(Text continued from page 1-86.)
and a blower assembly. These assemblies automatically perform self-tests and test flight control airborne components, evaluate system response, and verify operation of the pre-set pitch program. During system checkout, the gyro drift check is performed manually and a series of detailed automatic tests are performed in checking the flight control system. One test, performed during launch exercise, checks the flight control system in one complete operation. During launch operations, the flight control system is remotely controlled by the launch control and status system.

1-197. AIRBORNE EQUIPMENT. Components of the flight control system airborne equipment maintain correct missile attitude during powered flight. During Stage I powered flight the missile is directed on a preset flight path by the pitch programmer. Guidance is also provided by the ground guidance system during Stage I powered flight, Stage II powered flight, and vernier engine power flight. Missile steering and attitude control are accomplished by signals from the airborne components, applied to the servo-actuators, which in turn position the thrust chambers.

1-198. The Stage I airborne components consist of a Stage I rate gyroscope assembly, a Stage I autopilot amplifier package (magnetic amplifier), and four servo valves. The Stage I rate gyroscope assembly and the autopilot amplifier package are located in the Stage I transition compartment. The servo valves are in the Stage I engine compartment on the thrust chamber servo-actuators.

1-199. The Stage I rate gyroscope assembly senses missile deviation rates and produces proportional rate signals. The rate gyroscope assembly contains three rate gyroscopes, three heater circuits, and control circuits. Each rate gyroscope is positioned to measure the rate of missile deviation about one of the three missile control axes (pitch, yaw, and roll). (See figure 1-57.) Each rate gyroscope contains a gyroscope, a gimbal, a torsion bar, a signal generator, and a heater. The gyroscope is mounted in the gimbal and the gimbal is supported by the torsion bar and signal generator. As the missile moves around a control axis, the respective gyroscope precesses, causing the gimbal to exert a force on the torsion bar proportional to the angular rate of missile movement, and the signal generator produces an electrical output signal proportional to rate of missile deviation. The gimbal completely encloses the gyroscope and is immersed in high viscosity oil. The oil dampers gimbal oscillations and also reduces gimbal bearing friction. The heater maintains the damping oil at the proper operating temperature. The control circuits pitch rate signals from the signal generator to the Stage I autopilot amplifier package.

1-200. The Stage I autopilot amplifier package (magnetic amplifier) converts mixed rate signals, Stage I rate gyro rate signals, Stage II rate gyro displacement signals, and 3-axis reference gyro assembly displacement signals into correction signals, which are then transmitted to servo valves on the Stage I thrust chamber servo-actuators. The Stage I autopilot amplifier package has a gain change relay, three channel amplifiers, four mixer amplifiers, and four servo amplifiers as integral parts.

1-201. The Stage II airborne components consist of a 3-axis reference gyro assembly, a Stage II rate gyroscope assembly, a Stage II autopilot amplifier package (magnetic amplifier), a servo amplifier assembly, a transformer rectifier converter, a servo trim potentiometer box, a frequency converter, and six servo valves. Except for the servo valves, the airborne components are located in the transition compartment of Stage II. The servo valves are on the sustainer engine and vernier nozzle servo-actuators in the Stage II engine compartment.

1-202. The 3-axis reference gyro assembly establishes the missile attitude reference, senses missile deviations from this reference, and produces correction signals. The attitude reference is altered by pitch program signals and guidance signals to control the missile flight path. Guidance signals produce a roll program during the first 24 seconds of flight, superimpose an incremental pitch program on the pitch program generated in the 3-axis reference gyro assembly, and accomplish pitch and yaw steering during Stage I powered flight. During Stage II powered flight, there is no pitch program, guidance pitch and yaw signals only are used to control the missile flight path. Guidance signals control the missile in the yaw axis only during vernier powered flight. The 3-axis reference gyro assembly contains three displacement gyroscopes, three guidance amplifiers, three operational heaters, three standby heaters, three heater amplifiers, one time base, one time summing matrix, a pitch program power supply, and control stages.

1-203. Each displacement gyroscope is mounted so it will measure the angle of missile deviation about one of three control axes (pitch, yaw, or roll). (See figure 1-57.) Each displacement gyroscope contains a gyroscope, a gimbal, a torque generator, and a signal generator. Each gyroscope is mounted in a gimbal which is supported by the torque and signal generators. Just before launch, the signal generators are set to a zero error signal output by caging the gyroscopes. The zero error signal provides the missile with a zero reference during powered flight. If the missile deviates from the desired course during flight, the gyroscopes sense the angle and direction of deviation. As the missile moves off course, the gyroscopes precess, causing the gimbals to rotate and move the signal generator armature which generates an error signal. This error signal is sent to servo-actuators which change thrust chamber position and correct missile attitude.

1-204. To change the missile flight path a program or guidance signal is sent to a torque generator. The torque generator rotates the gimbal, which changes the gyroscope spin axis position in respect to the prelaunch position. The rotation of the gimbal causes the signal generator to produce an error signal. This error signal causes the missile to change attitude until the airframe control axis corresponds to the gyroscope reference.

1-205. The gimbal completely encloses the gyroscope and is immersed in high viscosity oil. The oil dampers gimbal oscillations and reduces gimbal bearing friction. The heaters and heater amplifiers keep the oil at the proper operating temperature. Guidance amplifiers demodulate and amplify signals from the guidance system before they are sent to the torque generators. The time base, time matrix, control stages, and pitch program power supply are utilized in supplying the pitch program to the torque generators.

1-206. The Stage II rate gyroscope assembly is identical to the Stage I rate gyroscope assembly.

1-207. The Stage II autopilot amplifier package (magnetic amplifier) amplifies and converts rate signals (from the rate gyroscope assembly) and displacement error signals (from the 3-axis reference gyroscope assembly) into correction signals. After amplification in the servo amplifier assembly, these signals reposition the Stage II thrust chamber and vernier nozzles. Signals are also sent to the Stage I autopilot amplifier package to position the Stage I thrust chambers.

1-208. The servo amplifier assembly amplifies the difference in voltage between the signals sent from the autopilot amplifier package and this voltage is fed to the servo-actuators to move the thrust chamber until the followup potentiometer voltage sent from the autopilot amplifier package. This insures that the thrust chamber is positioned according to the command from the autopilot amplifier package.

1-209. The transformer rectifier converter supplies regulated 25 VDC power within the airborne flight control components.

1-210. The servo trim potentiometers provide a zero reference for the autopilot amplifier package. Adjustment of the individual servo trim potentiometers (one each for Stage I and Stage II thrust chamber servo actuators, excluding vernier actuators) assures that the thrust chambers are in the neutral position when there are zero error signals.

1-211. GUIDED MISSILE TEST SET. The test set consists of eight test units mounted in drawers within a cabinet and a waveguide assembly mounted to the rear of the cabinet. In addition, the test set employs a test board which couples the test set waveguide to the guidance set. Periodically, a checkout of the guidance set is performed to insure proper operation. This checkout is performed by the guided missile test set AN/DRM-5B(V). The test set performs the checkout by sending RF guidance signals, similar to those used during actual flight operation, to the guidance set. The test set verifies reception and decoding of the RF guidance signals by checking monitor signals from the guidance set.

1-212. ELECTRICAL SYSTEM.

1-213. The electrical system consists of ground and airborne electrical equipment. The electrical system converts facility power to 400 CPS, 60 CPS, and DC power; supplies AC and DC power for AOE and airborne equipment; controls ground hydraulic power and air conditioning for the missile; distributes electrical signals to the launcher system.

1-214. GROUND EQUIPMENT. The electrical system ground equipment consists of power switchboard JEU-7, power supply A/E24A, battery power supply A/E24A-5, power supply ECU-16, motor-generator A/E24A-3, launch and checkout circuits in control-monitor group OA-2438/GJQ-11, electrical umbilical disconnects, and launcher platform electrical AOE.

1-215. The power switchboard distributes 60 CPS facilities power to the electrical system units, the missile air conditioning system, the ground hydraulic equipment, and the instrumentation system. The unit is located on Level IV of the equipment terminal. It contains rack mounted removable assemblies which include remote-start and local-start enable circuits for the missile air conditioning system and the ground hydraulic system.

1-216. Power supply A/E24A-4 converts 480 V 60 CPS facilities power to 28 VDC. The unit is a skid-mounted transformer-rectifier, located on Level IV of each equipment terminal.

1-217. The battery power supply is a backup 28 VDC power source for power supply A/E24A-4. The battery power supply is a skid-mounted unit comprised of storage batteries and battery chargers. The unit is located on Level IV of the equipment terminal.

1-218. Power supply ECU-16 converts 480 V 60 CPS facilities power to 28 VDC. This power is used in starting and operating the airborne battery inverter-accessory power supply (BI-APS) and the Stage II hydraulic pump motor until the airborne battery power is transferred. The skid-mounted unit, located on Level IV of the equipment terminal, is a transformer-saturable reactor power supply.

1-219. Motor-generator A/E24A-3, driven by 60 CPS facilities power, produces 400 CPS power. The skid-mounted unit is located on Level IV of the equipment terminal.

1-220. Control-monitor group OA-2438 on Level III of the equipment terminal contains the electrical system launch and checkout equipment. The electrical system assemblies include the following: circuit breaker panels, prelaunch checkout assembly number 1, prelaunch checkout and control indicator assembly, voltage monitor, launch control assembly number 1, launch control assembly number 2, prelaunch checkout assembly number 3, time and cycle recorder, and centrifugal fan assemblies.

1-221. The circuit breaker panels contains circuit breakers and power contactors for protection and control of the 28 VDC, 117 V 400 CPS and 120 V 60 CPS circuits. These circuits supply power to the AOE and missile buses.

1-222. The prelaunch checkout assembly number 1 contains electrical system readiness-monitoring circuits and part of the control circuits for an automatic checkout stepper circuit. The front panel contains ten dual-lamp indicators that display equipment readiness condition as follows: Green for normal and red for malfunction.

1-223. Prelaunch checkout and control indicator assembly contains an electrical system operating mode selector, a lamp verification selector, manual checkout power pushbutton indicators, a system checkout-initiate pushbutton indicator, a system-checkout-step-digital readout indicator, and part of the electrical system checkout control circuits.

1-224. The voltage monitor chassis contains AC and DC voltage meters, selectors, and a frequency meter that permit monitoring of primary electrical system power during system checkout and service operation.

1-225. The launch control assembly number 1 contains remotely controlled circuits that sequence approximately the first half of the electrical system launch operations. The assembly has no front panel controls or indicators.

1-226. The launch control assembly number 2 contains remotely controlled circuits that sequence approximately the last half of the electrical system launch operations. The assembly has no front panel controls or indicators.

1-227. The prelaunch checkout assembly number 3 contains electrical system checkout circuits. The assembly has no front panel control or indicators.

1-228. The time and cycle recorder assembly contains the run-time monitor circuits for the electrical system. Run-time is recorded during both checkout and launch operations.

1-229. The centrifugal fan assemblies contain squirrel cage blowers that cool their associated rack of launch and checkout assemblies. Each assembly has a front panel fuse that protects the blower motor circuit.

1-230. ELECTRICAL UMBILICAL DISCONNECTS. The AOE electrical circuits are connected to the missile equipment through seven electrical umbilical disconnect plugs. The missile umbilical disconnect jacks are recessed in the missile skin and terminate the missile wiring. During launch, the plugs and jacks are mechanically disconnected by lanyards located on the umbilical tower and launcher platform.

1-231. LAUNCHER PLATFORM ELECTRICAL AOE. The launcher platform electrical AOE consists of junction boxes, a transition box, and wiring for all explosive bolts located on the launcher platform. The explosive bolts are electrically detonated to free the missile release mechanisms, and tower tilting mechanism. The electrical system arms and fires the explosive bolts.

1-232. AIRBORNE EQUIPMENT. During flight, the electrical airborne equipment supplies both AC and DC power at required voltages to the airborne equipment.

1-233. Stage I electrical equipment consists of DC power distribution bus panels located in the transition, between tanks, and engine compartments. These power panels are supplied with 28 VDC from the accessory power supply (APS) battery located in the Stage II engine compartment.

1-234. Stage II electrical equipment consists of a 117 400 CPS battery inverter-accessory power supply (BI-APS), a 28 VDC nickel-cadmium accessory power supply (APS) battery, main power control relays, AC power distribution bus panels, and DC power distribution panels. The BI-APS battery, and main power control relays are located in the Stage II transition compartment and are supplied with 117 V 400 CPS power from the BI-APS. The DC power distribution buses are located in the transition, between tanks, and engine compartments of Stage II. The DC buses are supplied with 28 volts by the APS battery.

1-235. Command signals from the launch sequencer to the electrical system control-monitor group OA-2438 initiate the start sequence of the electrical system. The sequence is started when the missile launch officer presses the launch control console LOAD PROPELLANTS pushbutton indicator. The airborne electrical equipment is placed in operation at different times during the countdown. During the countdown, airborne electrical equipment is powered by ground operating equipment power supplies until the airborne equipment is transferred to the airborne batteries. The APS battery and Stage II hydraulic pump motor battery are activated during the countdown. The batteries are activated when a squib ruptures a bag (in each battery) containing the electrolyte. The electrolyte is under gas pressure and is forced into the battery when the bag is ruptured.

1-236. ENGINE SYSTEM.

1-237. The rocket engine system includes the Stage I and Stage II engines (figures 1-58 and 1-59) and the associated aerospace operating equipment (AOE). The engines are physically and functionally complete and separate assemblies, and are installed in their respective missile stages. The rocket engines are connected to the ground operating equipment through the missile umbilicals.

1-238. The engines burn liquid oxygen and RP-1 fuel, and exhaust the resulting hot gases at supersonic velocities. The AOE starts the Stage I engine after checking that both engines are ready to fire. The Stage I engine (booster engine) is started on the ground and provides the thrust for missile lift off and initial acceleration. The Stage II engine is started at altitude and sustains the acceleration and establishes the programmed final velocity. The total operating time of both engines approaches 6 minutes for maximum range.

