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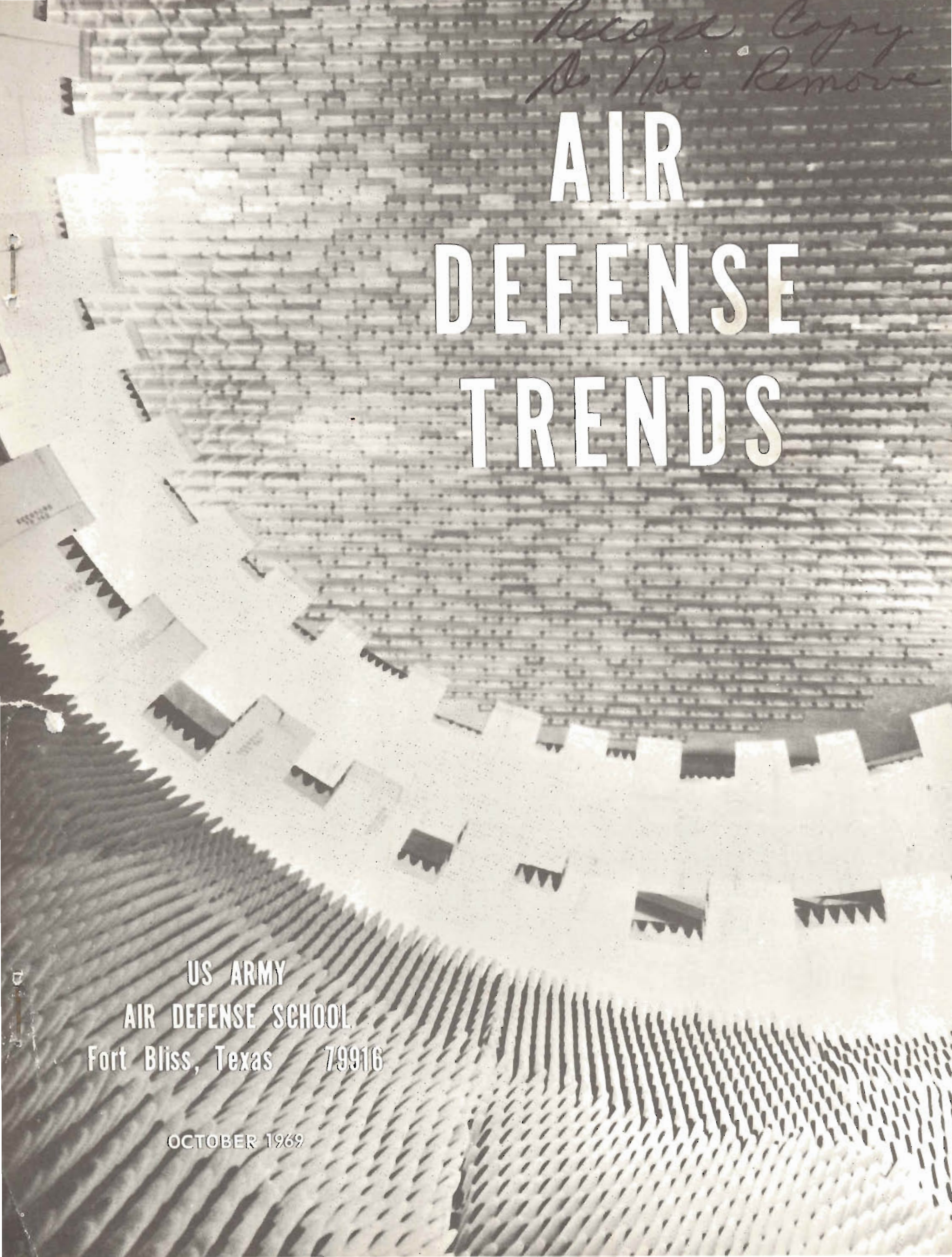
AIR DEFENSE TRENDS



US ARMY
AIR DEFENSE SCHOOL
Fort Bliss, Texas 79916

OCTOBER 1969

AIR DEFENSE TRENDS
US ARMY AIR DEFENSE SCHOOL
Fort Bliss, Texas 79916

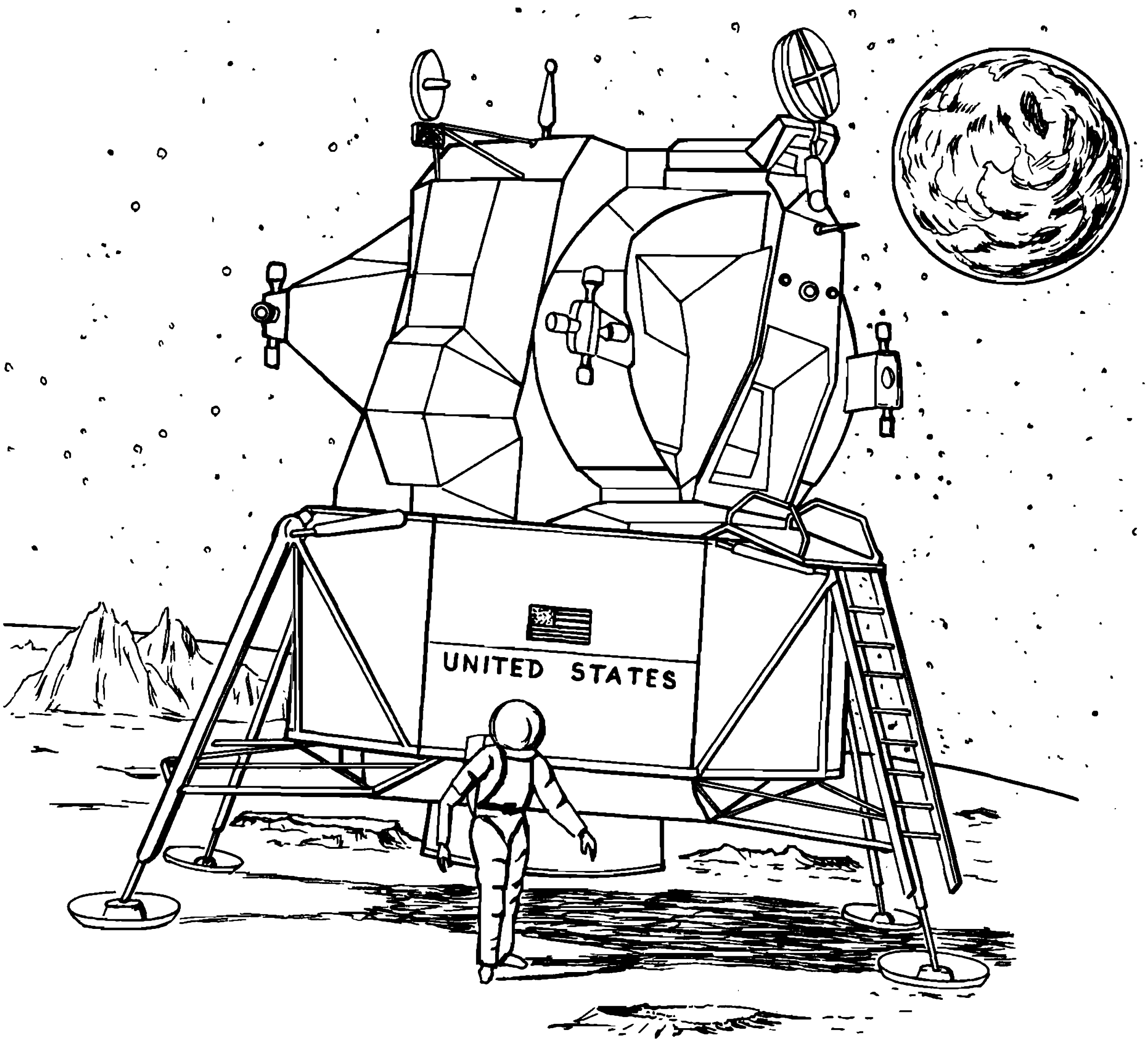
IN THIS ISSUE

89805

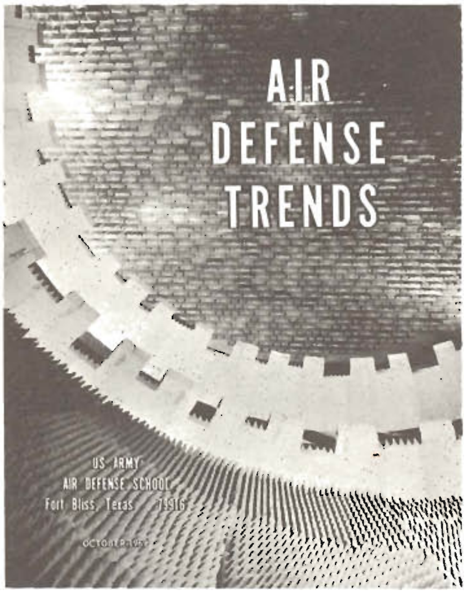
Air Defense Trends is an instructional aid of the United States Army Air Defense School; it is published when sufficient material of an instructional nature can be gathered.

The unfailing formula for production of morale is patriotism, self-respect, discipline, and self-confidence within a military unit, joined with fair treatment and merited appreciation from without. It cannot be produced by pampering or coddling an army, and it is not necessarily destroyed by hardship, danger, or even calamity . . .

—Douglas MacArthur
Annual Report,
Chief of Staff
US Army 1933



Air Defense Trends *takes pride in saluting* NASA *and the astronauts upon the epic flight of* Apollo 11. A *world looks in wonder upon a crowning achievement of the military-industrial complex that staggers the imagination and milks the dictionary dry of superlatives.*



COVER We might call this an optometrist's view of the eye of a Cyclops. In a sense it is an eye—and a big one—for it belongs to a gigantic radar system known as hard point demonstration array radar (HAPDAR).

Technically, this "eye" is the collector side of the 700-square-foot array as viewed from the vertex of the cone-shaped feed assembly. In the foreground is absorptive material within the cone. The irregular rings are absorptive material suspended between the feed assembly and the array.

This radar system, located at White Sands Missile Range (WSMR), was initially sponsored by the Advanced Research Projects Agency but is now sponsored by the Army's Advanced Ballistic Missile Defense Agency (ABMDA). The original objective of the system was to demonstrate the feasibility of producing a low-cost, high-performance, phased-array radar.

The Sperry Gyroscope Division of Sperry Rand Corporation was awarded a contract in June 1964 to demonstrate this feasibility by the design, development, construction, and test of a full-scale model. The first contract was a receive-only, single-target, tracking model, and acceptance tests were completed in January 1966. In May 1966 a high-power transmitter was added to give the system an independent target illumination capability. Shortly thereafter the system's general-purpose, real-time-control computer was reprogramed and slight hardware modifications were made to the receiver and video processor to enable the tracking of five targets simultaneously.

The HAPDAR has been fully operational at WSMR since October 1966 and has been used as a test bed for detailed analysis of multitarget tracking performance and array antenna phenomena. Most recently, a unique technique developed by the Syracuse University Research Corporation (SURC) for cancellation of side-lobe jamming from multiple sources has been installed on HAPDAR with the express intent of complete evaluation on a phased-array radar. This work by SURC is sponsored by ABMDA.

The system is highly pertinent to air defense because many of its principles are incorporated in the radars of some of our latest air defense weapons. A more comprehensive report on HAPDAR appears on page 34 of this issue of Air Defense Trends.

AIR DEFENSE TRENDS

An instructional aid of the United States Army Air Defense School, Air Defense Trends is published when sufficient material of an instructional nature can be accumulated. It is designed to keep air defense artillerymen informed of unclassified tactical, technical, and doctrinal developments because it is essential to national defense that all levels of air defense command be kept aware of these developments and their effect on the air defense posture.

Distribution of this publication will be made only within the School, except for distribution on a gratuitous basis to Army National Guard and USAR schools, Reserve component training and ROTC facilities, and as requested by other service schools, ZI armies, US Army Air Defense Command, Active Army units, major oversea commands, and military assistance advisory groups and missions.

Qualified individuals may purchase copies of Air Defense Trends by writing to The Book Store, US Army Air Defense School, Fort Bliss, Texas 79916.

When appropriate, names and organizations of authors are furnished to enable readers to contact authors directly when they have questions concerning an article.

Unless otherwise indicated, material may be reprinted provided credit is given to Air Defense Trends and to the author.

Articles appearing in this publication do not necessarily reflect the opinions of the US Army Air Defense School or the Department of the Army.

Air Defense Trends announces with regret the passing of two general officers whose distinguished records in peace and war will live long in military history. Both had chosen to retire in the Fort Bliss area.

Major General
Terry de la Mesa Allen

1 April 1888-12 September 1969

Major General
James R. Pierce

23 August 1899-3 October 1969

US ARMY AIR DEFENSE SCHOOL

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Office of Doctrine Development, Literature, and Plans	Colonel M. W. Niemann
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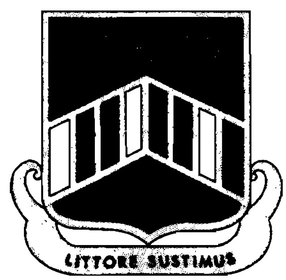
Commanding General . . . . Brigadier General H. J. Schroeder, Jr

6TH ARTILLERY GROUP (AIR DEFENSE)

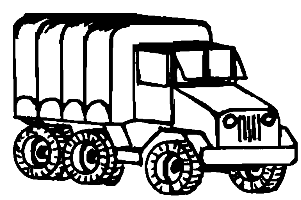
Commanding Officer . . . . Colonel D. H. Sudderth, Jr

15TH ARTILLERY GROUP (AIR DEFENSE)



Commanding Officer . . . . Colonel B. B. Sapp

SPECIAL TROOPS



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US ARMY AIR DEFENSE HUMAN RESEARCH UNIT, HUMAN RESOURCES RESEARCH OFFICE (George Washington University)

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GENERAL ROGERS LEAVES USAADS

Brigadier General Jack A. Rogers, after having served as Assistant Commandant of the US Army Air Defense School since June 1968, has been ordered to Verona, Italy, where he has assumed the position of Deputy Chief of Staff for Logistics and Administration at Headquarters, Allied Land Forces, Southern Europe. A native of California, General Rogers received his bachelor of arts degree from the University of California and a master of arts degree in International Relations from George Washington University. A graduate of five top-level military courses, including the Air War College, he was appointed brigadier general in June 1968. He served in Europe during World War II and subsequently in Canal Zone, Korea, Japan, and Germany.

AIR DEFENSE TRENDS EDITORIAL STAFF

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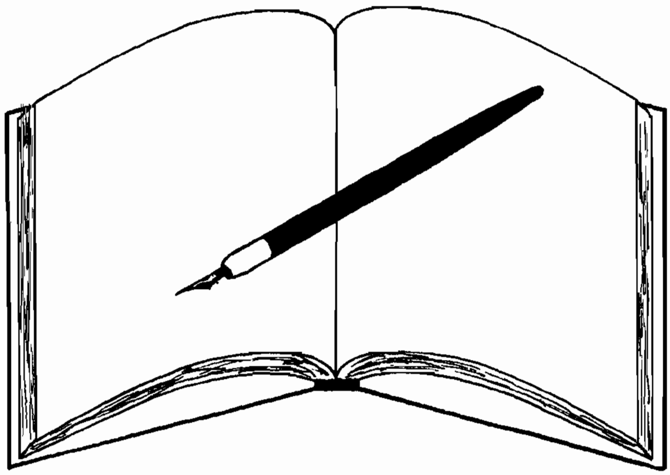
Lieutenant Colonel E. C. Teatom . . . . Chief

W. E. Sanford . . . . Editor

Major J. E. Wilson . . . . Associate Editor

Major T. G. Green . . . . Associate Editor

Staff Sergeant A. E. Hartelt . . . . Illustrator



LETTERS

to the EDITOR

Sir:

The cover story of the June 1969 issue of Air Defense Trends may have caused some confusion concerning nomenclature. I believe the term rapid alerting and identification display unit (RAID), as you have called it, is actually target alert data display set (TADDS) AN/GSQ-137. Reference is TM 9-1430-589-12.

Sincerely,

D. W. BARTLETT
MAJ, ADA, USAR
4160th El Paso USAR School

When we went to press, it was RAID. By the time the publication was distributed, it was TADDS—and still is. Thanks.

Ed.

Sir:

One of the fellows in our office came across the inclosed picture [*Ed. Note: See artist's concept of Redeye below.*] and we thought it might interest your readers. They should be interested, as we were, to learn that Redeye may have an air-to-air application.

O. J. VAILLANCOURT
USAADS
Fort Bliss, Texas

Air-to-air Redeye.

Sir:

Air Defense Trends makes exceptionally worthwhile reading for all air defense artillerymen. I look forward to each publication, and after I read it, it is filed with my other reference material. However, there is an error in the June 1969 edition which should be corrected.

On page 1 in the last paragraph is a statement that each square of a RAID matrix "contains two colored disks that are green on one side and red on the other." If this were true, the RAID could display 98 friendly or 98 hostile targets at a time instead of 49 each as stated. The reason that a maximum of 49 each can be displayed is that within each square is one disk that is green on one side and one disk that is red on one side. Both disks are black on their reverse sides. When the black side is exposed, this indicates that no objects have been detected within that block of airspace. Incidentally, this is a feature that does not appear to be available from the way the paragraph is written because it appears that there must be two colored disks, either red or green, exposed in each square at all times.

I am confident that many others have commented on this also, but I did want to let you know that I'm paying attention. I also recommend that a numbering system be used so that interested personnel can be sure that they have a copy of each edition.

JAMES L. PATTERSON
Major, ADA
ADA Instr, USAFAS

Thanks for your interest. Our FAAR experts say you're right about RAID. Regarding a numbering system for Air Defense Trends, again we agree with you but we think publishing an index at the beginning of each year containing a list of issues and articles of the previous year would be more valuable.

Ed.

Hi . . . I'm Renée Rockette. You'll be seeing more of me in future issues of Air Defense Trends. If you need help with air defense problems (or want to help someone else), all you have to do is spell out the facts in a letter to me in care of the Editor.

USAADS Instructional Notes

Hinman Hall

OFFICE OF DOCTRINE DEVELOPMENT, LITERATURE, AND PLANS

ELECTRONIC WARFARE TRAINING

The Department of the Army is placing increased emphasis on electronic warfare (EW) training to improve and revitalize the Army's electronic warfare capability. In a recent communication to service schools concerned, US Continental Army Command directed that a comprehensive study be conducted toward this end. Some areas to be examined and EW improved (or added) include related school publications, instructional materials, MOS courses, officer basic and advanced courses, training activities, tables of distribution, and field exercises. Changes resulting from the study are expected to be in effect by April 1970.

STATUS OF TRAINING DEVICE PROJECTS

1. The Redeye moving target simulator X12A11 service test has been completed. A favorable service test report on training effectiveness is expected and production items (four) are anticipated to be delivered to Fort Bliss, Texas, for Redeye gunner training in late 1970.

2. Release for production of the Redeye tracking head trainer XM49E3 has been initiated. Production units should be available to the field soon.

3. The Chaparral simulator/evaluator has been contracted for development. Delivery of prototype units for test is expected in late 1969.

4. The low cost, booster-propelled, gunnery target, now called ballistic aerial target system (BATS), is expected to be delivered for service test in late 1969. Plans are to test a number of prototype targets from several contractors prior to selecting the final configuration.

5. New items are as follows:

a. A small development requirement for an improved slide kit for aircraft recognition was submitted to USCONARC in April 1969. The kit is based on HumRRO, Division No. 5, Fort Bliss, Texas, studies and has the acronym GOAR for ground observer aircraft recognition.

b. An abbreviated performance characteristic for a low-cost synthetic target system for Hawk was submitted to USCONARC in April 1969. Purpose of the device is to provide an inexpensive target for Hawk annual service practice and training firings. Initial installations of the device is planned for Fort Bliss, Texas. Subject to favorable evaluation, additional systems may be required for other installations where Hawk units conduct firing practice. A similar item is being considered for SAM-D.

c. A requirement for two Improved Hawk training facilities was submitted to USCONARC in June 1969. The facilities would provide training of officers and enlisted personnel on a complete spectrum of tactical conditions for each operating position. Each facility would consist of two rooms with a total of 18 operating positions. One facility is to be provided US Army Training Center (Air Defense) for enlisted operator training and the other to the US Army Air Defense School for training officers and other enlisted personnel concerned with the Improved Hawk system.

TRAINING LITERATURE REPORT

Here is a list and the status of Department of the Army training literature produced by the US Army Air Defense School for the fourth quarter of fiscal year 1969 and the first quarter of fiscal year 1970.

a. FM 44-1-1, US Army Air Defense Artillery Operations (new), which supersedes TC 44-12. Final draft is completed.

b. (C) FM 44-4A, Procedures and Drills for Chaparral Self-Propelled Weapon System (new), was submitted to TAGO in July 1969.

c. FM 44-62, Air Defense Artillery Automatic Weapon Gunnery (revision), was submitted to TAGO in July 1969.

d. FM 44-99, Procedures and Drills for Hawk Missile Battery, Towed and Self-Propelled (revision), was printed in May 1969.

e. FM 44-( ), Procedures and Drills for Vulcan Towed Weapon System (new). Final draft is in progress.

f. TC 44-8, Air Defense Section, Airspace Control Element, Tactical Operations Centers (revision). Final draft is in progress.

g. ATP 44-8, Air Defense Artillery Target Detachment (revision), was submitted to TAGO in June 1969.

h. ATP 44-85, Air Defense Artillery Automatic Weapon Units (revision), was submitted to TAGO in June 1969.

i. ASubjScd 23-17, Redeye Gunner and Air Defense Section Training (revised), was printed in May 1969.

j. ASubjScd 44-6, Air Defense Artillery Forward Area Alerting Radar Platoon (new), was submitted to TAGO in June 1969.

k. ASubjScd 44-12, Air Defense Artillery Service Practice Procedures (revision). Final draft is in progress.

l. ASubjScd 44-14, Automatic Weapon Section (M42) (revision), was submitted to TAGO in June 1969.

m. ASubjScd 44-33, Assembly and Monitoring Team (Missile Warhead Support Detachment) (revision), was submitted to TAGO in June 1969.

n. ASubjScd 44-34, Hawk Self-Propelled Platoon (new), was submitted to USCONARC in July 1969.

o. ASubjScd 44-41, Communications Section (revision), was submitted to TAGO in June 1969.

p. ASubjScd 44-42, Air Defense Artillery Communications (revision), was submitted to TAGO in June 1969.

q. ASubjScd 44-16D10, Advanced Individual Training and Refresher Training of Hawk Missile Crewman, MOS 16D10 (revision). Final draft is in progress.

r. ASubjScd 44-16E10, Advanced Individual Training and Refresher Training of Hawk Missile Fire Control Crewman, MOS 16E10 (revision). Final draft is in progress.

s. ASubjScd 44-16F10, Advanced Individual Training and Refresher Training of Light Air Defense Artillery Crewman, MOS 16F10 (new), was printed in June 1969.

t. ASubjScd 44-16R10, Advanced Individual Training and Refresher Training of Vulcan/Chaparral Crewman, MOS 16R10 (revision). Final draft is in progress.

u. ATT 44-85, Air Defense Artillery Automatic Weapon Units (revision), was submitted to TAGO in June 1969.

