crewmen during ground maintenance operations. Refer to section IV and Drawing No. 7260-421001 for more detailed information.

1-17. HYDROGEN PEROXIDE TANKS - Two hydrogen peroxide tanks are mounted on the vehicle, one on each side. Refer to section VII and Drawing No. 7260-471001 for more detailed information.

1-18. FUEL (JP4) TANKS - Two JP4 tanks are mounted on the vehicle and are spaced symmetrically about the vehicle center of gravity: one in front of the engine and the other directly behind the engine. Refer to section VI and Drawing No. 7260-424017 for more detailed information.

1-19. COCKPIT STRUCTURE - The cockpit structure consists of a sheet metal platform, ejection seat support, and a cockpit enclosure. Refer to section IV and Drawing No. 7260-150008 for more detailed information.

1-20. EQUIPMENT STRUCTURE - The equipment structure consists of a movable tray, and an adjustable platform. Refer to section IV and Drawing No. 7260-153001 for more detailed information.

1-21. LEG INSTALLATION/SHOCK STRUTS - Four identical interchangeable legs are mounted on the vehicle. A conventional air-oil shock strut is mounted at the end of each leg truss to absorb the landing impact. Refer to section IV and Drawing No. 7260-155001 for more detailed information.

1-22. WEIGHT AND BALANCE

1-23. WEIGHT - The vehicle structure and equipment weight is approximately 4000 pounds. This weight varies due to different types of engines and payloads, and does not include the pilot and personal gear. Refer to LLTV Weight and Balance Manual No. 7260-954003 for additional information.

1-24. CREW CAPACITY - The vehicle is designed to carry one pilot whose weight, including 15 pounds of personal equipment, is no less than 115 pounds or more than 215 pounds.

1-25. BALANCE - For balance information, refer to Weight and Balance Handbook, Report No. 7260-954003. Figure 1-2 is a two-view sketch of the LLTV.

1-26. BALANCE ADJUSTMENT - The LLTV center of gravity can be changed by simple adjustments of the aft platform and equipment. Sufficient adjustment is provided to permit compensation for the maximum difference of 60 pounds in pilot weights.

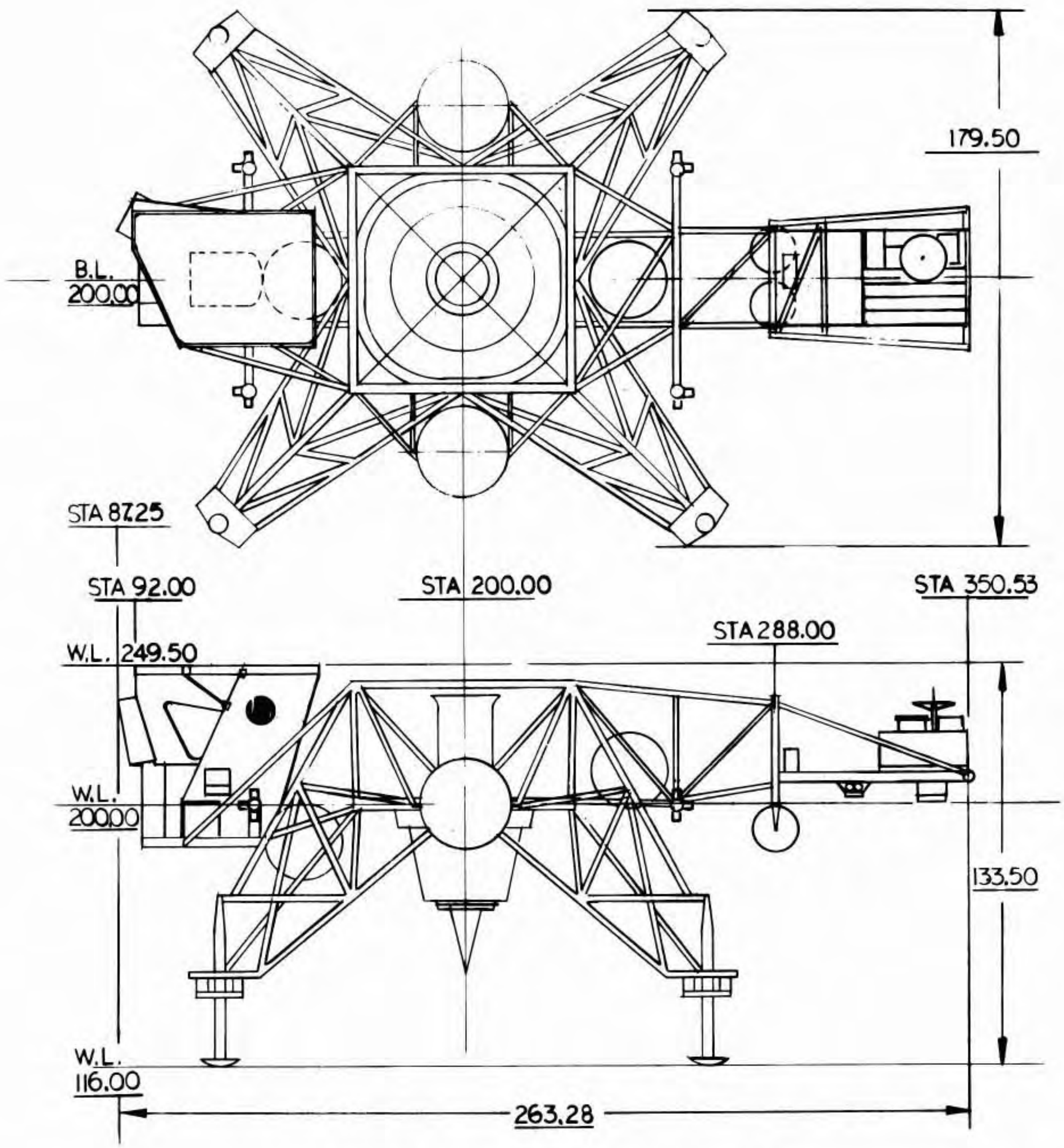


Figure 1-2. Two View Sketch of the LLTV

1-27. The weight and adjustment of the aft platform permits center of gravity adjustments with increments of 0.1 inch or less at the fully-serviced weight. The center of gravity of the vehicle is measurable to within 0.1 inch in all three axes.

1-28. Additional minor adjustments to vehicle C.G. are made by variance of weights in leg cans - (which can be mounted on any combination of legs, as required), or by adding or removing ballast plates to the underseat ballast system.

1-29. JET ENGINE CENTER OF GRAVITY - The center of gravity of the CF 700 2CV jet engine is as follows:

A. The engine longitudinal center of gravity is 7.5 $\pm$ 0.5 inches from the main engine mounts center line and toward the engine inlet.

B. The lateral center of gravity is located at Engine Buttock Line 100.3 $\pm$ 0.1 (vehicle body station 199.7 $\pm$ 0.1) and Engine Waterline 99.0 $\pm$ 0.1 (vehicle buttock line 199.0 $\pm$ 0.1). For further information, refer to General Electric Company Drawing No. 6010T65.

1-30. JET ENGINE SYSTEM

1-31. The Jet Engine system provides thrust requirements for takeoff and flight, or to simulate lunar gravity by providing thrust capability to counteract five-sixths of the earth's gravitational attraction during the Lunar Simulation mode. The system includes a Turbojet Engine, Fuel, system, Gimbal Hydraulic system, and a Power Control system. Refer to section VI for detailed information.

1-32. JET ENGINE - The jet engine is a General Electric CF 700-2CV aft fan turbojet having an SFC of 0.70 or less, throughout the specified flight regimes. This engine provides a static sea level thrust of at least 4200 pounds at temperatures up to 82 degrees F. (Refer to General Electric Manual SEI-157 for detailed information.)

1-33. ENGINE INSTALLATION - The engine is mounted in a position on gimballing mounts, that permit ± 40 degrees pitch and ± 25 degrees roll relative to the vertical position of the vehicle. (Refer to section VI for more detailed information.)

1-34. ENGINE INSTRUMENTS - Instruments for cockpit and ground inflight monitoring of engine performance are: oil pressure gage, low oil pressure warning indicator, exhaust gas temperature gage, fan RPM gage (ground only) and gas generator percent RPM gage. (Refer to section VIII for detailed information on all instrumentation.)

1-35. JET FUEL SYSTEM - The Jet Fuel system (figure 1-3) consists of fuel storage tanks, tank pressurization provision, fuel level switches and calibrated fuel level probes, pressure balancing fuel flow proportioner, fuel level warning indicators and tank pressure gages (cockpit mounted), check valves, filters, and quick-disconnect fill and drain plugs. (Refer to section VI for detailed maintenance instructions.)

1-36. JET ENGINE THROTTLE CONTROL SYSTEM - A combination hydraulic and electrical manual throttle (figure 1-4) provides the pilot with a primary and backup control of the jet engine main fuel control, respectively. (Refer to section IV for detailed maintenance instructions.) An automatic Electronic Throttle Control subsystem controls the jet thrust during lunar simulation. The pilot can manually override or disengage the automatic throttle at any time. (Refer to section V for detailed maintenance instructions for the automatic throttle control.)

FUEL SYSTEM

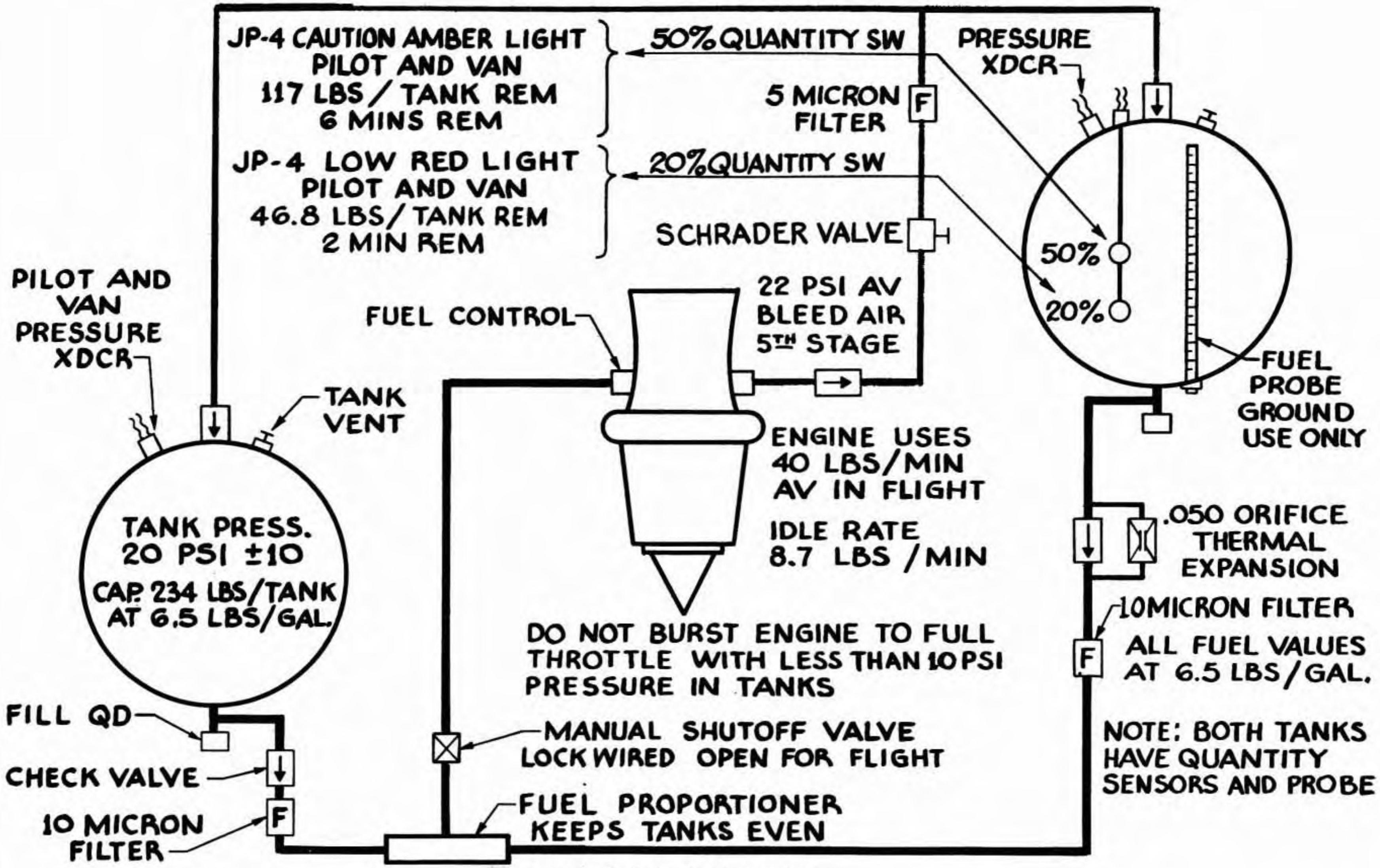


Figure 1-3 Jet Fuel System

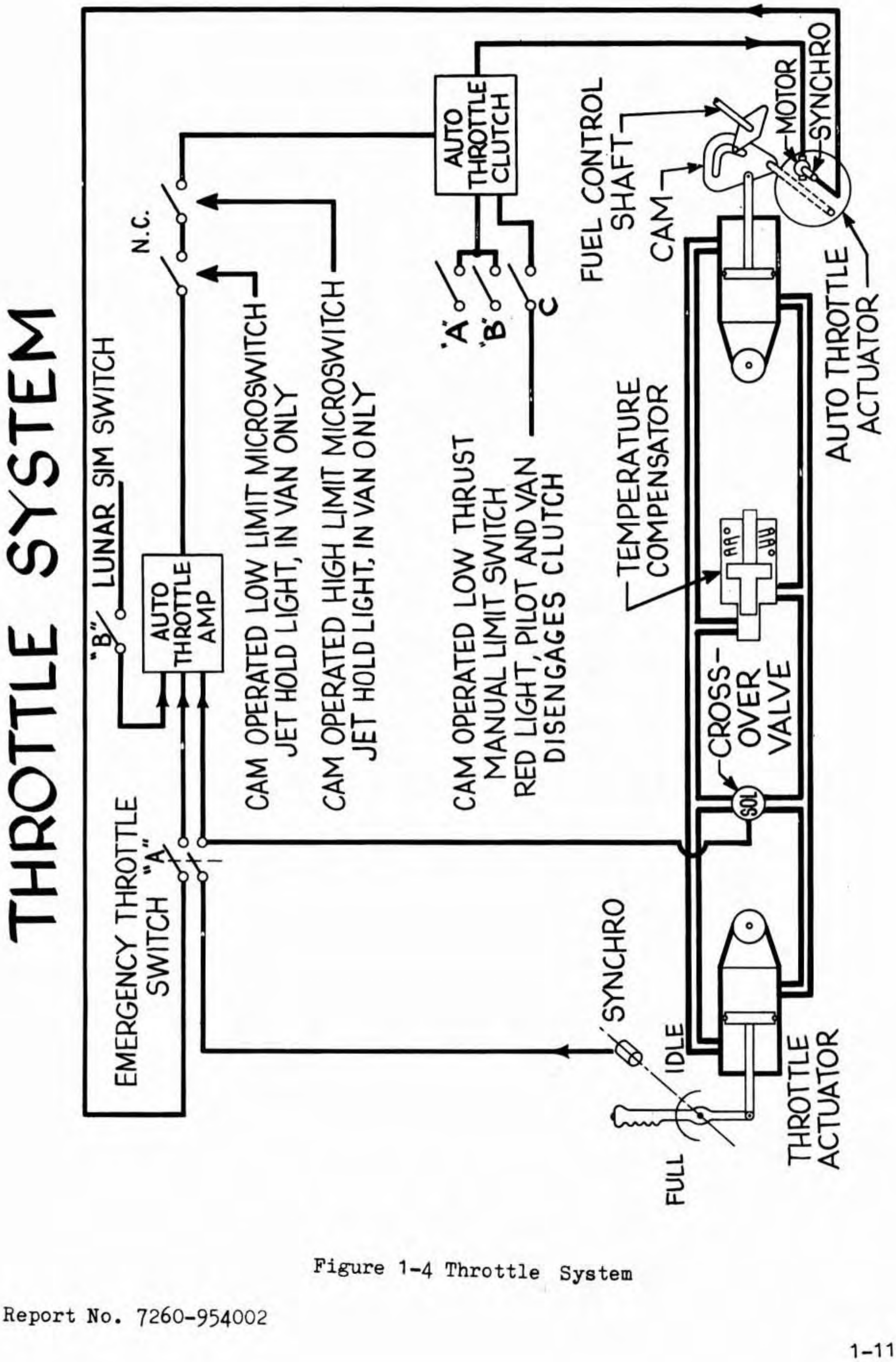


Figure 1-4 Throttle System

1-37. AUTOMATIC ELECTRONIC THROTTLE - The automatic jet throttle is used during the lunar simulation. The pilot arms the automatic throttle with the Lunar Simulation Arm switch on the left console. By increasing lift rocket thrust until the chamber pressure is greater than 100 psia, the system then engages the auto throttle and commands the jet thrust to five-sixths of the vehicle weight.

1-38. OVERRIDE AND DISENGAGE CAPABILITY - The auto throttle system is provided with a clutch which permits the pilot (25 to 30 pounds force) to override the automatic system with the hydraulic throttle control without disengaging the automatic system. An additional pushbutton switch on the throttle also permits disengagement of the auto throttle at any time to permit hydraulic throttle control. Actuation of the pushbutton or deactivation of the Lunar Simulation Arm switch will disengage the auto throttle.

1-39. AUTO THROTTLE LIMIT SWITCHES - Three auto throttle microswitches disengage or limit the motion of the auto throttle actuator so that the throttle will not exceed the required range of engine operation for the Lunar Simulation mode. (Refer to section XI for detailed description.)

1-40. THROTTLE INSTRUMENTATION - A potentiometer is installed on the jet throttle for ground monitoring and recording of throttle position.

1-41. YAW CONTROL INSTALLATION - An air jet utilizing jet engine compressor bleed air is used to counteract jet engine exhaust gas swirl induced moments on the vehicle. The system is sized to reduce yaw moments from amount 80 ft-lb to less than 20 ft-lb.

1-42. JET ENGINE GIMBAL HYDRAULIC SYSTEM - The hydraulic system supplies power to two electro-hydraulic servo-actuators for pitch and roll attitude control of the jet engine during the Gimbal Lock, Local Vertical, Engine

Centered, and Jet Stabilization modes of operation. Emergency hydraulic accumulator is used for centering the engine in the emergency Gimbal Lock mode in the event of main system hydraulic pressure loss, or in case the normal Gimbal Lock switch fails to function. (Refer to section V for detailed information on the hydraulic system.)

1-43. ROCKET PROPULSION SYSTEM

1-44. The three major subsystems are: (1) A propellant pressurization (figure 1-3) subsystem containing high pressure helium which is regulated down to pressurize propellant tanks, (2) a propellant storage subsystem (figure 1-5) consisting of two hydrogen peroxide tanks with associated plumbing and valves, and (3) a propellant utilization subsystem (figures 1-6 and 1-7) consisting of two variable thrust lift rockets and 16 pulse-type fixed (ground adjustable) thrust attitude control rockets. (Refer to section VII for detailed information.)

1-45. PRESSURE SYSTEM INSTRUMENTATION - Pressurization sensors for both cockpit and ground monitoring during flight include:

A. Pressure indicators for both helium tanks.
B. Helium Source Low Level Warning indicator that indicates helium source pressure below 1775 psig.
C. Pressure indicators for both H_2O_2 propellant tanks.

1-46. PROPELLANT STORAGE SUBSYSTEM - The Propellant Storage system contains two hydrogen peroxide tanks, liquid level probes, temperature probes, fill, and vent valves. Each propellant tank has a nominal capacity of 392 pounds of propellant in addition to ullage. Total minimum capacity of the two tanks without ullage is approximately 784 pounds. A slosh and anti-vortex baffle minimizes sloshing to prevent gas from entering the Lift and Attitude Rocket systems. A lift rocket standpipe in each tank assures a propellant reserve of 35 pounds per tank for the

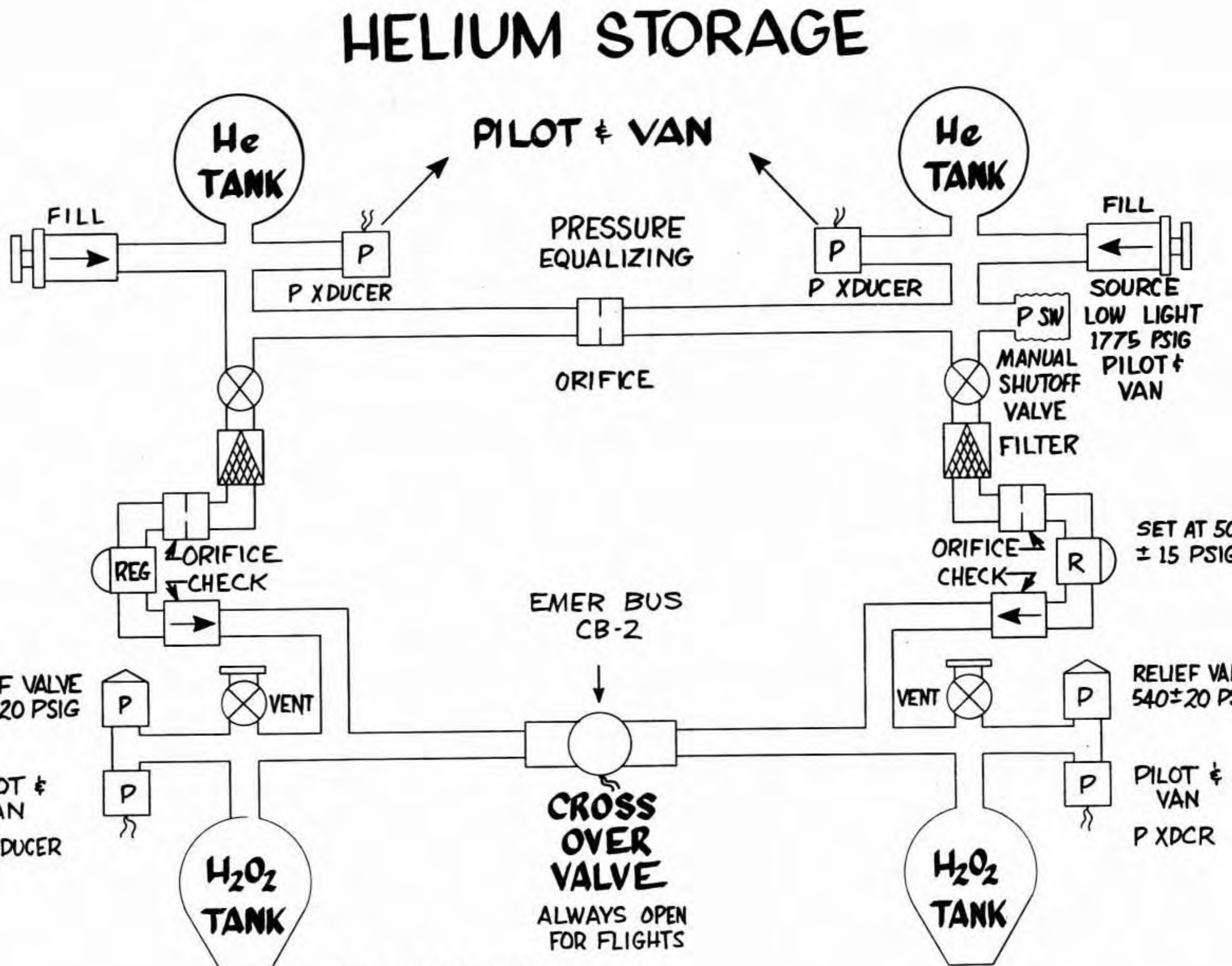


Figure 1-5 Helium And H_2O_2

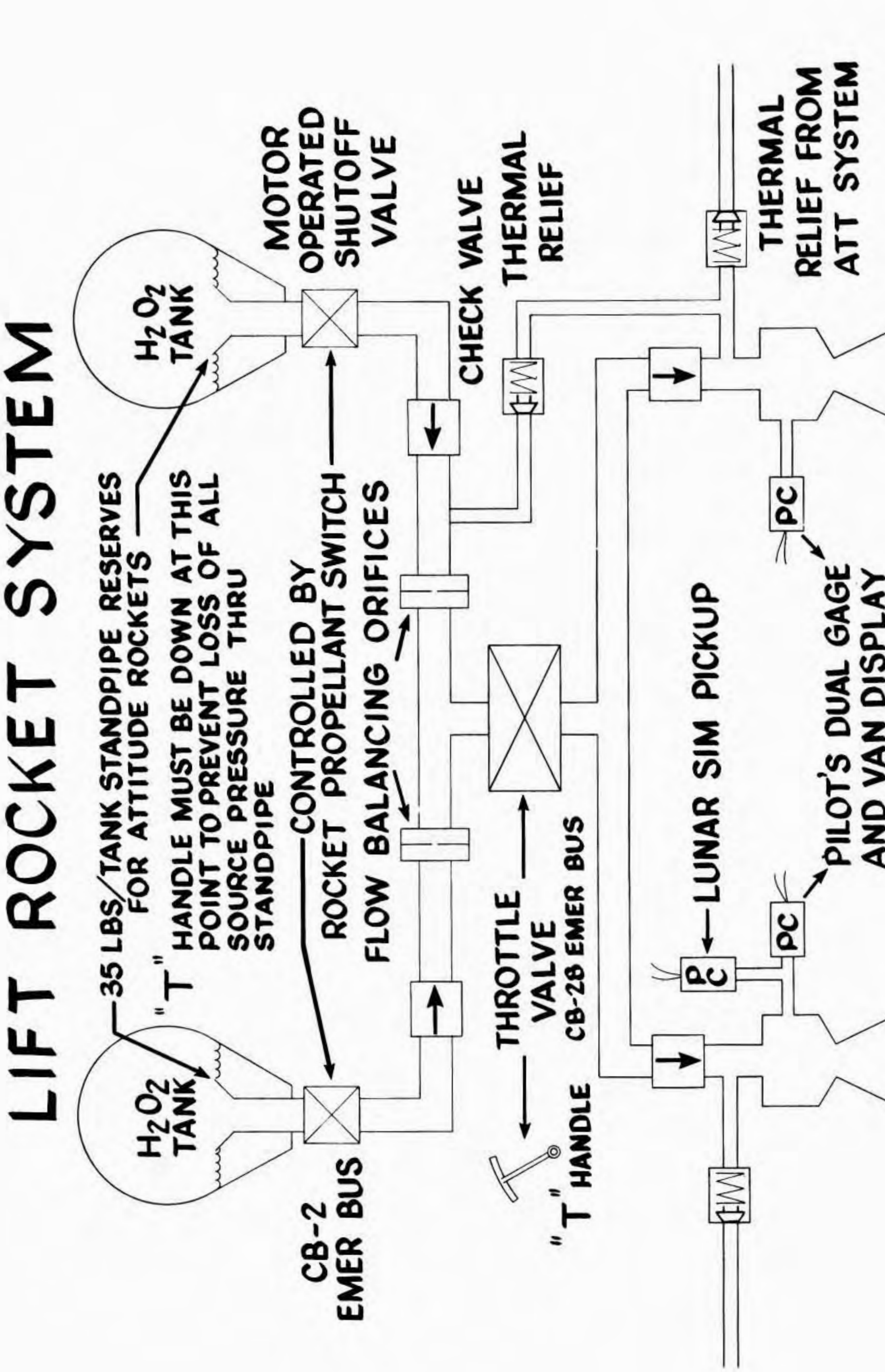


Figure 1-6 Lift Rocket System

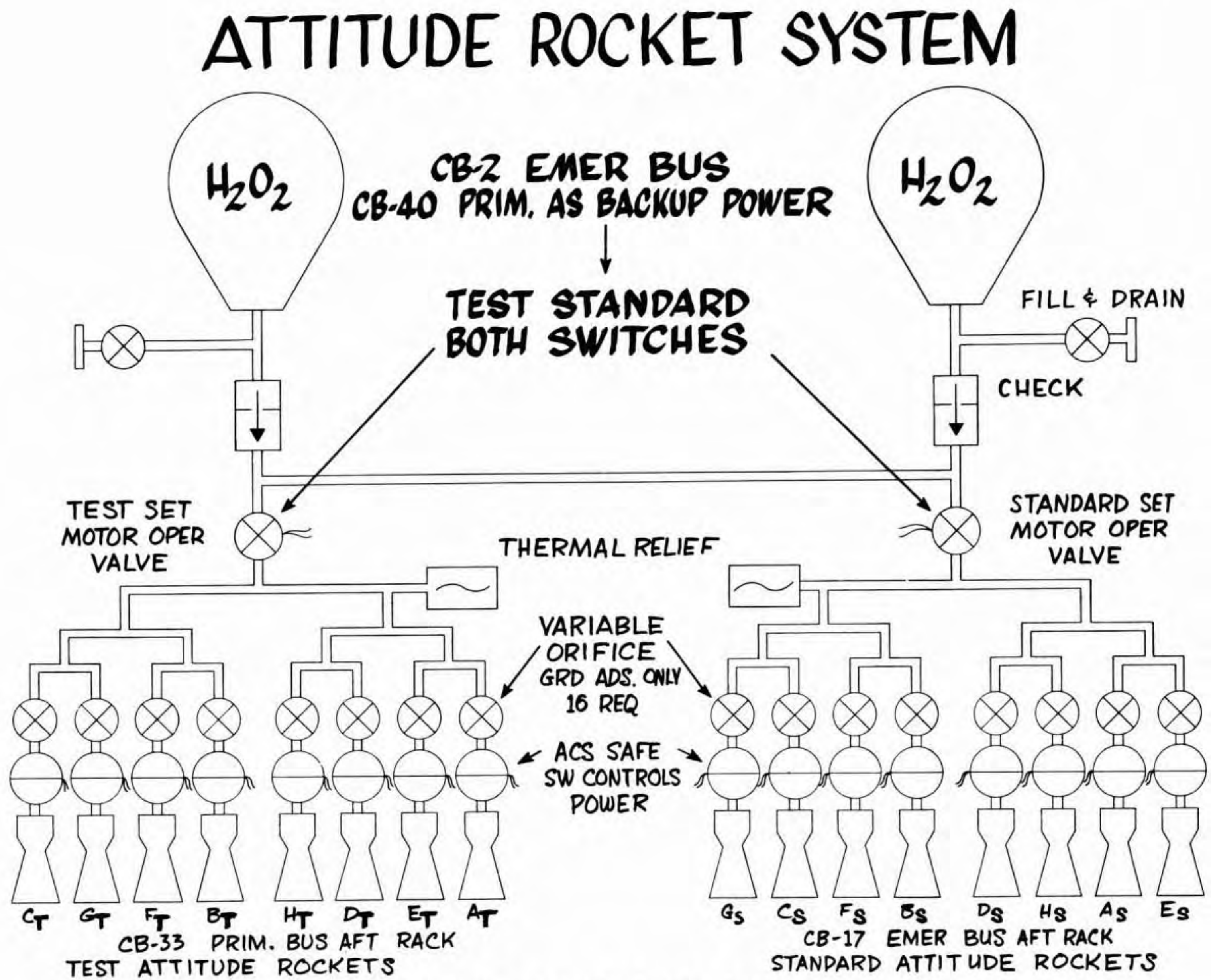


Figure 1-7 Attitude Rocket System

Attitude Control system. A temperature probe permits monitoring of hydrogen peroxide temperature during ground operations. The tanks are filled or drained through a valve at the bottom of the tank. A manual vent valve is located on leg member to permit ground servicing. Seal redundancy is provided by capping the valves with orifice caps during flight. The hydrogen peroxide filling, venting and purging valves are located as remotely as possible from systems using JP4 fuel and other hydrocarbons.

1-47. PROPELLANT SYSTEM INSTRUMENTATION - Propellant storage sensors (figure 1-8) for both pilot and ground monitoring during flight are:

A. H_2O_2 low level warning probes in both left and right tanks activate the corresponding H_2O_2 Low indicator in the cockpit when propellant level in either tank is down to $85\,^{+5}_{-0}$ pounds (static level).

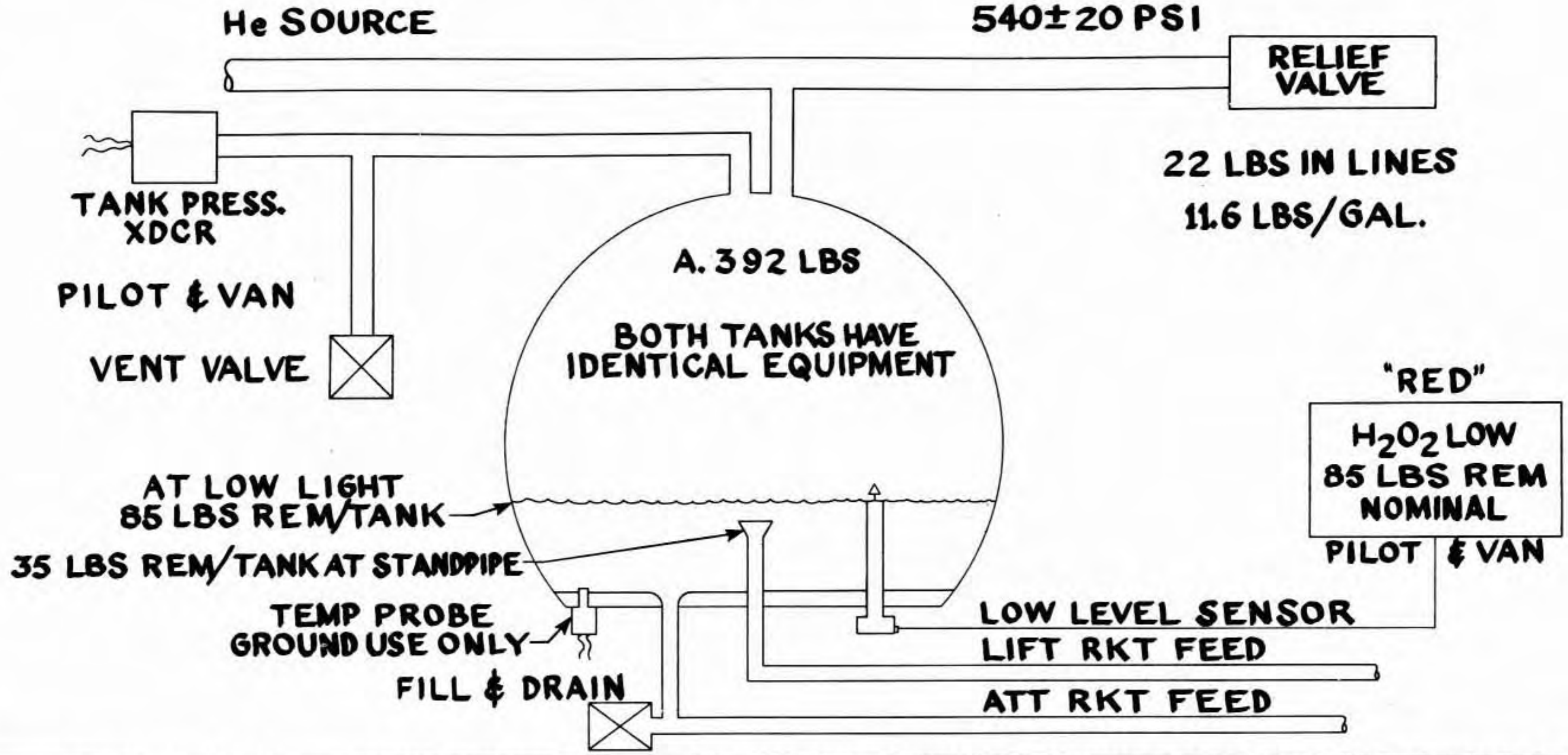
B. An H_2O_2 Remaining digital counter set prior to takeoff indicates the total H_2O_2 remaining. It is activated by a signal from the H_2O_2 Remaining Computer.

1-48. PROPELLANT UTILIZATION SUBSYSTEMS

1-49. The two utilization subsystems are the lift rockets and the attitude control rockets with their respective propellant lines and valving.

1-50. ATTITUDE CONTROL ROCKETS - Two sets of eight attitude control rockets with separate fuel lines provide redundancy. Two motor-operated isolation valves permit the pilot to select the Standard, Test, or Both sets of attitude rockets for flight operation or to isolate one set of attitude rockets in the event of failure of either system and effect a safe landing. The valves are controlled by manual operation of the Attitude Rockets Test-Standard-Both selector switch in the cockpit. Each

H_2O_2 TANK



CONDITION	TIME REMAINING LOW LIGHT 170 LBS	TIME REMAINING AT STANDPIPE 70 LBS
ONE SET ATTITUDE RKTS	4 MINUTES	1.5 MINUTES
TWO SETS ATTITUDE RKTS	MAY LIMIT CYCLE 1.5 MINUTES	MAY LIMIT CYCLE 30 SECONDS
ONE SET ATTITUDE RKTS AND LIFT RKTS	13 SECONDS TO STANDPIPE	"T" HANDLE MUST BE DOWN TO PREVENT LOSS OF ALL SOURCE PRESSURE THRU STANDPIPE

Figure 1-8. H_2O_2 Tank

rocket chamber has an associated solenoid valve to control the flow of propellant and a variable orifice hand valve to provide ground adjustment of the rocket thrust between 30 and 90 pounds. A Guarded Attitude Control System switch marked ACS-SAFE inhibits or arms the Attitude Control Rocket system.

1-51. <u>LIFT ROCKETS</u> - Two lift rockets provide a variable lift thrust nominally equal to one-sixth of the vehicle weight when the remaining five-sixths of the weight is supported by the Jet Engine system (simulated lunar gravity). A "T" handle is provided in the cockpit for control of lift rocket thrust during lunar simulation operation. (Refer to section VII for detailed information.)

