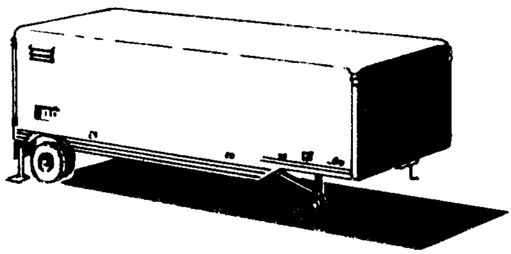

LESSON 8. TARGET SIMULATION

MMS Subcourse No 150	Nike Radars and Computer
Lesson Objective	To give you a general knowledge of the purpose, capabilities, and functions of major units of the AN/MPQ-T1 (target simulator).
Credit Hours	Three

TEXT

1. INTRODUCTION.

a. Fire control systems, although fully automatic and containing so-called electronic brains, must still depend on the human operator for efficient operation. As marvelous as some computers are, the machine that thinks or reasons has not yet been invented. The output of any computer depends on the data fed into it and the purpose for which it was designed. For example, the elevation and azimuth data pots, located on the tracking radar antennas, provide the data necessary for the computer to determine the pointing direction of the antenna. The accuracy of these tracking antennas depends on proper adjustment and trained operators. Early in the history of the Nike system, the need for trained operators was satisfied by targets of opportunity and annual service practice. With development of the AN/MPQ-36 radar signal simulator, controlled training under all weather conditions was available. Subsequent improvement of the Nike system made this simulator obsolete. A new simulator, the AN/MPQ-T1, was designed to be compatible with the basic Hercules and the improved Nike Hercules.

b. The AN/MPQ-T1 is a highly complex piece of equipment containing a large number of transistors, phase modulated servo systems, IF amplifiers as gain control stages, and employing digital techniques to develop chaff and simulate a masking function. The AN/MPQ-T1 has approximately one thousand *more* vacuum tubes and transistors than the basic Nike Hercules system. Some of these electronic stages function identically since the T-1 simulates six identical targets.

c. The T-1 operates on 400 hertz, 3-phase power requiring at least a 25-kilowatt source. Three air conditioners require 6 kilowatts each and the other circuits require 7 kilowatts.

2. PURPOSE.

a. The guided missile radar signal simulator (AN/MPQ-T1) is used in training personnel to operate the Nike Hercules and the improved Nike Hercules systems under simulated combat conditions. Operator personnel are trained in detecting, acquiring, and tracking high performance targets in either a quiet or ECM environment. When the T-1 is properly adjusted, it generates video signals that are realistic and indistinguishable from the real thing.

b. The T-1 is designed to have a no loading effect that could impede the Nike system's effectiveness.

However, quick disconnect circuits are provided to disconnect the T-1 from the Nike system by ejecting the interconnecting cables at the HIPAR building, director station, and tracking station trailers. These three cables provide all data interchange between the T-1 and the Nike system.

3. CAPABILITIES.

a. **Acquisition and track channels.** These channels generate video for the LOPAR, HIPAR, AAR, TTR, and TRR systems. The four types of simulated video are airborne targets, ECM, passive interference (clutter), and chaff. Masking off all video except clutter is also simulated. The masking occurs when a target flies behind an object, the top of which makes a greater angle in the vertical plane than the simulated target. The masking inhibits any target, ECM, or chaff which could otherwise be observed at the coordinates of the mask area.

b. **MTR channel.** Only range video is generated for the MTR; Ajax and Hercules missile flight characteristics are simulated by selecting the desired type. In addition, there are provisions for simulating conventional and nuclear warheads and for burst effects to be applied to multiple targets if the simulated target position falls within the lethal radius of the warhead. Circuits are built in which allow the battery commander to select a simulated or live missile. In this manner, simulated missiles can be directed against simulated targets, live missiles against simulated targets, or simulated missiles against live targets.

c. **Modes.** The T-1 may be operated in the "aline" mode for checking its operation before connecting it to an operational Nike system. To accomplish this, circuits are provided within the T-1 to generate sync pulses and antenna positioning voltages for the acquisition and track channels. There are also two cathode ray tubes for displaying video; one for acquisition video (PPI monitor) and one for track video (track control indicator). These indicators are used to display video before it leaves the T-1, or when the T-1 is in the radar mode, the indicators can display video returning from the radar if the Nike radars are operational. In the "radar" mode, the PPI monitor is connected in parallel with the director station PPI and the track control indicator is connected in parallel with the range scope, located in the tracking station trailer.

d. **Auxiliary circuits.**

(1) IFF circuits simulate an IFF response emanating from any of the six simulated targets. The five available responses are sent to the director station presentation system when the IFF generator receives a "challenge" signal from the director station trailer. These responses appear slightly out range from the challenged target. Selection of the target that will give a reply is accomplished by switches on the IFF generator. At the time of this writing, research is being done on an SIF generator which will provide more codes and a more realistic simulation of the identification function.

(2) Scoring circuits in the T-1 provides a means for timing the sequences which must take place during an engagement. These are: appear to designate, designate to lock on, lost to regain, and burst to fire. In the appear to designate sequence, the acquisition operators are timed. After the target is designated, the track elevation operator must search in elevation to lock on and track the target. This sequence times the track operators and provides a means for evaluating their performance.

(3) Recording circuits record errors in tracking, tuning, and missile flight on a paper chart. Switching determines which of these are recorded. When tracking errors are selected, azimuth, elevation, and range errors are recorded. When tuning is selected, TTR and LOPAR tuning is recorded. With missile flight selected, yaw commands (G y) and pitch (G p) are recorded. In addition, meters allow monitoring of track azimuth and elevation error sensing.

4. MAJOR UNITS.

a. **General.** The interior of the T-1 trailer is shown in figure 1. The power supply cabinet modifies and distributes power required for operation of the T-1's electronic circuits. The three passive interference generators (PIG), at the extreme right of figure 1, simulate masking of video for TTR, TRR, HIPAR or AAR, and LOPAR. They also generate clutter signals for each of these radars. Cabinet (1) is for HIPAR or AAR, cabinet (2) is for TTR and TRR, and cabinet (3) is for LOPAR. The auxiliary cabinet contains circuits which allow the T-1 to be operated in the "aline" mode, independent of the Nike system. The operator's console is the heart of the T-1 since it contains six target coordinate generators, a missile velocity and coordinate generator, and most of the pulse circuits of the T-1. The ECM cabinet contains circuits for the generation and control of ECM. Finally, the chaff cabinet contains circuits for positioning the simulated chaff to the simulated target position. A brief description of the function of each of these units is covered in the

