CHAPTER VII

PNEUMATIC SYSTEM

This page has been left blank intentionally.

CHAPTER VII

PNEUMATIC SYSTEM

In the REDSTONE Missile, the pneumatic system is used for pressurization, operation of valves, flight control, missile separation, and air bearings in the guidance system.

A supply of high-pressure air for the propulsion system and missile separation is carried in six spheres mounted in the missile tail unit. Also, two additional high-pressure spheres in the body unit supply air to the control system, air bearings, and separation system.

The air used in the missile system must be oil-free, dry air with a dew point of at least -65°F. Air pressure requirements range from a maximum of 3,000 psi to a minimum of 21 psi.

A Clark horizontally opposed, six-cylinder compressor unit driven by a gasoline engine supplies the air requirements for the missile pneumatic system. The compressor unit is equipped with a Vortox air filter which filters the air before it enters the first-stage cylinders and after it leaves the dehydrators. Moisture separator bottles are provided after each stage of compression for the purpose of condensing and removing water vapor from the compressed air. The dryer unit (or dehydrator) removes the remaining moisture and oil vapors. Purolator filters for removing foreign particles larger than ten microns in size from the compressed air are installed in the main air flow line after the oil and water dehydrators and before the spherical receiver. Oil-free, dry air at 5,000 psi is delivered from the air compressor to the air servicer.

The air servicer stores high-pressure air (5,000 psi) received from the air compressor truck and supplies regulated air pressure to the launcher valve box during missile pre-issue checkout, horizontal checkout, and vertical checkout. The air servicer also supplies high-pressure air (750 psi) to the LOX replenishing valve during the LOX replenishing operation. The air servicer chassis is a standard M-200, 2-wheel, heavy-duty chassis which has been modified by adding a rear bumper assembly and a subframe assembly on which the air servicer unit and floor assembly are mounted. The air servicer carries four air bottles which have a combined capacity of ten cubic feet. These bottles function as an air reservoir to assure a continuing air supply at periods of peak demand. In addition, they provide a reserve air supply when it becomes necessary to shut down the air compressor truck. Various valves, gages, regulators, and pneumatic lines are provided for adjusting, monitoring, and directing the path of pressurized air through the system.

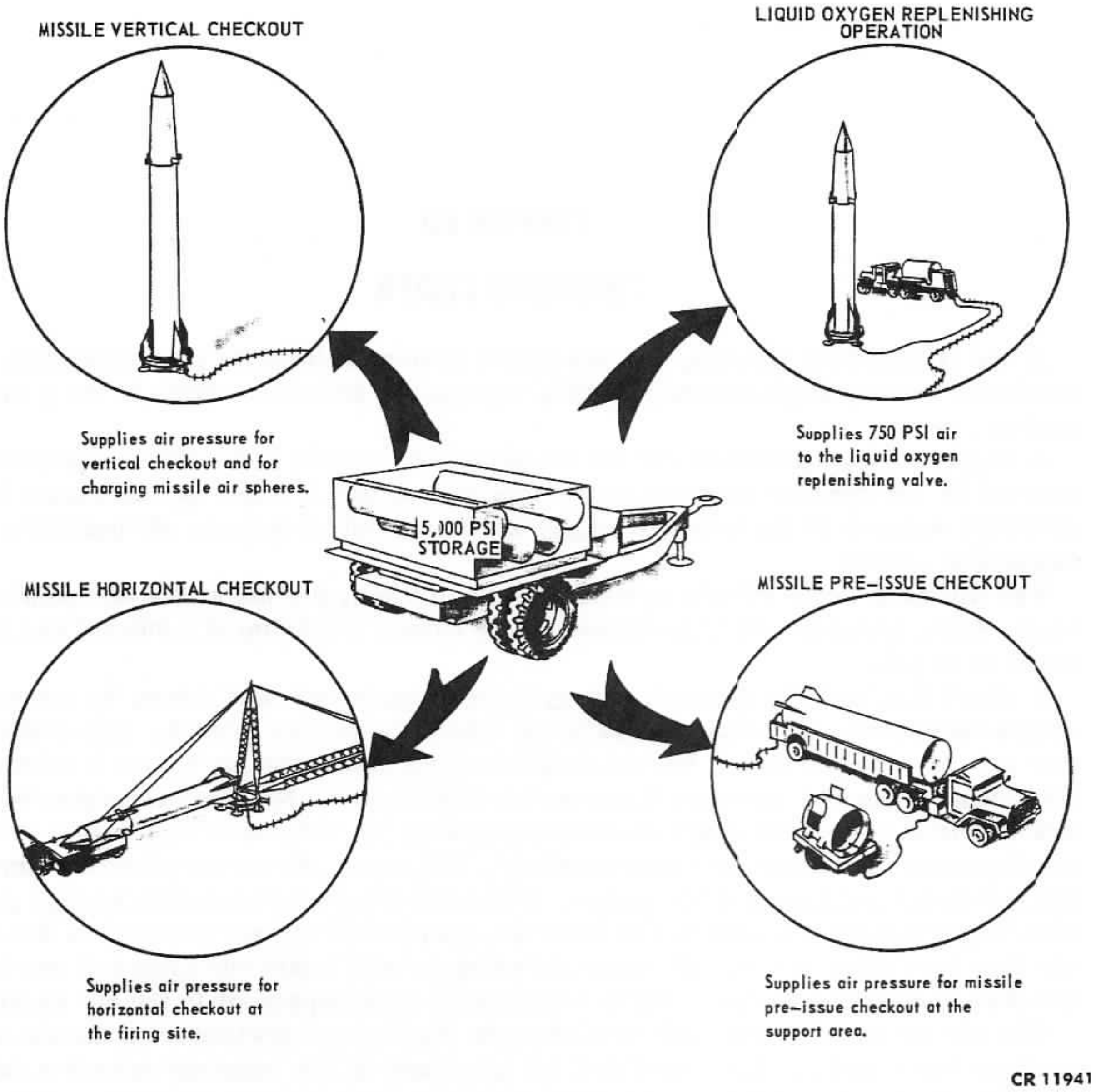


Figure VII-1 – Function of the Air Servicer

High-pressure air (3,000 psi) is supplied to the ground control valve box by the air servicer until missile liftoff. All pneumatic connections between the missile and the valve box are made through a multiple coupling head on the valve box. The ground control valve box contains components such as valves, regulators, switches, and gages for control and testing of missile functions before and at the time of missile

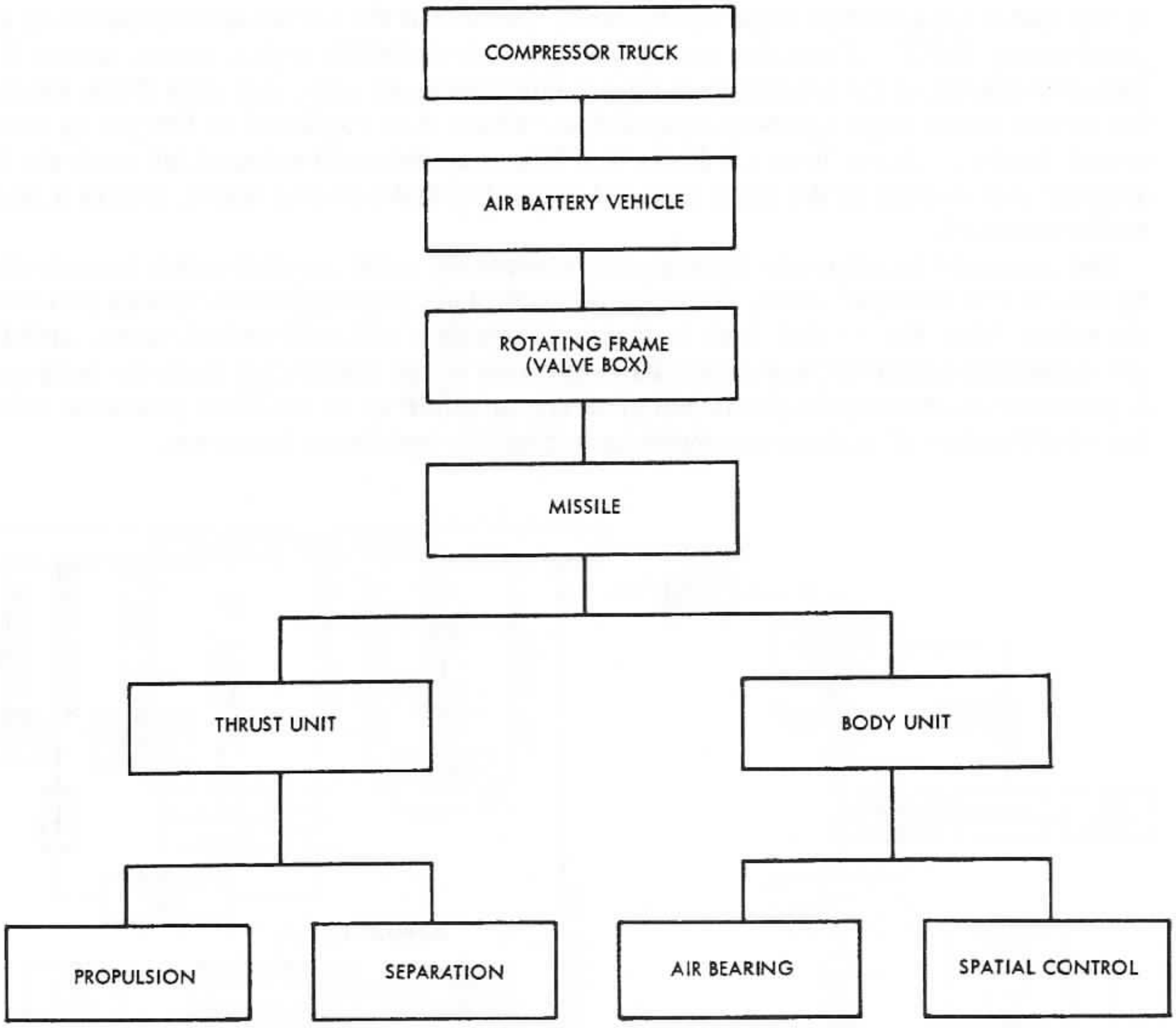


Figure VII-2 – Pneumatic System

firing. Normal control of the ground valve box is from the propulsion control panel (in the fire control and test truck) and from the remote firing panel (located in a foxhole).

A solenoid valve in the valve box allows air (3,000 psi) to pass through the multiple coupling into a high-pressure fill line. From a standard tee on the high-pressure fill line, the triplex spheres are filled to 3,000 psi.