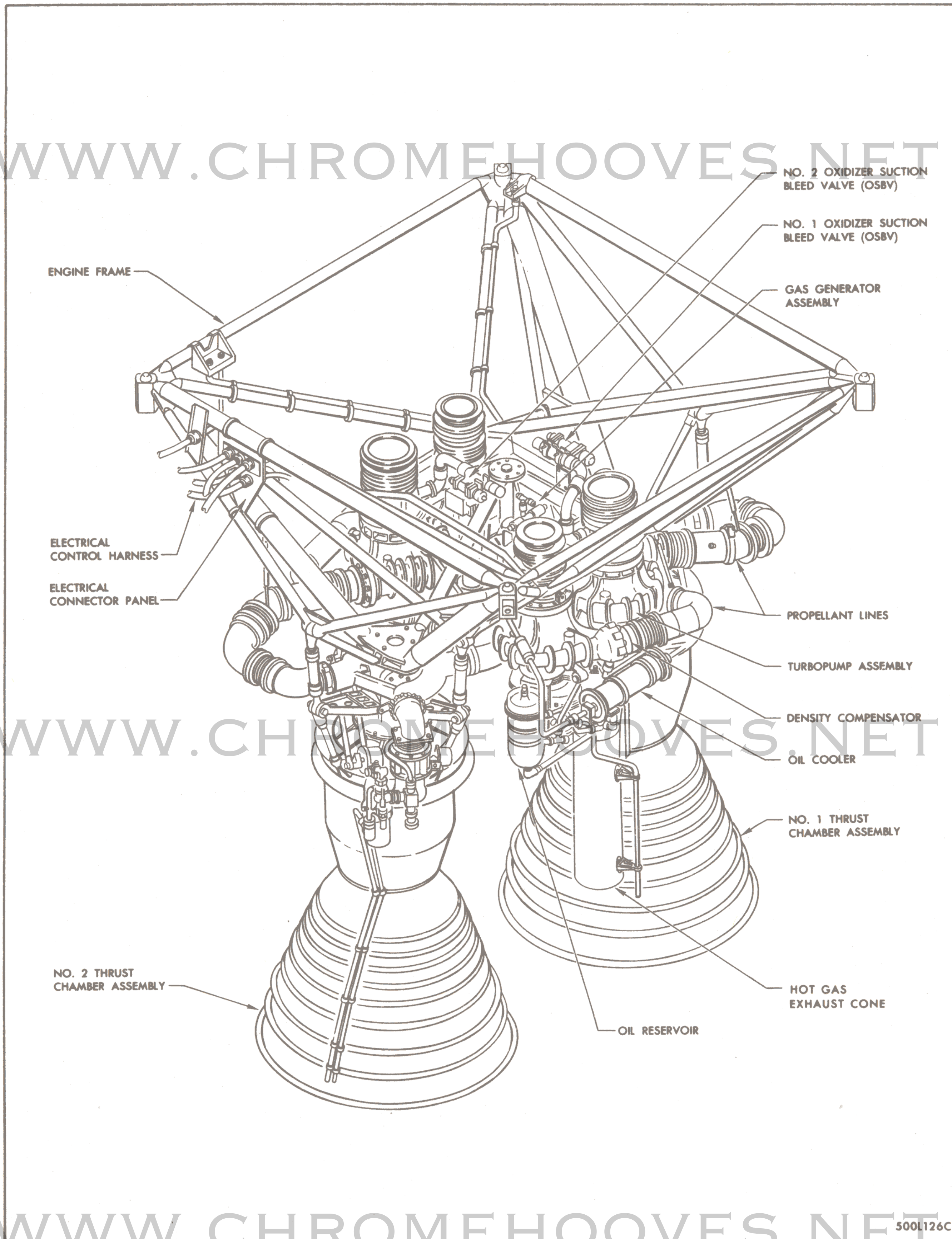


Figure 1-58. Stage I Engine

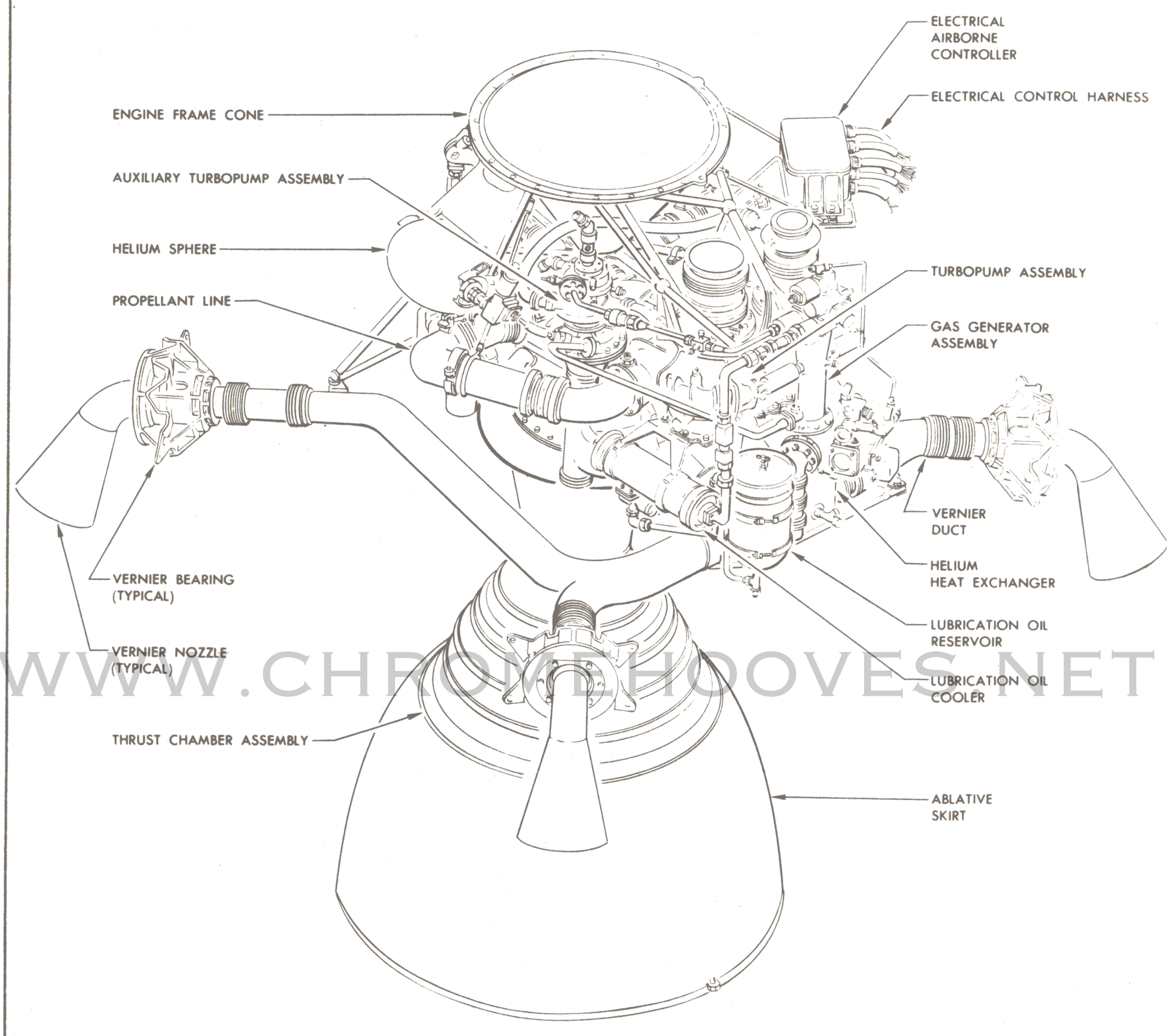


Figure 1-59. Stage II Engine

1-239. GROUND EQUIPMENT. The ground equipment for the engines consists of AOE and aerospace ground equipment (AGE).

1-240. The rocket engine AOE consists of an engine control system (ECS) and engine start equipment. This equipment fires the Stage I engine and arms the Stage II engine upon receipt of proper countdown commands from the launch sequencer. The rocket engine AOE is basically the same for all missiles. Differences will be covered in the text when necessary.

1-241. The ECS is contained in control-monitor group OA-2441 located on Level III of the equipment terminal. The checkout portions of the ECS are used in performing scheduled checkout and maintenance on the engines. The checkout and self check portions of the ECS are completely isolated from the control portion.

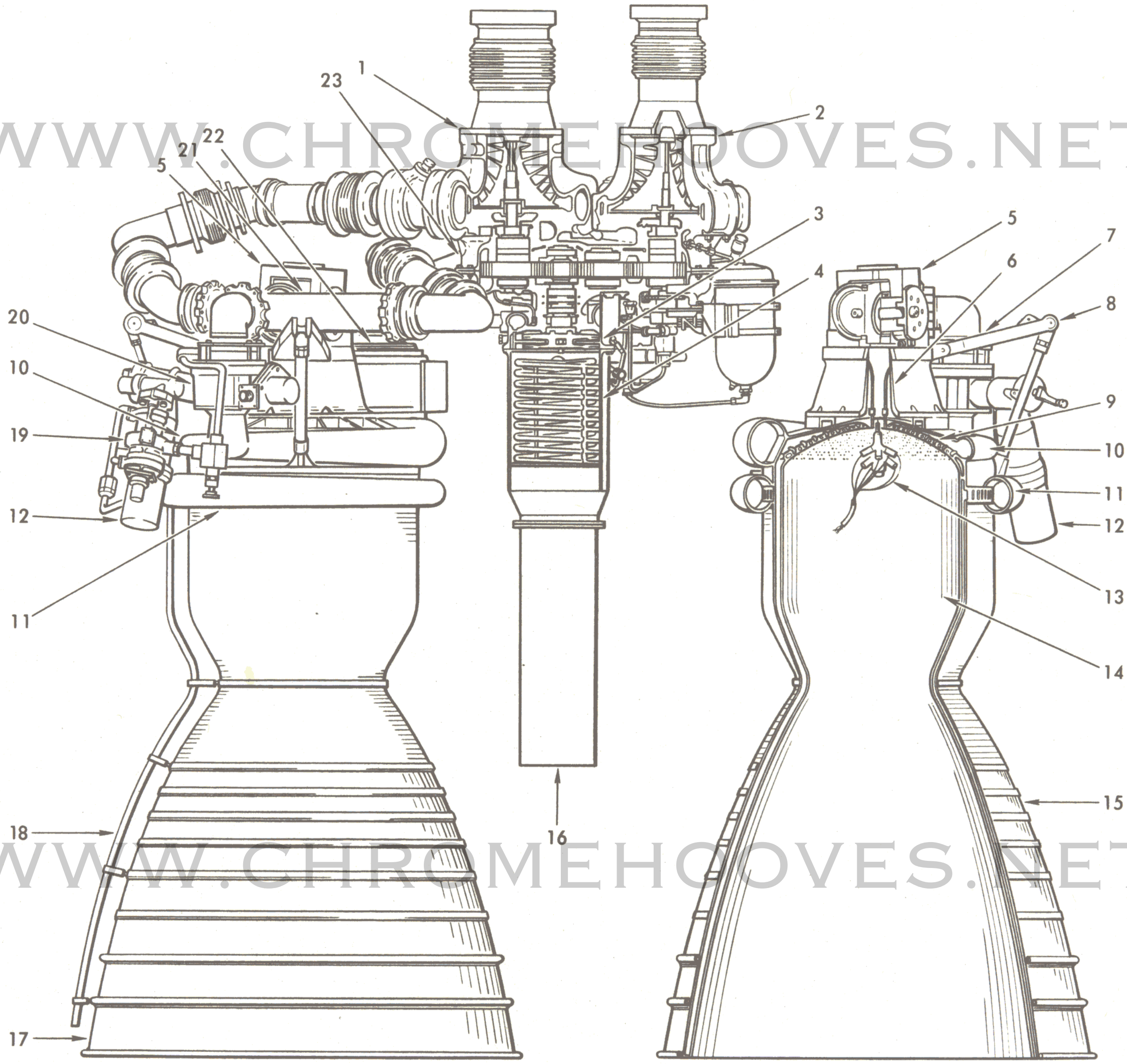
1-242. The engine start equipment is used to initiate operation of the Stage I engine. The start equipment includes two banks of nitrogen K-bottles pressurized to 3000 PSI. There is a 3-way hand valve (CV-505) that provides a capability for selecting either of the two banks before re-servicing becomes necessary. Other components include a nitrogen start valve (SOV 530), and a supply line equipped with a quick disconnect that is connected to the Stage I nitrogen start umbilical (1E1N). When the nitrogen is released by the start valve, the turbine of the turbopump assemblies of the Stage I engine subassemblies are accelerated and drive the turbopump. The flow of nitrogen to the turbines is cut off when the gas generators fire and provide sufficient power to sustain operation of the turbopump assemblies.

1-243. STAGE I ROCKET ENGINE. The Stage I rocket engine, designated LR87-AJ-3, consists of two engine subassemblies. (See figure 1-60.) The two subassemblies develop a total of 300,000 pounds of thrust and are mounted on a common engine frame that transfers the thrust to the missile airframe. The subassemblies are similar and are interconnected by instrumentation and electrical components. The subassemblies are started and shut down simultaneously, and each must reach 77 percent of its rated thrust before the missile is released from the launcher platform. Each engine subassembly includes a thrust chamber assembly, a turbopump assembly (TPA), a gas generator assembly, and propellant lines and valves. One subassembly also contains a helium heat exchanger.

1-244. The turbopump assembly (TPA) in each engine subassembly includes propellant pumps, a hot gas turbine, and lubrication equipment.

1-245. The gas generator assembly generates hot gases to drive the turbopump assembly. The gas generator assembly is bolted to the hot-gas inlet of the turbopump turbine. The gas generator includes a combustion chamber and injector, a valve assembly, and igniters. Two pyrotechnic igniters are used to start the burning of propellants in the combustion chamber.

1-246. The helium heat exchanger is installed on the trubine of the turbopump assembly of engine subassembly number two, and uses hot gases exhausted from the turbine to raise the temperature and expand the helium used to pressurize the propellant tanks. The helium flows from the storage spheres in the Stage I liquid oxygen tanks to the heat exchanger, circulates through a coil of tubing, and flows back to pressurize both propellant tanks of Stage I. The hot gases are exhausted from the heat exchanger through an exhaust duct and add approximately 600 pounds to the engine thrust.



1. LIQUID OXYGEN PUMP
2. FUEL PUMP
3. HOT GAS TURBINE
4. HELIUM HEAT EXCHANGER
5. GIMBAL BEARING ASSEMBLY
6. GIMBAL MOUNT
7. GIMBAL ACTUATION ARM
8. SERVO-ACTUATOR ATTACHMENT
9. INJECTOR
10. LIQUID OXYGEN TORUS
11. FUEL TORUS
12. THRUST CHAMBER VALVE ACTUATOR
13. IGNITER
14. COMBUSTION CHAMBER
15. THRUST CHAMBER NO. 1
16. HOT GAS EXHAUST CONE
17. THRUST CHAMBER NO. 2
18. OVERBOARD DRAIN LINES
19. PRESSURE SEQUENCE VALVE
20. FUEL VALVE
21. PROPELLANT FEEDER MANIFOLD
22. LIQUID OXYGEN VALVE
23. TURBOPUMP ASSEMBLY GEARBOX

Figure 1-60. Stage I Rocket Engine Subassembly

1-247. STAGE II ROCKET ENGINE. The Stage II rocket engine subassembly (figure 1-61), designated LR91-AJ-3, consists of a single thrust chamber assembly and an integrated hot-gas vernier assembly. The thrust chamber operates as the sustainer engine and develops 80,000 pounds of thrust at an altitude of 250,000 feet. The sustainer engine operates after stage separation and accelerates and directs the missile along a programmed trajectory. The verniers provide attitude control during stage separation, roll control during sustainer engine operation, and final trimming control of missile velocity and attitude after sustainer engine shutdown.

1-248. The components that make up the Stage II rocket engine include a thrust chamber assembly, a turbopump assembly (TPA), a gas generator assembly, a hot-gas diversion valve assembly, an auxiliary turbopump assembly (ATPA), vernier components, helium heat exchanger, propellant lines, altitude start components, an airborne controller, and an electrical harness.

1-249. The engine frame is a stainless steel cone with a welded structure of steel tubes. The base of the steel cone is attached to the support structure of the liquid oxygen tank, and the apex of the cone is attached to the thrust chamber assembly. The welded steel tubes support the turbopump and auxiliary turbopump assemblies. Removable rods support the vernier ducts and propellant lines.

1-250. The engine assembly has a thrust chamber assembly which is gimbal mounted and allows directional control of the thrust to provide pitch and yaw control of the missile. The major components of the thrust chamber assembly include a combustion chamber and ablative skirt, an injector, propellant valves, a gimbal assembly, a gimbal manifold and swivel assembly, and an igniter assembly.

1-251. The turbopump assembly (TPA) supplies propellants to the thrust chamber at the flow rates required to develop rated thrust. Incorporated in the turbopump assembly are propellant pumps, a hot-gas turbine, and lubrication equipment.

1-252. The gas generator assembly burns a mixture of liquid oxygen and fuel to develop the hot-gas driving force used by the turbopump assembly, an auxiliary turbopump assembly, vernier components, and a helium heat exchanger. The gas generator assembly consists of a combustion chamber and injector, propellant valves, and igniters.

1-253. The operation of the diversion valve initiates the switching between vernier solo phase and thrust chamber phase during Stage II engine operation. The diversion valve is a three-way poppet valve located at the outlet of the gas generator. The hot gas diversion valve assembly directs hot gas from the gas generator to the turbopump assembly during thrust chamber operation, and by-passes hot gases through the hot-gas bypass line to the helium heat exchanger during vernier solo operation.

1-254. The auxiliary turbopump assembly (ATPA) supplies the gas generator with propellants. The assembly includes an oxidizer pump, a fuel pump, and a hot-gas turbine mounted on a common shaft. The liquid oxygen and fuel pumps are single stage, centrifugal pumps. The housing for the fuel pump forms the main body of the assembly and includes mounting pads, bearing supports, and internal bearing lubrication passages. The turbine is a single stage unit with one rotor and two gas inlets.

1-255. Vernier components include four nozzles, four bearings, and stainless steel hot-gas ducts. The nozzles are placed 90 degrees apart on the outside of the

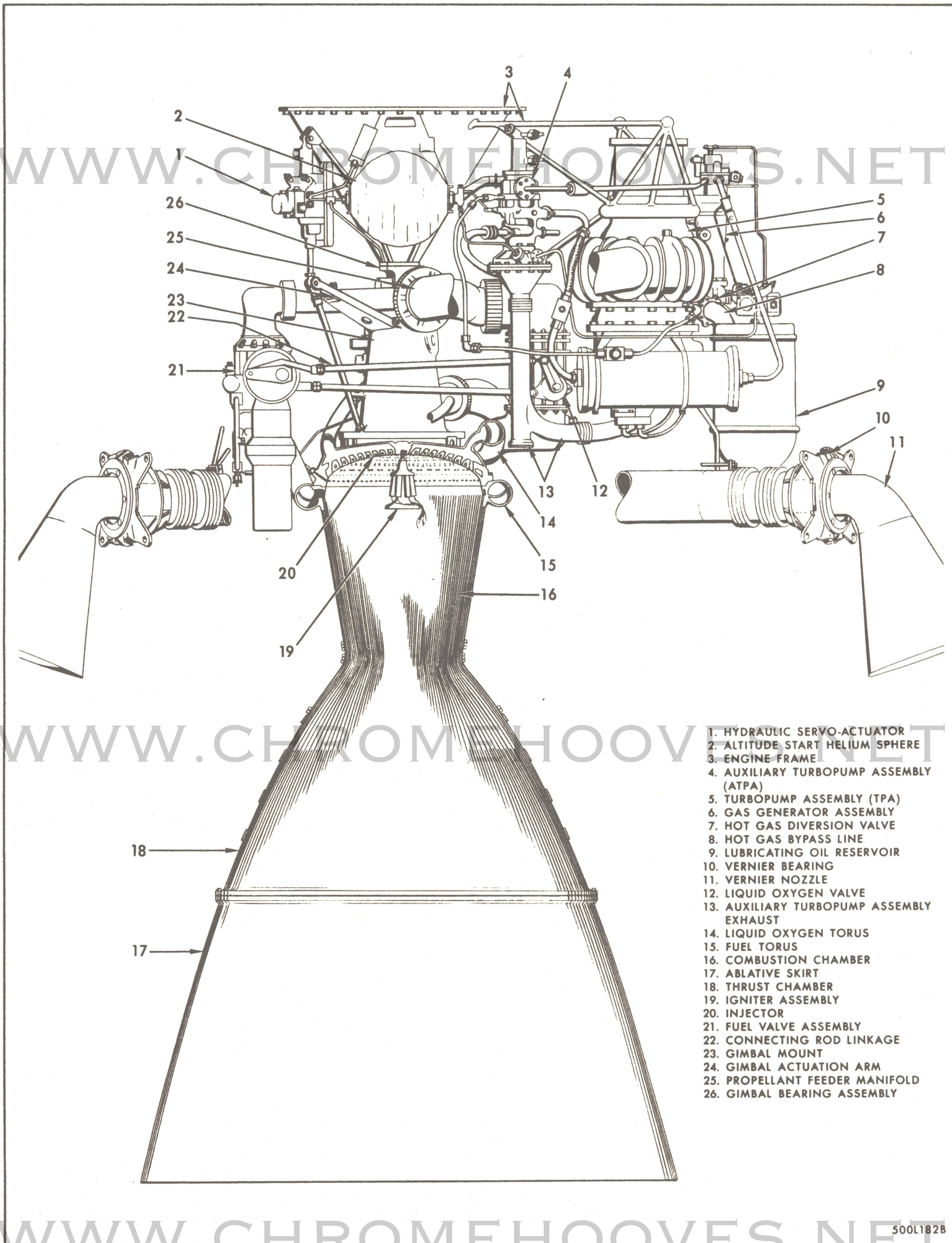


Figure 1-61. Stage II Rocket Engine Subassembly

Stage II engine compartment and are controlled by four hydraulic actuators. The nozzles are fastened to the engine compartment framework by bearings that allow a hydraulic servo-actuator to rotate each nozzle through an arc of 140 degrees. The hot-gas ducts conduct hot gases from the helium heat exchanger to the nozzles. During thrust chamber operation, the hot-gas is used after it is exhausted from the turbopump and auxiliary turbopump assemblies into the helium heat exchanger. During vernier solo operation, the hot-gas from the gas generator passes through the bypass line to the helium heat exchanger.

1-256. The helium heat exchanger is installed in the TPA turbine exhaust duct and uses hot gases exhausted from the turbine, or directly from the gas generator. Operation is the same as Stage I.

1-257. The propellant lines are the discharge and suction lines for both the turbopump assembly and the auxiliary turbopump assembly.

1-258. Altitude start components include a spherical helium start bottle and a start valve. The helium start bottle supplies helium at 3000 PSI. The start valve is installed at the outlet of the helium tank, and is solenoid operated. A helium line routes helium from the start valve to the turbine inlet on the auxiliary turbopump assembly. An electrical signal opens the start valve at the same time that the gas generator pilot valve is opened and the gas generator igniters are energized. The high pressure helium starts the auxiliary turbopump assembly and propellants are admitted to the gas generator and ignited. Hot gases from the generator sustain the operation of the auxiliary turbopump assembly, and the start valve is closed.

