Pershing Ia

System Description

June 1974

OR 13,149

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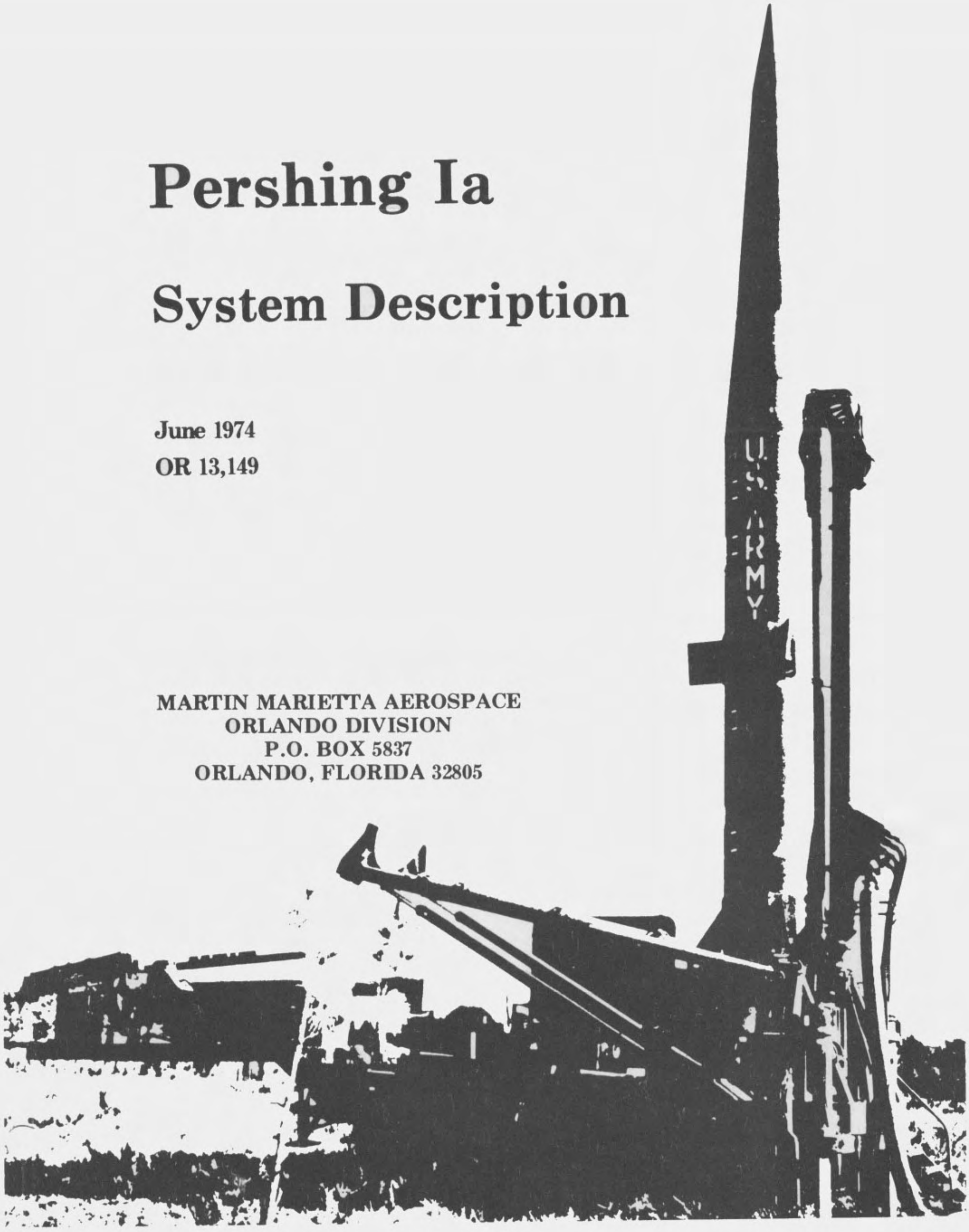

Foreword

The Pershing Weapon System constitutes one of the United State's major nuclear deterrent forces. The system is deployed operationally in Europe and continues to make a substantial contribution to the balance of power and the maintenance of peace.

The current version is the Pershing Ia (PIa) which was derived by an evolutionary process of continuous improvements to the initial system configuration. This book provides a functional description of the Pershing Ia major equipment items.

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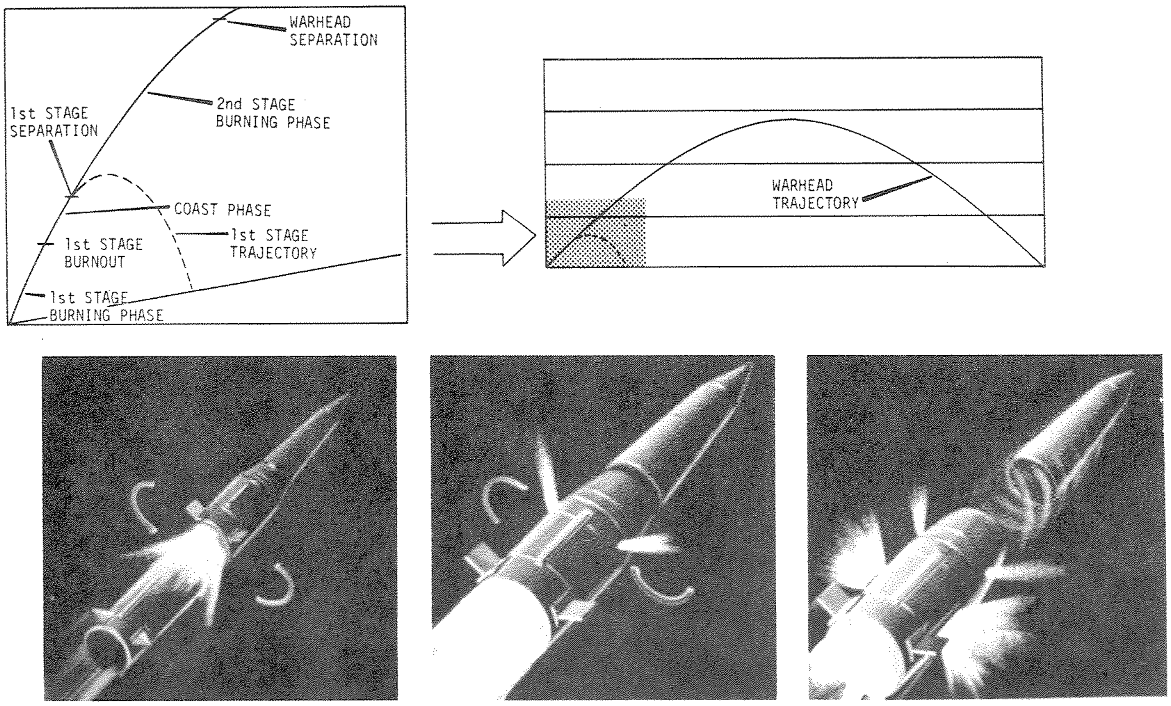
chapter one

General System Description

The Pershing Ia Weapon System is a tactical, mobile ballistic missile system possessing the capability to respond effectively to any nuclear or major nonnuclear threat to the United States or its allies.

The system is comprised of all firing battery components required to conduct launch operations as well as equipment necessary for rear area support and maintenance functions.

In its basic scenario, the missile delivers a nuclear warhead to preselected target out to a range of 400 miles from the launch point (Figure 1-1). When the missile is fired, the first stage rocket motor is ignited, Pershing liftoff occurs and the missile begins a predetermined pitchover maneuver toward the target. When first stage burnout is achieved the missile enters a coast period. At the end of the coast period, first stage separation occurs and the second stage rocket motor is ignited to accelerate the remaining missile sections along the flight path. During second stage burn, the guidance computer constantly computes the missile's velocity and displacement. When the proper values of attitude, range, and velocity have been attained a thrust termination signal is applied, second stage separation occurs, and the warhead is spun at 32 rpm to stabilize its forward motion as it continues on a ballistic trajectory to the target.



First Stage Separation — *Warhead Separation* — *Warhead Spinning for Stabilization*

Figure 1-1. Typical Pershing Flight Scenario

Pershing Ia Firing Battery Components

The various components required to conduct launch operations at the firing battery are the missile, erector-launcher, programmer-test station and power station, azimuth laying set, battery control central, and the radio terminal set. All of these components are mounted on wheeled vehicles (Figure 1-2) except for the azimuth laying set which is transported on a 2 1/2 ton cargo vehicle and unloaded for use.

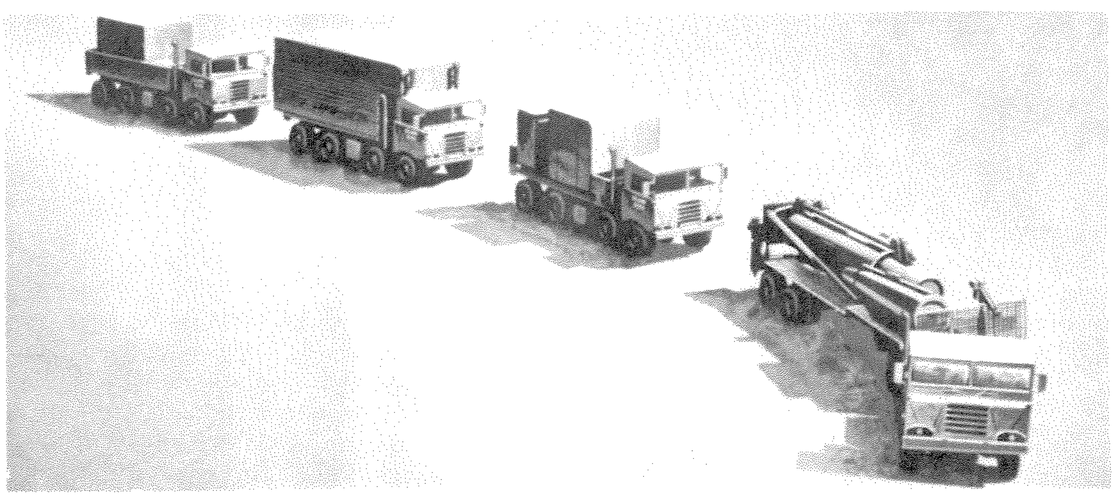


Figure 1-2. Pershing Ia Firing Battery Components

Missile

The Pershing missile (Figure 1-3) is a two-stage, surface-to-surface ballistic weapon capable of engaging targets out to 400 miles. It has an all-inertial guidance system which places the nuclear warhead in a preselected ballistic trajectory by using data inserted into the guidance and control computer before liftoff. Once the missile is airborne, it is completely free of ground control and therefore unaffected by all known methods of guidance countermeasures.

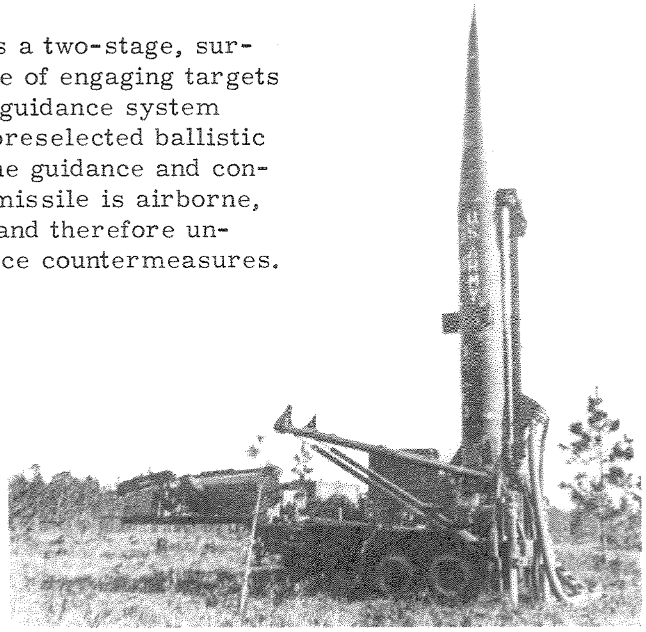


Figure 1-3. Surface Attack Guided Missile XMGM-31A (Pershing Missile) on Erector-Launcher

Erector-Launcher

Designed for simplified transportation and fast erection and firing of the Pershing missile, the erector-launcher (Figure 1-4) is capable of paved road or cross country travel. At the firing site automatic erection and leveling contribute to a very rapid rate of fire. The erector-launcher (EL) with missile aboard is towed by the XM757 tractor. The erector-launcher with missile aboard can also be transported by C-130, C-133, and C-141 aircraft.

Figure 1-4. Tractor with Erector-Launcher

Programmer-Test Station and Power Station

The programmer-test station (PTS) shown in Figure 1-5 is carried on an M656 vehicle and features rapid missile checkout and countdowns, with complete computer control, and automatic self-test and malfunction isolation. Additionally, the PTS performs tests that simulate airborne missile operation, programs the trajectory of the missile, and controls the firing sequence. Modern electronics packaging, featuring plug-in micromodules, increases maintainability and allows the PTS operator to perform 80 percent of all repairs at the firing position. The power station, which provides the primary electrical and pneumatic power for the missile and ground support equipment at the firing position, is transported on the same vehicle.

Figure 1-5. Programmer-Test Station/Power Station

Azimuth Laying Set

The azimuth laying set (Figure 1-6), which is similar in design and function to standard surveying equipment, is used to align the missile inertial guiance system to the correct target azimuth. All of the equipment is stored in two protective containers and carried aboard an auxiliary equipment vehicle.

Figure 1-6. Azimuth Laying Set

Battery Control Central

To control the Pershing battery and ensure nuclear safety, the battery commander monitors and directs firing site activities by maintaining communications with all units from a firing battery control central (BCC) (Figure 1-7). The BCC is also linked with other batteries and battalion headquarters for positive command and control. The BCC is housed in a modified M4 van which is carried aboard a modified M656 vehicle.

Figure 1-7. Battery Control Central

Radio Terminal Sets

To control and coordinate firing battery operations, several communication links are established with higher headquarters. Battalion communications are maintained with the radio terminal set, AN/TRC-80 (Figure 1-8). The radio terminal set (RTS) provides voice and teletype communications between missile firing units and higher headquarters. During travel the inflatable antenna is stored in a recessed space in the roof of the RTS. Like the other elements of the firing battery the RTS is carried on an M656 vehicle.

Radio terminal set, AN/TRC-133A, is also used at the firing site as the primary QRA (Quick Reaction Alert) release message system. The AN/TRC-133A is government furnished equipment.

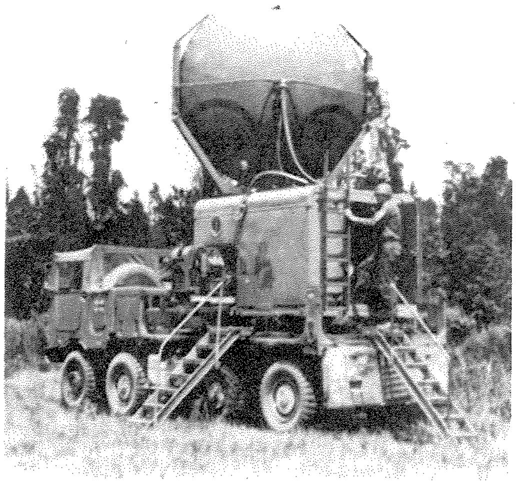


Figure 1-8. Radio Terminal Set AN/TRC-80

Rear Area Support Components

All elements of the system are maintained in a state of combat readiness by the rear area support equipment.

System Components Test Station

The system components test station (SCTS) is used to perform rear area maintenance of the Pershing system (Figure 1-9). Housed in a mobile center, the SCTS utilizes a computer and tape programs for testing missile sections, assemblies, cards, relays, and modules from the guided missile and associated ground support equipment. Diagnostic tape programs are also provided for verification and troubleshooting of major SCTS assemblies. The SCTS contains a dismounted PTS and has facilities whereby one missile guidance section can be tested and another repaired simultaneously under controlled temperature conditions. Power for the SCTS originates from the power station equivalent.

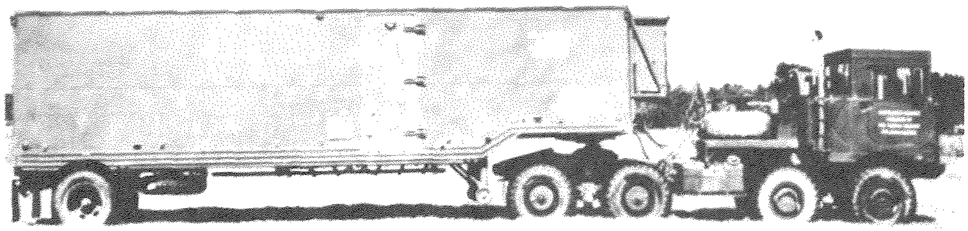


Figure 1-9. System Components Test Station

Power Station Equivalent

The power station equivalent (PSE) provides the same outputs as the firing battery power station but is capable of more sustained operation. Comprised of two trailer mounted power stations and one facilities distribution trailer (Figure 1-10), the PSE furnishes all the power required for rear area checkout.

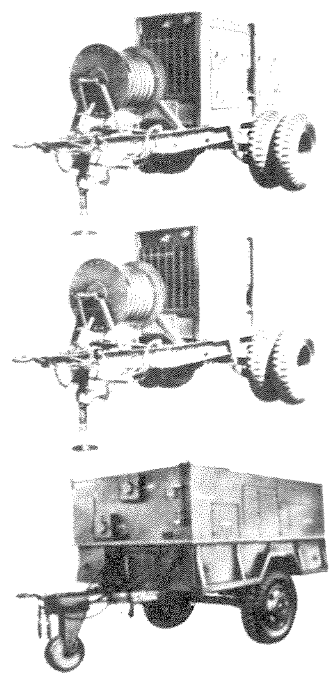


Figure 1-10. Power Station Equivalent

Support Shops

Several shops and semitrailer vans (Figures 1-11 and 1-12) are assigned to the rear area to provide facilities for electrical and mechanical maintenance and repair, parts storage, and offices for direction and control of direct support and general support maintenance functions.

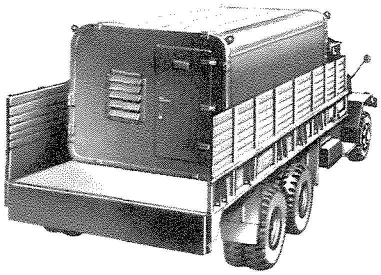


Figure 1-11. Typical Repair Shop

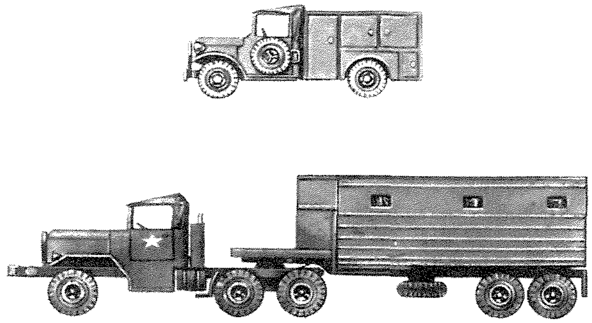


Figure 1-12. Typical Maintenance Shop and Supply Van

Missile Section Containers

Separate reusable shipping and storage containers (Figure 1-13) are provided for each of the four missile sections. The containers protect the missile sections from the effects of excessive vibration, abnormal handling, and intolerable atmospheric conditions.

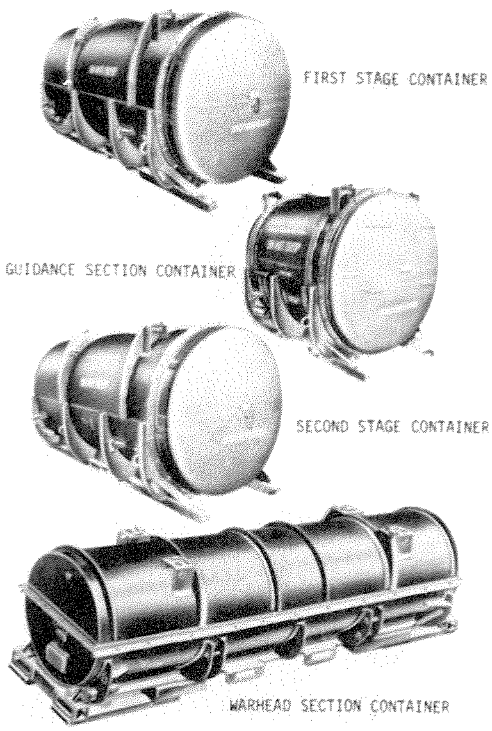


Figure 1-13. Missile Section Shipping and Storage Containers

chapter two

The Missile

Airframe

Pershing is a two stage, solid propellant ballistic missile (Figure 2-1). The missile airframe is 415.27 inches long, has a major diameter of 40 inches, and weighs approximately 10,000 pounds. Monocoque in construction, the missile has an outer skin assembled to transverse rings for rigidity during flight and ground handling. Splice rings make warhead sections, guidance and control sections, and second and first stage motor sections completely interchangeable. Flight control is maintained by using sets of three air and jet vanes at the aft end of each motor section; these vanes are mounted 120 degrees apart around the motor periphery. Specific locations along the missile longitudinal line are measured in inches from station 100, a point 3.99 inches in front of the missile nose. Pershing is structurally and functionally divided into four sections: the warhead section, the guidance and control section, and the second and first stage motor sections (Figure 2-2).

Warhead Section

The warhead section is constructed on an aluminum substructure with an ablative type plastic shell of varying thickness. This shell is fabricated from layers of pheonolic-impregnated, random oriented asbestos tape, cured into a homogeneous structure under heat and high pressure. The surface is hard and brittle with ablative characteristics.

In the final phase of flight, the warhead section becomes a reentry body exposed to the heating effects of high speed passage through atmosphere. The varying thickness of the skin is designed in accordance with the rate of ablation experienced by the reentry body when subjected to these heating effects. Nose cone, center, and aft subsections form the warhead section.

1 BOLT, EXPLOSIVE (2)
2 BAND, SECTION (4)
3 BAND, SECTION (4)
4 COVER, ELECTRICAL CABLE
5 BOLT, EXPLOSIVE (2)
6 THERMAL INSULATOR ASSEMBLY
7 COVER, ELECTRICAL CABLE
8 JET VANE (3)
9 THERMAL INSULATOR ASSEMBLY
10 FLAME SHIELD (3)
11 AIR VANE (3)
12 PAD, AIR VANE (3)
13 SHELL, BODY, FIRST STAGE
14 ROCKET MOTOR ASSEMBLY, FIRST STAGE
15 JET VANE (3)
16 FLAME SHIELD (3)
17 BOLT, MACHINE (2)
18 AIR VANE (3)
19 PAD, AIR VANE (3)
20 BAND, SECTION (4)
21 SHELL, BODY, SECOND STAGE
22 ROCKET MOTOR ASSEMBLY, SECOND STAGE
23 CASE VENTING SYSTEM
24 THRUST REVERSAL PORT COVER (3)
25 THRUST REVERSAL PORT (3)
26 BOLT, MACHINE (2)
27 CONNECTING LINKS (2)
28 BASE STRUCTURE ASSEMBLY
29 COVER ASSEMBLY
30 BOLT, MACHINE (2)

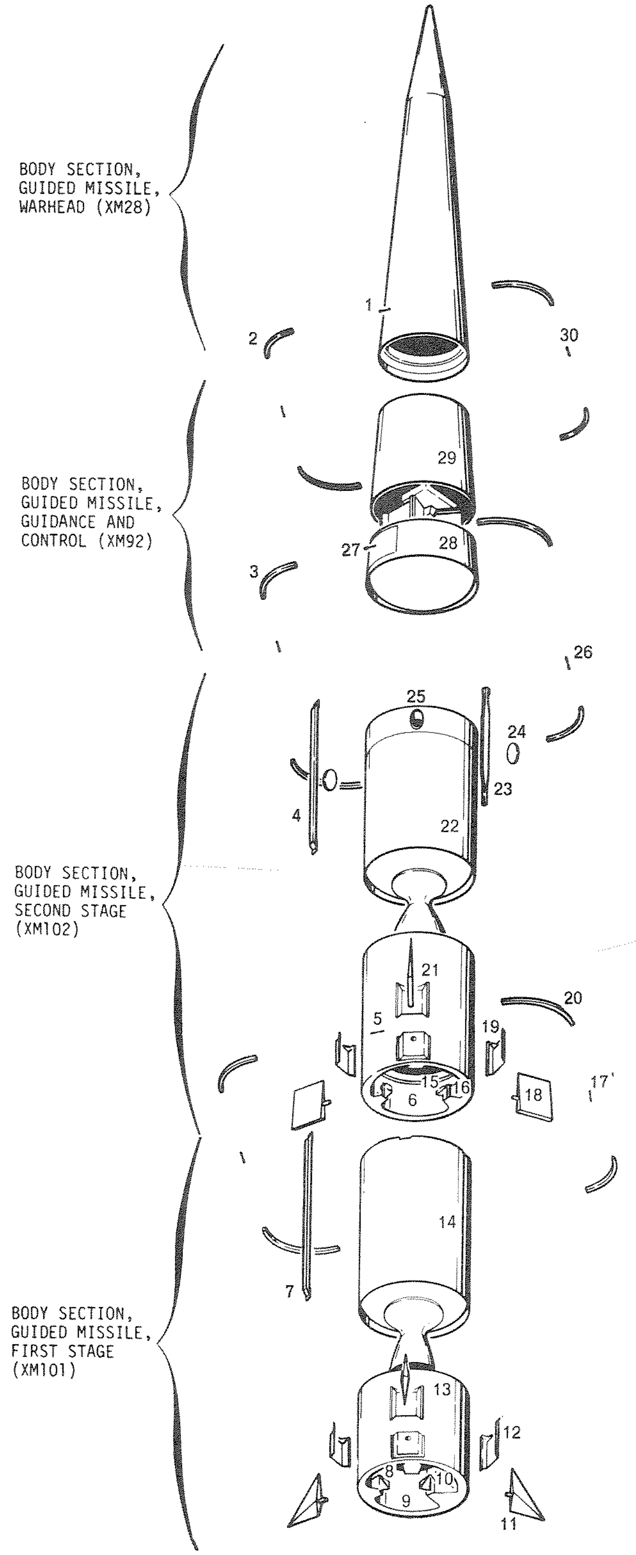


Figure 2-1. Pershing Missile Aero and Structural Components

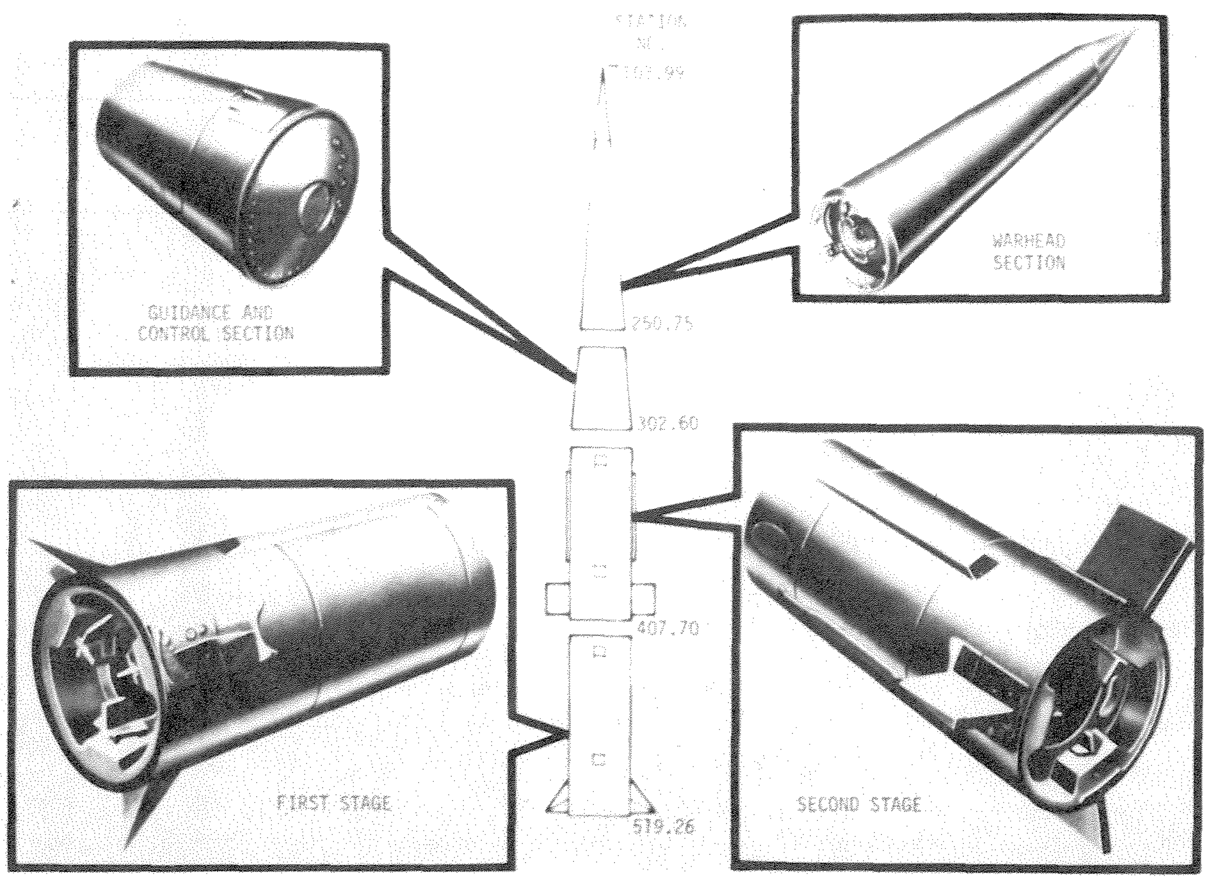


Figure 2-2. Pershing Missile Sections

The nose cone subsection is a plastic cone assembled with a nonstructural nose liner having an aluminum splice ring at the aft end. The center subsection is a double-cone frustum shaped assembly with the peripheral shear type of aluminum splice rings located at its forward and aft ends. An additional frame with longitudinal stiffeners placed radially in the aft end is used to support the warhead and related networks. The aft subsection, similar in construction to the center subsection, is mated to the center subsection with an aluminum splice ring. An insulated, domed aluminum bulkhead, located at the aft end of this subsection, is the closure for the warhead section. Both the spin system and cover plate are mounted on this bulkhead. A splice ring assembly couples the warhead section with the guidance and control section. The splice ring is held together by explosive bolts to permit inflight separation of the two sections.

Guidance and Control Section

The guidance and control section is a two piece, metal conical, frustum shaped structure pressurized to permit temperature and pressure control for airborne guidance and control equipment. The two pieces are the cover (forward section) and the base (aft section). A splice ring assembly joins the guidance and control section and second stage motor section. Conventional bolts are used to hold the splice ring together since no inflight separation occurs at this interface. Support brackets for the components and wiring, and the air ducts and manifold for the ST-120 air supply are integral parts of the internal structure.

Second Stage Motor Section

Three major structural parts comprise the second stage motor section: the second stage motor case, the forward motor adapter, and the aft controls package.

The hydrospun, high strength D6AC steel case serves a dual purpose in being both the propellant container and the outer skin of the missile in the center of the section. The forward motor adapter, attached to the domed end of the motor case, adapts to the guidance and control section by a V-band splice ring. The forward motor adapter is 40 inches in diameter and 19.93 inches wide.

Structural support between the second stage motor case and the first stage motor section is provided by the aft controls package which houses the air vane and jet vane assemblies, three hydraulic actuator units, a flame shield, and air vane pads.

In addition to the internal structure, a conduit cover and case venting shaped charges are attached to the outer skin of the missile.

First Stage Motor Section

Like the second stage, the first stage is comprised of three major structural parts: first stage motor case, forward motor adapter, and aft controls package. Material and construction techniques used for the first and second stage motor cases are the same; however, the first stage is larger and houses no impulse control equipment. The first stage motor case also serves as the outer missile skin in the center portion of the section.

The forward motor adapter is provided to adapt the first stage motor section to the second stage. The splice ring V-band, a four segment band having explosive links with detonator assemblies adapted to it, mates the sections.

Structural support between the first stage motor case and the azimuth ring of the erector-launcher is provided by the first stage aft controls package. It also provides support and housing for the three hydraulic actuation systems, flame shield, air and jet vanes, forward air vane pads, and the tail plug assembly. In addition to the internal structure, a conduit cover is externally mounted between the forward motor adapter and the aft control package.

Propulsion

The primary function of the rocket motors (Figure 2-3) is to propel the Pershing missile from liftoff to first stage separation and from second stage ignition to cutoff. At this time the warhead section is separated from the guidance and control and second stage sections and becomes a free ballistic missile.

Propellant

Motor propellant used is of a composite cast formula using aluminum powder as the fuel, ammonium perchlorate as the oxidizer, and polybutadiene acrylic acid (PBAA) as the binder (the PBAA also serves as a fuel). Both motors have an internal burning cylindrical core which terminates in a dome shaped slot at the head end. Since PBAA binder is basically a synthetic rubber, this formula and configuration resist creep or slump during storage periods.

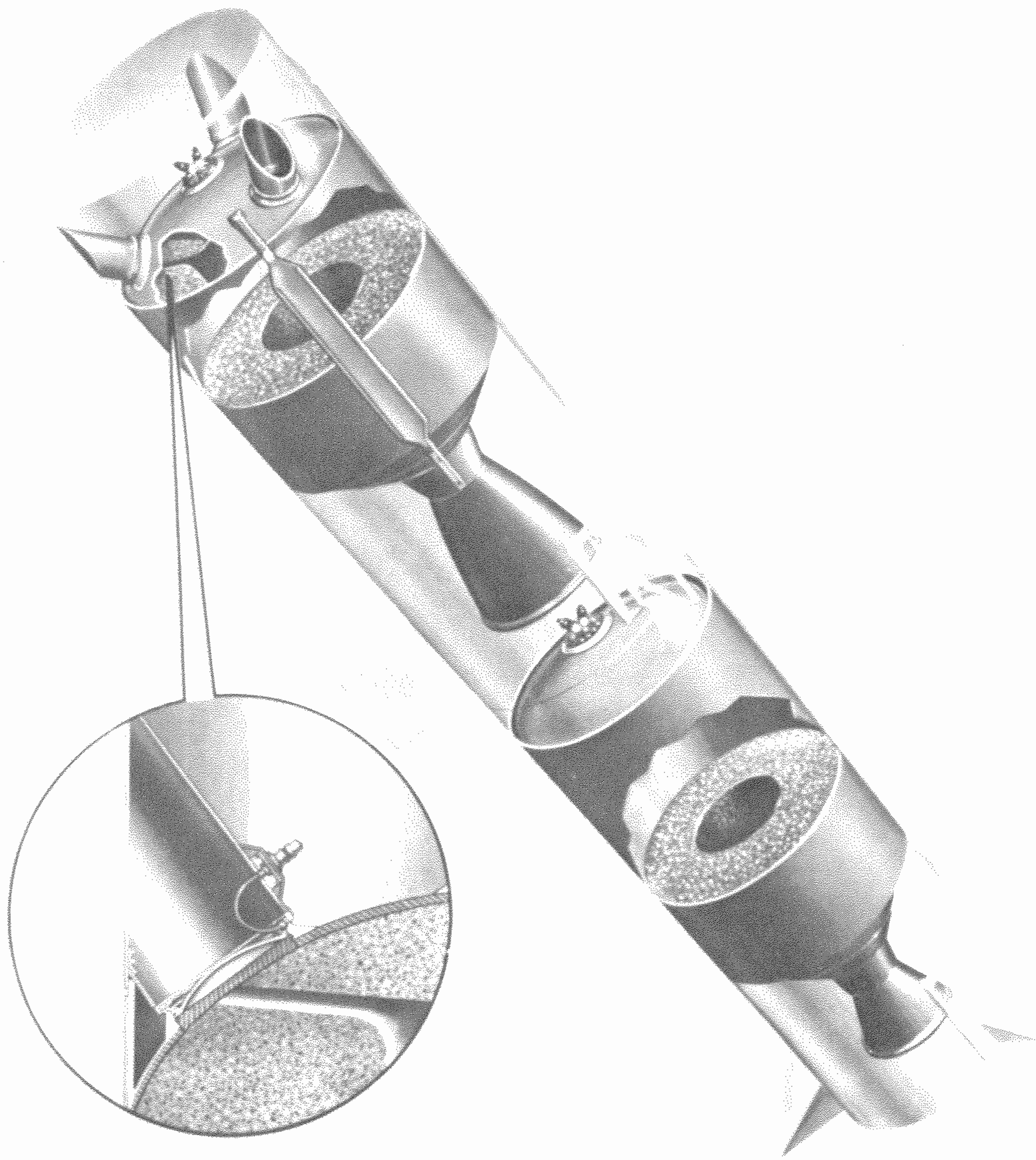


Figure 2-3. Pershing First and Second Stage Motors

First Stage Motor Assembly and Case

The first stage motor assembly consists of one solid propellant rocket motor with integral forward adapter, one V splice band, two firing unit assemblies, three hydraulic packages, three air vanes, three jet vanes, three air vane pads, flame shield, initiators, detonators, separation links, torquing links, electrical networks harnesses, and external conduit cover (Figure 2-4).

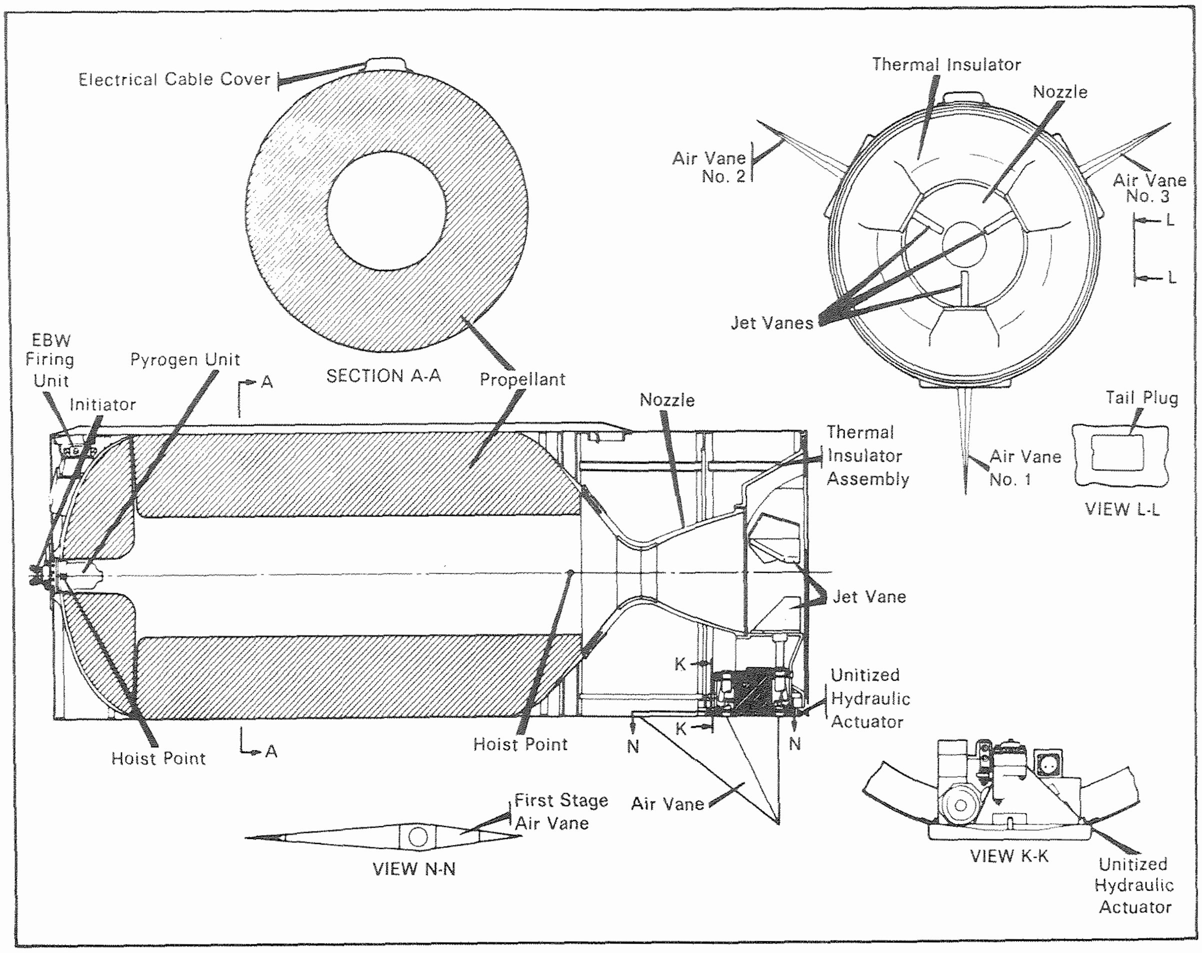


Figure 2-4. First Stage Motor Section, Inboard Profile

A hydrospun cylindrical section, the first stage motor case is girth welded to an elliptical forward dome and a conical aft dome. The entire case is made of D6AC high strength steel. The forward dome has an opening in the center for the pyrogen unit and the aft dome contains provisions for attaching the nozzle to the motor. A forward adapter is riveted to the case to provide for interstage connection. The PBAA propellant is cast into the motor case, then cured, and the nozzle attached.

Second Stage Motor Assembly and Case

Except for length the second stage motor assembly is similar to the first stage. Shorter than the first stage motor assembly, the second stage case also has a case venting system and impulse control system (Figure 2-5).

An impulse control system is provided to reduce forward thrust of the second stage motor, at any predetermined time over the designed operating range of the system, to permit effective warhead section separation. The system consists of three parts placed symetrically, 120 degrees apart in the motor forward dome. An impulse control tube projects from each port at an angle of 36.5 degrees from the motor longitudinal centerline to an opening in the motor forward adapter. Each port is plugged with an aluminum pressure dome, backed by molded insulation to protect the dome during motor burning; the domes are held in place by a snap ring in a groove in the impulse control port. Each ring has a section removed which is replaced by a frangible sector. This sector shatters when an explosive squib is actuated, permitting the ring to compress and be forced out of the locking groove, thereby allowing the impulse control system to actuate. Detonation of the sector is provided by an exploding bridgewire system. The openings in the forward adapter are closed with covers held in place by screws passing through spring clips. At system actuation, the force of the domes hitting the covers exceeds the holding power of the spring clips, permitting the covers to fly free.

The case venting system contains two linear shaped charge retainer assemblies mounted on the external horizontal centerline of the second stage motor. Two rectangular holes are cut through the case and propellant immediately after impulse control. This vents the propellant gases through the side in addition to the impulse control ports, thus reducing flow interference between the warhead section and second stage.

In addition to the shaped charge a mechanically out-of-line safe and arm device and interconnecting mild detonating fuze explosive lead assembl y make up the internally mounted part of the system for earlier configurations. Later configurations have been redesigned from a mechanical safe and arm device to exploding bridgewire system.