1-52. <u>ROCKET INSTRUMENTATION</u> - Pressure transducers monitor all 16 attitude control rocket chamber pressures for: (1) the stuck valve malfunction detection circiut (activates valve stuck warning indicator in cockpit and is monitored in telemetry van), and (2) for inflight ground monitoring. Two pressure transducers monitor both lift rocket chamber pressures for cockpit display and ground monitoring. A third transducer supplies signals for the T/W computer, and the H_2O_2 Remaining computer, and for activating the automatic jet throttle for lunar simulation.

1-53. <u>ELECTRICAL SYSTEM</u>

1-54. The Vehicle Electrical system (figure 1-9) supplies both direct and alternating current, and consists of a Primary system for normal operation and an Emergency system in the event of a primary subsystem failure. (Refer to section IX for detailed information.)

1-55. <u>PRIMARY SUBSYSTEMS</u> - The source of direct current for the Primary system (figure 1-10) is a 28-volt DC generator that is mechanically driven by the jet engine. Alternating current is supplied by a main

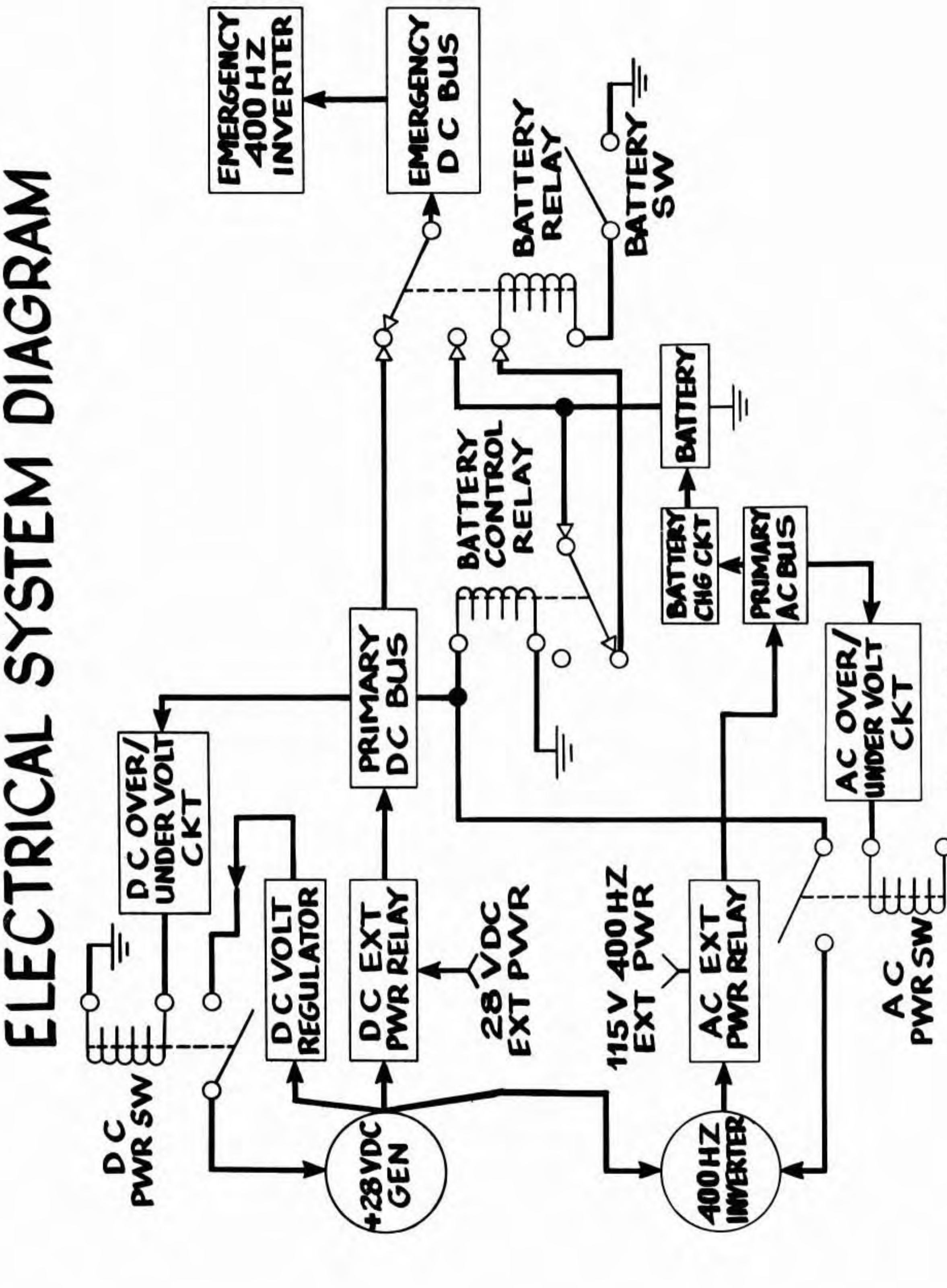
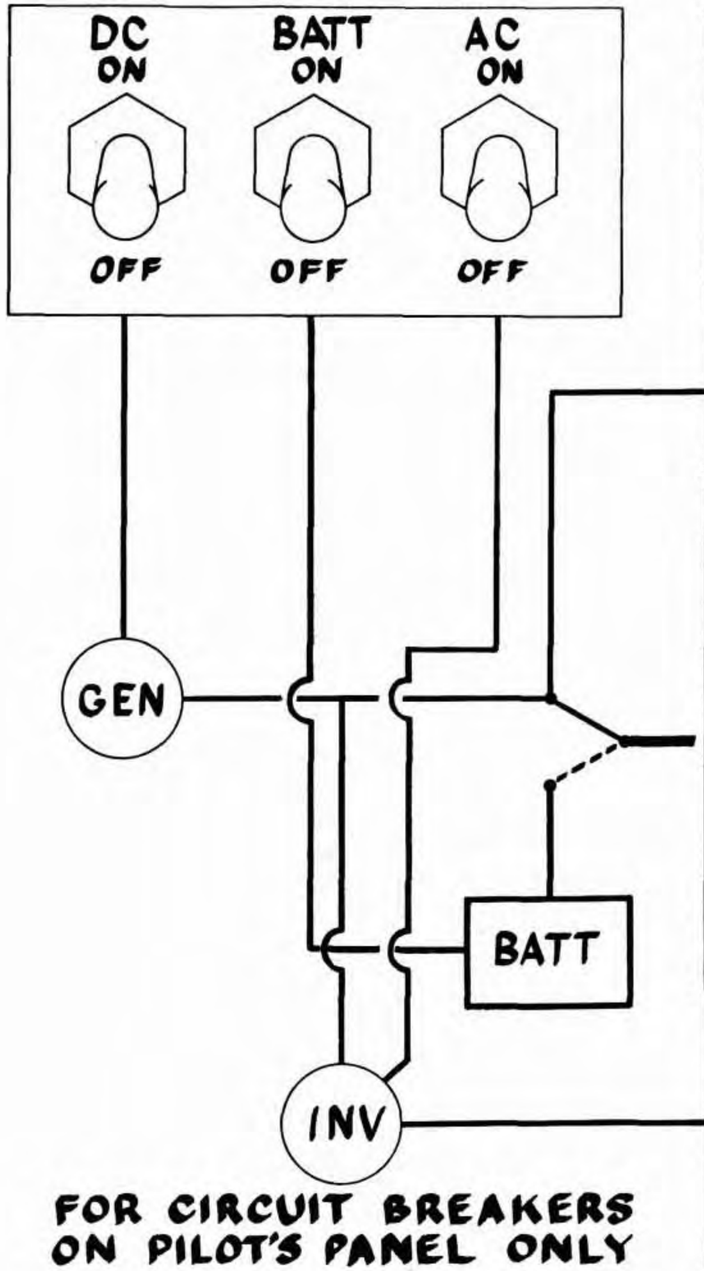


Figure 1-9 Electrical System Diagram



CB	PRIMARY DC BUS
5	AC OVERUNDER BOARDS
7	DETENT SWITCHES, ACS MONITOR ELECTRONICS
19	DC OVERUNDER BOARDS-AC-DC FAILURE LIGHTS
20	EMERGENCY THROTTLE-DRAG COMPENSATION SYSTEM
29	3 AXIS BALL IND-INST LIGHTS
40	ATTITUDE RKT SYS VALVES, TEST STANDARD, BOTH
	EMER DC BUS (ESSENTIAL)
1	COMMUNICATIONS
2	He XOVER VALVE, LIFT RKT TANK ISOL VALVES ATTITUDE RKT SYS VALVES, TEST, STANDARD, BOTH
3	DC VOLTMETER, ANN PANEL, H_2O_2 LEVEL INDICATOR AC POWER SWITCH, MASTER WARNING BOX
4	800 Hz INVERT, ATT GYRO, NORMAL GIMBAL LOCK CIRCUIT
8	20 V MODULE FOR FLIGHT INST
28	LIFT ROCKET THROTTLE
35	EMERGENCY GIMBALS LOCKED CIRCUIT
CB	PRIMARY AC BUS
6	JET ENGINE EGT XDUCER H_2O_2 REMAINING INDICATOR
30	AC RADAR INST LIGHTS, ANEMOMETER PS 3 AXIS BALL (FUSED)

Figure 1-10 Electrical System Switch Functions

inverter which converts the generator's output to 115 $\pm$ 2.5 volts, AC, three-phase, 400 cps. External DC and AC power receptacles provide ground operation and checkout capability.

1-56. EMERGENCY SYSTEM - The Emergency system power source is a 24-cell nickel cadmium battery that is continually trickle charged by the primary AC system during normal operation. A battery switch, located on the Pilot's Console, arms the battery relay to provide DC power from the battery to the emergency DC bus. This switch is actuated by the pilot before takeoff to ensure that emergency power from the battery will be available without pilot action during flight.

1-57. DATA SYSTEM EXTERNAL POWER - A receptacle is provided under the aft section of the vehicle to permit the operation of the data system with external power when the vehicle electrical system is on emergency power. The necessary relay switching is accomplished automatically when a powered plug is placed into the receptacle.

1-58. CIRCUIT BREAKERS - Overload protection is provided by circuit breakers. Those breakers which contribute to flight safety are located in the cockpit within reach of the pilot and are provided with reset capabilities. Other circuit breakers are located at the aft equipment shelf, and jet engine.

1-59. ELECTRICAL INSTRUMENTATION - Voltmeters in the cockpit indicate primary AC and DC voltages. The DC voltmeter monitors the emergency DC bus, and, when the generator is off, also monitors battery voltage (backup). AC and DC warning indicators for cockpit and ground monitoring indicate primary electrical failures. The AC warning indicator monitors both phase A and phase C.

1-60. ELECTRONIC SYSTEMS

1-61. The major Electronic systems are the Vehicle Attitude Control system, Jet Engine Attitude Control system, and Lunar Simulation system that includes the jet engine stabilization control, thrust/weight computer, and automatic jet throttle control.

1-62. VEHICLE ATTITUDE CONTROL SYSTEM (ACS) - The Vehicle Attitude Control system provides the intelligence to fire 16 attitude control rockets to produce control moments in response to pilot commands and/or vehicle motions. The ACS system consists of a Primary Control system, Backup Control system, and Monitor systems for detection of failures and for automatically switching the Control system to a safe mode of operation. (Refer to section XI for detailed maintenance instructions.)

1-63. PRIMARY ATTITUDE CONTROL SYSTEM - The Primary Attitude Control subsystem (figure 1-11) is normally used for the entire mission (including lunar simulation phase). The Primary Attitude Control system includes primary Rate Command with attitude hold, Primary Direct, with attitude hold in roll and pitch, no attitude hold in yaw, moment compensation, and the attitude rocket logic.

1-64. PRIMARY RATE COMMAND WITH ATTITUDE HOLD - In this mode, a vehicle angular rate is commanded proportional to stick deflection when the stick deflection exceeds the hand controller deadband of approximately $\pm$ 1.5 degrees. Attitude hold is engaged whenever the stick is in the detent position, and the vehicle rate is less than the rate switching value (adjustable from 1 to 3°/sec, presently set at 3°/sec). When operating in attitude hold, the vehicle attitude is maintained with an average drift less than $\frac{1}{2}^\circ$/min in pitch and roll and 6°/min in yaw. Refer to table 11-1. There is no option given the pilot for engaging or

ATTITUDE CONTROL SYSTEM

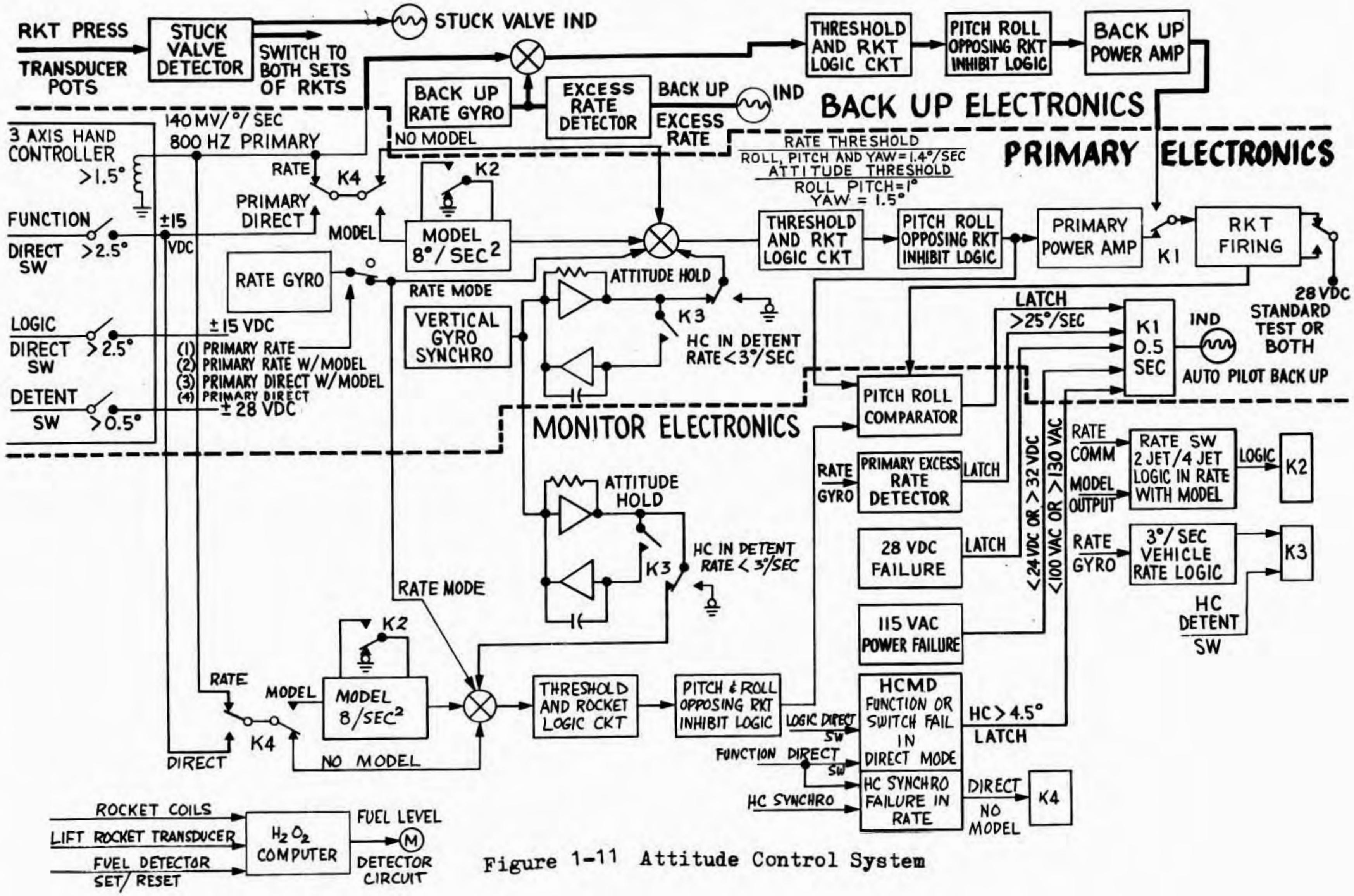


Figure 1-11 Attitude Control System

disengaging the attitude hold feature in primary rate command. When the above conditions are met, the attitude hold feature is selected automatically.

1-65. PRIMARY DIRECT COMMAND WITH ATTITUDE HOLD - When this mode is selected, and the hand controller deflection exceeds approximately $2\frac{1}{2}^{\circ}$ in any direction, the vehicle is commanded at a rate of $10.5^{\circ}/\text{sec}$. The attitude hold feature is present in the roll and pitch axis. This is identical to the attitude hold feature described in paragraph 1-64. There is no attitude hold present in the yaw channel.

1-66. MOMENT COMPENSATION - The moment compensation limits the maximum average pilot commanded acceleration capability of the vehicle to a fixed value presently set at $8^{\circ}/\text{sec}^2$ in each axis. This maximum average acceleration capability is independent of thruster settings or the number of thrusters firing. Accelerations which are not commanded by the pilot, i.e., those which are in response to rate and attitude gyro feedback, are not limited by the model and will be limited only by the thruster capability. The model accelerations are ground adjustable. When the system is operating in the Direct mode, the preset angular acceleration is commanded when the three-axis controller stick is deployed in excess of $2\frac{1}{2}^{\circ}$ of the neutral position. After the controller is returned to within $2\frac{1}{2}^{\circ}$, the control system maintains the velocity developed. When the system is operating in the Rate Command mode, an angular rate is commanded proportional to hand controller rotation. The angular acceleration command to acquire the desired rate is preset into the model.

1-67. The pilot does have the option of engaging or disengaging moment compensation. However, manual separate axis selection is not provided; all three axes are engaged or disengaged together.

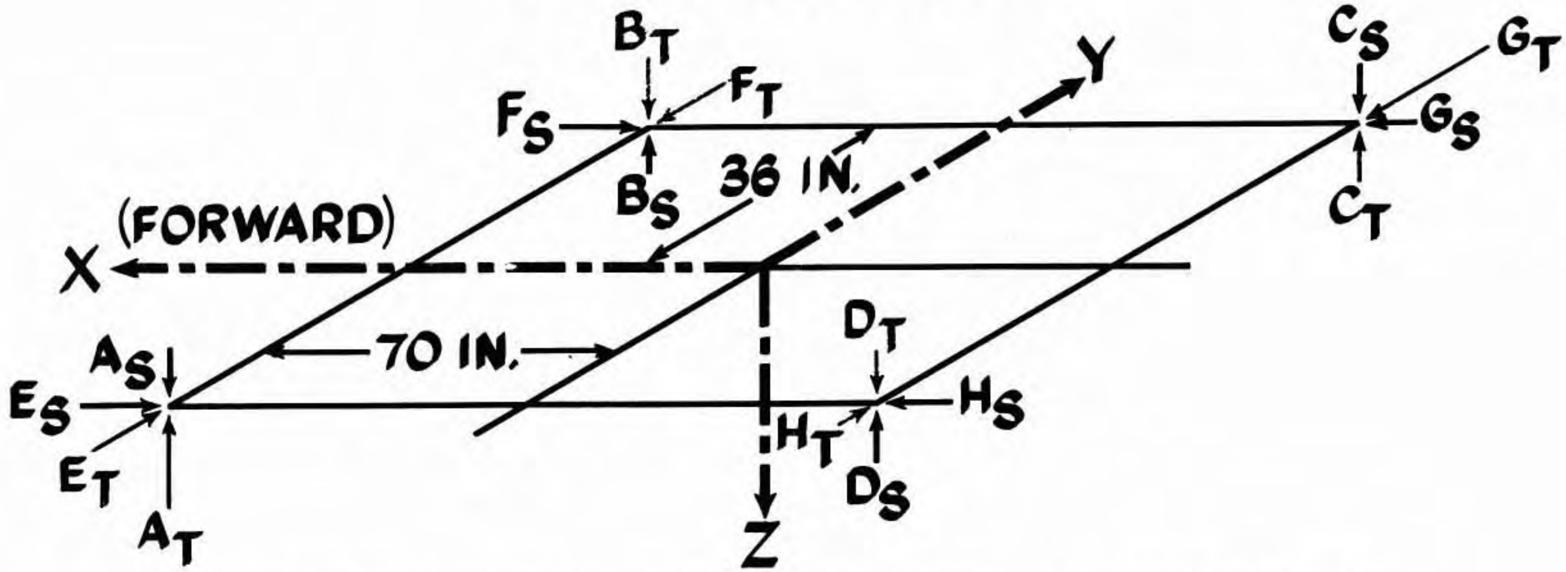
WARNING

Whenever flying with Moment Compensation ON, the Test set of attitude rockets should be selected. This is because the yaw moment arm is greater in Test than in Standard, thus allowing greater accelerations to be commanded with the fixed thrusters.

1-68. ROCKET THRUSTER LOGIC - The attitude rocket engines fire in an ON/OFF manner. Two sets of 8 control rockets each (Test and Standard) are provided (figure 1-12). Normally those designated as Test are used during lunar simulation training operations. The Standard set is used in an emergency through the Backup mode when control is automatically switched to Both sets. Either one or both sets may be selected to fire to provide redundancy. (Refer to paragraph 2-3-3-1, Attitude Control Rockets, in the Flight Handbook, Report No. 7260-954001.) For individual pitch, roll, or yaw commands, the system will fire two rockets if the Standard or Test set is selected, or four rockets if Both sets are chosen. For combined pitch and roll commands, however, only one rocket will fire if the Standard or Test set is selected, or two rockets if Both sets are chosen. This selection is automatically controlled by the opposing rocket inhibit logic, which prevents opposing rockets from firing at the same time. The system is also designed so a large command in one axis does not result in loss of control in another axis.

1-69. MONITOR SUBSYSTEM - Monitor comparator, excess rate, and hand controller malfunction detection circuits are used to monitor operation of the Primary Rate and Primary Direct attitude control modes. (Refer to section XI for detailed information.)

ATTITUDE CONTROL-ROCKET FIRING LOGIC



ROCKETS WITH SUBSCRIPT S DENOTE STANDARD ROCKETS FIRE

ROCKETS WITH SUBSCRIPT T DENOTE TEST ROCKETS FIRE

FOR DUAL-SYSTEM OPERATION, BOTH STANDARD AND TEST ROCKETS FIRE

Figure 1-12 Attitude Control-Rocket Firing Logic

1-70. PRIMARY RESET SWITCH - In the event the monitor comparator subsystem automatically switches the ACS from Primary to Backup as a result of spurious signals emitted by either the primary or monitor channel, but in fact the two systems are operating satisfactorily, the pilot is able with Moment Compensation switch OFF, to manually switch the ACS from Backup to Primary by momentarily actuating the Primary Reset Control switch on the left console. Caution must be exercised in the use of the Primary Reset switch, in as much as the pilot cannot be completely sure that the Primary system is working properly. During normal operation, reset will be attempted on the ground only. (Refer to section XI for detailed information.)

1-71. JET ENGINE ATTITUDE CONTROL SYSTEM

1-72. The Jet Engine Attitude Control system performs in four selected modes of operation: Gimbal Locked, Local Vertical, Engine Centered, and Jet Stabilization mode (performs as a portion of Lunar Simulation mode). For flight safety, one mode has priority over another.

1-73. MODE PRIORITY - For flight safety, the modes have the following priority. The Gimbal Locked mode, whether pilot or automatically selected, overrides all other modes. When the vehicle is on the ground or when the jet engine deflects more than $15 \pm 1^{\circ}$ from the vertical (including in the Lunar Simulation mode), the Local Vertical mode shall be automatically actuated and override all modes except the Gimbal Locked mode. If the jet engine deflects more than $15 \pm 1^{\circ}$ from local vertical and Local Vertical mode is not automatically selected within 0.35 to 1.0 second, the system shall automatically switch to the Gimbal Locked mode. If no mode has been selected and the vehicle is airborne, actuation of the Local Vertical Release switch shall place the system in the Engine Centered mode. (Refer to section XI for detailed information.)

1-74. LOCAL VERTICAL MODE - The Local Vertical mode aligns jet engine with the local vertical as sensed by the attitude gyros, regardless of vehicle outer frame motion. The signal from the vehicle attitude gyros is compared with the engine gimbal angles obtained from potentiometers on the gimbal actuators. The resulting error signal is used as an input command to the gimbal actuators. The pilot may select this mode with a switch on the console. This mode is automatically selected when:

A. The vehicle is on the ground and any one of the four leg micro-switches located on each of the four shock struts indicates a compression of more than one-half inch, or

B. The jet engine deviates more than $15 \pm 1^{\circ}$ from the local vertical while in the Engine Centered or Lunar Simulation modes.

To manually disengage this mode, the pilot must momentarily activate the Local Vertical Release switch on the console, which places the jet engine attitude control in the Engine Centered mode if no other mode is selected.

1-75. JET STABILIZATION MODE - This Jet Attitude Control mode performs as a portion of the Lunar Simulation system (refer to paragraph 1-76), and is initiated when:

A. The Lunar Simulation switch is placed at LUNAR SIM.

B. Lift rockets have been initiated and chamber pressure has exceed 100 psia (Pressure transducer measurement).

C. Gimbal Lock switch is OFF.

D. Engine angle is less than $15 \pm 1^{\circ}$ from the local vertical.

Deactivation of this mode is accomplished by actuating the Lunar Simulation Arm switch to OFF, or actuating the Lunar Simulation Release button on the jet throttle, or by actuating the Gimbal Lock switch to ON. Either of the first two deactivation methods place the jet engine attitude control in the Local Vertical Mode.

1-76. LUNAR SIMULATION SUBSYSTEM

1-77. The Lunar Simulation mode is comprised of: (1) Drag Compensation, and (2) Thrust/Weight control through the automatic jet engine throttle command of five-sixths of the vehicle weight. Drag compensation is accomplished through the jet stabilization.

1-78. Lunar simulation is effected in two steps:

A. The Automatic Jet Engine Throttle system is activated with the jet engine in Gimbal Lock mode; this resluts in jet engine thrust equal to five-sixths of vehicle weight, without any drag compensation.

B. Unlocking the Gimbal Hydraulic system by positioning Gimbal Lock switch in the hand controller to OFF, thus activating the drag compensation (jet stabilization) mechanism.

1-79. The Lunar Simulation system creates an artificial lunar gravity situation in which five-sixths of the vehicle weight is automatically supported by the jet engine and a pseudo lunar vacuum by automatically tilting and controlling the jet engine thrust to cancel aerodynamic drag on the vehicle. The system establishes a reference signal of 5/6 g which is resolved into vehicle coordinates using a vertical gyro and gimbal resolvers. To this signal, acceleration caused by lift rockets (computed based on rocket thrust and vehicle weight) are vectorially added. The resulting acceleration information is compared with the measured vehicle accelerations obtained from body-mounted accelerometers. The resultant errors are used as command signals to the automatic throttle and jet engine attitude control.

1-80. <u>AUTOMATIC JET THROTTLE</u> - The automatic jet throttle continuously controls jet engine thrust so that the local vertical component of force equals five-sixths of the instantaneous vehicle weight plus or minus the vertical drag force. The throttle control loop, which employs a linear acceleration feedback, is capable of adjusting the jet engine main fuel control angle at the rate of 6 deg/sec. The same automatic jet throttle serves as the emergency system for the primary hydraulic throttle. When used as the emergency throttle, a synchro feedback is used for jet engine fuel control.

1-81. MANUAL OVERRIDE - The manual jet throttle is hydraulically coupled to the main jet engine fuel control such that the pilot can manually override the automatic throttle system through the range of 70 to 100 percent RPM without exceeding force limits at the throttle gradient. The override force in lunar simulation is 25 to 30 pounds.

1-82. AUTOMATIC THROTTLE LIMIT SWITCHES - Three microswitches limit the motion of the automatic throttle actuator such that the angular displacement of the jet throttle will not exceed the engine operating range during the Lunar Simulation mode. These switches are preset as follows (degrees given refer to main fuel control shaft position on the jet engine and are nominal settings):

A. Maximum automatic throttle signal cutoff - 75° or 96 to 98.5% RPM.

B. Low automatic throttle signal cutoff - 45° or 82 to 84% RPM.

C. Low automatic throttle clutch disengage - 40° or 78 to 80% RPM.

The maximum and low cutoff switches limit and motion of the automatic throttle actuator. The limits are based on sea level altitude and General Electric curves for CF700-2V engines. In the event of an excessive command by the auto throttle, the engine main fuel control will remain at the limited position until the lunar simulation commands the throttle position within the limits set. The low clutch disengage switch acts as a backup to the low cutoff switch. When the low clutch disengage switch has been activated, the pilot must take over manual control of the jet throttle. This switch operates the low thrust manual warning indicator in the cockpit on all throttle modes (Hydraulic, Electric, or Automatic).

1-83. LIFT ROCKET THRUST CONTROL - A closed loop position system connects the lift rocket control (T-handle) with the lift rocket throttle valve. Thrust is linearly proportional to stick deflection.

1-84. LUNAR SIMULATION INSTRUMENTATION - A cockpit and ground monitored thrust-to-weight indicator displays normal acceleration in lunar g's. The thrust/weight computer output signals are also telemetered for ground station monitoring. Cockpit and ground monitored status indicators indicate when the automatic throttle has been engaged (green light) and when the auto throttle has been disengaged by the Low Auto Throttle Clutch Disengage switch, low thrust manual (red light). Additional telemetry data recorded by the ground station include jet engine throttle position (potentiometer output) and low auto throttle signal cutoff.

1-85. BREATHING OXYGEN

1-86. The pilot shall breath oxygen at all times when the jet engine is operating, to avoid inhalation of exhaust gas. This oxygen is provided in a single tank equipped with a shutoff valve, regulator, and gage. The tank is located under the right hand side of the cabin floor. The oxygen tank contains 22 cubic feet of breathing oxygen pressurized to approximately 1800 psi, when fully charged. This amount of oxygen provides the pilot with breathing oxygen for approximately 20 minutes when used at demand flow. Recharging is accomplished through a charging fitting on the tank and requires removal from the LLTV.

1-87. EJECTION SEAT - (See figures 4-1, 4-2, and 4-3.)

1-88. The Weber pilot ejection seat provides seating for the pilot during normal vehicle operation and emergency escape, if required, when vehicle emergency conditions warrant. (Refer to Weber Seat Manual DR 5773-1 and Bell Pilot's Flight Manual 7260-954001 for detailed information.) The seat is designed for zero velocity and zero altitude capabilities. (Refer to section IV for detailed information.)

1-89. COCKPIT CONTROLS AND INDICATORS

1-90. All controls and indicators necessary for pilot operation of the LLTV are located convenient to the pilot. All controls and indicators located in the cockpit are described in table 1-2 and are illustrated in figures 1-13 through 1-21.

1-91. AERODYNAMIC BOOM

1-92. An aerodynamic boom is mounted to the left side of the cockpit floor and extends four feet forward from the cockpit. The boom has two vanes to measure inflight aerodynamic data.