DIRECTOR OF INSTRUCTION

SCHOOL PANEL WILL SPREAD AIR DEFENSE STORY

A panel of US Army Air Defense School officers has been formed to tell the story of air defense artillery to nationwide audiences in a guest speaker presentation.

The panel will present the program to Army service schools, military academies, and war colleges during the 1970 fiscal year. Other military groups will be addressed upon request to the School Director of Instruction.

The program consists of color slides, film clips, and narration covering the aircraft threat, current weapon systems, the worldwide deployment of air defense weaponry, tactics, trends, and new developments.

The program was prepared to update the military's knowledge of techniques and training in air defense weaponry.

Documentary film clips show the history of air defense from early World War I weapons to the present sophisticated missile systems. The presentation includes detailed briefings on the Nike Hercules and Hawk guided misile systems and also covers the new forward area weapons, including Chaparral, Vulcan, and Redeye.

Film clips of Sprint and Spartan missile firings show the subsystems of the Safeguard system which is being developed to counteract the ICBM threat. The SAM-D system is shown in its drawing board stage as a future replacement for Nike Hercules and Hawk systems and as a complement to the Safeguard system.

The presentation concludes that air defense is required to provide the field Army commander a "protective umbrella" against an air attack so that he can safely maneuver his forces on the battlefield.

NONRESIDENT INSTRUCTION DEPARTMENT

GROUP CORRESPONDENCE COURSE STUDY VALUABLE TRAINING TOOL

Current regulations provide for group correspondence course study which can be a valuable aid to commanders in achieving their training mission. Group study under the correspondence program may be undertaken by two or more individuals when properly enrolled. The objectives of group study are:

> To provide an opportunity for two or more individuals with common educational or occupational interests and needs to study together and participate in joint discussions and critiques for their mutual benefit.
>
> To provide commanders at all echelons with an additional instructional medium which may be tailored to meet requirements for training individuals.

Members of the Active Army and Reserve components and eligible civilian employees of the Federal Government may participate in group study. DA Form 145, Army Correspondence Course Enrollment Application, will be approved for group study by the commander or military supervisor.

Group study will be conducted under a group study leader who will establish seminars and appoint study seminar leaders. The local commander or military supervisor will select or approve the group leader, who may be an enrolled student.

Each student will complete all lesson exercises without assistance and will certify that the solutions are his own and were made on an individual basis.

For active duty personnel, seminars may be conducted in installation Army education centers where students can be assisted by education center staff members and can use classrooms, study halls, and MOS library facilities. Enlisted members of the Active Army may earn up to 30 promotion points for completion of 30 credit hours of correspondence subcourses.

Active members of the Reserve components may earn retirement points, credited by the US Army Air Defense School, upon successful completion of each subcourse. Group study will not be conducted during, or as a substitute for, unit training assemblies. US Army Reserve centers and Army National Guard armories will be used for Reserve components when feasible.

Army regulations provide that commanders, to accomplish their missions, may train individuals by enrolling their personnel in US Army correspondence courses. Regulations also provide that group study may be conducted on duty time under certain conditions. The use of group study can give the commander an effective presentation of material pertinent to the unit's training mission.

Responsibilities of the commander, service school, and group leader are explained in detail in DA Pamphlet 350-60, section VI. Additional information is given in paragraphs 3j, k, and l, AR 350-60.

Commanding officers and military supervisors interested in establishing a group study program may obtain detailed information by writing to:

Commandant
US Army Air Defense School
ATTN: Nonresident Instruction Department
Box 5330
Fort Bliss, Texas 79916

USAADS Pamphlet 350-8, Correspondence Courses Catalog, 1 July 1969, has been published and distributed. If you want copies of this catalog, write to:

Commandant
US Army Air Defense School
ATTN: Nonresident Instruction Department
Box 5330
Fort Bliss, Texas 79916

Notes From
US Army Air Defense Center and Fort Bliss

THE FORT BLISS ARMY EDUCATION CENTER OFFERS–

College Program

Preparatory Education

Vocational Training

Military Subjects

Project Transition

Off-Duty Group Study Classes

Reading Development

Counseling Services

Testing Center

Correspondence Courses

Accreditation Assistance

Education advisers are available for individual assistance at education centers.

The Army Education Program

Military personnel have a world of opportunity to pursue their own educational interests while in the service. Many have achieved goals that have opened the way for promotions, new vocational opportunities, and new interests. It is a voluntary program, and it challenges the man who wants a future.

Counseling and Testing Services

The beginning of any sound educational plan is a counseling session with an Education Center counselor. No appointment is necessary; counselors are available during normal duty hours and during certain evening hours.

Over-the-counter service is available for high school level GED tests, general examinations of the College-Level Examination Program, and most of the USAFI end-of-course and subject examinations. Special order testing service is also available.

The high school GED tests offer a way for military personnel to obtain a high school Certificate of Equivalency or, in some cases, a diploma. Successful completion of this test is equivalent to graduation from high school for all Army purposes, including promotion and service school entry.

Some colleges and universities accept the college-level tests for credit; a total of 30 semester hours are possible.

College Program

The University of Texas at El Paso conducts a trimester program of undergraduate degree credit courses on post. Current schedules and registration information are available at the Education Center. Tuition assistance is available to qualified applicants.

Evening courses are offered on campus, including upper division and graduate level courses. Free bus transportation is normally provided from the Center Motor Pool to the campus for students attending these courses.

Group Study Classes

A new term of evening classes is offered each calendar quarter, consisting of some 18 or 20 high school, technical, and college courses. There is no tuition cost, and textbooks are loaned for most of these courses. Some courses are provided on film.

Correspondence Courses

An extensive list of high school, technical/vocational, and college correspondence courses is available from the United States Armed Forces Institute. The initial enrollment fee is $5; successful completion within 12 months entitles the student to reenroll without charge. Most civilian schools accept these courses for credit.

It is also possible to enroll in correspondence courses with a large number of cooperating colleges and universities at a greatly reduced cost. This makes it possible for many military students to work with the school they attended before they entered the service or the school they plan to attend when they leave the service.

Preparatory Education

On-duty instruction is provided for enlisted personnel below the high school level. Students attend on a voluntary basis with the approval of their commanders.

MOS Library/Instruction

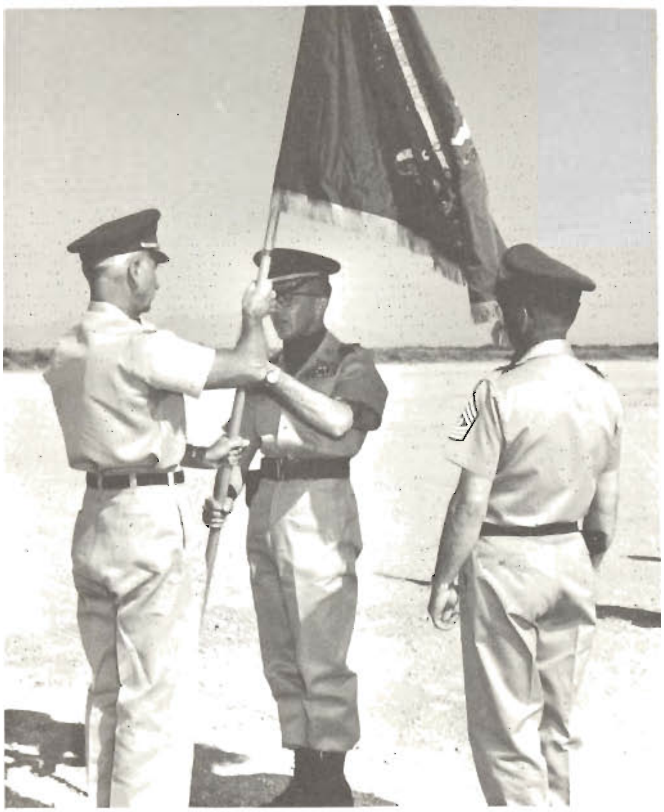
Special assistance is available to the enlisted man who desires to improve his MOS knowledge and proficiency, including a comprehensive MOS library with study aids and advisory assistance. On-duty instruction in selected military subjects is offered on a continuing basis to meet commanders' needs for skills training in their respective units.

Project Transition

Counseling, testing, and training are available to enlisted men who are within 6 months or less of their date of separation from the service. Private industry and other Government agencies provide much of the instructional and on-the-job training, and every effort is made to prepare each man for immediate employment following his separation.

1ST OF 59TH REACTIVATED

A unit that weathered the savage struggle for the fortress of Corregidor early in World War II was reactivated recently as the 1st Battalion, 59th Artillery, in ceremonies at McGregor Range, New Mexico. Colonel Landon A. Witt, US Army Air Defense Center and Fort Bliss Deputy Commander, presented the colors to Lieutenant Colonel Walter G. Kersey, commanding officer of the 1st Battalion, 59th Artillery. Colonel Witt commanded the Battalion when it was activated in 1948 as the 59th Antiaircraft Artillery Battalion at Fort Bliss as an automatic weapons battalion.



Colonel Landon A. Witt (left) presents unit colors to Lieutenant Colonel Walter G. Kersey.

First organized as the 59th Coast Artillery Regiment, it was part of the coastal defense of New York City. The Regiment joined the American Expeditionary Force in France during World War I.

Returning from France and duty in the Rhineland, the Regiment continued on active status until it was reorganized and redesignated 30 June 1924 as the 59th Coast Artillery. Following World War II, the 59th was inactivated in 1946 and then designated the following year as the 59th Antiaircraft Artillery Battalion (Automatic Weapons) (Self-Propelled).

In 1948, it was again activated at Fort Bliss and 5 years later was reorganized and redesignated as the 59th Antiaircraft Artillery Battalion (Automatic Weapons) (Self-Propelled). The following year the unit became the 59th Artillery, a parent regiment under the combat arms regimental system.

The 59th will be equipped with the Chaparral/Vulcan systems, and its mission will be low-altitude air defense.

AIR DEFENSE UNIT WILL LEAVE FORT BLISS

The Army's first tactical Chaparral/Vulcan battalion—the 6th Battalion, 67th Artillery—has moved to Fort Riley, Kansas, to join the 24th Infantry Division.

Commanded by Lieutenant Colonel Jack A. Merrigan, the unit will provide low-level air defense support to the Fort Riley-based division. The Battalion was reactivated in ceremonies at Fort Bliss last October and has undergone 8 months of training at the US Army Air Defense Center and Fort Bliss and McGregor Guided Missile Range.

Major General Richard T. Cassidy, US Army Air Defense Center and Fort Bliss Commander, presented the Battalion's reactivation colors last fall, an event which marked the 50th anniversary of the founding of the original unit as the 67th Coast Artillery Regiment.

This Vulcan air defense guncrew has now deployed from Fort Bliss to Fort Riley, Kansas, where it has joined the 24th Infantry Division.

SSAN IS IN

Effective 1 July 1969, active duty personnel must use their social security account number (SSAN) as well as their Army service number (ASN) on all correspondence. In notifying publishers, correspondents, and postal directory activities, obtain DD Form 1175, Change of Address and Directory Record, which is available at all Army postal activities and unit mailrooms. The SSAN will be entered in the "service number" block and the service number in the "remarks" column.

The SSAN changeover is service-wide. It not only will affect correspondence, but will be used on new ID cards, outpatient and clinical records at uniformed services facilities, and many other areas where the service number had previously been used.

Notes From US Army Air Defense Command

ARADCOM AVIATION MOBILIZATION TABLES OF ORGANIZATION AND EQUIPMENT

An action recently staffed at DA is the standardization of the aviation elements of air defense brigades and groups. This recommendation was initiated by HQ, ARADCOM, to establish a firm requirement and authorization for modern aircraft to satisfy the logistical and personnel transportation needs of the defenses.

A study known as the "Aviation Requirements for the Combat Structure of the Army (ARCSA I)" was started in 1964 and completed in 1965, with the objective of defining specific aircraft requirements by type and number for the US Army. Upon approval, it was used to develop new TOE's and to justify aircraft purchases. The ARCSA I recommendations did not provide sufficient numbers or types of helicopters needed to accomplish the aviation missions with the brigade and group defenses. Upon receipt of ARADCOM objections, DA initiated a second study in 1967. The results of this new study again did not fully satisfy our requirements.

A command letter to DA at that time generated a request to develop MTOE's for DA which would provide the minimum required aircraft. These MTOE's authorize one UH-1 and one LOH helicopter for each defense. In addition, at certain brigades, a twin-engine command aircraft is authorized when an area as well as a defense responsibility exists.

The ARADCOM proposals were approved as requirements in the new MTOE's. However, due to nonavailability of aircraft, authorization for issue has not been given. It is anticipated that, as the new aircraft become available, authority for replacement of older aircraft will be given.

AIR FORCE AND ARMY WAGE SILENT DUEL IN SKY

Unnoticed except by United States Army Air Defense Command radars, a jet bomber whistles through heavy cloud cover far above one of America's largest cities.

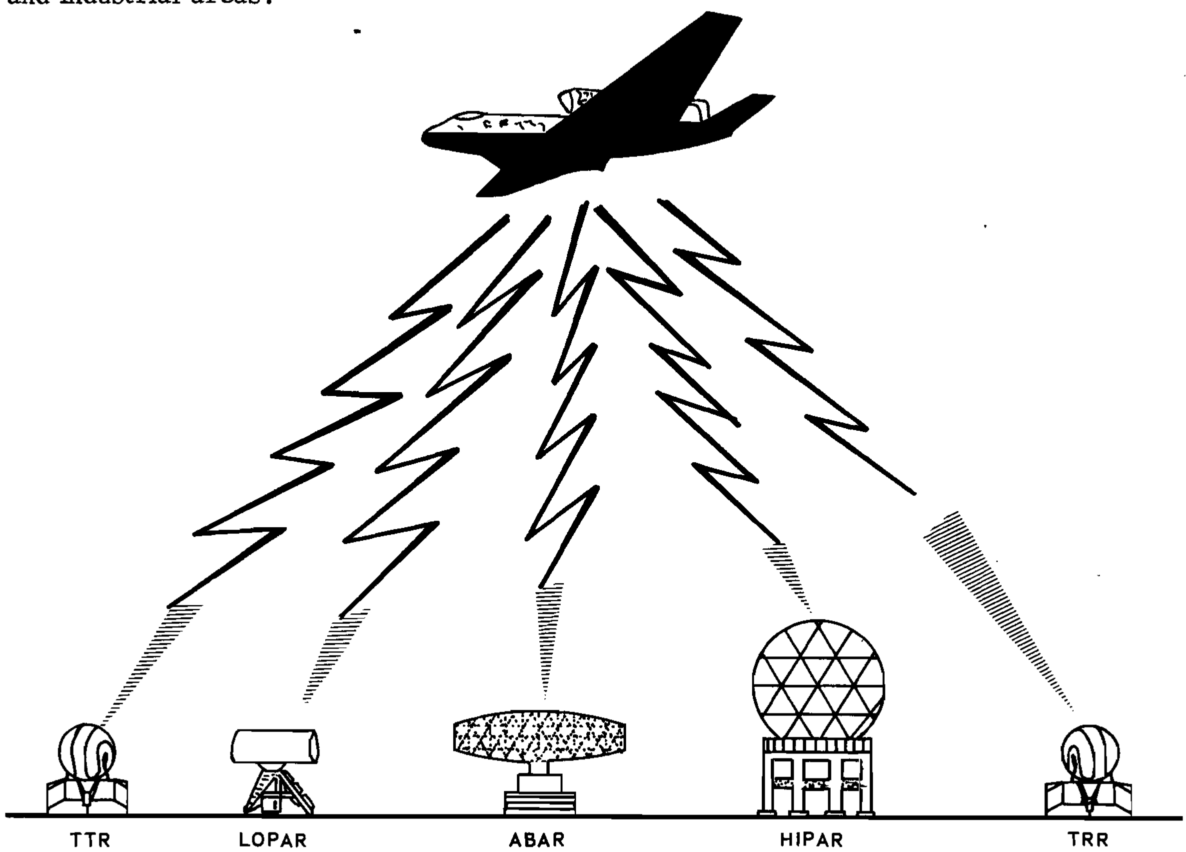
The swift aircraft is neither seen nor heard by the millions of people below. They don't know it is there and probably wouldn't even glance up if they did.

Reaction would be drastically different, however, if the friendly EB-57 was an enemy aircraft and the city below was its target.

Expressly for this reason, US Air Force jets and ARADCOM missilemen wage a silent duel—each calling on the utmost in guile, technical skill, and ability.

From Holloman Air Force Base, New Mexico, special ECM (electronic countermeasure) equipped EB-57's fly to designated ARADCOM defense locations throughout the United States to test the ability of ARADCOM units to defeat complex radar jamming typical of the electronic subterfuge enemy aircrews would throw at them during an actual attack.

Such exercises go under the rather inappropriate nickname of "College Dropout." Their purpose, however, is not only appropriate but essential to the air defense of major US cities and industrial areas.



College Dropout.

On a typical College Dropout mission, the commander of an ARADCOM defense in the San Francisco area, for instance, is assigned control of one of the special-equipped EB-57's for a 5-day period. Each aircraft can be used up to 6 hours in 24.

The pilot and his electronic warfare officer, in coordination with defense personnel, plan varied attack routes and ECM programs.

Packed with the very latest ECM equipment, the EB-57's subject every radar in the ARADCOM arsenal to the severest test of counteracting effects, permitting engagement and simulating a successful "kill."

And not only can the electronic warfare officer, sitting in the aircraft's back seat, toss out every electronic curve in the book, the EB-57 pilot can, at speeds in excess of 400 miles per hour, throw in a wide variety of evasive maneuvers very similar to what would be expected from an actual attacker.

Moments to React

It all adds up to pressure time for ARADCOM radar crews. Using built-in antijamming features, crews must acquire their target and track and launch a simulated missile attack, all in a matter of seconds.

Now just what is ECM, and what problems does it present to a radar operator? Aircraft are shown on the operator's radar scope as target video. The enemy realizes this because his radars work the same way.

To cloud up or smear this target video, the enemy uses his electronic countermeasures, knowing that if we can't "see" him, we can't shoot him down or any of the friends he might have in the air with him.

ECM is used to confuse both the radar and its operator.

Training Essential

There is at present no magic black box that can burn through or clear off such clouding or smearing. So, the basic theme of programs such as College Dropout is to train an operator to recognize such artificially induced clutter and, by using his electronic "fixes," be able to see through it with sufficient quality to allow completion of the engagement process.

Underlying importance of such training is the recognized fact that if any aerial or ICBM attack is ever launched against the United States, it will come in an environment of extreme ECM activity.

In addition to College Dropout, Army missilemen gain additional valuable practice during North American Air Defense Command exercises.

When exercises are scheduled, routes of aircraft taking part in the operation are planned so they traverse multiple ARADCOM defense locations, thus providing additional drill against ECM.

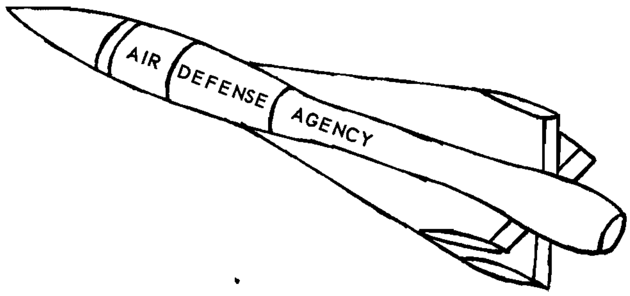
Attack at Intervals

The "beauty" of this exercise is that five to seven aircraft are attacking at different time intervals, providing a real test of the ARADCOM firing batteries' ability to acquire, track, and destroy, then rapidly switch to another aircraft. All this is done in the face of intense jamming.

As for College Dropout, ARADCOM units are enthusiastic about the training benefits derived by both experienced and novice radar operators.

Many commanders in the field feel that the realistic aspect of this ECM training vehicle has done more to make operators aware of what they can expect in actual aerospace battle than any other training device or program in use today.

Notes From the US Army Combat Developments Command



FIELD MANUALS

A new FM 44-1, U.S. Army Air Defense Artillery Employment, is on the way through channels to the printers. Major changes, compared to the July 1967 issue, include expanded doctrine on division air defense operations; coordination of air defense operations, communications, and nuclear weapons employment; and new doctrine on ADA tactical missions (p 38, Air Defense Trends, January 1969), the airspace control element (p 42, Air Defense Trends, June 1969), principles of organization for combat, and Safeguard ballistic missile defense system operations. Also, a considerable amount of nondoctrinal material has been deleted—this material will be picked up in FM 44-1-1, U.S. Army Air Defense Artillery Operations, prepared by the US Army Air Defense School.

A final draft revision of (S) FM 44-1A, US Army Air Defense Artillery Employment (U), has been forwarded for approval and publication. The manual supplements both FM 44-1 and FM 44-1-1. The revised FM 44-1A contains updated system characteristics for Nike Hercules, Redeye, Chaparral, Vulcan, and forward area alerting radar (FAAR). Nuclear weapons employment coverage has been expanded to include material recently deleted from FM 101-31-1 and (S) FM 101-31-2. Upon publication, and by mutual agreement, the US Army Combat Developments Command Air Defense Agency will transfer proponency of this manual to the US Army Air Defense School.

ORGANIZATION

TOE 44-510G, Air Defense Artillery Service Organization, was recently printed at DA and distributed to the field. This new TOE, prepared by the Agency, contains as cellular teams all those pre-G series TOE sections that could not qualify for retention in G-series TOE as organic sections. Example teams include those required for operation and maintenance of defense acquisition radars and fire distribution systems, performance of nuclear warhead custodial duties, and liaison with the supported force and other services. For each of these teams (32 in all), TOE 44-510 provides a listing of authorized personnel and equipment and also provides statements of team capability, mobility, and basis of allocation.

Notes From the Human Resources Research Office

HumRRO—which has been a part of The George Washington University since first established in 1951—will soon separate from the University and become a private nonprofit corporation.

The separation was requested by Dr. Meredith P. Crawford, HumRRO Director, to give HumRRO the administrative and fiscal flexibility to pursue an expanded research and development program in the fields of education and training.

The George Washington University established HumRRO in 1951 to undertake research and scientific studies and evaluations for the Army. Until 1967, HumRRO worked exclusively for the Army; however, in that year the University-Army contract was modified to allow HumRRO to work for other sponsors—including other agencies of Government (Federal, State, and local) and nonprofit and private organizations.

This contractual change was sought by the University because it was believed that the expertise HumRRO had developed in its years of research on Army training and education problems could benefit other agencies and organizations concerned with the development and application of training and educational technology.

Further, many HumRRO scientists were eager to apply their skills to civilian as well as military problems. Finally, diversification of sponsorship was seen as a mechanism by which HumRRO could attain a modest growth rate—considered desirable by both HumRRO and University administrations.

Early HumRRO diversified sponsorship efforts have included a series of studies on the selection and training of postal maintenance employees for the US Post Office Department, a survey of present and future training requirements for tumor registry technicians for the Louisiana Regional Medical Program, a study of automotive maintenance procedures and practices for the Ford Motor Company, a study of rotary-wing aircraft-simulator training requirements for the US Coast Guard, and an intensive literature survey of leadership research for the Office of Naval Research.

The HumRRO commitment to build a diversified sponsorship of its research efforts was given impetus recently when Secretary of Defense Melvin Laird encouraged all Federal contract research centers—including HumRRO—to help other governmental departments and agencies with the solution of pressing societal problems.

