Chapter 4
Current Air Defense Weapon Systems

GENERAL

With the advent of aircraft, armies of the world began searching for weapon systems to counter this threat. World War II brought a new era to aircraft performance and tactics. To counter these threats, AD weapons were developed with increased range and rate of fire. Many weapon systems used advanced types of computing sights and radar. Even with these improvements, the aircraft still had an inherent advantage in that after the projectile left the gun it was unguided (followed a ballistic trajectory), resulting in a very low kill probability.

In the fall of 1944, the first U.S. AD missile was conceived at Fort Bliss, Texas. Development of a radically new weapon system, based on the guided surface-to-air missile as a means of destroying enemy aircraft, was begun in 1945. The project was named after the Greek goddess of victory, Nike.

In December 1953, the first Nike Ajax battery became operational at Fort Meade, Maryland. Because of additional requirements, the Nike Hercules and the low-altitude Hawk were developed and produced; Nike X, Mauler, and Redeye systems are currently under development.

NIKE HERCULES

Nike Hercules, successor to the first-generation Nike Ajax AD weapon system, has dramatically demonstrated the dynamic growth potential of the Nike family of missile systems. Even now, most of the Nike Hercules systems in the field have been updated by modifications to form the Improved Nike Hercules system. This system increases many of the tremendous capabilities of the basic Nike Hercules system while incorporating the most advanced and sophisticated electronic counter-countermeasures (ECCM) equipment available.

CAPABILITIES

Nike Hercules, with its ability to engage high-performance aircraft at both high and low altitudes, its long ranges, and its nuclear capability, can engage and destroy an entire formation of hostile aircraft. Reliable, extremely accurate, and possessing a large kill radius, the system has demonstrated its effectiveness against airborne targets traveling at speeds in excess of 2, 100 miles per hour (mach 3), at ranges greater than 75 miles, and at altitudes up to 150, 000 feet. In addition, the system can effectively engage surface targets at ranges greater than its surface-to-air range capability.

Normally, this flexible system will function as part of an integrated AD complex; however, each firing battery is capable of functioning as an autonomous fire unit when required. The Nike Hercules system is emplaced in two distinct areas that are normally separated by a distance of approximately 1 to 3 miles. The guidance and control equipment is located in

the battery control area, while equipment and facilities needed to assemble, store, check out, and launch a Hercules missile are located in the launching area. Figures 50 and 51 depict these areas for a typical CONUS Improved Nike Hercules site.

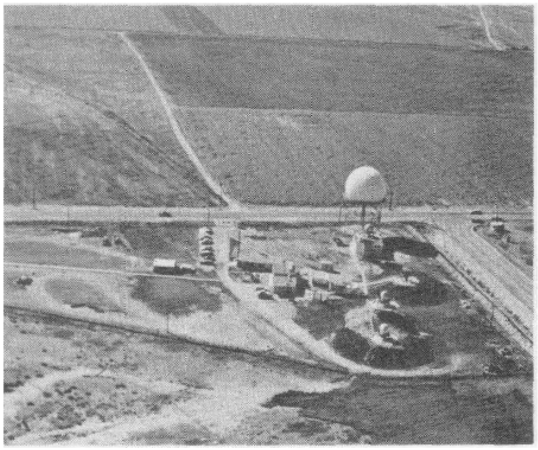

Figure 50. Typical Nike Hercules battery control area.

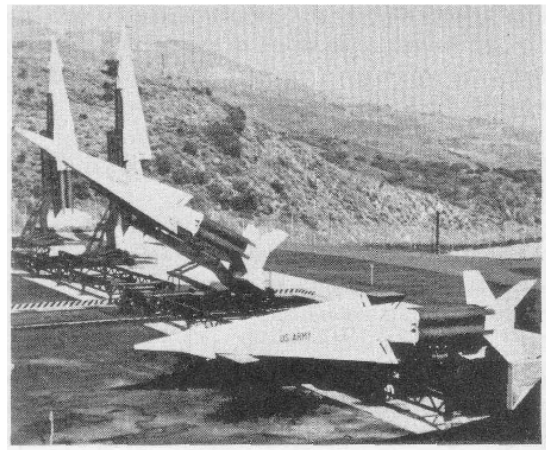

Figure 51. Nike Hercules missiles in the launching *area.*

SCHEME OF OPERATION—SURFACE-TO-AIR

The same basic concept of operation and command guidance is used for Ajax, Hercules, and Improved Hercules. To understand how Nike Hercules works, only the major items of equipment need be considered: an electronic computer and three radars (fig 52).

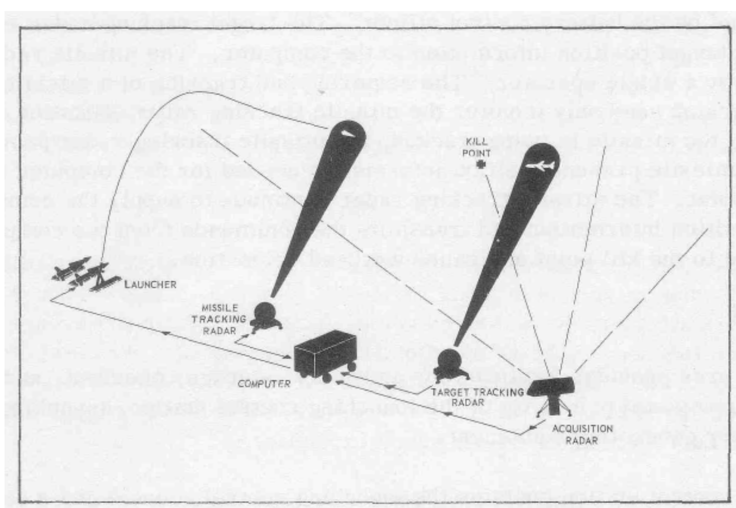

Figure 52. Scheme of operations, Nike Hercules system.

The acquisition radar detects a target which, when identified as hostile, is designated to a target tracking radar. The target tracking radar acquires and tracks the target; measures range, azimuth, and elevation to the target; and continuously sends these data to the computer. A third radar, the missile tracking radar, locks on the missile; measures range, azimuth, and elevation; and continuously sends this information to the computer. The computer, knowing the location of the target and missile, continuously computes a kill point, directs the missile to the target, and causes the burst command to be sent to the missile at the appropriate time.

BATTERY CONTROL AREA—BASIC NIKE HERCULES

The major equipment items in the battery control area are the director station, tracking station, target tracking radar, missile tracking radar, and acquisition radar. The director station houses the computer, battery control console, and communications switchboard. The computer, using target and missile present position information, computes a predicted kill point. With this information, it formulates the commands which the missile tracking radar must send to the missile to guide it to the kill point. The battery control console is the control center of the Nike Hercules system. The acquisition radar operator, stationed at this console, operates the acquisition radar, a long-range search radar capable of detecting targets approaching the defended area. From information provided by the acquisition radar, and from other information supplied to the battery control console, the battery control officer analyzes the tactical situation and directs operations of the battery during an engagement. The switchboard provides the battery control officer with communications to the necessary elements of the battery.