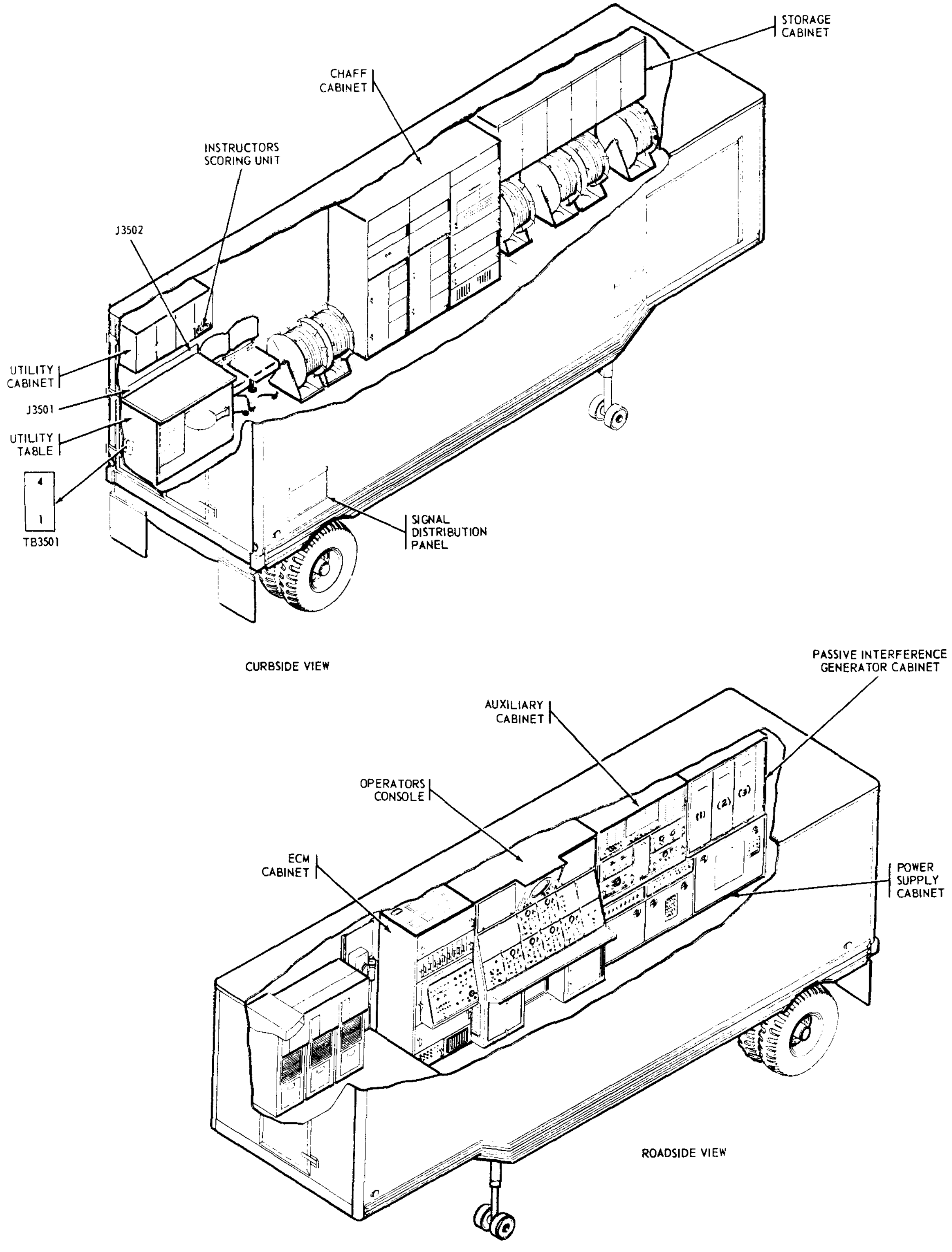

Figure 1. Simulator station AN/MPQ-T1 - location diagram.

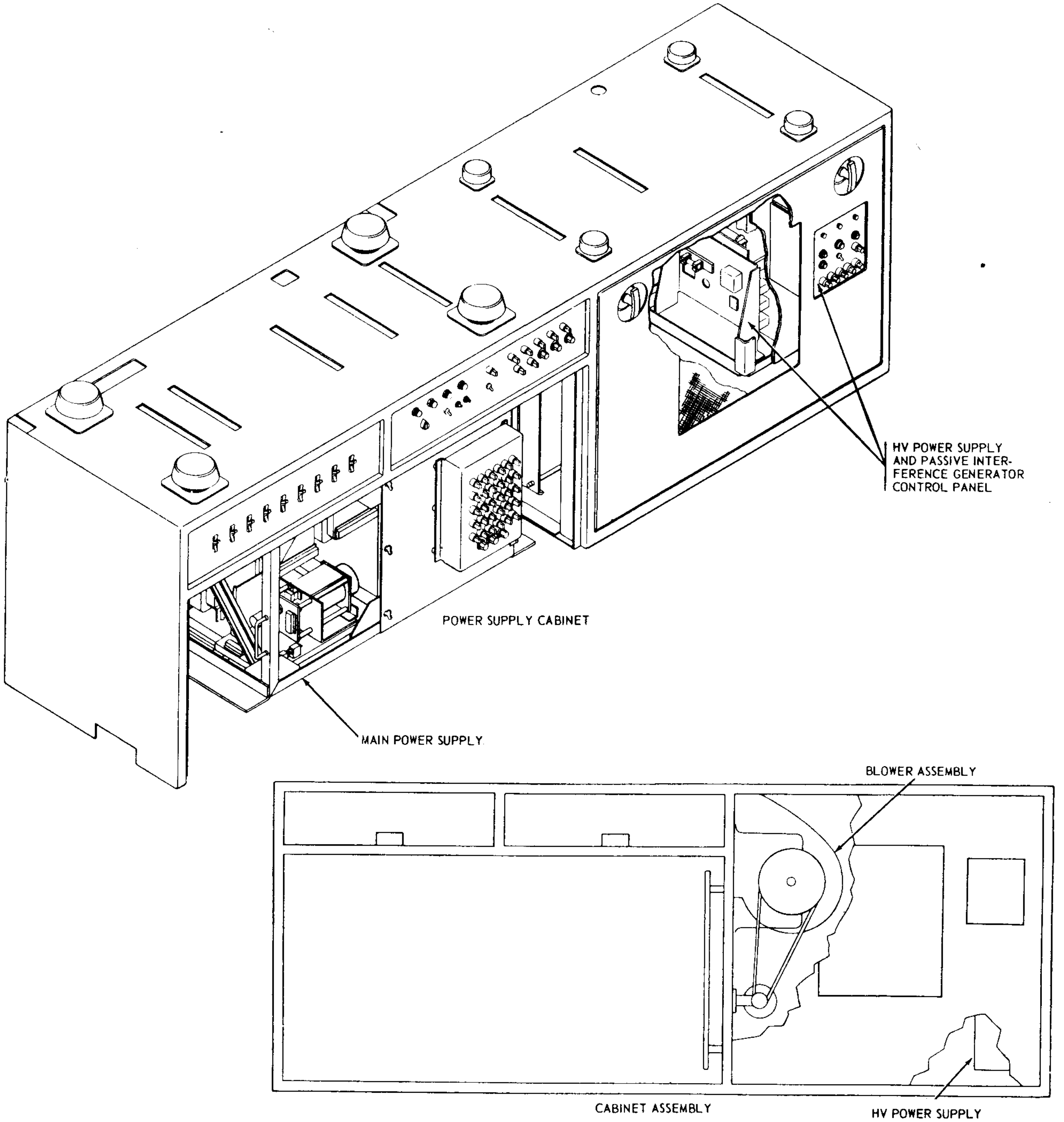

Figure 2. Power supply cabinet.

remainder of this lesson.

b. **Power supply cabinet**. The power supply cabinet (fig 2) receives all power necessary for operating the simulator station from a 120-volt, 3-phase, 4-wire, 400-hertz external source. This power is modified by AC regulators, transformers, and DC power supplies before being distributed throughout the T-1.

(1) Main power supply. AC regulators, in the main power supply, provide the inputs to the low voltage DC supplies, high voltage DC supplies, servo power transformers, and filament transformers. The regulated AC voltages are fed to seven DC supplies and three DC regulators. These DC voltages are then distributed throughout the T-1 when B+ is on. The servo power transformer converts 3-phase power, 120 degrees

