Chapter 3
Army Air Defense Control Systems

The exchange of information between missile fire units and command posts must be instantaneous. Army AD units require timely and continuous information on the location of friendly and hostile aircraft. Immediate collection and dissemination of target data are required to insure rapid fire unit response and concentration of effort directed toward the enemy threat. To provide AD commanders with this required capability, the Army employs electronic fire distribution systems and associated equipment.

MISSILE MASTER (AN/FSG-1)

Oldest of the U.S. Army electronic fire distribution systems currently in use is the Missile Master (AN/FSG-1), having become operational in 1957. Missile Master systems, located only within CONUS, provide a rapid and accurate flow of information between the Army air defense command post (AADCP), AAD fire units, adjacent AADCP's, and SAGE (fig 34). Track information and commands are transmitted as digital data via automatic data link (ADL) between the AADCP and missile fire units. At the fire units, track information and commands are converted from digital data and presented on the commander's consoles. Using electronic displays and controls, the air defense commander can monitor or direct the actions of 24 Nike Hercules batteries against approximately 50 targets.

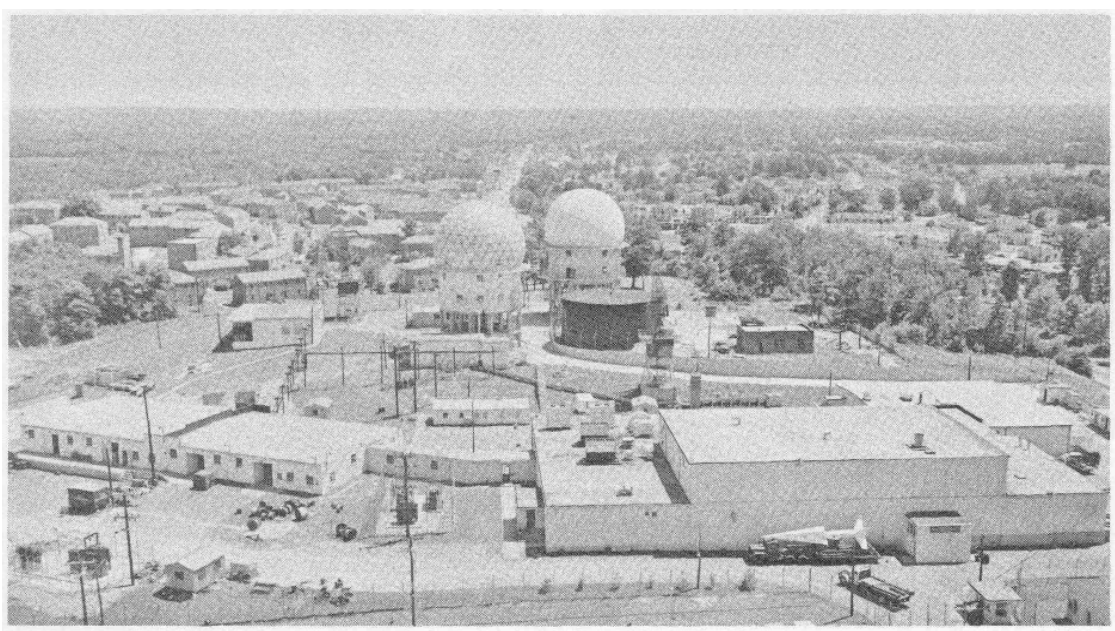

Figure 34. Missile Master installation.

Major items of equipment in the Missile Master system include an AN/FPS-33 defense acquisition radar (DAR) or similar radar, two height-finder radars, a tracking subsystem, a tactical display subsystem, ADL transmitters and receivers, and computing and storage equipment (fig 35).

The DAR provides slant range and azimuth of targets to the tracking subsystem. Associated identification, friend or foe (IFF), equipment furnishes IFF video to the tracking subsystem.

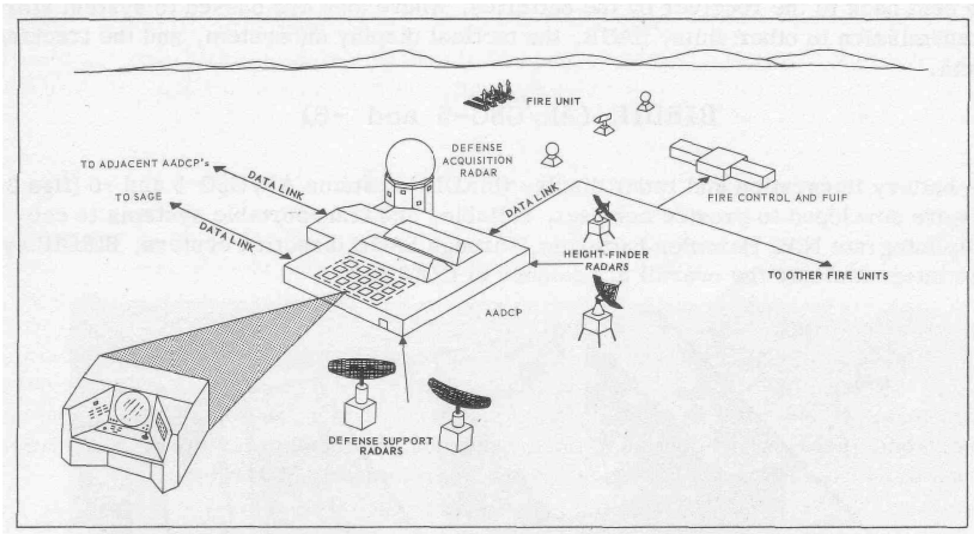

Figure 35. Missile Master data flow.

