LESSON ASSIGNMENT SHEET

ADA SUBCOURSE 703-3	--Nike Hercules Launching Area.
LESSON 2	--Nike Hercules Missile.
CREDIT HOURS	--2.
TEXT ASSIGNMENT	--Attached memorandum.
MATERIALS REQUIRED	--None.
SUGGESTIONS	--See appendix for unfamiliar terms and abbreviations.

TRAINING OBJECTIVES

Listed below are the training objectives for this lesson. These objectives tell you what you should be able to do as a result of your studies. Therefore, you should be familiar with the objectives before you start to study.

When you have completed this lesson, you should be able to:

1. State the purpose of the Nike Hercules missile body and rocket-motor cluster and list the three major components of each.

2. List the major components of the forward body section, warhead body section, missile motor section, equipment section, actuator section, and main fins and recognize the purpose of each.

3. Recognize the relationship between elevon movement and pitch (P), yaw (Y), and roll maneuver effects.

4. List the components of the rocket-motor cluster and recognize the purpose of each.

5. State the three functions of the guidance system; list the four groups of circuits in the guidance system and recognize the function of each.

6. State the function of the hydraulic system, list its five components, and recognize the function of each.

7. Recognize the functional components of the rocket motor (rocket-motor cluster) and the missile rocket motor and the method of igniting the propellant in each.

8. List the three components of the warhead system and state the function of each.

ATTACHED MEMORANDUM

(This memorandum consists of material approved for resident instruction in the US Army Air Defense School and conforms to current Department of the Army doctrine.)

Section I. PHYSICAL DESCRIPTION

1. MAJOR COMPONENTS

The Nike Hercules missile has a cruciform, dart configuration. It is approximately 39 feet long overall and weighs 10,550 pounds. It consists of a missile body and rocket-motor cluster (fig 2-1).

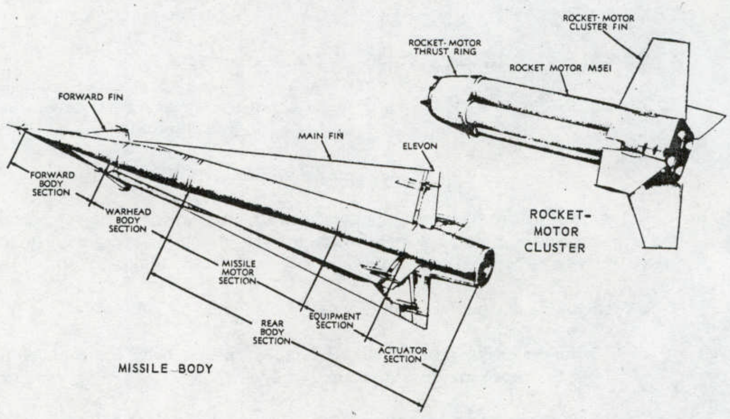

Figure 2-1. Nike Hercules missile body and rocket-motor cluster.

a. Missile body. The missile body delivers the Nike Hercules high-explosive (HE) or nuclear warhead to the target in response to commands originating in the computer and transmitted by the MTR. The missile body is 27 feet long and weighs 5,250 pounds. Its maximum diameter is 31.5 inches.

b. Rocket-motor cluster. The rocket-motor cluster provides initial thrust for lift-off and acceleration of the missile. It is 14 feet long and weighs 5,300 pounds. It consists primarily of a thrust ring, four rocket motors, and four fins. The thrust ring fits over the rear two feet of the missile body.

2. MISSILE BODY

The missile body (fig 2-1) consists of a forward body section, warhead body section, and rear body section. The rear body section, in turn, consists of a missile motor section, equipment section, and actuator section. The missile body is formed by riveting aluminum skin sections to structural frames. Four forward and four main fins are attached to the missile body.

a. Forward body section. The forward body section (fig 2-2) consists of a nose tip, forward nose section, rear nose section, and four forward fins. It contains the missile guidance set and four ram pressure probes.

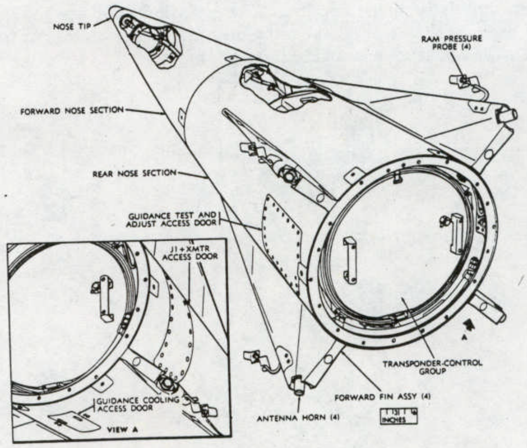

Figure 2-2. Forward body section.

