# LESSON 2. MISSILE FUNCTION

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| MMS Subcourse No 151 . . . . . . . . . . . . . . . . . . . . | Nike Missile and Test Equipment |
| Lesson Objective . . . . . . . . . . . . . . . . . . . . . . . . | To provide you with a general knowledge of the basic functions of the units in the Nike Hercules missile, to include the rocket motor cluster, missile rocket motor, hydraulic system, guidance system, and the warhead system. |
| Credit Hours . . . . . . . . . . . . . . . . . . . . . . . . . . | Two |

## TEXT

1. **INTRODUCTION.** The Nike Hercules guided missile is a two-stage solid propellant missile. The complete round consists of five major units: rocket motor cluster, missile rocket motor, guidance set, missile hydraulic system, and warhead system. This lesson will explain how each of these units function to deliver and explode the warhead at the intercept point.

2. **ROCKET MOTOR CLUSTER.**

a. The rocket motor cluster (fig 1) is a solid propellant booster unit consisting of a thrust structure, four igniters, four rocket motors, four fins, fairing, filler blocks, and the necessary hardware for assembly. The four cruciform fins are mounted at 90 degree angles around the booster and are used to stabilize the missile aerodynamically during the boost period.

b. The thrust structure joins the rocket motor cluster to the missile body. The thrust structure is a rigid slip joint with a tapered opening so it will mate with the boattail of the missile and lock the missile elevons into position. Relative motion between the missile and the rocket motor cluster is prevented by an indexing pin on the missile boattail which engages a recess in the thrust structure.

c. Each of the four rocket motors in the cluster is identical and only one will be discussed. It consists of a steel head, a steel combustion chamber, and a steel nozzle as shown in figure 2. The combustion chamber contains a solid propellant fuel, cast in a symmetrical pattern, forming nine gas passages (A, fig 2). To insure uniform burning, each gas passage contains a steel resonance rod. A linear of inhibited cellulose acetate around the propellant prevents burning on the outside of the propellant. An insulating coating on the inside surface of the combustion chamber protects the thin metal wall from the high heat of combustion. A nozzle closure provides a cemented seal that protects the propellant prior to ignition. When the propellant ignites, the seal blows out and the escape of gases through the nozzle produces the thrust required to propel the missile during the boost period.

d. The rocket motor igniter (B, fig 2), consists of 2.2 pounds of explosive – a mixture of two grades of black powder and mortar propellant – housed in a polystyrene cup. Ignition is accomplished one-half second after the launch order by applying a 120-volt alternating current (AC) to the rocket motor igniter. The current flow through the four squibs fires the explosive charge in each of the rocket motor igniters thereby

