LESSON 3. LAUNCHING EQUIPMENT FUNCTION AND MAINTENANCE

MMS Subcourse No 151 . . . . . **Nike Missile and Test Equipment**

Lesson Objective . . . . . **To provide you with a general knowledge of the basic function and support maintenance of launching area equipment, to include the monorail launcher, gyro azimuth, launcher control indicator, and the section control indicator.**

Credit Hours . . . . . **Three**

TEXT

1. **INTRODUCTION.** The Nike Hercules guided missile launching area equipment is necessary to select, test, and prepare a missile for launching. The basic functions of the equipment used will be discussed in paragraphs 2 through 5 below. The launching area consists of a launcher control trailer and four firing sections (in many installations only three firing sections are used) with four launchers per section as illustrated in figure 1. This lesson will also cover some aspects of direct support maintenance required to return this equipment to a serviceable condition.

2. **LAUNCHING CONTROL TRAILER.**

a. **Launching control console.** The launching control console (fig 2) is mounted on the curbside wall of the trailer. The access door swings upward to permit access to storage space. The middle section contains right- and left-hand control panels. These two panels contain the meters, controls, and indicator lights required for mission, missile, and section selection. Through these panels, firing circuits between the battery control area and launching sections are completed. A work counter is provided for the convenience of the launching control console operator. The panel beneath the counter provides access to electrical equipment associated with the flight simulator system. In addition to the flight simulator group the trailer contains an intercommunication cabinet and a personnel heater.

b. **Flight simulator group.** The flight simulator control unit and power supply (located in the rear of the launching control console) and the responder section (located on the extreme left of the panel shown at 2, fig 2) are the main components of the flight simulator system. The flight simulator (fig 3) receives transmitted RF command signals from the missile tracking radar and converts these command signals into monitoring voltages that control meters and lights on the responder section of the launching control console. During missile firings, prior to missile designation, the flight simulator is also used as a standby beacon target for the missile tracking radar. When interrogated, the flight simulator transmits a response pulse back to the missile tracking radar. To perform these functions, the flight simulator components duplicate or simulate many of the important circuits of a missile guidance set.

(1) The flight simulator system can be operated in either the Nike Hercules or the Nike Ajax mode, depending on the mode of operation of the missile tracking radar. Pulse transfer relays in both the

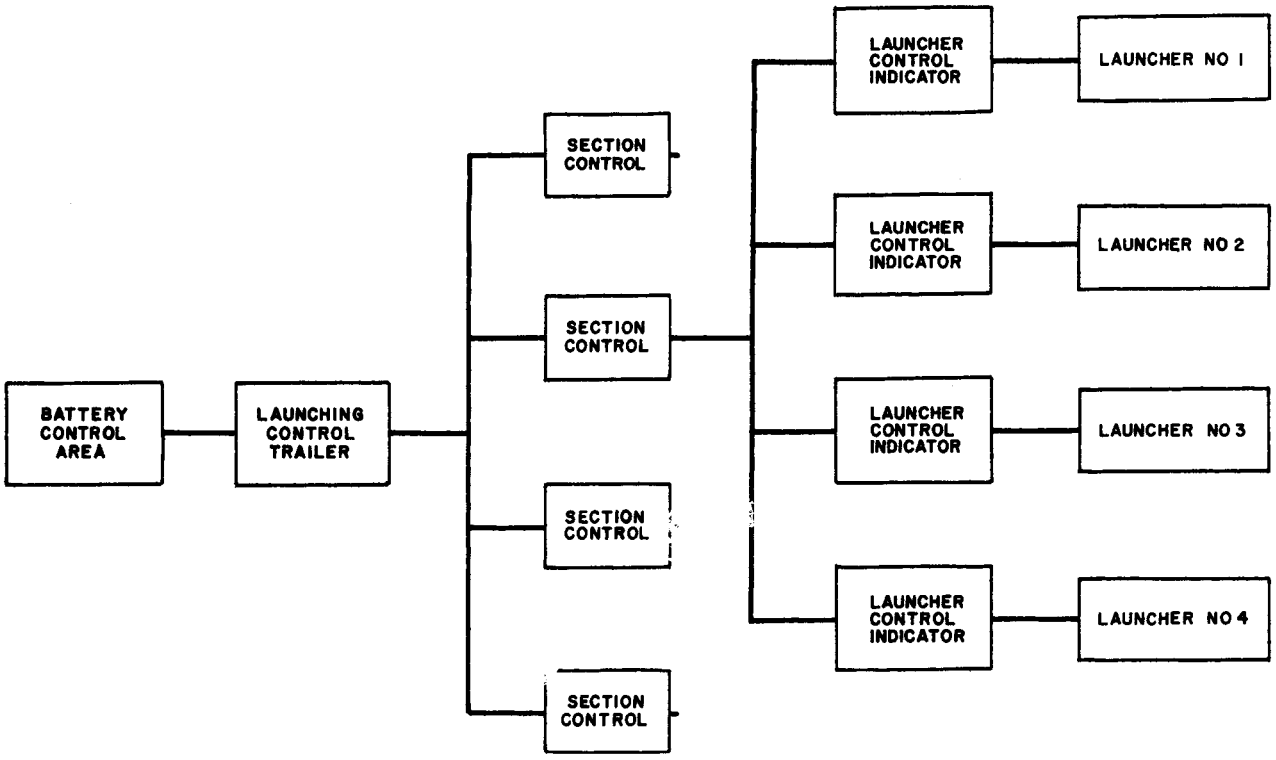

Figure 1. Launching area block diagram.

flight simulator group and the flight simulator control unit switch the flight simulator system from the Nike Ajax to the Nike Hercules mode. Transfer is normally made by continuously grounding these transfer relays at the radar course directing central. These relays may also be grounded at the section control indicator and simulator group (fig 4) with the MANUAL ORDERS - MISSILE switch.

(2) In the Hercules mode, the pulse transfer relays (fig 3) of the flight simulator group are energized. Coded command signals are received from the missile tracking radar by the two receiving antennas. The pulses are detected and sent to the amplifier decoder, which amplifies and sends only the properly coded pulses to the signal data converter, through the pulse transfer relay in the launching control console. The signal data converter demodulates the properly coded pulses and converts the pulses into a DC voltage and applies it to a pulse transfer relay that passes the DC voltage to a yaw meter, pitch meter, or a command burst light. The fail safe system works the same as the one discussed in lesson 2 (guidance set). The radar modulator generates a magnetron trigger pulse that triggers the magnetron. The magnetron then generates a response pulse that is transmitted back to the missile tracking radar.

c. **Communication cabinet.** The communication cabinet consists of a switchboard that is used for communication between the battery control area and the launching section. The switchboard has three modes of operations.