1-259. The airborne controller is mounted on the engine frame behind the turbopump assembly and relays electrical signals from AGE and the flight controls auto pilot to sequence and control Stage II engine operation.

1-260. The electrical harness connects the engine electrical components to the controller. The harness is completely enclosed in a molded silicon rubber cover that is highly resistant to fuel, extreme temperatures, and abrasion.

1-261. Checkout and maintenance activities associated with the rocket engine system are performed at control-monitor group OA 2441.

1-262. OPERATION. During countdown, the liquid oxygen tanks of both missile stages are filled and pressurized, and both engines are bled and checked. If both engines, the ground start system, and the other missile systems fulfill the go requirements, the Stage I engine is fired. The missile is released from the launcher when both subassemblies of the Stage I rocket engine reach 77 percent thrust. The engine control system signals the launch sequencer for shutdown if both thrust chambers of the Stage I engine do not reach 77 percent thrust within a specified period of time.

1-263. During the countdown prior to firing the Stage I engine, the final preparations are made to ready the Stage II engine for operation. The engine control system initiates the bleeding of gaseous oxygen from the Stage II engine propellant lines and checks the continuity of the electrical system. The gaseous oxygen bleed of the Stage II engine continues during first stage operation.

1-264. The Stage I engine subassemblies operate independently; however, their starting and shutdown sequences are closely synchronized by the electrical system and the single gas generator valve pilot valve.

1-265. The gas generator valve pilot valve is opened at T-279.9 to bleed actuation fuel into the gas generator valve actuators at static tank pressure. The pilot valve is closed 35 seconds before firing and a nitrogen purge is applied to the liquid oxygen manifold of the gas generator injector through a purge valve. The purge valve closes when the gas generator is started.

1-266. When the fire-switch-one (87FS1) signal is received to start the rocket engine, the ground based nitrogen start valve is opened and the thrust chamber igniters are energized. With the opening of the nitrogen start valve, nitrogen at 3000 PSI enters the turbines of the turbopump assembly to start the propellant pumps rotating to supply the propellants to the thrust chamber.

1-267. The rising fuel pressure from the turbopump assembly positions the thrust chamber valve pressure sequencing valve to the open position, admitting actuation fuel to the actuator. The actuator initiates the opening of the fuel valve and the fuel fills the combustion chamber cooling jacket.

1-268. The connecting rod from the fuel valve opens the oxidizer valve to admit liquid oxygen to the thrust chamber injector. The fuel enters the injector from the combustion chamber cooling jacket. The propellants are sprayed into the combustion chamber and ignited.

1-269. The position switch on the thrust chamber fuel valve assembly is actuated as the fuel valve opens, providing an electrical signal to open the gas generator valve pilot valve and energize the gas generator igniters. The pilot valve admits actuation fuel to the actuator to open the propellant valves. Propellants from the turbopump assembly are admitted to the injector and sprayed into the gas generator combustion chamber where they are ignited.

1-270. The position switch on the gas generator valve assembly is actuated as the valve opens, providing an electrical signal for closing the nitrogen start valve and de-energizing the thrust chamber and gas generator igniters. The hot gases developed by the gas generator continue to accelerate and drive the turbopump assembly. The turbopump assembly supplies propellants to the thrust chamber and gas generator. The rising pressure in the combustion chamber closes the thrust chamber pressure switch to complete the start missile release circuit.

1-271. The hot gas expelled by the gas generator drives the turbopump assembly. The hot gas developed by the thrust chamber provides the thrust for missile lift-off and initial acceleration.

1-272. The hydraulic servo-actuators pivot the thrust chamber to vary the direction of the thrust in accordance with signals received from the flight control system. Directional control of the thrust provides directional and orientation control of the missile.

1-273. The thrust control transducer and amplifier assembly monitors the pressure in the thrust chamber, and signals the gas generator valve control valve when a variation in chamber pressure is detected. The thrust is kept constant by varying the operation of the gas generator to maintain a constant chamber pressure.

1-274. To terminate the operation of the Stage I rocket engine, the fire-switch-two (87FS2) signal is initiated by low level sensors in the propellant tanks. The gas generator valve pilot valve is closed, draining the actuation fuel from the actuator. The propellant valve is closed, terminating the operation of the gas generator.

1-275. The position switch on the gas generator valve assembly is actuated as the gas generator propellant valves close. The position switch provides a signal to the pilot valve on the thrust chamber valve pressure sequencing valve.

1-276. The pilot valve returns the pressure sequencing valve to the closed position, draining the actuation fuel from the actuator. The actuator closes the propellant valves, terminating thrust chamber operation.

1-277. During the countdown (prior to Stage I firing), ground power is supplied to the oxidizer pump bearing heaters (TPA and ATPA) to prevent the lubricant from freezing. When Stage I fires, this heater power is transferred to airborne 28 VDC for missile flight. The auxiliary turbopump assembly and gas generator bleed valves are opened 35 seconds prior to Stage I firing and closed when the Stage I engine fires. The auxiliary turbopump assembly (ATPA) oxidizer suction bleed valve is opened at the start of the countdown launch phase, and will remain open until gas generator operation is initiated.

1-278. The gas generator is started approximately 7 seconds prior to shutdown of Stage I. The gas generator start signal opens the altitude start valve, gas generator pilot valve, and energizes the gas generator igniters. Pressurized helium is released to accelerate the turbine of the auxiliary turbopump assembly. The propellants pressurized by the auxiliary turbopump assembly are sprayed into the combustion chamber of the gas generator and ignited. The hot gases are by-passed the hot-gas diversion valve directly into the helium heat exchanger and exhausted to the vernier. Hot gases are used to sustain operation of the auxiliary turbopump assembly. The verniers operate solo for approximately 4 seconds to provide missile orientation while separation of stages occurs.

1-279. Approximately 11 seconds after the gas generator starts, the thrust chamber-start signal is received. The hot gases are diverted to the turbopump assembly, accelerating the turbopump. The rising fuel pressure opens the thrust chamber propellant valves and propellants are forced into the injector. During the steady-state operation, the verniers provide roll control and the servo-actuators pivot the thrust chamber to compensate for flight path error detected by the missile guidance system. The thrust control transducer and amplifier assembly controls the gas generator control valve to maintain constant thrust.

1-280. With the receipt of the shutdown signal, the hot-gas diversion valve is returned to the bypass position, terminating the turbopump assembly operation. The pilot valve closes and vents actuation fuel, which allows the propellant valves to close, terminating thrust chamber operation. The gas generator and auxiliary turbopump assembly continue to operate and provide vernier thrust for final missile velocity and orientation trimming.

1-281. When the signal for vernier shutdown is received, the gas generator valve pilot valve closes. The actuation fuel is vented, allowing the gas generator propellant valves to close. The gas generator is shut down and this terminates the operation of the auxiliary turbopump assembly and shut down the Stage II rocket engine.

1-282. PROPELLANT SYSTEM.

1-283. The propellant system (figure 1-62) includes ground and airborne equipment. Storage tanks in and adjacent to the propellant terminal contain liquid oxygen, helium, and nitrogen. Fuel is stored in the fuel terminal and is loaded in the

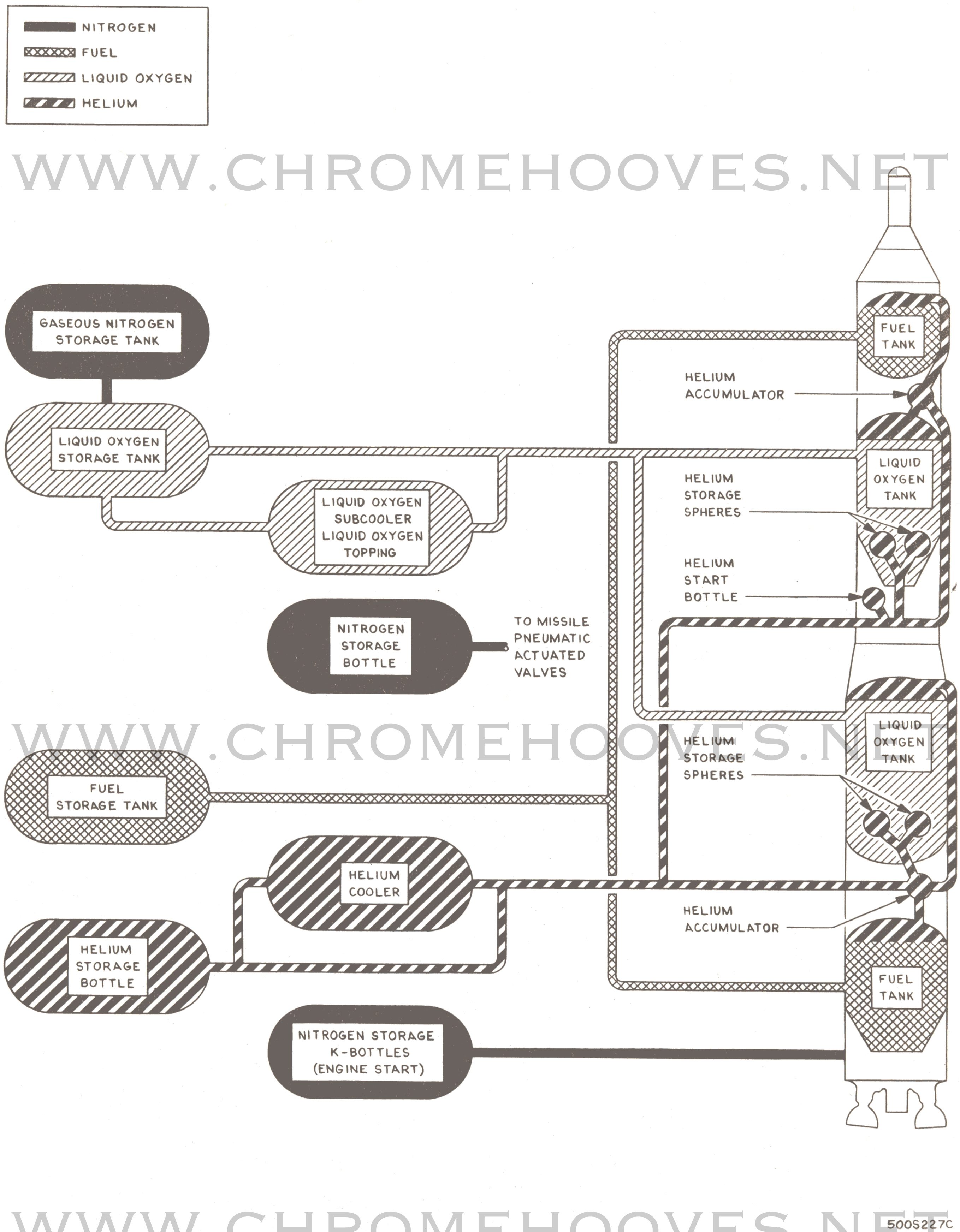


Figure 1-62. Propellant System Flow Diagram

missile fuel tanks during post installation system checkout. During countdown, liquid oxygen and pressurizing gas (helium) are transferred from the propellant terminal to the missile. The propellant system equipment includes features for stopping transfer safely at any time during countdown, for returning the liquid oxygen to the propellant terminal, and for returning fuel to the fuel terminal.

1-284. GROUND EQUIPMENT. The propellant system ground equipment consists of aerospace operating equipment (AOE) and aerospace ground equipment (AGE). The AOE consists of the equipment for handling liquid oxygen, helium, nitrogen, liquid nitrogen and fuel. The AGE consists of a liquid fuel water separator, a recipro cating power-driven compressor, a pumping method liquid oxygen-liquid nitrogen converter, a specimen examining ultraviolet light, a dew point indicator, and a liquid dispensing portable tank and converter unit.

1-285. LIQUID OXYGEN HANDLING EQUIPMENT. The liquid oxygen storage tank is a doubled-walled fabricated pressure vessel consisting of a stainless steel inner cylinder within a carbon steel outer cylinder. The annular space between the inner and outer tank walls is packed with insulation and the air is evacuated by a vacuum pump. Taps provided on the tank permit the measurement of the liquid and the ullage pressure.

1-286. Liquid oxygen catchpots are provided to catch spillage during transfer operations. The catchpots are closed stainless steel vessels located below and connected to the umbilical line drain connections. Before the umbilical lines are disconnected from the missile, their contents are drained into the catchpots so that spills will be eliminated during umbilical line retraction.

1-287. A liquid oxygen subcooler supplies a flow of subcooled liquid oxygen for topping operations. The subcooler consists of a doubled-walled tank having heat transfer coils inside the inner tank. A vacuum pump mounted on the tank maintains the vacuum in the annular space.

1-288. Transfer of liquid oxygen from the storage tank to the missile is accomplished by using nitrogen gas pressure to force the liquid oxygen through the transfer components and piping to the missile. The transfer piping to the Stage I and Stage II liquid oxygen tanks is sized so that transfer operations are completed at approximately the same time. The missile liquid oxygen tanks are unloaded through the Stage I liquid oxygen transfer piping by means of a pump located near the base of the missile silo.

1-289. HELIUM HANDLING EQUIPMENT. The helium handling equipment consists of helium storage tanks and a helium cooler. This equipment provides helium to pressurize the helium storage spheres located within the missile liquid oxygen tanks, and to pressurize the missile fuel and liquid oxygen tanks during and after elevation of the missile. During flight, helium pressure is applied from the helium spheres to operate the lox and fuel tank vent-relief valves.

1-290. The helium cooler consists of a doubled-walled tank with heat transfer coils inside the inner tank. The insulating annular space between the two tanks is evacuated, and a pump maintains the required vacuum. The cooler contains liquid nitrogen for lowering the temperature of the gaseous helium before it enters the missile helium storage spheres.

1-291. NITROGEN HANDLING EQUIPMENT. Nitrogen handling equipment consists of five high pressure nitrogen tanks. One storage tank (T502) supplies nitrogen gas pressure for the unloading of liquid nitrogen from the helium cooler, purging of the missile fuel tanks, and for blanketing the missile helium, lox, and fuel tanks during standby. One storage tank (T503) supplies nitrogen gas for the operation of leak detection and leak test equipment. One storage tank supplies nitrogen gas pressure for the pneumatically operated airborne valves prior to launch. One storage tank (T505) supplies nitrogen gas for purging of the missile liquid oxygen tanks after liquid oxygen has been unloaded. The same tank supplies nitrogen pressure for the blanketing of the liquid oxygen fill-drain transfer and topping lines, and for the pressure unloading of liquid nitrogen from the liquid oxygen subcooler. One storage tank (T301A,B,C) supplies nitrogen pressure for transferring liquid oxygen from the propellant terminal liquid oxygen tank (T201) to the missile liquid oxygen tanks.

1-292. FUEL HANDLING EQUIPMENT. The fuel terminal components include the storage tanks (nitrogen T510, RP1T110), and necessary lines and valves required to perform fueling operations. The tank and lines are blanketed with low-pressure nitrogen, which minimizes explosion hazards and excludes air and moisture. A fuel transfer pump, located in the central fuel storage access room, is controlled from the fuel transfer panel. Totalizing flowmeters register the transfer of the fuel and prevent overfilling of the missile fuel tanks. Fuel unloading and line drain pumps, located in each missile silo, are used for unloading fuel from the missile and for draining fuel lines.

1-293. CONTROL AND CHECKOUT EQUIPMENT. The propellant system AOE is controlled and checked out by control-monitor group OA-2440 located on Level III of the equipment terminal. The master launch and checkout assembly (6A2) performs readiness checkout, selects modes of system operation, and controls emergency unloading operations. The functions of the other propellant system control and checkout assemblies, located within control monitor group OA-2440, are listed in figure 1-63. Valve position pushbutton indicators are located on the panels of the assemblies. These indicators have the letters C and O engraved in them. The letters, in combination with colored lamps under the translucent indicator face, indicate valve positions.

1-294. AIRBORNE EQUIPMENT. During missile flight, liquid oxygen and fuel are supplied to the rocket engines by the airborne propellant equipment. Both stages rely upon pressurized tanks (fuel and liquid oxygen) and turbopump assemblies for the transfer of propellants. The propellant tanks are pressurized by helium gas from the helium storage spheres in the liquid oxygen tanks. The helium passes through the helium heat exchangers on the rocket engines; then, it passes through the primary regulators, accumulators, and secondary regulators into the propellant tanks.

1-295. STAGE I PROPELLANT EQUIPMENT. The Stage I propellant equipment includes a liquid oxygen tank, a liquid oxygen tank vent-relief valve, a liquid oxygen tank secondary regulator, a liquid oxygen high level sensor, a liquid oxygen fill-drain line and quick disconnect, a liquid oxygen tank pressure switch, two helium storage spheres, a helium accumulator and related components, a helium fill line and quick disconnect, a fuel tank, a fill-drain disconnect, a fuel tank secondary regulator, a fuel tank pressure switch, a fuel tank vent-relief valve, two fuel storage shutoff valves, and a gaseous nitrogen ground start line and quick disconnect.

1-296. STAGE II PROPELLANT EQUIPMENT. The Stage II propellant equipment is comprised of a liquid oxygen tank, two liquid oxygen tank vent-relief valves, a liquid oxygen tank secondary regulator, a liquid oxygen high level sensor, a liquid oxygen fill-drain line and quick disconnect, a liquid oxygen tank pressure switch, a

CHASSIS	FUNCTION
Missile fuel load and launch assembly 5A1	Enables the facility fuel control unit to load and unload fuel from the missile, monitors the fuel system airborne valves, and performs automatic checkout of fuel system airborne valves.
Facility liquid oxygen checkout assembly 5A2	Monitors liquid oxygen system facilities components.
Missile liquid oxygen checkout assembly 5A3	Performs automatic checkout of the liquid oxygen system, and monitors the liquid oxygen system airborne valves.
Missile liquid oxygen launch control assembly 5A7	Contains circuit components for the liquid oxygen checkout assembly 5A3.
Facility liquid oxygen control launch assembly 5A8	Contains circuit components for facility liquid oxygen checkout assembly 5A2.
Propellant quantity monitor assembly 6A1	Contains indicators to read out percent of desired level of liquid oxygen for Stage I and Stage II.
Master launch and checkout assembly 6A2	Serves as the master control panel for the propellant system AGE, selects mode of system checkout, performs readiness checkout, and controls emergency unloading operations.
Gas launch and checkout assembly 6A3	Performs automatic checkout of the helium and nitrogen systems and monitors the helium and nitrogen systems facility and airborne valves.
Propellant quantity control checkout assembly 6A4	Checks the operation of Stage I liquid oxygen propellant quantity control assembly 6A7 and Stage II liquid oxygen propellant quantity control assembly 6A8.