The two height-finder radars furnish data to the range-height determining equipment of the tracking subsystem. The tracking subsystem consists of two surveillance and entry (S&E) consoles, a channel status unit, six tracking consoles, and two range-height indicator (RHI) consoles. The S&E consoles display acquisition radar data, locally generated tracks, and SAGE backup interceptor control (BUIC) tracks. A channel status unit, using illuminated indicators, shows the status of data channels in the Missile Master system. Tracking consoles display acquisition radar data the same as the S&E consoles. Tracks are assigned from S&E consoles to the tracking consoles for monitoring and updating. The height determination equipment contains two RHI consoles, which receive and display height and range data from the height-finder radars. Track data are sent from the tracking subsystem to the memory storage equipment.

The tactical display subsystem includes three tactical monitor consoles—friendly protector console, operations officer's console, and Army air defense commander's console. The tactical display subsystem receives track information from the system storage and displays it as symbology on the subsystem consoles. The tactical monitor consoles have the necessary controls to send commands to the batteries and to correlate battery tracks with targets. Symbology and illuminated indicators present the battery status of the eight batteries under the control of each tactical monitor console. The friendly protector console has a HOLD FIRE pushbutton for each battery in the defense. Track symbology enables the friendly protector to determine that a friendly aircraft is being tracked and also the battery that is tracking it. A HOLD FIRE command is sent to the battery by pressing the proper HOLD FIRE pushbutton. The Army air defense commander's console and the operations officer's console are identical and display the same symbology as the other tactical consoles. Indicators show the status of the batteries, but direct data commands cannot be sent from these consoles. A signal from either of these consoles determines whether friendly data, hostile data, or both will be passed from storage by the output control. The data to be passed are accepted by the transmitter and passed to the battery. Report-back data are sent back to the receiver by the batteries, where they are passed to system storage for retransmission to other units, SAGE, the tactical display subsystem, and the tracking subsystem.

BIRDIE (AN/GSG-5 and -6)

The battery integration and radar display (BIRDIE) systems AN/GSG-5 and -6 (figs 36 and 37) were developed to provide compact, reliable, and transportable systems to economically integrate Nike Hercules batteries. Through SAGE direction centers, BIRDIE systems are integrated into the overall air defense of CONUS.

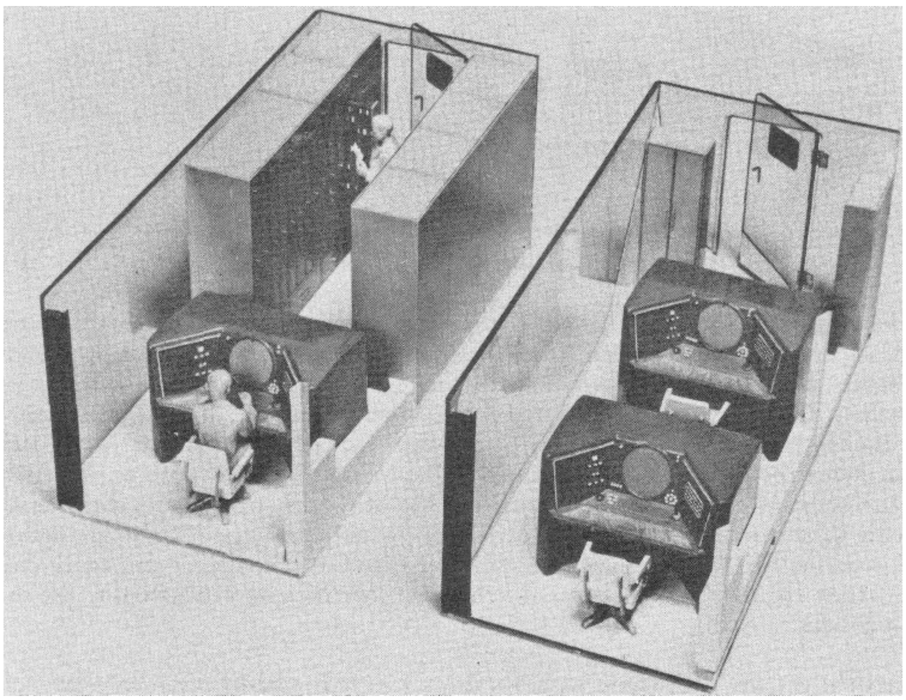

Figure 36. AN/GSG-5 (BIRDIE) system.

Major components of the AN/GSG-5 system include a defense acquisition radar (DAR) AN/FPS-36, AN/FPS-69, or any acquisition radar with a pulse rate of 200 to 400 pulses per second, and the AADCP equipment.

The DAR furnishes target slant range and azimuth, but no height data, to the AADCP. The DAR has IFF equipment which is used for identification.

The AADCP contains display equipment, computer and storage facilities, voice communications, and power and test equipment. The situation display console has controls and indicators that enable the controller to enter target identity, position, and velocity into the memory system. The controls and indicators also enable the controller to make or erase target assignments to batteries and to dump data from the memory system. The plan position indicator (PPI) displays video from the DAR, local track symbols, SAGE track symbols, battery return symbols, and other symbols as selected by the controller.

The AN/GSG-5 can integrate a maximum of 16 Nike Hercules batteries and display approximately 30 SAGE and local tracks plus 16 battery returns. If modified for Hawk, the AN/GSG-5 will integrate eight batteries. The computer and storage system allows semi-automatic tracking of targets up to a velocity of 2, 250 knots. The ADL permits automatic transmission of digital data between AN/GSG-5 and SAGE. The battery data link (BDL) transmits data from the AN/GSG-5 to the batteries; the batteries transmit data back to the AN/GSG-5 and all other integrated batteries. This battery-to-battery data transmission is known as repeat-back data.