From the triplex spheres, the air flows through a filter to the heat exchanger located in the steam exhaust duct from the turbine. The heat of the air is then increased to approximately 212°F. From the heat exchanger, air is fed through a cross, where it is routed to the top of the alcohol tank for pressurization (21 psi). Air also flows through the cross to the engine pressure regulator, where it is regulated to 585 psi by an internal loader. From here air flows to a four-way solenoid valve which controls the opening and closing of the main LOX valve and the main alcohol valve, and to a pneumatic manifold.

The manifold supplies air 1) for the main peroxide valve opening which is controlled by means of a solenoid valve, 2) for the peroxide tank pressurization by way of a shuttle valve, 3) to the alcohol tank vent valve through a solenoid control valve, and 4) to the expulsion cylinders to accomplish separation of the thrust unit from the body unit. A pressure relief valve is also mounted on the manifold as is an off-on pressure switch for confirmation of system pressurizing during the countdown sequence.

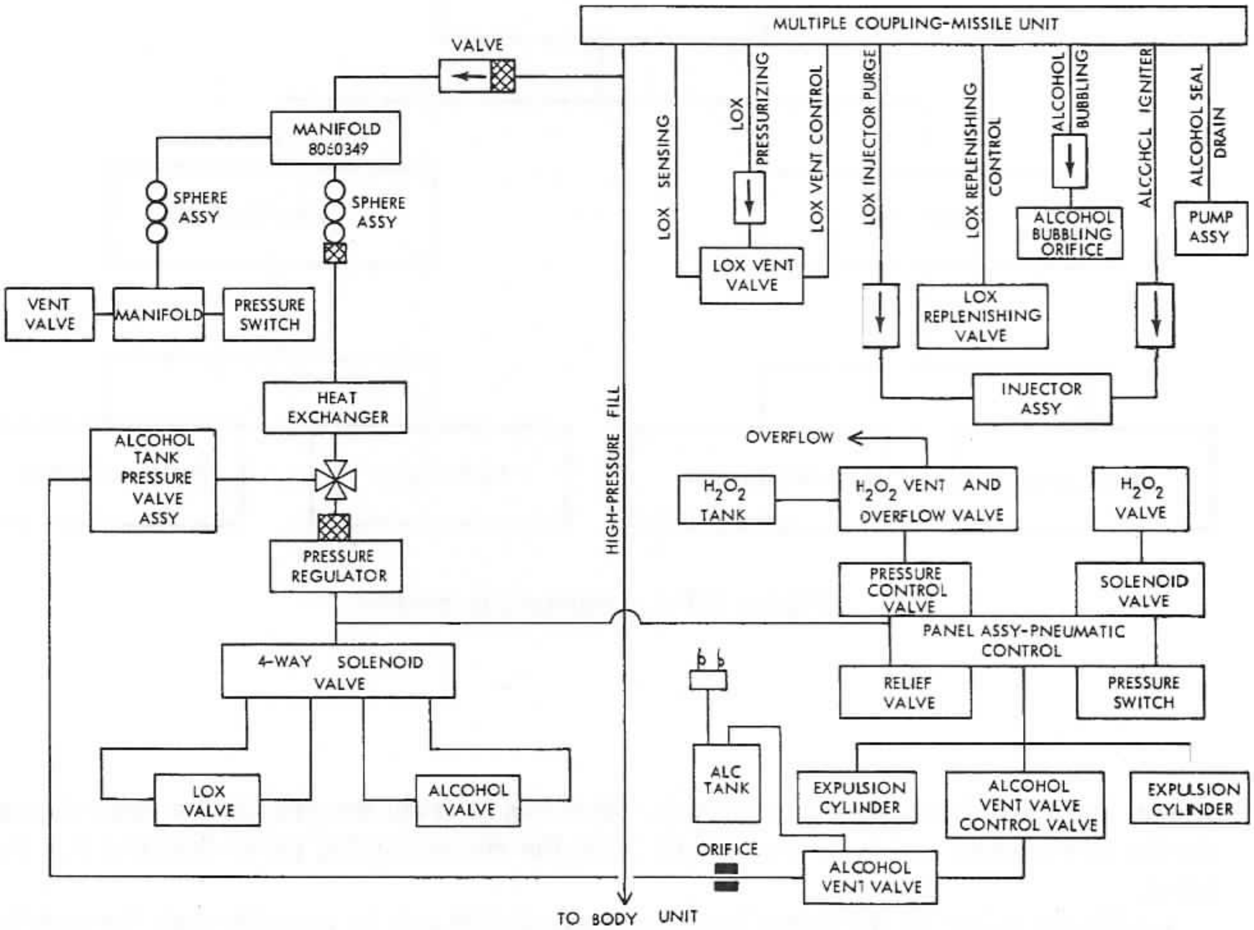


Figure VII-3 – Thrust Unit Pneumatic System

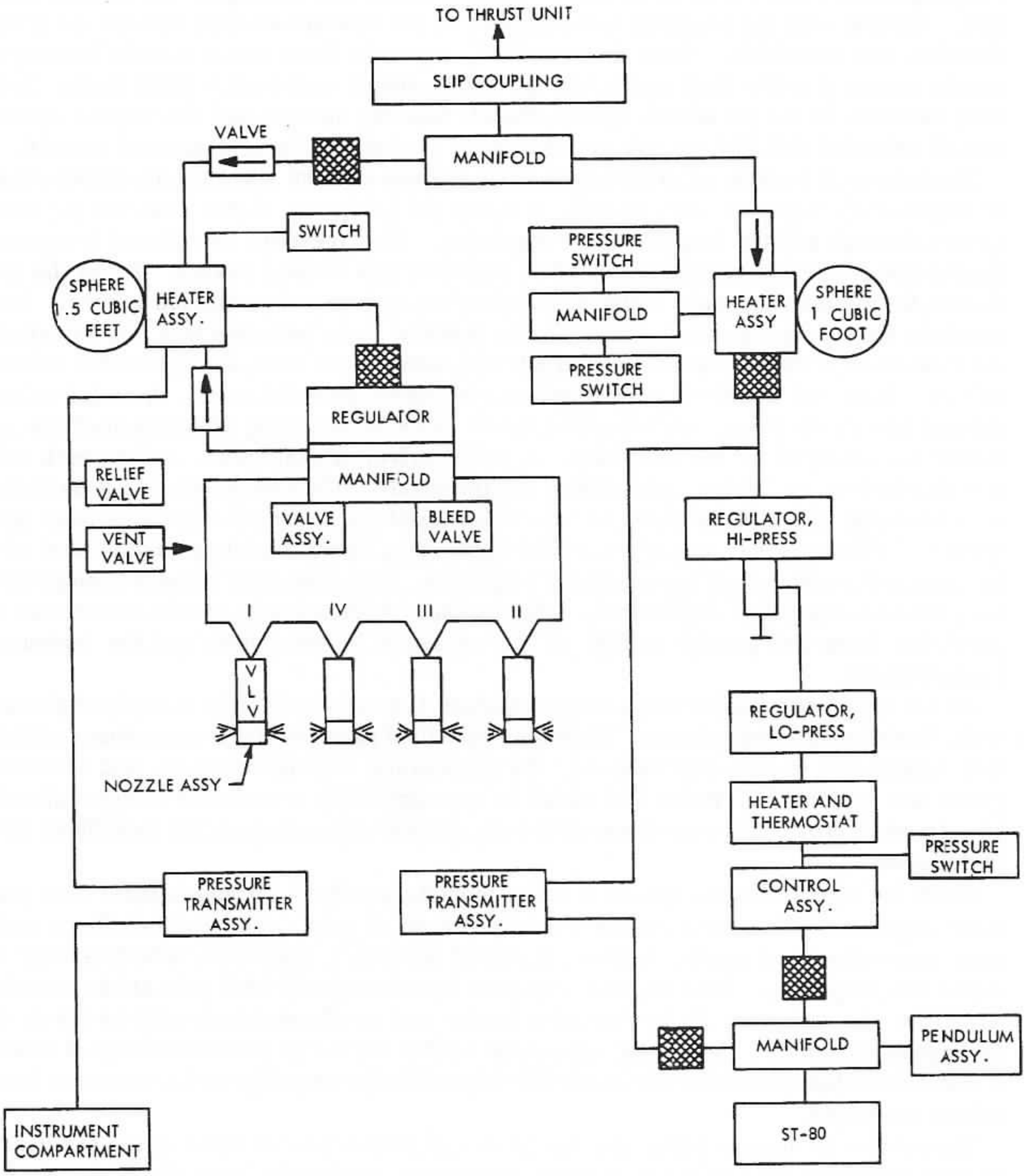


Figure VII-4 – Body Unit Pneumatic System

From the standard tee on the high-pressure fill line (to the triplex sphere assembly), a high-pressure line leads up to a slip coupling located at the top of the missile thrust unit. Mating with the coupling is an adapter in the missile aft unit and the air flow is directed to a manifold. From the manifold, separate lines run to the air bearing air supply sphere (1 cubic foot) and to the jet nozzle supply sphere (1.5 cubic feet). Pressure switches at the jet nozzle sphere, the air bearing sphere, and the triplex spheres are all actuated at 3,000 psi and are closed as part of the firing command circuit.

The jet nozzle system provides for spatial attitude control when the air vanes exceed an angle of ±5 degrees. Air, initially at 3,000 psi pressure, flows from the jet nozzle sphere through a filter to a pressure regulator. The pressure is reduced to approximately 300 psi by the regulator, which is adjusted by a loading device. From the regulator, the air then passes to a manifold and on to the jet nozzle solenoid valves. Commands to the electrical network system are derived from switches that are actuated by the movement of the air vanes. The electrical network, in turn, energizes the solenoid valves. Each jet nozzle is controlled by a separate solenoid valve. A relief valve to protect the downstream system and a bleed valve used during adjustment of the regulator are mounted on the manifold. A relief valve, a vent valve, and a check valve are attached to the heater assembly of the jet nozzle. The check valve is provided for unidirectional flow of bypassed air downstream of the pressure regulator back to the sphere. This flow will occur when the pressure in the sphere drops below that of the jet nozzle downstream of the pressure regulator. This pressure balance also protects the pressure regulator diaphragm. The pressure transmitter permits continuous supervision from the ground station of the pressure in the sphere and the instrument compartment.