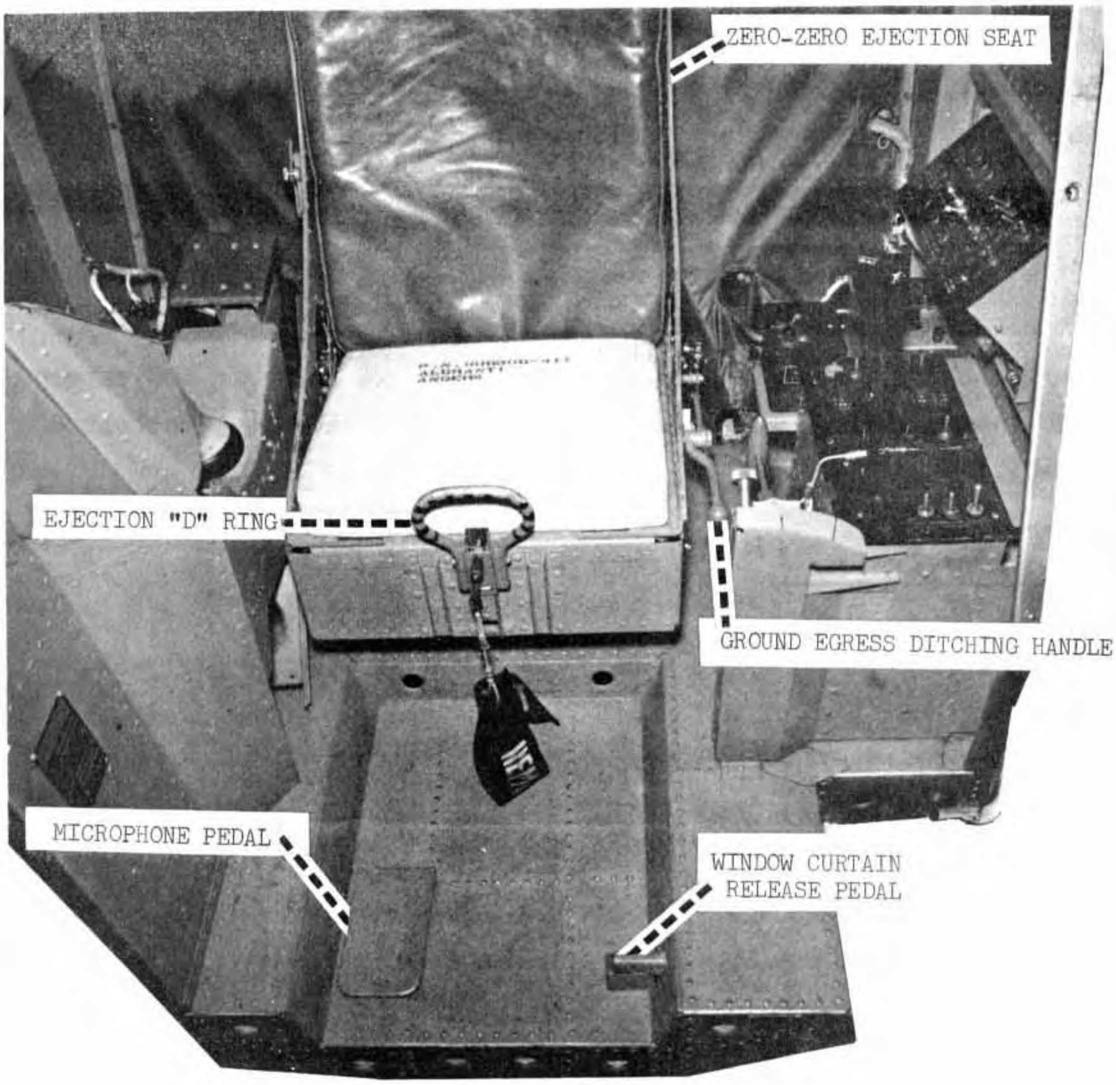


Figure 1-13. LLTV Cockpit - Front View

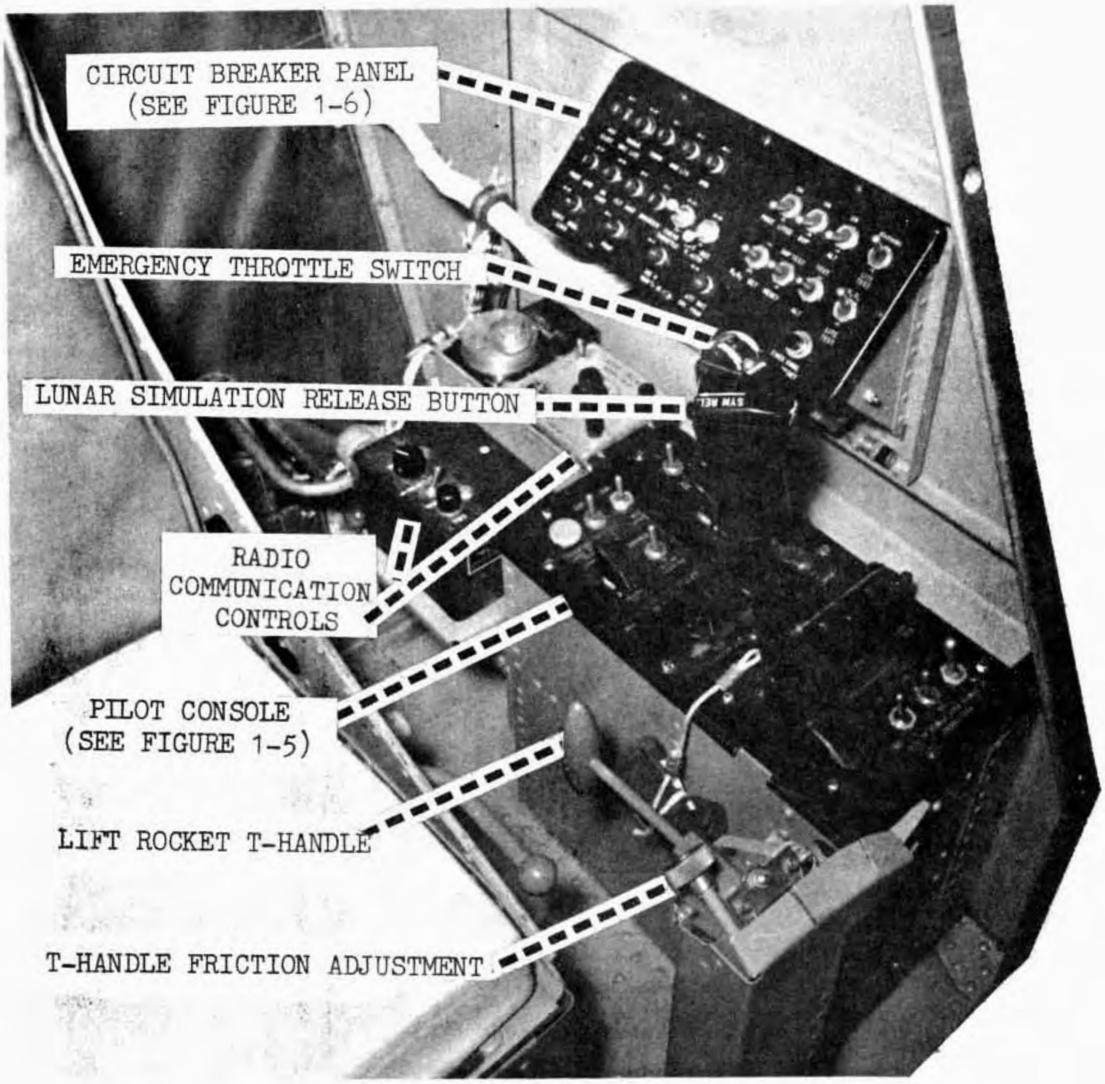


Figure 1-14 Cockpit Layout - Left Hand Side

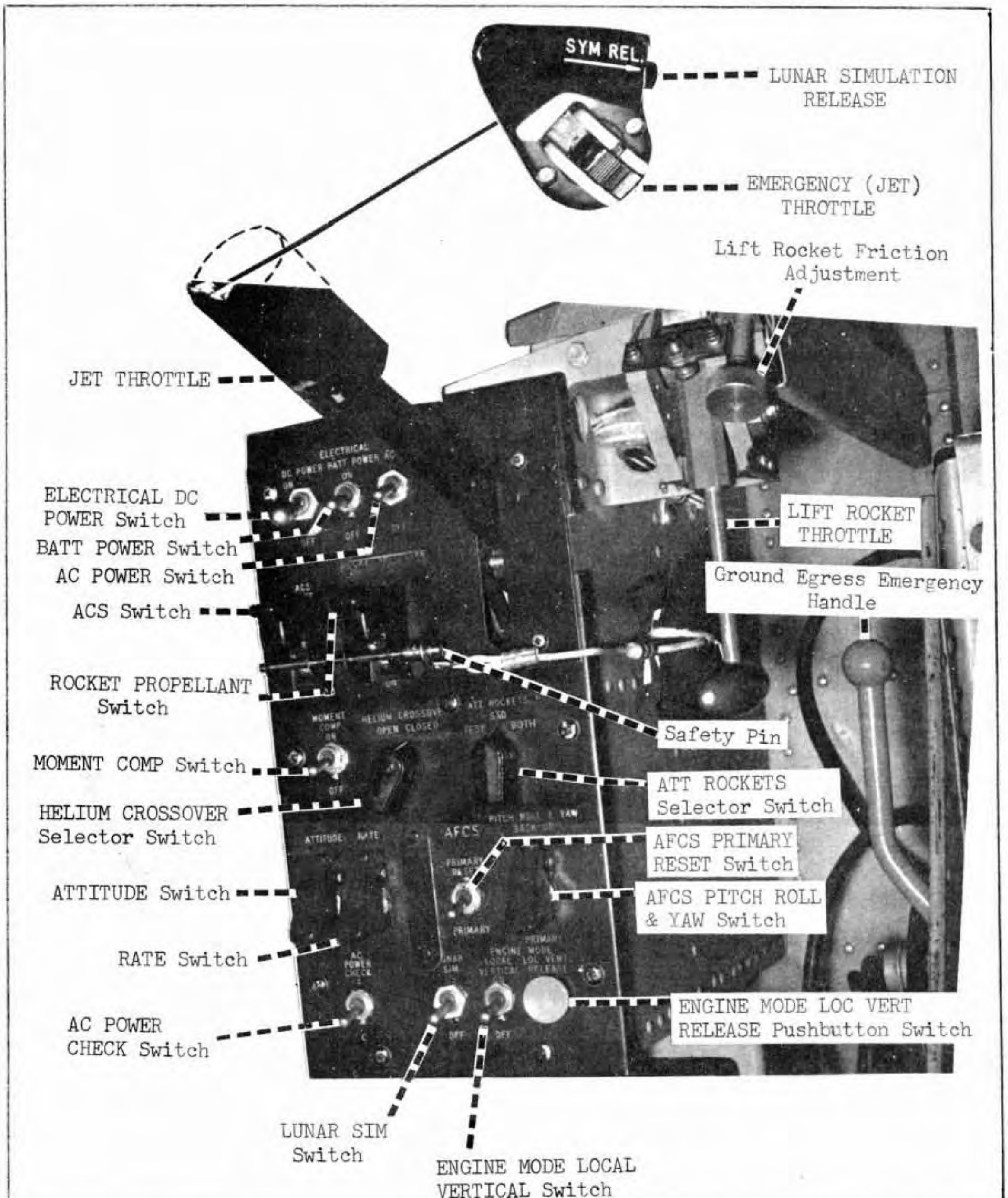


Figure 1-15 Pilot's Console

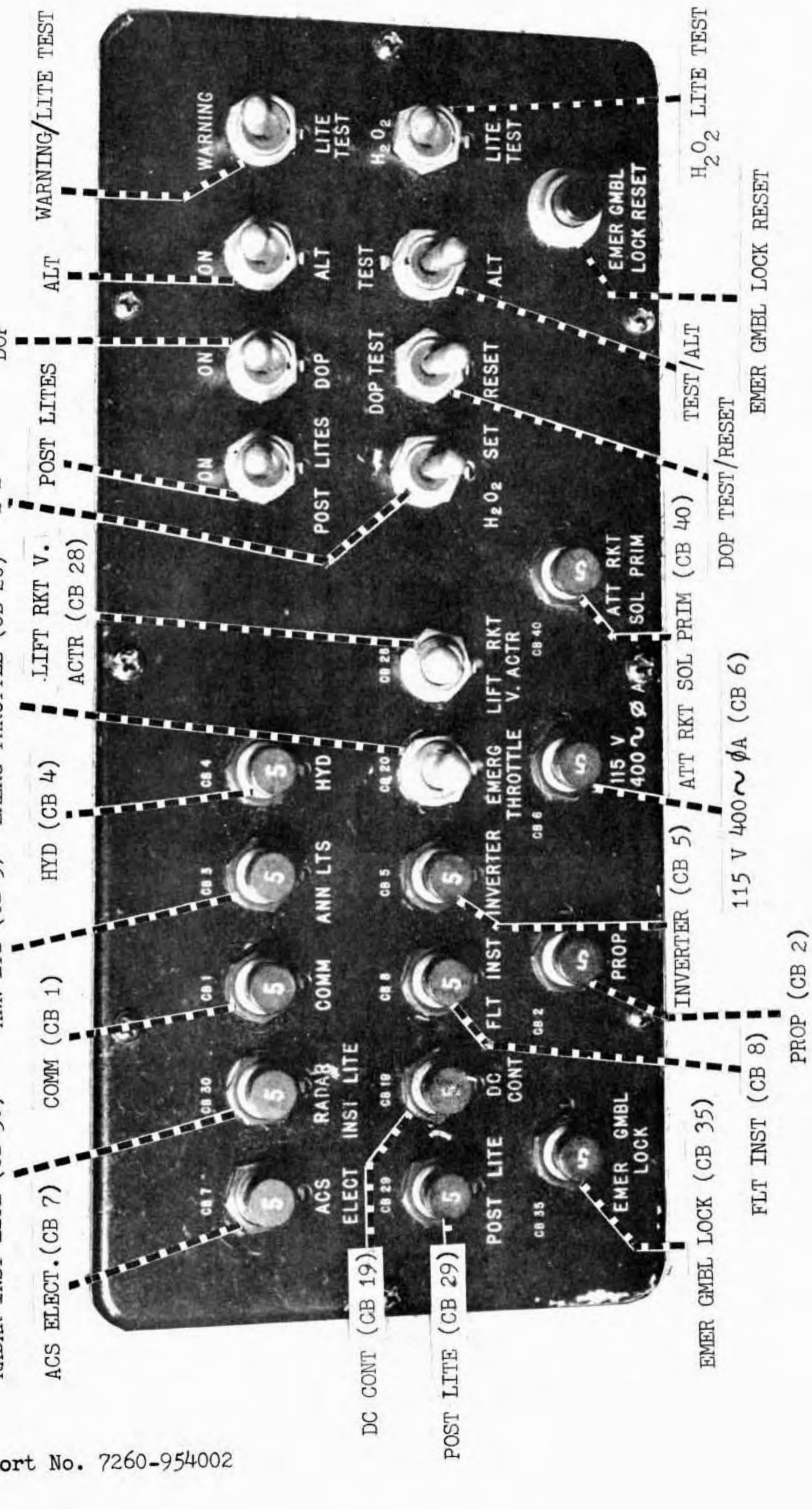


Figure 1-16. Circuit Breaker Panel

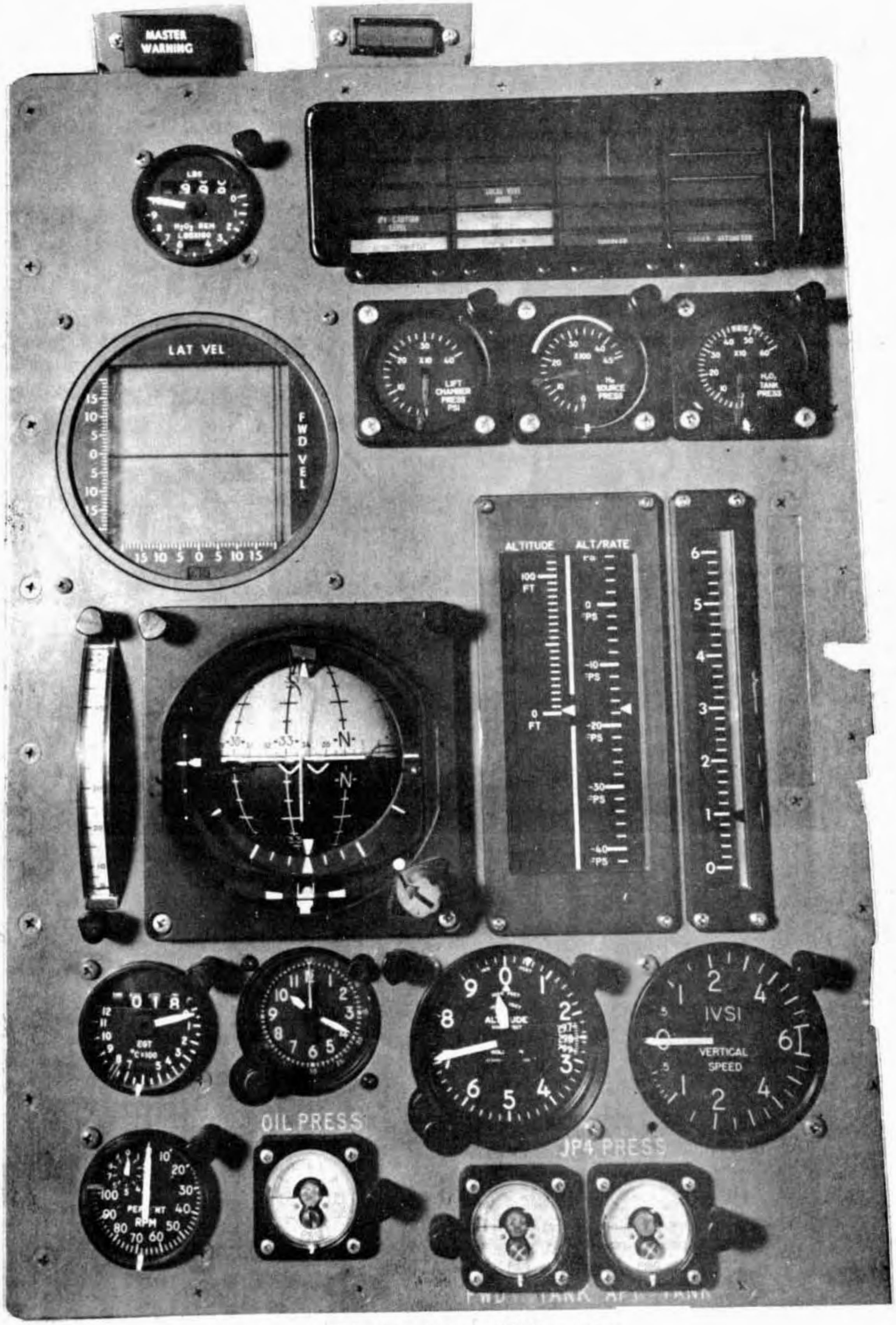


Figure 1-17 RH Console

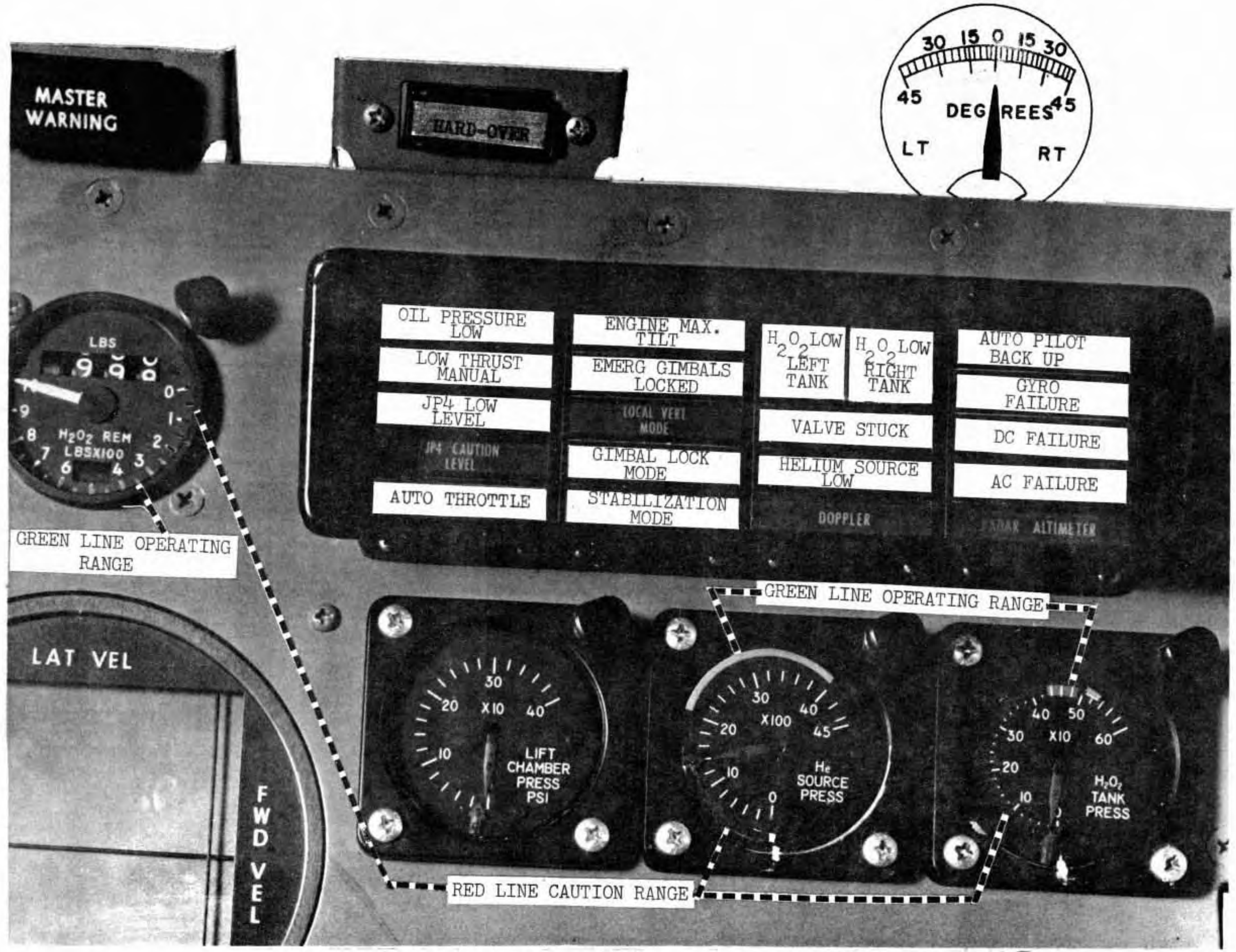


Figure 1-18 Rocket Instruments and Annunciator Panel Warning Lights

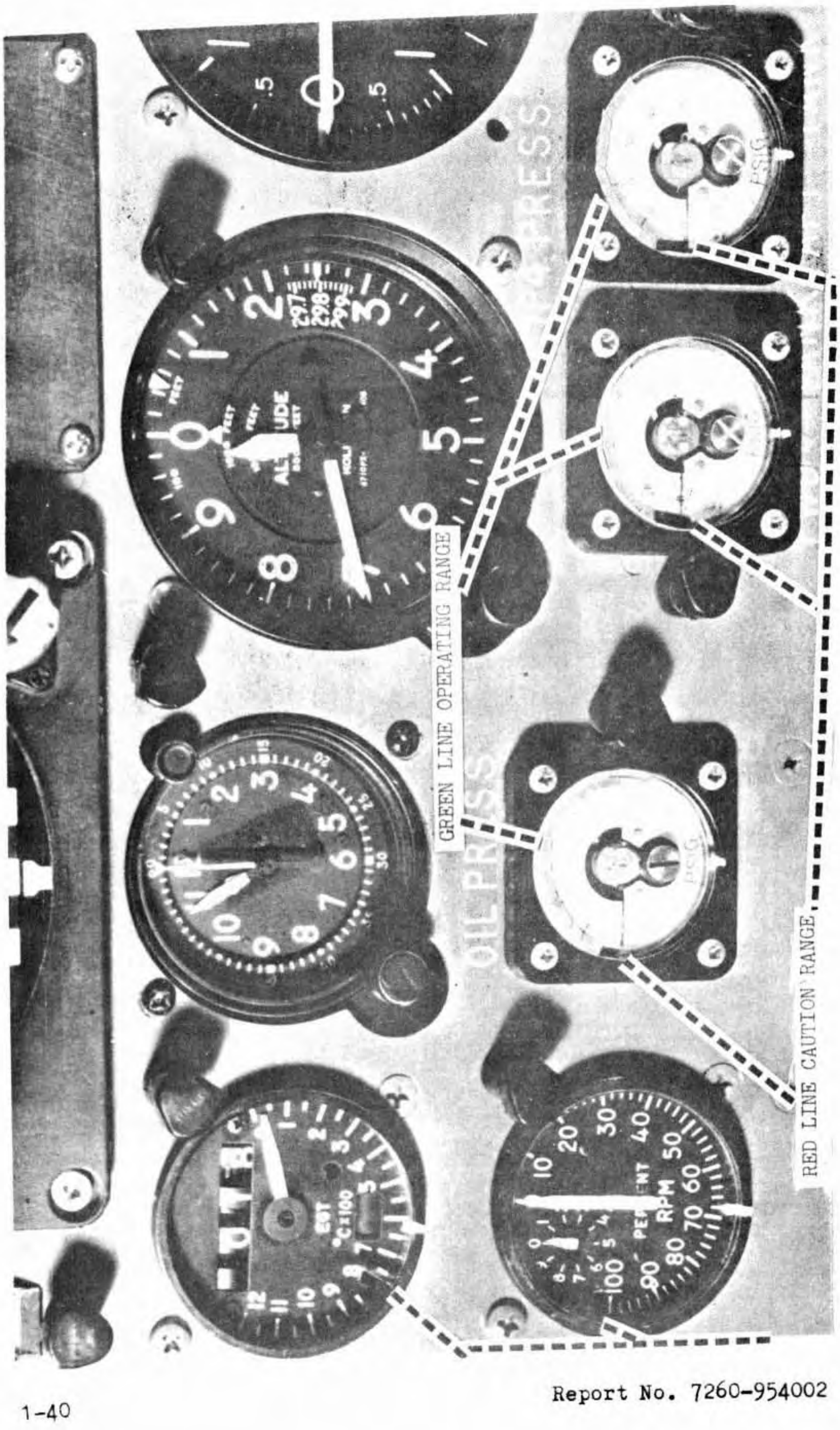


Figure 1-19 Pilot Instrument Panel - Bottom Portion

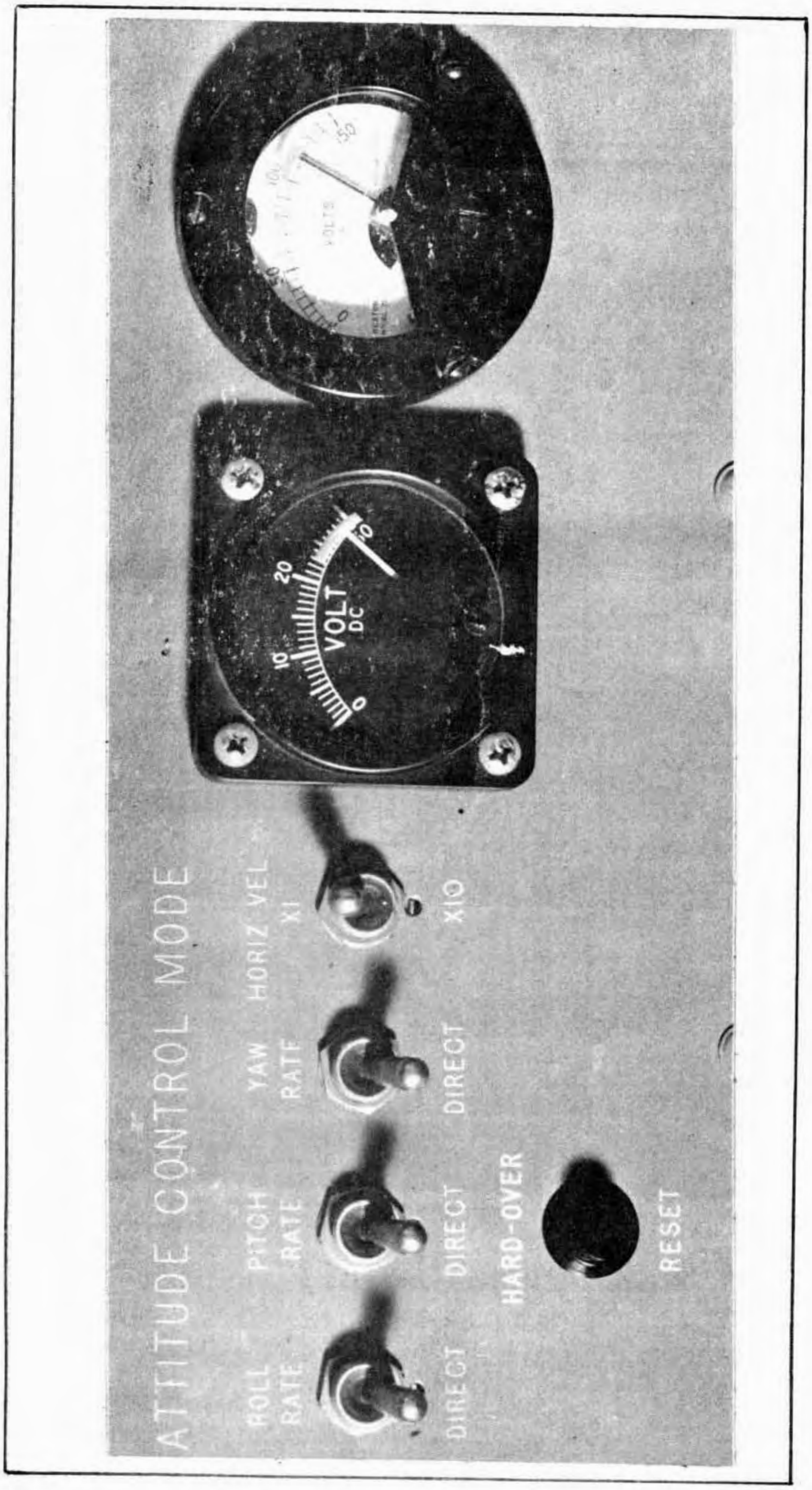


Figure 1-20 Lower RH Console

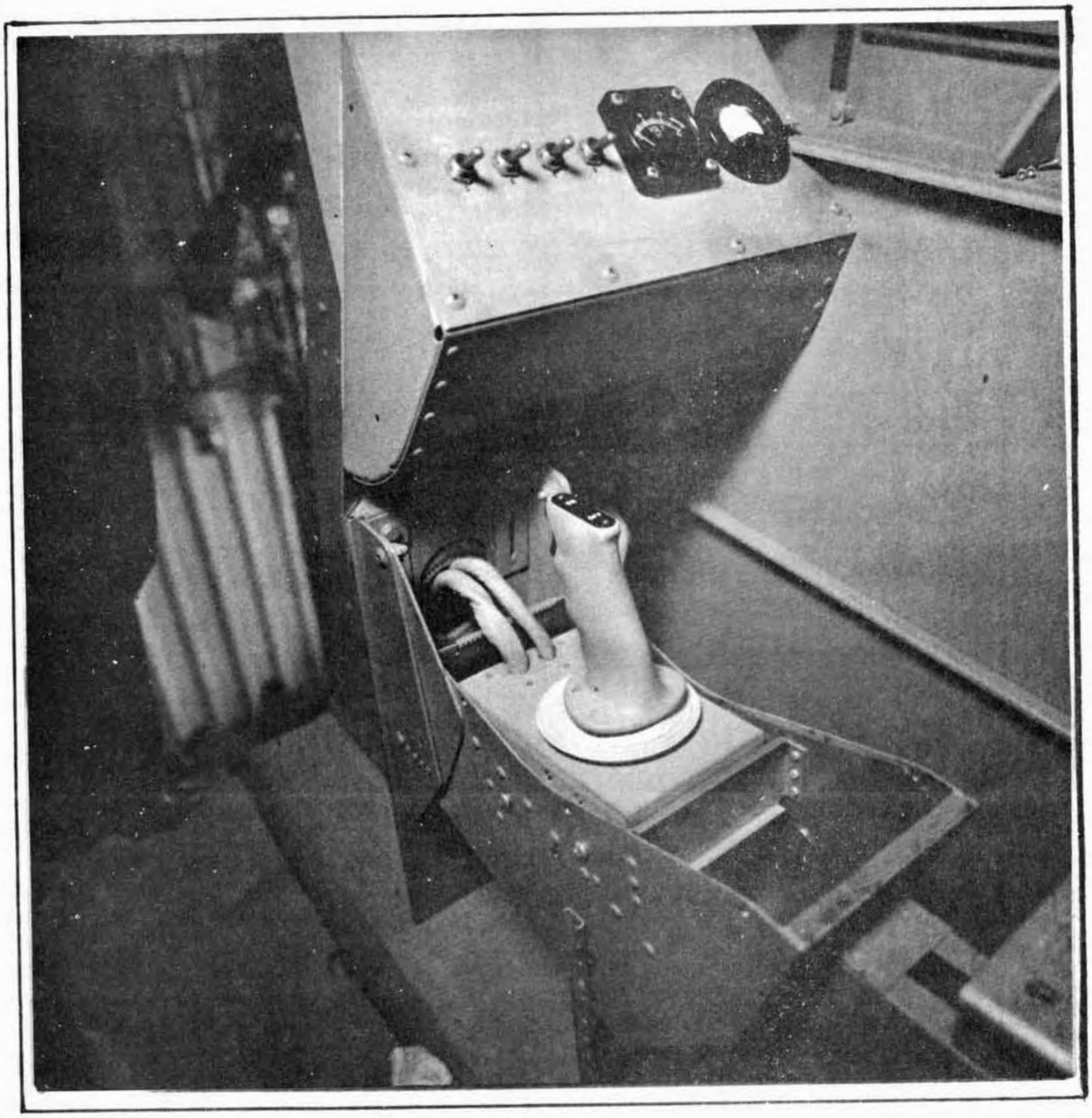


Figure 1-21. Hand Controller

TABLE 1-2

COCKPIT CONTROLS AND INDICATORS

CONTROL OR INDICATOR	FUNCTION
PILOT CONSOLE (Figure 1-15)	
ELECTRICAL DC POWER Switch	In the ON position, applies 28 vdc from DC generator to actuate DC generator voltage regulator.
BATT POWER Switch	In the ON position, applies ground to arm battery relay K1 which applies 28 vdc from the emergency battery to the 28 vdc. emergency bus when K5 control relay de-energizes by loss of primary power.
ACS SAFE Switch (Attitude Control System)	Arms attitude rocket firing circuit.
MOMENT COMPENSATION Switch	With this switch engaged, the electronic model commands $8^{\circ}/sec^{2}$ nominal angular accelerations in each axis in response to pilot commands.
ROCKET PROPELLANT Switch	In the OFF position, applies 28 vdc from the 28 vdc emergency bus to valve-close terminals of the right lift rocket shutoff valve, and the left lift rocket shutoff valve.

TABLE 1-2. Cockpit Controls and Indicators (Continued)

CONTROL OR INDICATOR	FUNCTION
PILOT CONSOLE (Figure 1-15 Continued)	
ROCKET PROPELLANT Switch (Continued)	In the ON position, applies 28 vdc from the 28 vdc emergency bus to valve-open terminals of the right lift rocket shutoff valve and left lift rocket shutoff valve.
ATT ROCKETS Selector Switch	Selects Test, Standard, or Both sets of attitude rockets for attitude control. In the TEST position, applies 28 volts DC from the 28-volt DC emergency bus across closed contacts of energized relay K2 to the valve-close terminal of the Standard attitude rocket shutoff valve and to the valve-open terminal of the Test attitude rocket shutoff valve and to the ACS power amplifier to condition it for the Test mode. In the STD position, applies 28 volts DC from the 28-volt DC emergency bus across closed contacts of energized relay K2 to the valve-open terminal of the Standard attitude rocket shutoff valve, to the

TABLE 1-2. Cockpit Controls and Indicators (Continued)

CONTROL OR INDICATOR	FUNCTION
PILOT CONSOLE (Figure 1-15 Continued)	
ATT ROCKETS Selector Switch (Continued)	valve-close terminal of the Test attitude rocket shutoff valve, and to ACS power amplifier to condition it for the Standard mode. In the BOTH position, applies 28 volds DC to valve-open terminals of Standard attitude rocket shutoff valve and Test attitude rocket shut-off valve. Section D of this switch provides the T/M functions.
ATTITUDE Switch	Used to switch power to attitude gyros.
RATE Switch	Used to switch power to the rate gyro package.
AFCS PRIMARY RESET Switch	If a malfunction is detected by the monitor comparator, the system automatically switches to rate backup. If the pilot momentarily actuates this switch after a malfunction indication, the system shall revert to and stay in the primary

TABLE 1-2. Cockpit Controls and Indicators (Continued)

CONTROL OR INDICATOR	FUNCTION
PILOT CONSOLE (Figure 1-15 Continued)	
AFCS PRIMARY RESET Switch (Continued)	electronics only if the malfunction has disappeared. (Ground Use Only)
AFCS PITCH, ROLL, AND YAW BACK UP PRIMARY Switch	Pilot's manual selection of primary or backup attitude control system electronics.
AC POWER CHECK Switch	Used to switch from voltmeter phase A to phase C.
LUNAR SIM Switch	Arms auto jet throttle system and engine attitude systems such, that subsequent firing of the lift rocket (excess of 100 lb pressure) will result in automatic control of jet engine thrust and engine attitude.
ENGINE MODE LOCAL VERTICAL Switch	Aligns jet engine with respect to gyro vertical (earth vertical). Manual select switch.
ENGINE MODE LOC VERT RELEASE Switch (pushbutton)	Manually releases from local vertical when Local Vertical switch is OFF, but cannot override Local Vertical switch if ON.

TABLE 1-2. Cockpit Controls and Indicators (Continued)

CONTROL OR INDICATOR	FUNCTION
PILOT CONSOLE (Figure 1-15 Continued)	
JET THROTTLE	Controls jet engine thrust. An idle detent prevents throttle from retarding below idle point.
EMERGENCY (JET) THROTTLE	Used in the event of a hydraulic throttle system failure to engage electrical throttle system and thus nullifies jet throttle hydraulic pressure.
LUNAR SIMULATION RELEASE	Disengages auto throttle clutch for manual control of engine throttle and restores the Local Vertical mode; also throws Lunar Sim switch OFF.
Lift Rocket Throttle	T-handle for controlling lift rocket thrust.

TABLE 1-2. Cockpit Controls and Indicators (Continued)

CONTROL OR INDICATOR	FUNCTION
PILOT CIRCUIT BREAKER PANEL (Figure 1-16)	
POST LITES Switch	Controls cockpit instrument indicators
DOP Switch	Provides power to Doppler radar.
ALT ON Switch	Provides power to radar altimeter.
LITE TEST Switch	Used to verify lamp operations of warning indicators.
H_2O_2 SET (Slew) Switch	This switch is used for adjusting the hydrogen peroxide remaining indicator to any setting. (Up to advance, down to reduce, center is neutral.)
DOP TEST (Slew) Switch	Used to verify operation of Doppler radar.
ALT TEST Switch	Used to verify operation of the radar altimeter.
H_2O_2 LITE Test Switch	Used to verify operation of H_2O_2 low level controller and indicators.
EMER GMBL LOCK RESET Pushbutton	Breaks latching circuit to emergency Gimbal Lock relay. (Ground Use Only)

TABLE 1-2. Cockpit Controls and Indicators (Continued)

CONTROL OR INDICATOR	FUNCTION
PILOT CIRCUIT BREAKER PANEL (Figure 1-16 Continued)	
ACS ELECT Circuit CB7	Attitude gyro, ACS monitor, 3-axes side arm controller.
RADAR INST LITE Circuit Breaker CB30	M17 Altitude/Alt. Rate indicator, aneomometer power supply.
COMM Circuit Breaker CB1	Radio and interphone control box.
ANN LTS Circuit Breaker CB3	Master warning control box, Annunciator indicators, DC voltmeter, Power switch.
HYD Circuit Breaker CB4	Gimbal lock solenoid, 800 hertz generator, and attitude gyro.
POST LITE Circuit Breaker CB29	Instrument indicators, attitude indicator.
DC CONT Circuit Breaker CB19	DC volt sensor, AC + DC Failure indicators, and master warning box.
FLT INST Circuit Breaker CB8	20V supply module (Oil Pressure indicator, aft fuel tank, fwd fuel tank press, lift rocket chamber

TABLE 1-2. Cockpit Controls and Indicators (Continued)

CONTROL OR INDICATOR	FUNCTION
PILOT CIRCUIT BREAKER PANEL (Figure 1-16 Continued)	
FLT INST Circuit Breaker CB8 (Continued)	press, helium source press and H_2O_2 tank press indicator).
INVERTER Circuit Breaker CB5	AC sensors and AC failure indicator
EMERG THROTTLE Switch-Type Circuit Breaker *CB20	Emergency throttle switch, drag compensation, throttle crossover valve.
LIFT RKT V ACTR SWITCH-Type Circuit Breaker *CB28	Lift rocket valve actuator.
EMERG GMBL LOCK Circuit Breaker CB35	Emergency gimbal lock solenoid.
PROP Circuit Breaker CB2	Attitude rocket valves, lift rocket valves, helium crossover valve, supplies power to ACS switch
*Toggle Switch-Type Circuit Breaker	

TABLE 1-2. Cockpit Controls and Indicators (Continued)

CONTROL OR INDICATOR	FUNCTION
PILOT CIRCUIT BREAKER PANEL (Figure 1-16 Continued)	
115 V 400 ∅ A Circuit Breaker CB6	H_2O_2 remaining, jet engine exhaust temp transducer.
ATT RKT SOL PRIM Circuit Breaker CB40	Standard and Test attitude rocket shutoff valves.

TABLE 1-2. Cockpit Controls and Indicators (Continued)

CONTROL OR INDICATOR	FUNCTION
PILOT INSTRUMENT PANEL (Figure 1-17)	
Primary Flight Instruments	
ATTITUDE Indicator	3-axes ball indicating pitch, roll, and yaw.
ALTITUDE/ATTITUDE RATE Indicator	Tape meters, driven by the radar altimeter, indicate altitude and rate of descent or ascent.
Horizontal Velocity Indicator	A cross pointer, vector sum indicator as derived by the Doppler radar; horizontal needle indicates longitudinal velocity, and vertical needle indicates lateral velocity.
Thrust/Weight Indicator	Displays body axis referenced normal acceleration in lunar g's with a fixed scale and moving pointer.
Secondary Flight Instruments	
Wind Direction Indicator	Located in front-right corner of cockpit ceiling. Pointer indicates wind direction.
Wind Velocity Indicator	Indicates wind speed in feet per second.

TABLE 1-2. Cockpit Controls and Indicators (Continued)

CONTROL OR INDICATOR	FUNCTION
PILOT INSTRUMENT PANEL (Figure 1-17 Continued)	
Secondary Flight Instruments (Continued)	
Inertial-Lead Vertical Speed Indicator	A pressure sensing meter with acceleration lead which displays vertical velocity.
Clock	Includes a sweep second hand and runs for 8 days on one winding.

TABLE 1-2. Cockpit Controls and Indicators (Continued)

CONTROL OR INDICATOR	FUNCTION
PILOT INSTRUMENT PANEL - TOP SECTION (Figure 1-18)	
Rocket Instruments	
Helium Tank Pressure	Indicates pressure of helium in right and left helium tanks, operates from electrical signals from pressure transducers in right and left helium tanks. A duel needle pressure indicator displays pressure for each tank (0-4500psia).
H_2O_2 Tank Pressure	Indicates right and left H_2O_2 tank pressures; operations from electrical signals from pressure transducers in right and left H_2O_2 tanks. A dual needle pressure indicator displays pressure for each tank (0-600 psia).
Lift Rocket Chamber Pressure	Indicates chamber pressure (lift) of right and left lift rockets; operates from electrical signals from pressure transducers at right and left lift rocket thrust chambers. A dual needle pressure indicator displays chamber pressure in each lift rocket (0-400 psia).