The tracking station houses electronic equipment and operational controls of the missile tracking and target tracking radars. Separate control consoles are provided for each radar. At the target radar control console, three operators, using the controls and indicators, track the target designated by the battery control officer. The target tracking radar automatically sends the required target position information to the computer. The missile radar control console is manned by a single operator. The acquiring and tracking of a missile are entirely automatic—the operator need only monitor the missile tracking radar operation during an engagement. When the missile is being tracked, the missile tracking radar provides the computer with the missile present position information needed for the computer to determine the predicted kill point. The missile tracking radar continues to supply the computer with missile present position information and transmits the commands from the computer necessary to guide the missile to the kill point and cause warhead detonation.

LAUNCHING AREA

The launching area provides facilities for assembly, storage, checkout, and launching of missiles. It is composed primarily of the launching control station, launching sections, and associated power generating equipment.

The launching control station contains the launching control console and a communications switchboard. Under the direction of the launching control officer, a panel operator selects the launching section from which the missiles are to be fired. Each launching section contains a launching section selector which distributes power to the launchers within the section and exercises control of them.

HERCULES MISSILE

The Hercules missile is a two-stage, solid propellent missile. When the missile is launched, it is accelerated to supersonic velocity by the rocket-motor cluster (booster). After the first few seconds of flight, the booster separates from the missile, igniting the missile rocket motor. Guidance commands in the form of steering orders are sent from the missile tracking radar to steer the missile to the predicted kill point. At the optimum time, warhead detonation occurs.

IMPROVED NIKE HERCULES

The Nike Hercules system, operational on sites in the United States and certain foreign countries since June 1958, is rapidly being modified to become the Improved Nike Hercules system. Modifications that will be complete in the near future follow the concept that AD systems must advance with the increased threat to our defended areas. Improved Nike Hercules, using the basic system as its foundation, has one additional radar and advanced electronic devices to improve the system capability to counter the changing threat. No improvements were required in the launching area. Thus, the useful life of Nike Hercules has been extended, giving it the ability to neutralize advanced weapon systems equipped with the latest electronic devices.

Improved Nike Hercules retains all of the capabilities of the earlier models of Hercules; it retains the long-range, surface-to-surface capability and the high- and low-altitude, surface-to-air coverage. Added to the system is an increased tracking capability, attained by modification of the fire control platoon equipment and addition of the target ranging radar.

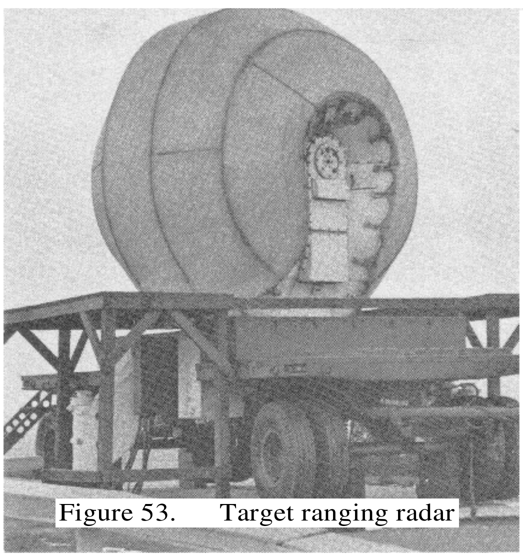
Figure 53. Target ranging radar

Outwardly, the only discernible change to the battery control area is the addition of the target ranging radar (fig 53) whose external appearance is almost identical to that of the other tracking radars. This additional radar improves the presentation of target present position data in an electronic countermeasures environment.

MOBILITY

Emphasis on air defense deployed in depth in support of the army in the field prompted the Army to undertake a series of studies to determine if Nike Hercules, with a minimum of cost and new equipment, could be more effectively employed as a mobile AD system. As a result of these studies, tests were begun to explore this new potential. By modifying existing equipment and developing new equipment, a mobile Nike Hercules system was attained.

The standard launcher was converted to a mobile launcher (fig 54) by the application of three modification kits: a transport kit consisting of an axle and kingpin suspension; a field adaption kit consisting of jacks, outriggers, and footplates; and a blast deflector kit consisting of a blast shield, emplacement linkage, and tiedown linkage. The transport and field adaption kits permit the converted mobile launcher to be towed by a prime mover and to be easily emplaced without need for a concrete pad, while the blast deflector kit tends to stabilize the launcher by proper distribution of the thrust load.

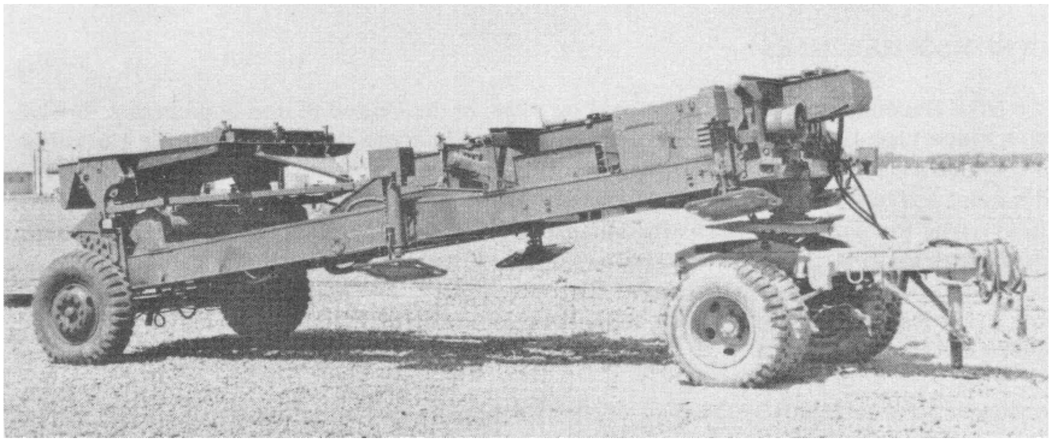

Figure 54. Nike Hercules mobile launcher.

A new item of equipment, the ready-round transporter (fig 55), was developed to carry an assembled Nike Hercules round, eliminating the necessity of missile and rocket-motor cluster (booster) joining on the launcher. The mobile launcher receives the round directly from the ready-round transporter, thus conserving time and effort.