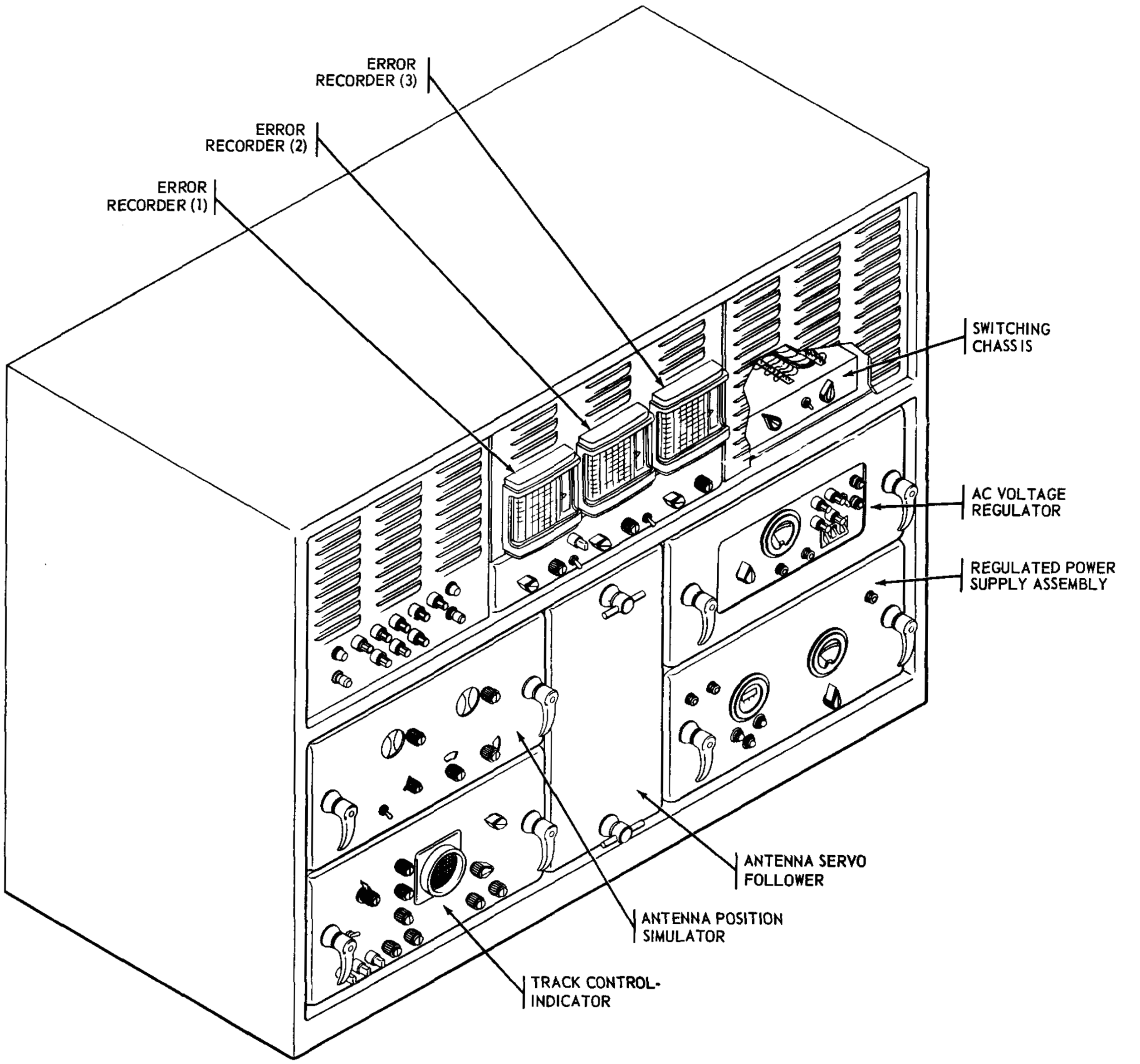

Figure 3. Auxiliary cabinet.

apart, into phase 0 degree, 90 degrees, and 180 degrees which is required for proper control of the servomotors. The filament transformer supplies vacuum tube heater voltage.

(2) High voltage power supply and passive interference generator control panel. The high voltage power supply and control panel on the right side of the main power supply cabinet (fig 2) generates and controls the application of 20,000 volts to each of the cathode ray tubes located in the passive interference generator cabinets (fig 1).

(3) Blower assembly. The blower assembly circulates air for equipment ventilation through the power supply, auxiliary and PIG cabinets, and the operator's console.

c. **Auxiliary cabinet.**

(1) General. The auxiliary cabinet (fig 3) provides circuits for generating a basic timing pulse and antenna position voltage necessary for operating, testing, and alining the AN/MPQ-T1 before it is connected to an operational Nike system. The problem of simulating video for a pulse radar system involves three major parameters. The video pulse must have range, azimuth, and elevation to define its position in space. Simulating video for the Nike system, then, is a problem of synchronizing on the system's basic timing pulse or radar

range zero and developing a time delay before generating a video pulse. This will locate the video some time or slant range away from the radar and solves one of the space coordinates. The video's azimuth and elevation angles can be determined by gating the video pulse ON only when the antenna is pointed in the direction of the simulated target, chaff, clutter, or electronic countermeasures (ECM).

(2) Track control indicator. The track control indicator (fig 3) contains an RC coupled Wein bridge oscillator for simulating the radar sync when in the aline mode. This oscillator drives a multivibrator which, in turn, drives a blocking oscillator that finally develops a simulated sync pulse. The simulated sync is sent to the switching chassis for distribution to all major units of the T-1. The track control indicator contains a sweep generator that develops a sawtooth voltage that rises linearly and returns to zero volts between each sync pulse. The sawtooth voltage deflects the electron beam and provides a time base for displaying target track video on the track control indicator 5-inch cathode ray tube. The track control indicator also contains a monopulse error detector to permit monitoring the simulated tracking functions. When this is done, the sawtooth voltage is not applied to the CRT. Instead, the monopulse error detector produces positive or negative DC voltages which, when applied to the CRT, produce deflection of the CRT electron beam. A positive DC voltage is produced by the monopulse error detector if the simulated target is above, or to the right, of the center of the track antenna team. These positive voltages deflect the intensified spot on the CRT up and to the right. The spot now represents the simulated target's position in the track antenna beam. Negative ouptuts from the monopulse error detector are produced if the target is below, or to the left of center of the track antenna beam. If no antenna error exists--the target is in the center of the antenna beam--the intensified spot appears in the center of the CRT.

(3) Antenna position simulator. The antenna position simulator drawer (fig 3) contains circuits for generating voltages representing antenna position. The track antenna position is simulated by two synchro transmitters; one for track antenna azimuth and the other for track antenna elevation. The acquisition antenna movement is simulated by a motor driven resolver rotor. Both methods are essentially identical to the methods used to transfer antenna position data from the moving antennas to the other portions of the track and acquisition radar system. These antenna position voltages, like simulated sync, are sent to the switching chassis which selects simulated antenna position in the aline mode or radar antenna position in the radar mode. The simulated or radar antenna position signals are applied to the antenna servo follower drawer.

(4) Antenna servo follower. The antenna servo follower (fig 3) contains circuits that prevent the T-1 from loading the Nike system antenna circuits. These T-1 circuits are synchro receivers that repeat the simulated or radar antenna position. The antenna movement is distributed from the servo follower to the operator's console, ECM cabinet, PIG cabinet, and chaff cabinet where it is used to determine where the antenna is positioned at any instant.

(5) Regulated power supply assembly. The regulated power supply assembly (fig 3) receives DC input voltages from the power supply cabinet and provides three regulated outputs. These are +150, -150, and +300 volts DC which are supplied to all cabinets of the T-1. These regulators prevent fluctuations in source voltages having an effect on operation of circuits within the T-1.

(6) AC voltage regulator. The AC regulator (fig 3) receives a 3-phase AC voltage from an external primary power source. By using one phase from the primary power source, this regulator holds all three phases near 120 volts. The regulated output power is used as AC servo power and as the input for a -28 volt DC supply.

(7) Switching chassis. The switching chassis (fig 3) provides a means for selecting a simulated sync pulse and antenna position in the aline mode or the Nike radar's sync pulse, antenna rotation, and control voltages in the radar mode.

(8) Error recorders.

(a) The error recorders (fig 3) record pitch and yaw commands sent to the simulated missile during a simulated engagement. The recorder function selector switch on the switching chassis also allows these recorders to make a permanent record of tuning errors made by the LOPAR and TTR operator or errors made in tracking the simulated target. Recorder 1 records only range errors made in tracking. Recorder 2 records Gp commands, TTR tuning or azimuth tracking errors. Recorder 3 records G_Y commands, LOPAR tuning, or elevation tracking errors.