TABLE 1-2. Cockpit Controls and Indicators (Continued)

CONTROL OR INDICATOR	FUNCTION
PILOT INSTRUMENT PANEL - TOP SECTION (Figure 1-18 Continued)	
Rocket Instruments (Continued)	
H_2O_2 REM	Digital counter indicates H_2O_2 remaining to nearest two pounds. Adjustable initial source weight.
Annunciator Panel Warning Indicators	
JP4 LOW LEVEL	Red warning indicator illuminates when jet fuel level falls below 20% (46.8 $\pm$ 1.7 lb) of individual tank capacity. Operates from a ground signal sensor control when JP4 (fuel) supply decreases below 20% level.
JP4 CAUTION LEVEL	Amber caution indicator illuminates when jet fuel level falls below 50% (117 $\pm$ 2.2 lb) of individual tank capacity. Operates from a ground signal sensor control when JP4 (fuel) is below 50% level.
AUTO THROTTLE (Jet Engine)	Green status indicator illuminates when auto throttle is engaged, and indicates that power is applied to automatic throttle control to initiate its action; operates from 28 volts DC, from the weight and

TABLE 1-2. Cockpit Controls and Indicators (Continued)

CONTROL OR INDICATOR	FUNCTION
PILOT INSTRUMENT PANEL - TOP SECTION (Figure 1-18 Continued)	
Annunciator Panel Warning Indicators (Continued)	
AUTO THROTTLE (Continued) (Jet Engine)	drag computer, when auto throttle switch, on the power control lever, is actuated.
ENGINE MAX TILT	Red warning indicator illuminates when jet engine pitch or roll tilt exceeds $15^\circ \pm 1^\circ$ with respect to local vertical or when sum of the pitch and roll angles of the engine relative to the vehicle exceeds 64°, and operates from 28-volt DC signal from jet stabilization system.
GIMBAL LOCK MODE	Green status indicator illuminates when this mode is manually selected by pilot placing Gimbal Lock switch to ON.
STABILIZATION MODE	Green status indicator illuminates when Lunar Simulation mode is armed. Operates from 28 volts, DC signal from jet stabilization system.

TABLE 1-2. Cockpit Controls and Indicators (Continued)

CONTROL OR INDICATOR	FUNCTION
PILOT INSTRUMENT PANEL - TOP SECTION (Figure 1-18 Continued)	
Annunciator Panel Warning Indicators (Continued)	
EMERG. GIMBALS LOCKED	Red warning indicator illuminates when Gimbal Locked mode is automatically selected when: 1) Primary hydraulic pressure falls below 1350 $\pm$ 50 psig; the hydraulic low pressure switch illuminates this light and trips a solenoid valve allowing accumulator pressure to command the jet engine to gimbal lock, 2) Jet engine attitude exceeds $15^{\circ} \pm 1^{\circ}$ from local vertical and Local Vertical mode does not restore engine to within 15° in 0.5 seconds. 3) AC Power Failure 4) DC Power Failure 5) When normal Gimbal Lock switch fails to operate.-In which case a pressure switch in normal system side of the shuttle valve loop, triggers the emergency gimbal lock solenoid in the emergency side of the shuttle valve loop.

TABLE 1-2. Cockpit Controls and Indicators (Continued)

CONTROL OR INDICATOR	FUNCTION
PILOT INSTRUMENT PANEL - TOP SECTION (Figure 1-18 Continued)	
Annunciator Panel Warning Indicators (Continued	
EMERG. GIMBALS LOCKED (Continued)	5) (Continued) The green Gimbal Lock mode indicator and the red Emergency Gimbal Lock indicator would be illuminated.
LOCAL VERT MODE	Amber caution indicator illuminates when Local Vertical mode is selected by pilot, when jet engine deflects more than $15^{\circ} \pm 1^{\circ}$ from local vertical, or when any landing gear shock strut is deflected more than one-half inch; in the last two cases the Local Vertical mode is automatically selected. Operates from 28 volts, DC signal from jet stabilization system.
H_2O_2 LOW LEFT TANK AND H_2O_2	Red warning indicator illuminates when H_2O_2 level in either tank falls below $85 {}^{+5}_{-0}$ lb. Operates by level sensor probes in each tank.
VALVE STUCK	Red indicator illuminates when chamber pressure indicates two opposing rockets are firing. Automatically selects BOTH sets of rockets.

TABLE 1-2. Cockpit Controls and Indicators (Continued)

CONTROL OR INDICATOR	FUNCTION
PILOT INSTRUMENT PANEL - TOP SECTION (Figure 1-18 Continued)	
Annunciator Panel Warning Indicators (Continued)	
HELIUM SOURCE LOW	Red warning indicator illuminates when helium tank pressure falls below 1775 psig. Operates from a ground signal from the Helium Low Pressure switch when the helium pressure decreases below 1775 psig.
DOPPLER	Amber caution indicator illuminates when signals from Doppler radar are unreliable.
RADAR ALTIMETER	Amber caution indicator illuminates when signals from radar altimeter are unreliable.
AUTO PILOT BACK UP	Red warning indicator illuminates when vehicle attitude control system switches to an emergency mode.
AC FAILURE	Red warning indicator illuminates when primary AC voltage falls below 100 volts or increases above 130 volts.

TABLE 1-2. Cockpit Controls and Indicators (Continued)

CONTROL OR INDICATOR	FUNCTION
PILOT INSTRUMENT PANEL - TOP SECTION (Figure 1-18 Continued)	
Annunciator Panel Warning Indicators (Continued)	
DC FAILURE	Red warning indicator illuminates when primary DC voltage falls below 24 volts or increases above 32 volts.
GYRO FAILURE	Red warning indicator illuminates when excess rate detector senses a rate in excess of 25 deg/sec from any backup rate gyro.
MASTER WARNING - indicator and audio tone	Red warning indicator above pilot instrument panel illuminates, and audio tone sounds in pilot headset, whenever any of the annunciator panel red warning indicators illuminate.
HARD-OVER	Red warning indicator above instrument panel illuminates when BOTH sets of attitude rockets have been selected automatically by the pilot moving the hand controller to any extreme or hard stop. Cancels out moment compensation. NOTE If any axis direct mode had been selected, BOTH sets of attitude rockets will not be automatically selected.

TABLE 1-2. Cockpit Controls and Indicators (Continued)

CONTROL OR INDICATOR	FUNCTION
PILOT INSTRUMENT PANEL - BOTTOM PORTION (Figure 1-19)	
EGT Gage	Displays engine exhaust gas temperature. In addition, a digital readout displays temperature to nearest 2°C, and operates from electrical signal from thermocouples in jet engine thrust chamber.
PERCENT RPM Gage	Displays gas generator speed as a percentage of maximum; operates from electrical signals from tachometer generator on jet engine.
OIL PRESS Gage	Displays jet engine oil pressure (0-60 psig).
JP4 TANK PRESS Gage	Two tank pressure indicators display pressure for each fuel tank (0-50 psig).

Table 1-2. Cockpit Controls and Indicators (Continued)

CONTROL OR INDICATOR	FUNCTION
AUXILIARY SWITCH AND INSTRUMENT PANEL (Figure 1-20	
	Electrical
AC Voltmeter	Displays primary inverter AC voltage. AC power check switch allows voltmeter to be used to check both phase A and phase C.
DC Voltmeter	Displays emergency DC bus voltage. (This is primary DC during normal operation.)
Mounting Box Assembly	
ATTITUDE CONTROL MODE	Provides the pilot with individual axis selection of rate command or direct command about the pitch, roll, and yaw axes.
a) ROLL Switch	Rate/Direct
b) PITCH Switch	Rate/Direct
c) YAW Switch	Rate/Direct
HORIZ VEL Switch	Used to select scale on Horizontal Velocity indicator (X1 or X10).

TABLE 1-2. Cockpit Controls and Indicators (Continued)

CONTROL OR INDICATOR	FUNCTION
HAND CONTROLLER (Figure 1-21)	
Gimbal Lock	Controls centering of the gimbal actuators using main hydraulic pressure to align the jet engine with the vertical axes of the vehicle, or accumulator pressure in event of normal Gimbal Lock switch malfunction.

SECTION II

SECTION II

HANDLING, SERVICING, LUBRICATION

2-0. SCOPE OF SECTION

2-1. This section provides instructions for ground handling, servicing, and lubrication of the vehicle. The ground handling instructions are covered first, servicing instructions follow, and lubrication instructions as the last part of this section. To avoid duplication, some areas of this section refer to other sections of this handbook that cover in detail the required information.

2-2. GROUND HANDLING

2-3. TOWING - The vehicle is first placed on the LLTV transporter (figure 2-1), then the transporter is towed. The LLTV vehicle transporter consists of a steel I-beam chassis suspended by four wheels, four pivoting arms, an inner support frame for the LLTV, and a hydraulic jack system for raising and lowering the LLTV support frame. The following steps prepare the LLTV for towing:

A. Inflate the landing gear shock struts. (Refer to paragraph 2-61.)
B. Lower transporter inner support frame to its lowest position by releasing Hydraulic By-pass valve.
C. Position transporter under vehicle, aligning the four transporter pivoting arms cradle to the vehicle legs crossarms. (See figure 2-2.)
D. Raise transporter inner support frame until transporter pivoting arms cradle firmly contact the vehicle legs jacking points.

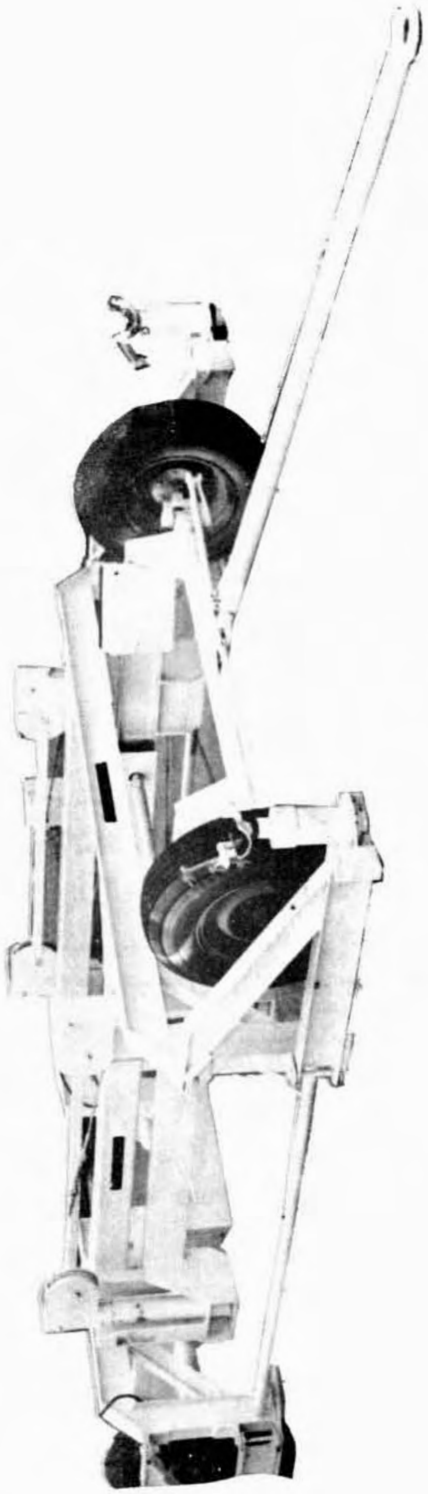


Figure 2-1. LLTV Vehicle Transporter

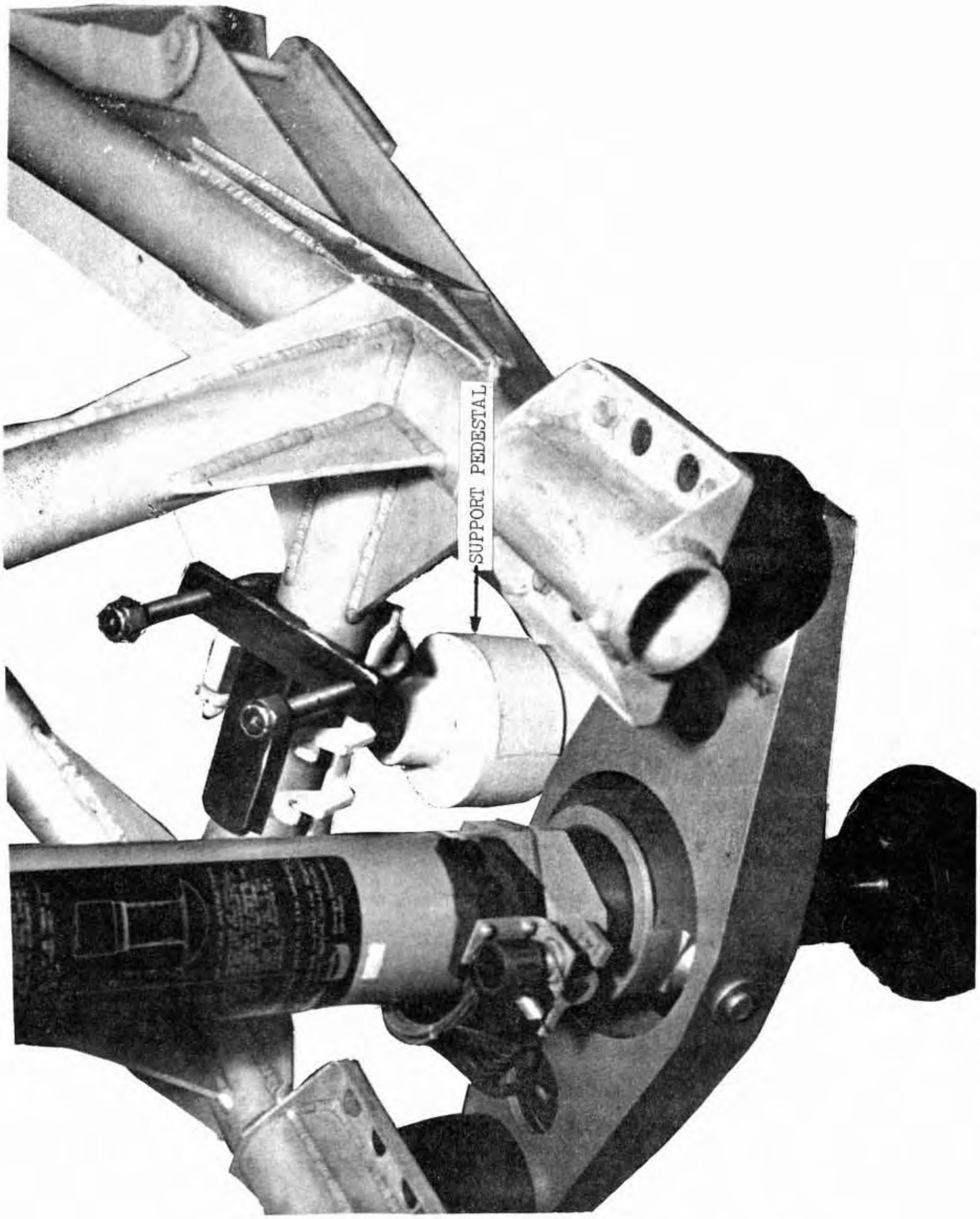


Figure 2-2. LLTV Transporter Typical Support Pedestal and Clamp

E. Clamp vehicle leg crossarms to transporter cradle using clamps attached to transporter pivoting arms.

F. Deflate landing gear shock struts and retract struts by hand, lock off valves.

G. Raise transporter inner support frame until vehicle landing pads clear ground approximately six inches.

H. Connect transporter tow handle to tractor hitch.

I. Transporter and vehicle are ready to be towed.

NOTE

The vehicle is towed in this manner within the operation and maintenance areas around the hangar and flight areas. However, the vehicle can also be moved in this manner to areas outside of these operational areas for short distances.

CAUTION

Do not exceed 5 miles per hour when towing transporter with vehicle. Also, avoid sudden starts and stops.

2-4. JACKING - The vehicle can be jacked with loads distributed equally to the four jack locations at the center of the lower cross tube of each leg. To remove vehicle leg, either the front or rear of the vehicle is raised with jacks placed at two points of the vehicle frame. (Refer to Section IV, paragraph 4-26.

2-5. CASTERS - The caster installation (figure 2-3) kit, part number 7161-191005-5, is installed on all four landing struts and used for positioning or turning the vehicle within the hanger work areas and are installed as follows:

NOTE

In the event of an emergency, such as a fire, the casters may be used to move the vehicle from the area of immediate danger.

A. While vehicle is still on the transporter, in the hangar align casters under each leg.

B. Lower transporter bed slowly until vehicle legs rest on casters.

C. Lower transporter bed as low as possible and move it out from under vehicle.

D. Vehicle can now be rolled on the casters.

2-6. HOISTING - To hoist the vehicle, an overhead hoist is used, having a lifting capacity of at least two tons and a minumum overhead look height clearance of 26 feet. Hoisting the vehicle is accomplished by utilizing the terminals located at each of the four top corners of the vehicle center body structure. An LLTV horizontal hoist sling (attached to the overhead hoist hook) with drop cables, is attached to the vehicle terminals with four AN5 bolts. This hoisting method is used for the fixture test, weight and balance check, leg maintenance or removal, and in preparing the vehicle for air transport.

2-7. LEVELING PROVISIONS - To ensure that the vehicle is level for preflight checks, one of two methods of leveling is used; (1) Threaded metal rods are installed at each vehicle lower leg and rotated until the vehicle just clears the hangar floor. Further adjustment is required of each rod until vehicle is level. (2) Four wooden block, each shaped so the top of the block is absolutely level when placed on its marked space on the hanger floor. Whenever the vehicle has to be level, the blocks are placed on their marked floor space and the vehicle legs are placed on the blocks. Refer to Weight and Balance Handbook No. 7260-954003 for additional leveling procedures.

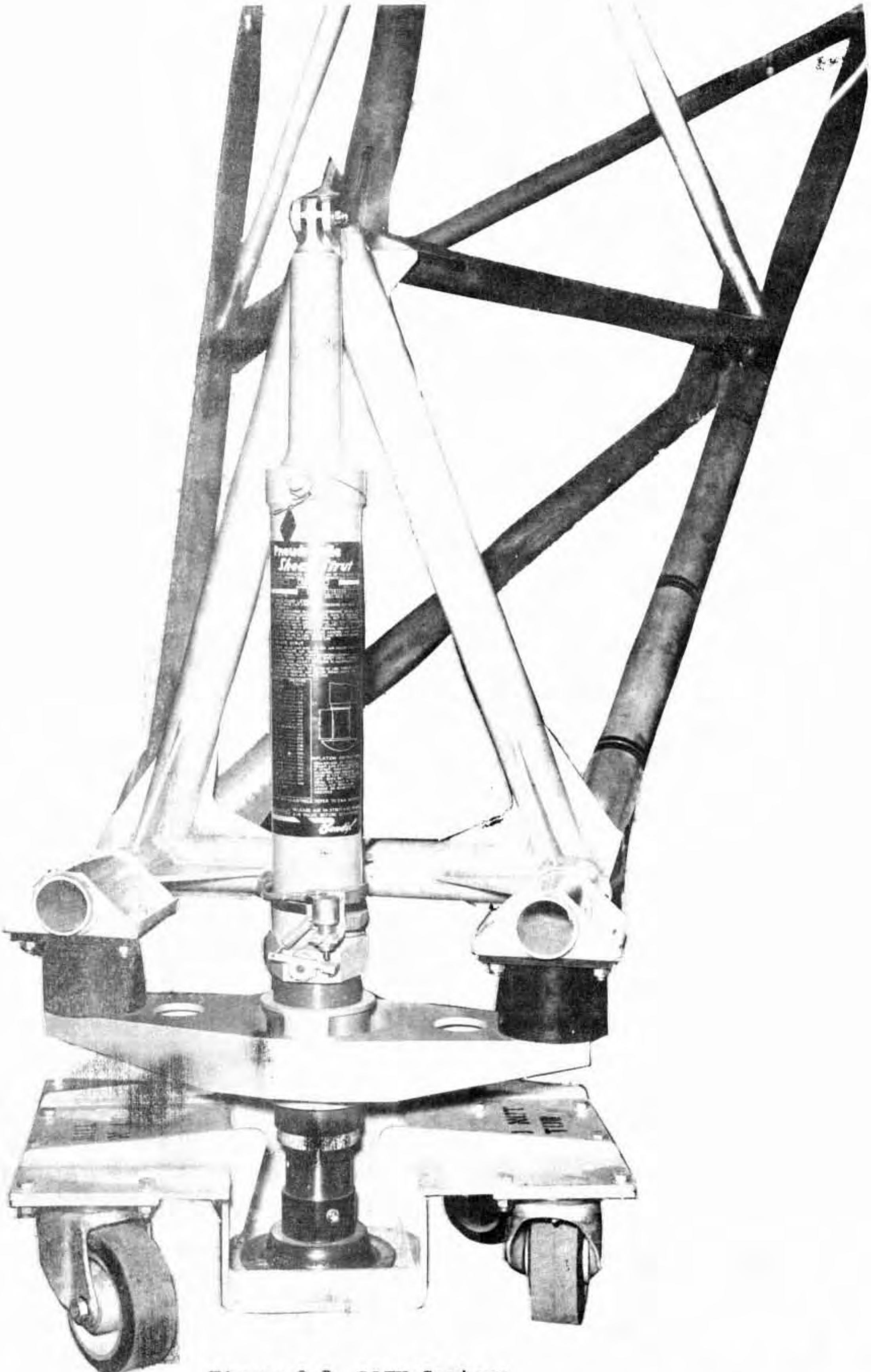


Figure 2-3. LLTV Casters

2-8. VEHICLE GROUND OPERATIONS

2-9. Ground operation of the LLTV consists of two major types; ground tiedown runs and CG fixture operations.

2-10. GROUND TIEDOWN RUNS - These operations are normally conducted with various limited objectives. For example, turbofan jet engine runs can be made, rocket system runs, combined systems runs, or simulated missions can be performed during these ground tiedown runs. These activities will serve to acquaint the pilot with actual feel of the primary flight controls. Through these operations he will learn how much movement is necessary to control a certain response in the systems. In particular, he will learn the movement of the three-axes hand controller; i.e., how much movement in one direction is required to fire a desired combination of attitude rockets. Similar familiarization activities will also be helpful in learning the use of the lift rocket T-handle and the jet engine throttle.

2-11. CENTER OF GRAVITY FIXTURE RUNS - The prime objective of operations of the LLTV on the Center of Gravity (CG) fixture is to perform functional operations and checkout of the vehicle attitude control system about the pitch and roll axes in addition to pilot familiarization with the attitude control system. The vehicle is supported on the fixture by the jet engine mount only. When mounted on the fixture, the vehicle legs are approximately 5 feet off the ground. This clearance allows vehicle movement about the gimbals to permit closed loop operations of the attitude control rocket system for about $\pm 13^{\circ}$ in pitch or roll with unrestricted motion and an additional $\pm 13^{\circ}$ (or a total of $\pm 26^{\circ}$) of motion through the soft stops (bungee cords tied to the vehicle legs) before the hard stops are reached.

2-12. The turbofan jet engine is not run during fixture operations. In addition, the primary gimbal hydraulic system is not in flight status; i.e., the gimbal hydraulic actuators are removed from the vehicle. In this way a very realistic evaluation of hovering free flight attitude control in pitch and roll only is obtained.

2-13. RESTRAINTS DURING CG FIXTURE RUNS - During operations of the LLTV on the fixture, cables are attached to the vehicle to prevent the vehicle from reaching extreme attitudes which could cause damage to the vehicle. These cables provide a hard stop restraint. In addition to the cables, shorter soft stops are attached in the form of stretchable ropes (bungees). These serve to gradually stop vehicle motion as the limits of attitude are approached. During normal operation on the fixture, handling ropes from the vehicle legs are left slack. In an emergency, such as rocket or jet fuel leakage, these ropes can be used by the ground crew to return the vehicle to an attitude where pilot can safely egress.

CAUTION

Yaw commands must not be initiated by the pilot during CG fixture runs.

2-14. PREPARATION OF LLTV AND FIXTURE FOR CG CHECK - The following steps prepare the LLTV and the fixture for CG checks:

NOTE

Refer to the Weight and Balance Handbook, Report No. 7260-954003, for additional information.

A. Strap a 200 pound anthropomorphic dummy in cockpit seat.

B. Remove pitch and roll actuators and replace with dummy actuators.

CAUTION

Note location of the pitch and roll actuators before removing. These items must be replaced in the same locations. Ascertain that all vehicle tanks are empty, except the hydraulic reservoir and the engine oil reservoir.

C. Weigh the CG fixture and level the fixture with a inclinometer.

2-15. PROCEDURE FOR PLACING THE LLTV ON THE CG FIXTURE - The following place the LLTV on the CG fixture:

A. Remove 12 NAS674-4H bolts from the bottom side of the LLTV engine mount.

CAUTION

Do not remove the seven 3/16-inch diameter bolts found in the same general area.

B. Loosely attach three engine mount plates with centering pins, using 12 NAS674-16H bolts.

NOTE

The engine mount plates consist of two plates of part no. 503 and one plate of part no. 502. Plate part no. 502 has shorter hole spacings, and should be located at the most aft mounting point.

C. Remove large tang from master ring (at engine mount location) and position the master ring beneath the LLTV engine so that the portion stamped "FWD" and "USE AGAINST VEHICLE" are properly oriented with respect to the LLTV.

D. Raise the master ring up and around the LLTV engine assembly until the aft tang on the inside diameter of the ring engages the unused aft main engine mount slot.

E. Replace and engage the forward tang in the unused forward right engine mount slot.

NOTE

During this operation, the spherical ends of the centering pins in the loosely attached engine mount plates are inserted into appropriate positioning holes of the master ring.

F. Attach master ring to LLTV engine using two captive pins inserted through the ring tangs and main engine mounts.

G. Tighten the 12 NAS674-16H bolts in the engine mount plates.

I. Remove the large tang from the master ring and remove the master ring from the LLTV.

J. Replace tang on master ring.

K. Install LLTV gimbal ground locks.

L. Attach the link of the LLTV horizontal hoist slight to an overhead hoist.

CAUTION

The overhead hoist must have a capacity of at least two tons, and a minimum overhead hook height clearance of 26 feet.

M. Using the overhead hoist, lower the LLTV horizontal hoist sling so that the drop cables can be attached with AN5 bolts to the terminals located at each of the four top corners of the LLTV center body structure.

N. Position the CG fixture in the area accessible to the overhead hoisting device with the "FWD" notation on the triangular base oriented properly with respect to forward on the LLTV.

O. Position three platform scales under the 1-3/4-inch adjusting screws, located at each corner of the CG fixture triangular base.

NOTE

Scales should be located so that the adjusting screws are as close as possible to the center of the weighing platform with the scale indicating dials located as outlined in step (p) and (q).

P. The most forward scale should have the indicating dial directly forward of the CG fixture adjusting screw.

Q. The left and right scales should have their indicating dials forward of the scale base and approximately parallel to a line joining the adjusting screws and the center of the triangular base.

NOTE

If the flush scale installation is used, it will be necessary to position the CG fixture over the platforms, then locate the 10-$\frac{1}{4}$-inch spacers under the adjusting screws.

R. Transfer the weight of the CG fixture from the casters to the weighing scales by turning the adjusting screws.

S. Lock the CG fixture casters as directed on the triangular base.

CAUTION

The casters must be locked in the same position for each weighing exercise, to ensure consistent results.

T. Level the CG fixture in the lateral and longitudinal planes, using the adjustment screws and a clinometer applied to the top support ring fittings.

NOTE

Access to the fittings will require either a ladder or maintenance stand.

U. Using the overhead hoist, lift and position and complete LLTV, to permit clearance between the engine exhaust cone and the top of the CG fixture.

V. Lower the complete LLTV onto the CG fixture until the centering pins of the engine mount plates slip into the alignment holes of the mount fittings attached to the top ring of the fixture.

CAUTION

Proceed with extreme care when lowering the LLTV to assure that clearances exist between components and the fixture, and that no damage occurs as the alignment pins engage the mount fittings.

W. Secure the LLTV to the CG fixture by installing three $\frac{1}{2}$-inch diameter socket head cap screws.

WARNING

Attach warning streamers up through the top of the mount fittings and into the engine mount plates.

X. Remove the LLTV horizontal hoist sling.

Y. Perform the weight and balancing procedures outlined in the LLTV Weight and Balance Handbook, Report No. 7260-954003.

2-16 PERFORM CG CHECK - The following steps are required to perform the CG check:

A. Locate the zero points:
   1) Behind the left hydrogen peroxide tank.
   2) Behind JP4 tanks.

B. Refer to Pilot Familiarization on CG Fixture, Checklist No. 7260-931003, for complete CG check.

2-17 PROCEDURE FOR REMOVING THE LLTV FROM THE CG FIXTURE - The following steps outline the procedure required to remove the LLTV from the CG fixture:

CAUTION

The LLTV must be in a horizontal attitude with gimbal locks installed before starting the following procedure.

A. Attach the link of the LLTV horizontal hoist sling to the overhead hoist.

B. Using the overhead hoist, lower and position the horizontal hoist sling so that the drop cables can be attached witn AN5 bolts to the terminals located at each of four top corners of the LLTV center body structure.

<u>CAUTION</u>

Do not attempt to raise the overhead hoist at this time. Severe damage to the LLTV is possible. The horizontal hoist sling is attached at this time only to eliminate possible LLTV tipping and subsequent damage to the LLTV during scale and fixture removal operations.

C. Transfer the weight of the fixture and the LLTV from the scales to the casters by turning the adjusting screws.

D. Remove the scales.

<u>NOTE</u>

Remove the 10-1/4-inch spacers if a flush weighing facility is used.

E. Remove three 1/2-inch diameter socket head cap screws with the warning streamers.

<u>NOTE</u>

These screws attach the LLTV engine mount plates to the mount fittings of the CG fixture.

CAUTION

Do not attempt, under any circumstances, to hoist the LLTV without first removing the three 1/2-inch diameter screws. Serious damage to the engine mount could occur if the LLTV is hoisted while still attached to the fixture.

F. Using the overhead hoist, carefully raise the LLTV up and out of the CG fixture to a point where the engine exhaust cone will clear the top fittings of the truss.

CAUTION

Proceed with extreme care when raising the LLTV out of the fixture, to assure that clearances exist between vehicle components and the fixture.

G. Unlock the casters and remove the support truss assembly from beneath the LLTV.

H. Carefully lower the LLTV to the floor using the overhead hoist.

I. Remove the four AN5 bolts that attach the LLTV hoist sling to the lifting terminals.

J. Remove the overhead hoist and the LLTV horizontal hoist sling.

L. Secure the LLTV terminals to the ball end terminals at the corners of the center body structure with AN5-10 bolts.

L. Remove three engine mount plates from underside of LLTV engine mount.

NOTE

These plates are attached with
12 NAS674-16H bolts.

M. Install 12NAS674-4H bolts in the holes.

N. Remove the 200 pound dummy.

O. Place the pitch and roll actuators in their original locations.

2-18 LEVELING - Leveling of the vehicle is only necessary during the fixture check and weight and balance check. Refer to Weight and Balance Handbook, Report No. 7260-954003, for leveling procedure.

2-19 PROTECTIVE COVER - A portable hanger, made with canvas walls and a sheet metal roof, is used as a protective cover for the vehicle when it is not in the permanent hangar. The portable hangar is on wheels and can either be towed by a tractor, or pushed by several men to where the vehicle is located. This hangar is also used as a wind breaker for the vehicle and as a work area while repairing or testing the vehicle.

CAUTION

Do not attempt to position
portable "Roll Over" hangar
over LLTV in winds above 15 mph.
In winds of 15 mph or less,
reduce sail area by retracting
side wall curtains.

2-20 GROUND SAFETY LOCKS AND PINS - The ground safety locks and pins shall be removed and/or installed at specific times during preflight, pilot entry, or after touchdown, The following paragraphs indicate when these safety locks and pins are to be installed and when they are to be removed.

2-21 ENGINE SUPPORT CABLE - The engine support cable holds the engine in a rigid position to protect the engine during movement of the vehicle. The following steps indicate when the cable is to be removed and installed.

A. Remove - Just prior to pilot entry.
B. Install - After touchdown. After the 3-way hrdraulic valve is switched to DUMP position and just before the vehicle is towed from the landing area.
C. During Hangar Test Procedures, the cable is removed whenever Hydraulic Mule is connected and operating.

CAUTION

Exercise extreme care when installing and removing cable. Cable falling into jet engine could cause damage to engine components.

2-22 STATIC GROUND WIRE - A ground receptacle has been provided on the outer gimbal to which the ground cable shall be attached whenever the vehicle is on the cound, and its jet engine is not operating.

2-23 The static ground wire, when connected, protects personnel from possible shock hazard due to faulty GSE. It also provides a static ground point to which fueling truck grounds can be attached.

2-24 The static ground wire shall be attached at all times, except during vehicle movements, flight, and ground transport. Removal of the static ground wire prior to flight shall be accomplished at the time that the jet engine igniter cable is attached.

2-25 ACS SAFE SWITCH AND ROCKET PROPELLANT SWITCH SAFETY PINS - Safety pins are installed through the ACS Safeand Rocket Propellant switches to prevent them from being accidently tripped. The following steps indicate when the pins are to be inserted and removed:

A. Remove - During preflight prime check. After checking H_2O_2 vent valves are closed and area cleared for prime pressurization.

B. Install- During preflight cockpit check. After checking ACS Safe switch is at SAFE position, and after placing Rocket Propellant switch to OFF.

2-26 PARACHUTE AND EJECTOR SEAT "D" RING SAFETY PINS - The parachute and ejector seat "D" ring safety pins are installed to prevent accidental firing of the ejector seat and parachute. The following steps indicate when the safety pins are removed and installed. Refer to paragraph 4-16 and Weber Aircraft Company Manual DR 5773-1 detailed information .

(See above referred to steps on next page)

(2-26) Cont.

Remove -

Ejector seat M27 and M32 initiator safety	-	Prior to installing parachute, after topping off helium tanks and before JP4 tank pressurization.
Lanyard safety pin	-	After pilot's parachute is installed.
Pilot's parachute "D" ring safety pin	-	After pilot entry and after oxygen hose and communications cord are connected.
Ejection seat "D" ring safety pin	-	After pilot's parachute "D" ring safety pin has been removed.

Install -

Ejection seat "D" ring safety pin	-	Prior to pilot exit and immediately after engine shutdown.
Pilot's parachute "D" ring safety pin	-	After ejection seat "D" ring safety pin has been installed.
Ejector seat M27 and M32 initiator safety pins	-	After parachute and pilot seat cushion has been removed.
Lanyard safety pin	-	Prior to parachute and pilot seat removal and after pilot exit.

WARNING

Install safety pins during any emergency on the ground that occurs after pilot entry, especially when pilot is incapitated, and requires assistance in leaving LLTV cockpit.

2-27. <u>ACS SAFE AND ROCKET PROPELLANT SWITCHES SAFETY LOCK PIN</u> - A safety lock pin is installed through the guards of the ACS Safe and Rocket Propellant switches to prevent accidental movement from their SAFE or OFF positions. The following steps indicate when the safety lock pin is removed and installed.

A. Remove - After H_2O_2 servicing when the area is cleared for prime pressurization.

B. Install - During purge after the ACS Safe switch is placed in SAFE (GUARD UP) position and the Rocket Propellant switch is placed to OFF position.

2-28. <u>EXTINGUISHING GROUND FIRES</u> - Ground fire is an ever present danger around the vehicle. It is important that the ground crew observe safety precautions at all times. It is also necessary to have the proper fire fighting equipment on hand at all times. The following paragraphs detail the fire fighting equipment required and its use.

2-29. A crash truck shall be on site during vehicle testing, flight and whenever there is a possibility of a fire occurring. The crash truck crew is responsible for fire-fighting and pilot rescue. The master fireman of the crash truck is responsible for overseeing training of the crash truck crew and directing the operation of pilot rescue and fire-fighting during an emergency. The vehicle ground crew will not become involved in fire-fighting and pilot rescue unless directed to do so by the Operations Engineer.

2-30. Of all the LLTV systems, the hydrogen peroxide propellant for the attitude and lift rocket systems is the most dangerous. Hydrogen peroxide is a clear, colorless liquid slightly heavier than water. When hydrogen peroxide is contaminated, it decomposes rapidly into steam and oxygen. This decomposition will give off heat with temperatures as high as 1300 degrees F. With this heat and the oxygen liberated, any affected material will burn easier than in air. Hydrogen peroxide will mix with water and the best way to make safe any spillage or leaks is to flood the affected areas with water to dilute the hydrogen peroxide to prevent decomposition.

2-31. <u>CRASH TRUCK</u> - The 0-11A crash truck is operated by four men working in heat resistant protective clothing. The truck has UHF and VHF two-way radio communication. It is capable of up to 6-wheel drive with a turn radius of 40 feet 3 inches. The top of the cab is 12 feet high and contains a trap door. Two swiveling nozzles, located on the cab roof, can be adjusted to control the water from a straight stream to water-fog or semi-fog. The straight stream can be thrown a distance of 90 feet. The downwind range of the fog spray is approximately 50 feet. Three fixed-spray nozzles adjusted for level spray are located on the lower front of the vehicle. The truck has a 19-inch ground clearance and two fixed-spray nozzles pointed downward to protect the underside of the truck. Two 150-foot hand lines are equipped with nozzles that can be adjusted from water-fog to straight stream. In the present configuration, the crash truck has a water capacity of 1,100 gallons. With all nine nozzles discharging at maximum rate, the water supply will be exhausted in 3 minutes. (It is planned to fight hydrogen peroxide and jet engine fuel fires with water.)

2-32. <u>TAKEOFF PAD FIRE FIGHTING EQUIPMENT</u> - The fire-fighting equipment at the takeoff pad includes one charged 2.0-inch diameter fire hose with a nozzle that can vary the stream from straight stream to water-fog, using water at hydrant pressure, a garden hose with no nozzle (giving low pressure water), and a 100-pound carbon dioxide bottle mounted on a two-wheel cart, available for electrical fires.

2-33. ENGINE GROUND OPERATION

2-34. ENGINE PRE-START CHECK - For the engine pre-start check, refer to the Lunar Landing Training Vehicle Preflight Checklist No. 7260-931005.

2-35. COCKPIT CHECK - For the cockpit checks, refer to the Lunar Landing Training Vehicle Pilot Flight Checklist No. 7260-931008.

2-36. AIR START UNIT (GSE)

A. Blow down hose and connect air start hose to vehicle.

WARNING

After pilot entry, and upon request from the pilot (1 finger signal) proceed with the following steps.

B. Turn GSE unit ON.

C. Switch air ON and ignition when requested from the pilot (2 finger signal).

WARNING

If directed by the pilot (throat cut signal) switch ignition OFF. Leave air ON to purge fuel from combustion and exhaust sections.