Figure 1-63. Table of Propellant System Control Assemblies

helium storage sphere, a helium accumulator and related components, a helium fill line and quick disconnect, an ATPA liquid oxygen container, a fuel tank, a fuel fill-drain quick disconnect, a fuel tank secondary regulator, a fuel tank pressure switch, a fuel tank vent-relief valve, a fuel storage shutoff valve, and a 3-way valve.

1-297. OPERATION. During alert status monitoring the PLPS monitors the missile vent valves, and fill and drain valves for preset condition; and that CV-537, CV-607, and CV-608 are not closed. When the countdown is initiated the PLPS automatically controls the loading of liquid oxygen and helium aboard the missile by controlling the applicable valves throughout the launcher area and within the missile. In the event of an abort the PLPS automatically returns the missile and propellant loading valves to a safe condition. After shutdown, missile helium and lox unloading is initiated manually at the appropriate pushbutton indicator and controlled automatically by the PLPS logic circuits.

1-298. FUEL TRANSFER. The transfer of fuel to the missile fuel tanks is a manual operation and is controlled at the fuel transfer panel and assembly 5A1 in control-monitor group 2440. For simplicity of control and safety of operation, the two missile stages are loaded sequentially rather than simultaneously. Flowmeters, one mounted at the end of each fill line, monitor the flow of fuel. The flowmeter will automatically shut off the fuel flow when the missile fuel tanks are full. The pump is stopped manually by a pushbutton at the fuel transfer panel or automatically upon the closing of the flowmeter. When fuel transfer operations are complete, the fuel system is manually returned to the standby condition.

1-299. LIQUID OXYGEN TRANSFER. The missile liquid oxygen tanks are filled automatically during launch operations. When a start-propellant-loading signal is received, the propellant system AOE automatically operates remote-controlled valves to start liquid oxygen loading. Liquid oxygen is transferred to the missile by pressurizing the liquid oxygen storage tank with nitrogen. Some liquid oxygen is routed into the fill lines to reduce boil-off of liquid oxygen as it is transferred. During lox loading subcooled liquid oxygen is routed into the tanks at a topping flow rate to balance boil-off and maintain the liquid oxygen tanks at a specific level.

1-300. HELIUM TRANSFER. Helium is transferred to the missile automatically during launch operations. The helium storage cylinder pressure regulating valve and the cold line valve open to let helium flow through the helium cooler, the line filter, and the umbilical connections to the airborne helium storage spheres. The helium storage spheres are charged to a pressure of 3100 PSI. The cold helium supply is maintained until the stop-topping signal is received. At that point, the cold line valve closes, the warm line end valve opens, and uncooled helium at 3100 PSI is transferred directly to the missile for propellant tank pressurization. The warm line valve and the transfer pressure regulating valve close when the start-Stage-I-engine signal is received.

1-301. PNEUMATIC OPERATION. Compressed air from the facility instrument air supply system is used to operate facility components. Nitrogen gas pressure is supplied to the missile during countdown to actuate pneumatic valves and umbilical disconnects and to purge the missile gas generator valve just prior to engine firing. The flow of gas is automatically controlled by flow control and pressure regulating valves.

1-302. MISSILE LAUNCHER SYSTEM.

1-303. The launcher system provides structural support for the missile during launching, positions the missile in a launch (soft) or static (hard) configuration, and positions the support equipment for launch or checkout. In addition, the launcher system supplies propellants, liquid nitrogen, and helium to the missile during countdown, transmits electrical and hydraulic power to the missile, provides protection for personnel and equipment from environmental conditions and nuclear attack, and incorporates monitoring checkout equipment.

1-304. SILO DOOR INSTALLATIONS. The silo doors provide access to the silo for missile emplacement and protect the silo equipment from environmental conditions and nuclear blast. The doors are electrically controlled and hydraulically actuated. Automatic operation is sequenced, controlled, and checked out by the launcher logic circuitry. The doors may be operated locally for maintenance and checkout at the tunnel entrance control station.

1-305. When the doors are closed, the upper door lip overlaps the lower door lip. This overlapping, together with the compression of the environmental seal around the edges of the doors, provides environmental protection for the silo.

1-306. Two hydraulic actuator cylinders operate the silo doors. Each cylinder is mounted on a pivot bracket located on the door foundation.

1-307. SILO DOOR FOUNDATION FITTING INSTALLATION. The silo door foundation fitting installation consists primarily of the breakaway cylinders and hinge coverplates.

1-308. The breakaway cylinders are installed in recesses in the door foundation. There are two cylinders for each door. The breakaway cylinders help raise the doors in the initial stages of the opening cycle and also help overcome loads caused by ice or debris.

1-309. SILO DOOR HYDRAULIC SYSTEM. The power pack supplies hydraulic pressure to the actuator and breakaway cylinders. Manual shutoff valves are located at various points on the supply lines to permit total or partial isolation of the supply system for trouble analysis and maintenance. The hydraulic circuit for both doors is the same. The system operates on 3000 PSI on the pressure side and 75 PSI on the return side.

1-310. CRIB STRUCTURE AND ASSOCIATED EQUIPMENT. The crib structure and associated equipment provide a rigid connection between the launcher platform, and the door foundation and the missile silo during the launch sequence. When the launcher system is hard, the crib structure is flexibly suspended to protect the missile from ground shock.

1-311. The crib structure is a steel framework mounted vertically within the missile silo. The crib structure consists of three main components: top support members, crib sections, and crib base.

1-312. The crib suspension and locking mechanisms lock the crib in a level position during tactical exercise, missile emplacement, and maintenance. When the silo is soft and the launcher platform is to be raised, the crib locks secure the crib rigidly in place to provide a stable platform for moving the launcher platform and launching the missile. The crib suspension and locking mechanisms contain the spring assemblies, crib locks, and all the electrical and hydraulic equipment that control and operate the crib locks.

1-313. LAUNCHER PLATFORM AND ASSOCIATED EQUIPMENT. The launcher platform and associated equipment consist of the following major units: the launcher platform assembly, the launcher platform drive power unit, and the launcher platform counterweight assembly. Each assists in raising or lowering the missile for launcher maintenance, exercise, or launch.

1-314. The launcher platform assembly supports the missile in the silo, and carries and supports the missile during ascent to the launch position. When the system is in the hard condition, the launcher platform assembly is held in position by its own weight and by that of the missile. The launcher platform assembly consists of the following major components: launcher platform-to-crib locks and seals, missile support installation, idler pulleys, flame deflectors, flame deflector extension, flame deflector safety net, flame shielding, guide rollers, service platforms and guard rails, water spray, and a base for the umbilical tower.

1-315. Four vertical and four lateral load locks secure the launcher platform to the crib when the launcher platform has reached the upper end of its travel. The locks absorb wind loads and engine thrust, and help support the weight of the launcher platform and fueled missile.

1-316. Each vertical load lock consists of a T-shaped locking key, a hydraulic motor, and a worm gear assembly. When the actuator motor is energized, the worm gear assembly rotates the locking key to engage two lugs mounted on the crib.

1-317. Each lateral load lock consists of wedge blocks and hydraulic cylinders. When energized, the cylinders pull the wedges vertically against stationary wedges on the launcher platform, completing the locking cycle.

1-318. When the launcher platform is raised to the launch position, the seals shield the gap between the launcher platform and crib and between the crib and silo.

1-319. Three sections guard against the entrance of exhaust gases, water, and propellants to the crib area. The launcher platform is sealed by a horizontal deck located directly under the flame deflector. The deck is pitched slightly from center to permit liquid run-off. A flange mounted at the outer edge of the deck mates with a compression seal when the flange is engaged.

1-320. The area between the launcher platform and the crib is sealed by the crib deck. The crib deck is mounted to the top of the crib and contains the flange with a strip of silicone sponge rubber on its outer edge. The flange on the deck meets the flange on the launcher platform, forming a compression seal. Also located on the crib deck are two clearance areas for the closure door cylinders. These act as sumps and contain drains to carry liquids away. The pitch of the crib deck guides the liquid to the sumps.

1-321. The area between the top of the crib and the bottom of the door foundation is sealed by a silicone rubberized glass fabric which is secured to the outer edge of the crib supports and to the outer edge of the door foundation opening. The gasket is flexible and can withstand ground shock.

1-322. The support installation consists of four A-shaped support assemblies with a missile release mechanism mounted on each support assembly. To permit missile emplacement, the missile release mechanism hold-down arm is removed. Once the missile is emplaced the hold-down arm is installed and tightened against the missile longeron fittings. During the launch cycle, the explosive bolts mounted on the missile release mechanism free the hold-down arm, permitting the missile to rise from the support assemblies.

1-323. A screw and spring mechanism extends the supports during missile emplacement and retracts them at missile lift-off. The retract mechanism contains lead washers that absorb the shock of support retraction.

1-324. An idler pulley assembly includes support and guard brackets, support blocks, a pulley, and an idler shaft and bearing. The idler pulleys, located at each bottom corner of the launcher platform, guide the wire rope cables (part of the drive mechanism) under and around the launcher platform. Each pulley has five grooves, one for each wire rope. A guard bracket prevents the wire ropes from slipping out of the grooves.

1-325. When the Stage I engines fire, the flame deflector acts as a scoop to direct the exhaust flames and gases horizontally.

1-326. The flame deflector extension prevents fuel, liquid oxygen, and water from entering the gap between the flame deflector and the ground line concrete. The deflector extension and retraction mechanisms are hydraulically actuated.

1-327. The flame shielding includes the launcher platform flame shielding and the tower base shielding. The launcher platform shielding consists of flame plates, shields, and supports mounted on the platform structure. It protects the launcher platform and structurally-mounted equipment from the effects of Stage I engine exhaust. The tower base flame shielding consists of a plate and bracket arrangement mounted on the umbilical tower base. The flame shielding extends from approximately 1 foot above the top of the launcher platform to 17 feet above the top of the launcher platform. The flame shielding protects the tower base from Stage I exhaust.

1-328. The safety net is built of a flexible, non-combustible material. It is secured to the pedestals by safety snap hooks and vibration-proof plate rings. The safety net may be removed to provide access to the Stage I engines from the flame deflector.

1-329. The water spray equipment (figure 1-64) consists of the flame deflector spray, engine compartment spray, and associated nozzles.

1-330. The flame deflector spray cools the flame deflector before the descent of the launcher platform and prevents damage to wiring and other components. The manifold, which contains nozzles and orifices, spans the width of the flame deflector.

1-331. The engine compartment spray cools the Stage I engines compartment in the event of an abort after engine firing before lift-off. The spray manifold is on a plane immediately above the engine exhaust and is protected by the flame shielding.

1-332. Both the engine compartment and the flame deflector spray manifold with their associated piping, fittings, and valves are secured to the launcher platform structure. Both manifolds are connected to a common water supply by a coupling, consisting of two self-aligning halves. The mechanism also includes an automatic valve which automatically turns the flow of water on or off. The service disconnect automatically engages and disengages with the raising and lowering of the launcher platform.

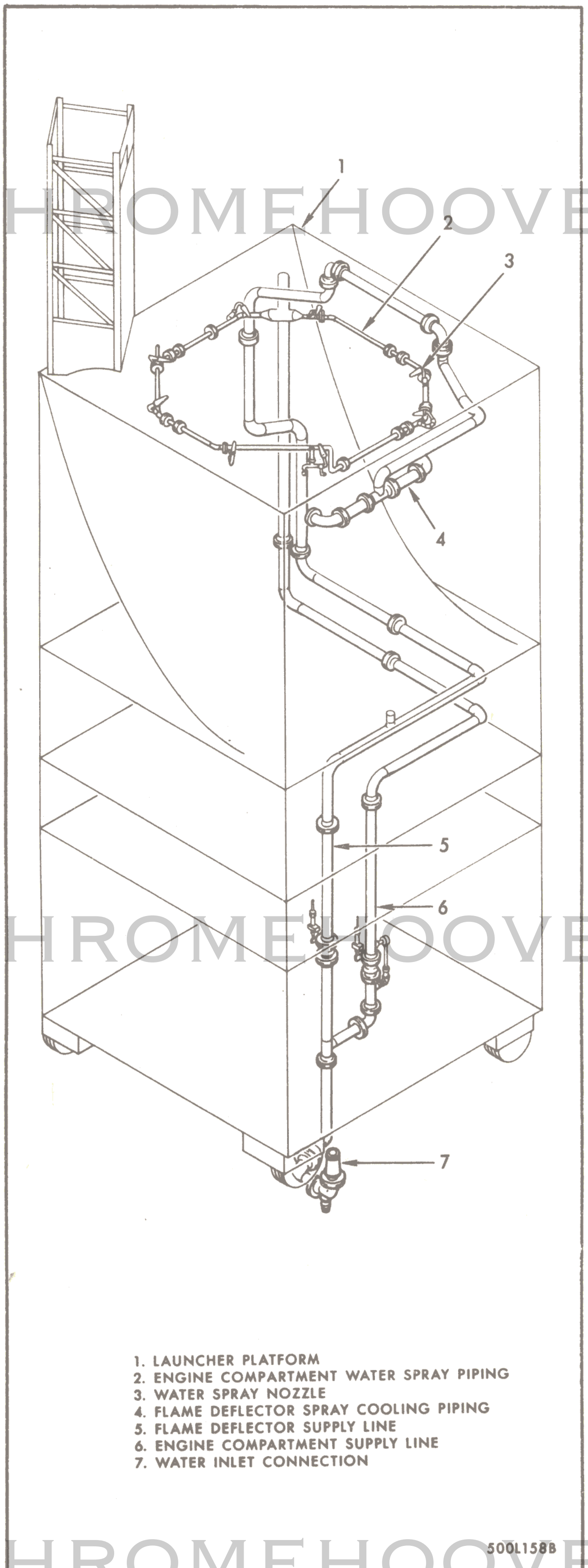


Figure 1-64. Water Spray Equipment

1-333. The guide roller assemblies enable the launcher platform to raise or lower smoothly, counteracting any forces due to wind, sheave friction, or center of gravity eccentricity. The assemblies consist of four large and one small guide rollers. They are mounted on the launcher platform structure. Both large and small guide roller assemblies consist of a mounting bracket, two guide roller shafts, two spherical roller bearings, and various bearing and shaft retainers.

1-334. RE-ENTRY VEHICLE SYSTEM.

1-335. The Mark 4 re-entry vehicle system consists of a re-entry vehicle and its associated ground equipment. The re-entry vehicle is connected to the ground equipment through the missile electrical cabling and connectors (interfaces).

1-336. The external contour of the re-entry vehicle is designed so that an aerodynamic righting moment occurs at the start of the re-entry regardless of the angle of attack. Spin fins impart a rotating moment to the vehicle to maintain the desired trajectory. The external surface of the re-entry vehicle is covered with an ablative type heat shielding material.

1-337. The re-entry vehicle houses the missile payload, protects it during re-entry into the atmosphere, fuses and arms the warhead, and transports the payload to the target area during the final portion of flight. The structure consists of a nose section, center section, and after section. Functional systems include a separation system and an arming-fuzing system. Prearming of the warhead occurs at a predetermined position during flight upon receipt of a signal from the ground guidance system.

1-338. The re-entry vehicle is held in place on the second stage airframe by tension applied through the separation mechanism to a tension cone. The cone firmly grasps the flare of the re-entry vehicle and provides for electrical interface with the missile airframe. When the separation command is received the separation mechanism releases the tension on the cone, causing it to spring apart and free the re-entry vehicle. The electrical interface is broken at this time.

1-339. GROUND EQUIPMENT. The re-entry vehicle ground equipment consists of aerospace operating equipment (AOE) and aerospace ground equipment (AGE). The AOE is used to program re-entry vehicle operation and to monitor re-entry vehicle operational readiness. The re-entry vehicle AGE includes both mechanical and electrical equipment. The mechanical equipment is used to handle components of the re-entry vehicle during transport, assembly, checkout, disassembly, and installation. The electrical equipment is used to check out the components of the re-entry vehicle during assembly and installation.

1-340. The re-entry vehicle aerospace operating equipment (AOE) sets the airburst switch in the re-entry vehicle for the programmed burst altitude and to establish airburst range. The AOE also monitors the ready or fault status of selected circuits within the re-entry vehicle system.

1-341. The AOE is mounted in one rack of control-monitor group OA-2440 located on Level III of each equipment terminal. This rack contains five AOE assemblies, three blank assemblies, and a blower assembly for cooling the operative assemblies.

1-342. The five AOE assemblies include a control indicator, a monitor indicator, a self-test indicator, a fuze-set programmer, and a digital-to-decimal converter. The five assemblies operate as a unit; each one is dependent on the other four assemblies for normal performance of its specific functions. The equipment has self-test capability for isolating malfunctions to the assembly level.

1-343. The burst selection function of the AOE selects groundburst and airburst in the re-entry vehicle and, if airburst, selects a burst altitude and range. The signals that actuate the fuze-setting mechanism of the re-entry vehicle originate from the target control system of control-monitor group OA 2439 in the control center and are transmitted to the AOE in the equipment terminal. There are no provisions in the AOE for introducing a fuze-setting signal other than through the launch control system. The signals transmitted from the target control system are in modified digital form. Appropriate circuits in the AOE convert the digital input to the decimal form that can be used by the re-entry vehicle for setting the airburst switch.

1-344. The monitoring function of the AOE includes monitoring the continuity of safety circuits within the re-entry vehicle. Continuity within the safety circuits results in a go (ready) indication appearing in the appropriate re-entry vehicle indicators. The fuze setting is monitored during the fuze-setting operation and is a representation of the chronological order of the setting procedure and the continued integrity of the fuze-setting circuit. These monitors function during both the readiness checkout and countdown.

1-345. The monitoring and burst-setting circuits of the re-entry vehicle AOE are provided with self-test circuits. Self-testing is divided into two related operations. The first is a functional test in which the fuze setting mechanism is exercised and the second is a fault recognition test in which simulated fault conditions are introduced into the circuits. An associated panel light identifies the assembly in which a fault condition exists.

1-346. LAUNCH SEQUENCER.

1-347. The launch sequencer contains four launch control and status system assemblies. They are the launch sequential timer assembly, launch sequence controller assemblies number 1 and 2, and the launch sequencer filter assembly. The launch sequencer controls, sequences, and monitors the related systems during launch countdown, exercise, and shutdown operations. It monitors the maximum time allowed for the above operations, the go/no-go status of the associated missile and facility, and controls the lower launcher operation. Detailed operation of the assemblies is classified and can be found in the launch control and status system function manual, T.O. 21-SM68-2J-15-1 or T.O. 21-SM68-2J-15-2.

1-348. CONTROL CENTER CIRCUITS.