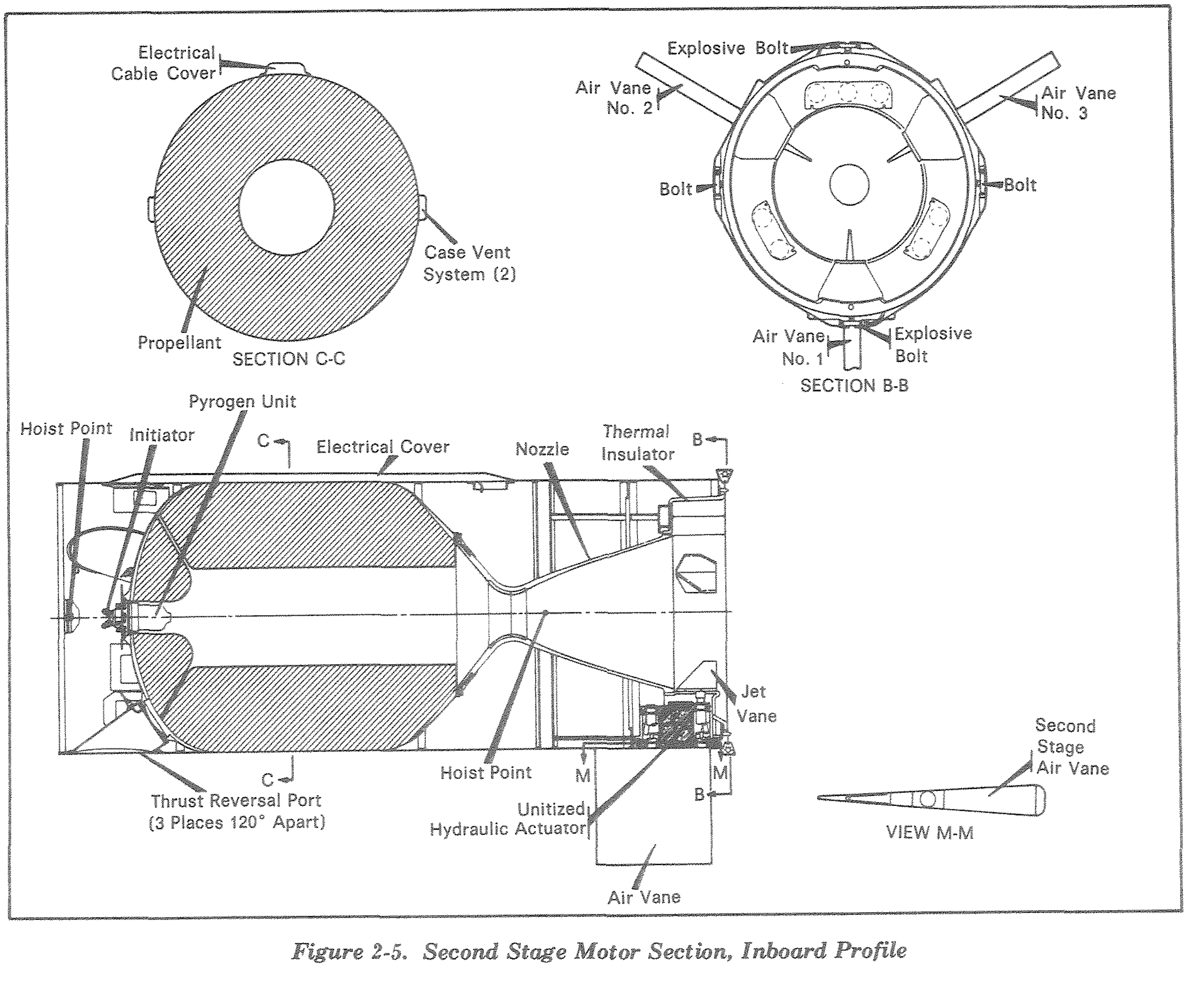


Figure 2-5. Second Stage Motor Section, Inboard Profile

Motor Case Insulation

During burning, the motor case interior is protected by a combination of the unburned propellant, a layer of liner, swept-in-insulation in the forward dome insulation is a carboxyl terminated PBAA (CTPB) polymer composition which is swept into the forward dome. The aft dome insulation, a hard, premolded plastic, sealed with an epoxy and polysulfide composition, is bonded to the aft dome of the motor with the same material used for the forward insulation.

Motor Ignition

Pershing motors are ignited by a pyrogen unit which, in turn, is ignited by two exploding bridgewire initiators and a small pyrotechnic charge. The pyrogen unit is a miniature rocket motor which vents its rocket exhaust products into the combustion chamber of the motor to bring the temperature and pressure up to the point where the propellant grain will ignite. The grain of the pyrogen unit is also PBAA cast and shaped to expose as much burning surface as possible. This, in turn, provides a very short burning time for achieving the highest possible pressure and temperature in the first stage motor combustion chamber to ensure instantaneous ignition. The pyrogen unit case is filament wound fiberglass attached to a steel adapter to permit attachment to the main motor case. Each pyrogen unit is fitted with two initiators, each on a separate channel to ensure ignition.

First and Second Stage Motor Nozzles

The first stage flight nozzle has an average expansion ratio of 7.06; the second stage ratio is 15.06. These nozzles consist of interlocked steel attachment rings, an entrance and exit section of molded chopped graphic cloth, a carbon throat insert, and a fiberglass shell. The shell is a combination of resin-impregnated, bidirectional glass cloth and alternate layers of resin-impregnated, circumferential fiberglass winding, attached to the aft end of the motor case with bolts through the steel attachment ring.

Guidance and Control

The guidance and control section (Figure 2-6) contains the electrical and electronic assemblies that control the trajectory of the missile. The major assemblies of the guidance and control section are the ST-120 stabilized platform and its associated servoamplifier, the guidance and control computer (G&CC), main distributor, and power supplies. The primary power supplies consist of the missile batteries and a static inverter. Other components are an air bottle, a high-pressure air distribution system, and safety relays for discontinuing a firing sequence, if necessary, after ground power has been removed. The guidance system detects errors in the missile trajectory, as compared to the predetermined flight path, and converts these errors into guidance signals. The control system combines the guidance signals with attitude signals to generate a corrective signal for transmission to the control packages. In the guidance system, the ST-120 provides missile attitude and velocity information from which deviations from the programmed trajectory are computed by the G&CC. The servoamplifier works with the ST-120 to create a stable reference from which the trajectory deviations are obtained. The G&CC combines the guidance signals with the missile attitude reference data from the ST-120 to create the combined control signal that operates the control packages. The guidance system continuously monitors the actual velocity and displacement of the missile along the trajectory, compares the actual data with the preset information, and calculates the exact instant for second stage cutoff and warhead separation.

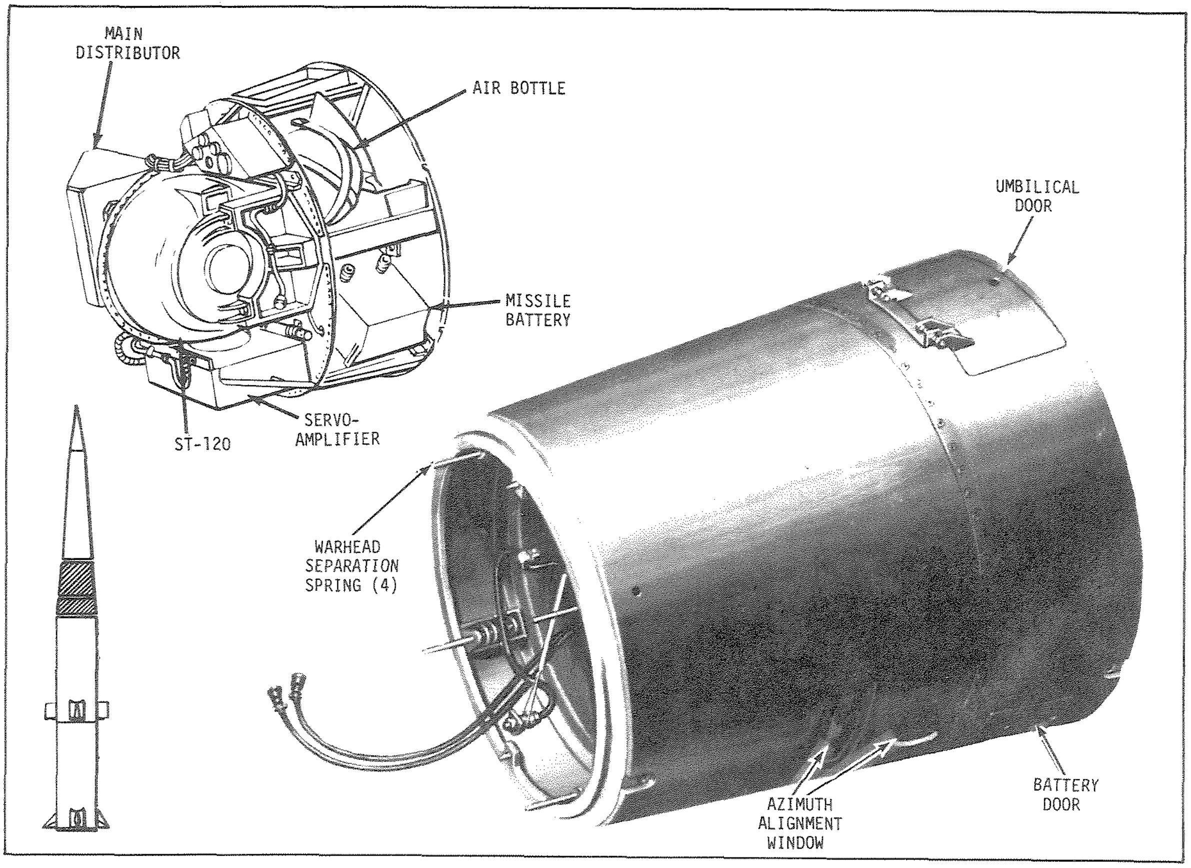


Figure 2-6. Guidance and Control Section

The improved PIa guidance and control system is designed to function in an almost identical fashion as its predecessor. The implementation of both the guidance scheme and the control scheme were based on identical carryover requirements from the analog missile. The guidance scheme is an implicit scheme which is based on a great number of computer flown trajectories to arrive at the presets for a given mission. The steering scheme is optimized so that two basic pitchover programs (as a function of time) are used to cover all targets over the Pershing range. The control system is an attitude-plus derived rate type of system using microsyn pickoffs from the ST-120 to compute the necessary pitch, yaw, and roll commands. These commands which drive the vanes in such a fashion to perform simultaneous guidance and control in all three axes. A diagram of the guidance and control system is shown in Figure 2-7. Basically, the ST-120 provides three velocity and three attitude signals to the G&CC for guidance and control computations, respectively. The G&CC in turn computes the necessary vane commands and initiates discrete events (i.e., staging, cutoff, etc.) as required during flight.

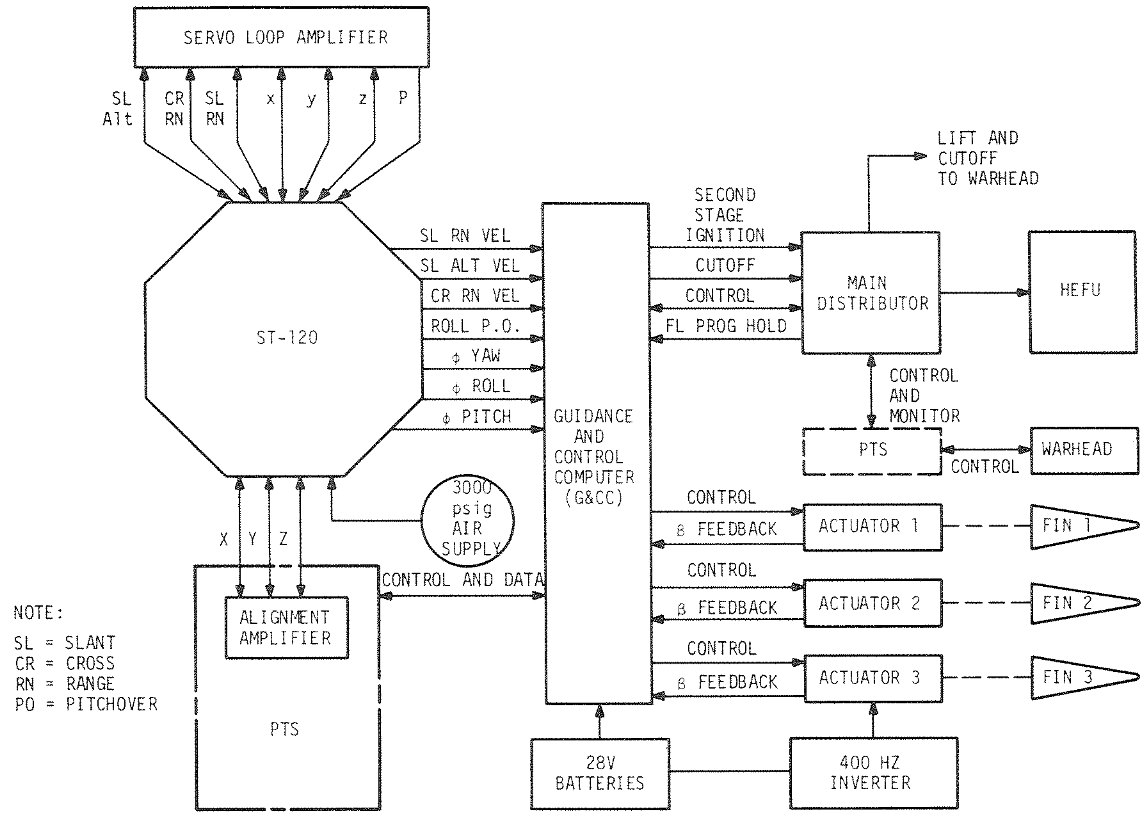


Figure 2-7. Guidance and Control System Functional Schematic

Guidance Scheme

The Pershing guidance scheme constrains the total time of flight such that the target position at impact and the firing azimuth can be computed. This reduces the guidance problem to a planar problem of reaching the required cutoff conditions as defined in the guidance plane. The guidance coordinates and guidance errors are illustrated in Figure 2-8. The crossrange coordinate, by definition, lies perpendicular to the guidance plane defined by the slant altitude and slant range coordinates. The steering scheme always drives the crossrange velocity and position errors to zero. The slant range coordinate is not used for steering but for computing a precise cutoff time based on the presets (i.e., stored velocity as illustrated in Figure 2-8) for a given target. The slant altitude coordinate is used for pitching over the missile so that its velocity and position history and final values are as near as possible to the nominal trajectory preflown in deriving the presets.

Control Scheme

Pershing employs air and jet vanes, actuated by hydraulic actuators, for control. Missile attitude errors are sensed by the ST-120; guidance path errors are derived in the G&CC. These error signals are operated on by compensation filters in the G&CC and resolved into individual vane commands.

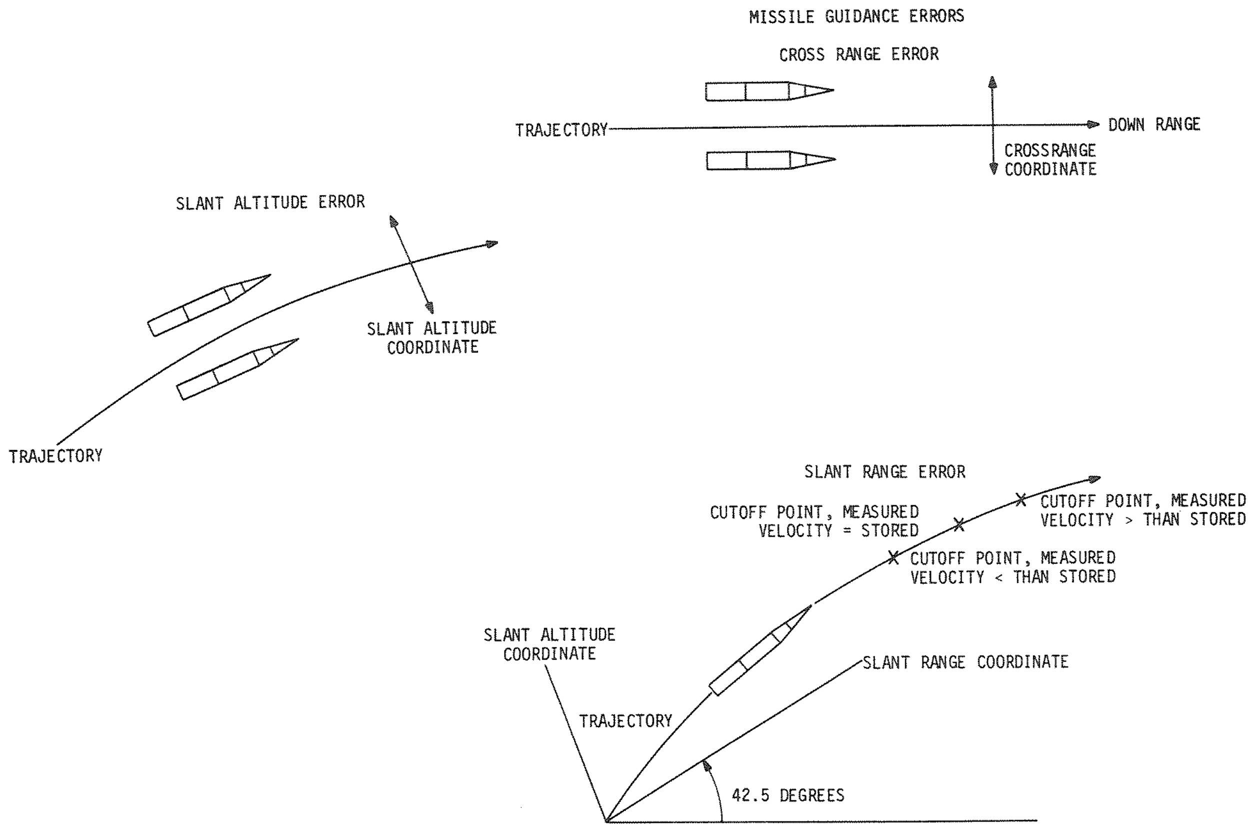


Figure 2-8. Missile Guidance Coordinates and Errors

Missile rotations in roll and yaw are sensed as errors relative to the ST-120 reference; i.e., outputs of the roll and yaw gimbal angle synchros are used directly as error signals. The pitch attitude error is computed by subtracting (by means of a synchro differential) the pitch gimbal angle synchro output from a cam-generated pitch attitude program.

Sign conventions relative to attitude control are defined in Figures 2-9 and 2-10. In Figure 2-9, the sense of the attitude errors is defined for roll, pitch, and yaw motions. In Figure 2-10, fin rotations and resulting missile attitude correction, corresponding to a given attitude error, are tabulated.

The axes of the three integrating accelerometers mounted on the ST-120 to sense acceleration in cross range, slant altitude and slant range are defined in Figure 2-11. Velocity outputs of the accelerometers are fed into the G&CC. The slant range velocity input is used to determine second stage cutoff. The crossrange velocity input is used directly as a guidance path error since a zero value of crossrange velocity is desired. The slant altitude velocity input is effectively compared to a stored program (in the G&CC) to derive a slant altitude velocity error signal.

Attitude control is accomplished by processing the pitch, yaw, and roll attitude errors in the G&CC to generate corresponding vane commands. Guidance is accomplished by processing the slant altitude and cross range accelerometer outputs. The resulting attitude and guidance components of the vane commands are summed to generate error signals for the hydraulic actuators. Thus, five control loops exist:

1 Pitch attitude

2 Yaw attitude

3 Slant altitude

4 Cross range

5 Roll attitude.

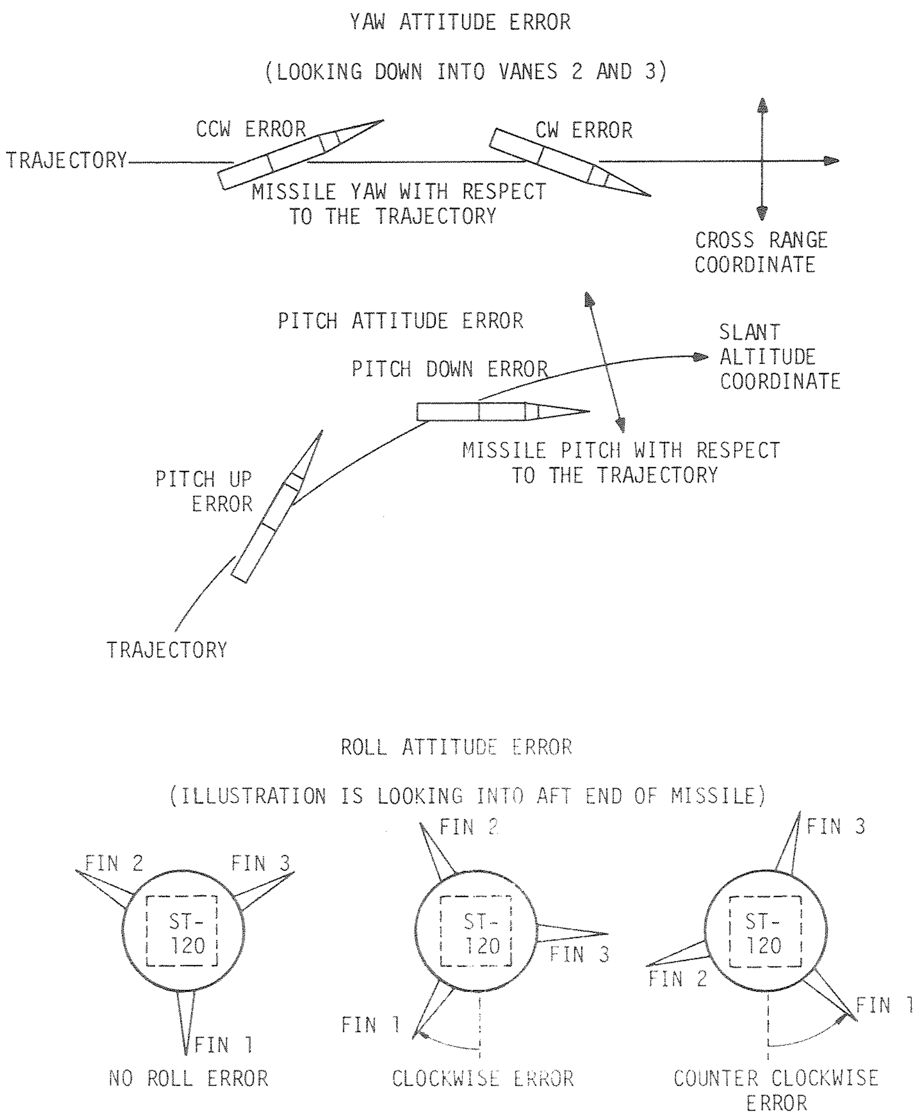
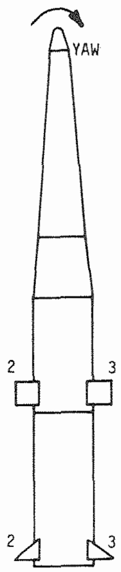
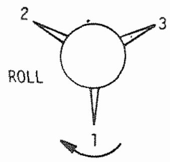


Figure 2-9. Missile Attitude Errors

Missile Error	Fin Corrections			Missile Movement
	Fin 1	Fin 2	Fin 3	
Pitch up	None	CW	CCW	Pitch down
Pitch down	None	CCW	CW	Pitch up
Yaw CW	CCW	1/2 CW	1/2 CW	Yaw CCW
Yaw CCW	CW	1/2 CCW	1/2CCW	Yaw CW
Roll CW	CCW	CCW	CCW	Roll CCW
Roll CCW	CW	CW	CW	Roll CW





CW = CLOCKWISE
CCW = COUNTER-CLOCKWISE

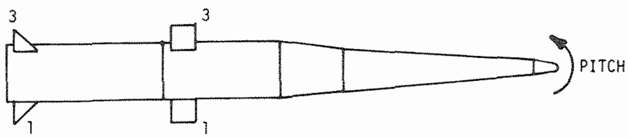


Figure 2-10. Missile Response to Attitude Errors

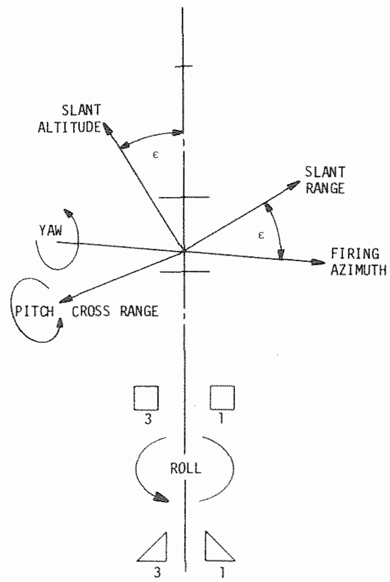


Figure 2-11. Missile Coordinate System

The first four of these loops are block diagrammed in Figure 2-12. For yaw attitude and cross range control, the programmed inputs (ϕ_p and η_p) are set to zero. The attitude error is demodulated and analog filtered prior to being sampled at 122 samples-per-second (sps) rate. The sampled attitude error signal is compensated by a digital filter. This filter is depicted as $(a_0+a_1s)D(Z)$ in the block diagram to emphasize the proportional-plus-derivative terms inherent in the digital filter. The "D(Z)" terms in the attitude compensation block represents the higher frequency roll-off terms.

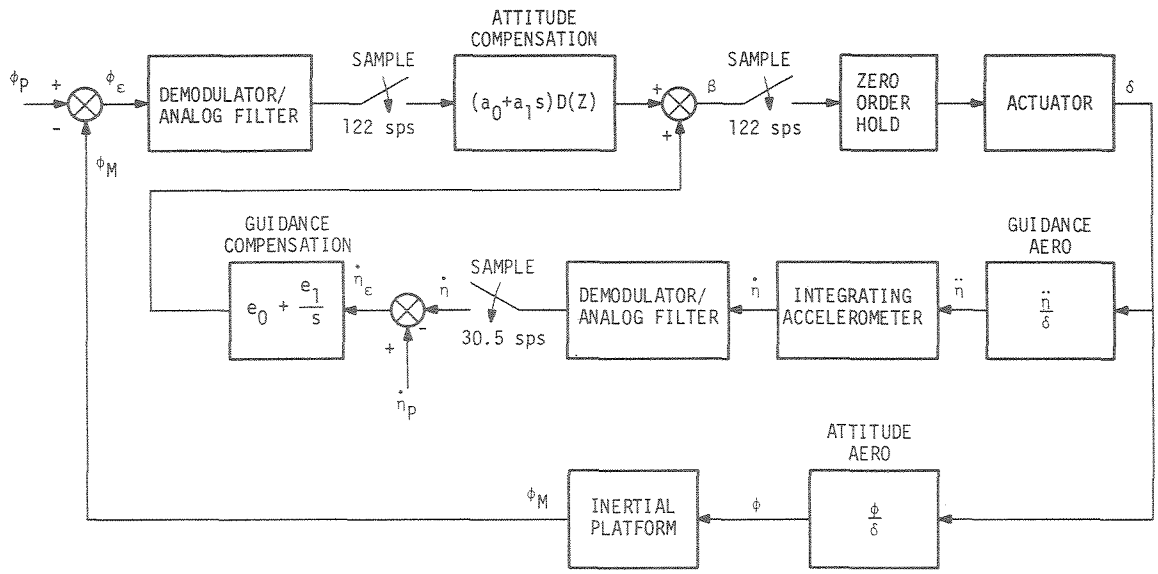


Figure 2-12. Pitch/Yaw Loops

The accelerometer outputs are demodulated and analog filtered prior to being sampled at 30.5 sps. The guidance error signal, $\dot{\eta}_\epsilon$, is in general digitally compensated by proportional-plus-integral control. This operation is depicted in the guidance compensation block as $e_0 + e_1/s$.

The roll attitude loop is block diagrammed in Figure 2-13. The roll attitude error is demodulated and analog filtered prior to being sampled at 122 sps. The sampled error signal is compensated by a digital filter of the same form as described above for pitch/yaw control. Guidance inputs are not required in the roll control loop.

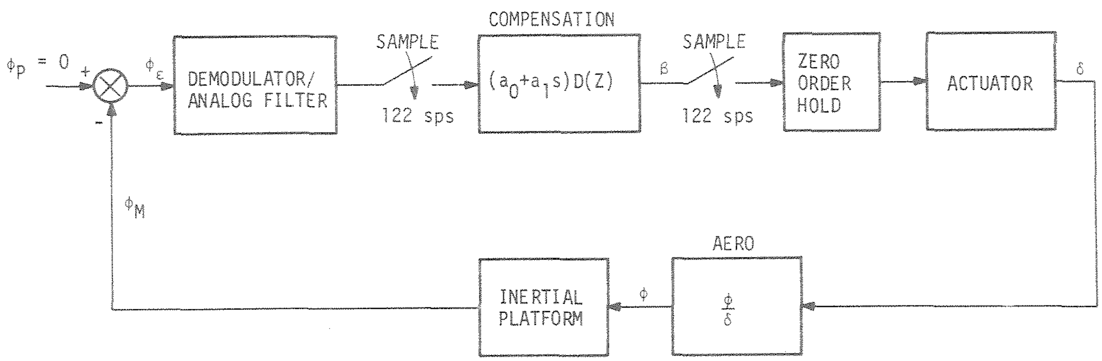


Figure 2-13. Roll Loop

The generalized control law which closes the pitch loop is:

$$\beta = a_0\phi_\epsilon + a_1\dot{\phi}_\epsilon + e_0\eta_\epsilon + e_1\dot{\eta}_\epsilon$$

where

$$\phi_\epsilon = \phi_{Program} - \phi_{Missile}$$

$$\dot{\eta}_\epsilon = \dot{\eta}_{Program} - \dot{\eta}_{Missile}.$$

The yaw control law is similar except cross range replaces slant altitude.

The roll plane control law is merely:

$$\beta = a_0\phi_\epsilon + a_1\dot{\phi}_\epsilon.$$

Vane deflections resulting from the above control laws are described by the following equations:

$$\beta_P = a_{0P}\phi_{P\epsilon} + a_{1P}\dot{\phi}_{P\epsilon} + e_0\eta_\epsilon^* + e_1\dot{\eta}_\epsilon$$

$$\beta_Y = a_{0Y}\phi_{Y\epsilon} + a_{1Y}\dot{\phi}_{Y\epsilon} + e_0\zeta_\epsilon + e_1\dot{\zeta}_\epsilon$$

$$\beta_R = a_{0R}\phi_{R\epsilon} + a_{1R}\dot{\phi}_{R\epsilon}$$

where $\beta_P, \beta_Y, \beta_R$ = command vane deflections in pitch, yaw roll

a_{0P}, a_{0Y}, a_{0R} = pitch, yaw, roll attitude error control gain

a_{1P}, a_{1Y}, a_{1R} = pitch, yaw, roll attitude error rate control gain

e_0 = control gain for guidance path error in slant altitude and cross range

e_1 = control gain for rate of guidance path error in slant altitude and cross range

$\phi_{P\epsilon}, \phi_{Y\epsilon}, \phi_{R\epsilon}$ = attitude error in pitch, yaw, roll

$\dot{\phi}_{P\epsilon}, \dot{\phi}_{Y\epsilon}, \dot{\phi}_{R\epsilon}$ = attitude error rate in pitch, yaw, roll

η_ϵ = slant altitude displacement error

$\dot{\eta}_\epsilon$ = slant altitude velocity error

ζ_ϵ = cross range displacement error

$\dot{\zeta}_\epsilon$ = cross range velocity error

* = The η_ϵ integration starts at second stage ignition.

Since the missile is aligned with vane 1 along the firing azimuth, as shown in Figure 2-11, pitch control is obtained from vanes 2 and 3. Yaw and roll controls are obtained from all three vanes. Because vanes 2 and 3 are displaced by 30 degrees from the pitch axis (see Figure 2-10), the total vane force in the pitch plane is the cosine of 30 degrees times the force of both vanes or 1.732 times the effectiveness of one vane.

In the yaw plane, vanes 2 and 3 deflect one-half the amount and opposite to vane 1, to prevent a roll moment. Since vanes 2 and 3 are each displaced by 60 degrees from the yaw axis, the total vane force in the yaw plane is the force of one vane plus the cosine of 60 degrees times the force of two vanes, or one and one-half times the effectiveness of one vane.

All three vanes deflect equally for roll correction and the total force available is three times the force available from one vane. Thus, the vane deflection equations become:

$$\text{Vane 1} = \beta_R + \beta_Y$$

$$\text{Vane 2} = \beta_R - \beta_P - 1/2\ \beta_Y$$

$$\text{Vane 3} = \beta_R + \beta_P - 1/2\ \beta_Y$$

Steering Implementation

The steering function is accomplished with the ST-120, G&CC, vanes and actuators, and necessary networks interconnecting the subsystems.

Cross Range - Crossrange steering is illustrated in Figure 2-14(a). The crossrange accelerometer provides velocity information to the G&CC. This velocity is sampled frequently by the G&CC analog-to-digital (A/D) converter to determine the amount of crossrange velocity error. By integrating this input the position error is also calculated. Proper gains are applied to the velocity and position errors to form a yaw com-

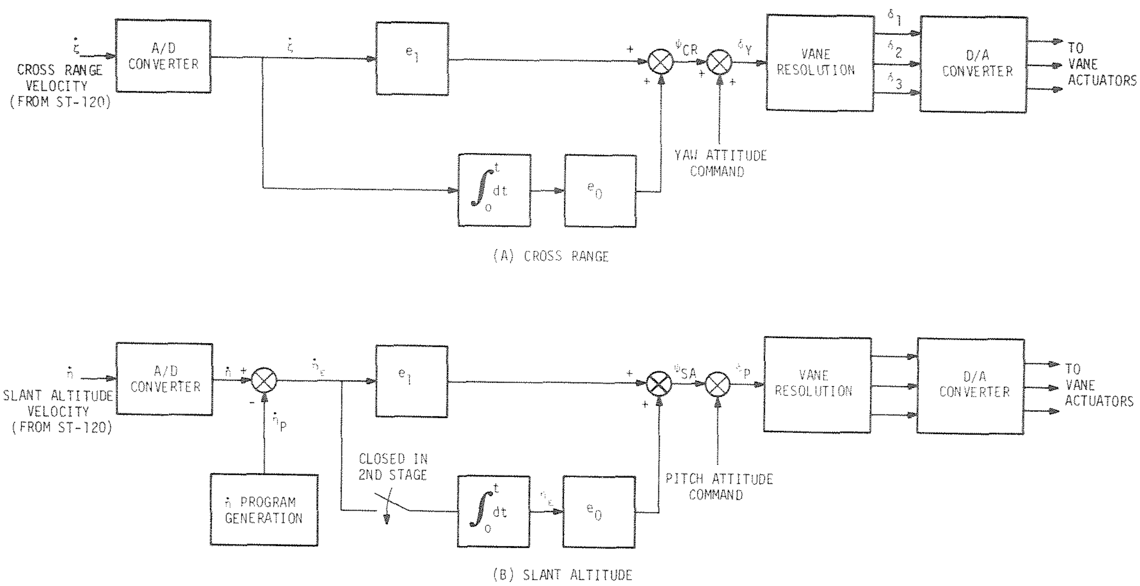


Figure 2-14. Steering Scheme

mand. This command (ψ_{CR}) is summed with the yaw attitude compensation output and resolved into proper vane commands before being outputted by the G&CC. The outputting is accomplished through the digital-to-analog (D/A) converter, with the resulting dc voltage applied to the vane actuators. The vane deflections redirect the missile's flight path to null out these errors.

Slant Altitude - The slant altitude steering is implemented in a similar fashion to cross range as illustrated in Figure 2-14(b). The slant altitude accelerometer is sampled by the G&CC A/D converter to obtain slant altitude velocity. The slant altitude velocity is compared to a slant altitude velocity program value (continuously computed as a function of time in the G&CC) to obtain the slant altitude velocity error. In the same fashion as cross range, the velocity and position errors are weighted and summed to form a pitch command. (The position input, however, is neither used nor integrated until the second stage of flight.) This pitch command (ψ_{SA}) is then summed with the pitch attitude compensation output and resolved into proper vane commands before being outputted by the G&CC. These outputs, through the D/A converter, are applied to the vane actuators. The vane deflections redirect the missile flight path to null out these errors.

Cutoff Implementation

The completion of the Pershing guidance function occurs when the cutoff command is issued and the warhead section separates from the second stage beginning its free flight ballistic path to the target. The cutoff solution is calculated exclusively from the slant range accelerometer output and the presets stored prior to flight. The following cutoff equation is solved by the G&CC:

$$\lambda = (SRV_P + SRV)\ T + (SRD_P + SRD)$$

where λ = the cutoff parameter

SRV_P = the slant range velocity preset (negative value)

SRD_P = the slant range displacement preset

T = the weighting factor applied to the velocity error (SRV_P + SRV)

SRV = slant range accelerometer provided velocity

SRD = slant range displacement (integrated from SRV).

The cutoff parameter (λ) at liftoff is a large negative value and reaches zero well into second stage flight at which time the cutoff command is issued. As λ nears zero, the G&CC determines the precise instant of cutoff by using a fast, iterative countdown routine.

ST-120 Inertial Reference System

The ST-120 inertial reference system (Figure 2-15), consisting of a stable platform and an associated servoamplifier assembly, provides an earth fixed coordinate reference system defined by the local horizontal and firing azimuth at the launch site. At liftoff this orientation becomes space fixed (Figure 2-16).

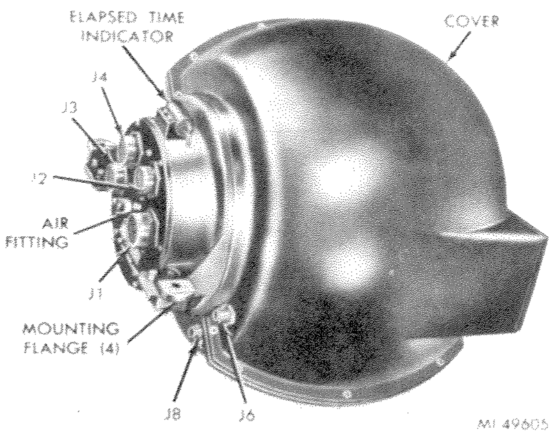


Figure 2-15. ST-120 Inertial System

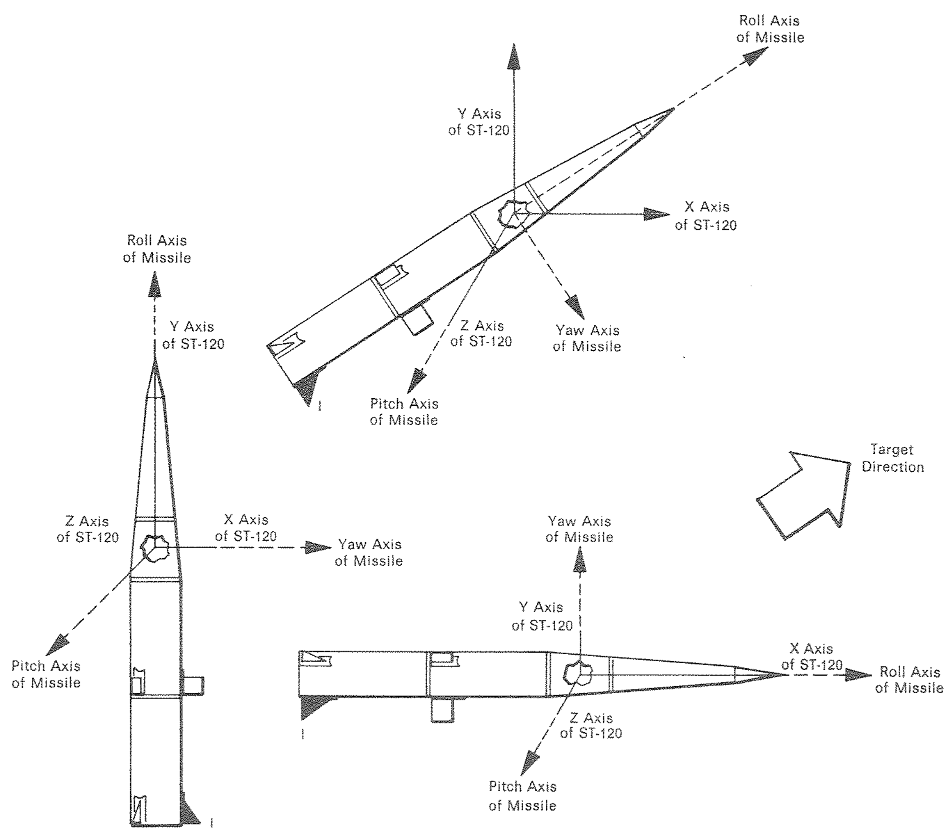


Figure 2-16. ST-120 Missile Axes Orientation

Stable Element and Gimbals - Missile disturbances are sensed through the main shaft of the ST-120 platform which is rigidly connected to the missile structure (Figure 2-17). A three-axis gimbal arrangement supporting the stabilized part (carrier ring) allows for the angular motions of the missile. Three AB-5 stabilizing gyros (Figure 2-18), mounted perpendicular to each other on the carrier ring surface, sense any movement of the platform about its inertial reference (Figure 2-19). Associated servo amplifiers and motors hold the platform space fixed during flight.

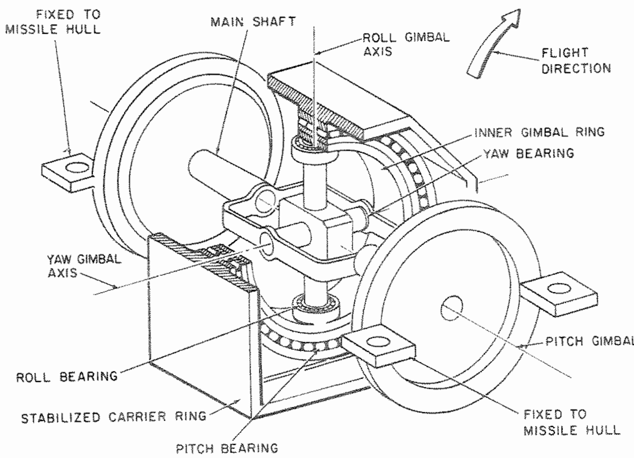


Figure 2-17. ST-120 Gimbals

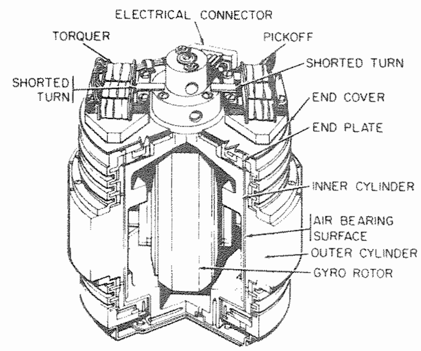


Figure 2-18. AB-5 Gyroscope

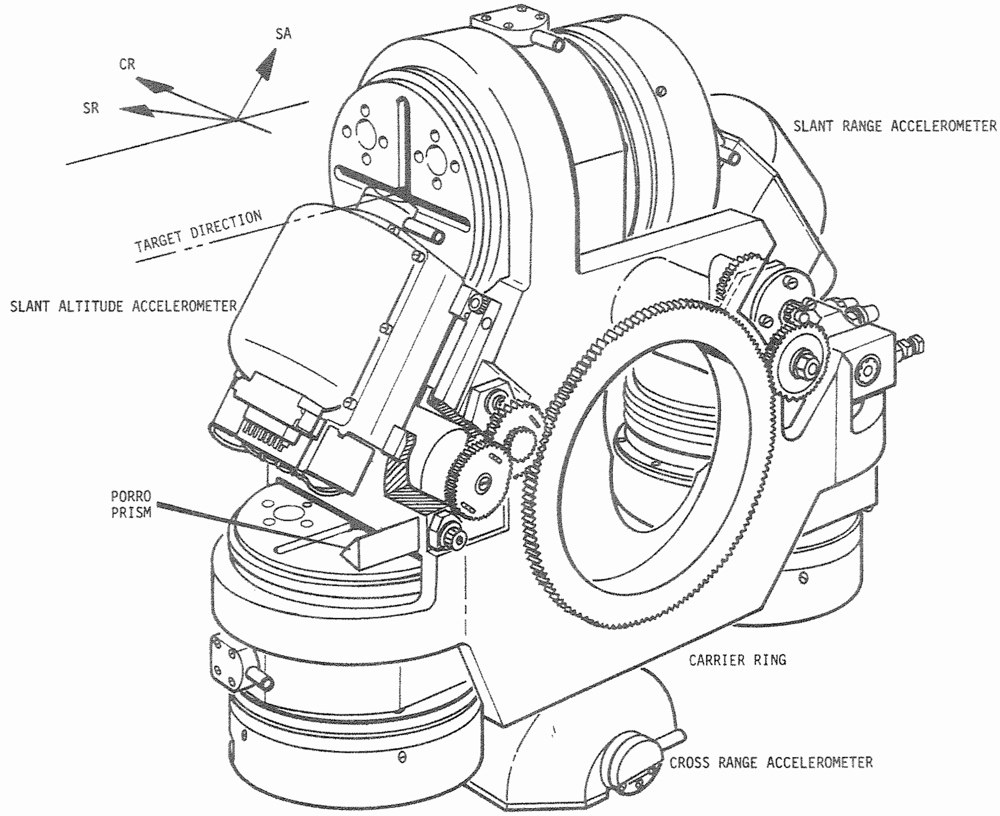


Figure 2-19. ST-120 Accelerometer Orientation and Subassembly Location

Attitude Measurement - The ST-120 platform provides attitude signals, in three mutually perpendicular axes (yaw, roll, and pitch), to the G&CC. Missile attitude with respect to the platform reference axes is measured by two microsyns for yaw and roll, (Figures 2-20 and 2-21) and a control synchro for pitch (Figure 2-22). The pitch control synchro receives a signal from the pitch cam programmer unit located in the servo-amplifier assembly and supplies a pitch error signal to the missile control system. This error signal is the difference between the missile attitude and program signal. The missile is pitched over into the desired attitude for second stage motor cutoff.