(1) In the normal mode the switchboard operator uses cable communication that is permanently emplaced underground between the launcher control trailer and the battery control area.

(2) In the wire mode the switchboard operator uses field wire that is emplaced by the using unit as an alternate means of communication in the event of a cable failure.

(3) In the radio mode the switchboard operator uses radios that are installed in the launcher control trailer and the battery control trailer. This is another alternate means of communication to insure continuous voice communication with the battery control officer for the launching of a missile.

d. **Personnel heater.** The personnel heater is a gas-operated, thermostatically controlled heater using two 12-volt batteries in series to operate the ignition system. Incorporated in the heater cabinet is a battery

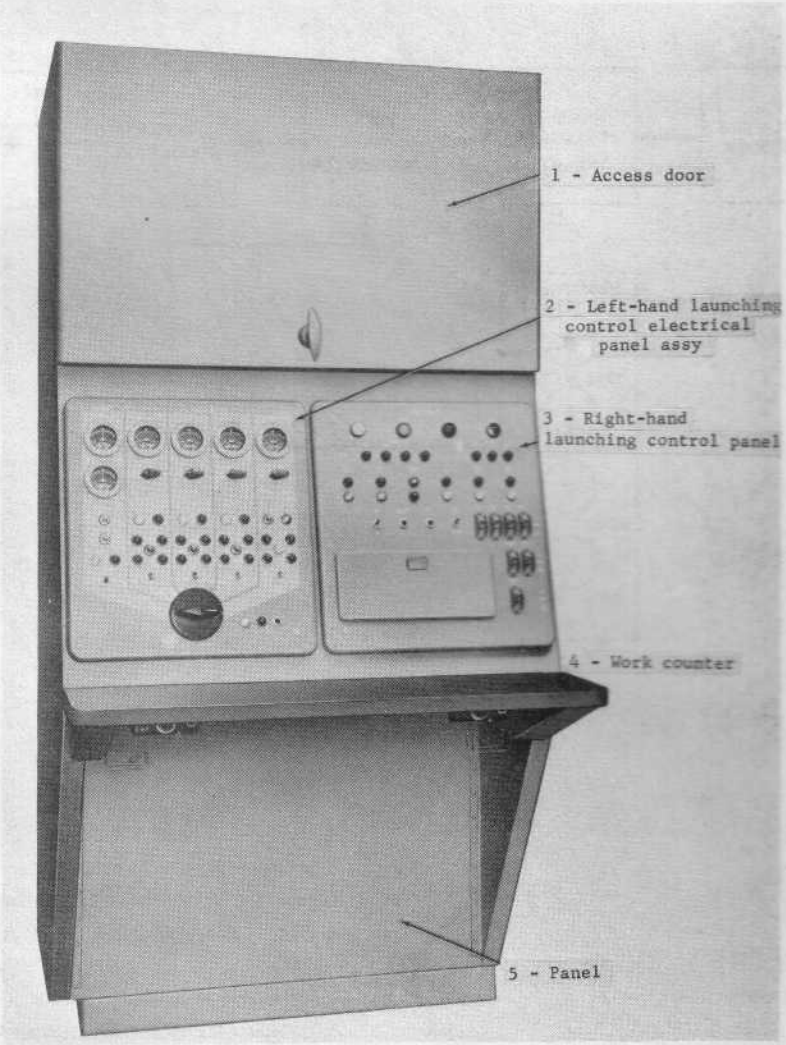

Figure 2. Launching control console.

charger to keep the two 12-volt batteries charged. The batteries are also used to operate the alert siren to notify launcher personnel when they are required to man their battle stations.

3. LAUNCHING SECTION CONTROL INDICATOR AND SIMULATOR GROUP.

a. **Section control indicator.** The section control indicator (fig 4) consists of a voice communication network, A_L resolvers (azimuth of launcher), relay panel, and the necessary front panel switches, meters, and lights for the control of four monorail launchers.

(1) Voice communication. The voice communication network provides two-way communication between personnel in the launcher area and the operator at the section control indicator.

(2) A_L resolvers. There are four A_L resolvers, one for each monorail launcher in a firing section. When the launcher is emplaced in the launching section, the A_L resolvers are manually set to the azimuth of the launcher, measured from true north as illustrated in figure 5. Prior to target acquisition, A_G (gyro azimuth) is aligned in the direction of A_L. The A_L resolver reading will be used to determine how far the gyro must be turned to reach the corrected A_G, the azimuth to the predicted kill point, and this corrected A_G is set into the roll amount gyro prior to launching. After launch the roll amount gyro will cause the missile to roll stabilize with its belly pointed toward the predicted target kill point. The corrected solution for A_G, which is performed by the A_G transmission system, is illustrated in figure 6. Example: If A_G is 800 mils and A_L is 1,600 mils what is the corrected A_G or predicted kill point (PKP)?

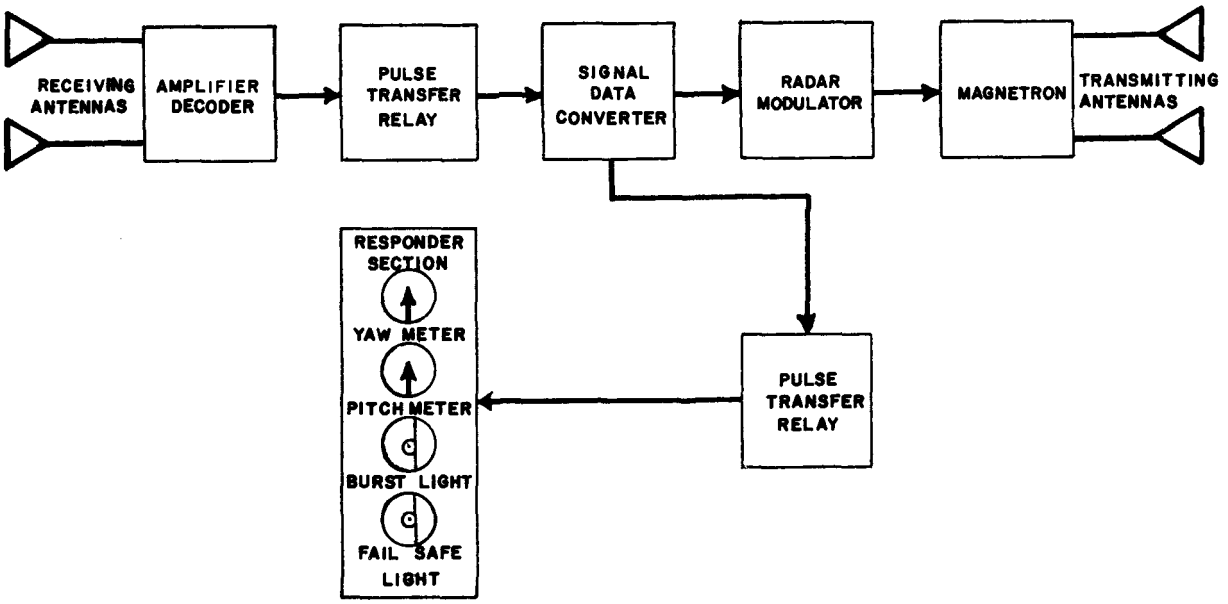

Figure 3. Flight simulator block diagram.