(1) Missile guidance set consists of a transponder control group, four antenna horns, a waveguide set, fail-safe control, and sequential timer. The transponder control group, in turn, consists of a radio set and flight control group. The antenna horns, mounted at the rear of the forward fins, receive radiofrequency (RF) signals transmitted by the MTR and radiate signals produced by the radio set. The waveguide set provides RF signal paths between the transponder control group and antenna horns. The fail-safe control initiates detonation of the warhead if the missile fails to receive guidance commands from the MTR. The sequential timer introduces additional time delay between the burst command and warhead detonation. The fail-safe control and the sequential timer, although part of the guidance set, are installed in the warhead body section.

(2) Forward fins, mounted on the exterior of the forward body section, position the center of pressure on the rear main fins at supersonic speeds to permit instantaneous response to elevon deflection.

(3) Ram pressure probes, mounted on the forward fins, sample stagnation pressure (summation of atmospheric and dynamic (ram) pressure) for the pressure transmitter in the flight control group.

b. Warhead body section. The warhead body section (fig 3-3) contains the warhead, two safety and arming devices, an explosive harness, and the guidance set fail-safe control and sequential timer. The safety and arming devices are acceleration-type, arming-delay devices that prevent accidental warhead detonation. The explosive harness provides a firing path between the safety and arming devices and the warhead. A T-hook adapter extends downward from the rear of the warhead section to secure the missile to the launching-handling rail.

c. Missile motor section. The missile motor section (forward portion of the rear body section) (fig 2-3) contains the missile rocket motor, two initiators, safety and arming switch, and heating and insulating equipment.

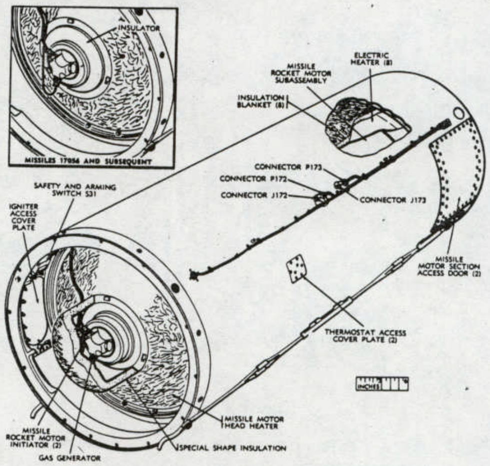

Figure 2-3. Missile motor section.

(1) The missile rocket motor provides increased missile acceleration after rocket-motor cluster burnout. A blast tube extends from the rear of the motor through the equipment and actuator sections, culminating in a nozzle at the rear of the missile body. The blast tube directs the gases generated by the motor through the nozzle, which, in turn, provides maximum thrust for propelling the missile body.

(2) Initiators, installed on the gas generators at the front of the missile rocket motor, are threaded fittings that contain explosive charges. They ignite the gas generator, which, in turn, ignites the propellant in the missile rocket motor.

(3) The safety and arming switch, on the inner forward portion of the missile motor section, is an inertia-type switch. It is armed during missile acceleration after lift-off to complete an electrical path between the initiators and thermal batteries (e below).

(4) Heating and insulating equipment maintains the missile rocket motor at the correct operating temperature prior to lift-off. This equipment consists of eight electric heaters, a head heater, eight insulation blankets, an insulator, and two thermostats. The heaters operate on external power.

d. Equipment section. The equipment section (fig 2-4) contains a hydraulic pumping unit (HPU), HPU squib battery, ventilator assembly, missile battery system, missile distribution box, and missile umbilical cable.

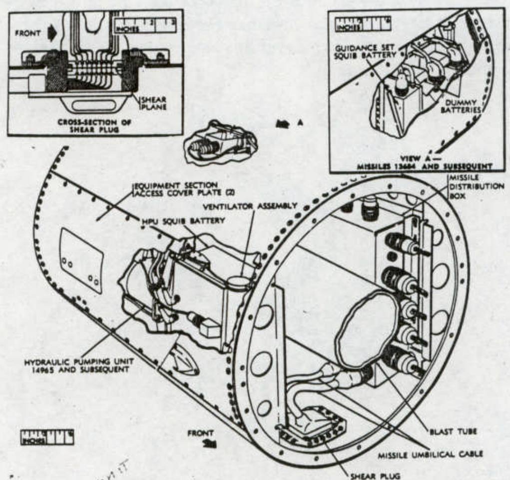

Figure 2-4. Equipment section.

(1) The HPU provides hydraulic power for three actuator assemblies in the actuator section.

(2) The HPU squib battery, on the right side of the equipment section, provides electrical power for the HPU. The ventilator assembly provides ventilation for the HPU squib battery.