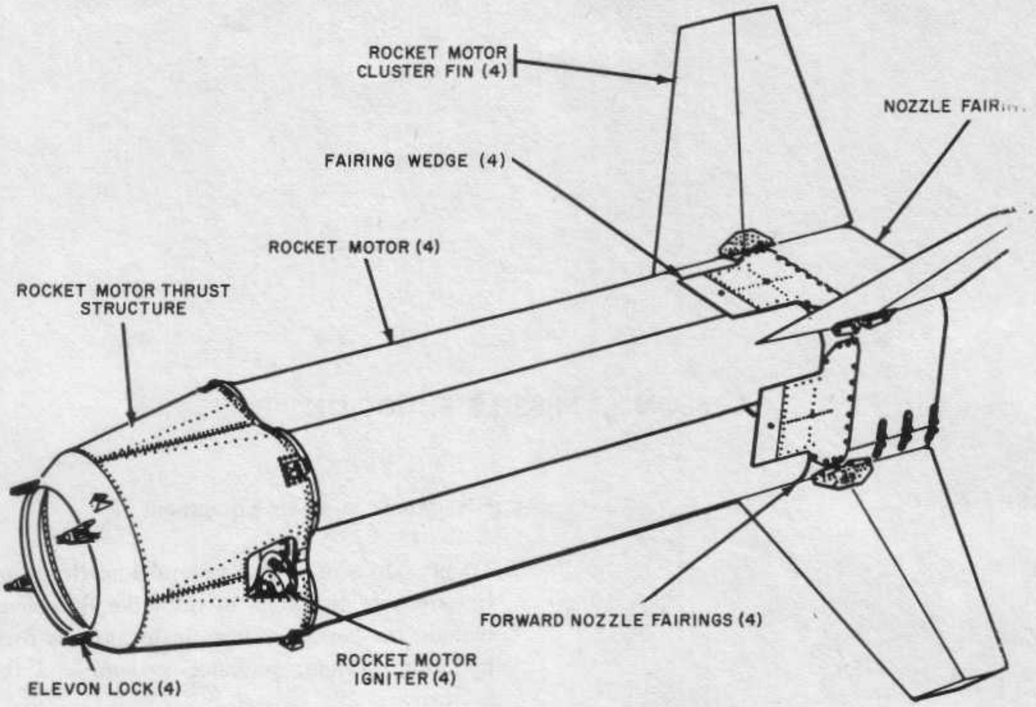


*Figure 1. Rocket motor cluster.*

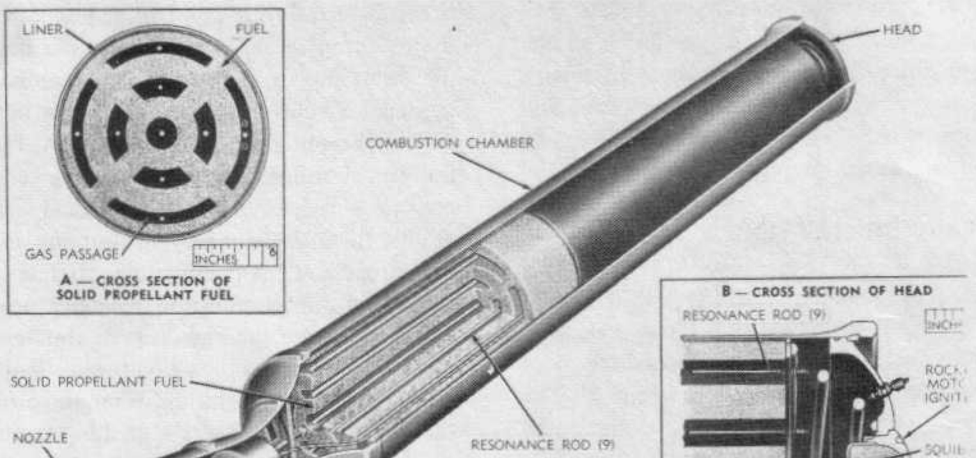


*Figure 2. Rocket motor.*

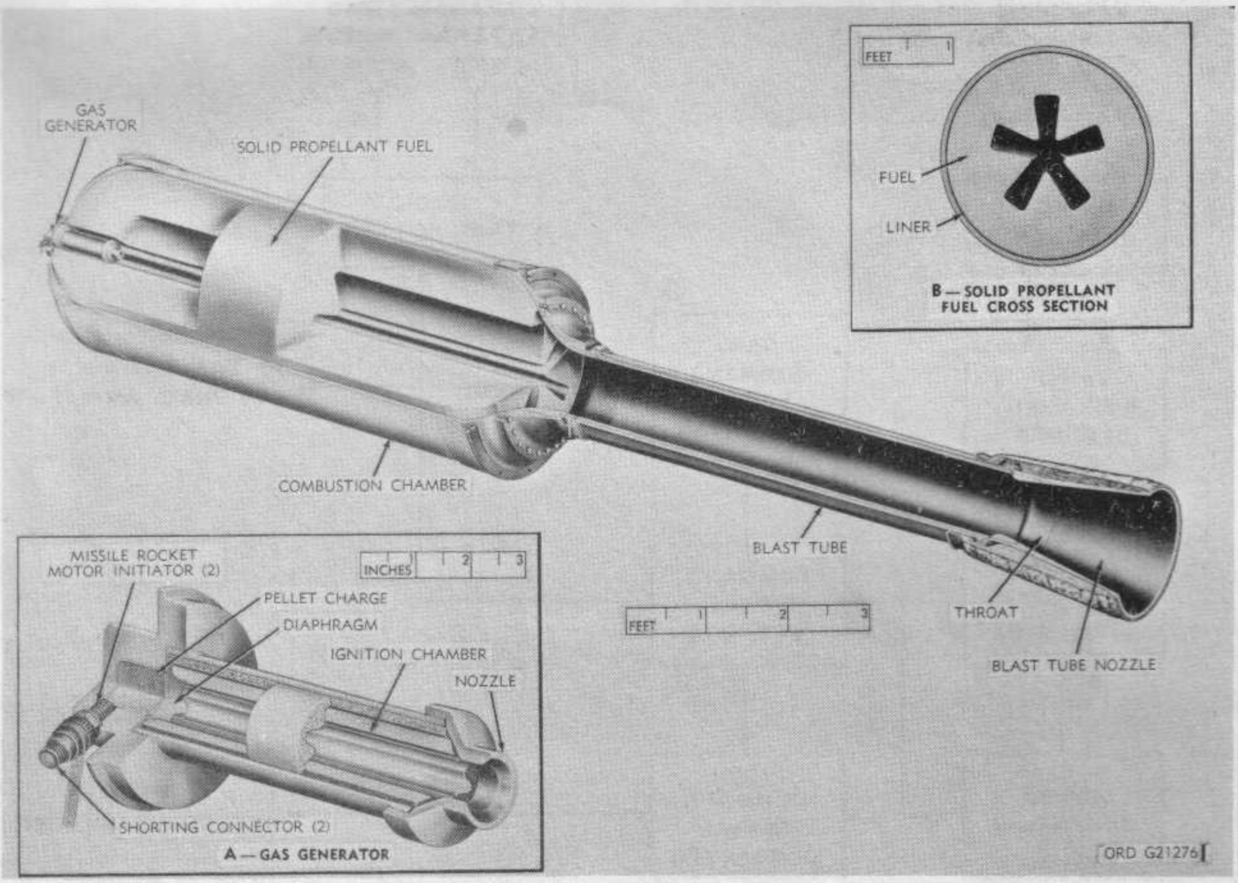


*Figure 3. Nike Hercules missile rocket motor.*

igniting the propellant in the rocket motors. The rocket motor cluster will burn for approximately 3.4 seconds, producing thrust of approximately 200,000 pounds.

e. Accidental ignition of the propellant in the rocket motor during shipment and storage is prevented by removing the igniter and inserting a plastic shipping plug in the igniter receptacle. To prevent stray voltages from firing the rocket motor igniter, a shorting connector is inserted on the free end of the wiring harness that protrudes from the igniter.

## 3. MISSILE ROCKET MOTOR.

a. The missile rocket motor (fig 3) consists of a gas generator (A, fig 3), a steel combustion chamber, a blast tube, a olast tube nozzle, and two missile rocket motor initiators. The combustion chamber contains a solid propellant grain of polysulfide perchlorate (B, fig 3), which weighs 2,196 pounds. When the propellant is ignited, the gases that are produced escape through the blast tube and the blast tube nozzle and provide the required thrust.

b. Firing of the missile rocket motor initiators is prevented before the boost period by a safe and arm switch that applies a short across the two initiators and opens the circuit from the voltage source. During the boost period, the force of acceleration arms the safe and arm switch, thereby removing the short and completing the circuit to the thermal batteries. At rocket motor cluster burnout, separation occurs due to the drag on the cluster. When the booster separates the elevons are unlocked and the missile roll stabilizes due to presetting of the roll amount gyro. The propulsion arming lanyard, which extends from the thermal battery assembly to a bracket on the forward end of the rocket motor cluster, mechanically activates the thermal batteries. The voltage is developed in about three-fourths of a second to cause current flow to ignite the initiators in the rocket motor. This will ignite the pellet charge in the forward end of the gas generator. The pressure caused by the ignition of the pellet charge breaks a diaphragm in the gas generator and combustion spreads into the ignition chamber. The gas generator forces hot burning gases through the nozzle onto the solid propellant fuel which burns for approximately 29 seconds. Accidental ignition is