An air supply and temperature control system is provided for the stabilized platform in the instrument compartment. When the stabilized platform is in operation (including test runs) prior to and after take-off, the pendulums, accelerometers, and stabilizing gyros are supplied with dried air, which is measured with a flow rate of approximately 11 scfm at 32.5 psi. This pressure will vary slightly depending on the individual ST-80 installation.

From the high-pressure sphere (1 cubic foot) the air flows through a filter to a pressure regulator which reduces the pressure to 65 ±5 psig. The air then flows past a gage connection and needle valve to a second pressure regulator, which further reduces the pressure. This second regulator is set to obtain 32.5 psig at the manifold. Air from the regulator flows through a heater and thermostat assembly to the orifice or bypass assembly. From the bypass assembly the air is passed through a filter to a manifold which directs the air to the ST-80 pendulum assembly and a pressure transmitter assembly.

The orifice or bypass assembly and pressure switch are included in the air bearing system to protect the air bearings in the event that, during checkout, the high-pressure air supply drops below 750 psig. When air pressure drops below 750 psig, the pressure switch causes a normally open solenoid valve in the bypass assembly to close, thus bypassing the air through an orifice. The reduced flow provides sufficient time for the gyros to run down before exhausting the air supply. The pressure switch also allows the stabilizing gyros to be started when pressure increases to the desired level (15 psig). Adjustment of the pressure regulator is done during ground checkout. Gage connections on the valve assembly and on the manifold are provided for the purpose of monitoring during adjustment. The pressure transmitter enables supervision of the pressures.

The LOX tank pressurization is controlled by a solenoid valve in the valve box which is actuated directly from the propulsion control panel and indirectly from the remote firing panel. The firing command switch on the remote firing panel initiates a series of operations, one of which is the LOX tank pressurization (to 31.5 psi).

Air at 3,000 psi from the high-pressure system is released through a hand-operated valve in the valve box to a pressure regulator. The regulator is adjusted so that 750 psi is released into the control valve system. A pressure gage indicates the pressure within the control valve system, and a safety valve prevents overpressurization. This 750-psi control system performs the following functions:

1) LOX tank venting is pneumatically controlled by a solenoid valve actuated from the propulsion control and remote firing panel. This valve is normally open. Air from the 750-psi system keeps the missile LOX vent valve open. When the solenoid valve is closed, pressure is cut off from the LOX tank vent valve and the vent valve closes.

2) The LOX replenishing fill and drain valve in the missile is pneumatically controlled by a solenoid valve also actuated from the propulsion control and remote firing panels. This solenoid valve is normally closed, and when opened, the pressure opens the normally closed LOX replenishing fill and drain valve located in the missile.

3) The injector plate is flushed with air in order to prevent the accumulation and freezing of moisture. A connection is made between the igniter alcohol pressurization fitting on the valve box and the injector purge fitting on the missile. Injector plate flushing is accomplished by operation of a hand valve.

4) After hose connections have been made between the valve box and the ignitor alcohol container, pressurization of the container is accomplished by opening a hand-operated valve. A solenoid valve controls the flow of igniter alcohol from the container to the missile during the ignition stage.

5) An air supply is provided by a solenoid valve for bubbling the alcohol at the alcohol pump inlet elbow of the rocket engine turbopump assembly. Bubbling begins during missile alcohol tank and LOX tank filling, and continues until liftoff. This bubbling prevents the possible freezing of alcohol in the pump suction line. Danger of freezing is caused by the proximity of LOX in the missile LOX tank over a projected length of time.

The LOX sensing system limits LOX tank pressurization. One of two pressure switches, which is used during testing, interrupts pressurization at 7 psig for leakage tests. At firing of the missile, pressurization is continued above 7 psig and is interrupted at 31.5 psig by the second pressure switch.

The leakage of the alcohol pump bearing seals is carried by a drain line which passes through the multiple coupling to the ground.

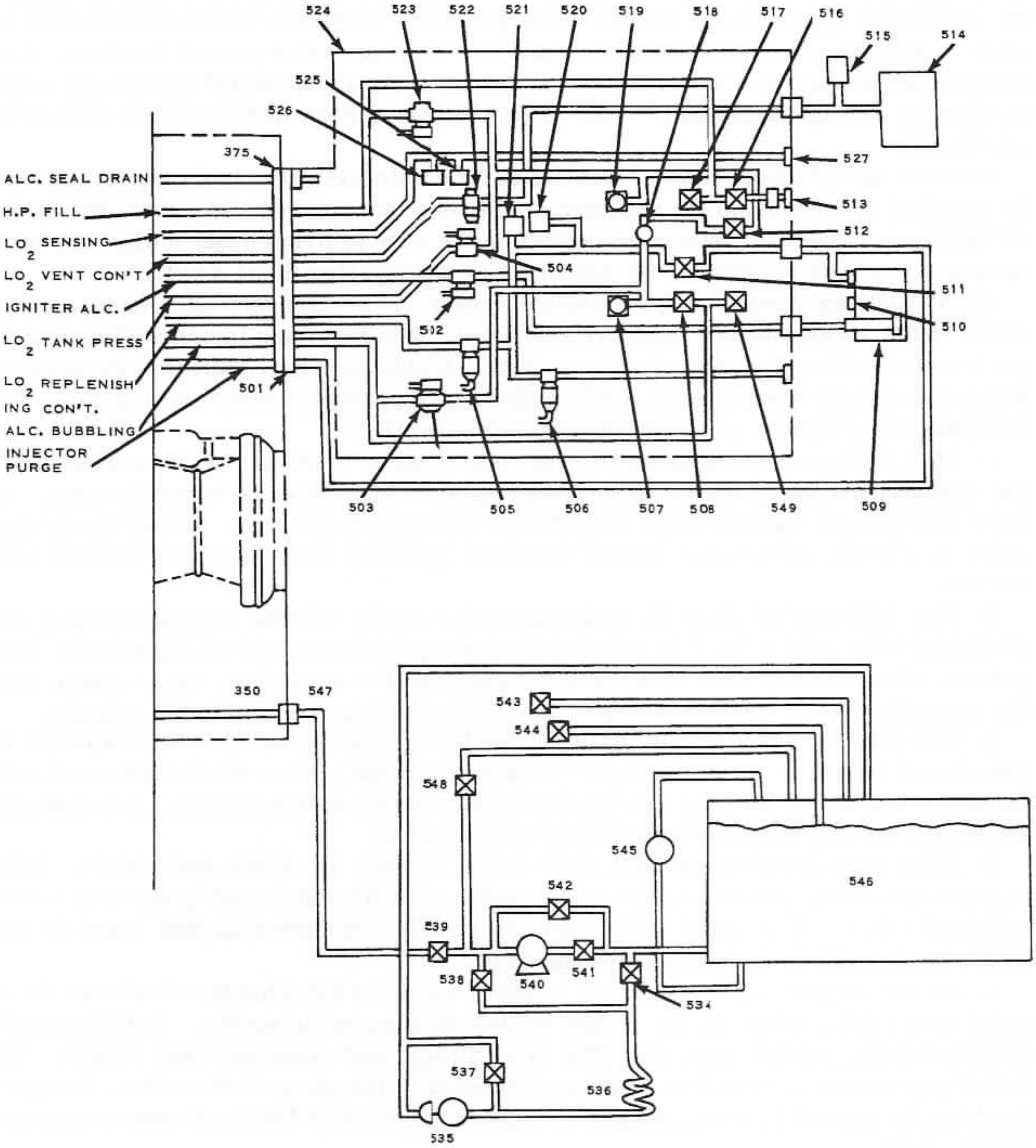


Figure VII-5 – Ground Control System

KEY TO COMPONENTS

350 – Slip Coupling, Missile Half
375 – Multiple Coupling Assembly, Missile Half

501 – Multiple Coupling Assembly, Ground Half
502 – Igniter Alcohol Control Valve
503 – Pressurizing Valve, Solenoid-Controlled
504 – Pressurizing Valve, LOX Control
505 – Control Valve, LOX Replenishing
506 – Control Valve, Pressurizing
507 – Pressure Gage
508 – Valve, Alcohol Bubbling, Air Pressure, Hand-Operated
509 – Igniter Alcohol Container
510 – Igniter Alcohol Fill Inlet
511 – Pressurizing Valve, Hand-Operated
512 – Shutoff Valve, Filter, Hand-Operated
513 – Filter, High-Pressure Air
514 – Auxiliary Pressure Container
515 – Pressure Relief Valve
516 – By-pass Valve, Hand-Operated
517 – Pressure Test Valve, Missile Check Valves
518 – Regulator, High-Pressure Air
519 – Pressure Gage
520 – Pressure Switch, Alcohol Container
521 – Vent Valve, LOX Tank
522 – Control Valve, LOX Vent, Normally-Open
523 – Solenoid Valve, Missile High-Pressure Fill
524 – Ground Control Valve Box
525 – Pressure Switch, 7 psig
526 – Pressure Switch, LOX Control, 31 psig
527 – Gage Connection, LOX Tank Pressure-sensing
534 – Pump Suction Valve
535 – Regulator, Pressurizing
536 – Coil, Pressurizing
537 – By-pass Valve, Pressure Regulator, Hand-Operated
538 – Coil Inlet Valve
539 – LOX Trailer Coupling, Ground Half
540 – LOX Pump
541 – Pump Suction Valve
542 – Pump By-pass Valve
543 – LOX Vent Valve
544 – LOX Full Trycock Valve
545 – Pressure Gage, LOX Tank
546 – LOX Tank
547 – Slip Coupling, Ground Half
548 – Priming Line Valve
549 – Vent Valve, Alcohol Bubbling System, Hand-Operated

This page has been left blank intentionally.

CHAPTER VIII
FIRING SITE OPERATIONS

This page has been left blank intentionally.

CHAPTER VIII
FIRING SITE OPERATIONS

GENERAL

The purpose of this section is to provide a description of the operational sequence in which the REDSTONE Weapon System, including the missile and ground support equipment required at the firing site, might be deployed, prepared, tested, and fired during a tactical situation.

Because of the variables that are peculiar to each situation, the methods and procedures for conducting a firing operation, as described herein, should be regarded only as examples and not as established tactical concepts. The final decision concerning the approach, methods, and procedures necessary to the firing mission will be made by the Firing Battery commander, subject to the concurrence of his Group Commander.

Before the firing operations are covered, a brief presentation of the general organization of the Field Artillery REDSTONE Missile Group is included. The group can be considered the smallest self-sustaining element within the theater organization. The control center of the group is the Headquarters and Headquarters Battery, whose primary function is to direct and coordinate all group operations. The using units of the group are the two field artillery missile batteries (firing batteries). The support units consist of an Ordnance Company and Engineer Company.