The AN/GSG-6 system (fig 37) is similar to the AN/GSG-5 system, but it does not include computer and storage equipment. This system has a maximum capability of integrating two Nike Hercules batteries.

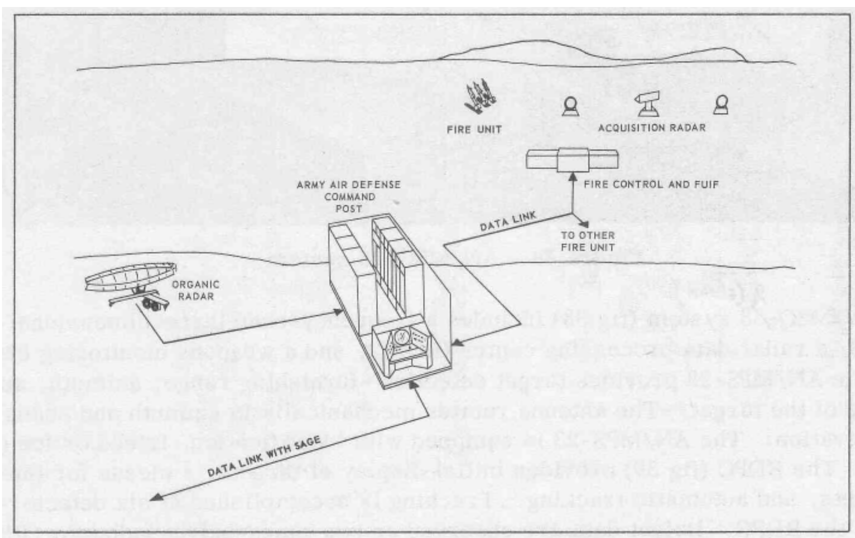

Figure 37. AN/GSG-6 (BIRDIE) system.

MISSILE MONITOR (AN/MSG-4)

The Missile Monitor (AN/MSG-4) fire distribution system was developed by the U.S. Army to coordinate the fire of Nike Hercules and Hawk missile batteries with the army in the field. These systems make it possible to observe and influence the entire air battle from the widest viewpoint so separate actions of numerous batteries can be supervised and unified into an integrated defense.

The AN/MSG-4 system is composed of two basic subsystems: the AN/MSQ-28 (or AN/MSQ-56, if modified) subsystem located at group/brigade level and the AN/MSQ-18 (or AN/TSQ-38, if helicopter-transportable) subsystem located at battalion and battery levels.

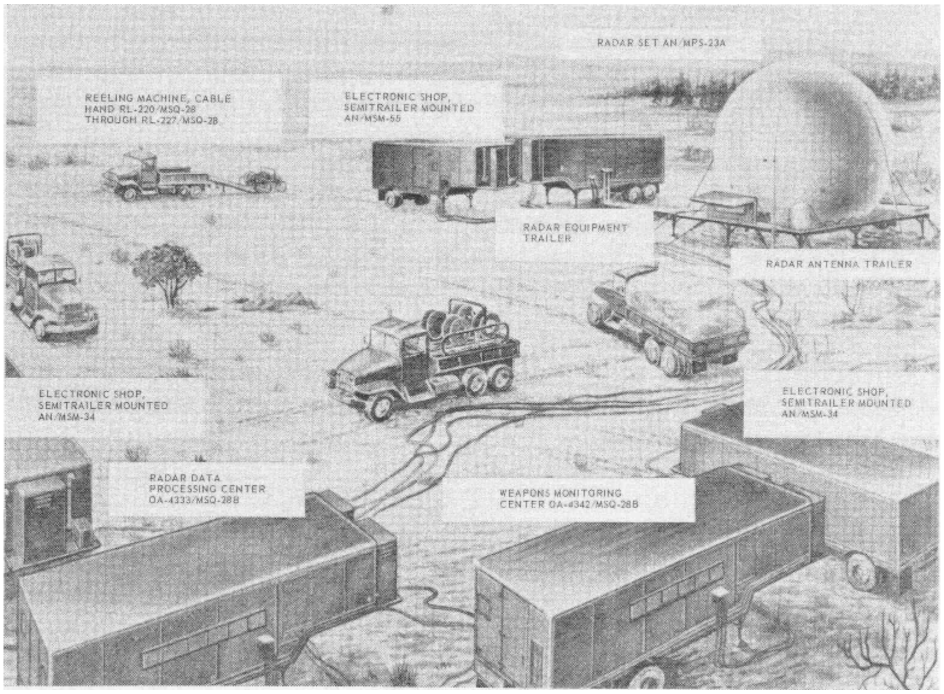

Figure 38. AN/MSQ-28 system.

The AN/MSQ-/38 system (fig 38) includes a frequency-scan three-dimensional radar AN/MPS-23, a radar data processing center (RDPC), and a weapons monitoring center (WMC). The AN/MPS-23 provides target detection-furnishing range, azimuth, and elevation angle of the target. The antenna rotates mechanically in azimuth and scans ele^on-ically in elevation. The AN/MPS-23 is equipped with identification, friend or foe (IFF), equipment. The RDPC (fig 39) provides initial display of targets, a means for interrogation of targets, and automatic tracking. Tracking is accomplished at six detector-tracker consoles in the RDPC. Height data are observed on two range-height indicator (RHI) consoles. The H, X, and Y coordinates of targets, plus X and Y velocities, are stored as track data and sent to the WMC.

The WMC (fig 40) provides the group commander with an immediate presentation of the tactical situation at all times. Track marker data are displayed in the form of symbology on weapons monitoring consoles. Battery status also is received from the battery and displayed on these consoles. This combined symbolic and readout display of information enables the commander to view the entire air battle and make assignments from the WMC to the batteries under his control. The WMC can accept and utilize data from Air Force agencies and adjacent defenses. The AN/MSQ-28 system has the capability of directing more than 30 fire units against more than 150 targets.