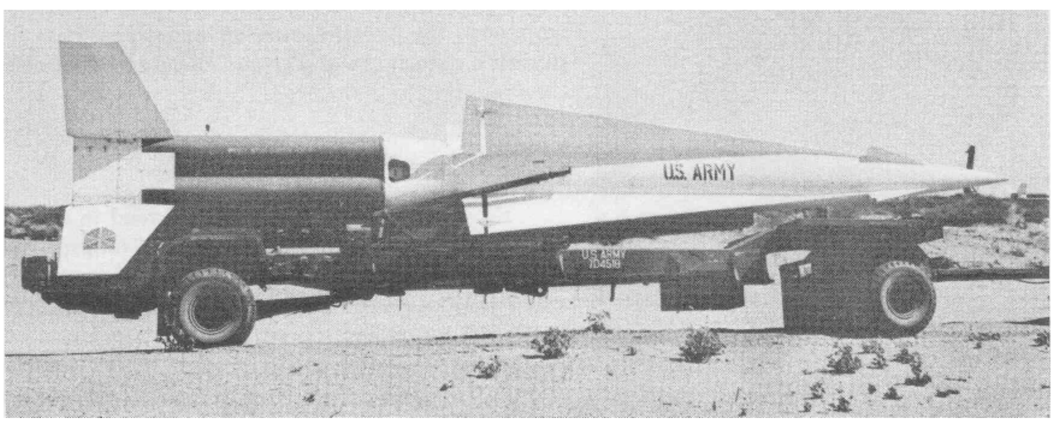

Figure 55. Nike Hercules ready-round transporter.

In addition, other equipment was modified to enhance mobility. These items include the section operating equipment trailer (fig 56) housing the launching section selector; the test station truck (fig 57) containing the equipment for servicing, testing, and performing organizational maintenance on the missiles; and a dolly-mounted launching control-indicator (fig 58),

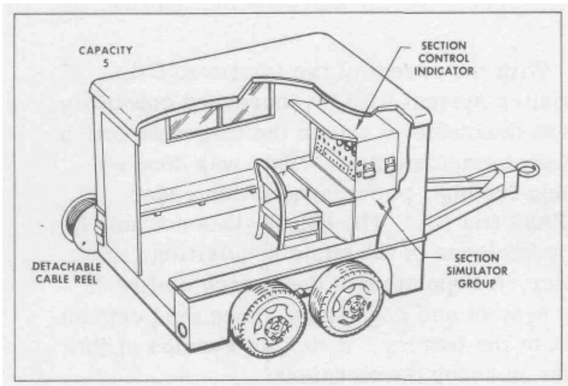

Figure 56. Nike Hercules section operating equipment trailer.

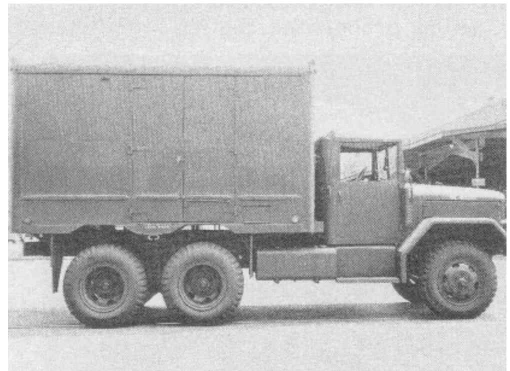

Figure 57. Nike Hercules test station truck.

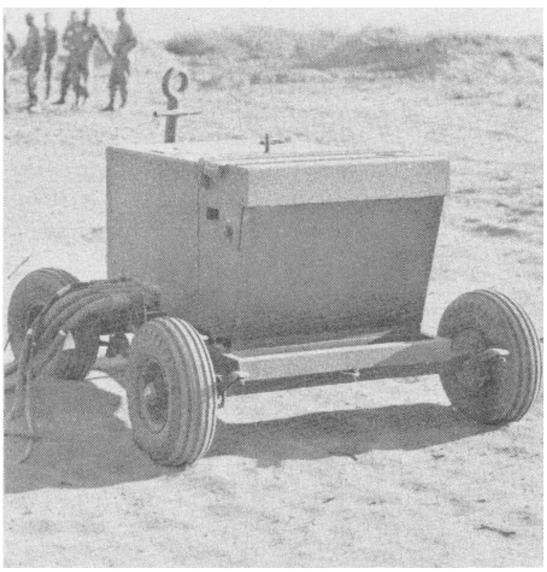

Figure 58. Nike Hercules dolly-mounted launching control-indicator.

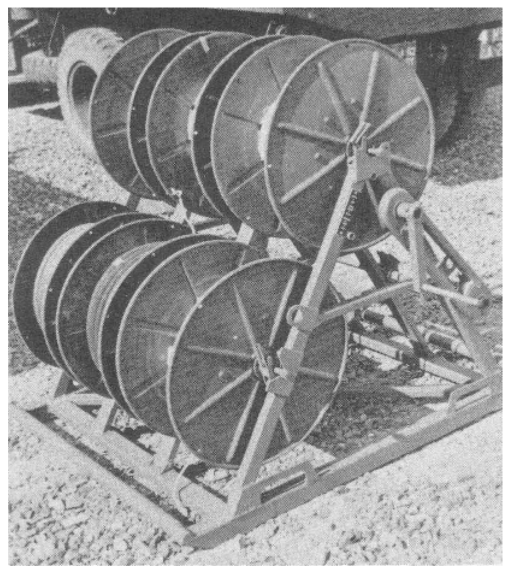

Figure 59. Cable reel rack.

Special tools and equipment are provided in the battery control area to reduce the time required to emplace and march order the equipment. Cable reel racks are utilized to rapidly pick up and lay interarea cables (fig 59). A vehicle-mounted A-frame is provided for

emplacing the acquisition antenna-receiver-transmitter group, in conjunction with a hoisting beam, for removing the cable reel racks from the prime movers. Thus, the capabilities of cross-country mobility, rapid emplacement, and march order with minimum manpower were achieved without sacrifice of reliability or performance.

HIGH-POWER ACQUISITION RADAR

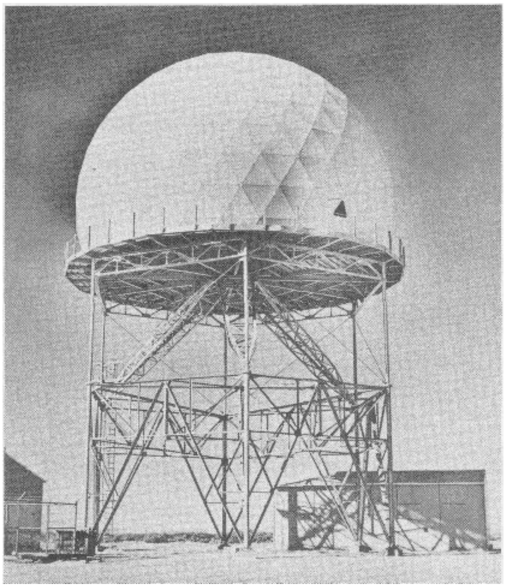

Figure 60. High-power acquisition radar (HIPAR).