$PKP = A_G - A_L$

800 − 1,600

(6,400 + 800) − 1,600

7,200 − 1,600

5,600 mils

NOTE: If A_L is larger than A_G, 6,400 mils must be added to A_G since the predicted kill point is measured clockwise from true north.

(3) Relay panel. The section control indicator panel (fig 4) is used in the preparation, designation, launching, selecting, and the comparison of a missile and mission request from the launching control trailer or the battery control area. The battery control officer will select a missile with a certain type warhead for a certain type mission. In the selection of this missile, the launching section relay panel, which is behind the section control indicator panel, will energize certain relays if the section has this type missile. When the relays energize, indicator lights will illuminate on the section control indicator panel to give the operator a visual indication that the missile is ready for launching. The section control operator will designate the missile to the launcher control trailer, thereby notifying the battery control officer that he may launch the missile.

b. **Simulator group.** The simulator group (fig 7) contains many components of the gyro azimuth transmission system which presets the roll amount gyro in the selected missile. The A_G angle is continuously determined by the computer and is supplied to the gyro azimuth transmission system as shown in figure 8. The A_G information is transmitted to the launching set as a phase angle between two voltages, the A_G preset voltage and the A_G reference voltage. The A_G reference is always phase zero degrees and the A_G preset may vary from 0 mils to 6,400 mils, determined by the enemy target approach. Components within the simulator group convert the angle between the two voltages into a DC preset voltage that is used to preset the roll amount gyro in the designated missile. The components of the A_G transmission system are discussed in (1) through (10) below.

(1) An auto-gyro preset relay, in the energized condition, switches the A_G transmission system into the automatic mode of operation. In the manual mode the computed A_G angle is transmitted by voice communication from the battery control area to the operator at the launching section, who sets the A_G angle manually by using the gyro preset knob on a manual gyro preset resolver. In the automatic mode, A_G is sent from the computer to the launching set via the cabling system as shown in figure 8.

(2) A phase adjust variable resistor com-

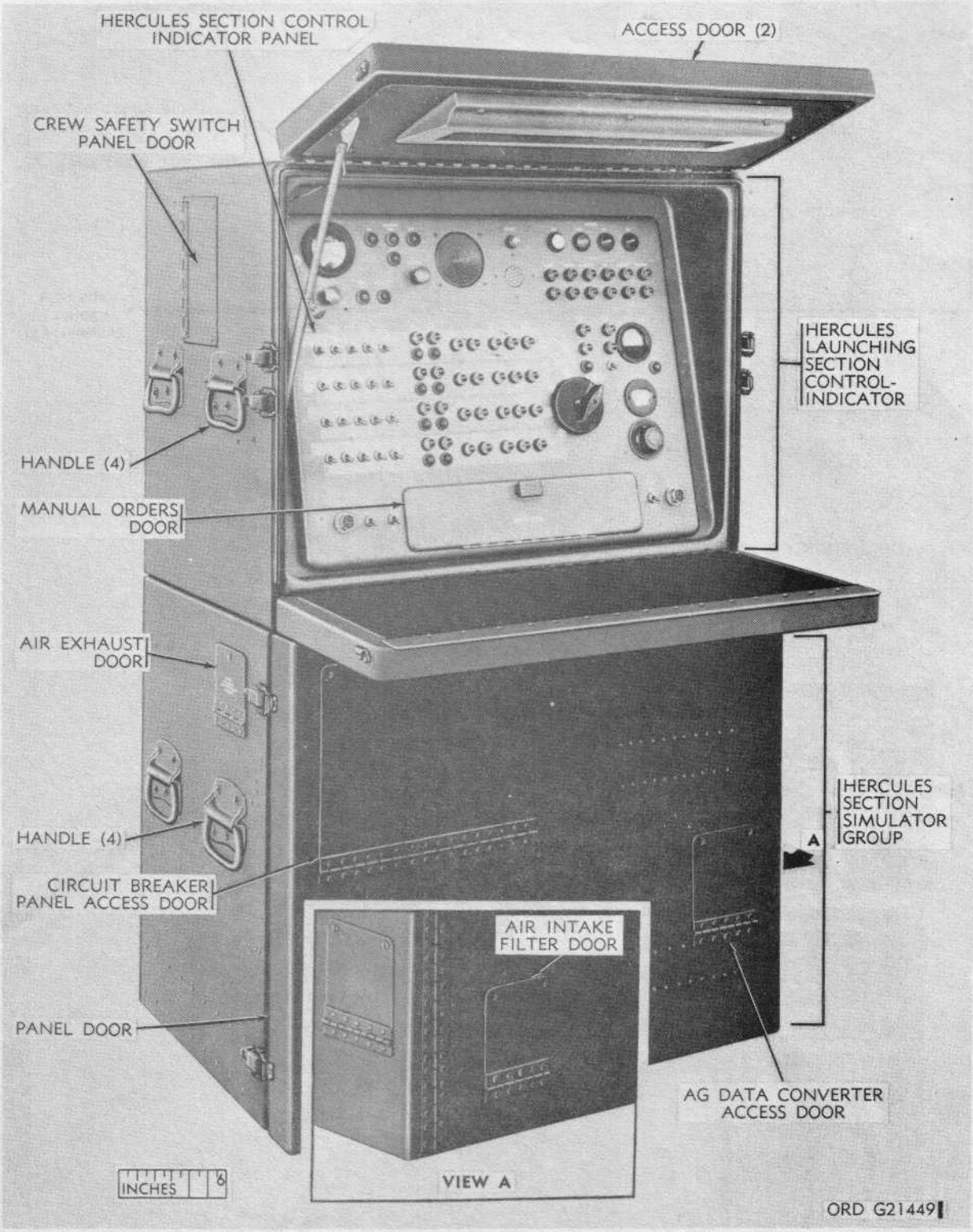

Figure 4. Section control indicator and simulator group.