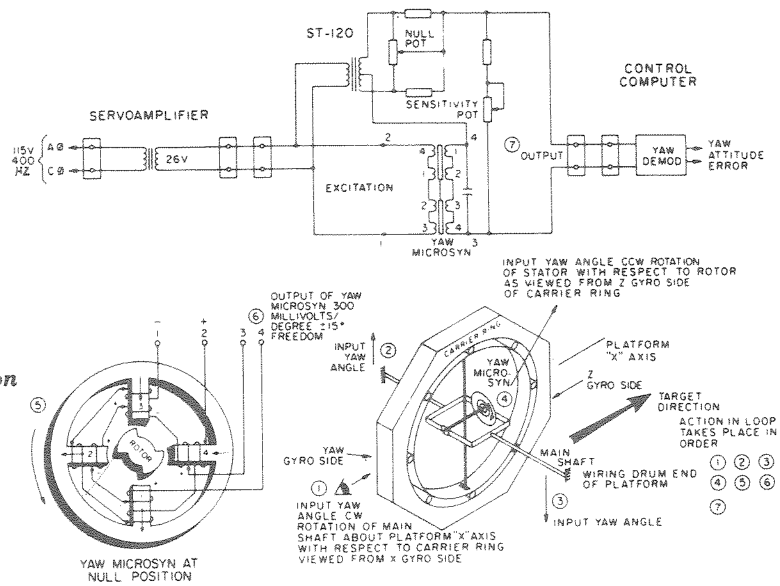


Figure 2-20. Yaw Microsyn Operation

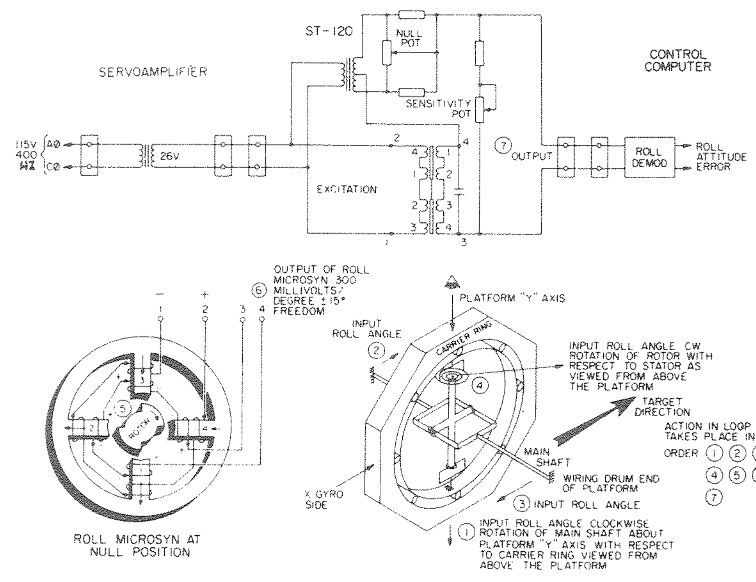


Figure 2-21. Roll Microsyn Operation

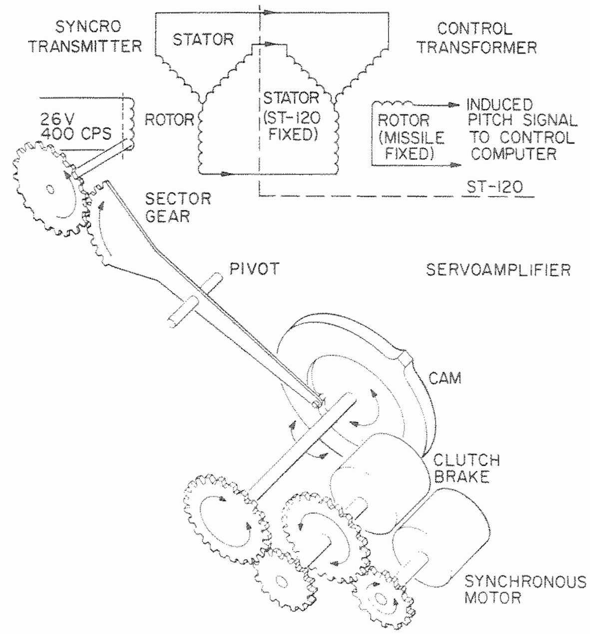


Figure 2-22. Pitch Programming

Acceleration Measurement - Three AMAB-3 accelerometers (Figure 2-23) are mounted on the carrier ring so that each accelerometer is sensitive to missile acceleration along a specific direction. Acceleration is sensed in the direction illustrated in Figure 2-19. The cross range, slant range, and slant altitude accelerometers are of the integrating gyro type. The output of each unit is a precessional rate proportional-to-input acceleration with the total displacement angle being the integral of the total acceleration. Synchro transmitters supply this output to the guidance computer.

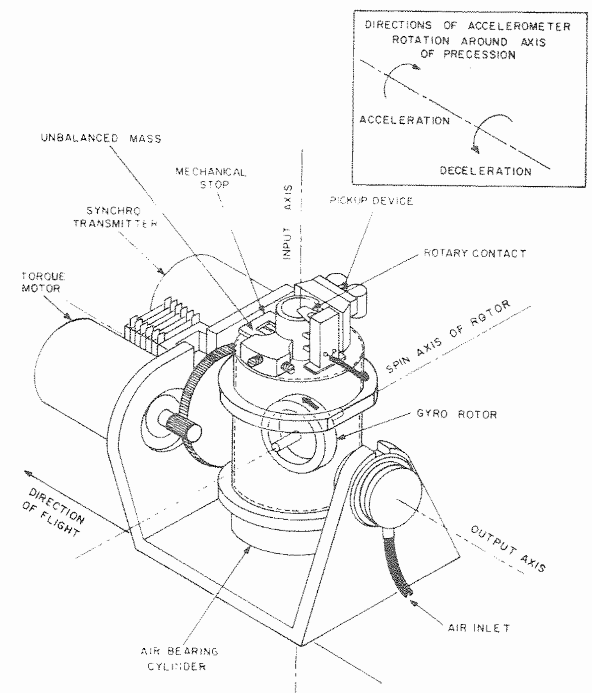


Figure 2-23. Integrating Accelerometer

Leveling and Alignment - Two leveling pendulums are used in the ST-120 platform (Figure 2-24). These pendulums, together with the alignment amplifier and platform dynamics, level the ST-120 carrier ring with respect to the local horizontal (Figure 2-25). The Z-pendulum detects leveling errors about the Z-axis and the X-pendulum detects leveling errors about the X-axis. The output signal voltages, indicating both the amount and direction of leveling error, are routed to the alignment amplifier in the programmer-test station. The amplified signal is returned to the appropriate X- or Z-stabilizing gyro torquer, causing the stability loops to precess the carrier ring to a level attitude.

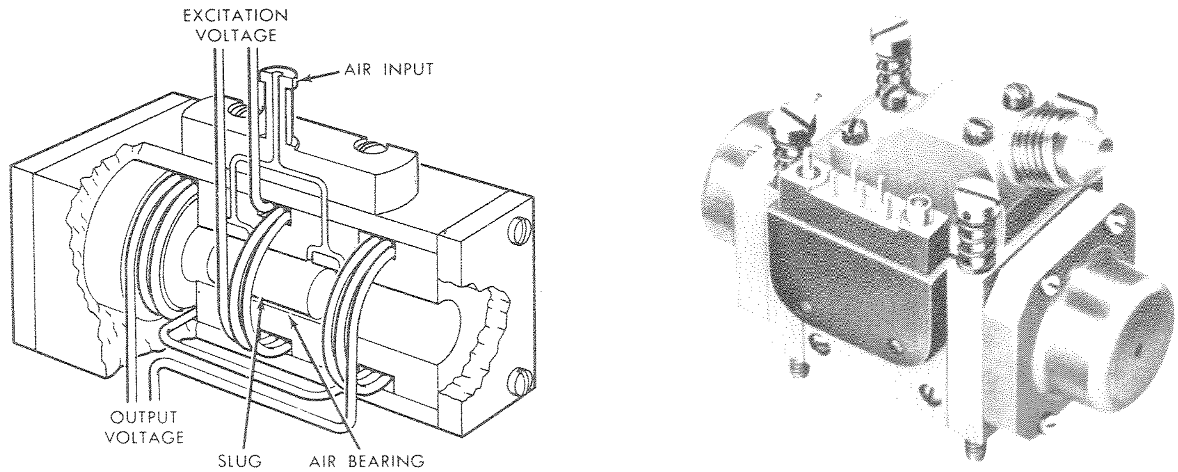


Figure 2-24. Air Bearing Pendulum

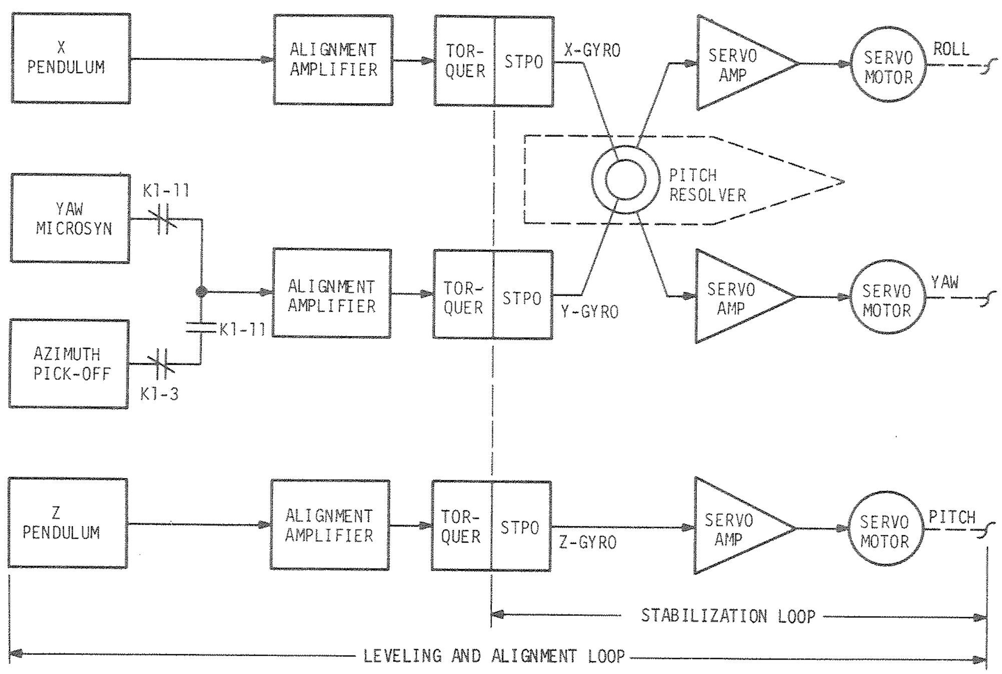


Figure 2-25. ST-120 Stabilization and Alignment Loop, Missile Horizontal

The azimuth pickoff is a high-sensitivity bridge-type microsyn used only in the ground alignment scheme. The pickoff provides information necessary to align the missile and platform in azimuth (Figure 2-26). A porro prism is mounted on the carrier ring for determining platform azimuth heading. It is oriented so that a reflected image (theodolite light source) indicates perpendicularity to the X reference axis. The heading of the platform, with respect to true north, is viewed 90 degrees from this heading. The pendulums, azimuth pickoff, and porro prism have no function after launch.

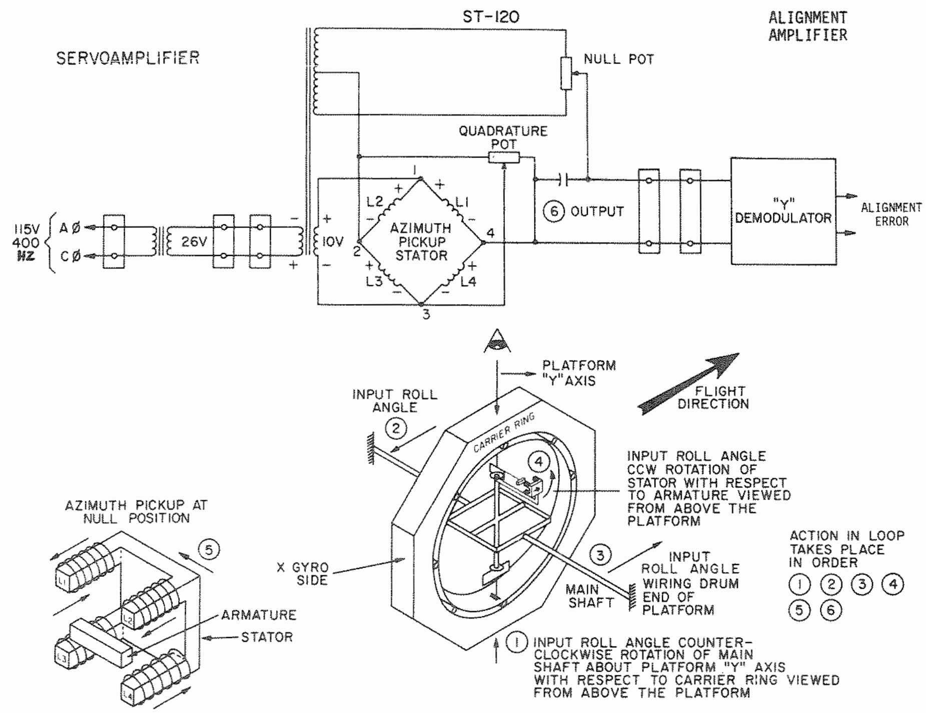
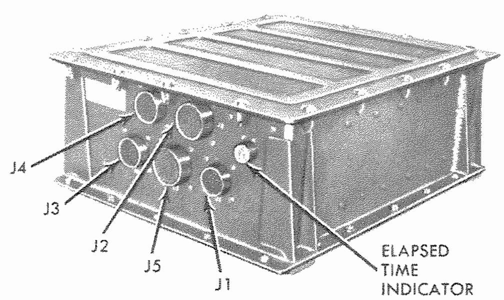
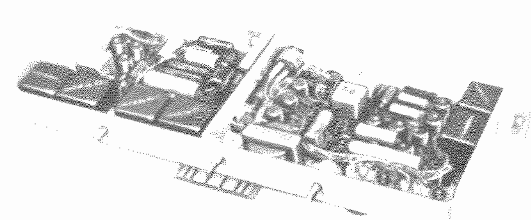


Figure 2-26. Azimuth Pickoff Operation

Servoamplifier Assembly - The servoamplifier assembly, used in conjunction with the ST-120 stabilized platform, contains six amplifiers: three AMAB-3 electronic control amplifiers, and three AB-5 electronic control amplifiers (Figure 2-27). These two types of amplifiers differ only in circuit component values. The AMAB-3 amplifiers are used with the three accelerometers. The accelerometer pickoff sensor provides the input signal to the amplifier with power to the control phase winding of the accelerometer servo motor provided by the amplifier output.



(a) Assembly



(b) Typical Amplifier Card

Figure 2-27. ST-120 Servoamplifier

One AB-5 amplifier provides power to the control phase winding of the roll gimbal servo motor, and the other provides power to the yaw gimbal servo motor. The inputs to these two amplifiers (roll and yaw) are the outputs of the pitch resolver. Resolver output voltages are dependent upon the pitch angle of the missile and the output of the X and Y gyro precession sensors.

The third AB-5 amplifier receives an input from the Z gyro precession sensor. Power to the control phase of the gimbal servo motor is provided by the amplifier output.

Power transformers are used to provide the required excitation voltages for the pendulums, gyros, accelerometers, servo motors, and attitude sensing devices.

Pitch Programmer - The pitch cam programmer is a modular electromechanical device which produces a variable electrical reference from which the pitch attitude error many be measured. The cam profile provides both a long and short coast program, the program selection being dependent on direction of rotation of the cam. The time base for the program is supplied by a synchronous motor which drives the cam through a gear reduction and clutch brake (Figure 2-28). A relay assembly provides the switching function required for testing and presetting the pitch program.

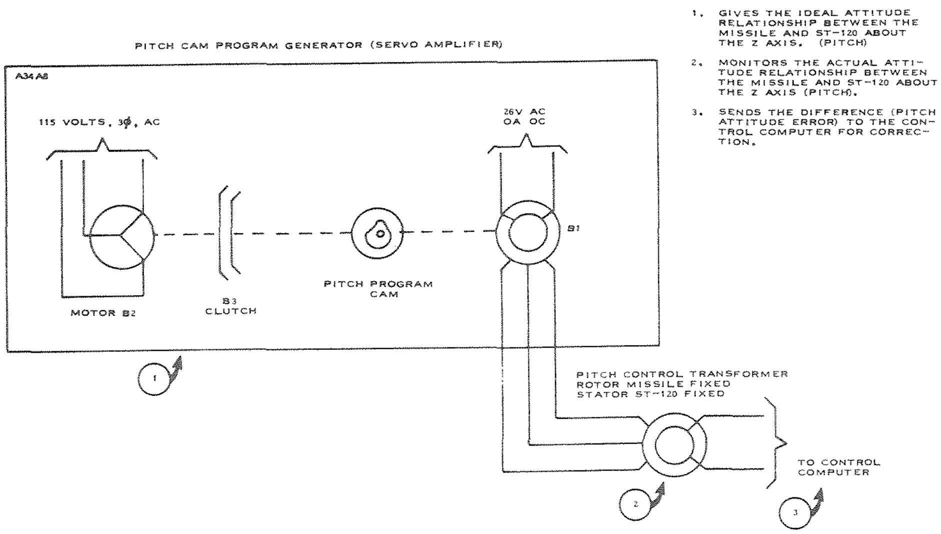


Figure 2-28. Pitch Cam Program Generator

Before launch, the pitch cam programmer is checked to determine whether or not the cam is turning in the proper direction for either pitch program. During flight, the pitch control transmitter produces the pitch program as dictated by the groove in the cam. It is used by the ST-120 to cause the missile to assume the trajectory attitude.

Air Supply System - The air supply system provides the clean, dry air required for proper operation of the platform during controlled flight. The air system, located in the guidance and control section, consists of a spherical air bottle, filters, regulators, and a heater. The air bottle serves as a storage area and contains 400 cubic inches of air, pressurized to 3000 psig. The bottle is charged by air from the power station through the umbilical mast and coupling. When the mast is disconnected, just before launch, the umbilical coupling and check valve seal the missile air system.

Figure 2-29 depicts the installation of the air distribution system while Figure 2-30 is the air system functional diagram.

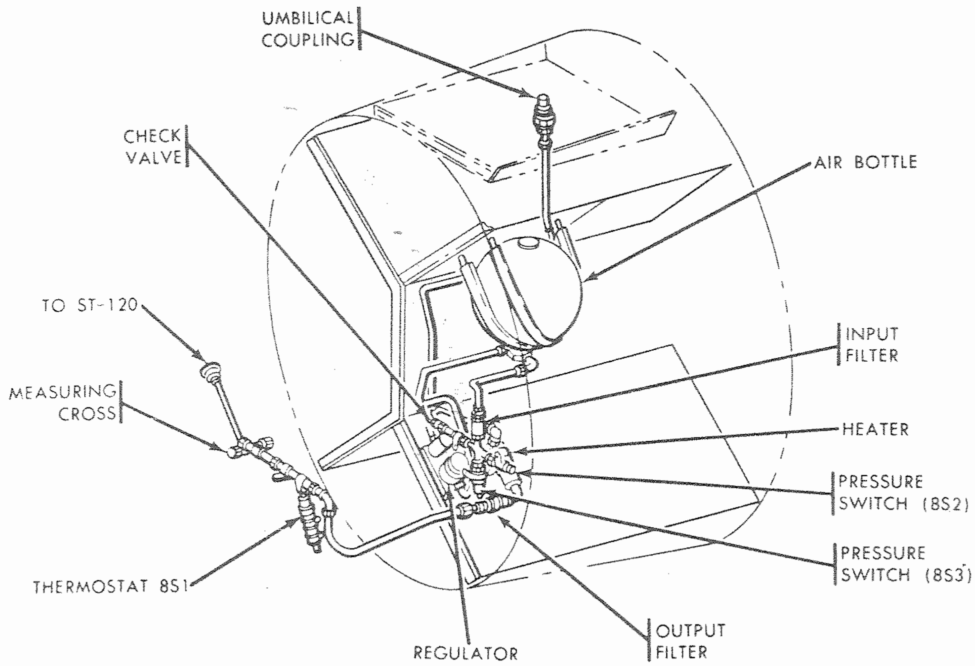


Figure 2-29. ST-120 Air Supply Installation

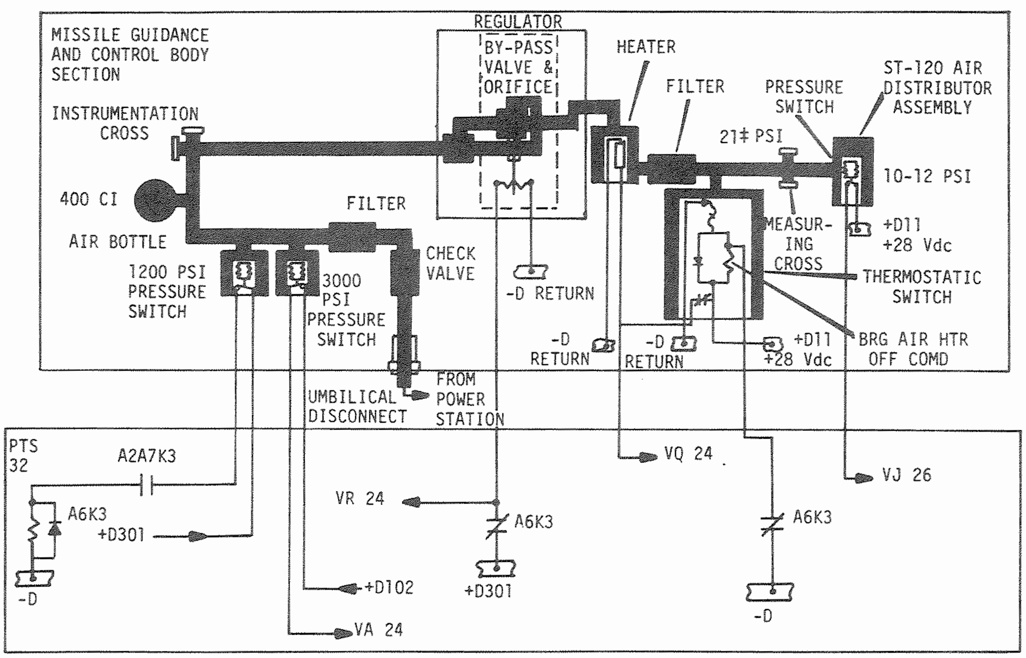


Figure 2-30. Air System Functional Diagram

Guidance and Control Computer

The digital guidance and control computer is a Bendix BDX 820 computer containing a central processor and memory, an input/output (I/O) processor designed to interface with the Pershing missile and ground support equipment, and a power supply.

The computer interfaces with the ST-120 stabilized platform, and contains all necessary functions to properly condition the accelerometer output and attitude reference signals required for controlling the missile first and second stage control surfaces. Interfaces also exist between the computer and the missile main distributor, telemetry transmitter, and prelaunch ground support equipment. In addition, special interface provisions are made to facilitate testing and memory loading at the SCTS. A system organization diagram is shown in Figure 2-31.

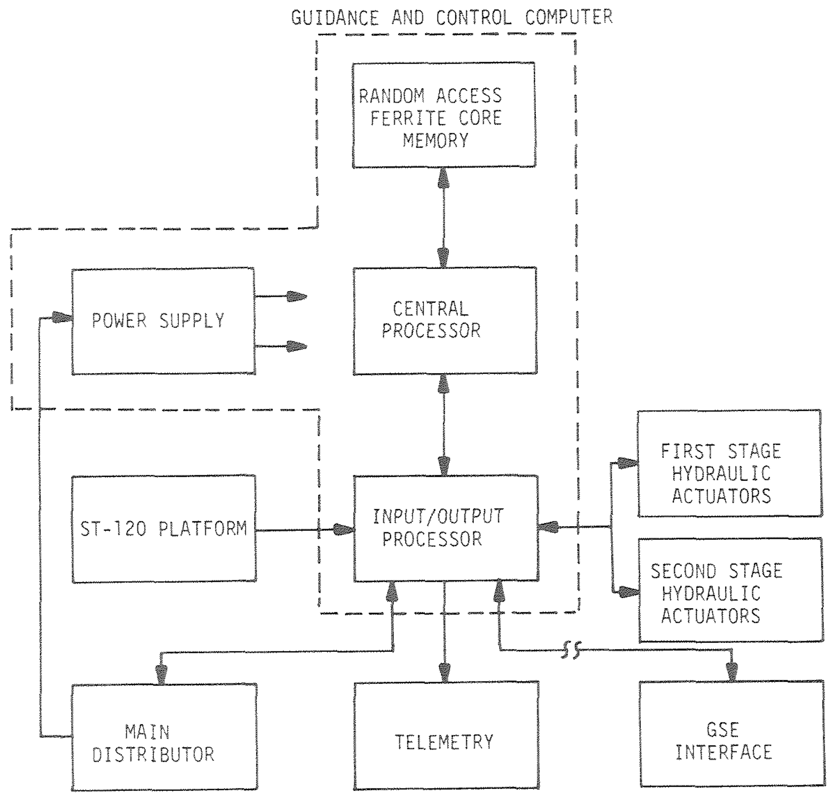


Figure 2-31. Guidance and Control Computer System Organization

Computer power is obtained from the missile electrical bus system and converted to voltages required by the central processor, memory, and I/O processor. The guidance and control computer also generates time sequence signals to the missile for staging and a cutoff signal to terminate second stage motor thrust and cause warhead separation when guidance parameters are satisfied.

Where possible, design considerations for the digital computer use existing missile electrical and mechanical interface requirements. The guidance and control software and hardware use state of the art techniques to produce acceptable reliability against guidance subsystem failure.

Figure 2-32 is a signal flow diagram of the guidance and control functions performed by the computer. The functions are specified by the requirements for a delta-minimum guidance profile.

The airborne functions may be divided into six groups: guidance, stability, control, good guidance, time discrete generation, and telemetry. The computer accepts bus 28 Vdc and 115V, 400 Hz power, and converts the power to usable voltages for the central processor, I/O, memory, and sensor excitations. The detailed design of the functions is discussed below.

Hardware and software are defined such that optimum accuracies and timing efficiency are achieved. Reliability of the guidance and control function is optimized by software techniques, such as redundant calculation and self-test features. Scaling to optimize word accuracies and an extended length algorithm are used to increase accuracy in the cutoff solution. A/D and D/A conversions are multiplexed to and from a common ladder network, and I/O analog signal processing is designed to optimize use of the full digital I/O word.

Guidance Function - The guidance function accepts the missile velocity signals in the form of accelerometer synchro voltages and outputs yaw and pitch steering signals to the control function and a cutoff signal to the good guidance function. The input signals from the accelerometers are three groups of amplitude modulated signals between the stator terminals of synchro transmitters and represent instantaneous missile velocity along each of the three mutually perpendicular axes.

The guidance function converts the sampled input signals to dc signals proportional to the sine and cosine of crossrange velocity, slant range velocity, and slant altitude velocity. These dc signals are used as excitations for the A/D converter. The A/D converter in turn uses a successive approximation technique for determining digital words proportional to the sine and cosine of the scaled velocity signals.

The crossrange guidance function integrates the crossrange velocity to obtain a crossrange displacement signal, and scales and sums the velocity and displacement signals to form a crossrange steering command for the control function.

The slant altitude guidance function subtracts from the slant altitude velocity signal a desired velocity profile from the slant altitude program to form a slant altitude velocity error signal.

The slant altitude velocity error signal is integrated, as in the crossrange guidance function, to form a slant altitude displacement error signal, which in turn is scaled and summed with the velocity error to form a slant altitude steering signal for the control function.

The slant range comparator guidance function subtracts from the slant range velocity a ground preset velocity value. The velocity difference signal is integrated to form a displacement signal which is in turn reduced by a displacement preset value. The resultant displacement difference and velocity difference signals are used to solve the cutoff equation, λ.

A cutoff discrete signal is issued by the slant range comparator guidance function when λ changes sign after second stage ignition. This cutoff signal in conjunction with the good guidance determination is used to terminate second stage thrust and initiate

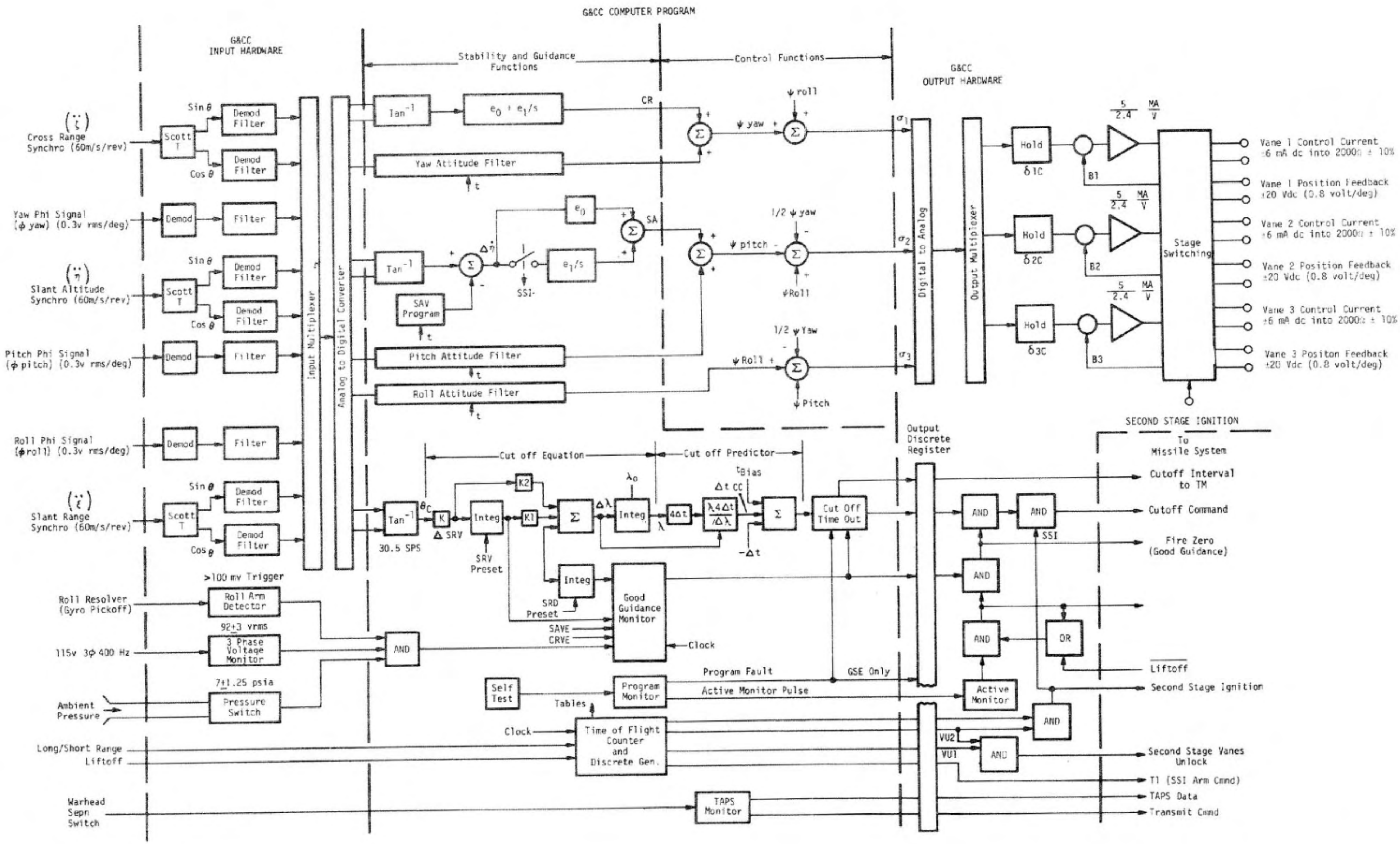


Figure 2-32. G&CC Signal Flow

warhead separation. Cutoff is issued to the main distributor upon receipt in the I/O unit of the cutoff discrete, the good guidance discrete, and the second stage ignition discrete.

Integration techniques used in the guidance function are implemented using trapezoidal integration for all three channels. The resultant errors are small for the crossrange and slant altitude, due to closed loop control of the missile dynamics. The slant range displacement integration, being a monotonic function, experiences a small error buildup; but since the standard profile is fixed, and the sampling and iteration rate is high, the $\Delta\xi$ error is insignificant.

Good Guidance Generator - The good guidance generator is designated as a fail-safe system. Failure of the computer to operate does not allow a good guidance signal to occur. The good guidance signal is generated only when the following conditions have been satisfied:

1 Crossrange velocity error less than limit;

2 Slant altitude velocity error less than limit;

3 Slant range velocity difference within tolerance;

4 Slant range displacement difference within tolerance;

5 ST-120 pitch gimbal roll/yaw resolver roll output has not exceeded 100 mV;

6 Voltage monitor signal present;

7 Pressure monitor signal present;

8 Computer has not failed;

9 Time of flight is greater than a predetermined value.

Time Discrete Generator Function - The time discrete generator function issues the following signals in real time: T1, arm command, vane unlock, and first stage separation/second stage ignition. The signals are issued at prescribed times for both a short range profile and a long range profile, by comparing fixed timing data words to the real time clock. The second stage ignition signal is issued to the control function for the purpose of first to second stage control system current and feedback switching.

Stability Function - The stability function accepts missile attitude signals from the inertial reference in the form of 400 Hz suppressed carrier amplitude modulated sensor outputs. The yaw and roll inputs are platform microsyn outputs carrying missile yaw and roll attitude information. The pitch signal is the output of a back-to-back CX-CT pair, and is the difference between actual missile attitude about the pitch axis and the desired pitch program angle. Maximum input voltage for the yaw-roll channels is 4.5 Vrms. Maximum input voltage for the pitch channel is 17.5 Vrms but is saturation limited to a 10 volt peak level for I/O design considerations. Saturation of the pitch input signal does not degrade performance, as computer gains of this magnitude signal saturate the vane output signals and no overflow detection is required in software.

The input signals, designated ϕ_{yaw}, ϕ_{roll}, and ϕ_{pitch}, are demodulated and filtered. The resulting dc voltages are converted to digital words in the common A/D converter. The digital ϕ signals are then processed to provide proportional and differential gain compensation of the input, with additional filtering of the differential (dynamic) path to form a forward transfer function meeting defined missile stability requirements. The filters are selected in relation to the timing signals generated by the time discrete generator function to provide compensation for changing missile dynamics due to propellant consumption, aerodynamics, and staging. Filter characteristics also differ for long and short range trajectories. The digital filter is essentially a difference equation of fourth order maximum for yaw and pitch, and second order for roll.

Control Function - The control function accepts the signals from the guidance and stability function and processes them to form command signals for the vane control hydraulic actuator packages. The processed ϕ_{yaw} signal is summed with the crossrange steering signal to generate the ψ_{yaw} steering signal. The processed ϕ_{pitch} signal is summed with the slant altitude steering signal to generate the ψ_{pitch} steering signal. The ϕ_{roll} steering signal alone comprises the ψ_{roll} steering signal. The output data in body space is then transformed into three vane position command signals, designated σ_1, σ_2, and σ_3, according to the following matrix definition:

$$\begin{bmatrix} \sigma_1 \\ \sigma_2 \\ \sigma_3 \end{bmatrix} = \begin{bmatrix} +1 & +1 & 0 \\ -1/2 & +1 & -1 \\ -1/2 & +1 & +1 \end{bmatrix} \begin{bmatrix} \psi_{yaw} \\ \psi_{roll} \\ \psi_{pitch} \end{bmatrix}$$

Positive ψ_{yaw} is defined as the steering command about the body yaw axis which is directed downrange at launch. Positive ψ_{roll} is the steering command about the body roll axis which is directed away from the earth at launch. Positive ψ_{pitch} is the steering command completing a right-handed orthogonal yaw-roll-pitch coordinate system. The vane command vectors lie in a plane normal to the missile roll axis, with the positive direction defined outward from the missile body. The σ_1 command vector passes through the vane 1 axis of rotation and lies parallel to the missile downrange yaw axis. The σ_2 and σ_3 command axes pass through vanes 2 and 3, respectively, and are oriented at angles of 120 degrees and 240 degrees respectively, counterclockwise from the σ_1 vector when viewed looking down the missile body from the missile nose.

Each of the three vane drivers provide a control current to one hydropack valve which is proportional to the algebraic difference between commanded vane angle (σ_1, σ_2, or σ_3) and the actual vane position (β_1, β_2, or β_3). The command angles (σ) are converted to scaled analog signals in the multiplexed D/A converter and compared directly to the dc vane position feedback signal (β) from the hydropack.

The stage switching function accepts the vane driving current signal from the vane driver and also receives the vane position and vane drive current feedback signals from both first and second stage hydropacks. During first stage flight, the switching function directs the vane driving current signal to the first stage hydropacks and connects the vane position and vane drive current feedback signals from the first stage hydropacks to the vane driver. In addition, during first stage flight, the switching function inverts the second stage vane position feedback signal and connects it directly to the input of the second stage hydropack to hold the second stage vanes at zero deflection. Upon receipt of the first stage separation/second stage ignition command, the switching function redirects the vane driving current signal to the second stage hydropacks and connects the vane position and vane drive current feedback signals from the second stage hydropacks to the vane drive, disconnecting and deadfacing all previously made first stage connections.

Power and Telemetry - A dc to dc converter in the I/O unit converts the +28 Vdc missile bus voltage to levels usable by the I/O and central processor. Inverter 400 Hz power through transformation is used for demodulation and accelerometer synchro excitation. The dc/dc converter provides bias supplies for electronics in the I/O, central processor, and memory. Additional dc power supplied by the PTS interface is used to supply ground interface hardware only.

The computer I/O unit contains serializer and parity generator for digital word transfer to the telemetry system. Telemetry output is under software control in the central processor. Required analog signals and voltages in the I/O and signal discretes are also available at the telemetry connector.

Hardware Organization - The Pershing guidance and control computer is a Bendix BDX 820 computer consisting of a general purpose digital computer and a set of I/O equipment specifically optimized for application to the Pershing Ia guidance and control requirement. The computer organization is shown in Figure 2-33.

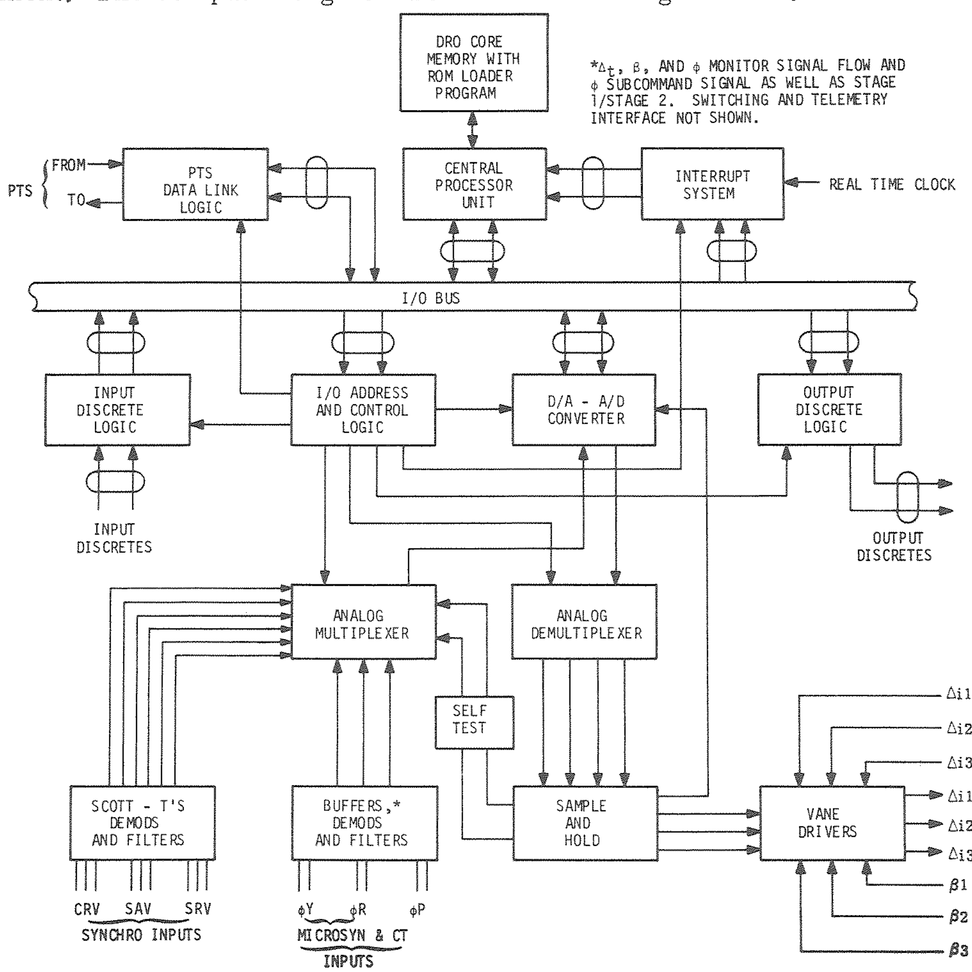


Figure 2-33. G&CC Hardware Organization

The central processor unit (CPU) is the main logic, computational, and data management element within the guidance and control computer. Under direction of the operational program stored within the memory, the CPU performs all of the logic manipulation and arithmetic calculations necessary to implement the Pershing guidance and control equations. In addition, the CPU directs, in accordance with the stored operational program, the operation of the PTS data link logic unit; D/A-A/D converter unit; input and output discrete logic units; telemetry; and analog multiplexer and demultiplexer units. Control of these units is exercised by the CPU through the I/O address and control logic unit.

In the BDX 820 all program and data are stored within the memory. All of this program or data can be accessed only by the CPU which has provisions to read from the memory or write into the memory. The CPU also has a two way data transfer path to and from the PTS data link logic unit and D/A-A/D converter unit, a one way data transfer path to the output discrete logic, a one way data transfer path from the input discrete logic unit, and a one way data transfer path to the interrupt system indicators and masks. Control of the data transfer to and/or from these units is exercised by the CPU by directing the I/O address and control logic unit to take appropriate control action. Transfer of address and control data to the I/O address and control unit is accomplished via the transfer path from the CPU to that unit.

The interrupt system provides a method of informing the central processor of events requiring immediate attention by the program, e.g., liftoff and data transmission. Interrupts are also used to indicate the passage of a fixed interval of real time which is used as a time base for numerical integration and for telemetry update commands.

When addressed by the CPU, and under direction of the I/O address and control logic unit, the analog multiplexer unit selects one of the inputs available to it from the Scott-T, demodulator, and filter units or the buffer amplifier, demodulator, and filter units, and applies the selected signal to the input of the D/A-A/D converter unit. This latter unit, under the direction of the I/O address and control unit, converts the applied analog signal into a digital representation of its amplitude, and transfers these data to the CPU for processing and/or storage.