(3) The missile battery system, on the left side of the equipment section, provides electrical power for the guidance set. It consists of a guidance set squib battery and two dummy batteries mounted on a rack.

(4) The missile distribution box is the distribution point for electrical power to the entire missile body.

(5) The missile umbilical cable provides electrical connections for external power and control signals prior to lift-off. It passes through the missile body skin at the bottom of the equipment section by means of a shear plug, which severs external connections at lift-off.

e. Actuator section. The actuator section (fig 2-5) contains three actuator assemblies, a propulsion arming lanyard, and a thermal battery assembly. The rear end of the blast tube and blast tube nozzle extend into this section. The actuator assemblies hydraulically activate a series of mechanical linkages to position the elevons. The propulsion arming lanyard is a steel cable screwed into the thermal battery trigger at one end and fastened to a bracket on the rocket-motor cluster thrust ring assembly at the other end. When the rocket-motor cluster separates from the missile body at burnout, the lanyard is pulled, activating two thermal batteries of the thermal battery assembly. The thermal battery assembly, at the forward end of the actuator assembly, provides an electrical charge that activates the missile rocket-motor initiators.

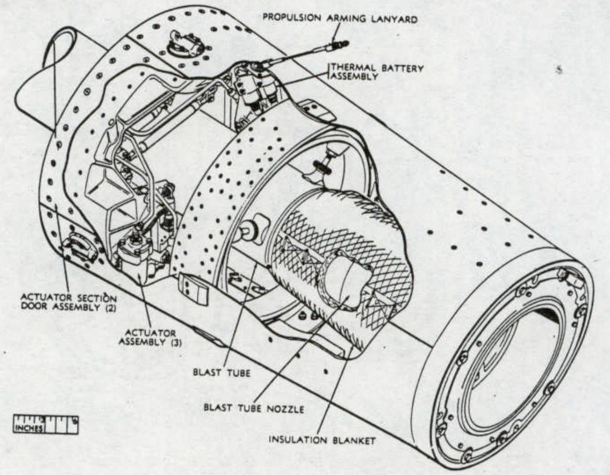

Figure 2-5. Actuator section.

f. Main fins and elevons. The main fins (fig 2-6) provide aerodynamic lift and flight stability. Each consists of a forward main fin and rear main fin. The forward main fin is attached to and extends through most of the length of the warhead section. The rear main fin is attached to and extends through most of the length of the rear body section. The fins are formed of aluminum skin attached to structural members. The elevons provide aerodynamic maneuverability. An elevon is attached to the trailing edge of each rear main fin and to the actuator section. A balance is bolted to the leading edge of the elevon to maintain aerodynamic stability.

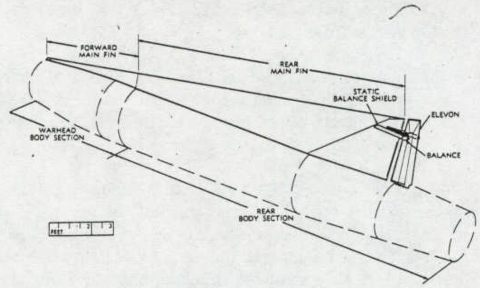

Figure 2-6. Main fin.

g. Missile body orientation and maneuver. The missile body maintains the same orientation on its trajectory as it does on the launching-handling rail. Proper orientation is evidenced by the location of the missile body T-hook adapter and umbilical cable on the underside and an indexing pin at the 12-o'clock position at the rear of the missile body. Facing the rear of the missile, the main fins and elevons are numbered 1, 2, 3, and 4 clockwise, starting with the fin at the left of the indexing pin (fig 2-7(1)). The forward fins, ram pressure probes, and antenna horns are in line with the main fins and are numbered accordingly. The elevons control missile maneuver in pitch, yaw, and roll. Pitch and yaw are movement about the horizontal and vertical axes of the missile body, respectively. Roll is movement about the longitudinal axis of the missile body. Elevons 2 and 4 are designated the pitch elevons and 1 and 3, the yaw elevons; however, neither of these pairs is alined with its respective axis. Therefore, a pitch (climb or dive) or a yaw (right or left) missile displacement requires operation of both pairs of elevons. The direction of elevon movement and the resultant (R) missile displacement for each maneuver are shown in figure 2-7.

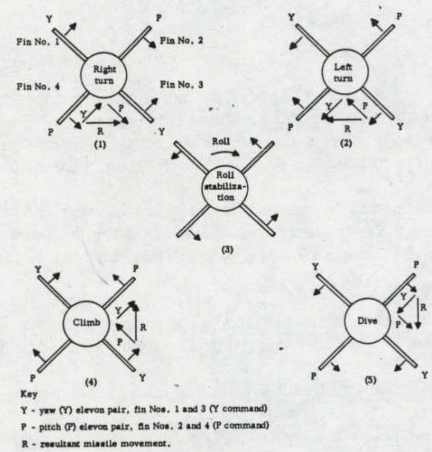

Figure 2-7. Missile body orientation and maneuver.