D. Upon vehicle engine ignition, switch Air Start Unit ON and ignition OFF when directed by the pilot (thumb down signal), and disconnect starter air hose and ignition cable.

2-37. JP4 FUEL SERVICING

2-38. JP4 FUEL LEVEL CHECK

A. Attach QD and drain hose to forward JP4 tank fuel level probe.

B. Release probe and record the level at which fuel starts to drain.

C. Secure probe and remove QD and drain hose.

D. Repeat steps A, B, and C for aft JP4 tank.

CAUTION

Check that JP4 LOW LEVEL and CAUTION LEVEL indicators on the annunciator panel are illuminated, if fuel remaining is below the following levels:

1) 50% - JP4 CUATION LEVEL indicator illuminated when remaining fuel quantity is approximately 117 lb or less as indicated in either tank.

2) 20% - JP4 LOW LEVEL indicator illuminated when remaining fuel quantity is approximately 46.8 lb or less as indicated in either tank.

2-39. REFUEL

A. Disconnect aft JP4 tank low level indicator probe cannon plug to ensure valid operation of JP4 CAUTION LEVEL and LOW LEVEL indicators on annunciator panel.

B. Attach QD and drain hose to forward tank fuel level probe.

C. Release probe and set to fuel level required.

D. Connect JP4 fill hose from supply trailer to botton of forward tank.

E. Service JP4 until fuel overflows through fuel probe.

F. Shut off JP4 flow from JP4 trailer and disconnect fill lines.

G. When drainage has creased from level probe, secure fuel probe and record quantity serviced on Operations Log.

H. Disconnect QD and drain hose.

I. Connect aft tank level indicator probe cannon plug and check indicator lights on annunciator panel are illuminated.

J. Repear steps A through I for aft JP4 tank.

2-40 JP4 TANK PRESSURIZATION

NOTE

This servicing procedure requires man in cockpit.

A. Check that forward and aft JP4 tank bleed valves are CLOSED and the fuel level probe is UP and secure.

B. Verify that the throttle lever is in the FULL CLOSE position with IDLE STOP UP.

C. Connect nitrogen pressure source from the helium and nitrogen gas service truck (figures 2-6 and 2-7), with a 60 psi (max) relief valve, to the gas charging valve.

D. Slowly pressure the system to $20 {}^{+10}_{-0}$ psig.

NOTE

Man in cockpit will verify correct pressure indicated on the cockpit gages. Man operating pressurizing equipment will also verify correct pressure indicated on the Service Truck Control Panel.

E. Check system components for visible fuel leaks. Check cockpit JP4 tank pressure gages for indication of nitrogen leaks.

2-41. H_2O_2 SERVICING

A. Connect the H_2O_2 tank temperature monitor to the vehicle sensor.

B. Perform the following cockpit functions prior to H_2O_2 servicing.

1) Verify that the lift rocket T-handle is down to the CLOSED position.
2) Verify that the LIFT RKT V ACTUR, CB28 is in the OFF (DOWN) position.
3) Place the Helium Crossover switch to the CLOSED position.
4) Verify that the Att Rockets selector switch is placed to the BOTH position.
5) Verify that the ACS Safe switch is placed to the SAFE (GUARD UP) position.

NOTE

A fire truck is required whenever 90% H_2O_2 is serviced.

WARNING

All personnel clear area except for the following assignments that require the wearing of appropriate protective H_2O_2 suits.

Crew Chief - With communications and checklist frequently monitoring H_2O_2 temperature box.

H_2O_2 Trailer - Servicing requires two men.

Inspector - At vehicle, with communications (one also at the van).

C. Install H_2O_2 overflow line to tank vent valve and insert other end in a bucket of water.

D. Open both H_2O_2 vent valves.

E. Attach the fill line to the right hand H_2O_2 tank filler valve.

F. Open right hand fill valve and fill until there is an overflow from vent line.

NOTE

Certify H_2O_2 LOW RIGHT TANK indicator extinguishes, if applicable.

G. Close right hand fill valve.

H. Repeat steps C through G for servicing the left hand H_2O_2 tank.

NOTE

Certify H_2O_2 LOW LEFT TANK indicator extinguishes, if applicable.

I. After servicing is completed, close H_2O_2 tank vent valves and disconnect vent lines and cap.

WARNING

Clear area.

J. Disconnect H_2O_2 temperature probe wires from vehicle and store in GSE service truck.

2-42. HELIUM SERVICING

CAUTION

Throughout helium servicing, monitor the helium tank surface temperature. If necessary, cool the helium tank by running water over the tank surface to maintain temperature below 150° F up to 3800 psi and below 110° F from 3800 to 4000 psi.

NOTE

Helium servicing may be continued while other operations are being performed.

A. Connect the helium tank temperature monitoring box.

B. Verify that the helium manual shutoff valve is CLOSED.

C. Hook up helium servicing harness from GSE helium service truck to vehicle and commence servicing.

D. If applicable, verify HELIUM SOURCE LOW indicator extinguishes at 1775 $\pm$ 50 psi.

E. Continue servicing helium system to 4000 $\pm$ 50 psi.

F. Close helium tank schrader valves.

G. Detach and cap helium service hoses.

H. Cap helium tank schrader valves.

I. Disconnect helium tank temperature monitoring box.

J. Secure the helium servicing equipment and remove equipment from the immediate area.

2-43. ENGINE TESTS - For engine testing, refer to G.S. SEI-133 and to Lunar Landing Training Vehicle Pilot Flight Checklist No. 7260-931008.

2-44 HAND SIGNALS - The hand signals covering operations and movement of the vehicle are covered in the following steps.

A. Turn Start Unit ON - Pilot - 1 finger.

B. Switch ON Air and Ignition - Pilot - 2 fingers.

C. Switch Ignition Off - Pilot - Throat-cut signal.

D. Switch OFF Air and Ignition - Pilot - Thumb down signal.

E. Switch DC POWER Relay ON - Pilot - (1st time) T-disconnect Distribution Box to OFF hands signal.

F. Switch OFF Data System - Pilot - (2nd time) T-disconnect Power on Power Distribution Box hands signal.

2-45 STOPPING ENGINE - For instructions to stop the engine, refer to Lunar Landing Training Vehicle Pilot Checklist No. 7260-931008.

2-46 SERVICING - Servicing instructions include replenishment of JP4 fuel, H_2O_2 propellant, helium, engine oil, hydraulic fluid, nitrogen and oxygen, and the equipment required to perform these operations.

2-47 HYDRAULIC SYSTEM SERVICING - The hydraulic system of the vehicle provides power for the positioning of the turbofan jet engine mounting gimbals about the roll and pitch axes. The hydraulic pump only operates when the jet engine is running, so as external hydraulic test stand such as the type D6-D6A or equivalent is required for the servicing of the hydraulic system. All hydraulic fluid shall conform to MIL-H-5606A (red color) and shall be filtered through a 15 micron absolute filter. (Refer to Hydraulic Systems Hangar Ground Test Procedure No. 7260-928055 for additional information).

CAUTION

The outlet of the test stand shall have a 15 micron absolute filter to prevent contamination of the hydraulic system.

NOTE

The jet engine gimbal locks must be removed for servicing.

2-48. HYDRAULIC TEST STAND - The test stand D6 or D6A (figure 2-4) is a self-contained, mobile, testing unit, enclosed in steel weather resistant cabinets mounted on a trailer assembly. Doors are provided to permit access to all components within the cabinet. The test stand consists of the following assemblies: (1) cabinet assembly, (2) trailer assembly, (3) electric motor, (4) hydraulic reservoir, (5) pump, (6) filter and manifold assembly, (7) the control panel mounted opposite the hydraulic compartment, (8) a 50-foot power cable and two hoses for connecting the test stand to the LLTV hydraulic system.

2-49. FLUSHING PROCEDURE - After installing the hydraulic system (or repair to major portions) flush with fluid which meets MIL-H-5606 and is filtered through a 25 micron absolute filter.

A. Setup

1) At the actuators, disconnect the flexible lines and connect the pressure line to the return line, and disconnect the shuttle valve lines at each shuttle valve and connect together each set of lines.
2) At the reservoir, disconnect the return line and connect it to the return outlet on the test stand.
3) At the pump, disconnect the pressure line and connect it to the pressure outlet on the test stand.
4) Open the 7260-390001-1 manual shut-off valve in the reservoir reline line.
5) Pressurize the accumulator to 1200 $\pm$ 50 psi with dry nitrogen.
6) Connect a jumper line across the 7260-390005-1 & -3 quick disconnects.
7) Place 7260-390009-1 manual hydraulic 3-way valve in PRESSURIZE position.

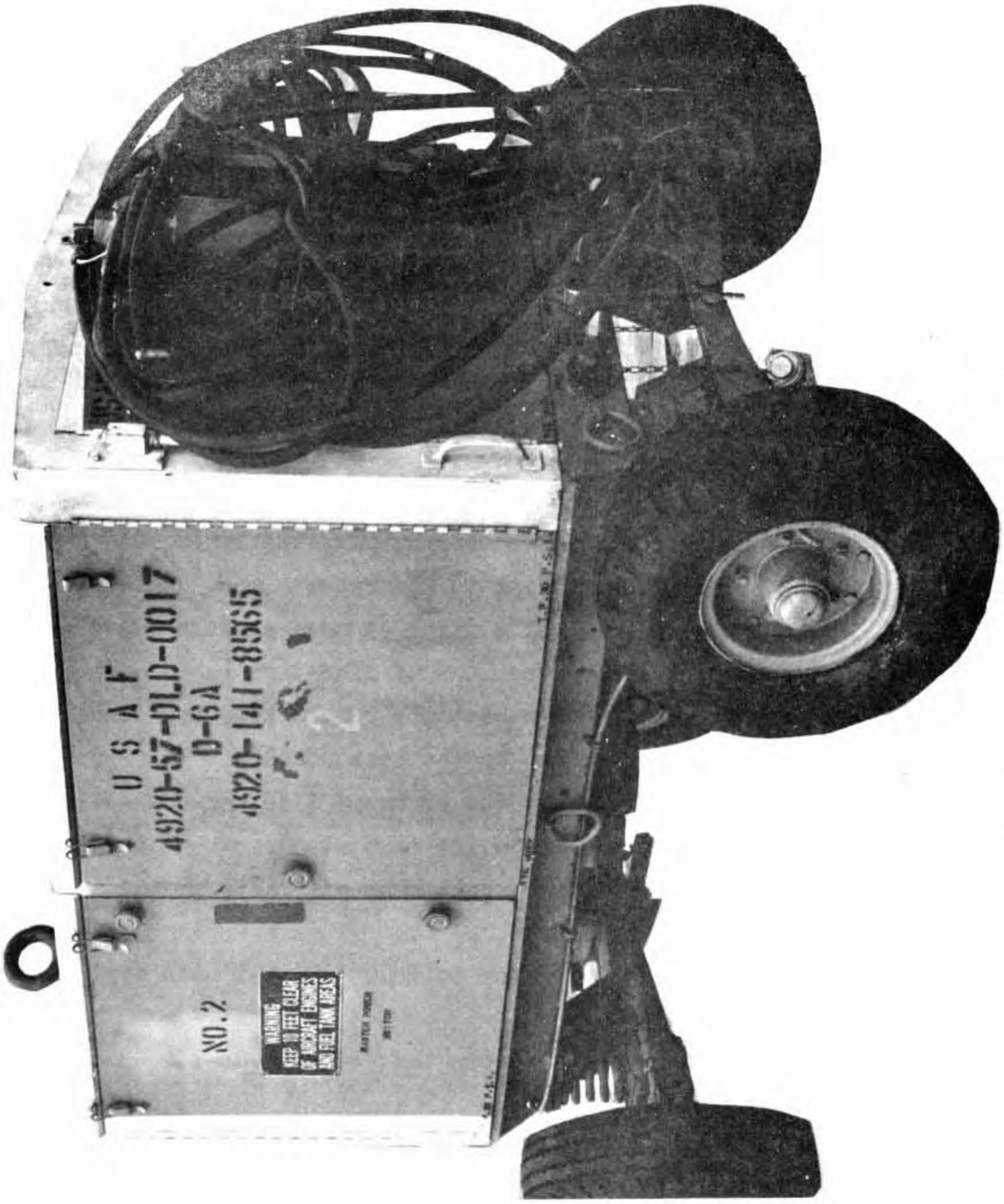


Figure 2-4. Hydraulic Test Stand D-6A

B. Circulate Fluid

1) Disconnect both 7260-390002-1 solenoid valves from the vehicle electrical system and energize either valve with 28 volts, dc.
2) Adjust the test stand pressure to provide 3.0 GPM and circulate fluid for 15 minutes.

NOTE

Place a 25 micron absolute filter on the outlet of the test stand. Use test stand fluid meeting the following standard for minimum contamination (NAS 1638, class 5):

Particle Size (microns)	Count per 100 ml (per ARP 598)
5-15	8000
15-25	1425
25-50	253
50-100	45
Over 100	8

3) De-energize the 7260-390002-1 solenoid valve and energize the other 7260-390002-1 valve and circulate fluid for 15 more minutes.
4) Have a sample of the fluid analyzed to show that it meets NAS 1638, class 5.

C. Reconnect

1) Shutdown and disconnect the test stand. Restore the hydraulic system to normal configuration.
2) Place the 7260-390009-1 manual valve in the accumulator circuit in the CLOSED position.

2-50. FILLING - After initial installation and after major maintenance fill system as follows.

A. Place the 7260-390001-1 manual valve in the reservoir return line in the CLOSED position, and the 7260-390009-1 manual 3-way valve in the PRESSURIZE position.

B. Connect the hydraulic test stand to the system through the quick disconnect couplings on the structure ring.

C. Increase the test stand pressure to about 300 psi and cycle the actuators through five cycles by applying and reversing a 5-ma current across pins A and C of both 7260-390008 servo actuators.

D. With the actuators in one extreme position, energize either 7260-390002-1 solenoid valve with 28 vdc to center the actuators with the gimbal centering mechanism.

E. De-energize the solenoid valve and repeat the centering action using the other 7260-390002-1 solenoid valve to center the actuators from the opposite extreme position.

F. Reduce the test stand pressure to zero. De-energize the 7260-390002-1 solenoid valve.

2-51. TESTING - To test for external and internal leakage proceed as follows.

A. External leaks.

1) Connect the hydraulic test stand to the system through the quick disconnect couplings.
2) Place the 7260-390001-1 manual valve in the reservoir return line in the CLOSED position, and the 7260-390009-1 manual valve in the PRESSURIZE position.

2-50. FILLING - After initial installation and after major maintenance fill system as follows.

A. Place the 7260-390001-1 manual valve in the reservoir return line in the CLOSED position, and the 7260-390009-1 manual 3-way valve in the PRESSURIZE position.

B. Connect the hydraulic test stand to the system through the quick disconnect couplings on the structure ring.

C. Increase the test stand pressure to about 300 psi and cycle the actuators through five cycles by applying and reversing a 5-ma current across pins A and C of both 7260-390008 servo actuators.

D. With the actuators in one extreme position, energize either 7260-390002-1 solenoid valve with 28 vdc to center the actuators with the gimbal centering mechanism.

E. De-energize the solenoid valve and repeat the centering action using the other 7260-390002-1 solenoid valve to center the actuators from the opposite extreme position.

F. Reduce the test stand pressure to zero. De-energize the 7260-390002-1 solenoid valve.

2-51. TESTING - To test for external and internal leakage proceed as follows.

A. External leaks.

1) Connect the hydraulic test stand to the system through the quick disconnect couplings.
2) Place the 7260-390001-1 manual valve in the reservoir return line in the CLOSED position, and the 7260-390009-1 manual valve in the PRESSURIZE position.

3) Increase the test stand pressure to 100 psi at a slow enough rate so that any leak can be immediately detected as it occurs.

NOTE

If any fitting leaks, reduce the pressure to zero and retorque the fitting - but not beyond the following values:

1/4" lines	300 inch pounds
3/8" lines	450 inch pounds

4) Energize both 7260-390002-1 solenoid valves with 28 vdc and check connecting lines for leakage.

5) Increase the pressure to 2400 psi at a slow enough rate so that any leak can be detected immediately as it occurs. Hold this pressure at 2400 psi for three minutes minimum while checking for leaks.

6) Increase the pressure until the 7260-390003-1 relief valve opens ($2750 {}^{+275}_{-0}$ psi).

7) Reduce pressure to zero. De-energize solenoid valves and reconnect the 7260-390002-1 solenoid valve in the accomulator circuit into the vehicle electrical system. Remove the electrical connectors from the 7260-390008 actuator servo valves.

B. Internal leaks and system tests.

1) With DC electrical power on the vehicle, increase hydraulic pressure from 1200 psi to 2400 psi in 400 psi increments. Check the readings of the accumulator 7260-390006-1 pressure gage versus a master gage. Accuracy shall be ± 80 psi.

NOTE

The main system hydraulic pressure gage should read approximately in the center of the green band at 2400 psi.

2) The EMERGENCY GIMBAL LOCK warning indicator shall extinguish before 1600 psi maximum pressure is reached. (The Emergency Gimbal Lock Reset pushbutton must be held down for the indicator to extinguish.) The following steps are required to check the back up pressure switch:

   a) Place GIMBAL LOCK switch to ON position. The green GIMBAL LOCKED MODE indicator will illuminate.
   b) Pull circuit breaker CB4, to deenergize the normal gimbal lock solenoid. This will cause the green GIMBAL LOCKED MODE indicator to extinguish and the red EMERGENCY GIMBALS LOCKED indicator to illuminate.
   c) Push circuit breaker CB4 back in, and reset the EMERGENCY GIMBALS LOCKED RESET button. This will energize the normal gimbals locked solenoid, causing the green GIMBALS LOCKED MODE indicator to illuminate, unlatch the emergency gimbals locked solenoid, causing the red EMERGENCY GIMBALS LOCKED indicator to extinguish.
   d) Place GIMBAL LOCK switch to OFF position. The green GIMBAL LOCKED MODE indicator will extinguish.

3) Place the 7260-390009-1 3-way manual valve in the CLOSED position and, after one minute, record accumulator pressure at one minute intervals for ten minutes. Plot the data on figure 2-5. The resultant curve must lie above curve (1).

4) If the natural unbalance of the servo valves has not caused the actuators to go hard-over, apply 5-ma to Pins A and C of the valves.

5) Reduce hydraulic pressure at a rate which will enable detection of the pressure at which the EMERGENCY GIMBAL LOCK indicator illuminates and the gimbals center. This pressure should be 1350 ± 50 psi and gimbal centering should be without oscillation or hunting.

(B) 6) Place the 7260-390009-1 (3-way valve) in the PRESSURISE position. Slowly increase the test stand pressure to 2400 psi.

NOTE

Do not press Emergency Gimbal Lock Reset pushbutton. The engine will remain centered. EMERGENCY GIMBAL LOCK indicator will remain illuminated.

7) Set the three-way valve to OFF (center) and reduce test stand pressure to zero.
8) Record accumulator pressure at one minute intervals for ten minutes. Plot the data on figure 2-5. The resultant curve must lie above curve (2).
9) Set the 7260-390009-1 manual valve in the accumulator circuit to DUMP.
10) Disconnect the hydraulic test stand and remove electrical power from the vehicle. Replace the electrical connectors to the main system solenoid valve and the actuator servo valves.
11) Open the 7260-390001-1 manual valve in the reservoir return line.

2-52 ACCUMULATOR CHARGING AND SYSTEM FILL

A. Remove cap from charging valve on accumulator.
B. Connect a regulated source of dry, filtered nitrogen to the accumulator charging valve and open the charging valve.
C. Slowly increase nitrogen pressure to accumulator until pressure stabilizes at 1200 $\pm$ 50 psig.
D. Close charging valve, reduce source pressure, vent hose, and disconnect hose from charging valve.

E. Cap valve.

F. Fill hydraulic system reservoir on turbofan engine to FULL indication in sight glass.

G. Check that manual shutoff valve is safety wired in it OPEN position.

WARNING

If the manual shutoff valve is not opened, the engine gimballing system will not operate, creating an operational hazard.

2-53 TURBOFAN ENGINE OIL SERVICING - The turbofan engine is provided with an integral pressure oil system. This system supplies oil under pressure for lubrication of gears, accessory drives, and bearings located throughout the engine. The engine oil tank is located on the left side of the engine when viewing the LLTV from the rear, and is supplied with a 25 micron filter. The following steps are for servicing the system by adding or changing the oil.

A. Check the oil level in the tank within 10 minutes after engine shutdown.

NOTE

While the engine is inoperative, oil seeps from the tank into the gear box and may give a false indication of a low oil supply if the level is checked after the engine has been inoperative for a length of time. If a preflight inspection receals that the oil level in tank is low, motor engine for 30 seconds and recheck oil level.

Accumulator Pressure Decay

Curves are based on maximum component leakage rates specified on blueprint. For normal operating conditions, record accumulator pressure at one minute intervals for 10 minutes. Plot the first data point at the appropriate pressure on Curve 1. Define this point at time zero, plot the remaining data. The resultant "faired" curve must lie above Curve 1. For emergency "hydraulic failure" conditions, plot pressures as in previous procedure but use Curve 2. The resultant "faired" curve must lie above Curve 2.

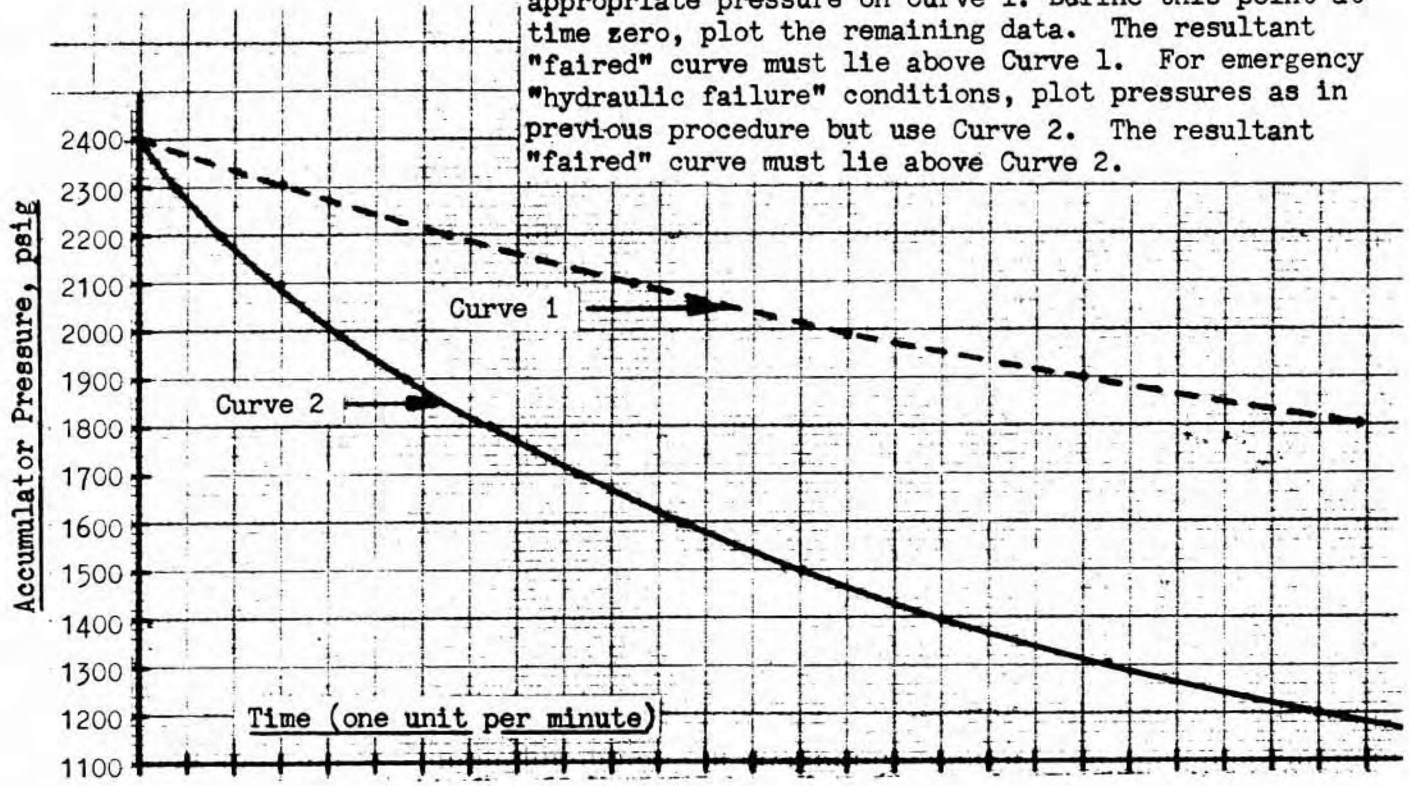


Figure 2-5. Accumulator Pressure Decay

CAUTION

Contact with MIL-L-7808 oil can cause skin irritation. Skin should be washed thoroughly after contact. All areas in which jet engine oil is used should be well ventilated.

B. Add MIL-L-7808 oil as required.

NOTE

Do not mix oils, and oil should be passed through a 25 micron filter prior to using it.

C. When checking oil level, remove the oil tank filter cap.

D. Check oil level on dip stick (Refer to I/A/W GE Memo, dated 24 Oct 1968.) and add MIL-L-7808 oil to bring oil level to full mark.

2-54 CHANGING OIL

A. Remove the oil tank filter cap.

B. Remove the drain plugs from the oil tank, accessory gear box, and transfer grear box.

NOTE

Catch the draining oil in a suitable container.

C. Remove and clean the oil filter.

D. Examine the magnetic drain plugs for metal particles.

CAUTION

If metallic particles are present, perform the procedure in paragraph 2-55 before proceeding.

E. Remove and discard the O-rings and clean the drain plugs with an approved solvent such as trichloroethane or kerosene.

F. Install new O-rings on the drain plugs and filter, and replace plugs and filter.

G. Fill the oil tank with oil MIL-L-7808 to the full mark.

NOTE

Engine will require additional oil, after first engine run, to bring the oil to full mark on the dipstick.

2-55 METALLIC PARTICLE CHECK

CAUTION

Due to the close tolerance to which the engine is manufactured, metallic chips in the lubrication system can be a serious problem. Since each incident has peculiar circumstances, caution and good judgement must be exercised prior to operating the engine.

A. Determine whether the particles are magnetic or non-magnetic and whether the lube filter is clogged

B. Check to see if the particles are non-magnetic and bronze in color. If so, suspect a bearing failure.

C. Check the rotor for smooth operation and try to determine source of particles prior to engine operation.

D. If the particles are only a few in number and are not bronze in color, whether magnetic or non-magnetic and have the appearance of a curl (machine chip) or lockwire chip, immediately suspect foreign nontamination. Start and operate the engine for a period of 15 minutes at idle power setting.

E. Shut the engine down normally and drain the lubrication system in accordance with paragraph 2-54.

F. Examine the filter and drain plugs for metallic particles. If none are present, continue with the oil change procedure of paragraph 2-54. If metallic particles are present, locate the faulty component and replace and refill the oil system. If the faulty component cannot be identified, replace the engine.

2-56 ELECTRICAL AND PNEUMATIC TEST CART - The Electrical and Pneumatic test cart, P/N 7260-710001, is used for functional testing of the LLTV Rocket system and can be used for servicing the vehicle Helium supply prior to vehicle rocket system operations. The cart has the capability of filtering and regulating an inlet gas supply of 0-4500 psig to provide the individual regulated pressurization of the LLTV Helium system and both H_2O_2 tanks. Using a 28 vdc supply to the cart and the four electrical cables mounted inside the cart, individual control of the 16 attitude rocket solenoid valves is provided by connecting the electrical cables to the appropriate electrical connector mounted on the 90 pound rocket cluster assembly, actuating the E/P cart circuit breaker and actuating the individual panel switches on the cart's control panel. See figure 2-6 for Test Cart Pneumatic schematic.

2-57 <u>E/P CART OPERATIONS METHOD FOR HELIUM SERVICING OF LLTV HELIUM SUPPLY TANKS</u>. The preliminary checkout procedure and servicing is as follows:

A. Check that both Helium tank and H_2O_2 tank regulators are backed off fully counterclockwise.

B. Close the inlet source valve.

C. Close the Helium tank supply valve.

D. Close the common H_2O_2 tank supply valve.

E. Close both H_2O_2 tank vent valves.

G. Open the Helium tank vent valve.

H. Remove the Helium outlet port cap and attach the Helium supply line. Attach the supply service manifold to the line and close the manifold hand valve. Attach Kellum Safety grip to cart hook.

<u>CAUTION</u>

Do not attach manifold to vehicle service port.

I. Install the helium source supply line to the E/P cart inlet Port A and attach the Kellum safety grip to the cart hook, then attach supply line and Kellum safety grip to service truck helium supply.

J. Apply pressure to source line (4500 psig max) using servicing truck valves.

<u>NOTE</u>

Check connection for tightness if leakage is observed.

K. OPEN THE INLET SOURCE VALVE AND NOTE SOURCE PRESSURE GAGE READING NOT GREATER THAN 45 PSIG.

L. Open the Helium system service valve to apply pressure to Helium regulator.

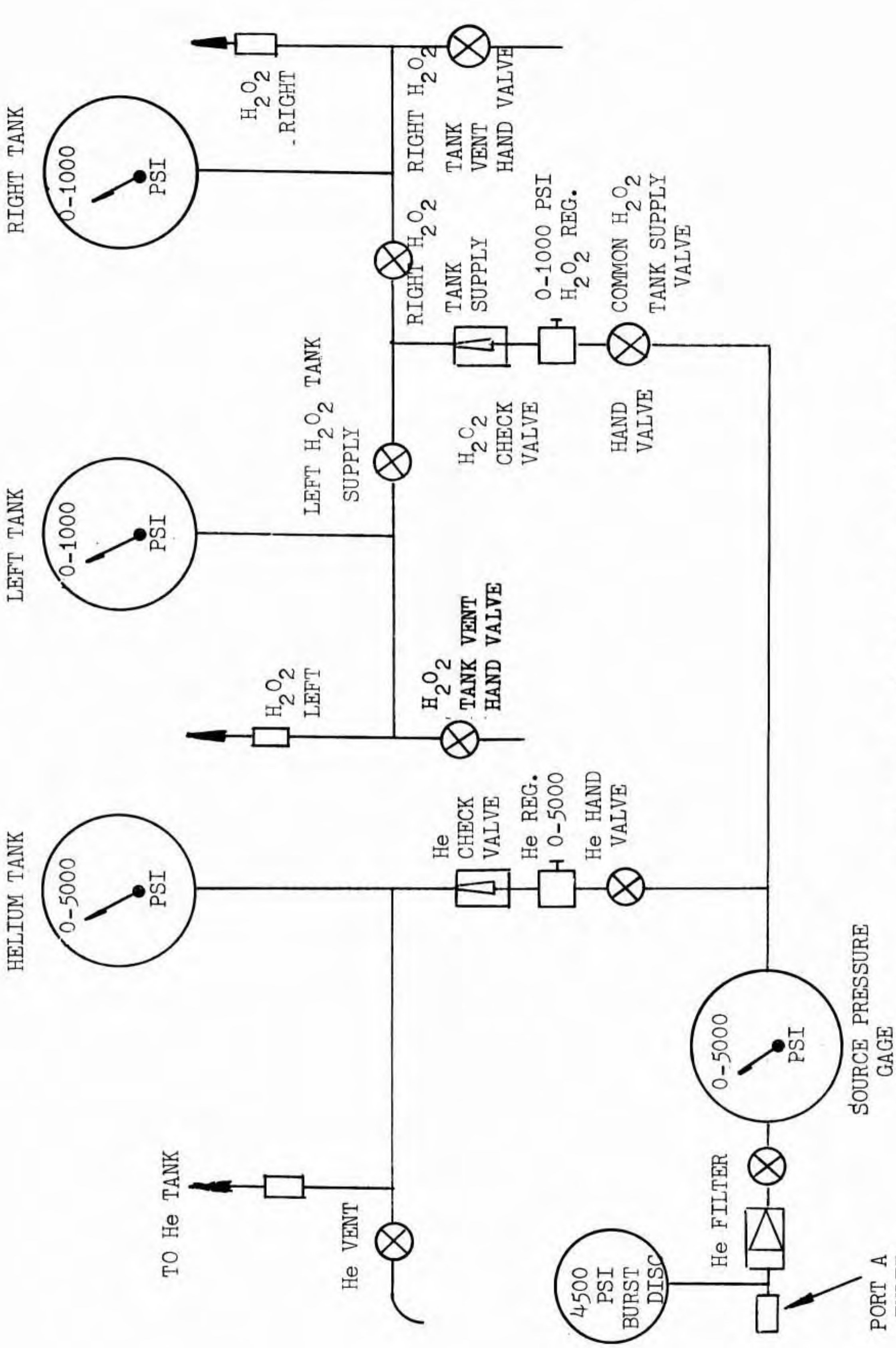


Figure 2-6. E/P Test Cart Pnuematic Schematic

(2-57) M. Slowly open the regulator valve and note audible gas flow from Helium vent, then close vent valve.

N. Continue pressurization of the vehicle service line and E/P Cart system to 4500 psig.

CAUTION

Note that the regulator controls the pressure indicated on the Helium tank gage and check system when pressurized for leakage by shutting off inlet source valve and noting pressure decay. Note that the helium regulator has a built in relief valve which may cause pressure loss. Repair leaks immediately; if repair is not practical and leakage is minimal and not a hazard to operations, repair at a more practical time.

O. Open the servicing manifold hand valve slowly and purge the service lines prior to attaching to the Helium tank schraeder valves; then close manifold hand valve and attach the manifold to the tanks.

P. Back out the regulator and vent any pressure from the cart system.

Q. Check that the vehicle Helium manual shutoff valves are closed and schraeder valves on Helium tanks are open.

R. Open the inlet source valve closed in step N.

S. Service the Helium tanks to the desired pressure using the regulator.

T. When pressurization is complete, close the Helium tank servicing schraeder valves.

U. Close the source valve on the supply truck.

V. Back out regulator to zero.

W. Disconnect and store the Helium servicing line and manifold if not needed for continuation of tests, or topping off Helium tank pressures, cap and plug open ports.

X. Shut off helium source supply valve on truck.

Y. Carefully disconnect helium supply line from the source truck and allow pressure to relieve from the loosened fitting the cap and plug the opened ports.

Z. Disconnect the helium supply line from the E/P Cart. Cap and plug the open ports and close the E/P Cart inlet source valve.

2-58 E/P CART H2O2 TANK PRESSURIZATION.- The preliminary checkout procedure and servicing is as follows:

A. Check that both Helium tank and H_2O_2 tank regulators are backed off fully counterclockwise.

B. Close the inlet source valve.

C. Close the Helium tank supply valve.

D. Close the common H_2O_2 tank supply valve.

E. Open both H_2O_2 tank supply valves.

F. Open both H_2O_2 tank vent valves on E/P Cart.

G. Close the Helium tank vent valve.

H. Remove the H_2O_2 tank port caps and install the H_2O_2 tank service lines as necessary.

I. Install the helium source supply line to the E/P cart inlet.

J. Apply pressure to source line (4500 psig max) using servicing truck valves.

NOTE

Check connections for tightness if leakage is observed.

K. OPEN THE INLET SOURCE VALVE AND NOTE SOURCE PRESSURE GAGE READING NOT GREATER THAN 4500 psig.

L. Open the common H_2O_2 tank supply hand valve.

M. Open the H_2O_2 tank cart vent valve.

N. Open the LH/RH tank H_2O_2 supply valves and increase the regulator setting to purge the cart; then close the vents.

O. Increase pressure on the plugged service lines to 600 psi and check for obvious fitting leakage; tighten as necessary any fitting. Shut off inlet source valve and observe any unusual pressure loss.

CAUTION

Note that the regulator has a built in relief system and may be venting. Repair the leakage immediately. If the repair is not practical and leakage is minimal and not a hazard to operations, repair at a more practical time.

P. With the inlet source valve shut off, vent the system by backing off the regulator to zero psi indicated on the H_2O_2 tank gages.

Q. Open the inlet source valve.

R. Remove the service line plugs. Using the regulator, purge the lines prior to installation on the H_2O_2 tank manual vent valve outlet port, or other fitting if so directed.

S. Open the vehicle H_2O_2 tank manual vent valves.

T. Pressurize the H_2O_2 tanks as necessary for tests using the regulators.

U. When pressurization work is complete, back out regulator to zero psig and open the LH and RH H_2O_2 tank vent valves on cart.

V. Close the Helium supply truck shut off valves.

W. Carefully disconnect the Helium supply line allowing pressure to relieve through the fitting. Then cap and plug the opened ports.