However, as a largely self-contained but nondepartmental portion of The George Washington University Office for Sponsored Research, HumRRO has not had the administrative or fiscal flexibility to pursue diversified sponsorship efficiently and effectively. It is to attain this flexibility that HumRRO will now separate itself from the University.

HumRRO's relationship to the University has been under study for 3 years, and serious discussions between the University and HumRRO have been underway for more than a year.

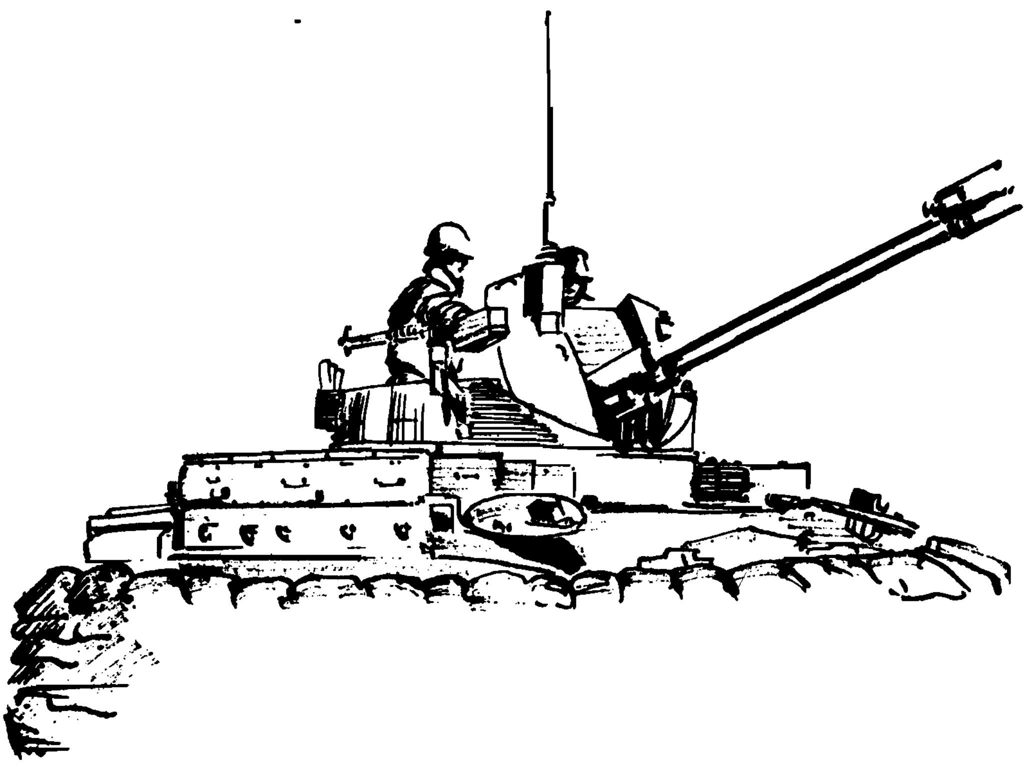
While there has been mutual agreement between the University and HumRRO on the intent to separate, the exact nature of the new HumRRO organization has not yet been fully determined. However, steps have already been taken to establish HumRRO as a private nonprofit corporation.

The new organization, Human Resources Research Organization, Inc. (HumRRO), will contine to work uninterruptedly for current sponsors, and the seven separate HumRRO Research Divisions (laboratories) will continue to occupy their present quarters. Research Division No. 5 is located at Fort Bliss.

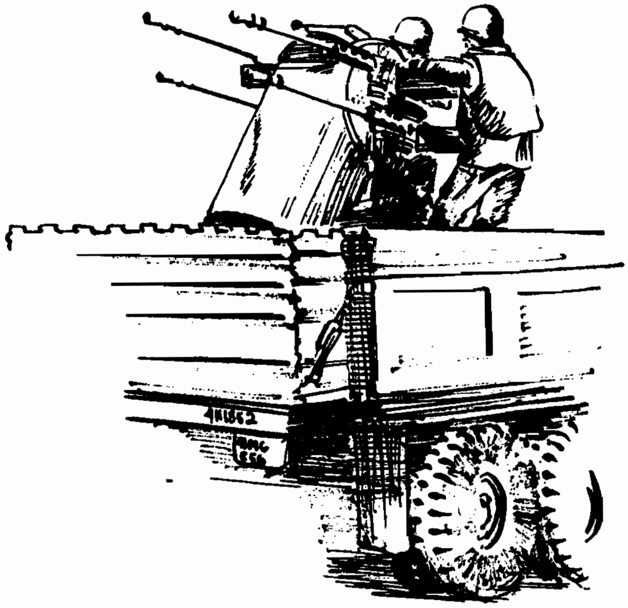
From the Field

Editor's Note:

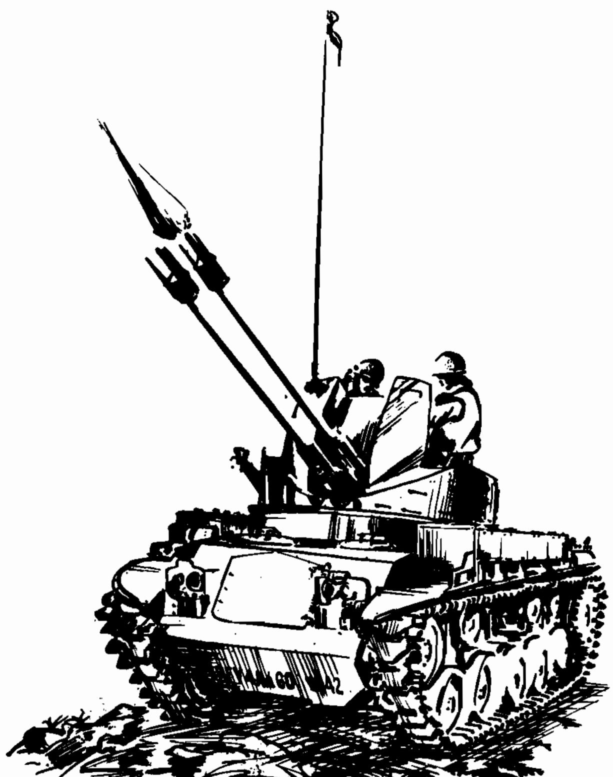
The next four drawings are an artist's concept of the air defense forward area weapons that are constantly turning the tide of battle in Vietnam, especially when our convoys are ambushed and on the verge of being overrun. These drawings are the work of freehand combat artist SP4 Reggie R. Macabasco who is draftsman for the 4th Battalion (AW) (SP), 60th Artillery, presently engaged in combat in Vietnam. SP4 Macabasco was born in the Philippine Islands and educated in the United States. He holds a 2-year degree in commercial art from City College in San Francisco. The drawings are published with the idea that they can be cut out and used as training aids or displays by interested units.



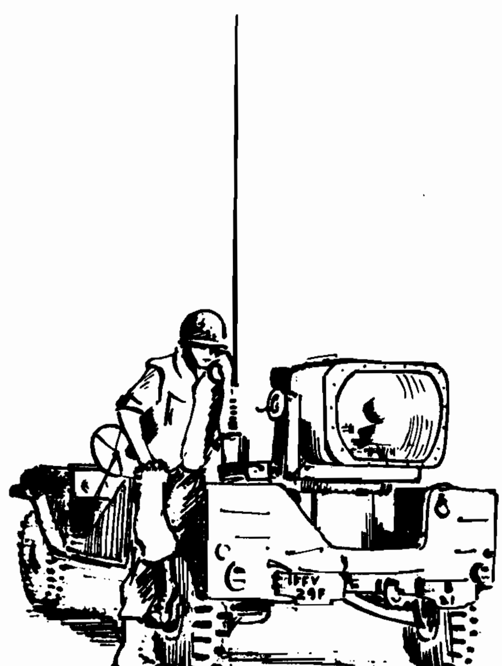
Twin 40-mm self-propelled gun M42 (Duster) in the defense.



Multiple cal .50 machinegun M55 (Quad 50).



M42 (Duster) in the offense.



23-inch Xenon searchlight (Big Flash).

Exercise Hawk/Wild Weasel

Lieutenant Colonel Gust H. Mastricola
Commanding Officer
8th Battalion (Hawk-MBL), 7th Artillery
Fort Bliss, Texas

Recently the 8th Battalion (Hawk/MBL), 7th Artillery, 6th Artillery Group (AD), Fort Bliss, Texas, participated in a joint exercise called Hawk/Wild Weasel. The exercise, lasting approximately 90 days, was conducted at Fort Huachuca, Arizona, and was designed to test the effectiveness of the Hawk missile system against the so-called "Wild Weasel" aircraft.

Wild Weasel is the Air Force code name for the fighter wing responsible for air defense site suppression. Wild Weasel aircraft are F-105's, carrying a two-man crew consisting of a pilot and an electronic warfare officer (EWO), and F-4C's which fly on the wingtips of the Wild Weasel aircraft.

All aircrews participating in the exercise were recent Vietnam returnees. The Wild Weasel pilots used the same type of tactics that have been so successful in Vietnam.

Although the parameters of the exercise were well established, sufficient latitude was provided to insure freedom of decision; i.e., site selection, overall defense, battery occupations, and displacement. This latitude provided an opportunity to innovate tactics and techniques probably not heretofore permitted. As a result, additional experience was gained other than that established for the exercise.

EXPERIENCE DISCLOSURES

Tactics of air defense systems tend to become extremely defensive. With today's low-flying, highly maneuverable aircraft and development of aircraft systems designed to suppress air defense positions, air defense tactics need to become more offensive.

Air defense sites, by nature of their equipment, present a prominent objective to a potential enemy in two distinct ways. Because of the size of a site area and the camouflage limitations on such electronic equipment as radar antennas, VHF antennas, and launchers, competent photo reconnaissance will usually reveal an air defense position. With the electronic monitoring capability of our forces as well as those of our potential adversaries, an air defense site can be pinpointed by its radar emissions. The Hawk system has the capability of minimizing both of these drawbacks, and this capability was explored during the exercise.

The high degree of mobility of the system and its ability to deploy assault fire units and augmented assault fire units can present a constantly changing defensive posture to an enemy. This requires a constant updating of Aggressor intelligence information and continuous modification of attack plans to maintain their validity and success probability.

The Hawk system radars are capable of changing frequencies. Electronic monitoring permits a "fix" of a certain frequency at a position on the ground. By coordinating frequency changes and coupling frequency changes with a mobile defense, we are able to continually confuse a potential enemy.

The current employment posture of surface-to-air missile systems is static. Our reactions are based on the threat or actions of others. Lack of threat, then, has a tendency to create a lull in our offensive thinking in the tactical employment of air defense. With the highly mobile air defense systems presently in the inventory, attention should be given to developing tactics and techniques to employ a more flexible and effective defense.

LESSONS LEARNED

Aircraft performance in a low-altitude environment indicated that units need not necessarily be deployed on the highest ground. Lower level employment takes advantage of the optimum low-altitude coverage of the continuous-wave acquisition radar (CWAR). High-performance aircraft have the capability of consistently flying under the coverage of the pulse acquisition radar (PAR). Had the units been deployed on higher terrain, the aircraft could have escaped detection by the CWAR.

Aircraft operating against an air defense system prefer to maintain terrain masking between themselves and their objectives to the fullest extent. Present tactics provide for establishing and employing a defense based on specific targets, altitude, and speed. These tactics need to be supplemented, placing a greater emphasis on combat kill of highly maneuverable, high-performance, extremely low-altitude aircraft.

Operator training must be greatly emphasized. Our Air Force, as well as the air forces of our potential enemies, has developed specific tactics and equipment to defeat the air defense systems. The exercise proved that operators who have undergone a training cycle which exposed them to aircraft tactics and equipment were capable of engaging more effectively. The training prepared the fire control crews to anticipate aircraft tactics, allowing the operator to accomplish manual tracking through "zero" doppler.

The natural hearing ability of the continuous-wave target detection console (CWTDC) operator is of paramount importance. Medical records should be closely scrutinized and a standard established and periodically evaluated to insure that CWTDC operators have the necessary hearing capability to perform the function of this position.

Several new engagement doctrines and firing techniques were employed during the exercise. Each maneuver by an aircraft dictates a separate engagement principle, such as the optimum time to fire against each aircraft tactic. Once again operator and crew training becomes extremely important. Because the fire control crews had the opportunity to train against "type" aircraft maneuvers, they were expected to engage each maneuver at the optimum target position and speed. There is a definite requirement to develop and incorporate these techniques throughout the Hawk system.

The exercise explored new engagement principles for the Hawk air defense system. Hawk can employ tactics designed to lure the enemy into the defensive and greatly confuse him once he is within the Hawk battle zone. Hawk also has a purely electronic capability to deceive Aggressor aircraft and gain precious seconds during engagements. These principles should be made available in the field as soon as possible.

The limited design features of the AN/GSS-1 electronic search central used in conjunction with the AN/TSQ-38 system were shown to be entirely inadequate in the exercise environment. Due to the radar scope sweep rate, moving target indicator (MTI) circuitry, and target presentations at ranges inside 80 kilometers, the command control from the battalion operations central and the AN/TSQ-38 automatic data link was severely impaired. For exercise purposes, a manual Army air defense command post was established, using a pulse acquisition radar (PAR) and battery control central (BCC) coupled with a frequency-modulated (FM) operational control net. The arrangement proved highly successful.

Coordination with the Air Force should be firmly established to insure that latest tactics being developed by that service may be monitored continually to enable development of techniques for tactical employment into air defense systems.

The nature of the exercise, together with its purpose and classification, precludes mention in this article of many of the lessons learned. Authorized individuals may obtain further information on Exercise Hawk/Wild Weasel by contacting Headquarters, 6th Artillery Group (AD), Fort Bliss, Texas 79916.

Hardpoint Demonstration Array Radar (HAPDAR)

Editor's Note:

Much of the material for this article was taken from Proceedings of the IEEE, Vol. 56, No. 11, November 1968.

INTRODUCTION

As the intercontinental ballistic missile threat becomes more complex, conventional radars become less effective in dealing with this high-speed, multiple-target environment. The limitations imposed on these systems by the inertia of their antenna drives and the response time of the human operator require an increased number of specialized sensors to search, track, and discriminate. In the search for new methods to overcome these problems, electronic (inertia-less) scanning under computer control came to the forefront as the only practical method of coping with the situation without having to resort to the deployment of many individual systems. However, a drawback of an electronic scanning radar (ESR) was the high cost associated with the construction and logistic support of an operational system. The Advanced Research Project Agency (ARPA), realizing the need for a cost breakthrough in this area, undertook the development of a radar of reasonable cost specifically designed to perform the desired mission. Since mid-1968, this effort has been sponsored by the US Army Advanced Ballistic Missile Defense Agency (ABMDA).

There are two primary antenna systems that can be employed in ESR. One uses a "hard-wired" transmission line feed system, known as a corporate feed, to a large number of identical elements in the array. The complexity of the distribution network required to provide the desired antenna beam shape, and the duplication of network components for each radiation element, causes corporate-feed systems to be very expensive. The second antenna system, known as a space-fed array, is illuminated with the transmitted energy via a feedhorn behind the lens and is thus much less expensive. By "thinning" the number of elements in the array, the cost of the lens can be further reduced.

The hard point demonstration array radar (HAPDAR) system was designed to demonstrate the feasibility of "thinned" lens, space-fed antenna systems. It is a computer-controlled, multifunction-array, L-band radar which electronically scans a pencil beam in a 90° conic sector. It employs a single transmitter with monopulse beam splitting in the antenna. The thinned aperture computed lens (TACOL) antenna uses three-bit, digitally controlled, diode phase shifters to accomplish beam steering. Although operation is fully automatic, a mode is included to permit operator intervention or control if desired.

A block diagram of the radar is shown in figure 1. The heart of the system is the UNIVAC model 1218, general-purpose, digital computer that controls all functions, determines priorities, and provides commands to each subsystem to insure fulfilling all the required tasks in the allotted time. It operates in real time; that is, no data or computation is backlogged from transmission to transmission. Its general-purpose nature (software control) allows a great degree of flexibility of operation. This flexibility feature is best appreciated by comparing HAPDAR to a conventional radar system. For example, to change a conventional system from a constant velocity servosystem to a constant acceleration servosystem, costly hardware modifications with prolonged radar downtime is required. This conversion operation is so simplified in the HAPDAR that only a program (software) change requiring approximately 20 seconds to read into the computer is needed. Additionally, since the servo loop consists almost entirely of software, the loops are not subject to the annoying and time-consuming maintenance caused by drift in the servoamplifiers of the conventional radar.

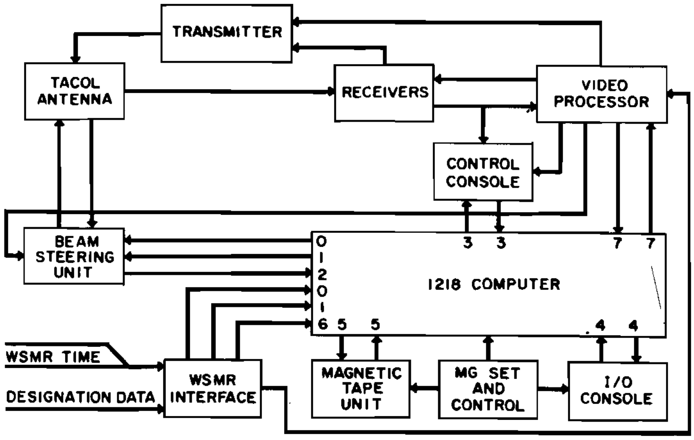


Figure 1. HAPDAR functional block diagram.

Upon designation from the White Sands Missile Range (WSMR) precision acquisition systems, handwheels on the control console, or its own internal search scanning table, the computer calculates commands for the phase shifters to steer the beam and range gate position. At this point in time the transmitter is triggered and a pulse of energy is sent in the commanded direction. If a target is present, a return is received at the antenna and processed into sum, azimuth, and elevation signals. Three identical receiver channels process the radiofrequency (RF) into video returns which are then converted to digital words and transferred to the computer for recording and processing to determine the position for the next transmission. Several such transmissions constitute the verification routine which confirms the presence of the target. When the target is confirmed, it is placed in a track channel and tracked. New targets may then be acquired until the five track channels are filled. The HAPDAR's inertia-less beam with instantaneous steering allows simultaneous tracking of up to five targets located anywhere in the radar's coverage volume.

Maintenance is simplified substantially by the addition of computer-controlled, self-check routines. Each phase shifter diode in the array is interrogated and failures are printed out all within the space of 3 to 4 minutes. It is then only necessary to replace (in about 12 seconds) the faulty phase shifter during radar downtime and repair it on the bench as time permits.

Pulse-to-pulse control loops perform the alinement of the receiver channel in gain and phase automatically, eliminating the constant adjusting of controls associated with conventional monopulse receivers.

Solid state construction (with a few exceptions) makes the system extremely reliable. Control of the system requires a single operator at the control console. A full operation and maintenance crew consists of no more than four people for a one-shift operation. The high reliability and small crew allows the HAPDAR to operate at a cost generally less than for a single-target conventional radar.

The HAPDAR equipment is housed in a modified Nike Zeus missile array radar receiver building at WSMR. The building was modified to accept the HAPDAR array by adding a

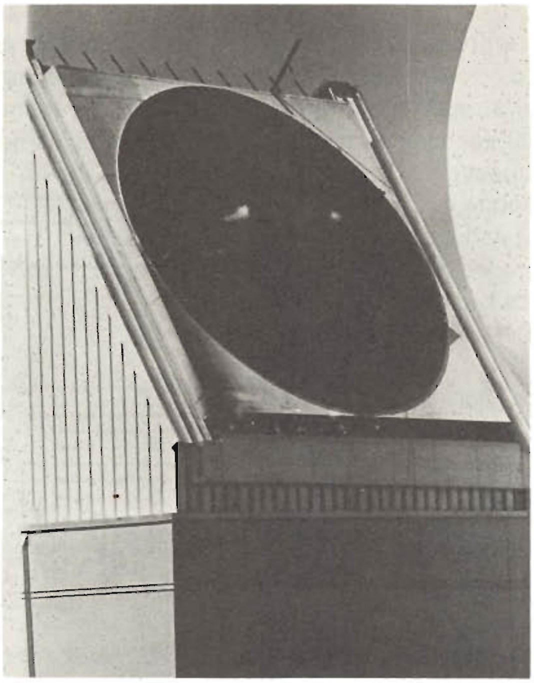


Figure 2. "Top Hat."

Figure 3. Sperry UNIVAC 1218 computer, 1240 dual tape transport, and UNIVAC 1004 line printer.

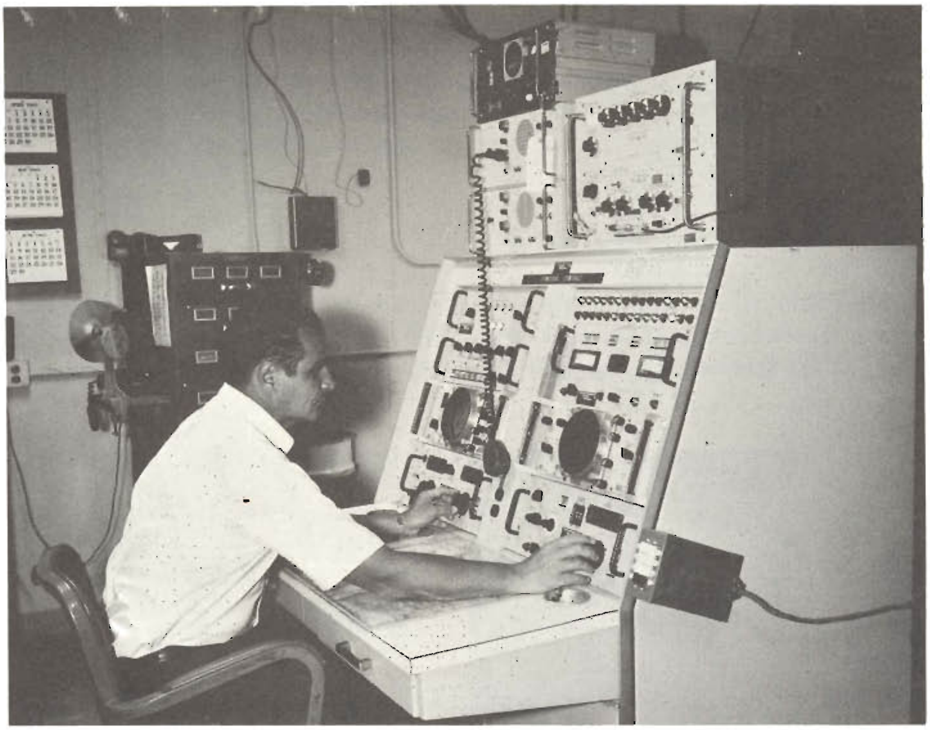


Figure 4. Operator at HAPDAR controls.