3. ROCKET-MOTOR CLUSTER

The rocket-motor cluster (fig 2-8) consists of a rocket-motor thrust ring assembly, four rocket motors, four igniters, four fins, four fitting assemblies, and fairings.

a. Rocket-motor thrust ring assembly. This assembly supports the forward end of the rocket-motor cluster. It contains an internally tapered opening that mates with the taper of the rear body section to form a rigid slip joint. Four elevon locks at the forward end of the thrust ring assembly hold the elevons motionless during the boost phase of the missile.

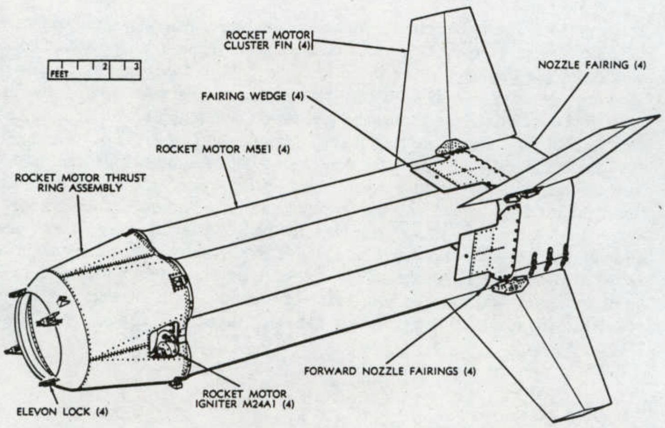

Figure 2-8. Rocket-motor cluster.

b. Rocket motors. The four rocket motors provide initial thrust for the missile. Each consists of a solid propellant encased in a steel cylinder with a steel closure at the forward end and a steel nozzle at the rear end. The rocket motors are held together by the thrust ring assembly at the front and four fitting assemblies at the rear.

c. Rocket motor igniters. One igniter is located on the forward end of each of the four rocket motors. Each igniter is a threaded fitting that contains an explosive charge for igniting the propellant in the rocket motor. The igniters are installed during final preparation of the missile.

d. Rocket-motor cluster fins. These fins stabilize the missile aerodynamically during the boost phase. They are formed of aluminum riveted to a spar and ribs.

e. Fitting assemblies. The fitting assemblies provide support for the rocket motors.

f. Fairings. The forward nozzle fairings, fairing wedges, and nozzle fairings are attached to the fitting assemblies to improve the aerodynamic characteristics of the rocket-motor cluster.

Section II. FUNCTIONAL DESCRIPTION

4. GUIDANCE SYSTEM

The guidance system (fig 2-9) is one of the four functional systems of the Nike Hercules missile. The others are the hydraulic, propulsion, and warhead systems. The guidance system performs three primary functions: controls missile flight according to computer-generated guidance commands; transmits RF response pulses that enable the MTR to track the missile; and detonates the warhead upon receipt of a burst command, if ground guidance ceases, or if a malfunction occurs within the missile. To perform these functions, the guidance system has receiving and decoding circuits, transmitting circuits, command and fail-safe detonation control circuits, and steering control circuits. Before launch, power for operating these circuits is provided by the launching section. Just prior to lift-off, the 28-volt, guidance-set, squib battery is activated to provide power for these circuits.

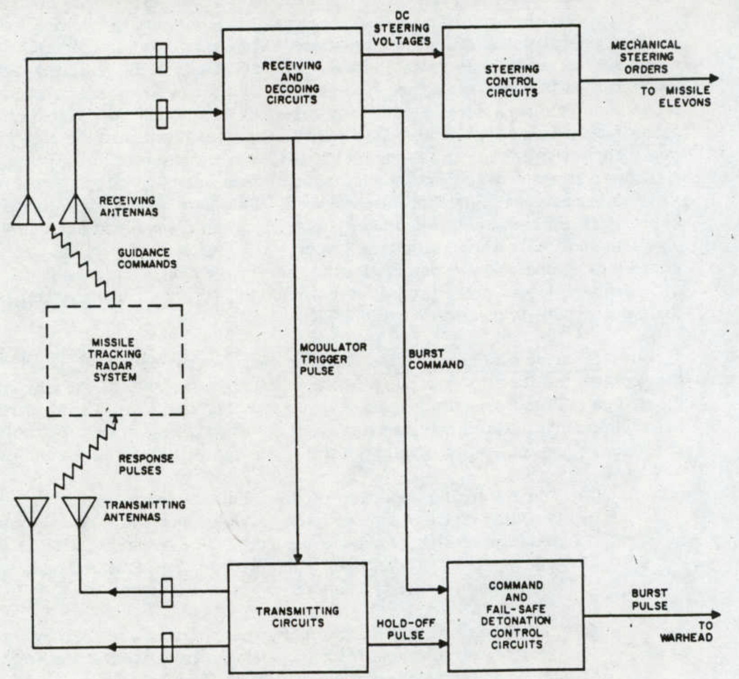

Figure 2-9. Guidance system block diagram.