With the advent of the Improved Nike Hercules system with its increased capability, it was desirable to extend the target detection range of selected sites. This was done by adding the high-power acquisition radar (HIPAR) (fig 60). The HIPAR does not nullify the usefulness of the basic acquisition radar; rather, it supplements the search ability of this system and greatly enhances the performance of the battery. A mobile version of this radar is under development.

ALTERNATE BATTERY ACQUISITION RADAR

The inherent growth potential of Nike was again demonstrated when it was decided to supplement the search and acquisition capability of those Improved Nike Hercules sites not designated to receive HIPAR . The radar selected for installation on these sites was designated the alternate battery acquisition radar (ABAR) (fig 61). (See chapter 3.)

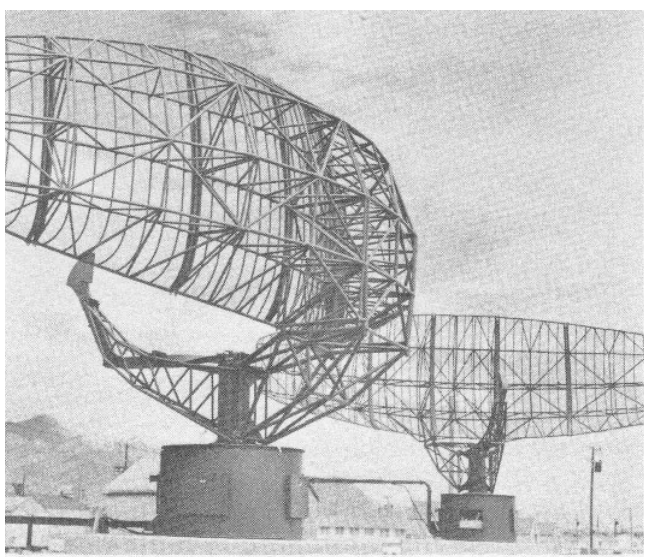

Figure 61. Alternate battery acquisition radar (ABAR).

ANTITACTICAL BALLISTIC MISSILE (ATBM) CAPABILITY

On 3 June I960, *the* Improved Nike Hercules system destroyed a Corporal surface-to-surface missile (fig 62), the first known kill of a ballistic missile by another missile. On 12 August 1960, Improved Nike Hercules destroyed another Hercules missile that had been launched as a target (fig 63). The Nike Hercules missile presented a far more difficult target, having a higher velocity and smaller size than the Corporal missile. Further tests have been conducted to determine the extent of ATBM capability.

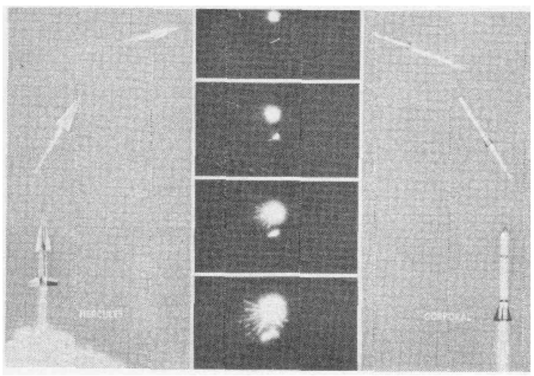
Figure 62. Nike Hercules destroys Corporal missile.

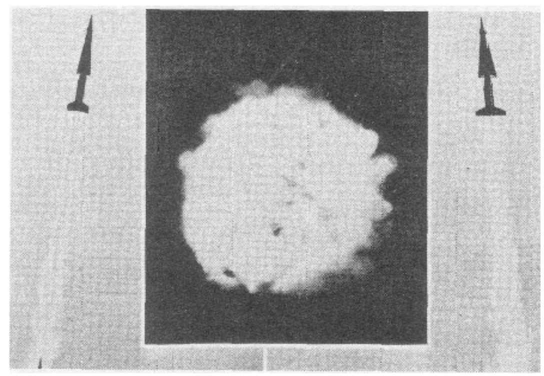
Figure 63. Nike Hercules destroys Nike Hercules.

To improve on this antimissile capability, certain Improved Nike Hercules systems have received additional modifications, increasing their ability to engage some types of hostile tactical missiles before they can penetrate defended areas.

NIKE HERCULES IN THE SURFACE-TO-SURFACE ROLE

The use of AD artillery in a secondary role against surface targets has historical precedent in both World War II and Korea. When surface-to-air missiles replaced antiaircraft guns, it appeared that this traditional role would no longer exist. It is common knowledge that Nike Hercules has a deadly capability against high-performance aerial targets. Not so well known, however, is that the pinpoint accuracy of Nike Hercules against distant surface targets permits it to effectively engage enemy ground concentrations. This dual capability is retained in the Improved Nike Hercules system.

Since the inception of the Nike Hercules program, the tactical advantage of developing Hercules into a highly mobile weapon to support the Army in the field has been recognized. In 1959, the potential of Nike Hercules as a mobile AD weapon became evident and interest in the surface-to-surface capability increased.

In I960, the U.S. Army Air Defense School began presenting formal instruction on Hercules surface-to-surface employment and computation of firing data. During 1961, troop firings provided additional testing of Hercules as a surface weapon. The U.S. Army Air Defense School, U.S. Army Artillery and Missile School, U.S. Army Air Defense Board,

and the prime contractor have studied numerous concepts and made subsequent recommendations regarding organization and mobility to improve the Hercules system capability in the surface-to-surface role. The Nike Hercules, with its quick reaction time, can be used to attack targets of opportunity in support of Army operations.

SCHEME OF OPERATION—SURFACE-TO-SURFACE

Firing data are computed by an ADA group operations section (or battalion operations section in a separate battalion defense). The data required by the firing battery are target range, azimuth, and elevation; fuze setting for proper height of burst; and computer dial settings. Figure 64 shows the scheme of operation for *a* Nike Hercules surface-to-surface mission.