The D/A-A/D converter unit also accepts digital data from the CPU, under control of the I/O address and control unit, and outputs a dc voltage proportional to the binary number represented by the input. The dc output voltage is applied to the input of the analog demultiplexer unit which, under direction of the I/O address and control is used to feed back a voltage to the D/A-A/D converter unit to compensate for any offset in that unit. Three other sample and hold circuits provide the input to the three identical summation and drive amplifiers in the vane driver unit. Two are used for self test purposes. Each summation and drive amplifier in this unit sums the vane position β feedback signal and a voltage derived from the vane servo valve (Δi) drive current feedback with the input from the sample and hold unit and provides an output drive current proportional to this summation.

The input discrete logic unit accepts 28 Vdc input discrete signals and transforms them to the 5 Vdc level of all guidance and control computer logic signals. When addressed by the CPU, and under direction of the I/O address and control logic unit, the input discrete logic unit transfers the data into the CPU for processing and/or storage.

The output logic unit, under direction of the I/O address and control logic unit, accepts data concerning output discretes from the CPU as a 5 Vdc signals and transforms

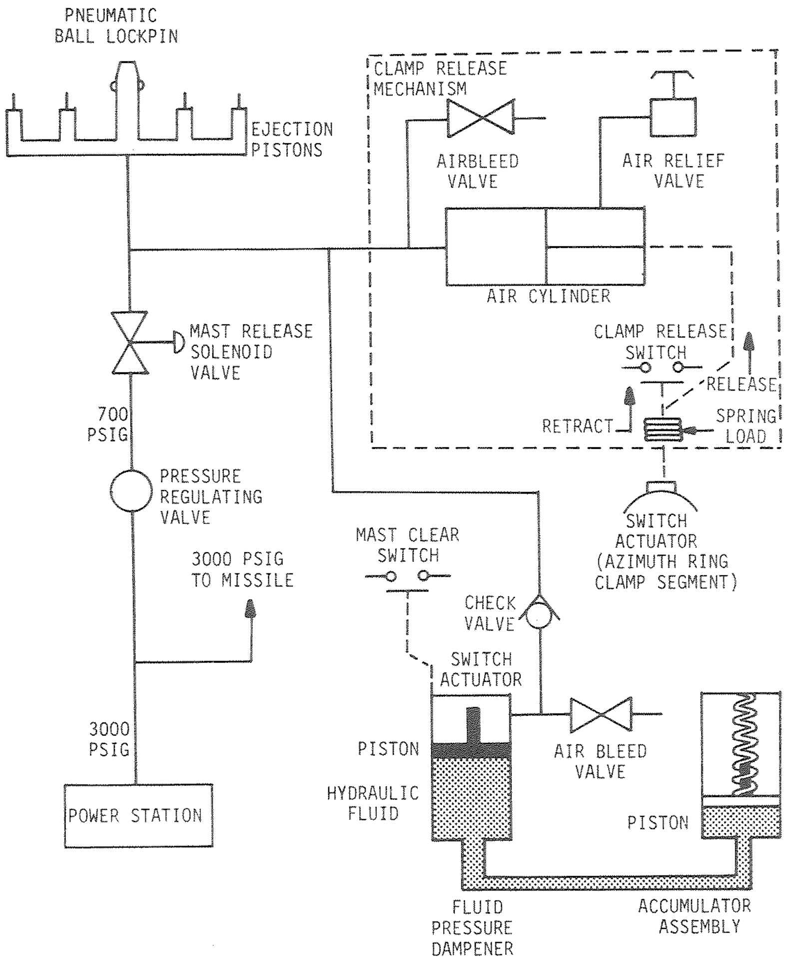
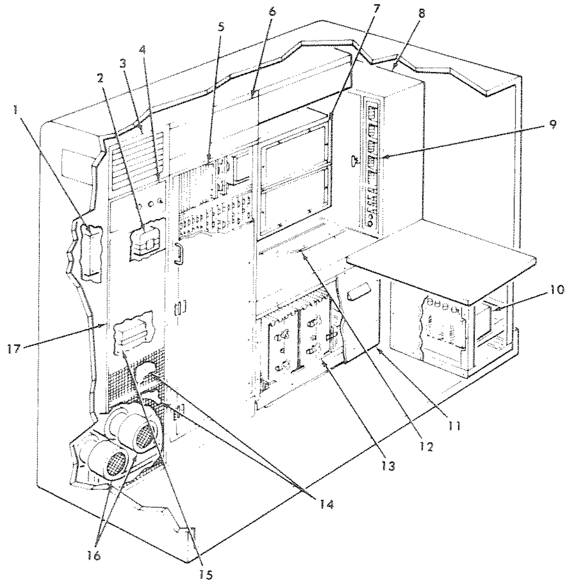


Figure 3-11. Cable Mast and Clamp Release Mechanism Pneumatic Diagram



1 - REMOTE FIRING BOX
2 - AZIMUTH LAYING CONTROL BOX
3 - AIR DUCT REGISTER
4 - PHONE CONTROL PANEL ASSEMBLY
5 - ADAPTER
6 - STORAGE CABINET
7 - CARD AND MODULE TEST SET
8 - POWER DISTRIBUTION ASSEMBLY
9 - POWER DISTRIBUTION ASSEMBLY CIRCUIT BREAKER PANEL
10 - SIGNAL DISTRIBUTION BOX
11 - COMPUTER BOX FRONT ACCESS PANEL
12 - COMPUTER BOX TOP ACCESS PANEL
13 - COMPUTER
14 - AIR FILTER
15 - FIRST AID KIT
16 - BLOWER
17 - STORAGE CABINET

Figure 4-2. PTS Interior Left Side View

1 - LAUNCH CONTROL PANEL ASSEMBLY
2 - MAINTENANCE PANEL ASSEMBLY
3 - STORAGE CABINET
4 - UTILITY PANEL ASSEMBLY
5 - UTILITY CIRCUIT BREAKER PANEL ASSEMBLY
6 - AIR DUCT REGISTER
7 - TELEPRINTER
8 - TAPE STORAGE CABINET
9 - AIR CONDITIONER
10 - AIR SUPPLY REGISTER
11 - AIR CONDITIONER FILTER
12 - AIR CONDITIONER CONTROL PANEL
13 - REMOTE FIRING BOX CABLE REEL ASSEMBLY (TRAVEL POSITION)
14 - STORAGE CABINET
15 - CONVENIENCE OUTLET (4)
16 - AUXILIARY HEATER
17 - WORKBENCH
18 - SIGNAL DISTRIBUTION BOX
19 - BLOWER
20 - CONSOLE
21 - VOLTAGE-PHONE MONITOR PANEL ASSEMBLY
22 - COUNTDOWN CONTROL PANEL ASSEMBLY
23 - AZIMUTH LAYING CONTROL PANEL ASSEMBLY
24 - TAPE READER
25 - HAND LANTERN

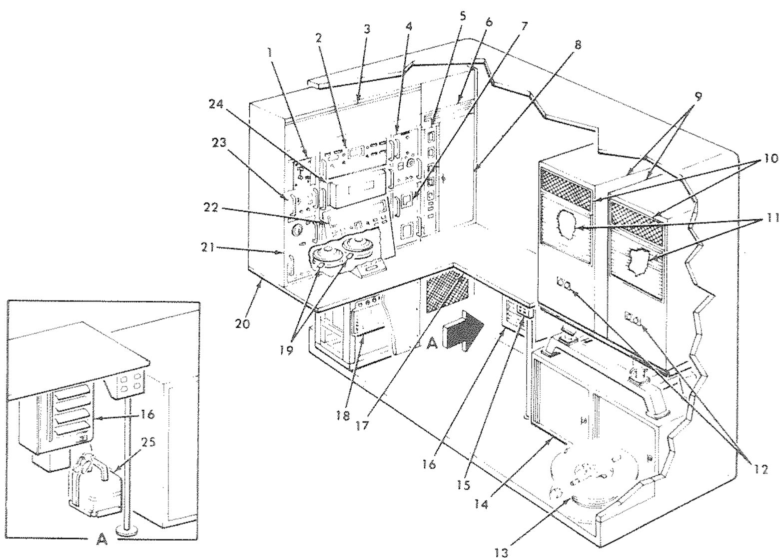


Figure 4-3. PTS Interior Right Side View

Computer

The basic controlling and sequencing element in the PTS is a compact general-purpose computer. The computer is a stored program, parallel, binary, fixed point machine, whose major components are a central data processor, an input/output assembly, four core memory units, a power supply assembly and an electrical equipment rack assembly (Figure 4-4). The basic word length is 23 data bits plus sign and parity (25 bits total). The memory is magnetic core, random access, with a 4 microsecond cycle time. The computer is normally supplied with 16,384 words of memory capacity, but can be expanded without redesign. The computer employs 47 basic instructions, but by using microprogramming techniques, up to 300 instruction variations are available to the programmer. The memory is protected so that accidental interruption of input power to the computer will not cause the contents of the memory to be altered. The input and output circuits of the computer are compatible with devices using field data codes. Figure 4-5 presents a simplified block diagram of the computer.

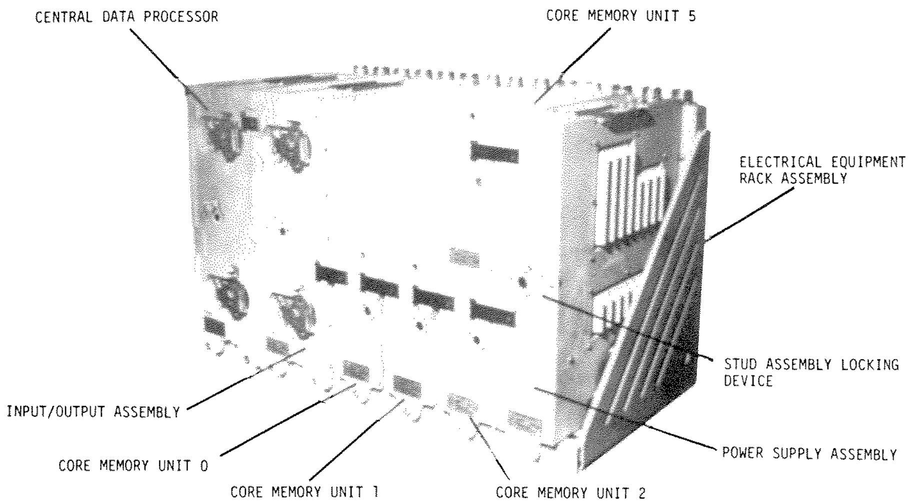


Figure 4-4. Computer Assemblies

The input/output assembly is the unit through which all signals to the computer are routed. The input circuits decode input information to the central data processor and the core memory units. The output circuits decode output information, which is routed to the adapter for controlling missile functions and to the console where it is displayed visually and/or printed out on the teleprinter.

The central data processor is the heart of the computer. It consists of three interrelated subsystems: arithmetic and logical operations, program execution and control, and input/output control. All arithmetic operations (addition, subtraction, multiplication, and division) and manipulation of data to accomplish a desired result are performed in the arithmetic and logical operations subsystem. All necessary timing signals and subcommands required in the instruction execution are generated in the program execution and control subsystem. The input/output control subsystem controls the transfer of data between the core memory units and the input/output assembly.

The core memory units store all required data. Each unit is capable of storing 4,096 words of 25 bits each.

The countdown control panel assembly is used for manually entering data into the computer during program execution. A visual display indicator on this panel indicates which phase of the program is in progress, the reason for hold conditions when a hold condition exists, and the cause of a malfunction when a malfunction occurs.

The tape reader is used for entering various taped program data into the computer.

The teleprinter provides a historical record of all data and all information displayed on the countdown control panel assembly information readout indicator during a fire sequence.

The maintenance panel assembly is used in conjunction with prepunched diagnostic tape when fault isolation procedures are being performed on the computer. It contains three alphanumeric display tubes. A number is displayed for each step of the test. Comparison of the number displayed with similar numbers in the repair data tables results in isolation of the malfunction.

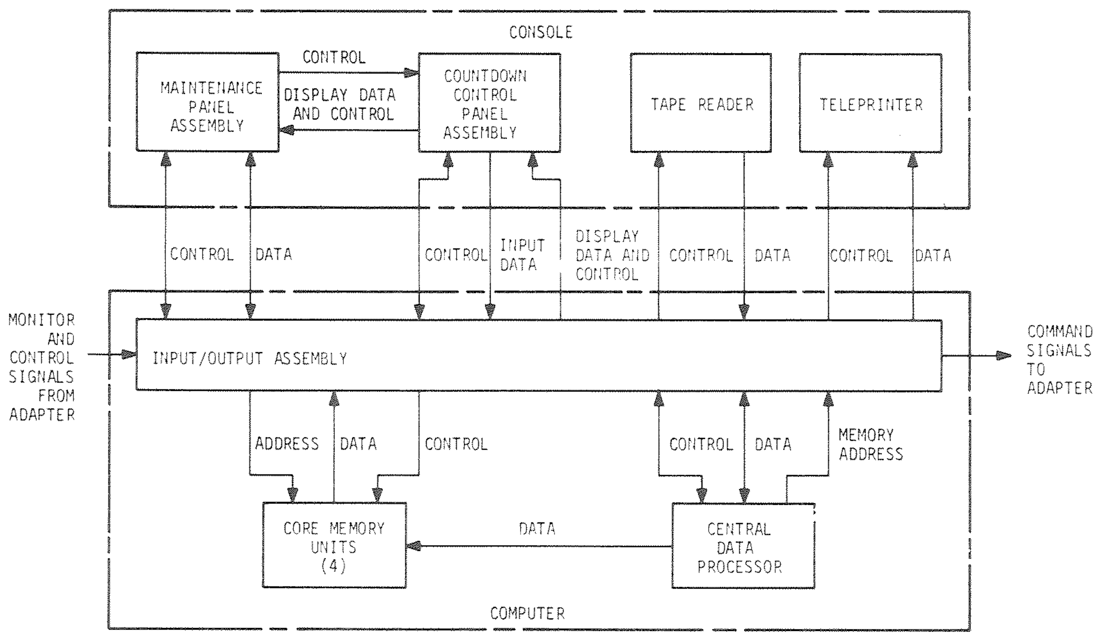


Figure 4-5. Computer Block Diagram

Adapter

The adapter serves as the electrical interface between the computer and the rest of the missile system. All electronic circuits of the PTS which are not part of the computer, the utility circuits, or the console equipment are included in the adapter (Figure 4-6).

Operating under the control of the computer, the adapter circuits perform most of the actual controlling and monitoring function of the PTS. There are 215 control lines which can be switched on and off by the computer through adapter circuits; this number can be increased to 360 without basic design changes if required by future developments. An additional 215 lines are monitored for the presence or absence of signals; this number can be increased to 396 without basic design changes if required in the future.

The adapter accepts digital information, in the form of an 18-bit parallel word, from the computer and converts this information into analog information for presetting the guidance system and sequencing the countdown of the missile for flight. Circuits within the adapter also convert analog information from the card and module test set (CMTS) and the ground support equipment to digital information for the computer (Figure 4-7).

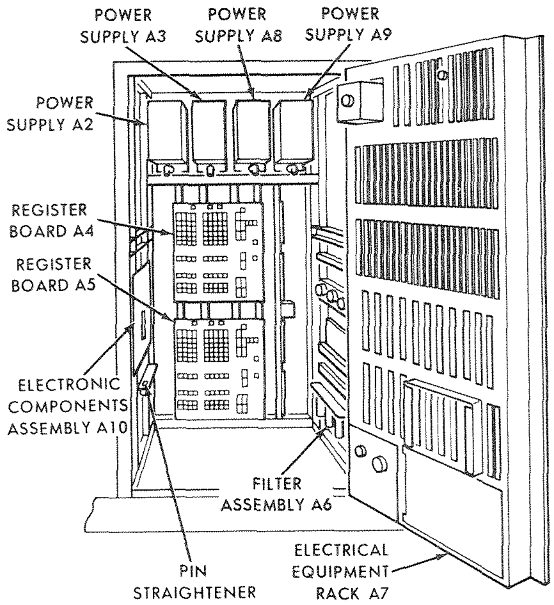


Figure 4-6. Adapter Assemblies

Operations Control Function

Operating under computer control, the operations control function receives reset, row select, and data set signals from the computer. These signals cause command signals to be generated that are used throughout the adapter, CMTS, azimuth laying control box, and console. The command signals control a specific function in the missile or the adapter. Monitor signals are sent to the operations control function from throughout the adapter, azimuth laying control box, and CMTS. The monitor signals indicate that a function necessary to complete an operation has been accomplished successfully. The signals are converted to an acceptable voltage level and routed to the computer.

Command and Monitoring Function

This function produces control signals that are applied to the missile, ground support equipment, and CMTS and receives monitor signals from the same equipment. The control signals are initiated by the command signals from the operations control function. The command and monitoring function routes countdown status indications to the remote firing box and receives firing control signals from the remote firing box. Manually generated command signals such as "missile power on" and "counting" are received by this function from the countdown control panel assembly. Status indicator signals such as "holding, counting, and missile power on" are fed from the command and monitoring function to the countdown control panel assembly.

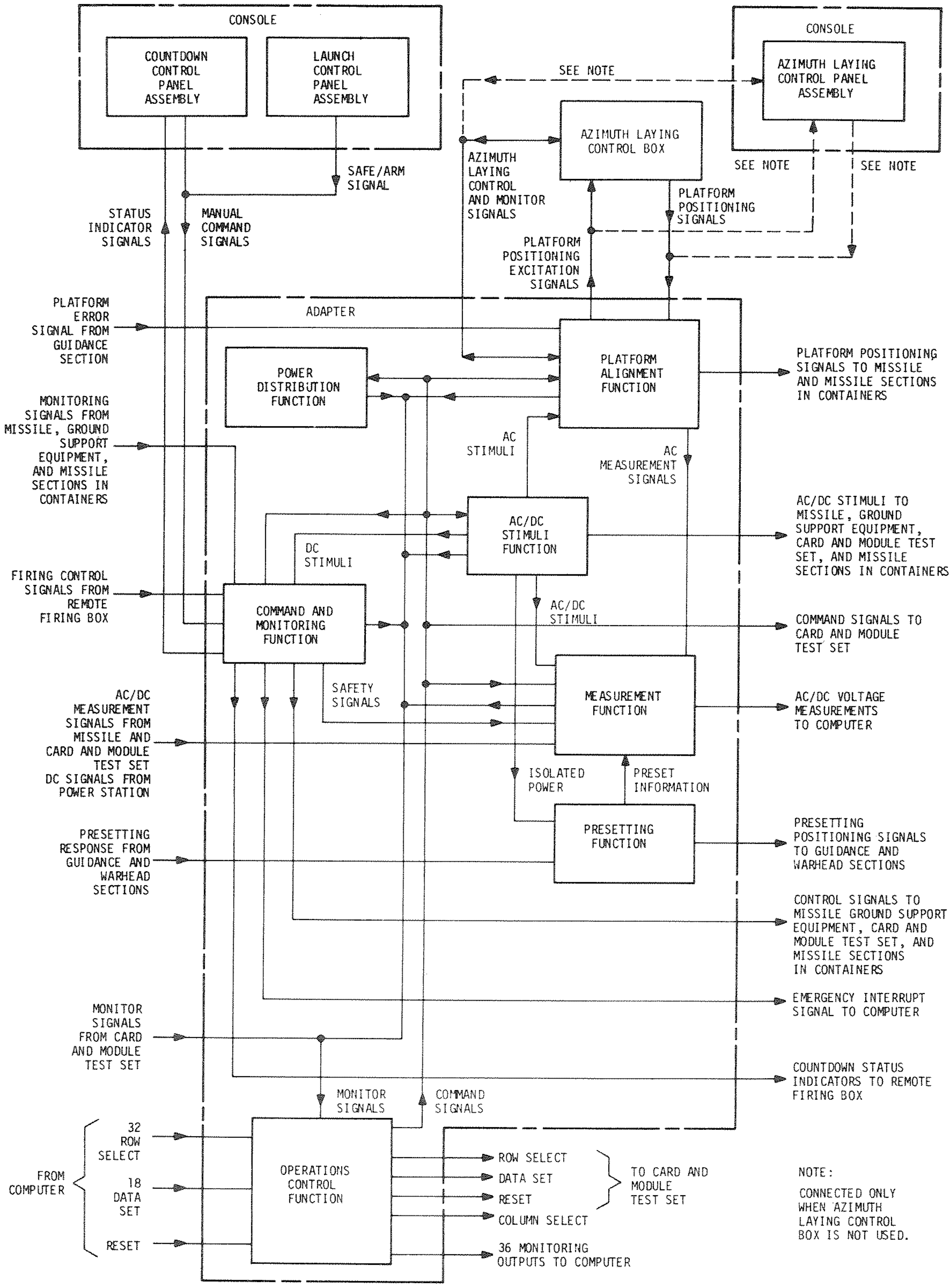


Figure 4-7. Adapter Block Diagram

Platform Alignment Function

This function, operating in conjunction with either the azimuth laying control box or the azimuth laying control panel assembly, is used to align the ST-120. Operation of the function is controlled by command signals from the operations control function. AC stimuli are applied as reference signals to the function during testing to permit location of malfunctions. AC measurement signals are sent to the measurements function during normal operation to indicate that the platform alignment function is operating correctly. During testing, the ac measurement signals indicate the location of malfunctions.

AC/DC Stimuli Function

This function provides variable level ac and dc signal voltages for use in the platform alignment, command and monitoring, measurements, and presetting functions. The level of the ac or dc stimuli is controlled by the computer. In addition, the ac/dc stimuli is also fed to the missile, ground support equipment, CMTS, and missile sections in containers.

Measurements Function

This function, under computer control, performs ac/dc voltage measurements, ac frequency measurements, and ac phase comparison checks on signals received from the missile, CMTS, power station, command and monitoring function, and ac/dc stimuli function.

Presetting Function

This function forms a loop with circuits in the warhead and guidance sections of the missile. The signals applied to the loops are used to preset the guidance and warhead sections for a particular firing. Preset information is routed to the measurements function to determine the level of the next presetting signal to be sent to the guidance or warhead sections.

Modules

Five types of modules are used in the adapter: command modules, monitor modules, matrix driver modules, capacitor modules, and load modules. A decal on the top of each module identifies the type. The command, monitor, and capacitor modules and their respective receptacles are keyed to prevent a module from being inserted into an incorrect receptacle. Figures 4-8 and 4-9 show the type, quantity, and proper location of the modules used in the adapter.

Adapter Filter Assembly

The adapter filter assembly consists of three low-pass ac filters for the 400 Hz power input to the adapter. The filters are mounted on a chassis on the right-hand panel inside the cabinet.

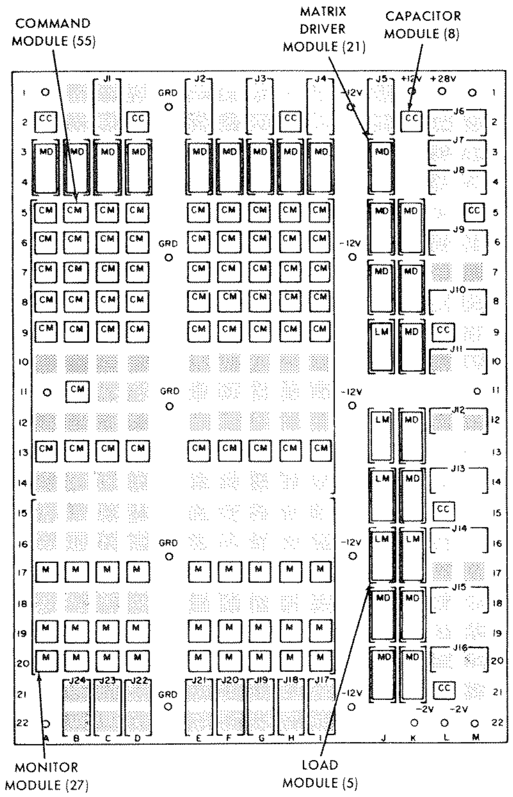


Figure 4-8. Adapter Register Board 32A2A4 Module Locations

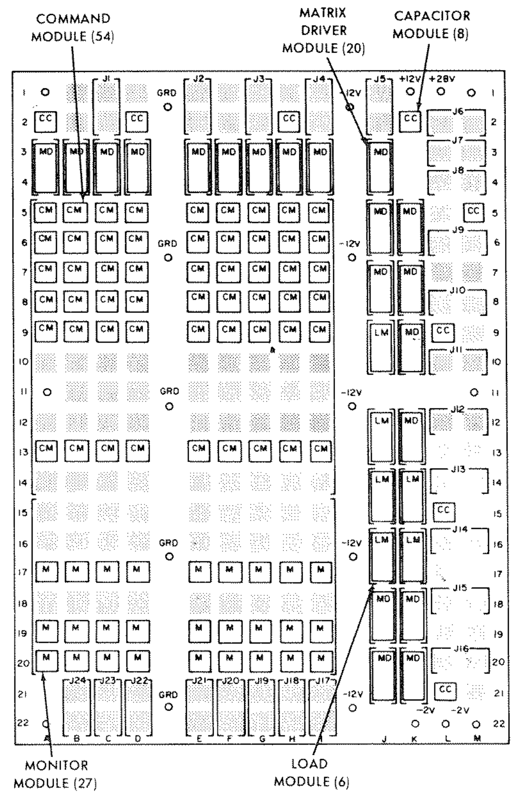


Figure 4-9. Adapter Register Board 32A2A5 Module Locations

Adapter Electrical Equipment Rack

The major portion of the adapter circuits consists of 70 printed circuit cards (18 different types) mounted on a swing-out equipment rack (Figure 4-10). The printed circuit cards are of an epoxy fiberglass base material laminated with copper and etched on both sides. The connectors for each type of card are individually keyed to prevent a card from being inserted into an incorrect location.

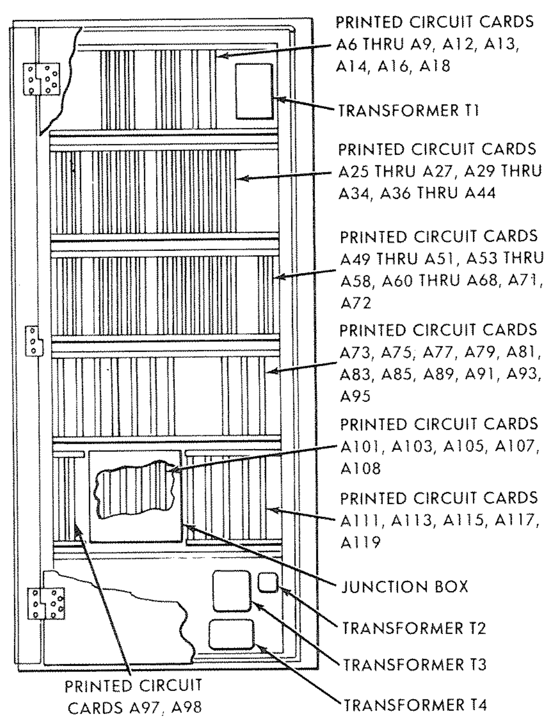


Figure 4-10. Adapter Electrical Equipment Rack Assemblies

Voltage Measurement

The dc voltage measurement capability of the adapter circuits over the whole environmental range is as follows:

Voltage Range	Accuracy
1.0 to 128.0 volts	±0.5% of the reading
0.010 volt to 1.0 volt	±0.010 volt

The ac voltage measurement capability of the adapter circuits is as follows:

Voltage Range	Accuracy
4 volts to 128 volts rms	1% of the reading
0.5 volt to 4.0 volts rms	2% of the reading
0.010 volt to 0.5 volt	10 millivolts

In the basic measurement mode, the root mean square (rms) value of the fundamental 400 Hz sinusoidal component of the unknown is measured; all other frequency components are attenuated. Accuracy requirements stated above apply to signals with a fundamental frequency between 380 and 420 Hz with not more than 5 percent total harmonic distortion.

Stimuli Voltage

The stimulus voltage generating capability of the adapter is as follows:

1 For dc voltages, 0 to 16 volts in 2 millivolt steps, either polarity

2 For ac voltages, 0 to 35 volts in 2 millivolt steps, in phase with any of the three phases of the 400 Hz supply voltage.

The final stimulus voltage amplitude is set with the voltage measurement circuits monitoring it, so that the accuracy of the stimulus voltages is essentially the same as the measurement circuits, plus an additional error of ±2 milliwatts due to the resolution of the stimulus generators.

Inverter Frequency

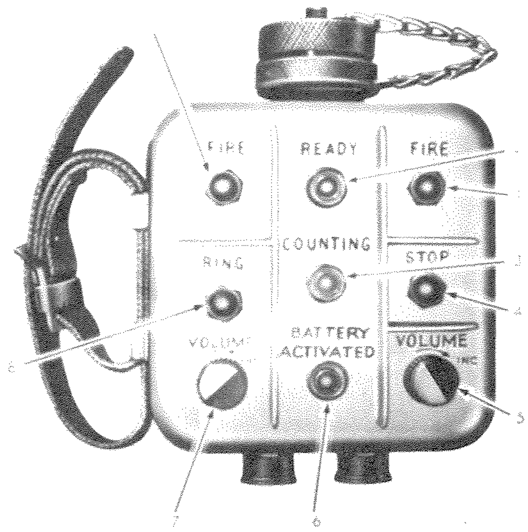
The inverter frequency can be monitored by the PTS with a measurement error of less than ±0.01 Hz.

Synchro Preset

The adapter circuits preset the synchros of the guidance computer well within the required accuracy of 0.3 meter per second for the slant range velocity channel and 30 meters for the slant range displacement channel under worst case conditions. The warhead synchros are preset with an accuracy of 9 degrees of the warhead fine synchro under worst case conditions.

Remote Fire Box

The remote fire box (RFB) in Figure 4-11 is considered a functional part of the adapter. It is connected to the PTS by a 500 foot cable and provides the necessary controls and indicators to initiate the firing sequence and indicates that the firing sequence is in progress.



Key	Control or Indicator	Function
1	FIRE switches	When both switches are pressed simultaneously, initiates firing phase.
2	READY indicator	Indicates that missile is ready to fire.
3	COUNTING indicator	When lit, indicates that firing phase is progressing normally.
4	STOP switch	Provides emergency stopping of fire sequence up to first stage ignition.
5	VOLUME control	Provides adjustment for volume of headset connected to J3.
6	BATTERY ACTIVATED indicator	Indicates that missile batteries have been activated.
7	VOLUME control	Provides adjustment for volume of headset connected to J2.
8	RING switch	When pressed, light flashes on BCC intercom select panel.

Figure 4-11. Remote Firing Box Controls and Indicators

The remote fire box has external receptacles for two headset/microphone cables. These receptacles are enabled at the "warhead preset and verification" point in the countdown sequence and provide access to both "all phones" and "discrete" circuits up to the remote transfer point, and "discrete" only from remote transfer to the end of the countdown. The RFB has a ring button which enables it to ring either the PTS or BCC depending on the communication network hookup. It also has individual volume controls for each of the receptacles.

Console

The console provides the controls and indicators by which the operator controls and monitors the operation of the PTS (Figure 4-3). From the console, the operator controls the application of power to the adapter and the computer, enters data, and observes indicators that display the status and condition of the fire sequence. The console contains the azimuth laying control panel assembly, voltage-phone monitor panel assembly, maintenance panel assembly, tape reader, countdown control panel assembly, utility panel assembly, teleprinter, and launch control panel assembly.

Azimuth Laying Control Panel Assembly

The azimuth laying control panel assembly (Figure 4-3) contains controls and indicators for performing azimuth laying procedures from inside the PTS if the azimuth laying control box or its cable is defective. An indicator on the panel informs the operator when the azimuth laying procedures are to be performed from inside the PTS.

Voltage-Phone Monitor Panel Assembly

The upper portion of the voltage-phone monitor panel assembly (Figure 4-3) contains a meter for monitoring all internal PTS power supply voltages and an indicator for monitoring the primary ac and dc power. The lower portion of the panel contains a headset connection point for establishing intercommunications with all stations or discrete station-to-station contact between the PTS, BCC, and remote firing box only.

Maintenance Panel Assembly

The maintenance panel assembly (Figure 4-3) contains controls and indicators for troubleshooting the computer. A three-character readout indicator displays data from a punched tape or from the computer program. Indicators inform the operator when the computer power supply is malfunctioning, when the central data processor (CDP) is operating under program control, when a computer timing error exists, or when an input parity error from the tape or keyboards exists.

Tape Reader

The tape reader (Figure 4-3) contains controls and indicators for entering the tape programs into the computer. Operation of the tape reader can be controlled automatically by signals generated through use of the tape reader controls. The tape reader uses three types of circuit network modules (CNM) of the same basic design as those in the computer, and they are identified in a like manner. Eight CNM's are used in the tape reader.

Countdown Control Panel Assembly

The countdown control panel assembly (Figure 4-3) contains controls and indicators for manual entering data into the computer, and sequencing the firing sequence. Controls are also included for applying power to the adapter, computer, and missile, and for transferring control of the firing sequence to the remote firing box. The assembly uses seven types of CNM's of the same basic design as those in the computer, and they are identified in a like manner. Fifty six CNM's are used in the countdown control panel assembly.

Utility Panel Assembly

The utility panel assembly (Figure 4-3) contains controls for regulating the brightness of the PTS shelter lights and the console panel lights. The panel contains an 8-day clock, three elapsed time meters, a signal horn switch, switches for turning the shelter lights on and off, and indicators that signify a requirement for shelter heating, a loss of airflow through the equipment, and computer overheating. The assembly also contains a fire warning horn that sounds in the event of a fire in the power station.

Teleprinter

The teleprinter (Figure 4-3) supplies a permanent record of the calculated firing data. It consists of a printer unit and a paper takeup unit. The printer unit contains controls for applying power and for manually advancing the tape. The paper takeup unit contains a paper takeup reel and paper transport mechanism. The teleprinter is capable of printing at the rate of 30 characters per second.

Launch Control Panel Assembly

The launch control panel assembly (Figure 4-3) provides an additional safe-arm feature that enables the Pershing Ia system to meet nuclear safety requirements. The safe-arm feature centers around a mechanical safe/arm switch that interrupts three critical arming and firing signals. These signals are "first stage ignition arm command, first stage ignition fire plus (+), and missile battery activate command". A safe condition is in effect when the switch is set to the safe position. An arm condition is in effect when the switch is set to the arm position. The panel provides the necessary hardware for securing the safe-arm switch in a safe condition by means of a combination lock, which prevents unauthorized operation of the switch to the arm position. To prevent unauthorized removal of the launch control panel assembly, the hardware that secures the assembly to the console is bound by safety wire and secured with metallic seals.

chapter five

Power Station

General Description

The power station (Figures 5-1 through 5-3) is a self contained multipurpose unit of the Pershing system, capable of delivering electrical power, pneumatic power and conditioned air for the missile and launch site ground support equipment. It is carried aboard the same vehicle as the PTS.

The power station is contained in a skid mounted aluminum housing lined with sound absorbing material to reduce the noise level produced by the gas turbine engine. The power station is comprised of the following major functional components:

1 Gas turbine engine

2 Air compressor and purification system

3 Alternator (with voltage regulator and exciter)

4 DC generator and regulator (2)

5 Air cycle conditioning system

6 Miscellaneous-electrical distribution center and control cubicle

7 Fuel system

8 Cranking system

9 Battery charging system

10 Unit protection

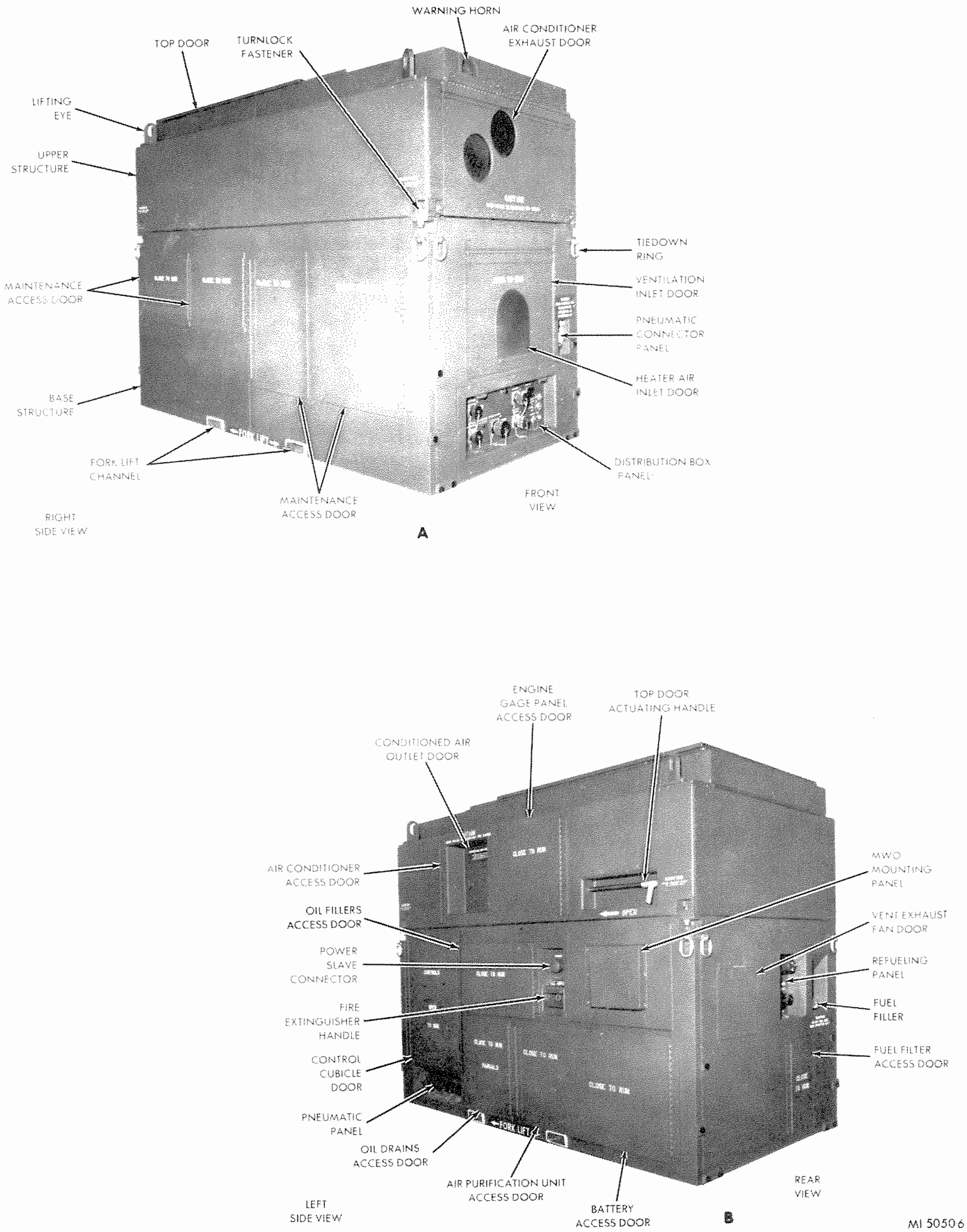


Figure 5-1. Power Station Enclosure, Three Quarter Front and Rear Views

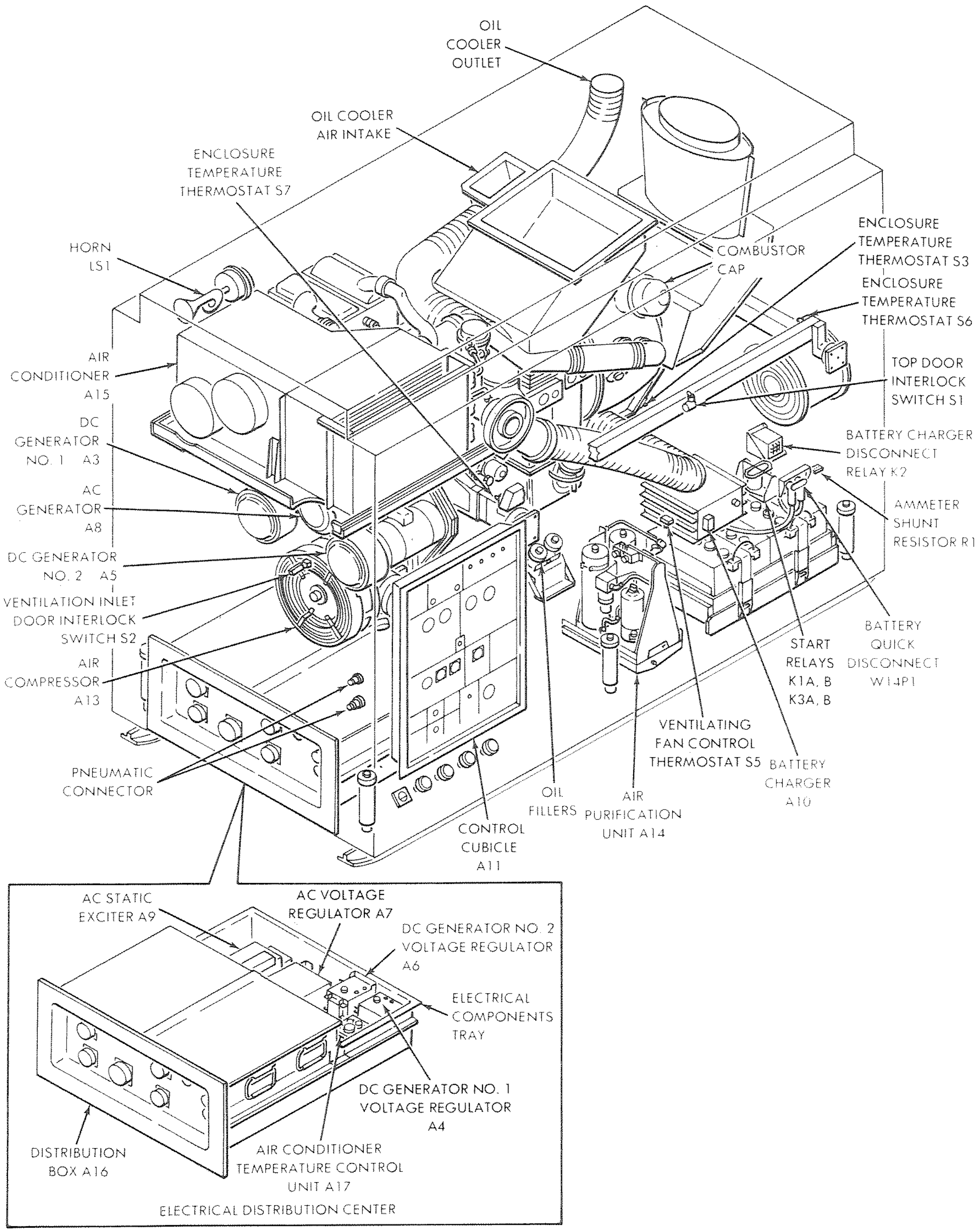


Figure 5-2. PS Three Quarter Front Internal View

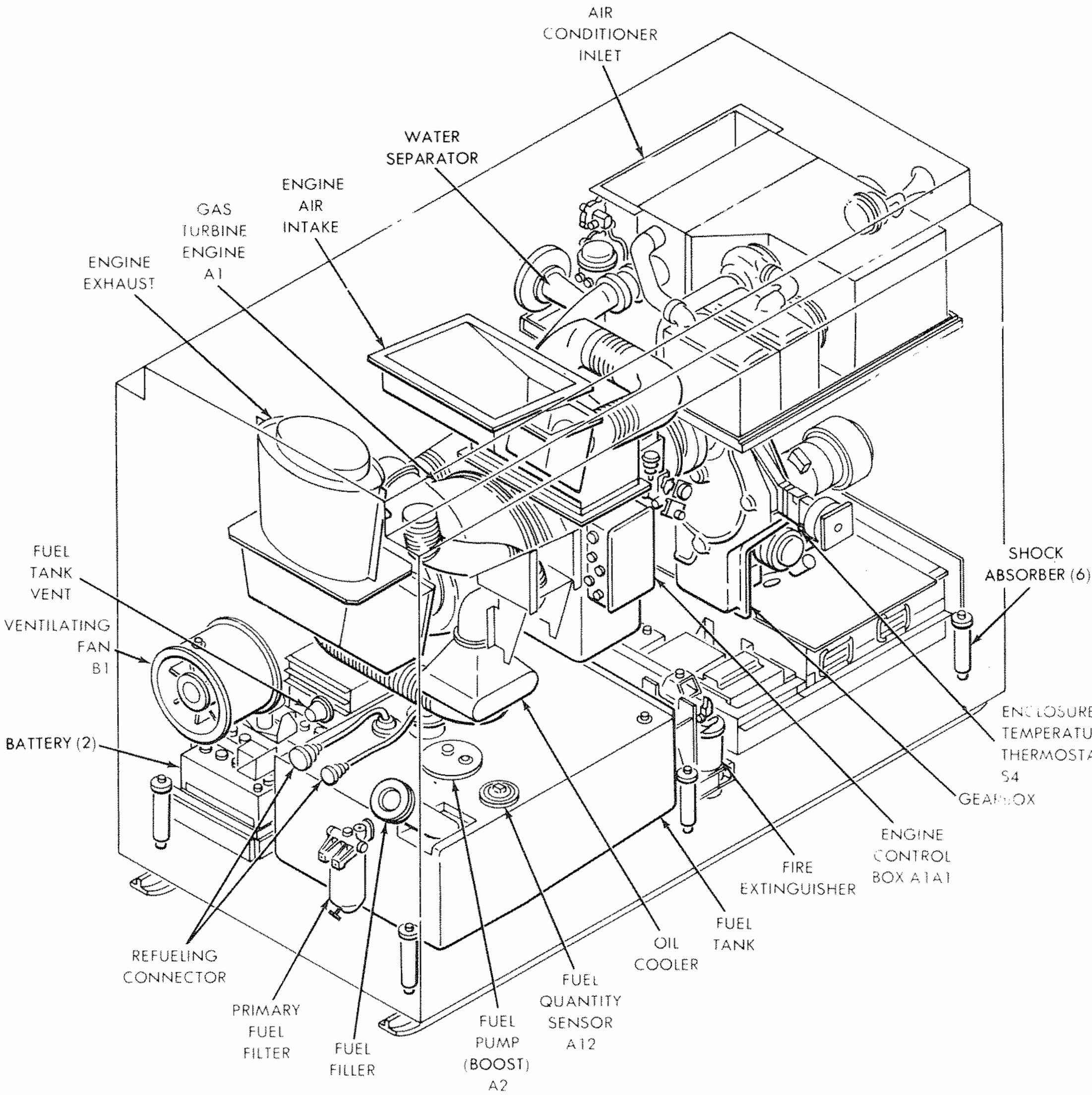


Figure 5-3. PS Three Quarter Rear Internal View

Gas Turbine Engine

The gas turbine engine is a lightweight, compact source of shaft power and bleed-air pneumatic power. Shaft power from the engine is delivered through a gearbox to drive the ac generator, two dc generators, and an air compressor (Figure 5-4). Turbine bleed air is delivered to the air conditioner. The engine, which has two centrifugal compression stages and a single turbine stage, runs at a constant speed of 42,000 rpm. Speed is automatically controlled by a governor; however, fine speed adjustment is operator controlled by a switch on the control cubicle panel. Engine starting power is derived from a 24-volt dc battery supply or from an external auxiliary power source.