1-349. The control center circuits consist of circuit assemblies in control-monitor group OA-2439. The assemblies function as a unit to distribute signals between equipment in the control center and equipment in other parts of the launch complex. Command and status signals generated by the functional systems at each of the three missile launchers, the facility damage control system, and the ground guidance station are distributed by the control center circuits to the corresponding indicators on the panels of the launch control console and the launch complex facilities console. The control center circuits include the logic circuitry for isolation of signals from the ground guidance station, for the interlock of the launcher raising and lowering sequence for each of the three missile launchers, for control of the manual missile and facility no-go signal from the facilities console to the corresponding missile launcher, and for the actuation of the hazard-alert buzzer in the facilities console.

1-350. The control center circuit assemblies consist of three control center circuits launcher assemblies (designated as 1, 2, and 3) and a control center circuits common assembly.

1-351. Control monitor group OA-2439 contains a control center circuit hazard warning assembly in addition to the other control center circuits assemblies. The control center circuits hazard warning assembly receives signals from the LCFC. The assembly sends signals to the facility above ground hazard lights to change color for appropriate above ground hazard conditions. It also sends coded signals to the facility warning horns located above ground and lights the respective indicators on the LCFC.

1-352. CONTROL CENTER CIRCUITS LAUNCHER ASSEMBLY. The control center circuits launcher assembly controls the energizing and de-energizing of the indicators on the launch console and on the facilities console in accordance with the status signals generated by the three control-monitor groups at each equipment terminal, the ground guidance station, and the launch complex damage control system. Command and status signals generated by the functional systems at each of the three missile launchers, the facility damage control system, and the ground guidance station are distributed by the control center circuits to the corresponding indicators on the panels of the LCC and the LCFC. The control center circuits also control the manual missile and facility no-go signal from the facilities console to the corresponding missile launcher, and control actuation of the facilities console hazard alert buzzer.

1-353. CONTROL CENTER CIRCUITS COMMON ASSEMBLY. The control center circuits common assembly contains the interlock circuits that prevent raising and lowering of more than one launcher platform at a given time. This assembly also distributes ground guidance no-go, handover, not-ready, loop-check complete, and in-progress signals between the launch control and status equipment in the control center and the launch sequencer in the equipment terminal and ground guidance station.

1-354. The control center circuits common assembly is equipped with pushbutton indicators and selector switches that display, select, and initiate a system checkout for each vital circuit of the launch control and status equipment. The vital circuits include circuitry which inter-changes information between the launchers and circuitry which applies launch sequence information to the ground guidance system during countdown. In addition to initiating system checkout of the vital control center circuits, the pushbutton indicators provide go/no-go displays of the status of the vital control center circuits for each missile launcher.

1-355. TARGET CONTROL. The target control in control-monitor group OA-2439 consists of three target card reader and logic assemblies (one for each missile launcher). These assemblies receive target selection signals from the launch console. Each assembly consists of a card reader and logic circuits that select, read out, and verify (by coded punch-hole type cards) the target information for the reentry vehicle AOE. The target information contained on the card must be compatible with the target information in the guidance system. The three target card reader and logic assemblies are identical, and each assembly is supplied with three target cards. The cards are color coded blue, white, or yellow for association with missiles in launchers 1, 2, and 3 and target card reader and logic assemblies 1, 2, and 3 respectively. A corresponding color strip identifies target card reader and logic assembly and the associated target selector knob on the launch console. A target card is inserted in each of the three card readers, which are located on the front panel of the assembly. The target card is locked in place by pressing a PUSH TO CLOSE pushbutton actuator on the front of each card reader. Pressing the actuator also closes electrical contacts to complete the necessary circuitry for targeting control. When the proper target card is inserted correctly and locked, the card status indicator for that card lights green. The card status indicator lights red if a card is inserted improperly. White lamps behind the target cards light when the corresponding target is selected from the launch console. A spring-loaded key lock is provided to unlock each PUSH TO CLOSE pushbutton actuator for removal of the target cards.

1-356. CONTROL CENTER POWER SUPPLY. The control center power supply in control-monitor group OA-2439 consists of three assemblies that function as a unit to develop 28 VDC power. The 28 VDC power is provided for launch control and status system equipment in control room 2 (VAFB); indicator lamp verification circuits of launch consoles and facilities consoles; checkout of control center circuits; launch complex damage control system sensors, logic circuits, and associated equipment; and for contact closure signals from the guidance equipment to its corresponding control and checkout equipment. The three assemblies that make up the control center power supply include a 28 VDC power supply, a 28 VDC standby battery, and a power control assembly.

1-357. 28 VDC POWER SUPPLY ASSEMBLY. The 28 VDC power supply assembly is a transformer-rectifier power supply that converts 115 V, 60 CPS, 3-phase power to 28 VDC power. A temperature sensing device to detect overheating is included in the power supply assembly.

1-358. 28 VDC STANDBY BATTERY ASSEMBLY. The 28 VDC standby battery assembly serves as a source for 28 VDC power if a failure occurs in the 28 VDC power supply assembly. The standby battery assembly includes a sensing circuit, a nickel cadmium storage battery, and a battery charger.

1-359. The sensing circuit controls the application of voltage from the 28 VDC power supply assembly to the load bus. The sensing circuit transfers the load from the power supply assembly to the standby battery assembly when the sensing circuit detects a failure or out of tolerance condition in the power supply assembly output voltage. The power supply assembly DC output is out of tolerance when it is less than 27.5 V or more than 32.5 V.

1-360. The nickel cadmium storage battery is a chargeable storage battery that is capable of withstanding a minimum of 100 cycles of charge and discharge. The battery supplies the load bus with an output of from 27 V to 30 VDC at 25 amperes for 30 minutes. A BATTERY OUTPUT circuit breaker on the front of the standby battery assembly protects the battery from overloads.

1-361. The battery charger maintains the nickel cadmium storage battery in a fully charge condition when the battery is not connected to the load bus. The charger can fully charge a discharged battery in 8 hours. The rate of charge is controlled to maintain the battery in a non-gassing condition. A STORE-USE switch inside the standby battery assembly, when manually actuated, connects or disconnects the charger and the battery.

1-362. POWER CONTROL ASSEMBLY. The power control assembly controls the operation of the 28 VDC power supply assembly and the 28 VDC standby battery assembly. The power control assembly contains the controls and indicators to regulate input and output power to check the operation of the 28 VDC power supply assembly. The power control assembly also contains manually operated circuit breakers for the control center 28 VDC power distribution circuits. A LOAD TRANSFER RECT ON LINE pushbutton indicator, when pressed, connects the 28 VDC power supply to the load bus. At this time, the pushbutton indicator lights white and remains on until the power supply is disconnected from the load bus or until the BAT ON LINE pushbutton indicator is pressed. When the BAT ON LINE pushbutton indicator is pressed, the 28 VDC power supply is disconnected from the load bus and the 28 VDC standby battery is connected. The BAT ON LINE pushbutton indicator lights red and remains on until the standby battery is disconnected from the load bus.

1-363. TIME DISPLAY BOARD.

1-364. The control center time display board (figure 1-65) includes one standard 24-hour military clock, one residual time indicator for each launcher, one direct reading clock for each launcher, three control assemblies, and ENABLE/DISABLE indicators that indicate if it is possible to launch a missile.

1-365. RESIDUAL TIME INDICATOR. The residual time indicator is a 1000-second clock with primary and secondary sweep hands. The primary hand makes one revolution of the dial in 1000 seconds and the secondary hand makes one revolution of the dial in 10 seconds. The residual time indicator is started by the launch sequencer at the start of the countdown when the launch control console LOAD PROPELLANTS pushbutton indicator is pressed. At each countdown hold point, the residual time indicator is stopped and restarted when the countdown is resumed.

1-366. DIRECT READING CLOCK. The direct reading clock is a digital clock with three digits for minutes and two digits for seconds. The clock is started, stopped, and reset to zero by the launch sequencer. At each countdown hold point, the clock is automatically started and runs until the countdown is resumed.

1-367. CONTROL ASSEMBLIES. The three control assemblies, one for each residual time indicator and direct reading clock, are located inside the time display board. These assemblies contain relay logic circuits which couple control signals from the launch sequencer and power distribution panel of the control-monitor groups to each residual time indicator and direct reading clock.

1-368. ENABLE AND DISABLE INDICATORS. The ENABLE and DISABLE indicators indicate if a missile may or may not be launched. These indicators are part of a remotely controlled system designed to prevent the inadvertent or unauthorized launch of a missile. The DISABLE indicator is normally lighted, indicating that a missile cannot be launched. If the ENABLE indicator is lighted a missile may be launched.

1-369. HYDRAULIC SYSTEM.

1-370. The hydraulic system includes ground and airborne hydraulic equipment. The ground hydraulic equipment supplies filtered and demulsified hydraulic fluid under pressure to the airborne equipment during checkout and countdown. During flight, the airborne equipment provides the hydraulic power to position the Stage I and Stage II thrust chambers and to rotate the vernier nozzles at the command of the flight control system.

1-371. GROUND EQUIPMENT. The ground equipment consists of hydraulic pumping unit A/E27A-2 and the plumbing that connects the unit to the missile. The ground operating equipment supplies hydraulic fluid to both missile stages for filling and flushing the airborne equipment and maintains a continuous flow of hydraulic fluid to the airborne equipment during hydraulic system checkout and countdown.

1-372. Hydraulic pumping unit A/E27A-2 is a console type unit located on Level II of the equipment terminal. The unit may be operated either remotely by the electrical system or locally from its own control panel. During electrical system check-

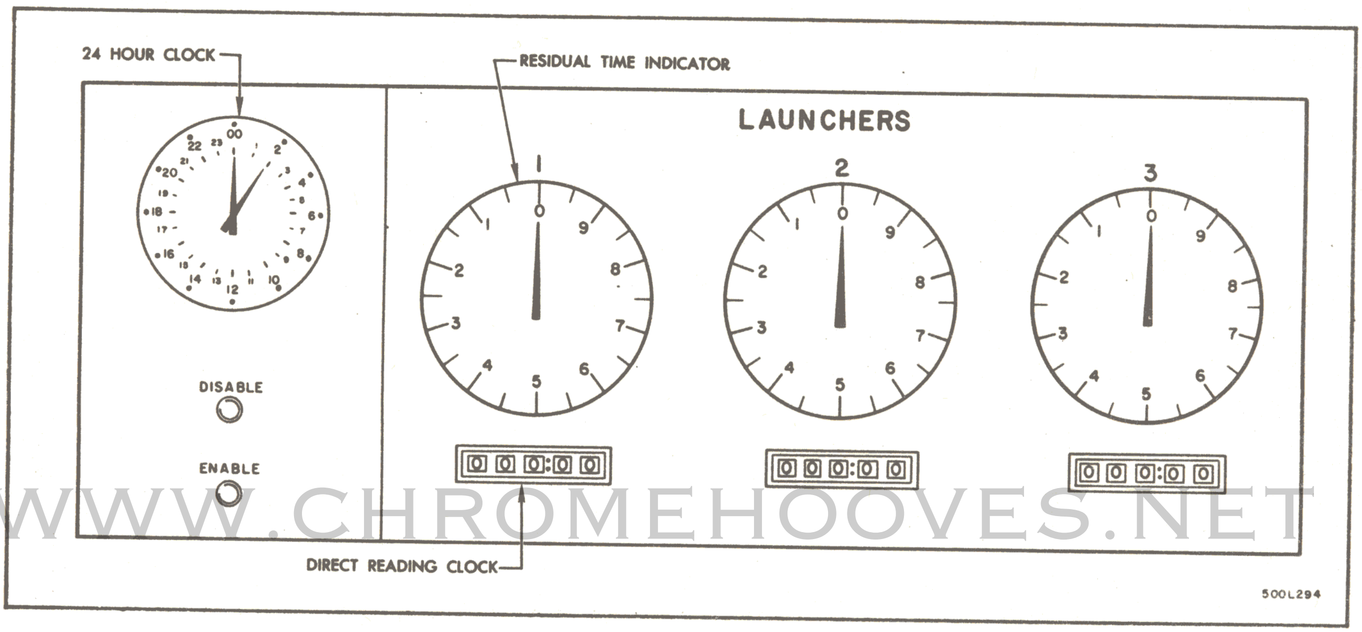


Figure 1-65. Time Display Board (Operational Bases)

out and launch countdown, the unit starts automatically in responce to signals from the launch sequencer. In addition to a reservoir, pressure gages, a temperature gage, flow direction valves, and a fire extinguisher, the unit contains a main fluid circuit and an auxiliary fluid circuit.

1-373. The main fluid circuit supplies hydraulic fluid at regulated flows of approximately 10 GPM to Stage I and 5 GPM to Stage II, at a pressure of 3250 PSI. A suction filter in the main circuit, between the reservoir and the main pump, removes 40-micron size particles from the fluid. The outlet line from the main pump contains two high pressure filters in series.

1-374. The main hydraulic pump is an axial-piston, variable volume, pressure compensated unit capable of delivering hydraulic fluid at a flow rate of 18 GPM at a pressure of 3250 PSI.

1-375. The auxiliary fluid circuit contains a filter pump and a demulsifier filter. The auxiliary fluid circuit is used to break up water emulsions within the hydraulic fluid.

1-376. The ground equipment plumbing directs pressurized hydraulic fluid to the missile in both the stored (in-silo) and raised (launch) positions for Stage I and in the stored position only for the Stage II. A pressure and a return line for each missile stage is routed from the hydraulic pumping unit through the utilities tunnel to an interface at the missile silo wall.

1-377. The hydraulic umbilical disconnects are mechanical self-sealing units that are disconnected from the missile by lanyards. The Stage II hydraulic umbilical disconnects are released as the launcher platform raises the missile to the launch position. The Stage I hydraulic umbilical disconnects are released at missile lift off.

1-378. AIRBORNE EQUIPMENT. The airborne hydraulic equipment provides a continuous flow of hydraulic fluid during flight. Pressurized hydraulic fluid is supplied to the servo-actuators, which position the rocket engine thrust chambers and vernier nozzles in accordance with signals received from the flight control system. Each stage of the missile contains a separate grouping of hydraulic components.

1-379. All components of the Stage I hydraulic equipment (figure 1-66) are located in the Stage I engine compartment. These components consist of a hydraulic pump, an accumulator and reservoir unit, four booster engine servo-actuators, a fluid level switch, and a pressure transducer.

1-380. The hydraulic pump is mounted on the turbopump accessory drive pad of rocket engine subassembly number 2. The pump is capable of supplying 15 GPM at a pressure of 3000 PSI.

1-381. The accumulator and reservoir unit consists of an accumulator, a reservoir, and a reservoir level switch. The unit maintains the required fluid level within the Stage I hydraulic components, dampens pressure fluctuations, maintains return pressure, and provides a means of measuring fluid level.

1-382. The regulator assures an ample supply of fluid to the pump and absorbs pressure surges during actuator motion. If the hydraulic pump fails, the accumulator portion of the regulator will supply pressure for the servo-actuators so that thrust chamber positioning control will be maintained for a short time.

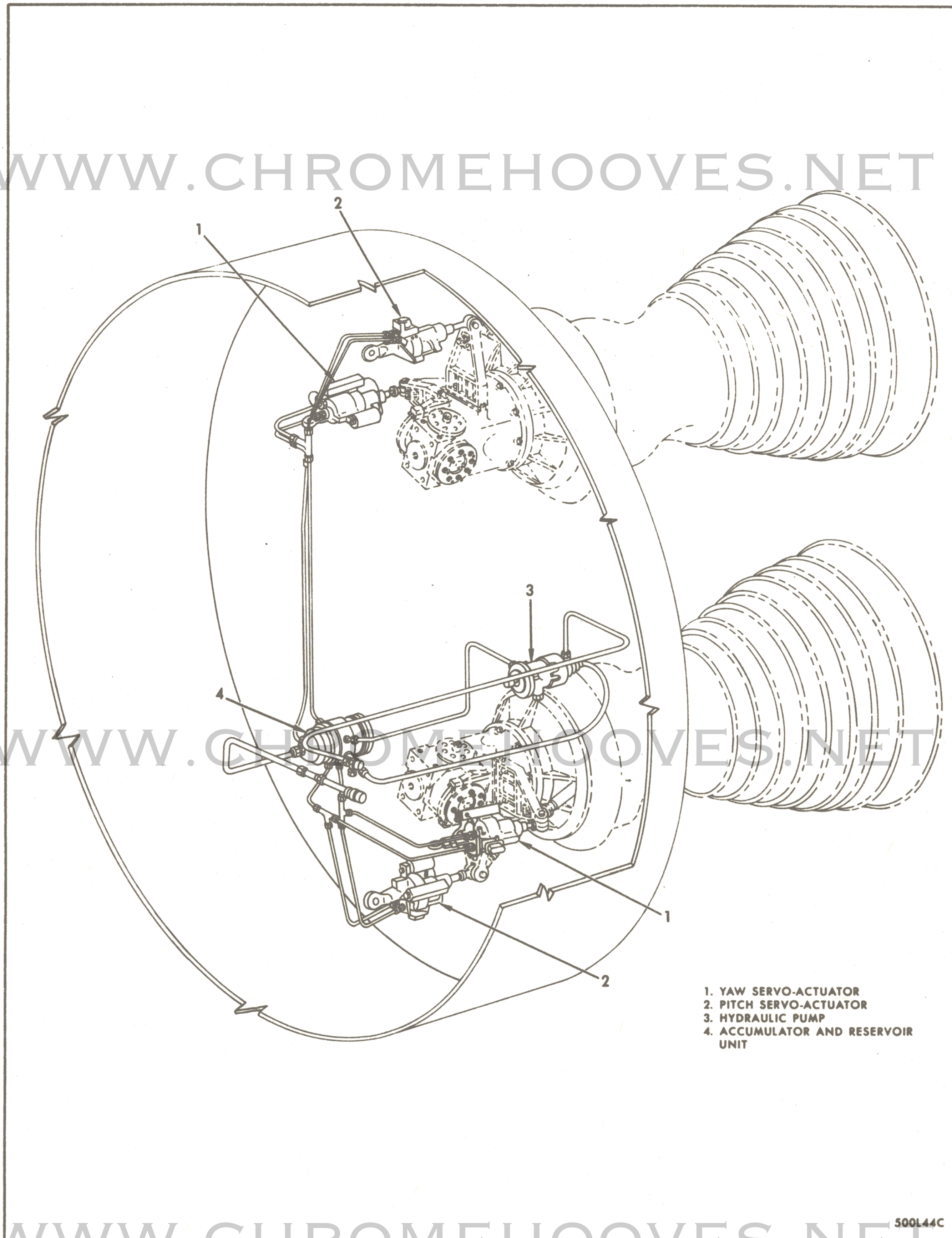


Figure 1-66. Stage I Hydraulic Equipment Location

1-383. The Stage I rocket engine (booster engine) requires four hydraulic servo-actuators to position the two thrust chambers. Each thrust chamber has one servo-actuator for yaw control and one for pitch control. Each servo-actuator contains a cylinder and piston, a servo valve, and a linear follow-up potentiometer.