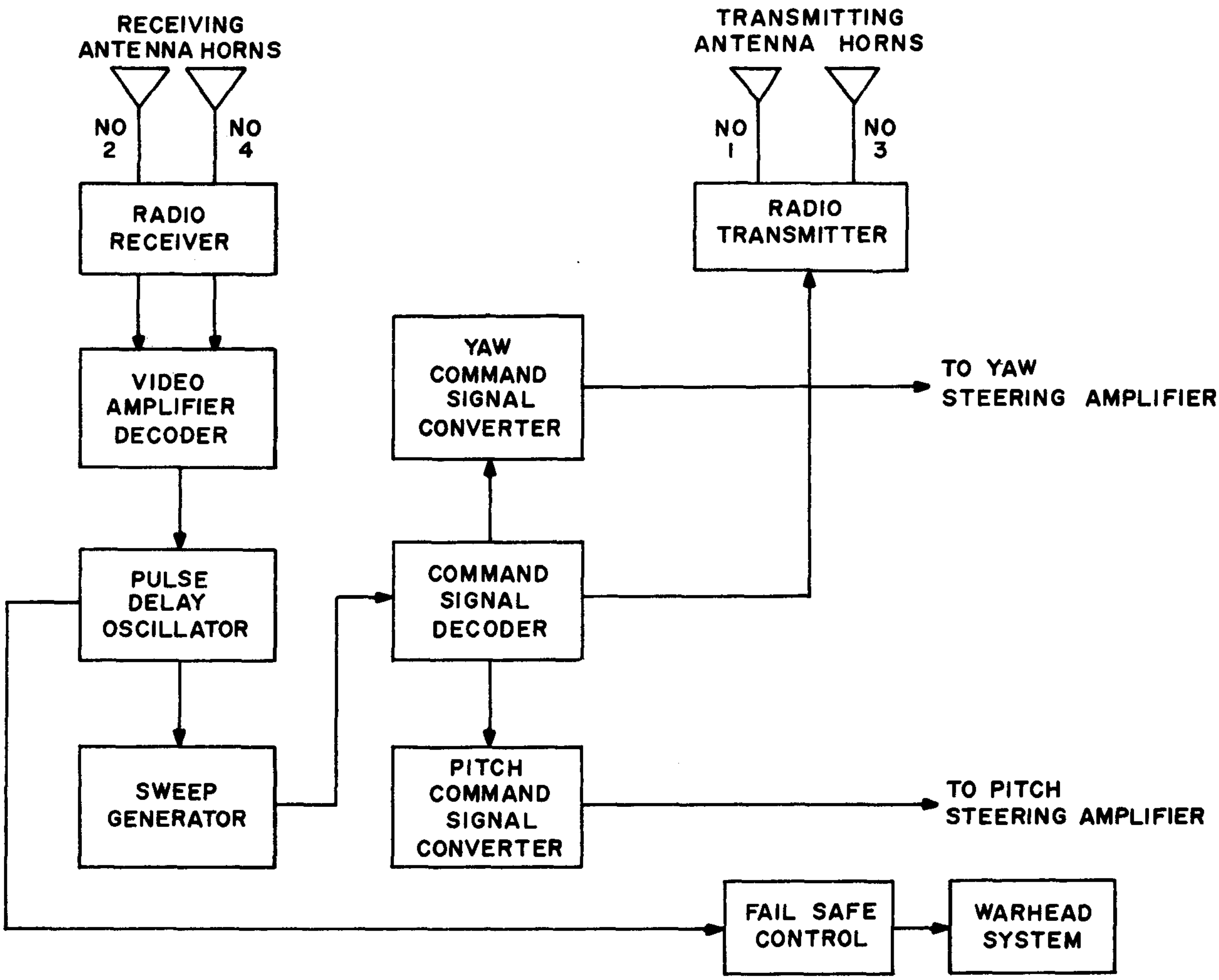


*Figure 4. Nike missile guidance radio set block diagram.*

prevented by a shorting connector as described in paragraph 2e above.

## 4. GUIDANCE SET.

a. **General.** The missile guidance set performs three main functions in controlling and detonating the Nike Hercules guided missile. First, it controls the flight of the missile in accordance with commands initiated by the computer and transmitted to the missile by the missile tracking radar. Second, it transmits RF response pulses which enables the missile tracking radar to track the missile. Third, it causes detonation of the warhead when a burst command is received. In addition, the guidance set will detonate the warhead (thru the fail safe system) if ground guidance ceases or if the missile malfunctions. The guidance set will be discussed as two separate groups: the radio set and the steering control circuits.

b. **Radio set.** The receiving and decoding circuits consist of two receiving antenna horns (fig 4), two transmitting antenna horns, a radio receiver, an amplifier decoder, pulse delay oscillator, sweep generator, command signal decoder, and the pitch and yaw command signal converters. You will remember from lesson 1 that these components are located in the forward body section of the missile.

(1) The two receiving antenna horns (fig 4) are located on the missile to insure reception of the guidance commands regardless of the missile position during flight. The antenna horns use polystyrene polarizers which vertically polarize the RF energy with respect to the waveguide in the missile, regardless of the missile roll angle. The vertically polarized RF energy is fed through the waveguide to the radio receiver.

(2) The radio receiver (fig 4) consists of

two detector cavities, each cavity containing a crystal detector. Each cavity provides a low Q resonant circuit in the frequency range of the missile tracking radar transmitter. The resonant cavity represents a low impedance to frequencies outside the range of the missile and missile tracking radar thereby limiting reception to the desired frequencies. The crystal detectors convert the received RF energy into direct current (DC) pulses. The resulting DC pulses are applied to the amplifier decoder.

(3) The amplifier decoder (fig 4) will amplify the incoming DC pulses and reject false (incorrectly coded) signals. This will prevent stray RF signals from another missile tracking radar giving commands to the missile. The amplified video pulses are then fed to the pulse delay oscillator.

(4) The pulse delay oscillator will receive and shape the pulses from the amplifier-decoder. These shaped pulses are delayed and used to trigger a phantastron circuit that produces two outputs. One output, an enable gate pulse, goes to the sweep generator; the other, a burst gate pulse, goes to the fail safe control.

(5) The sweep generator (fig 4) uses the enable gate pulse to generate a P enable pulse or a Y enable pulse, depending on the command from the missile tracking radar. The P or Y enable pulse will be sent to the command signal decoder.

*NOTE: If you have completed the Nike radars and computer subcourse (MMS 150), you will recall the missile rotates around its longitudinal axis so that the pitch (P) and yaw (Y) control surfaces are at a 45 degree angle with respect to horizon after "roll stabilization" and the missile is "belly-down." If you have not completed MMS 150, refer to figure 8 of this lesson which illustrates the position of the P and Y elevons. In this position the P and Y control surfaces do not produce pure pitch and yaw maneuvers. However, for the ease of discussion and identification of equipment the terms (P) for "pitch" and (Y) for "yaw" will be used in this subcourse as they are in the equipment.*

(6) When the command signal decoder (fig 4) receives the P or Y enable pulse in proper sequence, it will produce a P or Y trigger pulse that is applied to the respective P or Y command signal converter. The command signal decoder is composed of two identical channels. These channels operate alternately, since pitch and yaw commands are received alternately.

(7) Since P or Y command signal converters (fig 4) are identical, only the P will be discussed. The P trigger pulse from the command signal decoder will be used to determine the amount of DC voltage generated to represent the magnitude and direction of the pitch command issued by the computer. A resulting plus or minus DC voltage will be applied to the P steering amplifier. The DC voltage will be discussed during the steering phase of the guidance set.

(8) The fail safe control (fig 4) receives the burst gate pulse from the pulse delay oscillator. As long as the pulse is present, the missile warhead will not detonate. When the missile tracking radar transmits a burst command, the burst gate pulse is removed. This will allow a capacitor to discharge, applying sufficient voltage to the warhead system for detonation. If the missile guidance set malfunctions or if the ground guidance equipment malfunctions, the burst gate pulse is also removed, thereby detonating the warhead system (fail safe). This will permit destruction of the missile and prevent the missile from falling into the hands of enemy agents.

(9) The command signal decoder (fig 4) will generate one RF response pulse for every properly coded input pulse to the guidance set. The pulse will be sent to the radio transmitter and antenna horns (No 1 and No 3) then radiated to the missile tracking radar to insure continuous tracking of the missile until intercept of the target.

c. **Steering control circuits.** Due to the high altitude and extreme velocities attained, the missile encounters varying aerodynamic conditions throughout the duration of its flight. The steering control circuits (fig 5) must incorporate a positive means of compensating for changing pressures and velocities, both of which directly affect the amount of elevon deflection required to move the missile to the intercept point. This is accomplished by direct feedback from the steering control instruments to the steering amplifiers. The steering control circuits consist of seven flight control instruments: P and Y accelerometers; P, Y, and roll rate gyros; roll amount gyro and pressure transmitter. The P and Y steering amplifiers (fig 5) receive the DC steering voltages from the guidance radio set (fig 4) and feedback voltages that stabilize the steering of the missile from the flight control instruments. The steering control amplifiers convert these steering voltages into appropriate signals which, through the actuator assembly, control the elevon displacement. This results in controlled flight maneuvers that maintain the desired trajectory to target intercept.

(1) Roll control circuits.