X. Disconnect and store the helium supply line from the E/P Cart.

Y. Close the E/P Cart inlet source valve.

Z. Disconnect the H_2O_2 tank service lines. Cap and plug open ports and store the lines in the E/P Cart.

2-59. HELIUM AND NITROGEN GAS SERVICE TRUCK - The helium and nitrogen gas service truck (figure 2-7) is a standard make, flat-bed truck with two storage racks that contain helium and nitrogen bottles. Each storage rack has a control panel (figure 2-8) containing pressure gages shutoff valves, and pressure regulators required for helium and nitrogen

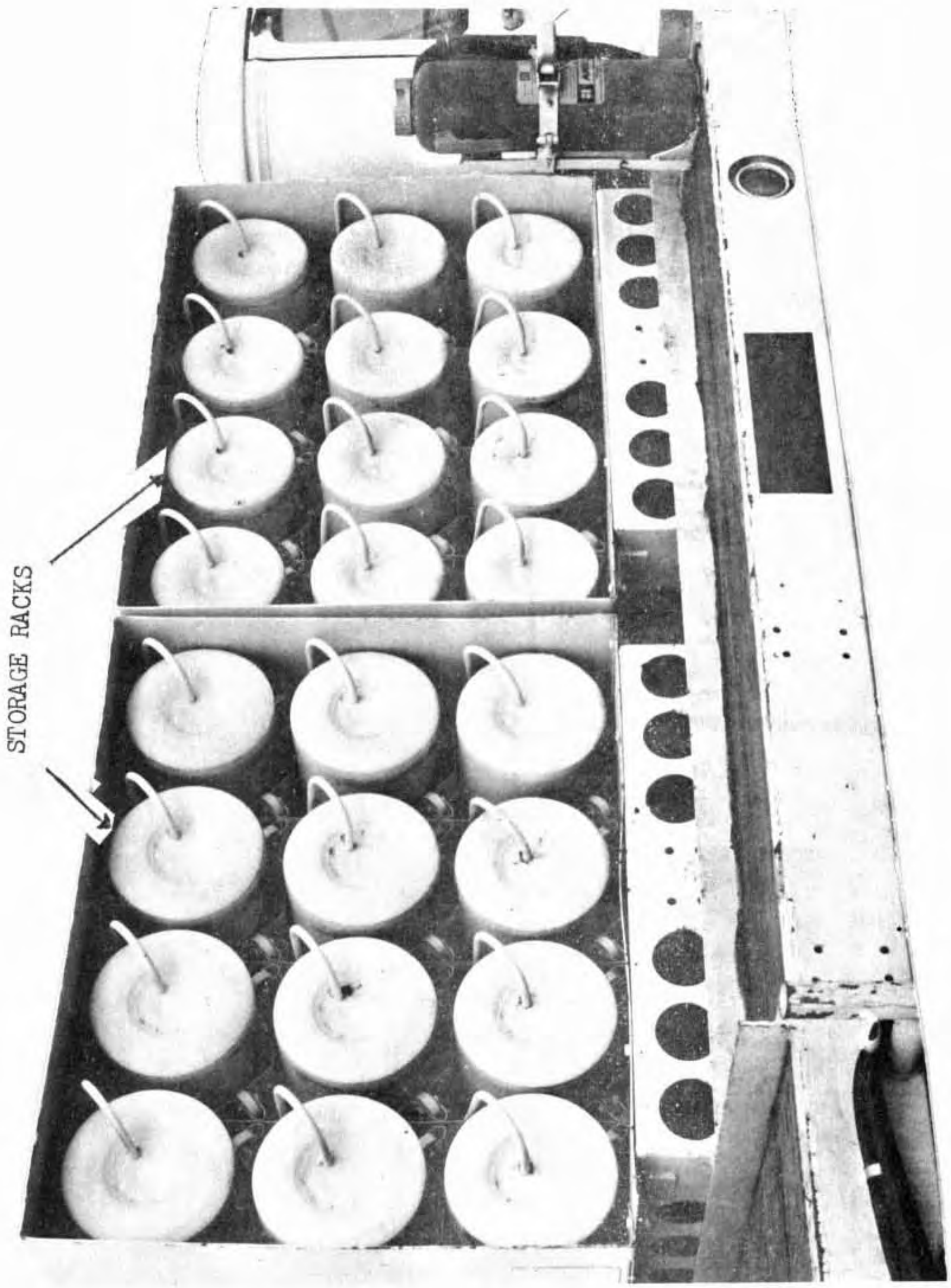


Figure 2-7. Helium and Nitrogen Gas Service Truck

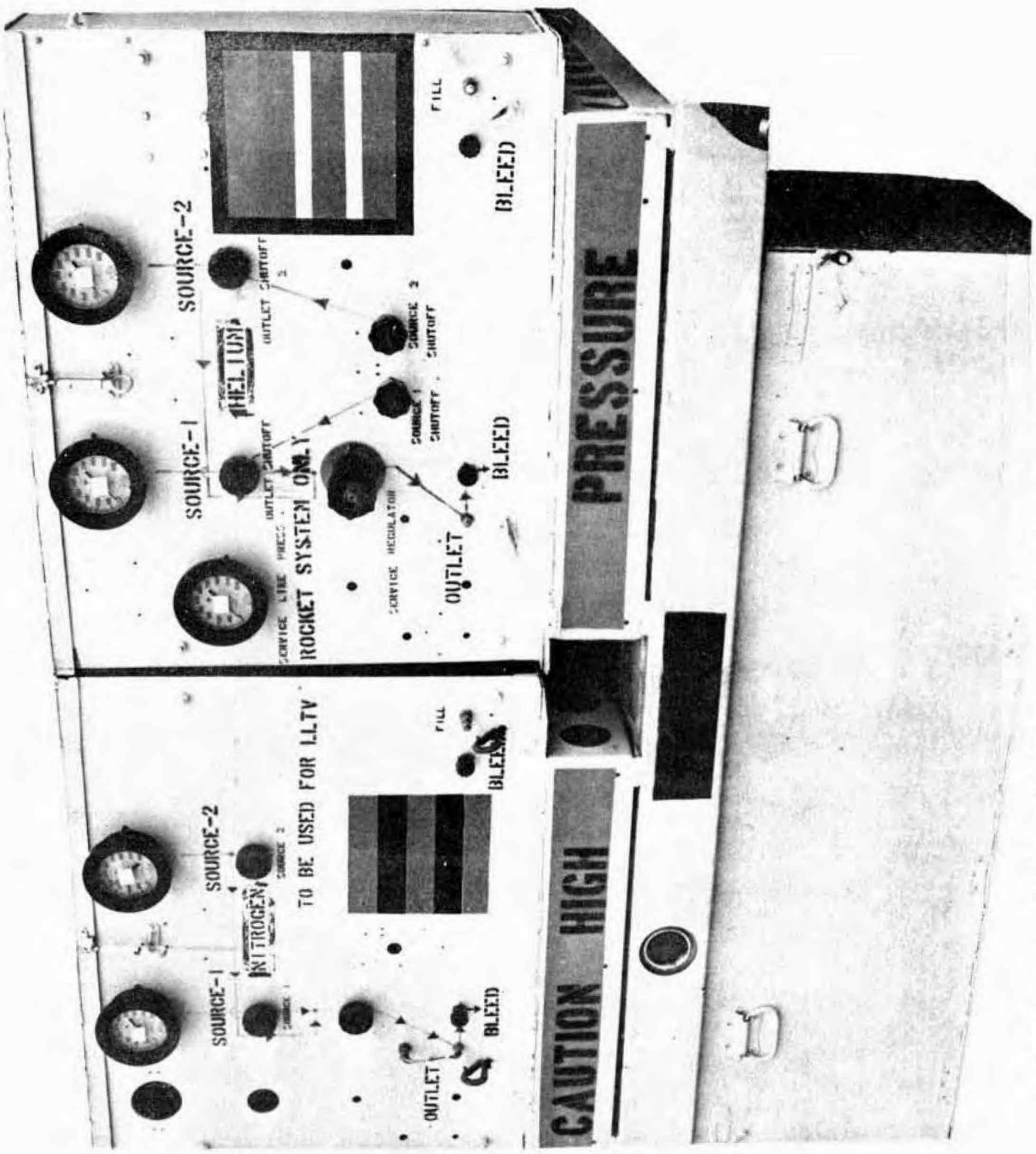


Figure 2-8. Helium and Nitrogen Gas Service Truck Control Panel

servicing the LLTV. The service truck also has two independent 28 volt dc generators driven by a gasoline engine to supply electric power to the LLTV. Operating procedures for the service truck are contained in NASA Operating Procedures, MSC-12-C, D, and E.

2-60 <u>ACCUMULATOR PRESSURE CART</u> - The accumulator pressure cart (figure 2-9) is a two-wheel, portable rack with a nitrogen bottle. It also contains a pressure gage, pressure regulator, and a shutoff valve, and is used to supply a pre-charge to the hydraulic accumulator on the LLTV. Procedures for operation of cart for accumulator use are contained in Accumulator Pressure Cart Operating Procedure MSC-12-G.

2-61 <u>LANDING GEAR SHOCK STRUTS PRESSURE CART</u> - The landing gear shock struts pressure cart (figure 2-9) is the same cart that is used for the accumulator. Operating procedures for servicing the shock struts are contained in Landing Gear Pressure Cart Operational Procedure MSC-12-J.

2-62 <u>PILOT'S OXYGEN CART</u> - The pilot's oxygen cart (figure 2-10) is a portable, wheel mounted, rack containing two oxygen bottles. The cart is equipped with pressure gages and shutoff valves for servicing the pilot's oxygen bottle on the LLTV. Procedures for operating the oxygen cart are contained in the Pilot's Breathing Oxygen Cart Operational Procedure MSC-12-F.

2-63 <u>LUBRICATION</u> - The only lubrication required is as follows:

A. Use Florolube LG-160 (grease) on new H_20_2 service fittings to prevent galled threads.

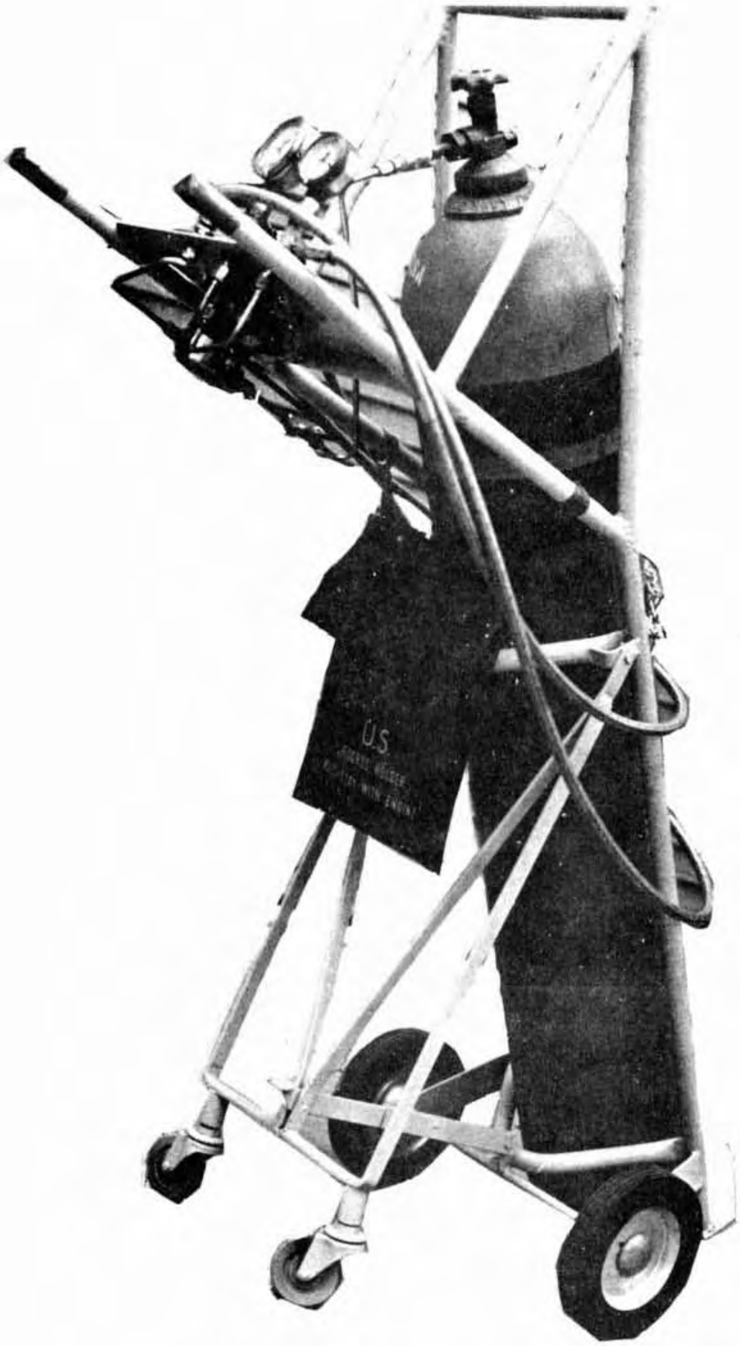


Figure 2-9. Nitrogen Pressure Cart

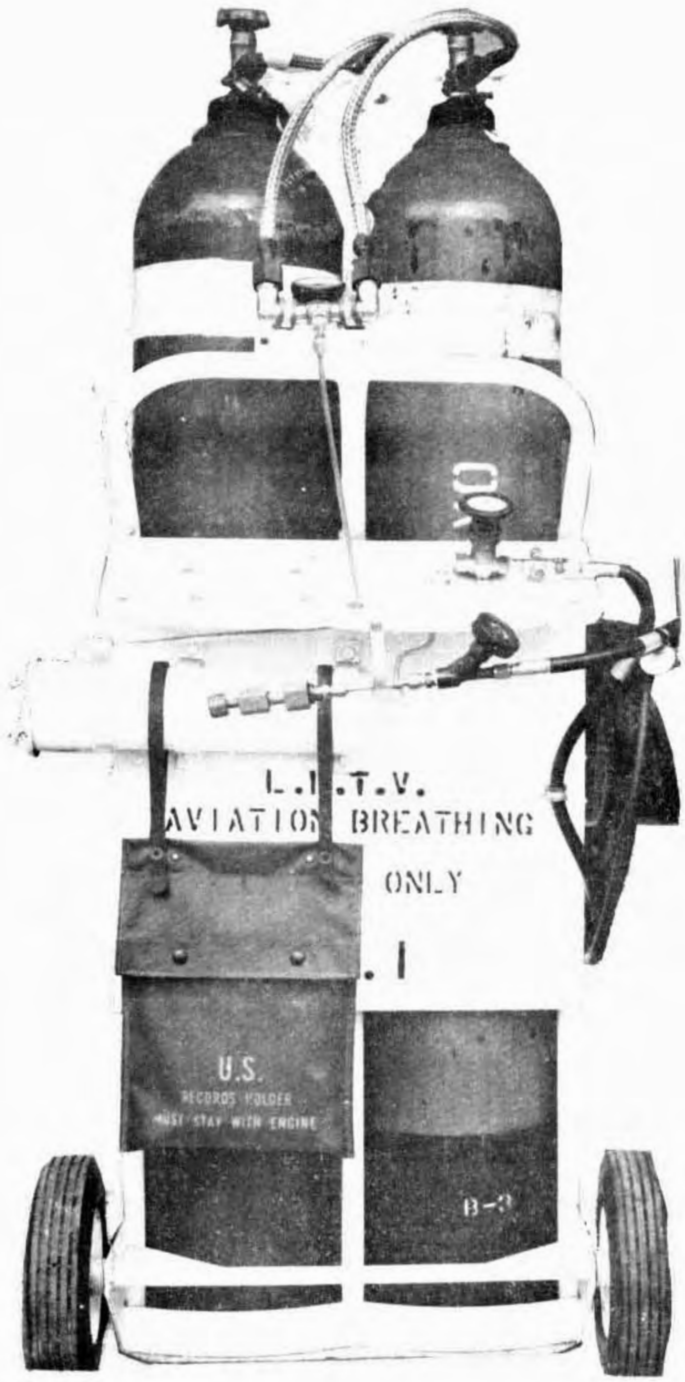


Figure 2-10. Pilot's Oxygen Cart

SECTION III

SECTION III

VEHICLE PREPARATION FOR SHIPPING

3-1. GENERAL

3-2. This section contains the necessary instructions to prepare the vehicle for shipping, removing LLTV components from their shipping containers and to assemble them at their destination. Instructions also include the steps necessary to ship the LLTV, fully assembled, by air.

3-3. LLTV REMOVAL FROM SHIPPING SKID - The shipping skid has been fabricated to provide support and protection for the center body, turbofan jet engine, and pilot's compartment, as a single unit, during transportation. Proceed as follows for the removal sequence.

NOTE

Retain the shipping skid for future shipping requirements.

3-4. LLTV ASSEMBLY

NOTE

Assembly of the LLTV requires use of an overhead hoisting device with a minimum capacity of two tons.

CAUTION

Ladders or maintenance stands shall be used during all erection procedures. The aluminum tubing construction of the LLTV will not support the weight of service personnel.

A. Remove the covers from the LLTV structure and release all points of attachment to the skid.

B. Attach the LLTV hoist sling to the terminals at the four upper corners of the center body.

CAUTION

Do not raise the LLTV at this time.

C. Check that cable assemblies between the diagonally opposite upper corners of the center body structure are in place and properly torqued.

D. Carefully raise the structure from the skid to a height of approximately eight feet.

E. Remove the skipping skid.

3-5. LEG INSTALLATION AFTER UNPACKING - Unpack the four leg and landing gear strut assemblies, and attach each leg to the center body according to the following procedures and Bell Drawings No. 7260-155001 and 7260-155002. For leg maintenance, or removal/installation after the vehicle is fully assembled, refer to Section IV, paragraph 4-26.

A. Align the three longeron attachment clevis fittings below tangs at one upper corner of the center body structure and two hard points on main support ring. Raise leg assembly into position to engage clevises with tangs.

B. Install bolt, washer, and nut through clevises and tangs and tighten finger tight.

C. Position the tube assemblies so the bolt holes are aligned and secure in place with original hardware.

D. Tighten all attachment hardware, and torque to 35 inch pounds.

E. Repeat steps A through D for installation of the remaining three legs.

F. Lower the LLTV until entire vehicle weight is supported on landing gear shock strut pads.

G. Install external power receptacle on right rear landing leg and secure cable to leg.

H. Engage electrical connectors at each leg.

I. Service shock struts.

CAUTION

Do not remove LLTV hoist sling until leg installation is completed.

3-6. AFT EQUIPMENT PLATFORM INSTALLATION - The aft equipment platform is adjustable according to balance requirements. Consult the NASA Weight and Balance engineer to determine the exact points of attachment to the vehicle structure and proceed as follows:

A. Remove the aft equipment platform from its shipping container.

B. Align the platform attachment flanges with the appropriate set of mounting holes in the vehicle structure and secure with bolts, washers, and nuts.

CAUTION

Support the aft equipment platform to prevent strains at the attachment points, until all bolts are in place, and the diagonal braces installed.

C. Loosely attach the diagonal braces to the upper corners of the forward equipment structure with bolts and washers through the single hole in braces.

D. Select hole in the aft end of diagonal braces, checking that platform position is perpendicular to the vertical H beams. Then select the appropriate holes in the other end of the diagonal braces and align them with the holes in the ends of the aft equipment platform tubular beam. Attach with bolts and washers.

E. Tighten all mounting hardware and torque to 55 inch pounds.

3-7. ROCKET SYSTEM INSTALLATION - Installation of the lift and attitude control rocket system is described in the following paragraphs. Use one or two drops of Fluorolube LG-160 (Hooker Electrochemical Company, Niagara Falls, New York) on piping connections. Be certain of exact torque values required for mounting hardware and fittings.

3-8. H_2O_2 TANK INSTALLATION - Refer to paragraph 7-22 for the left and right H_2O_2 tank installation.

3-9. HELIUM TANK INSTALLATION - Refer to paragraph 7-23 for installing the two helium pressure tanks.

3-10. ROCKET SYSTEM PIPING INSTALLATION - The rocket system piping is installed in accordance with Bell Aerosystems Company Drawings No. 7260-460001 and 7260-460002, and 7260-460003. Prior to the piping installation, conditioned valves should be installed. The entire system should then be leak checked and conditioned for H_2O_2.

WARNING

Do not remove any caps on fittings, until they are to be connected, to avoid contaminating the H_2O_2 system. Wear protective clothing and have water floods available at all times after H_2O_2 has been introduced into the system.

3-11. LIFT ROCKET INSTALLATION - The two lift rockets are installed on brackets attached to the main structural ring of the center body. The rocket engines are sealed in individual transparent bags to prevent contamination. Use extreme care to avoid contaminating the rocket engines with oil, dust, dirt, or foreign particles during installation. Apply one or two drops of Fluorolube LG-160 (Hooker Electrochemical Company, Niagara Falls, New York) to the male threads of all fittings to facilitate assembly. Maintain caps on all fittings until just prior to connection to prevent contamination of rocket engines and piping. Refer to paragraph 7-24 for installation procedures.

3-12. ATTITUDE CONTROL ROCKET INSTALLATION - Refer to paragraph 7-26 for installation procedures. The attitude control units are attached to the main structure. Each cluster of four attitude control rockets is installed according to the procedures listed in 7-26. Maintain caps on all fittings until just prior to connection to prevent contamination of piping and valving. Apply two drops of Fluorolube LG-160 to the male threads of all fittings to aid in assembly. All attitude control rocket clusters are identical.

3-13. JP4 TANK INSTALLATION - Refer to paragraph 6-66 for JP4 tank installation.

3-14. LANDING STRUT INSTALLATION - The landing struts, as shipped, are installed on the legs. The following procedure is for installing the strut on the leg.

A. Align the lower end of the strut with the centering guide in bracket and insert strut through guide.

B. Secure strut to clevis on landing leg with bolt, washer, nut, and cotter pin.

C. Install pad on strut and secure with bolt, washer, nut, and cotter pin.

D. Connect microswitch leads.

3-15. TURBOFAN JET ENGINE REPLACEMENT

3-16. The LLTV is shipped with the turbofan jet engine installed. Refer to Section VI for jet engine removal and installation procedures.

3-17. LLTV DISASSEMBLY - Disassembly of the LLTV is the reverse of assembly. (Refer to paragraph 3-4).

3-18. LEG REMOVAL - Removal of the leg is the reverse of installation. (Refer to paragraph 3-5 .)

NOTE

Removal of front legs requires removal of several rocket system propellent lines.

3-19. AFT EQUIPMENT PLATFORM REMOVAL - Removal of the aft equipment platform is the reverse of installation. (Refer to paragraph 3-6.)

3-20. H_2O_2 TANK REMOVAL - Removal of the H_2O_2 tanks is the reverse of installation. (Refer to paragraph 3-8.)

3-21. HELIUM TANK REMOVAL - Removal of the helium tank is the reverse of installation. (Refer to paragraph 3-9.)

3-22. ROCKET SYSTEM PIPING REMOVAL - Removal of the rocket system piping is the reverse of installation. (Refer to paragraph 3-10.)

3-23. LIFT ROCKET REMOVAL - Removal of the lift rockets is the reverse of installation. (Refer to paragraph 3-11.)

3-24. ATTITUDE CONTROL ROCKET REMOVAL - Removal of the attitude control rockets is the reverse of installation. (Refer to paragraph 3-12.)

3-25. <u>JP4 TANK REMOVAL</u> - Refer to paragraph 6-36 for removal of the JP4 tanks.

3-26. <u>LANDING STRUT REMOVAL</u> - Removal of the landing strut is the reverse of installation. (Refer to paragraph 3-14.)

3-27. <u>TRANSPORTING LLTV BY AIR</u>

3-28. The vehicle can be transported, fully assembled (except removal of the aft equipment platform electronic boxes), in a Super Guppy transport plane. Figure 3-1 shows the vehicle ready for air shipment, except for its plastic cover.

3-29. <u>PREPARING VEHICLE</u> - The vehicle shall be prepared for air transportation by performing the following steps:

WARNING

> Ensure that all tanks (JP4, H_2O_2, and Helium) and lines are empty, before preparing vehicle for shipment.

A. Remove all electronic boxes from the aft equipment platform and place each electronic box into a shipping container.

NOTE

> The only boxes and equipment not removed are the Doppler antenna, circuit breaker box, and all cables.

B. Place plastic bag over each cable connector throughout the vehicle and secure plastic bag with cord or rubber band. (See figure 3-2.)

C. Tie cables together, when possible, then tie cable bundle to nearest strut or crossbar.

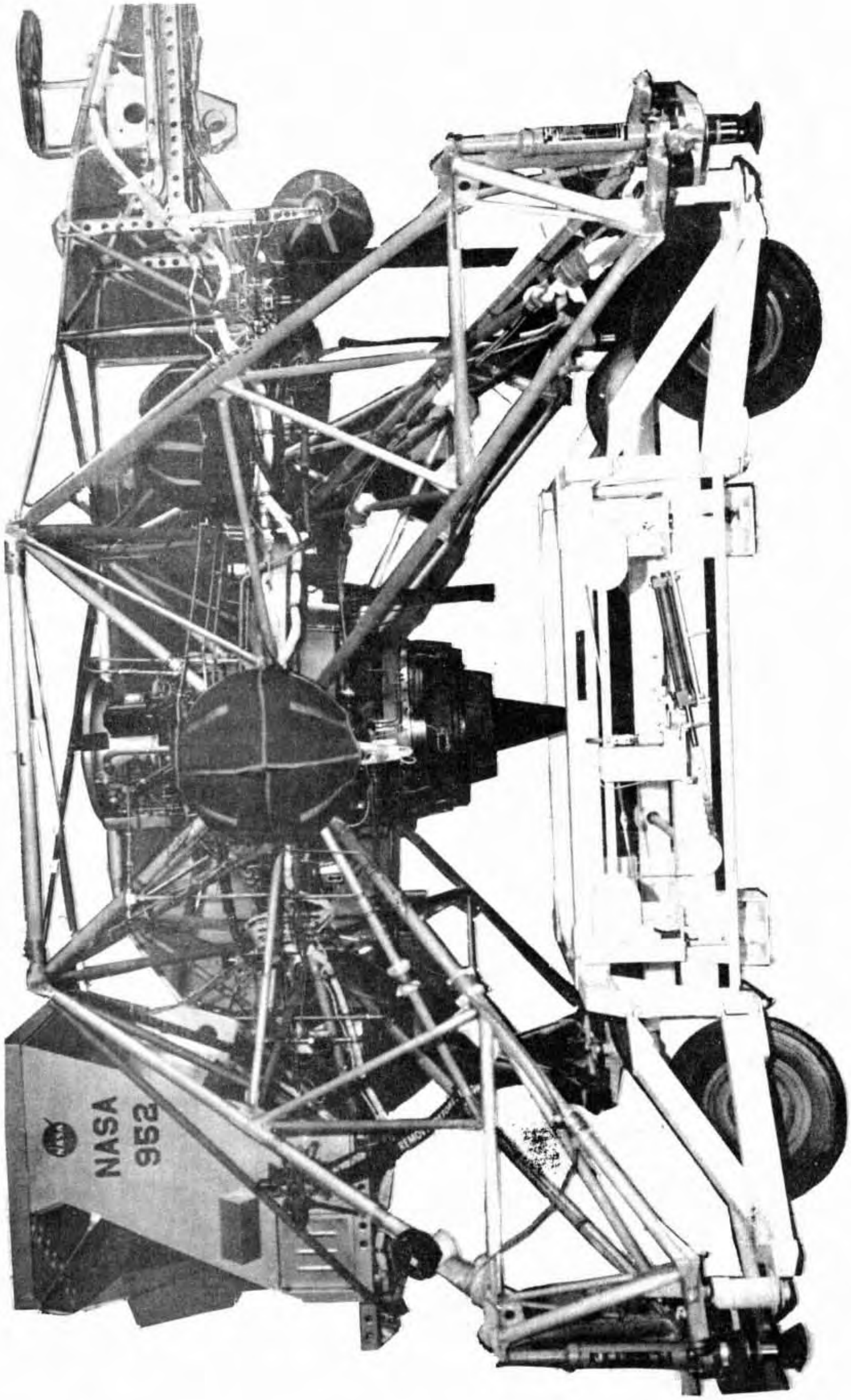


Figure 3-1. Vehicle Ready for Air Shipment

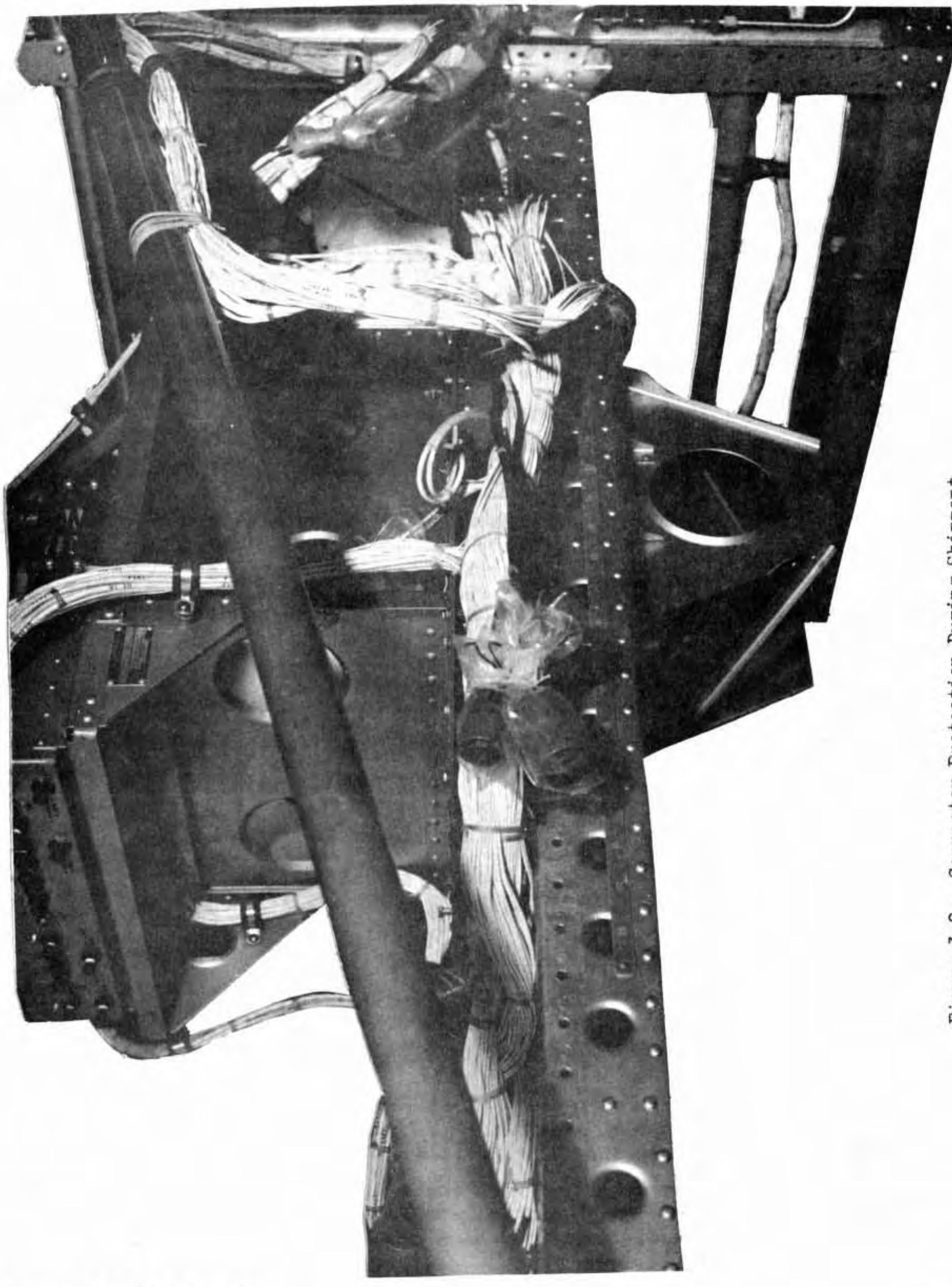


Figure 3-2. Connector Protection During Shipment

D. Tie all equipment platform cables into one bundle and secure to bottom of equipment platform with tape. (See figure 3-2)

E. Tape ground cable to right rear leg of vehicle.

F. Completely cover H_2O_2 tanks with padded protective covers. (See figure 3-3).

NOTE

The padded cover for each tank is made up of several pieces, to simplify fitting around brackets, pipe lines, and other obstacles. A velcron border on each piece simplifies installation.

G. Completely cover helium tanks with padded, protective covers. (See figure 3-4).

H. Cover only the top half of each JP4 tank with padded, protective cover. (See figure 3-1 and 3-5).

I. Plug exhaust nozzles of all attitude rocket clusters with special plugs, if available, or with plastic bags, or aluminum foil.

J. Place aluminum foil over the exhaust nozzle of both lift rocket engines and secure aluminum foil with rubber band.

3-30. LOADING VEHICLE ON SPECIAL PLATFORM - The following steps are required to load vehicle on the special platform:

A. Move vehicle on transporter to a clear area of ramp.

B. Extend each shock strut by servicing with nitrogen to 150 psi.

C. Remove U-clamps that secure vehicle strut to transporter cradle; one from each leg of vehicle. (See figure 3-6).

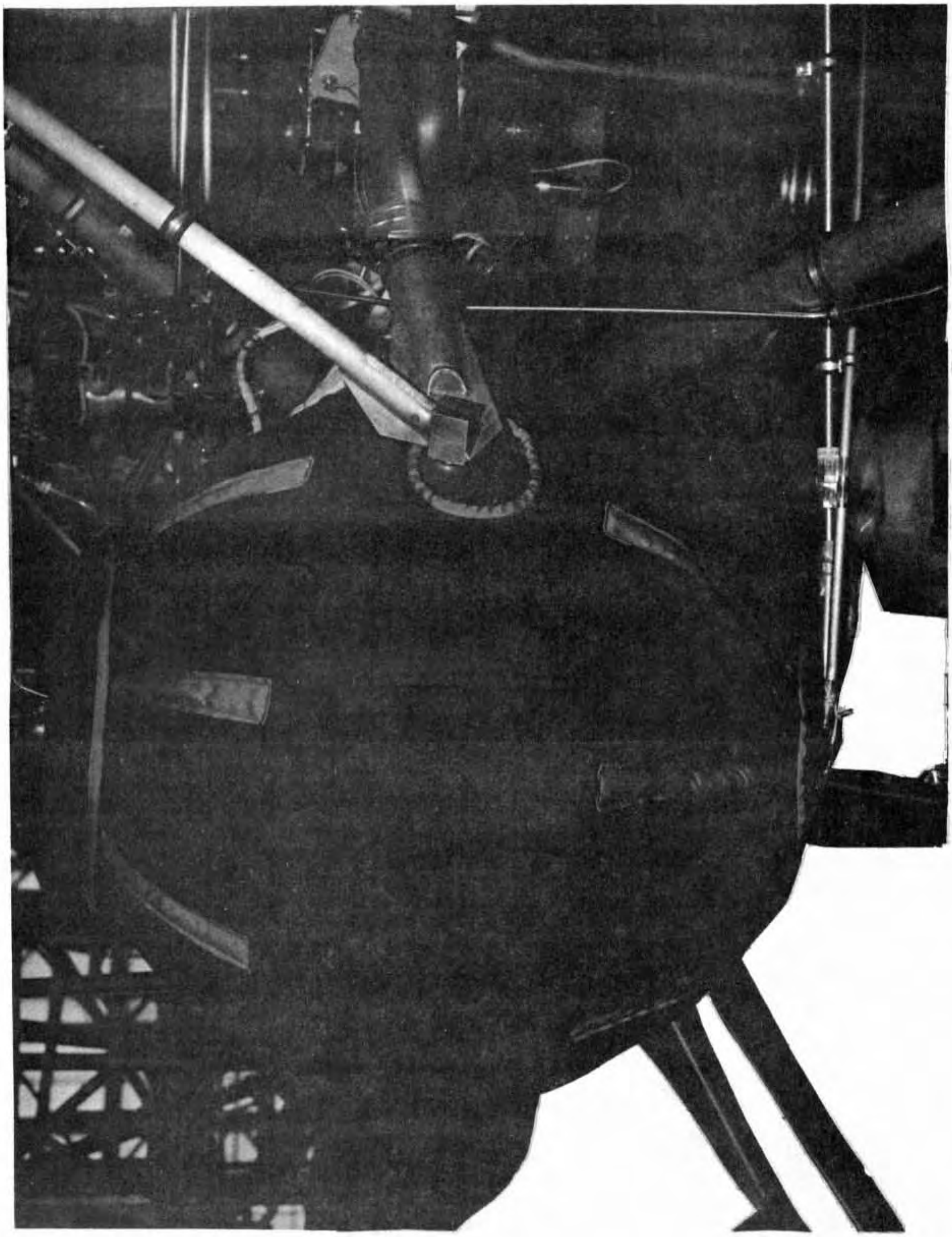


Figure 3-3. H_2O_2 Tank Completely Covered

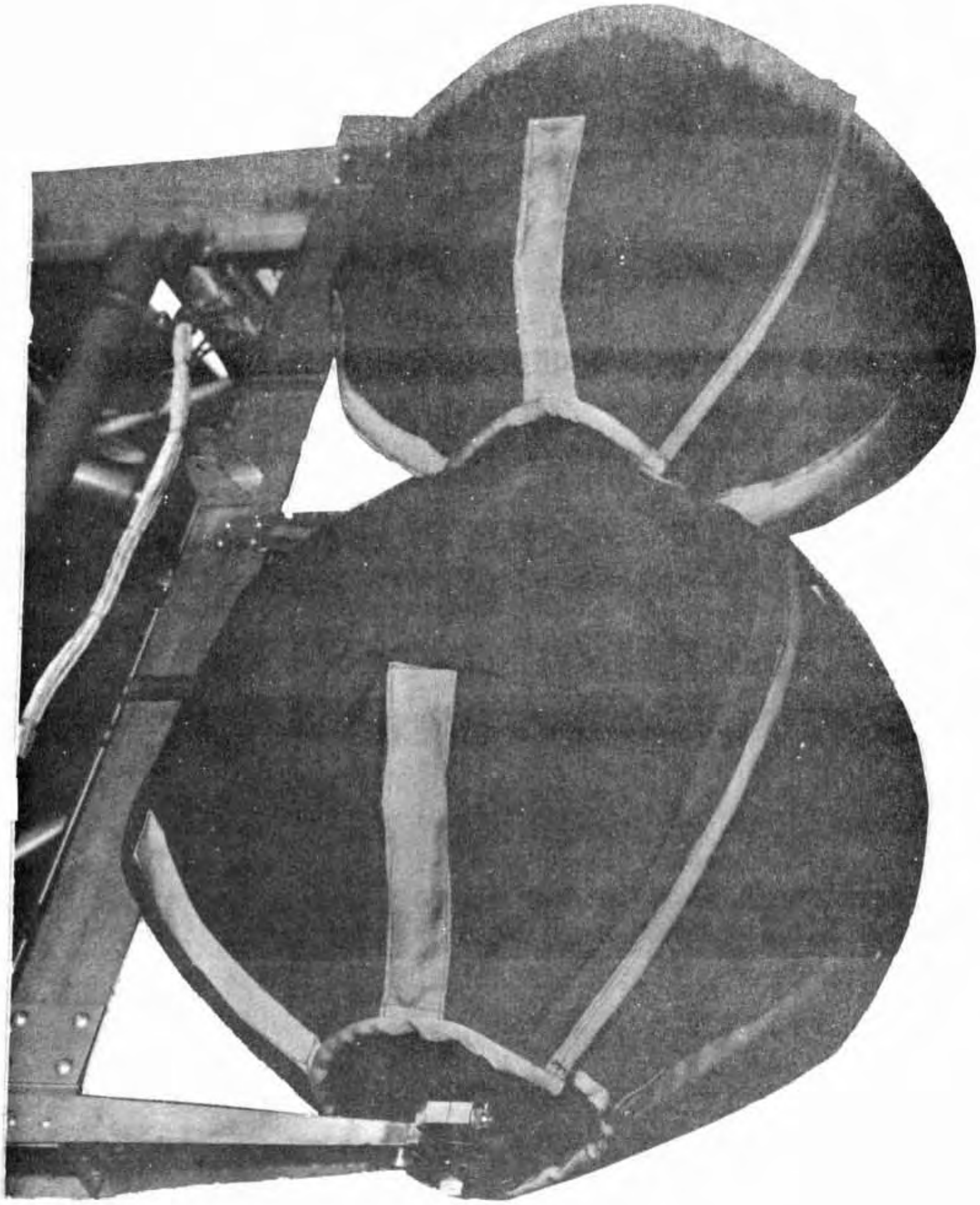


Figure 3-4. Helium Tanks Completely Covered

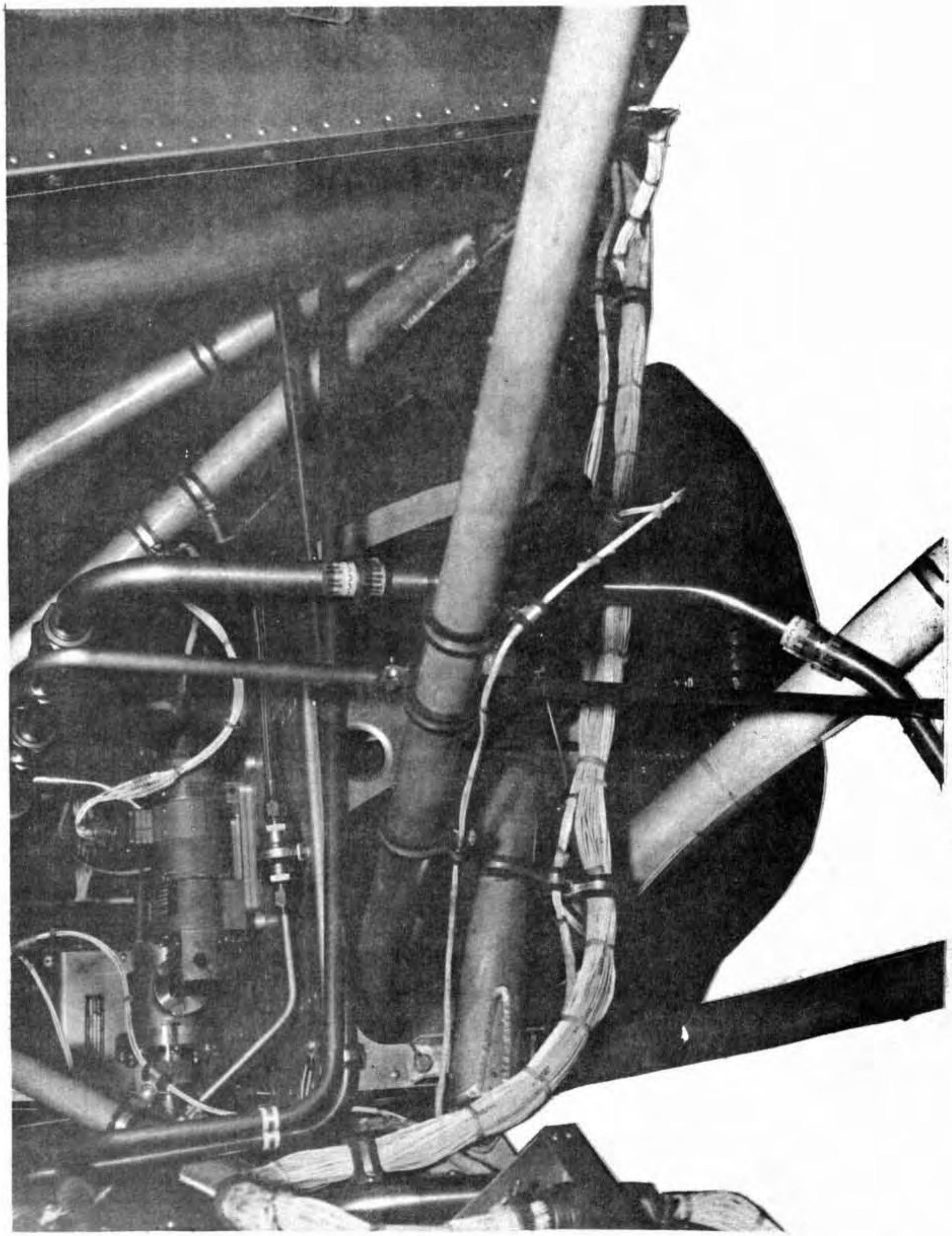


Figure 3-5. JP-4 Tank Padded for Air Shipment

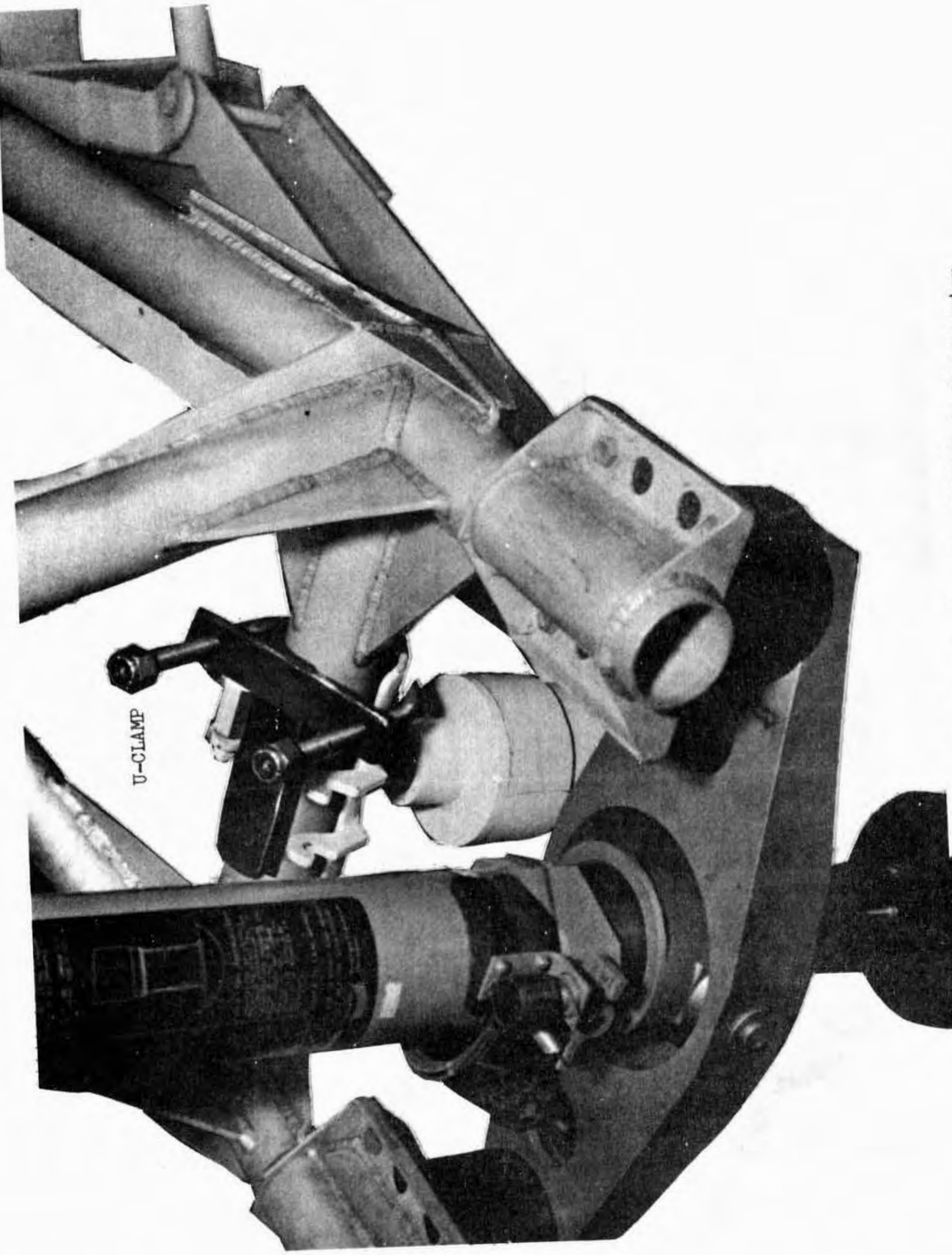


Figure 3-6. U-clamp Securing Vehicle to Transporter

D. Lower transporter until clear of vehicle, then pull transporter from under vehicle to a clear area.

E. Fold transporter cradle arms against transporter body and secure in position with pins.

F. Lift towing handle to its maximum upright position and secure with rope to transporter frame.

G. Load special platform (made to fit into Super Guppy transport plane) onto trailer bed.

NOTE

Trailer is a special type that can raise its bed to the height required for loading into transport plane.

H. Load special jig onto platform on trailer and secure with chains. (See figure 3-7.) This jig raises vehicle to clear bottom of cargo area.

I. Attach wire rope to transporter axles to form a sling and hoist transporter onto jig and secure with chains. (See figure 3-8.)

CAUTION

Attach guide lines to transporter axles to guide transporter during hoist.

J. Attach horizontal hoist sling to crane hook and hoist over center of vehicle.

K. Lower horizontal hoist sling until the four vehicle lift points (one on each corner of vehicle upper frame) can be attached to the cables of horizontal hoist sling. Secure with four AN5 bolts and nuts.

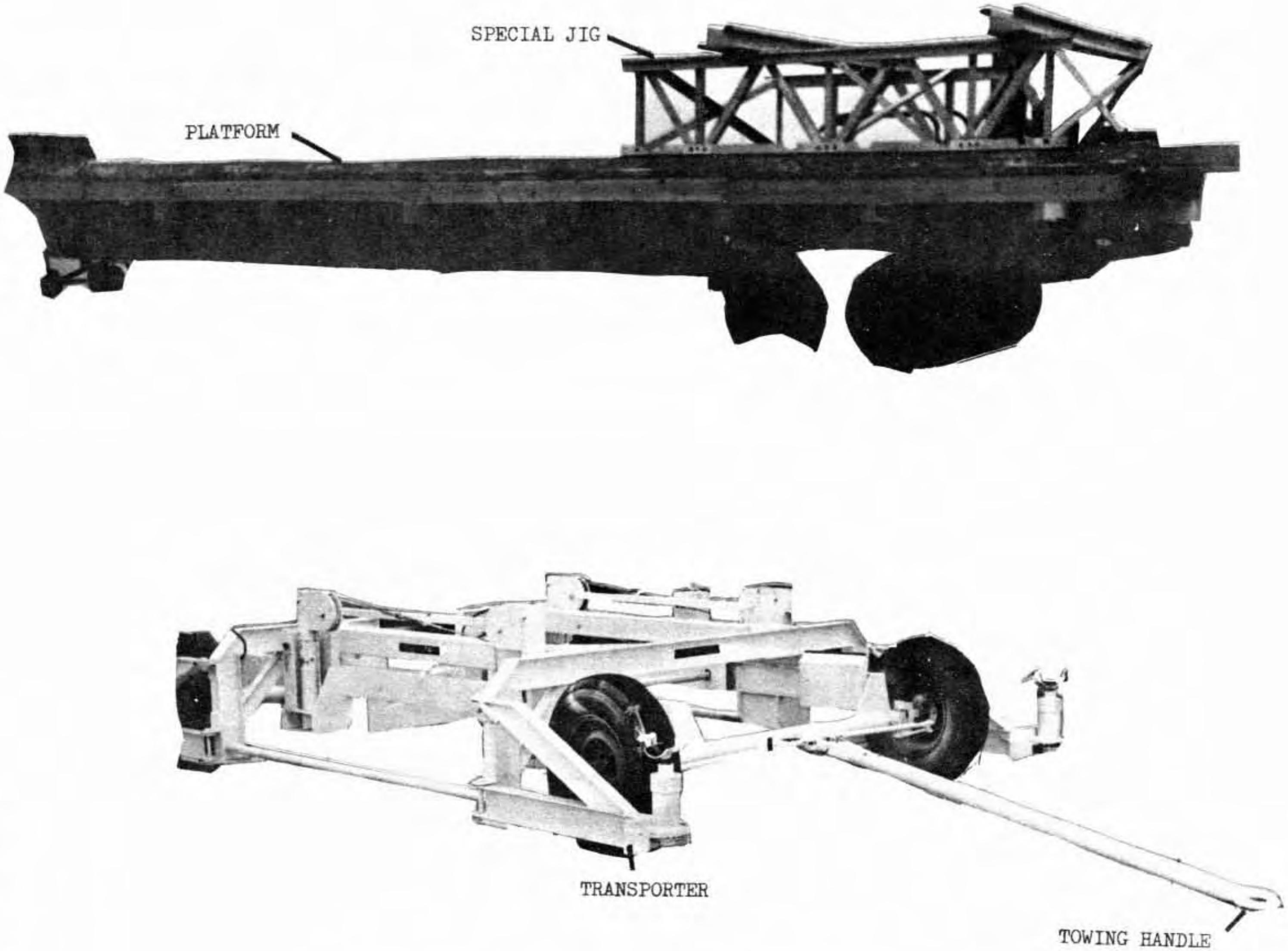


Figure 3-7. Transporter, Jig, and Platform

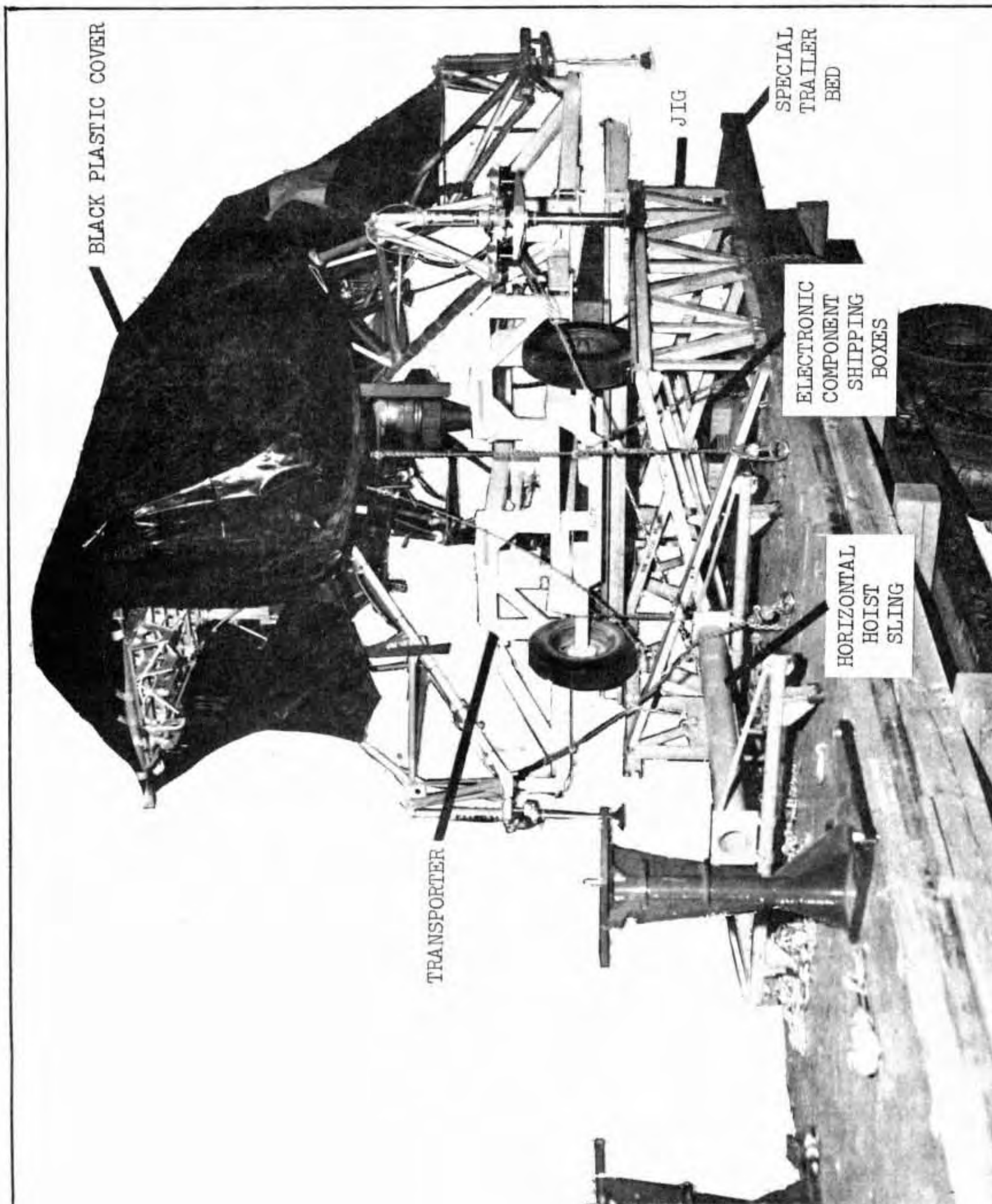


Figure 3-8. LLTV Ready for Air Shipment

L. Lift vehicle onto transporter.

NOTE

> Attach guide lines to opposing struts of vehicle. Four men are required at the transporter on the trailer, (one at each of the transporter cradle arms) to guide the cradles under the vehicle struts.

M. Secure vehicle jacking point to transporter cradle arms with U-clamps and nuts.

N. Place each electronic box (removed from equipment platform) into shipping container or box.

NOTE

> Insert cushioning material into shipping container or box to protect equipment against shipping damage.

O. Place electronic equipment boxes inside special jig under transporter on special platform floor. (See figure 3-8.)

NOTE

> Boxes do not need to be tied down.

P. Lift hoisting bar onto special platform and chain down. (See figure 3-8.)

Q. Cover entire top half of vehicle with a black plastic sheet, tying down corners and other sections to vehicle tubing and frame. (See figure 3-8.)

3-31. LOADING VEHICLE INTO TRANSPORT PLANE - The following steps are required for loading vehicle into the transport plane:

A. Tow trailer to an area about 100 feet in front of a transport plane.

B. Open nose of plane to its maximum position. (See figure 3-9.)

C. Back trailer to transport plane until platform is about six inches away from the cargo area of the transport plane, aligning the trailer to the platform rails of the cargo area. (See figure 3-9.)

D. Slowly raise trailer bed to level of cargo rails. (See figure 3-10.)

CAUTION

While raising trailer bed, continuously check and adjust trailer alignment, when necessary, to transport plane cargo rails.

E. Attach cargo area winch cable to special platform.

F. Slowly slide platform into cargo area until platform is completely inside cargo area and lock platform in this position. (See figure 3-11.)

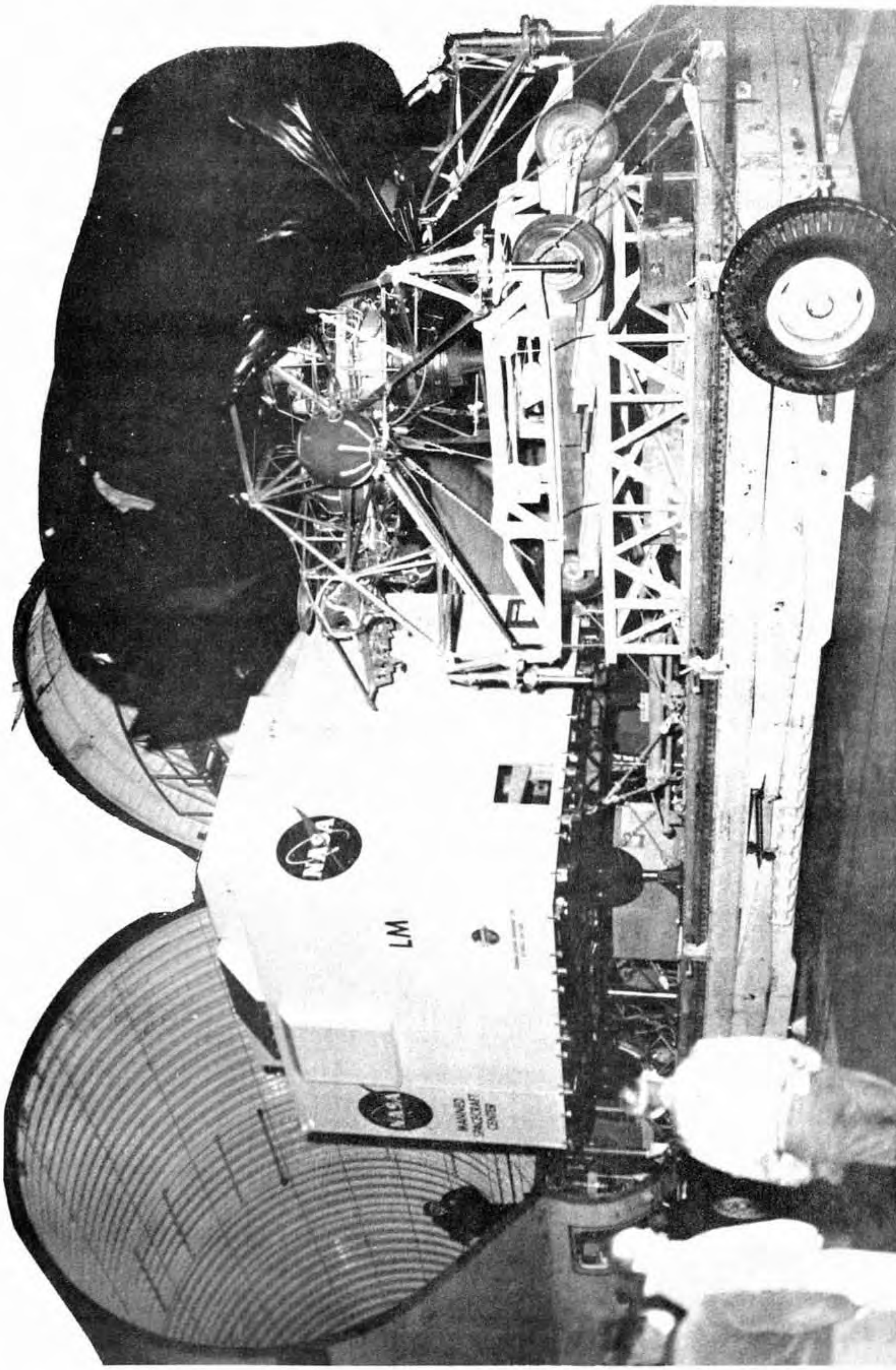


Figure 3-9. Special Trailer Aligned to Cargo Area of Transport Plane

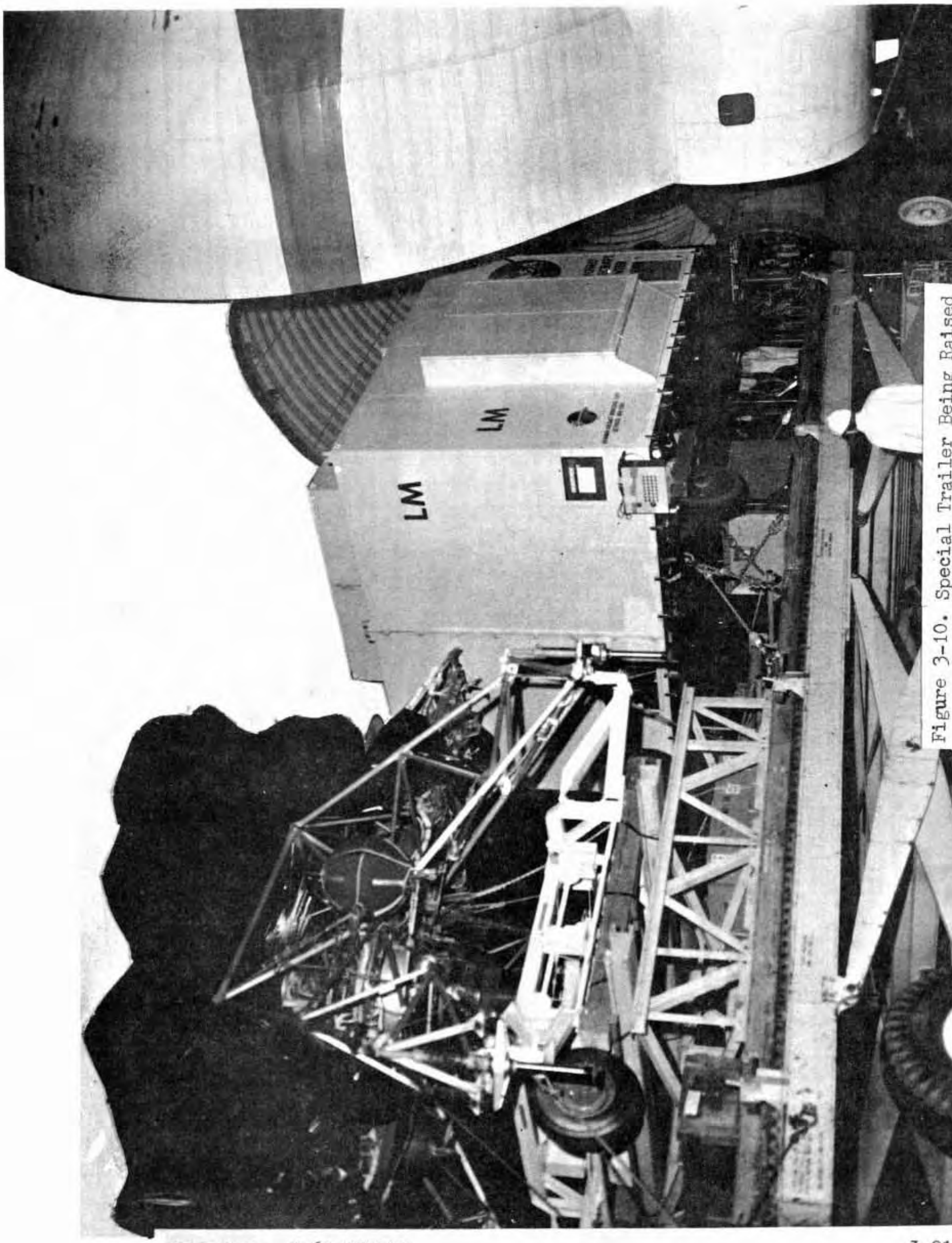


Figure 3-10. Special Trailer Being Raised

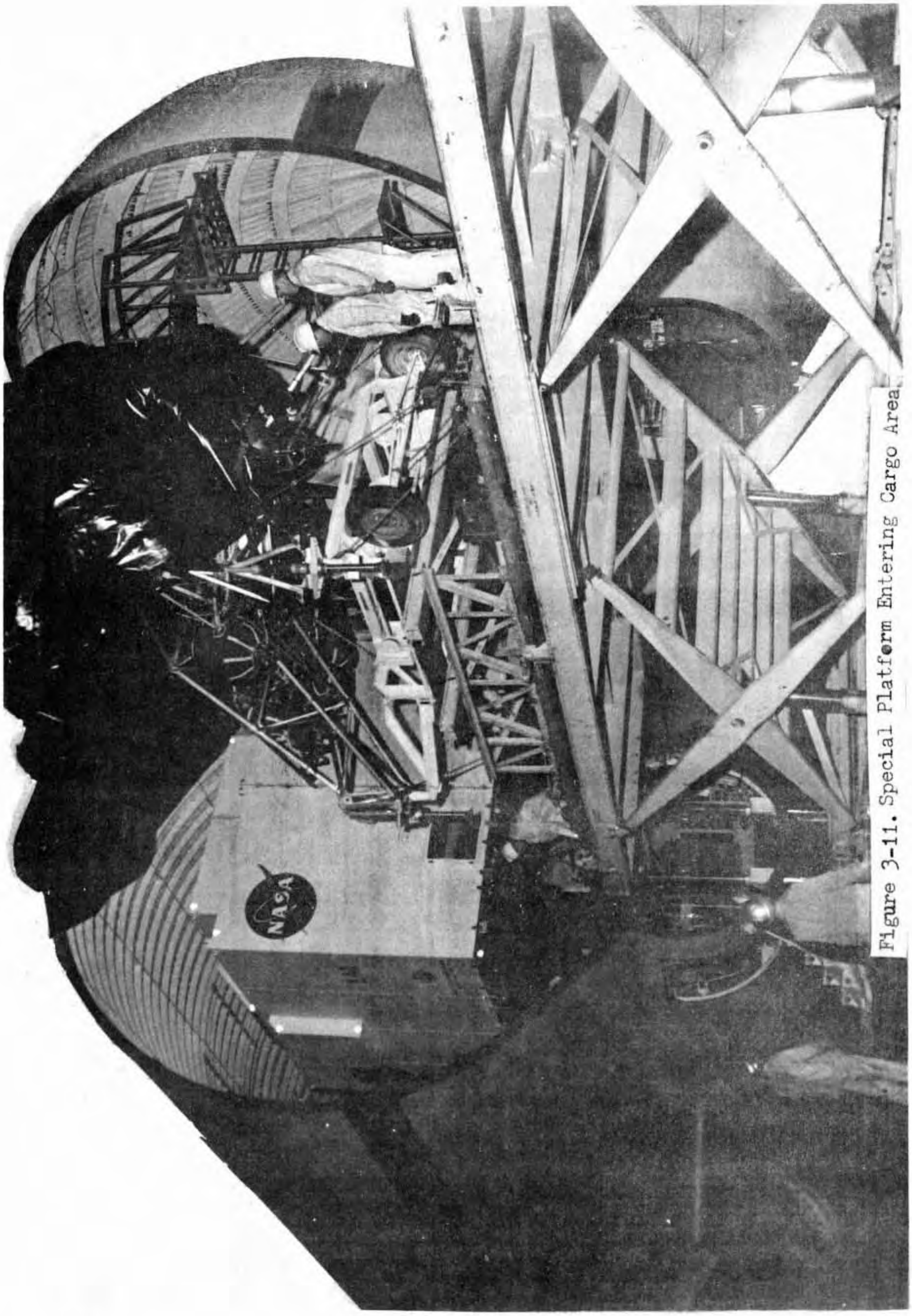


Figure 3-11. Special Platform Entering Cargo Area

SECTION IV

SECTION IV

AIRFRAME OPERATING SYSTEMS

MAINTENANCE

4-1. SCOPE OF SECTION.

4-2. This section provides a description, functional analysis, removal and installation procedures, adjustments and test equipment for the LLTV airframe structure, ejection seat, and oxygen system.

4-3. DESCRIPTION AND LEADING PARTICULARS.

4-4. The Lunar Landing Vehicle (figure 1-1), primary airframe structure consists of a pyramid-shaped tubular structure with four truss-type legs. The cockpit section extends forward between the two front legs. The Weber pilot ejection seat is located in the cockpit. The oxygen system is beneath the cockpit floor. See Bell Drawings 7260-099001 and 7260-153001.

4-5. MAJOR STRUCTURAL COMPONENTS.

4-6. The major structural components (figure 4-1) consists of a center body, an engine mount, a gimbal ring, peroxide tank mounts, fuel tank mounts, a cockpit structure, an equipment structure, and four leg structures with shock struts.

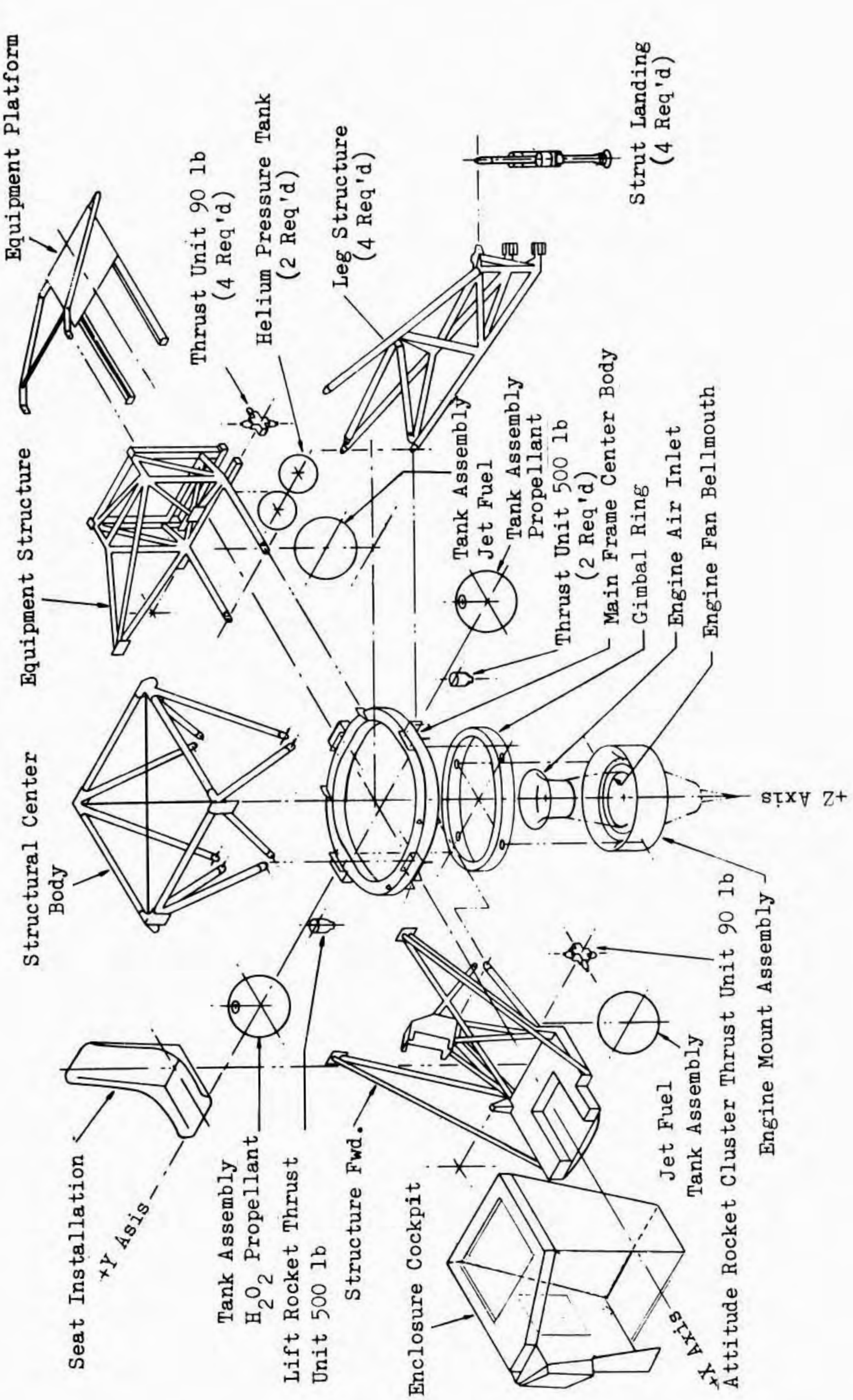


Figure 4-1. LLTV Structure and Component Arrangement

4-7. CENTER BODY. - The center body structure consists of an upper and a lower frame connected by diagonal tubes. The upper frame is formed by four equal length tubular side members and two wire diagonals. The lower frame is built-up sheet metal ring with fittings at four equally spaced locations for attachment of the leg lower longerons. Adjacent longerons of adjacent legs share each fitting. Two of the center body diagonals also terminate at each of the four fittings. One third of the forward fuel tank weight is supported at the forward fitting, and one third of the aft fuel tank weight is supported at the aft fitting. Trunnions for mounting the jet engine gimbal pitch bearings are attached to the right and left hand fittings. The lift rocket mounting brackets are also attached to the bottom of the right and left hand fittings. See Bell Drawing No. 7260-152001.

4-8. ENGINE MOUNT. - The engine mount is a built-up sheet metal ring, the inner surface of which is contoured to form the outer wall of the engine fan inlet. Closely spaced radial ribs stiffen the contoured inner surface and the other three surfaces, and redistribute primary ring bending and torsion loads into axial and shear forces on the four surfaces. Two machined fittings located 180 degrees apart in the fore and aft direction are built into the ring to provide hardpoints for the roll bearing trunnions. The forward fitting also incorporates the crank arm for the roll actuator. The engine is attached to the mount at the two points of the lower surface and by a steady-rest at the top of the forward fitting. One of the lower mounts has sufficient freedom in the radial direction to accommodate the thermal expansion of the engine.

4-9. GIMBAL RING. - The gimbal ring is circular in shape with a uniform rectangular cross-section three inches wide and four inches deep. It is constructed of two machined rings which are riveted together. The larger machined ring incorporates the bottom and both sides of the rectangular cross-section, plus all the integral internal ribs and bearing housings. The other machined ring forms the top surface and has a channel-shaped cross-section with the flanges extending downward over the sides of the lower ring to provide sufficient overlap for a row of rivets on each side. The top surface is attached to the internal ribs by clip angles which are riveted to the ribs and the upper surface. Bearings are mounted in the integral housings 90 degrees apart. The front and rear bearings permit the engine (and engine mount) to roll relative to the gimbal ring. The roll actuator is anchored to the gimbal ring by a machined fitting which is bolted to the basic ring. The right and left hand bearings permit the engine mount assembly and gimbal ring to pitch relative to the center body. A fitting bolted to the basic gimbal ring at the starboard bearing provides the crank arm for the pitch actuator. The pitch actuator is anchored to a fitting attached to the main frame of the center body.