a. Receiving and decoding circuits. These circuits receive pulse groups from the MTR through the receiving antenna horns (Nos. 2 and 4) and determine whether they contain the correct battery code. If so, they are processed to obtain a modulator trigger and to extract the incorporated pitch and yaw commands. A modulator trigger is produced for each pulse group received. It is applied to the transmitting system. The pitch (P) and yaw (Y) commands are converted to pitch and yaw dc steering voltages and applied to the steering control circuits. The pulse group is then applied to the command and fail-safe detonation control circuits for decoding to extract the burst command (if present).

b. Transmitting circuits. The transmitting circuits produce an RF response pulse for each modulator trigger pulse received from the receiving and decoding circuits. Upon receipt of the trigger pulse, the transmitter develops a high-voltage dc pulse. The high-voltage dc pulse is applied to a magnetron, causing it to oscillate and produce an RF pulse. The RF pulse is coupled to the transmitting antenna horns (Nos. 1 and 3) for radiation. At the same time, the transmitting circuits produce a dc hold-off pulse that is applied to the command and fail-safe detonation control circuits.

c. Command and fail-safe detonation control circuits. These circuits provide detonation of the warhead by ground guidance equipment (command detonation) or by operation of the fail-safe circuits (fail-safe detonation). They consist of an electronic switch in the guidance set and a fail-safe control and a sequential timer in the warhead section. Command detonation is initiated when the pulse groups from the MTR contain a burst command. The burst command consists of an enabling series of pulses that condition the electronic switch to accept the burst command and an additional series that cause the electronic switch to apply a burst voltage to the sequential timer. Upon receipt of the burst voltage, the sequential timer starts a timing action and, after a short delay, applies a burst pulse to the safety and arming devices to detonate the warhead. Fail-safe detonation is initiated when the fail-safe control fails to receive hold-off pulses from the transmitting circuits for 3 to 7 seconds. The fail-safe control then produces a burst pulse and applies it to the safety and arming devices to detonate the warhead. Failure to receive hold-off pulses may result from receipt of improperly coded pulse groups, a malfunction in the guidance system, or failure to receive the pulse groups transmitted by the MTR.

d. Steering control circuits. The steering control circuits (fig 2-10) generate voltages that control the flow of hydraulic oil to the actuator assemblies, thereby controlling elevon movement. These circuits consist of three steering amplifiers (P, Y, and roll control) and associated flight instruments and fin feedback variable resistors. The voltages produced by the steering amplifiers are applied to the P, Y, and roll actuator assemblies, respectively.

(1) The P steering amplifier receives dc steering voltages from the receiving and decoding circuits and feedback voltages from the P accelerometer, P rate gyro, and P fin feedback variable resistor. The feedback voltages reduce the magnitude of the pitch maneuver when missile acceleration, pitch movement, or elevon displacement, respectively, are excessive.

(2) The Y steering amplifier receives dc steering voltages from the receiving and decoding circuits and feedback voltages from the Y accelerometer, Y rate gyro, and Y fin feedback variable resistor. The feedback voltages reduce the magnitude of the yaw maneuver when missile acceleration, yaw movement, or elevon displacement, respectively, are excessive.

(3) The roll control amplifier receives dc voltages initially from the roll-amount gyro and subsequently from the roll-amount gyro, pressure transmitter, roll-rate gyro, and roll fin feedback variable resistor. The roll-amount gyro is preset prior to lift-off so that its spin axis is alined with the predicted intercept plane. After rocket-motor cluster separation, the roll-amount gyro produces a roll control voltage to aline the belly of the missile with the predicted intercept plane. After the missile is on trajectory, the roll-amount gyro produces a feedback voltage to maintain the belly-to-ground orientation of the missile. The pressure transmitter produces increased feedback for increased stagnation pressure, which includes atmospheric and dynamic (ram) pressure acting on the