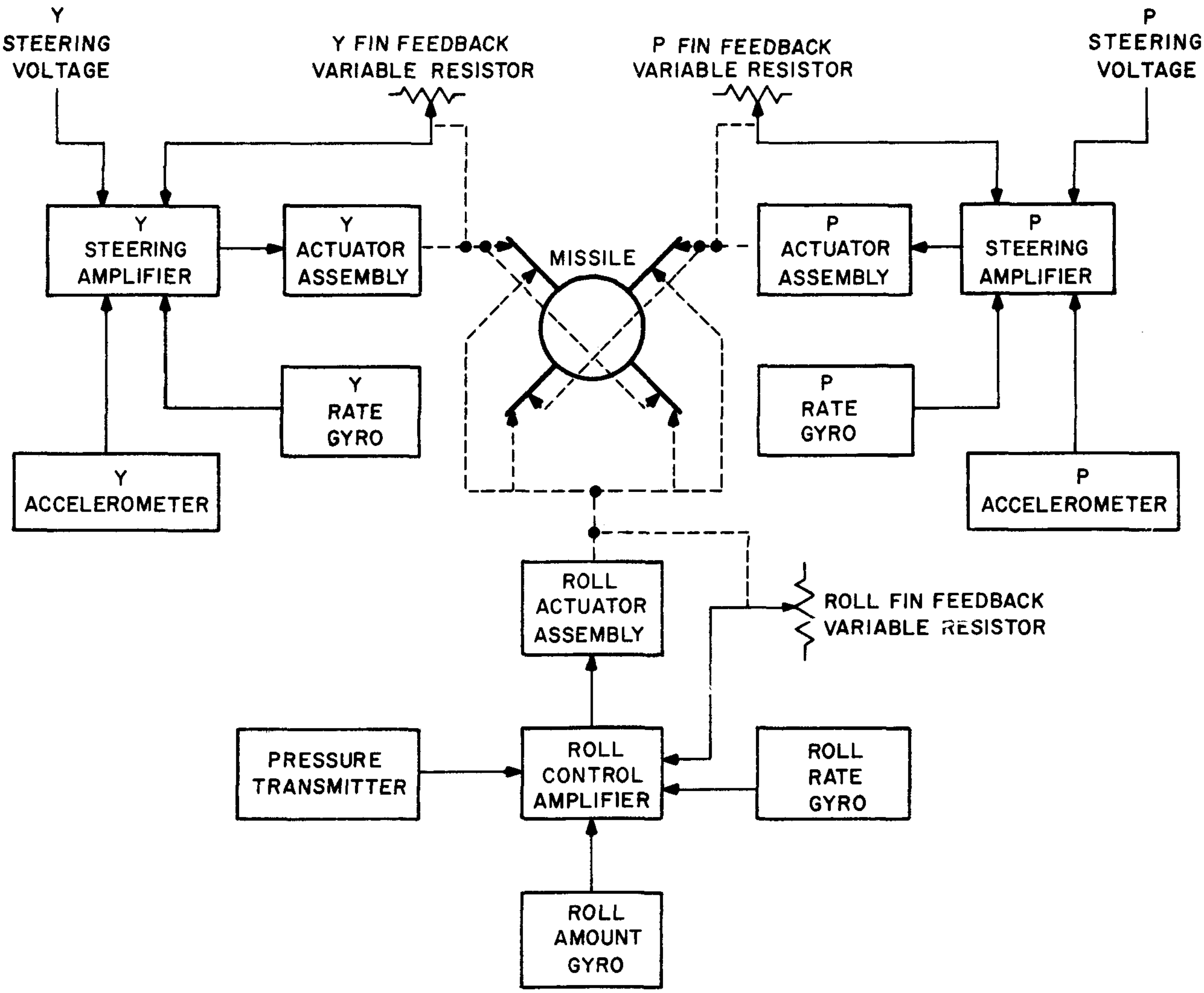


*Figure 5. Nike missile guidance settering control circuit block diagram.*

(a) Pressure transmitter. During flight the missile will be subjected to varying pressures depending upon the altitude of the missile. This will affect the amount of elevon deflection required, since less deflection is required when the missile is flying in dense atmosphere. (More elevon deflection is required in a rare atmosphere.) A pressure transmitter (fig 5), utilizing two diaphragms placed end to end, is used to measure the static pressure. The wiper arms of two variable resistors are physically attached to the two diaphragms. As the pressure increases or decreases, the variable resistors will provide a voltage directly proportional to pressure changes. This change in voltage will control the gain of the roll control amplifier (fig 5). An increase in static pressure causes a loss of gain. Therefore, higher pressure (or lower altitude) will result in a smaller elevon displacement and lower pressure (or higher altitude) will result in greater elevon displacement.

(b) Roll amount gyro. The roll amount gyro (fig 6) and its associated circuits serve two functions important to the controlled flight of the missile. Primarily, the roll amount gyro provides roll stabilization because it is preset to the target azimuth and started spinning prior to launch. The gyro also prevents the missile from rolling about the longitudinal axis after the missile has a "belly-down" reference in the predicted intercept plane. A variable resistor pickoff arm is physically mounted to the gyro. Missile roll movement is translated to the variable-resistor winding, due to the property of gyroscopic stability, and causes the wiper arm to pick off a voltage. The polarity and magnitude of the voltage will depend upon the direction and amount of missile roll. This voltage along with the output feedback voltage from the rate gyro, the pressure transmitter output, and the roll fin variable resistor feedback are fed to the roll control amplifier. This will increase the response of the roll servo loop to oppose

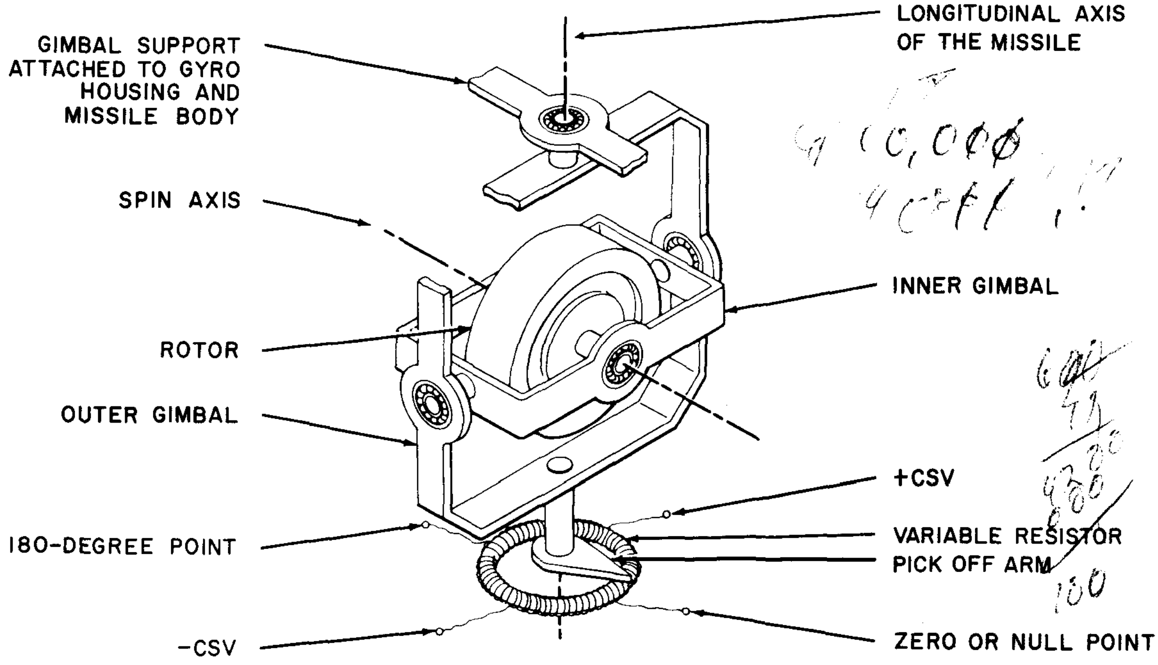


*Figure 6. Roll amount gyro.*

any sudden changes of missile movement about the longitudinal or roll axis. Should the missile attempt to rotate about its roll axis these four input voltages to the roll control amplifier will be used to drive the actuator, which in turn drives the missile elevons in the proper direction to stop the roll and maneuver the missile to the original "belly-down" flight poisition.