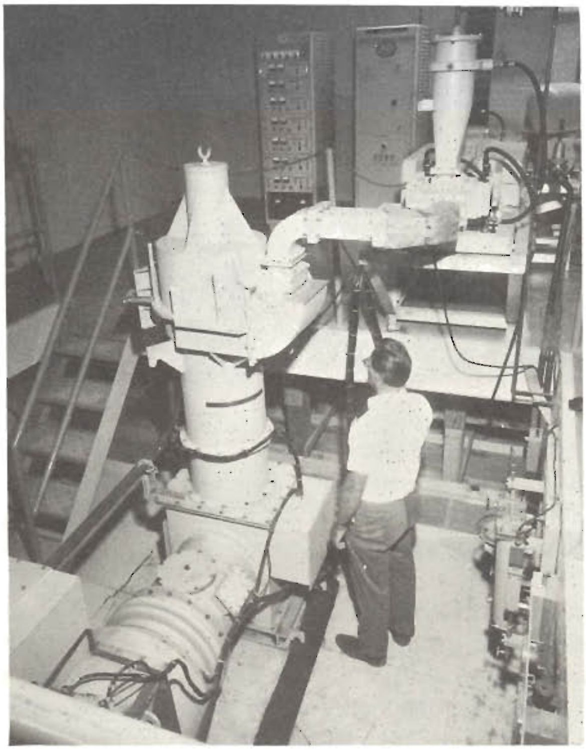


Figure 5. Transmitter klystron (foreground) and electronic equipment associated with transmitter controls and logic.

wedge-shaped "top hat" having a 30°, front-face inclination on one side of the building (fig 2). The top hat houses the array, feedhorn, monopulse comparator, duplexer, low-noise receiver front end, mixer preamplifier, and receiver local oscillator. The ground floor contains the remainder of the receiver beam-steering electronics, computer and peripheral equipment, and high-power transmitter (figs 3 to 5).

THINNED APERTURE

The HAPDAR thinned aperture computed lens (TACOL) array (figs 6 and 7) is based on a combination of novel array design concepts. The basic methods for scanning a beam electronically are phase, frequency, and real-time delays. TACOL is a phase-scanning technique.

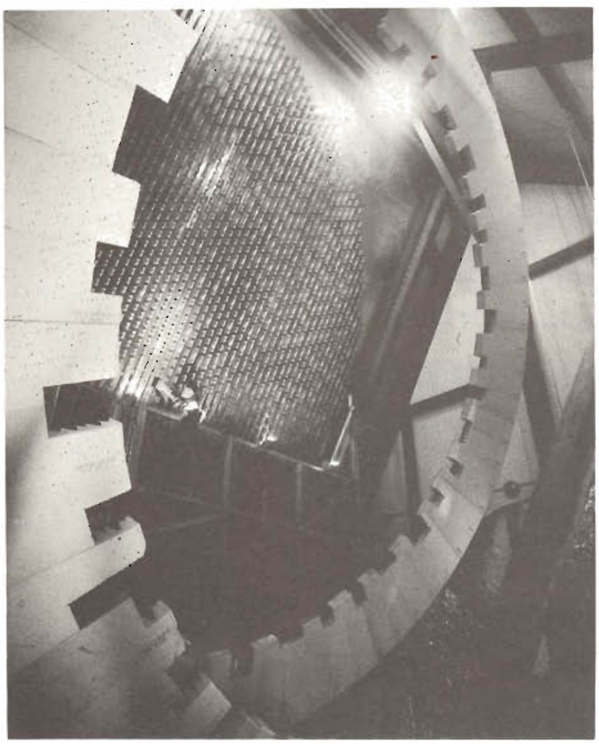


Figure 6. Collector side of lens with maintenance elevator in service position. Operator (center left) has removed a single element from the array.

Figure 7. Closeup showing a portion of the array with one element partially removed.

The input is a monopulse feedhorn with cosine illumination with a 9-decibel (db) edge taper. The energy is gathered in groups as it tapers off from the center of the lens to equalize power through each phase shifter and therefore obtain space distribution on the radiator side as shown in figure 8. The unused elements are terminated on the radiator side. High efficiency is obtained by fully filled collection. Only a few elements are terminated on the collector side, resulting in less than 0.2-db loss. The actual design employs

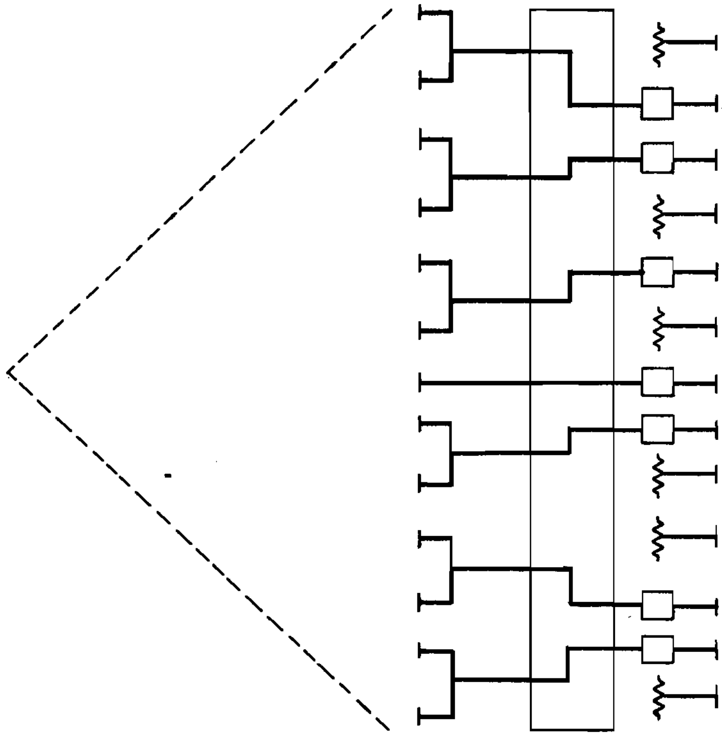


Figure 8. Thinned aperture.

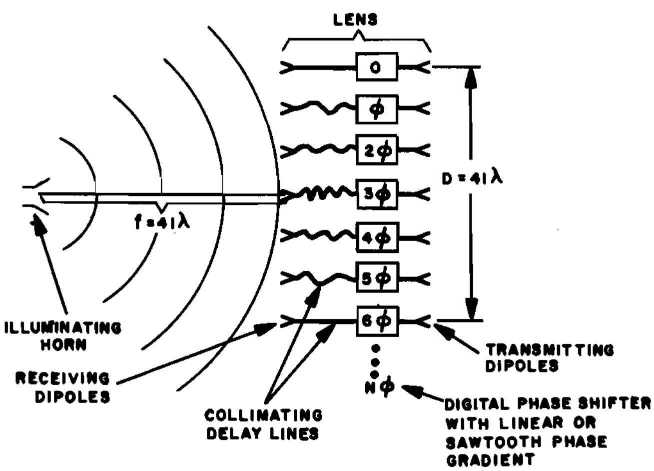


Figure 9. Delay line lens.

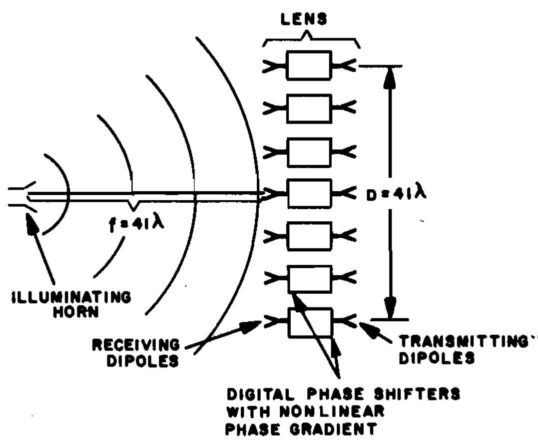


Figure 10. Computed lens.

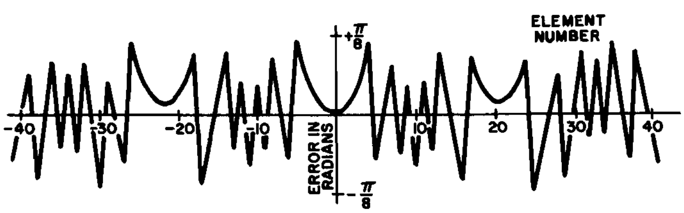


Figure 11. Computed lens error function.

only 1-to-1 and 2-to-1 collectors in the vertical plane. The exact location of 2-to-1 and 1-to-1 elements is randomly selected in a section to prevent symmetrical structures and therefore diffuse the side-lobe levels. A UNIVAC 1107 computer was used to calculate the probability of excitation of each randomly selected element based on the input and output patterns. A highly efficient pseudorandom number routine was used to (1) select location of active radiators by comparing the computer random number to the taper required at the selected point, (2) determine the use of 1-to-1 and 2-to-1 collectors, and (3) designate location of terminated collectors.

The overall element density on the radiator side conforms to the design amplitude taper, but local excitation is free of regularity to avoid rise of undesired side lobes. This is accomplished by superposition of perturbation due to thinning (randomization) on the equivalent amplitude taper.

Thinning has decreased the number of active elements in the HAPDAR-TACOL design by approximately 50 percent compared to a fully filled array.

Computed Lens

When the number of bits employed in a phase shifter is not equal to the number required to steer the wavefront perfectly, a structured periodic error function results which creates side-lobe levels. The maximum side-lobe level obtainable under these conditions is 6 db per bit; i.e., a three-bit phase shifter is limited to 18 db and a six-bit phase shifter is required to obtain from 30- to 36-db maximum side-lobe level performances. In a conventional lens design (fig 9), the spherical wavefront from the illumination horn is transformed to a planar wavefront by the use of discrete length RF delay lines. In a computed lens design, the phase shifters perform the dual function of electronic beam steering and collimation of the spherical wavefront to a planar wavefront as shown in figure 10. This technique randomizes the periodic error function of the quantized digital phase gradient (fig 11) and effectively smears the side-lobe level. The computed lens design eliminates the collimating RF delay lines and, more importantly, permits the realization of 30-db maximum side-lobe level performance with the use of only a three-bit (instead of five or six) phase shifter.

The TACOL design obtains the same beamwidth and side-lobe level performance as a conventional fully filled lens design at the substantial reduction of half the number of phase shifters and half the number of quantizing bits in the phase shifter.

EQUIPMENT

The HAPDAR-TACOL system employs a five-horn monopulse feed (fig 12) to provide independent sum and difference channel illumination tapers to obtain low side lobes in the antenna difference patterns as well as in the antenna sum pattern. The collector elements of the lens are printed dipoles (fig 13) connected to strip line three-bit digital phase shifters (fig 14) followed by a launcher element (fig 15) that feeds a radiating horn (fig 16). The complete assembled phase shifter module with a 2-to-1 collector is shown in figure 17. Three types of 2-to-1 collectors are used to provide the proper beam squint toward the feedhorn. The type used depends on the vertical location of the 2-to-1 elements in the array.

The array face (fig 18) is tilted 30° from the vertical. The main lens structure is constructed of modular truss sections with individual removable phase shifter modules for rapid servicing. The array contains approximately 4,000 elements, of which 2,165 are active (2,165 three-bit phase shifters). The collecting aperture contains 1,331 2-to-1 collectors, 834 1-to-1 collectors, and 485 terminated collectors. The elements are positioned on an equilateral triangle of 0.676 wavelength to provide 90° volumetric coverage without grating lobe formation at the highest operating frequency.

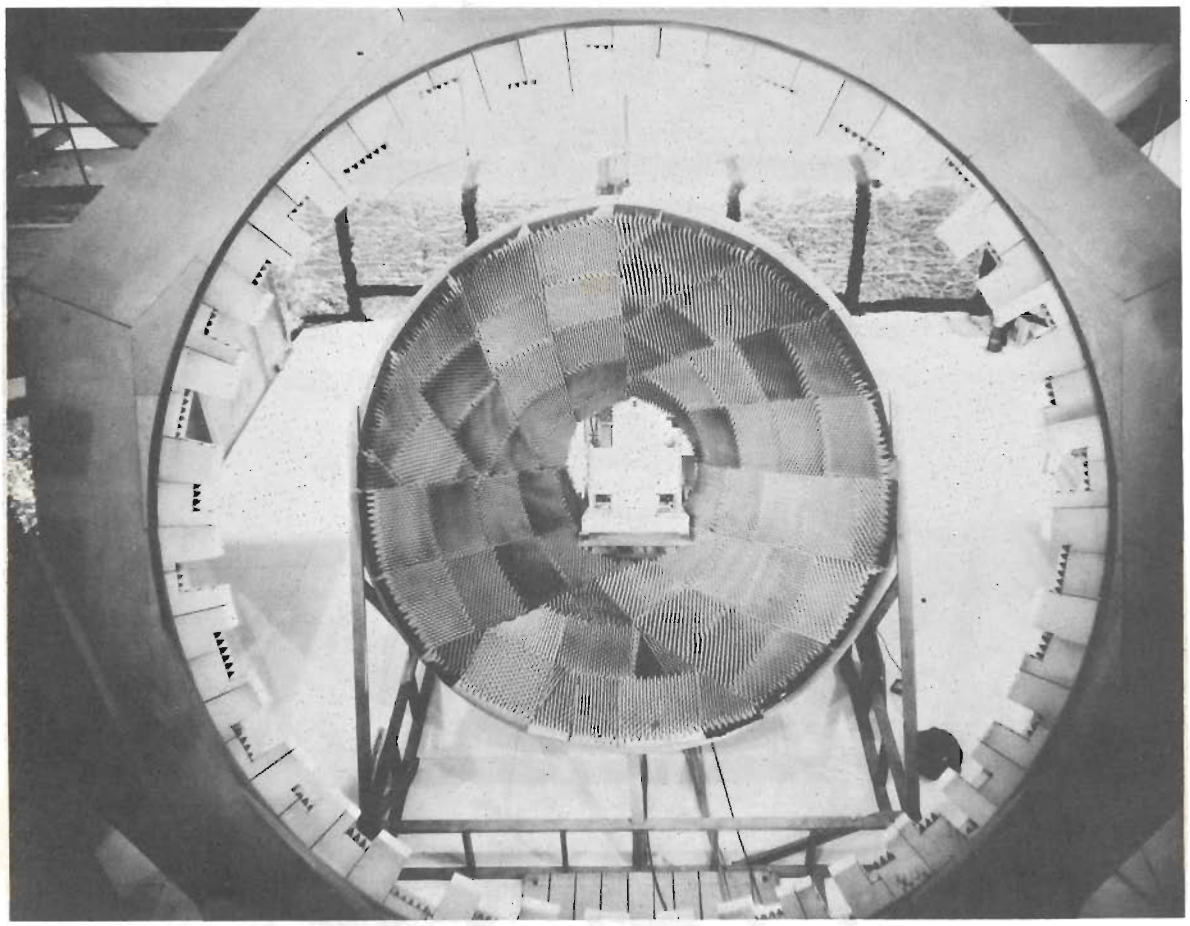


Figure 12. Line of sight view (on axis) from collector side of array to five-horn comparator feed assembly (center of picture). Note absorptive cone around comparator and irregular absorptive rings between comparator and lens.

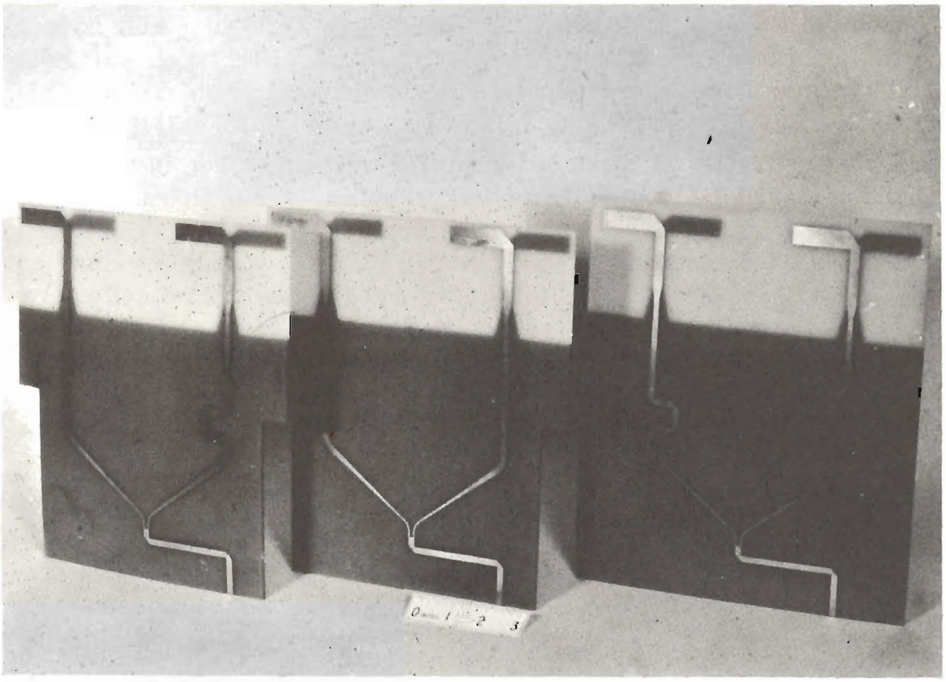


Figure 13. Printed dipole 2-to-1 collector elements.

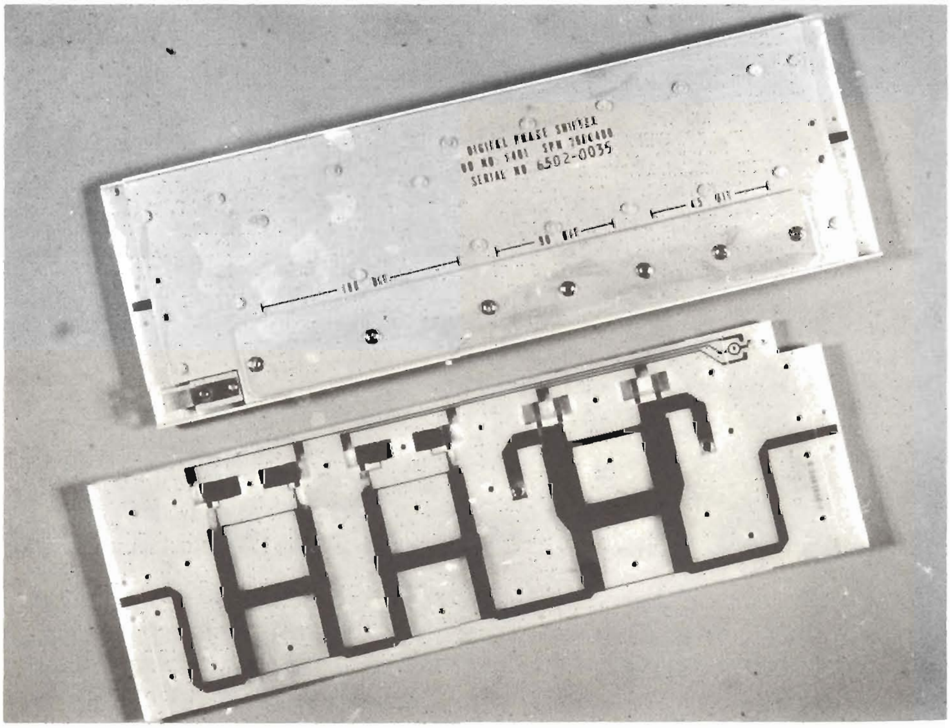


Figure 14. Three-bit diode phase shifter.

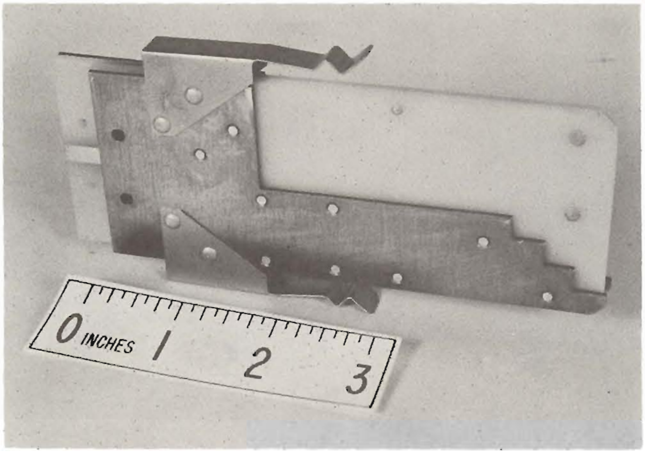


Figure 15. Launcher element.

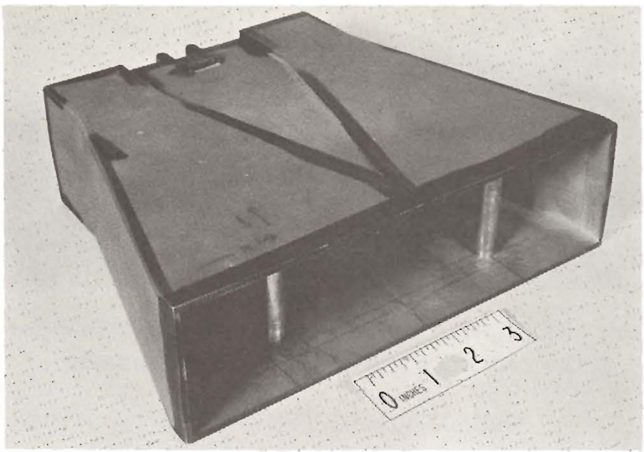


Figure 16. Radiating horn.

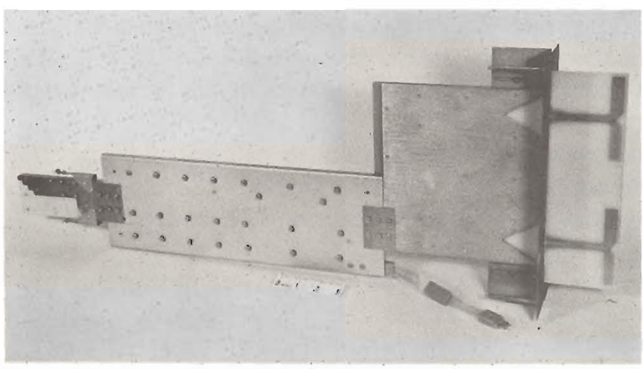


Figure 17. Phase shifter module.

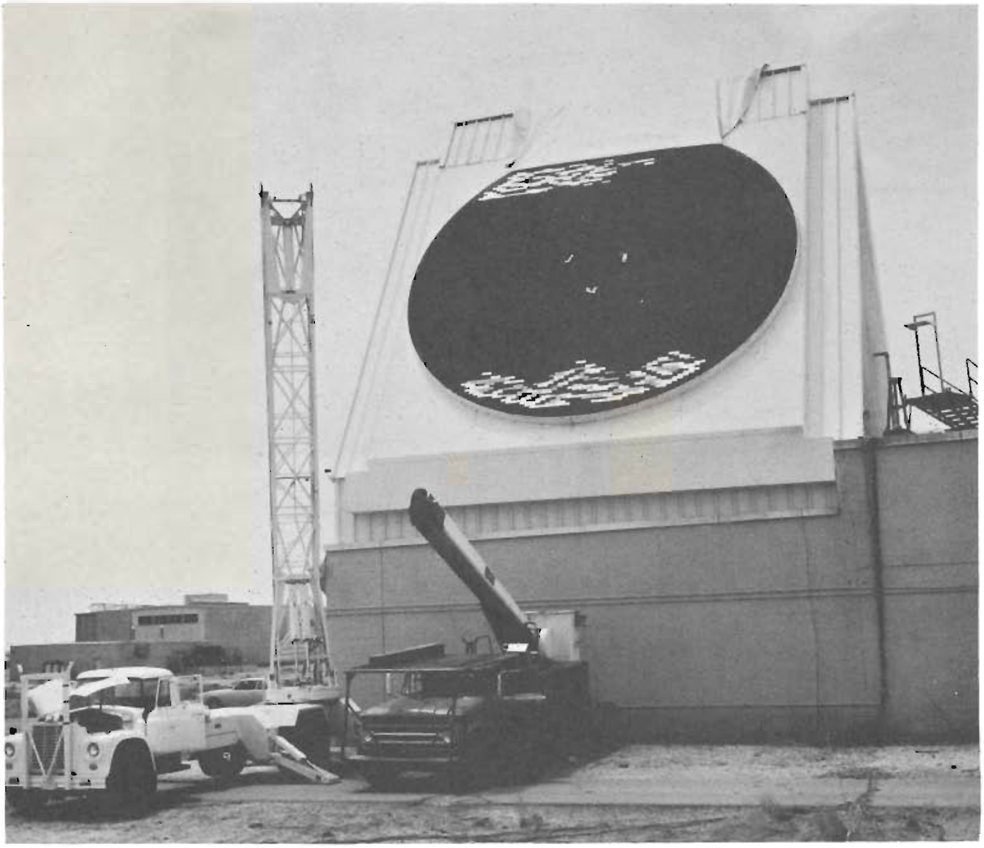


Figure 18. View of radiator side of array with a portion of the radiators shorted for experimentation.