1-384. The cylinder is attached to the engine frame and the piston is connected to the thrust chamber gimbal actuation arm. As the piston moves, due to the pressure differential within the cylinder, the thrust chamber is positioned by the gimbal actuation arm.

1-385. The servo valve controls the flow of hydraulic fluid into the cylinder. Signals from the flight control system actuate the valve, which restricts the flow of fluid to one side of the piston. This restriction in fluid flow creates a pressure differential within the cylinder and results in piston movement in the direction of the lower pressure. As the piston moves, it positions an internal wiper arm on the linear follow-up potentiometer. When the movement called for by the flight control system is made, the potentiometer balances an electrical circuit and the servo valve returns to neutral. At this time, the flow of hydraulic fluid to both sides or the piston is equal and piston movement ceases.

1-386. The level switch is mounted on the bottom of the regulating unit and sends a regulating unit level in-limit or out-of-limit signal to the hydraulic pumping unit panel and the electrical system.

1-387. All components of the Stage II hydraulic equipment (figure 1-67) are located in the Stage II engine compartment. These components consist of a hydraulic pump and motor, two sustainer engine servo-actuators, four vernier nozzle servo-actuators, an accumulator and reservoir unit, pressure switches, and a fluid level switch.

1-388. The functions of the Stage II accumulator and reservoir unit, pressure switches, and level switch are identical to the corresponding components used on Stage I.

1-389. The hydraulic pump in Stage II is an electric motor-driven variable-displacement, axial-piston pump. The pump motor is powered by a 28 VDC airborne battery and is coupled to the pump through a speed-reducer gear train. The pumping mechanism of the hydraulic pump consists of a drive shaft, pistons, and a block assembly. A spring-loaded pilot valve pressure-controller is mounted externally on the pump. Fluid delivery is 5 GPM at 3000 PSI. A pressure transducer (mounted as part of the IRRS kit on VAFB missiles only) monitors pump outlet pressure for telemetering instrumentation.

1-390. The Stage II rocket engine thrust chamber (sustainer engine) requires two hydraulic servo-actuators to position the thrust chamber. One servo-actuator for yaw movement and one for pitch movement are mounted between the thrust chamber and the engine frame. The sustainer engine servo-actuators are similar to the booster engine servo-actuators and operate in the same manner.

1-391. A vernier nozzle servo-actuator positions each vernier nozzle in accordance with signals received from the flight control system. Each servo-actuator consists of two cylinders and two pistons, a servo valve, and two linear potentiometers. The pistons are connected to a common drive cable, which is rigged over a cable drum on the vernier nozzle. When the servo valve restricts the flow of fluid to one cylinder of the servo-actuator, the piston in the other cylinder retracts and pulls the drive cable, causing the vernier nozzle cable drum to rotate and position the

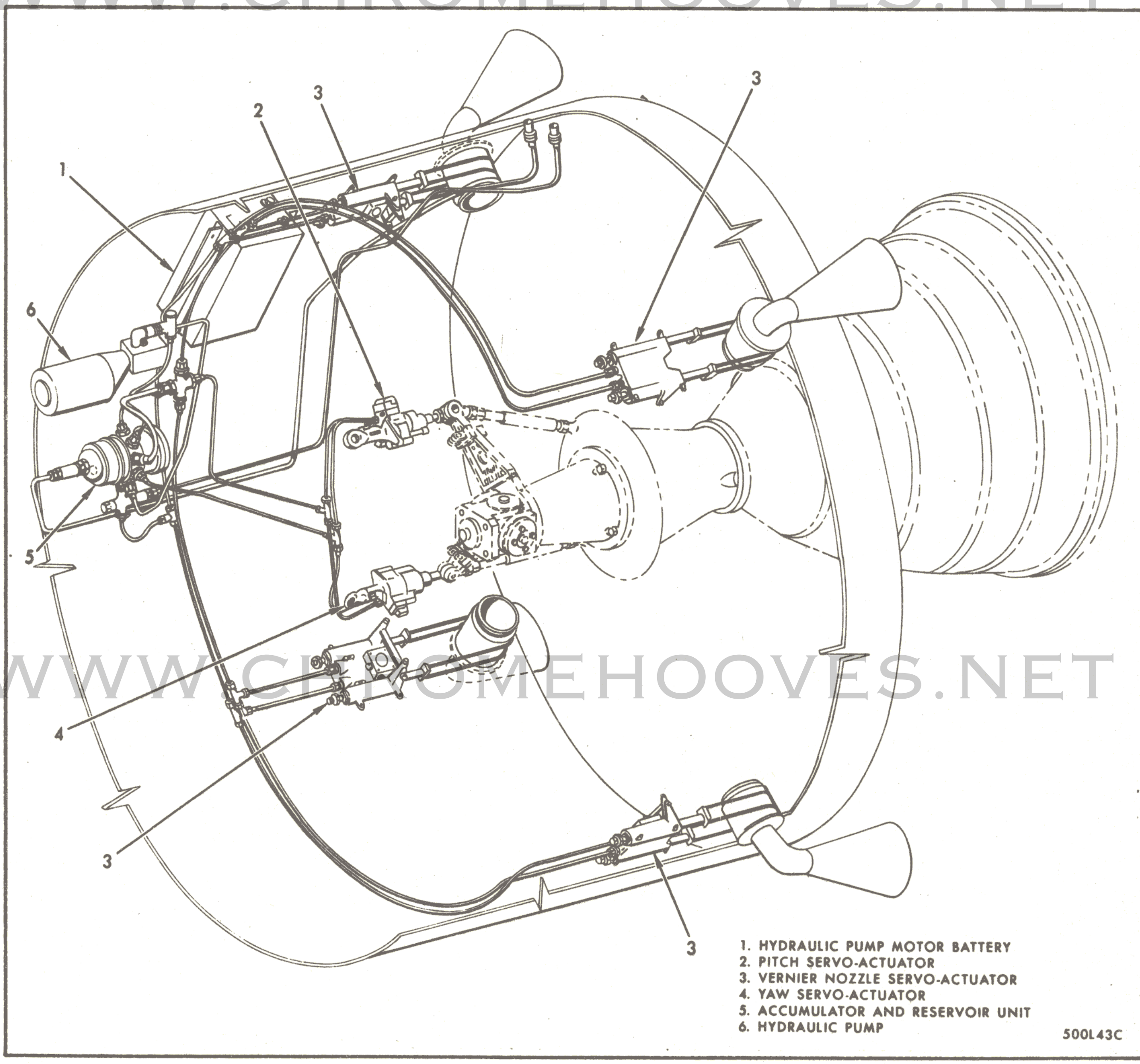


Figure 1-67. Stage II Hydraulic Equipment Location

vernier nozzle to the proper angle for attitude correction. Simultaneously, the opposite end of the drive cable extends the other piston of the servo-actuator. As the pistons move, they position a wiper arm on each linear follow-up potentiometer. When the vernier nozzle movement called for by the flight control system is made, the potentiometers balance an electrical circuit, and the servo-valve returns to neutral. At this time, the flow of hydraulic fluid is equalized to both cylinders, and piston movement ceases.

1-392. OPERATION. The hydraulic pumping unit is started during the countdown when a start-hydraulics signal is sent from the launch sequencer. The signal is received by the electrical system which starts the hydraulic pumping unit after the missile air conditioner has started and power has been applied to the missile electrical buses. The start-hydraulics signal is automatically initiated by the launch sequencer 180 seconds after the missile launch officer presses the launch control console LOAD PROPELLANTS pushbutton indicator.

1-393. After the RAISE LAUNCHER pushbutton indicator has been pressed, the Stage II hydraulic pump motor is started, the launcher platform is raised, the Stage II hydraulic umbilical disconnects are released, and the hydraulic pump motor battery is activated.

1-394. When the LAUNCH pushbutton indicator is pressed, ground power is removed from the missile buses, missile power is applied, the Stage I engine starts, and the engine operates the Stage I hydraulic pump. As the missile leaves the launcher platform, the Stage I hydraulic umbilical disconnects are released.

1-395. During Stage I flight operation, a turbine in the number 2 thrust chamber turbopump assembly drives the hydraulic pump through an accessory-drive gear train. Hydraulic fluid from the pump enters the accumulator portion of the regulating unit, which dampens pressure surges. The fluid is then routed to the booster hydraulic actuators. A servo valve in each actuator responds to signals from the flight control system and controls hydraulic fluid flow through the actuator. From the actuators, the fluid is returned to the regulating unit reservoir and then recycled by the hydraulic pump.

1-396. During Stage I and Stage II flight, the Stage II hydraulic pump motor is powered by the hydraulic pump motor battery. During Stage I operation, the sustainer engine servo-actuators are electrically locked in a neutral position by the flight control system. At stage separation the servo-actuators are unlocked, allowing them to position the sustainer thrust chamber in accordance with signals from the flight control system. In addition to the sustainer engine servo-actuators, Stage II has four vernier nozzle servo-actuators that position the vernier nozzles in response to signals from the flight control system.

1-397. MISSILE AIR CONDITIONING SYSTEM.

1-398. The missile air conditioning system (figure 1-68) provides conditioned air to the Stage II transition, between tanks, and engine compartments. The conditioned air maintains environmental temperatures necessary to the accuracy and reliability of the guidance, control, electrical, and propulsion components during checkout and launch operations. The system consists of the missile air conditioner A/F32C-5, the air conditioning ducting, and the air conditioning disconnects.

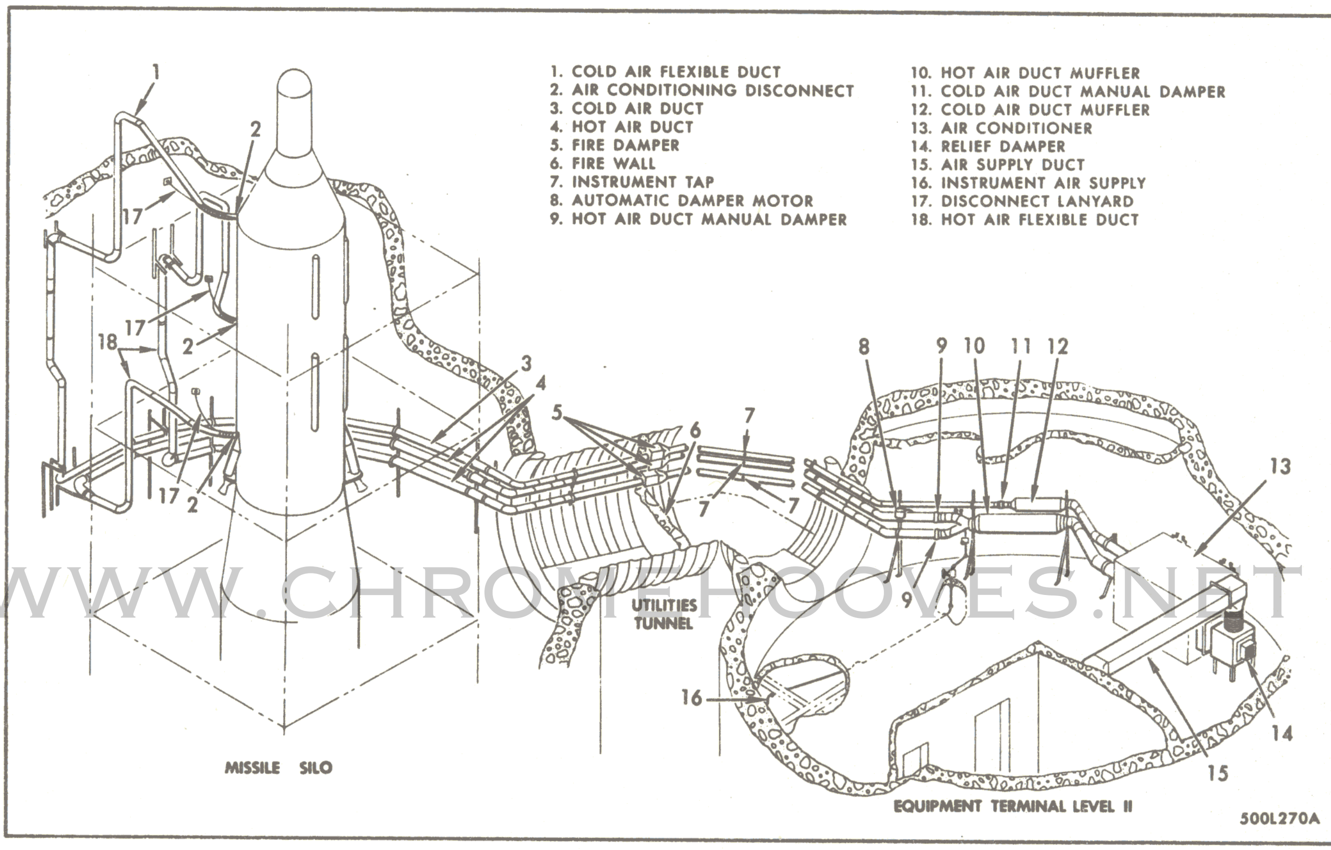


Figure 1-68. Missile Air Conditioning System (Operational Bases)

1-399. MISSILE AIR CONDITIONER. The missile air conditioner is located on Level II of the equipment terminal. Flush mounted hinged doors and panels cover the operating controls. The refrigeration, chilled water, hot water, and air flow components are enclosed and protected by removable access panels.

1-400. The chilled water circuit supplies water to a chilled water coil for cooling and dehumidifying incoming air and to the condenser for the condensation of high pressure gas. The chilled water coil is constructed of copper tubes and fins. The cooling capacity of the coil is 237,600 BTU/HR.

1-401. The hot water circuit supplies water to a hot water coil for the heating of conditioned air. The hot water coil is constructed of copper tubes and aluminum fins. The heating capacity of the coil is 205,000 BTU/HR.

1-402. The air flow circuit consists of a blower and the ducting required to induct air from the atmosphere, direct it through the air conditioner, and distribute it to the missile. Electrical controls maintain the proper volumes of discharged conditioned air.

1-403. ELECTRICAL CONTROL CIRCUITS. Six electrical control circuits operate and check the missile air conditioning system. Some of the electrical controls are located on the air conditioner control panel and the missile air conditioner control panel. Other electrical controls are located on control-monitor group OA-2438 on Level III of the equipment terminal. The remaining electrical controls are located on power switchboard JEU-7 on Level IV of the equipment terminal.

1-404. OPERATION. The missile air conditioning system is placed in operation automatically when the missile launch officer presses the LOAD PROPELLANTS pushbutton indicator on the launch control console. Intake air is blown through the chilled water coil and the evaporator where it is dehumidified and cooled. Part of the cold, dry air is then discharged through the cold air outlet. The remaining cold air is reheated at the hot water coil. The hot, dry air is then discharged through the hot air outlet. The conditioned air flow is illustrated in figure 1-69.

1-405. COMMUNICATION SYSTEM.

1-406. The communications system within the Titan I missile weapon system provides a means for integrating communications activities, such as command communications vital to launch functions, and maintenance communications required for location and repair of weapons system malfunctions as well as coordinating maintenance activities. This system also integrates security communications for visitor control and for movement of personnel and material, administrative communications for routing administrative operations, and emergency communications for reporting accidents and other emergencies. The communications system consists of communications paths and communications equipment. The primary alerting system provides alert and strike commands from SAC to all launch sites.

1-407. INSTRUMENTATION AND RANGE SAFETY SYSTEM FACILITIES (VAFB).

1-408. Instrumentation and range safety requirements are satisfied by a ground receiving station etc. The ground receiving station receives telemetered flight performance data from the airborne instrumentation system and a range safety system, which tracks the missile during flight and initiates command destruct signals if missile performance is erratic. The system includes an instrumentation control center building, a mobile telemetry station, a command destruct building, radar

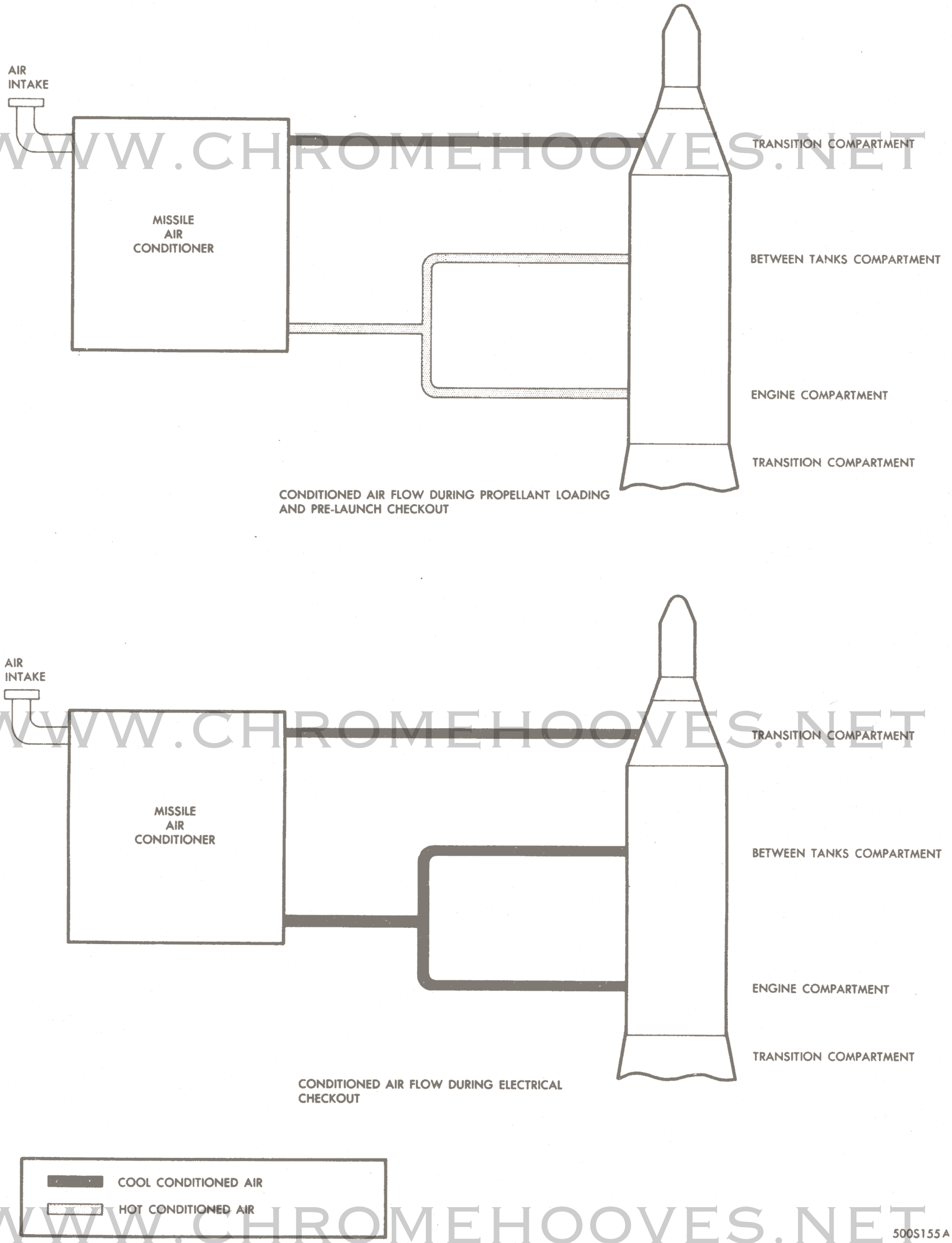


Figure 1-69. Conditioned Air Flow

tracking facilities, and two angle-measuring equipment-correlation tracking and ranging (AME-Cotar) fields.