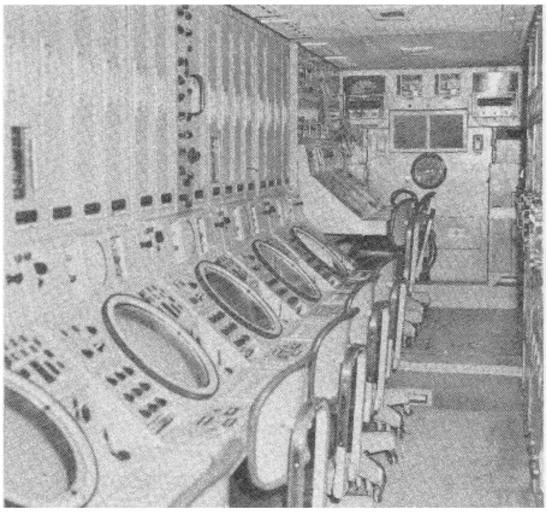

Figure 39. Interior view of RDPC.

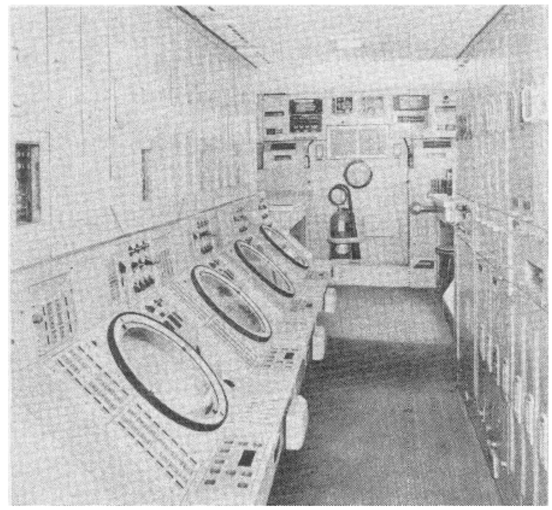

Figure 40. Interior view of WMC.

The battalion-level component of the AN/MSQ-18 consists of the battalion operations central (Bn OC) (fig 41). The Bn OC gives the battalion commander the capability of either monitoring reference data and the changing status or making assignments to the firing battery, depending upon the method and mode of operation. It links the battalion with the group WMC and fire units and displays battery status, target video, and symbology on each of two consoles. The electronic search central AN/GSS-1 (or AN/GSS-7) of the battalion is connected to the Bn OC and can furnish radar data to the Bn OC. In turn, the Bn OC can insert these data into the data link, thus providing additional information to the group WMC fire units under the normal method of operation.

The battery-level component of the AN/MSQ-18 is the coder-decoder group (CDG) (fig 42). The CDG functions as an automatic data link between battalion and battery. It is a transmitter-receiver that permits exchange of data between the battery and other elements of the system. Information which may have originated at the WMC, Bn OC, or other fire units is received at the CDG in the form of binary digital data. The CDG converts these data for display at the battery control console. Information originating at the battery is converted to binary digital data by the CDG and sent to the Bn OC and WMC.

The AN/MSG-4 system has six methods of operation. Three of these methods—normal, sector, and independent—are considered in tactical operations. In the normal method, the WMC sends reference information and commands through the Bn OC to the battery. The Bn OC monitors, but does not originate, commands to the batteries. In the sector method, reference information is sent to the Bn OC and the batteries and the Bn OC originates commands to the batteries. In the independent method, all reference information and commands originate at the Bn OC. The other three methods of operation are used for tests and in emergencies.

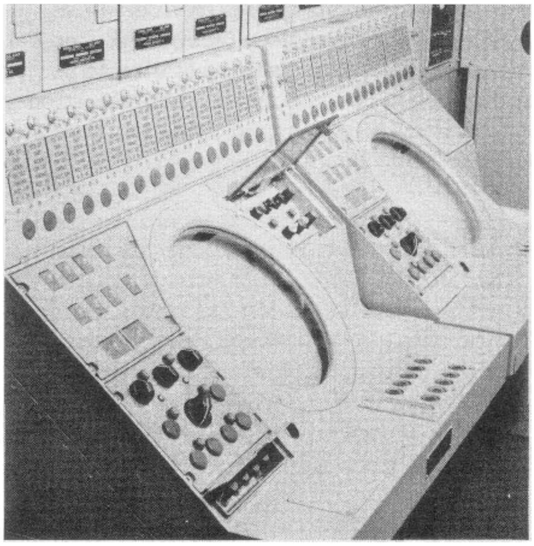

Figure 41. Battalion operations central consoles.

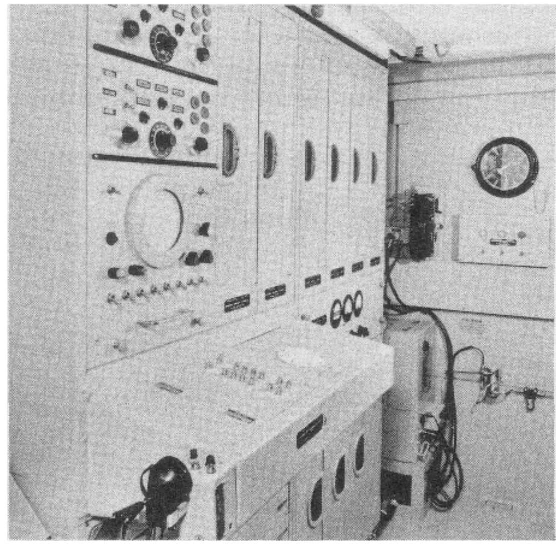

Figure 42. Interior view of coder-decoder group.