pensates for a phase error up to plus or minus 10 degrees which may occur during transmission. This is necessary due to phase shift in the signal, produced by the long cable between the battery control area and the missile. The phase shift is caused by the inductive-capacitive properties in the cables. The phase shift must be

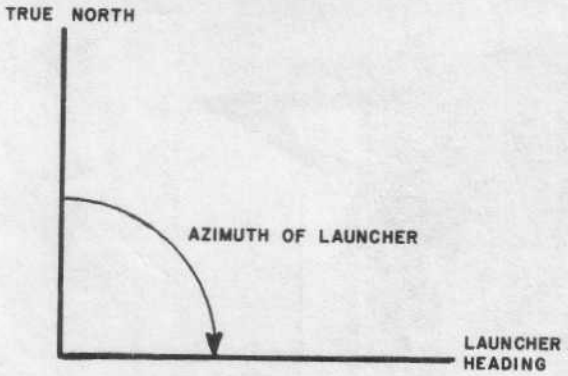

Figure 5. Azimuth of launcher.

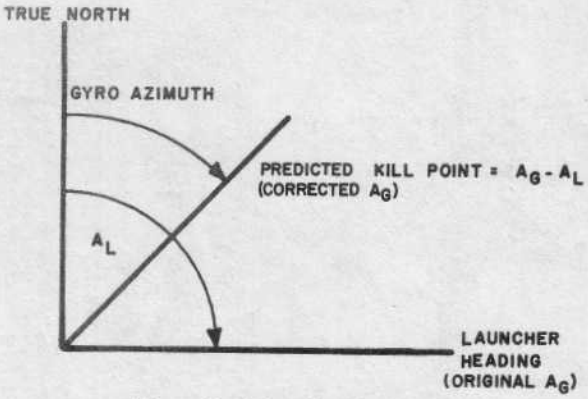

Figure 6. Azimuth of gyro.

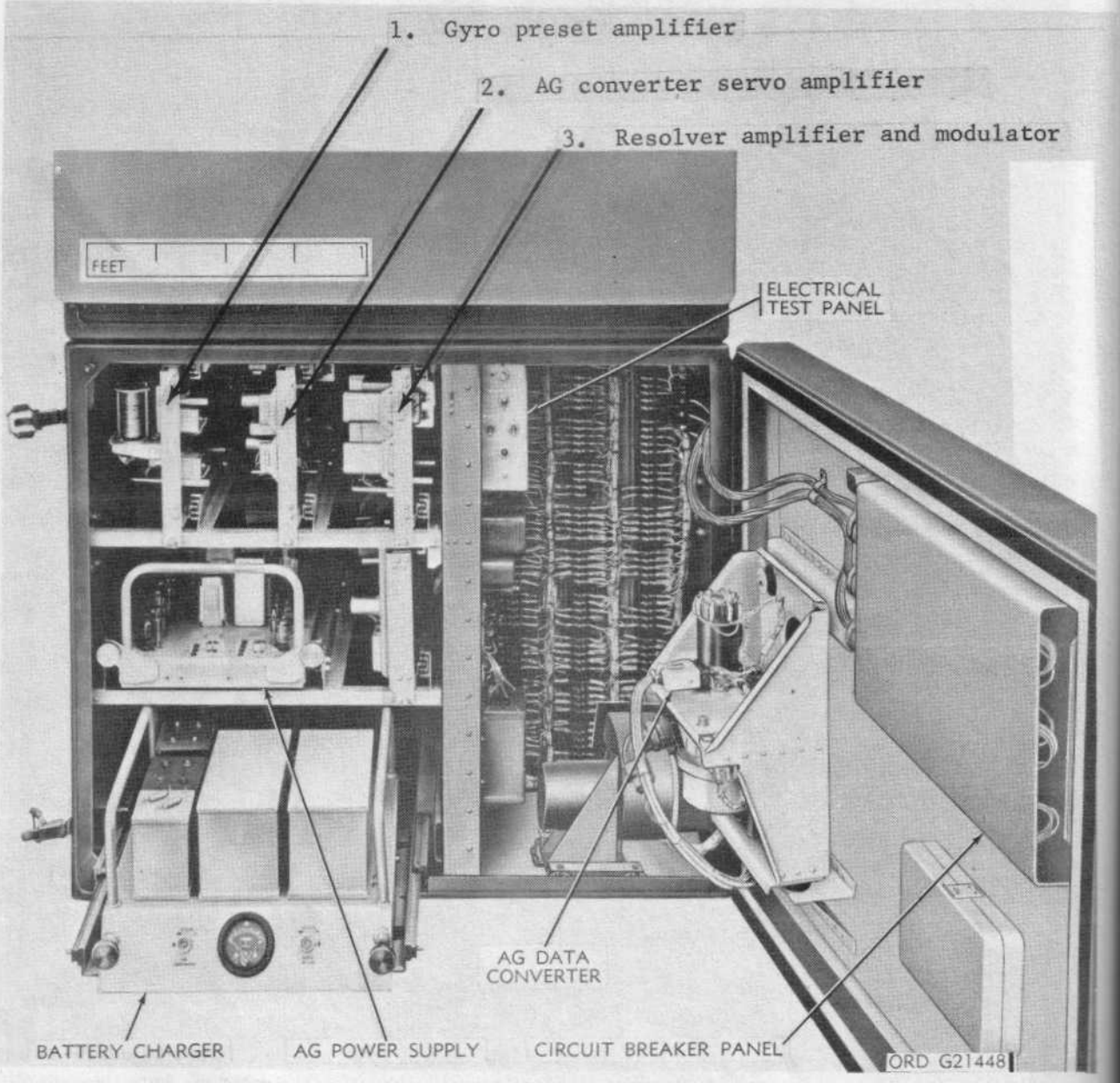

Figure 7. Simulator group.

compensated for since the A_G transmission system transfers the A_G data to the roll amount gyro by the phase difference in two signals (A_G preset and A_G reference).

(3) An A_G line amplifier, on slide No 1 in figure 7, provides impedance matching between the phase adjust variable resistor and the A_G resolver amplifier during the automatic mode of operation, or between the A_G resolver amplifier and the manual preset resolver during the manual mode of operation.

(4) A_G resolver amplifiers 1, 2, and 3, on slide 2 and 3 of figure 7, provide amplified 400 Hz voltage to their associated resolvers. This voltage is necessary to drive the A_L resolvers and the manual preset resolver.