The mission of the firing batteries is to serve as the firing components of the missile group, in general support of the field army, by projecting mass destructive fire on the enemy at ranges greater than those possible by conventional field artillery.

The primary function of the Ordnance Company is to provide ordnance maintenance and supply support for the missile and supporting Ordnance equipment. This company is responsible for the receipt, storage, inspection, acceptance testing, and issue of missiles, warheads, fuels, and line items which are not the direct responsibility of the Engineer Company. The Ordnance Company lends direct support to the Firing Battery by providing maintenance teams (with mobile field maintenance shops). These teams will move forward to the launching area when a malfunction occurs in a component or assembly for which the Ordnance Company is responsible and the troubleshooting and repair of which is not within the capability of the Firing Battery personnel and equipment.

The Engineer Company is responsible for three essential functions in its required support of the Field Artillery REDSTONE Missile Group in general and the Firing Battery in particular. One function is to generate, store, and transport LOX in sufficient quantities to meet the firing capability of the group. Another function is the generation, storage, and transportation of liquid nitrogen in sufficient quantities to meet group requirements. A third requirement of the Engineer Company is to provide field maintenance and repair on all basic motor-driven vehicles; that is, trucks, trailers, and diesel generators. The Engineer Company will supply contact teams in the launching area for the purposes of inspection, repair, or evacuation of items for which it is responsible.

All personnel of the Field Artillery REDSTONE Missile Group, with the exception of the chaplain and medical personnel, are equipped to fight as infantrymen, when required, to defend group installations against ground attack.

In the following discussion, it will be assumed that the firing order, with pertinent information, has been given to the Field Artillery REDSTONE Missile Group Commander by the Field Army Commander. This information would include: the geographic coordinates of the target, the desired time of missile firing, pertinent warhead information, and the general area of the launching site. It will further be assumed that a Corps of Engineers Survey Team has established two survey marks of at least third-order accuracy and separated by a distance of from 100 to 300 meters. The location of these two survey marks, their respective Universal Transverse Mercator (UTM) grid coordinates and elevations, and the grid azimuth between them will have been made known to the Survey Section of the Field Artillery REDSTONE Missile Group.

SITE SELECTION AND PREPARATION

Upon receipt of the firing order, the group commander will notify the respective commanders of a Firing Battery, the Ordnance Company, and the Engineer Company. The two support companies will immediately make preparations for the delivery to the Firing Battery of the missile and all other support equipment required for the firing operation when it is requested.

The Firing Battery Commander, accompanied by an operations officer and a survey team, will go forward to the designated general launching area for the purpose of selecting a suitable firing site. This reconnaissance may be conducted from the air or on the ground.

Because of the size and weight of equipment used to support a launching, the firing site selection is necessarily contingent on the following factors:

Accessibility

Roads, bridges, and trails leading to the firing site must be capable of supporting heavy equipment and must have sufficient width and clearance to permit passage of all the required loaded vehicles.

Size of Area

The size of the firing site is determined by the amount of space required to assemble and raise the missile and to accommodate the maximum concentration of ground support vehicles, which occurs during LOX filling. Within these limitations, over-all size will vary according to the ingenuity exercised in maneuvering vehicles and arranging equipment on the site.

Contour of Terrain

Uneven terrain can be used for a firing site provided the missile launcher can be leveled and the ground support equipment can be placed in an operational position.

Bearing Strength of Soil

The soil must have sufficient bearing capacity to support the emplacement of a launcher and a fueled missile under maximum wind load. The bearing capacity is determined as a figure called the cone index of the soil. In effect, the cone index is an empirical measure of the soil's shearing resistance and is determined with the aid of a cone penetrometer. The cone penetrometer is slowly pushed into the ground to a depth of 36 inches, if possible. Readings are taken at the surface and at 6-inch intervals. The average of these readings is the cone index. A cone index should be determined for each of the four launcher pad locations. The readings at these four locations should balance within 10 per cent. A cone index of 100 or greater is required for a single firing. This minimum figure provides a safety factor of one when the loaded missile is resting on the launcher and is under full wind load. If a multiple firing is anticipated from the same launcher location, the cone index must be 200 or greater.

Drainage

Natural and/or man-made drainage should be sufficient to prevent reduction of the soil bearing capacity around the launching area, especially around the launcher, in the event that the firing operation is undertaken during inclement weather. Drainage should also be sufficient to prevent standing water from hindering the firing operation in any way.

Cover and Protection

The firing site should have some natural cover to conceal the weapon system during the horizontal operations, which include firing site selection and preparation, vehicle deployment, and missile assembly and testing. Because of the height of the erected missile and because of LOX vapors and ice films, which can make the firing site prominent to enemy view and therefore vulnerable to attack, all vertical tests and firing preparations are completed as rapidly as technically feasible.

Survey Control

Because the azimuthal orientation of the missile is of paramount importance to the successful completion of the firing mission, and because this orientation is contingent, in part, upon the geographic location of the missile launcher, every effort is made to establish the firing site within a radius of 1000 meters of the surveyed marks which were described earlier. If this is not feasible, then the survey team should extend survey control from these survey marks to within 1000 meters of the launching point.

Lines of Sight

The firing site should afford clear lines of sight in order that the surveying and missile laying procedures can be performed rapidly, accurately, and with minimal opposition from natural obstructions.

Standby Area

An assembly area for the parking and dispersing of vehicles should be available near the launching site. Communication between these two points is necessary to assure the timely arrival of each vehicle as it is requested by the Firing Battery commander.

After all the aforementioned factors have been taken into consideration and an optimum suitability of the launching area has been realized, the area is ready for final preparation. This final preparation entails the clearance of trees, brush, and any debris which could hinder the vehicle march and emplacement, the surveying and missile laying, and/or missile assembly, testing, erection, fueling, and firing.

LAYING AND AIMING

The ultimate success of the firing mission is the delivery of the armed warhead into the desired target area within the prescribed radial tolerances.

The REDSTONE Missile is primarily a ballistic type, in that the greater part of its flight approximates the trajectory of a free-falling projectile. The entire flight is planned to follow a predetermined path from the launcher to the target. It becomes readily apparent that, to instill within the missile guidance system the necessary information to direct the missile to follow a fixed flight path, certain basic considerations are necessary. These considerations are: the geographic positions of the launching point and of the target with the resulting distance between them, their azimuthal bearing relationship, and the inherent errors of the composite missile.

The inherent errors of the missile are the result of all the imperfections, both material and operational, of the missile components and assemblies. The optimum condition of missile operation is therefore contained within the prescribed tolerances of the components and assemblies.

The firing azimuth that the missile must travel from the launching point to the target, and the distance between these points, are functions of the geographic coordinates and altitudes of these two points. Because the location and altitude of the target are known, the accuracy of the missile firing, irrespective of the composite missile tolerances, is dependent upon the accuracy in which the exact position and altitude of the launching point are determined.

PRELIMINARY CONSIDERATIONS AND PREPARATIONS

For every firing situation the individual pieces of laying equipment are restricted to emplacement either at fixed points or in a fixed general area. Because an optical method of laying the missile is employed, clear lines of vision between the pieces of laying equipment are essential. Any obstruction must be eliminated by the method most appropriate under the prevailing conditions.

The accuracy of optical equipment is affected by temperature variations. It is, therefore, necessary to protect this equipment from extremes in temperature changes. Umbrellas are utilized to protect the laying instruments from the direct rays of the sun or from the effects of rain, snow, or other adverse weather conditions.

The preliminary qualification adjustments to the laying equipment are the responsibility of the missile laying team and should be accomplished prior to arrival at the launch site. These adjustments are verified at the launch site prior to the performance of the laying procedures.

GIVEN INFORMATION

Certain information is required at the launching area in order to properly orient or aim the missile. As previously mentioned, the Corps of Engineers Survey Team is responsible for the establishment of two survey marks of at least third-order accuracy. The location of these two survey marks, their respective Universal Transverse Mercator grid coordinates and elevations, and the grid azimuth between them are made known to the Group Survey Section and the missile laying team. In addition to this information, the appropriate Transverse Mercator Projection tables and a map of the launching area sector are also needed to establish the coordinates and the elevation of the launching point.

NOTE: The surface of the earth is divided into five areas as far as military mapping is concerned. Each area is mapped with respect to a selected spheroid and data which permit accurate representation of the mapped area. The Transverse Mercator Projection (TMP) represents a map of a sector on an appropriate mapping spheroid. The sector represented on the TMP is bounded by longitudes of 3 degrees East and 3 degrees West of a meridian and ranges from 80 degrees North latitude to 80 degrees South latitude.

EQUIPMENT UTILIZED

The following equipment is required in the launching area:

- Two Wilde T-2 theodolites with night lighting equipment, theodolite mounted targets (TMT), tripods, and accessories.
- One Wilde T-2 precise traverse target with night lighting equipment, tripod, and accessories.

One pocket transit (magnetic compass similar to an M-2 compass but graduated in degrees).
One 30-meter steel tape.
Two surveyor's umbrellas with supports.
Two flashlights with blackout filters.
Two nails (any size from 4 penny to 12 penny).
Recording forms and pencils. The forms are the Orientation Computation Sheet (OCS), 4 each, and the Commander's Verification Check Sheet (COVCS), 2 each.

PRELIMINARY LAYING

The determination of the coordinates and elevation of the launching point should be completed as rapidly as possible after the firing site has been selected and, preferably, before all the ground support equipment has been emplaced. The reason for haste is that the determined laying information must be submitted to the Group Firing Data Section for the development of final laying data.

As the laying equipment is brought into the launching area, the individual instruments are checked for verification of the accuracy of their preliminary qualification adjustments.

Of primary consideration in the laying operation is the proper positioning of the individual instruments. One of the Wilde T-2 theodolites, which is referred to as the Reference Instrument (RI), is established over one of the two reference survey marks. This survey mark is referred to as the Orienting Station (OS). The Wilde Precise Traverse Target (WPTT) is positioned over the other survey mark. This second survey mark is referred to as the Orienting Station Mark (OSM). The straight line joining the OS and OSM is referred to as the Orienting Line (OL). After the RI is plumbed over the OS and the WPTT is plumbed over the OSM, the RI operator sights along the OL to the WPTT. The azimuth scale of the RI is rotated to coincide with the azimuth reading of the OL, which was included in the required given information. A magnetic reading of the OL is taken by means of the pocket transit. The difference between the true heading and the magnetic heading is determined and recorded for later use during final laying.