(b) The recording of errors is accomplished by applying a DC error signal to an electromechanical device that tunes a tuned plate-tuned

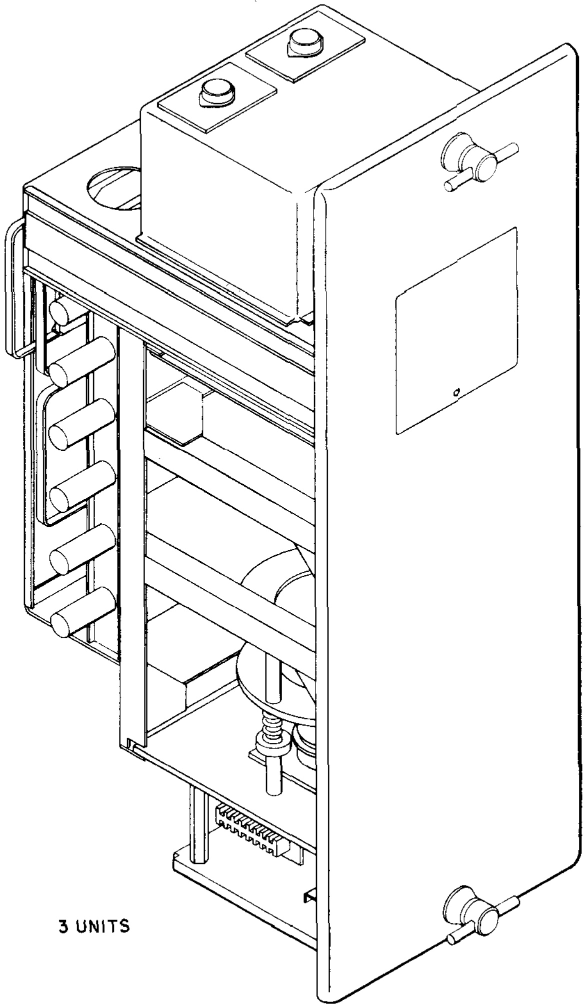

Figure 4. Passive interference generators.

grid oscillator. When no error exists, the average plate current from the oscillator causes the actuator to position the recorder pen to the center position on graph paper. If the missile is issued a pitch up or down command, the oscillator tuning is changed to produce an increase or decrease in plate current. The resulting change in oscillator plate current, flowing through the actuator, produces corresponding deflection of the pen. Graph paper is pulled under the pen at one of two selected speeds. Thus, the increment of time the command or error existed is permanently recorded.

d. Passive interference generators.

(1) The three passive interference generators (fig 4) simulate clutter and masking for the appropriate Nike radars. Generator 1 simulates clutter and masking for the HIPAR or AAR, generator 2 for TTR and TRR, and generator 3 for LOPAR. Their purpose is to trigger a clutter IF return to the radar that is proportional to the simulated clutter level and generate voltages used to shut off the simulated targets when they are in the masked area. The masking voltages are also used to inhibit ECM and chaff emanating from a masked target.

(2) The operational principle of each passive interference generator is illustrated in figure 5. Each contains a cathode ray tube whose sweep serves as a light source. The sweep voltage is initiated by the appropriate radar's basic timing pulse. The antenna azimuth data causes this sweep to rotate in sync with the radar antenna. As the sweep scans from the center to the outer edge of the CRT and is rotated in sync with the antenna, it produces an illuminated radial trace on the face of the CRT. The light rays from this trace are focused by lenses onto photographic slides which

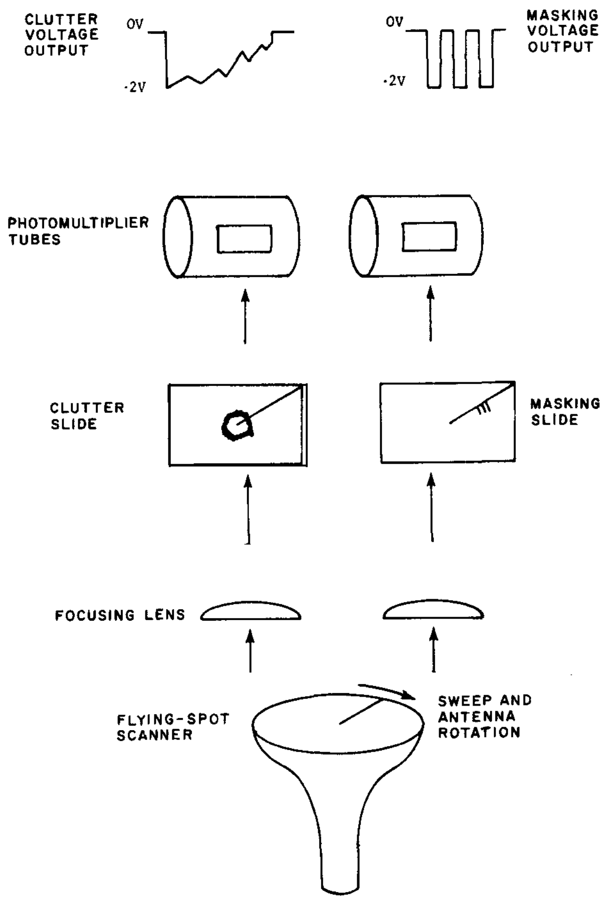

Figure 5. Mask and clutter generation.

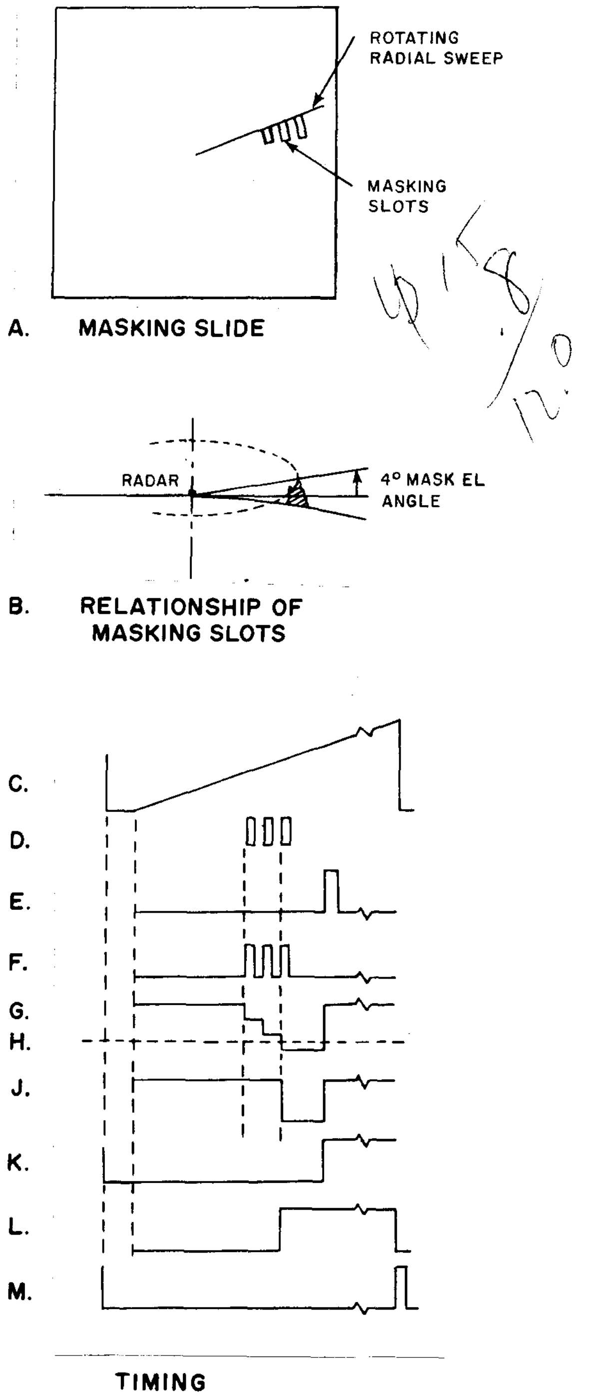

Figure 6. Mask timing - simplified.

represent pictures of the area. The clutter slide consists of five shades of gray with the lightest shade in the center of the slide and the darkest shade near the outer edges. The masking slide consists of small transparent slots positioned on the slide to indicate azimuth and range to the masked area. The light rays pass through the transparent areas and are filtered out by the dark areas.