(c) Rate gyros. Rate gyros utilize the principle of gyroscopic precession to sense any rate of change of missile movement about a specific axis of flight. Precession is described as the resulting movement or realinement of the gyro spin axis caused by the application of an outside force or pressure. Such a force is applied to the gyro each time the missile attempts to move about the specific axis of flight in which the rate measurement is to be made; this axis is commonly referred to as the input axis. The three principal axes of a rate gyro are shown in figure 7. These axes are spin, gimbal, and input. Without missile motion the three

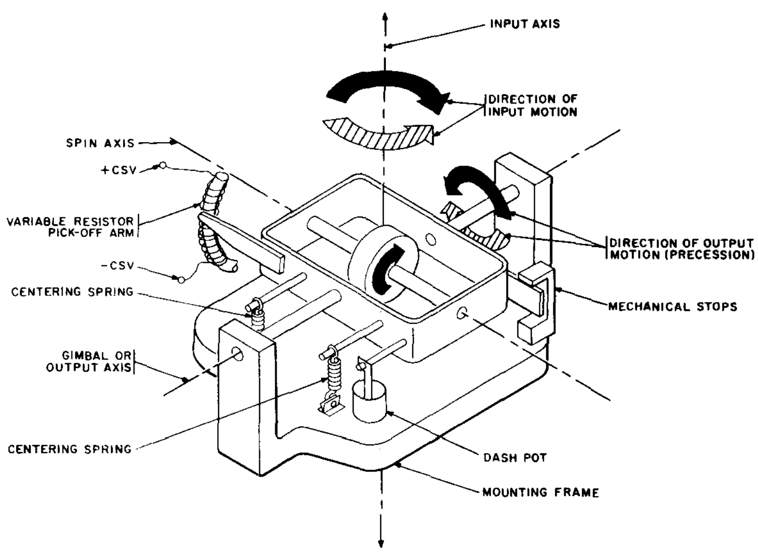


*Figure 7. Simple rate gyro.*

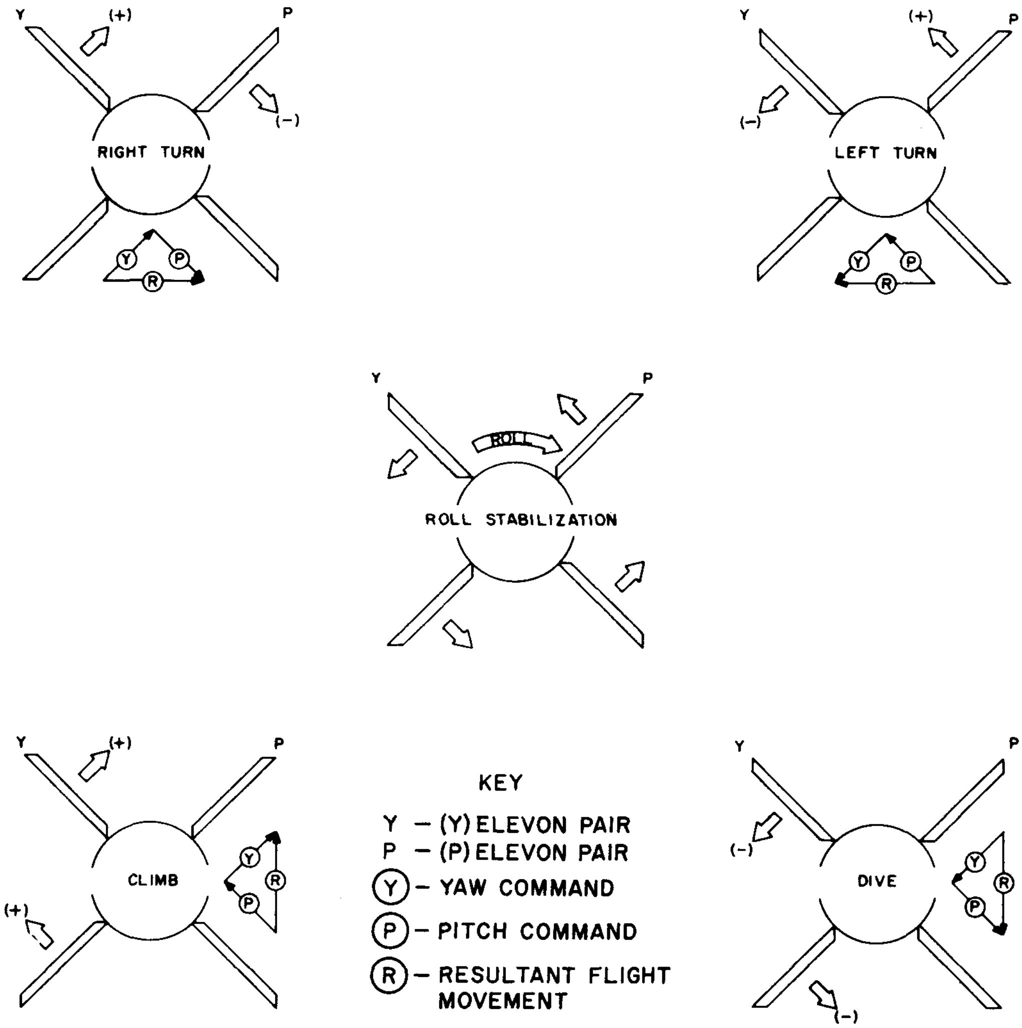


*Figure 8. Elevon displacement and resulting flight movement.*

mutually perpendicular axes are kept aligned with the missile by centering springs and the mounting frame, rigidly mounted to the missile. The gyro spin axis is allowed freedom of movement about the gimbal axis in one of two possible directions. Applied force, resulting from missile maneuvers, causes the gyro spin axis to precess in one of the two directions. The gyro precesses about the gimbal axis (output axis) which causes the pickoff arm to move on the variable resistor that is physically attached to the gimbal. Displacement of the pickoff arm away from the zero position and against the restraining influence of the centering springs produces a feedback voltage that is proportional to the rate at which a missile is turning. This output feedback voltage of the roll rate gyro is applied to the input network of the roll control amplifier in phase with the roll stabilization signal from the roll amount gyro, thereby increasing the response of the roll servo loop to oppose sudden changes of missile attitude about the roll axis. The output feedback voltages of the P and Y rate gyros are applied to the input network of the associated steering amplifier where this feedback voltage opposes the steering command voltage from the computer, thereby damping or restricting the rate of turn. The motors rotating the spinning mass of the three rate gyros are placed in operation during the "blue" alert status to warm up the gyro system. Gyro motor speed is held constant by a circuit consisting of a centrifugal switch and a resistance. An increase in motor speed causes the centrifugal switch to open, thereby placing the resistance in series with the motor armature. The increased resistance in the armature circuit reduces motor speed until the desired speed is attained, at which time the switch closes and shorts out the resistance, thereby holding the motor speed constant.