OPERATIONAL TEST RESULTS

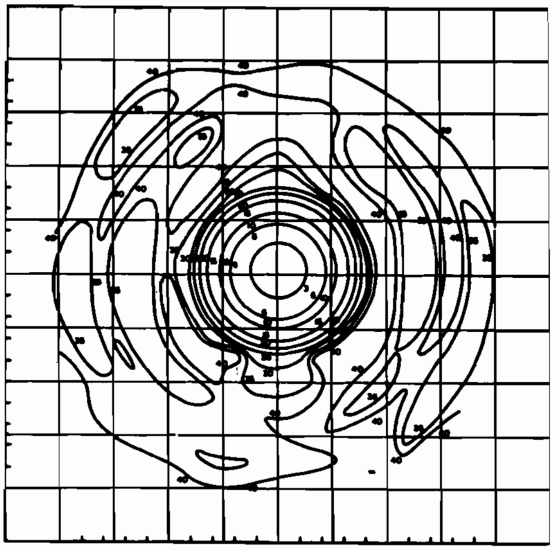
In the past 3 years, the various operational and technical features of the HAPDAR system have been tested and measured for conformance to technical specifications. Receiver sensitivities and noise levels are measured to insure proper operation of the tunnel-diode amplifiers. System noise figures of 5.5 db have been measured which are consistent with the 4.0-db noise figure of the preamplifiers, the calculated losses of the microwave plumbing, and the noise figures and gains of the early stages of the double-heterodyned receiver.

The beam-pointing stability of the system is monitored by periodically locking onto a test tower and reading out and recording in a logbook the "tracked" coordinates. Variations over the last year have been a negligible fraction of a beamwidth.

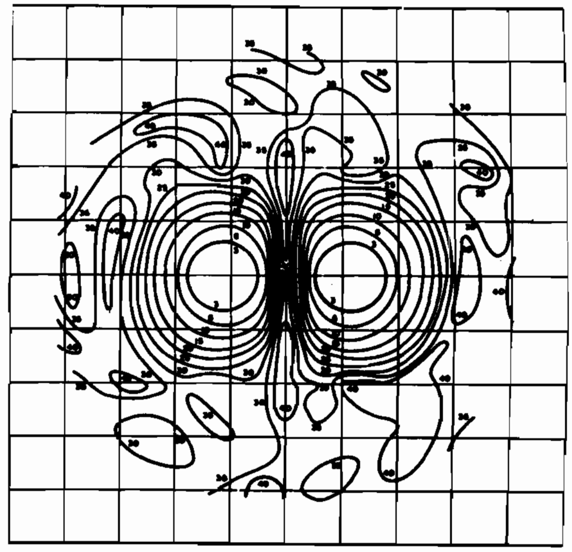
Routine tests performed through 1968 of the phase shifters in the array have indicated a mean time between failure of approximately 15,000 hours.

ARRAY PATTERNS

Transmit and receive antenna patterns have been taken using a test tower and compared against the calculated beam patterns shown in figure 19. A beam pattern is obtained by



(1) Sum pattern contour.



(2) Azimuth difference pattern contour.

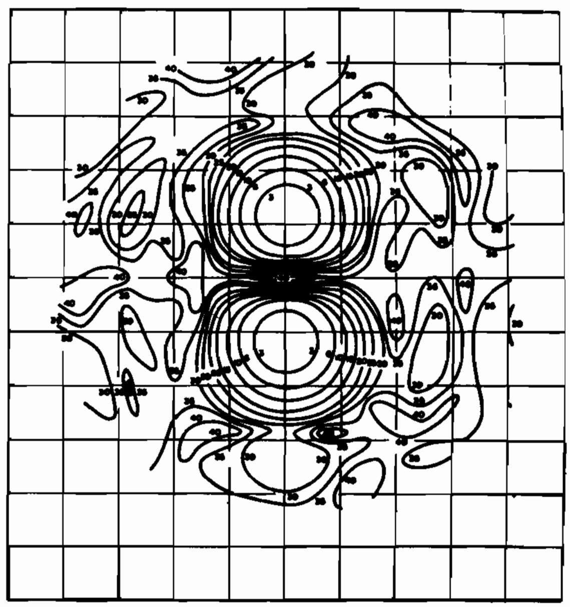


Figure 19. Contours.

moving a test probe in the far field of a fixed beam. An antenna pattern is obtained by scanning a series of beams past a fixed test probe. The antenna pattern actually consists of many segments of different beams. The beam pattern and antenna pattern are very similar in the main-lobe region of the beam. It is more convenient in phased-array radars (especially large ones) to make antenna pattern rather than beam pattern measurements.

TRACKING PERFORMANCE

Athena reentry vehicles, Sprint missiles, balloons, spheres, and numerous multitrack aircraft tracking missions have been completed successfully to date. Recorded comparison data have not been obtained on five targets tracked simultaneously because of the difficulty of obtaining five controlled targets and five monitoring tracking radars to use for comparison of results.

The three significant indicators of tracking performance are (1) the mean value as an indication of the radar coordinate bias error, (2) the standard deviation as an indication of the radar coordinate random error, and (3) the linear regression line as an indication of the target trajectory and radar tracking jitter.

The results obtained to date based on reduced data from several missions indicate that the weighted mean error and standard deviation in all three coordinates compare very favorably with the values obtained from conventional precision tracking radars and are well within design specifications.

On the Athena missile reentry missions that HAPDAR monitored, the standard deviation of the regression lines plotted is very small and of the same order of magnitude as the least significant bit of the analog-to-digital converters in all three coordinates.

The point-to-point (successive returns) angular jitter of the raw data has been reduced after system optimization to the smallest measurable deviation as determined by the least significant bit of angular data quantization.

All these results are well within design specifications.

HIGH-POWER ARRAY TESTS

In this series of tests the HAPDAR transmitter power was increased from zero to a level that applied approximately three times the rated peak power to some of the phase shifters in the array. At each power level a transmit array pattern was determined across the test tower, and the number of phase shifter failures was noted by comparing the failures before and after each test.

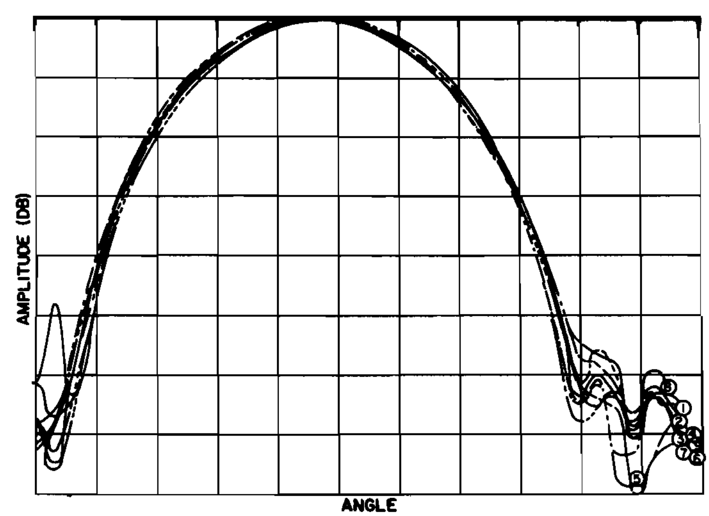


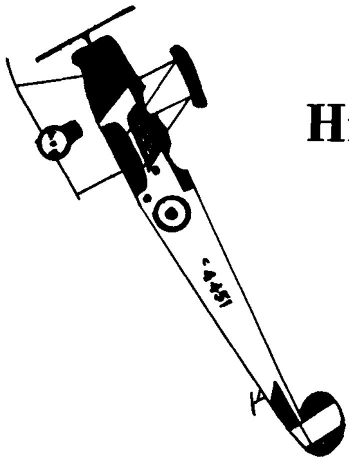
Figure 20. Composite transmit antenna pattern.

The superimposed patterns obtained at all the power levels are shown in figure 20. The power level was increased in increments of 10 percent of maximum power. The lowest power level is represented by curve 1, and the highest power level is represented by curve 9 in figure 20. The important results of this test are that (1) the transmit patterns are in good agreement with the receive patterns, (2) the beamwidth does not change nor shift with power level, (3) the side lobes increased slightly (as expected) with phase shifter failures at the higher power levels (only 1 percent of the phase failed when the power was raised to over three times the normal rating), and (4) the phase shifter failures occur randomly in the array.

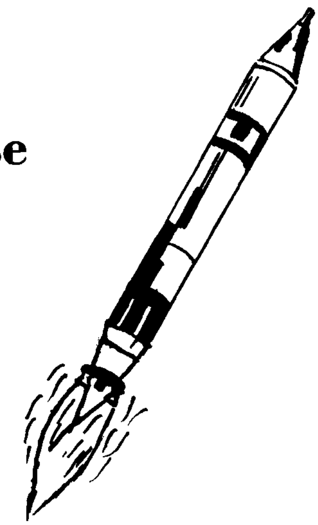
SUMMARY

All tests completed to date indicate that the HAPDAR system performance is equal to or better than design specifications and that it is built on sound array and electronic scanning radar system concepts. The HAPDAR-TACOL design concepts provide a firm basis for future radar design requiring high-performance, multifunction and multitarget track capabilities, and minimum complexity and cost.

During this fiscal year the HAPDAR system will be used as a test bed to further evaluate additional array design concepts and multitarget track performance. The system will be used to acquire performance data for answering various questions about the operational capabilities of phased-array antennas and radars. The most important tasks for HAPDAR in the coming months will be that of serving as the test vehicle for side-lobe canceler performance investigations.



History of Air Defense



Editor's Note:

This is the second of a series of articles portraying in word and picture a history of air defense as it involved the United States. The first installment described the advent of the military airplane and the threat it imposed as an attack aircraft and as a bomber. The defense measures that evolved as a result of the threat from the air were at first even more crude than the source of the threat.

ANTIAIRCRAFT

Prior to World War I no genuine antiaircraft defenses existed, but the genesis of AA artillery had occurred far earlier when on 29 August 1861, Professor T. E. S. Lowe made a balloon ascent to observe the Confederate forces massing against Washington and a rifled 6-pounder fired several rounds at the balloon, scoring no hits, but causing the balloon to be hauled down. During the Franco-Prussian War of 1870 balloons were used for observation and for movement in and out of besieged Paris. This led to the development of the Krupp balloon gun, a 75-mm gun which fired a 12-pound shell to an altitude of about 20,000 feet.

Soon after the start of hostilities in August 1914, both balloons and aircraft came into use. Since the major actions of this nature were confined to Europe and England, the major developments in antiaircraft occurred through the operations of the Germans, French, and British. Most of the early equipment used in World War I was of French design or adapted therefrom.

Progress by the French was due largely to the exclusive utilization of engineers and technical personnel in the new avocation. These personnel quickly acquired appreciation of the AA artillery gunnery problem, which lead to the analytical development of an AA artillery defense.

In August 1914 France was said to have had two mobile 77-mm guns. At the start of the war France had produced at least one 75-mm auto cannon mounted on a truck that was designed expressly to shoot at balloons.

After the first air raid in August 1914 by a lone German aircraft, the French development and manufacturing facilities exploded into action that took two directions: First, that of improvising with guns and mounts already available, and second, an intensive study of the mathematical solution to the antiaircraft gunnery and fire control problem coupled with the designing of needed equipment. In the early stages of World War I, almost all antiaircraft artillery defenses consisted of improvisations, using ground-type weapons.

During this period the French 75-mm fieldpiece was the mainstay of the antiaircraft defense, being mounted in various ways to provide some elevation and traverse for use in antiaircraft fire. Likewise, machineguns were mounted in various ways, such as on the rim of a wagon wheel with one end of the axle buried in the ground, thus giving all-round traverse and virtually unlimited vertical movement (fig 1). Heavy fenceposts were also used as machinegun pedestal mounts (fig 2).

Figure 1. Hotchkiss machinegun adapted to air defense.

Figure 2. Lewis machinegun on improvised mount.

About the middle of 1916, France produced two machines or computers which automatically solved the mathematical factors of the gunnery problem. One arrived at its solution electrically; the other, mechanically. The mechanical computer (called the R.A. corrector) took the lead, for at that time the production and operation of electrical circuit components were far from satisfactory.

The R.A. corrector (an improvement over the existing Brocq corrector (fig 3)) was the major developmental contribution of the French in World War I to the science of antiaircraft gunnery. This computer was adopted by the United States as the M1917 R.A. corrector and was used as late as 1930.

Figure 3. Tracking head of the Brocq corrector.

The French then developed a method of determining the altitude of aircraft. It consisted of two observing instruments (B' and B") placed at the end of a measured baseline. Each simultaneously tracked the target in angles of vertical elevation. Both observers continuously tracked the target, and at the command, "READ," the B" observer read the supplementary elevation angle over a telephone to the B' station. The B' station reader matched his pointer to the curve representing the supplementary angle from the B" station. The instrument then indicated the altitude of the target. The United States adopted this altimeter and designated it the M1917 altimeter. Later, with a minor improvement, this became the M1920 altimeter.

The R.A. corrector, used in conjunction with the M1917 or M1920 altimeter, was capable of producing reasonably exact deflection angles for application to the gunsights.

Due to the inadequacies of the 75-mm balloon gun, French engineers hurriedly developed a trailer-mounted 75-mm auto cannon (fig 4). This weapon was the peak of AA gun development during the war. It was a self-contained gun and data computing system with telescopes and abaci dials containing curves against which pointers were matched. This system contained a means of inserting wind effects and parallax corrections. The weapon required a large average number of rounds to bring down a plane. In 1916, the average was 11,000 rounds per kill; by 1917 this had decreased to 7,000. The trend continued downward as a result of better fire control methods.

Turning to the United Kingdom, for the defense of London, four 6-pounder Hotchkiss guns, six 1-pounder Pom-Pom's, and two 3-inch naval guns along with 12 acetylene searchlights were used. Manning crews initially were Royal Naval Volunteer Reserve antiaircraft corps personnel.

Figure 4. Mobile 1917 French 75-mm AA gun manned by Americans.

Figure 5. British AA gun in France, 1918.

Among these were a few mathematicians and engineers. These people played a predominant part in the development of antiaircraft gunnery in the United Kingdom.

The first method of fire control was to lay the gun ahead of the target and fire. The first antiaircraft engagement took place on Christmas Day, 1914, when a lone German airplane flew up the Thames estuary. He was engaged and, after prolonged evasive action, made his escape toward the sea. The old muzzle-loader method of gunpointing soon gave way to a system of deflection shooting, using sights.

As the war progressed, better guns were adapted to the antiaircraft role. Fire control methods and equipment improved, generally following French design.

The British 13-pounder AA 9-CWT gun (fig 5) became their antiaircraft defense mainstay, and by November 1918, 244 of these guns were in France. The first major development was a new gun, the 3-inch AA 20-CWT, in 1916. By war's end, 106 of these were in France and 268 were being used in the United Kingdom. Another larger AA gun, the OQF 3.6-inch, with a muzzle velocity of 2,200 feet per second (f/s), was under development. The number of antiaircraft units organized and operating rose from 25 to a total of 275 by the end of the war. Regular searchlight companies increased from 2 in 1915 to 17 in 1918. Night raids caused the development of the searchlight-fighter team. Searchlights were assisted by the M1 sound locator, and this operation gained some success.

At the start of World War I the United States had no antiaircraft artillery. Developments in Europe involving aerial observation, combat aircraft, and bombing tactics triggered the development of a weapon to provide antiaircraft protection to the major coast artillery emplacements of the United States and the defense of depots and other similarly vulnerable areas. This weapon was the fixed-mount 3-inch AA gun, model 1917. The design had been completed by the time the United States entered the War. By the time the war ended, about 100 of these units had been delivered. Eventually 159 units were produced.

Although we had a fixed antiaircraft weapon under development, it also became obvious, prior to our entry into the war, that a similar mobile antiaircraft weapon was needed. Time did not permit special design and development, so a fixed antiaircraft mount was improvised for field use. The French 75-mm model 1897 fieldpiece was available; therefore, a simple improvised mount built of structural steel was made for it. The design was completed by 1 May 1917, and 50 mounts were ordered. As fast as the orders were completed, they were shipped to France to be equipped with the French 75-mm field gun which had special Puteaux recuperators. The Puteaux Arsenal installed azimuth and elevation scales, and the French also furnished sights for these guns. To prepare the position and install the mount required about 2 weeks. By Armistice Day, 30 of these weapons were installed and manned in rear areas.

A mobile gun was still needed, and United States designers began improvising a mobile weapon. The gun was the United States 75-mm, model 1916, field gun. The gun was mounted over the rear axle of a $1\frac{1}{2}$-ton White truck. The low velocity and long time of flight of the projectile of this gun lessened its value. It did not see service in World War I, but was used for training following the war.

The 3-inch M1918 AA gun on the M1918 trailer mount (fig 6) was specially designed for mobile antiaircraft use. The gun was similar to the 3-inch M1917 AA gun, except that its muzzle velocity was lower by 200 feet per second. The recoil was variable between 40 inches at 10° elevation and 16 inches at 85° elevation. This long recoil at low elevations was needed to prevent overturning, and the short recoil was necessary at high elevations to limit the length of recoil. It used a bracket-type fuzesetter.

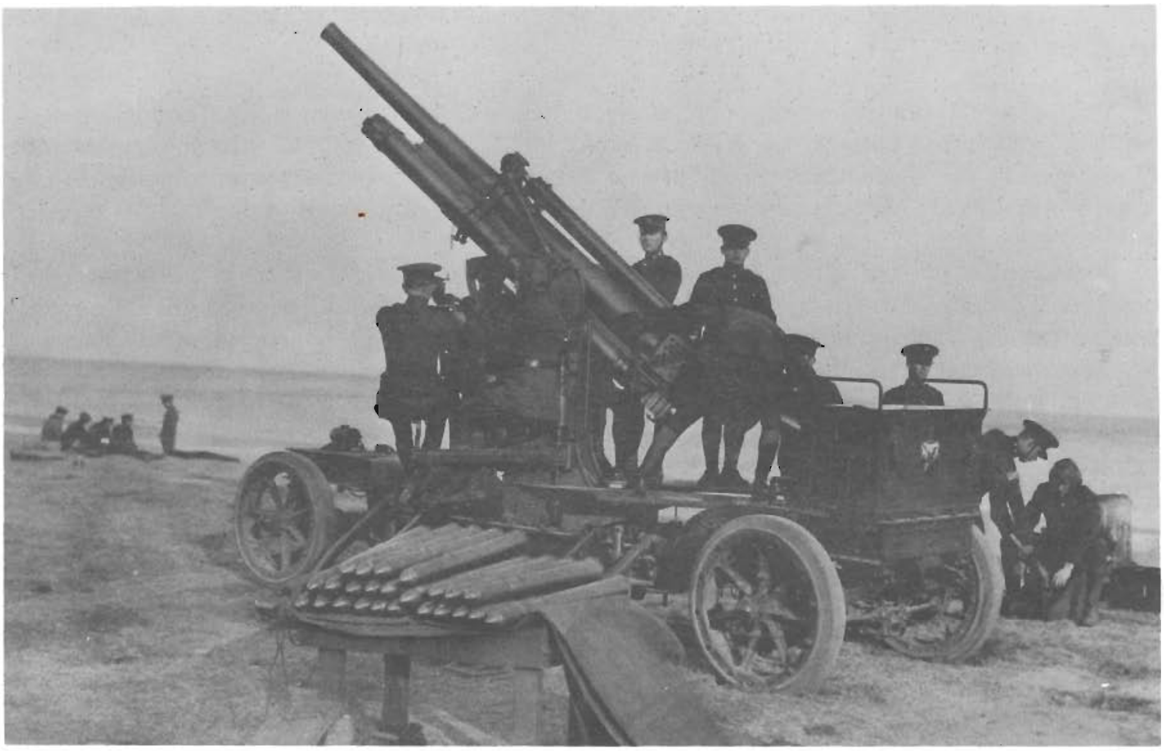


Figure 6. M1918 3-inch AA gun on trailer mount.

The model 1918 deflection sight was essentially a computing type of sight similar to the M1917 sight. The lateral deflection part was on the left side of the gun, connected by a shaft to the vertical deflection part on the right side. The sight was laid on the target, and when a lateral deflection was received from the R.A. corrector (or Brocq) and applied, the sight moved off the target. When the operator traversed the gun to bring the telescope crosshairs back on the target, the necessary lateral deflection angle was applied, and the gun barrel was moved to the proper set-forward point. In a like manner, the vertical deflection angle, including superelevation, was applied to the elevation side and the gun moved to the proper firing elevation.

As a result of demands from the field, research for a more effective antiaircraft weapon, mainly a larger gun, was initiated. General Pershing suggested a 4.7-inch gun. In January 1918, the military had settled on a 4.7-inch gun having a muzzle velocity of 2,400 f/s. It was designed to have an automatic loader because of the weight of a round.

One prototype was built and tested by November 1918. It had minor deficiencies which were being corrected at the time of the Armistice. After the war, the project was dropped. (Eventually this gun, with modification, including a large increase in muzzle velocity, was standardized in 1943 as the 120-mm gun.)

The accurate delivery of antiaircraft artillery fire posed severe problems. The field artillery was untrained to fire at moving targets. The coast artillery was trained to fire at slowly moving targets which could move only in two directions. Aircraft flew up to a speed of 100 knots, and this movement could take place in one direction or simultaneously in three dimensions.

The United States had no data computer or means of improvising such a computer so we used the French data computers, both the Brocq and R.A. correctors. The latter was actually adopted by the United States and became the M1917 R. A. corrector which was used in World War I and for some time afterward. Data transmission was by telephone.

Because the firing of all AA guns required visual laying, night aircraft operations required searchlights for target illumination. Again, improvisation was necessary, and the product was the Cadillac light—a 60-inch, open-type light using a parabolic mirror (fig 7). This became the first United States standard-type light. The chassis of a Cadillac car was extended, and the light was carried in a truck-type body covered by bows and canvas. A 20-kw dc generator mounted in the frame provided power for the light. The light itself was mounted on a two-bogie trailer with "Model T" wheels and was transported in the truck. It could be traversed 360° and elevated 180° and had a range of about 5,000 yards.