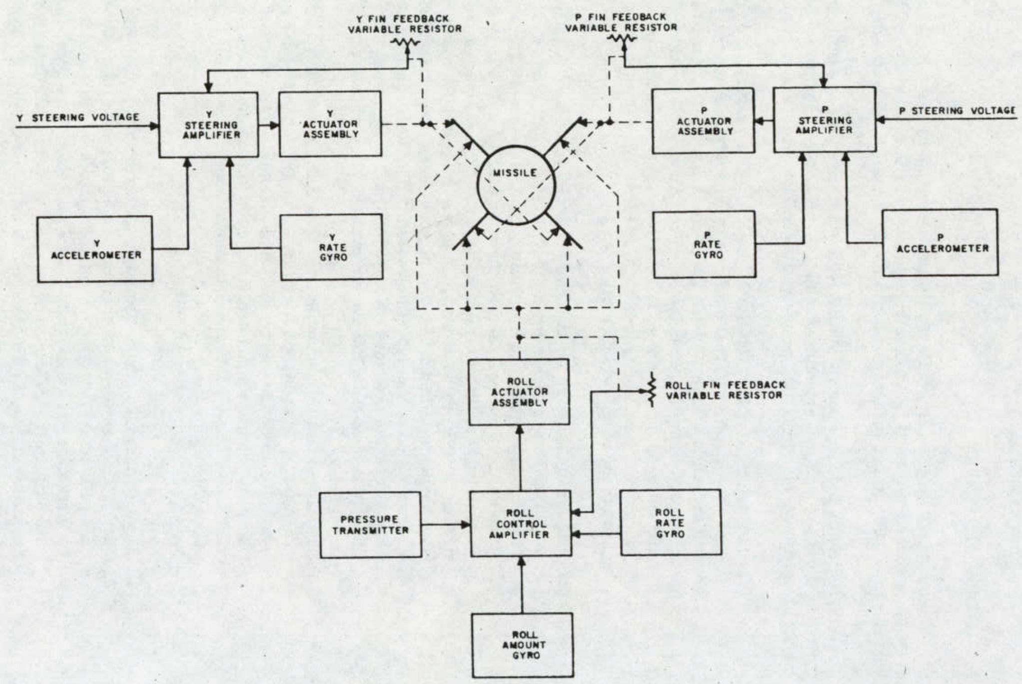

Figure 2-10. Steering control circuits, block diagram.

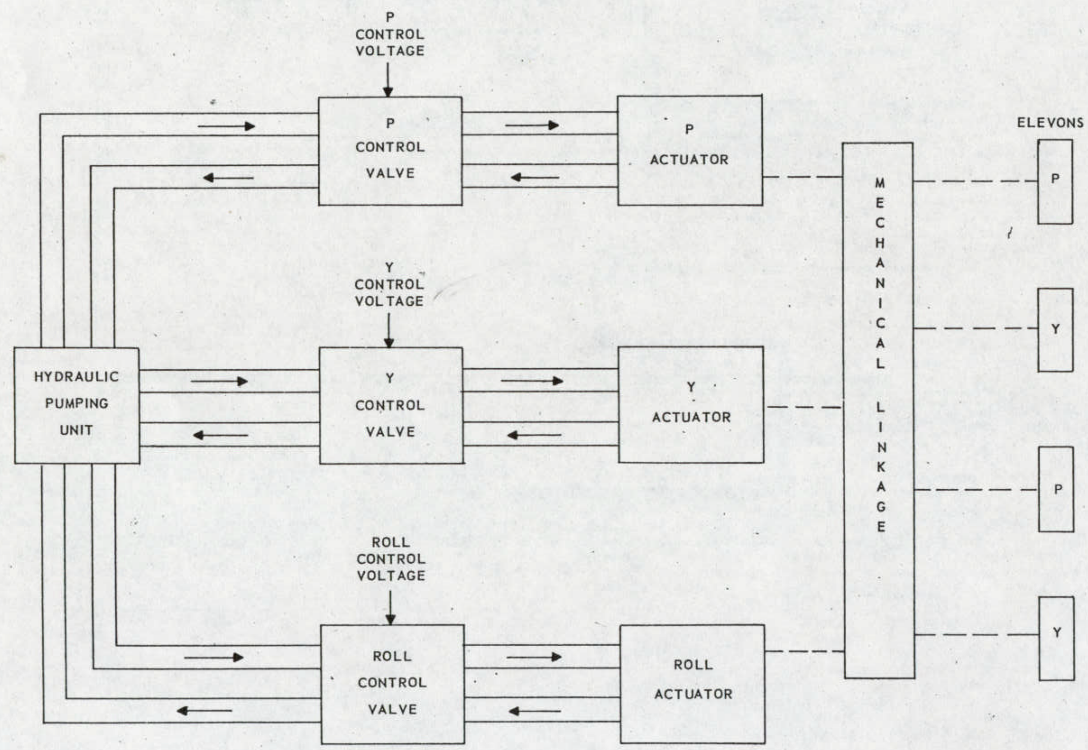

Figure 2-11. Hydraulic system, block diagram.