(d) Fin feedback variable resistors. There are three fin feedback variable resistors, one each for roll, pitch, and yaw. These resistors provide degenerative feedback voltages proportional to the

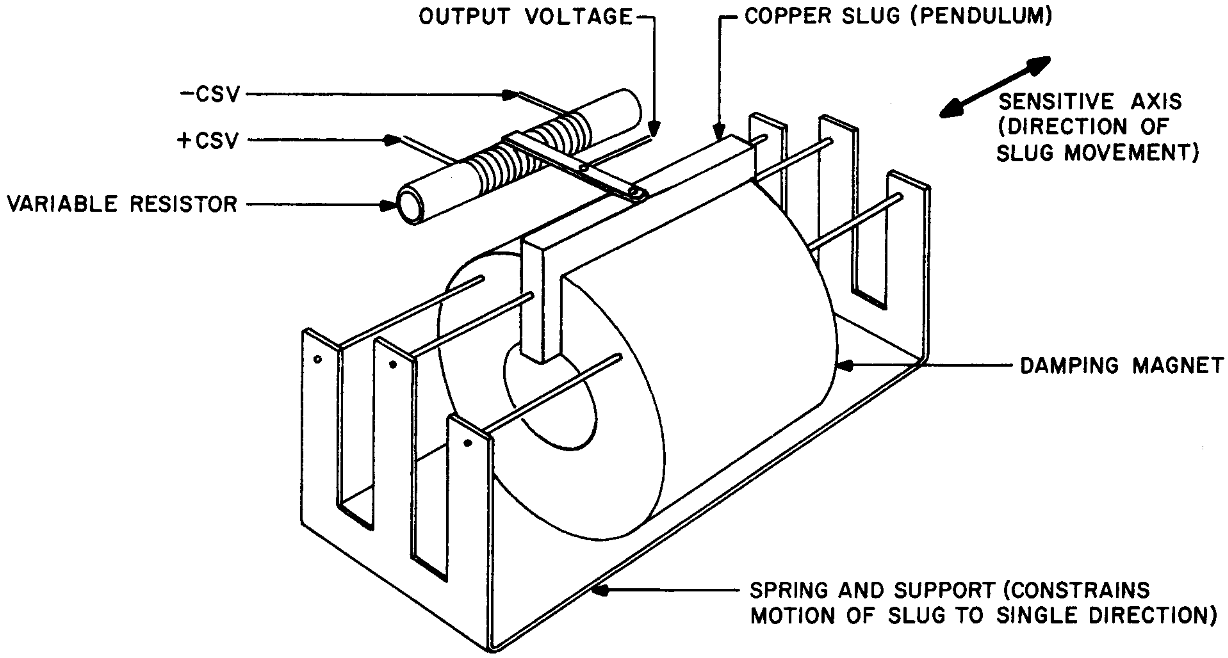


*Figure 9. Accelerometer.*

amount and direction of elevon displacement. The magnitude of the fin variable resistor feedback voltage is sufficient to stop the elevons at less than full scale deflection when the command is 2G's or less. Commands of greater magnitude initially drive the elevons full scale, then the other flight control instruments develop voltages that add to the fin feedback voltage to restore the elevons to a trimmed condition.

(e) Roll control amplifier. To summarize, the roll control amplifier (fig 5) has four signal inputs consisting of the roll amount gyro voltage; the roll fin variable resistor voltage, which produces a feedback voltage proportional to elevon displacement; the roll rate gyro voltage; and the pressure transmitter voltage. The roll amount gyro voltage is the primary input. The roll rate gyro and the variable resistor fin feedback voltage along with the pressure transmitter, which controls the gain of the roll control amplifier, will control the roll of the missile. If the missile rolls about its longitudinal axis, as shown in figure 8, the feedback voltage will reverse the direction of roll, thereby returning the missile to a "belly-down" reference.

(2) Pitch and yaw control circuits.

(a) Accelerometers. During flight, the missile is constantly subjected to various aerodynamic forces which are most apparent when the elevons deflect as shown in figure 8, thereby changing the flight attitude of the missile. A rapid maneuver will cause excessive lateral accelerations or a skidding tendency throughout a required maneuver. The P and Y accelerometers (fig 5 and 9), which are used to measure these accelerations, are mounted in the guidance set with their sensitive axes perpendicular to the pitch and yaw elevon plane. The accelerometers provide a feedback voltage proportional to the amount of acceleration in each plane. This voltage is produced any time the missile accelerates in the direction of the accelerometer's sensitive axis. The inertia of the slug (fig 9) causes the slug to "tend to remain at rest" while the housing, which is attached to the missile body, moves with the missile body and causes relative motion between the slug and its housing. Any movement between the slug and housing causes the wiper arm to move on the variable resistor (which is also mounted to the missile body). The wiper arm voltage is applied to the input network of the associated amplifier (P or Y), where this voltage acts as degenerative feedback to reduce skidding of the missile. Due to the mounting of the two accelerometers, their combined output is always a resultant in the lateral direction. The accelerometer feedback voltages are the largest controlling feedback in a missile.

(b) Pitch and yaw rate gyros. The pitch and yaw rate gyros function in the P and Y servo loop as described in c(1)(c) above.

(c) Pitch and yaw steering amplifiers. The pitch and yaw steering amplifiers (fig 5) are identical; therefore, only the pitch amplifier will be