4-10. PEROXIDE TANK MOUNTS. - A peroxide tank is mounted on each side of the vehicle by a tubular truss. Each truss supports the spherical tank at diametrically opposed trunnions on the tank equator, and attaches to the center body at two upper corners and four points on the main frame.

4-11. FUEL TANK MOUNTS.- The forward JP-4 fuel tank is mounted in a cradle between the two lower longerons of the cockpit structure. The cradle is supported by three fittings, spaced 120 degrees apart, at the equator. Two fittings are forward and attach to the longerons. The third fitting is aft and attaches to the forward fitting of the center body main frame. The aft JP-4 fuel tank is supported in the aft equipment section truss structure in a similar fashion. See Bell drawing No. 7260-420001.

4-12. COCKPIT STRUCTURE. - The cockpit structure consists of a sheet metal platform, ejection seat support, and a cockpit enclosure. The platform floor is attached to the center body by a tubular truss structure. Center body attachment is accomplished by multibolt fittings at the two upper corners and by single bolts in double shear at each of the two lower longerons. The seat support is a combination of a sheet metal box and tubular truss structure attached to the center body and floor truss. The cockpit instrument pedestal, controls, and console are mounted to the platform floor. A ballast installation is provided under the ejection seat to balance the vehicle. See Bell drawing No. 7260-150001.

4-13. AERODYNAMIC BOOM. - An aerodynamic boom is mounted to the cockpit floor and extends 4 feet forward from the cockpit. The boom has 2 vanes to measure aerodynamic data inflight. The angle of attack is measured by the alpha (α) vane and is used for visual reference by the pilot. The sideslip angle is measured by the beta (β) vane and is displayed on a 45 degree Left to 45 degree Right gage, mounted on top the right corner of the Instrument Panel, above the annunciator lights. The sideslip angle is real time monitored in the T/M Van. The α and β vane angles are recorded by TM for post flight analysis.

4-14. EQUIPMENT STRUCTURE. - The equipment structure consists of a moveable tray, and an adjustable platform supported by a tubular truss attached to the center body in the same fashion as the cockpit truss. The platform is adjustable vertically and the tray is adjustable fore, aft, and laterally to allow basic center of gravity adjustments for pilot weight variation. See Bell Drawing No. 7260-153004.

4-15. LEG INSTALLATION/SHOCK STRUTS. - Four identical interchangeable legs are mounted symmetrically at 45 degrees to the longitudinal centerline of the vehicle. Each leg is a three-longeron, two-bay tubular truss attached to the center body at the inboard end of each longeron by a single bolt in double shear. A conventional air-oil shock strut is mounted at the end of each leg truss to absorb the landing impact vertical component of energy. Lateral impact loads are attenuated by rubber shear mounts which permit lateral excursion of the lower end of the shock strut. Ballast is provided for, on the front legs and under the seat, to balance the light-weight pilots and provide a more rapid between-flight method of center of gravity adjustments. See Bell Drawing No. 7260-155001 and 7161-191005. Refer to paragraph 3-5 for installation procedures.

4-16. EJECTION SEAT.

4-17. - The weber pilot ejection seat provides seating for the pilot during normal vehicle operation and emergency escape, if required, when vehicle emergency conditions warrent. The seat is designed for zero velocity, zero altitude capabilities. The ejection seat system (figures 4-2, 4-3, and 4-4) consists of the following components: seat assembly fixed rail assembly, parachute assembly, fixed rail assembly, parachute assembly and drogue gun, rocket catapult initiator and a release initiator. See Bell Drawing No. 7260-501001 and Weber Seat Manual DR-5773-1.

4-18. FUNCTIONAL ANALYSIS. - Emergency ground egress or over-the-side bailout is accomplished by pulling upward on the lanyard release handle (figure 4-5) located on the left hand side of the seat bucket. Action of the lanyard release handle releases lap belt and shoulder restraints and

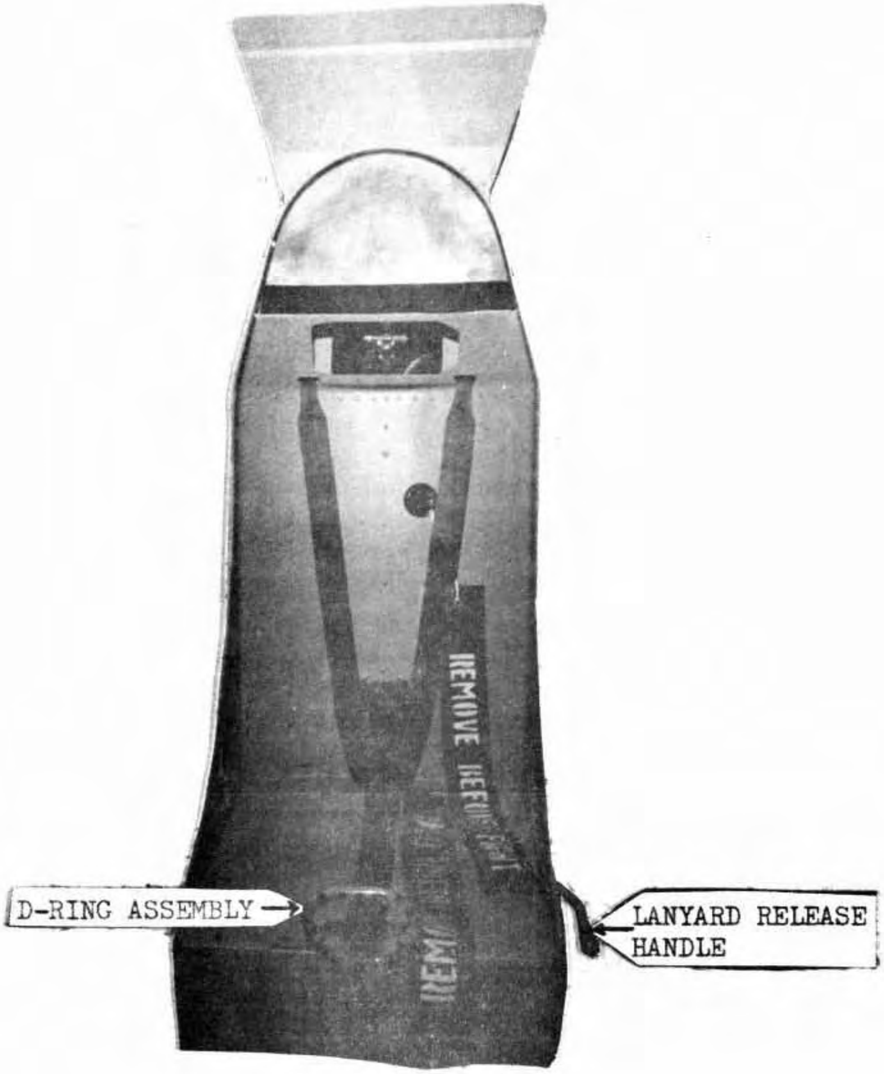


Figure 4-2. Weber Ejection Seat, **Front View**

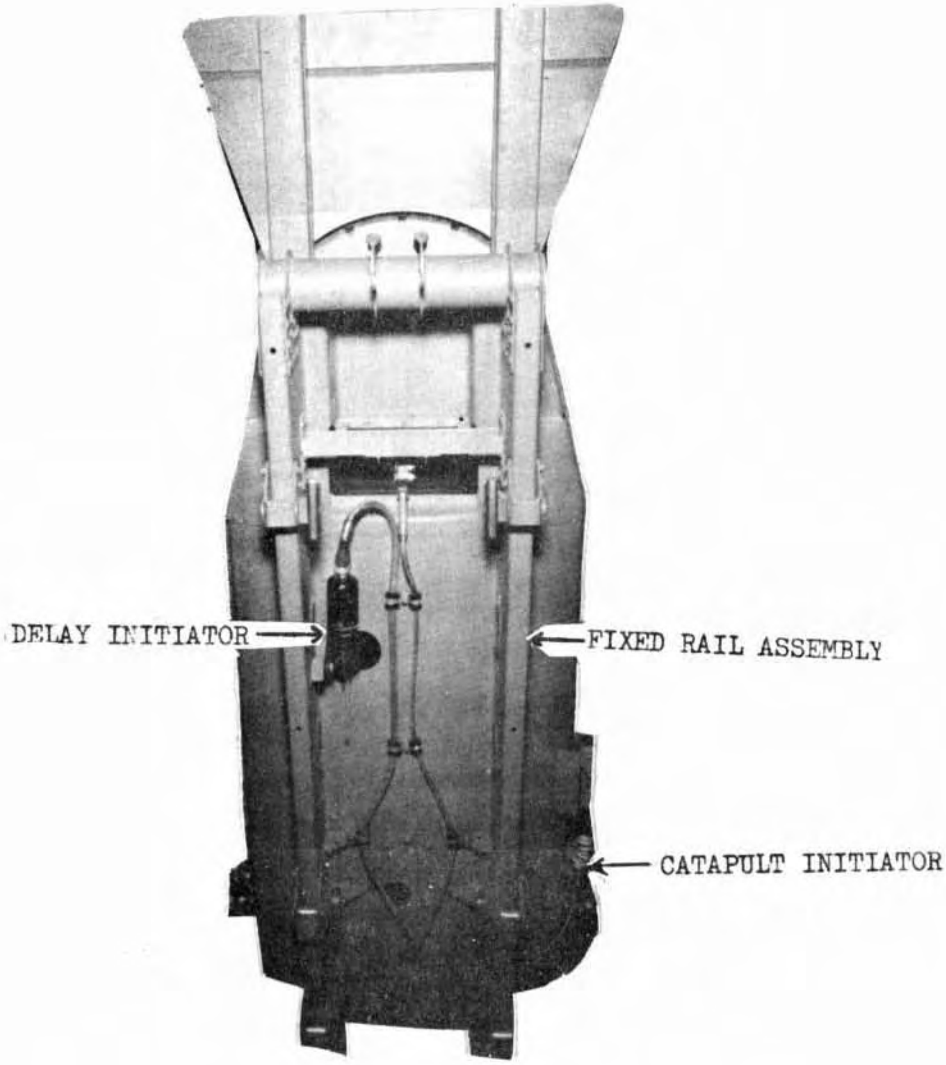


Figure 4-3. Weber Ejection Seat, **Rear View**

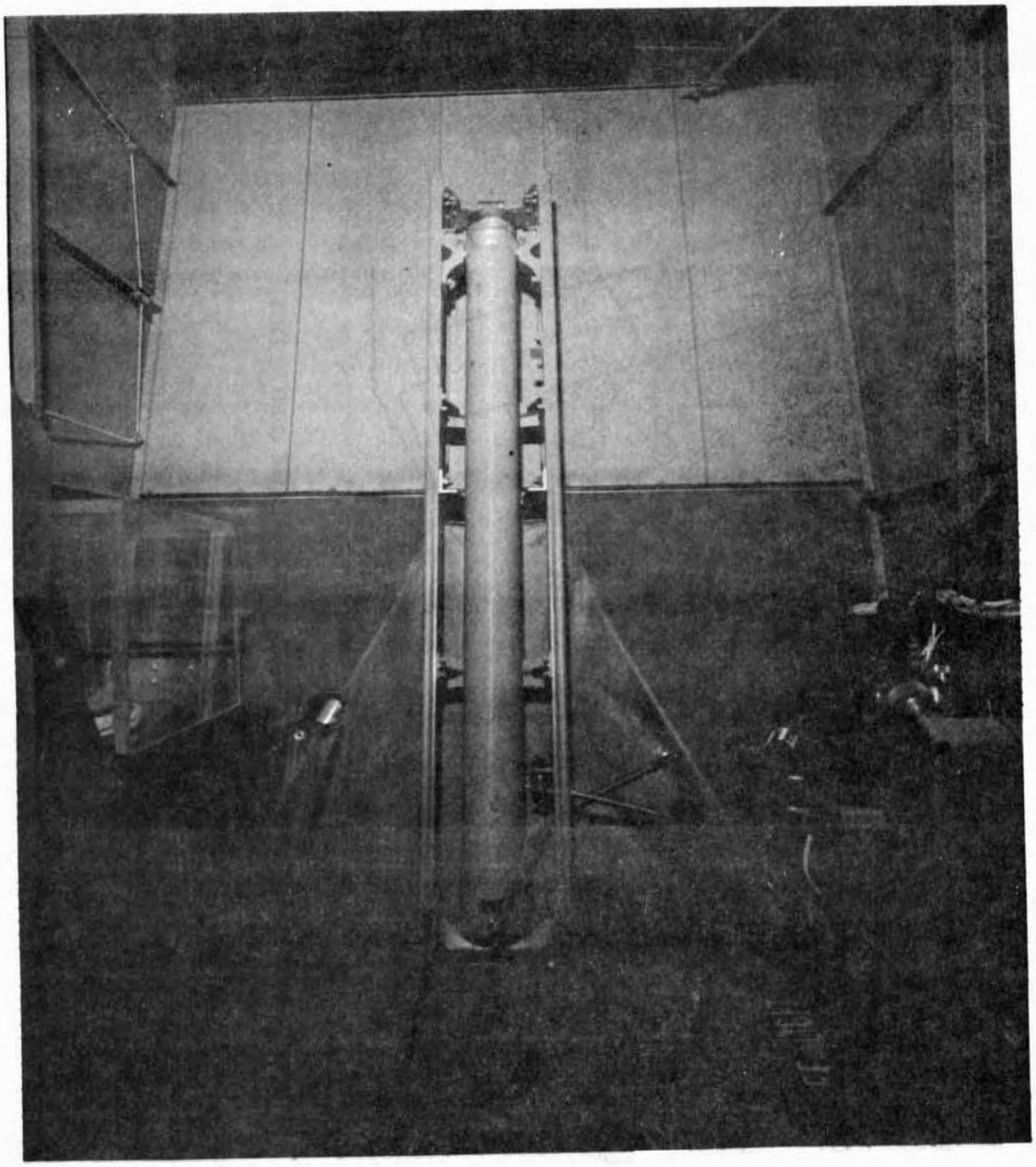
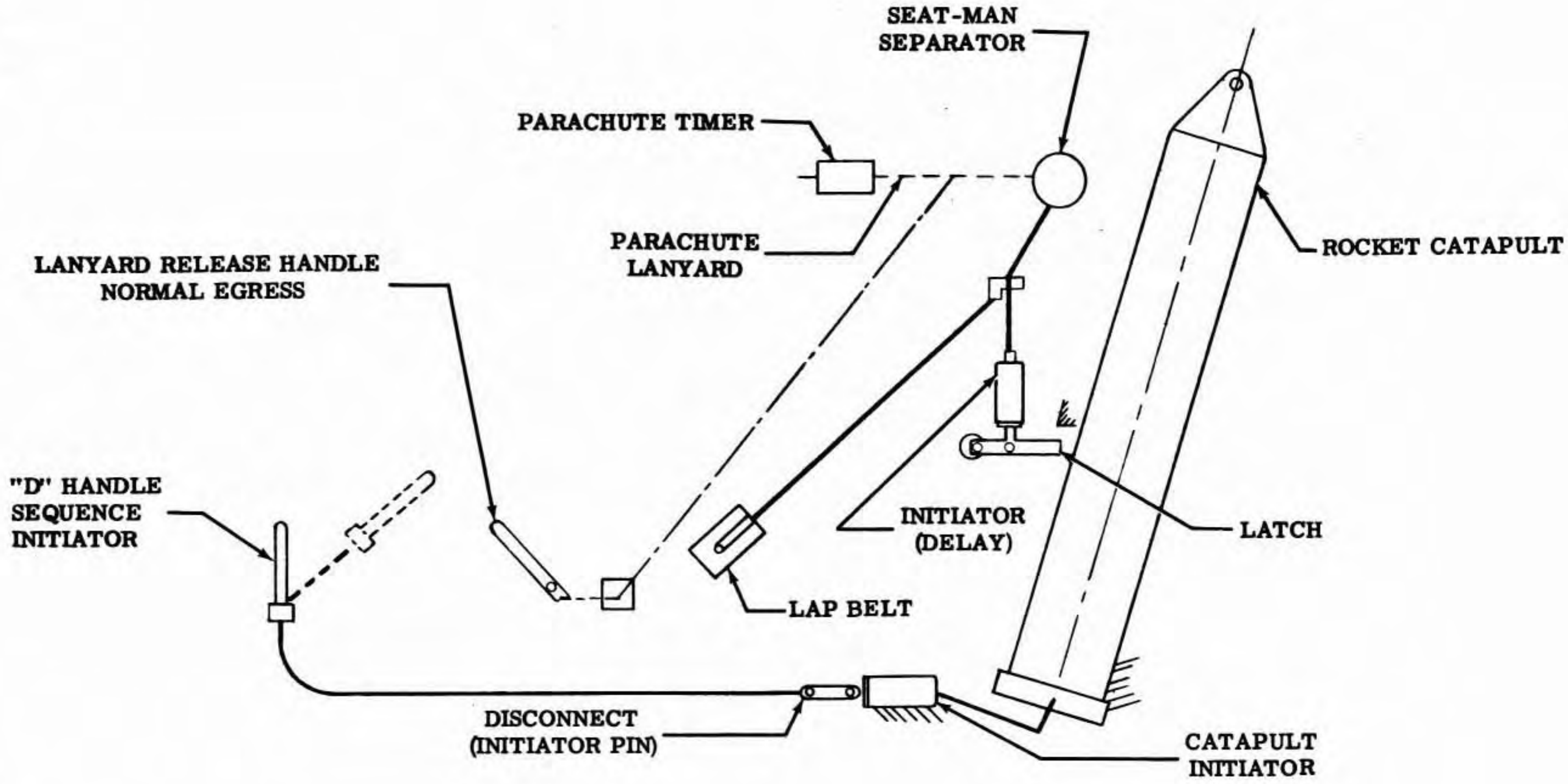


Figure 4-4. Rocket Catapult and Rails



NOTE:
THE FOLLOWING CARTRIDGE ACTIVATED DEVICES WILL BE USED IN THIS EJECTION SYSTEM:

(1)	INITIATOR - CATAPULT	INSTANTANEOUS
(2)	PARACHUTE DROGUE GUN	2.3 SECOND
(3)	ROCKET CATAPULT	INSTANTANEOUS
(4)	ROTARY ACT. (S/M SEP.)	INSTANTANEOUS
(5)	INITIATOR - LAP BELT	1.0 SECOND
(6)	LAP BELT TYPE MA-6	AUTOMATIC

Figure 4-5. Ejection Seat Operational Schematic Diagram

disconnects the parachute lanyard to permit exit of the pilot with parachute from the seat. In over-the-side bailout the parachute must be deployed by the manual parachute D-ring located on the left shoulder harness.

4-19. In emergency ejection the pilot must grasp the ejection seat D-ring assembly with both hands and pull sharply upward to fire catapult initiator. (25 to 50 lb pull may be required).

After the initiation of the rocket catapult the following sequence of events occurs:

A. Initial motion of the seat upward in the rails actuates the firing lever of the man-seat separation delay initiator by contact with tripper on the fixed rails.

B. After the delay interval of 1 second during which rocket burnout occurs, gas pressure is supplied to the release system through a hose. The gas pressure energizes the rotary actuator for seat-man separation. The release system cylinder assembly then actuates the three releases, pulls the drogure gun cable which fires the delay cartdridge in the parachute drogue gun, and releases the drogue gun cable from the disconnect.

C. Following the man-seat separation, the one second delay cartridge in the drogue gun mounted in the personnel parachute fires, deploying the pilot chute and main canopy.

Refer to Weber Aircraft Company manual DR 5773-1 for additional maintenance details on the ejection seat.

4-20. OXYGEN SYSTEM

4-21. The oxygen system (figure 4-6) is required to provide breathing oxygen for the pilot because of the exhaust gas from the jet engine. The system consists of the oxygen tank, a shut-off valve, a demand-type regulator, an oxygen pressure gage, and an oxygen hose assembly for attachment to a T-block on the pilot's harness. All component parts of the system are integrally mounted on the tank. (Mask Breakaway Connector, Scott Model 7025). See Bell drawing No. 7260-501001.

NOTE

At an average maximum demand rate the oxygen supply will last approximately 20 minutes.

4-22. REMOVAL PROCEDURES

4-23. The removal and installation of the airframe structure is provided in section III. The removal procedures for the cockpit roof, ejection seat, and oxygen system are provided in paragraphs 4-24 through 4-28.

4-24. COCKPIT ROOF REMOVAL

4-25. To remove the cockpit roof, proceed as follows:

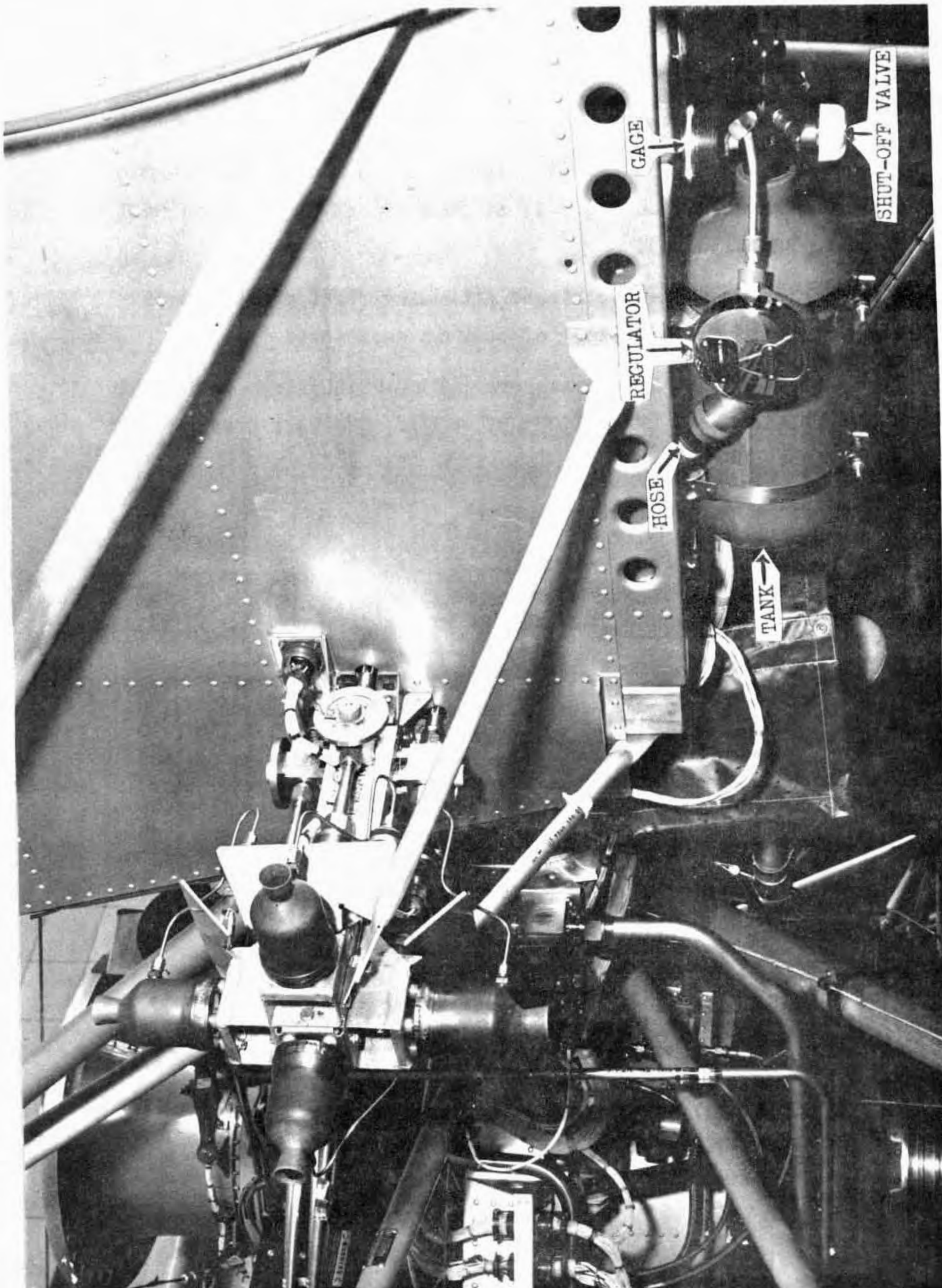


Figure 4-6. Oxygen System

CAUTION

Roof is made of styro-foam and must be handled with care.

A. Disconnect wind direction indicator leads.

B. Remove self-locking nut, bolt (AN3-4A), and washer (AN960-PD10) from tube brace (7260-15007-1) at roof end of brace. (See Bell Drawing 7260-150008).

C. Remove pins from the two hinges attaching right hand forward area of roof to front panel of cockpit enclosure.

D. Remove bolts (AN3-4A) and washers (AN960-PD10L) from right side and left side tabs (7260-15006-37, -39). See Bell Drawing No. 7260-150006).

E. Remove pin from aft piano pin hinge.

F. Lift cockpit roof from vehicle.

4-26. LEG MAINTENANCE OR REMOVAL -

4-27. To remove the vehicle forward legs, proceed as follows:

CAUTION

No other maintenance operation should be performed during this operation.

A. Place vehicle on transporter and remove from hangar. (Refer to Section II, paragraph 2-3).

B. Install two chain hoists on hangar "I" beam.

NOTE

Install hoists in such a way that proper clearance is available with vehicle suspended.

C. Attach the vehicle horizontal hoist sling (with drop cables) to chain hoists.

D. Using transporter, center the vehicle under the hoists then lower vehicle and remove transporter from area. (Refer to Section II, paragraph 2-3).

E. Deflate all vehicle leg struts.

F. Lower horizontal lifting sling and attach the drop cables to vehicle lifting terminals. (Refer to Section II, paragraph 2-6).

G. Remove all plumbing and electrical wiring attached to the forward legs.

H. Position two wing jacks (1 ton minimum capacity) symmetrically under the forward section of the main frame center body to support the forward section of the vehicle.

I. Place wooden blocks between each jack and the vehicle frame and snug jacks to frame.

J. Extend the jacks and raise the forward section of the vehicle until the footpads clear the hangar floor by approximately one-half (1/2) inch.

K. Take up slack on chain hoists until all lifting cables are snug.

L. Position sandbags around both of the rear landing strut footpads to hold down leg and prevent any sliding tendencies .

M. While supporting the leg assembly, remove the attachment bolts at the 3 attachment points on the upper corner of the center body structure (1) and main frame (2) and remove a forward leg.

4-28. To remove the aft legs, the procedure is the same as removing the forward legs, except that the jacks will be positioned under the aft section of the main frame center body, to support the aft section of the vehicle. Ballast will be positioned on the forward legs. All plumbing and wiring will be removed from the aft leg.

4-29. LEG BRACES OR STRUT REMOVAL

4-30. To remove leg braces or strut removal, perform steps A through K of paragraph 4-26, then proceed to remove braces or strut.

4-31. EJECTION SEAT REMOVAL

4-32. Prior to removal of ejection seat, remove cockpit roof in accordance with paragraph 4-24. To remove the ejection seat two men are required and proceed as follows:

WARNING

The ejection seat assembly has two actuators and three initiators for explosive charges. Refer to the Weber manual DR 5773-1 to determine how the initiators are set off. Treat the initiators and assemblies attached to them as a potential source of bodily harm.

NOTE

Safety pin installation at initiator be made so that the straight pin be installed through hole in annular grove of initiator and loop up so it can be easily seen.

A. Ensure that the maintenance safety pin (see figure 4-7) is in each initiator and actuator as follows:

   1) Seat Initiators and Actuator
      a) D-ring - catapult charge
      b) M-32 - seat harness release charge
      c) M-27 - pilot/seat separation charge

NOTE

Insert safety pin with loop up so it can be easily seen.

   2) Parachute Initiators and Actuator:
      a) Drogue gun cable
      b) Manual firing cable

CAUTION

Actuators are easily fouled by foreign matter. Cap cables when disconnected and keep units clean.

B. Detach ejection control cable (4, figure 4-8) from catapult initiator (1, figure 4-9).

C. Remove tripper (9) from fixed rail assembly (10) by removing attaching screws.

WARNING

The catapult contains the largest charge of explosives in the seat assembly. When the catapult charge is unbolted from the track in cockpit, it is awkward to handle. Advoid jaring the catapult.

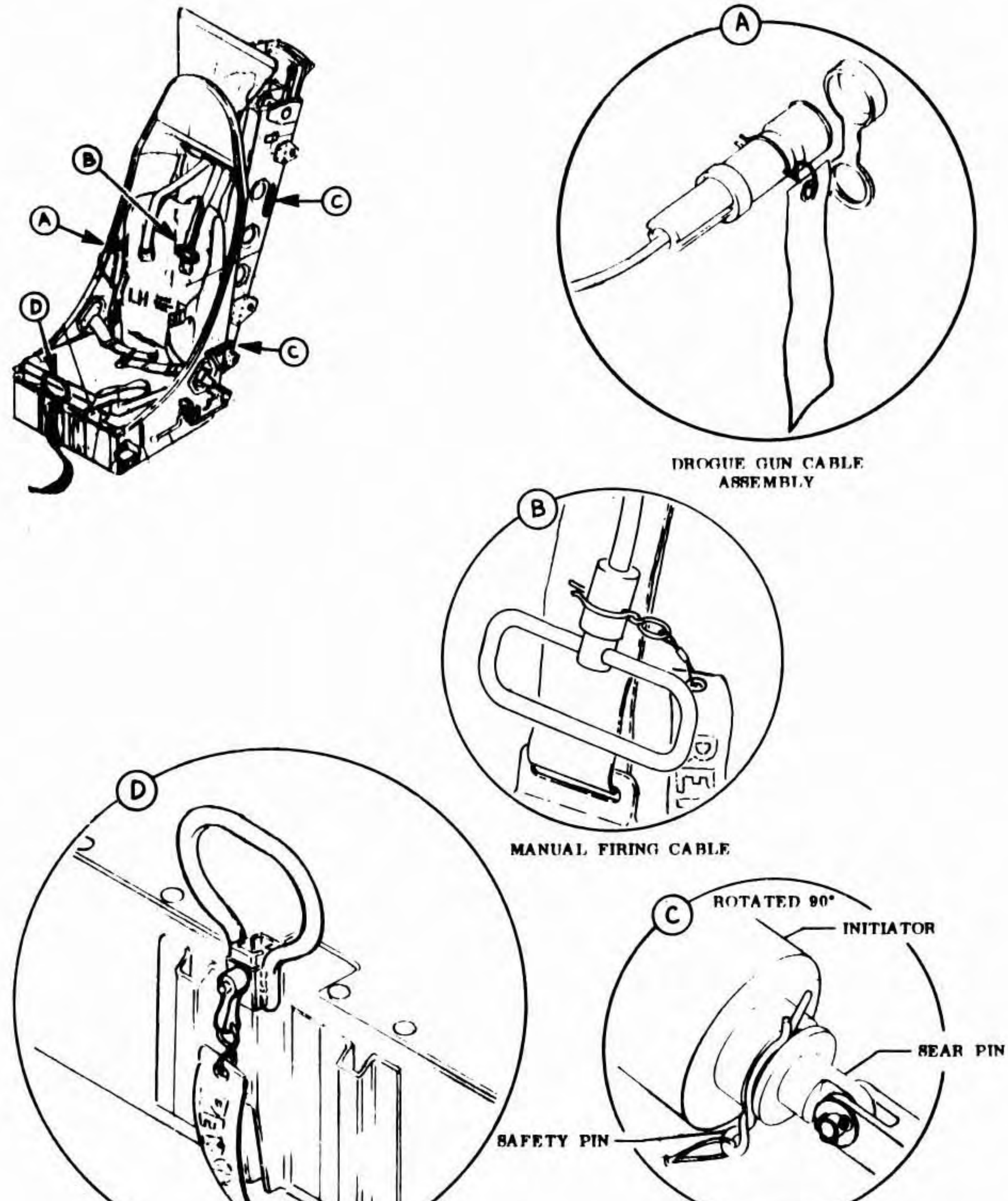
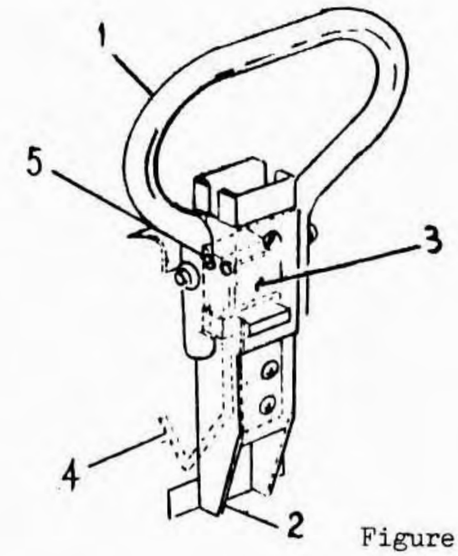
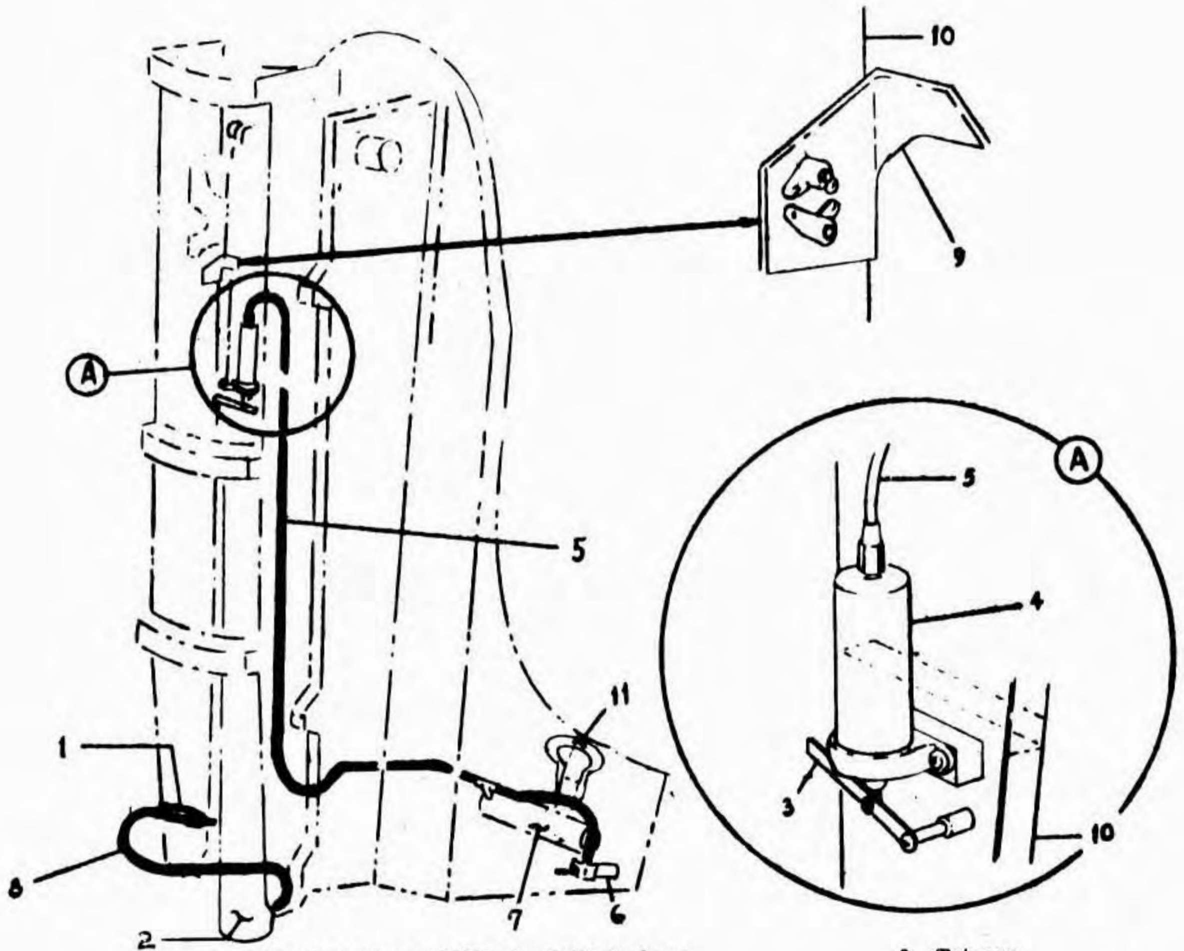


Figure 4-7. Safetying



1. "D" ring
2. Tube assembly
3. Block
4. Cable assembly
5. Pins

Figure 4-8. "D" Ring Assembly



1. **Catapult initiator (M27)**
2. **Rocket catapult**
3. **Firing lever**
4. **Delay initiator (M32)**
5. **Ballistic hose**
6. **Cylinder assembly (pin-puller)**
7. **Rotary actuator**
8. **Ballistic hose**
9. **Tripper**
10. **Fixed rail assembly**
11. **"D" ring assembly**

Figure 4-9. Ballistic Components

D. Detach seat from rocket catapult (2).

E. Remove seat from vehicle by sliding upward until separated from fixed rail assembly (10).

4-33. OXYGEN SYSTEM REMOVAL

4-34. To remove the oxygen system, proceed as follows:

A. Disconnect supply hose at oxygen tank regulator.

B. Loosen two lock-nuts on retaining strap bolts sufficiently to free tank.

C. Remove tank from retaining straps.

D. Remove hose clamp from oxygen hose and remove hose.

4-35. INSTALLATION PROCEDURES

4-36. Installation of components is performed in the reverse order of removal. Refer to paragraphs 4-24 through 4-33.

WARNING

Ensure extreme care is taken during installation of the ejector seat and initiators.

NOTE

Two men are required to install the ejector seat.

4-37. LEG INSTALLATION

4-38. Installation of vehicle legs is the reverse of removal (refer to Section III, paragraph 3-5 and 4-26 through 4-28).

CAUTION

All leg hardware must be fully installed before lowering vehicle.

4-39. LEG BRACES AND STRUT INSTALLATION

4-40. Installation of leg braces and struts is the reverse of removal. (Refer to paragraph 4-29).