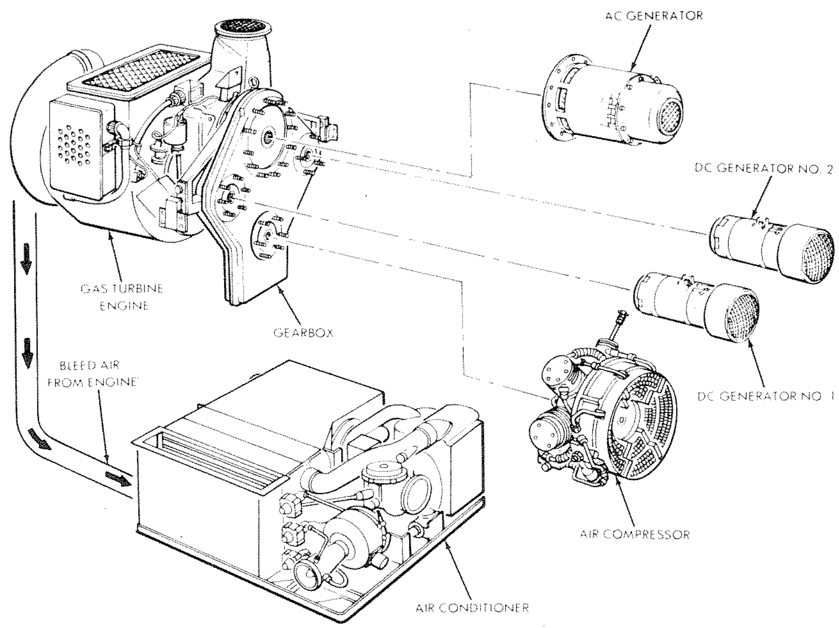


Figure 5-4. Engine Powered Assemblies

Gearbox

The gearbox and engine are coupled together by a turbine-gearbox coupling. The coupling consists of two coupling halves clamped together by a V-type clamping ring, with a single locating shear pin to prevent rotation by torquing effects. The engine and gearbox can be quickly separated by releasing the clamping ring. The two coupling halves form a matched set and must be retained together. A 6-inch floating splined shaft in the coupling provides the drive connection from the engine to the gearbox. The gearbox drives the three generators at 6,000 rpm, and the air compressor at 3,064 rpm.

High Pressure Air System

The power station has two separate high-pressure air systems (Figure 5-5). The primary system is comprised of an air compressor that supplies high-pressure air to an air purification unit, which in turn supplies purified high-pressure air to the missile through a network of hoses and valves. The air compressor delivers air at a pressure of 3000 ± 200 psig at a flow rate of 9 standard cfm minimum. The secondary high-pressure air system, referred to as the instant air system (Figure 5-6), uses a pressurized air cylinder to provide a limited supply of high-pressure air to the air purification unit for use by the missile until the primary high-pressure air system is fully activated. The instant air system is provided solely as support for the primary system.

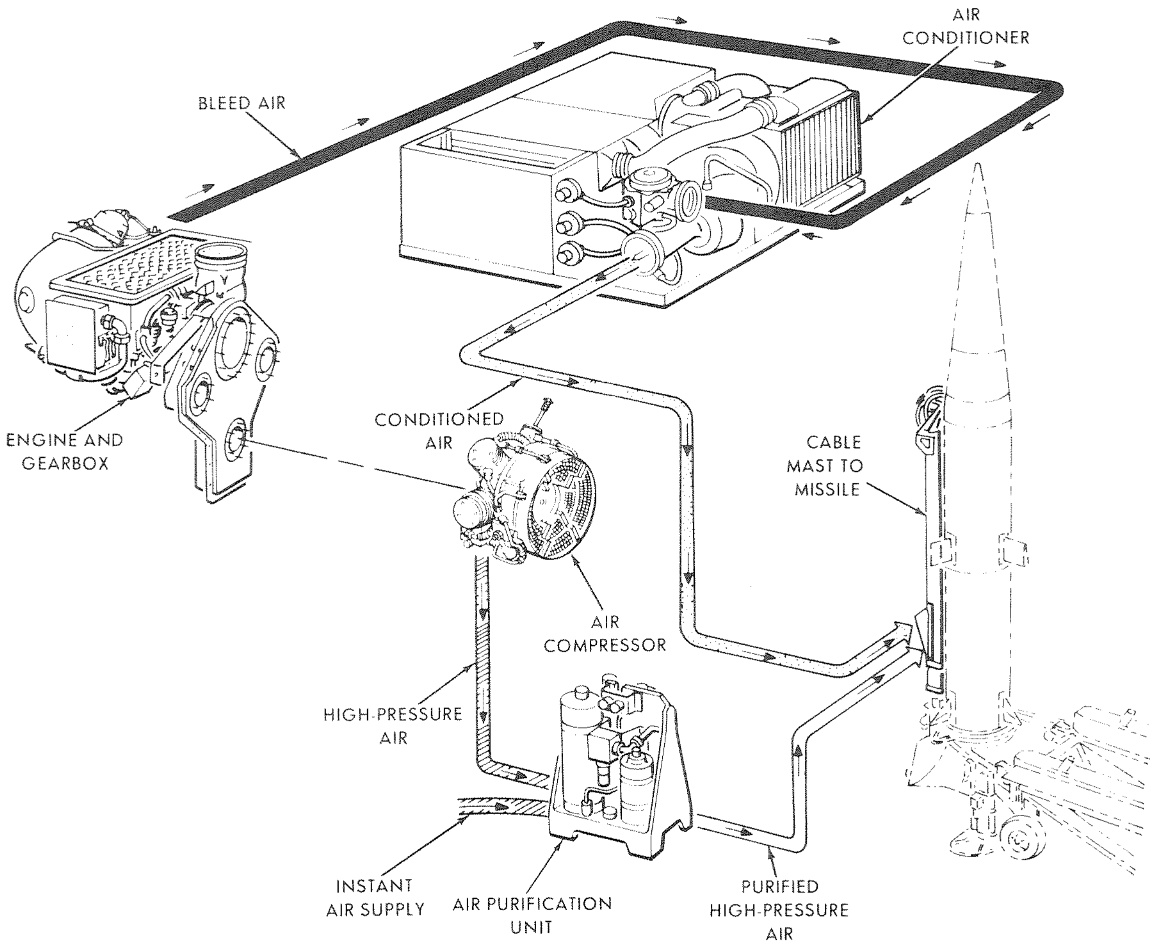


Figure 5-5. Air System Flow Diagram

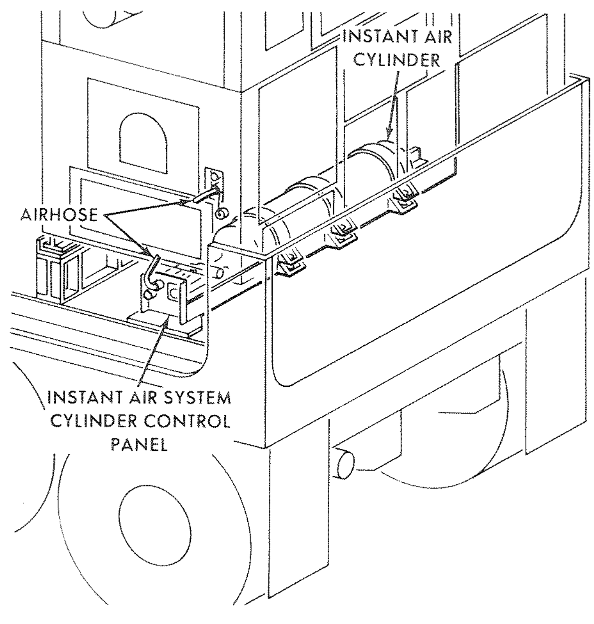


Figure 5-6. Instant Air System

Air Cycle Conditioning System

The air cycle conditioning system consists of:

1 Panel control assembly

2 Temperature sensor assembly

3 Air cycle assembly

4 Temperature selection assembly

Prelaunch cooling and heating to the missile during ground test and checkout are provided by this system (Figure 5-5).

Operating in conjunction with the missile air cycle conditioning system, the temperature control system is energized by a sensing element located in the missile instrument compartment. Temperature control is provided by a modulating valve which tempers the air to maintain a missile compartment temperature within ±1°F. At all stabilized temperature points (40° ± 5°F, 77° ± 1°F, and 160° ± 5°F) the conditioned air flow is 25 pounds of air per minute under sea level operating conditions.

DC Power System

The power station dc power system consists of two dc generators, each with a voltage regulator and output wiring. Each dc generator is compound wound and self ventilated with a rating of 300 amperes at 30 volts and a nominal speed of 6000 rpm. All windings of the generator are ungrounded and isolated electrically from each other and, with the voltage regulator disconnected, can be used as a starting motor. After startup, a transfer relay converts the starting motor to a generator.

With the generator under control of its voltage regulator and driven at any constant speed of 6000 ± 120 rpm, and adjusted to deliver any voltage within the specified range (25-35) at any load between no load and rated load, the voltage remains within ± 0.5 percent of the average no load and full load voltage. At any constant load, the generator terminal voltage is within 0.5 percent of its average value.

The voltage regulator is used for either remote or local sensing, and is equipped with compensating provisions which limit to less than 1 percent the voltage drift caused by warm-up of the shunt field and voltage regulator, and changes in ambient temperature.

AC Power System

The power station ac power system consists an ac generator or alternator with voltage regulation and excitation, and output wiring.

The alternator is self ventilated and has a rotating field synchronous alternator rated at 40 kVA, 0.75 power factor lagging, 120/208 volts, 400 Hz, 3-phase, four wire connected.

The voltage regulator and excitation system are completely static devices. Part of the alternator output is fed back into the alternator field for excitation; the amount of the feedback is dependent on the power factor of the load and is approximately equal to the field excitation to support that load.

Both the average and highest phase voltage are sensed by the sensing circuit. In normal operation, the average sensing provides the signal to the reference circuit. With unbalanced loads, highest phase sensing takes over. Regulator compensation minimizes drift in the regulated voltage caused by warm-up of the alternator field, exciter, and regulator, or changes in ambient temperature. Voltage drift does not exceed 1 percent when the equipment is installed in the power station.

Using a manual stepless rheostat, it is possible to adjust the regulated line-to-line voltage at any value between 200 and 218 volts, at any load from no load to full load, at any ambient temperature within the specified temperature range, and at any frequency between 380 and 420 Hz.

Other Subsystems

Other power station subsystems are the fuel system, cranking system, battery charging system, and unit protection system.

The fuel system includes a fuel filter, engine driven high pressure fuel pump, fuel flow regulating provisions integral with the engine control system, and the required tubing and fittings.

The cranking system starts the power station engine and becomes inoperative when the engine is running. The cranking system has a battery, one of the dc generators used as a starting motor, and a starting relay assembly. After the cranking period is over, the dc generators are electrically isolated from the battery.

The battery charging system consists of a trickle charger fed from the alternator, with a charging indicator provided on the control cubicle. Independent of the alternator output voltage, the charging rate is adjustable, with a current limiting device to prevent overcharging. The system maintains the batteries in a state of full charge through a readily accessible waterproof receptacle mounted on the power station so the batteries can be charged, in place, from an external source.

Engine, gearbox, and air compressor low oil pressure, air compressor high-stage pressure, and engine overspeed malfunctions will automatically produce station engine shut down. The protection devices which perform this automatic shutdown make up the unit protection system. Power is disconnected by ac or dc short circuit, ac and dc overvoltage, and ac undervoltage malfunctions. With the protection switch in the bypass position, the power station will continue operating unless the malfunction is engine overspeed or an ac or dc short circuit.

chapter six

Azimuth Laying Equipment Set

The azimuth laying set provides the means for laying the Pershing missile on its firing azimuth by establishing the guidance platform heading. The equipment includes standard optical survey instruments mounted on lathe bed tripods. The particular method to be employed (horizontal or vertical laying) is determined by initial erector-launcher alignment with respect to the firing azimuth laying equipment and the missile for both alignment schemes is indicated in Figure 6-1. A porro prism attached to the ST-120 (refer to Figure 2-19) is viewed through a window on the missile skin and is used as a reference in placing the ST-120 on the desired heading. The porro prism is displaced to the desired heading by inserting an electrical biasing signal into the platform azimuth alignment loop.

Equipment Description

The azimuth laying set consists of three reference theodolites (theodolite T2 with mil scales), two wood tripods (tripod T2), two metal theodolite tripods, two theodolite bed assemblies, one surveying target set, three sunshield tents, one illuminated sunshade assembly, three surveyor's umbrellas, six headset-microphone assemblies, three eyepiece adapter assemblies, and three winterization kits. Two azimuth laying sets are assigned to the firing section. Two shipping and storage containers per azimuth laying set are furnished for carrying the laying equipment. An azimuth laying control box (ALCB), stored in the PTS, and cable assemblies, stored in the auxiliary equipment vehicle, are used in conjunction with the azimuth laying set.

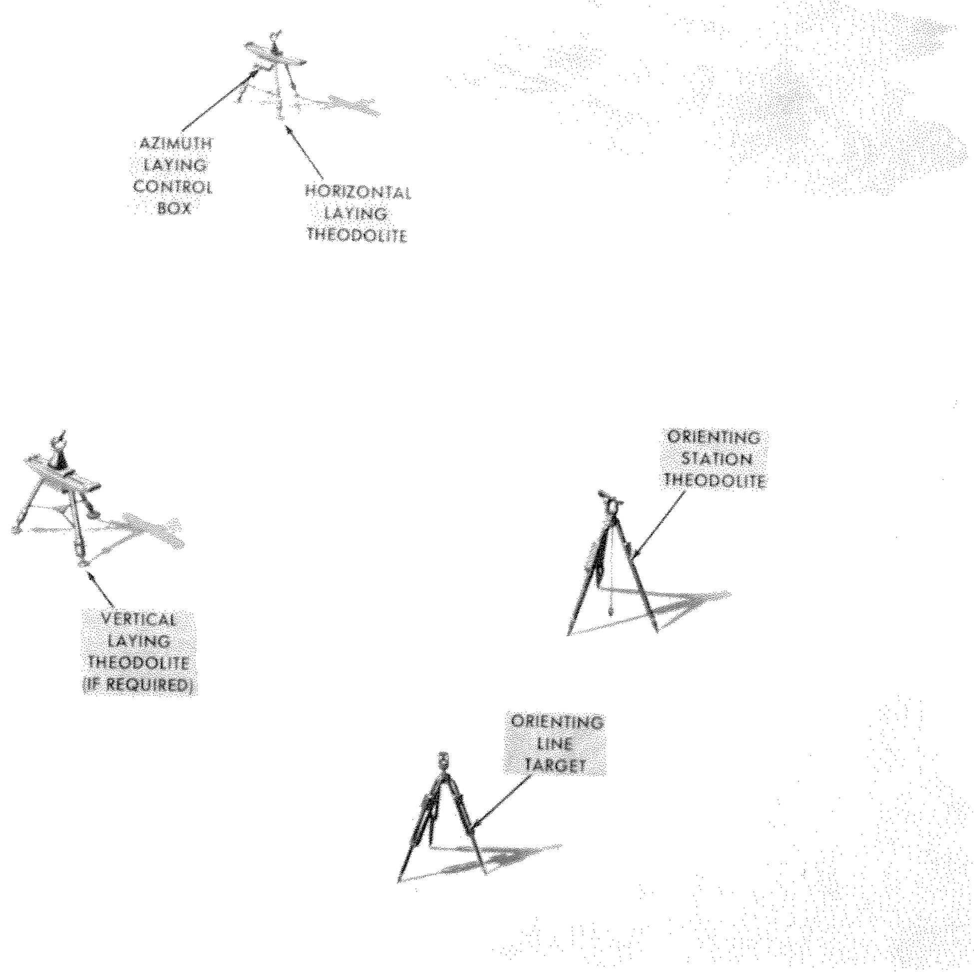


Figure 6-1. Principal Components of the Azimuth Laying Set

Horizontal/Vertical Laying Theodolite

The horizontal laying theodolite (HLT) and vertical laying theodolite (VLT) are identical. The HLT or VLT consists of a theodolite, bed assembly, and metal tripod (Figure 6-2). One control box is used with both the HLT and VLT. The HLT is used in aligning the ST-120 platform on the firing azimuth when the missile heading is within ±133 mils (7.5°) of the firing azimuth; it is also used to determine the heading of the ST-120 platform when the missile heading is not within ±133 mils but within ±1582 mils (89 degrees) of the firing azimuth. The VLT is used in aligning the ST-120 platform on the firing azimuth after the missile is rotated to a new firing azimuth.

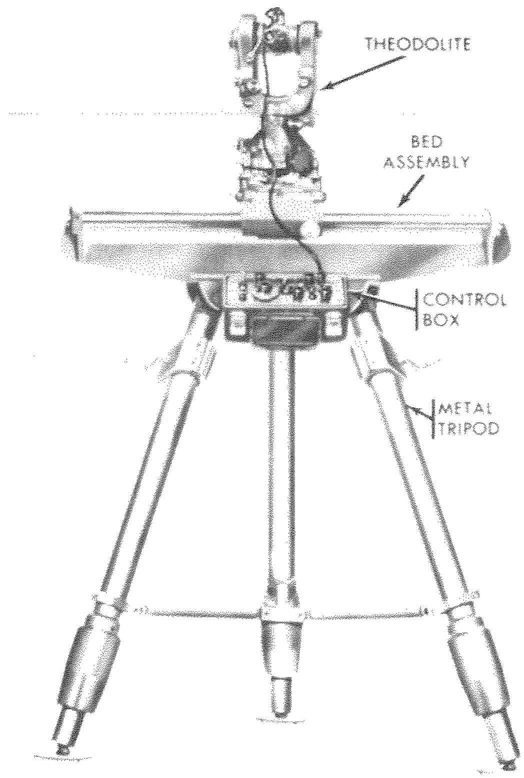


Figure 6-2. Horizontal or Vertical Laying Theodolite with Control Box

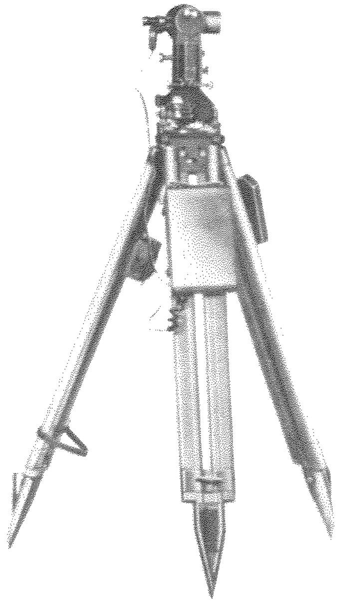


Figure 6-3. Orienting Station Theodolite

Orienting Station Theodolite

The orienting station theodolite (OST) consists of a theodolite mounted on a tripod T2 (Figure 6-3). The OST is used to transfer directional control to all of the other instruments used in laying the missile. Directional control is transferred using the process of reciprocal collimation (commonly referred to as reciprocal laying), after the OST has been oriented.

Orienting Line Target

The orienting line target (OLT) consists of a target, tribrach, battery box, and tripod T2 (Figure 6-4). A night light attachment is mounted on the back of the target for dark days and night operation. The OLT is used to obtain directional orientation.

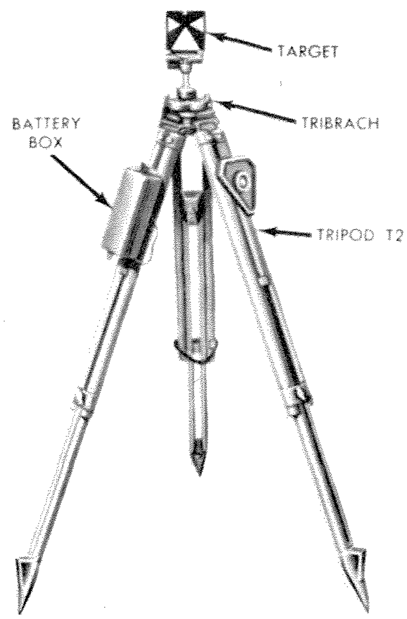
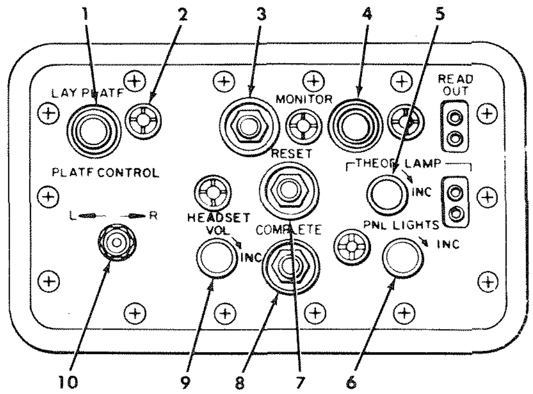


Figure 6-4. Orienting Line Target

Azimuth Laying Control Box

The azimuth laying control box (Figure 6-5) is a rectangular metal box containing electrical circuits which are connected (by cable) to and powered by the programmer-test station. These circuits provide illumination for the theodolite and the control box panel indicators, bias voltages for controlling the ST-120 inertial guidance platform, and switches for controlling the application of power to the PTS monitor, reset, and complete relay circuits. When the missile is horizontal, the control box is used with the horizontal laying theodolite. When the missile is vertical, the control box is used with the vertical laying theodolite. If the control box or its cable is defective, azimuth laying procedures may be performed inside the PTS, using the azimuth laying control panel assembly.



Key	Control or Indicator	Function
1	LAY PLATF indicator	When on, indicates that ST-120 cap be rotated. When flashing, indicates that ST-120 can be rotated and that MONITOR switch can be pressed.
2	Panel light (5)	Provides illumination for panel.
3	MONITOR switch	Initiates monitoring sequence after ST-120 is aligned on firing azimuth.
4	MONITOR indicator	When on, indicates that ST-120 is to be observed, but not rotated.
5	THEOD LAMP control	Controls intensity of theodolite light.
6	PNL LIGHTS control	Controls intensity of panel lights.
7	RESET switch	Extends firing sequence to allow further alignment of ST-120.
8	COMPLETE switch	Initiates the next system sequence when either horizontal or vertical azimuth laying function is completed.
9	HEADSET VOL control	Controls signal strength to the headset earphones.
10	PLATF CONTROL switch	Controls signal for rotating the ST-120

Figure 6-5. Azimuth Laying Control Box

The azimuth laying control box signal flow diagram is shown in Figure 6-6 and a description of the signal function is given below.

The azimuth positioning signal is developed in the platform control circuit in the control box from a 28 Vdc position excitation signal received from the power distribution assembly in the PTS. This signal is sent to the platform alignment circuit in the PTS and is used for rotating the ST-120.

The monitor command initiate signal is generated in the control box monitor switch circuit when the control box MONITOR switch is pressed. This signal is sent to the platform alignment circuit in the PTS and is used for initiating an optical monitoring period.

The lay platform command signal is sent from the platform alignment circuit in the PTS to the lay platform indicator circuit in the control box. This signal is used for lighting the control box LAY PLATF indicator. A steady or flashing LAY PLATF indicator signifies that the ST-120 may be rotated. The steady indication is used for informing the theodolite operator when azimuth laying procedures are to be started and when fast slew (rough alignment) of the ST-120 can be performed. The flashing indication is used to inform the operator when fine slew (fine alignment) of the ST-120 can be performed.

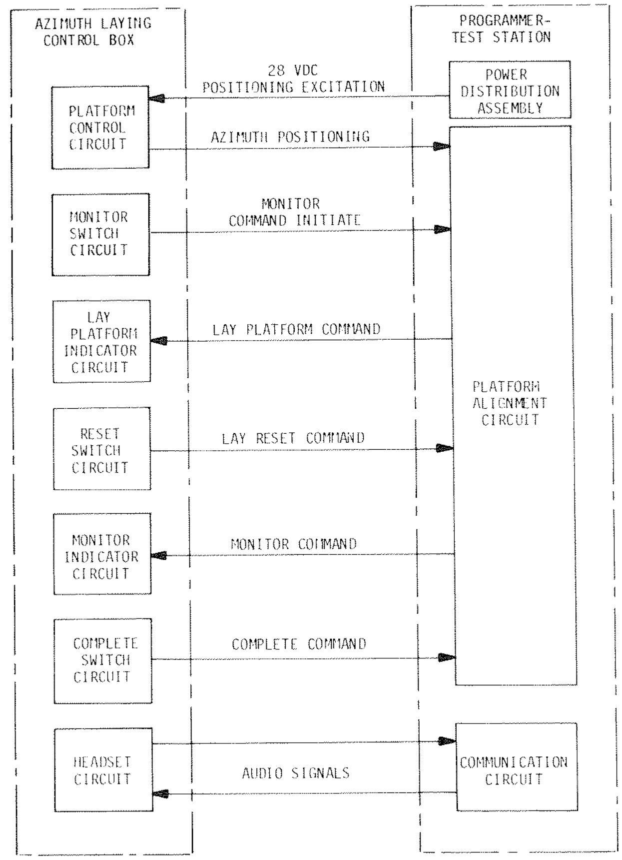


Figure 6-6. Azimuth Laying Control Box Signal Flow Diagram

The lay reset command signal is generated in the control box reset switch circuit when the control box RESET switch is pressed. This signal is sent to the platform alignment circuit in the PTS, and is used for informing the computer program that further positioning of the ST-120 is required.

The monitor command is sent from the platform alignment circuit in the PTS to the monitor indicator circuit in the control box. This signal is used for lighting the control box MONITOR indicator, indicating that the ST-120 stabilized platform should be monitored but not rotated.

The complete command signal is generated in the control box complete switch circuit when the control box COMPLETE switch is pressed. This signal is sent to the platform alignment circuit in the PTS and is used for terminating the horizontal or vertical laying verification phase.

The audio signals are the voice communications (telephone) signals that are transmitted between the headset circuit in the control box and the communication circuit in the PTS.

Miscellaneous Equipment

The major items of equipment which support azimuth laying operations are illustrated in Figure 6-7.

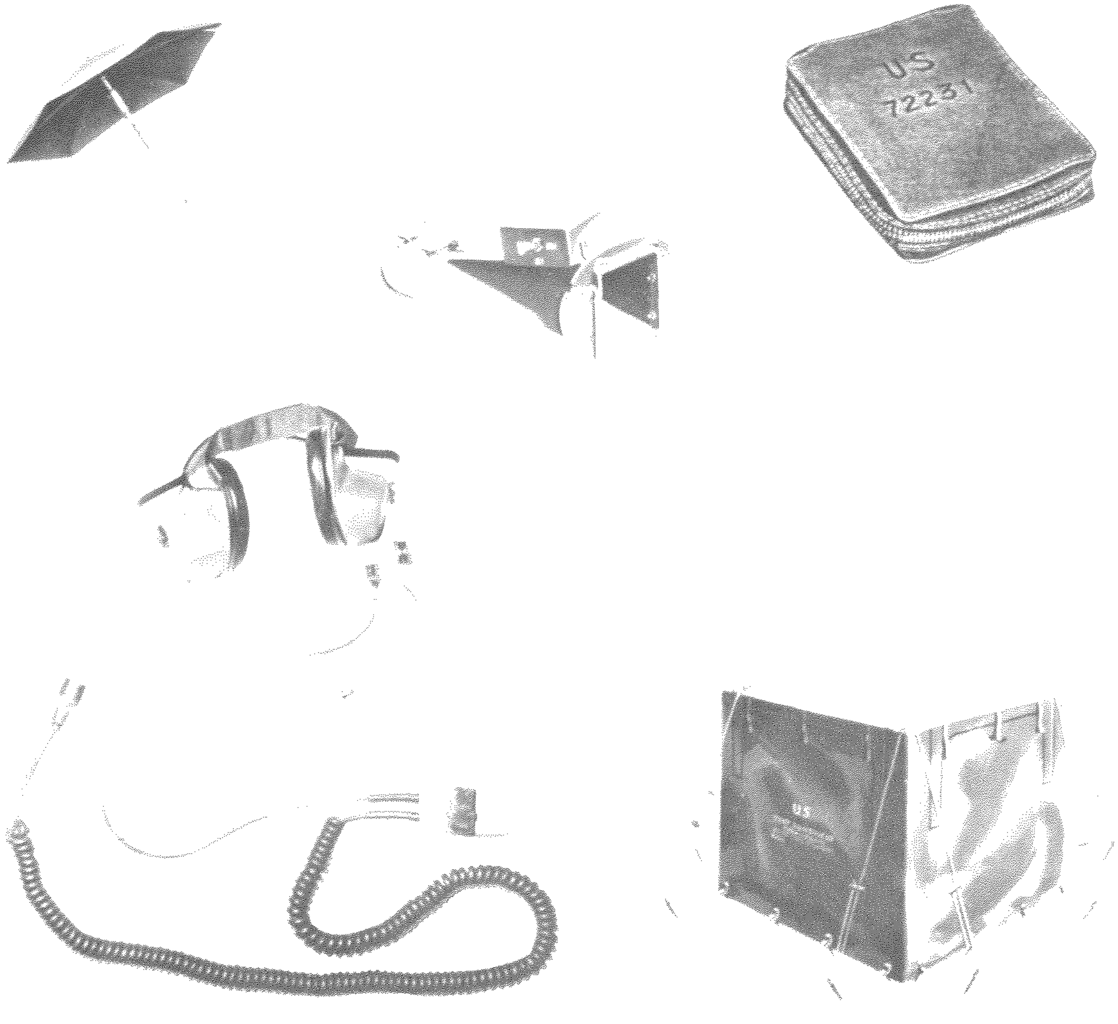


Figure 6-7. Azimuth Laying Set Auxiliary Equipment

Laying Methods

General

With the equipment arranged as illustrated in Figure 6-8, the missile is oriented in azimuth by using either the erect-and-fire mode (standard or quick count) or the vertical laying mode of azimuth laying. The erect-and-fire mode is used when the missile heading is within 133 mils (7.5 degrees) of the firing azimuth (FA). The vertical laying mode is used when a new target is selected and the missile heading is not within 133 mils (7.5 degrees) of the FA. Azimuth laying procedures performed during a confidence count are identical with those performed during a standard count.

Erect and Fire Mode

This mode refers to the operation performed to align the ST-120 on the FA while the missile is in the horizontal position. The missile is then erected and fired and rolls to the FA immediately following liftoff. During this operation, the OST is used to transfer directional control to the HLT. The ALCB, in conjunction with the HLT, is used to torque the ST-120 until it is accurately aligned on the FA, and to observe, maintain, and monitor the alignment of the ST-120 until the COMPLETE switch on the ALCB is pressed. In the confidence and standard counts, the HLT operator torques the ST-120 platform into rough alignment and fine alignment. During the confidence count, a voltage equivalent to the angular relationship between the missile longitudinal axis and the firing azimuth of the ST-120 is stored in the PTS computer memory for use in the quick count. During the quick count, the fast slewing of the ST-120 platform to rough alignment is automatic, and the azimuth laying sequence following the optical monitoring period is greatly reduced as compared with the confidence and standard counts.

Vertical Laying Mode

This mode refers to the operation performed when a new target is selected after the EL, with missile, has been emplaced and the FA of the new target is not within ±133 mils (7.5 degrees) but within ±1582 mils (89 degrees) of the initial missile heading. (If the FA of the new target is within ±133 mils of the initial missile heading, the laying procedures prescribed for the erect-and fire mode are performed.) The HLT, in conjunction with the ALCB, is used to determine and monitor the heading of the ST-120 until the COMPLETE switch on the ALCB is pressed. The position of the ST-120 is determined while the missile is horizontal. The missile is then erected and manually rotated until it is roughly aligned on the FA. During this operation, the OST is used to transfer directional control to the HLT and VLT. After the missile is erected and rotated to within 5 mils of the FA, the ALCB, in conjunction with the VLT, is used to torque the ST-120 until it is accurately aligned on the FA. The VLT is then used to monitor and maintain the alignment of the ST-120 until the COMPLETE switch on the ALCB is pressed.

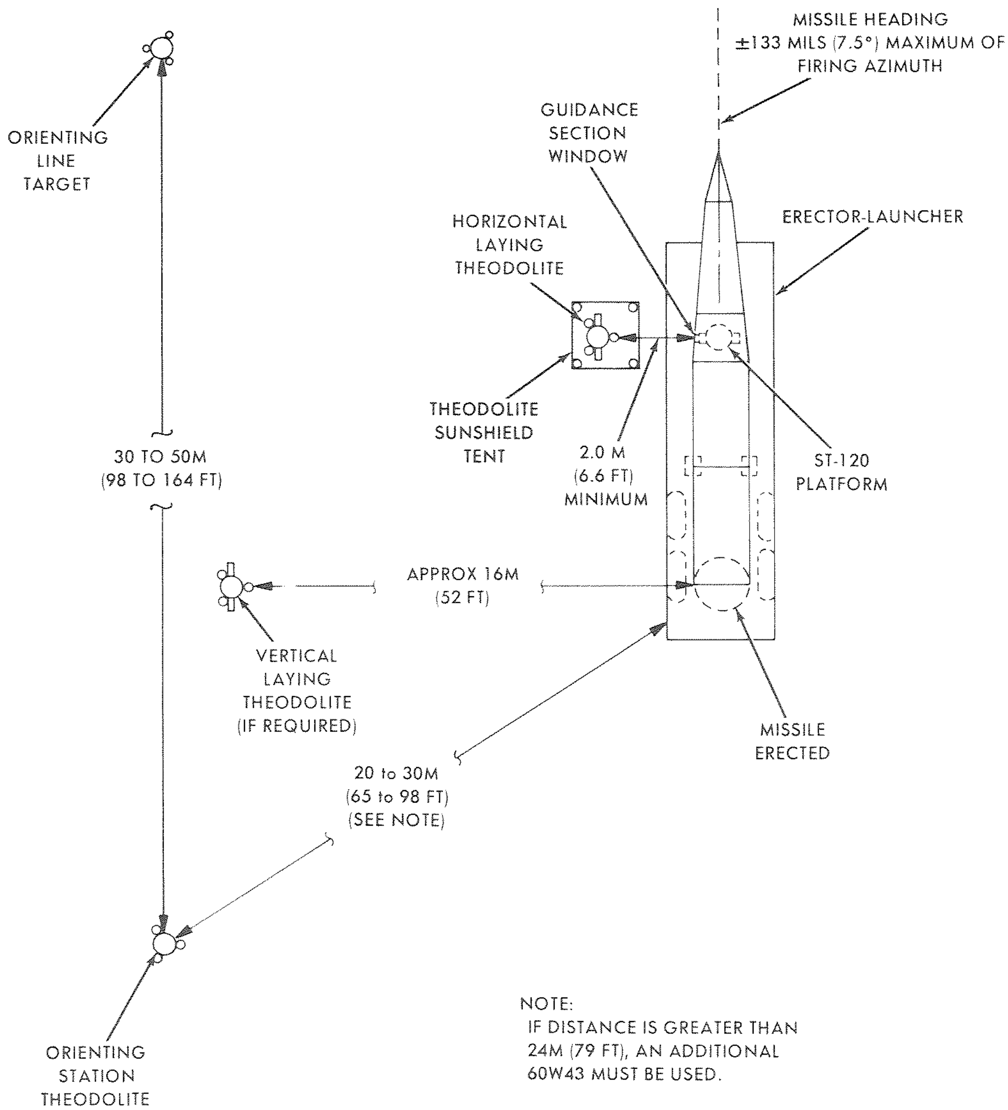


Figure 6-8. Typical Emplacement of Azimuth Laying Set

chapter seven

Battery Control Central

The battery control central (BCC) is a transportable unit that provides the firing battery commander or duty officer a centralized facility for exercising all battery command and control functions and access to all external and internal communications. It contains the necessary communications, display boards, and operator work stations to permit the battery commander or his representative to monitor the firing platoon activities, and external communications from one location on a 24 hour basis. A block diagram of the BCC equipment is shown in Figure 7-1.

The BCC provides landline communication with the PTS's in the three firing platoons, allowing the battery commander or duty officer to maintain control and monitor the firing platoon activities from a centralized location (Figure 7-2). In addition, BCC terminations for a local field switchboard and an area alert system are provided.

The BCC enables firing platoon control by means of the battery intercom, status display facility, remote fire boxes, and T-1500 controllers. The intercom permits the battery commander to receive platoon status information, initiate and monitor countdowns, and change target assignments. The status display facility permits a current display of platoon status. This information is continuously available for upline status reporting and for use in scheduling and controlling platoon activities. The remote fire box (RFB) and prescribed action link (PAL) controller (T-1500) provide the commander with the final authority to control missile launch and warhead enablement. The "good" light on the T-1500 assures the battery commander that the warhead has been enabled while the "ready" light on the RFB provides an indication that the countdown has progressed to the point where the missile may be fired. These indications and the RFB fire buttons permit the battery commander to positively coordinate and control multiple launches as required.

Three T-1500's and three RFB's are located in the BCC. These units are hardwired directly to the missile launchers and PTS, respectively, and the RFB's are provided a two-lock cover. During transit the T-1500's and RFB's are carried on the PTS vehicle to provide autonomous fire platoon capability.