The primary means of transmitting information, using binary digital data, is by ADL. Common carriers of ADL include spiral-4 cable or microwave, but any carrier capable of handling pulses of 600 and 1500 cycles per second will suffice.

THREE-DIMENSIONAL RADAR

Before any commander can engage an airborne threat, he must know the location of the threat in relation to his unit. The location of the threat is expressed in terms of azimuth, elevation, and range from the unit. In most current AD weapon systems, two types of radars are used to provide these data: an acquisition radar to determine azimuth and range and a height-finder radar to determine elevation. Use of two radars rather than one presents obvious problems; e.g., two radars must be moved in a mobile situation, two radars must be maintained and repair parts stocked for each, and two radars must be emplaced on carefully selected terrain to prevent masking of the height-finder radar so it can cover areas identical to the acquisition radar.

A three-dimensional (3D) radar can furnish all of these data; i.e., azimuth, elevation, and range. This type of radar utilizes electronic scanning. One of the new classes of electronic scanning radars, the AN/MPS-23 provides three-dimensional search. It supplies azimuth, elevation, and range data simultaneously from a single antenna (transmitter and receiver) channel. The beam scans electronically in elevation while the antenna rotates in azimuth. The antenna frequency-scan operation is similar in principle to that of a slotted waveguide with the microwave energy radiated from the slots combining to form a beam. When the frequency is matched and phased with the distance between the slots, the direction of propagation is straight ahead. If the frequency of the energy is changed, relative phase differences are set up from one slot to the next, changing the direction of propagation accordingly. Continuous phase shifting is achieved by using variable frequency exciters in the transmitter. These exciters can be programed digitally to provide various patterns of beams scanning in elevation. The AN/MPS-23 incorporates moving target indicator (MTI) circuits that blank out returns from stationary objects. It is capable of azimuth sector scanning as well as 6, 400-mil rotational scan. It provides variable scan rates in elevation and azimuth and uses variable pulse repetition frequencies. The changing radiation frequency gives this radar inherent resistance against electronic jamming.

Another proposed type of 3D radar incorporates many desirable characteristics such as mobility, compactness, light weight, ease of maintenance, and ability to operate in an EGM environment. Electronic equipment is sealed from such ambient conditions as sand and dust, salt spray, rain, and humidity and is cooled by built-in, air-to-air heat exchangers. Transportable by helicopter, cargo aircraft, or standard military vehicles, the lightweight 3D radar can be put into operation quickly at remote sites. Rugged, compact design enables the entire system to be packaged in two waterproof inclosures, 6f feet by 6-5- feet. The antenna package has a length of 12 feet and weighs 2, 300 pounds; the electric equipment shelter has a length of 9 feet and weighs 3, 500 pounds.

The antenna inclosure is uniquely designed for transportability and rapid assembly. The pedestal and simplified azimuth drive system are integral parts of the lower portion of the antenna package. Packed in the upper portion of the inclosure are the reflector panels and waveguide lengths. The thin-shelled parabolic reflector is assembled from four structural modules joined with quick-disconnect fasteners. Six men can perform the entire assembly and hookup procedure and have the system on the air in minimum time.

Literally skimming the ground, the radar's narrow pencil beam practically eliminates clutter, thereby providing highly effective low-altitude detection. This lightweight radar operates in three basic modes: normal, MTI, and fixed pulse repetition frequency (PRF) for synchronization with fire control tracking radars.

FIRE DISTRIBUTION SYSTEM (AN/TSQ-51)

A new fire distribution system (AN/TSQ-51) is being developed to replace some first-generation fire distribution systems. The new system will greatly reduce operational costs, simplify maintenance, and standardize fire distribution system equipment. The AN/TSQ-51 is expected to be mobile, not to require equipment air conditioning, and to be in the field prior to 1970. It is composed of equipment for an AADGP and associated remote radar integration stations (RRIS). The system is designed on the modular concept, allowing the addition or deletion of major functions so requirements of various defense complexes may be met economically. The system uses a general purpose computer capable of receiving and processing track data from U.S. Air Force command and control systems, adjacent AADGP's, remote radar integration stations, and locally generated tracks. The system is capable of simultaneously monitoring and coordinating Nike Hercules and Hawk fire units.

The major functions of the AADCP equipment are to detect and track (automatic or rate-aided) video, display local and remote tracks and status, assess the threat, control and monitor fire units, and exchange track data with other elements of air defense. The major function of the RRIS is to detect and track targets and transmit these data to the AADGP. The remote radar integration stations are located at suitable radars to supplement the acquisition radar coverage of the AADCP. The system uses rate-aided manual tracking and digital computing and storage and is capable of automatic exchange of data with the AADCP.

RADAR NETTING SYSTEM

All air defense must start with a knowledge of the attacking forces. As a result, any AD system must perform an aircraft tracking function which yields information that commanders can use to engage the attacking force. This tracking function can exist either as an integral feature of the AD system (such as the defense acquisition radar) or by the addition of radars specifically deployed for the purpose of early warning or gap-filling.

The term "radar netting" (fig 43) describes the process by which track data derived from several additional or remote radars are gathered at a single center to produce an integrated set of meaningful target information which can be distributed to all AD elements concerned.