With the aid of the aforementioned laying equipment, the Group Survey Section will determine the UTM grid coordinates and elevation of the launching point or launcher station (LS) by extending the existing survey control from the Corps of Engineers survey mark (OS) to the LS. For expediency, or of necessity, the missile laying team may be required to perform this standard survey operation. A survey stake, with a nail or some mark identifying the exact position of the LS, is then driven into the ground.

The results of the survey are transmitted to the Group Firing Data Computer Section in a manner most appropriate under the existing tactical circumstances. The computer section would normally be housed at or near the group headquarters. The computer section utilizes the LS survey information in conjunction with known target information to determine a geodetic azimuth or true line of fire (TLOF) at which the missile must be fired to strike the target. The computer section also provides the geodetic azimuth of the OL and specific guidance and control system presetting information.

Aside from laying equipment preparation and general emplacement, no further laying operations can be performed until the missile firing data have been received from the group computer section and the missile has been erected to the vertical position.

WEAPON SYSTEM EQUIPMENT REQUIRED AT THE FIRING SITE

The following is a list of major missile and ground support equipment required at the firing site:

Missile units and transport trailers
- (a) Warhead unit and semitrailer.
- (b) Aft unit and trailer.
- (c) Thrust unit and semitrailer.

Propellant service equipment
- (a) Alcohol tank semitrailer.
- (b) LOX tank semitrailer (2 each).
- (c) Hydrogen peroxide service truck.

Ground power and servicing equipment
- (a) 60-kw diesel generator (2 each).
- (b) Power distribution trailer.
- (c) Battery servicing trailer.

Missile launching and handling equipment
- (a) Erector-servicer truck.
- (b) Missile launcher platform.

Guided Missile Test Station

Pneumatic supply and storage equipment
- (a) Air compressor truck.
- (b) Air servicer trailer.

Stabilizer platform with shipping and storage container

Accessories transportation truck (2 each)

Fire fighting equipment
- (a) Fire truck.
- (b) Water tank trailer.

Liquid nitrogen container

LINE OF VEHICLE MARCH

The road march and vehicle emplacement is necessarily dependent upon the existing tactical situation and will be undertaken as directed by the Firing Battery commander.

The following is an example of an order of vehicle movement in a particular tactical situation:

1. The erector-servicer truck towing the Missile Launcher.
2. An accessories transportation truck towing a 60-kw diesel-generator trailer.
3. An accessories transportation truck towing the power distribution trailer.
4. The air compressor truck towing the air servicer trailer.
5. The stabilized platform shipping and storage container (including the ST-80) will be brought to the launch site by some vehicle designated by the Firing Battery commander.
6. The missile warhead unit (in its semitrailer) towed by a tractor truck.
7. The missile aft unit (in its trailer) towed by a cargo truck.
8. The missile thrust unit (in its semitrailer) towed by a tractor truck.
9. The liquid nitrogen supply vehicle.
10. The guided missile test station (GMTS) towing the battery servicing trailer.
11. The fire truck towing a water tank trailer.
12. The alcohol tank semitrailer towed by a tractor truck.
13. The first LOX tank semitrailer towed by a tractor truck.
14. The second LOX tank semitrailer towed by a tractor truck.
15. The hydrogen peroxide servicer truck.
16. An auxiliary 60-kw diesel-generator trailer towed by some vehicle designated by the Firing Battery commander.

EQUIPMENT EMPLACEMENT

After the launcher station (LS) has been established, and before the vehicles arrive at the firing site, a centerline should be established. This centerline must pass through the LS and extend between the intended positions of the erector-servicer truck and the warhead unit semitrailer. This centerline can be a chalk line or a light rope. If existing conditions permit, the centerline should be laid out in such a direction as to result in the erected missile being quasi-aligned on the desired target azimuth.

It may be necessary to use aircraft landing mats to support the launcher and other heavy equipment if the soil is softened or washed out because of rain or other adverse weather conditions.

The following procedure is a description of a proposed deployment of vehicles and equipment; tactical considerations may dictate variations:

1. The erector-servicer truck, towing the missile platform launcher, moves into the firing site and straddles the centerline. The launcher is positioned over the LS survey stake. The hydraulic cart is unloaded. The erector-servicer truck is positioned behind the launcher, over the centerline, and the A and H frames are unloaded and assembled.
2. A 60-kw diesel-generator, towed by an accessories truck, is positioned approximately 150 feet from the launcher. The accessories truck is unloaded.

3. The power distribution trailer, towed by an accessories truck, is centrally located near the 60-kw generator.
4. The air compressor truck, with its air servicer trailer, is positioned. The air compressor is started for a warmup.
5. Sufficient cabling should be completed to allow the 60-kw generator to be started with no necessity for shutting it down during later cabling exercises. The generator is then started for a warmup.
6. A public address system and/or other methods of inter-area communications are activated as rapidly as possible in order to provide a means of coordinating the total operation.
7. The stabilized platform, in its container, is brought into the area and conveniently positioned for preparation for installation in the missile.
8. The warhead unit semitrailer is positioned, straddling the centerline, approximately 150 feet ahead of the launcher. The cover is removed from the warhead unit trailer.
9. The aft unit trailer is moved, over the centerline, ahead of the launcher and under the A-frame chain hoist. The aft unit trailer cover is removed and the aft unit is lifted by the chain hoist.
10. The warhead unit trailer is backed up to the suspended aft unit and the two missile units are mated, still supported by the warhead unit trailer. The warhead unit trailer is then moved ahead with the complete body section.
11. The thrust unit semitrailer, with cover removed, is positioned over the centerline, just ahead of the launcher.
12. With the chain hoist, the rotating frame is lifted away from the launcher and attached to the base of the thrust unit.
13. The chain hoist is then used to lift the thrust unit from its trailer, and the trailer is removed from the immediate area.
14. The warhead unit trailer, containing the complete missile body section, is backed up to the suspended thrust unit. The body section and thrust unit are mated.
15. The warhead unit trailer is backed further until the rotating frame can be reattached to the launcher.
16. The chain hoist is removed from the thrust unit and the erecting cables from the A-frame are connected to the missile body section.
17. The liquid nitrogen supply vehicle is brought into the area and positioned approximately 45 feet from the launcher and in the sector that conforms to the position of the installed heater-cooler drop tank.
18. The battery service trailer, towed by the Guided Missile Test Station (GMTS), is positioned near the 60-kw diesel-generator. The GMTS is then positioned approximately 25 feet from, and to the side of, the launcher.
19. Battery activation is started as quickly as possible.
20. The fire truck and water tank trailer are positioned in such a manner as to be readily available to combat any fires that might occur in any area.

21. The propellant service vehicles (the alcohol trailer, the two LOX trailers, and the hydrogen peroxide truck) are parked apart from each other and at a considerable distance from the firing site. This is a safety precaution because of the volatility of these substances. This parking method also reduces the congestion in the immediate area of the firing site.

The sand-bagged emplacement that houses the remote firing box is set up as the Firing Command Post. This emplacement should be positioned in such a manner as to permit an unobstructed view of the erected missile and the firing site in general, while affording sufficient protection for the personnel manning the post. The emplacement can be made at a distance of up to 200 yards from the launcher.

With the positioning of the propellant servicing vehicles, the initial vehicle emplacement is completed, and the stage is set for the preparation for the horizontal checkout of the missile.

HORIZONTAL CHECKOUT

This phase of the firing mission is directed toward the functional testing of the components and assemblies of the weapon system. In other words, the operational readiness ("go - no go" condition) of the complete weapons system is ascertained during this phase.

Preparation

Before the various tests can be performed, it is necessary that the electrical and pneumatic interconnections required between the missile and ground support equipment have been made. Ground power must be made available to all required areas. Qualified personnel must be on hand to perform the necessary operations. There must be a complete system of intercommunications throughout the entire firing site complex. The stabilized platform (ST-80) is installed in the instrument compartment of the body section, but the platform is not electrically connected.

Tests Performed

Many of the operations performed during the horizontal checkout phase will be carried out simultaneously. For simplicity, the tests performed will be discussed individually and in a feasible order as follows:

Pneumatic System Checkout – The dewpoint of the high-pressure air in the air servicer trailer is determined. After the dewpoint has been determined and all air lines have been connected, the air is admitted into the ground and missile pneumatic system. The entire pneumatic system is checked for leaks, and the various valves and regulators are tested and adjusted as required.

Horizontal Power Check – After the electrical cabling has progressed to a point which permits the application of power to the missile system, tests are undertaken to assure that the various power sources, both ground and missile, are properly connected into the system and are operating within prescribed tolerances.

Sequence Recorder Check

Powerplant Components Test – This test involves the checkout of all electrically and pneumatically controlled valves which appear in the missile propellant system.

Range Guidance Computer Test

Lateral Guidance Computer Test

Warhead Arming Check – This is a check of the velocity and displacement arming switches located in the guidance computers. These switches set up the parameters within which the missile warhead can be armed.

Control System Test – This is a checkout of all the circuitry which maintains the proper attitude of the missile during its flight.

Inverter Calibration Test – Because of the critical areas in which the missile inverter power is used, it is necessary that the inverter's output (both the frequency and the voltage) be maintained within very critical tolerances.

Thrust Controller Test – The thrust controller maintains the combustion chamber pressure at a constant value during the propulsion phase by indirectly controlling the flow rate of the propellants.

Program Device Test

Over-all Cutoff Tests – These tests provide a method of checking the circuitry involved in the automatic shutdown of the missile system under various abnormal circumstances.

Horizontal Simulated Flight Test – This test serves as a check of the composite missile system throughout the various phases from the issuing of the firing command to impact. The functions that cannot actually be performed, for example, propulsion ignition, pyrotechnic device firing, and missile separation, are simulated to effect a sequential test of the over-all system.

Missile Batteries Activation and Installation – The missile system requires three batteries (two 28-volt and one 60-volt) during actual flight conditions. Ground power is used to simulate missile battery power during component and horizontal simulated flight tests.

Power Transfer Test – The purpose of this test is to check the operation of the missile batteries under normal load conditions. The power transfer test is the last of the horizontal tests to be performed. With its completion, the missile is readied for erection and vertical testing.

VERTICAL CHECKOUT

This phase is directed toward the final prefiring check to assure that the missile system is operationally ready, within the prescribed tolerances, to fulfill the firing mission.

Preparation

All test cables, regulator pressure gages, and test equipment peculiar to the horizontal checkout phase are removed and stored. This includes such test equipment as the stabilization system amplifier load box, the booster servo interrupter box, and the simulated flight test box.