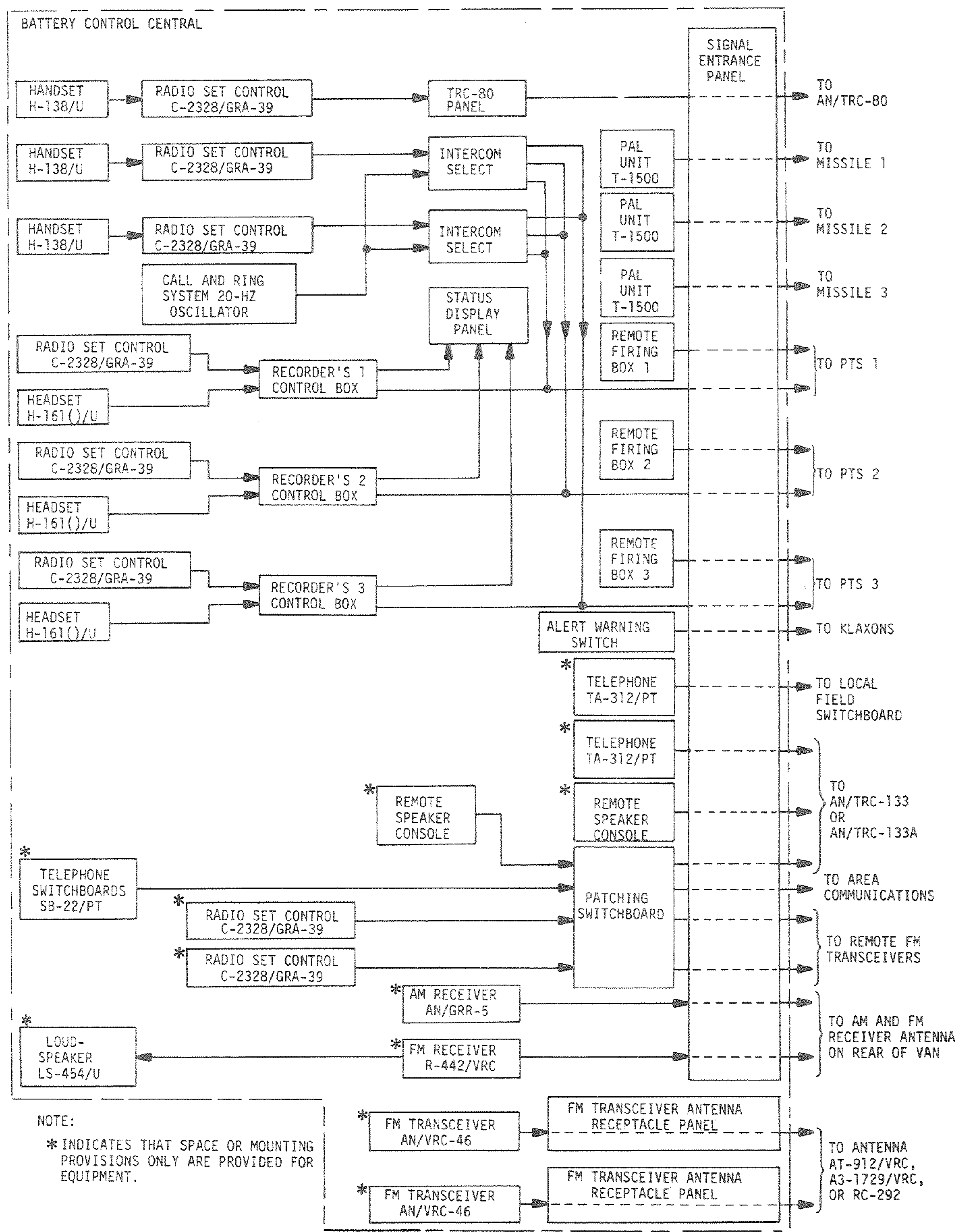


Figure 7-1. Battery Control Central Equipment Block Diagram

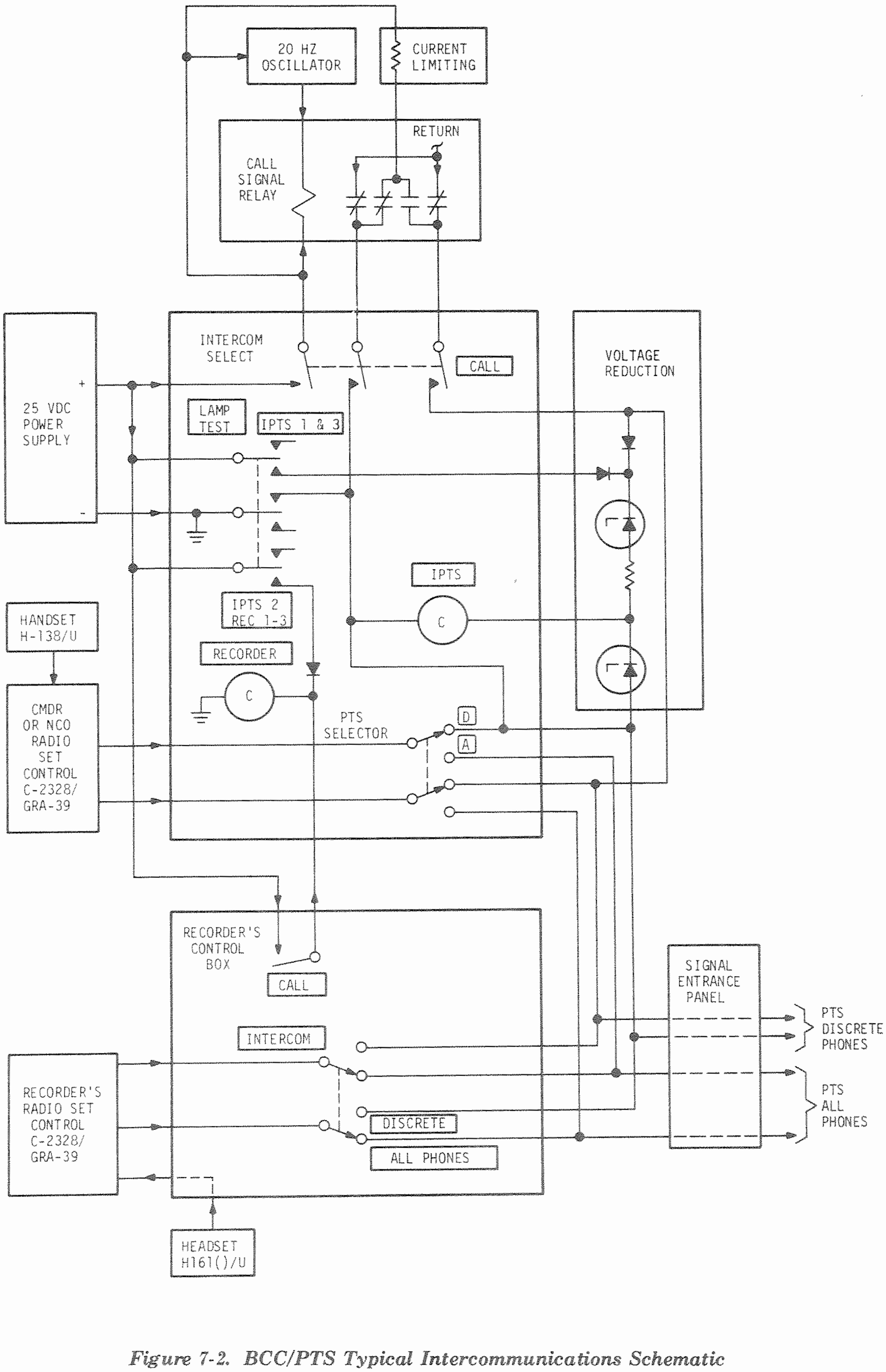


Figure 7-2. BCC/PTS Typical Intercommunications Schematic

Physical Description

The BCC is housed in an M-4 expansible van mounted on a modified M656 vehicle (Figures 7-3 and 7-4). Primary power for operating the BCC is normally supplied by a 15 kW, 60 Hz, 120/208 volt, 3-phase trailer-mounted generator which is towed behind the BCC. Emergency power is supplied by batteries on the M656 vehicle.

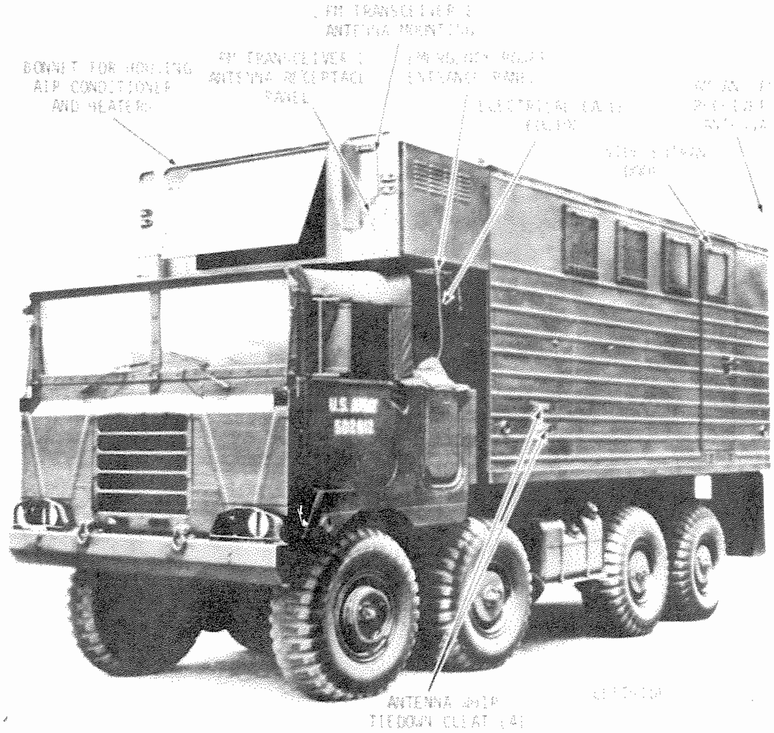


Figure 7-3. BCC Three Quarter Front Exterior View

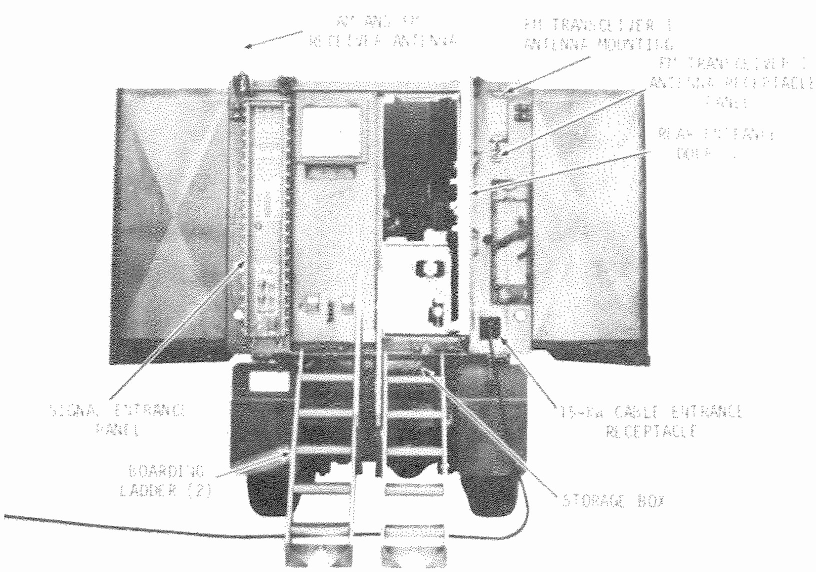


Figure 7-4. BCC Rear Exterior View

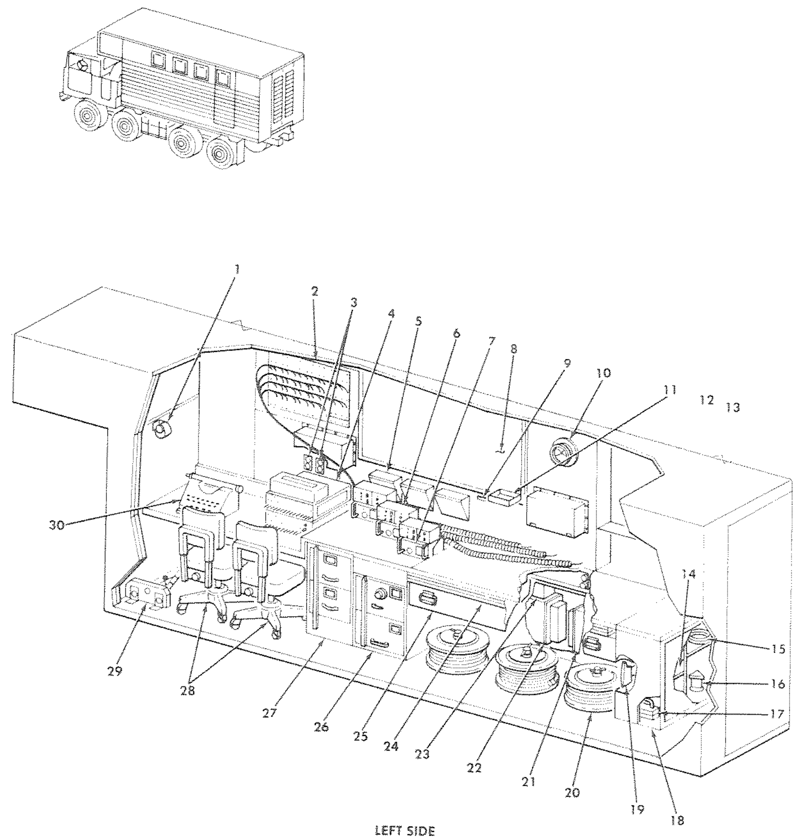
The BCC expands to approximately twice the volume it encloses when retracted. To expand the BCC the side panels are expanded and the counterbalanced hinged roof and floor sections are unfolded. The BCC is sealed against the entrance of water and the escape of light in both the expanded and retracted positions. An entrance door near the rear on each side of the BCC provides access when the BCC is expanded. Two entrance doors in the rear of the BCC provide access when the BCC is either expanded or retracted. Two ladders, stored on the rear doors, provide access to the BCC floor level. A signal entrance panel is mounted in the rear of the BCC next to the rear door on the left side. A 36,000-Btu air conditioning unit and two 60,000-Btu heating units are installed in a bonnet extending from the front of the BCC. The units provide heating and cooling for personnel and environmental protection for equipment in the BCC. Two fm antennas are mounted on the BCC with quick-disconnect fasteners. One of the fm antennas is located on the left front of the bonnet, and the other fm antenna is located on the right rear of the BCC. Feedthrough for the antennas is through a receptacle panel located below each antenna mount. The antenna matching units may be left in the mounts and the whip sections tied down to cleats on the BCC during travel in areas free of obstructions. A remote antenna can be used instead of an fm antenna mounted on the BCC. When the remote antenna is used, it is connected to the receptacle panel. One antenna, used for am and fm receiving, is mounted directly above and through the signal entrance panel at the left rear of the BCC.

The interior of the BCC is divided into two functional areas: the command and control area on the right side, and the recording area on the left side. The command and control area contains the equipment required for conducting tactical command and control functions. The equipment in the recording area is used for administrative and recording functions in support of the command and control operations. Figures 7-5 and 7-6 show the equipment locations for the left and right sides of the BCC.

Electrical Power

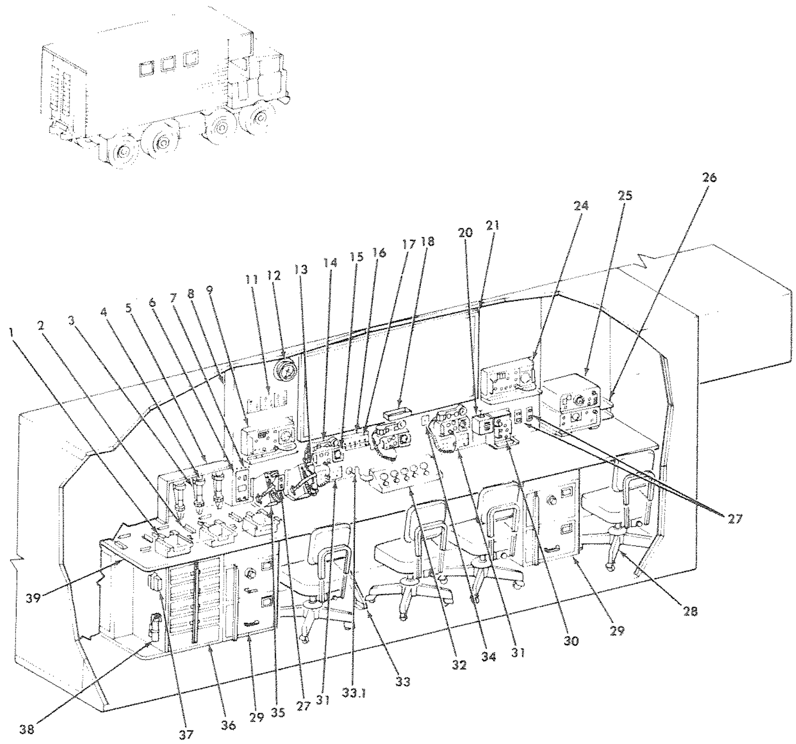
The trailer-mounted 15 kW generator supplies ac power for operation of the air conditioner, heaters, and lights, and supplies 120 volt, 60 Hz power for operation of equipment in the BCC. Five circuit breaker switches distribute ac power to the BCC equipment. DC power required for operation of the equipment is normally obtained from two 25 Vdc power supplies and one 9 Vdc power supply. Two telephones TA-312/PT and two telephone switchboards SB-22/PT contain an internal 3V battery power source. Electrical power or signal voltage for operation of the remote firing boxes or remote speaker console is supplied by the equipment to which it is connected outside the BCC. The two radio set controls, connected to the remote fm transceivers, contain an internal battery power source.

During emergency power operation, dc power, which is normally supplied by the two 25 Vdc power supplies and the 9 Vdc power supply, is obtained from the vehicle battery. Emergency power is used only for selective equipment and emergency lights. The vehicle battery power is applied through the emergency power entrance panel to the power panel.



1 - Pencil sharpener
2 - Patching switchboard
3 - 120 Vac convenience
4 - Telephone switchboard SB-22/PT (2)
5 - Headset H-161()/U storage bin (3)
6 - Recorder's control box (3)
7 - Radio set control C-2328/GRA-39 (3)
8 - Magnetic chalkboard
9 - Paper transfer slot
10 - Clock
11 - Chalk tray
12 - FM transceiver noise suppression cover (2)
13 - Blower unit
14 - Typewriter storage area
15 - Ground cable (2)
16 - Klaxon (3) and storage fixture
17 - Emergency lantern (2) and storage fixture
18 - Storage cabinet
19 - Ax
20 - Klaxon cable reel (3) and cables
21 - 25 Vdc power supply 1
22 - 25 Vdc power supply 2
23 - 9 Vdc power supply
24 - Bifold table
25 - Antenna storage box
26 - Security safe
27 - File cabinet (two-drawer)
28 - Chair
29 - Klaxon tripod
30 - Typewriter

Figure 7-5. BCC Recording Area Internal View



1 - Remote firing box housing (3)
2 - PAL unit T-1500 mount (3)
3 - PAL unit T-1500 connector (3)
4 - Remote firing box connector (3)
5 - Electrical rack
6 - Power panel
7 - Test points
8 - Console
9 - FM transceiver 1 AN/VRC-46
10 - (Deleted)
11 - Status display panel
12 - Clock
13 - Telephone TA-312/PT (TRC-133A)
14 - Handset H-138/U (3)
15 - Radio set control C-2328/GRA-39 (3)
16 - Paper transfer slot
17 - TRC-80 panel
18 - Chalk tray
19 - (Deleted)
20 - Loudspeaker LS-454/U
21 - Magnetic chalkboard
22 - (Deleted)
23 - (Deleted)
24 - FM transceiver 2 AN/VRC-46
25 - AM receiver AN/GRR-5
26 - Desk tray
27 - 120 Vac convenience outlet
28 - Chair (4)
29 - Security safe
30 - FM receiver R-442/VRC
31 - Intercom select panel
32 - Remote speaker console
33 - Removable brace
33.1 - Remote speaker console cable
34 - Alert warning system switch
35 - Telephone TA-312/PT (FIELD SWBD)
36 - File cabinet (four-drawer)
37 - First aid kit and mounting
38 - Fire extinguisher
39 - Worktable

Figure 7-6. BCC Command and Control Area Internal View

chapter eight

Communications

The Pershing system uses radio and wire communications to perform command and control, logistics, and administrative functions. Figure 8-1 shows the communications network utilized for quick reaction alert (QRA) operations. For these operations the AN/TRC-133A, radio terminal set (single side band or SSB in Figure 8-1) is the primary QRA release message communications means. The AN/TRC-80, radio terminal set (TROPO in Figure 8-1) is used as backup for the QRA release message and for battalion logistics and administrative functions. Short range FM radios (AN/URC-46, AN/URC-47, etc.), indicated as FM in Figure 8-1, and wire communications are provided for additional back up for the AN/TRC-133A and AN/TRC-80.

The communications within the firing battery, which include interfaces with the BCC, are shown in Figure 8-2.

AN/TRC-80, Radio Terminal Set

The AN/TRC-80 (Figure 8-3) functions primarily as a radio circuit terminal, capable of transmitting and receiving speech and voice frequency radio-teletypewriter (VFTTY) signals simultaneously, using the tropospheric scatter method of propagation. A maximum operating distance of up to approximately 100 miles is dependent on the horizon angle and on the degree of reliability desired.

The AN/TRC-80 shelter houses the communications equipment, antenna, and engine generator and is transported by an M656 vehicle.

The major equipment of the AN/TRC-80 consists of the following:

1 Circuit control and operating equipment

2 Frequency generation equipment

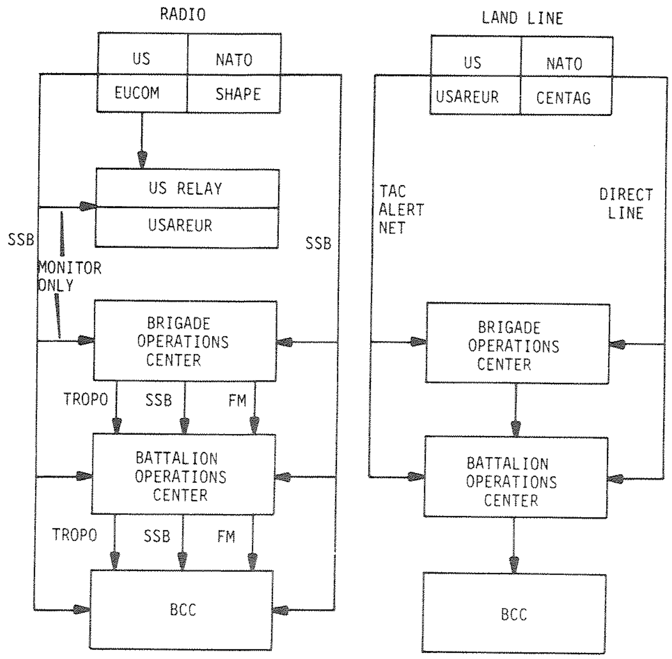


Figure 8-1. QRA Communications

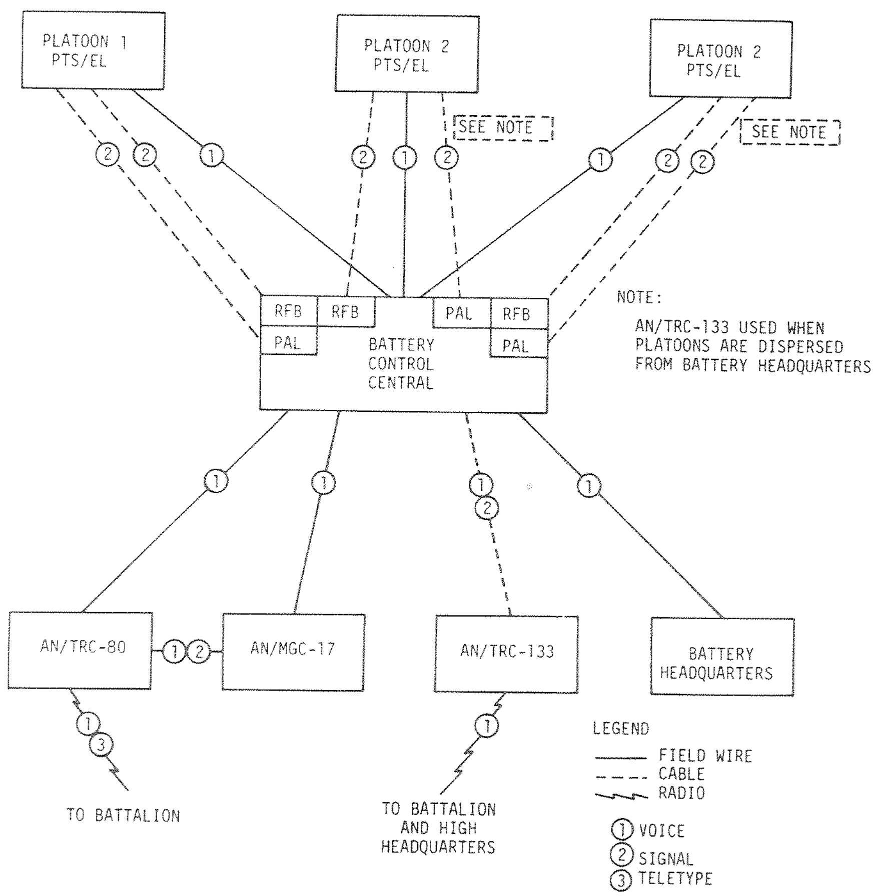
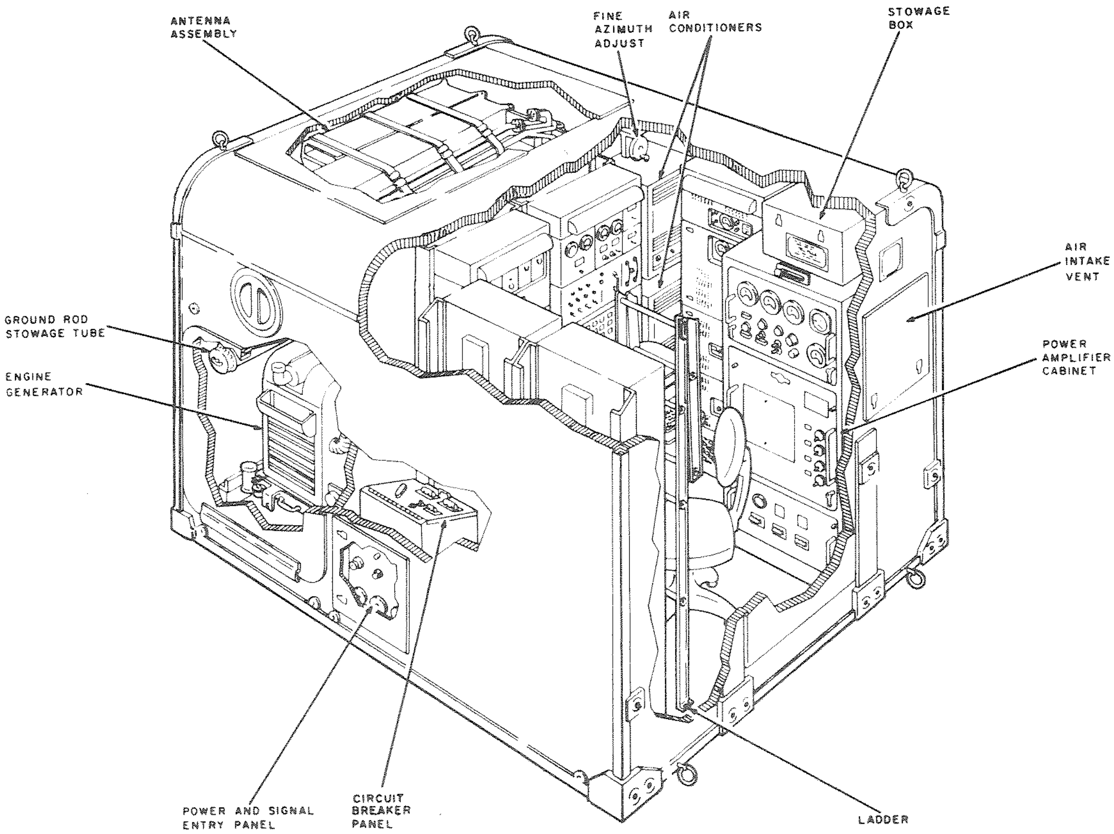


Figure 8-2. Firing Battery Communications



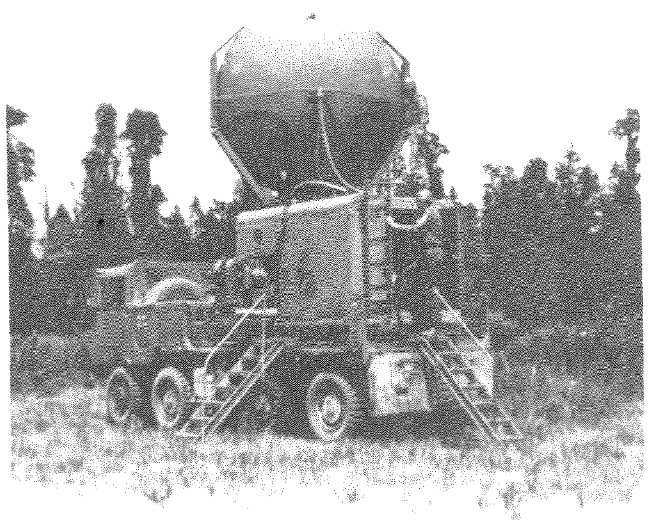


Figure 8-3. Radio Terminal Set AN/TRC-80 Interior and Exterior Views

3 Amplifier-modulator

4 Radio frequency amplifier

5 Antenna

6 Radio receiver

7 Primary power equipment

8 Air conditioning equipment

The circuit control group of equipment is comprised of the power distribution panel, communications control panel, teletype switch panel, telegraph terminal, and a demultiplexer-multiplexer.

Frequency generation equipment consists of three synthesizer units which supply local oscillator signals to the two converters in the receiver and the carrier signal to the transmitter converter.

The exciter consists of a modulator-multiplier and an amplifier-converter. The modulator-multiplier receives and converts a modulating signal from the multiplexer and provides a modulated signal to the amplifier converter.

The amplifier-converter receives a modulated signal from the modulator-multiplier and a carrier signal from a synthesizer, and delivers output-frequency driving power to the output power amplifier.

The radio frequency amplifier accepts a frequency modulated signal from the amplifier-converter and amplifies the signal to an output power of 1.0 kilowatt.

The AN/TRC-80 antenna assembly consists of an inflatable fabric bag having one metalized inner surface that forms a parabolic reflector when the bag is inflated.

Bag inflation is maintained by a blower. The blower and the compressor are mounted on the antenna platform on one side of the lower support platform.

An azimuth marker strip, calibrated in hundreds of mils, is located around the base of the azimuth platform. The antenna azimuth may be changed manually in 100 mil increments. Fine azimuth adjustment is controlled from inside the shelter.

The radio receiver consists of an amplifier-converter (receive), an intermediate frequency amplifier, and two power supplies. Two complete receivers are used.

Primary power for the AN/TRC-80 is supplied by a gasoline engine generator set. The engine generator is mounted on slide rails and is pulled out for operation and servicing.

AN/TRC-133A, Radio Terminal Set

The AN/TRC-133A is a single sideband voice radio terminal mounted in an S-141/G type shelter with radio equipment installed. A 2-1/2 ton truck is used to transport the shelter and pull the power unit trailer.

The AN/TRC-133A shelter contains five radio positions, each using a radio receiver-transmitter (TR-718/FRC-93), with radio set control (C-6118/FRC-93), power supply (PP-3990/FRC-93), quartz crystal unit set (CK-31/FRC), and a dynamic microphone (M-127/FRC-93). Each of the five radio equipments can be connected to a separate doublet antenna provided as part of the shelter equipment. Position 5 is also capable of operating with a 15-foot whip antenna when the radio terminal set is mobile. The five radio equipments are powered from 115V, 60 Hz, single-phase ac power when the terminal is in a fixed or semifixed position. Position 5 radio equipment is powered by the 28 Vdc vehicular electrical system (using dc power supply, PP-4151/FRC-92) during mobile operation. Radio frequency tuner (TN-339/GR) is used for operation of the mobile radio terminal set (position 5) on frequencies below 20 MHz.

Provisions are made for mounting the tiedown of a 15-foot whip antenna on the outside front wall of the shelter.

Nine standard antenna masts (AB-155/U), antenna wire, coaxial cable and associated hardware are provided to erect five doublet antennas for connection to the ac-powered radio sets when the radio terminal set is used in a fixed or semifixed position. Three masts (AB-155/U) support each of the doublet antennas.

A remote speaker console is provided to allow operation at a remote site. The audio output from the four normally ac-powered radio sets (positions 1 through 4) can be switched to either of two speakers in the remote speaker console (speakers 1 and 2). The audio output of position 5 is connected directly to speaker position 5 of the remote speaker console. A jack is provided for each remote speaker position to permit headset monitoring. The remote console controls the signal volume to each speaker or headset.

chapter nine

Ground Networks

The Pershing ground networks consist of electrical cables, high pressure air lines, and air conditioning ducts. The cables, lines and ducts are constructed in such away as to provide protection against the weather and hostile EMP environments. Table 9-I is a listing of the cables/air lines used in a tactical site layout.

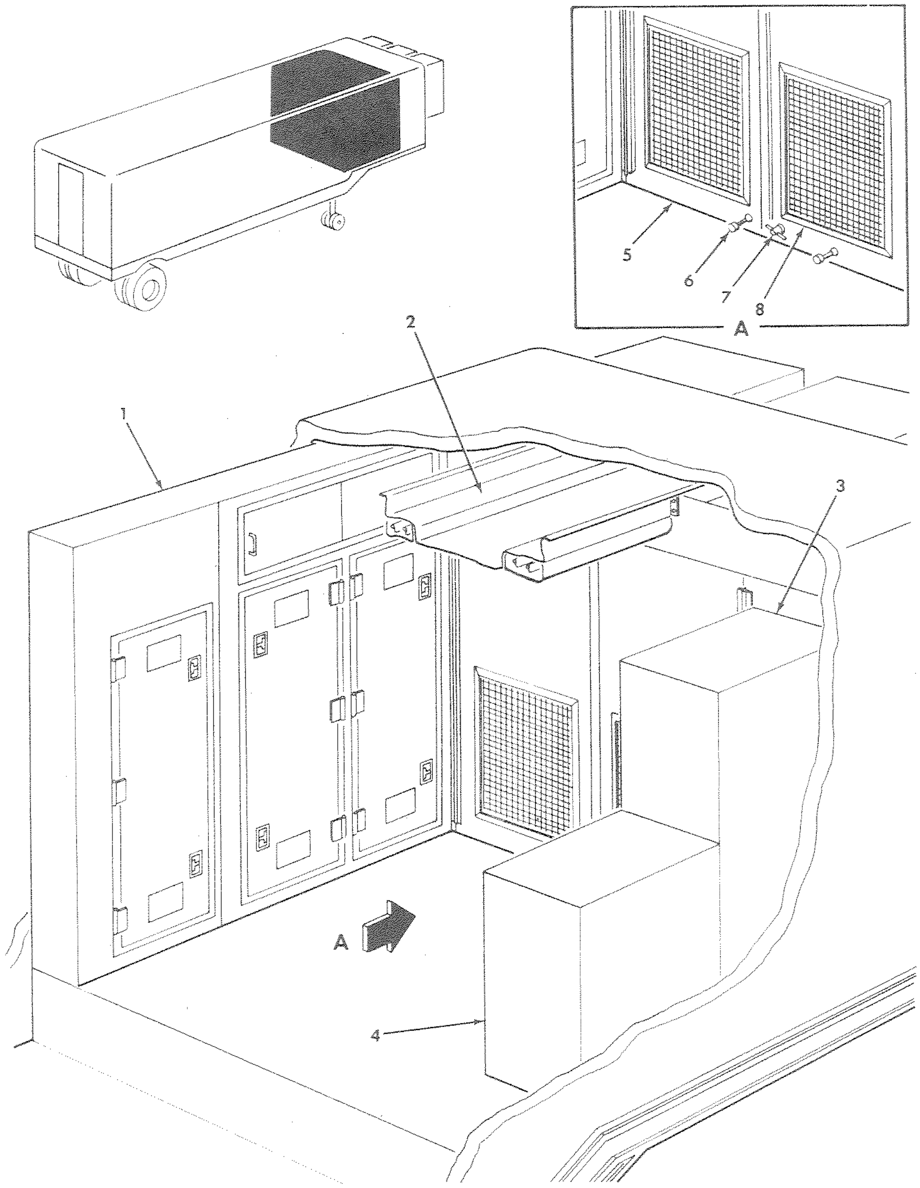
Ground networks interconnections are shown in Figures 9-1 and 9-2. Figure 9-1 shows the firing position for one missile; Figure 9-2 shows the firing position for three missiles in a QRA standby condition.

TABLE 9-I

Cables/Air Lines

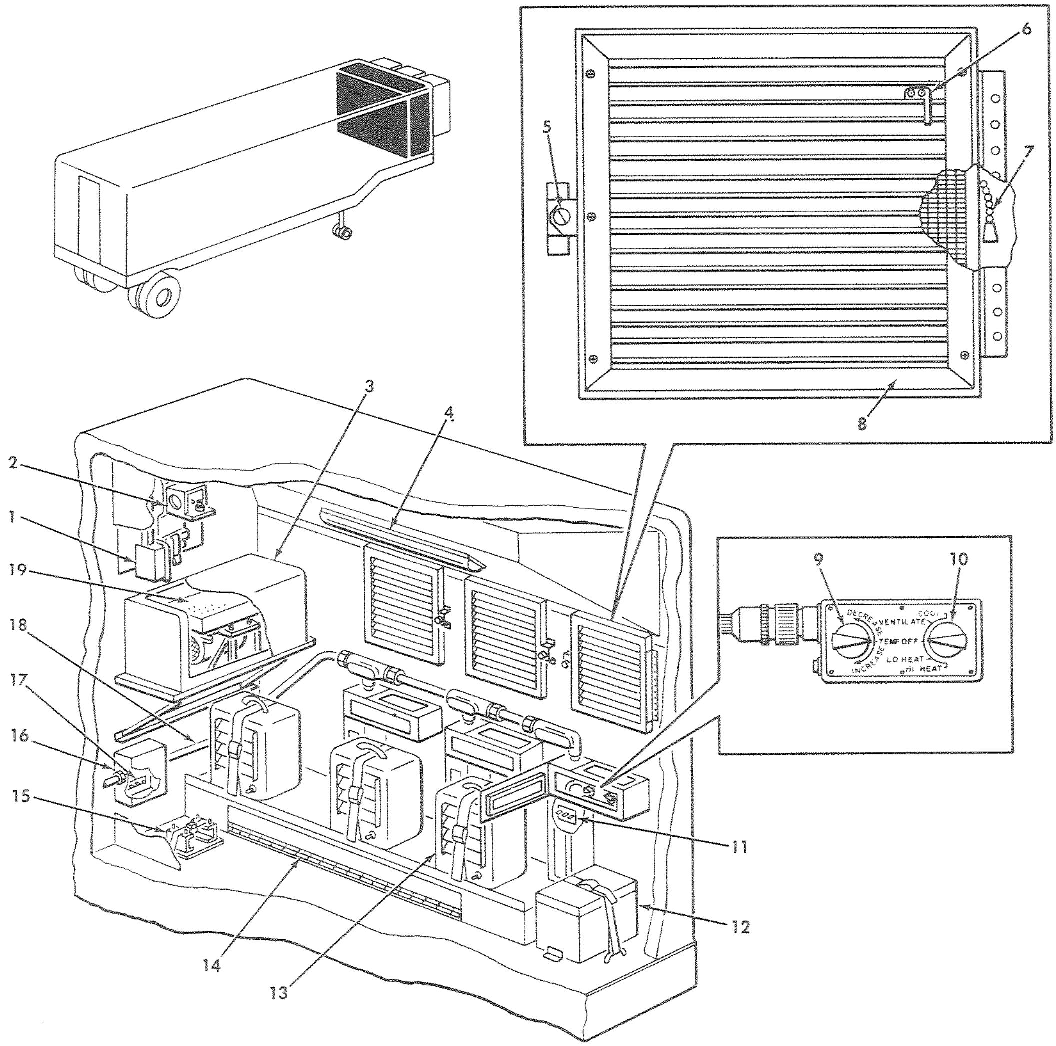
Cable	Length	Weight
42W50	50	29
42W54	50	44
60W3	35	75
60W9	40	38
60W10	40	31
60W11	40	34
60W12	40	38
60W16	5	7
60W17	5	8
60W18	500	86
60W21	20	13
60W32	45	36
60W34	40	40
60W40	40	44
60W43 (4)	100 each	15 each
60W44	100	42
60W101 (7)	50 each	12 each
60W103	35	48
60W105	550	91
60W109	150	73
60W115	12	3
Conditioned Air Duct	36	99
High Pressure Air Line	35	12

Figure 10-8 shows the exterior of the forward storage compartment while Figure 10-9 shows the interior and the equipment it contains.



1 - Distribution console
2 - Conditioned-air duct
3 - Cable storage cabinet
4 - Tape storage cabinet
5 - Bulkhead door
6 - Doorstop
7 - Door handle
8 - Return-air grille

Figure 10-8. Exterior View of Forward Storage Compartment



1 - Light switch
2 - Level sensor leveling fixture
3 - Inverter case
4 - Light fixture
5 - Bracket and fastener (3)
6 - Indoor return-air damper control (3)
7 - Outdoor-air damper control (3)
8 - Return-air register (3)
9 - Thermostat (3)
10 - Selector switch (3)
11 - Circuit breaker
12 - Storage box
13 - Heater (3)
14 - Storage compartment
15 - Inverter fixture
16 - Terminal box
17 - Terminal board
18 - Conduit
19 - Inverter

Figure 10-9. Interior View of Forward Storage Compartment

Distribution console, bulkhead doors, cable storage cabinet, and tape storage cabinet form the access area to the forward storage compartment. Bulkhead doors contain two return-air grilles. When the doors are closed, the air inside the SCTS van is pulled through the grilles and their filters and into the return-air registers of the three air conditioner-heaters, where the air is recycled. The conditioned-air duct which extends three-fourths the length of the SCTS van, carries conditioned air to the working area of the van.

The interior of the forward storage compartment contains equipment associated with the air conditioner-heaters, portable heaters, the rotary inverter, test fixtures, a light, a switch, a storage box, and a terminal box. Input power for the air conditioner-heaters enters the forward storage compartment through a terminal box, into electrical conduit, and to three circuit breakers that supply power to the air conditioner-heaters. A selector switch controls the operation of the air conditioner-heaters, so that cooling or heating can be provided, depending upon weather conditions. Three thermostats regulate the temperature of the air and maintain the conditioned air between 71°F and 83°F. Three return-air registers for the air conditioner-heaters are attached to the inside wall of the SCTS van. They each contain an indoor return-air damper control and outdoor-air damper control. Access to the outside-air damper control is gained by opening the return-air register fastener. Three 4,000-watt portable electric heaters are stored in the forward storage compartment.

A storage box mounted in the lower right-hand corner of the forward storage compartment contains 14 eye-bolts that serve as tiedown rings when securing the van for transportation. The storage compartment contains guidance section test cables. A rotary inverter (motor generator) supplies 115V, 400 Hz ac power to the assembly tester for purposes of UUT testing and also as primary power to certain assemblies of the assembly tester. Access to the rotary inverter is gained by removing the rotary inverter case. When an inverter is tested as a UUT on the assembly tester, the inverter fixture supports and establishes a stable platform for the inverter. The interior of the forward storage compartment is illuminated by fluorescent light. The level sensor leveling fixture, which is used in testing the level sensor as a UUT, is also located in the forward storage compartment.

The rear interior of the SCTS van contains equipment such as a hand lantern, a doorpost with associated hardware, two cover plates, and two equipment doors with associated interlock switches. Equipment doors provide a means of access for all equipment that is tested inside the SCTS van. When the guidance section is taken into the SCTS van for checkout or repair, the equipment doors are opened and the doorpost is removed. Two interlock switches above the equipment doors turn off the eight white fluorescent light assemblies whenever the equipment doors are opened. A hand lantern, which is used at night in the assembly area, is mounted on the storage shelf on the right rear wall of the SCTS van.

AC/DC Differential Voltmeter and Oscilloscope

The ac/dc differential voltmeter (Figure 10-10) is a precision voltmeter used during UUT testing and during troubleshooting of the equipment within the SCTS. During a UUT test, if the programmable voltage comparator (PVC) of the adapter cannot measure a critical voltage, the ac/dc differential voltmeter can be used since its sensitivity is greater than that of the PVC. Measurement jacks on the master control panel of the assembly tester are provided for this purpose. Convenience outlets, on the assembly tester, supply source power to the test equipment. An isolation transformer provides the means for making floating ac measurements.

The oscilloscope (Figure 10-11) displays waveshapes of adjustments made during UUT testing and is also used during troubleshooting of the equipment in the SCTS. It is equipped with an attenuator probe that is stored in the oscilloscope cover.

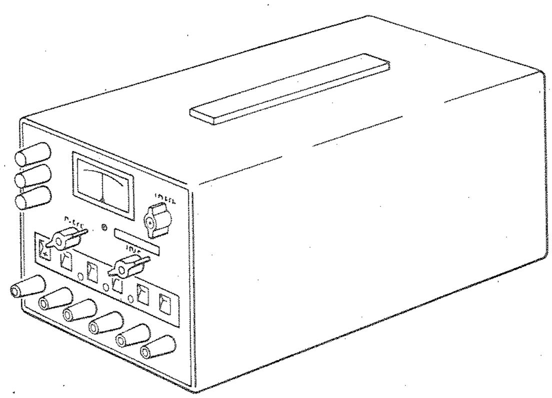


Figure 10-10. AC/DC Differential Voltmeter

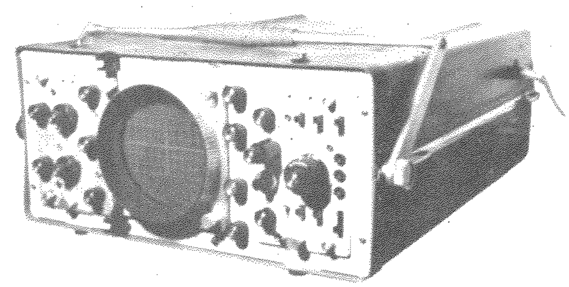


Figure 10-11. Oscilloscope

chapter eleven

ARS/SLA

The automatic reference system (ARS) and the sequential launch adapter (SLA) are improvements in ground support equipment for the PIa Weapon System. Under engineering development at this writing, this improved equipment will eliminate survey requirements and reduce personnel functions during countdowns thus improving PIa launch reaction time.

The ARS concept offers a number of distinct advantages to the PIa Weapon System. It employs an azimuth reference unit (ARU) which interfaces electrically with the PTS and optically with the porro prism on the ST-120 inertial platform. The PTS controls platform slewing to form the complete system. The ARU contains a north seeking gyro which establishes the azimuth reference line (true north) necessary to align the ST-120 platform to the firing azimuth and eliminates the need for presurveyed azimuth lines. Also contained in the ARU is an automatic optical link (AOL) which uses a low-level helium-neon laser to maintain the optical interface with the porro prism. Error signals necessary to cause PTS-controlled slewing of the platform are developed in the AOL. After initial manual optical acquisition of the platform by the AOL, the countdown is automatically controlled by the PTS.

Deployment of the ARS will eliminate the need for the present azimuth equipment laying set.