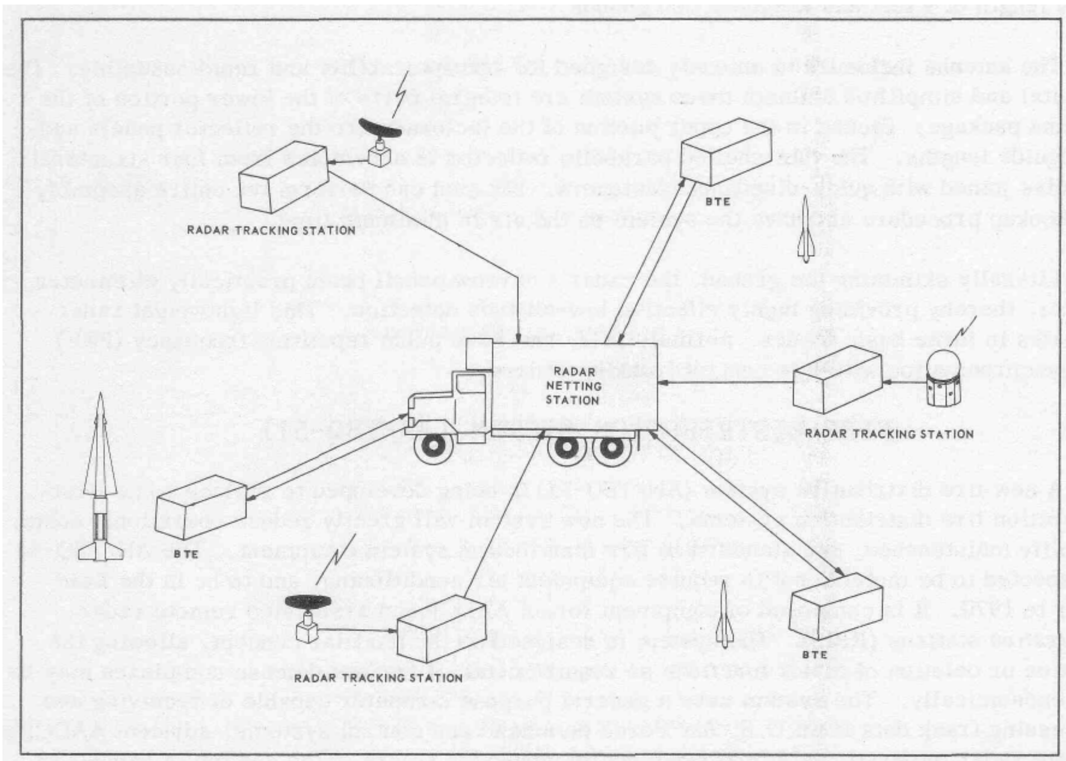

Figure 43. Radar netting concept.

Radar netting can provide concurrent coverage of a selected area by more than one radar. Each remote radar, independent of central computing facilities, can continue to furnish processed track data to another user even if its primary user is disabled. Another advantage is furnishing jam-strobe tracking or obtaining cross-bearings on a jamming target to determine its position by triangulation.

A radar netting system exchanges data between various radars, surface-to-air missile batteries, and command centers by advanced digital data transmission techniques. The standard operational system consists of the following subsystems: radar tracking station (RTS), radar netting unit (RNU), and battery terminal equipment (BTE).

The radar tracking station (fig 44) is a compact radar data processor which accepts track information from its associated acquisition radar. This track information enters the computer and is updated by manual tracking on the part of the console operator. The computer stores the track data in digital form, which are then made available by data link to any user in the netting system. The user receives position coordinates, velocity components, raid size, identification, track number, and target height.

Figure t<± uueiioi view of RTS.

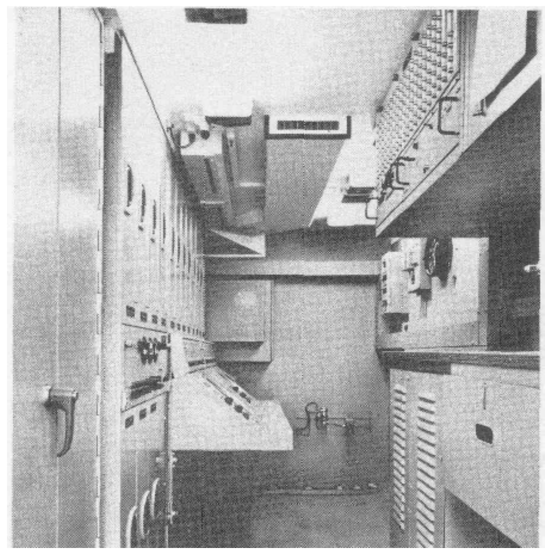

Figure 45. ivctucti neuing unit at OG.

Incoming track data from each RTS must be received at the operations central (OC) and relayed to the missile batteries as well as to the other RTS. At the OC, the radar netting unit (fig 45) acts as a sequencing and distribution device, channeling data from each RTS to the missile batteries through their terminal equipment, to the OC displays, and to the other RTS.

As the on-site processor which ties the missile battery to the OC, the battery terminal equipment (AN/GSA-77) functions as a two-way data link. Through the BTE, the battery commander is continuously informed of targets which other batteries are tracking and engaging and targets which may constitute a threat to his defense area in the immediate future. Conversely, the BTE also encodes the battery information into a digital message containing the coordinates of the target being tracked, battery status, and other data, such as parallax corrections. The BTE is capable of integrating any one of several guided missile batteries with any one of several AD operations centers, such as the AN/MSG-4, AN/TSQ-38, AN/ FSG-1, and AN/TSQ-51 Army fire distribution systems.

The AN/GSA-77 system is a much-improved version of its predecessors, weighs less than 250 pounds, is small (2 feet x 2 feet x 1 foot), and requires little or no maintenance.