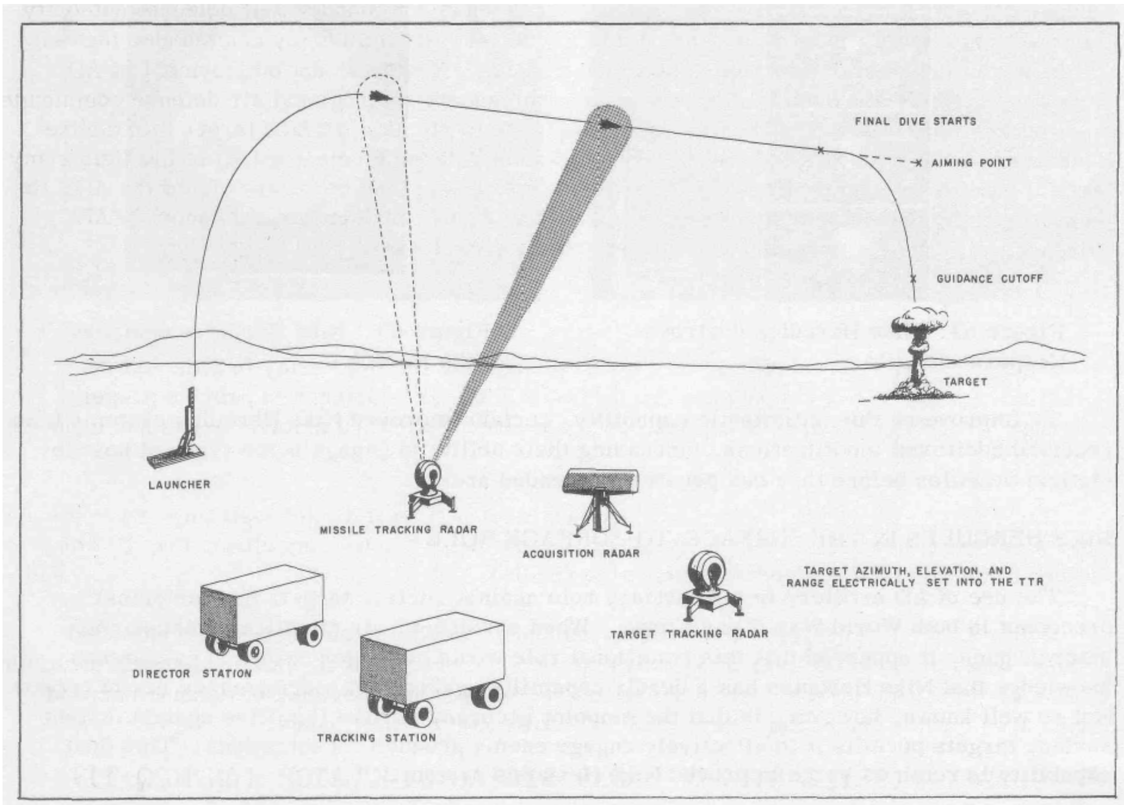

Figure 64. Nike Hercules surface-to-surface engagement.

Target range, azimuth, and elevation are set into the target tracking radar, and dial settings are made on the computer. The missile is fired, tracked by the missile tracking radar, and steered toward an aiming point above the target. As far as the system is concerned, the missile is heading toward a stationary target in space. At the proper instant, the missile is given a dive command to place it in the proper attitude to hit the target. After the dive command is executed, the missile tracking radar ceases tracking and the missile continues to the target on a ballistic trajectory.

Entering the computed firing data into the Hercules system is relatively easy. Tests conducted at Fort Bliss show that the time required for making the required settings does not exceed 5 minutes. During the time a battery is engaged in a surface-to-surface mission, it is still capable of searching with its acquisition radar to locate any approaching airborne object. After successfully completing the surface-to-surface mission, the battery can return to its AD mission in a matter of seconds.

AUTHORITY

Under current concepts, Nike Hercules units are assigned to the field army in an active theater of operations. The use of Nike Hercules in a surface-to-surface mission in the field army will depend on the authority delegated to the field army commander by the regional air defense commander. Normally, the regional air defense commander will delegate authority for operational employment of organic Army AD units. The field army commander then may utilize Nike Hercules in a surface-to-surface mission. If operational employment of AD units has not been delegated to the field army commander, the regional air defense commander must approve the mission. When a decision is made to attack a surface target with a Nike Hercules missile, the mission will be sent to the air defense element (ADE) of the field army tactical operations center (FATOC). The fire mission will then be relayed from the ADE to the Army air defense command post (AADCP). The Army air defense commander (AADC) will designate an ADA group (battalion) to perform the mission.

EMPLOYMENT

Normally, Nike Hercules units are utilized only with the field army in a theater of operations. Fire units overseas may be deployed in the area defense to provide proper coverage throughout the area being defended, but weighted toward priority areas and exposed boundaries.

Early target kill is desired and achieved by placing Nike Hercules well forward in the field army area; however, units normally should not be positioned any closer than 30 kilometers to the forward edge of the battle area (FEBA).

Within CONUS, Nike Hercules is deployed about the vital area to provide a balanced defense, one which can deliver an approximately equal amount of firepower along all directions of attack. It is used by Army air defense to give NORAD an inner ring of defenses around target areas which encompass more than 100 cities and military bases.

GUIDED MISSILE SYSTEM RADAR SIGNAL SIMULATOR (AN/MPQ-T1)

Although the basic simulator for the Nike Hercules system, the AN/MPQ-36, was an important aid in training, simulated targets and ECM could be readily distinguished from true presentations. A contract to greatly improve the AN/MPQ-36 during 1963-65 was awarded in December 1961. Designated the AN/MPQ-T1 (fig 65), the first deliveries occurred in July 1964. The first maintenance class started training in October 1964.

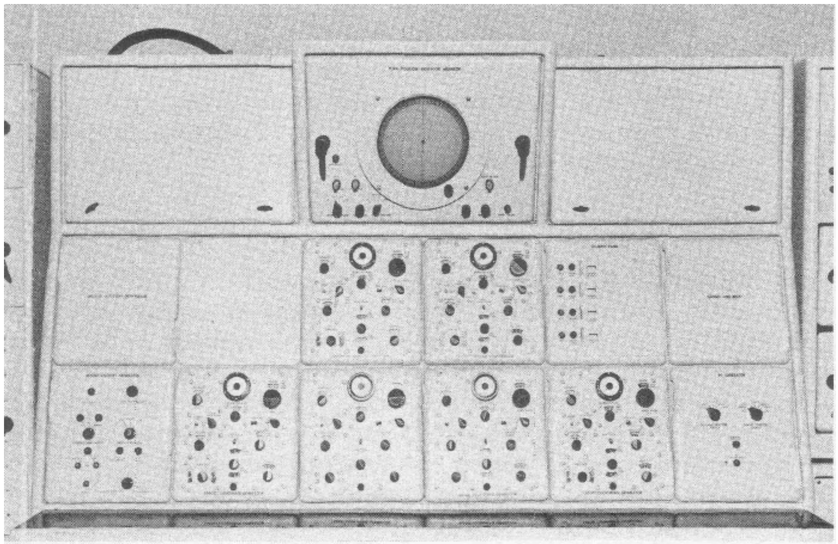

Figure 65. AN/MPQ-T1 operator console.