(5) The A_L resolvers, one for each monorail launcher, supply an input to the A_G transmission system which modifies the phase angle of the A_G preset voltage to compensate for angular displacement of the launcher from due north as discussed in paragraph 3a(2).

(6) An A_G converter servoamplifier, slide No 2 of figure 7, compares the phase angle between the A_G preset voltage and the A_G reference voltage to produce a direct current drive voltage.

(7) The A_G converter modulator, on slide 3 of figure 7, converts the direct current drive voltage into a 400 Hz drive voltage that is applied to the A_G data converter two-phase motor.

(8) The A_G data converter produces plus or minus 20 volts DC (A_G–A_L) which are applied through the launcher to a variable resistor in the missile roll gyro package. The roll amount gyro and variable resistor are mechanically connected to a DC preset servomotor. If the roll amount gyro and variable resistor are not positioned to the correct A_G angle, a plus or minus DC error will be produced and applied to a gyro preset servoamplifier (fig 8).

(9) The amplified DC signal from the gyro preset servoamplifier is applied to a gyro preset motor. The gyro motor rotates the gyro and the variable resistor until the DC input to the gyro preset servoamplifier is zero volts. At this time the gyro is positioned to the correct A_G angle and the motor will stop.

(10) The A_G power supply (fig 7) provides the operating voltages for the components of the A_G transmission system that are located in the simulator group.

4. LAUNCHER CONTROL INDICATOR. One launcher control indicator (fig 9) per launcher is supplied with each launching set. The launcher control indicator (LCI) is used to provide the LCI operator local control of the launcher and missile while performing electrical and hydraulic tests. Local control is accomplished by placing the test-fire switch on the LCI to the test position. In the fire position, the section control indicator operator exercises electrical and hydraulic control of the launcher and missile.

5. HERCULES MONORAIL LAUNCHER HYDRAULIC SYSTEM.

a. **General.** The monorail launcher provides a hydraulic system to elevate and lower the missile for launching. Before the hydraulic system can operate, the equilibrator accumulator, the hydraulic surge accumulator, and the air reservoir, all shown on the left side of figure 10, must be externally precharged. The equilibrator accumulator is precharged with dry air or nitrogen to a pressure of 600 pounds per square inch (PSI). This provides a cushion of compressed air to absorb rapid changes in the hydraulic pressure used in the two equilibrator erecting cylinders shown on the right of figure 10. The hydraulic surge accumulator is precharged to 2,000 PSI and is located in the high pressure line to absorb sudden surges of hydraulic pump

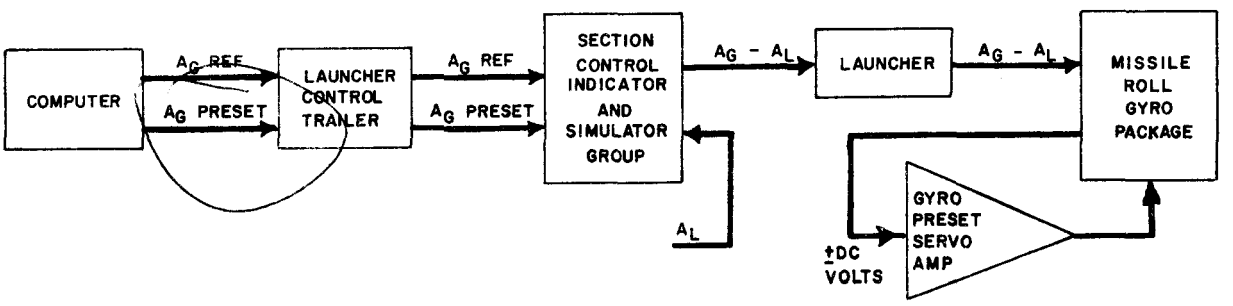

Figure 8. AG transmission system.

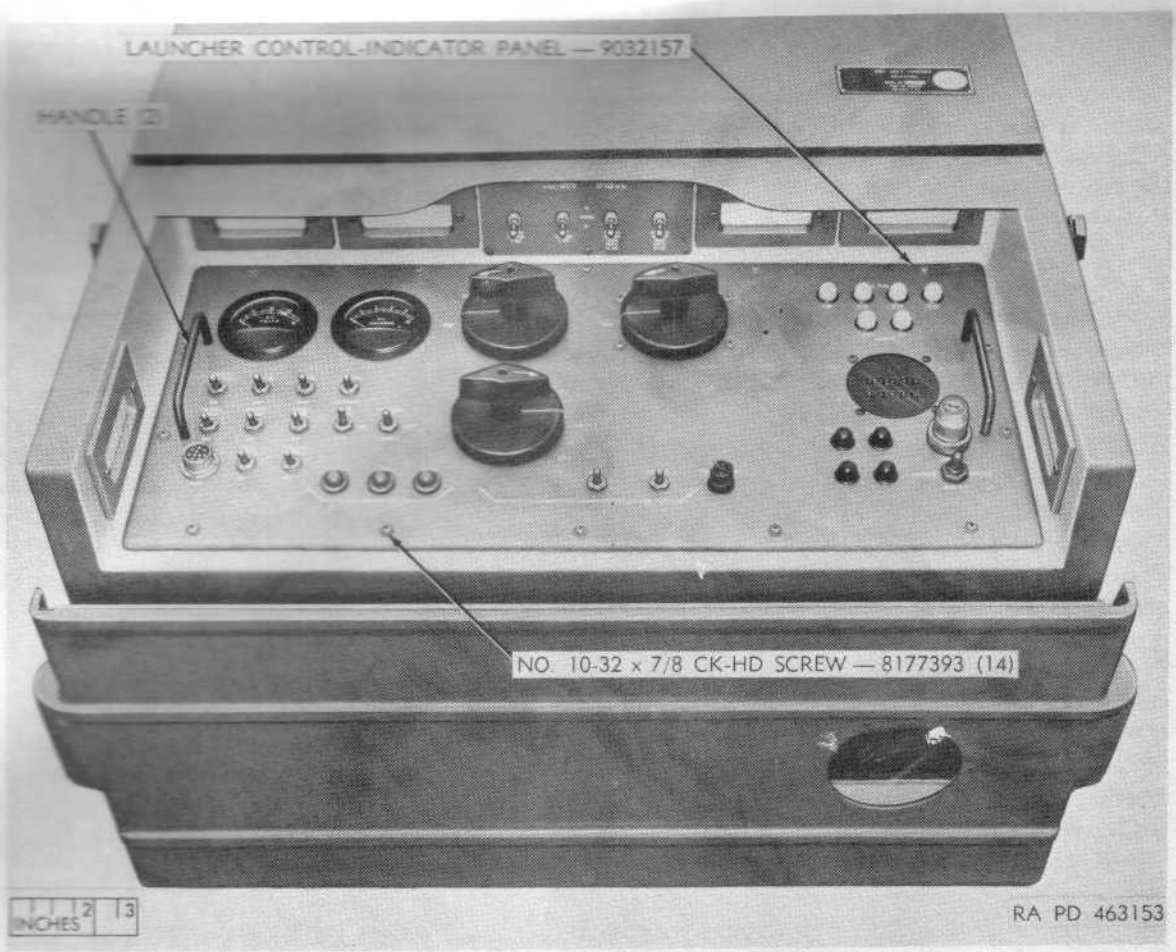

Figure 9. Launcher control indicator.