The SLA will provide the PIa platoon commander with a capability to sequentially count down and launch up to three missiles with a single PTS and PS without recabling between individual firings (Figure 11-1). The SLA consists of the SLA box; cables, air ducts, and air hoses; and a transport vehicle. One portion of the SLA box houses the system signal interface electrical connectors, electrical switches, relays, and necessary circuits. The other part of the box houses the high pressure and conditioned air interface couplings, valves, and ducts as well as the system power interface connectors and relays. Panels on both sides of the box can be removed to perform maintenance on the internal parts.

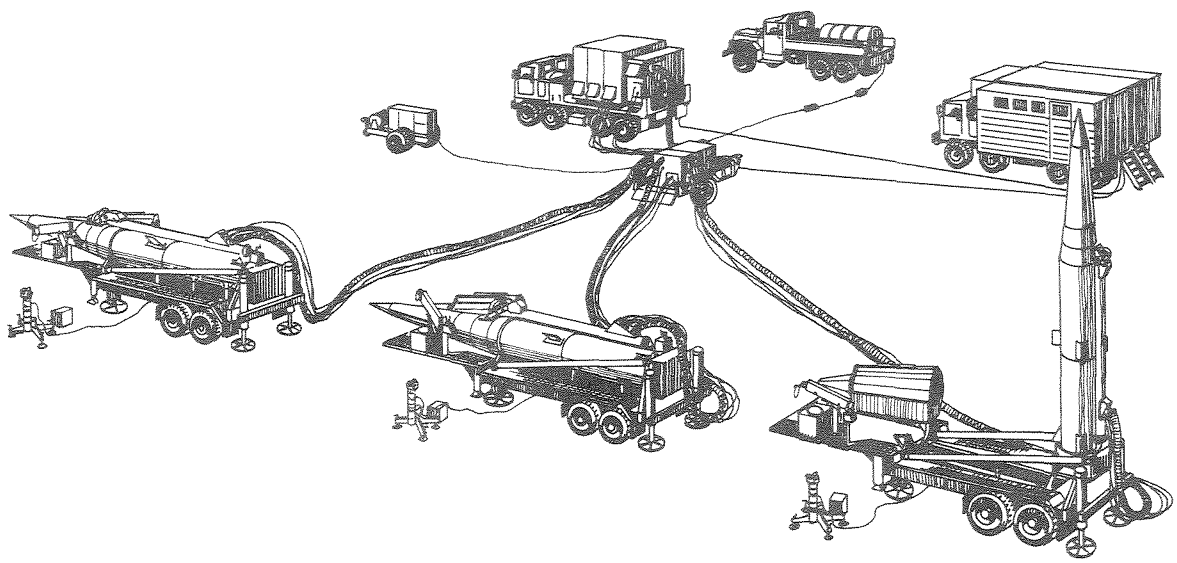


Figure 11-1. ARS/SLA Tactical Site Layout

Automatic Reference System

The ARS is comprised of the ARU, the Programmer-Test Station, and the ST-120 platform. The ARU interfaces electrically with the PTS and optically with the ST-120 inertial platform. The PTS controls platform motion to form the complete system. After setup and initial manual alignment of the ARU, the system is controlled by the PTS computer for fully-automatic system operation through completion of platform alignment.

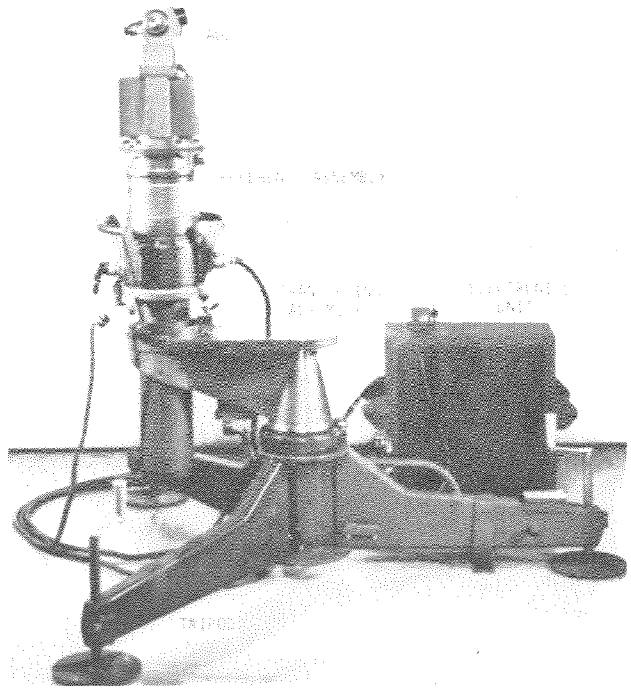
Azimuth Reference Unit

The ARU is composed of a reference assembly (RA), an electronics unit (EU), a translating assembly (TA), a tripod, a manual control unit, and four intra-connecting cables (Figure 11-2). Three transportation containers are required - one for the RA, one for the TA and tripod, and the third for the EU, manual control unit, and intra-connecting cables.

In the RA a north seeking gyro establishes geographic north (true north) to required system accuracy, an automatic optical link containing a low-output helium-neon laser and detectors optically acquires and tracks a porro prism located on the ST-120 platform, and a digital encoder provides a binary indication to the PTS computer of the azimuth angle between geographic north and the AOL optical axis.

Under program control the PTS drives the optical axis of the AOL toward the firing azimuth perpendicular, causing error signals to be generated in the AOL. These error signals are used to control the slewing of the inertial platform toward the firing azimuth

Figure 11-2. Azimuth Reference Unit



and to translate the AOL as necessary to maintain acquisition of the platform porro prism. Thus, the inertial platform tracks the AOL until it is aligned along the firing azimuth, where its orientation is maintained automatically until the PTS inhibits further ST-120 platform slewing just prior to missile erection.

In a typical platoon deployment configuration, the ARU (Figure 11-3) is positioned opposite the erector-launcher and the missile centerline. Precise emplacement is achieved by using a tripod-locating rod attached to the erector-launcher (an ARS-required EL modification).

The ARU is connected by a single 61-conducter cable to the PTS through the sequential launch adapter (SLA) in a typical three-missile launch configuration, or it may be connected directly (with the same cable) to the PTS for a single-missile configuration. Initial optical interface is made between the ARU and the ST-120 inertial platform by varying the AOL's heading/position to cause the laser beam transmitted through the AOL exit aperture to reflect directly back into the AOL telescope from the porro prism on the ST-120 platform. The low-level laser light returned through the 30X AOL telescope is centered on the telescope reticle when proper alignment is achieved. After initial alignment, both the ARU and the inertial platform are automatically controlled by the PTS during azimuth laying.

The missile centerline must be oriented within 7 1/2 degrees of the firing azimuth during horizontal laying because of the physical limitation on the angle through which the inertial platform may be slewed.

When the ARU has been emplaced and leveled to an accuracy of 50 arc seconds, optical acquisition of the platform porro prism begins (refer to Figure 11-4). Prior to the application of ARU power, the ARU operator manually rotates the AOL and translates the reference assembly to achieve approximate optical alignment of the

AOL on the caged ST-120 porro prism. At the time of application of ARU power, the AOL is enabled, turning on the helium-neon laser, and automatic AOL leveling begins. After AOL leveling, the ARU operator, using the remote control unit, completes the optical acquisition of the porro prism by rotating the AOL and translating the RA as necessary to center the low-level laser light returned from the porro prism through the AOL telescope on the telescope reticle. At the beginning of the coarse north determination interval, the countdown program disables the manual control capability, permitting no further operator movement of the AOL and RA unless a recycle mode is initiated. All remaining ARS functions are automatic.

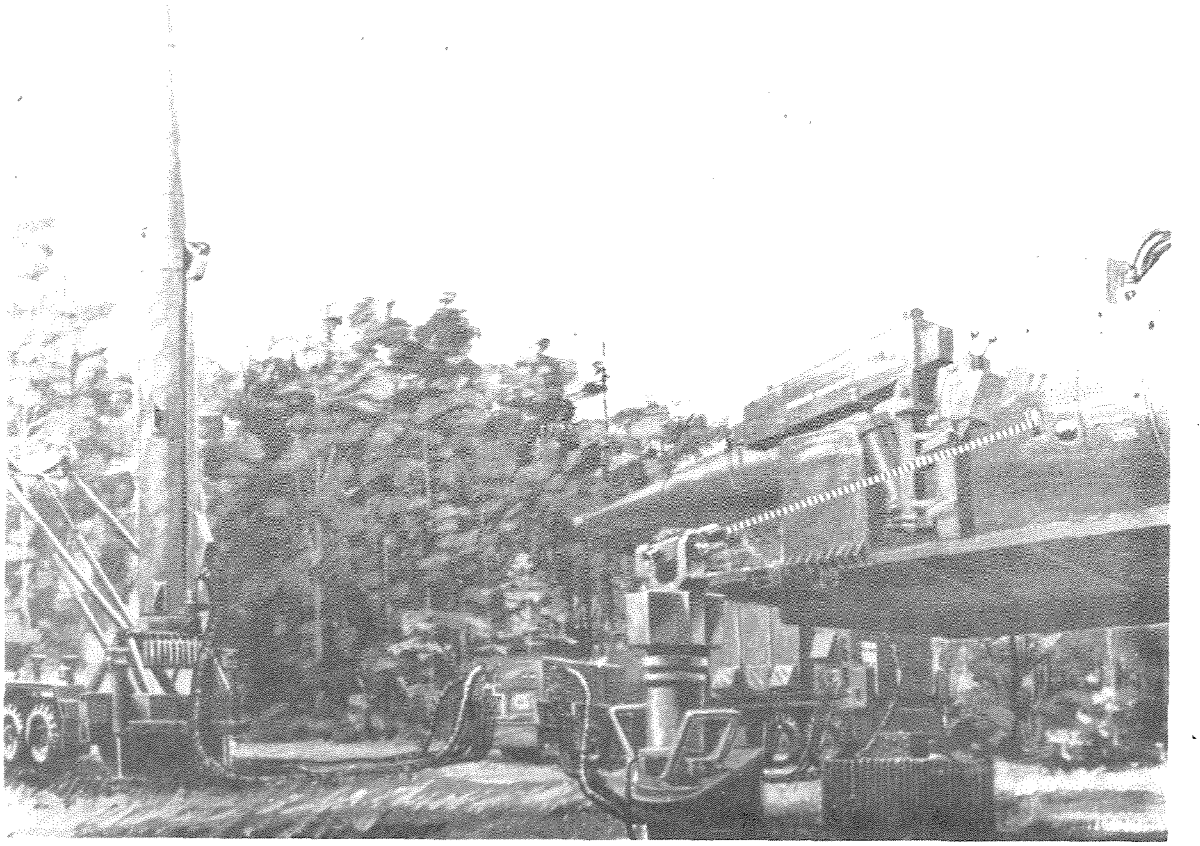


Figure 11-3. Position of ARU Relative to Missile

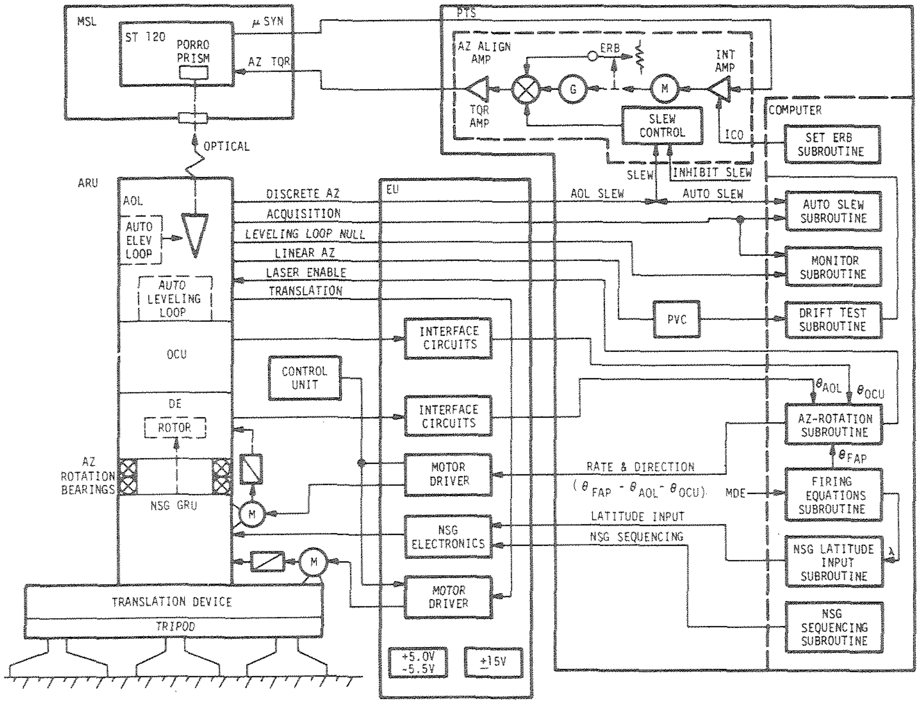


Figure 11-4. ARS Block Diagram

Reference Assembly

The reference assembly (Figure 11-5), consists of the gyroscopic reference unit (GRU) portion of the north seeking gyro (NSG), an automatic optical link, a digital encoder (DE), and an offset correction unit (OCU). In addition, the AOL, the OCU, the DE and the azimuth rotation subroutine in the PTS computer function in combination to form the rotation control system.

The NSG-GRU mounting flange is secured to the lower flange of the reference assembly housing and the RA is supported in the translating assembly by this flange combination.

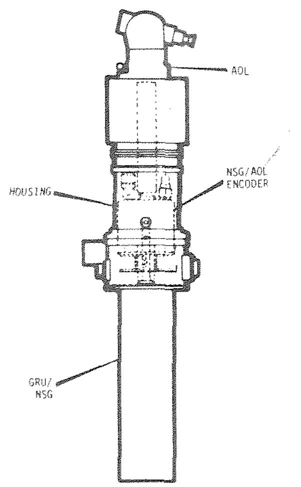


Figure 11-5. Reference Assembly

The AOL is mounted on the upper flange of the rotating (top) portion of the RA housing, which is driven by a stepper motor coupled to a worm azimuth drive gear assembly. The DE case also is secured to the upper RA housing. Because of the high input/output gear ratio (720:1) in the azimuth drive mechanism and the resulting low AOL rotation rate (11 degrees per minute maximum), provision is made for mechanically disengaging the drive mechanism for manual AOL rotation during initial ARU setup and alignment.

North Seeking Gyro - The north seeking gyro consists of the GRU and the electronic control unit (ECU). The ECU is located in the ARU electronics unit, and the GRU is a major component of the reference assembly.

The GRU consists of a pendulous gyroscope with its spin motor and associated suspension system, a servo-controlled followup assembly containing the output shaft (coupled to the digital encoder in the reference assembly) which tracks the pendulous gyroscope as it seeks the meridian, bias and damping torquer coils, pickoff coils, a pickoff preamplifier, three level sensors, and a motor-driven caging mechanism. The ECU contains power supplies and electronics circuits needed to accept and/or store necessary data and commands, to control the GRU, and to provide indications of system status or alignment.

The NSG is designed to determine coarse north with an accuracy of 5 arc minutes within 5 minutes and to determine fine north with an accuracy of 25 arc seconds within 9.75 minutes when initially positioned to within ±15 degrees of geographic north and between the latitudes of 55 degrees north and 55 degrees south.

Automatic Optical Link - The AOL is rigidly mounted atop the reference assembly housing. It contains a 30X telescope whose heading may be varied in elevation from -10 degrees to +45 degrees, an automatic leveling loop, a low-output helium-neon laser whose output is projected through a 12X optical system and through the exit aperture of the telescope, an automatic elevation control loop which vertically centers the laser output beam on the ST-120 porro prism, and two detectors which provide all signals necessary to control the ARS. Rotational stops in the RA housing permit 370 degrees (±185 degrees) rotation of the AOL.

The elevation control loop contains a permanent magnet stepper motor and control circuits which, reacting to error signals generated in a quadrant detector in the system, drive the telescope centerline either upward or downward to keep the laser output beam vertically centered on the ST-120 porro prism. A slip clutch in the elevation drive permits manual override of the drive mechanism using a tangent screw. The leveling loop contains a pendulum-type level sensor and control circuits which cause a second stepper motor to maintain the AOL level during system operation.

The following functions are performed by the AOL:

1 Sensing azimuth position of the ST-120 porro prism and generating approximate azimuth error signals;

2 Sensing the horizontal position of the missile porro prism with respect to the AOL optical axis and generating the required translation signals;

3 Sensing and automatically centering the vertical position of the AOL optical axis on the porro prism;

4 Automatically maintaining the level of the AOL trunnion axis;

5 Sensing the elevation angle of the AOL optical axis and generating a proportional elevation signal.

Digital Encoder - The digital encoder, mechanically coupled to the output shaft of the NSG, provides a digital readout of the angular difference between the north heading established by the NSG and the AOL line-of-sight. This angular readout is transmitted on command to the PTS via the electronics unit as a natural, cyclic binary number in serial format with the least significant bit first. The digital encoder is capable of operating over a full 360 degrees with no ambiguities or discontinuities and with clockwise rotation of the AOL line-of-sight causing the binary number to increase in value.

A simplified sketch of the rotation detection principle is shown in Figure 11-6. Only one track is shown for clarity, but the same basic illumination and detection principle is used for all 16 tracks. The light from the precisely registered filament of a special incandescent lamp is focused upon the code disk with the photodetectors located directly behind the disk. As the disk rotates, light emerging through a transparent segment of the code disk illuminates a corresponding photodetector to produce an electrical output. When illumination is cut off by an opaque segment of the code pattern, the photodetector output drops to near zero and remains there until the next transparent segment is optically aligned. For all code tracks the photodetector output is a quasi-square wave corresponding to a series of equally-spaced consecutive transparent and opaque segments.

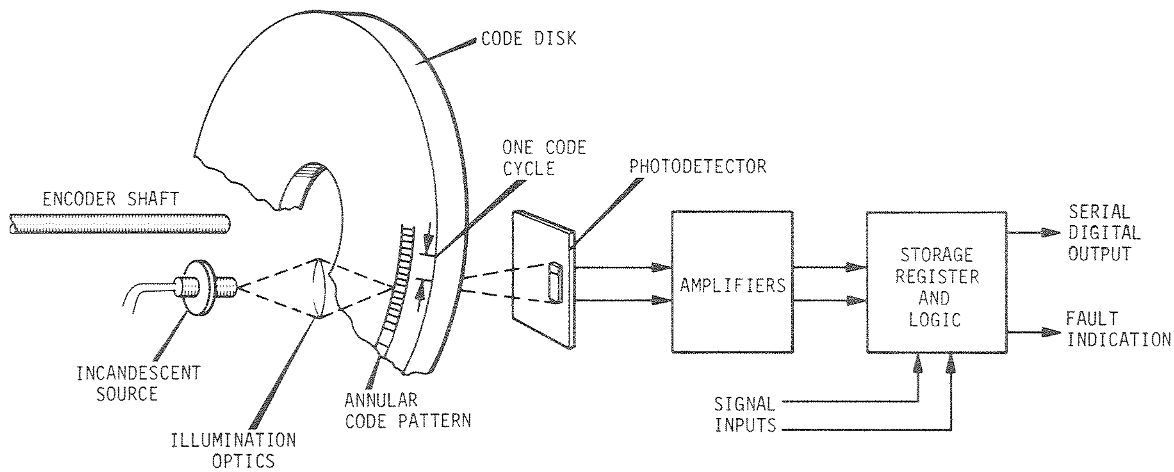


Figure 11-6. Digital Encoder Functional Schematic

Offset Correction Unit - The offset correction unit (OCU) contains an automatic programmable device for digital word storage. The OCU is programmed by the PTS and the OCU provides a digital readout to the PTS. This readout represents the mechanical alignment offset between the units of the reference assembly and is used by the PTS to modify the firing azimuth perpendicular.

The offset correction unit, located on a printed circuit board in the reference assembly, consists of control logic, demultiplexer, latching relays, and a multiplexer.

The PTS programs the OCU by first setting K1 (Figure 11-7). Relay K2 is set which unlatches the 16 latching relays; then K2 is reset. The load reset command is given to the control logic circuit which zeros the multiplexer and demultiplexer. A clock pulse initiates bit one. If the bit is to be a binary 1, K3 is set and reset at clock pulse high. This applies 28 Vdc from the PTS to latch the first (bit one) relay. For a binary 0 no action is taken during the clock pulse. Each succeeding clock pulse initiates a bit, up through 16 bits for the word. At the end of the sixteenth clock pulse, K1 is reset completing the procedure.

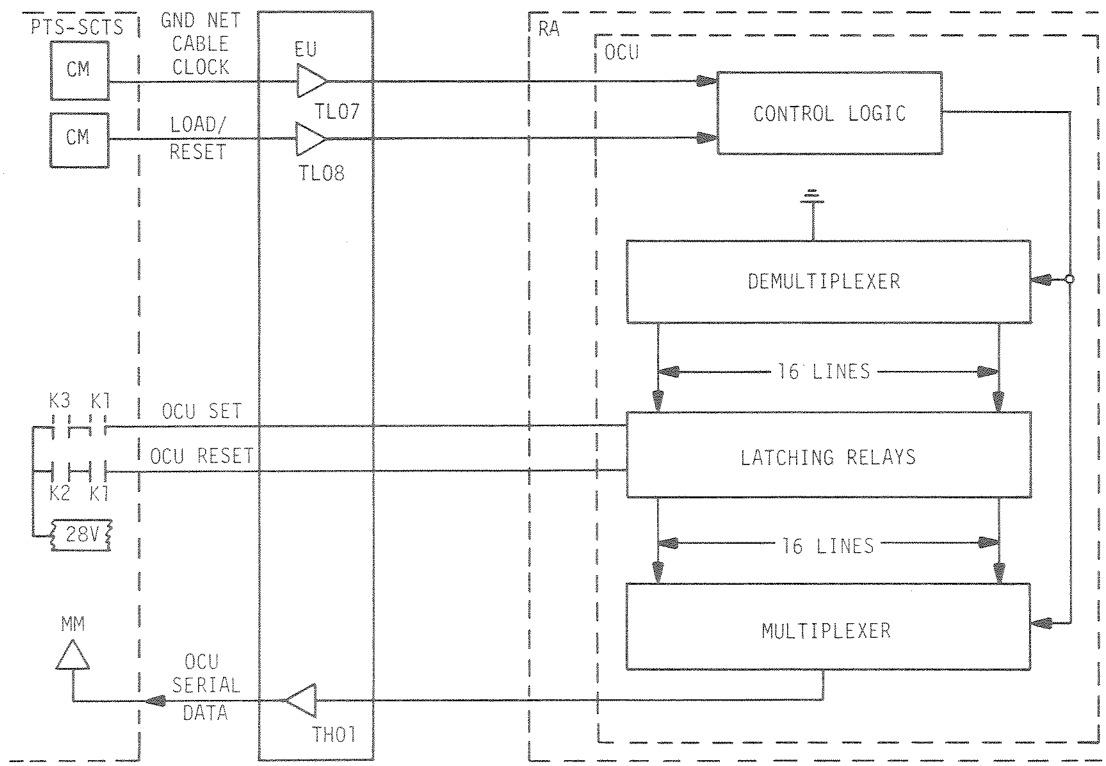
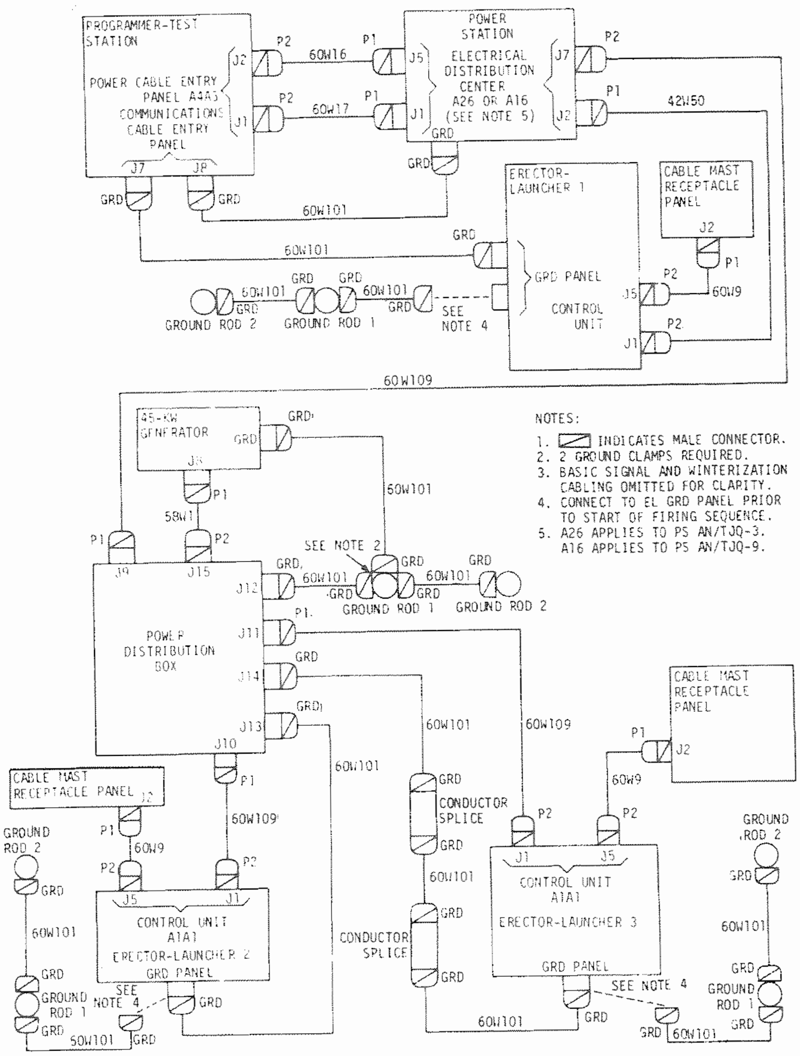


Figure 11-7. Offset Correction Unit Block Diagram

To start the read procedure by the PTS, the load reset command is given to the control logic. At each clock pulse the multiplexer provides an output based on the condition of the appropriate relay. The word is clocked out serially to the PTS and is used for modification of the firing azimuth perpendicular by the PTS.

Electronics Unit

The electronics unit (EU), Figure 11-8, is the sole interface point between the ARU and the PTS. During system operations it is placed upon the ground adjacent to the ARU, for interconnection between the ARU and the SLA/PTS. In the SLA configuration each of three ARU's, via their respective EU's, may be connected by a single 130-foot cable to the SLA. The SLA, in turn, is connected to the PTS by one 40-foot cable. In a single-missile launch site configuration, or in the event of SLA malfunction, the EU may be connected directly to the PTS with the 130-foot cable.



NOTES:

1. [symbol] INDICATES MALE CONNECTOR.
2. 2 GROUND CLAMPS REQUIRED.
3. BASIC SIGNAL AND WINTERIZATION CABLING OMITTED FOR CLARITY.
4. CONNECT TO EL GRD PANEL PRIOR TO START OF FIRING SEQUENCE.
5. A26 APPLIES TO PS AN/TJQ-3. A16 APPLIES TO PS AN/TJQ-9.

Figure 9-2. QRA Tactical Site, Standby Power Distribution chapter ten

System Components Test Station

The system components test station (SCTS) is used in performing rear area maintenance of the PIa system. As a housed mobile center, the SCTS utilizes a computer and tape programs for testing missile sections, together with assemblies, cards, relays, and modules from the guided missile and associated ground support equipment. Diagnostic tape programs are also provided for verification and troubleshooting of major SCTS assemblies. The SCTS contains a dismounted PTS and has facilities whereby one missile guidance section can be tested and another repaired simultaneously under controlled temperature conditions. Power for the SCTS originates from the power station equivalent (PSE).

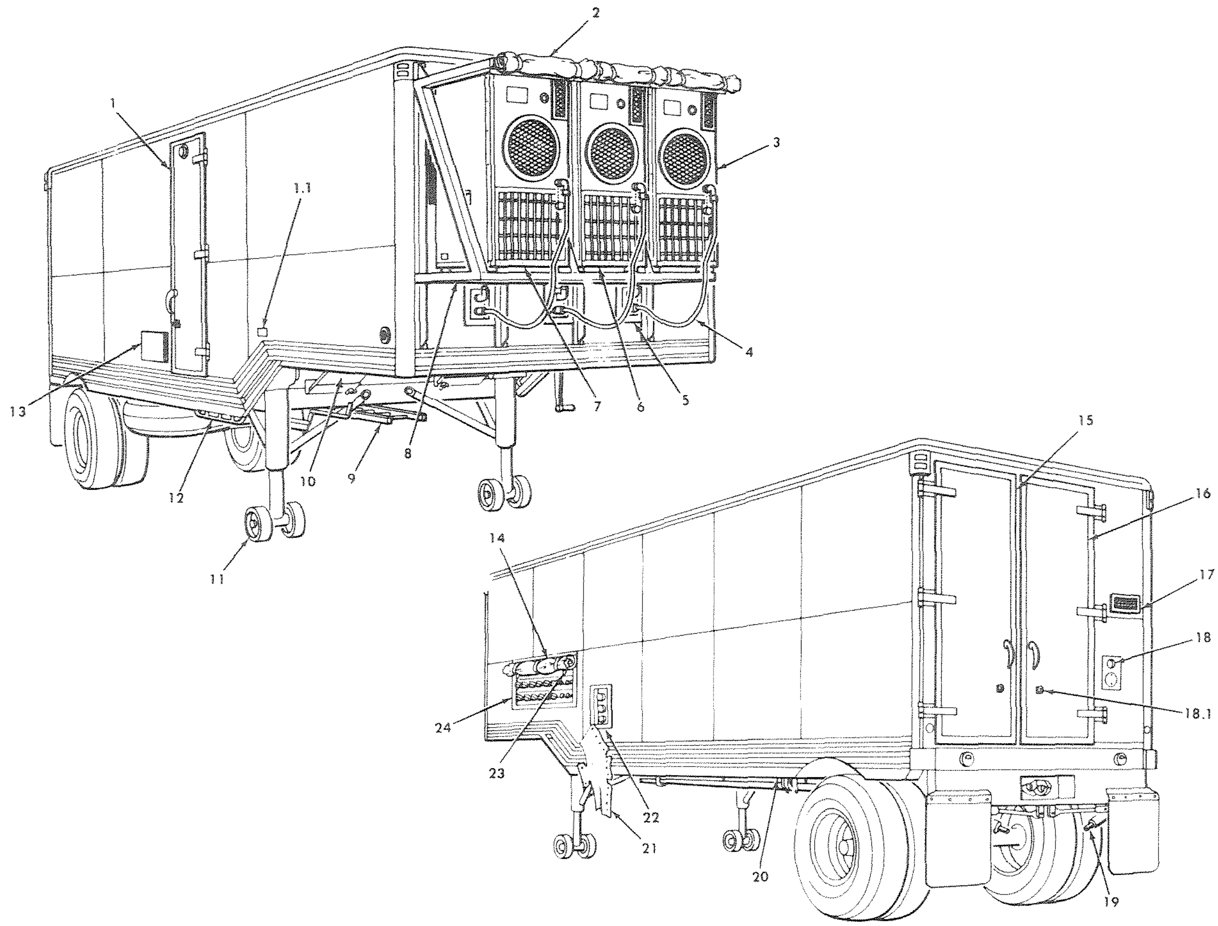
Exterior Description

The SCTS equipment is housed in a modified semitrailer van M373A2 (Figure 10-1). The significant exterior features are described below.

A personnel door, located on the right side, is the main access to the interior of the SCTS van.

Three air conditioner-heaters mounted on the front of the SCTS van establish the internal environmental conditions. A temperature of 77° ± 6°F is necessary for optimum operation of the SCTS equipment within the SCTS van. Each air conditioner-heater is shock mounted and attached to the front wall of the SCTS van by corrugated neoprene bellows, to ensure a minimum amount of vibration and shock during travel. Canvas covers are lowered and secured when the air conditioner-heaters are not in use.

Three connector panels, located directly below each air conditioner-heater, are attached to the front wall of the SCTS van. Input power is supplied to the air conditioner heater controls.



1 - Personnel door
1.1 - Identification plate
2 - Air conditioner-heater protective cover (3)
3 - Air conditioner-heater
4 - Power cable (3)
5 - Air conditioner-heater connector panel (3)
6 - Air conditioner-heater
7 - Air conditioner-heater
8 - Air conditioner-heater mounting frame
9 - Access ladder
10 - Sand pad (2)
11 - Landing gear (2)
12 - Personnel ladder (2)
13 - Modification mounting panel
14 - SCTS cable entry panel protective cover
15 - Doorpost
16 - Equipment entrance door (2)
17 - Air vent filter
18 - Humidity indicator
18.1 - Eyebolt (3)
19 - Leveling jack (2)
20 - Tarpaulin storage compartment
21 - PTS cable entry panel protective cover
22 - PTS power cable entry panel
23 - Safety lanyard
24 - SCTS main cable entry panel

Figure 10-1. System Components Test Station Exterior View

The SCTS main cable entry panel consists of four cable entry panels: tactical cable entry, test cable entry, SCTS power entry, and communications cable entry. The tactical and test cable entry panels connect test and response signals between the SCTS and the missile sections when the missile sections are installed in containers. The SCTS power entry panel connects power to all assemblies in the SCTS, except the PTS assemblies. The communications cable entry panel contains the following: two phone jacks that provide communication between personnel inside and outside the van; one phone jack and switch for use with the instrumentation monitor; SCTS grounding terminals and a pneumatic quick-disconnect connector. High-pressure air is supplied to the SCTS through the pneumatic quick-disconnect connector.

An access ladder is used to gain access to the top of the SCTS van and to gain access to the air conditioner-heaters for maintenance.

The sand pads are used to emplace the SCTS van and are placed under the landing gear to stabilize the van on soft terrain.

The landing gears are lowered when emplacing the SCTS van and are adjusted along with the leveling jacks to level the van.

Two personnel ladders are used to gain access to the interior of the SCTS van through either the personnel door or the equipment doors.

A humidity indicator displays the relative humidity of the SCTS van through an observation port.

Two leveling jacks are used for leveling the SCTS van at an attitude of not more than 6 degrees (106 mils) from the horizontal position. They are lowered during van emplacement in the field maintenance area. The SCTS van must be nearly horizontal during guidance section testing for optimum checkout of the ST-120 platform.

The PTS power cable entry panel connects power from the power station equivalent to the PTS assemblies of the SCTS van.

SCTS Major Assemblies

The major assemblies of the SCTS are divided into two categories: PTS assemblies and SCTS assemblies (Figure 10-2).

Major PTS Assemblies

The major PTS assemblies are the adapter, card and module test set, power distribution cabinet, console, computer, utility circuit breaker panel assembly, and signal distribution box. The adapter, console and computer are discussed in Chapter Four. The major PTS assemblies are used when testing missile sections, PTS circuit cards, and PTS modules. The major PTS assemblies of the SCTS van are described below.

The card and module test set functionally tests the printed circuit cards, modules, and circuit network modules used in the adapter and the computer. It also tests its own cards and modules.

The power distribution cabinet contains the circuits that control the distribution of primary power to the console, adapter, computer, signal distribution box, and card and module test set. An interlock switch actuated by the cabinet door removes primary power from all the PTS assemblies whenever the door is opened.

The utility circuit breaker panel assembly controls power to the console and adapter blowers.

The signal distribution box is the distribution center for the signals entering and leaving the SCTS, which are generated during missile section in-container tests. It is also a convenient source of electrical test points. The test points are accessible through a hinged maintenance access panel. An interlock switch activated by the access panel removes power from all PTS assemblies whenever the panel is opened.

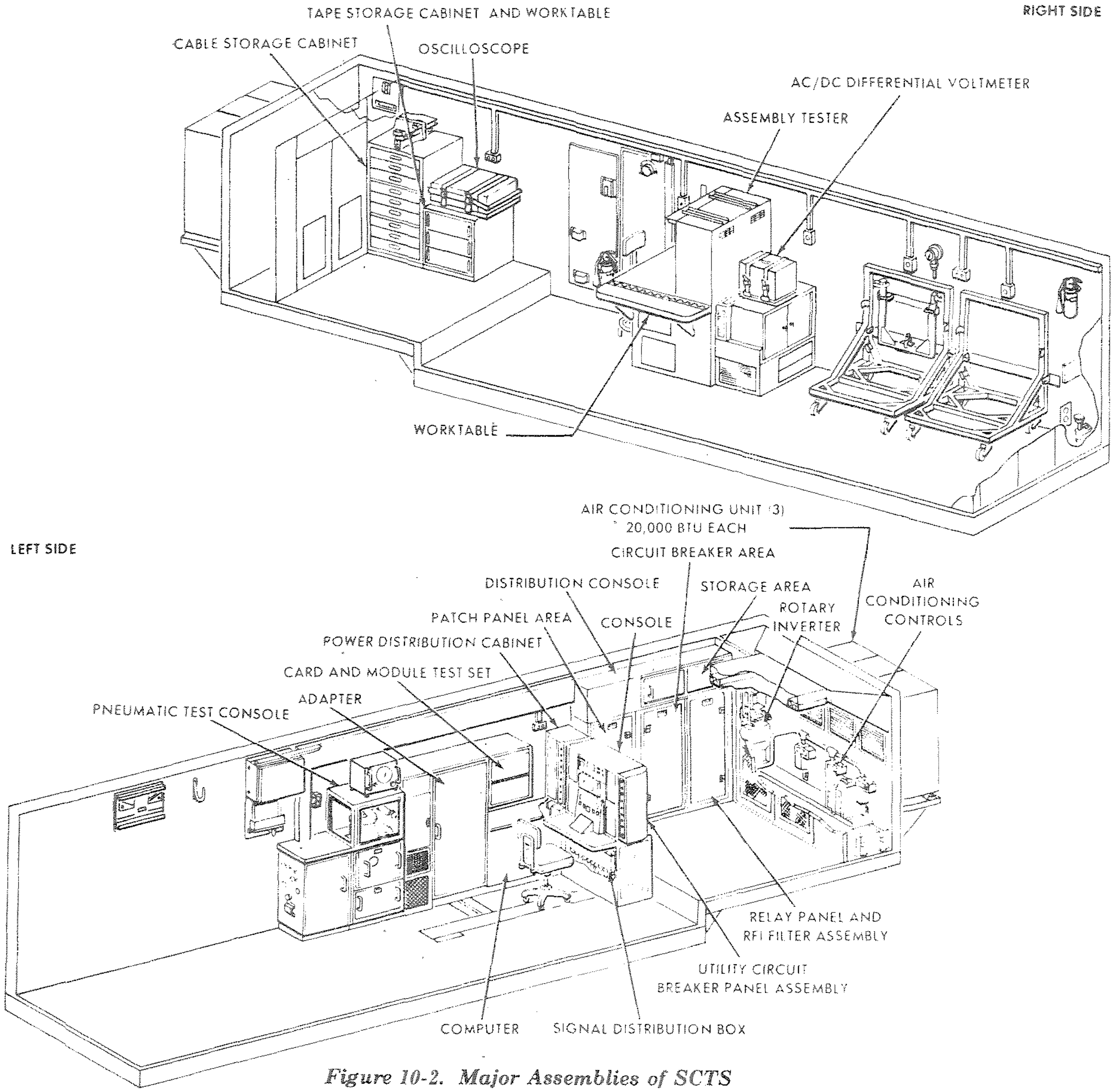


Figure 10-2. Major Assemblies of SCTS

Major SCTS Consoles and Assemblies

The major SCTS consoles and assemblies are the distribution console, pneumatic test console, and assembly tester. Significant assemblies of the SCTS also consist of the cable and tape storage cabinets, oscilloscope, and ac/dc differential voltmeter. The major SCTS assemblies and other significant assemblies of the SCTS van are described below.

The distribution console distributes primary power to all SCTS major consoles and assemblies within the SCTS van. In addition, it routes test signals to and from the missile sections under test. The distribution console contains a patchboard receptacle, a circuit breaker panel, a relay panel, radio frequency interference (RFI) filters, and a storage area for technical manuals.

The pneumatic test console is used to test and fault isolate the missile guidance section ST-120 air supply system components and to check guidance section compartment pressure.

The assembly tester uses programmed tapes to test the missile, PTS, EL, and SCTS assemblies by applying stimuli to the unit under test (UUT) and routing responses to the adapter. A work-table is provided on the assembly tester to support the UUT.

The rotary inverter supplies 115 volt, 3-phase, 400 Hz power to the assembly tester and to the applicable UUT's on the assembly tester.

The air conditioner-heater control panel is used to set the air temperature output of the air conditioner-heaters, which are rated at 20,000 Btu each for cooling and 12,000 Btu each for heating. The air conditioner-heaters supply either cool or warm air, depending upon the outside temperature.

The UUT cables and programmed tapes used during assembly tester checkout of a UUT are stored in the storage cabinets. A worktable is mounted on top of the tape storage cabinet. When not in use, the oscilloscope is stored on top of the worktable.

The oscilloscope and ac/dc differential voltmeter are supplemental pieces of test equipment used during UUT testing when adjustments and critical voltage measurements are required. They are also used for fault isolating and troubleshooting the assemblies within the SCTS.

Assembly Tester

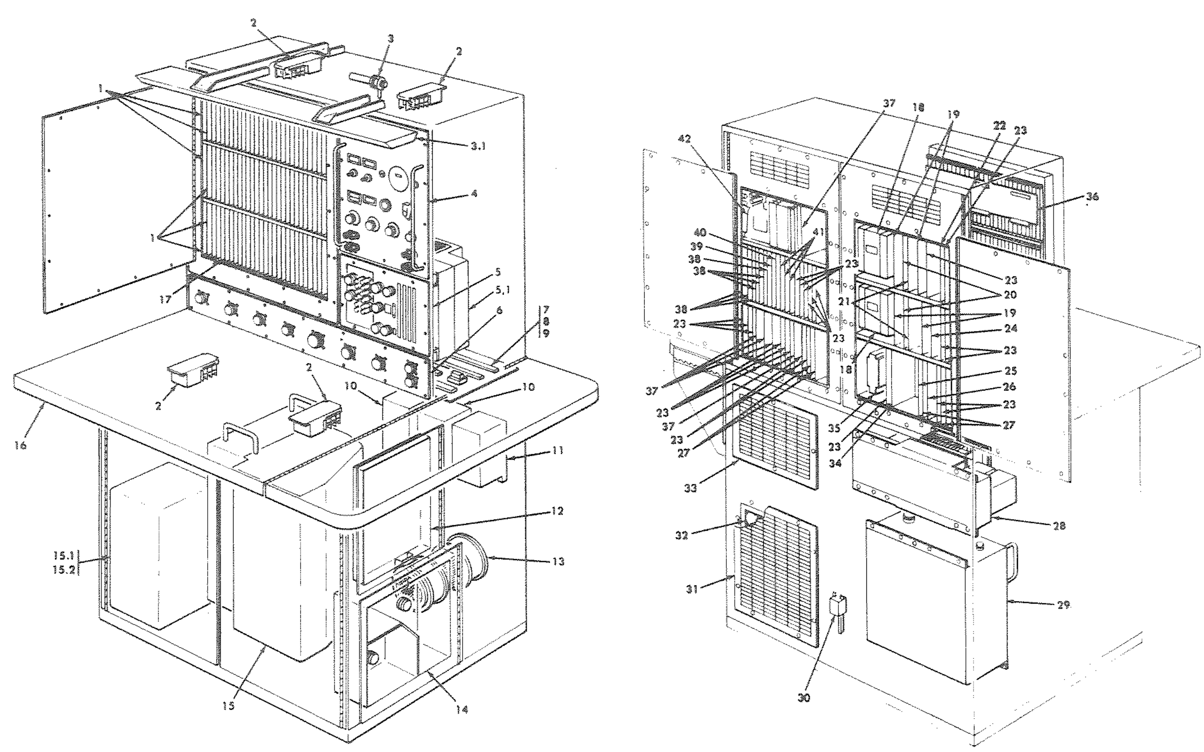
The assembly tester (Figure 10-3) provides the necessary stimuli, loads, and switching operations for functional testing of certain assemblies, printed circuit cards, and relays of the PIa system. Programmed by row select and column data signals from the adapter, the assembly tester performs essentially three functions through a relay matrix: generation of the required stimuli and loads, routing of the stimuli and loads to a UUT, and routing of UUT responses for measurement by the adapter.