The AN/MPQ-T1 is a compact, transistorized simulator designed for the Nike Hercules and Improved Nike Hercules systems and associated radars (HIPAR and ABAR). The improved simulator introduces realistic target simulation, sophisticated ECM, and chaff. Masking effects and radar clutter, variable with antenna elevation, can be simulated as well as identification responses from friendly aircraft.

Up to six independent simulated targets, generated by controlled electronic signals, can be displayed on the radar scopes. Each target can travel at speeds up to 2, 000 knots and at altitudes up to 150, 000 feet, dive at a rate of 80, 000 feet per minute and climb at half that rate, and turn at rates up to 20° per second. Size of targets can be varied to produce calibrated returns of any desired dimension from 0.1 to 100 square meters. The device can simulate a Nike Hercules missile, initiate the burst command by either the computer or simulator, program missile malfunctions, and fire additional missiles after burst order.

The addition of ECM and chaff cabinets (fig 66) provides one of the most important capabilities of the simulator—the ability to simulate several types of countermeasures which an enemy may be expected to use. Effects of mechanical jamming and five types of electronic jamming can be produced and displayed on the radar scope screens of the Nike Hercules system. Chaff, for instance, can be simulated as being dispensed forward, laterally, or to the rear of the simulated target or targets.

Training under simulated tactical conditions is provided by the AN/TPQ-T1; and by its use, Nike Hercules fire control operators can develop the speed and accuracy necessary to successfully engage actual combat targets. This simulator provides an improved, much-needed aid in training operators by use of organic scoring panels and error recorders. These timers and sensing devices provide a permanent record of operator performance.

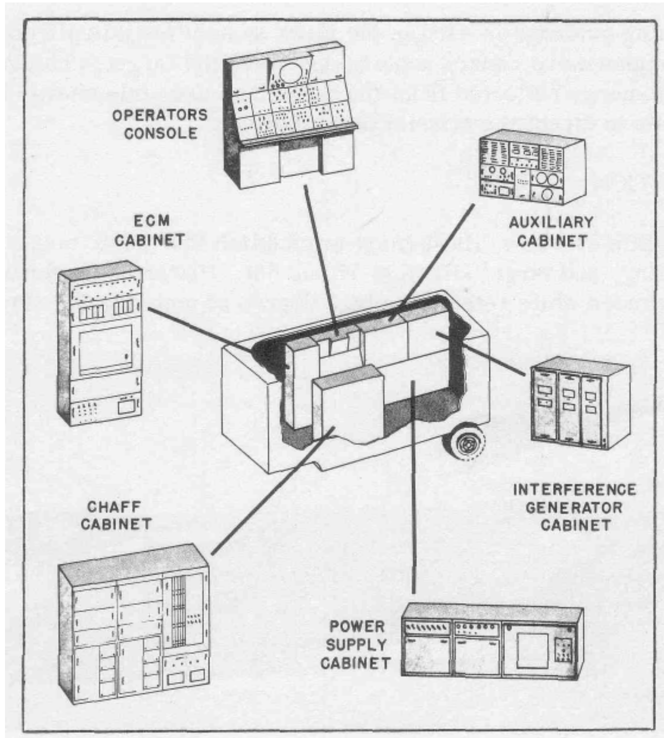

Figure 66. AN/MPQ-T1 (cutaway view).

All components of the AN/MPQ-T1 are housed in a semitrailer that has a dolly and towbar at the front. Equipped with a prime mover, the simulator is mobile over primary or secondary roads.

Eight AN/MPQ-36 simulators at McGregor Range have been modified to provide targets for short notice annual practice (SNAP) firings, and six AN/MPQ-T1 simulators are scheduled to be phased in by July 1965. It is significant to note that substantial savings in cost and time, as well as far superior tactical evaluation, have been realized by use of these simulators during practice firings. Approximately 65 percent of all targets used during SNAP firings in FY 63 were generated by simulators; during FY 64, 97 percent, or 736 of 761 firings, were fired against simulated targets.

HAWK

The success of Nike missiles against medium- and high-altitude targets caused aircraft to seek new methods of attack. Analysis of the characteristics of possible aerial targets, in the light of tactical usage, confirmed the need for defense against low-flying aircraft. The Hawk missile system was designed to counter the low-altitude threat. The system is reliable, mobile, and accurate and has the capability to engage two targets simultaneously. Several missiles can be in flight at the same time. Each missile battery has the personnel, equipment, and facilities required for operation or movement of the complete unit.

Semiactive homing guidance is used in the Hawk system for missile control during flight. Ground-based continuous-wave radars acquire and track the target. The missile receives radiofrequency (RF) energy reflected from the target and uses this energy in the development of steering commands to direct the missile to the target.

SCHEME OF OPERATION

Like all AD missile systems, Hawk must accomplish four basic tasks: detection, identification, tracking, and target kill (figs 67 and 68). Hawk can perform these functions at extremely low altitudes while retaining a high degree of mobility (fig 69).

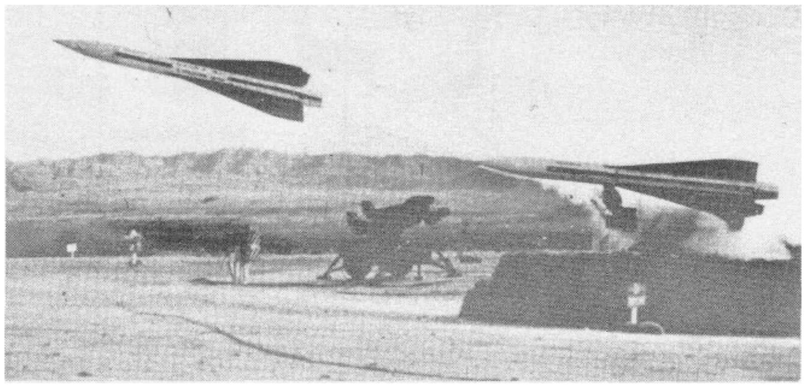

Figure 67. Hawk missile firing.