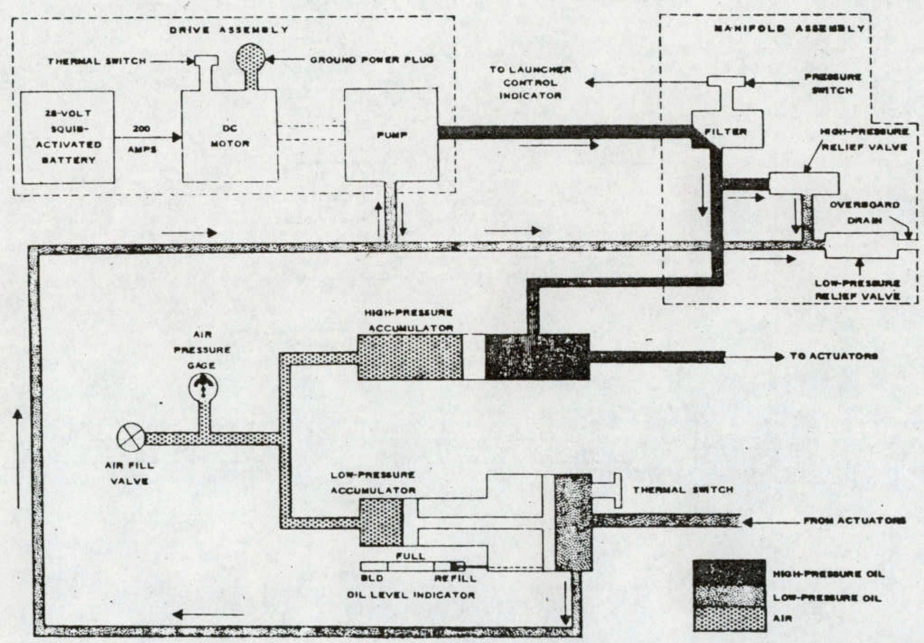

Figure 2-12. Hydraulic pumping unit, schematic diagram.

b. Actuator assembly. Each of the three actuator assemblies (P, Y, and roll) consists of a missile control valve, actuator, and fin feedback variable resistor (fig 2-13). The actuator assembly converts electrical signals from the control amplifier to mechanical displacements by controlling the flow of hydraulic oil. High-pressure oil enters the pressure port and passes through a filter to the missile control valve. When the current in the two solenoids of the missile control valve is unequal, the plunger moves toward the solenoid with the larger current permitting oil to flow to one side of the actuator cylinder. In figure 2-13, plunger is displaced to the left, permitting oil to flow into the left side of the actuator cylinder, moving the piston to the right. The pickoff arm on the fin feedback variable resistor also moves and produces a feedback voltage to the control amplifier. When the piston has moved to the position determined by the guidance command, the feedback voltage causes the control amplifier to equalize the currents in the two solenoids, thereby allowing the plunger to return to its center position, equalizing the pressure on both sides of the piston, and stopping movement of the piston.

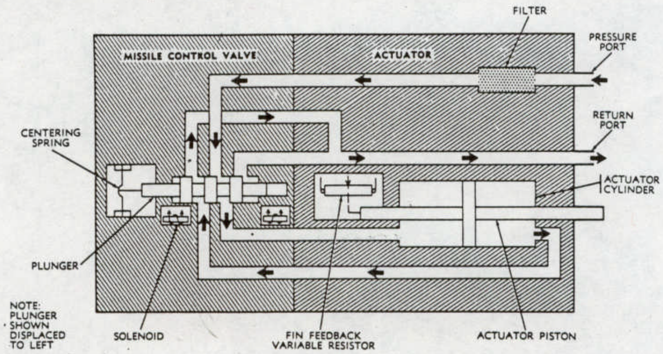

Figure 2-13. Actuator assembly, schematic diagram.

c. Mechanical linkage. The mechanical linkage converts movement of the P, Y, and roll actuator pistons into corresponding movement of the P and Y elevons. The mechanical linkage is capable of combining simultaneous P, Y, and roll orders.