The resultant modulated light beam is converted into a proportional voltage change by the photo-multiplier tubes. The clutter voltage, whose amplitude is a function of the shades of gray, is used to amplitude modulate an intermediate frequency (IF). This IF is routed through interconnecting cables to the appropriate radar. The masking pulses are converted into a mask angle DC voltage proportional to the number of slots on the slide. Each slot represents 1.33 degrees of mask elevation angle and a slide can have a maximum of 15 slots. As illustrated in figure 6, the masking pulses (F) are generated when the antenna rotates the sweep under the slots (A) and (D) (fig 6). The mask pulses are converted to a mask voltage (G) which steps 0.8 volts negative at each mask pulse. The negative mask angle voltage (G) is compared, in a differential amplifier, with the target elevation angle voltage DC level (H). The negative target elevation is generated by the target coordinate generator and goes more negative as the target increases in elevation. When the mask angle voltage is more negative than the target elevation angle voltage DC level, a mask condition for that particular target is detected and the differential amplifier generates mask pulse (J). The mask pulse (J) and the 100-mile mask gate (K) are applied to an "and" gate. When both (J) and (K) are on the negative excursion, the "and" gate triggers a storage flip-flop, which stores a mask gate (L). The mask gate (L) is held until the end of the sweep pulse (M) resets the storage flip-flop, removing the mask command. This entire sequence is repeated once each sweep as long as the sweep is at the azimuth of the mask slots. The mask gate (L), while on a positive excursion, inhibits target, ECM, and chaff video. The mask angle voltage (G), mask voltage (J), and 100-mile mask gate (K) are reset at a 100-mile range by the 100-mile reset pulse (E). The 100-mile reset is possible because of earth curvature. For example, a mountain would have to be approximately 4,000 feet high to cause a mask at 100 miles. The mask gate (L) simulates an object which has elevation, range, and azimuth, The object's range and azimuth are determined by the position of the mask slots and its elevation is determined by the number of slots on the mask slide.

e. **Operator's console.**

(1) Target coordinate generator.

(a) Since it contains six target coordinate generators and a missile velocity and position generator, the operator's console (fig 7) is the heart of the T-1. Each target coordinate generator (TCG) supplies voltages used to determine the simulated target's position in space in spherical coordinates. The front

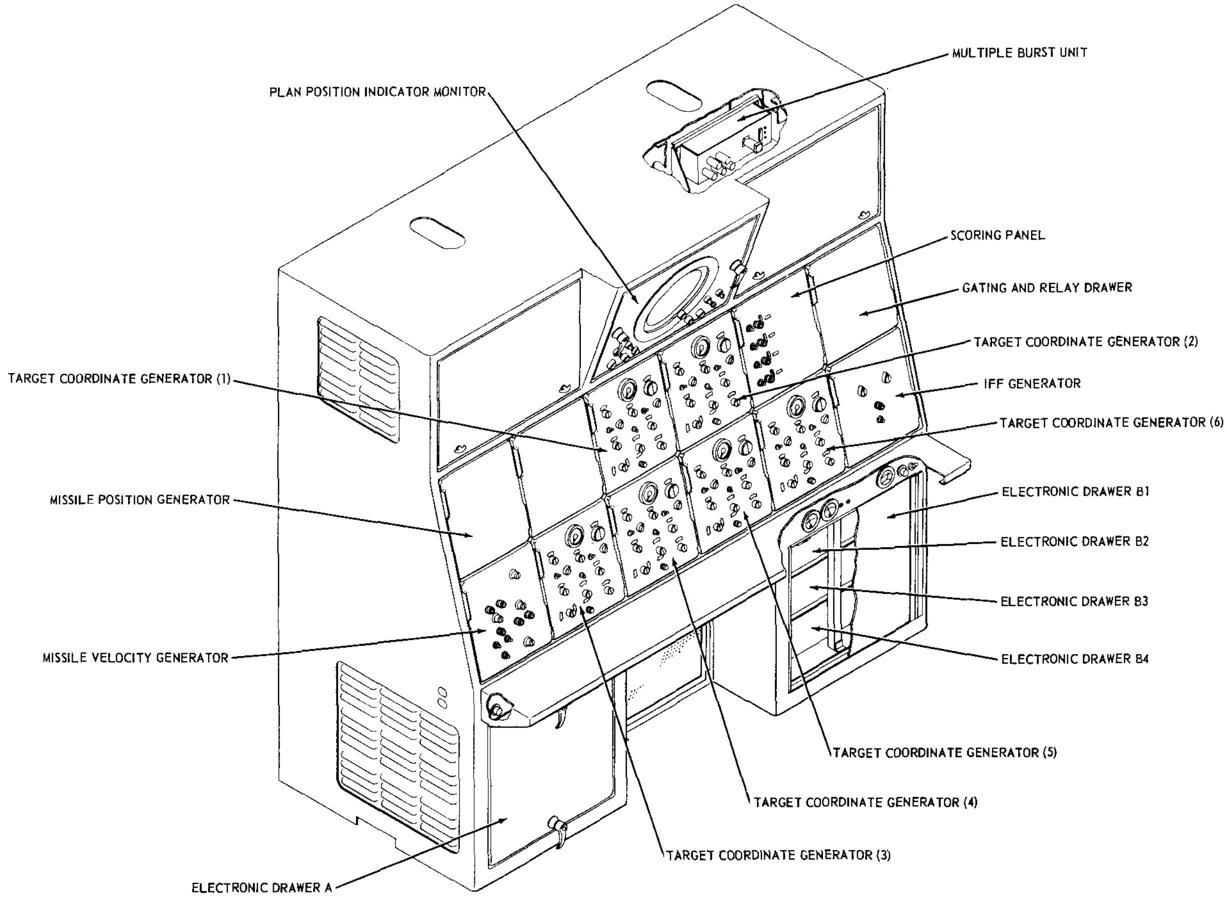

Figure 7. Operator's console.

panel controls on each TCG allow initial position, velocity, and direction of target flight to be selected as illustrated in figure 8. Once the target's initial position is determined, the target may be maneuvered the same as an actual target by using the climb, dive, and turn controls.

(b) The simulated target may have a calibrated position that falls within the following limits:

(D_T) Slant range = 0 to 400,000 yards
(E_T) Elevation angle = 0 degrees to 90 degrees
(A_T) Azimuth = 0 degrees to 360 degrees
(H_A) Heading = 0 degrees to 360 degrees
Climb = 0 to 40,000 ft/minute
Dive = 0 to 80,000 ft/minute
Turn rate = 0 degrees to 20 degrees per sec
Altitude = 0 to 150,000 feet
Velocity = 0 to 2,000 knots

(c) When the initial target position is placed into the TCG, servos position potentiometer wiper arms to obtain voltages which represent slant range (D_T), azimuth angle (A_T), elevation angle (E_T), and other voltages which represent the target's flightpath through space. Velocity is taken from the wiper arm of a potentiometer (R_1), as shown in figure 9. Twenty-six volts represent maximum velocity of 2,000 knots. This velocity is given direction by the rotor angle of the velocity resolver (B_1) in the heading servo. The heading servo (fig 9) resolves total velocity into velocity components along the X axis (X_T) and Y axis (Y_T). For example, if the target is headed northeast at 1,000 knots, the rotor angle of B_1 is at 45 degrees and the wiper arm of R_1 supplies 13 VAC to the stator of B_1. The voltage which represents the target's velocity component along the north axis is:

$$\dot{Y}_T = V \cos H_A$$
$$\dot{Y}_T = 13 \text{ VAC} \times .707$$
$$\dot{Y}_T = 9.191 \text{ volts.}$$

The voltage representing eastward velocity is:

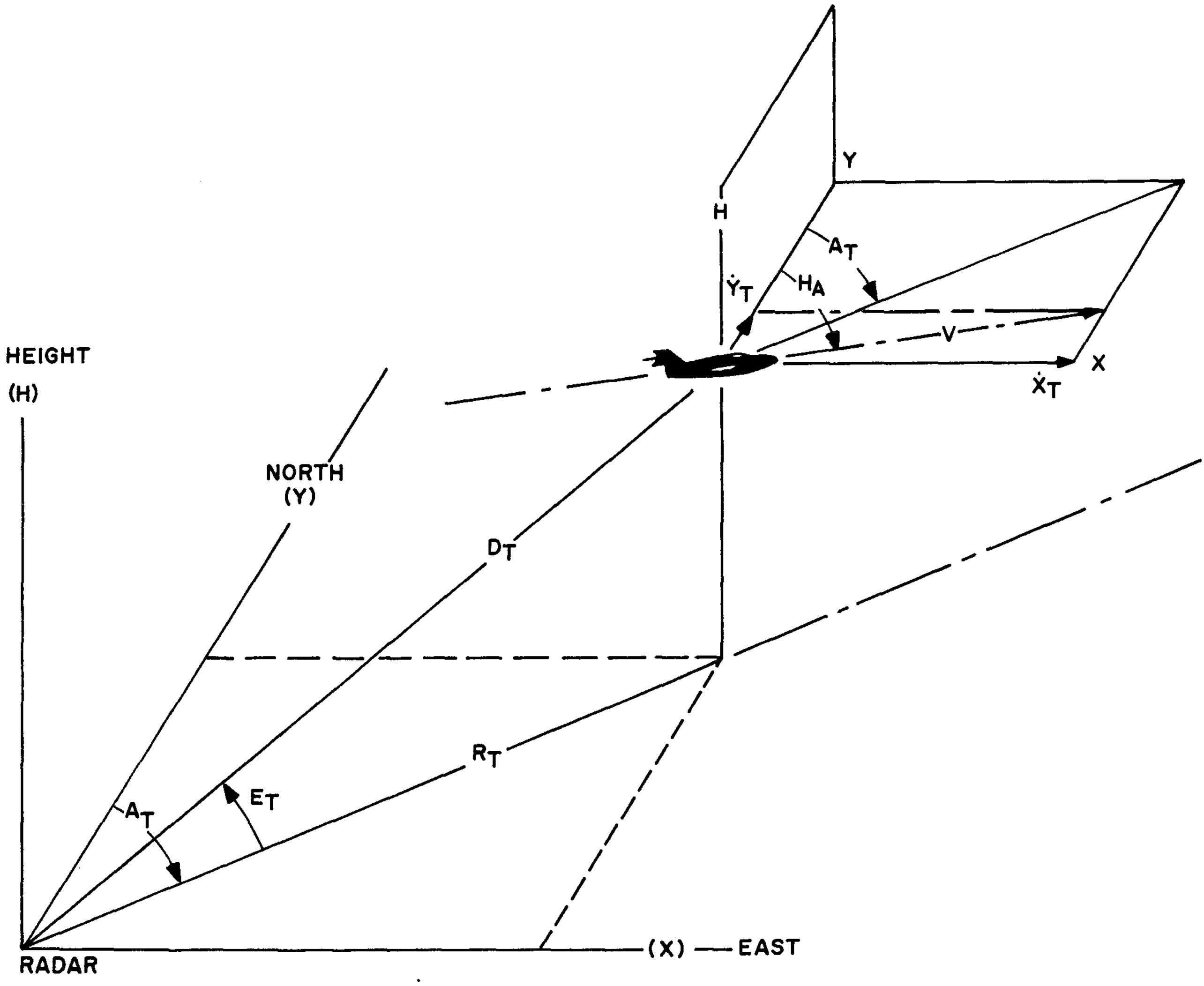

Figure 8. Target coordinates (spherical).

$\dot{X}_T = V \sin H_A$
$\dot{X}_T = 13 \text{ VAC} \times .707$
$\dot{X}_T = 9.191$ volts.

As long as the target continues flying due northeast at 1,000 knots, these values will remain constant. But suppose the target is given a right turn. This is accomplished by the front panel turn rate control that positions R_2 (fig 9) clockwise toward the phase 180 degrees voltage. Twenty-six volts, phase 180 degrees, represents a 20 degree per second right turn, which would cause H_A motor (fig 9) to rotate the rotor of B_1 clockwise at 20 degrees per second. As the rotor of B_1 is rotated, the sine winding of B_1 becomes parallel and the cosine winding becomes perpendicular to the stator winding. At this instant, all the velocity voltage is coupled into the sine winding and none into the cosine winding. At this instant, the heading is due east (90 degrees) and components of velocity voltage are:

$\dot{Y}_T = V \cos H_A$,
$\dot{Y}_T = 13 \times 0$,
$\dot{Y}_T = 0V$,

and

$\dot{X}_T = V \sin H_A$,
$\dot{X}_T = 13 \times 1$,
$\dot{X}_T = 13$ volts.

(d) The X and Y components of velocity ($\dot{X}_T$ and $\dot{Y}_T$) are sent to the azimuth servo which calculates a voltage ($\dot{A}_T$) that drives the azimuth servo. This voltage ($\dot{A}_T$) causes the target's azimuth (A_T) to change at the desired rate and if the turn rate remains at 20 degrees per second, the target will fly in a

circle. This is a simplified explanation of a typical calculation performed by the TCG heading servo. There are four calculating servos (H_A, E_T, A_T, and D_T) in each target coordinate generator. Voltages generated by the TCG are used to develop target video pulses that are sent to the appropriate radar. The acquisition radars receive simulated target video only when the acquisition antenna is pointed at the target. The TTR antenna must also point its beam at the simulated target in azimuth (A_T) and elevation (E_T). In addition, the TTR range unit must be positioned to the target slant range (D_T) to obtain all the target information necessary for the computer to calculate an intercept course for the simulated target.

(2) Missile velocity and missile position generators (fig 7). Functionally, the missile velocity and missile position generators are very similar to the TCG, except there are no guidance controls on the front panel or heading servo for the missile velocity and position generators. However, front panel controls are used to select an Ajax or Hercules missile and warhead lethal radius. Prelaunch information (A_G) from the computer positions the simulated missile azimuth servo to the calculated intercept azimuth. From "fire" to "on trajectory," the simulated missile flightpath is programed and the missile always appears to dive outward along the A_G line. The computer sees the simulated missile moving toward the target by way of DC voltages, which represent missile height, east-west position, and north-south position. These position voltages are sent to the computer from the T-1 missile position generator. If the simulated missile is flying the proper course, "on trajectory" is detected by the computer. The computer then sends yaw (G_Y) and/or pitch (G_P) commands to the missile velocity generator in the form of DC voltages. The amplitude of these DC voltages determines the amount of missile maneuver; the polarity determines the direction of the maneuver. Induction modulators, in the velocity generator, convert the DC G_Y and G_P commands into AC climb and turn orders. The climb and turn orders modify the simulated missile flightpath as required to effect an intercept with the target being tracked. The computer is constantly informed of simulated missile position by the missile height, east-west, and north-south position voltages. The computer constantly monitors simulated target position by way of the TTR if the TTR remains located on the simulated target. When the simulated target takes evasive action, the TTR tells the computer that, in turn, calculates the necessary correction in missile flight. These corrections, G_Y and G_P commands, are sent to the missile velocity generator which cause the simulated missile to maneuver for an intercept.

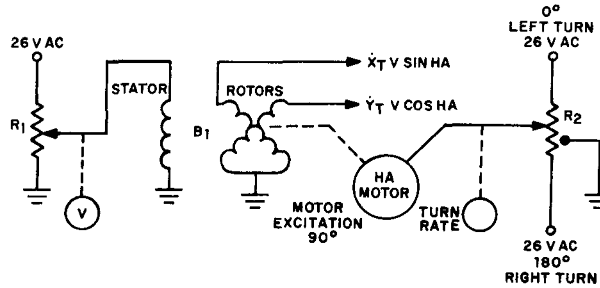

Figure 9. Heading servo calculation - simplified.