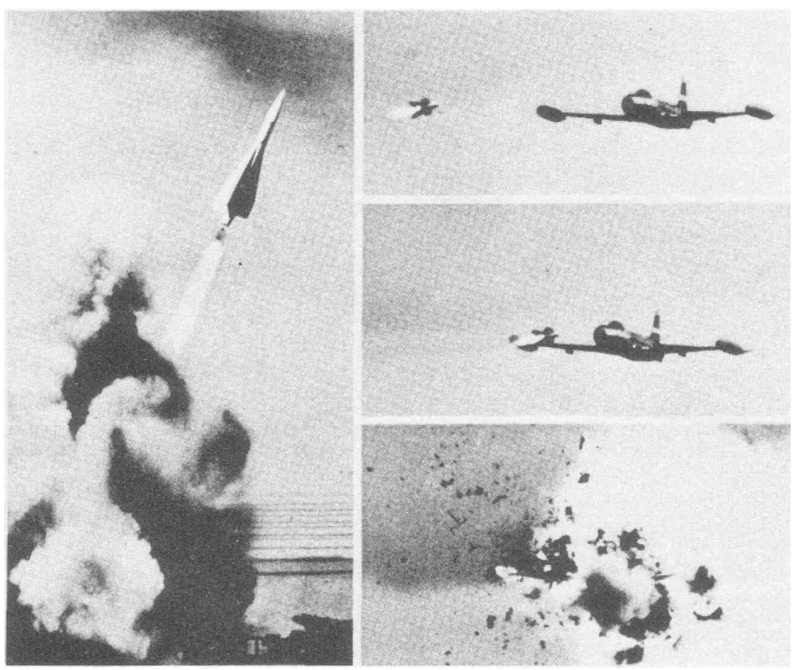

Figure 68. Hawk target kill.

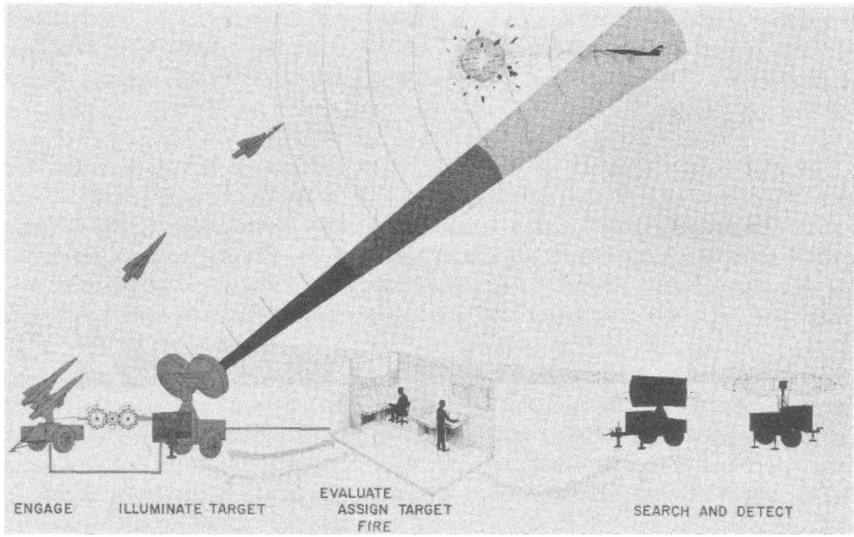

Figure 69. Scheme of operations, Hawk system.

To detect targets, the Hawk system uses two acquisition radars. One of these, the continuous-wave acquisition radar (CWAR), covers the low-altitude zone, the primary zone of consideration for Hawk. This radar utilizes the doppler effect to detect low-flying, airborne targets. The doppler effect is that effect produced by a change or shift in frequency due to the movement of the object reflecting that frequency. If the transmitted energy strikes a stationary object, such as a hill or building, it is returned to the radar with frequency unchanged. Within the radar, a comparison is made between the transmitted and received frequencies; and if there is no change, no video is presented on the associated radar screen. However, if the transmitted energy strikes a moving object, such as an aircraft, its frequency will be changed. The amount of change, which is the doppler effect, is directly proportional to the radial speed of the aircraft. When the reflected energy returns to the radar receiver, a comparison is again made with the transmitted frequency. This time, the radar will detect the frequency change, and video will be presented on the associated radar screen representing the radial speed of the target. The video will appear at the azimuth determined by the radar antenna position at the time of detection. Thus, low-flying targets are readily detected because reflection from stationary objects on the ground (ground clutter) will not be presented on the radar screen.

The other detection radar, the pulse acquisition radar (PAR), complements the coverage area of the CWAR and provides the volume air detection capability of the Hawk battery. This pulse-type radar is very similar to those found in other AD missile systems, but has some significant improvements over earlier types. The PAR provides a medium-altitude, medium-range detection capability to the system and is synchronized with the CWAR in rotation. The PAR has a limited capability at very low altitudes because its beam is directed slightly upward to avoid reflections from stationary ground objects.

Synchronized rotation of the two acquisition radars permits coordinated, continual searching for targets. Target information from both radars is automatically relayed to the

battery control central (BCC) by means of data cabling. Within the BCC, all operations of the battery are integrated and controlled during an engagement. Target identification is accomplished in the Hawk missile battery by use of the Mark X identification, friend or foe (IFF), equipment.

The tracking phase, the third basic function, now begins. A firing section consists of one illuminator radar and three missile launchers with missiles. Each launcher can accommodate up to three Hawk missiles. Upon receiving a target assignment, the illuminator in the assigned section is slewed to the azimuth of the detected target; then it searches a small area of the sky for the target. When the illuminator receives a reflected signal bearing a frequency change, it locks on the target and automatically tracks it during the remainder of the engagement.

Similar to the operation of the CWAR, the illuminator detects targets and tracks them on the basis of radial speed. As this radar also uses the doppler effect, it can track targets although they are flying at treetop level. Once the illuminator is locked on the target, the firing operator in the BCC selects one launcher within his firing section for firing. The illuminator and the selected launcher are now slaved together, causing the missiles on the selected launcher to be aimed directly at the target. In the BCC, the firing console operator is observing all of these actions closely, and the tactical control officer is monitoring the engagement. When all conditions for firing have been met, the firing pushbutton is pressed . and the Hawk missile is launched.

Launching the missile marks the beginning of the killing phase, the fourth basic function. The Hawk missile homes on energy reflected by the target. It continually watches its target through a tracking antenna on board the missile while the semiactive homing guidance system continually adjusts the missile's course to insure successful intercept. Target speed is determined by continuous comparison of the transmitted energy of the illuminator with the reflected energy from the target. Target maneuver is determined by the position of the missile's target tracking antenna. Using this information to make continuous adjustments in its course, the Hawk missile travels the most direct route to the kill point.

PULSE ACQUISITION RADAR

The function of the PAR (fig 70) is to detect moving targets and continually furnish target range and azimuth to plan position indicators (PPI) in the BCC. Components of the IFF system are also contained in the PAR. The PAR antenna control system supplies antenna synchronizing data to the CWAR. The PAR transmitter generates pulses of RF energy directed against an antenna reflector. As these pulses are being radiated, the antenna is rotating at 20 revolutions per minute. The antenna, therefore, scans 6,400 mils every 3 seconds. When a target enters the radar radiation field, pulses of RF energy which strike the target are reflected. This reflected energy is processed and sent as video information to the display consoles in the BCC. The PPI displays are synchronized to represent target position relative to the PAR location. The radar uses moving target indicator (MTI) circuitry to suppress stationary target return signals on the display consoles.