EVOLUTION OF ALTERNATE BATTERY ACQUISITION RADAR

All Nike Hercules batteries in ARADCOM are programed to receive either a high-power acquisition radar (HIPAR) or an alternate battery acquisition radar (ABAR) to provide long-range target acquisition. The present defense acquisition radar (DAR) and alternate battery acquisition radars have evolved from the search radar AN/TPS-1B. The AN/TPS-1B (fig 46) included only the bare essentials required of a search radar when it appeared in the military radar inventory about 1947. Many antiaircraft artillery units of this era used the AN/TPS-1B as an early warning radar.

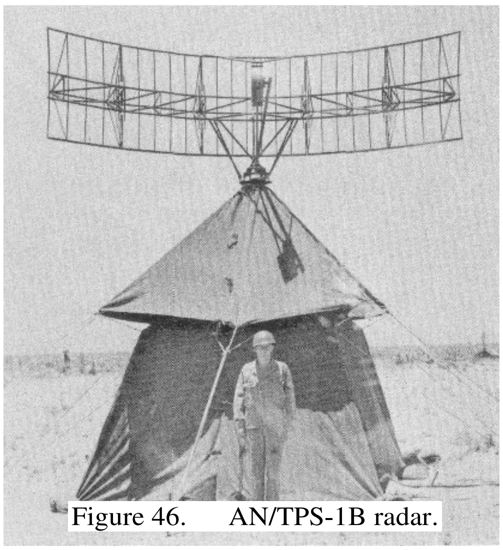
Figure 46. AN/TPS-1B radar.

In 1949, three modification kits were produced for the AN/TPS-1B. These kits provided moving target indicator (MTI) operation for the radar and changed its designation to the AN/ TPS-1G which appeared only as an experimental model. Research and experimentation on the AN/TPS-1C produced the AN/TPS-1D, a medium-powered search radar designed to detect air targets at ranges up to 160 nautical miles (297 kilometers). It was first issued to the Air Force to complement the radar coverage of the continental United States.

Later issue of the AN/TPS-1D to gun units satisfied the requirement for long-range radars at battalion level. To make the radar more compatible with unit mobility, the AN/GSS-1 electronic search central was designed. This metal shelter contains the AN/TPS-1D radar, radio and telephone facilities; identification, friend or foe (IFF), equipment; and a plotting board. Mounted on a 2-g-ton truck, it could shelter an emergency battalion AADCP.

In 1957, additional improvements to the AN/TPS-1D were made to provide better vertical antenna coverage, a more stable MTI, and a larger presentation system. The result of this was the AN/TPS-1G, which was issued to field army units overseas and to some training units in the United States. At the same time, the requirement for a radar with increased range for ARADCOM units resulted in the development of the AN/FPS-36 (fig 47). This radar is the basic AN/TPS-1D to which a 40-by 11-foot antenna was added. With other modifications, this antenna improved the reception of radar returns and extended the range to 200 nautical miles (371 kilometers). To provide an electronic counter-countermeasure (EGCM) capability, the phase I ECCM kit was added.

When integrated with the Nike Hercules system, the AN/FPS-36 without the EGCM capability becomes the AN/FPS-75; with ECCM receivers and appropriate ECCM devices,

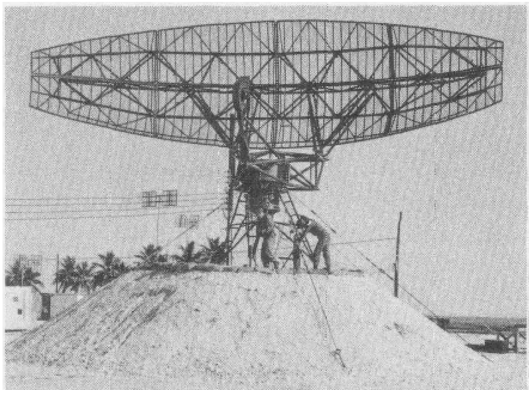

Figure 47. AN/FPS-36 radar.

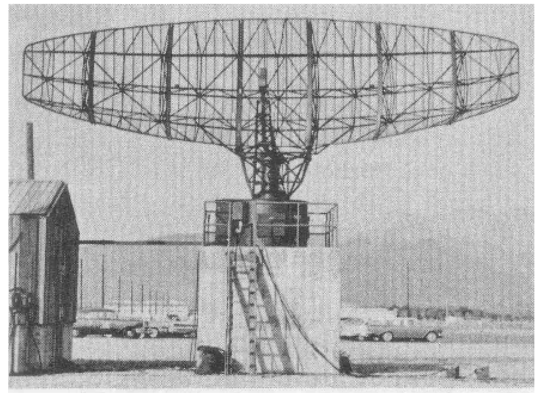

Figure 48. AN/FPS-69 radar.

it becomes the AN/FPS-71. Another version of the AN/TPS-1D, the AN/FPS-56, was developed for Nike Hercules units. This radar consists of two basic AN/FPS-36 radars that transmit and receive with one 40- by 11-foot antenna, providing two operating channels that function on different frequencies. The addition of ECCM capabilities to the AN/FPS-56 converted it to an AN/FPS-61. When integrated with the Nike Hercules system, the AN/FPS-61 becomes the AN/FPS-69 (fig 48). Any member of the AN/FPS family integrated with the Nike Hercules system is referred to as an alternate battery acquisition radar (ABAR). The acquisition radar is then called the low-power acquisition radar (LOPAR). The battery control officer (BCO) of a Nike Hercules battery equipped with ABAR may select either ABAR or LOPAR for target detection and acquisition. Video from either radar may be presented on the PPI in the director station. The BCO compares video from both radars and chooses the better presentation. Functions of a battery equipped with ABAR are the same as for a normal battery, except for this choice of acquisition radars.