pressure. The air reservoir is precharged to 2,000 PSI and feeds an air regulator that charges the air section of the hydraulic oil reservoir to 20 PSI. The hydraulic oil reservoir provides a constant flow of hydraulic oil at 20 PSI to the hydraulic pump and receives the return hydraulic fluid from the system. The Deloader valve is open when the HPU motor starts allowing fluid to circulate back into the reservoir. The valve closes as pump pressure builds up to 3,250 PSI. This valve prevents damage to the HPU motor by allowing it to start under a light load. The manual system globe bypass valve is used to manually relieve pressure on the hydraulic system for maintenance purposes. It allows hydraulic fluid to flow back into the oil reservoir and must be manually closed while raising and lowering the erecting beam. The solenoid valves control the direction of flow of the hydraulic fluid to and from the hydraulic cylinders, and in turn, determine if the erecting beam is raised or lowered. The system relief valve operates automatically to relieve excessive output pressure of the pump.

b. **Launcher UP cycle.** When the launcher UP-DOWN switch is placed in the UP position, the hydraulic pumping unit motor is energized, providing 3,250 PSI hydraulic fluid to the actuating components in the hydraulic system (fig 10). The wedge lock-unlock solenoid valve is then energized and fluid is channeled to the front and rear wedge locks (fig 10 and 11). Hydraulic pressure is also channeled through the launcher up-down solenoid (fig 10) to release the hydraulic down lock assembly. This disengages the down latch mechanism from the erecting beam. Hydraulic pressure is now channeled through the restrictor valve to operate the pistons in the two power and the two equilibrator erecting cylinders. All four erecting cylinders (fig 10 and 11) will elevate the erecting beam. The equilibrator cylinders provide additional necessary power to control the up and down movement of the launcher between 0 degrees and 70 degrees elevation of the erecting beam and maintain equal pressure on both sides of the erecting beam. When the line pressure reaches 3,000 PSI, safety valve 1 opens, channeling

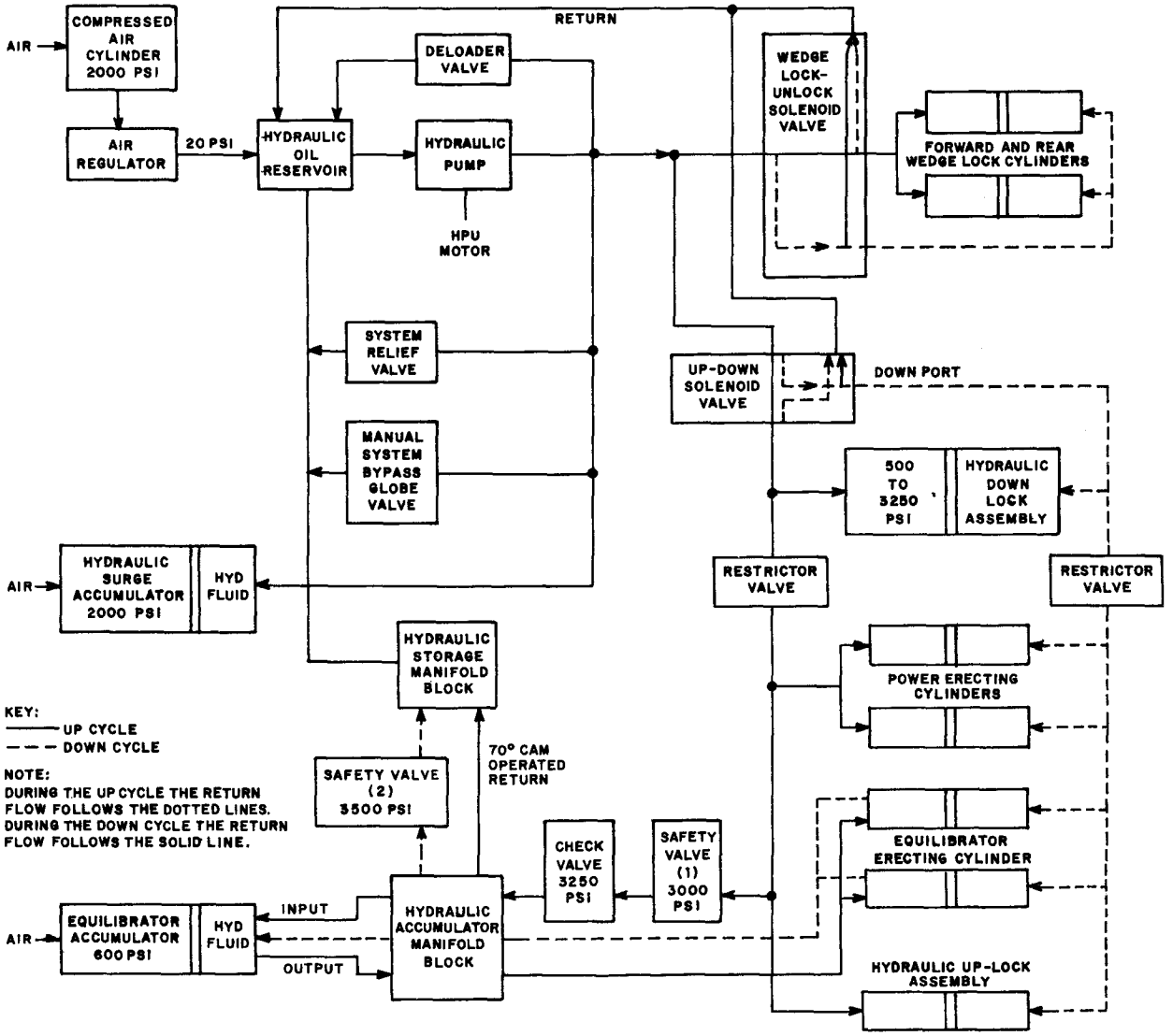

Figure 10. Simplified launcher hydraulic block diagram.