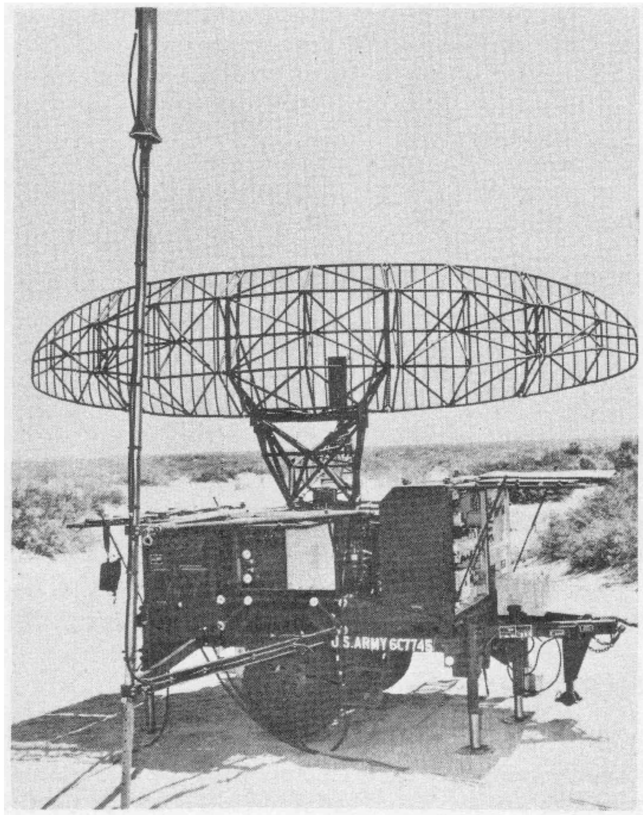

Figure 70. Pulse acquisition radar (PAR).

CONTINUOUS-WAVE ACQUISITION RADAR

Because it uses the continuous-wave principle, the CWAR has two antennas, the transmitter being in the upper portion of the antenna and the receiver in the bottom portion. A beam of RF energy transmitted by the CWAR (fig 71) is continually swept through 6, 400 mils by rotation of the antenna. When the beam strikes a moving object, a portion of the energy is reflected to the radar, is resolved into radial speed and azimuth, and is then displayed as video information in the BCC. The CWAR normally rotates synchronously with the PAR, thus the target data presented on composite displays can be easily correlated.

CONTINUOUS-WAVE ILLUMINATOR RADAR

The function of the remotely controlled continuous-wave illuminator radar (CWIR) (fig 72) is to automatically track the target, keep the target illuminated with RF energy, and provide information to the BCC, launchers, and missiles. The missile uses direct RF energy from the CWIR and reflected RF energy from the target to compute its own guidance commands.

There are two CWIR's in the Hawk missile battery. Because this is a continuous-wave radar, separate antennas are used for transmitting and receiving.

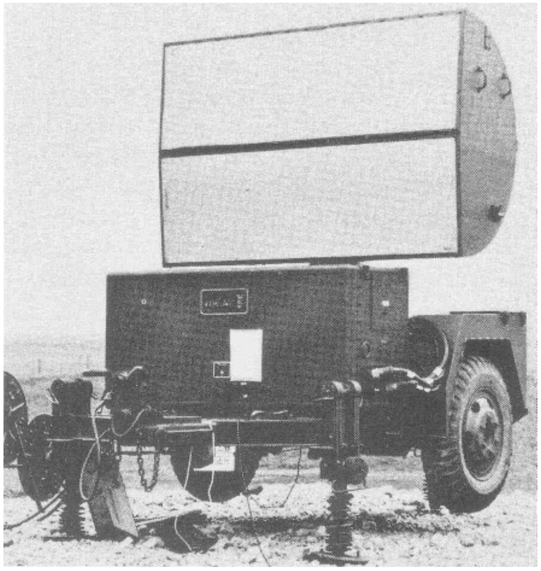

Figure 71. Continuous-wave acquisition radar (CWAR).

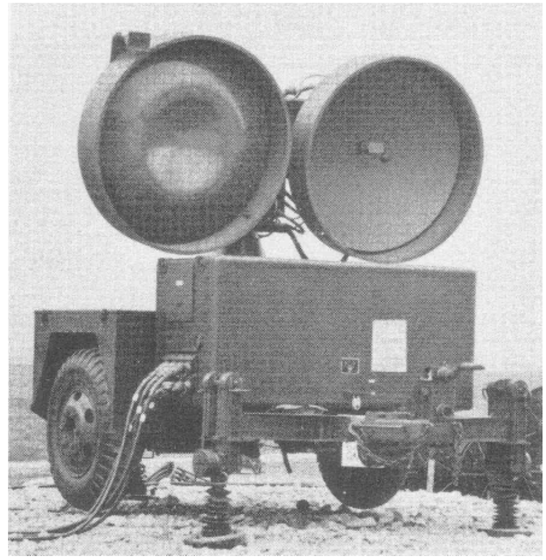

Figure 72. Continuous-wave illuminator radar (CWIR).

HIGH-POWER ILLUMINATOR RADAR

The tactical operation of the high-power illuminator radar (HIPAR) (fig 73) is identical to that of the CWIR, normally being operated remotely from the BCC. As a result of increased power, the range of this radar was increased and it is used in lieu of the CWIR to increase overall system capability. Due to this increased capability, HIPIR is rapidly replacing the CWIR in the field.

Figure 73. High-power illuminator radar (HIPIR).

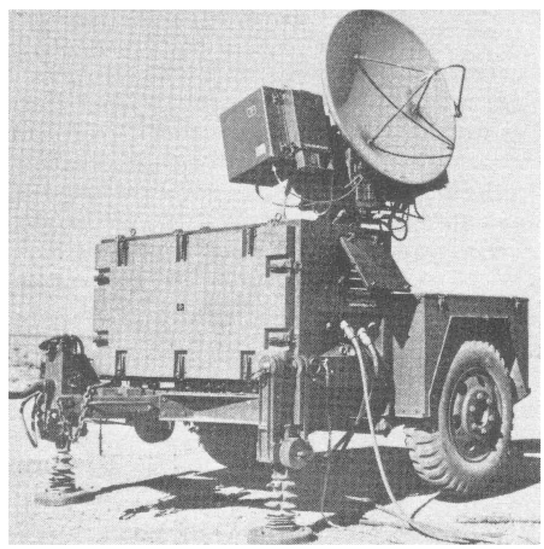

Figure 74. Range-only radar (ROR).