1-409. The fixed telemetry receiving and recording station monitors pre-launch missile telemetry equipment and receives and records telemetered in-flight missile data. The station also contains sufficient test and auxiliary equipment to assure the proper functioning of the ground telemetry components. In-flight tracking of missiles is performed by an M2 optical tracker. A telemetry receiving antenna is slaved to the M2 optical tracker by a telemetry antenna system operated by remote control.

1-410. MOBILE TELEMETER STATION.

1-411. The mobile telemetry station contains test and auxiliary equipment for checking out the airborne telemetry and destruct equipment and the receiving-recording equipment at the fixed telemetry station. Equipment contained in the mobile station is identical to that of the fixed station plus additional telemetering, recording, and listing facilities.

1-412. COMMAND DESTRUCT FACILITIES.

1-413. The command destruct building and the attached antenna tower houses the standard transmitters, power amplifiers, and antenna equipment. To insure reliability of operation, two 500-watt transmitters (primary and secondary) provide power to the antennas. For transmission of command destruct signals to a missile within a 30-mile radius, the power is supplied to the lower power omnidirectional antenna. As the missile passes the 30-mile radius, a variable timer switches transmitter power to a 10 KW amplifier and the directional antenna. The variable timer is started at the instant missile flight begins. The timer is equipped with a manual override to permit manual operation, if desired.

1-414. RADAR TRACKING FACILITIES.

1-415. Radar tracking facilities consist of an AFMTC MOD III radar set, two AN/MPS-19 radar sets, and a Mark 51 optical gun director for acquisition of initial missile lift-off. Each radar set is equipped with sinecosine potentiometers to convert azimuth, elevation, and range shift position to DC voltages for use with an analog-polar-to-cartesian-converter-plotting board display system.

1-416. AME-COTAR FIELDS.

1-417. There are two AME-Cotar antenna fields located approximately 6 miles apart. A building located near each antenna field contains the Cotar equipment.

1-418. <u>RADAR SURVEILLANCE SYSTEM AN/TPS-39(V).</u>

1-419. PURPOSE.

1-420. The radar surveillance system AN/TPS-39(V) (figure 1-70) provides an audible and visual indication of the presence of an intruder in restricted areas of United States Air Force installations. This surveillance function is accomplished by a combination of components in a configuration suited for a particular installation. The equipment may be arranged to perform four types of radar surveillance. These four types are designated class A, B, C or D surveillance. The class A surveillance detects intrusions around the perimeter of a specific area. The class B type of surveillance detects intrusions within the specific area. Class C surveillance is

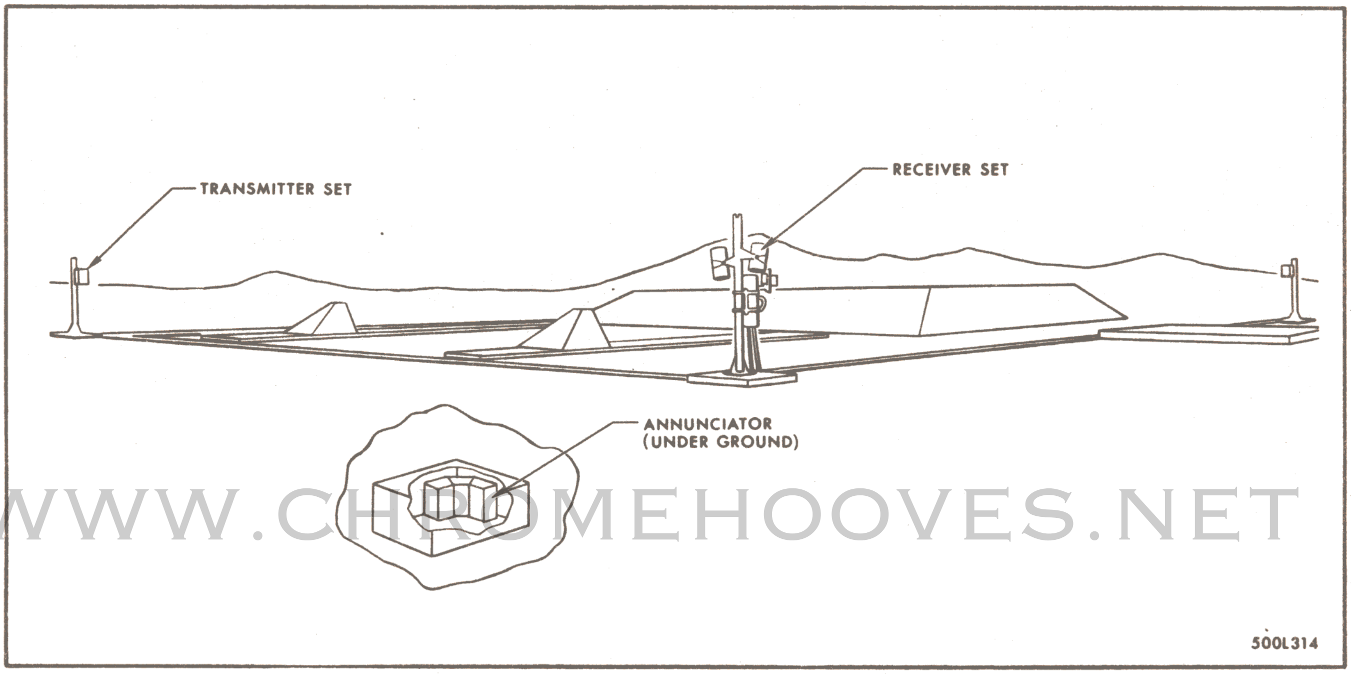


Figure 1-70. Typical Radar Surveillance System AN/TPS-39(v)

accomplished in such a manner that entry through a port is detected. Class D surveillance is similar to class B, except a greater area is under surveillance.

1-421. DESCRIPTION.

1-422. Radar surveillance system AN/TPS-39(V) can detect intrusions in areas where the longest distance between antennas does not exceed 200 feet, and the shortest distance between antennas is not less than 10 feet. Primary power is supplied to receiver and annunciator power supplies, which then provide operating power to the other components of the system through interconnecting cables.

1-423. A continuous wave, unmodulated RF signal is generated by the transmitter (figure 1-71) oscillator, divided into signals of equal magnitude by the power divider (located inside the transmitter), and applied to the transmitting antennas. The outputs from the transmitting antennas are received by the receiver set (figure 1-72) and transferred to the power combiner where they are combined and applied as one signal to the tuner-mixer-detector. The output of the tuner-mixer-detector to the receiver is a steady DC signal. When an intruder moves through the area between a transmitting antenna and a receiving antenna, a portion of the transmitter RF signal is deflected by the intruder and arrives at the receiving antenna slightly out of phase with the transmitter signal, resulting in an RF signal modulated by the movement of the intruder. The tuner-mixer-detector detects the modulation as a subaudio AC signal. When the AC signal is received, an alarm is initiated by the receiver. The receiver also initiates an alarm any time the RF signal is not received, denoting a transmitter failure. Figure 1-73 illustrates a class A antenna group, and figure 1-74 illustrates the components within a receiver group.

1-424. The alarm signal is transmitted to the annunciator (figure 1-75) by the receiver. The annunciator causes an alarm bell to sound and an indicator, located on its front panel, to light. In addition, an alarm indicator lights on the launch control console. The alarm bell and the indicator on the launch control console inform operating personnel that an intrusion into a designated area has occurred. The indicator on the annunciator panel shows the particular area of intrusion, since it signifies which receiver has transmitted the alarm signal. Figure 1-76 illustrates annunciator power supply and components.

1-425. System and component operating capabilities are contained in figure 1-77.

1-426. MAINTENANCE PLAN.

1-427. The weapon system maintenance plan is designed to provide maximum support through organizational maintenance and depot maintenance. Organizational maintenance is divided into two levels: organizational level, which includes removal and installation of components; and field level, which includes repair of removed components. Depot maintenance consists of maintenance beyond organizational maintenance capabilities such as major modifications and overhaul of equipment.

1-428. ORGANIZATIONAL LEVEL AND FIELD LEVEL MAINTENANCE.

1-429. Organizational level and field level maintenance is that maintenance authorized and performed within the operational squadron on its assigned equipment.

(Text continued on page 1-141)

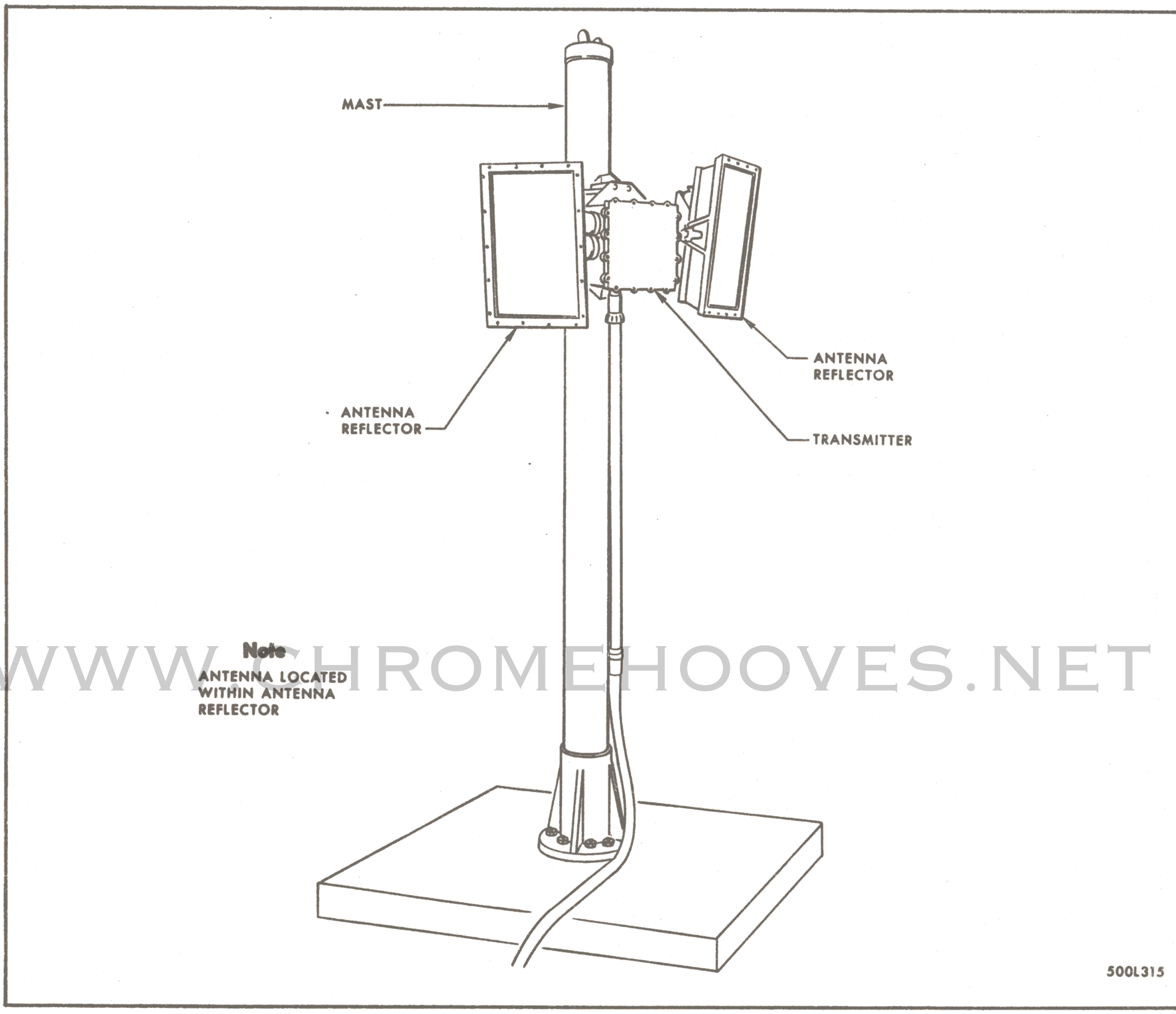


Figure 1-71. Class D Transmitter Set

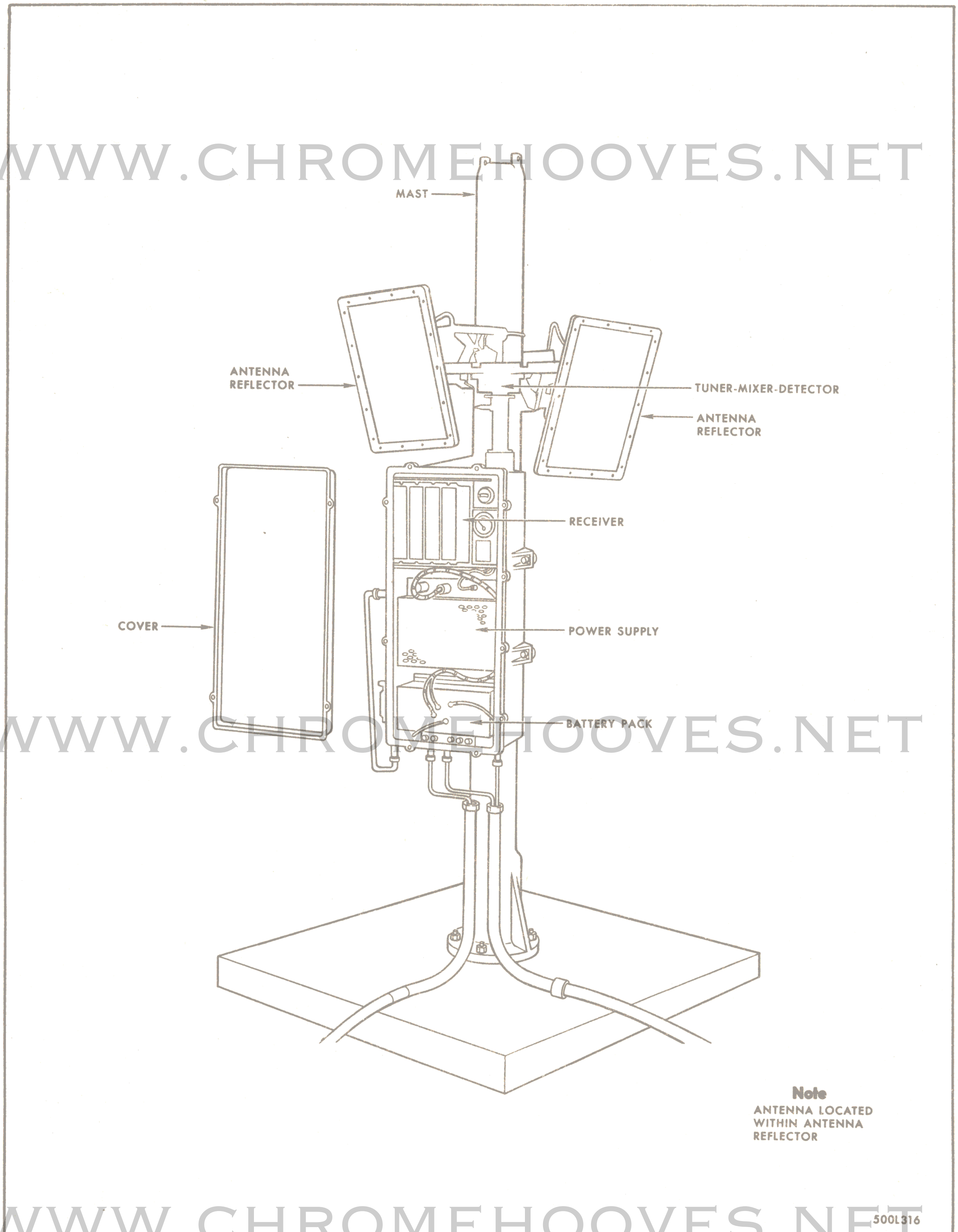


Figure 1-72. Class D Receiver Set (Receiver Group Cover Removed)