The stabilized platform (ST-80) is electrically connected to its amplifier boxes, the instrument compartment access doors are sealed, and a leak check is performed to verify the pressure seal of the instrument compartment.

The heater-cooler drop tank is prepared and installed on the missile. The launcher is leveled, and the missile is erected with the aid of the A-frame. After the missile is placed in a vertical position on the launcher, the H-frame is assembled to provide a platform for personnel who are servicing the vertical missile.

All necessary interconnections, both electrical and pneumatic, are made and verified.

The air rudders and carbon jet vanes are inspected and installed.

The missile is rotated for coarse target azimuth alignment.

Tests Performed

The number of tests performed, and the order in which they are undertaken, may vary with each tactical situation.

Vertical Power Check – This is a final test to assure that the system power sources are properly connected and operating.

Preset Timers Check – Presetting adjustments in the cutoff computer are very critical and, as the accuracy of presetting is dependent upon timing, care must be taken to assure against intolerable error in the timing device.

Stabilized Platform Presetting – The firing mission data sheet, provided by the Group Computer Section, contains certain presetting information for the stabilized platform (ST-80). This information includes the elevation angle (epsilon angle) of the range accelerometer and the earth-rotation bias settings for the three missile axes.

Control System Test – This is a final test of the guidance and control system components which are responsible for maintaining the attitude of the missile during the flight phases.

Vertical Simulated Flight Test – This is a check of the composite missile system from the firing command to 20 seconds after simulated liftoff. This provides a functional check of most of the circuitry involved in the propulsion system as well as the power transfer sequence and limited operation of some of the guidance and control components.

FINAL LAYING

Final laying should be started as soon as possible after missile erection, upon receipt of firing data from the Group Computer Section.

When the geodetic azimuth of the true line of fire (TLOF) has been made known from the firing mission data sheet, the missile laying team can position the second theodolite, which is called the azimuth control instrument (ACI). The ACI is responsible for the final orientation of the missile to the TLOF. An optical reflecting instrument, called a porro prism, is located on the ST-80 mounting frame in the missile between missile body fins I and IV and just slightly forward of fin IV. The face of the porro prism is visible from outside of the missile in a visibility-restricted sector extending away from the general area of missile fin IV. The porro prism is physically oriented so that its dihedral edge is parallel to the vertical plane passing through fins I and III and at the same time, parallel to the local horizontal (assuming the missile has been vertically leveled). The final laying of the missile will have been accomplished when the vertical plane passing through fins I and III is aligned along the azimuth of the TLOF.

The method used in the orientation of the missile is referred to as the perpendicular sighting method. In order for the ACI operator to receive an optical reflection from the porro prism, he must be sighting in a plane that is exactly perpendicular to the dihedral edge of the porro prism. From this it can readily be seen that to optically align the missile to the TLOF, it will be necessary to rotate the missile until the dihedral edge of the porro prism is parallel to the TLOF.

The final laying exercise is described in the following paragraphs.

Determination of the Magnetic Azimuth of the TLOF

The magnetic azimuth of the TLOF is determined by adding to or subtracting from (as is necessary) the geodetic azimuth the azimuthal difference between the true bearing and the magnetic bearing at the particular point on the earth's surface on which the launcher station (LS) is located. This azimuthal difference was determined and recorded during the preliminary laying exercise.

Determination of the ACI Sighting Magnetic Azimuth

The ACI sighting magnetic azimuth is determined by subtracting 90 degrees (or adding 270 degrees) to the magnetic azimuth of the TLOF.

Determination of the First ACI Ground Mark

A laying team specialist, standing near the booster air rudder IV and utilizing the pocket transit, sights along the ACI sighting magnetic azimuth. While maintaining the sighting along this azimuth, the specialist moves directly backward and away from the launcher to a distance of 30 to 60 meters. At a suitable spot on this line just traversed, the specialist will make the first ACI ground mark.

Determination of the Distance Between the ACI and Launcher

By means of the meter measuring tape the specialist measures the distance from the ground mark to the inside ring of the launcher to the nearest decimeter.

NOTE: The inside ring of the launcher is used as a terminus because it is roughly in the same perpendicular plane to the local horizontal as the face of the alignment porro prism.

Qualification of the ACI Azimuth Scale

The reference instrument theodolite (RI), which had previously been positioned and qualified over the orienting station (OS) during the preliminary laying exercise, is turned in azimuth to sight on the theodolite-mounted target (TMT) mounted on the ACI. The ACI is turned to sight on the TMT on the RI. The azimuth scale reading of the ACI should be the back azimuth of the azimuth scale reading of the qualified RI. The azimuth scale of the ACI is rotated to read the azimuth reading of the RI +180 degrees (or -180 degrees, as is necessary). The ACI is then considered qualified in its azimuth scale.

Missile Coarse Alignment

The missile is rotated so that the vertical plane that passes through vanes II and IV is roughly parallel to the ACI sighting magnetic azimuth, and the porro prism is sighted by the ACI operator.

The missile and the ACI are alternately rotated until autoreflection is achieved. This first ACI azimuth scale reading is recorded.

NOTE: This reading undoubtedly will be other than the desired reading (geodetic azimuth of TLOF -90 degrees or +270 degrees, as is necessary), and further operations must be undertaken.

Determination of the Reposition Constant

To arrive at the desired firing azimuth, it will be necessary to turn the missile and/or reposition the ACI. The missile can be turned easily. All that is necessary is to determine how much and in what direction the ACI must be displaced in order to achieve missile target alignment.

Because the firing azimuth is critical to within minutes of arc, it is necessary to position the missile within a minute of arc. The SIN-TAN of this minute angle is 0.0002909, or in round figures, 0.0003.

The recorded distance (D) from the ACI ground mark to the launcher (measured to the nearest decimeter) is converted into centimeters.

The direction that the ACI must be displaced is easily ascertained by comparing the actual azimuth scale reading of the ACI and the desired reading, TLOF -90 degrees (or +270 degrees, as is necessary).

The amount of necessary displacement of the ACI can be computed as follows:

d (amount of necessary displacement) = D tan (or sin) Θ

Θ is the difference between the aforementioned angles.

0.0003 D (cm) = cm/min of arc = Reposition Constant (Rk)

Repositioning of the ACI

After determining the angle (Θ) and the amount and direction of necessary ACI movement, the laying specialist accurately measures the distance in the proper perpendicular direction from the first ACI ground mark and makes a second ground mark. The ACI is plumbed over this second ground mark and its azimuth scale is requalified by again bucking (cross-sighting) with the RI.

Missile Fine Alignment

The missile and the ACI are again alternately rotated until auto-reflection is achieved. It is possible that the missile still is not correctly oriented, and further computation, ACI repositioning, and missile rotation are necessary. Each time the ACI is repositioned, it must be requalified in order to maintain its degree of accuracy.

The method of final laying, with the necessity for repositioning the ACI, is a trial-and-error method. However, an experienced laying specialist can perform the operation quite rapidly and with a minimum of ACI movement.

FINAL PREPARATIONS FOR FIRING

When all the proposed tests have been completed to the satisfaction of the Firing Battery commander, the final firing preparations are begun.

Preparation for Propellant Loading

Some of the fueling preparations can be started as soon as the missile has been erected. This activity would include the connection of the various alcohol and LOX lines and valves and the positioning of the fueling ladder. The fire-fighting equipment should be in the area during propellant loading operations.

Inert Lead Start Fluid Filling

The powerplant (engine) jacket is filled with lithium chloride, which is carried in a container on the alcohol trailer, to permit a smooth transitional flow of alcohol during the engine starting phases.

Alcohol Filling

This operation is started after the vertical simulated flight test has been performed. The alcohol trailer is positioned approximately 20 feet from the fueling ladder. The igniter alcohol container, located on the launcher, is filled by gravity flow from the alcohol trailer emergency valve. The alcohol trailer is connected, through the fueling ladder, to the missile alcohol tank, and the alcohol is pumped into the tank. When the missile alcohol tank is full, the alcohol trailer is disconnected and driven out of the immediate launching area.

LOX Filling

After the alcohol trailer has left the immediate area, the two LOX trailers are moved into position. They are simultaneously connected, through a "Y" connection, to the fueling ladder and then to the missile LOX tank. LOX pumping is started from one of the LOX trailers. After a delay of three or four minutes, the pumping of the second LOX trailer (replenishing trailer) is started. This delay is to assure that the depletion of LOX in the second trailer will be less than that of the first, after LOX filling is completed. When the missile LOX tank is full, the LOX pumping operation is stopped and the first LOX trailer is disconnected and driven out of the immediate launching area. The second LOX trailer (the replenishing trailer) is disconnected and moved away from the launcher to a distance of approximately 150 feet. A LOX replenishing line is then connected from the replenishing trailer to the replenishing arm, mounted on the launcher and connected to the missile LOX tank. Periodically, throughout the rest of the operation until missile firing, the normal boiloff of LOX from the missile LOX tank will be replaced by the operator of the remote firing box. A replenishing switch controls the LOX replenishing.

Hydrogen Peroxide Filling

After the LOX filling exercise is completed, the hydrogen peroxide truck is positioned near the missile, and the container is connected to the missile hydrogen peroxide tank. The hydrogen peroxide is then pumped into the missile tank. The hydrogen peroxide, in conjunction with catalytic pellets, produces the steam which drives the propellants turbopump.

Upon completion of the hydrogen peroxide filling, the hydrogen peroxide truck is disconnected and driven from the immediate area.

Vertical Range Computer Test and Presetting

This exercise includes the final check of the operational status of the range guidance computer and the cutoff computer, which are housed in the same assembly.

Upon verification of the in-tolerance operation of the range computer, the presetting information listed on the firing mission data sheet is instilled into the cutoff computer. This presetting information includes constant values of velocity and displacement, which are compensation for inherent errors peculiar to the individual trajectory of the missile.

Vertical Lateral Computer Test

This test is designed to effect a final check of the operational status of the lateral guidance computer.

Warhead Prelaunch Check

This check determines the condition of missile network circuitry related to the warhead. The type of warhead burst (air or surface) is also selected during this exercise.

Final System Preparations and Equipment Removal

The guided missile test station (GMTS) is disconnected from the missile system and driven out of the firing area.

The powerplant ignition system is readied and the blind plugs, which serve as deactivating or safety devices, are installed.

The missile laying team makes a last check to assure that the missile is properly oriented to the TLOF.

The immediate firing area is cleared of extraneous equipment and personnel.