The AN/FPA-15 and AN/FPA-16 ECCM consoles are display systems used when an alternate battery acquisition radar is integrated into the Nike Hercules system. Under the control of two operators and an officer, the console provides a central point where the outputs of the LOPAR and ABAR can be monitored. It allows the electronic warfare officer to quickly determine which ECCM features of the two acquisition radars provide the battery commander with the best scope presentation for observation of targets when the system is experiencing ECM.

The tactical employment of ABAR with an AD unit depends largely on the mission 4Mt. Throughout ARADCOM, BIRDIE and Missile Master fire distribution systems receive two-dimensional target data from either a defense acquisition radar or an ABAR. In a battalion-level air defense with a field army, the AN/TSQ-38 or AN/MSQ-18 operations central receives target data from electronic search central AN/GSS-1 or AN/GSS-7.

The electronic search central AN/GSS-1 (fig 49), later modified to encompass the AN/TPS-1G with a transportable version of the 40- by 11-foot antenna, then became the AN/ GSS-7.

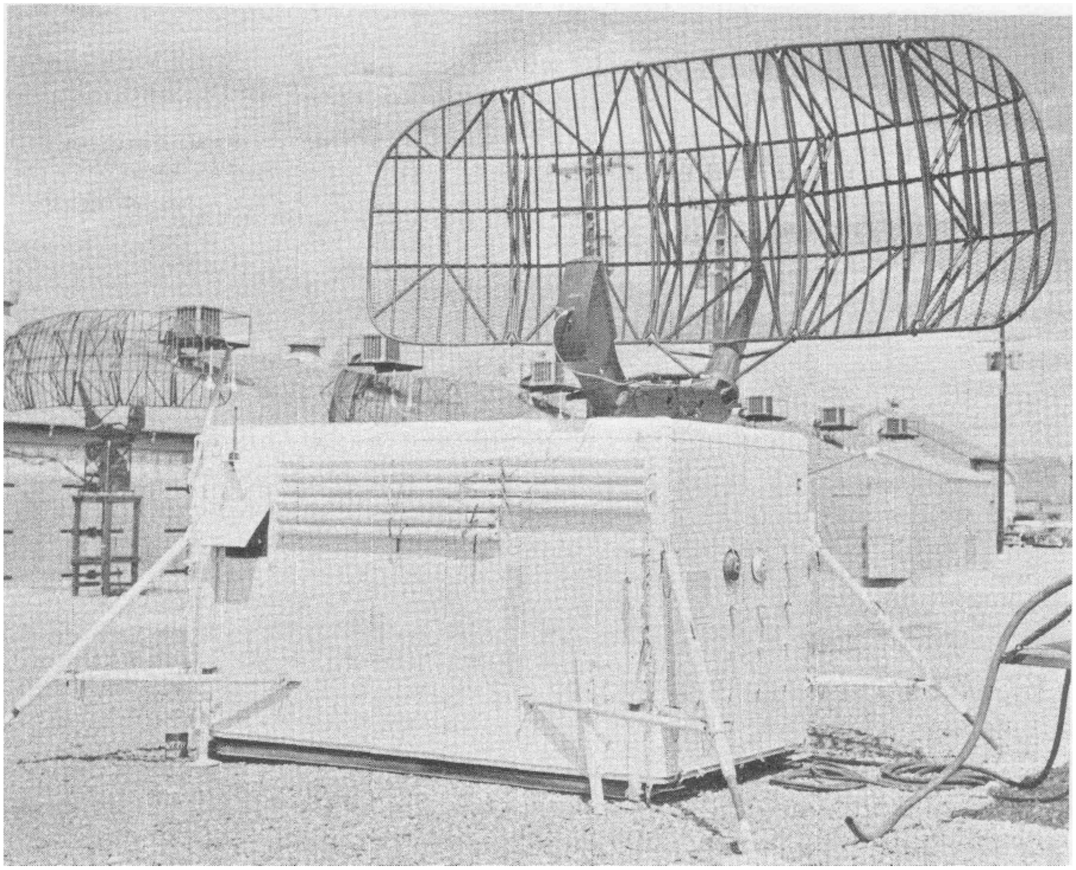

Figure 49. Electronic search central AN/GSS-1.

SUMMARY OF DAR/ABAR EMPLOYMENT

Radar	Type	Employment	Rated Range (nm (km))
AN/TPS-1D (Component of AN/GSS-1 or AN/GSS-7)	DAR without added ECCM devices	Bn, Gp, and Bde radar sections in the army in the field	AN/GSS-1 160 (297) AN/GSS-7 160 (297) with improved close-in altitude coverage
AN/TPS-1G (Component of AN/GSS-1 or AN/GSS-7)	DAR without added ECCM devices	Bn, Gp, and Bde radar sections in the army in the field	AN/GSS-1 160 (297) AN/GSS-7 160 (297) with improved close-in altitude coverage
AN/FPS-36	DAR without added ECCM devices	Nike battalion in ARADCOM	200 (371)
AN/FPS-56	DAR without added ECCM devices	No longer used with air defense	200 (371)
AN/FPS-61	DAR with added ECCM devices	ARADCOM sites	200 (371)
AN/FPS-69	ABAR with added ECCM devices	ARADCOM sites	160 (297)
AN/FPS-71	ABAR with added ECCM devices	ARADCOM sites	160 (297)
Improved AN/FPS-71 w/amplitron	ABAR with added ECCM devices	ARADCOM sites	160 (297)
AN/FPS-75	ABAR without added ECCM devices	ARADCOM sites	160 (297)
AN/FPS-76 w/amplitron	ABAR without added ECCM devices	Not used with air defense (developmental model)	230 (426) (160 (297) when integrated)