The assembly tester basic frame consists of welded structural aluminum extrusions covered with outside skins of aluminum sheet. A step in the frame and a hinged worktable form a workbench surface on which UUT's are placed for testing. The major assemblies, circuit cards, and associated equipment of the assembly tester are described below.

Six interface relay cards connect 15 signal buses to the assembly tester circuits. When opened, a hinged panel on the left front side of the assembly tester provides access to the interface relay cards.

Various light fixtures provide additional lighting during operation of the assembly tester, provide lighting for the interior of the assembly tester, and illuminate the signal buses, the back of the master control panel, the back of the card/relay test panel, and the inside wiring of the two access doors mounted on the rear of the assembly tester. Two other lights are mounted on the bottom of the worktable to illuminate the equipment area under the worktable. Two hinged doors, mounted on the lower front of the assembly tester, provide access to this area.

A thermostat switch actuates when the temperature is between 110°F and 120°F and lights the TEMP indicator on the master control panel, indicating that the assembly tester is overheating.



Front View

1 - Interface relay card
2 - Light fixture
3 - Thermostat switch
3.1 - Light fixture
4 - Master control panel
5 - Card/relay test panel
5.1 - Logic analyzer
6 - UUT connector panel
7 - Terminal board
8 - Terminal board
9 - Terminal board
10 - 12 Vdc power supply
11 - 28 Vdc power supply
12 - Test point panel
13 - Blower
14 - Cable access panel
15 - High power loads
15.1 - Card/relay test panel
15.2 - Card/relay test panel case
16 - Worktable
17 - Relay tree card

Rear View

18 - DC stimuli assembly
19 - 24 Vdc power supply
20 - Ladder network card
21 - DC stimuli regulator card
22 - Counter measurements card
23 - Relay card
24 - R-Z measurements card
25 - Special loads card
26 - Beta simulator card
27 - Relay card
28 - AC stimuli
29 - Low power loads
30 - Airflow switch
31 - Grille
32 - Filter
33 - Grille
34 - Special stimuli card
35 - Accelerometer simulator
36 - Signal buses
37 - Power relay card
38 - Current driver card
39 - Reed relay card
40 - Resistor card
41 - Diode card
42 - Five-volt power supply

Figure 10-3. Assembly Tester

The master control panel contains indicators, switches, controls, and test jack used during testing of a UUT.

The card/relay test panel contains connectors for UUT testing all of the relays and printed circuit cards of the assembly tester and pneumatic test console. The panel contains two connectors that supply power and signal inputs to the panel during UUT testing. An additional card/relay test panel is stored in the test panel case. This card/relay test panel tests certain missile assembly printed circuit cards and relays as UUT's.

The logic analyzer provides digital logic circuitry within the assembly tester for missile UUT testing purposes. The added digital logic capability enables the assembly tester to check out the guidance and control computer as a UUT.

The UUT connector panel supplies signal and input power to the UUT's to be tested.

The assembly tester contains seven terminal boards that distribute power during operation.

Two power supplies in the assembly tester supply positive and negative 12 Vdc used in UUT testing. A 28 volt dc power supply furnishes +28 Vdc to the assemblies of the assembly tester.

The test point panel contains test points where all row and column commands and other signals can be monitored.

A blower circulates air throughout the assembly tester for cooling purposes. The two access doors on the back of the assembly tester are louvered to dissipate heat generated by the components of the assembly tester. The blower maintains a steady airflow for dissipating the heat.

Seven connectors on the cable access panel provide input power and the adapter assembly tester interface.

High power loads are located in the lower portion of the equipment area in the front of the assembly tester. The high power loads are provided during UUT testing by this assembly.

A worktable supports the UUT's during testing. The hinged portion of the worktable can be raised or lowered. During operation, the worktable usually supports the oscilloscope or ac/dc differential voltmeter.

Seventy-eight relay tree cards are located on the left front side of the assembly tester. A hinged panel opens to provide access to the relay tree cards. The relay tree cards interface all cards and chassis to the UUT connector panel. Seventy-five of the relay tree cards form a functional portion of the assembly tester; this functional portion is the signal matrix. The remaining three relay tree cards are used for special measurements. All relay tree cards are identical and interchangeable.

Two dc stimuli assemblies in the assembly tester supply dc voltages to the signal buses. The output of each assembly can be varied from 0 to 40 Vdc in 0.004V steps by programming relays in the ladder network cards. Each dc stimuli output may also be adjusted manually by controls on the master control panel.

Four 24 volt dc power supply cards supply 24 Vdc to the chassis of the assembly tester.

Two ladder network cards contain reference network resistors used in developing dc stimuli signals.

Two dc stimuli regulator cards develop and regulate dc stimuli signals sent to the UUT's.

The counter measurements card contains circuits that shape and space pulses for frequency and time delay measurements.

Twenty-five relay cards electrically interface all of the remaining cards, assemblies, and chassis of the assembly tester. Four relay cards have conventional relays and 21 relay cards have latch-unlatch relays. Both types of relays perform the same function.

The R-Z measurements card converts resistance and impedance values into representative ac and dc voltages that are measured by the programmable voltage comparator (PVC) of the adapter.

The special loads card contains resistors that provide loads for the beta simulator output, and provide resistive values used in R-Z measurement self-test.

The beta simulator card simulates the angular displacement (beta) of the missile air vanes during UUT testing.

The ac stimuli assembly provides variable ac signals for UUT testing.

The low power loads assembly provides low power loads for UUT testing.

An airflow switch monitors the operation of the assembly tester blower. If the blower malfunctions, the airflow switch actuates circuits that light the air flow indicator on the master control panel.

The lower grille on the rear panel is the air intake for the assembly tester. The grille and its filter must be removed to provide access to the blower during maintenance. The upper grille is the air exhaust of the assembly tester. Heat generated through operation of the assembly tester is dissipated through the exhaust by the combination of louvers on the top of the assembly tester and on the rear access doors.

The special stimuli card provides an 800 Hz sine wave, a 400 Hz square wave, and a 120 Vdc signal for UUT testing.

An accelerometer simulator provides signals simulating the output of the missile accelerometers during UUT testing.

Five power relay cards route power to UUT's during assembly tester testing.

The signal buses provide stimuli and load inputs to each relay tree and also route UUT response signals to the assembly tester and adapter measurement circuits.

Seven current driver cards furnish row signals (grounds) for each row of the relay matrix during operation of the assembly tester.

The reed relay card connects column signals generated by the adapter to the relay matrix of the assembly tester.

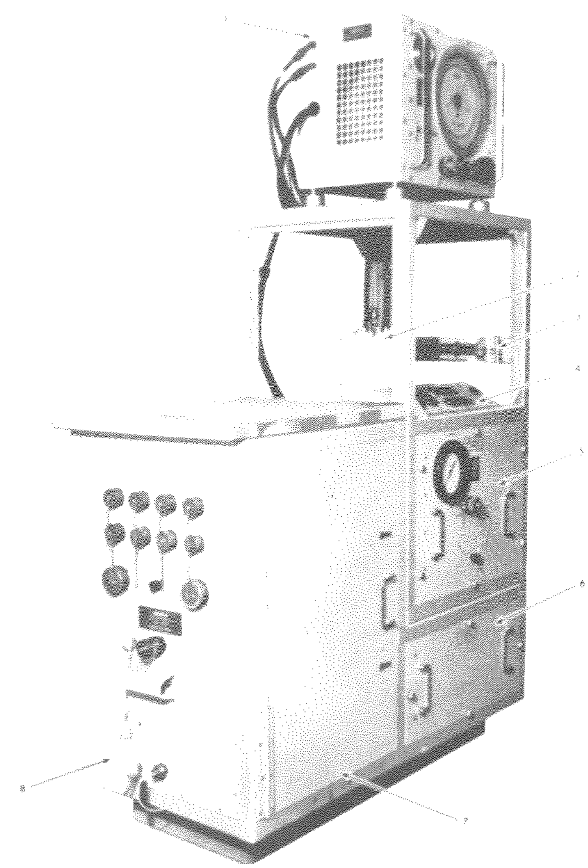
The resistor card provides a starting current for command modules in the adapter, and reduces turn-on time of relay coils of the relay matrix.

Three diode cards are used as blocking diodes during testing of current driver cards and as noise suppressors for grounding plug-in relays.

The 5 volt dc power supplies 5 Vdc to the digital logic analyzer (DLA) during normal operation and to the UUT connector panel during UUT testing of DLA circuit cards.

Pneumatic Test Console

The pneumatic test console (Figure 10-4) performs tests on the guidance section ST-120 air supply system when the guidance section is mounted on the test dolly inside the SCTS van. It also tests the ability of the guidance section to remain pressurized during flight. The replaceable items in the ST-120 air supply system that can be tested are the pressure switches, air pressure regulator, heater, and heater thermostat. The high-pressure air supplied by the pneumatic test console is also used to precharge the hydraulic actuators, if required, during their UUT testing.



1 - Pressure test set
2 - Pneumatic chamber
3 - Hand pump
4 - Pneumatic control panel
5 - Pneumatic test chassis
6 - Storage drawer
7 - Storage cabinet
8 - Connector panel

Figure 10-4. Pneumatic Test Console Assemblies

Distribution Console

The distribution console contains a patch panel, a circuit breaker panel, a relay panel, RFI filters, associated wiring, terminal boards, and a storage compartment. The distribution console and its major assemblies are shown in Figure 10-5.

Cable Entry Panels

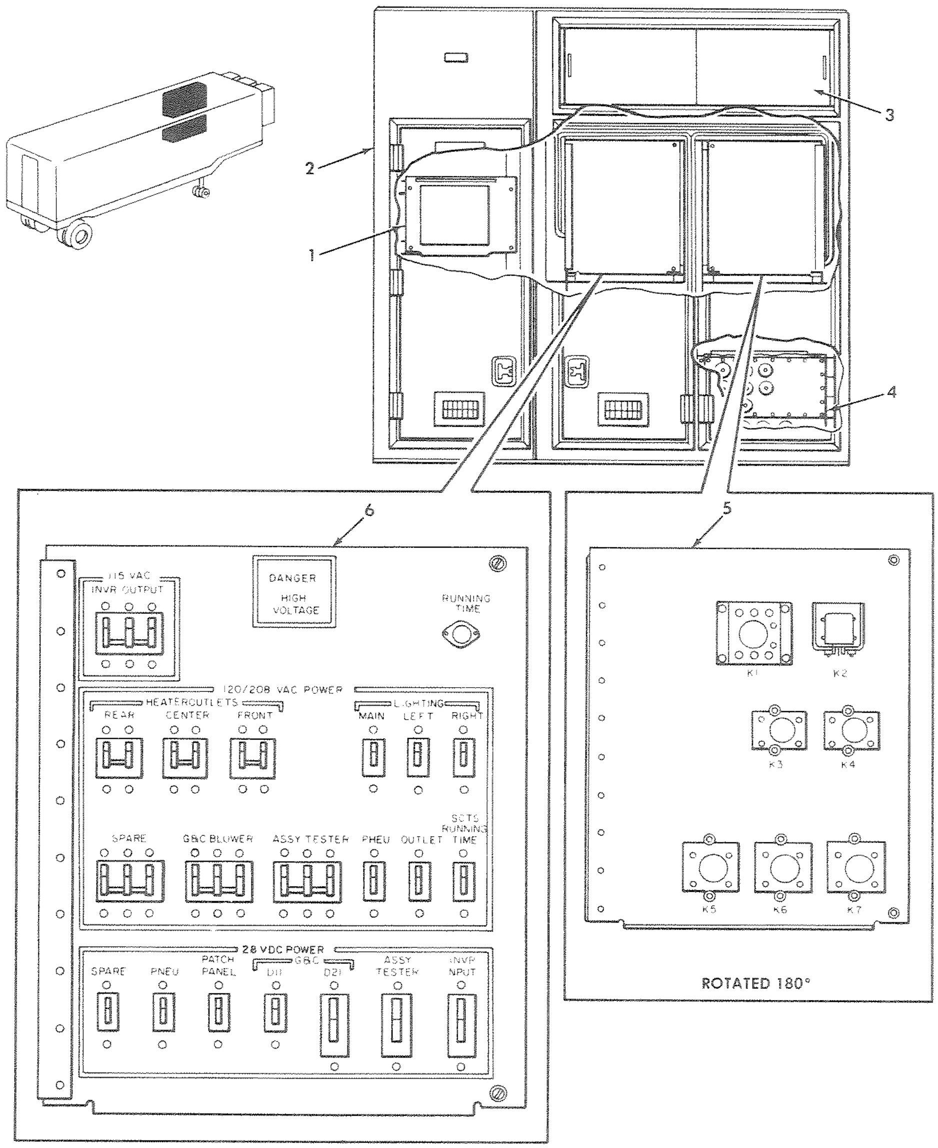
Two cable entry panels provide to the equipment inside the SCTS van. They are the SCTS main cable entry panel and the PTS power cable entry panel (Figure 10-6).

SCTS Main Cable Entry Panel - The SCTS main cable entry panel is divided into four separate panels, which are described below.

The SCTS power entry panel routes 120/208V, 400 Hz, and 28 Vdc to the distribution console in the van, and 120/208V, 400 Hz to air conditioner-heaters. This input power is supplied by the PSE through the three connectors mounted on the panel.

The test cable entry panel contains eight connectors, used during first stage, second stage, and guidance section in-container tests, that electrically connect the SCTS and the respective missile sections.

The tactical cable entry panel contains eight connectors that are used during missile in-container tests. Both the test cable entry panel and tactical cable entry panel are used during checkout of the first stage in-container and the guidance section in-container. The tactical cable entry panel is not used during the second stage in-container tests. Jumper caps (dummy connectors) are installed on the connectors of the test cable entry panel and tactical cable entry panel during self-test of the PTS equipment inside the SCTS.



1 - Patch panel
2 - Distribution console
3 - Storage compartment
4 - RFI filter
5 - Relay panel
6 - Circuit breaker panel

Figure 10-5. Distribution Console

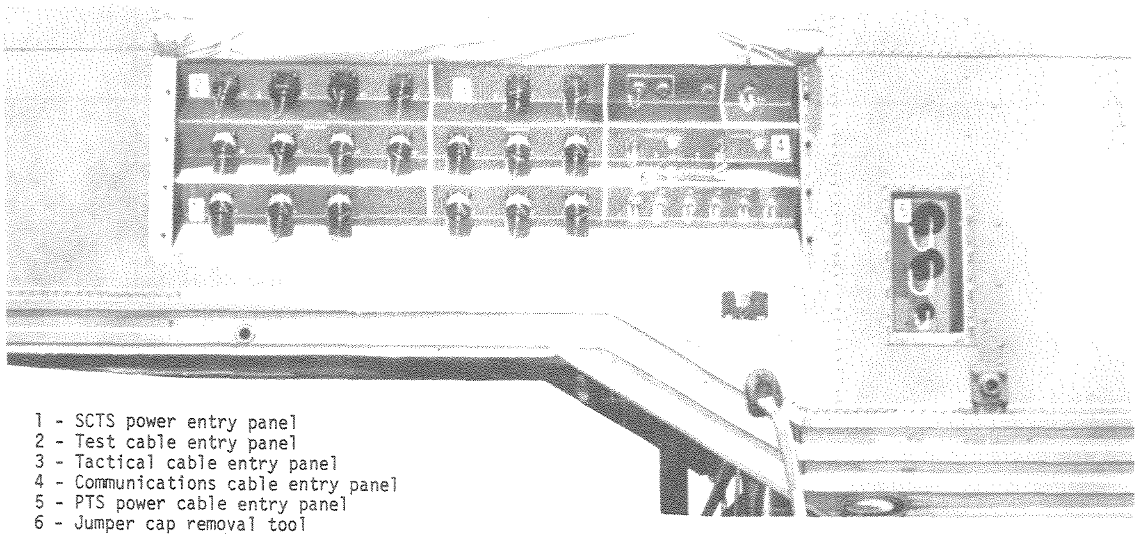


Figure 10-6. Cable Entry Panels

The communications cable entry panel contains six ground connectors, three communications panels, a selector switch, a pneumatic quick-disconnect connector, and a jumper cap removal tool. All equipment within the assembly area is connected to the ground connectors on this panel to ensure that no difference of potential exists between pieces of equipment. Two communications panels provide a means for communicating with the interior of the van. One communications panel and the selector switch are used when the instrumentation recorder is used with the SCTS. The pneumatic quick-disconnect connector provides a means for connecting high-pressure air between the power station equivalent and the SCTS van.

PTS Power Cable Entry Panel - The PTS power cable entry panel routes 120/208 Vac and 28 Vdc to the PTS assemblies through the power distribution cabinet. This panel contains three connectors; however, the bottom connector is not used.

Equipment Storage

The SCTS is equipped with four storage cabinets and a cable storage compartment which are described below. Figure 10-7 shows the location of equipment storage area in the SCTS.

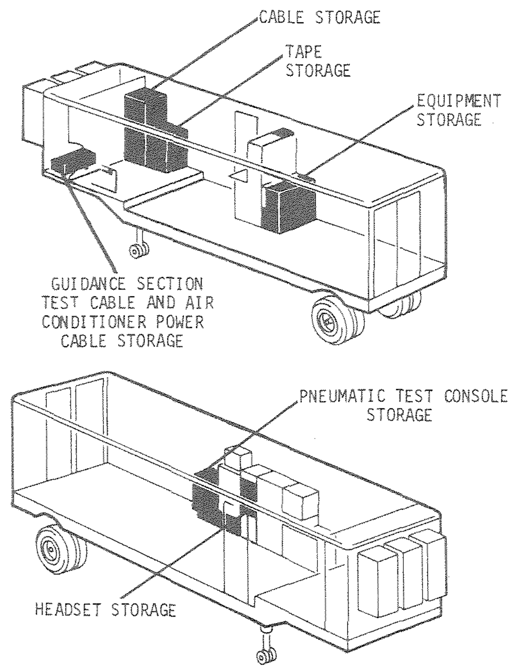


Figure 10-7. Storage Locations

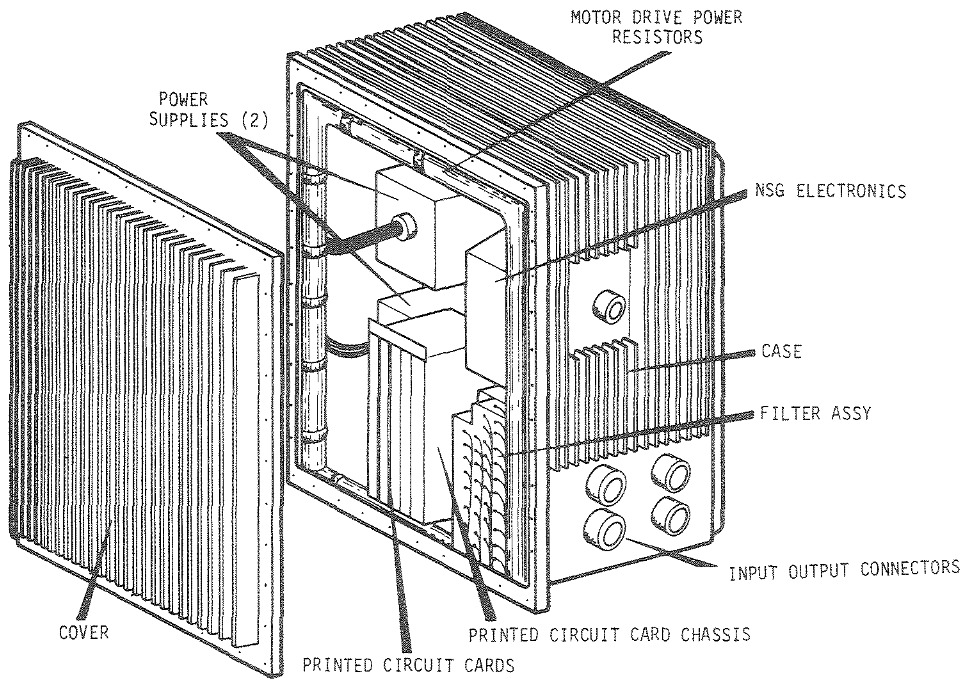


Figure 11-8. Electronics Unit

Contained in the EU are two power supplies (+5.0, -5.5, +15, -15 Vdc) which provide dc power for the ARU, a motor-drive power resistor assembly, the electronic circuits for the gyroscopic reference unit, an EMP filter package, and four printed circuit boards. Two of the PCB's contain the interface built-in test equipment (BITE) and signal conditioners, one board contains the azimuth drive circuits, and the fourth board contains the translation motor drive circuits.

Four intraconnecting cables are used in the ARU. Two cables connect the EU to the reference assembly (one cable to the GRU and the other to the AOL and DE), one cable connects the EU to the stepping motor in the TA, and the fourth cable connects the EU to the ARU manual control unit.

The EU housing is made of aluminum with cooling fins to dissipate the approximate 200 watt circuit power losses. A single finned side cover is used. Overall dimensions are: height - 18.37 inches, width - 19.75 inches, and depth - 11.82 inches.

Translating Assembly

The translating assembly, Figure 11-9, is mounted on the ARU tripod and is capable of translating the RA through an angle of ±67 degrees with an effective arm length of 14 inches. A stepper motor, which can rotate in either direction at a stepping rate of 125 steps/sec with an angular rotation of 1.8 degrees/step, is coupled to a harmonic drive speed reducer having a 100:1 input/output gear ratio. The speed reducer is coupled to a precision gear drive assembly in the TA which rotates the TA at a maximum angular rate of 2.2 degrees/sec. Counter-rotating gears in the TA maintain the AOL line-of-sight orientation constant within 3 arc minutes as the RA is translated.

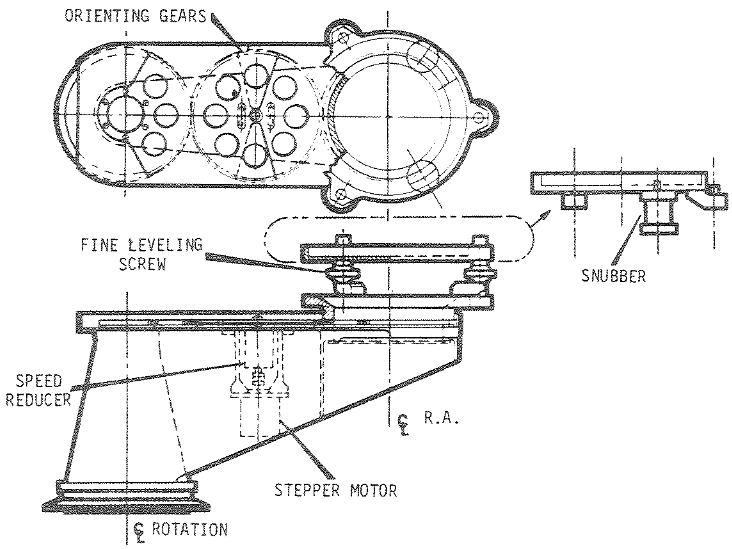


Figure 11-9. Translating Assembly

Because of the high value of inertia loading on the stepping motor at the start and stop of translation, stepping pulses recurring at the maximum step rate are not applied and removed instantaneously; rather, the input to the stepping motor is ramped, i.e., step rate is varied from zero to the maximum rate (125 steps/second) at start and from the maximum rate to zero at stop.

The RA support ring on the TA contains three snubbers which act as shock absorbers should the RA be accidentally dropped during assembly into the TA. These snubbers can withstand a drop of 12 inches while preventing impact damage to the RA.

Tripod

The ARU tripod (Figure 11-10) has two hinged legs which are locked in position during usage but fold back against the fixed leg for container stowage. A 1 inch diameter hole in the fixed leg near the leveling jack and one in the center of the tripod provide references for accurately aligning the tripod opposite the missile. Three handcranked leveling jacks provide initial tripod leveling. A ring clamp on the tripod permits installation of the translating assembly.

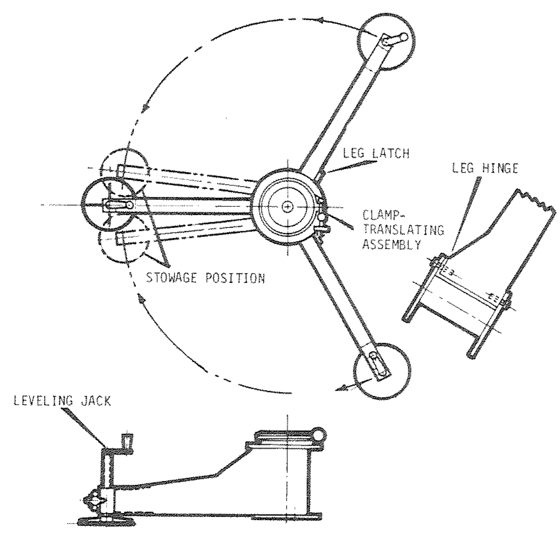


Figure 11-10. Tripod

Auxiliary Equipment

ARU auxiliary equipment consists of intraconnecting cables, an ARU manual control unit, containers for transporting ARU subsystems, a tripod emplacement device, and locating chains.

Three containers are required for transporting the ARU: one contains the RA and serves both as a transportation container and as a carrying case; the second is a transportation container for the tripod, translating assembly and locating chains; and the third is used to transport the electronics unit, the ARU manual control unit, and the intraconnecting cables. During ARU setup, the RA containers are removed from the transportation vehicle and carried to the ARU emplacement location. The other container remains on the transportation vehicle and its contents are hand-transported to the ARU site.

The three containers consist of upper and lower halves with compartmented vibration and shock isolation material and tie-down straps for securing the ARU subassemblies. The containers are formed of aluminum sheeting and are fitted with handles, environmental seals, hinges, clamps, and pressure relief valves.

The four intraconnecting cables transported with the ARU are those which connect the electronics unit to the reference assembly (2), to the translating assembly, and to the ARU manual control unit.

The ARU manual control unit is a small, hand-held unit used by the ARU operator only during the initial autoreflection phase of the ARS alignment procedure. This box has four control buttons, permitting AOL left-right and translating assembly left-right motion, a white indicator lamp which is illuminated only when the operator has control of translation and AOL azimuth rotation, and an amber lamp which flashes when the laser is in operation. A lamp mounted within the box provides control panel illumination for night-time operations. No provision for AOL elevation control is made in the manual control unit: AOL elevation angle changes during autoreflection must be made by manually varying the AOL heading. The ARU manual control unit is shown in Figure 11-11.

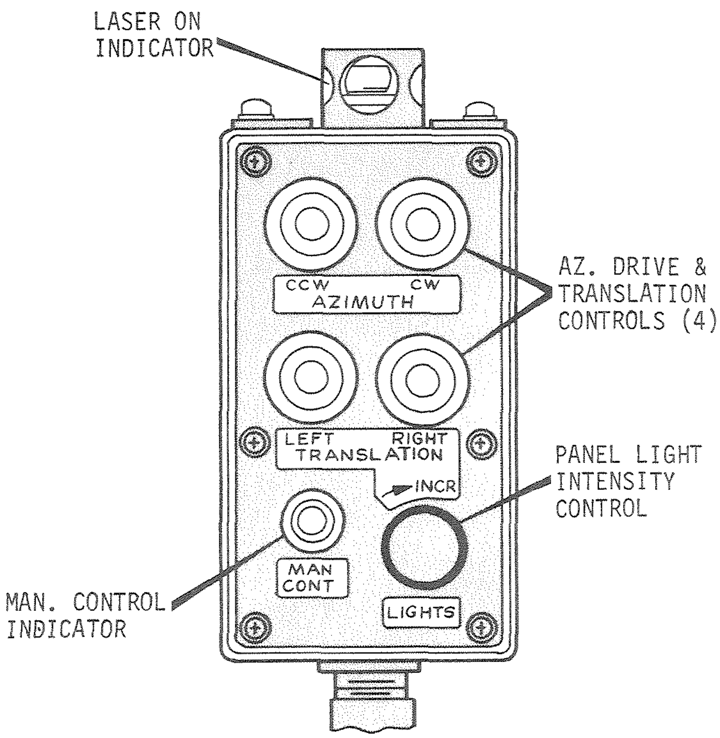


Figure 11-11. Manual Control Unit

Precise emplacement of the ARU tripod relative to the missile platform is achieved by the system shown in Figure 11-12. A modification to the erector-launcher provides an arm which is swung into position and accurately fixed. Two chains hang from this arm, and when the tripod is properly placed these chains pass through a 1 inch hole on the tripod's vertical rotational axis and through a 1-inch hole in the fixed tripod leg.

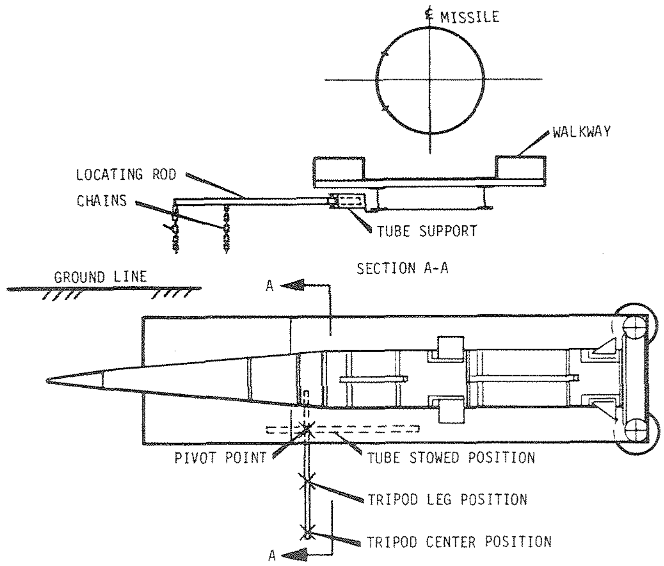


Figure 11-12. Tripod Emplacement Device

Sequential Launch Adapter

The sequential launch adapter (SLA) provides the Pershing platoon commander with a capability to sequentially count down and launch up to three missiles with a single PTS and PS without recabling between individual firings.

The sequential launch adapter consists of the SLA box, cables, air ducts, air hoses, and a trailer (Figure 11-13).

The SLA functions within the platoon as a centralized interfacing and control switching system, which serves as an interface between the PTS/PS, the 45 kW auxiliary power source, the battery control central, and the three launch position systems; missile, EL, and ARU. The SLA accomplishes switching of all applicable countdown functions from one firing platoon in less than 30 seconds. Switching is independent of missile firing order within the platoon. The SLA permits the performance of confidence/standard or quick (reduced) countdown operations sequentially on as many as three missiles without movement of the PTS/PS vehicle or disconnection/connection of cables, air ducts, and/or air hoses.

A representative SLA emplacement is shown in Figure 11-14. Using the SLA, each launch position system may be placed in a countdown or standby mode.

When a countdown (confidence, standard, or quick) is performed, the SLA switches out standby power and switches in countdown power and signals, as well as air conditioning and high pressure air to the missile being counted. This is accomplished by the

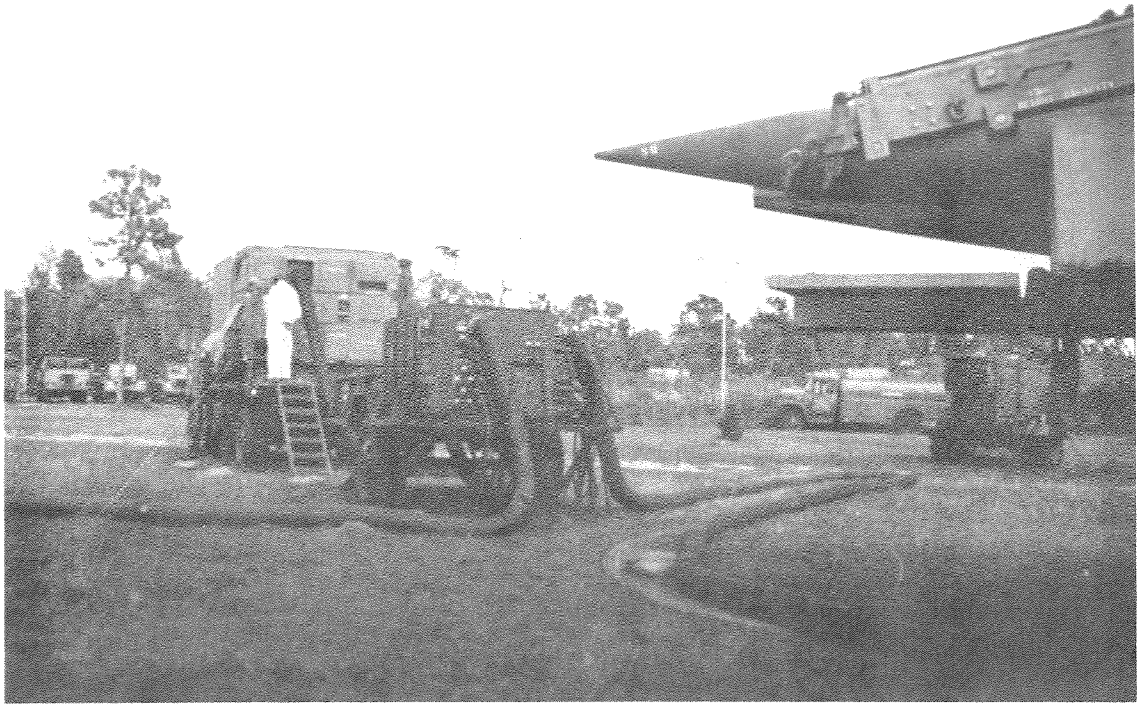


Figure 11-13. Sequential Launch Adapter

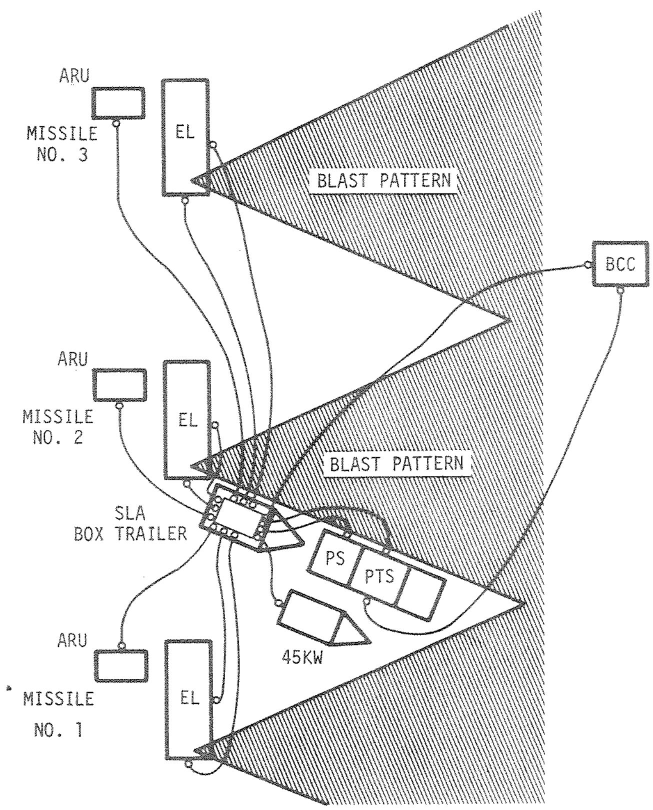


Figure 11-14. SLA Tactical Site Layout Configuration

PTS operator selecting the missile to be counted by entering it in the keyboard on the PTS console.

Standby power must be maintained at the other missiles. After a missile has been counted, countdown power and signals are switched through the SLA to the next missile to be counted. The SLA provides power to the other two EL's so that standby conditioning, gyro rundown, missile recapture, or EL evacuation operations may be performed. All prescribed action link (PAL) functions are switched by SLA to the missile being counted. The SLA switching of all functions related to the selected operating mode will be independent of the selected launch position system. A visual display of the selected operating mode of each launch position is incorporated on the SLA box status panel.

The system also retains the capability of operating without the SLA box if the SLA malfunctions. In this case, the cables for each missile-EL combination to be counted are connected (1 set at a time) directly to the PTS and PS. Standby power is provided via 45 kW generator and power distribution box in a manner similar to operations prior to usage of the SLA.

Countdown Mode

Whenever the countdown mode has been selected for a specific launch position, the SLA switches the following countdown functions to the selected launch position system:

1 All countdown, communications, recapturing, and firing operations required for the performance of standard/confidence or quick (reduced) counts initiating from the PTS/PS to the appropriate launch position system;

2 All conditioned and high pressure air required from the PS by the guidance and control section;

3 All ac and dc power required from the PS by the launch position systems. Power will be switched to the launch position after all signal channels have been connected;

4 All PAL functions exchanged between the BCC and the warhead.

The other launch positions are in the standby mode.

Standby Mode

Whenever a launch position has not been selected for countdown, that launch position is in the standby mode. The following standby functions are maintained at, or individually switched by, SLA to the launch position system(s):

1 G&C section blanket heater power

2 ST-120 strip heater power, control, and status

3 Erector-launcher power

4 Communications

5 Gyro rundown

In addition, during standby operations when the power station is shut down, environmental conditioning power is provided to the PTS.

The SLA permits simultaneous operation of the 45 kW generator (standby) and PS (counting) without detriment to the weapon system.

Electrical Section

The SLA electrical section consists of signal and power entry panels, signal and power switching, wiring, power supply, and status panel.

The signals and commands processed by the SLA are identical to those transmitted and received with a single PIa missile connected to the PTS/PS/BCC. Therefore, the Ledex switches used for signal and command routing within the SLA are of prime concern.

The selection of a missile for counting or standby is initiated by the PTS operator. This is accomplished by an entry on the PTS computer control panel where 0 through 3 are entered respectively for selection of standby or EL positions one through three. The select command signal through relay logic in the SLA selects the selected position on the S1 Ledex switch. The S1 Ledex switch reaching its selected position, which is monitored by a PTS monitor, in turn sends a signal to switch 2 and the selection methods cascade to switches 3 through 10. Switch 10 is then monitored by the PTS which, when a go condition is reached, indicates that all the switches 1 through 10 have been set to the prescribed input by the PTS operator.

The selected positions are monitored for proper position and constantly monitored to assure that the select enable is not reactivated and that once a position is reached the switch position does not change. If either of the foregoing occur the system is shut down by emergency interrupt before the switch can reach the next position.

The ten Ledex switches in the SLA, used to transfer signals between the PTS/PS/BCC and missiles, are stepping types that are actuated electro-mechically. They have 67 poles to each of the missile positions.

The input of each Ledex switch is connected to a single command or signal cable of the PTS. A typical Ledex switch connection between the PTS and the missile cable mast is shown in Figure 11-15. The concept of one Ledex switch connected to a single PTS input cable is used to preserve the work performed previously of selecting and analyzing signals/command wires for specific cables to eliminate problems of cross-talk or incompatibility.

The switch size is large enough so that the signal density of the cable connector is much greater than the density inside the switch. Each switch has five 61 pin connectors, one for control, one input, and three outputs.

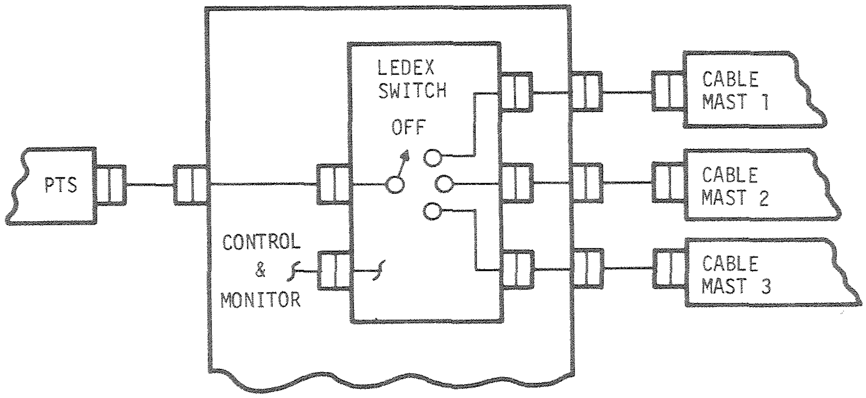


Figure 11-15. Typical One-Line SLA Connection Diagram

Pneumatic Section

The pneumatic section houses the high pressure and conditioned air interface couplings, switches, and ducts.

The high pressure air schematic is shown in Figure 11-16. The switches are electrically operated, normally closed, solenoid valves that are presently used and qualified in the Pershing Ia system. A pressure gage and a manual bleed valve are located adjacent to each of the three missile supply outlet couplings to comply with the personnel safety requirements for high pressure air systems. By monitoring the gage and operating the bleed valve as required, the operator will not connect or disconnect the missile supply hose under pressure.

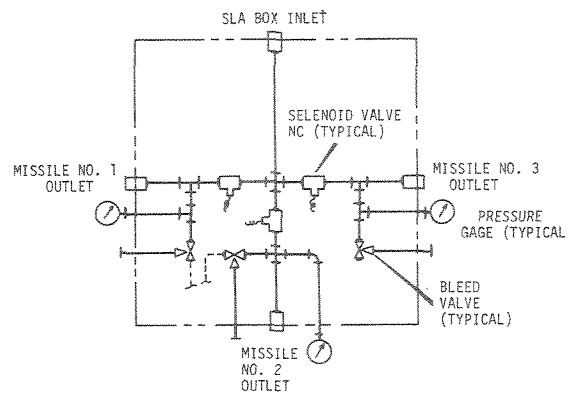


Figure 11-16. High Pressure Air Switching Schematic

This air is fed and exits from the SLA via 1/4 inch flexible hoses. Interface connectors are Wiggin types with automatic seals on both mating sections of each connector. All tubing inside the SLA is 1/4 inch stainless steel with flaired 'B' nut tubing connectors and is anchored at given intervals to the inside of the SLA structure to reduce the possibility of faulting due to vibration. All steel and flex hoses are initially proof-tested to 6,000 psig and undergo periodic testing at 4,500 psig with the transportable mechanical shop set maintenance shelter. In addition, protection to personnel consists of caution signs at each input/output high pressure port, high pressure bleed valves and associated gauges. All bleed valves are exhausted inside the SLA box and are directed away from all access openings. A final precaution is safety lanyards which connect the flexible interface hoses mechanically to the SLA housing, thereby preventing hoses whipping in case an unbled hose becomes disconnected and the valve within the disconnect fails to seat.

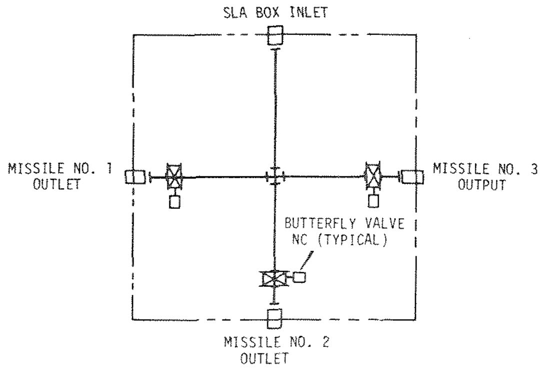


Figure 11-17. SLA Conditioned Air Switching Schematic

Three high pressure air hose assemblies (one each per missile) connect the SLA box to the EL cable masts. These high pressure air hose assemblies are 120 feet long and are made up of existing type hose assemblies connected together in series by standard MS type hose unions.

The conditioned air schematic is shown in Figure 11-17. The switches are electrically energized, normally closed, motor driven, butterfly type valves. The valves are programmed so one valve is always open to prevent excessive back pressure on the power station air conditioner.

Three conditioned air duct assemblies (one each per missile) connect the SLA box to the EL cable masts. Each of these conditioned air duct assemblies is 126 feet long and made up of seven sections of the existing type air ducts.

Communications

Communications are distributed to each EL position through the SLA and to two phone positions on the aft SLA panel. When all missiles are on standby, all EL's may transmit and receive hot loop communications. When a missile is selected for counting only, that EL position can transmit and receive. The EL's for the standby missiles in this case can receive but cannot transmit.

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