The remote firing box operator operates the LOX replenishing switch until LOX tank overflow is visible.

At the predetermined time and on order from the Firing Battery commander, the remote firing box operator closes the firing switch.

MISSILE FIRING

The general sequence of operation of the missile system after the firing command given, is as follows:

1.) The missile propellant system vent valves, which were opened for the propellant filling exercises, are closed.

2.) The missile pneumatic system is then utilized to pressurize the propellant tanks. The pressurization of the hydrogen peroxide and alcohol tanks is started immediately upon the firing command signal. When the alcohol tank pressure is sufficient, a pressure-sensing switch actuates to stop alcohol tank pressurization and to start the LOX tank pressurization.

NOTE: Throughout a portion of the flight, the propulsion system tanks pressurization is cycling because of the action of pressure-sensing switches.

3.) When the LOX tank pressure has reached a specific amount, a pressure switch is actuated to stop the LOX tank pressurization and to start the power transfer sequence.

NOTE: The missile system has been operating from ground power until this time in order to save the missile batteries. These batteries are very short-lived under normal loading conditions.

During the power transfer sequence, the missile batteries are connected to their respective missile busses, in parallel operation with the ground power sources. When the tie-in has been accomplished, the ground power sources are disconnected from the missile system. The operation results in a smooth transition from ground power to missile battery power.

4.) The completion of the power transfer sequence initiates action to propel the heater-cooler drop tank away from the missile.

5.) The physical breaking of the electrical connections between the missile and the heater-cooler drop tank actuates the ignition starting sequence. After a slight time delay, which allows the three missile batteries to settle down under the rather rapid loading action of the power transfer sequence, the igniter squib is fired and ignition takes place. LOX, in the ignition stage, is taken directly from the missile LOX tank under gravity flow while the alcohol is obtained under pressure from the igniter alcohol container located on the launcher.

6.) The mainstage stick link is physically located so as to be burned through by the heat of combustion within the engine. This results in the opening of the main alcohol and the hydrogen peroxide flow valves in anticipation of thrust buildup. The hydrogen peroxide flows onto the catalytic pellets in the steam generator and causes a steam buildup which drives the turbopump. The turbopump, in turn, drives missile alcohol and LOX into the combustion chamber, where the mixture is burned to produce engine thrust.

7.) When the engine thrust has developed to the point of overcoming the gravitational effects exerted on the missile mass, the missile rises from the launcher. At this point, the flight phases are started and the missile guidance and control system is activated.

8.) The program device is actuated to begin triggering certain critical electrical circuitry.

9.) The stabilized platform (ST-80) loses its earth-fixed reference and becomes inertially stabilized in space. Any attitude deviation of the missile from the prescribed trajectory is detected by the ST-80 and, through the operation of the missile control system, the deviation is cancelled out.

10.) The guidance computers are activated to detect and store any translational deviations of the missile from the desired trajectory.

11.) The cutoff computer is started and monitors the speed of the missile. When the missile reaches a predetermined velocity, this computer will shut down the propulsion system by cutting off the propellant flow to the engine. The missile will then be in the ballistic, or free-falling, phase of its flight.

12.) The propulsion system shutdown is followed by thrust decay, or burnout of the propellants remaining in the propulsion system downstream of the main propellant valves.

13.) At a predetermined time, the pulse step switch actuates the separation circuitry, and the missile thrust unit is forcibly detached from the body section.

14.) When the body section comes back into the sensible atmosphere, a "Q" switch is actuated. This is the start of the re-entry phase and the end of the ballistic part of the missile flight. The actuation of the "Q" switch also signals the start of the terminal guidance operation. During the flight, the guidance computers had detected and stored the translational deviations of the missile from the prescribed trajectory. After re-entry, this information is fed to control system in order to direct the missile back toward the prescribed trajectory to assure that the warhead will land within the radial tolerance distance of the target.

RETESTING, ABORT FIRING, AND POST-FIRING OPERATIONS

Retesting

If a misfire occurs after the spring-loaded fire switch on the remote firing box has been operated, the normal procedure is to wait 30 seconds and then push the fire switch again. If the missile has not fired within 1 minute after the initial command, the emergency cutoff switch is actuated. A misfire constitutes a condition that requires retesting. Any extended interruption between the time of guidance presetting and the firing command also necessitates retesting.

In the event that retesting is necessary, certain precautions should be taken and procedures followed to assure the safety of both personnel and equipment.

1.) The missile pneumatic system is vented, from the remote firing box, for 3 minutes.

2.) The blind plugs are removed to disable certain critical circuits.

3.) All necessary personnel and equipment start forward to the immediate launching area.

4.) The GMTS is electrically connected to the missile system in a definite sequence in order to prevent any circuit activations or interruptions.

5.) The missile control system is disabled from the GMTS, and the missile system is in a state which will permit either retesting or shutdown.

Retesting entails the troubleshooting of the weapons system to determine the reason for the misfire, the rechecking of the operation of the guidance and control components, the rechecking of the missile-target (laying) orientation, and the presetting operations.

NOTE: It may be necessary to circulate and heat the alcohol if the hold is long enough to drop the alcohol temperature below a specific limit.

Abort Firing

In the event that the firing mission cannot be carried out after all preparations have been completed up to the firing phase (because of equipment failure or orders cancelling the mission), the missile must be de-activated and disassembled in a specific sequence.

NOTE: The propellant tanks vent valves should be kept open during all abnormal downtime. Also, the fire-fighting equipment should be present in the immediate area.

The LOX trailers are reconnected, through the fueling ladder, and the LOX is transferred back to the trailers by gravity flow. The LOX trailers are disconnected and driven away.

The alcohol trailer is reconnected, through the fueling ladder, and the alcohol is transferred back to the trailer by pump action.

The hydrogen peroxide truck is reconnected to the missile hydrogen peroxide container, and the hydrogen peroxide is transferred back to the truck container by pump action.

All pyrotechnic devices, rudders, and carbon vanes are removed and stored.

All cabling and hoses are disconnected and stored.

With the aid of the erector vehicle, the missile is lowered, disassembled, and reloaded upon the transport trailers.

All equipment is stored and the road march of the vehicles is started.

Post-Firing Operations

If the missile firing was successful, there remains only the shutting down of the ground power equipment and the disconnection and storing of all equipment in preparation for leaving the launching area.

CHAPTER IX

TELEMETRY SYSTEM

This page has been left blank intentionally.

CHAPTER IX

TELEMETRY SYSTEM

GENERAL

Telemetry, by definition, is the complete measuring, transmitting, and receiving apparatus for indicating, recording, or integrating at a distance, by electrical translating means, the value of a quantity.

Since guided missiles, generally speaking, are not recovered after launching, telemetry provides a means of measuring physical quantities within the missile after launch. The physical quantities measured may vary from stresses on the vehicle skin to minute voltage changes in the power supplies. The number of measurements that can be made at one time varies with the type of measurement and system limitations. More than one telemetry package can be used if it is necessary to expand the amount of instrumentation on a missile.

The data transmitted via telemetry from a missile are received at a ground station, and the composite data are recorded. The recording can later be played back and individual data removed from the composite signal for processing and reduction.

TELEMETRY STANDARDS

Frequency band: 216 mc to 235 mc

NOTE: Band may extend to 265 mc

RF Bandwidth: ±150kc

Eighteen different channel frequencies (subcarrier frequencies) can be applied to modulate the rf carrier. The 18 channels may be applied to the carrier either individually or simultaneously.

Each of the 18 channels may carry more than one bit of instrumented data by time-sharing or by commutating the channel.

Channel frequencies, deviation, and upper and lower frequency limits are shown in table IX-1.

TYPICAL TRANSMITTER OPERATION

The transmitter is of a PAM-FM-FM type. Refer to figure IX-1. This means that the sensing device has a pulse output of varying amplitude determined by the quantity being measured. The pulse amplitude, in turn, is frequency-modulating the subcarrier oscillator. The subcarrier oscillator output is multiplexed with other channel outputs to frequency-modulate the transmitter. When a phase-modulated transmitter is used the system is a PAM-FM-PM type.

Commutation of several inputs is done only when the quantity being measured is not so critical that it has to be constantly transmitted, or it is a slowly-changing quantity. A commutated channel also has to be synchronized with the ground decommutator for data processing.

A calibrator is used to periodically feed the channels with fixed reference-level signals for data reduction. The calibration is programed on and off within the missile in order to assure that the calibrator will be off at a time of some critical measurement such as cutoff or separation of the missile.

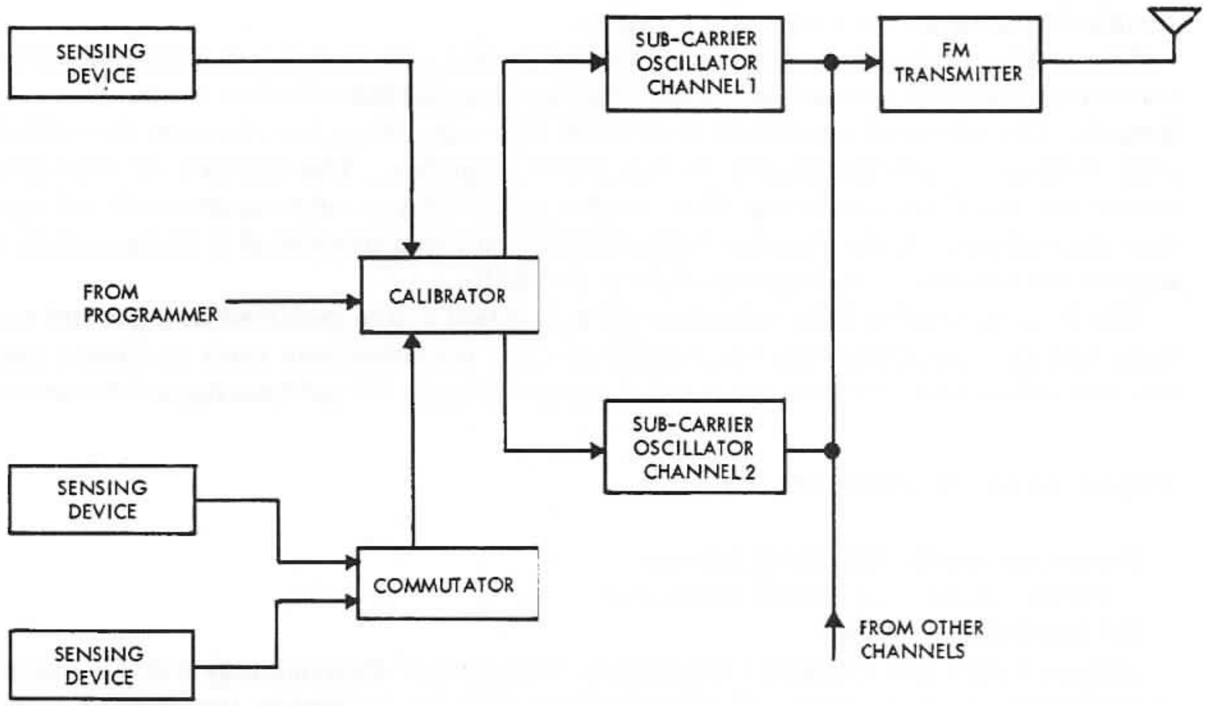


Figure IX-1 – Transmitter - Simplified Block Diagram

TELEMETRIC DATA TRANSMITTING SYSTEM AN/DKT-8 (XO-2)

This FM-FM system has a nominal power output of 35 watts and has a capacity of 17 subcarrier oscillators. Channel one is not used. Commutation is provided on one channel at a rate of 10 revolutions per second (rps). Information inputs to the straight channels may be either dc voltage type signals in the 0- to 5-volt range or frequency-type inputs such as that provided by a vibroton gage or external subcarrier oscillator. In the latter case, a band-pass filter is substituted for the subcarrier oscillator. Thus, the total system capacity is 16 straight plus 27 commutated inputs, or a total of 43 information inputs.