hydraulic fluid through a one-way check valve into the hydraulic accumulator manifold block and equilibrator accumulator. This pressurizes the equilibrator accumulator to 3,250 PSI and holds it. Pressurized fluid from the equilibrator accumulator flows back through the manifold and into the equilibrator erecting cylinders. All four erecting cylinders begin raising the erecting beam and missile. When the erecting beam reaches 70 degrees elevation a cam-operated valve that is connected to the accumulator manifold block opens, dumping the pressure on the equilibrator cylinders, through the hydraulic storage manifold block, back into the hydraulic oil reservoir. The power cylinders continue to elevate the erecting beam. When the erecting beam reaches the full UP position, the spring-loaded up-lock pistons in the up-lock assembly mechanically engage locking plates to the erecting struts; locking the erecting beam UP. At this point, the UP-LOCK limit switches are actuated and the hydraulic pumping unit motor will deenergize.

c. **Launcher DOWN cycle.** When the launcher UP-DOWN switch is placed in the DOWN position, the hydraulic pumping unit motor will energize. Hydraulic pressure from the down port of the up-down solenoid releases the up-lock assembly (fig 10), which releases the up locking plates from the erecting struts. Hydraulic pressure is channeled to the rear ports of the power and equilibrator cylinders, and the erecting beam begins to lower. Hydraulic fluid is forced from the forward ports of the power erecting cylinder through the restrictor valve and into the return port of the up-down solenoid. Fluid is forced from the forward ports of the equilibrator erecting cylinders through the accumulator

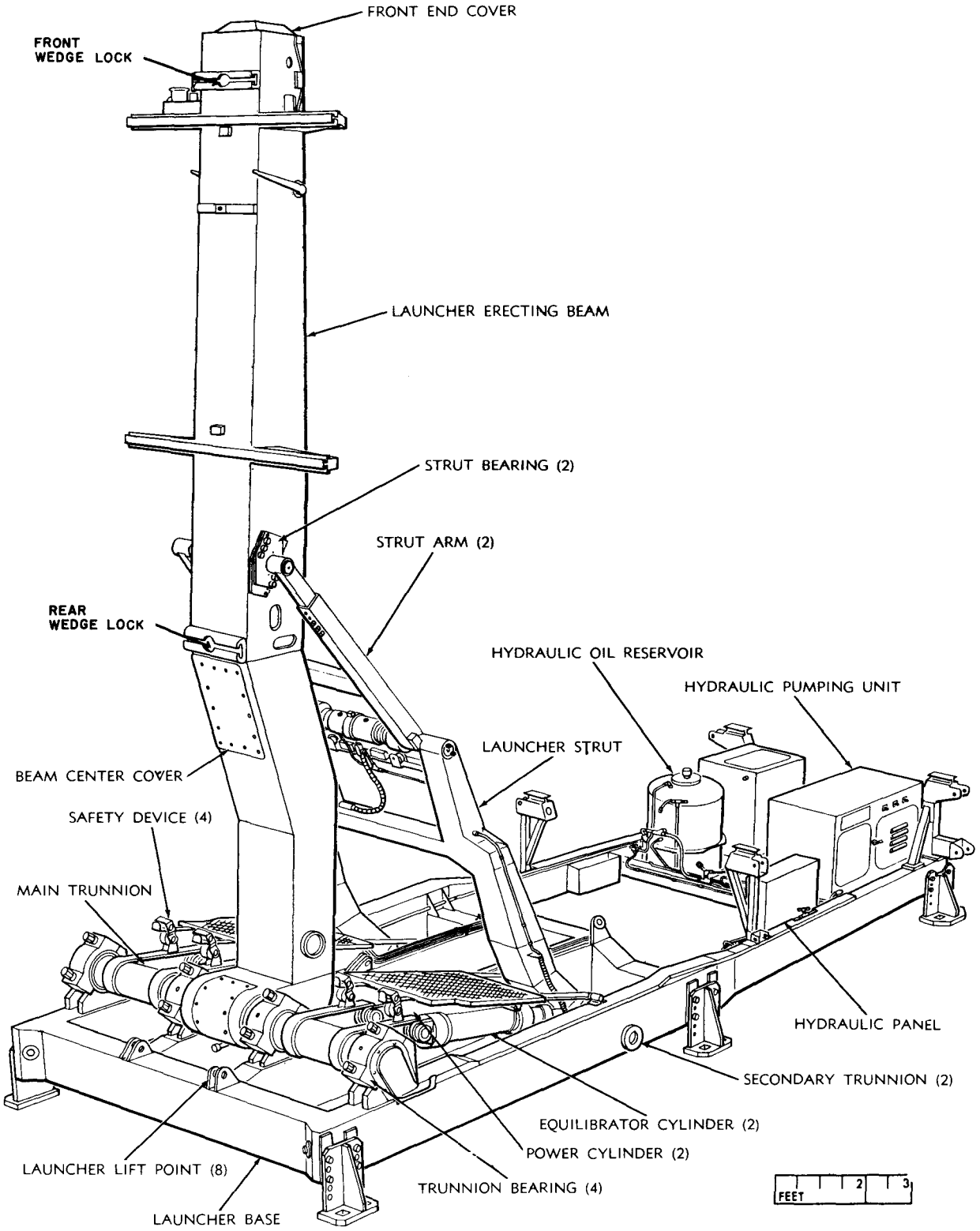

Figure 11. Hercules monorail launcher - rear view.

manifold block, cam operated valve, and storage manifold block into the hydraulic oil reservoir until the erecting beam reaches 70 degrees elevation. At 70 degrees elevation the cam operated valve closes and the fluid is forced into the equilibrator accumulator. If pressure in the equilibrator reaches 3,500 PSI, safety relief 2 opens allowing the fluid to return to the oil reservoir. When the launcher erecting beam is fully lowered, the erecting beam hook is mechanically engaged by a spring loaded down latch mechanism, locking the launcher down. This trips the down latch limit switch which energizes the wedge lock-unlock solenoid. This actuates the pistons in the front and rear wedge locks to disengage them. It also unlocks the launching and handling rail from the erecting beam and shuts off the hydraulic pumping unit motor.