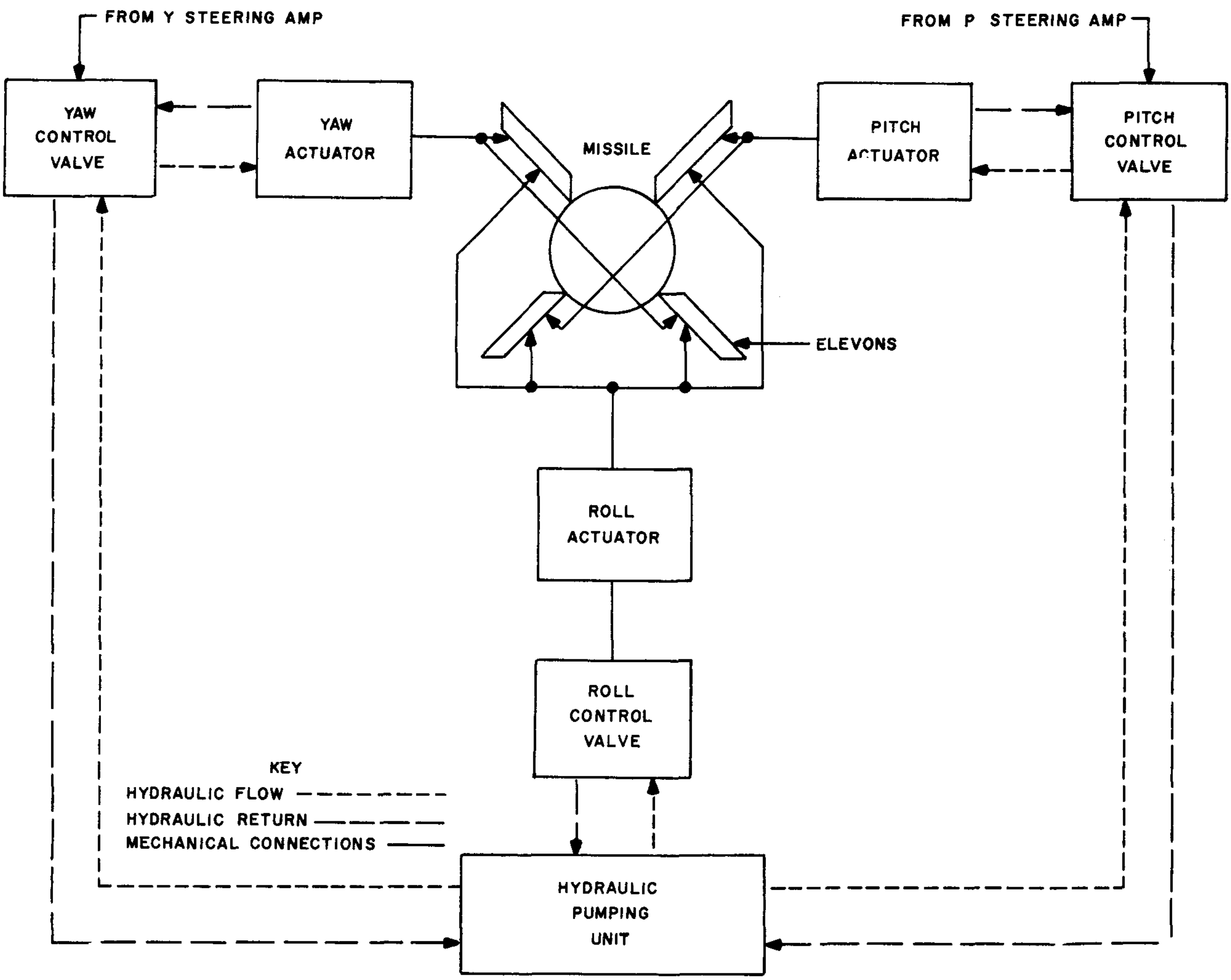


*Figure 10. Nike Hercules missile hydraulic system block diagram.*

discussed. The pitch amplifier is a two-stage DC amplifier consisting of four input networks, a paraphase amplifier, and a push-pull power amplifier. The four signal inputs are: the P steering voltage from the P command signal converter (fig 4), the P accelerometer voltage, P rate gyro voltage, and the P fin variable resistor feedback voltage. The P steering voltage, issued from the computer via the P command signal converter, represents the maneuver to be executed and is the primary signal voltage. The P accelerometer, P rate gyro, and P fin feedback voltages (fig 5) are feedback inputs that modify and stabilize the output of the P steering amplifier. The input network of the P steering amplifier is designed to combine the feedback voltages in the correct proportions. When a P steering voltage is applied to the P steering amplifier, unbalanced outputs are applied to the solenoid in the P actuator assembly (fig 5). This action produces a movement of the P elevons as discussed in paragraph 5a, which follows. The direction of elevon movement is determined by the polarity of the steering voltage and the amount of movement by the magnitude of the voltage. The missile responds to the steering command and rotates about the center of gravity and the P axis. The P rate gyro senses the rate of change, and the P accelerometer determines the amount of lateral (turning) acceleration. Then the gyro and accelerometer will produce feedback voltages proportional to the amount of acceleration around the P axis. As soon as the elevons are displaced from zero position, the P fin variable resistor produces a feedback voltage. The sum of the three feedbacks, acting in opposition to the P steering voltage, finally results in a balanced output from the P steering amplifier. In this balanced condition, the final displacement of the elevons is just sufficient to maintain the desired turning movement of the missile. When the missile is on trajectory, the elevons have zero deflection and the turn has been accomplished.

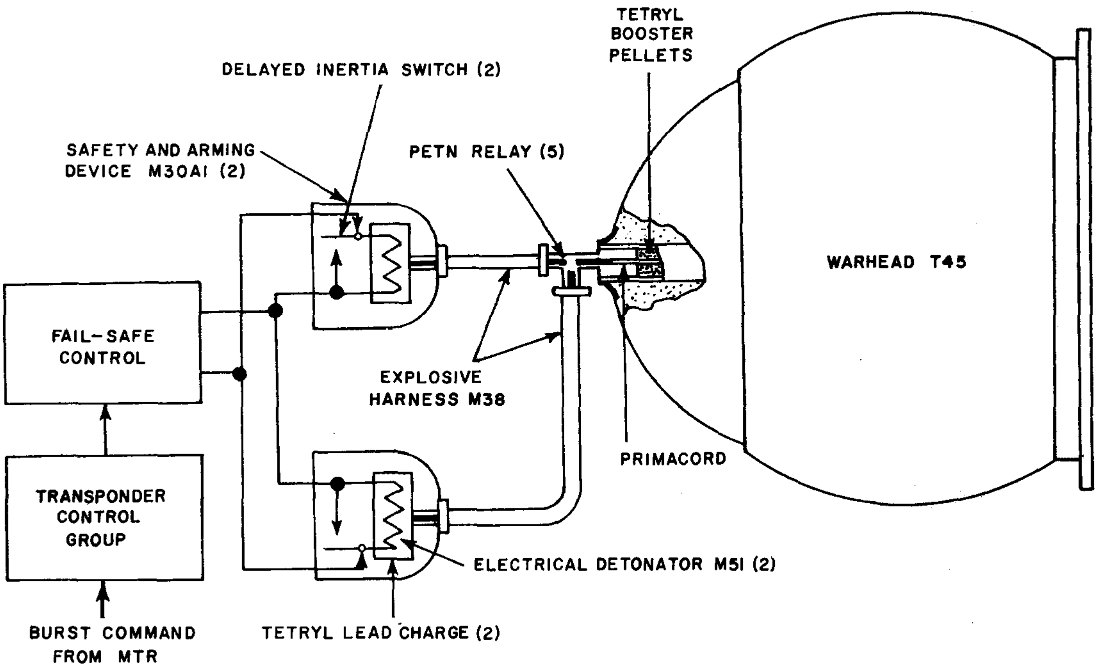


*Figure 11. Warhead system block diagram.*

## 5. MISSILE HYDRAULIC SYSTEM.

a. The hydraulic system (fig 10) consists of the pitch, yaw and roll actuators, a mechanical linkage between the actuators and elevons, and a hydraulic pumping unit (HPU). The hydraulic system, operated from guidance commands given through the missile guidance set (fig 5), positions the elevons in order to produce the required maneuver. The P and Y elevons are positioned independently by identical servo loops (fig 5) that include electrical, hydraulic, and mechanical components. The roll stabilization servo loop operates independently of the P and Y servo loops and moves all four elevons by means of separate mechanical linkages. When steering orders are applied to the P and Y steering amplifiers in the guidance set, unequal output currents unbalance the solenoid in the control valve associated with the P or Y actuators (fig 10). As the hydraulic fluid flows to the actuator, a piston in the actuator, connected to the mechanical linkages, is displaced and moves the elevons (P or Y). Movement of the elevons produces aerodynamic forces that maneuver the missile as shown in figure 8. When the required maneuver is achieved, a feedback voltage from the feedback variable resistors (fig 5) will balance the steering control amplifier. At this time, currents through the two solenoids of the control valves (fig 10) are equal, and the hydraulic system holds the elevon in position. A roll stabilization order causes a rotation of all four elevons (due to the mechanical linkage) in such a manner that any roll away from the normal flight attitude of the missile will be automatically corrected.