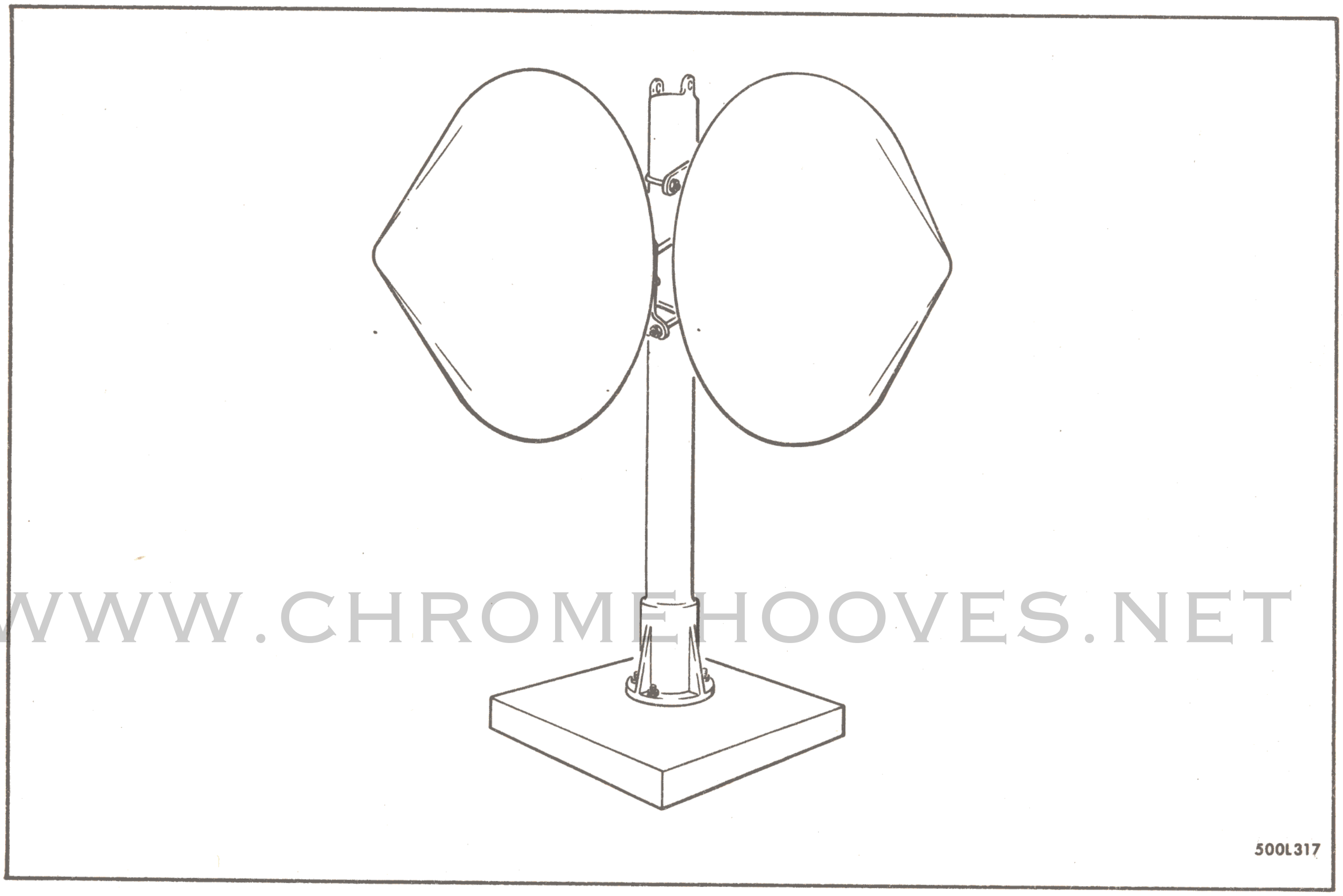


Figure 1-73. Class A Antenna Group (Receiver or Transmitter Set)

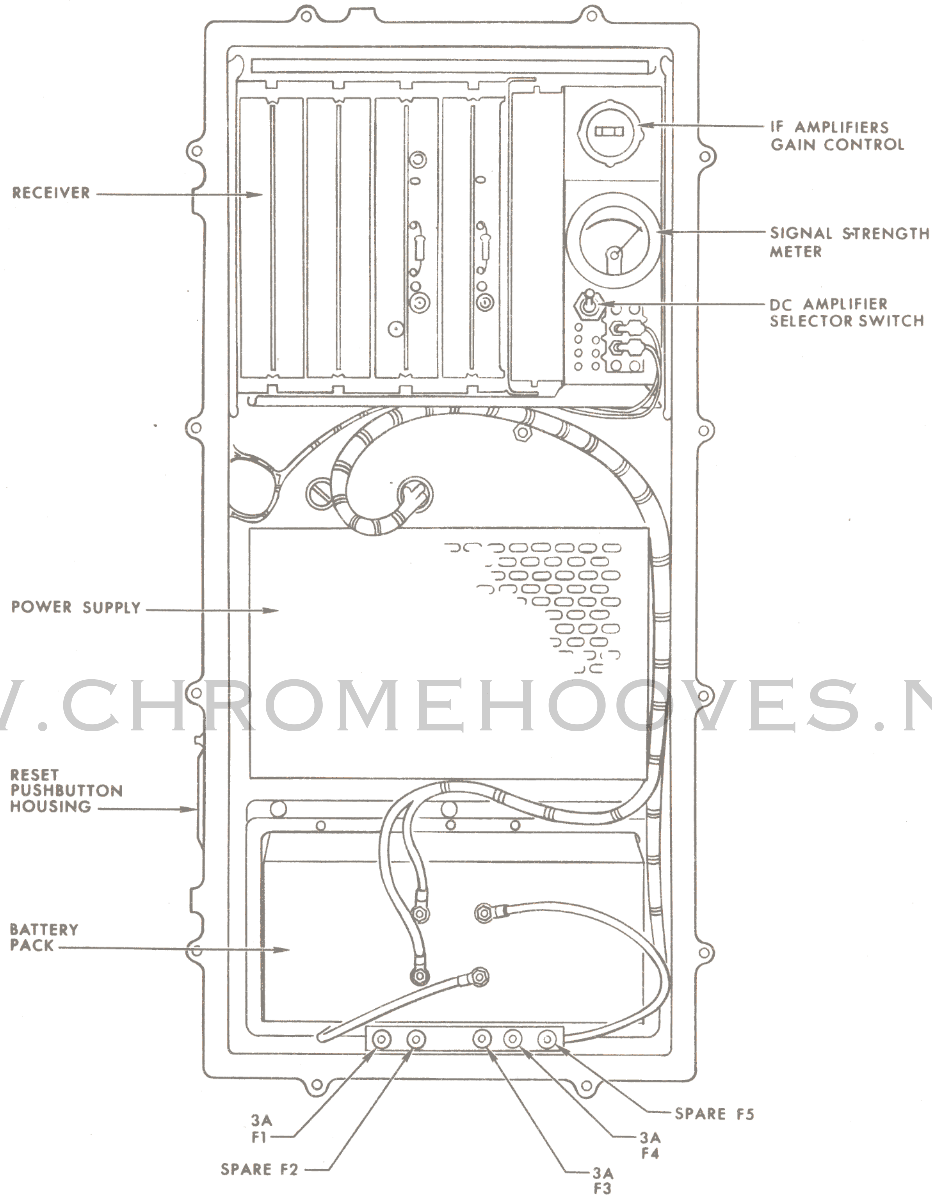


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Figure 1-74. Receiver Group

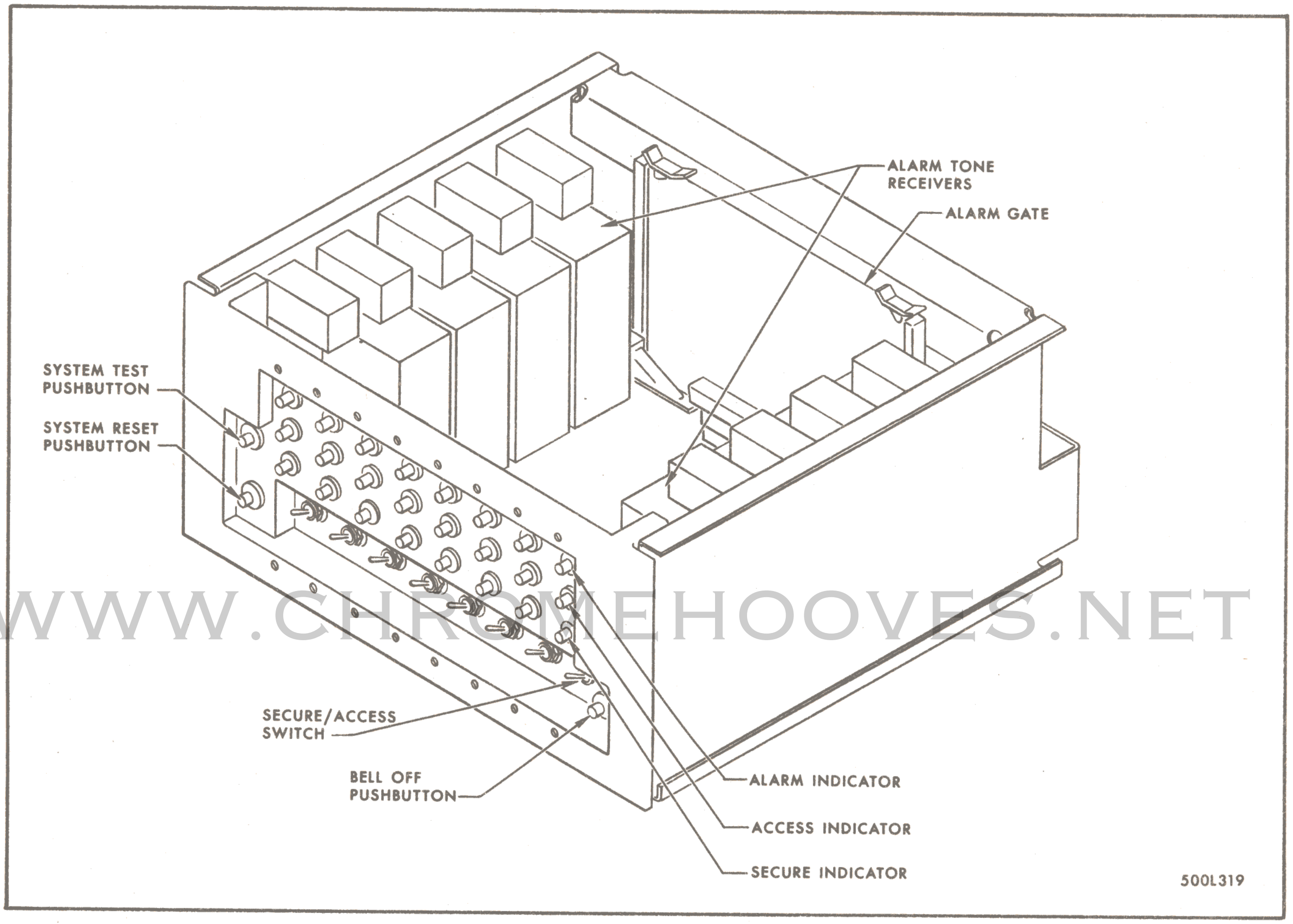

Figure 1-75. Annunciator

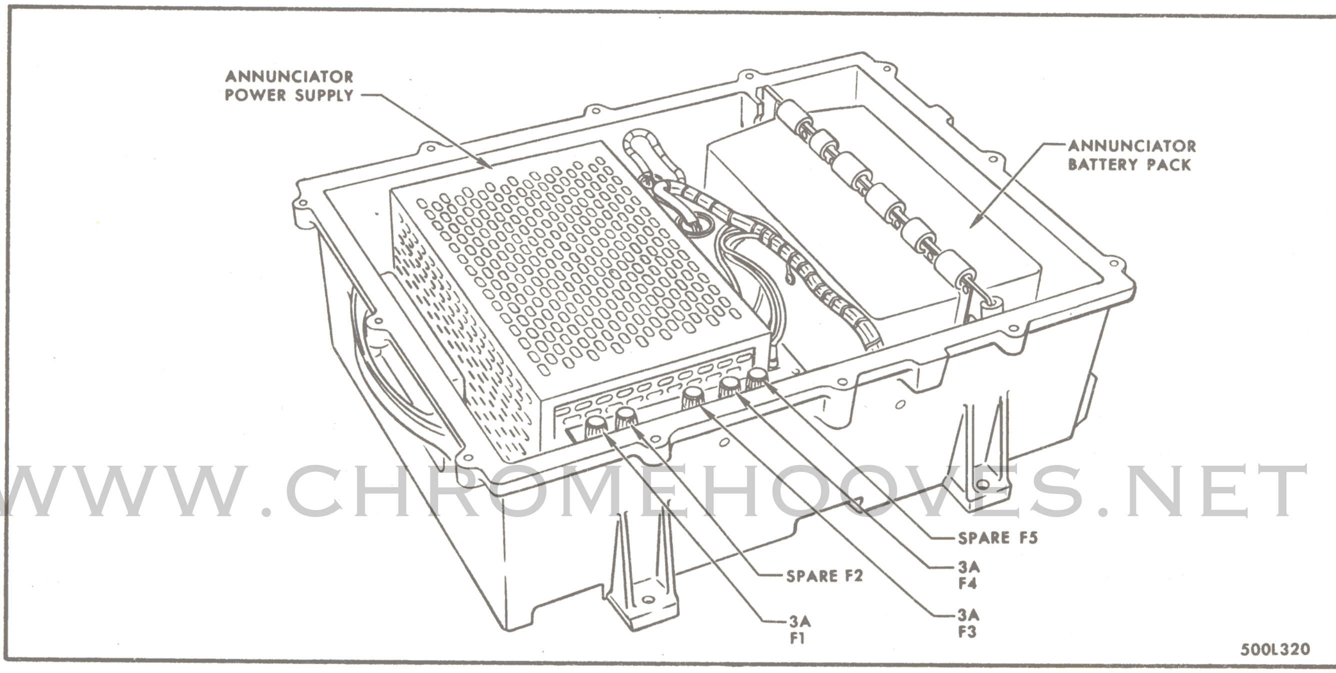

Figure 1-76. Annunciator Power Supply

Frequency range	1710 to 1760 MC
Type of operation	Continuous wave, bistatic detection.
Range and coverage	Detects intrusions in areas where longest dimension between antennas does not exceed 200 feet, and shortest dimension is not less than 10 feet.
Accuracy	Detects human intrusions into sensitive area with 0.1 to 5 CPS variations from the center frequency.
Class A antenna characteristics	Parabolic reflector.
Class B antenna characteristics	Modified corner reflector.
Class C antenna characteristics	Corner reflector.
Class D antenna characteristics	Two class B antenna reflectors.
Sensitivity and selectivity	Detects doppler frequency shifts from 0.1 to 5 CPS from the center frequency within the detection area.
Transmitter power output	0.3 watt to 2 watts per operating system.
Modulation characteristics	Continuous wave, unmodulated.

Figure 1-77. Table of Radar Surveillance System AN/TPS-39(V) Capabilities

(Text continued from page 1-133.)

1-430. Organizational level maintenance includes normal squadron functions such as readiness checkout, daily inspections, storage inspections, routine launch site servicing, preventive maintenance, and the removal and installation of specific components for the purpose of achieving operational readiness.

1-431. Field level maintenance includes functions such as bench maintenance, mobile maintenance, mating of missile stages, mating of re-entry vehicle and missile, periodic inspections, recycle maintenance on repairable items removed from missiles and ground equipment, technical order compliance, and reclamation and repair of components and parts.

1-432. Organizational level and field level maintenance is authorized for components of the airborne and ground equipment. Both levels of maintenance are performed at the launch complex and at the MAMS. Regardless of the area in which the equipment is located, the extent of authorized maintenance is limited by personnel skills, facilities, tools, test equipment, and equipment design.

1-433. Maintenance performed on the airborne and ground equipment at the launch complex consists of the following:

a. Periodic maintenance and servicing of components.

b. Testing to insure minimum performance standards.

c. Performing trouble analysis and isolating faulty components to the smallest replaceable unit, replacing faulty units, aligning and calibrating replacement units, and performance testing components to insure their being in a state of readiness required for all equipment within the complex.

1-434. Maintenance performed on the airborne and ground equipment at the MAMS consists of the following:

a. Making initial inspections and service checks on the missile and on replacement components.

b. Isolating malfunctions in items received from the launch complex, repairing the components, if possible, and aligning and calibrating components after repair.

c. Making periodic inspections and checking shelf (spare) components.

d. Maintaining test benches used in field level maintenance.

e. Repairing and calibrating test equipment.

1-435. AIRBORNE EQUIPMENT. Organizational level maintenance of airborne equipment is authorized. Field level maintenance of airborne equipment is authorized if the components are not in the following categories:

a. A sealed unit (unless maintenance is specifically authorized).

b. Batteries.

c. A gyro or some other finely machined, delicate unit.

d. A motor armature or stator that requires winding.

e. An item that becomes uncalibrated during repair, and recalibration requires a static firing or operation under simulated flight conditions.

f. An item that affects engine alignment and positioning.

g. High pressure spheres.

h. Major structural members that affect alignment or structural strength such as stiffener rings, longitudinal members, and braces.

i. Ordnance items.

j. An item requiring elaborate and special testing equipment.

1-436. GROUND OPERATING EQUIPMENT AND GROUND SUPPORT EQUIPMENT. Organizational level maintenance of aerospace operating equipment (AOE) and aerospace ground equipment (AGE) is authorized. Field level maintenance of AOE and AGE is authorized if the components are not in the following categories:

a. A sealed unit (unless maintenance is specifically authorized).

b. A motor armature or stator that requires winding.

c. A component requiring extensive repairs (rebuilding or complete overhaul).

d. A generator armature or stator that requires winding.

e. Gyro checkers.

f. An item that affects calibration of a complete component.

g. An item that requires precision mechanical repairs such as the ground guidance antenna drive equipment components.

h. Batteries.

1-437. DEPOT MAINTENANCE.

1-438. Depot maintenance is that maintenance beyond the capabilities of organizational maintenance personnel and equipment. It includes major modifications, repairs, and overhaul.

1-439. For Martin furnished components, depot level maintenance is accomplished at the Martin-Denver factory. Depot level maintenance on associate contractor items, such as the guidance system, rocket engines, and the re-entry vehicle, is accomplished at the contractor's facility: Bell Telephone Laboratories for guidance, Aerojet-General for the rocket engines, and AVCO for the re-entry vehicle. Repair on vendor and subcontractor items is accomplished at the manufacturer's facility.

1-440. Facility items and other hard-to-transport items are given depot maintenance in the area where they are installed. Teams from the contractor responsible for the equipment perform the maintenance.

1-441. SCHEDULED AND UNSCHEDULED MAINTENANCE.

1-442. Maintenance is divided into two categories: scheduled and unscheduled. Scheduled maintenance includes all periodic maintenance from the initial receipt of the missile at the MAMS to recycle. Unscheduled maintenance is unpredictable maintenance resulting from malfunctions and damage.

1-443. Recycle is the periodic removal of the missile from the silo. In an operational squadron, missiles are stored in the underground silos for several months and periodic recycling is necessary. A missile to be recycled is removed from the silo and towed to the MAMS building. A spare missile stored at the MAMS is towed to the silo to replace the recycled missile.

1-444. At the MAMS building, the recycled missile is given a thorough inspection, and components that have reached the maximum storage time for operational reliability are replaced. The missile is then stored at the MAMS until the next missile is recycled.

1-445. COMMODITY SERVICING.

1-446. DIESEL FUEL.

1-447. Diesel fuel is normally transported to the missile sites by commercial transport carrier. Fuel will be delivered on a prescheduled basis. Caution must be used when servicing fuel so as to not allow below ground tanks to overflow. Fuel is serviced by means of above ground fill pipes.

1-448. LIQUID OXYGEN, LIQUID NITROGEN, GASEOUS NITROGEN, HELIUM AND ROCKET FUEL (RP-1).

1-449. Liquid oxygen, liquid nitrogen, gaseous nitrogen, helium and RP-1 are the primary commodities utilized in the Titan I propellant loading and pressurization system. These commodities are serviced on a necessity basis determined by daily commodity status readings which are reported to the maintenance activity responsible for commodity replenishment. These commodities are transported, when required, and tanks are filled to a specified amount already established in system manuals. RP-1 is replenished only when necessary. Normally RP-1 will require no replenishment after the storage tank has been initially serviced to the desired capacity required for loading three missiles.