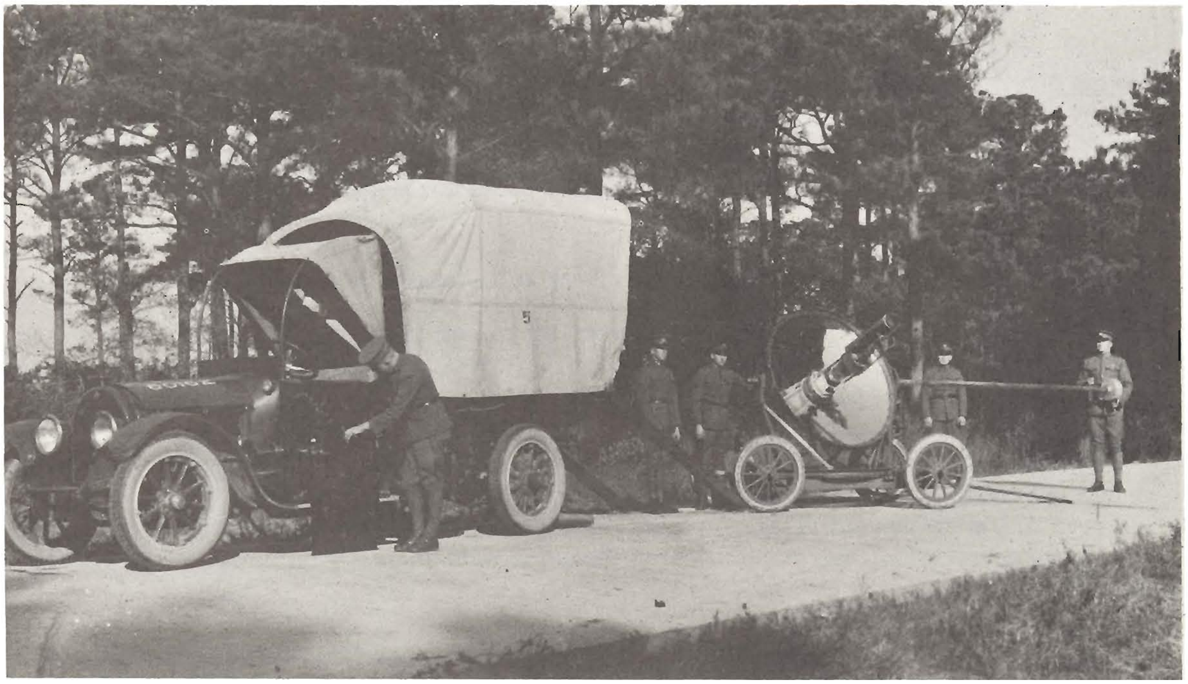


Figure 7. Cadillac 60-inch searchlight.

Locating a target by searchlight required knowledge of the plane's general location. The clue was the sound of the engine and propeller. The French developed the use of large acoustic horns to widen the binaural sensing baseline between the ears (fig 8). This sound horn facilitated aircraft pickup by searchlight. The United States used French sound-locating devices which generally consisted of three or four horns particularly placed so that one (or two) operated in the vertical plane and two in the horizontal plane. Stethoscopes placed at the apex of these horns had the effect of widening the binaural sensing ability of the operator.

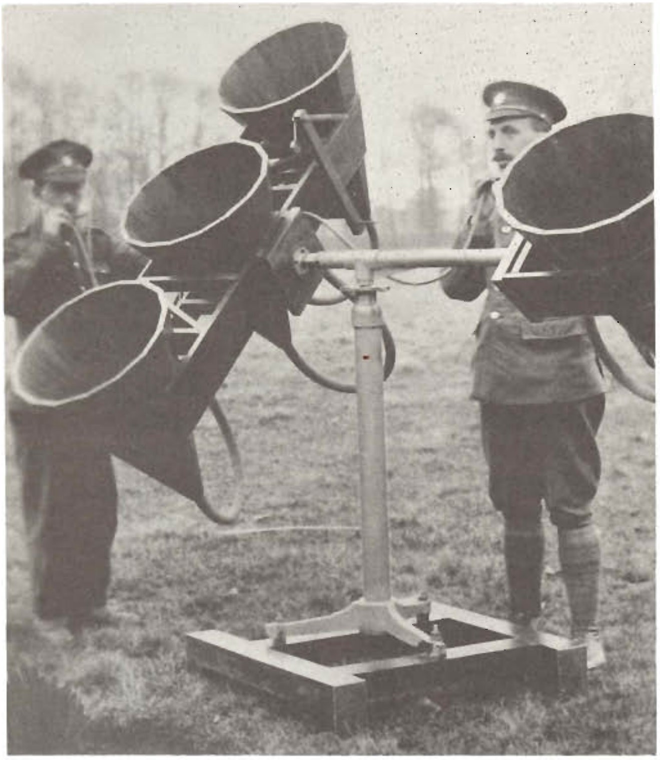


Figure 8. Early French sound locator, 1918.

Shortly after United States' entry into World War I, three Coast Artillery Corps officers were sent to France to study antiaircraft techniques and to establish a US antiaircraft school at Arnouville. The school was ready by the middle of September 1917, and approximately 25 students arrived in October 1917.

The American antiaircraft units engaged in World War I, using essentially improvised gun equipment and machineguns, achieved the following results between 17-21 July 1918:

Guns:	Shells fired	10,275
	Airplanes brought down	17
	No. of shells per plane	605
Machineguns:	No. of rounds fired	225,115
	Airplanes brought down	41
	No. of rounds per plane	5,500

Editor's Note:

The next installment of "History of Air Defense" will treat of advancements in aircraft design and capability (and the related aerial threat) between World Wars I and II.

Vulcan in Vietnam

Captain John S. Wilson
US Army, Deceased

Editor's Note:

In November 1968 the First Vulcan Combat Evaluation Test Team was formed at Fort Bliss and sent to Vietnam to test the suitability of Vulcan for ground support. The author volunteered for duty with the test team knowing the dangers that would be encountered since he had only recently returned from duty in Vietnam as an M42 platoon leader—wearing the Bronze Star with V Device and the Purple Heart with Oak Leaf Cluster. Impressed by the fury of combat, he wrote this article describing the ferocity of enemy attack and the still greater ferocity of our forward area weapons response—the Vulcan in particular. During a rocket attack on Long Binh Base Camp on 23 February 1969 Captain Wilson was killed. He has been recommended for posthumous award of the Distinguished Service Cross and the Legion of Merit.

The small convoy of seven armored personnel carriers made its way carefully along the narrow jungle road. The men of A Troop, 11th Armored Cavalry Regiment, scanned the dense, tangled jungle for signs of enemy activity. Viet Cong and North Vietnamese regulars had been reported operating in the area. The possibility of ambush was a constant threat along the road.

A Vulcan beats the brush at Binh Long Province outpost in Vietnam.

Suddenly, without warning, the jungle exploded in a hail of small arms fire. Within seconds, rocket gunners found their marks. Two of the trapped vehicles lay burning in the road. The North Vietnamese continued to pour intense fire into the convoy, inflicting heavy casualties on the men of A Troop. Another deadly enemy ambush was on the verge of success when a strange sounding roar of cannon fire erupted from the beleaguered convoy. An APC-mounted Vulcan air defense gun system attached to the convoy from the First Vulcan Combat Test Team had opened fire on the North Vietnamese. The air defense artillerymen manning the gun continued to bring accurate, deadly fire on the attackers until the ambush was broken and the enemy was routed. Air defense artillerymen had saved another American convoy.

Since 1966, air defense artillerymen have been distinguishing themselves in close combat with the enemy. Operating with frontline infantry, armor, and mechanized infantry troops, the artillerymen who man the twin 40-mm M42 "Duster" and the multiple machinegun M55 "quad-fifties" have made an outstanding contribution to the American effort in Vietnam. The fighting spirit born with the Coast Artillery in the War of 1812 (brought to maturity through the Civil War, World War I, World War II, and Korean conflict) has been reborn on the battlefields of Vietnam. After being buried for over a decade in the concrete of Hawk and Nike Hercules sites throughout the world, forward area weapons have again become an important, integral part of air defense artillery.

The rebirth began in the fall of 1966 when the first of three air defense automatic weapons battalions landed in Vietnam. M42's and M55's were recalled from the National Guard. Units were formed and received months of intensive training at Fort Bliss prior to oversea employment. The first battalion to arrive in Vietnam was the 1st Battalion (AW) (SP), 44th Artillery, with Battery G (.50 cal MG), 65th Artillery, attached. In the 3 years it has been in combat, the Battalion has become one of the most decorated artillery units in history. Along with its sister battalions, 5th Battalion (AW) (SP), 2d Artillery, and 4th Battalion (AW) (SP), 60th Artillery, it has proved that forward area air defense weapons have an important part to play in the modern field army.

The story of the 1st of the 44th is typical of the three battalions now operating in Vietnam. Names and places differ, but their missions and the combat roles they have fulfilled are similar. Upon its arrival in Vietnam, the 1st of the 44th was assigned to support the 3d Marine Division in the northern I Corps area. The Battalion established its headquarters at Dong Ha Combat Base near the junction of National Highway I and Route 9, approximately 10 miles south of the Demilitarized Zone. The enemy air threat which the Battalion had been sent to counter did not develop. The unit therefore was assigned the primary mission of direct support of ground troops. Fire units were deployed throughout northern I Corps, from Phu Bai in the south to Geolinh and Conthien in the north and Khe Sanh in the west.

As the Battalion began ground operations, field commanders realized that the high rate of fire and the ready mobility of the M42's and M55's made them extremely flexible systems. Since a scarcity of armored combat vehicles existed in I Corps, M42's were first employed as armor. Although the Battalion's organization and equipment were not designed for armor-type missions, the air defense artillerymen met the challenge. Supported units quickly learned the value of forward area weapons as time and time again air defense firepower neutralized enemy bunkers and troop concentrations. Air defense artillerymen distinguished themselves on numerous occasions and were decorated along with men in the other combat arms.

As the war progressed, combat experience dictated methods of employment which took full advantage of the weapon's capabilities. M55's were mounted on $2\frac{1}{2}$-ton trucks to further increase their mobility. Convoy escort and perimeter defense became primary missions for the "quad-fifties." M42's were also employed in these roles. In addition, missions of search and destroy, road security, night ambush support, and direct troop support were assigned. Weapons were even mounted on barges for riverine patrol. In all cases, regardless of the mission, the air defense artillerymen demonstrated ability to fight effectively in combat. Their courage, determination, and technical competence have made forward area weapons a respected part of air defense artillery.

While the M42's and M55's continued to perform a valuable ground mission in the Republic of Vietnam, the need for low-altitude air defense for forward combat units in the field army became an increasing concern of commanders at all levels. The acquisition of modern high-speed aircraft by Communist nations created a threat for which the field army had no defense. The Hawk system was determined to be incapable of effectively intercepting and destroying enemy aircraft during extremely low-level attacks on troops and installations. It also appeared that the combat proven M42 and M55 systems would be relatively ineffective against the supersonic air threat. New systems were required. The Air Defense Board tested a number of proposed forward area weapons and eventually decided upon the XM163 Vulcan gun system and the XM48 Chaparral guided missile system.

Vulcan is the latest gun system to join the air defense inventory. It consists of a 20-mm, Gatling-gun type of cannon mounted on a modified M113 tracked vehicle chassis. With the turn of a dial on the control panel, the Vulcan gunner can select a 10-, 30-, 60-, or 100-round shot burst at a rate of 3,000 rounds per minute. He can also select continuous fire at a rate of 1,000 rounds per minute. Utilizing a linkless feed system, Vulcan carries 1,200 rounds ready to fire and an additional 800 rounds ready to load. In the air defense role the system uses a computerized, solid-state, range-only radar to down aircraft at ranges up to 1,500 meters. In the ground role, a 6-power tank scope allows the gunner to place effective fire out to approximately 3,000 meters. Using indirect fire techniques, the Vulcan system is capable of a maximum range of 4,500 meters. For night firing each fire unit is equipped with a 7-power, crew-served, night-vision scope which allows the gunner to place effective fire on targets that would normally defy detection. In addition to the self-propelled Vulcan, there is a towed version for attachment to airborne and airmobile divisions.

With the advent of the new Vulcan and Chaparral systems, air defense artillery assumes a new dimension in combat. In the future, air defense artillerymen will continue to develop the fighting spirit which was reborn in Vietnam with the "Dusters" and the "quad-fifties." To a greater degree than ever before, air defense artillerymen will fight side by side with the infantry, armor, and field artillery. It was in this spirit that on 11 November 1968 five Vulcans, designated the Firt Vulcan Combat Test Team, deployed to Vietnam for 120 days of combat testing to determine their capability in the ground support role. The Army Materiel Command test was evaluated by the Army Concept Team in Vietnam. A main objective was to determine whether the Vulcan would be an adequate replacement for the M42 and M55 systems. The test plan called for the Vulcan to be attached to the 5th Battalion (AW) (SP), 2d Artillery. All types of missions, including perimeter security, convoy security, search and destroy, road outposting, riverine patrol, and mine sweeps were assigned in the 1st Infantry Division, 9th Infantry Division, and 25th Infantry Division tactical areas of operation within the Third Tactical Corps. According to initial reports from the combat zone, Vulcan is a spectacular success.

Vulcan blasting the enemy from his hiding place.

With the development of Chaparral and Vulcan and the continued success of the M42's and M55's in Vietnam, it appears that the future of air defense artillery will be strongly influenced by its forward area weapons. Concrete sites, revolving radars, and humming generators will no doubt continue to be identifying characteristics of air defense, but they will no longer dominate the air defense scene. Modern trends in forward area weapons have given the Army's newest branch an entirely new complexion. Air defense artillery again takes a place in the field with the combat soldier.

Static Radar Cross Section— Its Application and Measurement

Captain George D. Locke, Jr
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The introduction of radar in World War II created a new dimension in the detection and tracking of aircraft. The impetus provided by wartime environment resulted in the steady progress of this new device to a comparatively sophisticated state, even before the close of the war. The RAF successfully mounted night interception missions using radar for closing with enemy aircraft. During this period, rule-of-thumb estimates of target characteristics were entirely sufficient for the design and operation of those systems. Brute force techniques involving primarily power and long pulse widths were available which permitted targets to be detected and their general direction discerned.

Since World War II an exploding technology has given new tools to the radar designer, resulting in a sophistication unimagined in the early days of this unique tool. Added to this, requirements brought about by a large and expensive space program and the necessity to counter threats heretofore inconceivable have further extended the frontiers of radar operation. Radar has become a precise instrument with the ability to resolve smaller targets at greater ranges with improved accuracy. Under these conditions it has become necessary in many cases to have a complete and accurate description of the radar target for both systems design and operation. Similarly, the weapon system designer, in building the weapon system to either penetrate or operate in a hostile radar environment, has a whole new set of constraints if his efforts are to result in a successful operational weapon.

The characteristics of a radar target, or its radar signature, generally include its radar cross section (RCS). This term appears as the Greek letter sigma (σ) in basic radar equations and is dependent only upon frequency of the RF (radiofrequency) energy in the aspect angle at which the target is viewed by the radar. The advantage of designing a radar target using this parameter is that it is independent of all other parameters and, once determined, can be used in computations for prediction or analysis of any other radar operating at the frequency for which the radar cross section has been measured. Radar cross section is given in units of area, ordinarily metric units (square meters).

This report will be primarily concerned with the measurement of the static radar cross section of various radar targets; specifically, the techniques employed at the radar target scatter (RATSCAT) facility (fig 1), a division of the Air Force Missile Development Center, Holloman Air Force Base, New Mexico. Static radar cross section, as differentiated from dynamic radar cross section, is simply the radar signature of the target measured in a stationary position. This adequately describes the target except under the conditions of reentry into the earth's atmosphere for space-type targets. Reentry phenomena involves the generation of a plasma sheath surrounding the vehicle which both shields and absorbs radar energy. The advantages of static measurement techniques are that data of extremely high accuracy can be obtained while simultaneously having an exact knowledge of the aspect angle of the target to the radar. In addition, it is possible to obtain this information on many targets, which otherwise would have to be expended, if the radar cross section were measured under dynamic conditions. In most cases, this would be more expensive than would dynamic measurement (an example will be given later).

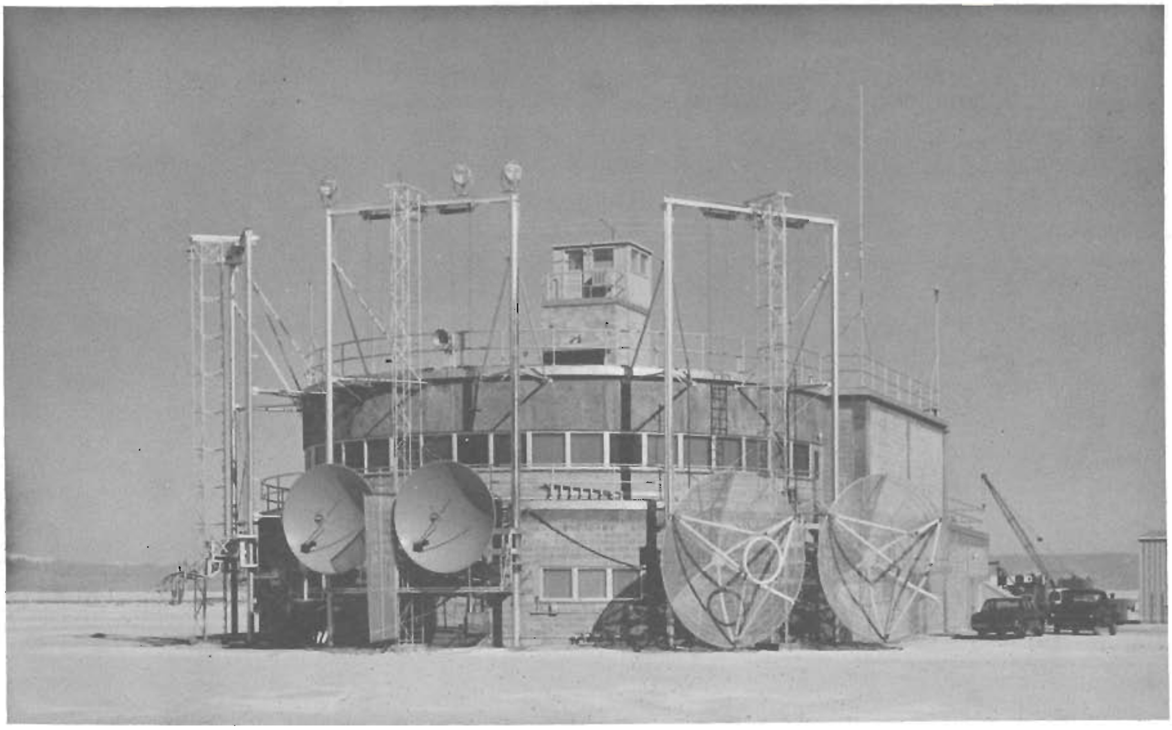


Figure 1. Frontal view of the RATSCAT operations building showing the antenna mounting towers.

The RATSCAT facility, located on the Alkali Flats in the White Sands Missile Range, is one of the most sophisticated and flexible electromagnetic laboratories in the free world. Available for use by all Government agencies, the RATSCAT facility consists of three separate radar backscatter ranges which operate simultaneously some 15 hours a day.

The targets to be measured are mounted on support structures made of polyfoam material, such as styrofoam, which are, in turn, placed on rotating platforms. These support structures place the target anywhere from 10 to 30 feet above the ground. The polyfoam materials are essentially transparent to the radar energy and permit the radar to see the target under free space conditions. Site visitors are generally surprised to find styrofoam used as a structural material. It is, however, surprisingly strong in a compression mode, but great care must be taken to insure that it is not subject to tension or bending moments. Using techniques which have been developed at the RATSCAT facility, targets weighing up to 12,000 pounds may be supported on these structures (fig 2).

Once the target supports have been designed, fabricated, and tested, a radar system is put together using a wide range of "black boxes" available at the RATSCAT facility. The resulting radar system will simulate precisely the radar environment specified by the requesting agency. RATSCAT routinely measures the radar cross section of all types of vehicles at frequencies ranging from 100 megaHertz (MHz) through 12 gigaHertz (GHz).

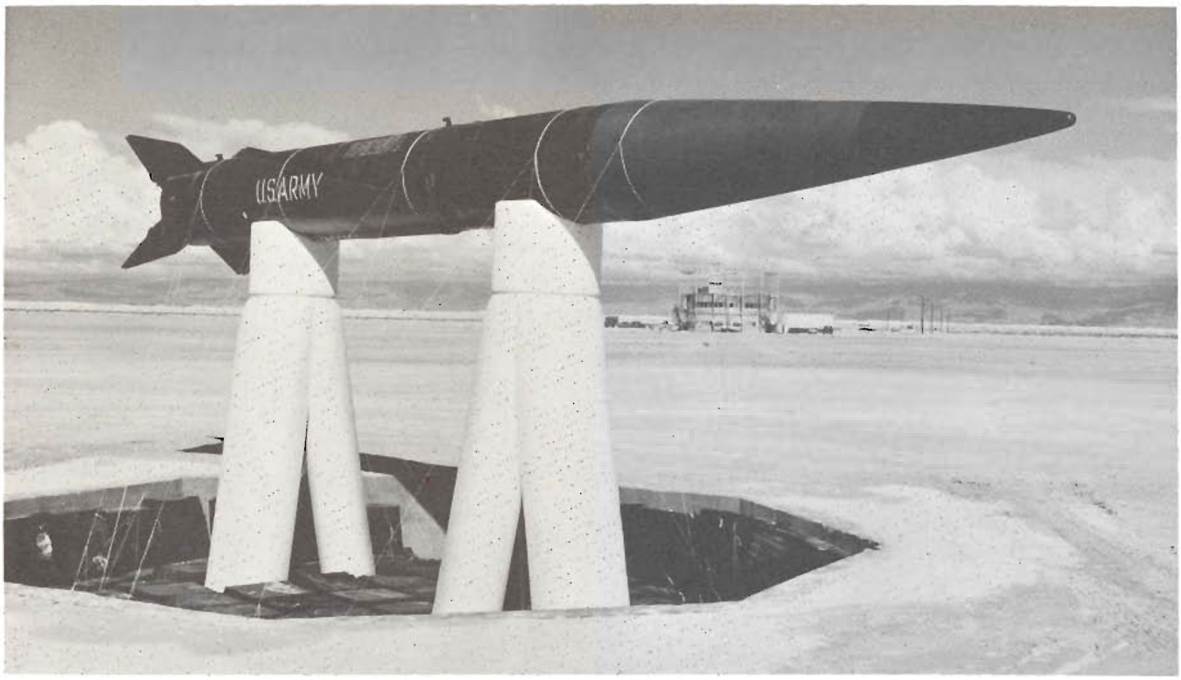


Figure 2. Sergeant missile on styrofoam tripods ready for measurement.

At this point in the measurement program, the RATSCAT facility employs some techniques which make this a truly unique facility and account for its remote location. By extremely careful adjustment of the relationship between the antenna heights and target height, constructive reinforcement of the energy radiated directly from the antenna to the target and the energy reflected from the ground to the target can be obtained in the areas of interest. This technique, which is frequency dependent, requires an extremely homogenous ground plain. The Alkali Flats near the White Sands National Monument exhibits such characteristics. The employment of this technique, as opposed to those techniques where ground clutter must be absorbed or baffled, results in an extemely low noise measurement environment.