b. The three actuators consist of a control valve, a fin feedback variable resistor, and an actuator. The P and Y actuators are identical. The roll actuator differs only in the amount of travel of the actuator piston and the fin feedback variable resistor pickoff arm. Each actuator assembly converts electrical signals into mechanical displacements by controlling the flow of hydraulic fluid. This fluid enters each actuator at a pressure port and passes through a filter to the control valve. The oil returns to the HPU through a return port in the actuator. The control valve regulates the direction and rate of flow of hydraulic fluid to the actuator in response to electrical command signals.

## 6. WARHEAD SYSTEM.

a. The warhead system (fig 11) consists of a warhead, two safety and arming devices, and an explosive harness. Detonation of the warhead is initiated by a burst command voltage or a fail safe voltage. Two identical paths are provided from the fail safe control to the warhead, thereby increasing overall reliability of the warhead system.

b. The safety and arming device (fig 11) is a plug-in, fuse-type mechanism that functions as a safety device and a detonator. The safety and arming device

consists of a delayed inertial switch, an electrical detonator, and a tetryl lead charge. The safe and arm switch is armed during the boost period by the force of acceleration on the inertial switch. Approximately 11G's of upward acceleration for 2 seconds is required to arm the switch. In the armed condition (as shown) the short is removed from the electrical detonator which allows the explosive charge to be initiated by a voltage (240 to 300 volts DC) from the fail safe control.

c. The explosive harness (fig 11) consists of two lead assemblies and each lead assembly contains two PETN relays (pentaerythrite tetranthrate). Detonation of the electrical detonator and tetryl lead charge in the safety and arming devices ignites the explosive harness that serves as an explosive coupling between the arming devices and the warhead.

d. The T-45 warhead (fig 11) consists of a large quantity of steel fragments arranged in single and double layers around an explosive charge and a warhead booster. The warhead booster consists of a PETN relay, primacord, and tetryl booster pellets. These charges cause actual detonation of the warhead. Upon detonation the fragment distribution is approximately spherical, with a conical dead zone in the rearward direction.

7. **SUMMARY.** In this lesson you have learned that the rocket motor cluster or booster is made up of four identical solid propellant rocket motors which are ignited simultaneously and burn for approximately 3.4 seconds, producing approximately 200,000 pounds of thrust. After the missile leaves the launcher and the booster burns out, separation occurs due to drag on the booster. At separation, the elevons on the missile are unlocked and due to presetting of the roll amount gyro the missile "roll stabilizes," turning its "belly" toward the intercept point. Also at booster separation, you learned that the propulsion arming lanyard causes ignition of the solid propellant missile rocket motor. After roll stabilization, a dive order is issued to the missile from the computer by way of the missile tracking radar, causing the missile to dive toward the target. You learned that the orders issued to the missile are received and processed by the missile guidance radio set. These orders are then sent to the steering control circuits which operate an actuator assembly. The actuator assembly, through control valves and pistons, hydraulically activates a mechanical linkage which moves the elevons. The elevons in turn produce aerodynamic forces which cause the missile to climb, dive or turn in accordance with the command received from the ground. The radio set transmits a beacon pulse back to the missile tracking radar which continuously monitors the missile position. As the missile maneuvers the rate gyro and accelerometers stabilize its flight by producing voltages which prevent any excessive maneuver. The pressure transmitter aids in stabilizing flight by controling the gain of the roll control amplifier as altitude or pressure varies. The roll amount gyro produces an error voltage every time the missile rolls from the "belly-down" position. This holds the proper reference attitude or flight orientation of the missile. You learned that the warhead can be detonated by a command from the ground or by the fail-safe control if "missile track" is lost.

## EXERCISES FOR LESSON 2

1. How much voltage is required to ignite the rocket motor cluster?

   A. 120
   B. 80
   C. 17
   D. 6.3

2. How many pounds of thrust is produced by the rocket motor cluster?

   A. 76,000
   B. 120,000
   C. 180,000
   D. 200,000

3. When is the warhead safe and arm switch armed?

   A. During assembly
   B. During prelaunch
   C. After fire
   D. Before missile away

4. What prevents motion between the Nike Hercules missile and the rocket motor cluster?

   A. Indexing pin
   B. Bolts that are torqued
   C. Thrust of the rocket motor cluster
   D. Thrust structure

5. What insures uniform burning of the solid propellant in the rocket motor cluster?

   A. An insulating coating on the propellant
   B. Steel resonance rods
   C. Nine gas passages
   D. A liner of cellulose

6. Which event occurs immediately prior to roll stabilization?

   A. Cluster ignition
   B. Dive command
   C. Belly-down
   D. Booster separation

7. What causes the rotation of all four elevons simultaneously?

   A. Roll stabilization
   B. Pitch command
   C. Yaw command
   D. Dive command

8. What prevents the Nike Hercules missile from receiving commands from several different radars?

   A. Amplifier decoder
   B. Radio receiver
   C. Command signal decoder
   D. Low Q resonant cavity

9. What is the maximum command the missile can handle and not respond with full scale deflection of the elevons?

   A. 1G
   B. 2G
   C. 3G
   D. 4G

10. Which are used to modify and stabilize the output of the yaw steering amplifier?

    A. Y accelerometer, Y rate gyro, push pull power amplifier
    B. Y accelerometer, Y rate gyro, DC voltage
    C. Y rate gyro, roll amount gyro, P accelerometer
    D. Y rate gyro, Y accelerometer, fin feedback voltage

11. What flight control instrument controls the gain of the roll control amplifier as altitude of the missile changes?

    A. Pressure transmitter only
    B. Roll rate gyro only
    C. Feedback voltage from P amplifier
    D. Pressure transmitter and roll rate gyro

12. What does the accelerometer do to affect the function of the guidance set?

A. Senses rates of change in missile longitudinal motion
B. Rotates the missile about its center of gravity
C. Measures the amount of lateral acceleration
D. Displaces the elevons from the zero position

13. What converts the electrical command signals into mechanical displacement of the elevon?

A. Roll rate gyro
B. Solenoids on the control valve
C. Current being equal in each solenoid
D. Relays on the actuator

14. How many servo loops are used in the missile hydraulic system?

A. 1
B. 2
C. 3
D. 4

15. What is the destructive burst pattern of the T-45 warhead?

A. Conical
B. Spherical
C. Scatter
D. Fan shape