6. OPERATIONAL CONTROL AND FIRING CIRCUIT.

a. **Alert alarm.** This circuit is used with the equipment status circuits to provide an audible indication of an alert. The alert alarm circuit is energized when the battery control officer places the battery in blue alert.

b. **On deck.** This circuit indicates that the launching sections should prepare their missiles for launching. "On deck" is given from the launcher control trailer as soon as blue status is received.

c. **Warhead and mission request.** This circuit indicates the type of warhead and mission requested from the battery control area.

d. **Missile prepared circuit.** This circuit indicates the total number of missiles prepared in each launching section. This information appears on a missile prepared meter at the launching control console and gives the launcher control officer and the battery control officer an indication of how many missiles they will be able to launch.

e. **Launcher elevation.** This circuit controls the erecting and lowering of the monorail launchers.

f. **Filaments and gyro circuits.** This circuit provides the necessary voltages to the missile guidance set.

g. **Missile ready circuit.** This circuit indicates that the launching section is ready to launch a missile. The information is fed from the section control indicator to the launcher control trailer, then to the battery control area, and will indicate to the battery control officer that he can commence launching missiles.

h. **Fire command circuit.** When the fire command switch in the battery control trailer is operated, voltage is applied to the rocket motor cluster for the launching of the missile.

7. **MAINTENANCE.** Preventive maintenance service intervals have been established to insure efficient system operation. Effective inspection criteria must be used along with good maintenance policies, so that the materiel can be declared either serviceable or unserviceable according to operational standards. Some maintenance procedures performed on the launching set by direct support personnel are listed below.

a. **Launcher control trailer.** When the flight simulator group is nonoperational and the using unit cannot repair it, direct support personnel will be required to return the flight simulator group to a serviceable condition. When the direct support personnel accept the flight simulator, they should require that the control unit and the power supply be sent to the ordnance shop along with the flight simulator. The flight simulator is checked out by the missile repairman (MOS 22M). To accomplish this the technician uses an RF and pulse test set group that will be discussed in lesson 4. The control unit and the power supply will be repaired by the Nike test equipment repairman (MOS 22L) using electronic shop 2, position 5, which is discussed in lesson 5. Other maintenance problems may arise in the many relays, the battery charger, and the heater control unit in the launcher control trailer.

b. **Launching section control indicator and simulator group.** Direct support maintenance is normally limited to the replacement of relays, installation of modification work orders, and the repair of the roll amount gyro (AG) preset system. Faulty chassis in the AG preset system will be removed from the simulator group, when replacement chassis are not on hand. These chassis are repaired after testing by use of electronic test equipment in shops 1, 2, or 3, which is discussed in lesson 5.

c. **Monorail launcher.** Maintenance problem areas on the monorail launcher are usually in the hydraulic system, hydraulic pumping unit, wedge locks, down-lock, and power and equilibrator cylinders. Components from the monorail launcher are checked out and repaired using the hydraulic test stand and associated equipment.

8. **SUMMARY.** This lesson has provided a discussion of the function of equipment located in the launching area and some aspects of support maintenance required to return the equipment to a serviceable condition. The discussion included the function of flight simulator, A_G transmission, and launcher hydraulic system.

MMS SUBCOURSE NUMBER 151, NIKE MISSILE AND TEST EQUIPMENT

EXERCISES FOR LESSON 3

1. What is used to check out the flight simulator?

   A. TS-352 multimeter
   B. AF and power test set
   C. RF and pulse test set
   D. Transponder control test set

2. What is the purpose of the pulse transfer relays in the flight simulator group?

   A. Select Ajax mode when energized
   B. Select Hercules mode when energized
   C. Provide local control of the flight simulator
   D. Reject improperly coded command signals

3. When does the flight simulator send a response pulse back to the missile tracking radar?

   A. Continuously
   B. Alternately
   C. When interrogated
   D. During missile flight

4. What causes the phase shift in A_G signal transmitted to the missile?

   A. Copper loss
   B. Skin effect
   C. Inductance and capacitance
   D. Resistance

5. Why is it necessary to have relay comparison in the section control indicator?

   A. To insure the proper warhead and mission selection
   B. To notify panel operator of a faulty warhead
   C. For servicing the missile hydraulic pumping unit
   D. To insure that the launcher control officer has selected the target

6. How is the radar modulator in the flight simulator used?

   A. Demodulates the command signal
   B. Generates the transmitted pulse
   C. Generates the magnetron trigger pulse
   D. Generates a trigger pulse to light the burst light

7. Who has operating control over the launcher and missile when the launcher control indicator test-fire switch is in the test position?

   A. Section control operator
   B. Launcher control indicator operator
   C. Computer operator
   D. Launching section chief

8. If A_G is 3,200 mils and A_L is 1,300 mils, through what angle, in mils, will the roll amount gyro rotate to stop at the predicted kill point?

   A. 1,300
   B. 1,900
   C. 3,200
   D. 4,500

9. If the A_G is 400 mils and the launcher azimuth is 1,400 mils, what is the corrected A_G or PKP?

   A. 400
   B. 1,000
   C. 1,400
   D. 5,400

10. What protects the launcher hydraulic pump motor from heavy starting loads?

    A. Surge accumulator
    B. Globe bypass valve
    C. System relief valve
    D. Deloader valve

11. When the launcher is in the full UP position, what deenergizes the hydraulic pumping unit motor?

A. 70 degrees cam operated valve
B. Down latch mechanism
C. Up-lock pistons
D. Up-lock switches

12. What is the flight simulator group used for during missile firing?

A. Standby beacon target
B. Missile calibration
C. Checkout missile tracking radar
D. For missile designation

13. To what pressure is the equilibrator accumulator precharged?

A. 20 PSI
B. 600 PSI
C. 2,000 PSI
D. 3,250 PSI

14. What is used to switch the gyro azimuth system into automatic operation?

A. Autogyro preset relay
B. A_G resolver amplifier
C. A_G line amplifier
D. Gyro preset knob

15. How is the A_G line amplifier used?

A. Load for the phase adjust variable resistor
B. Impedance matching
C. Amplifies A_L signal
D. Converts A_G–A_L to a DC voltage

16. How much pressure, in pounds per square inch, does the hydraulic pump provide to the actuating components in the hydraulic system?

A. 20 to 40
B. 600
C. 2,500
D. 3,250

17. What is an A_L resolver used for?

A. Orient the launcher
B. Level the launcher
C. Compensate for launcher azimuth
D. Stabilize A_G

18. The phase angle between which voltages transmitts gyro azimuth from the computer to the launching area?

A. A_G preset and A_L reference
B. A_G and A_L reference
C. DC preset and A_L reference
D. A_G preset and A_G reference

19. How much voltage is required to ignite the gas heater in the launching control trailer?

A. 24
B. 18
C. 12
D. 6

20. Which cylinders are used only between 0 degrees and 70 degrees while erecting the missile for launching?

A. Power
B. Equilibrator
C. Accumulator
D. Wedge-lock