Each measurement program conducted at the RATSCAT facility therefore entails the building of a complete radar system range. The entire system, once established, is calibrated using a precision sphere. Various sizes of calibration spheres are employed at the RATSCAT facility for this purpose, and each is maintained within a tolerance of one one-thousandth of an inch. Subsequently, the target is mounted on its polyfoam support and measurements taken from all aspect angles of interest.

Since its inception in 1963 the RATSCAT facility has measured targets which span the spectrum of vehicles susceptible to radar detection and tracking. These targets have included aircraft, missiles, reentry vehicles, satellites, tactical rockets, and mortar shells. These targets have ranged in weight from a few ounces to 12,000 pounds and in dimensions from fractions of an inch to 60 feet. The tremendous flexibility designed into this open air laboratory permits its use for almost any type of radar simulation imaginable. RATSCAT measurements have provided valuable data to Pershing, Poseidon, Minuteman, Nike, Apollo, and many other programs.

The Apollo measurement series conducted at the RATSCAT facility during the summer of 1968 provides an example of the typical RCS measurement program. Investigations into the tragic explosion and fire of the Apollo 1 spacecraft in early 1967 resulted in the removal of the C-band radar transponder from the Apollo command module. Officials of the National Aeronautics and Space Administration (NASA) became concerned as to the capability of various C-band radars to acquire and track the vehicle without benefit of the transponder. RATSCAT, with its unique capability, agreed to find the answer to this important question. A full-scale command and service module combination was mounted on two styrofoam tripods in the flight configuration of the vehicle as it would be in earth orbit (fig 3). This target, one of the most complex ever measured at the RATSCAT facility, was 33 feet in length and 13 feet in diameter and weighed approximately 6,000 pounds. Various combinations of vehicle attitude and antenna polarization were utilized to obtain the radar cross section from every aspect angle of interest. The data thus obtained were furnished to NASA with less expenditure of resources and money than would be required to fly the vehicle to obtain the same information.

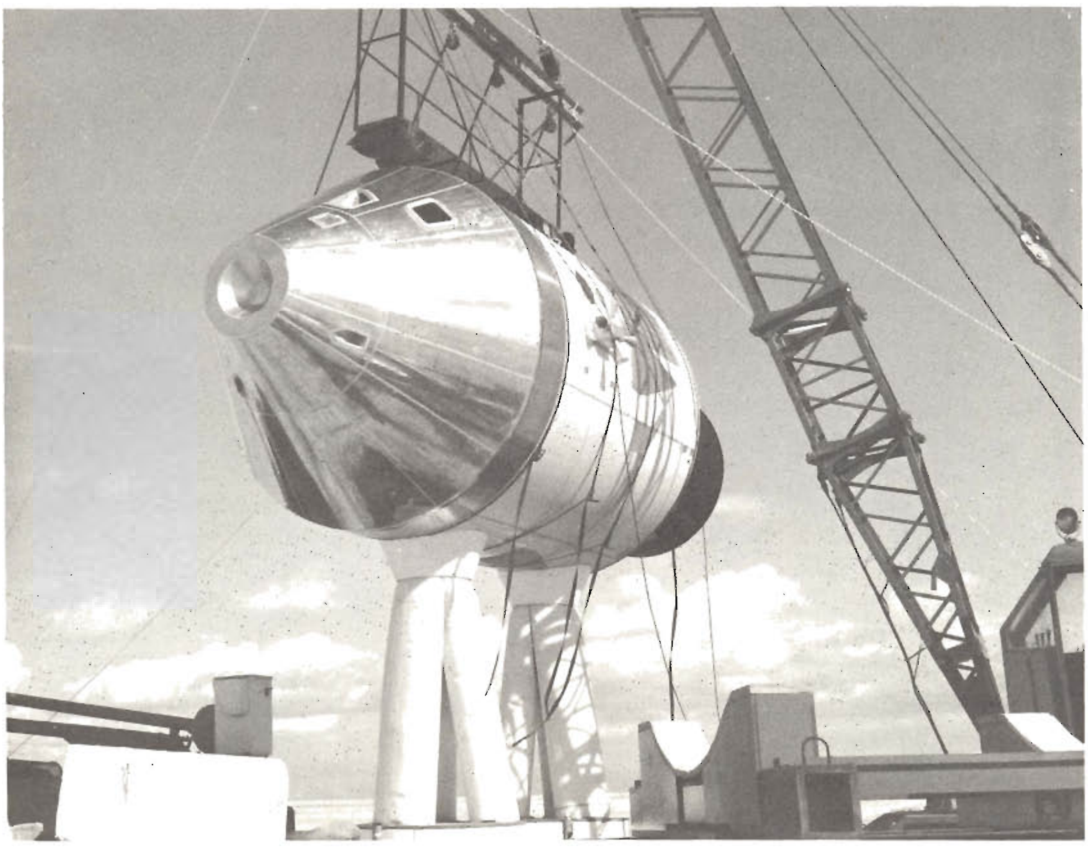


Figure 3. Mounted on radar-transparent styrofoam pillars at Holloman's radar target scatter (RATSCAT) site is the Apollo command and service module.

The current state-of-the-art in both radar techniques and the camouflaging of weapon systems from radar detection has resulted in the RATSCAT facility playing an increasingly important role in the development of both radars and weapons. Practically every weapon system in the operational inventory has had its radar signature measured at the RATSCAT facility. Many new weapon systems now under development have contractual specifications concerning radar cross section. In the future, radars employing new devices and methods will be able to discriminate between complex targets with greater accuracy at increased ranges. The RATSCAT facility is taking steps now to insure that it will be able to adequately simulate these new radar environments.

The high level of technical achievement in the field of radar has placed new demands on both the radars themselves and the weapons which must fly against them. RATSCAT is furnishing the information which leads the way to fulfilling many of these requirements.

Management and the Missile Site Commander

Major Edward R. Morrissey
Headquarters, US Army Air Defense Command
Ent Air Force Base, Colorado

HELP WANTED. MALE. MANAGEMENT POSITIONS. Manager to operate the following activities: Motel to accommodate 80 people (no swimming pool, room service, or television-in-every-room worries); restaurant serving 350 meals daily; personnel processing department serving 140 employees; data processing section requiring knowledge of analog and digital computers; school offering instruction in numerous subject areas; police force (includes guard dogs); repair parts retailing outlet; power generating plants; small library and chapel; short-haul trucking division. Persons applying must be familiar with law (especially regarding search and seizure), collection of evidence, and constitutional rights of accused persons; financial and marital counseling; data collection; property accounting; small firm bookkeeping; maintenance procedures for radars, computers, communications equipment, solid-fuel engines, missiles, rifles, and pistols, service station operation, and office management. Applicant will be expected to perform all functions in a faultless manner. Must have impeccable personal background with no history of emotional disturbance. Salary about $10,000 per year (not negotiable) with hospitalization, 30 days paid vacation per year, and other fringe benefits. No telephone calls please. Apply in person to US Army.

This want ad pretty well describes the nontactical duties of the missile site commander. Besides the positions and skills listed, the commander must be the tactical leader of his battery, and he must be thoroughly familiar with air defense combat procedures and employment criteria for some of our most awesome weapons. He must be proficient in the art of leadership and in the science of management.

At the close of World War II many civilian corporations were rushing to implement the superior management methods and techniques devised by the military to meet the enormous demands of modern warfare. Business leaders organized their corporations along the "line" and "staff" concepts, adopted the operations research and systems analysis procedures pioneered by the military, and improved their reporting systems to reduce response time to unfavorable situations.

In the years that followed a curious thing happened. The military emphasis on management waned while the civilian sector made great gains in methods and procedures. Now, due to the fantastic amount of national wealth being consumed by the war in Vietnam and the new, expensive, and sophisticated tools of war, a painful and long-delayed rebirth of military management is occurring.

Today's colonels and generals are the vice-presidents of the military management system, and they make their critical decisions in a complicated world—a world where continental defenses call for guided missiles, and where communications involve radios, computers, and satellites. To the air defense artillery officer, the responsibility to manage complex missile systems, computers, and communications, integrated into the traditional allocation problems of men, money, and materials, comes with jobs well below the level of colonel or general—generally at the grade of captain to the missile battery commander.

His site, except for maintenance and retrofit downtime, must never be more than a few hours from full combat operation. His unit may often be within only minutes of participation in general war. All of these tactical requirements demand that the missile site commander, in addition to being a tactical leader, be an expert manager. Through formal training and on-the-job experience, he must be conversant with the latest and best management techniques.

If forced to pick "a first among equals" from the five elements of management—planning, organizing, staffing, executing, and appraising—it would have to be planning. Planning begins with the assumption that the future will be different from the present and attempts to determine how enterprise can take advantage of that difference. Planning thus becomes a device for change to meet the future. The unit must always be ready to demonstrate its capability to fire a missile; to assemble, prepare, and employ nuclear weapons; and to maintain its materiel. The commander must plan so that his unit can accomplish its mission.

The unit commander spends a great deal of time writing plans. Unit plans tend to paraphase large sections of the plans or regulations of higher headquarters. Inspection teams often cause this fault by requiring that battery plans be all-encompassing. Better planning is to write unit supplements that include only the material necessary to adapt the plan to the unit concerned. The supplement states in clear and concise language what is expected of the site personnel. The plan is intended to be read and implemented perhaps every day or only in emergency situations. As conditions change, the plan must be updated. The unit commander may assume, or even state to an inspector, that a particular procedure is being followed when in fact the plan is widely ignored by unit personnel because it no longer meets the present need.

Supplementing the formal plan is informal planning which may be either short- or long-range. Short-range planning is for the unusual, probable, and possible situations. In informal planning, the plan is disseminated to the people who must implement it. For successful implementation, requirements must be received and understood by the people.

The unit commander must forecast change, draw the proper conclusions from his forecast, and innovate plans to successfully manage his unit. Through skillful planning, management functions can be effectively executed.

To meet the planned-for future, it is necessary to evaluate the unit's organization of personnel and equipment as established by the table of organization and equipment (TOE). Where the allotment of personnel and equipment is not adequate or the grade distribution does not provide for orderly career opportunity and advancement, the unit commander must have the necessary changes made. Conversely, personnel or equipment excess to the mission should be deleted. When organizing the watchword must be adequacy.

With the plans written and the allocation of personnel spaces and equipment decided, we come to staffing—the selection and retention of people to operate the site. Out of the individuals assigned, the commander must form an effective unit. The commander can significantly influence the number of men staying in or leaving the unit. He can begin by encouraging reenlistment. Many well-qualified men in the Army today, if shown the real advantages of remaining in the Army, would stay. The commander can insure that his men are happy and successful in a directed society. He should not attempt to retain men with excessive disciplinary history, who plan extensive formal civilian schooling, or who want to go back to their old hometown. The commander must try to guide each man in a direction best for the man and the service.

The unit commander must provide the motivation toward the end that the men shall be motivated in a positive direction. The key to motivation is to cause the worker to be responsible for something. The results of the undertaking then reflect upon the individual. A recent survey of seniors and graduate students, all anticipating military service, revealed the following motivational problem areas (in descending order): Emphasis on unquestioned behavior; lack of intellectually challenging work; nonacceptance of many of the traditional values of an educational institution (right of dissent, right to criticize, volition, respect for esthetics, knowledge for its own sake, and the like); boredom that will result from nonsatisfying work; autocratic, unreasonable demands; time spent learning such relatively simple skills as basic mapreading; lack of recognition of educational status; restrictions on promotion that may lead to men being promoted who have been in the service longer but who are less talented than they; these men being their superiors; military etiquette (such as saluting); demeaning status of being at the bottom of a highly structured organization; and living in barracks.

The officer and noncommissioned officer can do much to recognize and accommodate the rising intellectual level of the people in the Armed Forces, a trend which is to be welcomed. Because of the complex nature of air defense equipment, we can expect an increasing influx of men of the type surveyed.

After the men and material have been gathered, the commander/manager must use them effectively if he is to execute his mission. For his plans and orders to be properly executed, they must be reasonable and fair. The commander must understand the capabilities and limitations of his command and employ it with maximum efficiency. The modern commander must be conversant with the technical aids to decision-making. A basic understanding of operations research, systems analysis, linear programing, program evaluation and review technique, and modeling are essential to solving complex management problems.

One of the most important elements of management is evaluating the results of operations and decisions. The command spends hours gathering data, reading reports, making inspections, and observing. Evaluation is the careful study of results and the drawing of correct conclusions from that study.

The commander must pinpoint exceptional situations rather than devote attention to a mass of routine data that does not signal any need for action. The commander must devise information systems that will provide him with the "exceptional situations" in near real time and to identify trends soon enough to capitalize on favorable conditions or to halt the progress of unsatisfactory situations.

To state it briefly, the missile site commander is charged with the management of a significant number of people with widely varying skills, equipment worth millions of dollars, and an expensive physical plant. He must apply the elements of management, leadership, and command to these resources to insure successful accomplishment of the mission.

MAINTAINABILITY: A Look Into the Future

Thomas W. Wiggins
High Altitude Missile Department
US Army Air Defense School

Editor's Note:

This is the second in a series of articles dealing with the merits of simplicity in maintainability.

Maintainability engineering has developed as a result of the technical complexity of equipment placed on the market in recent years. Despite this equipment complexity, the buyer demands that the equipment be available for use, with a high degree of reliability, over the life cycle of the product. It is also necessary that the operation of the equipment be simple, the failure rate low, and repair costs minimal. For a product to survive in a highly competitive market, the manufacturer must satisfy these demands. Designing complex equipment that will satisfy these demands can no longer be accomplished by one man; it is now the combined effort of a design team. The importance of the maintainability engineer as a member of this team increases in relation to the increase in equipment complexity. As a member of the team that designs military equipment, his position is even more important, for here the competition is among nations and the goal is national survival. The ability of the United States to maintain a favorable military position among competing nations depends on its defense posture which, in turn, relies heavily on equipment readiness. Maintainability is a major contributor to this readiness posture.

Maintainability engineering, although still in its infancy, is receiving more and more interest from both industry and the military alike. In fact, the military services are now placing interest on maintainability similar to that placed on reliability a few years ago. As equipment has become increasingly complex, the problem of adequate maintenance support has increased enormously. To a great extent this increase is a result of inadequate planning for maintainability in the design and development stage. Actually, support requirements, in most cases, have had to bridge the gap between poor maintainability design and equipment availability requirements. To appreciate what is happening now, one must have an insight into how new military equipment and systems are brought into being in response to defense demands. Identification of these demands results from military weapon research—and, more specifically, from analysis of the capabilities of competing nations to produce more sophisticated and effective weapon systems.

Once identified, these demands must be translated into qualitative requirements which represent a desired new weapon system. The qualitative requirements are, in turn, translated into quantitative requirements that establish definite but broad design characteristics. It is at this early stage that the maintainability engineer must actively influence equipment design by providing for the orderly and timely development of an acceptable maintenance support concept.

The support concept is the basis for establishing plans for maintaining the equipment in the field. It defines the repair philosophy, techniques, and concepts that will guide support planning and provide a basis for defining support requirements. A properly formulated support concept becomes a valuable device for determining many of the system design characteristics. The concept must be translated into maintainability requirements before actual design of the system is begun. In particular, the concept must clearly state the repair policy that will best meet the needs of the proposed system. Selection of the repair policy requires a thorough analysis of the system's function, complexity, and use.

The repair policy will be a major factor in system design characteristics. If, for example, the decision is to repair by modular replacement, then modularization must be incorporated as a basic design feature. Because of the rapid advancement in modular construction and packaging techniques, particularly of electronic equipment, the maintainability engineer must consider a nonmaintained design. It is not intended to suggest here that a complex system, such as an air defense missile system, can be designed to be completely maintenance-free. It is to suggest, however, that some components can be designed to meet this goal. Recent developments in miniaturization of electronic components with their inherent reliability and long operational life make this possible. Such major system components as the missile lend themselves readily to maintenance-free design.

The repair policy selected must be justified in terms of the system operational requirements. The requirements include such factors as planned deployment and operational availability. The policy selected must then be developed into a detailed support program which lists the support tasks and techniques required for the new system. This, in turn, establishes the system's support requirements, such as repair facilities, tools, test equipment, handling equipment, spare parts, personnel skills, and technical manuals of the system. The support tasks must be worked out for each level of support: organizational, field, and depot. When preparing support tasks, two broad objectives should be used: provide maximum repair capabilities at the user level commensurate with the operational requirements and keep the need for skilled personnel and repair equipment at all levels of support to a minimum. Designing equipment so that most repairs are done at the organizational level has a very favorable effect on system support cost. This is because both the number of support personnel required and the degree of skill they must possess are reudced. This, in turn, will reduce training requirements and simplify the preparation of technical manuals that support the system.

The support concept for a new system ultimately consists of a series of support requirements, one set for each level of support. The requirements are designed to meet the needs peculiar to that system. If a high degree of availability is desired, the allowable mean downtime may be reduced to such a short duration that availability can only be met by providing for maximum repair capabilities at the user level. Because repair capabilities are limited at user level, the need for designing for fast fault isolation and easy repair is evident. This is best accomplished with a modular design.

When support requirements have been determined and design decisions made, general guidelines should be established to govern system design, as follows:

1. Modules will be removable by organizational personnel without the use of special tools.

2. Like modules will be interchangeable without requiring maintenance adjustments.

3. The cost of modules will be such that throwaway maintenance will be economically feasible.

4. The replacement time of modules will be such that downtime requirements can be met.

5. Design of modules will be standardized as much as possible to reduce repair parts stockage.

Such guidelines, when translated into maintainability requirements, become prime factors in the actual design of the proposed system.

In formulating a support concept for a proposed system, analysis of all relevant information may reveal several concepts that equally satisfy all the system operational requirements. When this occurs, the optimum support concept can be selected by making a trade-off study of all the concepts with cost as the prime consideration. The trade-off study will identify the concept that best meets the system's operational requirement at the lowest dollar cost. This should not be interpreted as a means of reducing support cost at the expense of system capabilities. The support concept selected must be the one that will best meet the system operational requirements.

In summary, the support concept is the most important document developed for system support. It is from this document that maintainability requirements are determined and, consequently, all support criteria. Considerable study and analysis are necessary to develop a useful document that will insure selection of the support plan that will provide the degree of support required with a minimum cost in material resources and personnel requirements.

Lessons Learned in Vietnam

TACTICAL EXPERIENCES OF DEPLOYED UNITS

(Introductory comments by the Editor)

•Noteworthy experiences and accomplishments of units in Vietnam will continue to be reported as they become available. Here is a brief account from the 5th Battalion (AW) (SP), 2d Artillery•

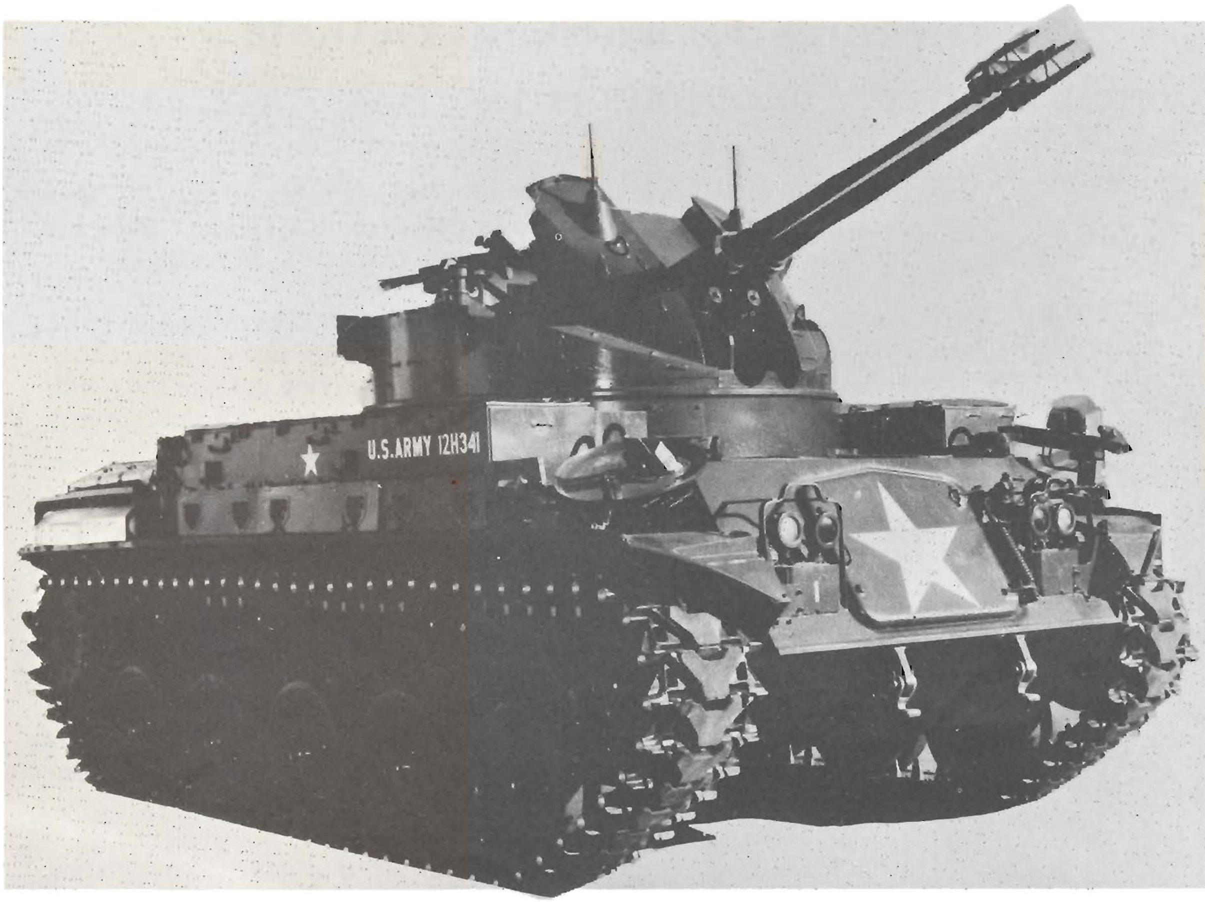
The Battalion developed a combat readiness evaluation (CRE) program designed to provide a more detailed and a more realistic evaluation of the mission capabilities of firing units in the field and also to serve as an instructional medium to standardize procedures and improve overall tactical and technical proficiency. To support the objectives of this program, a battalion CRE team was organized consisting of experienced officers and NCO's from the operations, communications, and maintenance sections of the battalion headquarters. The CRE is comprehensive in nature and provides a detailed evaluation of crew drill, direct and indirect fire procedures, job knowledge, communications procedures, artillery and automotive maintenance, field sanitation, and small arms employment. The results of the CRE's conducted to date indicate that the program is producing the desired results and has already brought about a marked improvement in the overall proficiency of the Battalion's firing elements.

• Sometimes, in the type of warfare we encounter today, we find it profitable to take "a forward step backward"•

Probably one of the oldest air defense weapons in the present Army inventory, the twin 40-mm self-propelled gun M42, dubbed appropriately the "Duster," is making a valiant comeback as an effective, versatile weapon. Amidst today's challenge of sophisticated, scientific weaponry, the vintage Duster is still highly acclaimed as an effective weapon.