(3) Multiple burst unit (fig 7). When the missile nears the tracked target, the computer issues a "burst enable" signal. At "burst enable" the multiple burst unit in the upper right of the operator's console compares all of the six target's positions with the missile position and generates an error voltage. This error voltage is compared with a voltage representing the lethal radius of the warhead. If the error voltage from any target is less than the lethal radius voltage, that target lies within the warhead lethal radius and "burst effects" are applied to the target. The following burst effects cause a realistic disintegration of the simulated target:

(a) Target velocity voltage is removed from R_1 (fig 9).

(b) A dive order is applied to the appropriate TCG (E_T) servo.

(c) A fading target size is applied to target video.

(d) Jittering tracking voltages are applied to the TTR.

(4) Gating and relay drawer (fig 7). The gating and relay drawer contains the relays necessary for operation of the multiple burst unit and for the application of burst effects to the appropriate target. It also contains circuits for generating elevation gating voltages. These gating circuits automatically adjust the intensity of the simulated target pulse as determined by the target's position within the elevation pattern of the acquisition radar beam. If the target is centered in the beam, its intensity is maximum. The intensity is reduced by the gating circuits as the target moves to the outer edge of the beam.

(5) Electronic drawer A. Drawer A contains circuits for regenerating the radar's basic timing

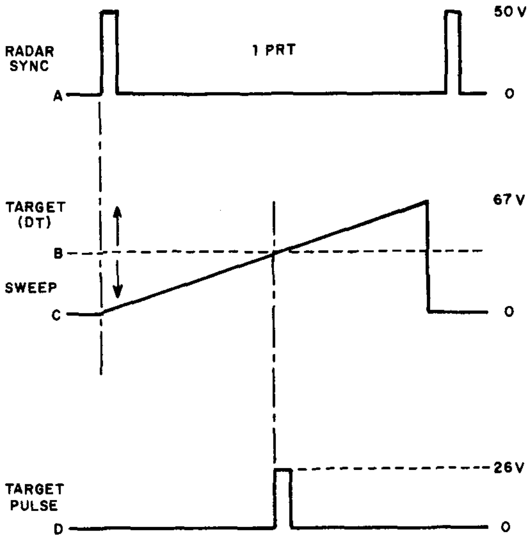

Figure 10. Target pickoff.

pulse (sync). This drawer also contains circuits for generating a time base voltage (sweep) that is used to develop a target range pulse. It also contains circuits for gating the target when the antenna azimuth is the same azimuth as that of the target. Figure 10 illustrates how the range pulse is generated. Radar sync (A) initiates sweep voltage (C) which rises linearly toward 67 volts. This sweep voltage and a target slant range DC level (D_T) (B) from the TCG slant range servo are compared by a differential amplifier. When the amplitude of the sweep voltage reaches the amplitude of the (D_T) voltage, a target pulse (D) is generated. This target pulse recurs once each sync and is sent to the appropriate radar, only when the TCG elevation and azimuth servo positions coincide with the appropriate radar antenna elevation and azimuth beam widths.

(6) Electronic drawers B1 through B4. There are four electronic drawers on the right side of the console (fig 7). Components in drawer B1 convert the missile range pulse to an IF signal which is sent to the MTR range scope. Components in drawer B-2 and B-3 convert TTR and TRR video pulses (target, clutter, and chaff) into IF signals for application to the TTR and TRR IF stages. Components in drawer B4 convert the acquisition radar video pulses (target, clutter, and chaff) into IF signals for application to the acquisition radar.

(7) PPI monitor. The PPI monitor (fig 7) provides a means for checking simulated acquisition radar video (S and L band) and is an important troubleshooting aid. When the Nike radars are energized, the PPI monitor can display S and L band radar video in addition to the range circle, flashing azimuth line, and electronic cross which appear on the director station presentation system.

(8) IFF generators and scoring panel (fig 7). The IFF generator and scoring panel are discussed in paragraph 3d(1) and (2), respectively.

f. ECM cabinet.

(1) General. The ECM cabinet (fig 11) produces simulated electronic countermeasures and acquisition antenna pattern information. The purpose of ECM is to confuse the radar operator. If he is a poor operator, ECM can make his system ineffective.

(2) ECM IF drawer (fig 11). This drawer contains circuits which amplify IF jamming and composite acquisition IF signals received from electronic drawer B4.

(3) ECM generator drawer (fig 11). This drawer contains six ECM generators, one for each target. It also contains two spoof generators and one variable PRF generator. Each ECM generator develops four types of jamming signals which amplitude modulate the acquisition and track IF signals. These four types are noise, pulse, square wave, and continuous wave (CW).

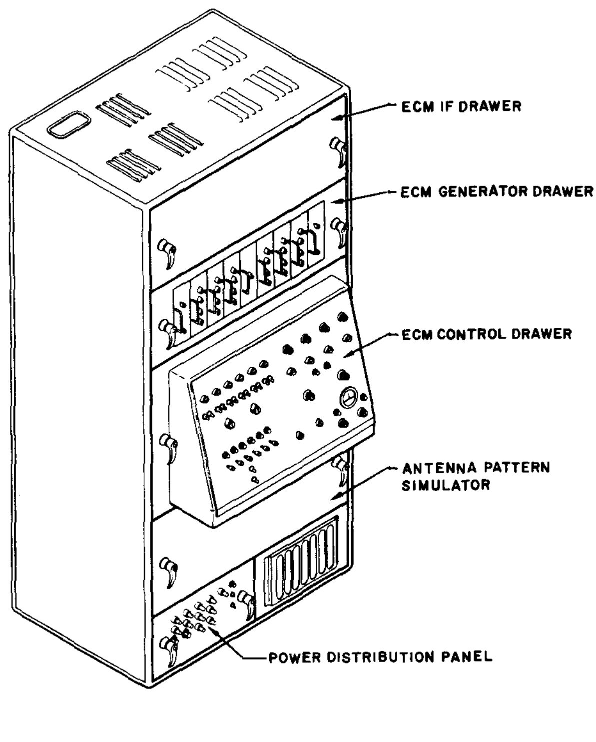

Figure 11. ECM cabinet.

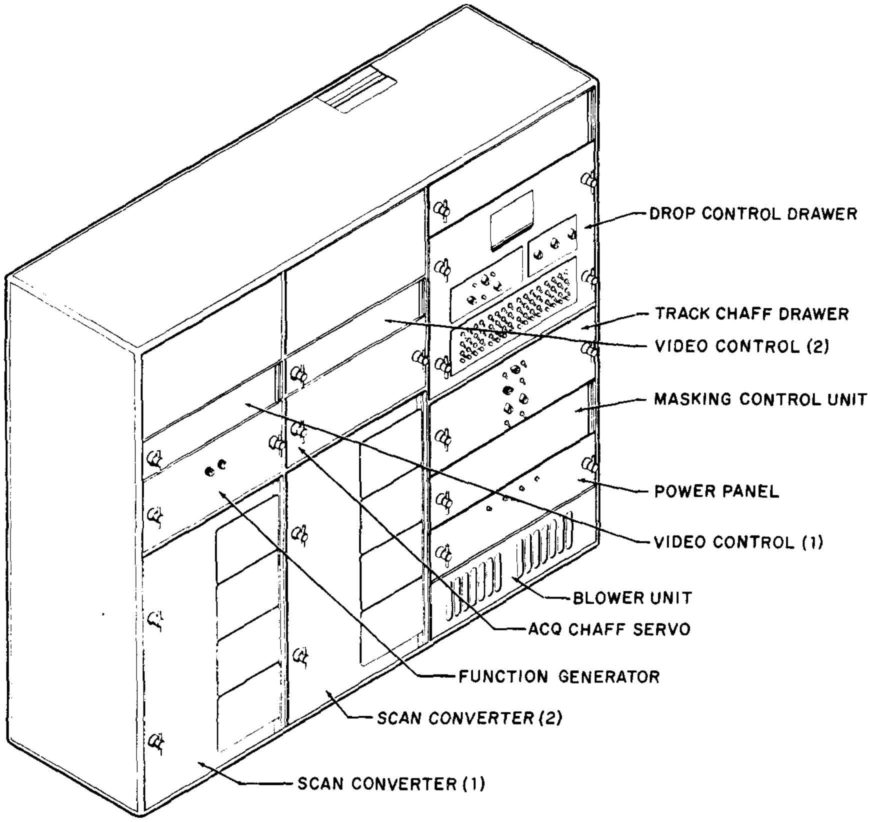

Figure 12. Chaff cabinet.