In some cases, the output of a sensing device is not of a voltage nature or is a very low voltage. In either case, an adapter is used to convert the output to representative voltages between 0 and 5 volts dc to modulate the subcarrier oscillator.

The telemetry package consists of two main assemblies, the main telemetry assembly and the power amplifier assembly.

The main telemetry assembly consists of:

Subcarrier oscillators (560 to 70,000 cps).
Distribution panel.
Video amplifier.
Transmitter.
150- to 250-volt power supply.
Commutator gating unit.
Calibrator.

The power amplifier assembly consists of an RF power amplifier and a 500-volt power supply.

MEASUREMENT

Table IX-II, which shows a list of the measurements, by channels, that were made on a typical missile, is included in this section. This list is used as an example of the type of measurements made in the missile during flight. The measurements allocated to each channel can be changed from missile to missile.

Although more than one measurement may appear for one channel, it does not necessarily mean that the channel is commutated. More than one measurement can be made per channel when one measured quantity no longer exists at the time the next quantity to be measured occurs. Another situation that allows for multiple measuring by a channel is when one measurement is more or less constant and another changes radically. A graphic presentation of this might show a gradually changing base line, representing one measurement, and superimposed on it, an occasional pip representing another measurement.

Table IX-I – OSCILLATOR DEVIATION CHART

Channel	Lower 7.5 % (5 volts)	Center	Upper 7.5% (0 volts)
1	370	400	430 (Not used on REDSTONE)
2	518	560	602
3	675	730	785
4	888	960	1,032
5	1,202	1,300	1,396
6	1,572	1,700	1,828
7	2,127	2,300	2,473
8	2,775	3,000	3,225
9	3,607	3,900	4,193
10	4,995	5,400	5,805
11	6,799	7,350	7,901
12	9,712	10,500	11,288
13	13,412	14,500	15,588
14	20,350	22,000	23,650
15 (commutated)	28,328	30,000	32,456
16	37,000	40,000	43,000
17	48,562	52,500	56,438
18	64,750	70,000	75,250

Table IX-II – MEASURING PROGRAM
(Typical Missile)

Channel	Frequency (cps)	Measurement	Measurement Range
2	560	H_2O_2 Flow Rate	0 to 7 lb/sec
3	730	(a.) Alcohol Flow Rate (b.) Bursting Diaphragm-Cylinder Fin IV	0 to 25 gal/sec
4	960	(a.) LOX Flow Rate (b.) Bursting Diaphragm-Cylinder Fin II	0 to 25 gal/sec
5	1,300		
6	1,700		
7	2,300	(a.) Input to Step Switch (b.) Tilting Program (ST-80)	 0 to 180°
8	3,000	(a.) Input to Step Switch (b.) Tilting Program (ST-80)	 0 to 180°
9	3,900	Inverter Frequency (1800 VA)	400 ± 0.25 cps
10	5,400	(a.) Deceleration Switch (b.) Turbine rpm	 0 to 5000 rpm
11	7,350	Pressure Combustion Chamber	0-400 PSIA
12	10,500	(a.) Acceleration Longitudinal (b.) Acceleration Longitudinal (c.) Acceleration Longitudinal	+1 to +6g +0.5 to -1g 0 to -6g
13	14,500	Lateral Displacement, Fine	500 m/rev
14	22,000	Range Displacement, Fine	1 km/rev
15	30,000	See Table 3	
16	40,000		
17	52,500	(a.) Range Velocity, Fine (b.) Cutoff Computer Output	10 m/sec/rev
18	70,000	(a.) Lateral Velocity, Fine (b.) Take-off (c.) Cutoff	10 m/sec/rev

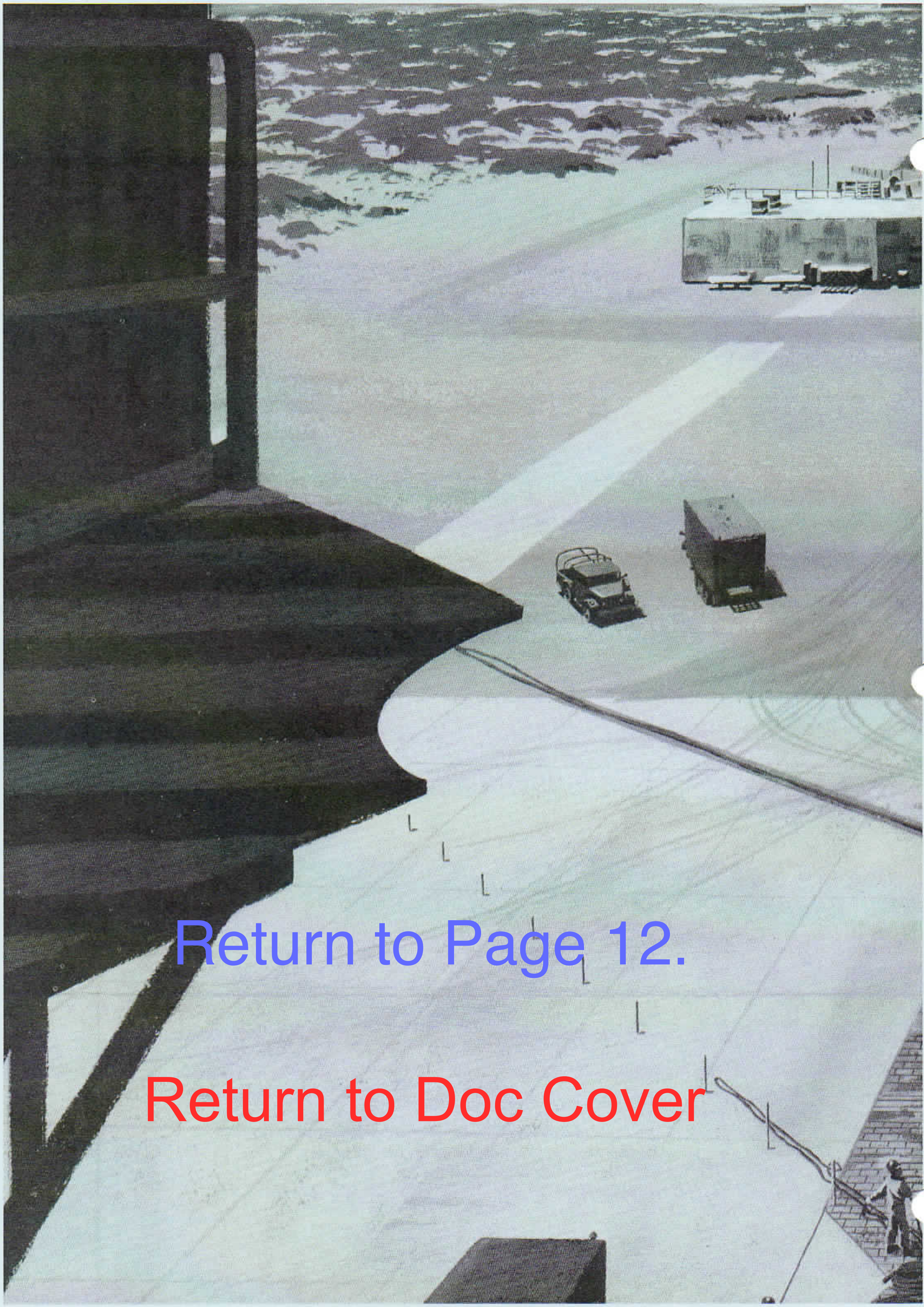
Table IX-III – MEASURING PROGRAM
Channel 15 Inputs
(Typical Missile)

Number	Measurement
1	(a.) Emergency Cutoff (b.) Pressure in Air Bottles
2	Pressure in Explosion Cylinders
3	Instrument Compartment Pressure
4	(a.) Air Vane 1 Deflection
5	(a.) Air Vane 2 Deflection (b.) Jet Vane 2 Deflection
6	(a.) Air Vane 3 Deflection (b.) Jet Vane 3 Deflection
7	(a.) Air Vane 4 Deflection (b.) Jet Vane 4 Deflection
8	Air Bearing Low-Pressure Supply
9	Top Jets Air Pressure
10	Platform Pitch Position – Minus Program
11	Platform Yaw Position
12	Platform Roll Position
13	(a.) Explosive Screw 1 (b.) Explosive Screw 2
14	Angular Velocity Pitch
15	Angular Velocity Yaw
16	Angular Velocity Roll
17	Pitch Acceleration
18	Yaw Acceleration
19	Voltage Servo Battery
20	Instrument Compartment Temperature
21	Temperature Inlet Air for Air Bearings
22	(a.) Explosive Screw 3 (b.) Explosive Screw 4

Table IX-III – MEASURING PROGRAM (Continued)
Channel 15 Inputs
(Typical Missile)

Number	Measurement
23	(a.) Explosive Screw 5 (b.) Explosive Screw 6
24	Lateral Displacement, Coarse
25	Range Velocity, Coarse
26	Lateral Velocity, Coarse
27	Range Displacement, Coarse

This page has been left blank intentionally.



Return to Page 12.

Return to Doc Cover