6. PROPULSION SYSTEM

The propulsion system (fig 2-14) consists of the rocket-motor cluster and the missile rocket motor. The rocket-motor cluster motors are ignited simultaneously to provide initial thrust for the Nike Hercules missile. The missile rocket motor ignites after rocket-motor cluster separation and provides final thrust.

a. Rocket-motor cluster. Each of the four rocket motors in the rocket-motor cluster (fig 2-14) consists of a head, combustion chamber, and nozzle. During final preparation of the missile, an igniter is inserted in the head. The igniter contains four squibs. The squibs are connected to a rocket-motor igniter cable that terminates in a connector. A shorting plug is attached to the connector to prevent accidental ignition. When the missile is prepared for firing, the shorting plug is removed and the igniter cable connected to the firing circuit. Shortly after the launch order is issued, external voltage is applied to the igniter cable causing current to flow through the cable to the squibs. The squibs fire, igniting an explosive charge in the igniter. The explosive charge ignites the propellant in the rocket motor. Gases generated by the burning propellant are expelled through the nozzle providing the thrust for missile lift-off and acceleration (boost phase).

b. Missile rocket motor. The missile rocket motor consists of two initiators, a gas generator, combustion chamber, blast tube, and blast tube nozzle (fig 2-14).

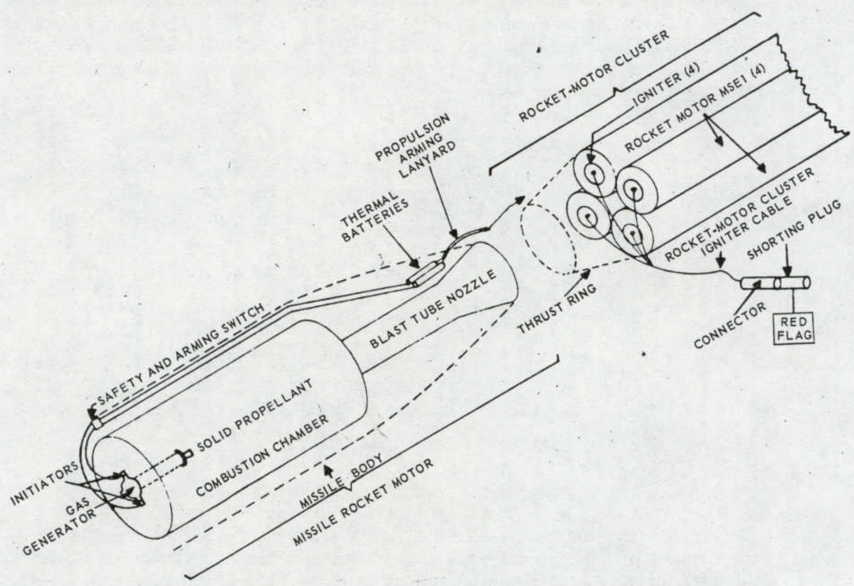

Figure 2-14. 'Propulsion system.

(1) The two initiators are activated by current from the thermal batteries. At burnout, the rocket-motor cluster separates from the missile body, pulling the lanyard. This action causes the thermal batteries to activate and produce the current for the initiators. Prior to the boost phase, the safety and arming switch applies a short across the two initiators and opens the circuit from the thermal batteries to prevent premature firing of the missile rocket motor. During the boost phase, the force of the acceleration arms the switch, thereby removing the short and completing the circuit to the thermal batteries.

(2) The gas generator contains a pellet charge, diaphragm, ignition chamber, and nozzle. The initiators, when fired, ignite the pellet charge at the forward end

of the gas generator. The pressure produced by the pellet charge ruptures the diaphragm, allowing the combustion to spread to the ignition chamber. Hot, burning gases are then forced through the nozzle onto the solid propellant fuel in the combustion chamber.

(3) The solid propellant fuel in the combustion chamber, ignited by the gases from the gas generator, burns, forcing gases through the blast tube and blast tube nozzle. Thrust is thereby produced to propel the missile.

7. WARHEAD SYSTEM

The warhead system provides the means for detonating the warhead. The Nike Hercules system uses an HE or nuclear warhead. The HE warhead system consists of two safety and arming devices, explosive harness, and HE warhead.

a. Safety and arming device. The two safety and arming devices are plug-in devices that initiate detonation of the warhead upon receipt of the burst voltage from the guidance system fail-safe control. They also act as a safety device to prevent accidental detonation of the warhead in the vicinity of the launching area.

b. Explosive harness. The explosive harness provides a detonation path from the safety and arming devices to the HE warhead.

c. HE warhead. Upon detonation, the HE warhead provides an approximately spherical distribution of fragments for destroying the target.

REQUIREMENT. Solve the following multiple-choice exercises and record your solutions on the optical scan answer form. All exercises are of equal weight (5 points). Select the one CORRECT choice. If more than one choice is correct, select the BEST one.

1. The warhead body section contains all the following components except the
   a. initiators.
   b. explosive harness.
   c. T-hook adapter.
   d. safety and arming devices.

2. The missile HPU provides power to the
   a. missile distribution box.
   b. actuator assemblies.
   c. elevons.
   d. guidance set.

3. The purpose of the propulsion lanyard is to
   a. activate the thermal batteries.
   b. activate the squib batteries.
   c. activate the igniters.
   d. initiate missile launch.