The spoof generators, one for S band and one for L band, generate pulses which appear as false targets on the acquisition presentation system. The variable PRF generator may be selected to synchronize the ECM at different pulse rates.

(4) ECM control drawer (fig 11). This drawer contains provisions for selecting target, mode, power level, and radar to which the ECM is applied. It also contains the IF amplifiers which distribute ECM to the TTR and TRR.

(5) Antenna pattern simulator (fig 11). The antenna pattern simulator generates voltage waveforms that simulate rotation of the acquisition antenna's main and side lobes. This antenna pattern voltage gates the acquisition targets ON when they fall in the main lobe. It also controls the intensity of the simulated ECM. The antenna pattern voltage causes a high jamming level when the antenna main lobe is pointed at the jamming source and a weaker level when the side lobes are pointed at the jamming source.

(6) Power distribution panel (fig 11). This panel contains switches for energizing the ECM cabinet. A blower on the panel's right side circulates air through the cabinet to cool electrical components located inside.

g. Chaff cabinet.

(1) General. Components in the chaff cabinet (fig 12) simulate chaff for TTR, TRR, and the acquisition radars of the improved Nike Hercules system. Chaff is tiny pieces of tin foil cut to the wavelength of the radar and dropped or ejected from an aircraft to cause radar interference. Since foil is light weight, it remains in the air for some time following a drop.

(2) Drop control drawer. The drop control drawer (fig 12) contains switches for selecting the target and type of chaff drop it will make. There are three types of drops: single, multiple, and corridor. This drawer also contains circuits which store the target position information. It operates in conjunction with the acquisition radars only and permits a maximum of 16 chaff drops.

(3) Track chaff drawer. The track chaff

drawer (fig 12) simulates only one chaff drop for distribution to TTR and TRR. The one drop may be reset and redropped an infinite number of times. This drop is made to grow in area and decrease in intensity for 5 minutes. The drawer can also apply effects which would move chaff as actual wind.

(4) Masking control unit. The masking control unit (fig 12), in conjunction with the PIG cabinet, prevents the appearance of any acquisition chaff launched within a masked area.

(5) Power panel. The power panel (fig 12) controls the application of power to the chaff cabinet. It also contains a blower unit for equipment ventilation.

(6) Scan converters (1) and (2) (fig 12). The scan converters, (1) for L band and (2) for S band, are storage tubes. Each tube, a CRT type, stores an electrical charge on its face at a position corresponding to that stored in the drop control drawer. A sweep is rotated around the face of the tube in sync with antenna rotation. A chaff pulse is produced as a readout when the rotating sweep coincides with the position of a stored chaff drop. This chaff pulse is sent to electronic drawer B-4 where it amplitude modulates an IF signal.

(7) Function generator. The function generator (fig 12) produces size, intensity, and wind voltages that are used to produce a realistic chaff appearance. The size voltages cause the area on which the chaff charge is stored, in the scan converters, to increase gradually until it reaches a maximum area 1 hour after drop. The intensity voltage causes the chaff charge to become increasingly weaker for 1 hour. Wind voltages, representing 8 points on the compass and velocities from 10 to 100 knots, move the chaff charge on the scan converter to simulate the effects of wind on the chaff cloud. Also contained in the function generator are two stepping switch drivers and two stepping switches (one for L band and one for S band) that synchronize the operation of the acquisition chaff cabinet.

(8) Acquisition chaff servo. The acquisition chaff servo (fig 12) receives five target coordinate signals (D_T, E_T, A_T, and N/S velocity and E/W velocity) from each of the six TCG's. The acquisition chaff servo resolves this analog position data into 10 bit binary words. The binary bits, representing chaff position, are then stored in the drop data storage units located in the drop control drawer.

(9) Video control unit (1) and (2). The video control units (fig 12) process voltages that dictate the presence of and regulate the size and intensity of simulated chaff video. Unit (1) operates with the L band and unit (2) with the S band radar.

EXERCISES FOR LESSON 8

1. Which voltage would represent $\dot{X}_T$ if the simulated target were headed northeast 45 degrees at maximum velocity?

A. 26
B. 18.38
C. 13
D. 9.19

2. How many negative steps would the mask angle voltage ((G) fig 6) have for simulating a 9.3 degree mask?

A. 15
B. 12
C. 9
D. 7

3. Which signal positions the simulated missile azimuth servo?

A. A_T
B. A_G
C. G_Y and G_P
D. Turn orders

4. What type oscillator is used in the error recorders?

A. Tuned plate
B. Colpitts
C. Tuned plate-tuned grid
D. Hartley

5. What is the maximum mask elevation angle, in degrees, that can be simulated by the passive interference generators?

A. 20
B. 15
C. 4
D. 1.3

6. Where is the voltage waveform generated that gates acquisition targets ON at the correct azimuth?

A. Antenna pattern simulator
B. Gating and relay
C. Target coordinate generator
D. Antenna servo follower

7. What target position information is applied to the acquisition chaff servo?

A. $\dot{A}_T$, $\dot{E}_T$, $\dot{D}_T$, and N/S and E/W velocities
B. A_T, E_T, D_T, and H_A
C. A_T, E_T, and D_T
D. A_T, E_T, D_T, and N/S and E/W velocities

8. What unit is used to select simulated or radar sync and antenna position voltages?

A. Track control indicator
B. Switching chassis
C. Function generator
D. Function selector

9. How many acquisition chaff drops are simulated?

A. 1
B. 9
C. 16
D. Infinite

10. Which indicates the direction a simulated missile should maneuver?

A. Polarity of the G_Y and G_P commands
B. Phase of the G_Y and G_P commands
C. Amplitude of the climb and turn orders
D. Polarity of A_G signal

11. Which missile flight characteristic(s) is/are simulated by the AN/MPQ-T1?

A. Hercules only
B. Ajax only
C. Hercules and Ajax
D. All air defense missiles

12. Which is NOT a capability of the AN/MPQ-T1?

A. Simulate targets
B. Score operators
C. Record tracking errors
D. Test the Nike system

13. Which video is masked by the T-1?

A. Clutter, target, and ECM
B. Target, ECM, and missile
C. ECM, chaff, and passive interference
D. Target, chaff, and ECM

14. How many cables are provided for T-1 connection to the Nike system?

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

15. What is the purpose of the servo power transformer in the power supply cabinet?

A. Steps up the input
B. Changes phase difference of the output
C. Steps down the output
D. Matches impedance

16. How many kilowatts of power are required to operate the AN/MPQ-T1?

A. 6
B. 13
C. 18
D. 25

17. What is the maximum velocity, in knots, of each simulated target in the T-1?

A. 3,000
B. 2,000
C. 1,000
D. 500

18. What value of AC voltage represents maximum target velocity in the T-1?

A. 26
B. 13
C. 9.19
D. 7.07

19. Which is recorded by error recorder (2) in the auxiliary cabinet?

A. G_Y commands, LOPAR tuning, and elevation tracking errors
B. G_P commands, LOPAR tuning, and azimuth tracking errors
C. G_P commands, TTR tuning, and azimuth tracking errors
D. G_Y commands, TTR tuning, and range tracking errors

20. Which drawer in the chaff cabinet contains circuits for storing target position information?

A. Drop control
B. Function generator
C. Video control
D. Acquisition chaff servo