Originally designed as an antiaircraft weapon providing air defense for armored divisions, the Duster saw duty in Korea and is currently employed in a ground support role in Vietnam.

Not a sleek or impressive looking weapon with its high silhouette, open turret, and blocky configuration, the twin 40-mm fully automatic gun mounted on the M41 light tank chassis provides a combination of devastating firepower and facile mobility which displays unique strength. The twin 40-mm gun is capable of firing 240 rounds per minute at targets up to 9,000 meters in range. Either direct or indirect fire methods may be used, depending on the range and location of targets. Since all 40-mm ammunition is tracer and the sighting system was designed primarily for direct fire, the gun is ideally suited for placing extremely accurate fire on pinpoint targets at ranges up to 2,000 meters. Reaction time in changing targets is instantaneous with the gunner's vision as he observes each round through tracer observation and splash on strike. When the gunner engages a different target, he may begin firing immediately upon obtaining a sight picture. He can then adjust his fire as necessary.



Duster.

The 40-mm projectile is often mistakenly compared with the 40-mm grenade and other grenade launcher systems. Although both projectiles are of the same caliber with point-detonating fuzes, there is little similarity in other characteristics. The 40-mm high-explosive, incendiary tank (HEIT) projectile weighs approximately 2 pounds and is propelled at 2,870 feet per second as compared to a 40-mm grenade projectile weighing 8 ounces and propelled at approximately 250 feet per second. The effects of detonation of the 40-mm HEIT projectile are intense, as should be expected from its size and high velocity. Deeper penetration is achieved through the force of impact, and additional fragmentation occurs due to its larger size. Against personnel in the open, or in hasty fortifications, the destruction results of the 40-mm HEIT round are appalling.

The lightly armored, basic M41 chassis has proved to be a rugged, sturdy, and adaptable firing platform for the 40-mm gun. Capable of speeds up to 45 miles per hour and fording depths of 40 inches and negotiating crevasses of 6 feet while weighing 25 tons fully combat-loaded, the vehicle has demonstrated durable mobility both on and off road networks in Vietnam. Another significant feature of the M42 is its inherent ability to withstand land-mine explosions with minimum crew fatalities. Certainly, landmines can and do produce extensive damage to the chassis, but the Duster's excellent suspension system and high ground clearance reduces casualties and damage to a great extent.

Extracts from lessons learned and correspondence originating in Vietnam have vividly illustrated the versatility of this remnant of World War II. Dusters have been successfully employed in almost every conceivable ground-support role in Vietnam from "search and destroy" to routine perimeter defense or security missions. In all of its many engagements, the Duster has seldom failed to provide effectively its notorious firepower in accomplishing the mission. Although the Duster is due for eventual replacement by the Vulcan system, it seems far from being outmoded now in view of its continued deployment. In Vietnam, Duster has performed outstandingly and was a welcome weapon in numerous instances. To name a few: the field artillery battery commander who witnessed supporting Dusters fire hundreds of rounds throughout the night in defense of his hard-pressed perimeter, the cavalry platoon leader who welcomed the Duster's arrival at his contested position one night, the adviser who embraced the Duster leader who broke through to the adviser's surrounded position early one morning, and even the MP's who consumed their fair share of dust daily while trailing for many miles behind the Duster convoy security escort clanging away up front.

Try Your Hand at Ohm's Law

Across

1. With 8 amperes through a 2-ohm resistance, the voltage is __________ volts.

5. The current drawn from a 120-volt line by a 1,200-watt toaster is ________ amperes.

6. E represents ________.

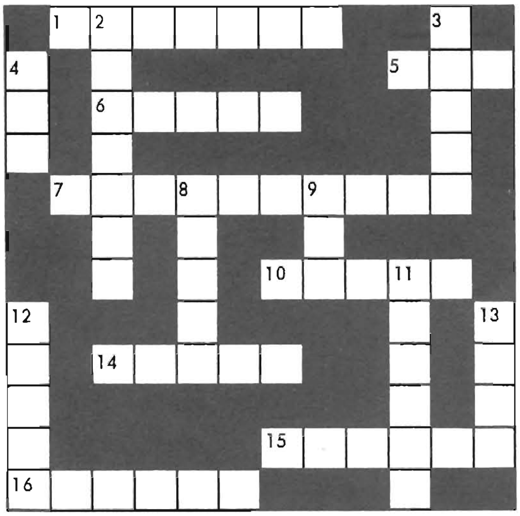
7. The current increase is in direct ________ to the voltage increase when resistance is constant.

10. The time rate of doing work.

14. If the power out is 9 watts and the circuit resistance is 1 ohm, then the current is ________^{2}.

15. I represents ________.

16. If 24 volts are dropped across a 2-ohm resistor, the related current is ________ amperes.



Down

2. The formula I = E/R implies an ________ relationship between I and R.

3. 7,000,000 ohms equals ________ megohms.

4. The number of amperes produced by 1 volt across 1 ohm of resistance.

8. It is measured in watts.

9. With 10 volts across 5 ohms, the current is ________ amperes.

11. How many amperes are needed for a 110-watt, 10-volt device?

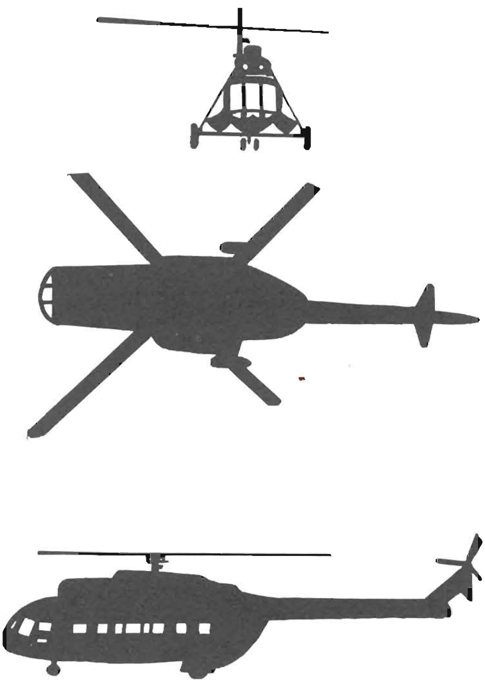
12. If resistance is constant and voltage is doubled in a 4-ampere circuit, the current becomes ________ amperes.

13. How many amperes must flow through a 24-ohm resistor that dissipates 600 watts?

Answers on page 77.

Do You Recognize These Aircraft?

1



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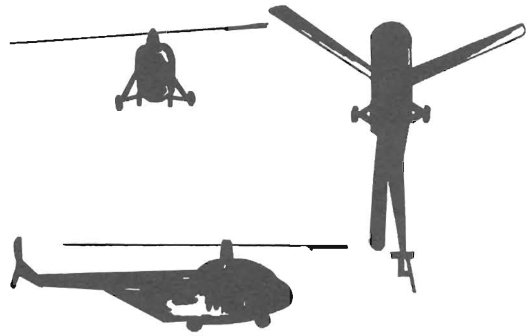

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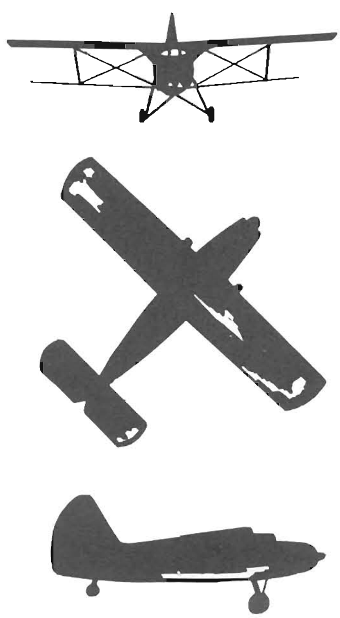

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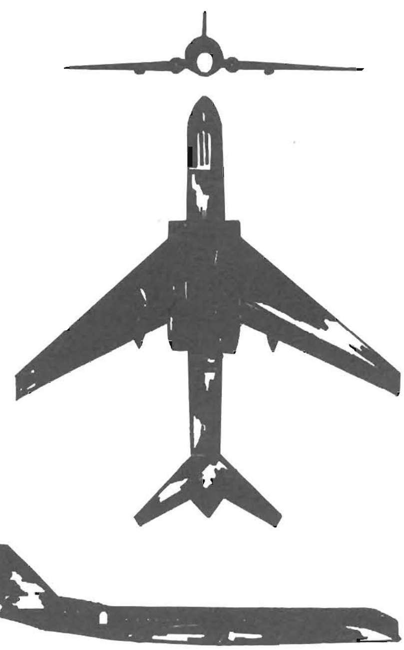

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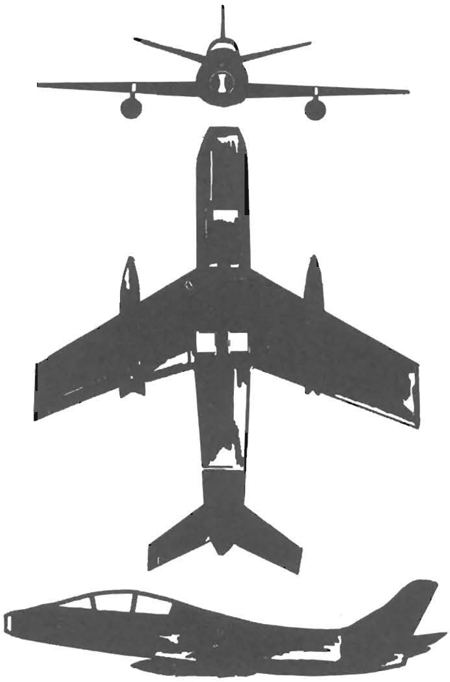

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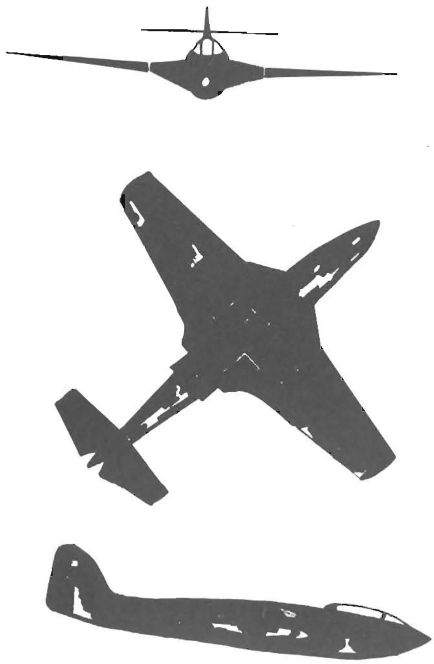

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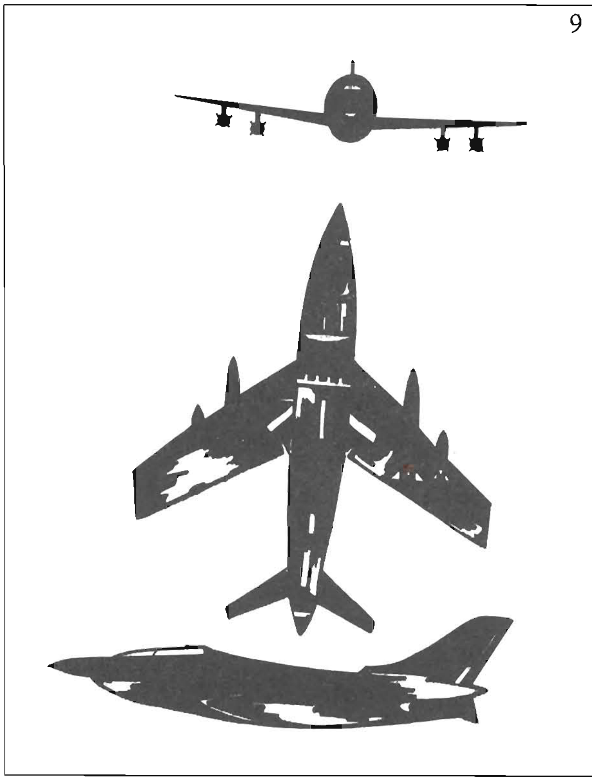
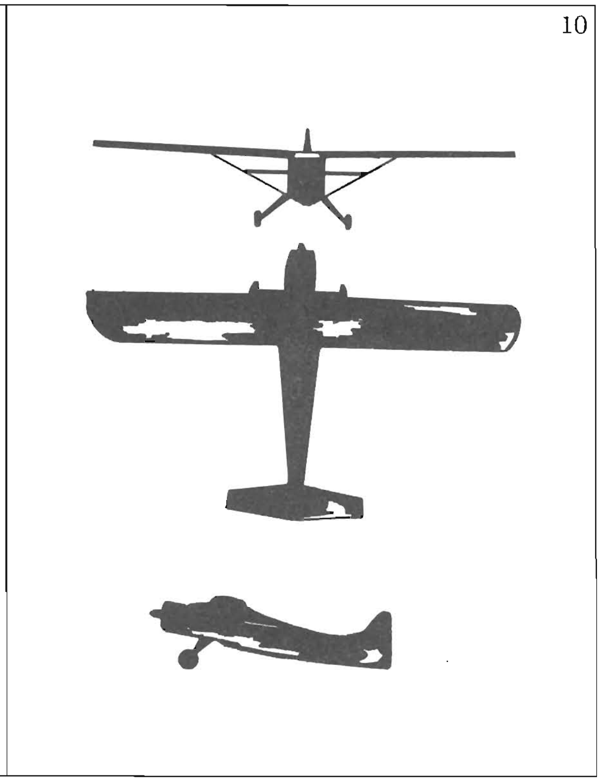




Correct identifications of aircraft:

1. Mi-8 (Russia).
2. UH-19 (US).
3. An-2 (Russia/North Vietnam/ North Korea).
4. Tu-104 (Russia).
5. Mig-19 (Russia/North Korea).
6. F-5 (US).
7. T-F2 (Japan)
8. Sea Hawk (Great Britain).
9. Fiat G-91 (West Germany).
10. U-6A (US).

Answers to crossword puzzle:

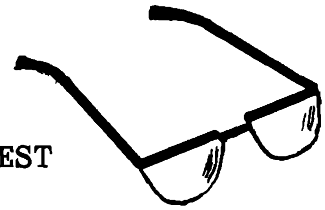
Across

1. Sixteen.
5. Ten.
6. Volts.
7. Proportion.
10. Power.
14. Three.
15. Ampere.
16. Twelve.

Down

2. Inverse.
3. Seven.
4. One.
8. Power.
9. Two.
11. Eleven.
12. Eight.
13. Five.

Reader's Corner



CURRENT BOOKS AND ARTICLES OF MILITARY INTEREST

This list is published to draw attention to worthwhile and informative books and articles in other publications. We realize that not all items will be available to all readers. Our motive is to be helpful to as many readers as possible.

The content of these publications does not necessarily represent the opinion of the US Army Air Defense School.

—Editor

BOOKS

DIODES
Diodes and Transistors, General Principles by G. Fontaine. Hayden Book Co., New York, 1963.
"The aim of this work, whose main care has been to avoid mathematical demonstrations, is to illustrate the fundamentals, either by physical explanations or by the very frequent use of graphs, to the extent required for the application of semiconductors in the most favourable conditions."

ELECTRIC WIRING
Assignments for Apprentice Wiremen by Murray L. Wykes. University of Texas Press, Austin, 1969.
This is a series of instructor's manuals and tests isssued by the Industrial Education Department of the University of Texas on the subject of electrical wiring.

LATIN AMERICA - POLITICS
Latin America: Myth and Reality by Peter R. Nehemkis. Knopf, New York, 1964.
This book, a Contemporary Military Reading List selection, is an attempt to unmask the mythology that blocks understanding of Latin Americans by North Americans, and of North Americans by Latin Americans.

MARSHALL, GEORGE CATLETT, 1880-1959
George C. Marshall by Forrest C. Pogue. Viking Press, New York, 1966.
This second of his four-volume biography covers his career from the day he was sworn in as Chief of Staff until the establishment of an allied beachhead in North Africa (1939-1942).

US - FOREIGN RELATIONS
The Obligations of Power by Harlan Cleveland, Harper & Row, New York, 1968.
This Contemporary Military Reading List book is probably the most informed and persuasive statement of American foreign policy to come out of Washington in the 1960's.

US - DEFENSES
Decision-Making for Defense by Charles J. Hitch. Univ of California Press, Berkeley, 1965.
"Mr. Hitch discusses, from the rare perspective of an analytically gifted insider, how the Department of Defense achieved balanced programs and more effective forces through the firm application of the new management techniques without sweeping changes of organization structure." A Contemporary Military Reading List book.

US - MILITARY POLICY
American Strategy: A New Perspective by Urs Schwarz. Doubleday, Garden City, New York, 1966.
"A European specialist's illuminating analysis of modern American strategy, in historical perspective - explaining for the layman the concepts that govern today's civil and military policy-making." A Contemporary Military Reading List book.

COMPULSORY MILITARY SERVICE
The Student's Guide to Military Service by Michael Harwood. Channel Press, New York, 1963.
"Facing the draft??? Here is the most complete, authoritative, and up-to-date handbook for young civilians."

ELECTRIC CIRCUITS
Circuit Problems and Solutions by Gerard Lippin. Hayden Book Company, New York, 1967.
"For the student and the hobbyist, here is a practical guide for the solution of electrical problems which serves as a supplement to electricity texts and as a handy reference tool for anyone involved in basic electrical studies."

ENGLISH LANGUAGE - COMPOSITION AND EXERCISES
Practice for Effective Writing by Vincent F. Hopper. Barons Educational Series, New York, 1961.
Here is a graduated series of practical exercises leading to mastery of basic writing techniques.

HOUSE BUYING
How to Avoid the 10 Biggest Home-buying Traps by A. M. Watkins. Meredith Press, New York, 1968.
"Expert, down to earth, time-saving tips on how to examine a house, new or old; how to judge construction quality; how to negotiate a fair price; how to get a good mortgage and hundreds of other suggestions to help you avoid pitfalls and find a home in the right place at the right price."

TRANSISTOR AMPLIFIERS
Transistors for Audiofrequency by Guy Fontaine. Hayden Book Co., New York, 1967.
"The present work gives a very detailed study of the principles of the audiofrequency applications of the transistor."

VIETNAMESE CONFLICT, 1961-
The Betrayal by William R. Corson. W. W. Norton, New York, 1968.
"This book is an attempt to help the individual to understand the situation and the problems created by the United States presence in Vietnam."

ARTICLES

ASTRONAUTICS
"Aerospace in Perspective," Space/Aeronautics (January 1969), entire issue.
"Sixth annual summary and forecast of US aerospace programs, reviewing all major advanced vehicle projects and including a first-time report on 'The New Directions' in civil systems."

CONTINENTAL ARMY COMMAND
"The CONARC Story," Jack Holden, Jr., Army Digest (March 1969), pp 38-42.
"The CONARC story involves many men, and the manner in which CONARC actions affect their lives and influence the defense of America; also makes it a story of the American people and their determination to remain free."

MIDDLE EAST - POLITICS AND GOVERNMENT
"The World of Islam," Current History (March 1969), entire issue.
"Articles in this issue cover various aspects of the impact of Western ideas on the traditional societies of Islam, and Israel's relationship to the Islamic world."

MILITARY LAW
"Search and Seizure," Martin J. Linsky, Armor (March-April 1969), pp 17-21.
"This article, as promised, has treated the complex subject of search and seizure vis a vis the military commander."

MILITARY SERVICE, COMPULSORY
"The Case for a Volunteer Army," Reader's Digest (April 1969), pp 119-122.
"A professional, voluntary military force seems clearly preferable to the inefficiencies and inequities of the draft. But the question remains: Can it Work?"

ARTILLERY
"Why the Artillery Branch Split," Joseph C. Fimiani and Jack G. Callaway, Army Digest (April 1969), pp 28-29.
"The study concluded that integration of the Artillery constituted a waste of training time, posed an unnecessary burden on the units in which the cross-assigned individual served, and lowered the professionalism of Artillery officers."

DECISION-MAKING
"Decisions, Decisions," J. S. Sinclair, Army Journal (March 1969), pp 14-19.
This article states and elaborates on the basic elements involved in all decision-making. While these elements do not of themselves make decisions, they are the necessary stepping stones to arriving at right and effective decisions.

GUERRILLA WARFARE - MIDDLE EAST
"Revolt of the Arab Refugees: We'll Meet in Tel Aviv," Christopher S. Wren, Look (May 13, 1969), pp 27-36.
"In 1948, the fathers lost a land called Palestine. Now their sons come with Russian guns to take it back. Are they freedom fighters or terrorists?"

RADAR
"Electronic Scan Radar," C. C. Kirkman, The Journal of the Royal Artillery (March 1969), pp 53-57.
"I hope in this article to explain simply how electronic scanning works and what is much more important, the implication for our military systems."

URUGUAY: POLITICS AND GOVERNMENT
"Uruguay: Welfare State Gone Wild," Henry Haxlitt, The Freeman (April 1969), pp 195-202.
"Uruguay's warning to the United States, and to the world, is that government welfarism, with its ever-increasing army of pensioners and other beneficiaries, is fatally easy to launch and fatally easy to extend, but almost impossible politically to reverse, no matter how obvious and catastrophic its consequences become."

VIETNAMESE CONFLICT, 1961-
"We Could Have Won in Vietnam Long Ago," U. S. Grant Sharp, Reader's Digest (May 1969), pp 118-123.
A retired admiral tells how we could have won the war in Vietnam as early as 1967 if we had used the existing power properly.

EARTH - NATURAL RESOURCES
"At Long Last, ERTS (Earth Researches Technology Satellite) Is on the Way," Alfred Rosenblatt and Paul Dickson, Electronics (May 12, 1969), pp 98-106.
"The long-delayed program to keep a running check on the earth's resources with sensors carried aboard orbiting spacecraft is moving into the RPF stage. A full-fledged system could prove well worth the wait, keeping tabs on soil, forests, water supplies, mineral deposits, and the like."

JUSTICE
"Judge Burger's Philosophy on Justice in U. S. - A Key Speech," Warren E. Burger, U.S. News & World Report (June 2, 1969), pp 82-85.
"The White House announcement of Judge Burger's nomination cited portions of this speech and said they 'accurately reflected' the personal philosophy of government of the prospective Chief Justice."

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"Plans Detailed for Lunar Landing," Wm. J. Normyle, Aviation Week (May 19, 1969), pp 16-19.
"NASA draws preliminary flight profile for Apollo 11 mission; Armstrong to take initial step onto moon's surface July 21."

RESISTANCE - CAPACITANCE FILTERS
"Active RC Filters," W. Thelen, Bell Laboratories Record (March 1969), pp 90-94.
"Active RC (resistance-capacitance) filters using tantalum thin-film technology and silicon integrated circuits are being developed. A new 'building block' approach simplifies the design of complex filter networks that provide high selectivity at very low frequencies."

Readers are invited to submit for publication articles and informative notes that are of professional interest to the air defense artilleryman. Articles should be current and forthrightly stated and should relate to some aspect of what air defense units in the field are doing to accomplish their mission, particularly in the technical and tactical areas. Miscellaneous articles expressing either technical or nontechnical ideas that may be of value to air defense will also be considered for publication.

Direct communication to the editor is authorized:

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